UGANDA COMMUNICATIONS COMMISSION

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UGANDA COMMUNICATIONS COMMISSION (UCC) GUIDELINE FOR THE ASSESSMENT OF RADIO FREQUENCY ELECTROMAGNETIC FIELD (RF EMF) EXPOSURE FROM COMMUNICATIONS INFRASTRUCTURE AND SERVICES

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1. INTRODUCTION

The Uganda Communications Commission (UCC)'s overarching vision of "Communications for All" reflects its commitment to ensuring universal access to communication services by expanding both wired and wireless infrastructure.

As wireless technologies increase from the backbone of communications services, spanning mobile networks, broadcasting, satellite, and other wireless platforms, their operation over the radio frequency (RF) spectrum becomes central to service delivery.

These technologies, while essential to modern connectivity, also emit Radio Frequency Electromagnetic Fields (RF EMF), which, in certain contexts, raise concerns about potential exposure impacts on human health.

UCC plays a pivotal role in establishing and enforcing technical safety standards for communication networks in line with its regulatory functions. Part of this mandate includes assessing general public and occupational exposure to RF EMF from communications infrastructure.

This ensures that such infrastructure operates within the limits set by both national and international guidelines and standards, particularly those developed by recognised bodies such as the International Telecommunication Union (ITU), the International Electrotechnical Commission (IEC), the International Commission on Non-Ionizing Radiation Protection (ICNIRP), and the World Health Organization (WHO).

This Guideline for the "Assessment of Radio Frequency Electromagnetic Fields (RF EMF) exposure from Communications Infrastructure and Services" supports the evaluation of the deployment and operation of ICTs infrastructure in Uganda. It provides procedures, technical benchmarks, and compliance measures for assessing RF EMF exposure. The objective is to safeguard human health, ensure the safe use and deployment of communications technologies, and promote adherence to international best practices and standards in the planning, installation, and operation of communication infrastructure. Transparency and public confidence in the safety of communications infrastructure are further reinforced through the consistent application of these standards as outlined in this Guideline.

1.1 Purpose of the Guideline

This guideline provides a reference for evaluating RF EMF exposure from wireless communications infrastructure in Uganda. It defines the operational procedures, technical measurement methodologies, and compliance evaluation criteria aligned with national and international exposure limits and safety frameworks, standards and best practices.

1.2 RF EMF Exposure Contexts: General Public and Occupational Scenarios

As Uganda's digital ecosystem grows, the deployment of various wireless technologies, including mobile broadband, Wi-Fi, fixed wireless access, and emerging Internet of Things (IoT) solutions, has led to an increase in the number and density of communications infrastructure such as base stations, antennas, repeaters, and small cells. These are now commonly installed in everyday environments, including homes, office buildings, schools, hospitals, and public spaces. This evolving landscape introduces two distinct exposure scenarios:

- General public exposure occurs in uncontrolled environments, where individuals often unaware of the presence or operation of RF emitting infrastructure may be exposed in the course of normal daily life. These settings include residential areas, schools, shopping centers, and other community spaces.
- Occupational exposure takes place in controlled environments, where trained personnel such as engineers and technicians work in close proximity to active RF equipment. These workers operate under safety procedures and are aware of potential exposure risks as part of their job functions.

Recognizing the difference in awareness, control, and access between these two groups, different methodologies are applied to assess RF EMF exposure. The approach used for evaluating public exposure emphasizes environmental measurements and precautionary thresholds, while occupational assessments consider work duration, task-specific proximity, and established safety procedures.

This guideline reflects both categories in accordance with international standards, including the ICNIRP 2020 framework, and forms the basis for ensuring that RF EMF exposure from communications infrastructure in Uganda is assessed appropriately across all relevant contexts.

1.3 Purpose of RF EMF Assessment

Public confidence in the safety of communications infrastructure is essential in today's increasingly connected society. To reinforce this assurance, UCC conducts RF EMF assessments as a regulatory function aimed at ensuring that emissions from wireless communications infrastructure comply with recognized national and international safety standards.

In addition to planned and routine assessments, UCC may undertake investigations in response to concerns or complaints raised by individuals, institutions, or communities. These may involve technical evaluations to assess RF EMF exposure levels in specific locations where safety is in question.

To address such concerns effectively, UCC has established a mechanism for receiving, reviewing, and responding to exposure-related queries in a structured and technically sound manner. This ensures compliance with exposure guidelines and contributes to broader goals of public health, workforce safety, and trust in ICT services.

Accordingly, UCC conducts RF EMF assessments to:

i. Ensure compliance with national and international RF EMF exposure limits for both public and occupational settings.
ii. Strengthen stakeholder confidence in the safety of communications infrastructure through transparent monitoring, public engagement, and technical reporting.
iii. Support evidence-based infrastructure planning, research, and policy development.

1.4 Scope and Applicability

This guideline covers all wireless communications technologies and establishes technical and procedural requirements to ensure compliance with RF EMF exposure limits for wireless communication technologies.

It applies to all stakeholders involved in the deployment, operation, use, and regulation of communication services in Uganda, including:

i. Telecommunication and broadcasting infrastructure and services providers,
ii. Ministries, Departments and Agencies (MDAs),
iii. The occupational workers and the general public.

1.5 Regulatory Framework

This guideline aligns with the national laws, regulations, policies frameworks and guidelines as well as international standards, guidelines, and best practices.

i. Uganda Communications Act Cap 103, 2013

The Act establishes the UCC and outlines its mandate to regulate, license, and monitor communications services. The Act empowers UCC to ensure public safety, environmental compliance, and infrastructure standards, including oversight of RF EMF exposure from communications infrastructure.

ii. National Environment Act Cap 181, 2019

This Act governs environmental protection in Uganda and mandates that all developments likely to have a significant environmental impact, including communications infrastructure must undergo proper environmental assessment and compliance processes. It empowers the National Environment Management Authority (NEMA) to enforce environmental safeguards in collaboration with lead agencies such as UCC.

iii. Environmental and Social Impact Assessment (ESIA) Regulations, 2020

These regulations provide the framework for identifying, assessing, and mitigating the environmental and social impacts of proposed projects. For communications developments, ESIA processes ensure that RF EMF-related concerns, land use, and public safety are adequately considered before approvals are granted.

iv. National Information and Communications Technology (ICT) Policy

This policy provides strategic guidance for the development and regulation of Uganda's ICT sector. It emphasizes the need for a safe, secure, and ICT infrastructure that upholds environmental integrity.

v. Framework for the Uganda Communications Commission Environment Management Function, 2023

This framework incorporates environmental considerations into the regulation of the communications sector, and this Guideline aligns with it. It sets out systematic approaches for compliance of ICT infrastructure, services, and operations with environmental standards while safeguarding human health and safety. In the context of RF EMF, the framework provides for the compliance assessment of communications infrastructure, advances the adoption of international best practices and standards, and strengthens transparency through assessments, research, public reporting, and stakeholder engagement.

vi. ICNIRP Guidelines

Uganda references the International Commission on Non-Ionizing Radiation Protection (ICNIRP) guidelines as the scientific basis for establishing safe human exposure limits RF EMF.

The ICNIRP 2020 Guidelines provide internationally accepted exposure limits for frequencies ranging from 100 kHz to 300 GHz, covering the full spectrum typically used in wireless communications.

These guidelines are grounded in decades of rigorous scientific research on the biological and health effects of RF EMF exposure. The limits are developed and periodically reviewed in collaboration with global health authorities such as the WHO to ensure they reflect the latest scientific consensus.

