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Immunity requirements for telecommunication equipment in close proximity use of wireless devices

Recommendation ITU-T K.127

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Immunity requirements for telecommunication equipment in close proximity use of wireless devices

Summary

Recommendation ITU-T K.127 specifies the immunity requirements for equipment used in the telecom facilities where wireless local area network (WLAN) devices are used in close proximity. This Recommendation is established in order to avoid malfunctions of the equipment due to radio frequency (RF) signals of devices. It contains requirements including test levels, test signal, test procedures and test facilities.

History

Edition	Recommendation	Approval	Study Group	Unique ID*
1.0	ITU-T K.127	2017-07-29	5	11.1002/1000/13281

Keywords

Close proximity, radiated immunity, vicinity, wireless devices.

* To access the Recommendation, type the URL http://handle.itu.int/ in the address field of your web browser, followed by the Recommendation's unique ID. For example, http://handle.itu.int/11.1002/1000/11830-en.

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Introduction

In recent years, the usage of tablet terminals connected to the wireless local area network has been widely spread because it helps to improve efficiency of maintenance work in the telecommunication equipment rooms. The work procedures or the indication from remote operators are displayed on the tablets. It is possible for workers to improve their efficiency by watching the displays while they work. In addition, with the Internet of things (IoT), it is assumed that the various sensors installed in the telecommunication equipment room are connected wirelessly. Therefore, when the various wireless devices are used in close proximity to telecom equipment, the radio waves emitted from these devices can cause malfunction of telecom equipment. This Recommendation defines radiated immunity requirements and test procedures assuming the usage of wireless devices in the vicinity of telecom equipment.

Recommendation ITU-T K.127

Immunity requirements for telecommunication equipment in close proximity use of wireless devices

1 Scope

This Recommendation specifies the immunity requirements for telecommunication equipment when radio-frequency transmitters are used in close proximity. It covers immunity requirements in the frequency range of 2.4 GHz, 5.2 GHz and 5.6 GHz band considering the usage of wireless LAN devices. This Recommendation is part of product family Recommendations applicable to equipment intended to be installed in telecommunication facilities, including switching equipment, transmission equipment, radio equipment, power supply equipment, supervisory equipment and control equipment. The Recommendation gives the minimum test levels to avoid malfunctions in a given environment. The requirements given in specific product Recommendations supersede those given in this Recommendation.

2 References

The following ITU-T Recommendations and other references contain provisions which, through reference in this text, constitute provisions of this Recommendation. At the time of publication, the editions indicated were valid. All Recommendations and other references are subject to revision; users of this Recommendation are therefore encouraged to investigate the possibility of applying the most recent edition of the Recommendations and other references listed below. A list of the currently valid ITU-T Recommendations is regularly published. The reference to a document within this Recommendation does not give it, as a stand-alone document, the status of a Recommendation.

[ITU-T K.43] Recommendation ITU-T K.43 (2009), *Immunity requirements for telecommunication network equipment*.

[IEC 61000-4-3] IEC 61000-4-3:2006, *Electromagnetic compatibility (EMC) – Part 4-3: Testing and measurement techniques – Radiated, radio-frequency, electromagnetic field immunity test*.

[IEC 61000-4-39] IEC 61000-4-39:2017, *Electromagnetic compatibility (EMC) – Part 4-39: Testing and measurement techniques – Radiated fields in close proximity – Immunity test*.

3 Definitions

3.1 Terms defined elsewhere

This Recommendation uses the following terms defined elsewhere:

3.1.1 auxiliary equipment (AE) [b-IEC 61000-4-4]: Equipment necessary to provide the equipment under test (EUT) with the signals required for normal operation and equipment to verify the performance of the EUT.

3.1.2 electric field strength [b-ITU-T K.83]: Magnitude of a field vector at a point that represents the force (F) on a small test charge (q) divided by the charge:

$$E = \frac{F}{q}$$

The electric field strength is expressed in units of volt per metre (V/m).

3.1.3 electromagnetic compatibility (EMC) [b-IEC 60050-161]: Ability of equipment to function satisfactorily in its electromagnetic environment without introducing intolerable electromagnetic disturbances to anything in that environment.

3.1.4 far field region [b-ITU-T K.52]: That region of the field of an antenna where the angular field distribution is essentially independent of the distance from the antenna. In the far-field region, the field has a predominantly plane-wave character, i.e., locally uniform distribution of electric field strength and magnetic field strength in planes transverse to the direction of propagation.

