CONTENTS

Section Page

FOREWORD 5

PART A - GENERAL INSTALLATION AND EARTHING REQUIREMENTS FOR CUSTOMER SWITCHING SYSTEMS

SECTION 1 WHERE DO YOU START?

A1.1 See the Site 6

A1.2 Know Your Patch 7

A1.3 Type of PABX System 7

A1.4 Educate Yourself 7

A1.5 Know Your Customer 7

A1.6 Get Your Customer Involved 8

SECTION 2 WHAT DO YOU DO?

A2.1 General Installation Principles 8

A2.2 Electrostatic Discharge 8

A2.3 Earthing Principles 9

A2.4 Earthing Practices 10

A2.5 Specific System Note 11

PART B - RADIO FREQUENCY INTERFERENCE

B1 Solving the Problem 12

B2 Corrective Action 12 - 15

Table 1:- 13

Possible Symptoms
Possible Sources of Interference
Interference Mechanisms

PART C - ABNORMAL 230 VOLT A.C. MAINS CONDITIONS — Page

C1 Abnormal Conditions — 16

C2 Corrective Action — 16

Table 2:- — 17
Possible Symptoms
Possible Sources
Interference Mechanism

Table 3:- — 18
Corrective Action

PART D - MISCELLANEOUS NOTES — 19

FIGURES

Fig. 1 General Earthing Requirements - PABX's

Fig. 2 (a)-(c) PABX Earthing Requirements using Mains Filter

Fig. 3 PABX Co-sited with Transmitter Aerials: Earthing Connections

APPENDIX 1

Radio Frequency Pollution: Comments by NZRFS

REFERENCES

New Zealand Electrical Wiring Regulations and Codes of Practice together with associated Amendments

IEC Standard 801 - Electromagnetic Compatibility for Industrial Process Measurement and Control Equipment, Parts 1 - 4

EMI Control Methodology and Procedure

by Donald R J White & Michel Mardigivan

Schaffner Technical Documentation and Brochures

Schaffner Components, Switzerland

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Telecom has provided this information to assist installers and will expect the basic operations of any device referred to in this Specification to be tested to ensure that the product does operate as claimed by the supplier.

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FOREWORD

There are a number of environmental aspects which can cause misoperation and/or damage to customer switching equipment. This guide addresses the following aspects for small PABX systems (including Key Telephone Systems) but the same general principles apply also to larger installations:-

(a) 230 Volt a.c. power fluctuations - causes and cures.

(b) High speed transients on the 230V a.c. power supply, (those very short rise time/pulse width transients that go straight through most detection equipment and can reset a microprocessor based system, often leaving no permanent damage).

(c) Electrostatic discharge to console or system, which can cause system misoperation.

(d) Radio frequency interference which ranges from the small annoyance through to almost unmanageable interference levels.

This information was originally published as a Telecom document for internal use to assist planning/installation personnel. It is the result of extensive investigative work into the problems of power and radio frequency interference experienced on customer installations, primarily at PABX sites.

In view of Telecom's aim to improve network service quality, it has now been decided to make this information available to both customers and industry by publishing it in the form of a "TNA Specification". In this way, some of the problems likely to affect privately installed PABX systems may be avoided and service can be improved for all concerned.

This document is written primarily for installers and those planning practical installations. It is not intended as a rigorous or comprehensive design document, but covers those aspects which Telecom experience has shown to be commonly encountered. In most cases, a simple practical approach can avoid these common sources of trouble at relatively low cost.

PART A
GENERAL INSTALLATION AND EARTHING REQUIREMENTS FOR CUSTOMER SWITCHING SYSTEMS

Section 1
Where do you start?

A1.1
Examine the site

Evaluate the site, and consider the type of product being installed. Obviously if the switching system is small, you do not want to commit too much money to the installation. Conversely if it is a major installation then the last thing you want is to be faced with re-siting the system.

Environmental conditions to watch for:-

- Heavy industry in the building.

- Heavy industry in the neighbourhood.

- Devices which may cause unexpected high power loads (e.g. electric heaters, spa pools, lift motors, photocopiers).

- Lightning prone areas.

- Standby power provision.

- Poor power practices.

- Noise generating machinery, e.g., typewriters, electric motors (particularly 3 phase units on contactor starters), thermostats, variable speed motor controllers.

- High power radio transmitting aerials on site.

- Close proximity radio frequency transmitting devices or stations.

- R.F. plastic welding machines in the building or neighbourhood.

- Low humidity causing static discharge problems at console level.

- When involved with "backyard" industries be watchful for poor power earths and "do it yourself" building and power techniques.

- Know the local earthing condition e.g., dry and sandy, wet peat, rock, etc.

A1.2
Know your product
Get to know your product. In the event of any radio frequency interference (RFI) problems, refer first to the system manufacturer for any proven solutions. You will not usually be the first to strike difficulties and suppliers often have standard hardware solutions or specific methods to overcome the variety of problems likely to be encountered. Normally you will discover general principles which apply. Use these as much as possible to achieve the most economic solutions.

A1.3
Type of PABX system
(1) Some switching systems are more susceptible to a.c. mains transients, noise and RFI than others.

