

ENGLISH TRANSLATION

**GUIDELINES FOR THE USE OF
WIRELESS POWER TRANSMISSION/TRANSFER
TECHNOLOGIES**

TECHNICAL REPORT

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Preface

The Broadband Wireless Forum was established on July 3, 2009 to contribute to the sound development of new systems and services utilizing radio waves. The forum has been performing various activities on wireless technologies, such as research, development and investigation of new wireless technology, the collection of information, liaison and coordination with related organizations, and dissemination and awareness-raising activities for the early realization and international expansion of systems and services using new wireless technology. One of the results of these activities, this technical information is compiled and released as a “technical report.”

This technical report is designed to specify a set of guidelines for the “use of wireless power transmission/transfer technologies.” In states where we can expect the early practical application of wireless power transmission/transfer technology due to its steady progress, this report will serve as a guideline that product manufacturers and service providers applying such technology should be referred in order to improve convenience for users and to guarantee the safety of such users.

We hope that these guidelines will be actively utilized by machine manufacturers, service providers, test institutes, and users.

Contents

Section	Page
1. Scope	5
2. Applicable regulations and normative references	6
2.1 Applicable regulations	6
2.2 Normative references	6
3. Definitions	7
4. General requirement	11
5. General requirement for the tests	12
6. Classification	12
7. Marking and instructions	14
8. Conditions for the use	15
8.1 Radio Acts referenced by these guidelines	15
8.1.1 Requirements of high frequency-based equipment covered by these guidelines that do not require permission	15
8.2 Safety measures for equipment or systems using wireless power transmission/transfer technologies	15
8.2.1 Basic safety measurements	16
8.2.2 Safety measures specific to wireless power transmission/transfer	16
8.2.2.1 Identification of reception sides and power transmission restrictions	16
8.2.2.2 Measures to prevent metal pieces located in the path of the power transmission line from overheating	16
8.2.2.3 Measures to prevent metal pieces located at the periphery of the power transmission equipment (transmission equipment) or reception equipment from overheating	17
8.2.2.4 Safety measures to protect any human body that is located in the path, or at the periphery, of the power transmission line	17
8.2.2.5 Safety measures for the case where a non-metal piece is located in the path of the power transmission line	17
8.2.2.6 Safety measures for the location of reception equipment	17
8.2.2.7 Safety measures against abnormal operation during power transmission	18
8.2.3 Safety measures for other types of wireless power transmission/transfer equipment or systems	18
8.2.3.1 Safety measures for a wireless power transmission/transfer technology that operates on microwave technology	18
8.2.3.2 Safety measures for a wireless power transmission/transfer technology that operates	

on coupled electromagnetic field	18
8.3 Conformance to the radio-radiation protection guidelines	18
8.3.1 Principles	18
8.3.2 Evaluation items for electromagnetic field exposure by frequency range	19
8.3.2.1 [Frequency range A] Evaluation items for the electromagnetic field exposure in the frequency range of 10 kHz to 100 kHz	20
8.3.2.2 [Frequency range B] Evaluation items for electromagnetic field exposure in the frequency range of 100 kHz to 10 MHz.....	21
8.3.2.3 [Frequency range C] Evaluation items for the electromagnetic field exposure in the frequency range beyond 10 MHz.....	22
8.3.3 Recommended flowchart for selecting an evaluation method and measurement method.....	23
Annex A (informative) Excerpt from the Radio Act related provisions.....	27
Annex B (informative) Excerpt of related provisions of the Regulations for Enforcement of the Radio Act.....	29
Annex C (informative) Notification of the Ministry of Posts and Telecommunications, No. 301 of 1999.....	31
Annex D (informative) Notification of the Ministry of Posts and Telecommunications, No. 300 of 1999.....	33
Annex E (informative) Safety measures against heat or other causes	42
Annex F (informative) Explanation of radio-radiation protection guidelines	44
Annex G (informative) Examples of exposure calculation	56
Appendix 1. Wireless power transmission beyond 50 W	58
Reference Standards.....	60

GUIDELINES FOR THE USE OF WIRELESS POWER TRANSMISSION/TRANSFER TECHNOLOGIES

1. Scope

These guidelines apply to wireless power transmission/transfer equipment meeting the following performance conditions.

- Transmission power does not exceed 50 W
- Power transmission/transfer distance does not exceed several meters
- Transmission frequencies: 10 kHz to 10 MHz, 13.56 MHz band (ISM band), 27.12 MHz band (ISM band), and 40.68 MHz (ISM band)

There is no restriction on the type of the equipment used or the power transmission/transfer method. Since these guidelines were revised, wireless power transmission/transfer technologies that were different from the performance of the above have been examined or researched/developed, and their standardization is now being considered. These guidelines will be reviewed and amended as required, in accordance with the progress of technical development, institutionalization, and standardization.

Remark 1: When applying these guidelines, note the following.

- In these guidelines, the usage scenes of wireless power transmission/transfer technology are categorized as shown in **Section 6 “Classification.”** In edition 2.0, the guidelines cover the wireless power transmission/transfer technology falling under the usage scene 1 and 2, along with usage scene 5 with a transmission power below 50 W.
- Various discussions are now being conducted concerning other usage scenes as well. Although usage scene 3 and 4, along with usage scene 5 with a transmission power beyond 50 W in **Section 6 “Classification,”** are not covered in the guidelines, Appendix 1 is added as a reference for institutionalization.
- The contents of “8.2 Safety measures for equipment or systems using wireless power transmission/transfer technologies” and “8.3 Conformance to radio-radiation protection guidelines” are applied to the more extensive usage scenes, in addition to usage scene 1 and 2, along with the usage scene 5 that falls under the category of transmission power below 50 W.
- These guidelines are stipulated so that they conform to laws and regulations in Japan as of the time of this writing. At the same time, they assume that the use of wireless power transmission/transfer technologies is widely extended at home and abroad.
- In countries other than Japan, additional requirements may be imposed by their regulating authorities.

Remark 2: These guidelines do not apply to the following devices, falling under the category of “Inductive reading and writing radio communication equipment” and “Mobile object-identifying radio communication equipment ” in the current *Radio Act*.

- Contactless IC card readers/writers
- Passive RFID interrogators

2. Applicable regulations and normative references

2.1 Applicable regulations

The following rules (laws) apply to the wireless power transmission/transfer covered by these guidelines. If there is any difference in interpretation between these guidelines and the following rules (laws), the interpretation of the following rules (laws) takes precedence over these guidelines.

[1] Radio Act (Law No. 131 of May 2, 1950) (See Annex A.)

[2] Regulations for Enforcement of the Radio Act (Radio Regulatory Commission Rules No. 14 of November 30, 1950) (See Annex B.)

[3] The strength of the radio wave in frequencies between more than 10 kHz and 100 kHz or less and the strength of the radio wave when the human body is exposed to the radio wave inhomogeneously, pursuant to the rule of the Regulations for Enforcement of the Radio Act, Appended Table 2, 2-2, Note 3 (Notification of the Ministry of Posts and Telecommunications, Number 301 of April 27, 1999) (See Annex C.)

[4] The methods of calculating and measuring the strength of the radio wave that is emitted from the radio equipment, pursuant to the rule of the Regulations for Enforcement of the Radio Act, Article 21, Paragraph 3, Item 2 (Notification of the Ministry of Posts and Telecommunications, Number 300 of April 27, 1999) (See Annex D.)

2.2 Normative references

The following standards contain provisions which, through reference in these guidelines, constitute part of the provisions of these guidelines. If the indication of the year of coming into effect or the year of publication is given to these referred standards, only the edition of the indicated year constitutes the provision of these guidelines, and the revision and amendment made thereafter do not apply. The normative references without the indication of the year of coming into effect or the year of publication apply only to the most recent edition (including amendments).

[5] Radio-radiation Protection Guidelines (Report of the Telecommunications Technology Council of the Ministry of Posts and Telecommunications [June 1990]: Inquiry No. 38 “Human Body Protection Guidelines for the Use of Radio Waves”)

[6] Radio-radiation Protection Guidelines (Report of the Telecommunications Technology Council of the Ministry of Posts and Telecommunications [April 1997]: Inquiry No. 89 “Method of Protecting

Human Bodies for the Use of Radio Waves”)

- [7] ICNIRP Guidelines for limiting exposure to time-varying electric, magnetic, and electromagnetic fields (up to 300 GHz)
- [8] IEEE std C95.1-2005: IEEE Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz.
- [9] IEC 62311: Assessment of electronic and electrical equipment related to human exposure restrictions for electromagnetic fields (0 Hz - 300 GHz).
- [10] IEC 62233: Measurement methods for electromagnetic fields of household appliances and similar apparatus with regard to human exposure.
- [11] IEC 60990 Ed. 2.0:1999 (b) Methods of measurement of touch current and protective conductor current
- [12] IEC 60335-1 Household and similar electrical appliances - Safety - Part 1: General requirements
- [13] IEC 60950-1: Information technology equipment - Safety - Part 1: General requirements

3. Definitions

The definitions of the main terms used in these guidelines are shown below.

- 3.1. Wireless power transmission/transfer:** Transmitting/Transferring and receiving electric energy among two or more pieces of equipment that are not connected through conductors by electromagnetic means
- 3.2. Transmitted/Transferred power:** Power transmitted/transferred from the power transmission/transfer side in a wireless power transmission/transfer
- 3.3. Power transmission/transfer distance:** In wireless power transmission/transfer, the distance between the center of a coil or another component that generates an electromagnetic field and the center of the component that receives the electromagnetic field; if the component is covered with resin or other material, it may mean the distance between their surfaces.
- 3.4. Type of power transmission/transfer:** The way of generating an electromagnetic field for power transmission/transfer and the method of combining the transmission and reception sides in wireless power transmission/transfer; the types include electromagnetic induction type, magnetic resonance type, electric resonance type, and radio emission type.
- 3.5. Transmission frequency:** In wireless power transmission/transfer, the frequency of the electromagnetic field that transmits/transfers electric energy; there are cases where information transmission is performed between transmission and reception sides with a frequency that is different.
- 3.6. Industrial, Scientific, and Medical band:** Frequency bands for industrial, scientific, and medical purposes stipulated in the Radio Regulations of the Constitution of International

Telecommunication Union; note that some of the frequency bands that are not applicable in Japan.

- 3.7. High frequency-based equipment:** Specific equipment using a high-frequency current of 10 kHz or more, which is stipulated in Radio Act, Article 100, Paragraph 1
- 3.8. Inductive radio communication equipment:** Equipment that performs communication by using induced radio waves generated by flowing a high-frequency current of 10 kHz or more into a power line
- 3.9. Transmission side:** In wireless power transmission/transfer, the side of transmitting /transferring power
- 3.10. Reception side:** In wireless power transmission/transfer, the side of receiving power
- 3.11. Temperature rise limit:** Allowable limit value specified in these guidelines concerning the temperature rise that occurs on the surface and periphery of the equipment and on the surface of alien substances inserted into the equipment during the operation of the equipment; the reference value of the temperature rise is set to 25°C.
- 3.12. Alien substance:** A substance that is not necessary for power transmission/transfer but is accidentally inserted between the transmission and reception sides
- 3.13. Test piece:** A metal piece with a shape defined for a test, particularly assumed as a metallic alien substance
- 3.14. Coil:** A coil for transmitting/transferring or receiving power in the transmission or reception side in wireless power transmission/transfer; in these guidelines, an electrode having a shape other than a coil, a transmission antenna, and a receiving antenna used for the same purpose are also treated as equivalent to a coil. If a coil is built into the equipment, the coil may not be able to be recognized from the outside. Therefore, when applying these guidelines, it may be necessary to check the position of the coil by using certain measures.
- 3.15. Coil plane:** Of the planes perpendicular to the coil axis, the part that includes the center point of the coil shape and to which the circumference of the coil is projected vertically is the coil plane. If the coil is not exposed on the equipment, the entire plane perpendicular to the coil axis, out of the surface of the equipment containing the coil, is treated as the coil plane.
- 3.16. Radio-radiation protection guidelines:** Recommended guidelines used when a person uses radio waves and whose body is exposed to an electromagnetic field (in a frequency range of 10 kHz through 300 GHz) to ensure that the electromagnetic field is safe without producing an unnecessary biological effect on the human body; these guidelines consist of numeric values related to electromagnetic strength, the method of evaluating the electromagnetic field, and the protection method to reduce electromagnetic field irradiation. [5]
- 3.17. Basic guidelines:** Guidelines for evaluating the safety of the human body based on various biological effects (body-core temperature elevation, current stimulation, high-frequency burns,

etc.), which may occur to the human body when it is exposed to an electromagnetic field; it is positioned as the basis of the concept of the Radio-radiation Protection Guidelines and described in SAR, induced current, and contact current. [5]

3.18. Administrative guidelines: Guidelines used for actual evaluation indicated by the actual measurable physical amount in order to meet the basic guidelines (electric field strength, magnetic field strength, power density, current, and specific absorption rate), and the guidelines consist of electromagnetic field strength guidelines, supplementary guidelines, and partial body absorption guidelines. [5]

3.19. Electromagnetic field strength guidelines: Guidelines for evaluating the safety of the target space from the standpoints of the electric field strength, magnetic field strength, and power density; if the radiation source is located at a sufficiently distant location and if there is no metal or other object that scatters radio waves at a place close to the space in which the human body exists, it can be assumed that the electromagnetic phenomenon inside the human body in the space bears an almost constant relation to the electric field strength and the magnetic field strength measured when the human body does not exist in said space. Under such a condition, protection guidelines can be set by using the electromagnetic field strength in a space in which no human body exists. This guideline is called the electromagnetic field strength guideline. Because the electromagnetic field covered by the protection guideline is usually a near field or an inhomogeneous place, the electromagnetic field strength guideline cannot apply as it is in many states. In an electromagnetic environment that does not meet such conditions, there are cases where evaluation only of the space is not appropriate. In this case, it is necessary to return to the basic guidelines when performing an evaluation. [5]

3.20. Supplementary guidelines: Guidelines used to perform a detailed evaluation based on the basic guidelines when the electromagnetic field strength guidelines are not met; if the state exposed to the electromagnetic field (e.g., inhomogeneous, partial, or surface exposure), target biological effects (contact current and induced current), and the attribute of the radio wave-emitting source (antenna power and frequency band) are obvious, guidelines are shown based on these states in a form such that the application of the electromagnetic field strength guidelines is relaxed or excluded. In addition, because the basic guidelines contain descriptions using immeasurable amounts, they cannot be used as practical protection guidelines if an attempt is made to evaluate all the inter-relationships between the electromagnetic radiation source and the human body based on the basic guidelines. To practically cope with this problem, it is necessary to establish guidelines with measurable evaluation amounts. These guidelines are called the supplementary guidelines. The supplementary guidelines are provided in the form of supplementing the electromagnetic field strength guidelines based on the basic guidelines, and they include:

- (1) Guidelines for when the human body is exposed to an electromagnetic field inhomogeneously or partially;
- (2) Guidelines concerning the contact current; and
- (3) Guidelines concerning induced ankle current.