3.1.5 immunity (to a disturbance) [b-IEC 60050-161-01-20]: The ability of a device, equipment or system to perform without degradation in the presence of an electromagnetic disturbance.

3.1.6 immunity test level [b-IEC 60050-161-04-41]: The level of a test signal used to simulate an electromagnetic disturbance when performing an immunity test.

3.1.7 radio frequency (RF) [IEC 61000-4-39]: Frequency in the portion of the electromagnetic spectrum that is between the audio-frequency portion and the infrared portion and that is useful for radio transmission.

3.2 Terms defined in this Recommendation

None.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

AE	Auxiliary Equipment
AM	Amplitude Modulation
EMC	Electromagnetic Compatibility
EUT	Equipment Under Test
IoT	Internet of Things
OFDM	Orthogonal Frequency Division Multiplexing
PM	Pulse Modulation
RF	Radio Frequency
TEM	Transverse Electromagnetic
WLAN	Wireless Local Area Network

5 Conventions

None.

6 Test condition and test method

When the WLAN devices are used in the vicinity of telecom equipment, intense electric field will be locally illuminated to the equipment. The electric field strength of WLAN devices at the distance of 1 cm is about 30 V/m (see Appendix I).

A test method simulating the usage of WLAN devices in the vicinity of telecom equipment is demonstrated in [IEC 61000-4-39]. For the purpose of this Recommendation [IEC 61000-4-39] is used as a base text and specifies the immunity test method for telecom equipment and a minimum of test level.

6.1 Test level and waveforms

The immunity test level is given in Table 1. This test level is the amplitudes of the unmodulated carrier signal (see Figure 1 a)) for level calibration. Performance criteria are in accordance with clause 6.1 of [ITU-T K.43]. The test waveform defined in Table 2 shall be applied to equipment under test (EUT) individually.

Table 1 – Test level

Test level	Unit	Performance criterion	Basic standard	Frequency range (MHz)	Frequency step (MHz)
30	V/m	A	[IEC 61000-4-39]	2 400-2 485 5 170-5 330 5 490-5 710	1 MHz
NOTE 1– The test level may be changed only if there are specific reasons requiring a different test level and there are agreement on this between telecom operators and manufacturers. NOTE 2 – Performance criteria are in accordance with clause 6.1 of [ITU-T K.43].					

Table 2 – Test waveforms

Test waveform	Specification	Figure of test waveform
AM (Amplitude Modulation)	Depth: 80% Rate: 1 kHz sine wave	see Figure 1 b)
PM (Pulse Modulation)	Duty cycle: 50% Modulation frequency: 217 Hz	see Figure 1 c)

