A Consultative Document

Proposed Maximum Permissible Exposure Limits for Radiofrequency Radiation in Trinidad and Tobago

October 6, 2006 TATT 2/9/3/2

Maintenance History		
Date	**Change Details**	**Version**
October 6, 2006	First Draft	1.0

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1 Introduction

1.1 Purpose of the Document

This document seeks to address the concerns of the public of Trinidad and Tobago with respect to radiofrequency radiation (RFR) emissions from all radiotransmitting equipment. The document will be adopted by the Telecommunications Authority of Trinidad and Tobago (the Authority) as part of its regulatory framework with respect to radiofrequency radiation emissions.

The document deals specifically with the radiofrequency radiation limits which will be adopted by the Authority. A comparison was made between the United States Federal Communications Commission (FCC) guidelines and those stipulated by the International Commission on Non-Ionising Radiation Protection (ICNIRP) in order to determine the final choice of standards to be adopted by the Authority.

1.2 Review Cycle

As the telecommunications sector grows and develops into more efficient and competitive markets the need will arise to revise and update the limits for radiofrequency radiation that is proposed by the Authority. This document will therefore be modified in consultation with concessionaires, stakeholders, interested parties and the public, as the Authority deems appropriate. The maintenance history will be modified accordingly.

1.3 Consultation Process

The Authority will seek the views and opinions of the general public and other stakeholders regarding the proposals made in this document in accordance with the Authority's *Procedures for Consultations in the Telecommunications Sector of Trinidad and Tobago.*

This draft document will be made available for consultation for a four (4) week period prescribed by the Authority.

2 Background

The Authority pursuant to Section 18 (1) (o) of the Telecommunications Act (2001) (the Act) quoted below

"18. (1) Subject to the provisions of this Act, the Authority may exercise such functions and powers as are imposed on it by this Act and in particular—

(o) test and certify telecommunications equipment, subject to section 48(3), to ensure compliance with— (i) international standards; and (ii) environmental health and safety standards, including electro-magnetic radiation and emissions;"

is responsible for the monitoring of the electromagnetic radiation emissions from radiotransmitting equipment in the Republic of Trinidad and Tobago for ensuring compliance with health and safety standards.

The Authority is cognizant of the fact that members of the public have expressed concerns about the radiofrequency radiation being emitted from cellular mobile sites as well as about the location of these sites. However the Authority also recognises that this concern can be extended to all forms of radiotransmitting equipment.

2.1 Objectives

The Authority has been working to address the concerns of the public as well as fulfill its mandate under the Act in achieving the following objectives:

(a) To establish radiofrequency radiation maximum permissible exposure limits for the Republic of Trinidad and Tobago in accordance with internationally accepted guidelines;

(b) To ensure that operators and\or owners of radiotransmitting equipment comply with the Authority's established standards to limit the exposure of their workers and members of the public to levels of radiofrequency radiation; and

(c) To educate the public of Trinidad and Tobago concerning the nature of radiofrequency radiation with respect to health and safety issues.

In order to achieve the objectives identified above the Authority has taken the following courses of action:

- Included a section on Public Health and Safety Criteria for radiotransmitting devices to be used in Trinidad and Tobago in the Schedule of Licences, shown in Appendix I, granted to operators of this type of equipment;

- Initiated a radiofrequency radiation monitoring exercise of cellular mobile sites commencing with those sites which have been the subject of complaints made by members of the public;

- Included the issue of radiofrequency radiation as part of its Public Education Program.

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3 Radiofrequency Radiation

3.1 Nature of Radiofrequency Radiation

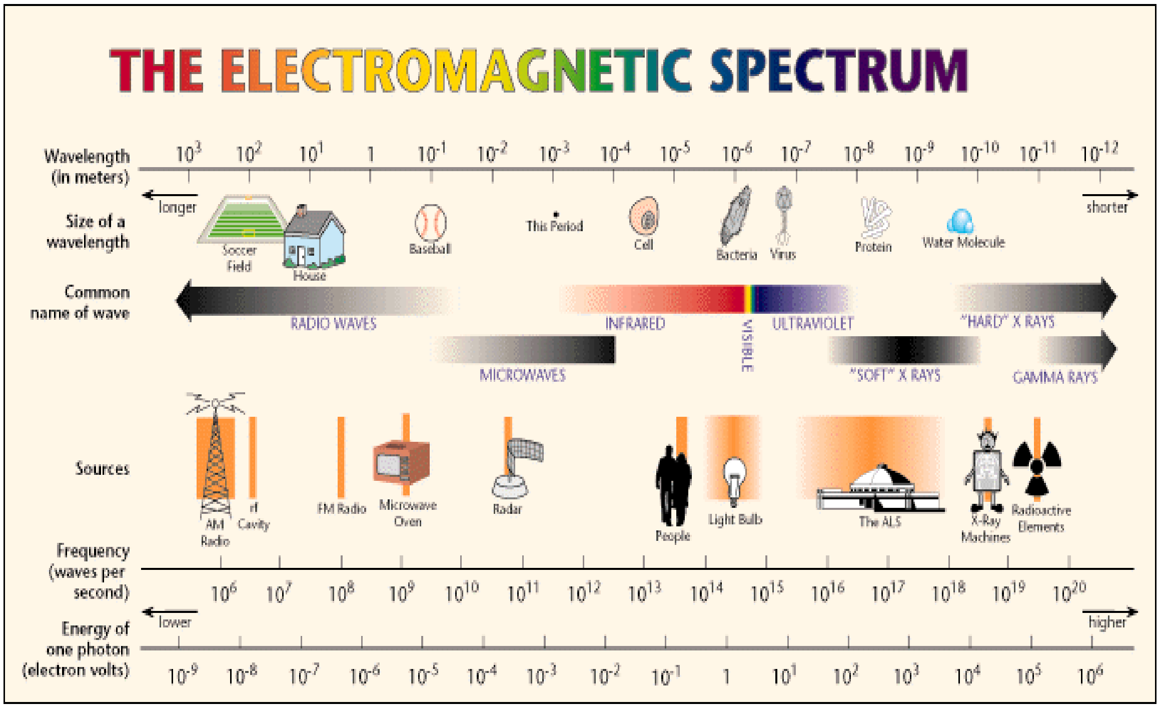
Radiofrequency or *RF energy* are terms which are used to collectively describe forms of electromagnetic energy such as Radio waves and microwaves. When energy is propagated through space in the form of particles or waves, radiation is said to have occurred. Waves of magnetic and electric energy propagating together through space describe electromagnetic radiation.

Electromagnetic (EM) waves are generated from antennas used by, for example, radio stations, television stations, cellular mobile telephones and cellular mobile base transceiver stations. After radiating through space these EM waves "cut" receiver antennas and through the process of electromagnetic induction, reproduce the original transmitted signal in these receiving devices.

In order to show that electromagnetic energy is present at a specified point the term *electromagnetic field* is used. This RF field can be specified in terms of its electric and magnetic components.

Figure 1 below shows the electromagnetic spectrum including all the various forms of electromagnetic energy from extremely low frequency (ELF) energy, with very long wavelengths, to X-rays and gamma rays, which have very high frequencies and correspondingly short wavelengths. Between these extremes are radio waves, microwaves, infrared radiation, visible light, and ultraviolet radiation, in that order. The RF part of the electromagnetic spectrum is generally defined as that part of the spectrum where electromagnetic waves have frequencies in the range of about 3 kHz to 300 GHz.

Figure 1: The Electromagnetic Spectrum



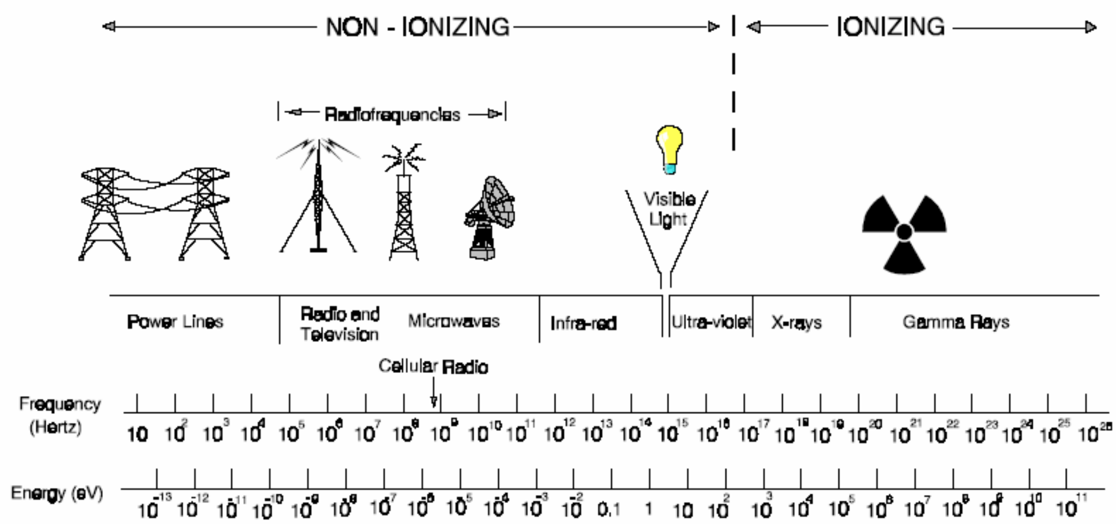
3.2 Ionising and Non-ionising Radiation

As shown by Figure 2 below the Electromagnetic Spectrum can be divided into ionising and non-ionising regions.