The supplementary guidelines have the character of a simplified evaluation method for the electromagnetic phenomenon inside the human body, as an alternative to the basic guidelines. Therefore, it is necessary to bear in mind that they should originally be handled as basic guidelines. [6]

3.21. Partial body absorption guidelines: These guidelines are used to perform detailed evaluation based on the basic guidelines when a part of the human body is intensively exposed to an electromagnetic field due to electromagnetic waves mainly emitted from radio equipment that is used at a place quite near to the human body. [6]

3.22. Controlled environment: An environment in which a state where the human body is exposed to an electromagnetic field is recognized, the radiation source of the radio wave can be identified, and control appropriate to the state can be performed. [6]

3.23. General environment: A case (environment) in which a state where the human body is exposed to an electromagnetic field cannot be recognized, appropriate control cannot be expected, and uncertain factors exist; for example, the state where residents are exposed to the electromagnetic field in general residential environment falls under this case. Therefore, the guidelines applied to the general environment are stricter than those applied to the controlled environment. [5]

3.24. Homogeneous exposure: Exposure of the whole human body to an electromagnetic field of a space in which the human body exists in states where the electromagnetic field of the space can be regarded as almost homogeneous; in this case, the condition where the free space impedance is less than $120 \pi [\Omega]$ is also included in this category. In a free space, the electromagnetic field is considered to be homogeneous if the distance from the wave source is sufficiently great compared with the body height. (For example, 15 m or more in a frequency of 0.3 MHz or less, 10 m or more in a frequency of 0.3 MHz to 300 MHz, and 5 m or more in a frequency of 300 MHz or more). [5]

3.25. Inhomogeneous exposure: A case where the exposure is not regarded as homogeneous exposure [5]

3.26. Partial body exposure: A case where a part of the human body is intensively exposed to an electromagnetic field; it includes irradiation at a place quite near to an antenna that is much smaller than the human body and spot irradiation due to radio waves with a short wavelength. [5]

3.27. Whole body exposure: A case where the whole body, rather than only part of a body, is

exposed to an electromagnetic field; the case where exposure is not partial though exposure is not necessarily homogeneous falls under this category. [5]

- 3.28. Averaging duration:** Time for measurement set based on the noted biological effect in order to evaluate the conformity to the guideline value; the average time used in Radio-radiation Protection Guidelines is one second or less in stimulant action and six minutes in thermal action. [5]
- 3.29. Specific Absorption Rate (SAR):** Energy amount that is absorbed in unit time by the tissue of unit mass when a biological body is exposed to an electromagnetic field; the SAR that is averaged throughout the body is called the “whole-body average SAR,” and the SAR that is averaged for 1 g or 10 g of any tissue of the human body is called the “local average SAR.” [6]
- 3.30. Contact current:** A current that flows through the contact point when the grounded human body touches the non-grounded conductive substance placed in the electromagnetic field [5]
- 3.31. Contact hazard:** A potential state that generates a contact current [5]
- 3.32. Induced current (density):** A current (density) that is induced into the human body when the human body is exposed to an electromagnetic field [5]
- 3.33. Ungrounded condition:** A condition in which the influence of the ground can be ignored because the induced current does not flow into the ground; for bare feet, for example, this condition applies when the feet are 10 cm or more apart from the ground [5]
- 3.34. Far field:** An electromagnetic field in conditions where the distance from the electromagnetic wave source is farther than both $2 D^2/\lambda$ and $\lambda/2\pi$ and where there is no reflection and scattering; where, D denotes the maximum size of the antenna and λ denotes the wavelength of the free space. [5]
- 3.35. Near field:** An electromagnetic field that is not a far field [5]
- 3.36. Electromagnetic field probe (sensor):** An antenna system with isotropy and broadband characteristics given by placing a physically small dipole antenna or loop antenna orthogonally to the two or three axes, as well as with improved interference characteristics by using a high-resistance line; it is mainly used for isotropic broadband electromagnetic field strength meters. [5]
- 3.37. Isotropy:** A characteristic of a probe (or antenna) in which sensitivity is not dependent on the incident direction of electromagnetic waves [5]

4. General requirement

The equipment to which these guidelines apply should conform to the laws and rules of the country in which the equipment is used and should have a structure that functions in a safe manner so that it does not do harm to the human body and the environment—even during the carelessness that often occurs in normal use.

This principle is accomplished by meeting the requirements related to these guidelines, and whether the requirements are met is checked by conducting all the related tests.

5. General requirement for the tests

Tests should be conducted in accordance with the laws and rules of the country in which the equipment is used, if any. If there are no such laws or rules, tests should be conducted in accordance with the international standards such as IEC or another appropriate domestic standards (JIS in Japan), unless otherwise specified in the guidelines.

6. Classification

In these guidelines, equipment using wireless power transmission/transfer technology is classified into several types of usage scenes as shown in Table 6-1. These guidelines apply to the equipment falling under the usage scene 1 and 2, along with usage scene 5 with a transmission power below 50 W.

Table 6-1: Wireless power transmission/transfer technology usage scenes

Usage scene	Assumed usage scene	Concrete application examples	Specifications and functions of the usage scene
Usage scene 1	Close proximity wireless power transmission of household digital appliances, etc., for home and outdoor use	Wireless power supplies and wireless charging for the following: (1) Cellular phones, smartphones (2) Notebook PCs, tablet PCs (3) Wall TVs, portable TVs (4) Digital still cameras, video cameras (5) Portable music players (6) Audio equipment (speakers, headphones, etc.) (7) Lighting equipment (8) Industrial equipment (9) Medical equipment, health care equipment (10) Game instruments, toys (11) On-board equipment (12) Business equipment	(1) Frequency: 10 kHz to 10 MHz, ISM band, (13 MHz, 27 MHz, 40 MHz) (2) Transmission power: Up to 50 W (3) Power transmission distance: Up to about 10 cm
Usage scene 2	Low-power wireless power transmission of household digital appliances, etc., for home and outdoor use	Wireless power supplies and wireless charging for the following: (1) Cellular phones, smartphones (2) Notebook PC, tablet PCs (3) Wall TVs, portable TVs (4) Digital still cameras, video cameras (5) Portable music players (6) Audio equipment (speakers, headphones, etc.) (7) Lighting equipment (8) Industrial equipment (9) Medical equipment, health care equipment (10) Game instruments, toys (11) On-board equipment (12) Business equipment	(1) Frequency: 10 kHz to 10 MHz, ISM band, (13 MHz, 27 MHz, 40 MHz) (2) Transmission power: Up to 50 W (3) Power transmission distance: Up to several meters
Usage scene 3	Medium-power wireless transmission of household electrical appliances, etc., for home and outdoor use	Wireless power supplies and wireless charging for the following: (1) Floor-standing household electrical appliances (refrigerators, washing machines, air conditioners) (2) Household electrical heating appliances (dryers, irons, rice cookers, hot plates, etc.) (3) Vacuum cleaners, etc. (4) AV household electrical appliances (large TVs, etc.) (5) Hairdressing equipment (6) High-output lighting equipment (7) Electric carts, two-wheeled electric vehicles	(1) Frequency: 10 kHz to 10 MHz, ISM band, (13 MHz, 27 MHz, 40 MHz) (2) Transmission power: 50 to several kW (3) Power transmission distance: Up to several 10s of centimeters

Usage scene 4	High-power wireless power transmission	(1) Wireless power supplies and wireless charging for electric vehicles (including plug-in hybrid cars)	(1) Frequency: 20 kHz to 150 MHz (2) Transmission power: 1 kW to several 10s of kW (3) Power transmission distance: Up to about 30 cm
		(2) Wireless power supplies and wireless charging for trams (streetcars), etc. (3) Industrial applied equipment (for factories, etc.)	(1) Frequency: Several kilohertz to several hundreds of kilohertz (2) Transmission power: Several kilowatts to several 10s of kilowatts (3) Power transmission distance: Up to about 30 cm
Usage scene 5	Various wireless power transmission that operates using microwaves	(1) Wireless power supplies for wireless sensors (for environmental monitoring, etc.) (2) Lighting equipment (3) Wireless power supplies to areas where power line installation is difficult	(1) Frequency: ISM band (2.4-GHz band, 5.8-GHz band, 24-GHz band) (2) Transmission power: Up to 1 kW (3) Power transmission distance: Up to about 1 km
		(4) Wireless power supplies for portable equipment (smartphones, Tablet PCs, etc.)	(1) Frequency: ISM band (2.4-GHz band, 5.8-GHz band) (2) Transmission power: Up to 50 W (3) Power transmission distance: Less than about 1 cm (almost contacting)
		(5) Shared use of wireless power transmission and high-speed wireless communication using wireless communication repeaters	(1) Frequency: ISM band (5.8-GHz band, 24-GHz band), 60-GHz band, unused frequency band among the range of 31.5 GHz to 54.25 GHz (2) Transmission power: Up to 50 W (3) Power transmission distance: Up to about 5 m
		(6) Wireless power supplies and wireless charging for electric vehicles (including plug-in hybrid cars)	(1) Frequency: ISM band (5.8-GHz band, 24-GHz band), unused frequency band among the range of 31.5 GHz to 54.25 GHz (2) Transmission power: 500 W–6 kW (3) Power transmission distance: About 2 m to 9 m

7. Marking and instructions

Manufacturers or distributors who apply these guidelines can describe the conformity to these

guidelines on their appliances or user manuals after confirming that these appliances conform to these guidelines.

8. Conditions for the use

8.1 Radio Acts referenced by these guidelines

In the present act, the high frequency-based equipment that requires permission to install the equipment is stipulated in the Radio Act, Article 100, Paragraph 1. (See Annex A.) These guidelines apply to the equipment that is exempt from the regulations of the Radio Act, conforming to the requirements of the high frequency-based equipment that do not require permission.

8.1.1 Requirements of high frequency-based equipment covered by these guidelines that do not require permission

In the regulations of the present Radio Act-related rules, the requirements of Paragraph 8.1 exemptions are met in any of the following cases.

- High frequency-based equipment other than communications equipment, in which the high-frequency energy is 50 W or less (interpretation from Regulations for Enforcement of the Radio Act, Article 45, Paragraph 3) (See Annex B.)
- Inductive radio communication equipment (which refers to equipment that performs communication by using an inductive radio wave that is generated by flowing a high-frequency current of 10 kHz or more into a power line), in which the electric field strength at a distance of $\lambda/2\pi$ (where, λ is the wavelength of the carrier wave in meters and π is the circular constant) is 15 $\mu\text{V}/\text{m}$ or less (Regulations for Enforcement of the Radio Act, Article 44, Paragraph 1, Item 2-(1)) (See Annex B.)

Even if the above requirements are met, if the equipment causes continuous and serious trouble to the functions of other radio equipment, the Minister for Internal Affairs and Communications can order the taking of necessary action to remove the trouble (Radio Act, Article 82, Paragraph 1, which is applied mutatis mutandis pursuant to the Radio Act, Article 101). (See Annex A.) Therefore, it is necessary to give consideration so that the equipment does not cause trouble for other radio equipment.

8.2 Safety measures for equipment or systems using wireless power transmission/transfer technologies

The wireless power transmission/transfer equipment or systems covered by these guidelines must deploy safety measures as follows.

8.2.1 Basic safety measurements

The equipment or systems using wireless power transmission/transfer technologies are essentially appliances for transmitting/transferring or receiving power. The wireless power transmission/transfer equipment therefore must have the same safety features as electrical products.

Most electrical products are required to implement safety features conforming to the IEC 60335 “Household and similar electrical appliances – Safety –” to ensure a minimum level of safety for users. In a similar way, wireless power transmission/transfer equipment or systems must basically meet and implement the safety requirements specified in IEC 60335 or IEC 60950 “Information Technology Equipment – Safety –.”

For the product and safety standard of electrical vehicles, which are not covered in the present guidelines, a standardization discussion is now being conducted, based on the “4. Standardization trend” in Appendix 1 “Wireless power transmission/transfer at higher than 50 watts.” When the guidelines are revised to have electrical vehicles covered by them, referring to the appendix above will be considered.

8.2.2 Safety measures specific to wireless power transmission/transfer

Equipment or systems using wireless power transmission/transfer technologies, which employ technologies different from those used for typical electrical products, are required to implement safety or hazard-avoidance measures specific to them.

The safety measures required for wireless power transmission/transfer equipment or systems are as follows.

