



# ASSESSMENT OF ELECTROMAGNETIC WAVES EMISSION IN SELECTED BUILDINGS AT THE FEDERAL UNIVERSITY OF TECHNOLOGY, AKURE: IMPLICATIONS FOR OCCUPATIONAL HEALTH AND RADIO FREQUENCY EXPOSURE

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## **Abstract**

This study presents a spatial assessment of electromagnetic field (EMF) and radio frequency (RF) emissions in three faculty buildings which are SEMS, Old SET, and New SET, at the Federal University of Technology, Akure (FUTA), Nigeria. The research aims to quantify indoor EMF exposure levels and assess their implications for occupational health and radio frequency safety. Using a TriField TF2 meter, over 90 measurement points were surveyed across multiple floors under both load and no-load conditions. Electric field strengths were recorded up to 400 V/m (standard) and 350 V/m (weighted), while magnetic fields peaked at 0.9 mG (standard) and 0.8 mG (weighted). RF power densities ranged from 0.9 mW/m<sup>2</sup> to a maximum of 1.8 mW/m<sup>2</sup>. Spatial variations revealed that hotspots occurred near sockets, routers, and electronic clusters, particularly in high-occupancy zones and along building perimeters. Contour plots generated via MATLAB provided visual insights into field propagation, identifying elevated exposures in biologically sensitive weighted readings, which were often underestimated by standard measurements. Although most values remained within ICNIRP and WHO exposure limits, several zones indicated potential long-term exposure risks. Consequently, strategic recommendations were proposed, including the repositioning of wireless access points, establishment of low-EMF zones, proper cable shielding, device usage awareness, and routine EMF audits. These findings underscore the need for proactive EMF management in academic environments to ensure safe learning and working conditions, and they establish a framework for future longitudinal monitoring of EMF exposure on university campuses.

**Keywords:** *Electromagnetic Field; Radio-frequency; Trifield TF2 Meter; Contour Distribution; Academic Building*

Nomenclatures	
<i>SEF</i>	Standard Electric Field
<i>WEF</i>	Weighted Electric Field
<i>SMF</i>	Standard Magnetic Field
<i>WMF</i>	Weighted magnetic Field
<i>RF</i>	Radio Frequency,
Greek Symbols	
<i>mW</i>	EMF Power measured in milli Watts/m <sup>2</sup>
Abbreviations	
ICNIRP	International Commission on Non-Ionizing Radiation
WHO	World Health Organization
FUTA	Federal University of Technology, Akure

## Introduction

Electromagnetic fields (EMFs) are physical fields produced by electrically charged objects, characterized by their frequency and wavelength (Siegel *et al.*, 2022). EMFs are broadly classified into ionizing and non-ionizing radiation. Ionizing radiation (e.g., X-rays, gamma rays) carries photons with energy exceeding ~10 eV, capable of removing electrons and causing molecular damage. In contrast, non-ionizing radiation including static fields, extremely low frequency (ELF), radio frequency (RF) power, microwave, infrared, and visible light, lacks sufficient photon energy to ionize atoms and generally interacts with matter via thermal or excitation effects rather than DNA disruption. (NCI, 2025)

Non-ionizing EMFs are pervasive in modern buildings, emitted by power lines, electrical wiring, lighting fixtures, office electronics, Wi-Fi routers, and telecommunications equipment. ELF EMFs (1 Hz–300 Hz) originate mainly from electrical systems, whereas RF and microwave fields (3 kHz–300 GHz) stem from wireless devices and base stations (Siegel *et al.*, 2022). Although non-ionizing EMFs lack the ionization capability, there is growing evidence that prolonged exposure particularly to RF is associated with non-thermal and biological effects, including oxidative stress, reproductive effects, and possible DNA damage. (Smith-Roe *et al.*, 2020; Jangid *et al.*, 2023)

Recent studies have focused on assessing indoor EMF exposure. In Nigeria, Ochu *et al.*, (2022) conducted indoor non-ionizing radiation

measurements in residential apartments using handheld meters. (Ochu *et al.*, 2022). Similarly, 5G base-station measurements in China showed EMF levels well within national standards, with minimal influence from 5G deployment. (Huang *et al.*, 2022). Isabel *et al.* (2022) and Samaila *et al.* (2023) emphasize the need for refined RF measurement protocols and highlight potential health effects at household exposure levels. (Isabel *et al.*, 2022; Samaila *et al.*, 2023) Additionally, RF exposure from mobile phone base stations in Nigeria has been documented to remain within ICNIRP limits, although concerns persist for sensitive tools (Sanusi and Okwudili, 2021).

Despite the ubiquity of EMF measurement studies in residential and urban settings, there remains a significant gap in data from university buildings in Nigeria, where dense occupancy, complex electronic networks, and varied architecture may contribute to unique exposure profiles. Few studies have quantified EMF levels in academic spaces such as lecture halls, laboratories, and administrative offices thereby limiting our understanding of occupational and educational exposure risks within such environments. This study evaluates EMF exposure levels in three selected university buildings within the Federal University of Technology Akure, Nigeria: The School of Engineering Main Block, Old Science Building, and

New Science Complex. Specifically, we aim to:

- i. Measure ELF and RF field strength at predetermined locations using a Trifield Meter TF2;

- ii. Create spatial EMF distribution maps through MATLAB-based contour plotting;
- iii. Compare observed levels with ICNIRP and WHO exposure guidelines;
- iv. Identify potential hotspots and recommend exposure-reduction interventions.

