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SERIES K: PROTECTION AGAINST INTERFERENCE

Low and high frequency EMC mitigation techniques for telecommunication installations and systems – Basic EMC Recommendation

ITU-T Recommendation K.37

(Previously CCITT Recommendation)

ITU-T K-SERIES RECOMMENDATIONS

PROTECTION AGAINST INTERFERENCE

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

ITU-T RECOMMENDATION K.37

LOW AND HIGH FREQUENCY EMC MITIGATION TECHNIQUES FOR TELECOMMUNICATION INSTALLATIONS AND SYSTEMS – BASIC EMC RECOMMENDATION

Summary

This Recommendation defines mitigation techniques which the telecommunication operators may use to avoid disturbances, interference and damages caused by power and electrified railway plants, radio transmitters, both intentional and unintentional, and electrostatic discharges.

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 telecommunications equipment, environmental control and well-designed cabling;

– proper working practices such as avoiding use of hand-held radios close to telecommunications equipment and applying special precautions when handling electrostatic discharge sensitive devices;

– proper working practices in areas subject to high levels of low-frequency induction.

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.

Source

ITU-T Recommendation K.37 was revised by ITU-T Study Group 5 (1997-2000) and was approved under the WTSC Resolution No. 1 procedure on the 26th of February 1999.

FOREWORD

ITU (International Telecommunication Union) is the United Nations Specialized Agency in the field of telecommunications. The ITU Telecommunication Standardization Sector (ITU-T) is a permanent organ of the 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.

In some areas of information technology which fall within ITU-T's purview, the necessary standards are prepared on a collaborative basis with ISO and IEC.

NOTE

In this Recommendation the term *recognized operating agency (ROA)* includes any individual, company, corporation or governmental organization that operates a public correspondence service. The terms *Administration, ROA* and *public correspondence* are defined in the *Constitution of the ITU (Geneva, 1992)*.

INTELLECTUAL PROPERTY RIGHTS

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As of the date of approval of this Recommendation, the ITU had not received notice of intellectual property, protected by patents, which may be required to implement this Recommendation. However, implementors are cautioned that this may not represent the latest information and are therefore strongly urged to consult the TSB patent database.

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Introduction

This Recommendation contains guidance for telecommunication operators on avoiding interference and damage caused by power and electrified railway plants, radio transmitters, both intentional and unintentional, and electrostatic discharges. The text is intentionally short, drawing the attention of the user to reference standards and documents listed.

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.

Telecommunications 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 Electrostatic Discharges (ESD) sensitive devices. Hand-held 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 – or other power users are creating a harsh environment. Practical rules are given for situations where interference occurs, e.g. due to low frequency harmonic disturbance from an a.c. power system or user.

This Recommendation is a basic EMC Recommendation for telecommunications.

Recommendation K.37

LOW AND HIGH FREQUENCY EMC MITIGATION TECHNIQUES FOR TELECOMMUNICATION INSTALLATIONS AND SYSTEMS – BASIC EMC RECOMMENDATION

(revised in 1999)

1 Scope

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

This Recommendation applies to installation and maintenance of the telecommunications network. This Recommendation does not apply to protective measures due to dangerous levels of power noise. This Recommendation does not apply to co-axial cables (i.e. no differential mode).

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.

[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-T Recommendation K.35 (1996), *Bonding configurations and earthing at remote electronic sites*.

[8] IEC 61000-5-2 (1997), *Electromagnetic Compatibility (EMC) – Part 5: Installation and mitigation guidelines – Section 2: Earthing and cabling*.

[9] ETSI Technical Report ETR 127 (1994), *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 60096-1 (1986), *Radio-frequency cables. Part I: General requirements and measuring methods*.

