자유기고문

Generic Standard for *in-Situ* Measurement -2006년 신년특집에 계속하여

이 중 근
한양대학교

Ⅰ. 서 론

월드컵 경기장의 전광판과 같은 대형 전기전자기기 또는 현장에서 조립되는 전기전자기기의 EMI/EMC 시험 평가는 전자파 무반사실 또는 전자파 잔향실과 같은 실내 시험실에서의 시험이 불가능하므로 현장(*in-situ*) 시험 방법을 하여야 하나, 설치 현장의 열악한 시험 조건 등으로 인하여 시험이 불가능한 경우가 대부분이다. 이와 관련해서 우리나라가 국제 규격으로 제안하여 추진 중인 IEC 61000-6-7(전자기 장해 현장 측정)의 연구가 2003년 9월 제주도 CISPR/I 회의 이후 현재까지 활발히 진행 중에 있다. 2006년에는 Korean National Committee에서 제안한 대형 LED 표지판에 의해 발생된 전자파 장해 복사 에너지에 관한 안건이 일본과 스웨덴에서 개최된 여러 번의 회의를 통해 수정 검토되어 오고 있다.

2006년 9월 스웨덴 Stockholm에서 개최된 IEC CISPR/SC-H WG04 회의에서 내용의 추가 및 수정이 되어 최종적으로 정리된 Draft 문서를 아래 본론에서 기술하려고 한다. 추후 일정으로는 Committee Draft for Comment에 이어, Committee Draft for Vote를 거쳐 대다수 국가의 찬성 시 새로운 국제 표준이 확정될 것으로 판단된다.

Ⅱ. 본 론

In-Situ Measurements of Disturbing Emissions Produced by Large Equipments

2-1 Scope

This document deals with *in situ* measurements of physically large systems and installations in any environment. It covers aspects of both types of emissions, conducted and radiated ones. It does not deal with test of immunity against electromagnetic phenomena and with emission phenomena related to networks.

This document is intended to be applied to such physically large systems which are not under the scope of any existing emission standards(as for example CISPR 11 and 22). It serves only as a guideline how to deal with emissions of those systems at the particular location of installation. It does not state any emission requirements.

NOTE: Examples for large equipment and installations: power stations, substations, large industrial plants, production machines, telecom centres, conveyors, large displays, aircraft simulators, traffic control systems, airport luggage transport systems, wind turbine stations etc.

The measurements described in this document can be applied to both, checking of compliance in the case of interference complaints and for demonstration of compliance. Due to the severe impact of the conditions exis-

ting at a particular location of installation, however, it is not intended to use the measurements in the frame of type testing.

Reference *in-situ* measurement distances will be given. This allows comparison of the measurement results with limits from existing relevant standards.

The frequency range under consideration is from 9 kHz to 18 GHz.

Dealing with effects on living matter is excluded from this document.

2-2 Normative References

The following normative documents contain provisions which, through reference in this text, constitute provisions of this document. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this document are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of IEC and ISO maintain registers of currently valid International Standards.

CISPR 11:XXXX, *Industrial, scientific and medical (ISM) radio-frequency equipment -Radio disturbance characteristics -Limits and methods of measurement*

CISPR 16-2-1:XXXX, *Specification for radio disturbance and immunity measuring apparatus and methods - Part 2-1: Methods of measurement of disturbances and immunity - Conducted disturbance measurements*

CISPR 16-2-3:XXXX, *Specification for radio disturbance and immunity measuring apparatus and methods - Part 2-3: Methods of measurement of disturbances and immunity - Radiated disturbance measurements*

CISPR 18-2 Ed. 1.1.b: 1986, *Radio interference characteristics of overhead power lines and high-voltage equipment -Part 2: Methods of measurement and procedure for determining limits*

CISPR 22:XXXX, *Information technology equipment -Radio disturbance characteristics -Limits and methods of measurement*

IEC 61000-2-4:XXXX, *Electromagnetic compatibility (EMC) - Part 2-4: Environment - Compatibility levels in industrial plants for low-frequency conducted disturbances*

IEC 61800-3:XXXX, *Adjustable speed electric power drive systems - Part 3: EMC requirements and specific test methods*

IEC 62236-2:XXXX, *Railway applications -Electromagnetic compatibility -Part 2: Emission of the whole railway system to the outside world*

NOTE: See also the bibliography in annex X.

2-3 Definitions -Terms and Abbreviations

For the purpose of this document, the following definitions as well as the definitions of IEC 60050-161 apply, see particularly electromagnetic disturbance(161-01-05) and electromagnetic interference(161-01-06).