By systematically assessing these environments, the study seeks to contribute empirical evidence to inform campus safety policies and broaden baseline data in the Nigerian academic context.

## Materials and Methods

### Study Area and Justification

The study was conducted within the Federal University of Technology Akure (FUTA), focusing specifically on three academic buildings: SEMS, Old SET, and New SET.

#### a) School of Earth and Mineral Sciences (SEMS)

SEMS is one of nine academic schools at FUTA and houses departments such as Applied Geophysics, Marine Science and Technology, Meteorology, and Remote Sensing and GIS etc. The school plays a pivotal role in advancing interdisciplinary research in environmental and earth sciences, supporting a mix of laboratories, equipment-intensive facilities, and high digital connectivity.

#### b) School of Environmental Technology (SET): Old and New Blocks

SET offers programs in Architecture, Urban and Regional Planning, Building, Quantity Surveying, and more, operating across the original (Old SET) and newer (New SET) buildings. As a hub for design and planning disciplines, both blocks are equipped with computer labs, drafting studios, and seminar rooms that have heavy usage of ICT and high student activity.

### Justification for Selection

- i. **High Occupancy and User Density:** SEMS and SET host large student populations and faculty across their specialized lecture halls, labs, and seminar rooms. Their daily operations involve frequent gatherings, making them representative of typical campus exposure environments.
- ii. **Extensive Electronic Infrastructure:** Both buildings feature significant electrical, instrumentation, and ICT installations ranging

from power transformers and laboratory instruments in SEMS to networked computers, Wi-Fi routers, and drafting equipment in SET thus providing varied EMF sources.

- iii. **Diverse Architectural Environments:** The study covers both older (Old SET) and newly constructed (New SET) buildings. This enables comparison of EMF distribution patterns in different structural designs and electrical installations within the same school.
- iv. **Relevance to Broad Academic Spaces:** Focusing on the three buildings captures a wide range of educational environments from hard science RF-intensive labs to ICT-rich architecture studios. This diversity makes findings broadly applicable across the FUTA campus and similar university settings.

By selecting SEMS, Old SET, and New SET, the study ensures comprehensive and representative EMF assessments in academic buildings with high electronic load, diverse spatial configurations, and significant student–staff interactions.

### Instrumentation: Trifield2 EMF Meter

Electric field emissions were measured using the TriField EMF Meter Model TF2 (Trifield TF2 Meter, 2018), a tri-axis handheld device calibrated to detect low-frequency electric and magnetic fields. The TF2 was selected for its accuracy, ease of operation, and broad frequency range suitable for measuring emissions from switched-mode power supplies and digital electronics. The Key EF Measurement Specifications are presented in Table 1.

### Measurement Procedure

The electromagnetic field (EMF) and radio frequency (RF) measurements were conducted across three buildings: SEMS, Old SET, and New SET, within the Federal University of Technology, Akure (FUTA). The measurement protocol was designed to ensure systematic data collection across a range of locations, field conditions, and device proximities.

Table 1: Trifield2 EMF Meter Specifications

Function	Specification	
<b>AC Magnetic Field</b>	3 Axis	
	Frequency Range	40Hz – 100kHz
	Accuracy	±40% @ 50/60 Hz
	Maximum Range	100Mg
	Resolution	0.1mG
<b>AC Electric Field</b>	1 Axis	
	Frequency Range	40Hz – 100kHz
	Accuracy	±5% @ 50/60 Hz
	Maximum Range	1000 V/m
	Resolution	1V/m
<b>RF/Microwave</b>	1 Axis	
	Frequency Range	20MHz – 6GHz
	Accuracy	±20% @ 1 GHz
	Maximum Range	19.999 mW/m <sup>2</sup>
	Resolution	0.001 mW/m <sup>2</sup>
<b>Battery</b>	9V Alkaline battery	
	Battery life Backlight off	>20 hrs
	Battery life Backlight on	> 12 hrs

The procedure is detailed as follows:

- a) **Number of Measurement Locations:** Measurements were taken in multiple zones per building, including common rooms, lecture rooms, laboratories, and hallways. Each building's ground floor and first floor were thoroughly assessed, with 15–20 discrete measurement points per floor, yielding a total of approximately 90 measurement points across all buildings.
- b) **Measurement Distances from EMF Sources:** To capture both environmental and device-proximal field strengths:
  - i. Electric fields were measured a few centimeters to 15 cm away from typical sources (e.g., sockets, routers, mobile devices).
  - ii. Magnetic fields were recorded at distances of up to 1 meter, especially near high-current appliances or exposed wiring.
- iii. For ambient readings, points were chosen at least 1.5 meters away from walls or known sources to capture background field levels.
- c) **Measurement Conditions:** The measurements were taken under both load and no-load conditions:
  - i. *Load conditions:* involved operating classroom appliances (e.g., lights, fans, projectors), powered lab equipment, and active wireless networks.
  - ii. *No-load conditions:* involved powering down nearby devices to capture ambient EMF values.
  - iii. The number of occupants was noted in each room, ranging from 0–25 individuals, to observe human-device interaction effects on field strength.
  - iv. Environmental variables such as open/closed windows, presence of metallic objects, and electrical panel proximity were also documented.