[12] ETSI Technical Report ETR 151 (1995), *Equipment Engineering (EE); ElectroMagnetic Compatibility (EMC) testing of telecommunication equipment above 1 GHz.*

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

3 Definitions

The definitions of IEC 60050-161 apply:

ISDN Integrated Services Digital Network

PSTN Public Switched Telephone Network

xDSL Digital Subscriber Loop

x = A Asymmetric

V Very High Speed

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 Low frequency EMC

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

Low frequency emission by telecommunication equipment and systems is not normally a problem and will not be considered in this Recommendation. When problems do occur they are normally symptomatic of a greater problem.

Immunity problems may be caused by low frequency phenomena such as a.c. power distribution systems, electrified railways, electrified fences (e.g. for animal containment), welding equipment and other high-power industrial systems causing induction to telecommunication lines. Some industrial systems also cause fast transient impulses to be induced onto the telecommunications system. LF interference is generally coupled into system cables serving the equipment. Whilst the majority of LF noise problems are conductive or inductive, there are instances of coupling by radiation

Immunity is initially controlled by designing equipment to meet standardized test requirements, by network design, proper installation, environmental control, and maintenance and correct working methods. The control of such emissions is the responsibility of the interferer, and in some instances a national authority. Generally, it is always most cost-effective for all parties concerned to solve the problem at source. In some instances, it may not be economical to design equipment to meet all circumstances and, as such, external mitigation techniques have to be used.

6 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 in 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 with the manufacturer or test himself that the equipment fulfils the requirements.

When considering low frequency aspects, the equipment shall generally be able to work without LF interference problems in the environment where it is intended to be installed (e.g. 200 mV common mode, psophometric noise should not cause a problem for voice circuits as per Recommendation K.10). Recommendation K.34 [1] defines the various classes of electromagnetic environment of telecommunications equipment. It is acknowledged that there will be circumstances when the interference levels are high enough to cause interference problems without resorting to uneconomical equipment designs for either party. This is generally a low frequency interference problem, and other measures need to be considered in these circumstances.

7 Environment

7.1 Distance to interference sources

It is not always practical to position telecommunication systems away from low frequency interference sources; in fact, the interferer may arrive at a later date and have an influence over a distance of a few kilometres. If no standard or Recommendation is being applied to the problem, the two parties should come to a suitable agreement on mitigation and costs.

7.2 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.

7.3 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 telecommunications sites is specified in [7].

From a 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. For low frequencies, the external cabling system should be of a standard not to introduce interference from disturbing sources (e.g. Balance measurement K.10 [10] should be used to verify if a problem may exist). Measurements at voice frequencies are a good indication of the system performance of wideband systems (e.g. ISDN, xDSL).

Bonding to the mechanical shield, earth reference of intrinsic protection and/or metallic moisture barriers in cables should be considered as most important. Earthing is considered to be of secondary importance, bonding being the most important. Low frequency mitigation measures usually requires a connection to earth.

7.4 a.c. power network and electrical equipment

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

In TT or IT 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 or IT 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 or IT power systems.

7.5 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 $10^8\ \Omega$.

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].

8 Installation

8.1 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 or a.c. equipment or systems that may generate a large amount of harmonics. This is a particular threat in industrial environments. Segregation by means of screening and separation of the earthing may be necessary.

8.2 Cabling

It is assumed that the internal cabling to a telecommunications installation is correctly installed and that no evidence of interference can be attributed to those cables. 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].

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].

Low frequency problems in twisted pair cables can sometimes be attributed to "split pairs". These do not always show as a large change in cable balance, and are therefore difficult to detect.

8.3 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 be 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].

Problems occurring on cables at low frequencies can generally be attributed to connection at joints, especially in twisted pair cables. Other cable parameters tend to drift from the norm (e.g. leg to ground insulation resistance) when problems occur.

9 Working methods

9.1 Restrictions to use disturbing equipment

Hand-held 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.

Certain a.c. powered equipment needs to be used with care in the vicinity of telecommunications installations (e.g. arc and induction welders), as they may cause widespread disruption to the system.

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 [12]. 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 hand-held radio telephones may produce radio frequency field over 1 V/m. Therefore, the use of hand-held 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.