2-3-1 Boundary

Boundary of the physically large system: imaginary straight line periphery describing a simple geometric configuration encompassing the system under consideration. All interconnecting cables should be included within this boundary.

2-3-2 Antenna Reference Point

Geometric centre of the antenna or the reference point referred to in the antenna calibration procedure.

2-3-3 Characterised Interference

Interference the origin of which is an identified electromagnetic phenomena, and for which the disturbance level at a given point is characterised by a collection of technical data for example the spectrum.

2-3-4 Deviation from Intended Use Regarding EMC

Installation and/or operation of a device, equipment or system, deviating from the instructions of the manufacturer given in the user's manual.

NOTE: The installation refers to both the defined environment and electrical conditions including cabling.

2-3-5 Distribution Point

Point on a data and communication network inside a system or an installation, electrically nearest to a particular communication equipment or terminal, at which other equipment or terminals are, or could be, connected.

2-3-6 Fixed Installation

A particular combination of several types of apparatus and, where applicable, other devices, which are assembled, installed and intended to be used permanently at a predefined location.

2-3-7 In-plant Point of Coupling(IPC)

Point on a network inside a system or an installation, electrically nearest to a particular load, at which other loads are, or could be, connected [IEC 61000-2-4].

NOTE: The IPC is usually the point for which electromagnetic compatibility is to be considered.

2-3-8 Point of Common Coupling(PCC)

Point on a public power supply network, electrically nearest to a particular load, at which other loads are, or could be, connected [IEV 161-07-15 MOD, IEC 61000-2-4]

2-3-9 Reference Point(for *in situ* Measurement)

Point at which *in situ* measurement is performed, in case of radiated measurements it is measured along a perpendicular line from the boundary to the antenna reference point.

NOTE 1: Two different values might be defined according to the frequency range.

NOTE 2: The boundary to be taken into account for measurement depends on different conditions.

2-3-10 Physically Large System

A group of items of equipment functionally connected to form a commercially specified system considered in a defined context as a whole and separated from their environment.

NOTE 1: The system is considered to be separated from the environment and from the other external systems by an imaginary surface, which cuts the links between them and the system.

NOTE 2: For the purpose of this document, the elements of the system are objects such as devices, equipment or sub-systems. They are interrelated for achieving an objective which is the performance of a function or a set of functions.

NOTE 3: A system can be considered as physically large when it has a total dimension exceeding that which is practical for testing on a conventional 10 m test site.

2-3-11 Victim

Interfered equipment having caused a complaint.

2-4 Methodology

2-4-1 Structure of Each Measurement

The investigated EUT shall be checked and measured at each type of port for which EMC requirements are

defined. Each measurement may be separated according to the following steps:

A preliminary measurement of the investigated port is carried out to detect the frequencies with the highest emissions by a measurement method which may deviate from the measurement method on the standardized test site.

Frequently appearing operating modes of the EUT have to be checked -if possible - in order to find the mode with the highest disturbance emission.

For each investigation the reference point has to be selected at the EUT and has to be used for the final measurements.

The measurement quantity has to be identified under environmental conditions for the final measurement, the value of the measurement quantity has to be determined in the direction in which compatibility is required. This value may have to be transferred to the standard conditions if necessary.

2-4-2 Preliminary Measurements and Selection of Measurement Method

It is useful to apply different approaches for the detection of the frequencies with the highest emissions. One approach could be to check the technical documentation of the EUT with respect to such emissions or another approach could be the check of highest emission in closer distance to the EUT.

The measurement method depends on the frequency range and EUT port under consideration.

The field strength measurement(see CISPR 16-2-3) is only to be used for radiated emission.

Three measurement procedures are taken into account for telecommunication ports and AC mains ports as following:

Measurement with the capacitive voltage probe(CVP) according to CISPR 16-1-2

Measurement with the current probe according to CISPR 16-1-2

Measurement with a high impedance voltage probe via an *in-situ* produced capacity for the measurement of the asymmetrical voltage.

2-4-3 Selection of the EUT Mode and the Reference Point Depending on the Environment

CISPR 16-2-x require the mode with the highest emission for the measurements. If it is possible to select this mode from different modes this has to be done.

The selection of the reference point for the measurements is different for the ports and depends on the environments. Fig. 1 to 4 show the different approaches.