3.2.1 Ionising Radiation

The process by which electrons are removed from atoms and molecules is termed ionization. Electromagnetic energy levels at a frequency of approximately 2420 Million MHz is sufficient to ionise water molecules. Therefore, frequencies at or above this level are classified as ionising (at approximately 10^{16} Hz). Molecular changes leading to damage in biological tissues can result from this process. The methods of monitoring this type of radiation usually involve personal dosimetry or area monitoring of the workplace.

Figure 2: Ionising and Non-ionising Electromagnetic Spectrum[1]



3.2.2 <u>Non-Ionising Radiation</u>

As Figure 1 indicates the energy levels possessed by non-ionising electromagnetic radiation are millions of times lower than ionizing radiation. The photon energies of RF electromagnetic waves are not great enough to cause the ionisation of atoms and molecules and therefore RF energy is characterized as non-ionising radiation along with visible light, infrared radiation and other forms of electromagnetic radiation with relatively low frequencies. The method of interaction of ionising and non-ionising radiation with the human body is different and as such should not be confused when discussing biological effects.

Research conducted by several organisations including the International Commission on Non-Ionising Radiation Protection (ICNIRP) has shown conclusively that non-ionising radiation acts through thermal effects. Thus the RF exposure standards adopted in many

[1] Federal Communications Commission, Office of Engineering and Technology, OET Bulletin 56, Fourth Edition, August 1999.

Western countries are based on the assumption that adverse effects occur due to, and accompanied by, a measurable change of body temperature (~0.1 - 1^{o}C). In order to achieve this measurable change in body temperature relatively high RF power densities are required.

Dosimetry for this type of radiation is difficult. In fact individual dosimeters do not even exist.

In summary therefore unlike the very high energy levels of electromagnetic energy found in X-rays and gamma rays, the energy levels associated with RFR, including both radio waves and microwaves, cannot ionize biological tissues so their effect is thermal in nature, that is, the biological effects that result from the heating of tissue by RF energy.

3.3 Measurement of Radiofrequency Radiation

A radiofrequency electromagnetic field has both an electric and a magnetic component or an electric field and a magnetic field. Thus it is often convenient to express the intensity or strength of the RF field in terms of units specific for each component. The unit "volts per meter" (V/m) is used to measure the field strength of the electric field, while the unit "amperes per meter" (A/m) is used to express the strength of the magnetic field.

Another commonly used unit for characterising an RF electromagnetic field is power density. Power density is defined as power per unit area. For example, power density can be expressed in terms of watts per meter squared (W/m^2), milliwatts per centimeter squared (mW/cm^2) or microwatts per centimeter squared (μW/cm^2).

Power density is most accurately used when the point of measurement is far enough away from the RF emitter to be located in what is commonly referred to as the far-field zone of the radiation source. The far field is that region at a distance of more than several wavelengths from a typical RF source.

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Since the angle between the electric field vector (**E**) and the magnetic field vector (**H**) in the far field is 90^o, then power density in the far field can be calculated from the vector product **E** x **H** = |E| |H|. In the far field, the electric and magnetic fields are related to each other by the equation E/H = 377 Ohms, which is the characteristic impedance of free space.

Thus in the far-field it is only necessary to measure one of these quantities in order to determine the other quantity or the power density.

The region in closer proximity to the source of the RF emission or antenna is known as the near-field zone. The outer boundary of this zone, for most antennas, is normally limited to a distance of one half of the wavelength of the emission from the antenna. In the near field the physical relationships between the electric and magnetic components are complex. In this case, it is necessary to determine both the electric and magnetic field strengths to fully characterise the RF environment. At frequencies above 300 MHz it is usually sufficient to measure only the electric field in order to characterise the RF environment if the measurement is not made too close to the RF emitter.

An example of far field and near field distances for a cellular mobile emission is given below:

The frequency of the RFR emission in this example is 845 MHz.

Speed of emission, c = Frequency of emission, f x Wavelength of emission, λ
The speed of all radiofrequency waves is the speed of light, which is 3×10^8 m/s.

Thus from the equation above the wavelength of the emission = c / f
= $(3 \times 10^8$ m/s) / $(845 \times 10^6$ Hz) = 0.355m or 1.1 feet.

Thus the near field of this emission is limited to a distance of 0.355m / 2 = 0.177m or 0.58 foot (6.9inches), which is half of the wavelength of the emission.

As the example above reveals the public exposure in the case of cellular mobile towers and rooftop locations will be in the far field region due to the distance of these antennas from the areas which are normally accessible by members of the public.

In the case of occupational exposure it is possible that a person working on a cellular tower or rooftop site may be able to get into the near field of the radiation due to the type of work being conducted. If this is the case then the service provider must ensure that the RF equipment is deactivated before allowing anyone to conduct work in such areas which may be hazardous.

The Authority is proposing that only the radiofrequency radiation present in the far field of the emission will be measured for both occupational and public exposure limits.

3.4 Instruments used to measure radiofrequency radiation

The instruments used to measure RFR emissions range from broadband RF field strength meters to spectrum analysers. The advantages and disadvantages of these instruments are discussed below.

3.4.1 Broadband RF Field Strength Meter

Broadband RF test equipment is designed to measure overall RFR present at a site as either a percentage of the particular standard adopted or in V/ m, A/m or mW/cm^2.The the total percentage contributed by all emitters is in this case measured by the instrument. This type of instrument cannot, however, easily identify the radiation emitted by a specific emitter at the site.

In fact it is practically impossible to make RF measurements of adequate quality for each emitter at sites where many services are operating in close proximity. For example the

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rooftops of buildings or towers may be used as sites for multiple RF emission sources from more than one licensee such as cellular mobile and paging service providers.

3.4.2 Spectrum Analyser

If it is desirable to measure the RFR emitted from each source at a site then a frequency selectable instrument such as a spectrum analyser can be used.

However radiated emission measurements have unique characteristics, which make spectrum analyzers a poor choice in this application. Spectrum analysers do not display an emitter's received signal strength as a percentage of a specific standard. Additionally since spectrum analysers are calibrated in dBm instead of dBμV, mathematical conversions are necessary to produce the strength of the RF emission in mW/cm^2.

Another challenge is that the only way to make these selective RFR measurements at such sites would be to evaluate individual emitters with all of the others deactivated.

Once the emitters are turned off, they are then turned on one by one. Their individual RFR emissions are then measured. Subsequently the percentage of the RFR standard is computed for each of these emissions.

At locations where numerous independent companies are continuously generating RF emissions for critical operations acquiring the cooperation from each licensee in order to conduct these measurements can become onerous to the licensee in terms of loss of revenue when the system is deactivated. This is especially true for radio and television broadcasters and cellular mobile operators where the loss of revenue due to a shutdown could be high. Hence, it is preferable to use the broadband RF field strength meters to measure RFR emissions.

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The Authority is proposing that broadband electromagnetic field strength meters which can measure overall radiofrequency radiation present at a site and produce results either in percentage of the adopted standard or in mW/cm^2 are the preferred choice for the measurement of radiofrequency radiation.

3.5 Biological Effects of Radiofrequency Radiation

A biological effect is said to have occurred when the introduction of some type of stimuli causes a measurable change in a biological system. It should be stressed however, that the observation of a biological effect does not necessarily imply the existence of a biological hazard. A biological effect only becomes a safety hazard when it causes a detectable impairment of the health of the individual or of his or her offspring. Thus there is a clear distinction between a biological effect and a biological *health* effect.

The biological effects that result from the heating of tissue by RF energy are often referred to as thermal effects. Exposure to high levels of RF radiation can be harmful due to the ability of RF energy to heat biological tissue rapidly.

For example microwave ovens use this principle to cook food. Exposure to very high RF power densities in the order of 100 mW/cm^2 or more can result in the heating of biological tissue and an increase in body temperature. In human beings tissue damage could occur during exposure to high RF levels because of the body's inability to cope with or dissipate the excessive heat that could be generated. Under certain conditions, exposure to RF energy at power density levels of 1-10 mW/cm^2 and above can result in measurable heating of biological tissue, but not necessarily tissue damage. The extent of this heating would depend on several factors such as:

(a) Radiation frequency;
(b) Size, shape, and orientation of the exposed object;
(c) Duration of exposure;

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(d) Environmental conditions;
(e) Efficiency of heat dissipation.