- c) **Field Strength Variants:** Both standard and weighted readings were obtained using the Trifield Meter TF2:
- i. *Standard readings:* provided base EMF values at rest.
  - ii. *Weighted readings:* accounted for biological sensitivity and peak detection, particularly relevant to RF and ELF emissions.
- d) **Geospatial Tagging:** The geographic coordinates (latitude and longitude) of each measurement point were recorded using Google Maps location services on a smartphone. These coordinates were essential for:
- i. Creating spatial visualizations of EMF variation across floors and buildings.
  - ii. Generating MATLAB-based contour plots, with latitude assigned to the X-axis, longitude to the Y-axis, and field strength values to the Z-axis.
  - iii. Ensuring spatial repeatability and traceability of measurement points.

This systematic procedure ensured a robust dataset that captured spatial, contextual, and technical variations in EMF emissions across the selected academic buildings. It also enabled a detailed comparison of field intensities between high-occupancy spaces and electronically dense environments.

### Data Analysis

To understand the spatial distribution of electromagnetic field (EMF) and radio frequency (RF) exposure across the measured locations, a geospatial data visualization technique was employed using MATLAB. The analysis aimed to generate contour plots that depict the intensity and propagation patterns of electromagnetic emissions

across the different building floors. The analysis began with the organization of all field measurements into structured datasets. For each measurement point, three data attributes were recorded:

- i. Geolocation coordinates (longitude and latitude)
- ii. Measured field values (electric field, magnetic field, and RF power density)

iii. Measurement mode (standard or weighted)

Using MATLAB, these data were processed to create 2D contour plots for each type of field measured. The spatial mapping was executed by assigning:

- i. Longitude values to the X-axis
- ii. Latitude values to the Y-axis
- iii. Field strength values to the Z-axis (magnitude of electric field in V/m, magnetic field in mG, or RF power in mW/m<sup>2</sup>)

Custom MATLAB scripts were written to interpolate the discrete measurement values and generate continuous contour maps, which allowed visual identification of high-intensity (hotspot) zones and low-intensity (attenuated) regions. These plots were used to identify field gradients and assess the influence of local sources such as electronic devices, power lines, and walls. Separate contour plots were developed for: (i) Standard electric and magnetic field. (ii). Standard magnetic field. (iii). Weighted electric and magnetic fields. (iv). Radio frequency (RF) emissions. This visualization approach facilitated the detection of patterns not easily interpretable from raw tabular data. It also allowed comparisons between different buildings and floors, revealing how structural layout, device density, and environmental factors influence electromagnetic wave propagation indoors. Ultimately, the contour maps served not only as analytical tools but also as intuitive visual aids for interpreting spatial EMF behavior in academic environments, thereby enhancing the quality and applicability of the study's findings.

### Results and Discussion

This section presents the spatial distribution of electromagnetic field (EMF) and radio frequency (RF) emissions across three faculty buildings at FUTA which are SEMS, OLD SET, and NEW SET, using contour plots generated in MATLAB. Each floor include plots for: (i) Standard Electric Field (SEF), (ii) Weighted Electric Field (WEF), (iii)

Standard Magnetic Field (SMF), (iv) Weighted Magnetic Field (WMF), (v) Radio Frequency (RF). Contour plots visualize the spatial variation and intensity of emissions, identifying hotspots, gradients, and attenuation patterns across rooms and corridors.

#### SEMS Building

##### a) First Floor

Figures 1a and 1b show the Standard and Weighted Electric Field distributions, Figures 2a and 2b show

the Standard and Weighted Magnetic Field distributions, while Figure 3 shows the RF distribution respectively.

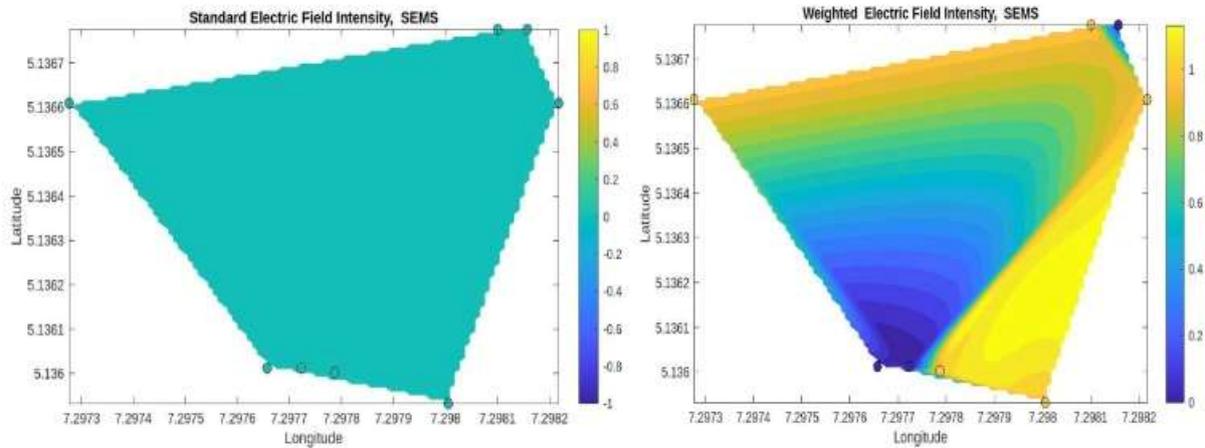


Figure 1: Electric Field Distributions in the First Floor of SEMS Building: (a). SEF Distribution. (b). WEF Distribution.

