Radio Radiation Protection Guidelines
(Revised September 12, 2018)

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1. Definitions

The following definitions shall be used in the interpretation of the Radio Radiation Protection Guidelines (hereinafter referred to as RRPG):

(1) "Electromagnetic waves" is a general term for waves consisting of oscillating electric and magnetic fields that propagate through a vacuum or matter. Electromagnetic waves include low-frequency electromagnetic fields (hereinafter EMFs), those used for telecommunications (so-called radio waves), light radiating from the sun (infrared, visible, and ultraviolet), and radiation used for medical purposes (X-rays and gamma rays). Electromagnetic waves are largely classified as either ionizing radiation with a wavelength shorter than that of ultraviolet light or non-ionizing radiation with a wavelength longer than that of ultraviolet light.

(2) The term "radio waves" refers to electromagnetic waves of up to 3 million MHz (3,000 GHz) in frequency, as specified in Article 2 of the Radio Law. The RRPG cover radio waves in the frequency range of 10 kHz to 300 GHz.

(3) The RRPG are the safety guidelines recommended to ensure that there are no undesirable biological effects to the human body when exposed to EMFs (specifically in the frequency range of 10 kHz to 300 GHz) in radio wave use.

(4) The term "basic guidelines" refers to the guidelines to determine the safety of the human body when exposed to EMFs. These are based on various biological effects that may occur to the human body when exposed to EMFs (such as thermal stress caused by body temperature rise and radio-frequency burn).

(5) The term "basic restrictions" refers to the mandatory limitations on the quantities that closely correspond to all known biophysical interaction mechanisms with tissue that may lead to adverse health effects.

(6) The term "administrative guidelines" refers to the guidelines based on measurable physical quantities (such as electric field strength, magnetic field strength, magnetic flux density, power density, current, and specific absorption rate) for practical application to the assessment of compliance with the basic guidelines and basic restrictions. The administrative guidelines consist of EMF strength guidelines, supplementary guidelines, and partial-body absorption guidelines.

(7) The term "EMF strength guidelines" refers to the guidelines used to evaluate the safety of a space based on electric field strength, magnetic field strength, power density, and magnetic flux density in that space.

(8) The term "partial-body absorption guidelines" refers to the guidelines used for the detailed evaluation in accordance with the basic guidelines when a part of the human body is intensively exposed to EMFs from radio devices used in extremely close proximity to the human body.

(9) The term "supplementary guidelines" refers to the guidelines used for detailed

evaluation in accordance with the basic guidelines when the EMF strength guidelines are not satisfied. These guidelines mitigate or exempt the application of the EMF strength guidelines when the following information is explicitly identified: the condition of exposure to EMFs (e.g., non-uniform, local, or superficial exposure), target biological effect (e.g., contact current or induced current), and the characteristics of EMF sources (e.g., antenna power and frequency range).

(10) The term "controlled environment" refers to an environment where exposure of the human body to EMFs is well understood and the source of the radio waves is identified such that it is properly controlled according to the RRPG. For example, a working environments in which radio waves are handled on a routine basis (such as broadcasting facilities and high-frequency utilizing factories) are considered controlled environments.

(11) The term "general environment" refers to an environment where exposure of the human body to EMFs is not well understood such that proper measures cannot be taken and uncertain factors therefore exist. For example, ordinary living environments are considered general environments. In such environments, stricter guideline values are applied compared to those in controlled environments.

(12) The term "specific absorption rate (SAR)" refers to the amount of energy absorbed by a unit mass of human body tissue per unit time when exposed to EMFs. The average of the SARs over the entire human body is defined as the "whole-body average SAR," and the average of the SARs over a certain mass (e.g., 1 or 10 g) of tissue in one part of the human body is defined as the "local SAR."

(13) "Electromagnetic fields (EMFs)" is a general term for electric and magnetic fields.

(14) "Electric field strength" refers to the strength of the electric field of an EMF.

(15) "Magnetic field strength" refers to the strength of the magnetic field of an EMF.

(16) "Power density" refers to the amount of power passing through the unit area of a plane normal to the propagation direction of electromagnetic waves. The incident power density should be evaluated for all spaces that may be occupied by the human body. However, the evaluation itself should, in principle, be performed in the absence of the human body.

(17) The term "induced current" refers to current generated by electromagnetic induction. In this document, it refers to the current generated by electromagnetic induction inside the human body when exposed to EMFs.

(18) The term "contact current" refers to the current that flows through the human body via the contact point when a grounded person touches an ungrounded conductive object placed under EMF exposure.

(19) The term "contact hazard" refers to a situation that may potentially cause

contact current.

(20) The term "ungrounded condition" refers to a condition where induced current does not flow to the ground so that the influence of the earth is negligible.

(21) The term "uniform exposure" refers to exposure where EMFs of the space to be occupied by the human body can be regarded as nearly uniform and the whole human body is exposed to EMFs. This type of exposure includes cases when the free-space impedance is not 120π Ω. In free space, EMFs can be regarded as uniform when the distance from the EMF sources is sufficiently greater than the height of a human (for example, 15 m or more for frequencies up to 0.3 MHz, 10 m or more for 0.3 MHz to 300 MHz, and 5 m or more for 300 MHz and above).

(22) The term "non-uniform exposure" refers to exposure that cannot be regarded as uniform.

(23) The term "localized exposure" refers to exposure where a part of the human body is intensively exposed to EMFs. This type of exposure includes exposure to EMFs from an antenna that is smaller than a human body and placed in extremely close proximity to a human body as well as spot exposure to short wavelength radio waves.

(24) The term "whole-body exposure" refers to exposure where the entire body is exposed to EMFs without any localized exposure. An exposure that is not necessarily uniform but not classified as localized exposure falls into this classification.

(25) The term "averaging time" refers to a time period for the measurement of electromagnetic quantities, which is set in accordance with the biological effects of concern to evaluate the compliance with a guideline value. The averaging times specified by the RRPG are 1 s or less for stimulation effects and 6 min for thermal effects.

(26) The term "far field" refers to EMFs in regions more distant than both $2D^2/\lambda$ and $\lambda/2\pi$ from EMF sources and where there is no reflection or scattering. Here, D is the maximum dimension of the antenna, and λ is the free space wavelength.

(27) The term "near field" refers to EMFs in any non-far field regions.

(28) The term "root mean square (hereinafter rms)" refers to the square root of the mean of the squares of a given quantity over the period of a periodic wave. The rms values of the electric field strength and magnetic field strength of periodically varying EMFs are associated with Joule heat.

2.1 Characteristics and structure of the RRPG

2.1.1 Biological effects of EMFs that form the basis of the RRPG

Each tissue type in the human body is regarded as a dielectric object having a certain electric constants. Theoretical analyses have been performed on the interactions of EMFs with the human body in terms of its electrical characteristics. Experimental analysis methods have also been established for said interactions using human phantoms with appropriate permittivity and conductivity. According to the outcomes of the above-mentioned research, the interactions of EMFs with the human body are classified roughly into the following three types: thermal effects, stimulation effects, and others (see Table 1).