8.2.2.1 Identification of reception sides and power transmission restrictions

Power transmission/transfer equipment (transmission equipment) shall be equipped with the ability to identify reception sides (reception equipment) and transmit power safely. When reception equipment cannot be identified, transmission equipment shall not transmit power. Any identification method can be employed.

When equipment fails to transmit power appropriately, it is not allowed to transmit power even though reception sides can be identified.

8.2.2.2 Measures to prevent metal pieces located in the path of the power transmission line from overheating

In a wireless power transmission/transfer technology where a metal piece that is located on the path of the power transmission line is subject to overheating, the upper limit of the temperature that the metal piece is allowed to reach shall conform to the IEC 60335. Also, take safety measures against possible overheating. Such safety measures include a metal detection ability to prevent the risk of

overheating, or an ability to stop power transmission when the overheating of a metal piece could occur.

For the method of measuring the temperature rise of a metal piece located in the path of the power line to prevent overheating, see Annex E.

8.2.2.3 Measures to prevent metal pieces located at the periphery of the power transmission equipment (transmission equipment) or reception equipment from overheating

With the method with which an electromagnetic field is generated at the periphery of the power transmission equipment (transmission equipment) or reception equipment, take safety measures so that any metal piece located in that area will not be overheated.

8.2.2.4 Safety measures to protect any human body that is located in the path, or at the periphery, of the power transmission line

In the case where wireless power transmission/transfer equipment or systems are under normal use and when all or part of a human body is located in the path, or at the periphery, of the power transmission line, safety measures shall be taken so that the human body protection guidelines in the *Radio Act* or the international guidelines (described in section 8.3 in the present guidelines) are satisfied. Any wireless power transmission/transfer equipment or system mentioned above to which all or part of a human body may come close shall be equipped with the ability to notify users that the protection guidelines are exceeded, stop the power transmission after detecting an abnormal condition, or decrease the power transmission output.

8.2.2.5 Safety measures for the case where a non-metal piece is located in the path of the power transmission line

In the case where a non-metal piece located in the path of the power transmission line causes abnormal power transmission, resulting in an irregular leakage electromagnetic field, the wireless power transmission/transfer equipment or system shall be equipped with the ability to stop the power transmission or decrease the power transmission output after detecting an abnormal condition.

8.2.2.6 Safety measures for the location of reception equipment

In the case where the transmission and reception equipment is limited in location during power transmission, the wireless power transmission/transfer equipment or system shall be equipped with the ability to stop the power transmission when its location is out of the scope of the design specifications, which could lead to an irregular leakage electromagnetic field stronger than the one produced in normal use.

8.2.2.7 Safety measures against abnormal operation during power transmission

In the case where an abnormal operation out of the scope of the design specifications, such as increased power load beyond specifications, is caused due to an abnormal condition or a failure of the transmission or reception equipment during power transmission, the wireless power transmission/transfer equipment or system shall be equipped with the ability to stop the power transmission or decrease the power transmission output.

8.2.3 Safety measures for other types of wireless power transmission/transfer equipment or systems

The wireless power transmission/transfer methods other than that said above that require a specific safety measure are as follows.

8.2.3.1 Safety measures for a wireless power transmission/transfer technology that operates on microwave technology

The following safety measures shall be implemented besides the ones specified from section 8.2.2.1 to section 8.2.2.7.

In the case where a human body is located between the transmitting antenna and the receiving antenna, affecting power transmission, safety or risk-avoidance measures shall be taken for the detection of the human body, intrusion prevention, or the structure that prevents the human body from intruding.

Also some countermeasures have to be taken to prevent a side lobe leakage, which is caused on the path between the transmitting antenna and the receiving antenna, from becoming higher than the level specified in the design specifications.

8.2.3.2 Safety measures for a wireless power transmission/transfer technology that operates on coupled electromagnetic field

In a wireless power transmission/transfer technology that operates on a coupled electromagnetic field, the human body could make contact with a component of the equipment, causing an electrical shock. The equipment therefore is required to implement safety measures to prevent human body contact and to stop the power transmission when such contact is detected.

8.3 Considerations for the radio-radiation protection guidelines

8.3.1 Principles

For the equipment to which these guidelines apply, it is necessary to verify that the electromagnetic field generated by the equipment does not do harm to the biological body during normal use status and to the environment by using a scientific evaluation method such as by measurement.

In Japan, the equipment should in principle follow the Radio-radiation Protection Guidelines reported by the Telecommunications Technology Council of the former Ministry of Posts and Telecommunications (the present Ministry of Internal Affairs and Communications).

Internationally, on the other hand, the ICNIRP (International Commission on Non-Ionizing Radiation Protection) guidelines and ICES (International Committee on Electromagnetic Safety) of the IEEE (Institute of Electrical and Electronics Engineers) standards are referred to as the authoritative guidelines, the latest editions of which are followed in the present guidelines as required.

Note: The radio-radiation protection guidelines set by the Japanese government, ICNIRP, and IEEE are hereinafter referred to as the “domestic guidelines,” “ICNIRP guidelines,” and “IEEE guidelines,” respectively. Also, the excerpts of those guidelines are attached as Annex F for reference.

8.3.2 Evaluation category for electromagnetic field exposure by frequency range

The effects of electromagnetic field exposure vary with frequency range. Therefore, for each frequency range, the guideline values, evaluation method, and measurement method to be applied should be defined. Also, a wide variety of implementations in wireless power transmission/transfer equipment and many different cases regarding the distance between the equipment and the human body make it difficult to narrow down evaluation or measurement methods into a single specific one. The present guidelines thus provide a procedure for selecting an appropriate one from the several methods available for each frequency range. Users of the guidelines should select an evaluation or measurement method that they think is appropriate and should evaluate the effect under a condition expected in normal use. The evaluation method, the measurement method, and the evaluation conditions employed should be pointed out explicitly in the resulting data.

Note: The frequency range classification shown below is in accordance with the domestic guidelines and the ICNIRP guidelines. The IEEE guidelines use a frequency range classification different from the one shown here. For details, see Annex F.

Table 8.3.2: Evaluation category for electromagnetic field exposure classified by frequency range

Usage scenes	Usage scene 1 and 2			Usage scene 3			Usage scene 4 (1) Electric vehicles	
Frequency range	A	B	C	A	B	C	A	B
Transmission power	Up to 50 W			50 W to several kilowatts			1 kW to several 10s of kW	

Transmission distance		Up to several meters		Up to about several 10s of centimeters		Up to about 30 cm	
Evaluation categories	Stimulant effect	(1)		(1)		(5)	
	Thermal effect	(2)	(3)	(2)	(3)	(6)	(7)
	Contact current	(4)		(4)		(8)	
	Induced current		(9)		(9)		(9)

A, B, and C represent the following ranges of frequency, respectively.

Frequency range A 10 kHz–100 kHz

Frequency range B 100 kHz–10 MHz

Frequency range C 13.56 MHz, 27.12 MHz, 40.67 MHz

Most peripheral electromagnetic fields generated by wireless power transmission equipment provide the case where the electromagnetic field is inhomogeneous or where the human body is exposed to the electromagnetic field only partially. While keeping this fact in mind, the evaluation items for electromagnetic field exposure by frequency range are described as follows.

8.3.2.1 [Frequency range A] Evaluation categories for the electromagnetic field exposure in the frequency range of 10 kHz to 100 kHz

- (1) Categories related to stimulant effect ((1) and (5))

In the domestic guidelines, reference values are provided in the electromagnetic field strength as a measurable administrative guideline.

Table F-1 in Annex F shows the spatial averages of the electric field and magnetic field in terms of stimulant effect, with the average time of less than one second.

In the case where the electromagnetic field is inhomogeneous or the human body is partially exposed to an electromagnetic field, in the space more than 20 cm away from the electromagnetic radiation source and metal substance, the spatial average of the power density distribution in the entire area corresponding to the space that the human body occupies (for the electric field strength and magnetic field strength, their root mean square value) shall be less than the guideline value of the electromagnetic field strength.

Note that for the equipment used in the space within 20 cm of the human body, a decision on a

case-by-case basis is required. If it is anticipated that the basic guideline values can be exceeded, an evaluation based on the basic guidelines is recommended.

In the ICNIRP guidelines for the low-frequency range, which was revised in 2010, only the values associated with stimulant effect are defined for this frequency range. Table F-3 shows the measurable reference levels.

For an extremely localized radiation source located within a few centimeters of the human body, determine the induced electrical field through an individual evaluation of the exposure. When the radiation source is more than 20 cm away from the human body, the spatial average of the electric field and magnetic field can be obtained, even though the electromagnetic field is inhomogeneous. The amount of localized exposure is allowed to exceed the reference level but not the basic guideline values.

(2) Categories related to thermal action ((2) and (6))

In the domestic guidelines, the guideline values for thermal effect are also defined, which is shown in Table F-2.

This means that, in the domestic guidelines, both stimulant effect and thermal effect have to be taken into account in this frequency range.

In the ICNIRP guidelines, no guideline values for thermal action are defined for this frequency range.

(3) Categories related to contact current ((4) and (8))

Both in the domestic guidelines and the ICNIRP guidelines, contact current is required to be evaluated in this frequency range.

In the domestic guidelines, the guideline values for contact current are provided in the frequency range of 10 kHz to 15 MHz. Also, when the emission source is within 20 cm of the human body, contact current is defined in the frequency range of 100 kHz to 100 MHz as the partial body absorption guidelines, when a contact hazard cannot be prevented.

In the ICNIRP guidelines, reference values for the contact current are defined in the frequency range of 2.5 kHz to 10 MHz.

In the IEEE guidelines, they are defined in the frequency range of 3 kHz to 110 MHz.

8.3.2.2 [Frequency range B] Evaluation items for electromagnetic field exposure in the frequency range of 100 kHz to 10 MHz

(1) Categories related to stimulant effect ((1) and (5))

In the ICNIRP guidelines for the low-frequency range, which were revised 2010, the reference values for the stimulant effect is defined also for this frequency range. In the domestic guidelines, no reference values for the stimulant action are defined for this frequency range (See Table F-3).

This means that, in the ICNIRP guidelines for the low-frequency range, which were revised in 2010, both stimulant effect and thermal effect have to be taken into account in this frequency range.

(2) Categories related to thermal action ((3) and (7))

In the domestic and ICNIRP guidelines, the reference values for thermal effect are defined, which are shown in Table F-2 and Table F-3, respectively.

For the evaluation method and measurement method for this frequency range, IEC 62311 should be referred to.

(3) Items related to contact current ((4) and (8))

Both in the domestic guidelines and the ICNIRP guidelines, contact current is required to be evaluated in this frequency range.

In the domestic guidelines, the guideline values for contact current are provided in the frequency range of 10 kHz to 15 MHz. Also, when the radiation source is within 20 cm of the human body, contact current is defined in the frequency range of 100 kHz to 100 MHz as the partial body absorption guidelines, when contact hazard cannot be prevented.

In the ICNIRP guidelines, guideline values for the contact current are defined in the frequency range of 2.5 kHz to 10 MHz. In the IEEE guidelines, they are defined in the frequency range of 3 kHz to 110 MHz.

(4) Items related to induced current (9)

Both in the domestic guidelines and the ICNIRP guidelines, induced current is required to be evaluated in this frequency range.

In the domestic guidelines, the guideline values for induced ankle current are provided in the frequency range of 3 MHz to 300 MHz.

In the ICNIRP guidelines in ICNIRP1998, the guideline values for the induced current in extremities are defined in the frequency range of 10 MHz to 110 MHz.

8.3.2.3 [Frequency range C] Evaluation items for the electromagnetic field exposure in the

frequency range above 10 MHz

(1) Items related to thermal effect (3)

In the domestic and ICNIRP guidelines, the guideline values for thermal effect are defined, which are shown in Table F-2 and Table F-3, respectively.

In ICNIRP1998, the reference levels (of electrical field strength, magnetic field strength, magnetic flux density, equivalent plane wave power density) are defined based on the basic limits of the whole-body average SAR in the frequency range equal to or higher than 10 MHz. The spatial average value of the entire body exposed to the electromagnetic field is evaluated. In a localized exposure, the measured SAR values shall not exceed the local average SAR.

(2) Items related to contact current (4)

Both in the domestic guidelines and the ICNIRP guidelines, contact current is required to be evaluated in this frequency range.

In the domestic guidelines, the guideline values for contact current are provided in the frequency range of 10 kHz to 15 MHz. Also, when the emission source is within 20 cm of the human body, the guideline values for contact current are defined in the frequency range of 100 kHz to 100 MHz as the partial body absorption guidelines, when contact hazard cannot be prevented.

In the ICNIRP guidelines, guideline values concerning the contact current are defined in the frequency range of 2.5 kHz to 10 MHz. In the IEEE guidelines, they are defined in the frequency range of 3 kHz to 110 MHz.

(3) Items related to induced current (9)

Both in the domestic guidelines and the ICNIRP guidelines, induced current is required to be evaluated in this frequency range.

In the domestic guidelines, the guideline values for induced ankle current are provided in the frequency range of 3 MHz to 300 MHz.

In the ICNIRP guidelines in ICNIRP1998, the guideline values for the induced current in extremities are defined in the frequency range of 10 MHz to 110 MHz.

8.3.3 Recommended flowchart for selecting an evaluation method and measurement method

The procedure for the evaluation of the electromagnetic field exposure is as follows.

- (1) Determine the guidelines to be applied. (Domestic guidelines, ICNIRP guidelines, etc.)

- (2) When the domestic guidelines are applied, evaluate the exposure based on the notification of the Ministry of Posts and Telecommunications, No. 300 of 1999, shown in Annex D.