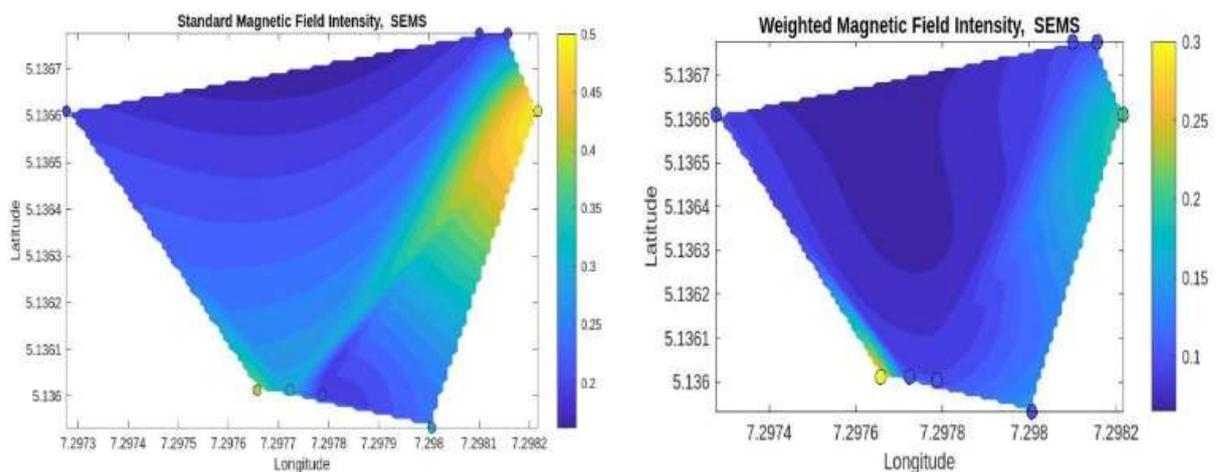


Figure 2: Magnetic Field Distributions in the First Floor of SEMS Building: (a). SMF Distribution. (b). WMF Distribution.

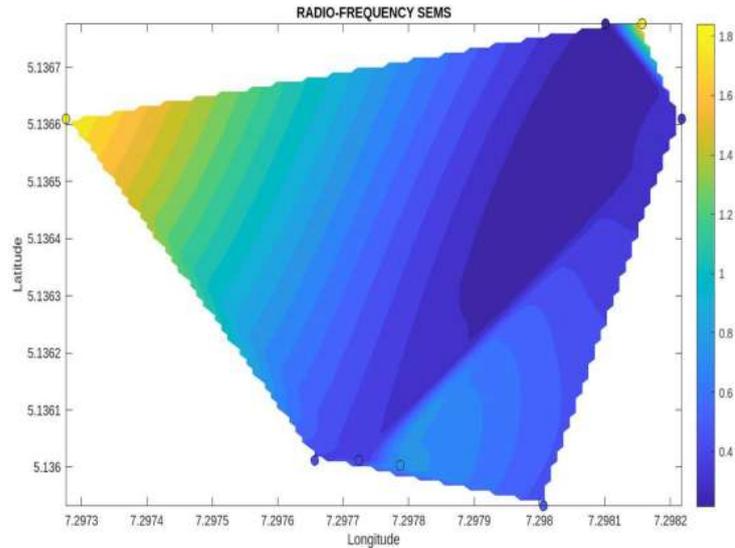


Figure 3: Radio Frequency (RF) Power Distributions for First Floor of SEMS Building

The contour plots for the SEMS first floor reveal distinct EMF patterns. The standard electric field remains uniformly low ( $\leq 0.1$  V/m), while the weighted electric field peaks at  $\sim 1.0$  V/m in the lower-right region, indicating biologically significant exposure likely from hidden routers or sockets. The standard magnetic field intensifies up to  $0.45$  mG near the upper-right corner, suggesting nearby current sources, whereas the weighted magnetic field stays below  $0.3$  mG with a more even spread. RF intensity reaches  $\sim 1.8$  mW/m<sup>2</sup> along the left edge and upper-right corner, pointing to active

wireless zones. These results underscore the importance of using both standard and weighted metrics, as key hotspots may go undetected with unweighted data alone.

**b) Second Floor**

Figures 4a and 4b present the Standard and Weighted Electric Field distributions, Figures 5a and 5b show the Magnetic Field distributions, and Figure 6 illustrates the RF distribution on the second floor.