The ICNIRP exposure limits aim to prevent potentially adverse health effects by accounting for several key considerations:

a. Findings from peer-reviewed scientific studies on how RF EMF interacts with human tissues, particularly the confirmed effect of tissue heating at high exposure levels.

b. Physiological differences across populations, including age, body size, and health status, which influence how the body absorbs RF energy.
c. Built-in safety factors to protect vulnerable groups, such as children, the elderly, pregnant women, and individuals with implanted medical devices.
d. Separate reference levels for occupational and public exposure, recognizing that exposure conditions and health risk profiles vary between workers and the general population.

The ICNIRP guidelines are widely adopted by governments, regulators, and institutions around the world. UCC applies these reference levels during field assessments to determine whether RF EMF emissions from communications infrastructure fall within acceptable safety margins for both public and occupational exposure scenarios.

vii. Technical Standards

UCC conducts RF EMF exposure assessments at communications sites using methodologies outlined in technical standards and recommendations developed by international standardization bodies.

These include.

a. The International Telecommunication Union (ITU), whose ITU-T Recommendations such as K.52[1], k.61[2], K.83[3], and K.91[4], K.100[5], K.121[6] provide frameworks for RF EMF measurement, compliance evaluation, and public exposure monitoring.
b. The International Electrotechnical Commission (IEC), with standards like IEC 62232[7] that detail methodologies for assessing RF field strength, power density, and specific absorption rate (SAR) near base stations, and;
c. The Institute of Electrical and Electronics Engineers (IEEE), particularly IEEE C95.1[8], which outlines safety levels for human exposure to RF EMF across a broad frequency range.

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[1] K.52: Guidance on complying with limits for human exposure to electromagnetic fields
[2] K.61: Guidance on measurement and numerical prediction of electromagnetic fields for compliance with human exposure limits for telecommunication installations
[3] K.83: Monitoring of electromagnetic field levels
[4] K.91: Guidance for assessment, evaluation and monitoring of human exposure to radio frequency electromagnetic fields
[5] K.100: Measurement of radio frequency electromagnetic fields to determine compliance with human exposure limits when a base station is put into operation
[6] K.121: Guidance on the environmental management for compliance with radio frequency EMF limits for radiocommunication base stations
[7] IEC 62232:2025 Determination of RF field strength, power density and SAR in the vicinity of base stations for the purpose of evaluating human exposure
[8] IEEE C95.1: Safety Levels with Respect to Human Exposure to Electric, Magnetic, and Electromagnetic Fields, 0 Hz to 300 GHz

These globally recognized standards offer structured, scientifically grounded methodologies that ensure consistency, accuracy, and comparability in RF EMF assessments and compliance verification.

1.6 Institutional Responsibility for RF EMF Assessment

The Communications Infrastructure and Services (CIS) Division, under the Engineering, Communications, and Infrastructure (ECI) Department, is the designated technical unit responsible for the oversight and execution of RF EMF assessments at UCC. This responsibility aligns with UCC's mandate to ensure that the communications infrastructure operates safely within established exposure limits.

Specifically, the CIS Division shall:

i. Plan and schedule RF EMF assessments at the national, regional, and case-specific levels, including on-request assessments initiated through public concerns or regulatory reviews.
ii. Verify and approve (as applicable) the procurement of measurement tools, equipment, and related resources used in RF EMF assessments.
iii. Coordinate the teams in the regional offices, through the respective department head, to conduct RF EMF investigations and assessments where necessary.
iv. Provide technical training and oversight to all personnel involved in RF EMF assessments to ensure quality assurance and adherence to measurement protocols during planning and execution.
v. Maintain and manage all RF EMF measurement records, ensuring proper documentation, analysis, and regulatory follow-up where required.

This coordinated structure ensures consistency, technical integrity, and regulatory accountability across all RF EMF compliance assessment activities undertaken by UCC.

1.7 Empowering Operators for Self-compliance and Sector Consciousness

As Uganda's communications sector continues to expand, UCC is working to foster a stronger compliance culture in which licensed operators take greater responsibility for monitoring and managing RF EMF exposure from their infrastructure. While UCC will continue to conduct direct regulatory assessments, operators will be progressively empowered to undertake self-assessments and submit self-declaration reports based on a harmonized methodology aligned with this guideline.

This approach is intended not only to enhance compliance with national and international RF EMF exposure limits, but also to promote technical consciousness and accountability within the sector particularly among field engineers and other personnel who may fall under occupational exposure categories. All self-declared compliance reports will remain subject to periodic verification and audit by UCC to ensure accuracy and adherence to regulatory standards.

While it is expected that operators implement internal measures to safeguard their staff in occupational settings, UCC may, at its discretion or upon request, conduct occupational RF EMF exposure assessments to verify compliance or respond to specific concerns where necessary.

1.8 Public Awareness and Communication

In addition to regulatory oversight, UCC is committed to developing and implementing effective communication and awareness strategies to address public concerns and combat misinformation regarding RF EMF exposure. These efforts aim to promote transparency, scientific literacy, and public confidence in the safe deployment of communications infrastructure.

2. KEY TERMS AND DEFINITIONS

i. ***Absorbed Power Density (Sab):*** A measure of the radio frequency (RF) energy absorbed at the surface of the body, expressed in watts per square meter (W/m^2). It is used to assess human exposure at frequencies above 6 GHz, where the energy does not penetrate deeply but is absorbed in the outer layers of the skin.

ii. ***Active Antenna System (AAS)***: advanced antenna technology that integrates the antenna and radio frequency (RF) components into a single unit, commonly used in mobile base stations. This integration allows for a more compact design, greater energy efficiency, and supports advanced technologies such as beamforming and massive MIMO (Multiple Input, Multiple Output).

iii. ***Averaging Time***: The time period over which the electric field strength or power density is averaged to evaluate compliance with RF exposure limits. It reflects how the body absorbs energy over time.

iv. ***Assessment***: Undertaking an evaluation of RF EMF exposure in order to arrive at a judgement about comparison with the applicable exposure limits.

v. ***Basic Restriction***: A limit on human exposure to EMF, defined in terms of internal quantities within the body such as the Specific Absorption Rate (SAR) or induced electric field that directly relate to potential health effects. These limits are set to prevent known adverse biological impacts and are derived from scientific evidence on how electromagnetic energy is absorbed or affects biological tissues.

vi. ***Broadband Measurement:*** An RF EMF measurement approach that captures the total electromagnetic field strength across a wide frequency range without distinguishing between individual frequency bands.

vii. ***Collocated Site:*** A site where two or more base stations from different operators or technologies are installed in close proximity, typically within 150 meters, either on the ground or on separate rooftop/building structures. These base stations do not share the same passive infrastructure (such as a mast or tower) but are located close enough to function within a shared environment or compound.

viii. ***Compliance:*** Adherence to RF EMF exposure standards and regulations. A site or device is in compliance if measured field levels do not exceed the prescribed exposure limits for the relevant scenario (public or occupational).

ix. ***Downlink Frequency****:* The radio frequency used by base station transmitters to send signals from the base station to the user devices.

x. ***Electric Field Strength (E):*** A measure of the intensity of the electric component of an electromagnetic field, expressed in volts per meter (V/m). It represents the force exerted by the field on electric charges and is a key external quantity used in assessing human exposure to electromagnetic fields. ICNIRP, sets reference levels for electric field strength to ensure exposures remain within safe limits, especially in both near-field and far-field conditions.

xi. ***Exposure Limit (Safety Limit):*** RF EMF energy that a person can be exposed to. These limits are set by expert bodies such as the ICNIRP 2020 guidelines based on scientific evidence. They are frequency-dependent and designed to protect against established health risks, such as tissue heating or nerve stimulation, ensuring the safety of the occupational workers and general public, including vulnerable individuals.

