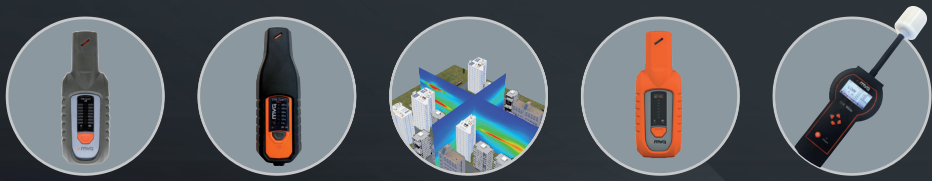
RF SAFETY

OVERVIEW



EMF
MEASUREMENT
AND
MONITORING
TOOLS

MVG
Microwave Vision Group

Your RF Safety is Our Priority!

Why do we measure exposure levels?

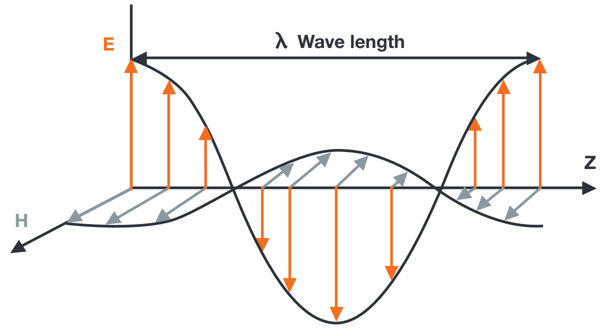
Electromagnetic fields are increasingly present in our living environment. For this reason they arouse ever more concern and raise questions about the possible harmful effects of these fields on health. As part of its public heath charter and in response to growing concerns, the World Health Organization (WHO) introduced the International Electromagnetic Fields Project in 1996. This Project aims to assess the health and environmental effects caused by static or variable electric and magnetic fields in frequencies from 0 to 300 GHz.

The Smart Choice for RF Safety

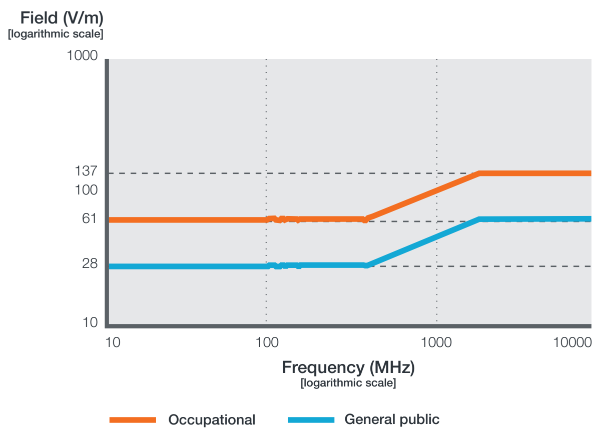
Since its inception in 1986, Microwave Vision Group (MVG) has developed a unique expertise in the visualization of electromagnetic waves. The Group's mission is to extend this unique technology to all sectors where it will bring strong added value. Year after year, the Group develops a complete range of Radio Frequency (RF) instruments to measure the level of exposure to electromagnetic fields and to address the following needs:

- **To continuously record the electromagnetic field level and alert the user to potential overexposure**
- **To monitor actual levels and compare them to the regulatory limits**
- **To address public concern through appropriate communication**
- **To simulate EMF radiation in real environments**

Wherever there is electricity (voltage or current), there is an electromagnetic field (EMF). All types of wireless transmissions (radio/TV broadcasting, voice/data wireless communication) use electromagnetic fields. The generated field propagates in the form of waves and is all around us even if we cannot see or hear it. The electromagnetic field has two components: the Electric E Field and Magnetic H Field, and they are proportional to each other in far field measurement.



ICNIRP - Reference levels for exposure to electric fields



Basic restrictions and reference levels

To protect individuals from the potential health effects of radio waves, protection levels known as **basic restrictions** were recommended by the International Commission on Non-Ionizing Radiation Protection (ICNIRP - http://www.icnirp.org). The ICNIRP is the non-governmental organization officially recognized by the WHO and the International Labor Organization (ILO) in the field of Non-Ionizing Radiation.

These basic restrictions were established on published biomedical studies relative to the health effects of electromagnetic waves. In the area of high frequencies, they are expressed in terms of **Specific Absorption Rate (SAR)** and the biological effects appear above 4 Watts per kilogram for the entire body (increase in body temperature of more than one degree) and above 100 watts per kilogram locally.