NOTE(to Fig. 1): In case of installations the reference point is recommended to be chosen according to the purpose of the measurements; the IPC should be used in case of compliance measurements and the PCC in case of investigating interference cases with respect to the characteristics of the interference victim.

NOTE(to Fig. 4): It is recommended to choose the appropriate requirements(for example limits to be met) with respect to the characteristics of the interference victim.

2-4-4 Interpretation of Measurement Results

It should be understood that measurement results obtained *in situ* are not comparable with any other results which are obtained on standardized test sites.

Therefore the results of *in situ* measurements can only be interpreted. In most cases such results will only be obtained if an interference case has occurred. It is obvious that if interference has occurred the emission of the EUT is too severe for its surroundings(which is its environment). This clearly can be interpreted.

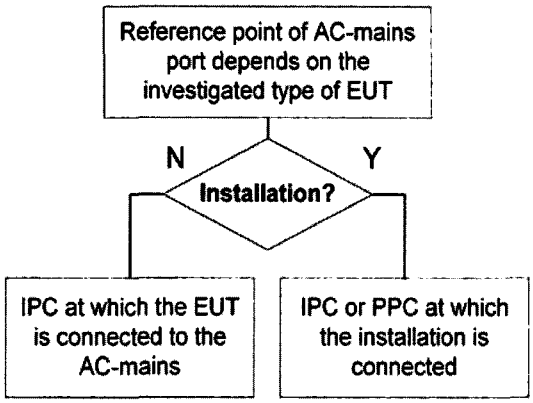

Fig. 1. AC-mains port.

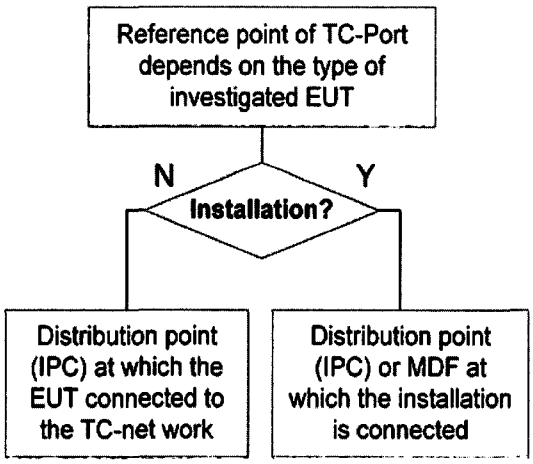

Fig. 2. TC-port.

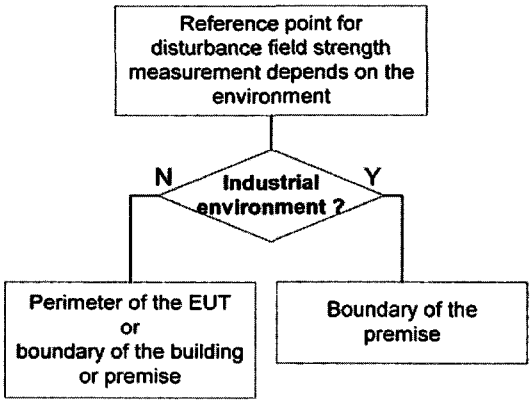

Fig. 3. Enclosure-port.

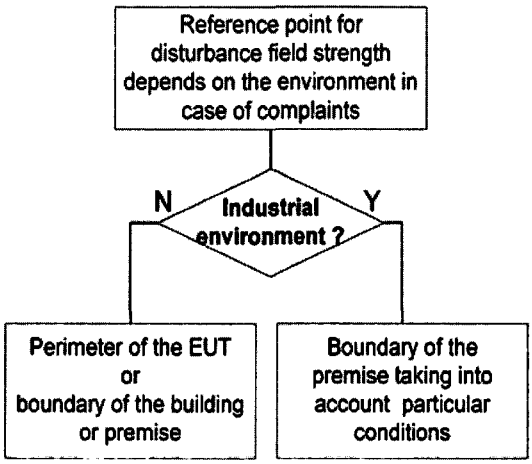

Fig. 4. Enclosure-port in case of complaints.

The question how much lower the emission has to be not to cause interference is definitely depending on the source and the victim again. Considering both sides(source and victim) it may be possible to consult standards which are applicable to these products for further assessment.

Also it is understood that it is in most cases not possible to measure in a standardized test distance.

Two approaches are possible.

The first possibility is the calculation as described in CISPR 16-2-3 Sub-clause 2-7-5 for an EUT inside of buildings or premises.