With respect to the absorption of RFR energy by the human body, electromagnetic fields can be divided into four ranges:

i. Frequencies from about 100 kHz to less than about 20 MHz, at which absorption in the trunk of the body decreases rapidly with decreasing frequency, and significant absorption may occur in the neck and legs;

ii. Frequencies in the range from about 20 MHz to 300 MHz, at which relatively high absorption can occur in the whole body;

iii. Frequencies in the range from about 300 MHz to several GHz, at which significant local, non-uniform absorption occurs;

iv. Frequencies above about 10 GHz, at which energy absorption occurs primarily at the body surface.

Two areas of the body, the eyes and the testes, are known to be particularly vulnerable to heating by RF energy because of the relative lack of available blood flow to dissipate the excessive heat load (blood circulation is one of the body's major mechanisms for coping with excessive heat).

Studies have shown that the levels of RF energy routinely encountered by the general public are far below levels necessary to produce significant heating and increased body temperature.

There may be situations, however, especially in the workplace, where proximity to high-powered RF sources may result in exposures beyond the recommended limits for the safe exposure of human beings. If this scenario occurs then restrictive measures or actions should be taken to ensure the safety of the individual.

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In addition to intensity, the frequency of an RF electromagnetic wave is important in determining how much RFR energy is absorbed. Specific absorption rate (SAR) is the quantity used to characterize this absorption and is measured in units of watts per kilogram (W/kg) or milliwatts per gram (mW/g). In the far-field whole-body absorption of RFR energy by a standing human adult has been shown to occur at a maximum rate when the frequency of the radiation is between about 80 and 100 MHz, depending on the size, shape and height of the individual. Thus the SAR is at a maximum under these conditions.

Due to this "resonance" phenomenon, RFR safety standards have taken account of the frequency dependence of whole-body human absorption, and the most restrictive limits on exposure are found in this frequency range which is known as the very high frequency or VHF range.

It is not presently known whether the "non-thermal" biological effects of radiofrequency radiation may pose a hazard to human health. Although there have been some research done in this field the results have not been conclusive. Additional research in this area is necessary before firm conclusions can be drawn and current internationally accepted RFR Maximum Permissible Exposure Limits changed accordingly. The Authority will however continue to monitor research in this field so that the RFR limits which it adopts will be in accordance with international best practice.

The Authority is proposing that the only biological health effect which will be considered with respect to radiofrequency radiation will be thermal in nature.

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4 Uses of Radiofrequency Energy

One of the most important uses of RFR energy is for telecommunications. Radio and TV broadcasting, wireless phones, pagers, cordless phones, police and fire department radios, point-to-point links and satellite communications all rely on RFR energy. Other uses of RFR energy include microwave ovens, radar, industrial heaters and sealers, and for medical treatments.

5 FCC RFR Safety limits

In 1985, the FCC first adopted guidelines to be used for evaluating human exposure to RFR emissions. The FCC revised and updated these guidelines on August 1, 1996, as a result of a rule-making proceeding initiated in 1993. The new guidelines incorporated limits for Maximum Permissible Exposure (MPE) in terms of electric and magnetic field strength and power density for transmitters operating at frequencies between 300 kHz and 100 GHz. Limits were also specified for localized (partial body) absorption that were used primarily for evaluating exposure due to transmitting devices such as hand-held portable telephones. Implementation of the new guidelines for mobile and portable devices became effective August 7, 1996.

The FCC's MPE limits were based on exposure limits recommended by the National Council on Radiation Protection and Measurements (NCRP) and, over a wide range of frequencies, the exposure limits developed by the Institute of Electrical and Electronics Engineers, Inc., (IEEE) and adopted by the American National Standards Institute (ANSI) to replace the 1982 ANSI guidelines. Limits for localized absorption were based on recommendations of both ANSI/IEEE and NCRP. In reaching its decision on adopting new guidelines the Commission considered the large number of comments submitted in its rule-making proceeding, and particularly those submitted by the U.S. Environmental Protection Agency (EPA), the Food and Drug Administration (FDA) and other federal health and safety agencies.

5.1 Basis of the FCC RFR Limits

The FCC's limits, and the NCRP and ANSI/IEEE limits on which they are based, are derived from exposure criteria quantified in terms of specific absorption rate (SAR). The basis for these limits is a whole-body averaged SAR threshold level of 4 watts per kilogram (4 W/kg), as averaged over the entire mass of the body, above which expert organizations such as the International Commission on Non-Ionizing Radiation Protection (ICNIRP) have determined that potentially hazardous exposures may occur.

All Western standards seek to limit whole body averaged specific absorption rate to less than 0.4 W/kg for whole body occupational exposure which is one tenth of the threshold level of 4 W/kg. An additional safety factor of five was introduced for exposure of the public, giving an average whole-body SAR limit of 0.4 x 0.2 = 0.08 W/kg.

The FCC guidelines incorporates two separate tiers of exposure limits that are dependent on the situation in which the exposure takes place and/or the status of the individuals who are subject to exposure. The decision as to which tier applies in a given situation should be based on the application of the following definitions.

Occupational/controlled exposure limits apply to situations in which persons are exposed as a result of their employment and in which those persons who are exposed have been made fully aware of the potential for exposure and can exercise control over their exposure.

Occupational/controlled exposure limits also apply where exposure is of a transient nature as a result of incidental passage through a location where exposure levels may be above general population/uncontrolled limits, as long as the exposed person has been made fully aware of the potential for exposure and can exercise control over his or her exposure by leaving the area or by some other appropriate means. The occupational/controlled exposure limits also apply to amateur radio operators and members of their immediate household.[2]

General population/uncontrolled exposure limits apply to situations in which the general public may be exposed or in which persons who are exposed as a consequence of their employment may not be made fully aware of the potential for exposure or cannot exercise control over their exposure. Therefore, members of the general public would always be considered under this category when exposure is not employment-related, for example, in the case of a telecommunications tower that exposes persons in a nearby residential area.[2]

[2] Federal Communications Commission , Office of Engineering and Technology , OET Bulletin 65

The FCC MPE limits were derived by incorporating safety factors that lead, in some cases, to limits that were more conservative than the limits originally adopted by the FCC in 1985. The new FCC exposure limits were also based on data showing that the human body absorbs RF energy at some frequencies more efficiently than at others. As indicated by Tables 1 and 2 below:

Table 1: Maximum Possible Exposure Limits for Occupational/Controlled Exposure[3]

Frequency Range (MHz	Electric Field Strength (E) (V/m)	Magnetic Field Strength (H) (A/m)	Power Density (S) (mW/cm^2)	Averaging Time $\|E^2\|$, $\|H^2\|$, or S (minutes)
0.3-3.0	614	1.63	(100)*	6
3.0-30	1842/f	4.89/f	$(900/f^2)$*	6
30-300	61.4	0.163	1.0	6
300-1500	--	--	f/300	6
1500-100,000	--	--	5	6

* Plane wave equivalent power density,

The parameter f in all tables is frequency expressed in MHz.

Table 2 : Maximum Possible Exposure Limits for Public/Uncontrolled Exposure[3]

Frequency Range (MHz	Electric Field Strength (E) (V/m)	Magnetic Field Strength (H) (A/m)	Power Density (S) (mW/cm^2)	Averaging Time $\|E^2\|$, $\|H^2\|$, or S (minutes)
0.3-3.0	614	1.63	(100)*	30
3.0-30	824/f	2.19/f	$(180/f^2)$*	30
30-300	27.5	0.073	0.2	30
300-1500	--	--	f/1500	30
1500-100,000	--	--	1.0	30

[3] Federal Communications Commission , Office of Engineering and Technology , OET Bulletin 65

The most restrictive limits occur in the frequency range of 30-300 MHz where whole-body absorption of RF energy by human beings is most efficient. At other frequencies whole-body absorption is less efficient, and, consequently, the MPE limits are less restrictive. MPE limits are defined in terms of power density (units of milliwatts per centimeter squared: mW/cm^2), electric field strength (units of volts per meter: V/m) and magnetic field strength (units of amperes per meter: A/m).

It should be noted that Canada has adopted standards for occupational and public exposure to radiofrequency radiation which are the same as those used by the FCC.

The Authority is proposing that there should be a two tier standard for maximum permissible exposure limits for radiofrequency radiation, one for occupational and the other for public exposure.

The Authority is proposing that the specific absorption rate for whole body occupational exposure should not exceed 0.4 W/kg while the specific absorption rate for whole body public exposure should not exceed 0.08W/kg.