xii. ***Exposure Level:*** The amount or intensity of RF EMF that a person is subjected to at a given location and time. It is typically quantified using measurable external field quantities such as electric field strength magnetic field strength, or power density and is compared against established reference levels to determine compliance with safety limits.

xiii. ***Far Field:*** The region at a sufficient distance from a transmitting antenna where the electric and magnetic fields are perpendicular to each other and to the direction of wave propagation, forming a uniform plane wave. In this zone, the fields are in phase and their relationship is predictable, making exposure measurements such as power density accurate and reliable for assessing compliance with safety limits.

xiv. ***Frequency (Hz):*** The number of cycles of an electromagnetic wave per second, measured in hertz (Hz). Higher frequency waves have more cycles per second and correspond to shorter wavelengths.

xv. ***Frequency-Selective Measurement****:* An RF EMF measurement approach that isolates specific frequency bands to allow results to be compared to frequency-specific exposure limits. It contrasts with broadband measurement and is preferred for compliance assessments because different frequencies have different allowable limits.

xvi. ***Magnetic Field Strength (H):*** A measure of the intensity of the magnetic component of an electromagnetic field, expressed in amperes per meter (A/m). It is one of the key external field quantities used to assess human exposure to radiofrequency electromagnetic fields. Reference levels for magnetic field strength are established by guidelines such as ICNIRP to ensure exposure remains within safe limits, particularly in the near-field region.

xvii. ***Mitigation Measures****:* Actions taken to reduce RF EMF exposure in situations where measurements approach or exceed safety limits.

xviii. ***Incident Power Density (S_{inc}):*** A measure of the RF EMF arriving per unit area on an exposed surface, typically expressed in W/m^2. It is one of the external field quantities used in setting reference levels for human exposure assessment, particularly in the far-field region.

xix. ***Near Field****:* The region close to a transmitting antenna where the relationship between electric and magnetic fields is complex and unpredictable. In this zone, electric field strength is typically measured due to non-uniform wave behaviour.

   a. ***Radiated Near Field:*** The region close to a transmitting antenna where the EMFs have begun to radiate away from the antenna but do not yet exhibit the uniform plane wave characteristics of the far field. In this zone, the electric and magnetic fields are not fully predictable or in phase, and their distribution can be complex and vary with position. This makes exposure assessments more challenging, often requiring detailed measurements or modeling rather than simple calculations.
   b. ***Reactive Near Field:*** The region immediately surrounding a transmitting antenna, typically within a fraction of a wavelength, where the EMFs are predominantly non-radiating and energy is stored rather than propagated. In this zone, the electric and magnetic fields are strongly coupled to the antenna and vary rapidly with distance and direction. Field strengths can be very high, but the energy does not radiate away efficiently. Exposure assessment in this region is complex and often requires specialized equipment and techniques.

xx. ***Occupational workers****:* Adults are exposed to RF EMF as part of their job duties, typically in controlled environments. They are trained to understand and manage their exposure.

xxi. ***Peak exposure****:* The highest level of RF EMF exposure observed during a measurement period. Often evaluated in conjunction with time-averaged exposure to assess potential short-term risks.

xxii. ***Power density (W/m^2):*** A measurement of the amount of RF power per unit area, typically used to assess exposure at frequencies in far-field conditions.

xxiii. ***Public****:* Individuals of all ages and of differing health statuses, including more vulnerable groups or individuals, who may have no knowledge of or control over their exposure to EMFs. *ICNIRP (2020) defines the foetus as a member of the public, regardless of exposure scenario, and subject to the public restrictions.*

xxiv. ***Public exposure limit****:* The RF EMF exposure threshold established for the general population. This limit includes a large safety margin to protect all individuals, including vulnerable groups (children, elderly, sick, etc.), in uncontrolled environments.

xxv. ***Reference level****:* This is a safety limit for how much electromagnetic energy is allowed in the environment. It is measured using values like electric field strength, magnetic field strength, or power density. These levels are based on what is considered safe for the human body and help assess whether a site is safe, without needing to measure the energy inside a person directly.

xxvi. ***RF EMF exposure***: The level of RF EMF present at a location that a person could absorb or be subjected to if they are in that location. Exposure can be quantified by electric field strength (V/m) or power density (W/m^2).

xxvii. ***RF EMF Exposure Assessment (Compliance Assessment)***: A systematic process to evaluate RF EMF levels and verify they meet safety standards. This typically involves on-site measurements of field strengths or power densities, data analysis, and comparison with reference limits.

xxviii. ***Shared site***: A communication in site where more than one operator or technology shares the same passive infrastructure.

xxix. ***Single site***: A base station site occupied by a single operator or technology, utilizing a single passive infrastructure.

xxx. ***Small cells:*** Low-powered radio access nodes that provide localized wireless coverage, typically over a short range from a few meters to a few hundred meters. They are used to enhance mobile network capacity and coverage, especially in dense urban areas, indoors, or places with weak macro network signals. Small cells are essential for supporting high data traffic and advanced technologies like 4G and 5G, and are often deployed on street furniture, buildings, or indoors.

xxxi. ***Specific absorption rate: (SAR):*** the measure of the rate at which the human body absorbs radio frequency (RF) electromagnetic energy when exposed to RF EMF. Expressed in units of watts per kilogram (W/kg).

xxxii. ***Spectrum analyzer***: A measurement instrument that detects and displays the strength of RF signals across a defined frequency range. It shows how much energy is present at each frequency and is used to measure signal levels (such as power density or field strength).

xxxiii. ***Time-averaged exposure:*** The average RF EMF exposure over a defined period, used to evaluate compliance with exposure guidelines that are based on time-averaged values.

xxxiv. ***Total exposure:*** In a multi-frequency environment, this is the combined exposure from all relevant frequency bands, expressed as a fraction of the allowable limit.

3. KEY ABBREVIATIONS AND ACRONYMS

5G	Fifth Generation Mobile Network
AAS	Active Antenna System
E	Electric Field Strength
EMF	Electromagnetic Field
F	Frequency
GHz	Gigahertz
H	Magnetic Field Strength
ICNIRP	International Commission on Non-Ionizing Radiation Protection

IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers
IOT	Internet of Things
ITU	International Telecommunication Union
ITU-T	International Telecommunication Union - Telecommunication Standardization Sector
kHz	Kilohertz
m	Meter
MHz	Megahertz
RF	Radio Frequency
RF EMF	Radio Frequency Electromagnetic Field
S	Power Density
S_{ab}	Absorbed Power Density
SAR	Specific Absorption Rate
S_{inc}	Incident Power Density
UCC	Uganda Communications Commission
WIFI	Wireless Fidelity

4. OVERVIEW OF RF EMF AND ASSESSMENT CONSIDERATIONS

Electromagnetic fields (EMF) are all around us and originate from both natural sources and human-made sources. These fields span a wide range of frequencies, collectively known as the electromagnetic spectrum, which includes various types of radiation with different wavelengths, frequencies, and energy levels.

EMF sources are generally categorized based on their frequency range and biological effects, not simply by their use in communications. Two key classifications are:

i. Ionizing vs. Non-Ionizing Radiation

a. Ionizing radiation includes the X-rays and Gamma rays, which carry enough energy to break atomic bonds and can potentially cause biological harm.

b. Non-ionizing radiation includes extremely low frequency (ELF) fields, radiofrequency (RF) electromagnetic fields, microwaves, infrared (IR) radiation, and visible light, which do not carry enough energy to ionize atoms or molecules and therefore cannot break chemical bonds. These forms of radiation are generally considered less biologically harmful when exposure is within established safety limits. RF EMF generated by the communication infrastructure falls under this category, i.e., non-ionizing.