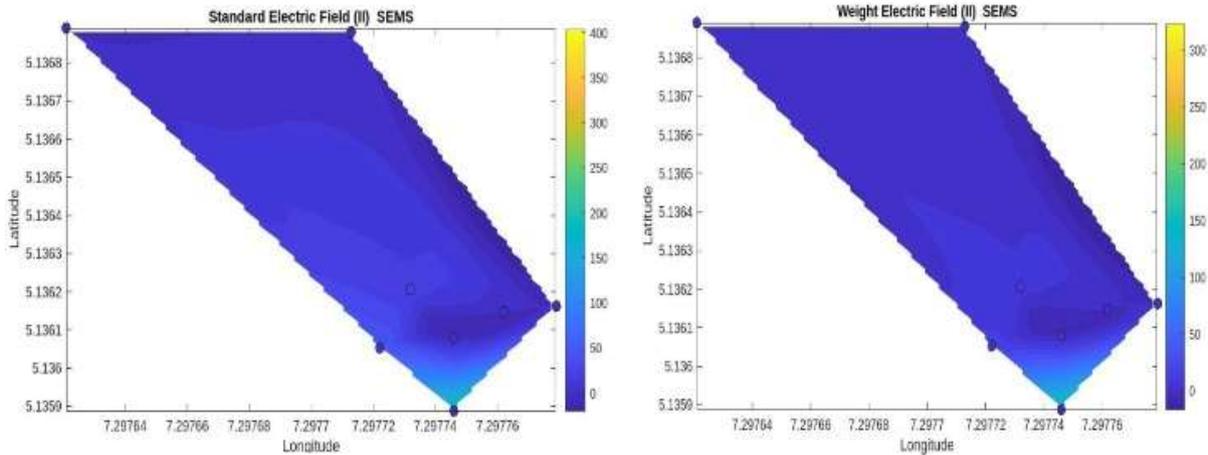


Figure 4: Electric Field Distributions in the Second Floor of SEMS Building: (a). SEF Distribution. (b). WEF Distribution.

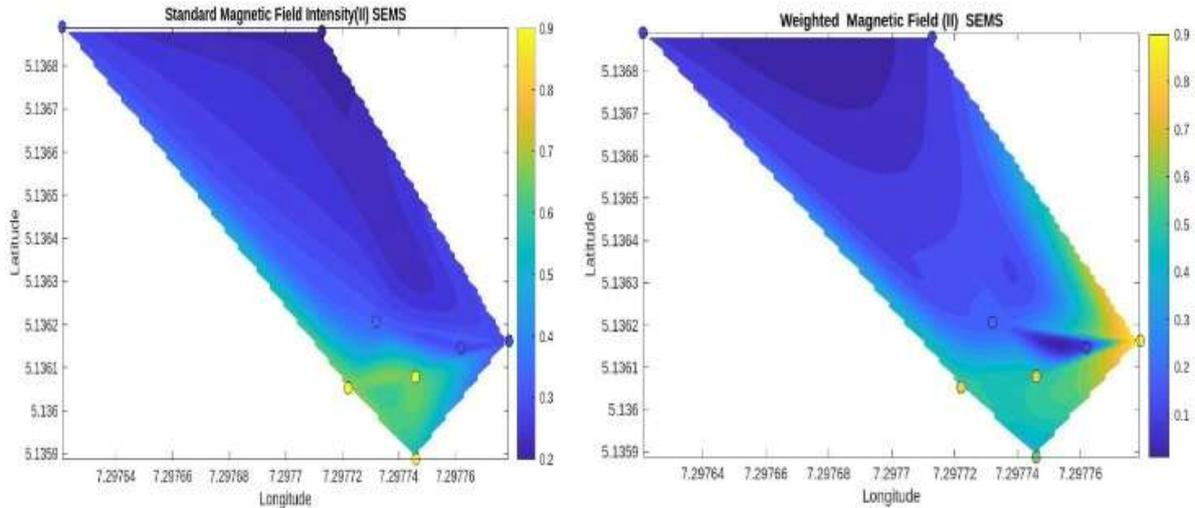


Figure 5: Magnetic Field Distributions in the Second Floor of SEMS Building: (a). SMF Distribution. (b). WMF Distribution.

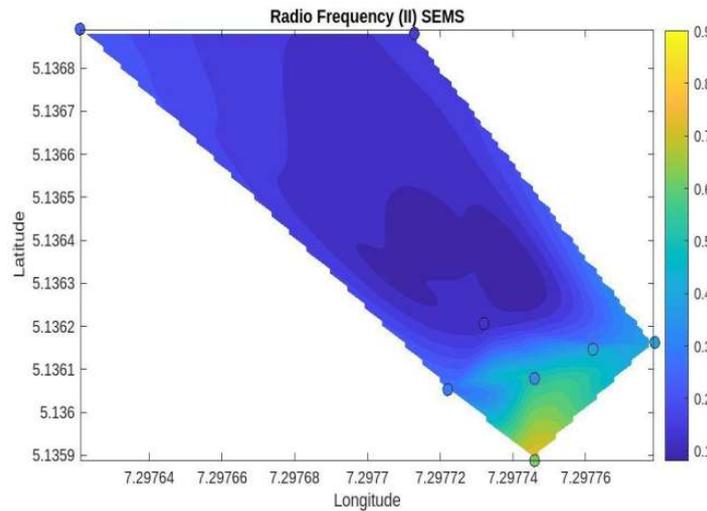


Figure 6: Radio Frequency (RF) Power Distributions in the Second Floor of SEMS Building

The contour plots for the SEMS second floor indicate generally low EMF exposure levels across the surveyed area. The standard and weighted electric field intensities remain below 400 V/m and 350 V/m respectively, with gradual gradients concentrated in the southeast corner, likely due to localized electronic sources such as wall sockets or inactive routers. The standard magnetic field peaks at approximately 0.9 mG, while the weighted magnetic field reaches up to 0.8 mG in the same region, suggesting proximity to electrical equipment or concealed cabling. RF exposure

levels are relatively minimal, with maximum values around 0.9 mW/m<sup>2</sup> concentrated along the southeast boundary. These values, while within general safety

limits, indicate potential zones for field buildup and signal reflection, underscoring the importance of spatial planning in electronics-heavy environments.