Table 1 Relationship between electromagnetic waves and biological effects

<table>
<tr><th colspan="2">Biological effects</th><th>Factors of biological change</th><th>Quantities to be evaluated</th><th>Relation to electromagnetic waves</th></tr>
<tr><td rowspan="2">Thermal effects</td><td>Whole-body temperature rise</td><td>Thermoregulatory responses
Core temperature rise
Thermal stress</td><td>Whole-body average SAR
Temperature rise (core)</td><td rowspan="3">Macroscopic interaction (dosimetric approaches are applicable)</td></tr>
<tr><td>Local temperature rise</td><td>Tissue temperature rise</td><td>Local SAR
Temperature rise (local tissue)</td></tr>
<tr><td colspan="2">Stimulation effects</td><td>Excitation of nerves and muscles due to current stimulation</td><td>Internal electric field strength</td></tr>
<tr><td colspan="2">Other effects</td><td>Unknown</td><td>EMF strength, etc. (modulation frequency)</td><td>Microscopic interaction</td></tr>
</table>

Among these biological effects, many research outcomes on thermal and stimulation effects have been accumulated. According to them, the causal relationship between those effects and EMF strength was quantitatively identified in most cases. Specifically, stimulation effects have been identified to occur mainly in the low-frequency range of up to 10 MHz, and thermal effects occur mainly at radio frequency range of 100 kHz and above. Meanwhile, no other biological effects besides thermal and stimulation effects have been identified as phenomena *in vivo*, and no evidence has been shown that these effects cause any adverse health effects.

Therefore, the RRPG deal only with thermal and stimulation effects as biological effects of EMFs. The RRPG also consider effects caused by pulsed waves and modulated waves, which are regarded as thermal or nerve stimulation effects. In addition, the contact current in association with EMFs is also considered even though it is not directly caused by EMFs.
It should be noted that while safety guidelines for EMF exposure have also been established in other countries based on similar concepts to those above, it has not been shown that exposure to EMFs complying with these guidelines causes adverse health effects by thermal, stimulation, or other biological effects.

2.1.2 Issues concerning quantities used in the RRPG

The thermal effects that EMFs cause inside the human body are body temperature rise or tissue temperature rise due to the generation of Joule heat in the tissue. This temperature rise is closely related to the amount of energy absorbed by the tissue and is evaluated in terms of the specific absorption rate (SAR), which is the amount of energy absorbed by a unit mass of tissue per unit time. Meanwhile, the stimulation effects are related to the strength of the electric field induced inside human tissues. SAR is considered to be dependent on the strength of electric field induced inside human tissues and the conductivity of the tissues.
As explained above, the biological effects of EMFs are closely related to the electric field strength inside human tissues. However, because the electric field strength inside human tissues cannot be measured directly, it is necessary to estimate the electromagnetic phenomena inside the human body using an alternative method. At present, such estimation procedures have only been established and standardized for limited types of radio devices. Therefore, using quantities that represent electromagnetic phenomena inside the human body for evaluation is currently not always practical.
The RRPG must provide a way to quickly assess the safety of cases where people use radio devices in various situations. The RRPG cannot serve as safety guidelines effectively if they are described only in terms of quantities representing the electromagnetic phenomena inside the human body, which cannot be measured directly. For this reason, it is necessary to convert the electromagnetic phenomena inside the human body into measurable quantities (such as electric and magnetic field strength) and use them to assess safety.

2.1.3 Structure of the RRPG

The evaluations that require the RRPG are roughly classified into the following three cases:

(i) Evaluation of the EMF environment of a target space

(ii) Evaluation of emissions from radio devices and how these devices are used

(iii) Evaluation of protective measures against EMF exposure

For (i), EMFs in the target space in the absence of the human body are evaluated. If the EMF sources are sufficiently far away and there are no metallic or other objects that could scatter radio waves nearby, electromagnetic phenomena inside the human body in a given space can be regarded as having an almost certain relationship with electric and magnetic field strengths measured in the same space without the presence of the human body. Under such conditions, electric and magnetic field strengths measured in the absence of the human body can be used to describe the "EMF strength guidelines" presented herein. Because EMFs to be evaluated by the RRPG are typically near field and/or non-uniform, cases where the EMF strength guidelines can be directly applied are limited. Evaluation in terms of only the space may not be appropriate for EMF environments that do not satisfy such conditions. For such EMF environments, case (ii) may be more relevant.

For (ii), the interaction of the EMF sources with the human body are evaluated. The evaluation can be regarded as for the EMF sources themselves if the sources and human body have a constant positional relationship. This means that the evaluation must be performed based on an understanding of the electromagnetic phenomena inside the human body in most cases, aside from the case where the EMF sources are sufficiently far for case (i) to be applied. The guidelines for evaluation based on electromagnetic phenomena inside the human body (except the evaluation for protection against stimulation effects) are referred to as the "basic guidelines."

In addition, "mandatory limitations on the quantities that closely match all known biophysical interaction mechanisms with tissue that may lead to adverse health effects" for protection against stimulation effects in the low-frequency range (10 kHz to 10 MHz) are referred to as the "basic restrictions."

However, some of the basic guidelines and basic restrictions are described using quantities that cannot be measured easily, so the RRPG cannot be expected to be practically effective if the basic guidelines or basic restrictions are to be used for the evaluation of all the case (ii). To address this issue with case (ii) practically, guidelines based on measurable electromagnetic quantities must be established. In addition, guidelines for contact current must be established in the EMF strength guidelines for situations where protection against contact hazards is not implemented. The guidelines introduced for the above-mentioned purposes are called the "supplementary guidelines." The supplementary guidelines are specified based on the basic guidelines, basic restrictions, and international guidelines concerning contact current to supplement the EMF strength guidelines. The supplementary guidelines consist of the following three clauses:

(1) non-uniform or localized exposure to EMFs,

(2) contact current, and
(3) induced ankle current.

It should be noted that supplementary guidelines (1) and (3) (Section 2.2.2) are used for simplified evaluation of electromagnetic phenomena inside the human body as a substitute for the basic guidelines and/or basic restrictions, and such evaluation should, in principle, be performed using the basic guidelines or basic restrictions wherever possible.

Case (iii) includes the requirement of direct evaluation of electromagnetic phenomena inside the human body. For this case, the evaluation must be performed using the partial-body absorption guidelines in principle, especially when the frequency is 100 kHz and above and the human body is within 20 cm (10 cm for frequencies of 300 MHz and above) of the EMF sources. In case the partial-body absorption guidelines are not applicable, evaluation using the basic guidelines and/or basic restrictions must be performed. In such cases, research institutes must be involved to carefully perform estimation and evaluation.

As stated above, the RRPG consist of the EMF strength guidelines, supplementary guidelines, partial-body absorption guidelines, basic guidelines, and basic restrictions. Among these, the EMF strength guidelines, supplementary guidelines, and partial-body absorption guidelines are provided to deal practically with actual cases. These three guidelines are considered administrative guidelines. The basic guidelines and basic restrictions form the basis of the administrative guidelines as well as providing a rational basis for determining safety in cases where the administrative guidelines cannot confirm the safety of the exposure.

The RRPG are established based on the latest scientific research outcomes and actual conditions of radio wave use. Therefore, they must be complemented or revised in response to changes in these conditions. The advancement of research on the biological effects of EMFs is primarily reflected in the basic guidelines and/or basic restrictions, while the advancement of research on methods to measure and estimate electromagnetic phenomena inside the human body and the consistency with actual society in response to changes in radio wave use are reflected in the administrative guidelines. Given their nature, the administrative guidelines should be revised when necessary, while the basic guidelines and basic restrictions should not be readily revised.

2.1.4 Two-tier structures of basic restrictions and administrative guidelines

To make RRPG-based evaluation reliable, the RRPG must be used properly, and unexpected changes in the electromagnetic environment must be controlled. When these requirements can be met, the administrative guidelines (EMF strength guidelines and supplementary guidelines), which are derived based on the basic guidelines and/or

basic restrictions, should be applied. However, if the conditions of radio wave use are not understood correctly, an EMF environment that does not satisfy the basic guidelines or basic restrictions may be formed without awareness, and actions based on the awareness of the existence of such EMFs cannot be expected. To ensure adequate safety even under such a condition, appropriate guidelines must be established in consideration of additional safety factors as a rational measure, as with the safety guidelines established in other countries.