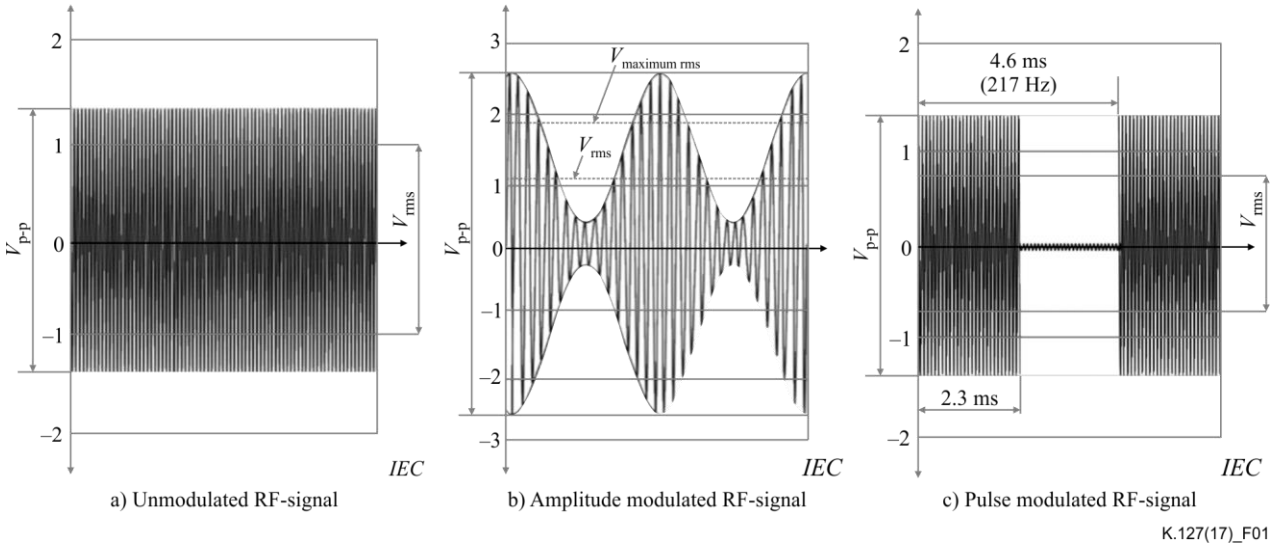

Figure 1 – Waveforms for test level calibration and for the test (from [IEC 61000-4-39])[1]

6.2 Equipment configuration and general operation during test

This configuration and operation is in accordance with clause 5 of [ITU-T K.43].

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[1] IEC 61000-4-39 ed.1.0 Copyright © 2017 IEC Geneva, Switzerland. www.iec.ch.

6.3 Test equipment

The test equipment is in accordance with clause 6.2.2 of [IEC 61000-4-39]. However, the use of transverse electromagnetic (TEM) horn antenna specified as a radiating antenna is not mandatory.

6.4 Verification of the uniformity of the electric field

The electric field uniformity of radiating antenna shall be verified in accordance with Annex A.4 of [IEC 61000-4-39].

6.5 Test facility

The test facility is in accordance with clause 7.2.1 of [IEC 61000-4-39].

6.6 Arrangement of equipment under test (EUT)

The arrangement of EUT is in accordance with clause 7.2.2 of [IEC 61000-4-39].

6.7 Test procedures

First of all, the setting of the test level is performed in accordance with section 8.6.1 of [IEC 61000-4-39].

The test shall then be performed in accordance with the following procedures:

(1) Divide the surface of the EUT into a grid based on the size of the uniform electric field plane according to clause 6.4.

(2) Install the radiating antenna 100 ± 5 mm away from the EUT to apply a vertically polarized wave to the EUT. The axis of the radiation direction of the antenna shall be aligned with the centre of the grid.

(3) The test frequency output power of the signal generator for the radiating antenna shall be set to the value obtained through the calibration described above.

(4) Apply AM signal as a test waveform to the EUT, and confirm the correct operation of the EUT using a monitoring device or other checking tools (bit error measurement apparatus, packet error measurement apparatus, etc.).

(5) Change the test frequency and execute (4) above.

(6) Apply PM signal as a test waveform to the EUT, and confirm the correct operation of the EUT using a monitoring device or other checking tools (bit error measurement apparatus, packet error measurement apparatus, etc.).

(7) Change the test frequency and execute (6) above.

(8) Apply a horizontally polarized wave to the EUT, and execute (4) to (7) above.

(9) Move the radiating antenna to the next grid, and execute (4) to (8) above.

In undertaking the above test procedures, attention should be given to the following:

a) Tests shall be performed with all covers and panels opened or removed.

b) The pulse modulation carrier of each test frequency shall be present for a longer time than is needed for the EUT to operate and respond (e.g., the processing time of the EUT). In any case, it shall be no shorter than 1 second.

c) Tests shall be conducted for all sides. However, no test is needed on any side if one part (panel, etc.) is no smaller than 1.5 times the uniform electric field plane of the electromagnetic field generating antenna, which is made of a uniform metal that is 0.25 mm or thicker, and is not to be removed at the time of maintenance work, etc. (e.g., the bottom or ceiling side of the EUT).

d) The radiating antenna shall not be moved while it is applying test signals.

6.8 Evaluation of test results

The test results shall be classified in terms of the loss of function or degradation of performance of the EUT, relative to the test level defined in clause 6.1. The classification of test results are in accordance with clause 6.1 of [ITU-T K.43] and performance criterion A is required.

6.9 Test report

The test report is in accordance with clause 10 of [IEC 61000-4-39].

Appendix I

The rationale of decision for the test level

(This appendix does not form an integral part of this Recommendation.)

I.1 Introduction

This appendix describes the rationale for defining the test level. The power of the orthogonal frequency division multiplexing (OFDM) modulated signal from a wireless communication device is distributed to a wide band. When the test is conducted by applying the narrowband signal equivalent to the power of the OFDM signal, it is assumed to be excessive testing. Meanwhile, OFDM is composed of a plurality of subcarriers. The objective in this case is to try to obtain the electric field strength of wireless devices considering a single subcarrier as a unit.