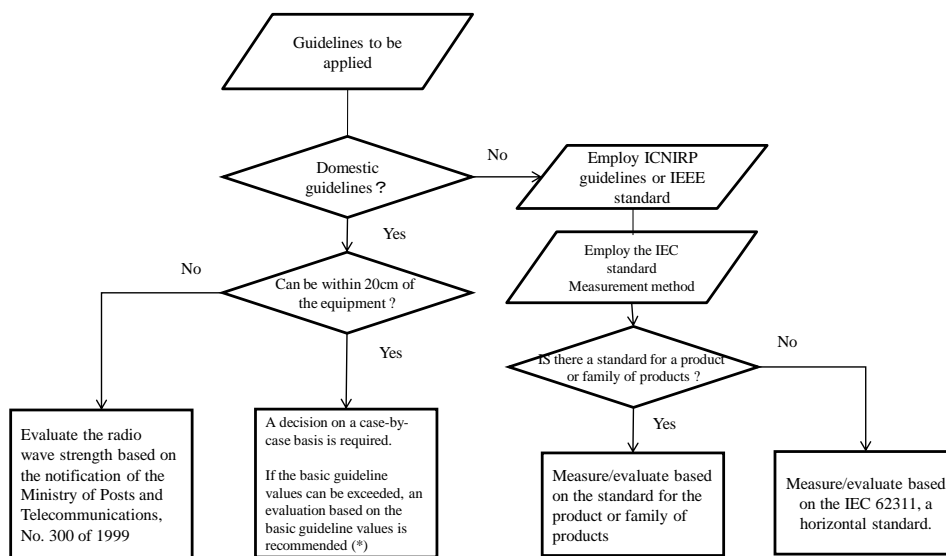
In the case where the human body could be within 20 cm of the equipment, follow the next procedure. A decision on a case-by-case basis is required.

- (2-a) First, evaluate the maximum electromagnetic field strength in the space that the human body occupies when it approaches nearest to the equipment. If the value does not exceed the electromagnetic field strength guideline, it is determined to be compliance.

- (2-b) If the electromagnetic field strength guideline is exceeded in any points in the area, employ the IEC 62311 evaluation method.

- (3) When the ICNIRP guideline is applied and the product or the family of products is covered by the standard measurement methods from IEC, employ that method. If they are not covered by the standard measurement methods from IEC, employ the IEC 62311, a horizontal standard.

The flowchart of the above procedure is shown in Figure 8.3.3-1.



* Since specific guideline values are not provided, refer to the IEC 62311, etc.

IEC 62233
 IEC 62209-2
 (IEC PT61980), etc.

Fig 8.3.3-1. Flowchart for selecting an evaluation method and measurement method (1)

Note:

- (1) IEC 62233: Measurement methods for the electromagnetic fields of household appliances and similar apparatus with regard to human exposure
- (2) IEC 62209-2 : Human Exposure to Radio Frequency Fields from Handheld and Body-Mounted Wireless Communication Devices – Human Models, Instrumentation, and Procedures – Part 2: Procedure to determine the specific absorption rate (SAR) for wireless communication devices used in close proximity to the human body (frequency range of 30 MHz to 6 GHz).
- (3) IEC PT61980: Electric vehicle wireless power transfer systems (draft)

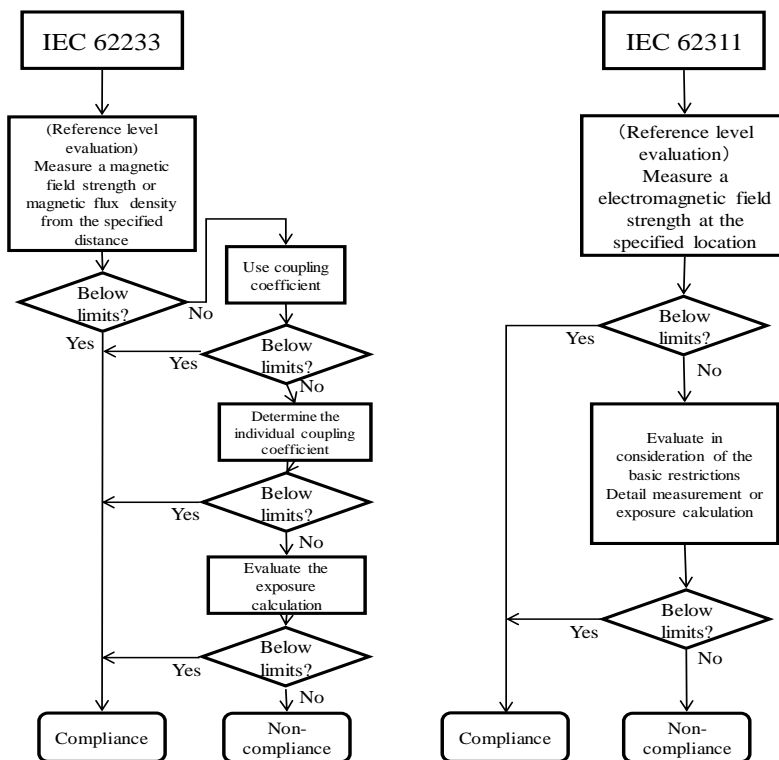


Fig 8.3.3-2. Flowchart for selecting an evaluation method and a measurement method (2)

As an example of the IEC standard for a product family, the flowchart for IEC 62233, which defines an exposure evaluation method for household electrical appliances, and IEC 62311, which is a product horizontal standard, are shown in Figure 8.3.3-2. For details, see the respective references.

For the case in which the evaluation of the electromagnetic field exposure considering the basic restrictions is required, various procedures are proposed, and the results of the latest research developments are expected to be reflected in them in the future. Although the present guidelines do not recommend a specific method, examples of the exposure calculation method are shown in Annex G for your reference.

Annex A (informative) Excerpt from the Radio Act related provisions

(High frequency-based equipment)

Article 100

- (1) Any person who wishes to install the following facilities shall obtain permission from the Minister of Internal Affairs and Communications:
 - (i) Telegraphy, telephony or other telecommunications facilities which apply radio frequency currents 10 kHz or above to the wired system (except power carrying cable facilities, two-bare-wire balanced type power carrying facilities or other communications facilities which are specified in the applicable MIC ordinance).
 - (ii) Radio facilities and facilities other than those of the preceding items, which use radio frequency currents 10 kHz or above and are specified in the applicable MIC ordinance.
- (2) Upon receipt of an application for permission under the preceding paragraph, the Minister of Internal Affairs and Communications shall permit the construction in the application where determining that the application satisfies the technical regulations of Article 28, 30 or 38 which shall apply to paragraph (5) and the use of frequencies related to the application causes no interference with other communications (including monitoring service at places specified in public notices made by the Minister of Internal Affairs and Communications).
- (3) When a person who has obtained permission under paragraph (1) transfers the facilities to another person, or effects a succession, merger or division (limited to the case where said equipment is succeeded to), the transferee who takes over such facilities, or the successor, the juridical person who is the surviving juridical person, the juridical person who is newly established after the merger or the juridical person who succeeds said equipment by division shall succeed to the status of the person who has obtained permission of the same paragraph.
- (4) A person who succeeds in accordance with the provisions of the preceding paragraph the status of the person who has obtained permission under paragraph (1) shall without delay notify the Minister of Internal Affairs and Communications with a document to prove that fact.
- (5) The provisions of Article 14 paragraphs (1) and (2) (Certificates of Radio Station License), Article 17 (Permission for Changes), Article 21 (Correction to a Certificate of Radio Station License), Articles 22 and 23 (Abolition of a Radio Station), Article 24 (Return of a Certificate of Radio Station License), Article 28 (Quality of Radio Waves), Article 30 (Safety Installation), Article 38 (Technical Regulations), Article 72 (Cessation of Emission of Radio Waves), Article 73 paragraphs (4) and (6) (Inspection), Articles 76 and 77 (Revocation of a Radio Station License, etc.), and Article 81 (Report) shall apply, mutatis mutandis, to the facilities which has obtained permission in accordance with the provisions of paragraph (1).

(Protection of the Functions of Radio Equipment)

Article 101.

The provisions of Article 82 paragraph (1) shall apply, *mutatis mutandis*, to when the radio waves or high frequency currents emitted spuriously by any facilities other than radio equipment (except the equipment of the preceding article) cause successive and serious hindrances to the functions of radio equipment.

**Annex B (informative) Excerpt of related provisions of the Regulations for
Enforcement of the Radio Act**

Chapter 3 High frequency-based equipment

Section 1 General Rules

(Communication equipment)

Article 44

1. The communication equipment that does not require the permission prescribed in the Radio Act, Article 100, Paragraph 1, Item 1 shall be as listed below:
 - (i) Power line carrier communication equipment (which refers to power line carrier communication equipment that performs communication by overlapping high-frequency currents of 10 kHz or over on the power line; the same shall apply hereinafter.) as listed in the following items:
 - (1) Equipment that uses a power line flowing a single phased alternate current with a rated voltage of 100V or 200V and a rated frequency of 50Hz or 60Hz, with its type specified by the Minister for Internal Affairs and Communications.
 - (2) Equipment used solely for receiving purposes.
 - (ii) Inductive radio communication equipment (which refers to equipment that performs communication by using inductive radio waves generated by flowing a high-frequency current of 10 kHz or more to a power line; the same shall apply hereinafter.) as listed in the following items:
 - (1) The electric field strength in a distance of $\lambda/2\pi$ from the power line (where, λ is the wavelength of the carrier wave in meters and π is the circular constant) is $15\mu\text{V/m}$ or less.
 - (2) Inductive reading and writing radio communication equipment (which refers to equipment that reads and writes information in the recording media by using inductive radio waves with a frequency of 13.56 MHz; the same shall apply hereinafter.), whose electric field strength in a distance of three meters from the equipment is 500 microvolt or less per meter.
 - (3) Inductive reading and writing radio communication equipment whose type is specified by the Minister for Internal Affairs and Communications
2. The specification by the Minister for Internal Affairs and Communications stipulated in Item 1-(1) of the preceding Paragraph shall be performed for each of the following classes.
 - (i) Power line carrier communication equipment listed below using a carrier wave with a frequency between 10 kHz and 450 kHz.
 - (1) Power carrying interphones (which refers to equipment that transmits/transfers and receives voice signals; the same shall apply hereinafter.)
 - (2) General power carrying digital transmission equipment (which refers to equipment that

transmits/transfers and receives digital signals using a power line equipped with a blocking filter with an attenuation of 40 decibels or more to prevent interference with other communication or a power line that is not branched to other equipment; the same shall apply hereinafter.)

(3) Special power carrying digital transmission equipment (which refers to equipment that transmits/transfers and receives digital signals without limitation of the power line used; the same shall apply hereinafter.)

(ii) Power line carrier communication equipment transmitting/transferring and receiving signals with a carrier wave with a frequency between 2 MHz and 30 MHz indoors (hereinafter referred to as the “Broadband power line carrier communication equipment”).

(Equipment requiring permission, except communication equipment)

Article 45

The equipment using high-frequency current that requires permission under the Radio Act, Article 100, Paragraph 1, Item 2 shall be defined as follows:

(i) Medical equipment (which refers to equipment that generates high frequency energy by using a high frequency output of greater than 50W and uses the energy for medical purposes; the same shall apply hereinafter.)

(ii) Industrial heating equipment (which refers to equipment that generates high frequency energy by using a high frequency output of greater than 50W and uses the energy for industrial production such as drying of timber and plywood, drying of cocoon, melting of metal, heating of metal, exhaust of vacuum tubes; the same shall apply hereinafter.)

(iii) Miscellaneous equipment (which refers to equipment that is used for heating and ionizing purposes by applying high-frequency energy to the load directly and that uses a high frequency output of greater than 50W, [excluding the equipment falling under the categories of the preceding two Paragraphs, ultrasonic cleaners, ultrasonic processors and ultrasonic welders with their types specified by the Minister for Internal Affairs and Communications, document printing and copying machines and electrodeless discharge lamps using electromagnetic induction heating, and microwave ovens and electromagnetic induction heating cookers for which type checks stipulated in Article 46 Paragraph 7 have been made]; the same shall apply hereinafter.)

**Annex C (informative) Notification of the Ministry of Posts and
Telecommunications, No. 301 of 1999**

(Note: Table 2-2-2 in the *Regulations for the Enforcement of the Radio Act* referenced in this notification is changed to Table 2-3-2 as of April 2001.)

Radio wave strength at a frequency between over 10 kHz and 100 kHz or less and radio wave strength in cases where the human body is exposed to a radio wave inhomogeneously, as stipulated in the Regulations for Enforcement of the Radio Act, Appended Table 2, 2-2, Note 3 (April 27, 1999) (Notification of the Ministry of Posts and Telecommunications, No. 301)

Based on the regulation of the Regulations for Enforcement of the Radio Act (Radio Regulatory Commission Rules No. 14 of 1950), Appended Table 2, 2-2, Note 3, radio wave strength at a frequency between over 10 kHz and 100 kHz or less and radio wave strength in cases where the human body is exposed to a radio wave inhomogeneously were specified as follows and came into effect on October 1, 1999.

1. The strength of a frequency between over 10 kHz to 100 kHz or less shall conform to the following in addition to the values specified in the Regulations for Enforcement of the Radio Act, Appended Table 2, 2-2—except in cases where the human body is exposed to a radio wave inhomogeneously.

Frequency	Electric field strength [V/m]	Magnetic field strength [A/m]	Average time
10 kHz < f ≤ 100 kHz	894	72.8	Less than one second

Note 1: The electric field strength and the magnetic field strength are the root mean square values.

Note 2: If multiple pieces of equipment in the same place or their periphery emit radio waves, or if one piece of equipment emits multiple radio waves, the sum of the rates for the values in the table of each frequency must not exceed one.

2. The strength of a radio wave in cases where the human body is exposed to the radio wave inhomogeneously is shown in Tables 1 and 2 below.