From the above-mentioned perspective, the EMF environments covered by the administrative guidelines are divided into controlled and general environments according to the following definitions: in a controlled environment, the objectives of the RRPG are well understood and the EMF environment is kept under control; in a general environment, neither the RRPG nor the conditions of radio wave use are well understood. For a general environment, additional safety factors are applied to guideline values for a controlled environment, equating to approximately fivefold stricter guideline values in terms of power density, taking into account of a higher degree of uncertainty due to insufficient EMF control compared to a controlled environment.

For the basic restrictions relevant to protection against stimulation effects caused by low-frequency EMFs (10 kHz to 10 MHz), different guideline values are also set for general and controlled environments.

2.1.5 Application procedures of the RRPG

The procedures to apply the RRPG, which consist of the administrative guidelines (EMF strength guidelines, supplementary guidelines, and partial-body absorption guidelines), basic guidelines, and basic restrictions, are described below.

In actual evaluation procedures, the EMF strength guidelines are applied first, regardless of the conditions, such as the types of EMF sources. When the actual conditions of radio wave use are well understood and in line with the objectives of the RRPG, the guideline values for a controlled environment should be applied; otherwise, those for a general environment should be applied. When the EMF strength guidelines are satisfied throughout the space to be evaluated, the space is deemed safe.

The EMFs in a space to be evaluated are often non-uniform or near field, so the EMF strength tends to be overestimated. If the EMF strength guidelines are not satisfied for this reason, detailed evaluation can be performed using the supplementary guidelines to determine the safety. Further, if the supplementary guidelines are not applicable, such as in cases where the human body is in close proximity to EMF sources, evaluation can be performed using the partial-body absorption guidelines.

If a space fails to satisfy the guidelines for a general environment by evaluation according to the above-mentioned procedures, it must be made a controlled environment, or measures must be taken to satisfy the guidelines. Failing to satisfy the

administrative guidelines suggests the possibility of failing the basic guidelines and/or basic restrictions as well. In such a case, protective measures must be taken to satisfy the administrative guidelines, or evaluation based on the basic guidelines or basic restrictions must be performed to identify potential hazards to the human body more directly.

Evaluations based on the basic guidelines and/or basic restrictions may entail issues such that measurement and estimation methods for quantities used to specify the guideline values are not well established. If this is the case, evaluation must be performed according to the method deemed appropriate by research institutions.

2.2 Administrative guidelines

The administrative guidelines are derived based on the basic guidelines and basic restrictions. The actual evaluation of EMF environments is performed using mainly the administrative guidelines. These guidelines consist of the EMF strength guidelines, supplementary guidelines, and partial-body absorption guidelines.

2.2.1 EMF strength guidelines

(1) Controlled environment

The EMF strength guideline values applicable to controlled environments are listed in Tables 2 (a) and 2 (b). For the frequency range of 100 kHz to 10 MHz, the values in both tables must be satisfied. When a specific part of an evaluated space fails to satisfy any of the guideline values in these tables, the supplementary guidelines specified in Section 2.2.2 (1) should be applied.

Figures 1 and 2 show graphical representations of the guideline values in Tables 2 (a) and 2 (b).

Table 2 (a) EMF strength guideline values for a controlled environment (averaging time: 6 min)

Frequency f	rms electric field strength E [V/m]	rms magnetic field strength H [A/m]	Power density S [mW/cm^2]
100 kHz to 3 MHz	614	4.9f (MHz)$^{-1}$ (49–1.63)	
3 to 30 MHz	1,842f (MHz)$^{-1}$ (614–61.4)	4.9f (MHz)$^{-1}$ (1.63–0.163)	
30 to 300 MHz	61.4	0.163	1
300 MHz to 1.5 GHz	3.54f (MHz)$^{1/2}$ (61.4–137)	f (MHz)$^{1/2}$/106 (0.163–0.365)	f (MHz)/300 (1–5)
1.5 to 300 GHz	137	0.365	5

Table 2 (b) EMF strength guideline values for protection against stimulation effects in a controlled environment

Frequency f	rms electric field strength E [kV/m]	rms magnetic field strength H [A/m]	rms magnetic flux density [T]
10 kHz to10 MHz	1.7×10^{-1}	80	1×10^{-4}

Note 1: If protective measures are not taken against contact hazards for frequencies of up to 15 MHz, protection against contact current can be secured by applying the supplementary guidelines specified in Section 2.2.2 (2).

Note 2: The rms electric field strength (averaging time: 6 min) for the case that the ungrounded condition of the human body is not satisfied must not exceed 3,200f (MHz)$^{-3/2}$ V/m (i.e., 614–20 V/m) in the frequency range of 3 to 30 MHz, 20 V/m in the frequency range of 30 to 100 MHz, and 0.2f (MHz) V/m (i.e., 20–61.4 V/m) in the frequency range of 100 to 300 MHz. However, the supplementary guidelines specified in Section 2.2.2 (3) can be applied for the case that these criteria are not met and the EMF strength of concern is below its guideline value specified in Table 2 (a).

Note 3: When the electric field strength or magnetic field strength varies within the averaging time specified in Table 2 (a), the rms values over the averaging time should be used. When the power density varies, the averaged values over the averaging time should be used.

Note 4: Regarding Table 2 (a), when EMFs have multiple frequency components of significant levels with respect to the guideline values, the following method should be used: for electric field strength or magnetic field strength, calculate the square-sum of the ratios to the corresponding guideline values for each

frequency component; for power density, calculate the sum of the ratios to the corresponding guideline values for each frequency component. The summed value must not exceed 1.

Regarding Table 2 (b), when EMFs have multiple frequency components of significant levels with respect to the guideline values, the following method should be used: for electric field strength, magnetic field strength, and magnetic flux density, calculate either the sum of ratios to the corresponding guideline values for each frequency component; or the weighted average of the ratios to the corresponding guideline values for each frequency component according to the frequency characteristics of the guideline values (see the Appendix). The summed value must not exceed 1.