The basic restrictions are set so as to take into account uncertainties related to personal sensitivity, environmental conditions and diversity in the age and state of health of the populations concerned. The protection levels for workers were established at one tenth of these exposure levels producing an impact, and fifty times lower for the general public.For the general public, the basic restrictions thus require that the power absorbed per kilogram (SAR) be at 0.08 W/kg maximum for the entire body and 2 W/kg maximum for 10 grams of tissue.

Given the complexity of measuring the SAR in situ, the ICNIRP (based on the studies carried out to find the relation between a plane wave power surface density and the power absorbed by an ellipsoid representing a human body) has defined **reference levels** deduced from basic restrictions and **expressed in Volts per meter or Watts per square meter.** Compliance with all the recommended reference levels will ensure that the basic restrictions are observed. If the measured values are higher than the reference levels, this does not necessarily mean that the basic restrictions have been exceeded. In this case, check whether these levels of exposure are lower than the basic restrictions.

Regulation linked To the exposure levels

In Europe, the exposure limits follow the **European Union Council Recommendation 1999/519/CE of July 12th 1999** regarding the **public** exposure to electromagnetic fields. The exposure limit values are revised periodically if needed. The last report from the Scientific Committee on Emerging and Newly Identified Health Risks (SCENIHR), an independent European Commission body, on the health effects of electromagnetic fields, came out in January 2009. The conclusions of this report do not challenge the exposure limit values proposed by the above-mentioned European recommendation.

The great majority of European Union member countries follow this recommendation either by incorporating it into national regulations (Austria, Czech Republic, Estonia, Finland, France, Germany, Hungary, Portugal, Romania, Slovakia, Spain) or in the form of recommendations (Denmark, Ireland, Latvia, Malta, Netherlands, Sweden, United Kingdom).

However, different approaches are applied in certain member states with the introduction of more restrictive limits in "living areas" (Belgium, Bulgaria, Greece, Italy, Lithuania, Luxembourg, Poland, Slovenia). The same goes for Switzerland and Liechtenstein. The values chosen by these States are based on the application of the principle of precaution related to potential health risks related to exposure to electromagnetic fields and the exposure limit values were in most cases set in an arbitrary manner.

Concerning **workers**, as part of the **European directive on exposure of workers to the risks arising from electromagnetic fields** (directive 2013/35/EU of 26 June 2013), all employers must now determine the exposure (levels, duration), assess risks and take the necessary measures to ensure safety and protect the health of workers from the risks arising from professional exposure to these electromagnetic fields. In particular, they must:

- measure and/or calculate the electromagnetic field levels to which workers are exposed, via the appropriate departments at regular intervals
- record the results of this assessment on a reliable medium that can be consulted subsequently

Other information concerning the regulation throughout the world may be found directly on the WHO website: http://www.who.int/docstore/peh-emf/EMFStandards/who-0102/Worldmap5.htm.

Measurement protocols and standards

in order to compare the exposure levels measured at the established limits, measuring protocols have been established by the main standardization bodies. Some examples are the ECC/REC/(02)04 recommendation and the EN50383, EN50413, EN50492, EN62311 standards in Europe and the IEEE Std.C95.3 standard in North America.

Why measure electromagnetic fields?

Measuring the electromagnetic field is essential to check that exposure levels respect the regulatory limits established in each country, and thus ensure the safety of individuals exposed, whether members of the general public or workers.

For individuals who work in proximity to high frequency emmiters, the measurement ensures that the emitter is switched off when the intervention takes place and/or that the electromagnetic fields are well below the recommended levels. It thus reassures these individuals who can then complete their work without worry. The introduction of a Monitoring network on the work site allows this exposure to be constantly monitored. In either case, the measurement allows the employer to check that employees have not been over-exposed during their assignments.

Unlike a simulation or calculation, a measurement is concrete. Communicating the measured exposure levels, which are mostly very low as compared to the reference levels, provides reassurance to the concerned public. If the measurement reveals high levels of exposure, it then allows remedial actions to be implemented. Here again, the measurement can be occasional in time and space: an exposure meter can be lent to an administration official, who for a given period can check the levels to which he/she is exposed in the home or workplace, or it can be performed via a Monitoring network, with each probe sending these measurements over time to a database or eventually to a website, which can then be used by the authorities (municipality for example) to communicate the overall exposure of a city to the public.