Table 1

Frequency	Spatial average value of electric field strength [V/m]	Spatial average value of magnetic field strength [A/m]	Spatial average value of power flux density [mW/cm ²]	Spatial maximum value of power flux density [mW/cm ²]	Average time [minutes]
10 kHz < f ≤ 30 kHz	275	72.8			6
30 kHz < f ≤ 3 MHz	275	2.18f ¹			
3 MHz < f ≤ 30 MHz	824f ¹	2.18f ¹			
30 MHz < f ≤ 300 MHz	27.5	0.0728	0.2		
300 MHz < f ≤ 1 GHz	1.585f ^{1/2}	f ^{1/2} /237.8	f/1500	4	
1 GHz < f ≤ 1.5 GHz	1.585f ^{1/2}	f ^{1/2} /237.8	f/1500	2	
1.5 GHz < f ≤ 300 GHz	61.4	0.163	1	2	

Note 1: “f” denotes a frequency in MHz.

Note 2: The electric field strength and the magnetic field strength are the root mean square values.

Note 3: If multiple pieces of equipment in the same place or their periphery emit radio waves, or if one piece of equipment emits multiple radio waves, the squared-sum of the ratios for the values in the table of each frequency must not exceed one for the electric strength and magnetic strength, and the sum of the ratios for the values in the table for each frequency must not exceed one for the power flux density.

Table 2

Frequency	Spatial average value of electric field strength [V/m]	Spatial average value of magnetic field strength [A/m]	Average time
10 kHz < f ≤ 100 kHz	894	72.8	Less than one second

Note 1: The electric field strength and the magnetic field strength are the root mean square values.

Note 2: If multiple pieces of equipment in the same place or their periphery emit radio waves, or if one piece of equipment emits multiple radio waves, the sum of the ratios for the values in the table of each frequency must not exceed one.

**Annex D (informative) Notification of the Ministry of Posts and
Telecommunications, No. 300 of 1999**

Methods of calculating and measuring the strength of a radio wave that is emitted from wireless
equipment, pursuant to the Regulations for Enforcement of the Radio Act, Article 21, Paragraph 3,
Item 2

(April 27, 1999)

(Notification of the Ministry of Posts and Telecommunications, Number 300)

In pursuant to the Regulations for Enforcement of the Radio Act, Article 21, Paragraph 3, Item 2 (Radio Regulatory Commission Rules No. 14 of 1950), the methods of calculating and measuring the strength of a radio wave that is emitted from wireless equipment were stipulated as follows and came into effect on October 1, 1999.

1. The meanings of the symbols in the formulas in this notification are as follows:

- (1) "E" is the electric field strength [V/m].
- (2) "H" is the magnetic field strength [A/m].
- (3) "S" is the power flux density [mW/cm²].
- (4) "P" is the antenna input power (the value obtained by subtracting the power supply system loss and the mismatch loss from the transmitter output; the same also applies hereinafter) [W]. For pulse waves, it is the mean time of the antenna input power.
- (5) "G" is the antenna absolute gain in the direction of the maximum radiated power of the transmitting antenna indicated with by power ratio.
- (6) "R" is the distance between the transmitting antenna pertaining to the calculation and the calculation target position [m].
- (7) "D" is the maximum size of the transmitting antenna [m].
- (8) "λ" is the wavelength of the transmission frequency [m].
- (9) "K" is the reflection coefficient; the following values should be assigned.
 - (A) When reflections from the ground are taken into account
 - (a) When the transmission frequency is 76 MHz or more: 2.56
 - (b) When the transmission frequency is less than 76 MHz: 4
 - (B) When reflections from places other than the ground plane, such as the surface of water, are taken into account: 4
 - (C) When all reflections are not taken into account: 1
- (10) "F" is the correction coefficient due to the rotation of the antenna; the following values should be assigned.

(A) When the antenna is not rotating: 1

(B) When the antenna is rotating:

(a) When the distance R exceeds $0.6 D^2/\lambda$: $\theta_{BW}/360$

“ θ_{BW} ” is the half-power width [degree]

(b) When the distance R is $0.6 D^2/\lambda$ or less: $\phi/360$

“ ϕ ” is the expected angle [degree] of the antenna diameter in the distance R and

$$\phi = 2 \tan^{-1} (D/2R)$$

2. To convert the power flux density into the electric field strength or magnetic field strength, use the following formula.

$$S = E^2/3770 = 37.7H^2$$

3. The strength of the radio wave should be calculated for places where people who exist at each azimuth of 45 degrees usually gather, pass, and enter/leave with respect to the direction of the maximum radiated power from the position of the transmitting antenna pertaining to calculation. (If the direction of its maximum radiated power is not determined, any direction is permitted.) Calculation should be performed at points in intervals of at least $\lambda/10$ [m] from the nearest point of the transmitting antenna (hereinafter referred to as the “calculation point”). At each calculation point, calculation should be performed at intervals of at least 10 cm (20 cm with a frequency of less than 300 MHz) in the range of 10 cm (20 cm with a frequency of less than 300 MHz) to 200 cm above the ground plane to obtain the maximum value. Each calculation point must be apart from the transmitting antenna and metal substance by at least 10 cm (20 cm with a frequency of less than 300 MHz).

4. If there is a building, steel tower, or metal structure, etc., near the calculation area and if there is the danger of the occurrence of a strong reflection, add six decibels to the calculated radio wave strength.

5. When calculating the strength of the radio wave, obtain the value of the power flux density from the following formula. For a frequency of 30 MHz or less, convert it to the value of the electric field strength.

$$S = (PG/40\pi R^2) \cdot K$$

6. When the calculation result using the method of Item 5 exceeds the strength of the radio wave stipulated in the Regulations for Enforcement of the Radio Act, Appended Table 2, 2-2 (hereinafter referred to as the “reference value”), and if the power directivity factor of the transmitting antenna D

(θ) is obvious, the strength of the radio waves should be obtained by obtaining the value of the power flux density from the following formula. For a frequency of 30 MHz or less, convert it into the value of the electric field strength.

$$S = S_0 \cdot D(\theta) \cdot F$$

Where, S_0 is the value of the power flux density calculated using the method of Item 5.

Note 1: To obtain the value of the power flux density near the transmitting antenna in the direction $D(\theta)=0$, make a calculation with the power directivity factor obtained by approximately representing the directional characteristics of the antenna in question with the envelope (the line connecting the local maximum values of the directional characteristics).

Note 2: If the calculation point is located outside the main radiation, the power directivity factor for the calculation point in question may be calculated by using the power directivity factor for the direction of the maximum sub-radiation.

Note 3: When an antenna on which two stages of elements are stacked is used in the radio equipment for VHF or TV stations, calculation may be performed with the power directivity factor on the vertical plane as 0.1 at a depression angle of 45 degrees or more.

7. If both results calculated using the methods of Item 5 and Item 6 exceed the reference value, and if the type of the transmitting antenna falls under any of the following, the calculation method of the antenna in question should be used.

(1) Inside the main radiation of the collinear antenna array (which refers to an antenna that falls under CL or SK of the antenna type basic code stipulated in the Notification of the Ministry of Posts and Telecommunications, No. 148 of 1998, Appended Table 6-1 [hereinafter referred to as the “antenna code”]), the strength of the radio wave when the distant R is $0.6 D^2/\lambda$ or less can be obtained by obtaining the value of the power flux density from the following formula. For a frequency of 30 MHz or less, convert it into the value of the electric field strength.

$$S = (P/20\pi RD) \cdot K$$

Note: For a sector-type antenna, calculate the strength using the following formula by utilizing the half-power width θ_{BW} [degree].

$$S = (P/20\pi RD)(360/\theta_{BW}) \cdot K$$

(2) For the strength of the radio wave on the surface or the main radiation direction of the aperture antenna (which refers to an antenna that falls under the antenna codes of PA, OP, FB, PG, HB, KG, CR, HR, DH, BH, CH, TW, GG, DG, CG, TD, MB, H, PR, TO, or O), obtain the value of the power flux density using the following method. For a frequency of 30 MHz or less, convert it into the value of the electric field strength.

(A) Calculate the value of the power flux density on the surface of the antenna using the following formula.

$$S = (4P/A) \cdot (1/10)$$

Where, A is the aperture area of the aperture antenna [m²].

(B) When the distance R is $D^2/4\lambda$ or less, calculate the value of the power flux density using the following formula.

$$S = 16(\eta P/\pi D^2) \cdot (1/10) \cdot K \cdot F$$

Where, η is the aperture efficiency.

(C) When the distance R is greater than $D^2/4\lambda$ and $0.6 D^2/\lambda$ or less, calculate the value of the power flux density using the following formula.

$$S = (D^2/4\lambda R) \cdot S_{nf}$$

Where, S_{nf} is the value of the power flux density calculated from (B).

(3) For the strength of the radio wave of a monopole antenna for medium-wave broadcasting (which refers to an antenna that falls under the antenna code V or TL) in a range where the distance from the antenna is greater than both $2 D^2/\lambda$ [m] and $\lambda/2\pi$ [m], obtain the values of the electric field strength and magnetic field strength using the following formula.

$$E = \sqrt{\left(|E_z|^2 + |E_\rho|^2\right)}$$

$$H = |H_\phi|$$

Where, E_z , E_ρ , and H_ϕ are the electric field strength and magnetic field strength of each direction component at the calculation point P (ρ , ϕ , z) shown in Appended Table 1. They can be calculated using the following formula.

$$E_z = -j \frac{\omega \mu_0 I_0}{4\pi k_0} \int_{-l}^l \sin\{k_a(l_t - |\xi|)\} \left[\left\{ \frac{k_0}{r} - \frac{1}{k_0 r^3} - \frac{k_0(\xi - z)^2}{r^3} + \frac{3(\xi - z)^2}{k_0 r^5} \right\} (\cos k_0 r - j \sin k_0 r) d\xi \right. \\ \left. + j \left\{ -\frac{1}{r^2} + \frac{3(\xi - z)^2}{r^4} \right\} \right]$$

$$E_\rho = -j \frac{\omega \mu_0 I_0}{4\pi k_0} \int_{-l}^l \sin\{k_a(l_t - |\xi|)\} \rho(z - \xi) \left[\left(-\frac{k_0}{r^3} + \frac{3}{k_0 r^5} + j \frac{3}{r^4} \right) \right] (\cos k_0 r - j \sin k_0 r) d\xi$$

$$H_\phi = \frac{I_0}{4\pi} \int_{-l}^l \sin\{k_a(l_t - |\xi|)\} \rho \left[\frac{1}{r^3} + j \frac{k_0}{r^2} \right] (\cos k_0 r - j \sin k_0 r) d\xi$$

Where, l is the total length of the circular tube [m], ρ is the radial coordinate [m] of the calculation point, and z is the z coordinate [m] of the calculation point, as shown in Appended Table 1.

Where,

“ ω ” is the angle frequency [rad/s];

“ μ_0 ” is the magnetic permeability of the free space [H/m];

“ r ” is the distance from the antenna [m];

$$r = \sqrt{\rho^2 + (z - \xi)^2}$$

“ ξ ” is the z coordinate at any point on the antenna [m];

“ I_0 ” is the current antinode [A];

“ k_a ” is the propagation constant on the antenna [rad/m];

“ k_0 ” is the propagation constant in the free space [rad/m]; and

“ l_t ” is the equivalent total length of the antenna considering the influence of the top hat [m].

“ I_0 ,” “ k_a ,” and “ l_t ” should be obtained from the length of the antenna, the thickness of the antenna, and the size and the structure of the top hat.

(4) The strength of the radio wave by the curtain antenna (which refers to an antenna that falls under the antenna code AW) should be calculated as follows.

(A) Depending on the distance from the transmitting antenna to the calculation point and its frequency, the strength of the radio wave should be calculated as follows.

(a) When the calculation point from the nearest transmitting antenna is farther than both $2D^2/\lambda$ [m] and $\lambda/2\pi$ [m], the electric field strength or the magnetic field strength should be calculated. (For a frequency of 3 MHz or less, only the electric field strength should be calculated.)

(b) When the calculation point is other than (a), the electric field strength and magnetic field strength should be calculated.

(B) When calculating the radio wave strength, regard each radiating element as an equivalent half-wave dipole and calculate as follows.

(a) Calculate the strength of the radio wave by each equivalent half-wave dipole using the following formula, obtain these composite values, and define them as the values of the electric field strength and magnetic field strength at calculation point P (ρ , ϕ , z), shown in Appended Figure 2.

$$E_z = \frac{-jk_0 I}{4\pi\omega\epsilon_0} \left\{ \frac{\exp(-jk_0 r_1)}{r_1} + \frac{\exp(-jk_0 r_2)}{r_2} \right\}$$

$$E_\rho = \frac{-jk_0 I}{4\pi\omega\epsilon_0 \rho} \left\{ \left(z + \frac{\lambda}{4} \right) \frac{\exp(-jk_0 r_1)}{r_1} + \left(z - \frac{\lambda}{4} \right) \frac{\exp(-jk_0 r_2)}{r_2} \right\}$$

$$H_\phi = \frac{jI}{4\pi\rho} \left\{ \exp(-jk_0 r_1) + \exp(-jk_0 r_2) \right\}$$

Where,

“ ω ” is the angle frequency [rad/s];

“ k_0 ” is the propagation constant in the free space [rad/m]; and

“ ϵ_0 ” is the dielectric constant in the free space [F/m].

The definitions of r_1 [m], r_2 [m], ρ [m], z [m], E_z [V/m], E_ρ [V/m], and H_ϕ [A/m] are shown in Appended Table 2.

“ I ” is an element current of the equivalent half-wave dipole and it is obtained by the antenna power, the number of elements, and the input impedance of each element.

(b) When there is a reflector or when reflection from the ground is considered, consider the reflected image of the equivalent half-wave dipole for each case.