* *Ultraviolet (UV) radiation occupies a transitional range between the upper end of non-ionizing radiation (e.g. sunlight, tanning beds) and the lower end of ionizing radiation (e.g. germicidal lamps, industrial sterilization).*

ii. *Natural vs. Artificial EMF Sources*

a. Natural sources of EMF include sunlight, which emits infrared, visible, and ultraviolet radiation, as well as the Earth's magnetic field.

b. Artificial (man-made) sources include high-voltage power lines, electrical wiring, mobile phones, broadcast antennas, and Wi-Fi routers, among others.

Of particular interest to regulators is the RF EMF, which occupies the frequency range between 3 kHz to 300 GHz. This segment of the electromagnetic spectrum is used primarily for wireless communication technologies, including:

i. Mobile phone networks (2G,3G, 4G and 5G),
ii. Terrestrial radio and television broadcasting,
iii. Maritime and Aeronautical operations,
iv. Wi-Fi, Bluetooth,
v. Radar and Microwave links,
vi. Satellite communications.

RF EMF is a subset of non-ionizing radiation. It does not possess sufficient energy to ionize atoms, and its biological effects such as tissue heating are the focus of ongoing scientific evaluation and regulation. The exposure levels from communication infrastructure and devices are subject to internationally agreed-upon safety guidelines.

This guideline focuses on RF EMF, specifically the non-ironizing emissions from telecommunications infrastructure and services that are regulated under the Uganda Communications Act Cap 103 (as amended).

Table 1: The electromagnetic spectrum

Type of electromagnetic radiation	**Frequency range**	**Wavelength range**	**Sources/uses**
Extremely low frequency (ELF)	<3kHz	>100km	Power lines, electrical wiring
Very low to medium frequency	3kHz – 3MHz	100km – 100m	AM radio, navigation systems.
High to very High frequency	3MHz – 300 MHz	1m – 10cm	FM radio, TV broadcasts
Ultra-high frequency (UHF)	300MHz- 3GHz	1m – 10cm	Mobile phones, WIFI, TV, radar

Super high frequency (SHF)	3GHz – 30GHz	10cm -1cm	Satellite communications, 5G, microwave links
Extremely high frequency (EHF)	30GHz – 300GHz	1cm – 1mm	Advanced radar, backhaul, experimental 6G
Infrared (IR)	300GHz – 400THz	1mm – 750nm	Remote controls, thermal imaging
Visible light	400THz – 790THz	750nm – 380nm	Sunlight, lamps, and human vision
Ultraviolet (UV)	790 THz – 30 PHz	380 nm – 10 nm	Sun, black lights, sterilization
X-rays	30 PHz – 30 EHz	10 nm – 0.01 nm	Medical imaging, airport security
Gamma rays	> 30 EHz	< 0.01 nm	Nuclear reactions, radioactive decay

**Hz – Hertz, kHz – Kilohertz, MHz – Megahertz, GHz – Gigahertz, THz – Terahertz, PHz – Petahertz, EHz - Exahertz*
**m – metre, cm, centimetre, mm – millimetre, nm – nanometre*

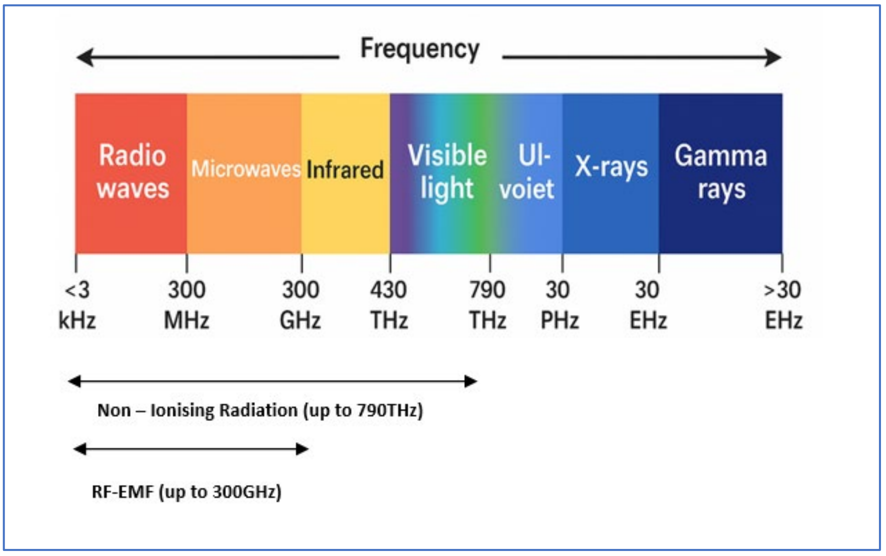

Figure 1: The Electromagnetic Spectrum

- *Radiofrequency (RF) EMF spans roughly from 3 kHz to 300 GHz – covering most communication technologies.*
- *Sunlight includes visible light, infrared, and some UV – all natural parts of the EM spectrum.*
- *Ionizing radiation (UV, X-rays, Gamma rays) has enough energy to break chemical bonds.*
- *Non-ionizing radiation (everything below UV) includes the RF used in communications and is considered less biologically harmful at regulated exposure levels.*

4.1 Sources of EMF in Communications Infrastructure

The Primary sources of EMF within the communications sector include:

- Telecommunications infrastructure (Wireless technology),
- Broadcasting infrastructure (radio and television towers),
- Satellite communication equipment,
- Microwave links,
- User devices such as mobile phones, computers, tablets, laptops, other Wi-Fi or Bluetooth-enabled devices, etc.

4.2 RF EMF Compliance Assessment

UCC evaluates RF EMF compliance using two approaches: one for communications devices and equipment, and another for communications infrastructure for wireless technologies.

i. For Communications Equipment and Devices:

UCC ensures that all communications equipment imported or used in Uganda complies with established RF EMF safety standards. This is achieved through a mandatory Type Approval and Type Acceptance process, which applies to both consumer and network equipment. This requires the submission of

- Manufacturers' technical documentation and certified test reports demonstrating that devices such as mobile phones, tablets, routers, transmitters, repeaters, and antennas comply with relevant international exposure standards and guidelines.
- Handheld devices intended for use near the human body must meet Specific Absorption Rate (SAR) limits, as defined by ICNIRP and other global frameworks. SAR ensures that the RF energy absorbed by body tissue remains within safe levels.

ii. For Communications Infrastructure:

Infrastructure such as mobile phone base transceiver stations, broadcasting towers, and microwave links is assessed through on-site field measurements and evaluations. UCC uses calibrated instruments and follows standardised procedures to measure RF EMF exposure levels in the surrounding environment. These measurements verify that emissions remain within the limits prescribed by national and international safety guidelines and standards mentioned herein.

This guideline specifically addresses this second approach RF EMF compliance assessments for communications infrastructure which is essential for ensuring safe deployment and operation of wireless networks across the country.

4.3 Technical Competency Requirements for RF EMF Assessments

Assessing compliance with RF EMF exposure limits is critical for safeguarding both public and occupational health. These assessments' accuracy, consistency, and integrity directly influence regulatory decisions and contribute to the broader goal of protecting communities in line with internationally recognised safety standards.

The procedures outlined in this guideline are based on globally accepted frameworks, particularly those established by the ICNIRP, whose exposure limits are endorsed by the WHO and adopted by the ITU. These standards provide the scientific basis for ensuring that RF EMF emissions from communications infrastructure remain within the prescribed safe exposure thresholds.

Given the technical and safety implications, RF EMF assessments must be carried out by qualified personnel with the appropriate expertise, training, and operational awareness. The assessor's competence in both theoretical and practical aspects of RF EMF compliance depends on reliable measurement and accurate interpretation.