The second possibility(in case if there are no obstacles between the antenna and the EUT) is to use the distance between measurement antenna and interference source, and to convert the measured field strength to the value referring to a standardized test distance. In this case the following equation is recommended:

$$E_{std} = E_{mea} + 20 \cdot \log \frac{d_{mea}}{d_{std}}$$

where d_{mea} is the actual measurement distance and d_{std} is a standardized test distance.

2-5 Selection of Measurement Location and General Condition

2-5-1 General

Both radiated and conducted measurement follow the same principle, in order to characterise the source of the emission.

The location of radiated emission measurement is defined to show the highest level of emission for a given frequency according to the purpose of the preliminary measurements, and according to local constraints. The procedure related to the highest emission is defined in CISPR 16-2-3.

CISPR 16-2-1 and CISPR 16-2-3 in general give the general conditions for conducted and radiated measurements.

2-5-2 Conducted Emission Measurements

The choice of the point of measurement between PCC or IPC is defined by the interfered area in which complaints is raised:

-PCC if the interfered area is outside the installation which contains the source of the emission;

-IPC if the interfered area is inside the installation which contains the source of the emission, in addition, the disturbance level at the PCC should be considered.

In the frequency range from 9 kHz to 30 MHz the conducted emission from mains is measured either at or near the point of coupling of the source of the emission.

2-5-3 Radiated Emission Measurement

In the case of compliance testing the measuring distance from the applicable product standard shall be used. Only if this is impossible due to the local installation conditions other distances may be considered.

In the case of an interference caused by a large installation the disturbing field strength shall be measured in the direct vicinity of the interfered victim.

If the EUT is mounted at greater height(e.g. on the top of a tall building) the actual measurement distance shall be determined by the direct line between the EUT and receiving antenna. In such a case the measurement distance is calculated by the formula (1).

$$d_{mea} = \sqrt{r^2 + h^2} \tag{1}$$

where

r is the horizontal distance from the EUT to the receiving antenna in meters;

h is the EUT height from the ground.

2-6 Method of Measurement for *in situ* Conducted Emission

2-6-1 General

The method of measurement for *in situ* conducted emission at any mains and telecommunication/signal ports of physically large equipment is proposed as follows.

Testing may be performed at the boundary of EUT installation premises. In this case, both the system and its location are considered as the system tested. The emission results are unique to the installation site because site containment properties affect the measurement.

2-6-2 Conducted Emission Measurement Procedure

The disturbance voltage and current shall be measured under the existing conduction conditions with ca-

pacitive voltage probe and current probe specified in CISPR 16-1-2. The conduction conditions and measurement results are affected by the following:

The existing ground according to the given installation. No changes shall be made to the existing ground system which might influence the performance of this system. In particular artificial mains networks are not to be used.

The RF characteristics and loading conditions for the power mains.

The ambient RF environment and the input impedance of the probes and their possible connection to ground.

2-6-2-1 Reference Ground for *in situ* Measurements

A comprehensive description of reference ground systems is given in CISPR 16-2-1.

The following particularity is to be considered for *in situ* testing.

If no suitable reference ground is available *in situ*(in the surroundings of the test object or at the place of measurement), a sufficiently large(for example 1 m square) conductive structure such as metal foil, a metal sheet or wire mesh set up in the proximity can be used as reference ground for the measurement. Care should be taken not to influence the behaviour of the EUT if such a measure is needed.

2-6-2-2 Disturbance Voltage/Current Measurements on Cables Carrying Symmetrical Signals

The testing of conducted disturbance voltage and current of cables is done with a capacitive voltage probe and a current probe respectively.

The following cases have to be considered.

Mains cables carrying power line communication(PLC) and telecom cables are to be measured during operation(when they carry the symmetrical signal). Both the voltage probe and the current probe measurements shall be performed to be able to compare the results with limits existing in product standards.

The following particularities have to be considered for *in situ* measurements.

- Cables have not to be cut or disconnected
- No metallic contact of the probes is allowed

The probes shall be placed at the measuring point specified in the clause 2-6-2-4.

2-6-2-3 Disturbance Voltage Measurements on Cables Carrying No Symmetrical Signals

The testing of conducted disturbance voltage is done with a voltage probe. This measurement is done at AC mains cables not carrying PLC signals or at AC mains cables where PLC is currently not operated. The applicable measurement procedure is given in CISPR 16-2-1.

2-6-2-4 Placing of the Voltage and Current Probes

The current probe shall be placed at the selected reference point for the measurement. Only if this is not possible the measurement may be undertaken by placing the probe in maximum 30 cm away from the reference point in direction towards the test object.