6 International Commission on Non-Ionising Radiation Protection (ICNIRP)

In 1974, the International Radiation Protection Association (IRPA) formed a working group on non-ionizing radiation (NIR), which examined the problems arising in the field of protection against the various types of NIR.

At the IRPA Congress in Paris, France in 1977, this working group became the International Non-Ionizing Radiation Committee (INIRC). In cooperation with the Environmental Health Division of the World Health Organization (WHO), the IRPA/INIRC developed a number of health criteria documents on NIR as part of WHO's Environmental Health Criteria Programme, sponsored by the United Nations Environment Programme (UNEP). Each document included an overview of the physical characteristics, measurement and instrumentation, sources, and applications of NIR. These health criteria provided the scientific database for the subsequent development of exposure limits and codes of practice relating to NIR.

At the Eighth International Congress of the IRPA (Montreal, 18–22 May 1992), a new, independent scientific organization—the International Commission on Non-Ionizing Radiation Protection (ICNIRP)—was established as a successor to the IRPA/INIRC.
The functions of the Commission are to investigate the hazards that may be associated with the different forms of NIR, develop international guidelines on NIR exposure limits, and deal with all aspects of NIR protection.

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7 Comparison of RFR Maximum Permissible Exposure (MPE) Limits, Canadian, FCC, ICNIRP and IEEE

The following compares the RFR exposure limits specified by various international regulatory and research organisations who have conducted studies in this field. The comparison is done using field strength in terms of equivalent power density in mW/cm^2 of the Electric (E) field for occupational (controlled) and public (uncontrolled) exposure.

Table 3: Comparison of occupational MPE Limits

Frequency range in MHz	CANADA SAFETY CODE 6 (99-EHD-237)	U.S. FCC MPE limits—47 CFR § 1.1310	ICNIRP Reference Levels 1998 for Time- varying Electric and Magnetic fields	IEEE C95.1-2005 Electric and Magnetic fields
10 to 300	1.0	1.0		
10 to 400			1.0	1.0
300 to 1500	f/300 (1 to 5 mW/cm^2)	f/300 (1 to 5 mW/cm^2)		
400 to 2000			f/400 (1 to 5 mW/cm^2)	f/400 (1 to 5 mW/cm^2)
2000 to 300000			5	
2000 to 100000				5
1500 to 100000	5	5		

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Table 4: Comparison of public MPE Limits

Frequency range in MHz	CANADA SAFETY CODE 6 (99-EHD-237)	U.S. FCC MPE limits—47 CFR § 1.1310	ICNIRP Reference Levels 1998 for Time- varying Electric and Magnetic fields	IEEE C95.1-2005 Electric and Magnetic fields
10 to 300	0.2	0.2		
10 to 400			0.2	0.2
300 to 1500	f/1500 (0.2 to 1 mW/cm^2)	f/1500 (0.2 to 1 mW/cm^2)		
400 to 2000			f/2000 (0.2 to 1 mW/cm^2)	f/2000 (0.2 to 1 mW/cm^2)
2000 to 300000			1	
2000 to 100000				1
1500 to 100000	1	1		

Tables 3 and 4 which were derived from the graphs shown in Appendix I, show that the ICNIRP\ IEEE exposure limits in the range 400 to 2000MHz when compared with the US FCC and Canada Limits are slightly more restrictive, in that the former specifies f/400 and f/2000 for calculating the equivalent power density for occupational and public, compared with f/300 and f\1500 for the US FCC and Canada Limits.

However as the following sample calculation illustrates the difference in the limits for a measurement of frequency of 850 MHz is extremely small.

Sample calculation for public exposure to an emission of 850 MHz:

a) US FCC \Canada MPE limit = f/1500 where f is frequency in MHz = 850/1500

$$= 0.566 \text{ mW/cm}^2$$

b) ICNIRP\ IEEE MPE limit = f/2000 where f is frequency in MHz = 850/2000

$$= 0.425 \text{ mW/cm}^2$$

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This indicates that for exposure to an emission of 850 MHz the US FCC \Canada MPE limit would allow 0.566 – 0.425 = 0.141 mW/cm^2 more exposure when compared with the ICNIRP\ IEEE MPE limit.

However it should be noted that the ICNIRP MPE limit for localized Specific Absorption Rate (SAR) for head and trunk exposure in the range 10 MHz to 10 GHz is 2 W/kg[4] while the FCC limit in this range is 1.6 W/kg[5].

[4] International Commission on Non-Ionising Radiation Protection (ICNIRP) Secretariat , Guidelines for Limiting Exposure to Time-Varying Electric , Magnetic and Electromagnetic Fields (up to 300 GHz), 1998, Page 511

[5] Federal Communications Commission , Office of Engineering and Technology , OET Bulletin 65 , 1997, Page 40

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8 Broadcast and Cellular Mobile Frequency Allocations in Trinidad and Tobago

Due to the widespread deployment of broadcasting and cellular mobile services in Trinidad and Tobago, and the public concern with respect to the RFR being emitted especially from the cellular mobile sites, it is important to note the frequency allocations and MPE limits in mW/cm^2 which are currently allocated for these services.

The main frequency allocations for these services in Trinidad and Tobago and the associated FCC and ICNIRP MPE limits are shown below:

Table 5: Broadcast and Cellular Mobile Frequency Allocations and MPE limits.

Frequency Allocation MHz	Service	Maximum Permissible Exposure (mW/cm^2) FCC Occupational	Maximum Permissible Exposure (mW/cm^2) FCC Public	Maximum Permissible Exposure (mW/cm^2) ICNIRP Occupational	Maximum Permissible Exposure (mW/cm^2) ICNIRP Public
54 to 216	Broadcasting	1.0	0.2	1.0	0.2
88 to 108	Broadcasting	1.0	0.2	1.0	0.2
470 to 806	Broadcasting	1.57 to 2.69 (f/300)	0.31 to 0.54 (f/1500)	1.18 to 2.02 (f/400)	0.24 to 0.40 (f/2000)
825 to 849	Cellular mobile	2.75 to 2.83 (f/300)	0.55 to 0.57 (f/1500)	2.06 to 2.12 (f/400)	0.41 to 0.42 (f/2000)
869 to 894	Cellular mobile	2.90 to 2.98 (f/300)	0.58 to 0.60 (f/1500)	2.17 to 2.24 (f/400)	0.43 to 0.45 (f/2000)
1740 to 1760	Cellular mobile	5	1	4.35 to 4.40 (f/400)	0.87 to 0.88 (f/2000)
1835 to 1855	Cellular mobile	5	1	4.59 to 4.64 (f/400)	0.92 to 0.93 (f/2000)
1880 to 1910	Cellular mobile	5	1	4.70 to 4.78 (f/4000	0.94 to 0.96 (f/2000)
1960 to 1990	Cellular mobile	5	1	4.90 to 4.98 (f/400)	0.98 to 1.0 (f/2000)

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9 RFR limits to be adopted the Authority

While it is clear that the ICNIRP\ IEEE MPE limit is slightly more restrictive in the 400 MHz to 2000 MHz band, the US FCC limit is more restrictive in terms of Specific Absorption rate for portable and mobile wireless devices. For example, cellular telephones being 1.6 W/kg compared with the ICNIRP limit of 2 W/kg. Both limits are however the same in the 10 to 300 MHz band and above 2000 MHz.

The Authority is proposing that the limits for radiofrequency radiation maximum permissible exposure for both occupational and general population should be that specified by the International Commission on Non-Ionising Radiation Protection (ICNIRP) for radiotransmitting equipment such as those used in broadcasting and cellular mobile base transceiver stations.

The Authority is proposing that the standard to be adopted for radiofrequency radiation maximum permissible exposure for both occupational and general population for mobile wireless devices such as cellular mobile telephones should be that specified by the United States Federal Communications Commission.

The proposed Maximum Permissible Exposure Limits for radiofrequency radiation which will be adopted by the Authority for both occupational and general population exposure is shown in Table 6.

Table 6: Proposed Maximum Permissible Exposure Limits to be adopted by the Authority

Frequency Range in MHz	Occupational/controlled Exposure Limit in mW/cm^2	General Population/ Uncontrolled Exposure Limit in mW/cm^2
10 to 400	1.0	0.2
400 to 2000	f/400 (1 to 5 mW/cm^2)	f/2000 (0.2 to 1 mW/cm^2)
2000 to 300000	5	1

The parameter f in the table above is frequency expressed in MHz.

In addition to the limits specified in Table 6 above the proposed maximum localized (head and trunk) Specific Absorption Rate (SAR) for mobile devices such as cellular mobile telephones will be 1.6 W/kg.

Appendix I: Schedule G

(Condition B16)

Public Health and safety Criteria for Radiocommunication devices Trinidad and Tobago

1. The following benchmarks are applicable to all radiotransmitter arrays operated for the provision of public telecommunications networks or in the provision of public telecommunications services and/ or broadcast services.