To ensure consistency and credibility in compliance evaluations, all individuals conducting RF EMF assessments shall meet the following minimum competency requirements:

i. Possess skills obtained through training in RF EMF measurement equipment, including correct usage and calibration procedures.

ii. Good understanding of national and international exposure standards, particularly the ICNIRP guidelines and relevant regulatory frameworks.

iii. Proficiency in standardized measurement methodologies and compliance evaluation procedures.

iv. Ability to analyze field data, interpret results accurately, and assess compliance with regulatory thresholds.

v. Practical knowledge of field operations, including site selection, equipment setup, measurement execution, and data documentation.

vi. Awareness of health and safety protocols, especially those related to occupational exposure and public interaction during on-site assessments.

4.4 Scope of RF EMF Assessments

To ensure effective monitoring and uphold regulatory oversight, RF EMF assessments shall be conducted strategically and responsively. UCC will adopt a dual scope approach to balance routine monitoring with targeted evaluations:

i. National Baseline Surveys:

These are periodic assessments conducted to evaluate RF EMF exposure levels across the country. They are designed to establish national exposure baselines, monitor changes over time, and identify emerging trends that inform regulatory action, public communication, and policy development.

RF EMF national surveys may be conducted every five years to track long-term exposure trends, assess the effects of emerging wireless technologies (such as 5G and IoT deployments), and support evidence-based regulatory and infrastructure planning. While there is no internationally mandated frequency for conducting such surveys, a 3- to 5-year interval is consistent with international best practices, striking a balance between data relevance, research and resource efficiency.

These assessments are broad in scope and typically rely on representative sampling across diverse geographic and urban contexts. Therefore, they are not intended to replace detailed, site-specific compliance evaluations but rather to provide a national-level overview of exposure conditions. across

ii. Scenario-Based or Targeted Assessments:

These are responsive assessments conducted in specific geographic and contextual situations, such as public complaints, infrastructure rollouts, or high human access environments (e.g. schools, hospitals, or densely populated areas). They are designed to address specific concerns or verify compliance under certain conditions.

These are responsive RF EMF assessments conducted in specific geographic or contextual situations that require focused investigation. Scenario-based assessments are triggered by developments such as new infrastructure deployments, upgrades to existing technologies, public complaints or concerns, stakeholder requests, regulatory inquiries, or the detection of unusual RF EMF exposure patterns that may warrant further analysis.

These assessments complement routine monitoring by providing detailed, situational insight into exposure levels in dynamic or evolving deployment contexts.

iii. Occupational exposure

UCC's framework for occupational RF EMF assessments includes operator-led assessments. Licensed operators are required to conduct routine exposure assessments in occupational settings as part of their internal health, safety, and environmental (HSE) compliance reporting. This includes zoning high-exposure areas, posting visible signage, applying power-down procedures, and ensuring technical staff use proper access protocols and personal monitoring devices where necessary.

iv. Special Considerations: Shared Rooftops and Mixed-Access Zones

An increasing number of base station antennas are being deployed on rooftops of buildings that also serve as residential or commercial spaces, such as apartment blocks, schools, or office complexes. These settings create mixed-access zones, where both trained personnel and members of the public may be present.

In such cases, operators are required to implement enhanced risk controls to distinguish between occupational and public access areas. This includes physical access restrictions, dual signage (for both workers and the public), and updated exposure assessments that reflect the presence of non-technical individuals.

UCC considers these environments as requiring additional regulatory oversight and may conduct targeted inspections to ensure that exposure mitigation measures are both effective and enforced.

4.5 Measurement Scenarios for RF EMF Assessments

Assessments will be conducted across various real-world scenarios to ensure a comprehensive and representative evaluation of RF EMF exposure levels. These scenarios reflect the diverse environments in which people live, work, and interact with telecommunications infrastructure.

The key measurement scenarios include:

i. ***Public Access Areas**:* These are locations where members of the general public are likely to be present for extended periods. Examples include trading centres, residential neighborhoods (indoor and outdoor), schools, hospitals, recreational parks, and public gardens. Assessments in these areas aim to evaluate population-level exposure under typical environmental conditions. Including indoor areas

ii. ***Proximity to Infrastructure**:* This refers to human access areas located near active RF EMF emitting infrastructure, such as base station antennas (e.g., mounted on towers, poles, or rooftops) and broadcast towers (used for television and radio transmission). Measurements in these locations are intended to assess public exposure in settings where transmitters are in close physical proximity to human activity, based on the public assumption that such proximity may be associated with elevated RF EMF exposure. Examples of such locations include residential buildings, walkways, adjacent to telecom towers or rooftop antennas, markets or commercial areas near mounted small cells, and schools or health facilities located close to base stations.

iii. ***Occupational Settings**:* These are workplaces where technical staff or maintenance personnel may come into direct contact with RF emitting equipment. These assessments focus on exposure in controlled environments such as tower sites, equipment rooms, and rooftops where occupational safety standards apply.

iv. ***High-Risk Exposure Scenarios**:* These scenarios include environments where the potential for peak RF EMF exposure is greatest typically near high-powered transmitters or locations where multiple RF sources are co-located. Such assessments are critical for validating safety under worse-case exposure conditions.

5. METHODOLOGY FOR CONDUCTING RF EMF ASSESSMENT

5.1 Site Selection and Preparation for RF EMF Measurements

Practical RF EMF assessment begins with a strategic and well-informed approach to site selection. The choice of measurement locations is directly influenced by the assessment's objectives. This is regardless of whether it is part of a routine survey, a targeted investigation following public concern, or a compliance check in response to infrastructure deployment.

Consideration shall be given to:

i. Areas with high population density or heightened public interest (e.g., schools, hospitals),
ii. Locations in close proximity to wireless communications infrastructure, and;
iii. Sites that reflect one or more of the predefined measurement scenarios described in Section 4.5.

Once sites have been identified, several preparatory steps must be completed before fieldwork begins. These include:

i. Securing access permissions from relevant authorities or property owners,
ii. Reviewing site-specific background information, such as infrastructure layout or historical concerns, and;
iii. Ensuring field teams are fully equipped with calibrated instruments**,** standard operating procedures, and personal safety gear.

5.2 Compliance Considerations for Shared Sites

In Uganda and many other countries, it is common for multiple operators to share passive infrastructure (such as towers, masts, or rooftops) or to install independent infrastructure in close proximity (co-located sites).

Total RF EMF exposure at shared and collocated sites must be assessed cumulatively, accounting for emissions from all transmitting equipment, regardless of ownership.

Operators sharing infrastructure must collaborate in exposure assessments, providing necessary technical information and coordinating on mitigation measures where needed. Compliance must be verified for both individual operator emissions and combined cumulative exposure relative to ICNIRP reference limits.

5.3 Special Considerations for Small Cells and Active Antenna Systems (AAS)

The growing deployment of small cells and Active Antenna Systems (AAS), particularly for 4G and 5G networks, introduces new exposure scenarios due to their closer proximity to public areas and dynamic beamforming capabilities. Although typically operating at lower power levels than macro sites, small cells are installed in urban environments such as lamp posts, bus shelters, and building arcades, often near areas of continuous public access. Similarly, AAS can dynamically direct RF energy, resulting in non-static exposure patterns. RF EMF assessments shall account for the specific characteristics of small cells and AAS, using realistic operational conditions, proximity to accessible areas, and worse-case beamforming scenarios where applicable, and in line with the objectives of this Guideline.