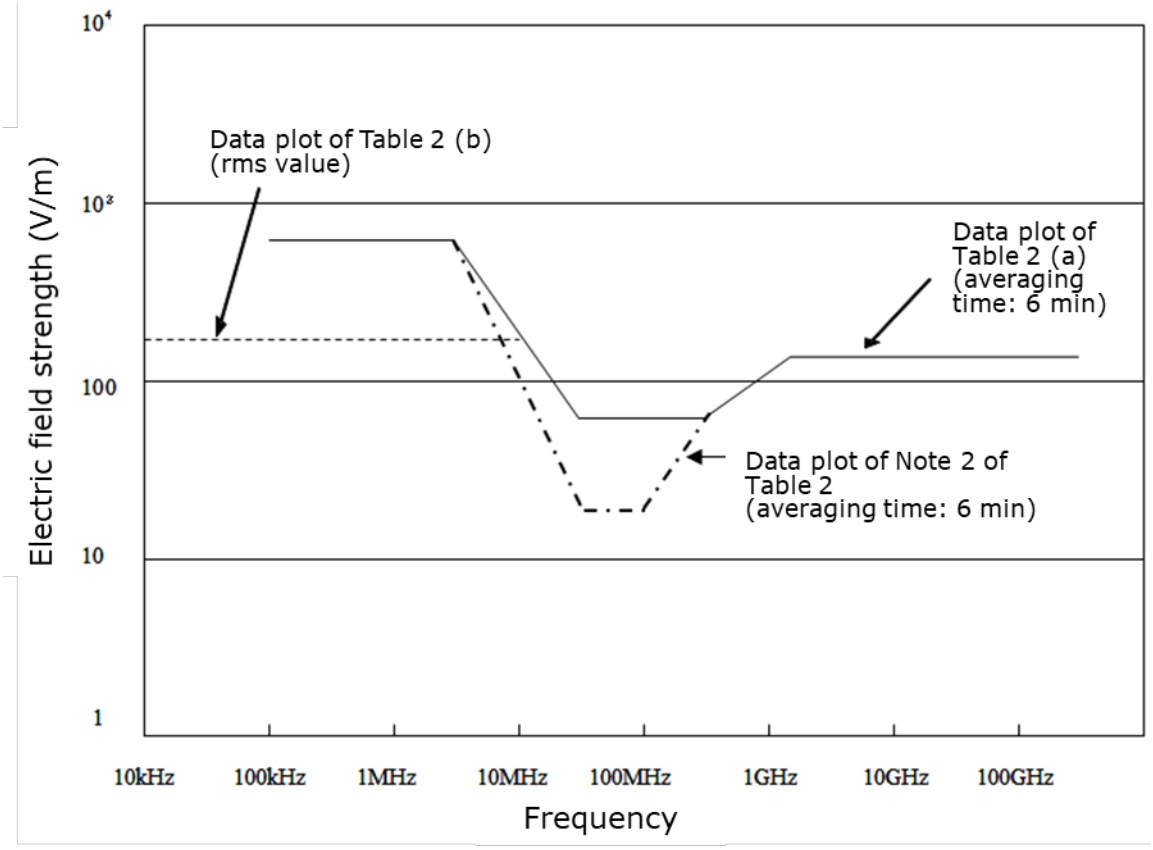

Figure 1 Guideline values for electric field strength (controlled environment)

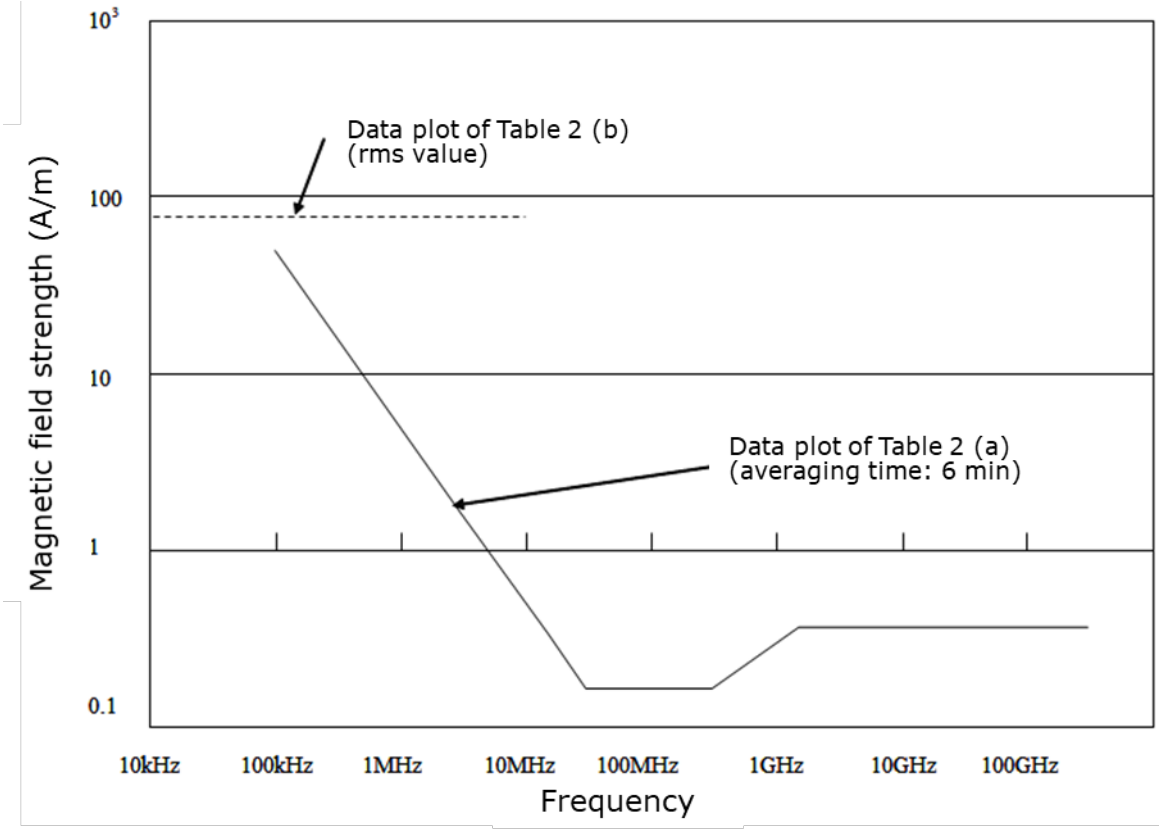

Figure 2 Guideline values for magnetic field strength (controlled environment)

(2) General environment

The EMF strength guideline values applicable to a general environment are listed in Tables 3 (a) and 3 (b). For the frequency range of 100 kHz to 10 MHz, the values in both tables must be satisfied. When a specific part of a space evaluated fails to satisfy any of the guideline values in these tables, the supplementary guidelines specified in Section 2.2.2 (1) should be applied.

Figures 3 and 4 show graphical representations of the guideline values in Tables 3 (a) and 3 (b).

Table 3 (a) EMF strength guideline values for a general environment
(Averaging time: 6 min)

Frequency f	rms electric field strength E [V/m]	rms magnetic field strength H [A/m]	Power density S [mW/cm^2]
100 kHz to 3 MHz	275	2.18f (MHz)$^{-1}$ (21.8–0.728)	
3 to 30 MHz	824f (MHz)$^{-1}$ (275–27.5)	2.18f (MHz)$^{-1}$ (0.728–0.0728)	
30 to 300 MHz	27.5	0.0728	0.2
300 MHz to 1.5 GHz	1.585f (MHz)$^{1/2}$ (27.5–61.4)	f (MHz)$^{1/2}$/237.8 (0.0728–0.163)	f (MHz)/1500 (0.2–1)
1.5 to 300 GHz	61.4	0.163	1

Table 3 (b) EMF strength guideline values used for protection against stimulation effects in a general environment

Frequency f	rms electric field strength [kV/m]	rms magnetic field strength [A/m]	rms magnetic flux density [T]
10 kHz to 10 MHz	8.3×10^{-2}	21	2.7×10^{-5}

Note 1: In case protective measures are not taken against contact hazards for frequencies of up to 15 MHz, protection against contact current can be secured by applying the supplementary guidelines specified in Section 2.2.2 (2).

Note 2: The rms electric field strength (averaging time:6 min) for the case that the ungrounded condition of the human body is not satisfied must not exceed 1,430f (MHz)$^{-3/2}$ V/m (i.e., 275–9 V/m) in the frequency range of 3 to 30 MHz, 9 V/m in the frequency range of 30 to 100 MHz, and 0.09f (MHz) V/m (i.e., 9–27 V/m) in the frequency range of 100 to 300 MHz. However, the supplementary guidelines specified in Section 2.2.2 (3) can be applied for the case that these criteria are not met and the EMF strength of concern is below its guideline value specified in

Table 3 (a).

Note 3: When the electric field strength or magnetic field strength varies within the averaging time specified in Table 3 (a), the rms values over the averaging time should be used. When the power density varies, the averaged values over the averaging time should be used.