Service	Evaluation Required if:
Experimental Radio Services	Power > 100W ERP (164W EIRP)
Multipoint Distribution Services	Non-rooftop antennae: height above ground level to radiation centre < 10m **AND** power > 1640 W EIRP Rooftop Antennae: power > 1640 W EIRP
Paging and Radio telecommunications Services (including Cellular – 800MHz)	Non Rooftop Antennae: height above ground level to radiation centre < 10m **AND** total power of all channels> 1000W ERP (1640W EIRP) Rooftop Antennae: Total power of all channels > 1000W ERP (1640W EIRP)
Personal Communications Services (1900 MHz band and above)	Narrowband: Non rooftop antennae: height above ground level to radiation centre < 10m **AND** total power of all channels > 1000W ERP (1640W EIRP) Rooftop Antennae: Total power of all channels > 1000W ERP (1640 W EIRP) Broadband: Non rooftop antennae: height above ground level to radiation centre < 10m **AND** total power of all channels > 2000W ERP (3280W EIRP) Rooftop Antennae: Total power of all channels > 2000W ERP (3280 W EIRP)
Satellite Communications	All included
Radio Broadcast Services	All included

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Transmitters, Facilities and Operations subject to routine environmental evaluation before Authority approval.

2. The following health and safety requirements are to be upheld by all concessionaires in the operation of authorised radiotransmitting equipment associated with their operations.

Maximum Permissible Exposure (MPE) Limits

a) Limits for Occupational/ Controlled Exposure

Frequency Range (MHz)	Electric Field Strength (V/m)	Magnetic Field Strength (A/m)	Power Density (mW/cm^2)	Averaging Time (minutes)
0.3 – 3.0	614	1.63	(100)*	6
3.0 – 30	1842/f	4.89/f	$(900/f^2)$*	6
30 – 300	61.4	0.163	1.0	6
300 – 1500	----	----	f/300	6
1500 – 100,000	----	----	5	6

f = frequency in MHz * = Plane Wave Equivalent Power Density

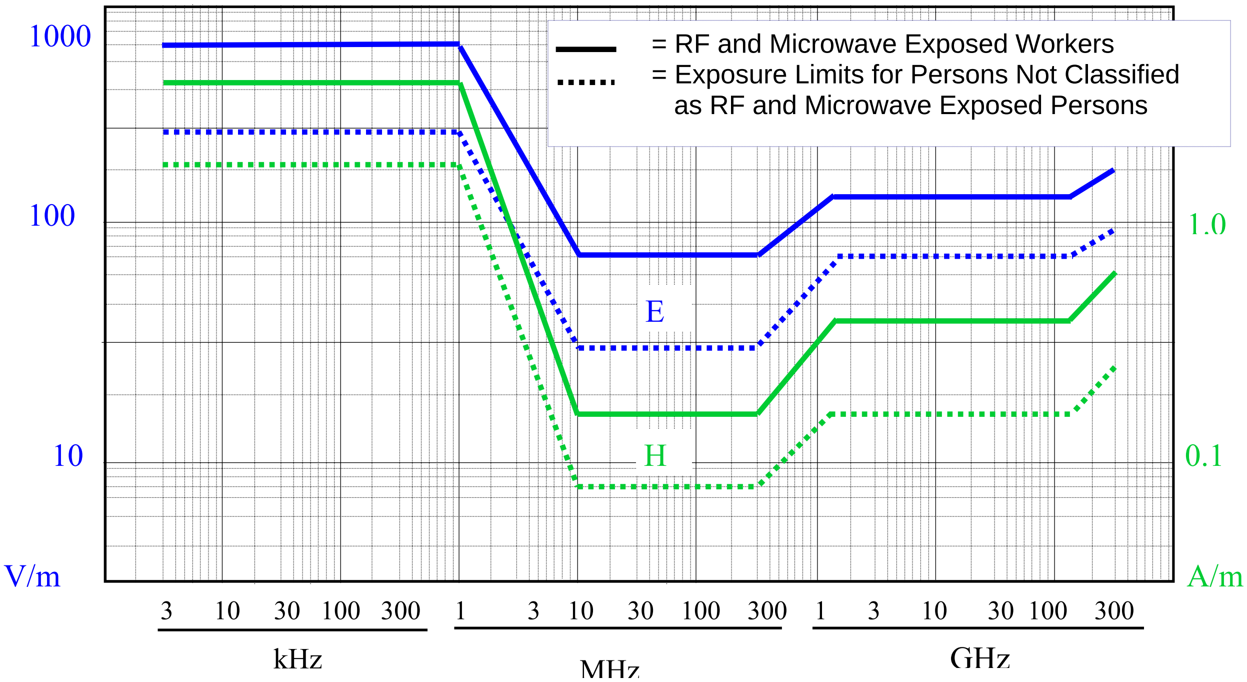
b) Limits for General Population/ Uncontrolled Exposure

Frequency Range (MHz)	Electric Field Strength (V/m)	Magnetic Field Strength (A/m)	Power Density (mW/cm^2)	Averaging Time (minutes)
0.3 – 1.34	614	1.63	(100)*	30
1.34 – 30	824/f	2.19/f	$(180/f^2)$*	30
30 – 300	27.5	0.073	0.02	30
300 – 1500	----	----	f/1500	30
1500 – 100,000	----	----	1.0	30

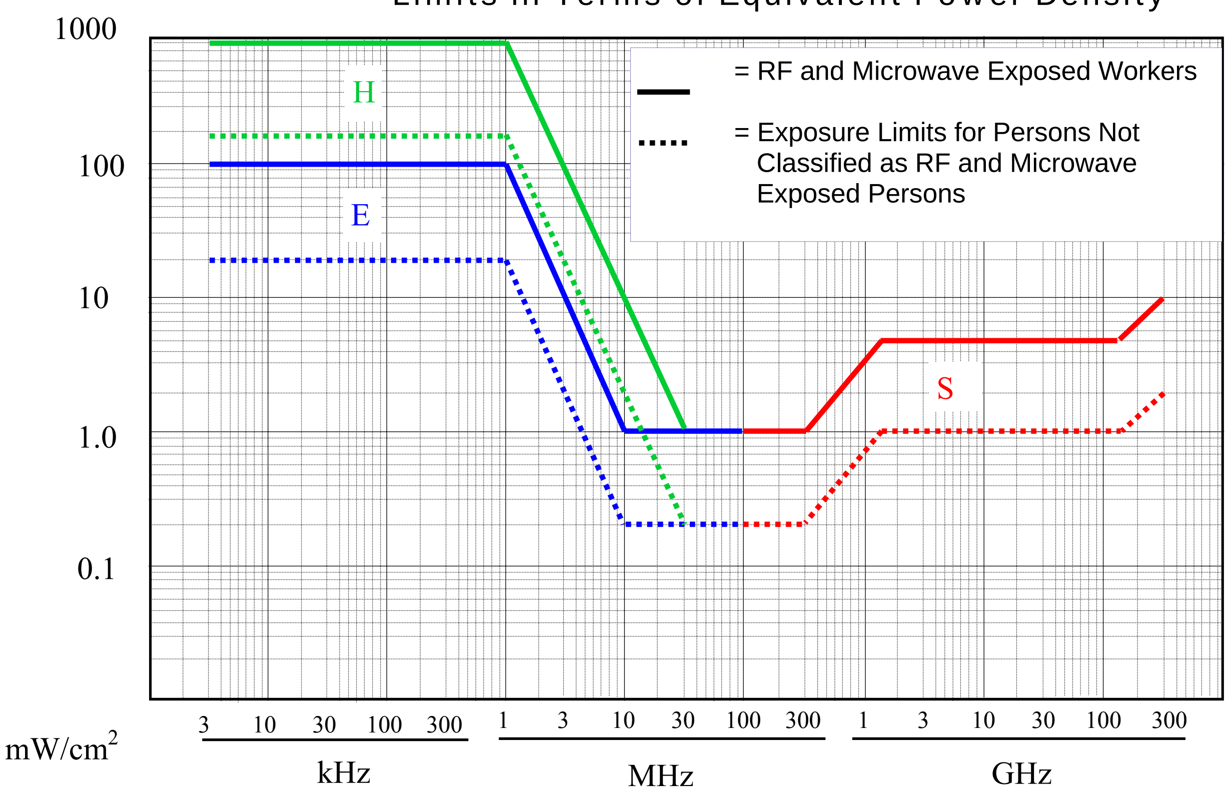
f = frequency in MHz * = Plane Wave Equivalent Power Density

Appendix II: RFR MPE Limits

CANADA SAFETY CODE 6 (99-EHD-237)