**Old SET Building: Second Floor**

Figures 7a and 7b present the Standard and Weighted Electric Field distributions, Figures 8a and 8b show the Magnetic Field distributions, and Figure 9 illustrates the RF distribution on the second floor of the old SET building.

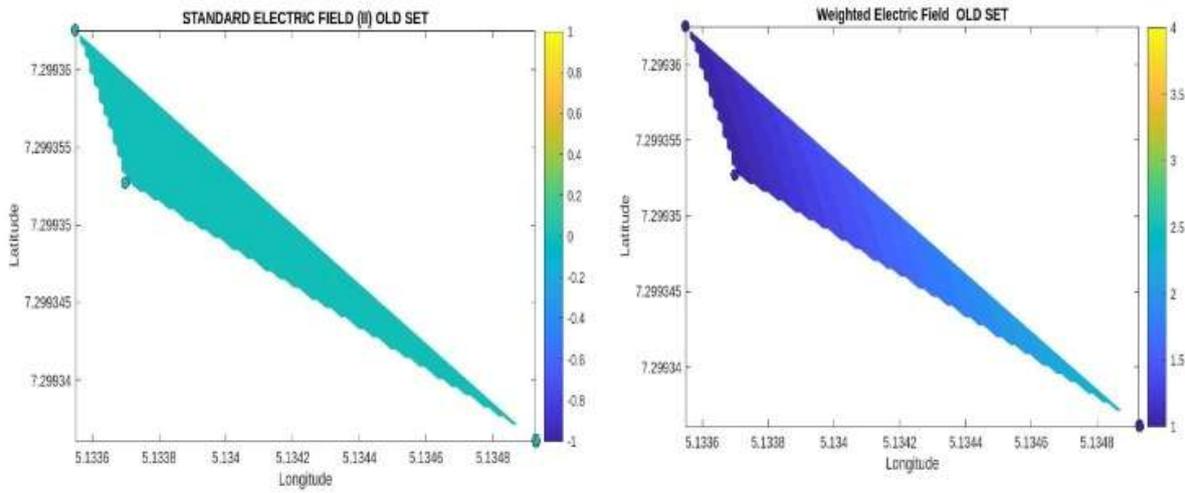


Figure 7: Electric Field Distributions in the Second Floor of Old SET Building: (a). SEF Distribution. (b). WEF Distribution.

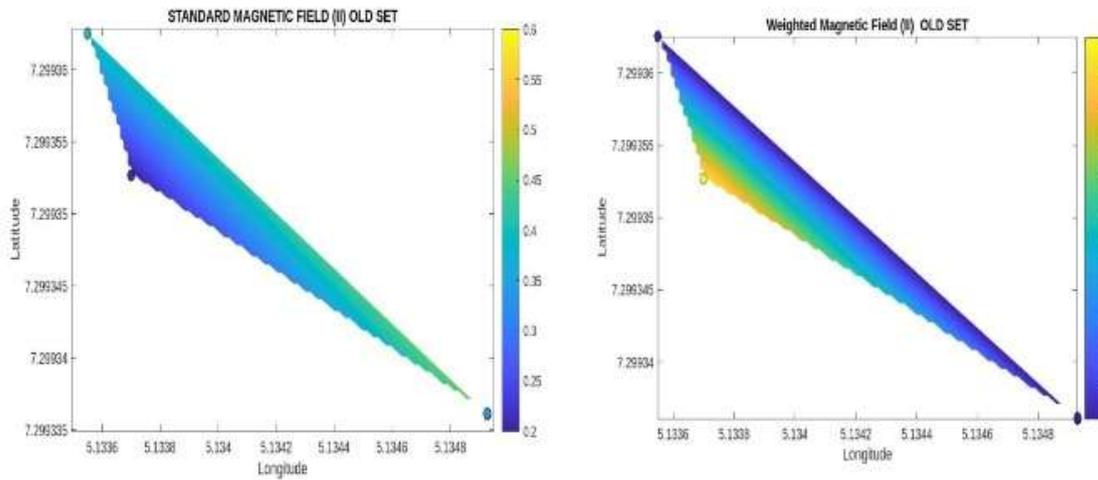


Figure 8: Magnetic Field Distributions in the Second Floor of Old SET Building: (a). SMF Distribution. (b). WMF Distribution.

