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SERIES K: PROTECTION AGAINST INTERFERENCE

High frequency EMC mitigation techniques for telecommunication installations (Basic EMC Recommendation)

ITU-T Recommendation K.37
Superseded by a more recent version

(Previously CCITT Recommendation)

Superseded by a more recent version

ITU-T K-SERIES RECOMMENDATIONS

PROTECTION AGAINST INTERFERENCE

For further details, please refer to ITU-T List of Recommendations.

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FOREWORD

The ITU-T (Telecommunication Standardization Sector) is a permanent organ of the International Telecommunication Union (ITU). The ITU-T is responsible for studying technical, operating and tariff questions and issuing Recommendations on them with a view to standardizing telecommunications on a worldwide basis.

The World Telecommunication Standardization Conference (WTSC), which meets every four years, establishes the topics for study by the ITU-T Study Groups which, in their turn, produce Recommendations on these topics.

The approval of Recommendations by the Members of the ITU-T is covered by the procedure laid down in WTSC Resolution No. 1 (Helsinki, March 1-12, 1993).

ITU-T Recommendation K.37 was prepared by ITU-T Study Group 5 (1993-1996) and was approved by the WTSC (Geneva, 9-18 October 1996).

NOTES

1. In this Recommendation, the expression "Administration" is used for conciseness to indicate both a telecommunication administration and a recognized operating agency.

2. The status of annexes and appendices attached to the Series K Recommendations should be interpreted as follows:

- an *annex* to a Recommendation forms an integral part of the Recommendation;
- an *appendix* to a Recommendation does not form part of the Recommendation and only provides some complementary explanation or information specific to that Recommendation.

CONTENTS

SUMMARY

This Recommendation defines mitigation techniques which the telecommunication operators may use to avoid disturbances, interference and damages caused by fast transient and radio frequency phenomena.

This Recommendation contains guidance for the telecommunications system normal operation:

- use of telecommunications equipment fulfilling relevant EMC requirements;
- proper installation practices such as well-controlled earthing and bonding networks and a.c. power distribution networks in buildings, avoidance of disturbing equipment close to telecom equipment, environmental control and well-designed cabling;
- proper working practices such as avoiding use of handheld radios close to telecom equipment and applying special precautions when handling electrostatic discharge sensitive devices.

Special mitigation methods like shielding and filtering are discussed for cases where EMC problems arise.

This Recommendation does not include circuit or equipment design rules or guidelines for manufacturing – it is noted that this information is already widely available.

INTRODUCTION

This Recommendation contains guidance for telecommunication operators on avoiding interference and damage caused by fast transient and radio-frequency electromagnetic phenomena. The text is intentionally short, drawing the attention of the user to reference standards and documents listed in the bibliography.

Equipment, when used in an environment where it is intended to be installed, should be able to function properly and without disturbing other equipment. This is assured by environmental classification and EMC test requirements.

Telecom equipment normally fulfils the EMC requirements when the doors of cabinets are closed and other covers are on. During installation and maintenance it is necessary to open the doors which require special precautions when handling ESD sensitive devices. Handheld radios may also cause interference in such situations.

Mitigation methods are also given for cases where interference exists due to fast transient or radio-frequency phenomena for some reason, e.g. the environment is harder than the class the equipment is designed for. Practical rules are given for situations where interference occur.

This Recommendation is a basic EMC Recommendation for telecommunications.

Recommendation K.37

HIGH FREQUENCY EMC MITIGATION TECHNIQUES FOR TELECOMMUNICATION INSTALLATIONS (BASIC EMC RECOMMENDATION)

(Geneva, 1996)

1 Scope

This Recommendation explains high frequency EMC mitigation techniques in order to avoid disturbances and interference caused by high frequency and fast transient phenomena.

This Recommendation applies to installation and maintenance of telecommunications equipment.

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; all 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.

– IEC 50(161):1990, *International Electrotechnical Vocabulary – Chapter 161: Electromagnetic compatibility.*

3 Definitions

The definitions of IEC Publication 50(161) apply.

4 High frequency EMC

High frequency EMC in telecommunications includes control of both emission and immunity in telecommunication equipment and installations.

High frequency emission is mainly caused by harmonics of clock frequencies of digital circuits which propagate by conduction or radiation. Spurious emissions from radio equipment can also be considered to belong under EMC. Emission control is performed by equipment design and correct installation.

Immunity problems may be caused by such high frequency and fast transient phenomena as radio-frequency fields of different radio systems, radio-frequency currents induced to telecommunication and power lines, fast transients caused by switches in equipment connected to mains or d.c. power and discharges of the static electricity. Immunity is controlled by designing equipment to meet standardized test requirements, by network design, proper installation, environmental control and maintenance and correct working methods.