Note 4: Regarding Table 3 (a), when EMFs have multiple frequency components of significant levels with respect to the guideline values, the following method should be used: for electric field strength or magnetic field strength, calculate the square-sum of the ratios of the strength to the corresponding guideline values for each frequency component; for power density, calculate the sum of the ratios to the corresponding guideline values for each frequency component. The summed value must not exceed 1.

Regarding Table 3 (b), when EMFs have multiple frequency components of significant levels with respect to the guideline values, the following method should be used: for electric field strength, magnetic field strength, and magnetic flux density, either calculate the sum of ratios to the corresponding guideline values for each frequency component or calculate the weighted average of the ratios to the corresponding guideline values for each frequency component according to the frequency characteristics of the guideline values (see the Appendix). The summed value must not exceed 1.

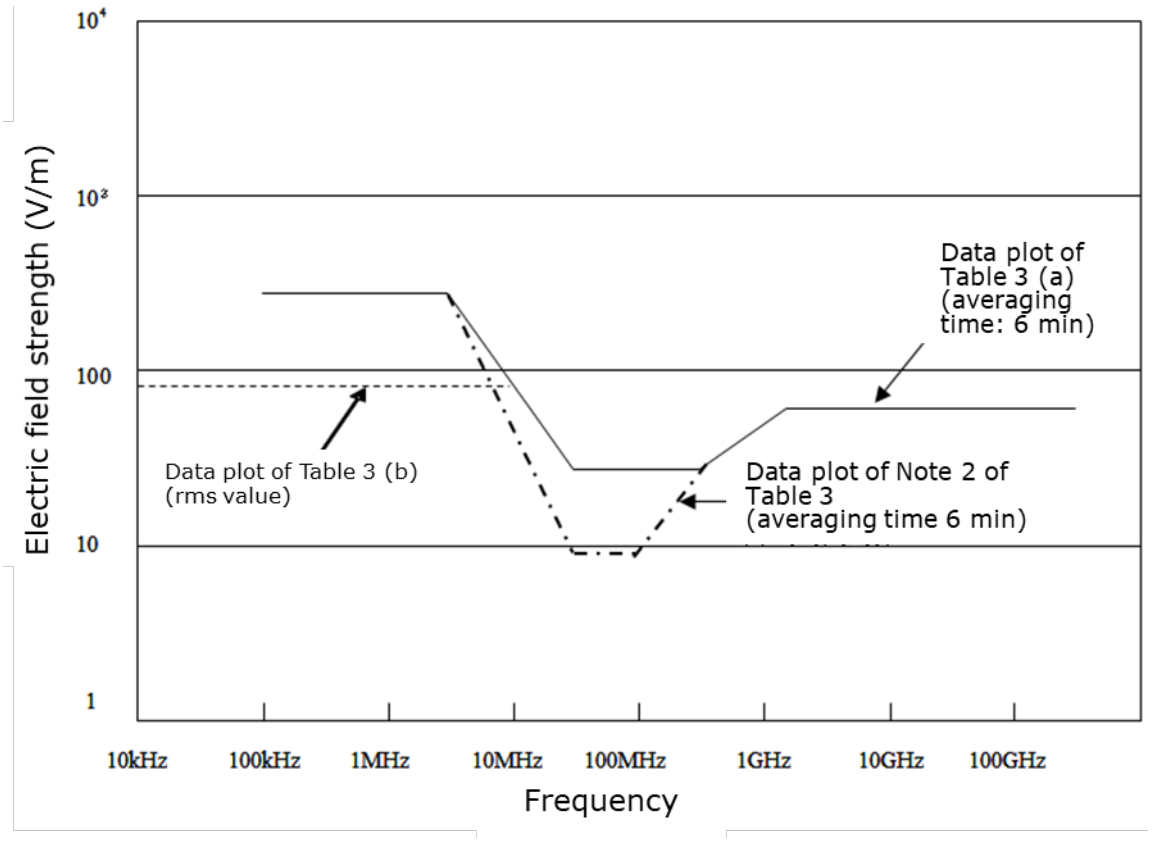

Figure 3 Guideline values for electric field strength (general environment)

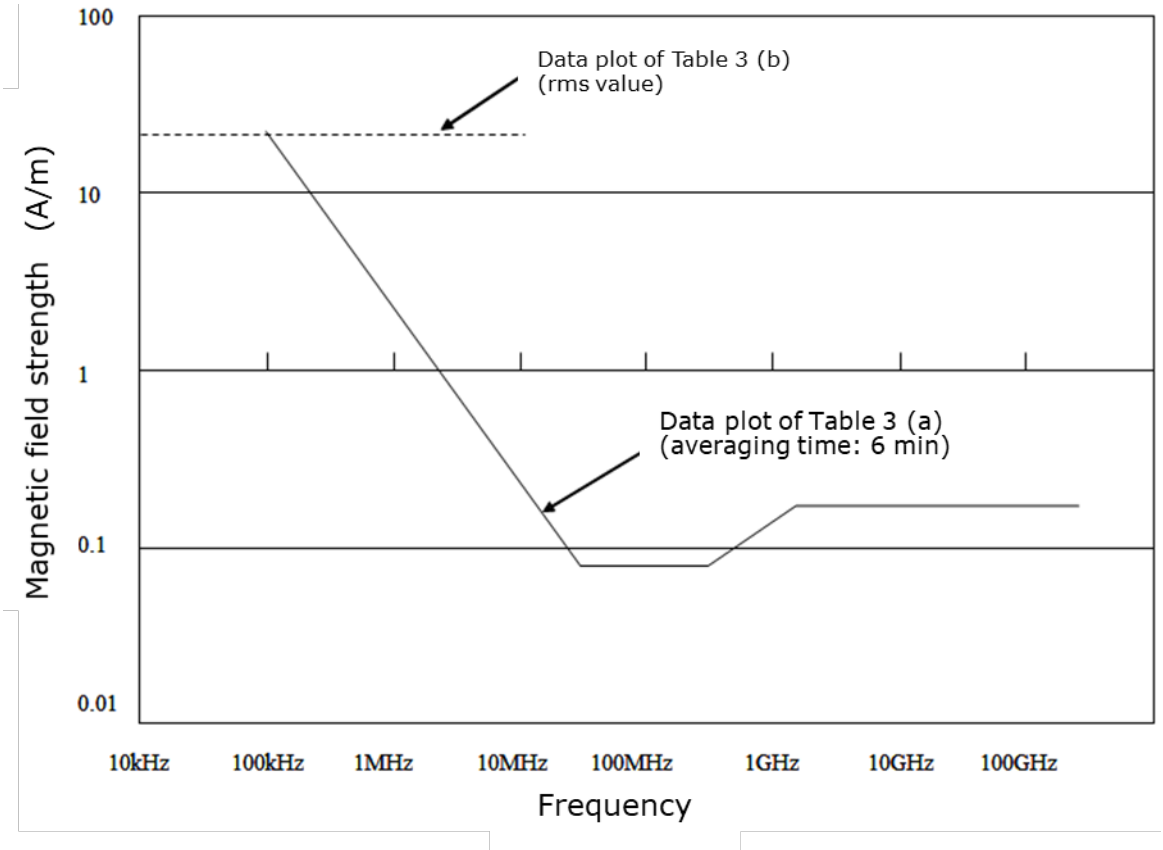

Figure 4 Guideline values for magnetic field strength (general environment)

2.2.2 Supplementary guidelines

These guidelines are to be used when the EMF strength guidelines alone cannot demonstrate compliance with the RRPG to perform a more detailed evaluation by focusing on the conditions in which the human body is exposed to EMFs and biological effects to be considered.