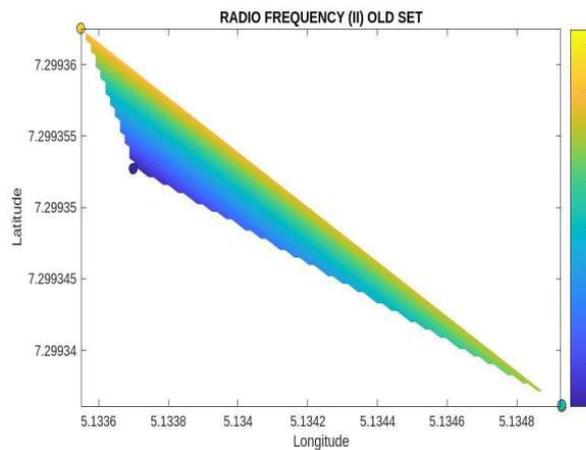


Figure 9: Radio Frequency (RF) Power Distributions in the Second Floor of Old SET Building

The contour plots for the second floor of the Old SET building display moderate EMF levels across all measured fields. The standard electric field remains nearly uniform around  $-1$  V/m, while the weighted electric field rises gradually to  $\sim 4$  V/m near the bottom-right, indicating increased exposure likely due to local electronics. The standard magnetic field ranges from 0.2 mG to 0.6 mG, with the highest intensity toward the upper-left corner, suggesting proximity to power lines or electrical devices. The weighted magnetic field shows a similar pattern with peak values around 0.2 mG. Radio frequency levels increase diagonally from

$\sim 1.1$  mW/m<sup>2</sup> to  $\sim 1.5$  mW/m<sup>2</sup>, peaking in the upper-left, which may be associated with Wi-Fi sources or active user zones. These values are within typical indoor exposure limits but suggest areas of higher cumulative EMF that warrant monitoring.

**New SET Building: First Floor**

Figures 10a and 10b present the Standard and Weighted Electric Field distributions, Figures 11a and 11b show the Magnetic Field distributions, and Figure 12 illustrates the RF distribution on the first floor of the new SET building.

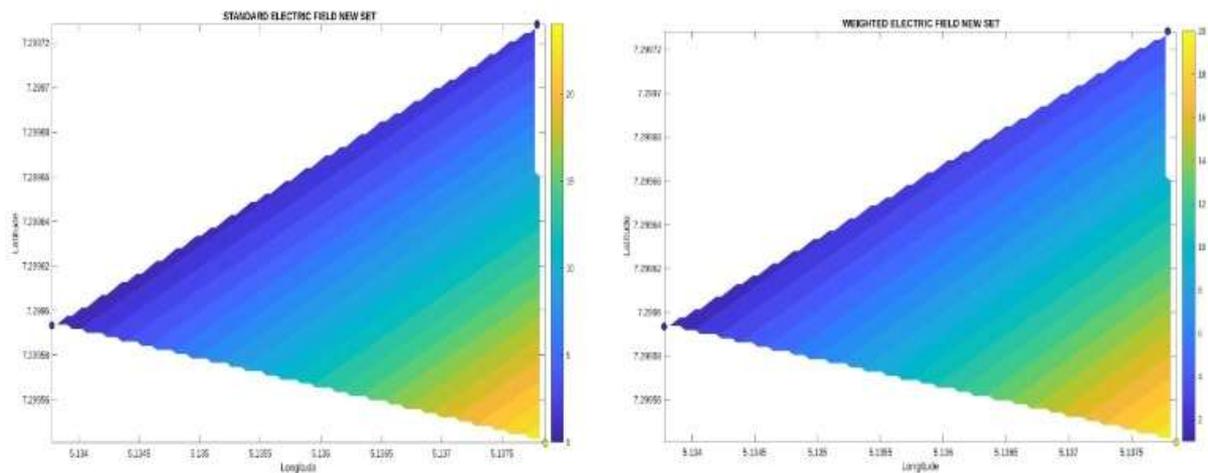


Figure 10: Electric Field Distributions in the First Floor of New SET Building: (a). SEF Distribution. (b). WEF Distribution.

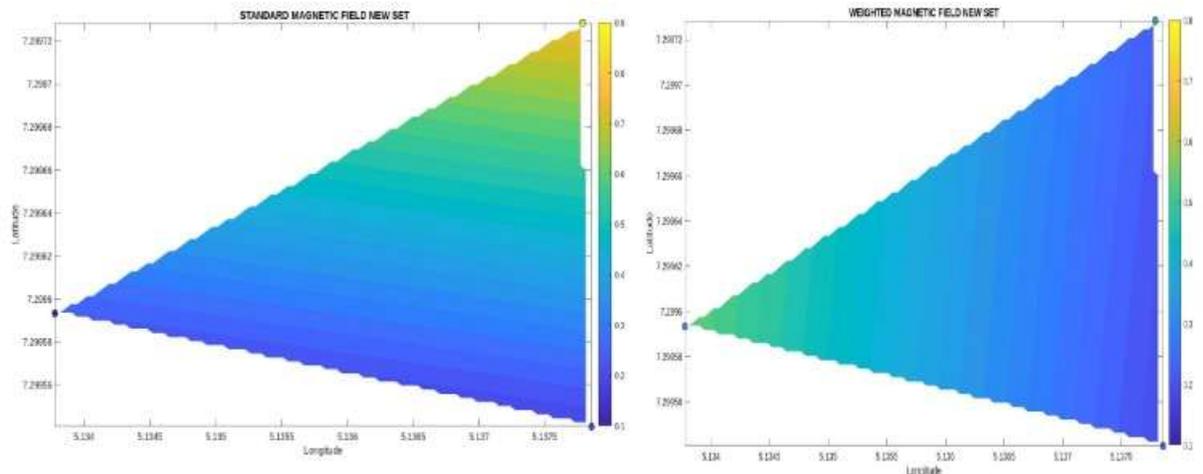


Figure 11: Magnetic Field Distributions in the First Floor of New SET Building: (a). SMF Distribution. (b). WMF Distribution.