9.2 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].

10 Special mitigation measures

A general guidance on high and low frequency interference mitigation methods is given in this clause. Application of these techniques to practical problem solution is discussed in Appendix I (high frequency) and Appendix II (low frequency).

10.1 Screening

10.1.1 Screening (high frequency)

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.

10.1.2 Screening (low frequency)

Low frequency immunity requirements for equipment intended to be installed in telecommunication centres is not generally a problem. In problem cases, there will also be problems at higher frequencies; screening may be added by the operator around the whole centre or around the disturbing equipment. Metal foil screening of the equipment and cabling may often be sufficient.

The source of the radiation should be identified and screening added accordingly, e.g. earthing of cable screens, metallic moisture barriers or spare pairs. When the source of interference can be shown to be induction along a cable route, the earthing of the screen at numerous points along the cable route is necessary to reduce the longitudinal voltage imposed on the signal wires. As a minimum, the earthing should be at each end and close to the noise source. Earthing at points in between these points can have a further influence. If no screen, strength member or metallic moisture barrier is available in the cable, then the burying of metallic (copper or steel) tape along side the cable may be used. Another method of forming a shield is to earth spare pairs from within the cable (the closer to the outside of the cable bundle the better).

10.2 Filtering

10.2.1 Filtering (high frequency)

In cases where high level radio frequency or transient phenomena cause disturbances via low frequency telecommunications 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 co-operation 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.

10.2.2 Filtering (low frequency)

Whilst filtering of voice grade circuits is not normally a problem, circuits supplying ISDN or other digital (xDSL) services will suffer from increased loss and may even fail to operate when filters are used. If a filter is not used, digital services would probably suffer from a high number of data errors or fail to operate at all. It is therefore crucial that any filtering is carefully constructed to accommodate the required services. The table below shows typical insertion loss figures for a common mode choke/drainage coil combination filter used to remove 50 Hz harmonic noise.

Service	Insertion loss (dB)
PSTN	0.5 at 1 kHz
Pair gain	2.5 at 40 kHz
ISDN	3.5 at 100 kHz
ADSL	not compatible

10.3 Common mode chokers

10.3.1 Common mode chokes (high frequency)

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.

10.3.2 Common mode chokes (low frequency)

In cases where minimizing the area of common mode loops is not sufficient, lines may be provided with common mode chokes to increase the impedance of the common mode circuit. The use of ferrites at such frequencies is not normally very effective. 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 and the system balance, but in many cases where they are effective, they can very conveniently be applied to an installed system. If the equipment that is to be filtered does not have an earth reference, the use of common mode chokes will be of little benefit. The use of common mode chokes on customer line cards is particularly effective.

10.4 Drainage coils (low frequency)

These are more commonly used at the customer end of a circuit and in conjunction with a common mode choke when the terminal equipment is not earth referenced (i.e. there is no natural common mode current flow to earth). For PSTN and other line-powered circuits, the drainage coil needs to be capacitively coupled to avoid a D.C path to earth (see Figure 1). These devices are able to provide a low common mode impedance to earth.

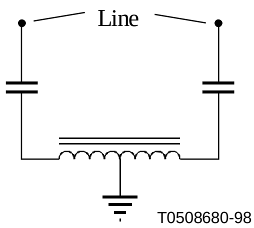

Figure 1/K.37 – Drainage coil

10.5 Active filters (low frequency)

With the advent of digital signal processors, the possibility of creating well-balanced active filters with specific functions is a reality. The main drawback to such filters is that they would probably need to be mains powered to be able to counteract the interference on the circuit as the power requirements are not inconsiderable. It can only be a matter of time before the power requirements of this type of circuit falls to a low enough level that is suitable to be line-powered from the switch (either over the active circuit or a spare pair).

Active filters would be able remove the offending common mode components and the associated differential components, and thereby have the advantage of being able to compensate for poorly balanced network cables. There should not be any line length limitation associated with these filters, as there is when using a digital transmission system (e.g. pair gain). Due to the signal processing involved, it may not be feasible to use active filters on telecommunication lines for high frequency interference.