5.4 Measurement Equipment

Effective RF EMF measurement depends on the use of specialised tools and how well those tools are configured, calibrated and maintained. Proper equipment setup ensures accurate data capture, while calibration guarantees the reliability of the results.

a. Equipment and Tools Used

The following equipment and tools are commonly utilized RF EMF measurement procedures:

i. ***Spectrum Analyzer or Measurement Receiver:*** Detects and displays RF signals across a defined frequency range, measuring signal strength, power density, and electric field strength, among other parameters.

ii. ***Calibrated Antennas:*** Receive RF signals for accurate frequency and power density or electric field strength assessments.

iii. ***Tripod stand:*** Provides stability and consistency in measurement positioning, minimizing measurement deviations**.**

iv. ***GPS device:*** Captures precise geographic coordinates for accurate location referencing of measurement sites.

v. ***Data logging system:*** Records and stores RF EMF measurement data for trend analysis and compliance assessment.

vi. ***RF EMF analysis software:*** Processes, visualizes, and interprets measurement data, enabling detailed exposure and compliance assessment.

vii. ***Camera:*** *A* vital tool for documenting measurement locations, equipment setup, and environmental conditions, ensuring assessment reproducibility and integrity.

**Separate hands-on training is provided for the use of specific equipment available at the time of assessment. While equipment models may vary, the underlying measurement principles and methodologies remain consistent across different tools.*

b. Calibration and Equipment Validation

RF EMF measurements require the use of precision-calibrated equipment capable of accurately assessing exposure levels across the relevant frequency bands. Calibration must be conducted in accordance with the manufacturer's specifications and applicable technical standards and is typically specific to the equipment model and its intended frequency range.

Proper calibration is essential to ensure measurement integrity and data reliability. The selected measurement approach, whether broadband or frequency-selective must align with the objectives of the assessment and the frequency allocations in use within the country.

Accordingly, calibration must take into account the alignment of frequency coverage for both the analyser or receiver and the associated antennas, ensuring that all components are suited to the operational frequency bands under evaluation.

c. Equipment Setup for Measurement

The equipment setup process involves preparing, configuring, and positioning all RF EMF measurement system components including associated software in line with standardized procedures and the manufacturer's instructions.

Measurement parameters must be configured to match the frequency bands under evaluation, with particular focus on downlink frequencies assigned in Uganda. Environmental factors such as reflections, physical obstruction, and nearby RF sources should be identified and minimized to ensure accurate and repeatable results. Equipment must be positioned and aligned appropriately to capture exposure within the context of the defined measurement objectives, such as height above ground level, distance from the RF EMF source, and orientation relative to antenna main beams.

5.5 Measurement Execution

RF EMF measurements are conducted to assess human exposure to RF fields and verify compliance with national and international safety limits. A defined set of technical and situational parameters is documented at each measurement location to ensure data accuracy, reliability, and traceability.

5.5.1 Site Identification and Location Details

At each measurement location, contextual site details are documented in line with the defined measurement objectives. These may include: the district and site name, the nature of the site (i.e., whether it is a single-operator installation, a shared site, or a co-located site), the distance from nearby human access areas, the type of supporting structure (such as a mast, tower, pole or rooftop), the antenna height on the structure, the environmental context (including surrounding buildings, vegetation, elevation, and potential obstructions), as well as the date and time of the measurement.

5.5.2 Frequency Range and Bands Information

RF EMF assessments cover all frequency bands utilized by wireless communication technologies operating within Uganda. This includes

i. Fixed and mobile telecommunications
ii. Broadcasting services (radio and television).
iii. Satellite communications.
iv. Fixed wireless access systems.
v. Wi-Fi and ISM frequency bands.

vi. Emerging services including 5G, Internet of Things (IoT), and wireless telemetry systems.

5.5.3 Averaging Time and Practical Measurement Duration

ICNIRP 2020 specifies a 6-minute or 30-minute time-averaging period for assessing public exposure to RF EMF, based on biological considerations related to energy absorption and thermal effects. However, this averaging period refers to the exposure evaluation timeframe, not the minimum required measurement duration at each site.

In practice, shorter measurement durations, typically up to 60 seconds may be used to reliably estimate the time-averaged field strength or power density. This is permitted under internationally recognized technical standards such as IEC 62232 standards and ITU-T recommendations, which provide validated procedures for short-term spot measurements and averaging techniques.

5.5.4 Exposure Evaluation Approach

RF EMF exposure assessments applies to either whole-body or localized exposure limits depending on the assessment objective, the proximity of the base station sites to human access and the characteristics of the RF source, in line with the ICNIRP 2020 guidelines.

Measurements focus on incident electric field strength (V/m) or power density (W/m^2), depending on the operational frequency band and field zone.

a. Whole-Body Exposure Assessment

Whole-body reference levels, as specified in ICNIRP 2020 applies in situations where individuals are uniformly exposed to multiple sources over time. This includes scenarios such as community-wide assessments of ambient RF EMF levels (e.g. around broadcast towers or in mixed urban RF environments) and long-term cumulative exposure from various sources.

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Table 5. Reference levels for exposure, averaged over 30 min and the whole body, to electromagnetic fields from 100 kHz to 300 GHz (unperturbed rms values).[a]

Exposure scenario	Frequency range	Incident E-field strength; E_{inc} (V m^{-1})	Incident H-field strength; H_{inc} (A m^{-1})	Incident power density; S_{inc} (W m^{-2})
Occupational	0.1 – 30 MHz	$660/f_M^{0.7}$	$4.9/f_M$	NA
	>30 – 400 MHz	61	0.16	10
	>400 – 2000 MHz	$3f_M^{0.5}$	$0.008f_M^{0.5}$	$f_M/40$
	>2 – 300 GHz	NA	NA	50
General public	0.1 – 30 MHz	$300/f_M^{0.7}$	$2.2/f_M$	NA
	>30 – 400 MHz	27.7	0.073	2
	>400 – 2000 MHz	$1.375f_M^{0.5}$	$0.0037f_M^{0.5}$	$f_M/200$
	>2 – 300 GHz	NA	NA	10

[a]Note:

1. "NA" signifies "not applicable" and does not need to be taken into account when determining compliance.
2. f_M is frequency in MHz.
3. S_{inc}, E_{inc}, and H_{inc} are to be averaged over 30 min, over the whole-body space. Temporal and spatial averaging of each of E_{inc} and H_{inc} must be conducted by averaging over the relevant square values (see eqn 8 in Appendix A for details).
4. For frequencies of 100 kHz to 30 MHz, regardless of the far-field/near-field zone distinctions, compliance is demonstrated if neither E_{inc} or H_{inc} exceeds the above reference level values.
5. For frequencies of >30 MHz to 2 GHz: (a) within the far-field zone: compliance is demonstrated if either S_{inc}, E_{inc} or H_{inc}, does not exceed the above reference level values (only one is required); S_{eq} may be substituted for S_{inc}; (b) within the radiative near-field zone, compliance is demonstrated if either S_{inc}, or both E_{inc} and H_{inc}, does not exceed the above reference level values; and (c) within the reactive near-field zone: compliance is demonstrated if both E_{inc} and H_{inc} do not exceed the above reference level values; S_{inc} cannot be used to demonstrate compliance, and so basic restrictions must be assessed.
6. For frequencies of >2 GHz to 300 GHz: (a) within the far-field zone: compliance is demonstrated if S_{inc} does not exceed the above reference level values; S_{eq} may be substituted for S_{inc}; (b) within the radiative near-field zone, compliance is demonstrated if S_{inc} does not exceed the above reference level values; and (c) within the reactive near-field zone, reference levels cannot be used to determine compliance, and so basic restrictions must be assessed.