Limits in Terms of Equivalent Power Density



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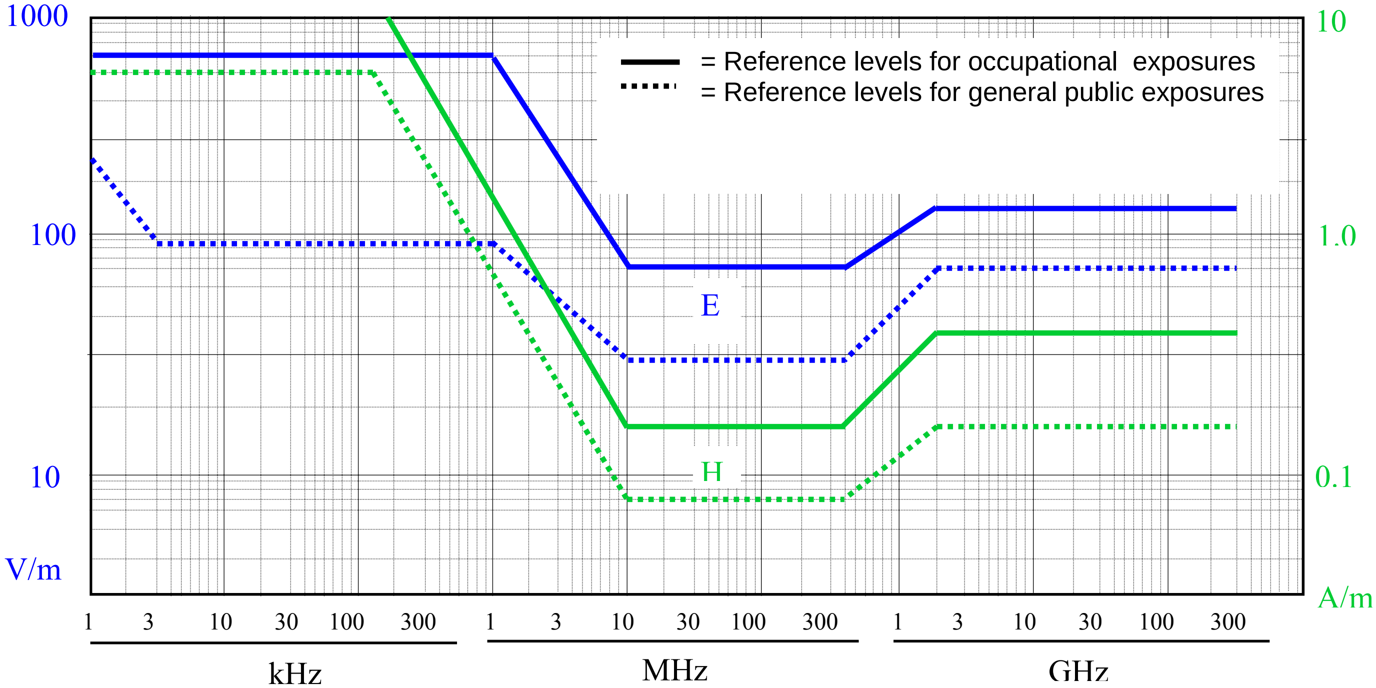
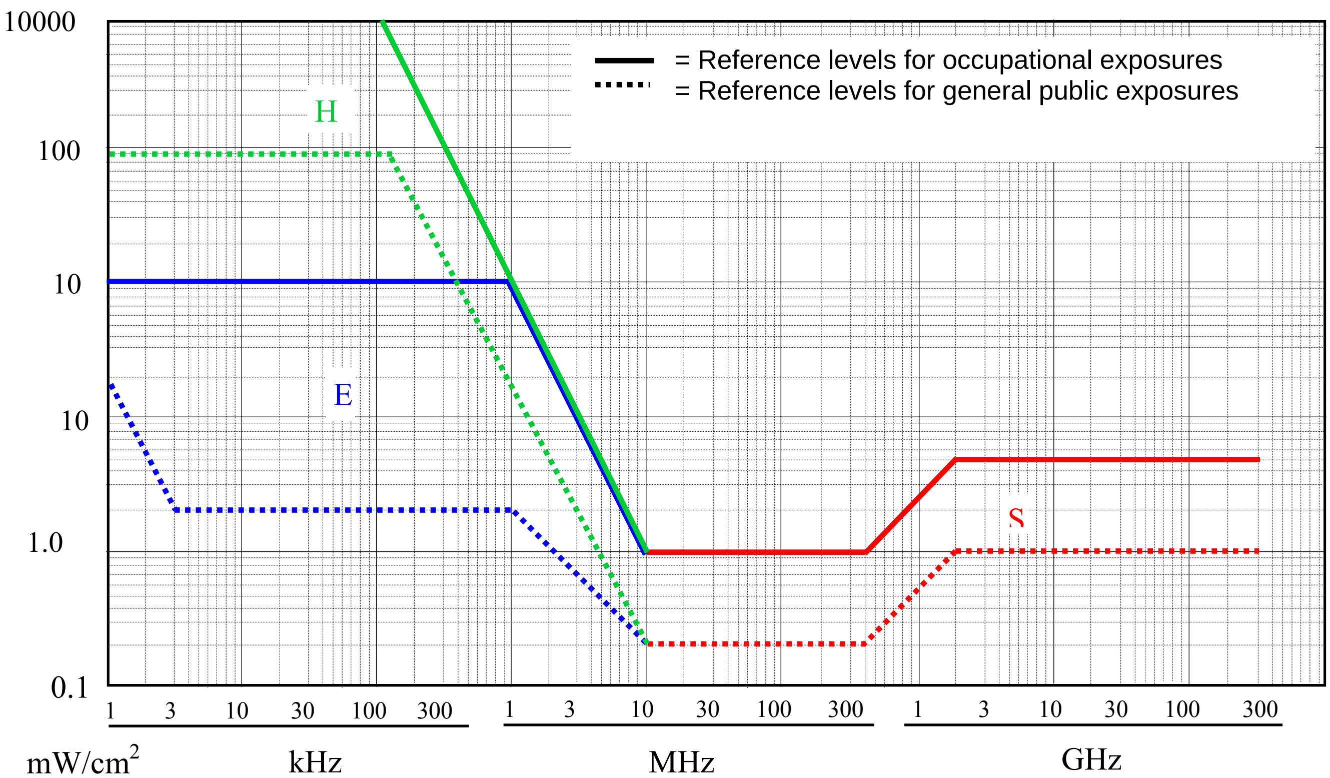
ICNIRP Reference Levels 1998 for Time- varying Electric and Magnetic fields