(1) Guidelines for human body exposure to non-uniform or localized EMFs

When all the conditions described in Table 4-1 for the frequency range of concern are satisfied, the administrative guidelines are deemed to be satisfied. When the frequencies of concern spread across multiple of the frequency ranges described below, specifically (i)(b); (ii)(a) and (b); (iii)(a) and (b); and (iv)(a), (b) and (c), the following method should be used: for electric field strength or magnetic field strength, calculate the square-sum of the ratios to the corresponding guideline values for each frequency component; for power density, calculate the sum of the ratios to the corresponding guideline values for each frequency component. The summed value must not exceed 1.

Note that special consideration is required for each individual case when a device is used within 20 cm (or 10 cm for frequencies of 300 MHz and above) of the human body. It is desirable to perform an evaluation based on the partial-body absorption guidelines if there is a possibility of exceeding the basic guidelines.

(i) Frequencies up to 300 MHz

(a) Regarding protection against stimulation effects in the frequency range of 10 kHz to 10 MHz, the following requirements must be satisfied: in a space that is at least 20 cm from EMF sources and metallic objects, the spatial average (simple average) of electric field strength or magnetic field strength over the entire space to be occupied by the human body must not exceed the EMF strength guideline values for the corresponding environment (i.e., controlled or general) specified in Tables 2 (b) and 3 (b) in Section 2.2.1. In this case, the EMF strength of localized exposure may exceed the EMF strength guideline values but should not exceed the basic restrictions.

Notes 1 and 4 below Tables 2 and 3 are applicable to the above as well.

(b) Regarding protection against thermal effects in the frequency range of 100 kHz to 300 MHz (EMF strength guideline values with a 6 min averaging time), the following requirements must be satisfied: in a space that is at least 20 cm from EMF sources and metallic objects, the spatial average of the power density distribution (rms value for electric field strength or magnetic field strength) over the entire space occupied by the human body must not exceed the EMF strength guideline values for the corresponding environment (i.e., controlled or general) specified in Tables 2 (a) and 3 (a) in Section 2.2.1.

Notes 1 to 4 below Tables 2 and 3 are applicable to the above as well.

(ii) Frequency range of 300 MHz to 1 GHz

(a) In a space that is at least 10 cm from EMF sources and metallic objects, the spatial average of the power density distribution (rms value of electric field strength or magnetic field strength) over the entire space occupied by the human body must not exceed the EMF strength guideline values for the corresponding environment (i.e., controlled or general) specified in Section 2.2.1.

Notes 3 and 4 below Tables 2 and 3 are applicable to the above as well.

(b) The peak spatial power density in a space occupied by a human body, excluding the limbs, must not exceed 20 mW/cm^2 (averaging time: 6 min) for a controlled environment or 4 mW/cm^2 (averaging time: 6 min) for a general environment. Note that this is applicable only to a space that is at least 10 cm from EMF sources and metallic objects.

Notes 3 and 4 below Tables 2 and 3 are to the above as well.

(iii) Frequency range of 1 to 3 GHz

(a) In a space that is at least 10 cm from EMF sources and metallic objects, the spatial average of the power density distribution (rms value for electric field strength or magnetic field strength) over the entire space occupied by the human body must not exceed the EMF strength guideline values for the corresponding environment (i.e., controlled or general) specified in Section 2.2.1.

Notes 3 and 4 below Tables 2 and 3 are applicable to the above as well.

(b) The peak spatial power density in a space occupied by a human body, excluding the limbs, must not exceed 20 mW/cm^2 (averaging time: 6 min) for a controlled environment or 4 mW/cm^2 (averaging time: 6 min) for a general environment. Note that this is applicable only to a space that is at least 10 cm from EMF sources and metallic objects.

Notes 3 and 4 below Tables 2 and 3 are to the above as well.

(c) The peak spatial power density incident to the head must not exceed 10 mW/cm^2 (averaging time: 6 min) for a controlled environment or 2 mW/cm^2 (averaging time: 6 min) for a general environment. Note that this is applicable only to a space that is at least 10 cm from EMF sources and metallic objects.

Notes 3 and 4 below Tables 2 and 3 are applicable to the above as well.

(iv) Frequencies of 3 GHz and above

(a) In a space that is at least 10 cm from EMF sources and metallic objects, the spatial average of the power density distribution (rms value for electric field strength or magnetic field strength) over the entire space occupied by the human body must not exceed the EMF strength guideline values for the corresponding environment (i.e., controlled or general) specified in Section

2.2.1.

Notes 3 and 4 below Tables 2 and 3 are applicable to the above as well.

(b) In a space that is at least 10 cm from EMF sources and metallic objects, the peak spatial power density incident to the surface of the body must not exceed 50 mW/cm^2 (averaging time: 6 min) for a controlled environment or 10 mW/cm^2 (averaging time: 6 min) for a general environment.

Notes 3 and 4 below Tables 2 and 3 are applicable to the above as well.

(c) In a space that is at least 10 cm from EMF sources and metallic objects, the power density incident to the eye must not exceed 10 mW/cm^2 (averaging time: 6 min) for a controlled environment or 2 mW/cm^2 (averaging time: 6 min) for a general environment.

Notes 3 and 4 below Tables 2 and 3 are applicable to the above as well.

All the supplementary guidelines described above are summarized in Table 4-1.

Table 4-1 Supplementary guidelines for exposure to non-uniform or localized EMFs

<table>
<tr><td></td><td>10 to 100 kHz</td><td>100 kHz to 10 MHz</td><td>10 to 300 MHz</td><td>300 MHz to 1 GHz</td><td>1 to 3 GHz</td><td>3 to 300 GHz</td></tr>
<tr><td>Simple average of EMF strength (stimulation effects)</td><td colspan="2">Controlled environment: must not exceed the EMF strength guideline values specified in Table 2 (b) (Notes 1 and 4 are also applicable).
General environment: must not exceed the EMF strength guideline values specified in Table 3 (b) (Notes 1 and 4 are also applicable).</td><td colspan="4"></td></tr>
<tr><td>Spatial average of EMF strength (thermal effects)</td><td></td><td colspan="5">Controlled environment: must not exceed the EMF strength guideline values specified in Table 2 (a) (Notes 1 to 4 are also applicable).
General environment: must not exceed the EMF strength guideline values specified in Table 3 (a) (Notes 1 to 4 are also applicable).</td></tr>
<tr><td rowspan="2">Peak spatial EMF strength</td><td colspan="3" rowspan="2"></td><td colspan="2">Other than limbs:
Controlled environment: 20 mW/cm^2
General environment: 4 mW/cm^2</td><td>Body surface:
Controlled environment: 50 mW/cm^2
General environment: 10 mW/cm^2</td></tr>
<tr><td></td><td>Head:
Controlled environment: 10 mW/cm^2
General environment: 2 mW/cm^2</td><td>Eye:
Controlled environment: 10 mW/cm^2
General environment: 2 mW/cm^2</td></tr>
<tr><td>Applicable space</td><td colspan="3">A space that is at least 20 cm from EMF sources and metallic objects and occupied by the human body</td><td colspan="3">A space that is at least 10 cm from EMF sources and metallic objects and occupied by the human body</td></tr>
</table>

(2) Guidelines for contact current

(a) When protective measures are not taken against contact hazards in a controlled environment

(i) In the frequency range of 10 kHz to 10 MHz, the measured contact current must satisfy the following requirements:

- Must not exceed 0.4f (kHz) mA (rms value) in the frequency range of 10 to 100 kHz.
- Must not exceed 40 mA (rms value) in the frequency range of 100 kHz to 10 MHz.