Figure 2: ICNIRP reference levels for exposure averaged over 30 min and whole body, to EMF from 100kHz to 300GHz (unperturbed rms values) Source: ICNIRP 2020 Guidelines

From the above figure, measurements are compared to frequency-dependent power density limits. For example, for the general public:

- **f/200 (W/m²)** for 400 MHz to 2 GHz
- **10 W/m²** for frequencies above 2 GHz

The averaging time in these contexts is 30 minutes. These assessments may be used in general exposure mapping but are not the primary method for site-level RF EMF compliance assessment.

b. Localized Exposure Assessment

Localized exposure, as defined in the ICNIRP 2020 guidelines applies when evaluating RF EMF exposure at specific public locations near communications infrastructure, such mobile phone base transceiver stations and rooftop installations, public streets or buildings near tower sites, and small cells or repeaters installed at low elevation in urban areas.

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Table 6. Reference levels for local exposure, averaged over 6 min, to electromagnetic fields from 100 kHz to 300 GHz (unperturbed rms values).[a]

Exposure scenario	Frequency range	Incident E-field strength; E_{inc} (V m^{-1})	Incident H-field strength; H_{inc} (A m^{-1})	Incident power density; S_{inc} (W m^{-2})
Occupational	0.1 – 30 MHz	$1504/f_M^{0.7}$	$10.8/f_M$	NA
	>30 – 400 MHz	139	0.36	50
	>400 – 2000 MHz	$10.58 f_M^{0.43}$	$0.0274 f_M^{0.43}$	$0.29 f_M^{0.86}$
	>2 – 6 GHz	NA	NA	200
	>6 – <300 GHz	NA	NA	$275/f_G^{0.177}$
	300 GHz	NA	NA	100
General public	0.1 – 30 MHz	$671/f_M^{0.7}$	$4.9/f_M$	NA
	>30 – 400 MHz	62	0.163	10
	>400 – 2000 MHz	$4.72 f_M^{0.43}$	$0.0123 f_M^{0.43}$	$0.058 f_M^{0.86}$
	>2 – 6 GHz	NA	NA	40
	>6 – 300 GHz	NA	NA	$55/f_G^{0.177}$
	300 GHz	NA	NA	20

[a] Note:

1. "NA" signifies "not applicable" and does not need to be taken into account when determining compliance.
2. f_M is frequency in MHz; f_G is frequency in GHz.
3. S_{inc}, E_{inc}, and H_{inc} are to be averaged over 6 min, and where spatial averaging is specified in Notes 6–7, over the relevant projected body space. Temporal and spatial averaging of each of E_{inc} and H_{inc} must be conducted by averaging over the relevant square values (see eqn 8 in Appendix A for details).
4. For frequencies of 100 kHz to 30 MHz, regardless of the far-field/near-field zone distinctions, compliance is demonstrated if neither peak spatial E_{inc} or peak spatial H_{inc}, over the projected whole-body space, exceeds the above reference level values.
5. For frequencies of >30 MHz to 6 GHz: (a) within the far-field zone, compliance is demonstrated if one of peak spatial S_{inc}, E_{inc} or H_{inc}, over the projected whole-body space, does not exceed the above reference level values (only one is required); S_{eq} may be substituted for S_{inc}; (b) within the radiative near-field zone, compliance is demonstrated if either peak spatial S_{inc}, or both peak spatial E_{inc} and H_{inc}, over the projected whole-body space, does not exceed the above reference level values; and (c) within the reactive near-field zone: compliance is demonstrated if both E_{inc} and H_{inc} do not exceed the above reference level values; S_{inc} cannot be used to demonstrate compliance; for frequencies >2 GHz, reference levels cannot be used to determine compliance, and so basic restrictions must be assessed.
6. For frequencies of >6 GHz to 300 GHz: (a) within the far-field zone, compliance is demonstrated if S_{inc}, averaged over a square 4-cm^2 projected body surface space, does not exceed the above reference level values; S_{eq} may be substituted for S_{inc}; (b) within the radiative near-field zone, compliance is demonstrated if S_{inc}, averaged over a square 4-cm^2 projected body surface space, does not exceed the above reference level values; and (c) within the reactive near-field zone reference levels cannot be used to determine compliance, and so basic restrictions must be assessed.
7. For frequencies of >30 GHz to 300 GHz, exposure averaged over a square 1-cm^2 projected body surface space must not exceed twice that of the square 4-cm^2 restrictions.

Figure 3: Reference levels for local exposure, averaged over 6 min, to electromagnetic fields from 100 kHz to 300 GHz (unperturbed rms values).

In these settings, RF EMF exposure is concentrated on a specific part of the body (e.g., head, torso/trunk), rather than being uniformly distributed. Accordingly, the exposure assessments are conducted over a 6-minute averaging period

The relevant ICNIRP exposure limit is calculated as:

- Incident power density (S_{inc}) = 0.058 × f^0.86 (W/m²) for 400 MHz to 2000 GHz (refer to Figure 3 above)
- A constant limit of 40 W/m² applies for 2-6GHz, if incident power density is used.

Localized exposure assessments are valid for both far-field and near field conditions where whole body assumption do not apply.

Example:
For a site operating at 900 MHz, the ICNIRP 2020 localized exposure reference limit is calculated as:

S_{inc} = 0.058 X (900) ^0.86

= 0.058 X 347.3 = 20.14W/m²

If the **measured power density** at the site is **0.0005 W/m²**, the exposure percentage is:

*Exposure (%) = (Measured power density/Incident power density (S_{inc}) – **the ICNIRP reference limit**) X 100%*

$$= (0.0005 / 20.14) \times 100 = 0.0025\%$$

This demonstrates that the exposure level is significantly below the ICNIRP limit for localized public exposure at that frequency and is therefore considered compliant.

c. RF EMF Exposure Assessment for AAS and 5G Small Cells

The introduction of 5G technologies, particularly Active Antenna Systems (AAS) and small cells brings new exposure dynamics. Unlike earlier technologies such as 2G, 3G, and 4G, which transmit signals in fixed directions and relatively stable patterns, 5G systems can change the direction and strength of signals in real time depending on network demand. This means exposure levels may vary based on a person's location and the time of day. Additionally, 5G antennas especially small cells are not only installed on outdoor structures like lamp posts and building walls but are also placed indoors in locations such as parking spaces, office buildings, and even homes. These installations bring technology to a much closer proximity to people than in previous technologies. As a result, exposure zones may fall within the radiative near-field, which requires careful attention to how measurements are conducted, including probe positioning and averaging.

For frequencies above 6 GHz, where RF energy is absorbed only at the surface of the skin, ICNIRP 2020 recommends assessing exposure using absorbed power density (S_{ab}), which more accurately reflects the biological effects at these higher frequencies. However, measuring S_{ab} requires specialized laboratory equipment, including tissue-equivalent phantoms, high-frequency surface-averaging probes, and controlled setups that simulate human skin interaction; tools that are not practical or readily available in field assessment environments. As such, incident power density (S_{inc}) is applied as a conservative alternative for field assessments, in accordance with ICNIRP 2020 guidelines. Worst-case assumptions such as maximum beam alignment, continuous signal transmission, and direct line of sight are used to ensure that public exposure remains within safe and protective limits.

In all such deployments, the 6-minute averaging time remains applicable.

Example: Exposure calculation above 6 GHz, (take for instance 28GHz)

Using ICNIRP 2020 (Figure 3), the reference limit for S_{inc} is given by:

Sinc = 55/f^0.177 (with frequency in GHz)

Substituting the frequency:

$S_{inc} = 55/(28)^{0.177} = 55/1.8 = 30.6\ W/m^2$

If the measured power density at that location is 1.2 W/m^2, the exposure percentage is calculated as

Exposure (%) = (Measured power density/Incident Power Density (S_{inc})) X 100%

$$= (1.2 / 30.6) \times 100 = 3.92\%$$

This result is compliant with the ICNIRP limit for localized exposure at 28 GHz.