The capacitive voltage probe is to be placed next to the current probe but separated by 10 cm±1 cm.

In the case of non-shielded and shielded signal, control and load cables with non-grounded shield leaving the boundaries, the asymmetric disturbance voltage and current shall be measured with the capacitive voltage probe and the current probe on the individual wires or the screens against reference ground.

2-7 Method of Measurement for *in situ* Radiated Emission

2-7-1 General

In situ measurements might be performed because of two reasons: for the investigation of an interference problem at a particular location or for the evaluation of compliance. Depending on the actual reason some of the conditions to be considered for the measurements might be different.

The used measurement equipment shall comply with CISPR 16-1-1 and CISPR 16-1-4.

The measurement of radiated emissions should preferably be made at a reference distance between antenna and reference points(see CISPR/H/WG4(Dunker)06-01) whereas the value for the direct distance should be used. This allows an easy assessment with respect to the applicable limits. If this is impossible due to local conditions, including safety reasons, measurements can be performed at deviating distances. A procedure to select a different measurement distance is for example defined in CISPR 16-2-3. In case of investigating interference complaints usage of reference distances is not necessarily the most suitable one in every case. It might rather be more appropriate to use such measurement distances which reflect the spatial situation of the interference case.

NOTE: If an item of equipment is disturbed which is located for example about 50 m away from a potential interference source it could be the first step to perform measurements at the location of the equipment and to assess the measured field strengths. In a further step then the emissions from the potential interference source might have to be measured for further evaluation and assessment of the interference situation.

In case of using other distances than the reference distances the measured field strengths have to be converted to the reference distance situation. This should be done according to the methods given in clause X.X(see CISPR/H/WG4(Dunker)06-01) whereas the limitations of such a conversion have to be kept in mind.

It is recommended to check that for field strength measurements the ambient emissions are at least 6 dB lower than the measured disturbance field strength, i.e. the applicable limits, under consideration of any transfer in the field strength levels due to deviating measurement distances. Where this is not possible the contributions due to any other equipment or installations in the environment should be taken into account.

NOTE: This requirement can be checked for example by switching off the equipment under test where possible by comparing the shape of the measured field strengths (equipment under test on) with the shape of the ambient emissions(equipment under test off).

In case the equipment under test cannot be switched off other procedures could be applied for example the directivity of the antenna can be used to check the maximum and the minimum of the equipment emissions. Other procedures could be a check of the dependence of the field variation with regard to the distance from the equipment under test. The signature of the spectrum obtained close to the equipment under test could also be used as a means to distinguish the equipment emissions from the ambient noise.

The effects of the various operational modes of the equipment under test on the radiated emissions should be taken into account. This can be done for example by varying the operating mode as a recording of the field strength spectrum is being performed.

2-7-2 Measurement Conditions

Weather conditions have a significant impact on the measurement results. In order to minimize their effect on the measured field strength levels, measurements should be carried out in dry weather,(after 24 hours

during which not more then 0, 1 mm rain has fallen), with a temperature of at least 5 ℃, and a wind velocity of less than 10 m/s. Since it is often necessary to plan the measurements before the weather conditions can be known, measurement might have to be carried out in weather conditions which do not meet the target conditions. In these circumstances the actual weather conditions should be recorded with the measurement results.

2-7-3 Measurement Methods

In case of *in-situ* radiated measurements the following parameters should be taken into account:

Antenna height

Antenna placement and orientation

Antenna tilting

Their actual relevance and the appropriate considering depend on the type of purpose for the measurements, i.e. for compliance purposes of for investigating interference complaints.

2-7-3-1 Measurements in Case of Interference Complaints

Antenna height, placement and tilting should be arranged in that way to allow concluding on the potential interference source. Preferably the antenna should be placed at or close to the location of the interference victim in order to measure the field strengths there and to allow for assessing them. It is recommended to vary the orientation and the tilting of the antenna to obtain the maximum reading.

For an assessment of the emissions from the identified interference source or sources it might be appropriate to perform additional measurements similar to those used for compliance measurements. The evaluation of both types of results could assist in deriving appropriate counter measures, for example under an economic point of view.

2-7-3-2 Measurements for Compliance Purposes

It is recommended to carry out measurements of radiated emissions in accordance to CISPR 16-2-3 for distances as mentioned in sub-clause 2-7-1 to allow for the assessment with respect to applicable limits.