8. When the human body is exposed to a radio wave inhomogeneously (which refers to a case where places exceeding the reference value and places not exceeding the reference value are mixed in an area within 200 cm aboveground; the same also applies hereinafter), the strength of the radio waves should be calculated by obtaining the special average value as shown below.

(1) For the power flux density, its average value

(2) For the electric field strength and magnetic field strength, their root mean square value; for a frequency greater than 10 kHz but not greater than 100 kHz, the square root of their average value and their root mean square value

9. When all of the calculation results using the methods from Item 5 to Item 8 exceed the reference value, the strength of the radio wave must be measured. If such calculation result is defined as the strength of the radio wave at the calculation point, no measurement is required.

10. Measure the strengths of the following radio waves.

(1) When the measurement point from the nearest transmitting antenna is farther than both $2 D^2/\lambda$ [m] and $\lambda/2\pi$ [m]:

(A) For a frequency of 3 MHz or less, measure the electric field strength.

(B) For a frequency of greater than 3 MHz but not greater than 30 MHz, measure the electric field strength or the magnetic field strength.

(C) For a frequency exceeding 30 MHz, measure the electric field strength, magnetic field strength, or power flux density.

(2) When the measurement point is other than (1):

(A) For a frequency of 1,000 MHz or less, measure the electric field strength and magnetic field strength.

(B) For a frequency exceeding 1,000 MHz, measure the electric field strength.

11. For measurement, use the following instruments.

(1) Isotropic electromagnetic field probe

(2) Frequency non-tunable measurement system (which refers to an antenna for measurement or a frequency non-tunable measurement instrument that responds to the strengths of radio waves uniformly over a wide range of frequencies; the same also applies hereinafter)

(3) Frequency tunable measurement system (which refers to an antenna for measurement or a

frequency tunable measurement instrument that tunes to a specific frequency and mainly responds to radio waves in the band centering on the frequency; the same also applies hereinafter)

12 The conditions of the measurement systems are as follows.

(1) Isotopic electromagnetic field probe

- (A) In the range of frequencies that the wireless equipment under measurement can emit, the fluctuation of values should be within three decibels when the probe is turned to an arbitrary angle or to an arbitrary direction.
- (B) In the range of frequencies that the wireless equipment under measurement can emit, the frequency characteristics of values measured in the same strength of radio waves should be flat. In addition, the response of the measurement instrument to frequencies outside the frequency range of radio waves is obvious.
- (C) In the range of frequencies that the wireless equipment under measurement can emit, the range of the strengths of the radio waves that can be measured should be obvious. In addition, the electric field probe should respond only to the electric field. The magnetic field probe should respond only to the magnetic field.
- (D) Attached cables should not affect measurement.
- (E) The response time should be less than one second.

(2) Frequency tunable/non-tunable measurement systems

- (A) The frequency range that can be measured by the instrument, the frequency resolution bandwidth (in the frequency tunable measurement system), the input sensitivity, the detecting method, and the maxim permissible input should be known.
- (B) Depending on the characteristics of radio waves emitted from the wireless equipment under measurement, an appropriate antenna with a known antenna coefficient should be used.
- (C) The input impedance of the antenna for measurement and the measurement instrument should be appropriate for the measurement cable.
- (D) Sufficient electromagnetic shielding should be provided for the measurement instrument and cable.
- (E) Necessary action should be taken so that the equipment under measurement is not affected by radio waves emitted from that other than the equipment under measurement.

13 Method of measuring the strength of a radio wave

(1) The strength of the radio wave should be measured using the following method.

- (A) Measure the maximum value of the strength of the radio wave by scanning the range between 10 cm (20 cm with a frequency of less than 300 MHz) and 200 cm above the measurement point vertically with an isotopic electromagnetic field probe or an antenna for measurement.

Note that the electromagnetic field probe or the antenna for measurement should be 10 cm or more (20 cm or more with a frequency of less than 300 MHz) from the transmitting antenna, the ground, and the metal substance.

(B) When the strength of the radio wave changes with time, define the strength of the radio wave obtained using the following method as the measurement value.

(a) For the power flux density, it is the average of the values measured for six minutes.

(b) For the electric field strength and magnetic field strength, they are the root mean square of the values measured for six minutes. In the frequency range between over 10 kHz and 100 kHz or less, it is the square root of their maximum value and the root mean square of values measured for six minutes.

Note: If the average of measurements for six minutes can be obtained in a period less than six minutes due to the modulation characteristics of radio waves emitted from the radio equipment under measurement, the measurement time may be shortened as required.

(2) For the strength of radio waves when the human body is exposed to a radio wave inhomogeneously, it is possible to measure the strength in intervals of 10 cm (20 cm with a frequency of less than 300 MHz) from 10 cm (20 cm with a frequency of less than 300 MHz) to 200 cm above the measurement point and to obtain its spatial average value in accordance with the method in Section 8.

(3) When making a measurement, note the following points.

(A) Place the antenna for measurement so that its direction and plane polarization maximize its reading.

(B) If one of the antennas for measurement and the transmitting antenna produces a circularly polarized wave and if the other produces a linearly polarized wave, add three decibels to the measurement value as the correction value.

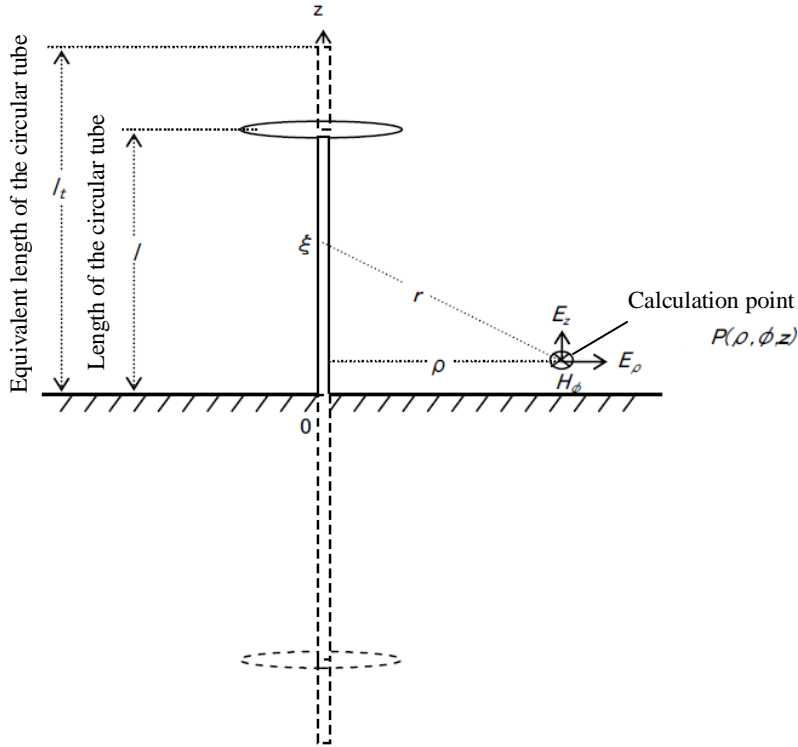
(C) When vertically scanning the electromagnetic field probe or the antenna for measurement, hold it so that influence on the human body and polarization is minimized.

(D) To measure the pulse wave, use a thermocouple-type electromagnetic field probe, a frequency non-tunable measurement system, or a frequency tunable measurement system having a frequency resolution band that is wider than the band occupied by the pulses.

(E) If the influence of radio waves emitted from other radio equipment cannot be ignored, use a frequency tunable measurement system.

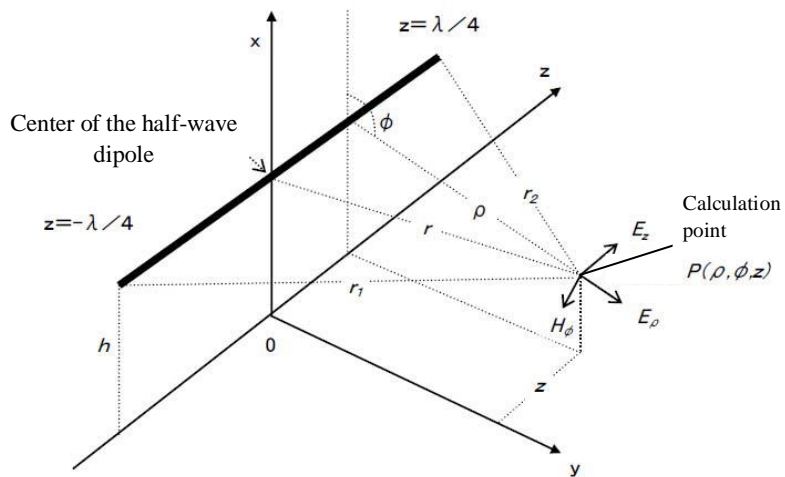
Appended Table 1

The coordinate system and formula symbols of the calculation formula stipulated in Section 7 (3) are shown in the following figure.



Appended Table 2

The coordinate system and formula symbols of the calculation formula stipulated in Section 7 (4) are shown in the following figure



Annex E (informative) Safety measures against heat or other causes

1. Safety measures against heat or other causes

- Temperature rise limits for the components comprising the transmission side and reception side shall be below 35 K for metals, 45 K for porcelains or glasses, and 60 K for molded products, rubber, and wood. (The base temperature for the above temperature rise limits is 25°C.)
- When a temperature rise limit is exceeded, take a measure such as power transmission stop. No restrictions are specified for power supply.

Note: See IEC 60335-1 “Household and similar electrical appliances – Safety – Part 1: General requirements 11. Temperature rise.”

- The above limits are also applied to any metallic alien substance piece located between the transmission side and the reception side.
- Devices and parts used for the equipment shall cause no smoke or fire when an abnormal condition occurs.

2. Measurement method for the temperature rise of a metallic alien substance located between the transmission side and the reception side

As a safety measure for the case where a metal piece is located between the transmission side and the reception side, the following procedure shall be carried out to measure a temperature rise, ensuring that the requirements described in section 8.2.2 are satisfied.

- (1) Measure the temperature rise of metals including iron, aluminum, and copper.
- (2) Test piece

A test piece is determined in the following way, using the equipment comprising the transmission side and the reception side (when more than one reception side exists, select the one with the highest load power), with the transmit coil and the receive coil facing.

- At the center of the coil:
 - Prepare a metal piece that measures 5 mm long, 5 mm wide, and 0.3 mm thick, and then try another one with its width and length increased in increments of 1 mm until the largest

piece that maintains the normal operation of the equipment is found,^{*1} naming it “test piece (1).”

- Repeat the same steps as above starting with two pieces of metal having a thickness of 0.5 mm and 1.0 mm, in order to find the largest piece that maintains the normal operation of the equipment,^{*1} naming each “test piece (2)” and “test piece (3),” respectively. Note that the largest piece shall fit in the power transmission coil or coil plane completely.
- Out of the center of the coil:
 - Repeat the same steps as above starting with three pieces of metal, measuring 5 by 5 by 0.3 millimeters, then try another one with its width and length increased in increments of 1 mm until the largest piece that maintains the normal operation of the equipment is found, naming it “test piece (4).” In case of having a thickness of 0.5 mm and 1.0 mm, in order to find the largest piece, name each “test piece (5)” and “test piece (6),” respectively.

^{*1} Normal operation refers to the one that lets the equipment achieve its given functions. Placing a metal piece between the transmission side and the reception side during operation could generate heat, leading to reduced safety. If the equipment achieves its given functions under this circumstance, it is under normal operation.

(3) Evaluation method

- Test pieces (1) to (6) are used for evaluation.
- Experiments are conducted under the same condition as the one where each test piece was determined in the above (2).
- The equipment (transmission side and reception side) are operated with a thermocouple connected to the test piece.
- The highest temperature before the saturated temperature is reached is taken as a test piece temperature. When the equipment stops operating before the saturated temperature is reached, the highest temperature before the stop of the equipment is taken as a test piece temperature. When the equipment is forced to stop due to its metal detection ability or temperature sensing ability, the highest temperature before the stop of the equipment is taken as a test piece temperature.
- A thermocouple with a thickness of 0.3 mm or lower is used so that a test piece is least affected by it (conforming to IEC 60335-1).

Annex F (informative) Explanation of radio-radiation protection guidelines

In the field of wireless power transmission/transfer technologies, it is believed that the guideline values for electromagnetic field exposure are often required to be followed, and these are stipulated in the domestic guidelines in Japan, or in the ICNIRP or IEEE internationally. However, since these guidelines may be revised reflecting the results of a study that has been continuously conducted from a scientific or epidemiologic point of view, the latest information has to be continuously checked.

The ICNIRP, which has revised the guidelines for the low-frequency range on November 2010, has already set out to revise guidelines for the high-frequency range, and is planning to release these new guidelines around 2014. For an evaluation method in accordance with the new guidelines, IEC TC106 is conducting the international standardization of the common evaluation method for the electromagnetic field exposure, but the method assumed to be used for the equipment described in the present guidelines has not yet been released.

In the domestic guidelines, on the other hand, the guideline values and their evaluation and measurement method are defined, but they are slightly different with the ICNIRP guideline values, evaluation method by the IEC TC106, or the IEEE guidelines. This results from the time lag between the discussion periods of these guidelines. Under the circumstances, the domestic guidelines can be revised considering the international trends.

In this discussion, based on the fact that the domestic guidelines differ from the international guidelines (that is, ICNIRP guidelines and IEEE standards), we put high priority on the domestic guidelines, presenting the ICNIRP guidelines as opposite to them. We also give an explanation about the IEEE guidelines.

The domestic guidelines presents, when his/her body is exposed to an electromagnetic field for radio wave use, the basic methods and reference values to determine whether the electromagnetic field is safe without producing an undesirable electromagnetic effect (core body temperature rise, electrical shock, high-frequency radio wave burn, etc.) on the human body, how to measure and estimate the electromagnetic field strength on the perimeter of the radio utilization facilities, and a protection method to reduce the strength of the electromagnetic field radiated to the human body, providing the guidelines for determining the safety standards, advisories, and operating procedures for the use of radio waves.