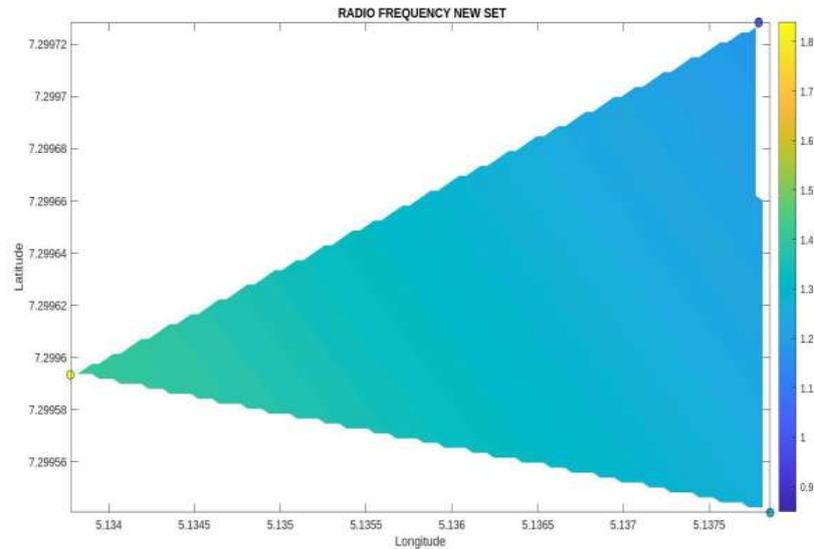


Figure 12: Radio Frequency (RF) Power Distributions in the First Floor of New SET Building

The contour plots for the New SET building indicate a smooth gradient of EMF intensities across the surveyed area. The standard electric field ranges from  $\sim 0$  V/m to 30 V/m, while the weighted electric field peaks at approximately 18 V/m near the far-right edge—implying increased exposure in areas possibly close to equipment clusters. The magnetic field intensities remain relatively low, with standard and weighted values rising gently from 0.1 mG to about 0.8 mG and 0.7 mG respectively, suggesting well-distributed low-current sources. RF levels range from  $0.9 \text{ mW/m}^2$  to  $1.8 \text{ mW/m}^2$ , increasing steadily toward the far

end of the building, likely due to a primary wireless access point. These values remain within safety limits, yet the directional gradients suggest centralized EMF sources that could be optimized for exposure balance.

### Recommendations and Measures

The results from this study indicate spatially varying levels of electric field, magnetic field, and radio frequency exposure across the three surveyed buildings, with certain hotspots consistently appearing near clustered electrical and wireless equipment. Although the recorded values largely

fall within acceptable exposure limits recommended by international bodies such as the World Health Organization (WHO) (Verbeek *et al.*, 2025), the International Commission on Non-Ionizing

Radiation ICNIRP (Marino *et al.*, 2025), the International Committee on Electromagnetic Safety (ICES), under the sponsorship of the Institution of Electrical and Electronic Engineers (IEEE), and Scientific Committee on Emerging and Newly Identified Health Risks (SCENIHR) (Bromeka, 2009). Some locations showed elevated levels especially in weighted field measurements indicating biologically significant EMF concentrations. To mitigate potential long-term exposure risks and enhance EMF safety on campus, the following measures are recommended:

- a) *Reposition Wireless Access Points:* Relocate routers to central, low-traffic areas and reduce overlapping signals to minimize RF hotspots without compromising coverage.
- b) *Create Low-EMF Study Zones:* Designate classrooms or reading areas free from routers and high-power devices to protect long-duration occupants and sensitive individuals.
- c) *Improve Cable Routing and Shielding:* Use shielded cables and ensure proper grounding near sockets and panels to reduce ambient magnetic fields in high-use areas.
- d) *Promote EMF-Safe Device Practices:* Educate students and staff on safe device usage like enabling airplane mode, limiting

Bluetooth, and avoiding constant charging to lower exposure.

- e) *Conduct Routine EMF Audits:* Include EMF inspections in building maintenance to identify faulty transformers, exposed cabling, or poorly placed wireless equipment.

## Conclusion

This study systematically evaluated the distribution and intensity of electromagnetic field (EMF) and radio frequency (RF) emissions across three key academic buildings -- SEMS, Old SET, and New SET -- at the Federal University of Technology, Akure. Using a TriField TF2 meter and MATLAB-based spatial analysis, over 90 measurement points were assessed, revealing that while most EMF and RF exposure levels fall within globally accepted safety limits, specific hotspots -- particularly in weighted electric and magnetic field measurements -- indicated biologically significant exposures. Peak values reached ~400 V/m for electric fields, 0.9 mG for magnetic fields, and 1.8 mW/m<sup>2</sup> for RF power density. These elevated concentrations were primarily found near electrical equipment clusters, sockets, routers, and high-occupancy zones. The findings highlight the critical importance of considering both standard and weighted metrics in EMF risk evaluation. Furthermore, the study provides practical, evidence-based recommendations for exposure mitigation, including infrastructure reconfiguration and awareness programs. Overall, the results underscore the need for sustained EMF monitoring and proactive exposure management in academic environments to safeguard both staff and students from potential long-term health effects associated with non-ionizing radiation.

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