For wireless LAN, the occupied bandwidth of a single subcarrier is 312.5 kHz. Moreover, because the output power is limited to 10 mW / MHz by radio legislation in Japan, the power supplied to one sub-carrier is 3.125 mW.

I.2 Measurement of electric field strength in the vicinity of dipole antenna

The electric field strength near the dipole antenna is measured when 3.125 mW is supplied to the antenna. The measurement set-up is shown in Figure I.1. The measurement of the electric field is conducted by using the optical electric field sensor that enables the non-intrusive measurement.

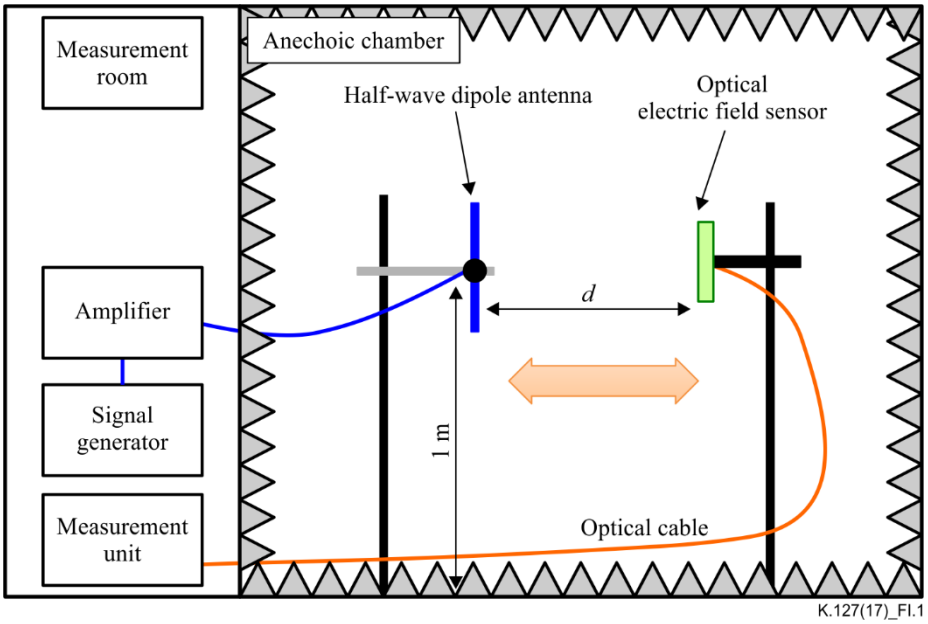

Figure I.1 – Measurement set-up for the electric field strength

The electric field strength at the far field region of the radio wave generated from the antenna is represented by equation (I.1).

$$E = \frac{7\sqrt{P}}{d} \quad \text{(I.1)}$$

where:

E: electric field strength (V/m)

P: equivalent isotropic radiated power (W)

d: distance from the antenna (m).

Equation (I.1) is a formula for calculating the electric field strength in the far field region of the antenna. The wave impedance in the vicinity of the antenna is not constant. Therefore, it is necessary to calculate the electric field strength by equation (I.2) where the wave impedance is taken into account.

$$E[\text{V/m}] = \sqrt{\frac{G \cdot P \cdot Z}{4\pi d^2}} \tag{I.2}$$

where:

G: absolute gain of the antenna

P: equivalent isotropic radiated power (W)

Z: wave impedance (Ω)

d: distance from the antenna (m).

In this case, the wave impedance *Z* is expressed by equation (I.3), undetermined coefficients *a* and *b* are determined by the ratio of the radius of the half-wave dipole antenna ρ (m) to the element length of antenna as shown in Table I.1. Also, *x* is the ratio of the wavelength λ to the distance *d* (*d*/λ).

In this calculation, the undetermined coefficient is determined from the dimension of the half-wave dipole antenna used in the actual measurement, and $2\ell/\rho = 100$ is applied.

$$Z = \frac{a_0 + a_1 x + a_2 x^2 + x^3}{b_0 + b_1 x + b_2 x^2 + x^3} \tag{I.3}$$

Table I.1 – Coefficients of the wave impedance *Z*

Coefficient	**The ratio of the length to radius of the half-wave dipole antenna (2ℓ/ρ)**		
	50	**70**	**100**
a_0	0.00011	0.00008	0.00007
a_1	0.01382	0.01195	0.01043
a_2	−0.00340	0.01732	0.03762
b_0	−0.00004	0.00001	0.00008
b_1	0.04276	0.04250	0.04275
b_2	−0.00026	0.01947	0.03828

Figure I.2 shows the measurement and calculation results. From this figure, the measurement results agree closely with the calculation. Also, if the wireless device is assumed to be used in the vicinity of 1 cm from the telecommunication equipment, the electric field strength is about 24 V/m in the calculation and 20 V/m in the measurement. From this result, the test level was defined as 30 V/m considering the variations of the electric field strength and safety margin.