The ICNIRP, on the other hand, describes a direct or indirect coupling mechanism between the electromagnetic field and the human body, a direct or indirect effect of the electromagnetic field on the human body, and the biological grounds for the restrictions of the electromagnetic field exposure. Based on them, it stipulates the guidelines for the restrictions, including the restrictions of occupational/public exposure, the basic restrictions, and the reference levels. The ICNIRP, which presents the restriction value of the exposure in its guidelines, leaves it to other international

organizations regarding how to implement a measurement method for the exposure.

In the following discussion, we mainly explain the radio-radiation protection guidelines, keeping in mind that, although the domestic guidelines and the ICNIRP guidelines are stipulated based on the common ideas, there are differences between them in their guideline values for the low-frequency range. The terminologies for ICNIRP are also specified, enclosed in double quotes, throughout the discussion.

There is a basic rule for evaluating the safety of the human body based on various biological effects caused in the human body under exposure to an electromagnetic field, and the guidelines for such is called the “basic restrictions.” However, since it is difficult to directly measure whether the basic restrictions are met, the administrative guidelines, defined using the actual measurable physical amount, are used for actual evaluation. The “reference level” is one of the administrative guidelines. If the radiation source is located at a sufficiently distant location and if there is no metal or other object that scatters radio waves at a place close to the space in which the human body exists, it can be assumed that the electromagnetic phenomenon inside the human body in the space bears an almost constant relation to the electric field strength and the magnetic field strength measured when the human body does not exist in said space. Under such a condition, protection guidelines can be set by using the electromagnetic field strength in a space in which no human body exists. This guideline is called the “electromagnetic field strength guidelines.” The electromagnetic field strength is a measurable physical amount. As the electromagnetic field covered by the protection guideline is usually a near-field type or in an inhomogeneous location, the electromagnetic field strength guideline cannot apply, as many states exist. In an electromagnetic environment that does not meet the requirements for the application of the guidelines, there are cases where evaluation only of the space is not appropriate. In the case where the electromagnetic field strength guideline cannot be applied as-is, the supplementary guidelines are provided. The supplementary guideline is a simplified evaluation method for the electromagnetic phenomenon inside the human body, as an alternative to the basic guidelines. Therefore, it is necessary to bear in mind that the evaluation based on the basic guidelines should always be considered when the supplementary guidelines cannot be applied.

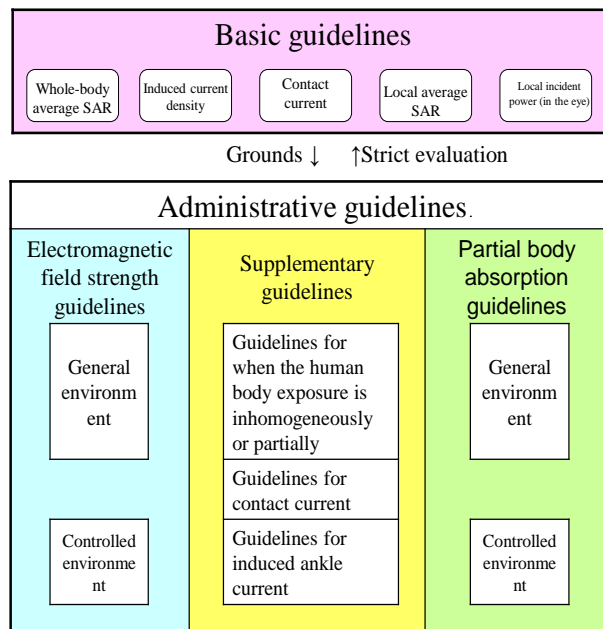


Fig. 8.3.1 Overview of the radio-radiation protection guidelines

The supplementary guideline values for the strength of a radio wave in cases where the human body is exposed to a radio wave inhomogeneously are stipulated in the notification of the Ministry of Posts and Telecommunications, No. 301 (released on April 27, 1999), shown in Annex C. Also, the calculation and measurement method for the strength of a radio wave radiated from wireless equipment is stipulated in the notification of the Ministry of Posts and Telecommunications, No. 300 (released on April 27, 1999), shown in Annex D. The excerpts from the domestic guideline values, the ICNIRP guideline values, and the IEEE guideline values are shown below in Table F-1, Table F-2, and Table F-3, respectively.

F-1. Excerpts from the domestic guidelines

(1) Guidelines concerning stimulant effect

The electromagnetic field strength guideline shown in the table below should be referred to in the frequency range of 10 kHz to 100 kHz. Note that in the case where the electromagnetic field is inhomogeneous or where the human body becomes within 20 cm of the equipment in normal use, the following restriction values can be exceeded without exceeding the basic restrictions. This case is described in section (3).

Table F-1: Limit values associated with stimulant action

Frequency	Spatial average of electric field strength [V/m]	Spatial average of magnetic field strength [A/m]	Average time
10 kHz < f ≤ 100 kHz	894	72.8	Less than 1 second

Note 1: The electric field strength and the magnetic field strength are the root mean square values.

Note 2: If multiple radiation sources of equipment in the same place or their periphery emit radio waves, or if one piece of equipment emits multiple radio waves, the squared-sum of the ratio of each electric strength or magnetic strength (which is the spatial average value) to the guideline value for the corresponding frequency in the table must not exceed one.

(2) Guidelines concerning thermal effect

When the equipment is large enough to cover a whole human body, the whole-body average SAR evaluation is appropriate, while when the exposure can be regarded as partial, the local average SAR evaluation is appropriate. Note that since the SAR evaluation in the frequency range below 30 MHz has not yet been established, it is desirable to evaluate the exposure using the guideline values shown in the table below.

Table F-2: Exposure limit values associated with thermal action

Frequency	Spatial average of electric field strength [V/m]	Spatial average of magnetic field strength [A/m]	Spatial average value of power flux density [mW/cm ²]	Average time [minute]
10 kHz < f ≤ 30 kHz	275	72.8	/	6
30 kHz < f ≤ 3 MHz	275	2.18f ⁻¹		

$3 \text{ MHz} < f \leq 30 \text{ MHz}$	$824f^{-1}$	$2.18f^{-1}$		
$30 \text{ MHz} < f \leq 300 \text{ MHz}$	27.5	0.0728	0.2	

Note 1: “f” denotes a frequency in MHz.

Note 2: The electric field strength and the magnetic field strength are the root mean square values.

Note 3: If multiple radiation sources of equipment in the same place or in their periphery emit radio waves, or if one piece of equipment emits multiple radio waves, the squared-sum of the ratio of each electric strength or magnetic strength (which is the spatial average value) to the guideline value for the corresponding frequency in the table must not exceed one; or the sum of the ratio of each power flux density (which is the spatial average value) to the guideline value for the corresponding frequency in the table must not exceed one.

(For reference) The attached sheet 1 of the normative reference [6] stipulates the following supplementary guidelines.

Supplementary guidelines (1): Guidelines for when the human body is exposed to an electromagnetic field inhomogeneously or partially

Administrative guidelines are considered to be satisfied when the appropriate requirements, varying depending on frequency, are all satisfied.

Note that for the equipment used within 20 cm of the human body (for a frequency range higher than 300 MHz, within 10 cm of the human body), a decision on a case-by-case basis is required. If it is anticipated that the basic guideline values can be exceeded, an evaluation based on the partial body absorption guidelines is recommended

<1> For the frequency range below 300 MHz

In a space more than 20 cm away from the electromagnetic radiation source and metal substance, the spatial average of the power density distribution in the space that the human body occupies (for the electric field strength and magnetic field strength, their root mean square value)

(3) Guidelines concerning contact current

In the domestic guidelines, the supplementary guidelines (2) quoted below are stipulated.

Supplementary guidelines (2): Guidelines concerning contact current

(b) In the case where contact hazard cannot be prevented in the general environment

A contact current measured in the frequency range of 10 kHz to 100 kHz is not higher than $4.5 \times 10^{-4} f$ [Hz]mA (with an average time of less than 1 second), and a contact current measured in the frequency range of 100 kHz to 15 MHz is not higher than 45 mA (with an average time of six minutes).

Note that, when it is not clear if a contact current caused by multiple frequencies cannot be neglected under this guideline, the squared-sum of the ratio of each measured value to the guideline value of the corresponding frequencies should be obtained. This squared-sum shall not exceed 1.

(4) Guidelines concerning induced current

In the domestic guidelines, the supplementary guidelines (3) quoted below may be followed.

Supplementary guidelines (3): Guidelines concerning induced ankle current

(b) In the case where an ungrounded condition is not satisfied in the general environment

An induced ankle current measured in the frequency range of 3 MHz to 300 MHz is not higher than 45 mA (with an average time of six minutes) per one foot.

Note that, when an induced current caused by multiple frequency components cannot be neglected under this guideline, the squared-sum of the ratio of each measured value to the guideline value of the corresponding frequency component should be obtained. This squared-sum shall not exceed 1.

Note:

The Report of the Telecommunications Technology Council (November 1998): Inquiry No. 104, Chapter 2 of “The methods of measuring and calculating the strength of the radio wave to check the conformity to the radio-radiation protection guidelines” describes the reasons why the associated measurement methods are not subject to any public regulation including notifications as follows.

The radio-radiation protection guidelines applied are the electromagnetic field strength guidelines and supplementary guidelines in the general environment. The supplementary guidelines for induced or contact current, however, which are desirable to be used as private guidelines as before, are not subject to any public regulation for radio-radiation protection for the reasons shown below. (ARIB STD-38 etc.)

- (1) The measurement method or equipment is not well established for induced current or contact current.
- (2) For the guideline values for induced current, there is no reasonable definition for an ungrounded condition of the human body, and it is very difficult to decide whether the condition, even if it is reasonably defined, is satisfied or not.
- (3) The guideline values for contact current, which are based on the sensing thresholds, are not the levels beyond which human health is immediately affected.
- (4) Electric fields equal in strength could cause a different level of current to flow into the human body depending on how large the metal substance to be measured is, making it impossible to constantly determine the electromagnetic field strength in terms of contact current.
- (5) In the United States or Australia, where public regulation has already been introduced or is considered to be introduced, there are no restrictions on contact or induced current.

F-2. Excerpts from the ICNIRP guideline values

The reference levels defined in the 1998 and 2010 edition of the ICNIRP guidelines are shown in the table below. Note that the frequency range brackets are overlapped between the 1998 edition and the 2010 edition.

Table F-3: Reference levels defined in the ICNIRP guidelines (1998 and 2010 edition)

Note: “f” in the 2010 edition denotes a frequency in Hz; “F” in the 1998 edition denotes a frequency in the unit specified in the “Ranges of frequency” column.

Exposure characteristics	Ranges of frequency		Electric field strength (kV/m)	Magnetic field strength (A/m)	Magnetic flux density (μT)	Equivalent plane wave power density (W/m^2)
Occupational exposure	1 Hz–8 Hz	2010 edition	20	$1.63 \times 10^5 / f^2$	$0.2 / f^2$	
	8 Hz–25 Hz		20	$2 \times 10^4 / f$	$2.5 \times 10^{-2} / f$	
	25 Hz–300 Hz		$5 \times 10^2 / f$	8×10^2	1×10^{-3}	
	300 Hz–3 kHz		$5 \times 10^2 / f$	$2.4 \times 10^5 / f$	$0.3 / f$	
	3 kHz–10 MHz		1.7×10^{-1}	80	1×10^{-4}	
	Up to 1 MHz	1998 edition	610×10^{-3}	$1.6 / F$	$2.0 / F$	–
	1 MHz–10 MHz		$610 \times 10^{-3} / F$	$1.6 / F$	$2.0 / F$	–
	10 MHz–400 MHz		61	0.16	0.2	10
	400 MHz–2,000 MHz		$3 F^{1/2}$	$0.008 F^{1/2}$	$0.01 F^{1/2}$	$F / 40$
	2 GHz–300 GHz		137	0.36	0.45	50
Public exposure	1 Hz–8 Hz	2010 edition	5	$3.2 \times 10^4 / f^2$	$4 \times 10^{-2} / f^2$	
	8 Hz–25 Hz		5	$4 \times 10^3 / f$	$5 \times 10^{-3} / f$	
	25 Hz–50 Hz		5	1.6×10^2	2×10^{-4}	
	50 Hz–400 Hz		$2.5 \times 10^2 / f$	1.6×10^2	2×10^{-4}	
	400 Hz–3 kHz		$2.5 \times 10^2 / f$	$6.4 \times 10^4 / f$	$8 \times 10^{-2} / f$	
	3 kHz–10 MHz		8.3×10^{-2}	21	2.7×10^{-5}	
	Up to 1 MHz	1998 edition	87×10^{-3}	$0.73 / F$	$0.92 / F$	–
	1 MHz–10 MHz		$87 / F^{1/2}$	$0.73 / F$	$0.92 / F$	–
	10 MHz–400 MHz		27.5	0.073	0.092	2
	400 MHz–2,000 MHz		$1.375 F^{1/2}$	$0.0037 F^{1/2}$	$0.0046 F^{1/2}$	$F / 200$
2 GHz–300 GHz		61	0.16	0.20	10	

F-3. Excerpts from the IEEE guideline values

The IEEE guidelines are the guidelines based on a consensus established through open scientific discussions in the United States. The IEEE, for which the precursor had been actively working on the issue of electromagnetic field exposure from the earliest time globally, now develops the guidelines and technology standards for the exposure from the viewpoint of biological effects at the ICES (International Committee on Electromagnetic Safety) TC95, a private organization of the IEEE. The following series have been released to date.