Limits in Terms of Field Strength



Limits in Terms of Equivalent Power Density



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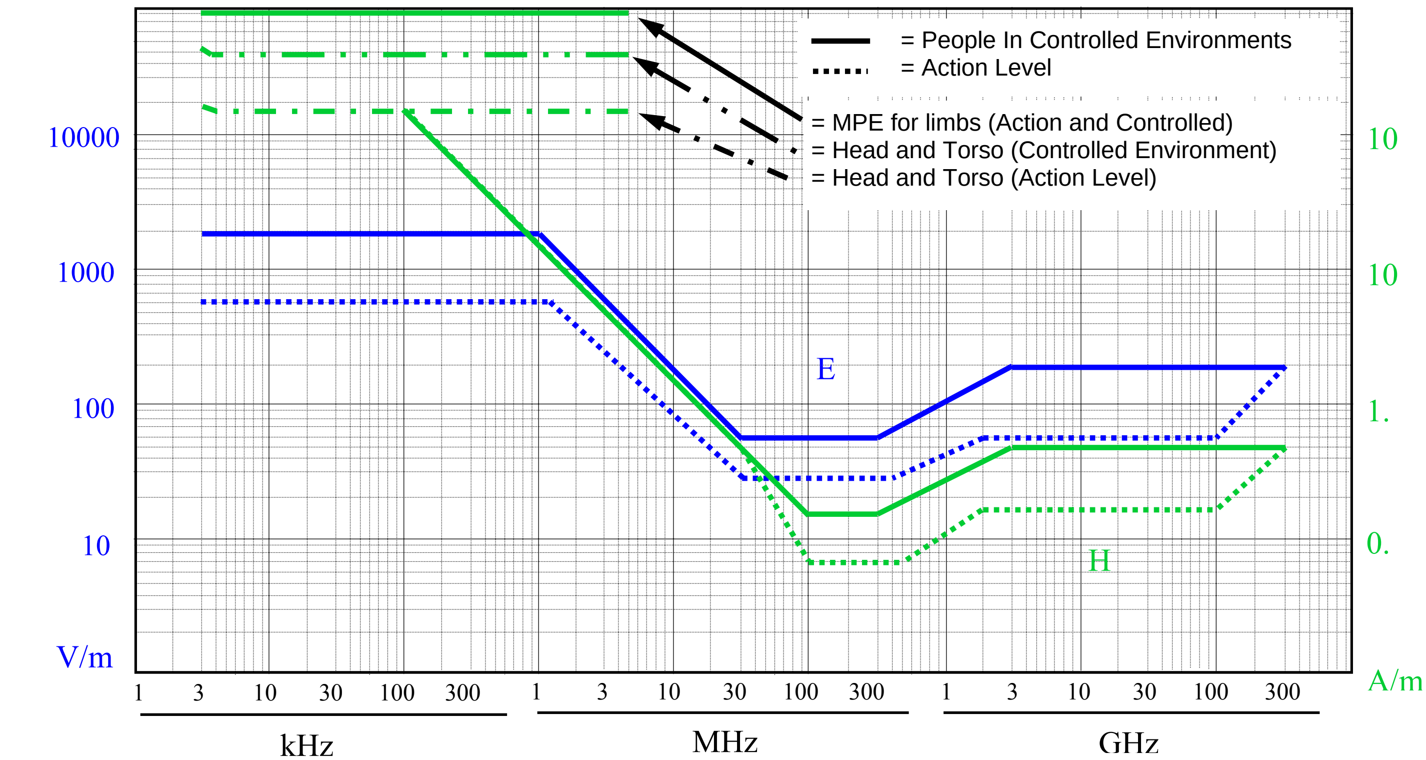
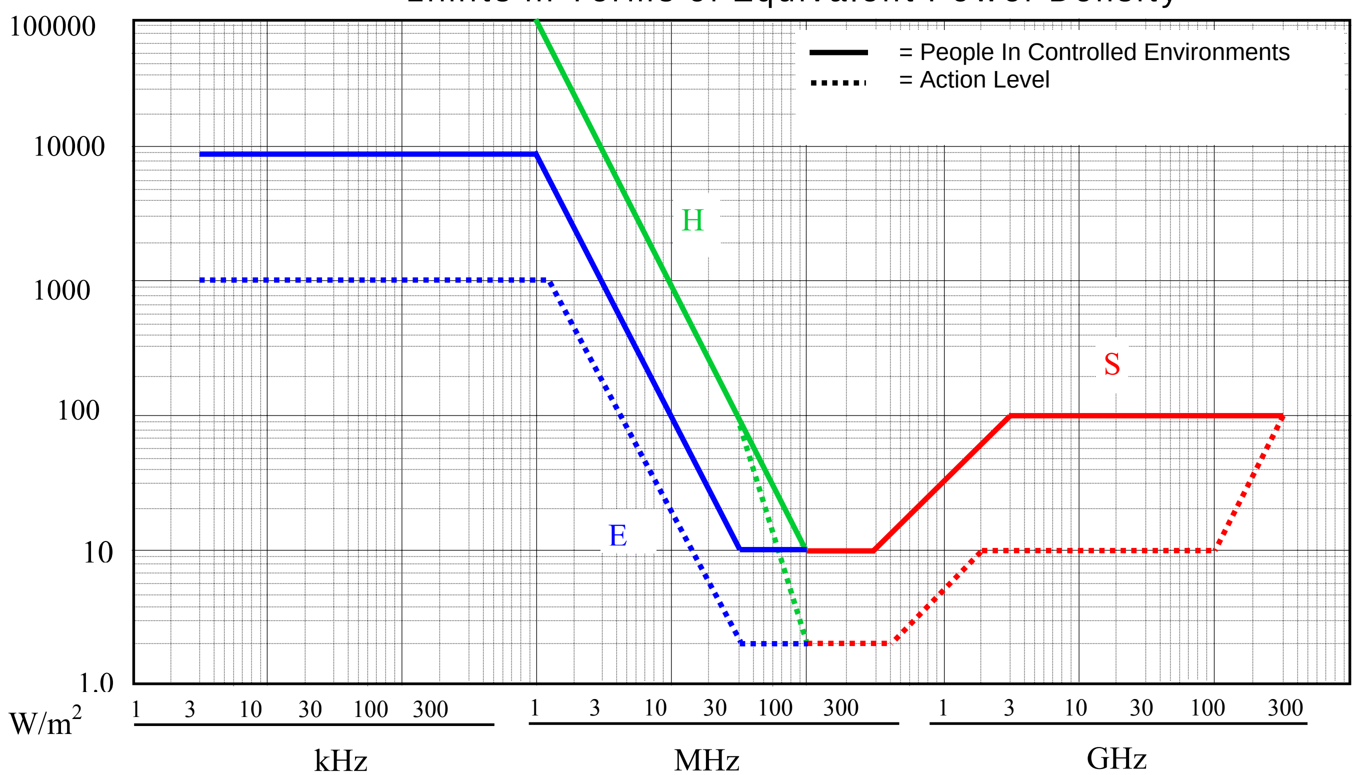
IEEE C95.1-2005 Electric and Magnetic fields

Limits in Terms of Field Strength



Limits in Terms of Equivalent Power Density



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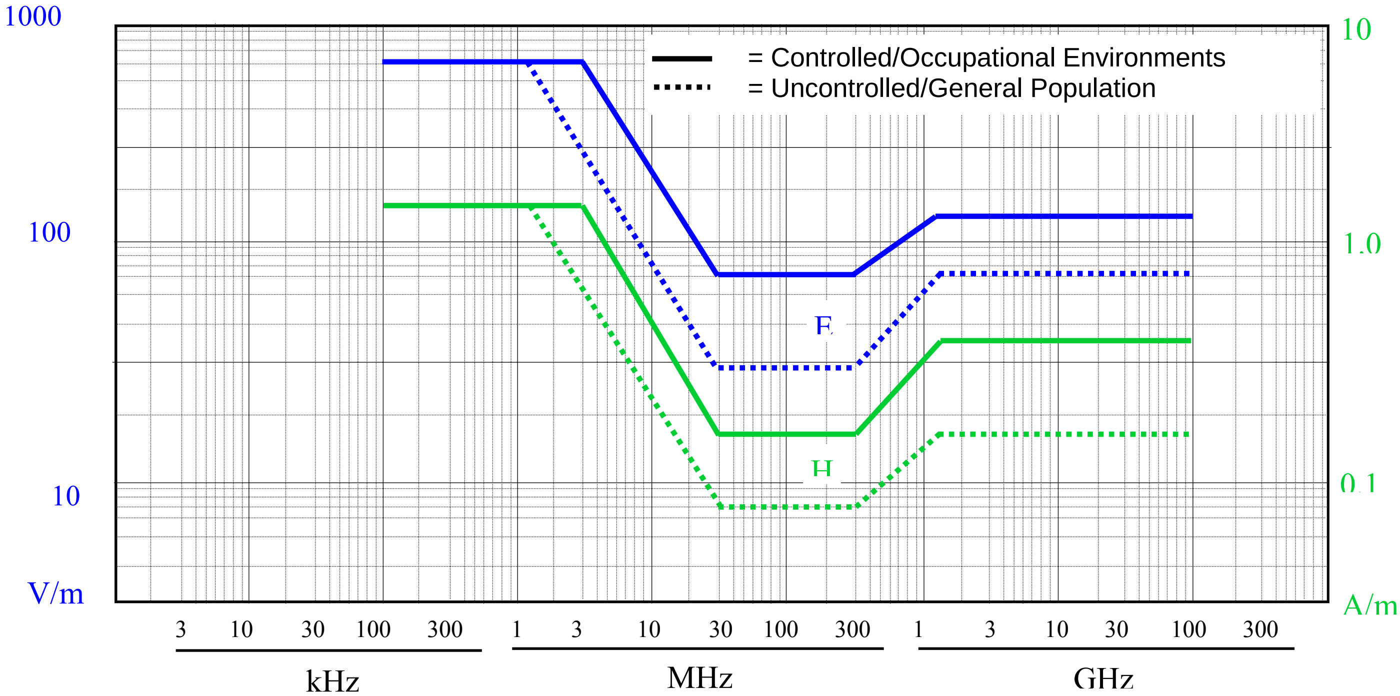
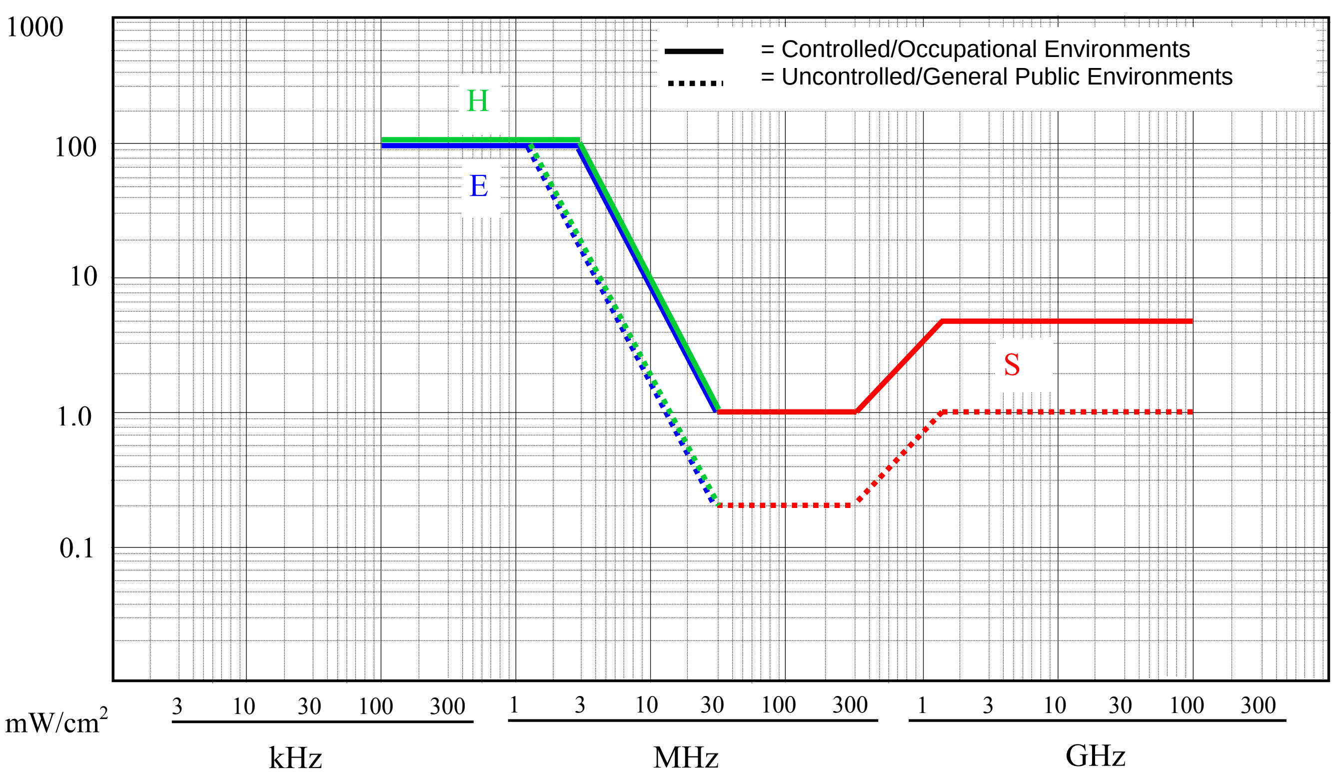
U.S. FCC MPE limits—47 CFR § 1.1310