10.6 Neutralizing transformers (low frequency)

Apart from being of use to provide isolation from rise of earth potential, neutralizing transformers can also be used to reduce the level on induced common mode voltage on a cable, especially when a number of circuits are involved. They have a benefit over the use of drainage coils in that they do not need any decoupling that would be necessary with d.c voltage fed circuits. Occasionally, neutralizing transformers may require a stronger excitation current.

10.7 Hybrid solutions (low frequency)

The combining of a common mode choke and a drainage coil is a common method of providing filtering when the equipment to be filtered presents a high longitudinal impedance. In some instances this method is not sufficient and the use of a drainage coil with a digital transmission system may be necessary to overcome cable deficiencies (resulting differential components). An example of such a situation is that of providing a clear speech circuit to a customer using a digital pair gain system with a drainage coil used to remove the longitudinal voltage on the digital side of the remote unit. The digital system rejects any differential component due to the noise and presents a good analogue signal to the customer.

10.8 Isolation transformers (high and low frequency)

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.

10.9 Optical components (high and low frequency)

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

10.10 Capacitors (high frequency)

The use of capacitors either across the signal conductors and/or to earth can be a satisfactory method of removing high frequency noise from a line. Care has to be exercised in the choice of component for both voltage rating and the service it is to be used with. The use of purely capacitive measures at low frequencies is not, generally, a satisfactory solution.

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 a high frequency 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 telecommunications 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 telecommunications 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 telecommunications 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 analyzing 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.

Telecommunications 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. Depending on the frequency involved, unscreened cable lengths as short as 8 cm could present a problem

I.4 Bibliography

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

APPENDIX II

Troubleshooting and fixing low frequency EMC problems

II.1 Introduction

This appendix is based on the experience of members of ITU-T Study Group 5 and contains guidance on how to proceed when a low frequency 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 telecommunications centres, but certain "thumb rules" can often be applied. It is nearly always more economic to find the cause of the interference and solve the problem at source. Depending on the nature of the problem, it is always wise to check that the telecommunications system has not degraded in any way (e.g. cable balance has deteriorated due to joint corrosion or ingress of water in a cable) before apportioning blame on the owner of the noise source.

II.2 Source verification

In cases where it is suspected that continuous low frequency noise either to or from telecommunications equipment is causing interference, it is possible to try to identify the source by monitoring with a broadband radio receiver. Some typical characteristics are the following:

- Industrial, scientific, medical or telecommunications equipment cause buzzing or humming of audio signals. In severe circumstances flickering of lighting may occur.
- Repetitive clicking sound heard using a handset connected to the line or a broadband receiver generally indicates that the cause is due to an electrified animal containment fence.
- Arc welders cause a strong broadband audio signal to be heard (with no particular harmonic content) that also extends to higher frequencies.

The use of a psophometer connected across a transmission system may also reveal other characteristics not easily detectable by ear, together with the ability to determine if the noise is originating from the external network cabling or the telecommunications equipment. Low frequency spectrum analysers are also good at determining the harmonic content of the interference

One can also try to identify the source of disturbance by looking for large industrial plants, power transformer stations, flickering street lamps or damage to power cables in the vicinity. An effective method is to switch on and off the suspected equipment while monitoring the change in the noise signal. 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 within the telecommunications centre and also what changes have been made along the cable route (e.g. farmer installed an electric fence).

II.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 drainage filter.
– Common mode currents on subscriber line: Install drainage filter.

Telecommunications 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. Replace cable sections if found to be poor balance.
– Poor earth contacts: Check that contact surfaces are not painted or corroded and that no foreign material like tape exist between contact surfaces.
– Common mode currents in cables: Apply chokes or other mitigation measures; choose properly screened cables; re-route 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.
– Insufficient screening: Apply screening on equipment level, building level or incoming cable level.

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