5 Equipment specifications

The equipment shall be able to work without EMC problems in the environment where it is intended to be installed. For this reason the electromagnetic environment of telecommunications equipment has been classified to four classes [1]. This classification has been used in specifying test requirements for different telecommunications equipment [2] and [3]. Emission requirements shall also be specified [4].

The operator should specify the requirements by reference to the relevant ITU-T Recommendation or corresponding document and either check from the manufacturer or test himself that the equipment fulfils the requirements.

6 Environment

6.1 Distance to radio transmitters

Telecommunication centres should have such a distance to radio transmitters that the field strength does not exceed the characteristic severity of the environmental class [1]. In planning radio relay routes, airport areas and other locations where radar signals are present should be avoided.

6.2 Earthing and bonding network

To achieve good EMC performance it is essential that the building where equipment is installed is provided with a well designed, designated earthing and bonding network. The environmental classes "Major telecommunication centres" and "Minor telecommunication centres" presume implementation of an earthing and bonding network according to [5]. Guidance on an earthing and bonding network for subscriber's buildings is given in [6]. The recommended earthing and bonding practice in remote telecom sites is specified in [7].

From fast transient and radio frequency point of view, the bonding inside the building is more important than the contact to earth via the earthing electrode.

6.3 a.c. power network and electrical equipment

For a.c. power distribution in buildings, TN-S system is preferred compared to TN-C system [5], [6] and [8]. These reference documents of the bibliography give guidance also for cases where power is served by a TT or IT distribution system.

In TT power distribution systems, the surge voltage to which telecommunication equipment is exposed from telecommunication and power lines may be much higher than in TN-S systems. Therefore, higher immunity or additional protection is required.

Care shall be taken to ensure that electrical equipment in the premises where telecommunications equipment is installed is provided with proper protection devices, e.g. fluorescent lamps for industrial use, not provided with disturbance suppression capacitors, have induced interference in high-capacity digital transmission systems.

Electrical equipment using inverter power supplies have caused severe disturbances especially when connected to TT power distribution systems. In particular, telecommunication equipment is adversely affected by disturbances when the common mode impedance from the telecommunication line is low. Therefore, high common mode impedance is preferred in equipment for TT systems.

6.4 Materials and humidity

The level of the electrostatic discharges which can be generated in an environment can be controlled by material and humidity control [9].

In an uncontrolled environment where all types of materials and levels of humidity are possible and the clothing and shoes of personnel are not specified, electrostatic charge voltages in excess of 8 kV are possible. Partial control, where restrictions in the use of materials with high tribo-charging properties are in force but all levels of humidity are possible, restricts the charge voltage normally below 8 kV.

Full control of materials and training of personnel and control of the relative humidity, e.g. above 40% will restrict the charge voltage normally below 4 kV. These measures are often possible in telecommunication centres. Instead of humidity control it is possible to restrict the charge voltage by selecting flooring and footwear materials so that the total resistance to the earthed bonding system is less than 10^8 Ω.

In a specially controlled environment, e.g. a printed circuit board repair centre, charge voltages shall be restricted to a minimum, typically below 200 V. Control measures are specified in [9].

7 Installation

7.1 Equipment

Equipment is normally bonded to the earthing and bonding network for safety reasons. Whenever possible, telecommunications equipment should not be installed close to high power radio-frequency equipment. This is a particular threat in industrial environments.

7.2 Cabling

The EMC performance of a system depends both on the characteristics of cables and their installation. Interference is caused due to the occurrence of a differential mode disturbance voltage in the victim circuit. The intention of the mitigation measures is to make this differential mode disturbance low enough compared to the signal flowing in the circuit.

Direct differential mode coupling of disturbances is normally prevented using twisted pair or coaxial cables; both constructions minimize coupling to the differential mode loop.

Common mode coupling results in common mode voltages and currents in a system. The coupling from common mode to differential mode can be reduced by symmetry of pair cables and by screening. The aspects of symmetry are presented in [10]; the symmetry of normal cables is not very good at high frequencies but specially designed cables are available. Screening can be applied to pair cables and the outer conductor of coaxial cables acts as a screen. Measures of the quality of the screen are the transfer impedance and the transfer admittance. Definitions of these characteristics and requirements for different types of cables can be found in [11] and [12].