5.5.5 Exposure Calculation Across Multiple Frequencies (Cumulative Exposure)

In many communications sites, especially those in typical deployment settings, multiple RF signals from different frequency bands are present at the same time. This is common at shared or co-located sites that host multiple technologies. Each of these services operates at a distinct frequency and contributes independently to the total RF EMF exposure at a given measurement location.

To accurately assess cumulative exposure at a location, RF EMF measurement equipment perform frequency-selective scanning, detecting and separating signals across a wide frequency range (e.g., 100 kHz to 6 GHz). Each detected signal is automatically associated with its corresponding frequency band (e.g., 400kHz, 900 MHz, 1800 MHz, 2100 MHz, 3500 MHz), and the appropriate ICNIRP reference limit is applied for that frequency.

Using either manual computation or built-in analysis software, the total RF EMF exposure at a location is determined through the following steps:

a. Calculate the exposure contribution for each detected frequency band by expressing the measured value as a percentage of the corresponding ICNIRP reference limit:

$$\text{Exposure (\%)} = \left[\frac{\text{Measured Value}}{\text{Reference Limit}}\right] *100$$

b. Sum the exposure contributions from all detected frequencies to determine the total RF EMF exposure at the measurement location:

Total Exposure (%) = Sum of all individual exposure percentages across the frequency bands

5.5.6 Interpretation of Total Exposure:

- **< 100%** → The site is compliant with ICNIRP public exposure limits.

- **= 100%** → The site is at the threshold, with no safety margin; further review is advised.
- **> 100%** → The site exceeds allowable exposure limits and requires investigation and possible regulatory action.

This approach is particularly valuable where multiple operators or systems share infrastructure or ground. Even without knowing which operator owns which antenna, the exposure level at the location can still be reliably determined using this method.

5.6 Addressing Measurement Uncertainty

All RF EMF measurements are subject to some degree of uncertainty, which refers to the potential difference between the measured value and the actual field strength at a given location. This uncertainty arises from a combination of factors, including the transient and variable nature of RF signals, limitations of measurement equipment, changes in environmental conditions (such as reflections or obstructions), and assumptions made in the measurement setup and methodology.

Recognizing this, it is essential that uncertainty is either quantified where possible using established calculation methods or acknowledged when drawing conclusions about compliance. Doing so helps maintain transparency and ensures that safety margins are preserved when interpreting results near the threshold limits.

This guideline shall follow international standards such as IEC 62232 and ITU-T K.100, which provide structured methods for evaluating and reporting measurement uncertainty.

6. OPERATOR COLLABORATION AND ACCOUNTABILITY

Operators sharing sites or operating within proximity must cooperate transparently to support RF EMF compliance. Each operator remains individually responsible for ensuring their equipment complies with exposure standards, while also participating in joint assessments for cumulative exposure verification. Collaborative procedures shall include data sharing, coordinated measurement campaigns, and collective reporting to UCC upon request. Operators will also be encouraged to build the capacity of their technical teams to undertake public engagements during installation and routine mainstem=nance of communications installations and infrastructure to further build the confidence of the host communities in the safety of the infrastructure and the installations.

7. DOCUMENTATION AND REPORTING

All RF EMF assessments shall be documented to ensure trend analysis, traceability, transparency, and regulatory compliance. Proper documentation provides a verifiable record of findings and supports informed decision-making, public communication, and ongoing monitoring efforts.

Each assessment shall be compiled into a formal report and recorded in a centralized RF EMF assessment results database maintained by UCC. This database serves as an official repository for storing, organizing, and retrieving all historical measurement data and related information, enabling long-term exposure trend analysis, compliance tracking, and stakeholder reporting.

The assessment report may include:

i. Introduction and objectives: *Outline the purpose of the assessment, scope, and key objectives.*
ii. Measurement date, location, and environmental conditions: *Specify when and where the measurements were conducted, along with relevant environmental factors (e.g., weather conditions, nearby structures).*
iii. Equipment description and calibration details: *Provide information on the measurement equipment used, including model specifications, calibration certificates, etc.*
iv. Data collected and exposure levels: *Present recorded RF EMF levels at various measurement points, categorized by frequency band where applicable.*
v. Compliance assessment: *Compare measured exposure levels against national and international exposure limits (e.g., ICNIRP, ITU, IEC, IEEE) to determine compliance.*
vi. Observations, conclusions, and corrective actions: *Summarize key findings, highlight any exceedances or concerns, and recommend necessary mitigation measures.*
vii. Public communication and stakeholder engagement: *If applicable, detail any engagement with local communities, authorities, or other stakeholders regarding assessment findings and compliance measures.*

8. STAKEHOLDER ENGAGEMENT AND PUBLIC RESPONSE APPROACH

UCC shall implement a structured stakeholder engagement and public response approach to support transparent communication, build public trust, and ensure effective handling of RF EMF exposure-related concerns. This approach integrates proactive information dissemination with a coordinated mechanism for receiving and addressing public queries and complaints.

To tailor engagement efforts appropriately, stakeholders are classified based on their power (influence on decisions) and interest (level of concern or involvement) in RF EMF exposure-related matters. The stakeholder engagement matrix in Table 4 outlines the engagement strategy.

Table 2: Stakeholder engagement matrix

Stakeholder group	**Power**	**Interest**	**Engagement approach**
UCC Management, Operators,	High	High	Direct engagement through joint planning, technical briefings, compliance and strategic dialogues, and decision-making processes.

Government Ministries, Parliament, Local Authorities,	High	Low	High-level policy briefs, strategic reports, and targeted consultations on planning, permitting, and regulatory alignment.
General Public, Civil Society, Media, Academia	Low	High	Public awareness campaigns, RF EMF data access, community forums and workshops, FAQs, media briefings, and educational content.
Indirectly Affected Groups or Institutions	Low	Low	General updates via newsletters, publications, or online platforms. Monitored for future relevance.

In addition to proactive engagement, UCC shall maintain a well-defined mechanism for managing public concerns related to RF EMF exposure.

Queries or complaints may be submitted through; the call centre, email, registry, walk-ins, or referrals from local authorities and community leaders. All concerns shall be routed to the Environment Management Unit for coordinated handling.

The process shall consist of the following stages:

i. ***Initial review:*** The query or complaint is reviewed to assess its nature and urgency. A determination is made on whether a technical investigation is required. If not, a formal written response shall be prepared and issued.

ii. ***Investigation****:* Where necessary, site-specific RF EMF measurements or technical inspections shall be conducted in collaboration with relevant stakeholders and authorities.

iii. ***Community engagement****:* Where concerns are widespread or of significant public interest, targeted community sensitization and stakeholder dialogue may be conducted as part of the response process.

iv. ***Formal response****:* Findings and outcomes are officially communicated to the party concerned. Relevant stakeholders may be copied, including internal UCC teams and external agencies.

v. ***Follow-up and enforcement:*** In cases where non-compliance is identified, corrective or enforcement action shall be initiated following UCC's regulatory procedures.

vi. ***Public reporting:*** Summary reports highlighting key findings, trends, and recurring public concerns shall be developed and shared through appropriate public communication channels to promote transparency and continuous learning.

**All submissions, actions taken, and outcomes shall be recorded in a RF EMF assessment and public response database. This database will serve as a reference for compliance tracking, trend analysis, planning, and public accountability.*

9. REFERENCES

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ii. National Environment Act Cap 181, 2019

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