NOTE: Due to imperfections in the measurement set-up compared to the situation on a standard test site, such as the presence of reflecting objects, the obtained measurement results might not be directly related to those theoretically to be expected on a standard test site. This should be considered for assessing the results.

There are some further aspects to be considered:

It is recommended to vary the height of the measurement antenna within a specified range to obtain the maximum reading. As a general rule, for measurement distances up to and including 10 m is as follows: the antenna height for electromagnetic field measurements shall be varied between 1 m and 4 m. At greater distances of up to 30 m, preferably the height should be varied between 2 m and 6 m. This variation applies for both horizontal and vertical polarization.

NOTE: In extreme cases, i.e. when the equipment under test is installed at a significant height above ground and when there might be the situation that potential interference victims could be located at a similar height, it might be appropriate to consider this height for the measurement antenna when practical.

In case that the equipment under test and the measurement antenna have quite different positions above ground it might be required to tilt the antenna according to its directivity pattern in order to obtain the maximum reading.

It is recommended to carry out measurements at dif-

ferent locations around the equipment under test. The number of locations should be chosen taking into account the *in-situ* conditions and the physical dimensions of the equipment under test.

2-7-3-3 Measurements below 30 MHz

In the frequency range below 30 MHz the magnetic field strength should be measured with a loop antenna as described in CISPR 16-1-4 at a height of 1 m(between the ground used for reference and the lowest part of the antenna). The maximum field strength should be determined by rotating the antenna.

2-7-3-4 Measurements above 30 MHz

For measurements above 30 MHz a procedure should be used as described in CISPR 16-2-3.

2-8 Test Report

The particular circumstances and conditions of the *in situ* measurements of a large EUT and the operational conditions during the measurements should be documented to allow the repeatability of the test. The documentation should include(see also CISPR 16-2-3):

Reasons for the *in situ* measurement instead of using a standard test site;

Technical documentation with the description of the measured EUT;

Details of all connections between the measured installation and the EUT: technical data and details of their location/configuration;

Scale drawings of the measurement site, showing the points at which measurements were made and description why these points are selected;

Description of the operating conditions;

Details of the measuring equipment

Measurement results at the different measurement point and the relation to the selected limits.

Ⅲ. 결 론

2003년에 Korean NC(National Committee)에 의해 제안되어 2004년 정식으로 IEC 61000-6-7(전자기 장해 현장측정)의 국제 규격 번호가 부여된 "대형 LED 표지판에 의해 발생되는 전자파 장해 복사 에너지"에 관한 안건은 2005 년 여러 국가의 대표 및 위원들과 논의 및 토론을 통해 우리나라가 주도적으로 작성할 수 있는 기회를 갖게 되었다.

2006년에 있었던 도쿄 IEC CISPR/H WG04WG04 국제회의에서는 CLC TS 50217 문서를 참고하여 새 기술 보고서를 만들고, "Care Taker"를 선정하여, CISPR 16-2 문서와의 비교 분석 연구를 동시에 수행하였다.

또한 스웨덴에서 열린 IEC CISPR/SC-H WG04 회의에서는 4-3절 'Selection of the EUT mode and the reference point depending on the environment' 부분의 Fig. 1~4가 수정되었고 제7장 'Method of measurement for *in situ* radiated emission' 내용이 새로이 추가되었다.

본문에 기술한 Draft 문서는 2007년 1월 24일~26일 독일 Erlangen에서 있을 차후 회의에서 재검토될 예정이며, 현재 CISPR/H/WG4 의장인 본 저자와 각국의 관련 대표자들과의 의견 및 Comment 교환이 활발히 이루어지고 있는 실정이다.

마지막으로 국제학회 및 국제표준회의에서 우리나라가 주도적으로 본 Draft 문서의 작성과 검토를 할 수 있게 지원을 아끼지 않았던 한국정보통신기술협회(TTA), 한국전자통신연구소와 산업자원부 기술표준원에 깊은 감사를 드리는 바이다.

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≡ 필자소개 ≡

이 중 근

1967년: 서울대학교 전기공학과 (공학사)
1973년: Univ. of South Florida 전자공학과 (공학석사)
1979년: Univ. of South Florida 전자공학과 (공학박사)
1990년: 한국전자파학회 초대 회장
1993년~1997년: 한국아마추어무선연맹 이사장
1998년~현재: 한양대학교 전자컴퓨터공학부 교수
2004년~현재: IEC/CISPR/SC-H/WG4 Convener
2006년~현재: IEC/IARU R3 Director
[주 관심분야] EMC, MW 부품, Antenna