The measurement taken by scientists by lending an exposure meter to a representative panel also allows us to find out the average exposure for a given population, and potentially the change in this exposure according to the technology (television broadcast, 2G, 3G, 4G mobile communications, domestic networks).

Finally, the measurements can be used to confirm and/or calibrate a propagation model. An appropriate combination of simulation and measurement allows us to obtain a precise mapping of exposure in a large geographic area, and to monitor changes to this exposure over time, in quasi-real time mode.

How to measure exposure to electromagnetic fields

Exposure to electromagnetic fields is generally measured using a probe and a receiver (Volt meter or power meter). An electromagnetic field probe is an "antenna" that has been optimized to measure exposure to electromagnetic fields.

There are two types of probes used for measuring exposure to electromagnetic fields: "broadband" probes and "frequency selective" probes.

A broadband probe is generally comprised of a dipole and a diode connected directly between the two poles of the antenna. Using this type of probe, the voltage proportional to the field level is measured. The quality of this type of probe will therefore depend on its ability to provide the same voltage for the same field and regardless of the frequency (frequency is of course within the usage bandwidth) of the field to be measured. These "broadband" probes provide information on the level of exposure, but do not indicate the frequency of the field to which the user is exposed. They are mostly used in warning products (worker exposure meter) or for a quick measurement of compliance when measured levels remain low. This type of probe is defined by its isotropy, its bandwidth, its sensitivity, its measurement dynamic, its frequency flatness and its linearity.

The second type of probe, depending on its receiver topology, provides information regarding the frequency and the amplitude of the measured field, as well as information on the level. They are incorporated into more refined compliance or information measuring products. They are defined by their isotropy, their bandwidth, and their antenna gain or factor: the dynamic, sensitivity and linearity in this case are dependent on the receiver topology used with a given probe.

Isotropy: The isotropy characterizes the ability of the field measuring probe to always provide the same response to a given field level, regardless of the direction of arrival of this field or its polarizations. It is a parameter required by most of the current measurement standards. There is no single naturally isotropic antenna: for electromagnetic field probes, this isotropy is thus obtained by combining the radiation pattern of three elementary antennae (dipole or monopole) appropriately placed with respect to each other.

Bandwidth: The performances of an electromagnetic field measurement probe vary according to the frequency of the field to be measured. They are thus defined to be used over a limited frequency range, known as the usage bandwidth.

Sensitivity: The sensitivity of an electromagnetic field measurement probe or system is the minimum level of the field that can be measured with this tool.

Dynamic range: The dynamic range of an electromagnetic field measurement probe or system is the difference between the maximum and minimum field that can be measured with this tool. It is generally expressed in dB.

Frequency flatness: This parameter characterizes the quality of a broadband probe. It represents the variations of the measured E-field at a fixed frequency, when the level of the E-field is varied over the dynamic range of the probe.

Linearity: This parameter characterizes the quality of a broadband probe. It represents the variations in the levels measured, with fixed frequency and making the level of the field measured over the probe's measuring range vary.

Antenna Gain and/or Factor: An antenna gain (respectively of an electromagnetic field measuring probe) characterizes its ability to emit (respectively receive) in a specified direction. It is generally expressed in dBi, taking as a reference an isotropic antenna, meaning a fictitious antenna that radiates uniformly in all directions. The gain of this antenna is thus 1, or 0 dBi (dBi for decibel-isotropic). The role of an electromagnetic field probe is to transform the recieved electromagnetic field level into RF power. The antenna factor is defined as the ratio of the electromagnetic field captured by this antenna to the voltage measured at the antenna terminals.

$$AF = \frac{E}{V_r}$$

The antenna factor (expressed in dB) is linked to its gain by the following equation:

$$AF = 20\,Log(F) - G - 29{,}78$$

In this equation, F is the frequency in MHz, and G is the gain in dBi.
The power received by an antenna capturing an electromagnetic field can easily be found using the following formula:

$$P_r = 20 * Log(E) - AF + 13$$

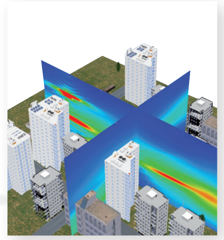
In this equation, Pr is expressed in dBm, E in V/m and the antenna factor in dB.