IEEE std C95.1-2005 3 kHz–300 GHz Safe levels with respect to electromagnetic field exposure

IEEE std C95.6-2002 0 kHz –3 kHz Safe levels with respect to electromagnetic field exposure

IEEE std 1528-2003 SAR measurement method (1 g or 10 g)

IEEE std C95.3-2010 SAR

The exposure evaluation methods through numerical calculation (1528.1 – 4) are currently being standardized under the dual logo agreement between IEC TC106 and the IEEE ICES TC34.

The IEEE Std. C95.1-2005 stipulates the basic restrictions (BR) and maximum permissive exposure (MPE) of stimulant action and thermal action, in the frequency range of 3 kHz to 5 MHz and 100 kHz to 300 GHz, respectively. This means that, in the frequency range of 100 kHz to 5 MHz, both stimulant action and thermal action are required to be considered. Also, in stimulant action, the exposure low in duty cycle has a higher restriction value.

Table F-4: Basic restrictions (BR) in parts of the human body

		Level of action (= public exposure)	Exposure in a limited environment (= occupational exposure)
Parts of the body to be exposed	f_e (Hz)	E_0 (effective value) (V/m)	E_0 (effective value) (V/m)
Brain	20	5.89×10^{-3}	1.77×10^{-2}
Heart	167	0.943	0.943
Hand, wrist, leg, ankle	3350	2.10	2.10
Other parts	3350	0.701	2.10

Table F-5: Maximum permissive exposure (MPE) associated with stimulant effect in the frequency range of 3 kHz to 5 MHz

	Level of action				Exposure in a limited environment			
	Head, torso	Extremity	Head, torso	Extremity	Head, torso	Extremity	Head, torso	Extremity
Frequency range	B effective value (mT)		H effective value (A/m)		B effective value (mT)		H effective value (A/m)	
3.0–3.35 kHz	$0.687/f$	$3.79/f$	$547/f$	$3016/f$	$2.06/f$	$3.79/f$	$1640/f$	$3016/f$
3.35 kHz–5 MHz	0.205	1.13	163	900	0.615	1.13	490	900

Table F-6: Maximum permissive exposure (MPE) associated with an external electric field in the frequency range of 3 kHz to 100 kHz

Frequency range	Level of action	Exposure in a limited environment
3 kHz–100 kHz	614	1842

In the case where the external electric field is inhomogeneous to the human body, the special average of the electric field shall not be higher than the limits shown in Table F-5.

In a limited environment, when the human body is not within the reach of grounded conductive material, the restrictions shown in Table F-5 may be exceeded. In that case, no restrictions are defined. In any circumstances, the basic restrictions shown in Table F-4 and the contact current limits shown in Table F-7 cannot be exceeded.

Table F-7: Limits of induced and contact current in the frequency range of 3 kHz to 100 kHz (effective values)

Condition	Level of action	Exposure in a limited environment
Both feet	$0.90f$	$2.00f$
One foot	$0.45f$	$1.00f$
Contact (gripping) (When trained in a limited environment)	—	$1.00f$
Contact	$0.167f$	$0.50f$

The above limits are applied to a current that flows between the human body and a grounded object.

The average time shall be 0.2 seconds.

Table F-8: Basic restrictions (BR) associated with thermal action in the frequency range of 100 kHz to 3 GHz

		Level of action SAR (W/kg)*	Exposure in a limited environment SAR (W/kg)*
Whole body exposure	Whole body average (WBA)	0.08	0.4
Partial body exposure	Partial body exposure (peak spatial-average)	2**	10**
	Extremity and auricle	4**	20**

* SAR is an average over six minutes.

** An average per a tissue mass of 10 g (a cubic tissue mass of approximately 10 cubic centimeters)

Table F-9: Limits of induced and contact current in the frequency range of 100 kHz to 110 MHz (effective values)

Condition	Level of action (mA)	Exposure in a limited environment (mA)
Both feet	90	200
One foot	45	100
Contact (gripping) (When trained in a limited environment)	—	100
Contact	16.7	50

Table F-10: Maximum permissive exposure (MPE) associated with thermal action in the frequency range of 100 kHz to 300 GHz (MPE, public)

Ranges of frequency	Effective value of electric field strength (E)	Effective value of magnetic field strength (H) (A/m)*	Effective value of magnetic flux density (S) Electric field, magnetic field (W/m ²)	Average time** $ E ^2$, $ H ^2$, or S (minutes)
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	(V/m)*				
0.1–1.34 MHz	614	$16.3/f_M$	$(1000, 100\,000/f_M^2) \cdot c$	6	6
1.34–3 MHz	$823.8/f_M$	$16.3/f_M$	$(1800/f_M^2, 100\,000/f_M^2)$	$f_M^2/0.3$	6
3–30 MHz	$823.8/f_M$	$16.3/f_M$	$(1800/f_M^2, 100\,000/f_M^2)$	30	6
30–100 MHz	27.5	$158.3/f_M^{1.668}$	$(2, 9\,400\,000/f_M^{3.336})$	30	$0.0636 f_M^{1.337}$
100–400 MHz	27.5	0.0729	2	30	30
400–2,000 MHz	-	-	$f_M/200$	30	
2–5 GHz	-	-	10	30	
5–30 GHz	-	-	10	$150/f_G$	
30–100 GHz	-	-	10	$25.24/f_G^{0.476}$	
100–300 GHz	-	-	$(9f_G-7000)/200$	$5048/[(9f_G-700)f_G^{0.476}]$	

Notes: f_M denotes a frequency in MHz, while f_G denotes a frequency in GHz.

* The table shows the MPE values for the electromagnetic field strength and power density for the case of homogeneous exposure throughout the entire body in far-field radiation.

In an inhomogeneous exposure, an average of the exposure field is taken. The averaging is done by averaging the power density or the square of the electromagnetic field strength throughout a narrow area depending on frequency or the vertical section (projected area) of the human body.

** The left and right column of the average time column shows the average time of $|E|^2$ and $|H|^2$, respectively. The average time column with the frequency equal to or higher than 400 MHz shows the average time of S.

Annex G (informative) Examples of exposure calculation

Examples of exposure calculation considering basic restrictions are shown below as reference.

Document 1: Yuki Isaka, Yuuhei Kubo, and Masao Taki, “Dosimetry and transfer characteristic of wireless transfer system of magnetic resonant coupling, ,” IEICE Society Conference, B-4-11, 2011.

This abstract, assuming a power transmission between two coils (200 x 200, five turns) placed 100 mm away from each other, describes an analysis of SAR distributions in the case where the system is placed at the feet of the human body. The resonant frequency is about 20 MHz. The finite-difference time-domain (FDTD) method is used for the analysis.

Document 2: A. Christ, M.G. Douglas, J.M. Roman, E.B. Cooper, A.P. Sample, B.H. Waters, J. R. Smith, and N. Kuster, “Evaluation of Wireless Resonant Power Transfer Systems with Human Electromagnetic Exposure Limits,” IEEE Trans. on Electromagnetic Compatibility, vol. 55, no. 2, pp. 265–274, 2013.

This paper, assuming a power transmission between two spiral coils (305 mm inside diameter, 580 mm outside diameter, 6.1 turns, 10-mm pitch, 2.54-mm wire diameter), describes an analysis of SAR in the case where a numerical human body model is located nearby. The resonant frequency is about 8 MHz. FDTD is used for analysis. First, an incident electromagnetic field generated only from the transmission side is calculated. Then, assuming that a Huygens box is present in the space that the human body occupies, a scattered electromagnetic field to the incident electromagnetic field generated due to the presence of the human body is analyzed, obtaining an electromagnetic field and SAR inside the human body. To examine an experimental evaluation method for SAR, another SAR analysis is also performed for the case where a cylindrical model is present near the coil.

Document 3: Ilkka Laakso, Shogo Tsuchida, Akimasa Hirata, and Yoshitsugu Kamimura, “Evaluation of SAR in a human body model due to wireless power transmission in the 10-MHz range,” Physics in Medicine and Biology, vol. 57, no. 15, pp. 4,991–5,002, 2012.

This paper, assuming power transmission between two solenoidal coils (300-mm diameter, 5 turns, 2-mm wire diameter) placed 300 mm away from each other, describes an analysis of SAR in the case where a numerical human body model is located nearby. The resonant frequency is about 10 MHz. First, an electromagnetic field at the periphery of the system is calculated through the Moment method. Then, a magnetic vector potential is obtained assuming that the current distribution in the coil does not change due to the presence of the human body. With that value, the electric field

distribution inside the human body is analyzed through the Scalar Potential Finite Difference (SPFD) method.

Document 4: S.W. Park, K. Wake, and S. Watanabe, "Investigation of Numerical Methods and Dosimetry for a Wireless Power Transfer System Using Electromagnetic Resonance," International Symposium on Electromagnetic Compatibility, 2012.

This abstract, assuming a power transmission between two solenoidal coils (300-mm diameter, 5.45 turns) placed one meter away from each other, describes an analysis of SAR and the inductive electric field inside the human body in the case where a numerical human body model is located nearby. The resonant frequency is about 10 MHz. First, an electromagnetic field at the periphery of the system is calculated through the Moment method. Then, an analysis is performed with the resulting electromagnetic field regarded as the incident electromagnetic field, assuming that the current distribution in the coil does not change due to the presence of the human body. In the analysis, the amount of the induced field is compared in two different cases. Firstly, the FDTD method is used to analyze the induced electric field inside the human body with both the incident electric field and the incident magnetic field being taken into account. Next, the Impedance method is used with only the incident magnetic field being taken into account, in order to compare both results.

Document 5: Yuuhei Kubo and Masao Taki, "Interaction of wireless power transfer and human body using resonators with coupled electric fields," IEICE Society Conference, B-4-12, 2011.

This abstract, assuming power transmission of a coupled electric field type with two 50-mm square plates facing each other, 10 mm apart, describes an analysis of SAR and the inductive electric field inside the human body in the case where the human body is located nearby. The resonant frequency is about 9 MHz. The Finite-difference Time-domain (FDTD) method is used for the analysis.

Appendix 1. Wireless power transmission beyond 50 W

This appendix describes a technology not covered in edition 2.0 of the guideline, which could be covered in the future through technology developments, improvements in institutionalization, and standardization.

We take the example of a wireless power transmission/transfer of 50 W or higher using the frequency range beyond 10 kHz, shown in usage scenes 3, 4, and 5 in Table 6-1 “Wireless power transmission/transfer technology usage scenes.” The status of this technology at the time of this writing (April 2013), the regulations applied to it, and technical problems are as follows.

1. Status of the technology at the time of this writing (guideline 2.0)

The wireless power transmission/transfer of 50 W or higher using a frequency range beyond 10 kHz has not been put into full-fledged practical use, being used only for the experiment or test operation of the battery charging for electric vehicles or for the demonstration of the wireless charging of home electrical appliances such as TVs at trade shows, etc.

2. Regulations applied

The regulation for a high-frequency wave utilizing facilities as stipulated in the *Radio Act* is applied to this technology.

According to the *Radio Act*, Article 100, Paragraph 1, any person who wishes to install a facility that uses high-frequency currents of 10 kHz or above shall obtain permission for that facility from the Minister of Internal Affairs and Communications. Also, according to the same article, Paragraph 2, the Minister of Internal Affairs and Communications shall permit the construction in the application when determining that the application satisfies the required technical regulations and that the use of frequencies related to the application causes no interference with other communications (See Annex A)

The facilities requiring the above permission are actually stipulated in the enforcement regulation of the *Radio Act*, while wireless power transmission facilities other than communication equipment fall under the categories specified in the *Radio Act*, Article 45, Paragraph 3, stipulating that equipment that uses a high-frequency output of greater than 50 W requires permission (see Annex B). Also, as technical standards for a high-frequency utilizing facility other than communication equipment, the acceptable values for the electromagnetic field strength are stipulated in Article 65 of the wireless equipment regulations, while interference preventions, etc., are stipulated in Article 66 of the same regulation.

Thus, although installing a wireless power transmission/transfer equipment of 50 W or higher requires applying for the above permission, once the permission application is accepted, the equipment can be installed and operated.

3. Technical problems

The following technical problems are required to be solved, depending on the characteristics of each product.

- (1) Selection of a frequency that does not interfere with other equipment
- (2) Establishment of an evaluation method for a leakage of electromagnetic field
- (3) Development and employment of interference-reducing technology
- (4) Establishment of an evaluation method for protecting the human body against radio radiation
- (5) Development and employment of radio radiation protection methods and other safety measures

4. Standardization trend

For wireless power transmission/transfer used for electric vehicles categorized in the usage scene 4, discussions are now being conducted to establish the following standards in the U.S.A. and the world.

- (1) SAE J2954: (U.S.A.) Wireless Charging of Plug-in Vehicles and Positioning Communication
- (2) UL2750: (U.S.A.) Wireless charging safety (Draft: SU2750)
- (3) IEC61980 series: (International)
 - a) IEC61980-1: Electric vehicle wireless power transfer (WPT) systems – General requirements
 - b) IEC61980-2: Electric vehicle wireless power transfer (WPT) systems – Specific requirements for communication between electric road vehicle (EV) and infrastructure with respect to wireless power transfer (WPT) systems
 - c) IEC61980-3: Electric vehicle wireless power transfer (WPT) systems – Specific requirements for the magnetic field power transfer systems

Note: SAE (Society of Automotive Engineers International)
UL (Underwriters Laboratories)

Reference Standards

JIS C 9335-1 Household and similar electrical appliances - Safety - Part 1: General requirements

RCR STD-38 Edition 2.0, ARIB standard “Radiofrequency-exposure Protection Standard”

ARIB TR-T11 Edition 1.0, ARIB technical report “Methods of Evaluating Compliance for the Radiofrequency-exposure Protection Standard”

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