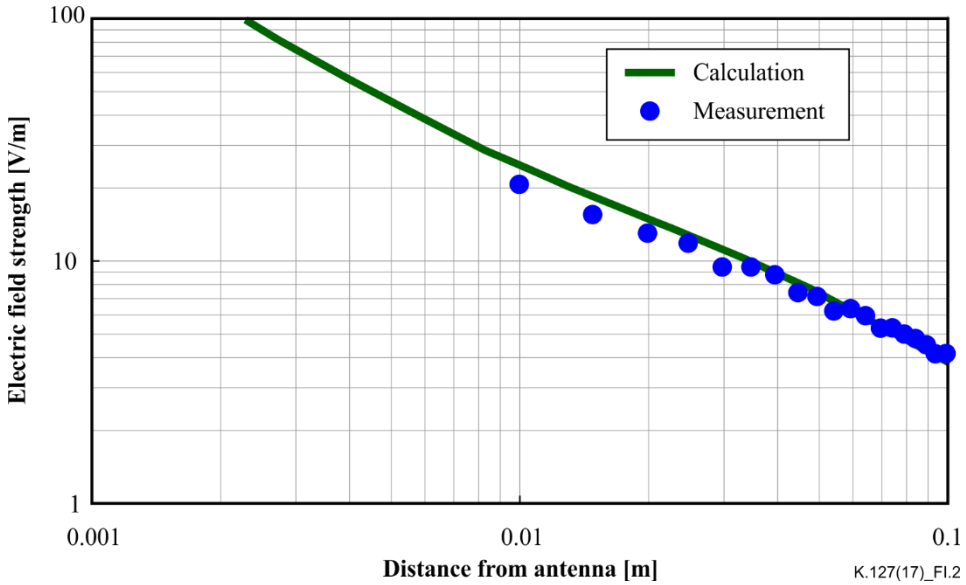

Figure I.2 – Measurement results of electric field strength in the vicinity of the antenna

Appendix II

The protection distance considering the radio law of each country

(This appendix does not form an integral part of this Recommendation.)

II.1 Introduction

In this Recommendation the test level of 30 V/m is required for the radiation immunity test in close proximity. However, the protection distance considering the usage of wireless devices in close proximity is needed because the maximum transmit power of each wireless LAN device is different according to the radio law of each country. Therefore, this appendix introduces the protection distances obtained by the calculation based on the radio law of each country.

II.2 Protection distance

The protection distance is calculated using equation (II.1):

$$d = \frac{\sqrt{30PG}}{E_{rms} \times 1.8} \quad \text{(II.1)}$$

where:

d: protection distance (m)

P: radiated power (W)

G: antenna gain, *G* = 3 is used in this calculation

E_{rms}: electric field strength, E_{rms}=30 (V/m) is used in this calculation.

From the examination of the radio law related to wireless LAN devices in each country, the maximum transmission power is approximately from 60 mW to 4 W. Therefore, the calculation results of protection distance corresponding to the transmit power are shown in Table II.1.

Table II.1 – Calculation results of protection distance

Maximum transmit power	Protection distance
60 mW	0.05 m
100 mW	0.06 m
120 mW	0.07 m
200 mW	0.08 m
600 mW	0.14 m
1 W	0.18 m
4 W	0.36 m

Bibliography

[b-ITU-T K.52] Recommendation ITU-T K.52 (2014), *Guidance on complying with limits for human exposure to electromagnetic fields*.

[b-ITU-T K.83] Recommendation ITU-T K.83 (2011), *Monitoring of electromagnetic field levels*.

[b-IEC 60050-161] IEC 60050-161:1990, *International Electrotechnical Vocabulary. Chapter 161: Electromagnetic compatibility*.

[b-IEC 61000-4-4] IEC 61000-4-4: 2012, *Electromagnetic compatibility (EMC) – Part 4-4: Testing and measurement techniques – Electrical fast transient/burst immunity test*.

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