Common mode coupling can be reduced by increasing the distance of signal cables to power cables and by minimizing the area of earth loops. Different types of cables should preferably use different cable trays, at least in telecommunication centres. Metallic cable trays bonded to each other and to the earthing and bonding system help to reduce the area of earth loops. Sometimes a closed metallic cable tray can be used to form a screen around cables. A complete set of EMC rules for cable and wire installation is given in [8].

7.3 Connectors

To be effective at high frequencies the screen of cables should be in contact with the metallic wall of an equipment enclosure. It is important that this connection is made with a good connector whose transfer impedance is adequately low or with another specially designed circuit which makes contact around the screen. Contact made by one connecting wire is not effective at high frequencies.

Some aspects on connectors are given in [8].

8 Working methods

8.1 Restrictions to use disturbing equipment

Handheld radios are more and more commonly used by public or by personnel of telecommunication companies. Especially the new systems like GSM, using a time division multiplexing technique (TDMA), represent a potential disturbance source because the TDMA signal is rectified in the victim equipment.

The field strength of a handheld GSM telephone is almost 8 V/m at the distance of 1 m and about 2.5 V/m at the distance of 3 m [13]. The immunity requirement of radio frequency field for equipment intended to be installed in telecommunication centres is normally 1 V/m or 3 V/m. The handheld radio telephones may produce radio frequency field over 1 V/m. Therefore, the use of handheld radio telephones in telecommunication centres should be restricted by the operators by administrative rules to ensure that radio frequency fields above the appropriate field strength do not occur in the immediate vicinity of equipment.

8.2 Avoiding ESD in maintenance and repair

Although telecommunications equipment which is designed to be ESD immune is not normally disturbed during its operation, special precautions are necessary when handling printed circuit boards and components. In telecommunication centres, equipment racks can be provided with earth bonding points where personnel can earth themselves by wrist-straps. Technical and safety requirements of such earth bonding points are given in [9].

If earth bonding points are not available as in customer premises, ESD shall be prevented using specially designed tools and work surfaces to allow potential equalization during handling of ESD sensitive devices. Electrostatic protection packaging shall be used in the transport of such devices and repair shall be made in a specially designed repair centre where all materials, tools, furniture, clothing and footwear are controlled [9].

9 Special mitigation measures

A general guidance on high frequency EMC mitigation methods is given in this clause. Application of these techniques to practical problem solution is discussed in Appendix I.

9.1 Screening

Radio frequency field immunity and emission requirements for equipment intended to be installed in telecommunication centres are often based on the class “Major telecommunication centres”. When installed in minor telecommunication centres or remote electronic sites [7], problems may sometimes arise due to location of the centre close to a radio transmitter or due to emission from telecommunications equipment which disturbs radio or television reception in houses close to the telecommunication centre or the remote electronic site. In such cases screening may be added by the operator around the whole centre or around the disturbing equipment. Metal foil screening may often be sufficient and sometimes a properly earthed screen on one wall only may solve the problem.

Screening may also be necessary in cases where telecommunications equipment causes interference to a radio system in the same telecommunication centre. The source of the radiation should be identified and screening added accordingly, e.g. around the main distribution frame or cable screens shall be connected to equipment enclosures.

9.2 Filtering

In cases where high level radio frequency or transient phenomena cause disturbances via low frequency telecom lines or via power leads, it is possible to use filters to prevent interference. Filters should be combined to screening or contained in the equipment in cooperation with the manufacturer.

Customers using only ordinary telephones may in the future be provided with wideband digital services via the existing subscriber line. In such a case it will be necessary to remove a low pass filter used to restrict high frequency disturbances.

9.3 Common mode chokes

In cases where minimizing the area of common mode loops is not sufficient, lines may be provided with common mode chokes or ferrites to increase the impedance of the common mode circuit. Such a device reduces the common mode current but does not affect the differential mode signal. Whether an effective reduction of the common mode current is achieved depends on the original impedance of the common mode circuit, but in many cases where they are effective, they can very conveniently be applied to an installed system.

9.4 Isolation transformers

Isolation transformers are mainly used to break the low-frequency path of common mode loops in power and signal circuits. Depending on the capacitance between primary and secondary of the transformer, they may increase the impedance of the common mode circuit also at higher frequencies.

9.5 Optical components

Optical isolators and especially optical links which use glass fibre instead of metallic cables are an effective measure to avoid radio frequency and fast transient interference coupling via signal ports.

10 Bibliography

[1] ITU-T Recommendation K.34 (1996), *Classification of electromagnetic environmental conditions for telecommunications equipment – Fast transient and radio frequency phenomena*.

[2] ITU-T Recommendation K.32 (1995), *Immunity requirements and test methods for electrostatic discharge to telecommunication equipment – Generic EMC Recommendation*.