When the contact current has multiple frequency components of significant levels with respect to the guideline values, calculate either the sum of the ratios to the corresponding guideline values for each frequency component or the weighted average of the ratios to the corresponding guideline values for each frequency component according to the frequency characteristic of the guideline values (see the Appendix). The summed value must not exceed 1.

(ii) In the frequency range of 100 kHz to 15 MHz, the measured contact current must not exceed 100 mA (averaging time: 6 min). When the contact current has multiple frequency components of significant levels with respect to the guideline values, calculate the square-sum of the ratios to the corresponding guideline values for each frequency component. The summed value must not exceed 1.

*All requirements specified in both (i) and (ii) above must be satisfied in the frequency range of 100 kHz to 10 MHz.

(b) When protective measures are not taken against contact hazards in a general environment

(i) In the frequency range of 10 kHz to 10 MHz, when induced current is generated in an extremely large ungrounded metallic object or contact current is expected to occur under the influence of a magnetic field, the measured contact current must satisfy the following requirements:

- Must not exceed 0.2f (kHz) mA (rms value) in the frequency range of 10 to 100 kHz.
- Must not exceed 20 mA (rms value) in the frequency range of 100 kHz to 10 MHz.

When the contact current has multiple frequency components of significant levels with respect to the guideline values, calculate either the sum of the ratios to the corresponding guideline values for each frequency component in each

frequency range or the weighted average of the ratios to the corresponding guideline values for each frequency component according to the frequency characteristics of the guideline values (see the Appendix). The summed value must not exceed 1.

(ii) In the frequency range of 100 kHz to 15 MHz, the measured contact current must not exceed 45 mA (averaging time: 6 min). When the contact current has multiple frequency components of significant levels with respect to the guideline values, calculate the square-sum of the ratios to the corresponding guideline values for each frequency component. The summed value must not exceed 1.

* All the requirements specified in both (i) and (ii) above must be satisfied in the frequency range of 100 kHz to 10 MHz.

(3) Guidelines for induced ankle current

(a) When the ungrounded condition is not satisfied in a controlled environment

The induced current measured at the ankles in the frequency range of 3 to 300 MHz (averaging time: 6 min) must not exceed 100 mA per ankle.

When the induced ankle current has multiple frequency components of significant levels with respect to the guideline values, calculate the square-sum of the ratios of to the corresponding guideline values for each frequency component. The summed value must not exceed 1.

(b) When the ungrounded condition is not satisfied in a general environment

The induced current measured at the ankles in the frequency range of 3 to 300 MHz (averaging time: 6 min) must not exceed 45 mA per ankle.

When the induced ankle current has multiple frequency components of significant levels with respect to the guideline values, calculate the square-sum of the ratios to the corresponding guideline values for each frequency component. The summed value must not exceed 1.

2.2.3 Partial-body absorption guidelines

(a) Scope of application

These guidelines are applicable to the frequency range of 100 kHz to 300 GHz.

These guidelines are mainly applicable to small-sized radio devices, such as mobile phone terminals, and they assume that cases where antennas or enclosures of such EMF source devices are used in close proximity to the human body.

Specifically, the guidelines are applied to cases where the distance between the human body and EMF sources (mainly antennas) or metallic objects that contribute to EMF radiation (such as enclosures) is 20 cm or less. In addition, even at greater distances, it can be determined that the basic guidelines are satisfied if any one of

the EMF strength guidelines, supplementary guidelines, or partial-body absorption guidelines are met. However, for the frequency range of 300 MHz to 300 GHz, there is no exemption for the application of the EMF strength guidelines or supplementary guidelines at a distance of 10 cm to 20 cm.

For radio stations with an average antenna power of up to 20 mW in the frequency range of 100 kHz to 6 GHz, the guideline values for local SAR are satisfied even if the entire output power of the radio station is absorbed by a small part of the human body, so such evaluation is not required. Similarly, evaluation is not required for radio stations with an average antenna power of up to 100 mW used in a controlled environment.

For radio stations with an average antenna power of up to 8 mW in the frequency range of 6 to 30 GHz, the guideline values of incident power density are satisfied even if the entire output power of the radio station is absorbed by a small part of the human body, so such evaluation is not required. Similarly, evaluation is not required for radio stations with an average antenna power of up to 40 mW used in a controlled environment.

For radio stations with an average antenna power of up to 2 mW in the frequency range of >30 to 300 GHz, the guideline values of incident power density are satisfied even if the entire output power of the radio station is absorbed by a small part of the human body, so such evaluation is not required. Similarly, evaluation is not required for radio stations with an average antenna power of up to 10 mW used in a controlled environment.

(b) Controlled environment

All the following requirements must be satisfied:

[1] The whole-body average SAR averaged over any 6 min period must not exceed 0.4 W/kg.

[2] At frequencies of up to 6 GHz, the local SAR averaged over any 10 g of tissue (averaging time: 6 min) must not exceed 10 W/kg (20 W/kg for limbs).

[3] In the frequency range of 6 to 30 GHz, the incident power density averaged over any 4 cm^2 of body surface (in any space to be occupied by the human body) (averaging time: 6 min) must not exceed 10 mW/cm^2.

[4] In the frequency range of >30 to 300 GHz, the incident power density averaged over any 1 cm^2 of body surface (in any space to be occupied by the human body) (averaging time: 6 min) must not exceed 10 mW/cm^2.

[5] For simultaneous exposure to radio waves with multiple frequency components, the summed value of the ratios to the corresponding guideline values for each frequency component in [2], [3], and [4] above must not exceed 1.

[6] If protective measures are not taken against contact hazards, the contact

current (rms value) must not exceed 40 mA in the frequency range of 100 kHz to 10 MHz, and the contact current (averaging time: 6 min) must not exceed 100 mA in the frequency range of 100 kHz to 100 MHz.

When the contact current has multiple frequency components of significant levels with respect to the guideline values, for the frequency range of 100 kHz to 10 MHz, calculate either the sum of the ratios to the corresponding guideline values (40 mA in rms value) for each frequency component or the weighted average of the ratios to the corresponding guideline values for each frequency component according to the frequency characteristics of the guideline values. The summed value must not exceed 1. In addition, for the frequency range of 100 kHz to 100 MHz, calculate the square-sum of the ratios to the corresponding guideline values (100 mA, averaging time: 6 min) for each frequency component. The summed value must not exceed 1.

[7] The internal electric field strength must not exceed $2.7 \times 10^{-4} \times f(Hz)$ V/m in the frequency range of 100 kHz to 10 MHz.

When the internal electric fields have multiple frequency components of significant levels with respect to the guideline values, calculate either the sum of the ratios to the corresponding guideline values for each frequency component or the weighted average of the ratios to the corresponding guideline value for each frequency component according to the frequency characteristics of the guideline values (see the Appendix). The summed value must not exceed 1.

Note that radio stations with frequencies of 100 MHz and above are exempt from the evaluation of contact current specified in [6] above. Similarly, radio stations with frequencies of 10 MHz and above are exempt from the evaluation of internal electric field strength specified in [7] above.

(c) General environment

All the following requirements must be satisfied:

[1] The whole-body average SAR averaged over any 6 min period must not exceed 0.08 W/kg.

[2] For frequencies of up to 6 GHz, the local SAR averaged over any 10 g of tissue (averaging time: 6 min) must not exceed 2 W/kg (4 W/kg for limbs).

[3] In the frequency range of 6 to 30 GHz, the incident power density averaged over any 4 cm^2 of body surface (in any space to be occupied by the human body) (averaging time: 6 min) must not exceed 2 mW/cm^2.