Limits in Terms of Field Strength



Limits in Terms of Equivalent Power Density



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Appendix III: Glossary of Terms[6]

Average (temporal) power. The time-averaged rate of energy transfer.

Averaging time. The appropriate time period over which exposure is averaged for purposes of determining compliance with RF exposure limits.

Continuous exposure. Exposure for durations exceeding the corresponding averaging time.

Decibel (dB). Ten times the logarithm to the base ten of the ratio of two power levels.

Dosimetry. The accurate measurement of doses, especially radiation.

Duty factor. The ratio of pulse duration to the pulse period of a periodic pulse train. Also, may be a measure of the temporal transmission characteristic of an intermittently transmitting RF source such as a paging antenna by dividing average transmission duration by the average period for transmissions. A duty factor of 1.0 corresponds to continuous operation.

Effective radiated power (ERP) (in a given direction). The product of the power supplied to the antenna and its gain relative to a half-wave dipole in a given direction.

Equivalent Isotropically Radiated Power (EIRP). The product of the power supplied to the antenna and the antenna gain in a given direction relative to an isotropic antenna.

Electric field strength (E). A field vector quantity that represents the force (F) on an infinitesimal unit positive test charge (q) at a point divided by that charge. Electric field strength is expressed in units of volts per meter (V/m).

[6] Taken from the Federal Communications Commission, Office of Engineering and Technology, OET Bulletin 65

Energy density (electromagnetic field). The electromagnetic energy contained in an infinitesimal volume divided by that volume.

Exposure. Exposure occurs whenever and wherever a person is subjected to electric, magnetic or electromagnetic fields other than those originating from physiological processes in the body and other natural phenomena.

Exposure, partial-body. Partial-body exposure results when RF fields are substantially non-uniform over the body. Fields that are non-uniform over volumes comparable to the human body may occur due to highly directional sources, standing-waves, re-radiating sources or in the near field. See RF "hot spot".

Far-field region. That region of the field of an antenna where the angular field distribution is essentially independent of the distance from the antenna. In this region (also called the free space region), the field has a predominantly plane-wave character, i.e., locally uniform distribution of electric field strength and magnetic field strength in planes transverse to the direction of propagation.

Gain (of an antenna). The ratio, usually expressed in decibels, of the power required at the input of a loss-free reference antenna to the power supplied to the input of the given antenna to produce, in a given direction, the same field strength or the same power density at the same distance. When not specified otherwise, the gain refers to the direction of maximum radiation.

Gain may be considered for a specified polarization. Gain may be referenced to an isotropic antenna (dBi) or a half-wave dipole (dBd).

General population/uncontrolled exposure. Applies to human exposure to RF fields when the general public is exposed or in which persons who are exposed as a consequence of their employment may not be made fully aware of the potential for exposure or cannot exercise control over their exposure. Therefore, members of the general public always fall under this category when exposure is not employment-related.

Hertz (Hz). The unit for expressing frequency, (f). One hertz equals one cycle per second.

Magnetic field strength (H). A field vector that is equal to the magnetic flux density divided by the permeability of the medium. Magnetic field strength is expressed in units of amperes per meter (A/m).

Maximum permissible exposure (MPE). The rms and peak electric and magnetic field strength, their squares, or the plane-wave equivalent power densities associated with these fields to which a person may be exposed without harmful effect and with an acceptable safety factor.

Near-field region. A region generally in proximity to an antenna or other radiating structure, in which the electric and magnetic fields do not have a substantially plane-wave character, but vary considerably from point to point. The near-field region is further subdivided into the reactive near-field region, which is closest to the radiating structure and that contains most or nearly all of the stored energy, and the radiating near-field region where the radiation field predominates over the reactive field, but lacks substantial plane-wave character and is complicated in structure. For most antennas, the outer boundary of the reactive near field region is commonly taken to exist at a distance of one-half wavelength from the antenna surface.

Occupational/controlled exposure. Applies to human exposure to RF fields when persons are exposed as a consequence of their employment and in which those persons who are exposed have been made fully aware of the potential for exposure and can exercise control over their exposure. Occupational/controlled exposure limits also apply where exposure is of a transient nature as a result of incidental passage through a location where exposure levels may be above general population/uncontrolled limits (see definition above), as long as the exposed person has been made fully aware of the potential for exposure and can exercise control over his or her exposure by leaving the area or by some other appropriate means.

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Power density, average (temporal). The instantaneous power density integrated over a source repetition period.

Power density (S). Power per unit area normal to the direction of propagation, usually expressed in units of watts per square meter (W/m2) or, for convenience, units such as milliwatts per square centimeter (mW/cm2) or microwatts per square centimeter (μW/cm2). For plane waves, power density, electric field strength (E) and magnetic field strength (H) are related by the impedance of free space, i.e., 377 ohms, as discussed in Section 1 of this bulletin. Although many survey instruments indicate power density units ("far-field equivalent" power density), the actual quantities measured are E or E^2 or H or H^2.

Power density, peak. The maximum instantaneous power density occurring when power is transmitted.

Power density, plane-wave equivalent or far-field equivalent. A commonly-used terms associated with any electromagnetic wave, equal in magnitude to the power density of a plane wave having the same electric (E) or magnetic (H) field strength.

Radiofrequency (RF) spectrum. Although the RF spectrum is formally defined in terms of frequency as extending from 0 to 3000 GHz, for purposes of the FCC's exposure guidelines, the frequency range of interest in 300 kHz to 100 GHz.

Specific absorption rate (SAR). A measure of the rate of energy is absorbed by (dissipated in) an incremental mass contained in a volume element of dielectric materials such as biological tissues. SAR is usually expressed in terms of watts per kilogram (W/kg) or milliwatts per gram (mW/g).

Guidelines for human exposure to RF fields are based on SAR thresholds where adverse biological effects may occur. When the human body is exposed to an RF field, the SAR experienced is proportional to the squared value of the electric field strength induced in the body.

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Wavelength (λ). The wavelength (λ) of an electromagnetic wave is related to the frequency (f) and velocity (v) by the expression $v = f \lambda$. In free space the velocity of an electromagnetic wave is equal to the speed of light, i.e., approximately 3×10^8 m/s.

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