Quick Guide of MVG's RF Safety Solutions

> WORKER SAFETY

System name	EME Guard XS 71 GHz	EME Guard XS 40 GHz	EME Guard XS Radar	EME Guard Plus
Key feature	• Accurate measurement with tri-axis sensors • Instant audio and visual alarm • Robust, reliable and user-friendly • Covers 5G/6G bands, measuring up to 71 GHz	• Accurate measurement with Tri-axis isotropic sensor • Instant audio and visual alarm • Robust, reliable and user-friendly • Measurements up to 40 GHz	• Accurate measurement with Tri-axis isotropic sensor • Instant audio and visual alarm • Robust, reliable and user-friendly • Measurements up to 30 GHz • Detects short pulsed signals	• Accurate measurement with triaxial isotropic probe • Customization of audio alarm thresholds • Data storage software • Ruggedized design for all weather conditions • Measurements up to 40 GHz
Utilisation mode	Portable	Portable	Portable	Portable
Selectivity	Broadband	Broadband	Broadband	Broadband
Frequency bands	1 MHz – 71 GHz	1 MHz – 40 GHz	80 MHz – 30 GHz	1 MHz to 40 GHz
Audio alarm	•	•	•	•
Visual alarm	•	•	•	•
Monitoring	•	•	•	•
Data storage				•
Software	NA	NA	NA	EME Guard Analysis
Industries/ Users	• Antenna installer & maintenance companies • Operators (cellular network, broadcast, PMR, ...) • Military/Defense • RF laboratory workers • Local and national authorities	• Antenna installer & maintenance companies • Operators (cellular network, broadcast, PMR, ...) • Military/Defense • RF laboratory workers • Local and national authorities	• Antenna installer & maintenance companies • Operators (cellular network, broadcast, PMR, radar, ...) • Military/Defense • RF laboratory workers • Local and national authorities	• Antenna installer & maintenance companies • Operators (cellular network, broadcast, PMR, radar, ...) • Military/Defense • RF laboratory workers

> PUBLIC SAFETY



System name	FlashRad	EME Wide	INSITE Free	EMF Visual
Key feature	• Connected for data transfer and alarms • Alert users with sound, light or mail • Cover frequencies of all cellular networks including short pulsed signals • Monitor low EMF levels in public areas • Various power supply possibilities	• Real time display of Maximum, RMS or Time/ Spatial average of isotropic field value • 0.35 V/m sensitivity • User definable alarm thresholds • Data storage Software	• Measurements NEW up to 8 GHz • Frequency selective system for in-situ spot measurement • Compatible with most spectrum analyzers available on the market • Fully automatic measurement process	• Completely redesign interface • GPU-accelerated computing for fast exposure evaluation • Precise and fast creation of 3D environment • Beam Steering function for simulations using 5G Massive MIMO antennas • The RF exposure results as part of the assessment report for EN 62232
Utilisation mode	Stationary	Portable	Portable	
Selectivity	Broadband	Broadband	Selectivity per channel	
Frequency bands	Probe dependent: • 700 MHz to 18 GHz • 700 MHz to 6 GHz • 700 MHz to 3 GHz	100 KHz – 6.5 GHz	100 KHz to 8 GHz	
Audio alarm	•	•		
Visual alarm	•			
Monitoring	•	•		
Data storage	•	•	•	
Software	FlashRad software	EME Wide Analysis	INSITE Free software	EMF Visual Standard (CPU) or Advanced (GPU)
Industries/ Users	• Military/Defense • Telecom Regulators • RF laboratory • Local and national authorities • Operators (cellular network, broadcast, PMR, radar, ...)	• Antenna installer & maintenance companies • Telecom Regulators • RF laboratory • Local and national authorities • Research agencies, R&D labs, universities • Operators (cellular network, broadcast, PMR, radar, ...) • Military/Defense	• Certification agencies • Telecom Regulators • Operators (cellular, network, broadcast, PMR, radar, ...) • Research agencies, R&D labs, universities • Military/Defense	• Cellular network operators • Installer • Broadcast companies • Regulatory bodies • Municipalities

Testing Connectivity for a Wireless World

The Microwave Vision Group offers cutting-edge technologies for the visualization of electromagnetic waves. With advanced test solutions for antenna characterization, radar signature evaluation and electromagnetic measurements, we support company R&D teams in their drive to innovate and boost product development.

For more information:
https://www.mvg-world.com

Contact us:
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