[4] In the frequency range of >30 to 300 GHz, the incident power density averaged over any 1 cm^2 of body surface (in any space to be occupied by the human body) (averaging time: 6 min) must not exceed 2 mW/cm^2.

[5] For simultaneous exposure to radio waves with multiple frequency components, the summed value of the ratios to the corresponding guideline values for each frequency component in [2], [3], and [4] above must not exceed 1.

[6] If protective measures are not taken against contact hazards, the contact current (rms value) must not exceed 20 mA in the frequency range of 100 kHz to 10 MHz, and the contact current (averaging time: 6 min) must not exceed 45 mA in the frequency range of 100 kHz to 100 MHz.

When the contact current has multiple frequency components of significant levels with respect to the guideline values, for the frequency range of 100 kHz to 10 MHz, calculate either the sum of the ratios to the corresponding guideline values (20 mA in rms value) for each frequency component or the weighted average of the ratios to the corresponding guideline values for each frequency component according to the frequency characteristics of the guideline values. The summed value must not exceed 1. In addition, for the frequency range of 100 kHz to 100 MHz, calculate the square-sum of the ratios to the guideline values (45 mA, averaging time: 6 min) for each frequency component. The summed value must not exceed 1.

[7] The internal electric field strength must not exceed $1.35 \times 10^{-4} \times f$ (Hz) V/m in the frequency range of 100 kHz to 10 MHz.

When the internal electric fields have multiple frequency components of significant levels with respect to the guideline values, calculate either the sum of the ratios to the corresponding guideline values for each frequency component or the weighted average of the ratios to the corresponding guideline values for each frequency component according to the frequency characteristics of the guideline values (see the Appendix). The summed value must not exceed 1.

Note that radio stations with frequencies of 100 MHz and above are exempt from the evaluation of contact current specified in [6] above. Similarly, radio stations with frequencies of 10 MHz and above are exempt from the evaluation of internal electric field strength specified in [7] above.

2.3 Basic guidelines

The basic guidelines are listed in Table 5-1 The basic guidelines provide a conceptual basis for the administrative guidelines used to ensure human body protection against thermal effects. At the same time, they provide grounds for judging the possibility of biological effects.

Table 5-1 Basic guidelines

1 The whole-body average SAR averaged over any 6 min period must not exceed 0.4 W/kg.
2 (Deleted)
3 For the frequency range of 100 kHz to 100 MHz, the current that flows in from outside the human body, such as contact current, must not exceed 100 mA (averaging time: 6 min).
4 In addition to the above guidelines, the followings cautions must be considered:
(a) Even if the whole-body average SAR averaged over any 6 min period does not exceed 0.4 W/kg, the SAR averaged over any 1 g of tissue (averaging time: 6 min) should not exceed 8 W/kg (25 W/kg for the body surface and limbs).
(b) The incident power density to the eye (averaging time: 6 min) must not exceed 10 mW/cm^2 for frequencies of 3 GHz and above.

2.4 Basic restrictions

The basic restrictions regarding protection of the human body against stimulation effects caused in the low frequency range are listed in Table 5-2. The definition of the term “basic restriction” is “the maximum permissible limit for a physical quantity that directly relates to biological phenomena inside the human body caused by exposure to radiofrequency EMFs that may lead to adverse health effects.” The basic restrictions are assumed to be actively evaluated for compliance assessment, while compliance assessment based on the basic guidelines is assumed to be an exceptional alternative only for cases where compliance assessment based on the administrative guidelines is not applicable.

Table 5-2 Basic restrictions used for protection against stimulation effects (rms value)

Exposure characteristics	Frequency range	Controlled environment	General environment
		Internal electric field [V/m]	Internal electric field [V/m]
All tissues of the head and torso	10 kHz to 10 MHz	$2.7 \times 10^{-4} \times f$	$1.35 \times 10^{-4} \times f$

(Note 1) f represents the frequency (in Hz).

(Note 2) Guideline values for thermal effects must also be considered for frequencies of 100 kHz and above.

(Note 3) When EMFs have multiple frequency components of significant levels with respect to the guideline values, the following method should be used: for electric field strength, magnetic field strength, and magnetic flux density, calculate either the sum of ratios to the corresponding guideline values for each frequency component (10 kHz to 10 MHz) or the weighted average of the ratios to the corresponding guideline values for each frequency component according to the frequency characteristics of the guideline values (see the Appendix). The summed value must not exceed 1.

2.5 Notes regarding the RRPG

(1) EMF use for medical purposes

When EMFs are used for medical purposes, the exposure of medical staff to them is subject to the application of the RRPG. With regard to patients, application of the RRPG should be judged in consideration of medical benefits, and it is deemed to be outside the scope of application of the guidelines as long as doctors use them with full understanding of their limitations in terms of safety. However, there are cases where special consideration is required; for example, electromagnetic waves that are effective for knee joint treatment are potentially harmful to the eyes. Therefore, the area of exposure to EMFs must be kept at a minimum, and sufficient attention must be paid to leaked EMFs.

(2) Pacemaker wearers

When pacemaker wearers use radio waves, they should follow the instructions of the doctor in charge. The RRPG do not apply to pacemaker wearers.

(3) Metallic implants

Certain cautions must be applied to individuals with metallic implants because there is a possibility of unexpected problems, such as local temperature rise by EMFs, even if they are compliant with the corresponding guidelines.

(4) Wearing metallic items

Certain cautions must be applied to individuals wearing metallic items on their body, especially when they are near an induction heating furnace or similar device because the metal may generate heat by EMFs, even if they are compliant with the corresponding guidelines.

Appendix. Exposure to non-sinusoidal waves

Exposure to non-sinusoidal waves with a frequency range of 10 kHz to 10 MHz can be handled as follows:

At low frequencies, the electric and magnetic fields in particular are most often distorted by harmonic components distributed over a wide frequency range. As a result, the waveforms of the electric and magnetic fields show complex (often pulsed) patterns. It is always possible to decompose such electric and magnetic fields into discrete spectral components, such as by using the Fourier transform, and apply the rules for multiple frequency components described above. This method is based on the assumption that the spectral components are added in the same phase, i.e., all maximum values occur at the same point in time, resulting in a single sharp peak value. This assumption becomes realistic when the number of spectral components is limited and their phases are non-coherent, i.e., they vary randomly. If the phases are coherently fixed, this assumption leads to an overly conservative safety assessment. Moreover, the linear sum of exposure ratios may be artificially increased due to spurious frequencies generated by sampling and the use of window functions in Fourier transform spectral analysis.
As an alternative to the spectral method, a method to calculate the weighted values of the strength of the external electric and magnet fields, induced electric field, and induced current using filter functions related to the basic restrictions or reference level is available (see ICNIRP 2003; Jokela 2000). In the case of electric and magnetic fields with a broad frequency range with harmonic components, the limit imposed by filtering can be mathematically expressed as follows:

$$\left|\sum_i \frac{A_i}{E_{Li}} \cos(2\pi f_i t + \theta_i + \varphi_i)\right| \le 1$$

$$\left|\sum_i \frac{A_i}{E_{L_i}} \cos\left(2\pi f_i t + \theta_i + \varphi_i\right)\right| \le 1$$

where t is time, E_{Li} is the exposure limit at the i-th harmonic frequency f_i, and A_i, θ_i, and φ_i are the amplitude, phase angle, and filter phase shift of the electric and magnetic fields at the i-th harmonic frequency, respectively. Detailed guidance on a practical method of weighting (determination of the weighted peak exposure) can be found in the Appendix of the ICNIRP guidelines: Guidelines for limiting exposure to time-varying electric and magnetic fields (1 Hz to 100 Hz) (2010).