[3] CCITT Recommendation K.15 (1972), *Protection of remote-feeding systems and line repeaters against lightning and interference from neighbouring electricity lines*.

[4] CISPR 22, *Limits and methods of measurement of radio disturbance characteristics of information technology equipment*.

[5] ITU-T Recommendation K.27 (1996), *Bonding configurations and earthing inside a telecommunication building*.

[6] ITU-T Recommendation K.31 (1993), *Bonding configurations and earthing of telecommunication installations inside a subscriber's building*.

[7] ITU Recommendation K.35 (1996), *Bonding configurations and earthing at remote electronic sites*.

[8] IEC 77B (Sec.) 121 (July 1995), *Electromagnetic Compatibility (EMC) – Part 5: Mitigation methods and installation guidelines – Section 1: Earthing and cabling*.

[9] ETSI Technical Report ETR 127, *Equipment Engineering (EE); Electrostatic environment and mitigation measures for Public Telecommunications Network (PTN)*.

[10] ITU-T Recommendation K.10 (1996), *Low frequency interference due to unbalance about earth of Telecommunication equipment*.

[11] IEC Publication 1196-Series, *Radio-frequency cables – Specifications*.

[12] IEC 46A (Central office) 159, *Generic specification for radio-frequency cables – Part 4: Test methods – Chapter 7: Screening effectiveness*.

[13] ETSI Technical Report ETR 151, *Equipment Engineering (EE); EMC testing of telecommunications equipment above 1 GHz*.

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Appendix I

Troubleshooting and fixing high frequency EMC problems

I.1 Introduction

This Appendix is based on the reference in I.4 and contains guidance on how to proceed when an EMC problem is encountered in practice. A logical approach is first to identify the reason for the problem and then fix it in the most economical way. The approach may be different in customer premises, in outdoor locations and in telecom centres but certain "thumb rules" can often be applied.

I.2 Source verification

In cases where it is suspected that continuous radio-frequency signals either to or from telecom equipment are causing interference, it is possible to try to identify the source by monitoring radio or TV. Some typical characteristics are the following:

- Disturbances caused by amateur or citizen band radio tend to cause garbled audio signals so that it is hard to understand conversation and diagonal lines across TV screen.
- Broadcasting stations cause understandable voice or music and FM radio may cause wavy lines from top to bottom of TV screen.
- Industrial, scientific, medical or telecom equipment cause buzzing or humming of audio signals and static or "snow" on TV screen.

One can also try to identify the source of disturbance by looking for large antennas or industrial plants or hospitals in the vicinity. An effective method is to switch on and off the suspected equipment while monitoring the change in radio or TV. This is obviously not acceptable for large switching equipment.

In the case that transient disturbances are suspected, it is possible to switch on and off nearby electrical equipment or fluorescent lights while monitoring the victim system.

Useful information can be obtained by analysing when the EMI began, whether there are noisy and quiet periods, whether somebody has installed a new personal computer, telefax, refrigerator, coffee cooker etc., or whether some electrical appliances are malfunctioning.

I.3 Check list for problem solution

The check list below contains proposals whose costs may vary on a large scale. One should always find the reason for the problem to be able to apply the best technical and economical solution.

Single telephone problems:

- Poor connections: clean, dirty or corroded connections.
- Damaged insulation: replace.
- Defective overvoltage protectors: replace.
- Demodulation in telephone set: check using high quality telephone set; replace or install filter or choke.
- Common mode currents on subscriber line: install filter or choke.

Telecom network problems:

- Poor earthing and bonding: verify that bonding recommendations are followed; check for continuity; clean, dirty, corroded or painted connections; verify that the main earthing mechanism is still sound.
- Missing bonding of cable screens: repair.
- Differential mode coupling (twisted pair) problem: minimize untwist at cross connections.

– Missing electromagnetic screening: check that all gaskets are installed around doors, faceplates etc.; check that contact surfaces are not painted or corroded and that no foreign material like tape exist between contact surfaces.

– Damaged electromagnetic screening: verify that gaskets make contact at all points when doors are closed; replace corroded or damaged gaskets; clean contact surfaces.

– Common mode currents in cables: apply ferrite chokes or other mitigation measures; choose properly screened cables; reroute affected cables.

– Faulty circuit card: replace circuit cards one at a time and monitor interference.

– Too close proximity: move suspected equipment away from each other.

– Common frequency with licensed service: contact spectrum management authorities.

– Insufficient screening: apply screening on equipment level or building level.

I.4 Bibliography

– Bell Canada: EMC Engineering Guide – DL CG 92-307, Issue 2, March 1993.

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