- Systems which are pure loop working and have a "double insulated" design with no earth connection, are often quite immune to problems. However, most of the systems installed to date respond unsatisfactorily in some way to their typical environment.

(2) Improved techniques are now available to screen for environmental susceptibility before purchase. Consequently, either a general improvement should be noticed for future new machines, or prior warning with regards to filter requirements will be available.

A1.4
Educate yourself
(1) Study this guide together with other material published on the subject. Many articles exist on the topics of mains transients, and some are very helpful.

(2) Set up a few reference sites, some free of problems, some with regular problems, and look for differences. Institute a systematic approach to the problem sites. Remember there may be other causes to the problem. Any improvement should be grasped, analysed and improved on.

A1.5
Know Your Customer
(1) Find out how critical the telephone service is to the customer. For example, a hospital or emergency service organisation may need special attention which might not be justified for the average commercial customer.

(2) Civil Defence is a potential problem with local radio transmitters being brought into action only during emergencies. These may cause the PABX to fail on the most critical day. Endeavour to check the system while radio sets are being used.

A1.6
Get Your Customer Involved
(1) If there is any likelihood of a proposed site causing environmental problems tell the customer before installing the system. Make them aware that they may be faced with increased installation costs because of their peculiar environmental situation.

(2) If there is a possibility of encountering environmental issues under the Resource Management Act, consult a lawyer on what your obligations are.

Section 2
What do you do?

A2.1
General installation principles
(1) Encourage customers to provide a dedicated power circuit for the switching system. This limits the metallic coupling of 230V a.c. mains noise from other devices on the same feed. If any other outlets (or tap-on plugs) exist on the circuit, disconnect them, or at least blank them off with "kiddie stops". This will reduce the risk of them being used on a casual basis for appliances likely to cause interference.

(2) Avoid any inadvertent earthing of the system. This can occur where the mounting system penetrates a wall, a cable tray attaches to the system, or where any other similar incidental metallic contact is made.

(3) If possible keep the 230 V a.c. mains feed well away from extension, trunk and other telecommunications cabling.

(4) Where there is a choice of installation accommodation, remember that any problems involving noise on the mains, trunks or extensions will be easier to handle if the system is close to ground level.

(5) Short earth leads of low resistance are especially useful when ridding a system of troublesome RF interference. They also limit the extent to which the earth leads can function as aerials, which is especially relevant when using filters to shunt RF signals to ground.

A2.2
Electrostatic discharge
(1) Many systems which have attendant consoles provided, misoperate when their console is exposed to static discharge. If the system console environment is static prone (dry, nylon carpet, vinyl flooring) then anti-static procedures are essential to avoid system problems.

(2) Some proven methods of static control around the console are:-

(a) A "touch me first" resistive earth pad under, and in front of, the console itself.

(b) Request that the customer supplies a fabric covered chair for the operator.

(c) Fit a resistive earthed touch pad to the handset.

(d) Spray the area with antistatic spray (short term solution only).

(e) Fit an earthed static mat on the floor around the console.

(f) Static discharge to the machine case can also corrupt data and machine operation. If YOU are a maintenance person, use your personal wrist strap from the first system contact to the last.

A2.3
Earthing Principles

A2.3.1
Low Frequency
This is basically associated with safety precautions against 50 Hz a.c. mains and, to a lesser degree, signalling (some PABX systems will not detect trunk signalling without a system earth connection).

- The Electrical Wiring Regulations and Electrical Codes of Practice take care of most (if not all) low frequency interference via the normal 230 V a.c. mains earth system.

A2.3.2
High Frequency
(1) This aspect is much more complex. All three 230 V a.c. mains conductors (phase, neutral and earth) are exposed to a wide range of interference sources. These range from broadcast radio waves to radiation produced by motor contactors and any other sources of radio frequency interference. As the frequency increases, the natural inductance of a length of wire becomes a very significant factor in its impedance.

- At 10 MHz it only requires 10 meters of wire to produce 1000 ohms. The thickness of the wire has very little effect upon this impedance. While the earth lead impedance is rising with frequency, the capacitive earth leakage paths from the system to its surroundings are becoming more pronounced. For example, a 30 pF earth leakage path

has an impedance of 530 ohms at 10 MHz. Any interference prefers this path to ground (via the system) rather than the 1000 ohm metallic route.

(2) The problems of high frequency earthing are compounded by capacitive coupling between phase, neutral and earth along with the natural existence of resonant paths all over the building.

(3) The New Zealand multiple earthed neutral system in which the earth and neutral terminations are bonded at sub-main distribution boards can produce noisy earth systems. The recommended solution to this problem is the use of filters which include an earth line choke. The choke effectively screens the PABX from high frequency noise which can exist on the power and earthing system.

- Extensive tests have indicated a considerable performance improvement to systems operating with these filters installed. The Ministry of Commerce has approved the use of some earth chokes after independent tests proved that safety was not compromised.

- In all circumstances, the requirements of Electrical Wiring Regulation 152 must be complied with.

(4) Two quite different filter types have been used as follows :-

(a) One with a saturable earth choke.

(b) The other has an air gap choke which will not saturate under normal operating conditions.

- Application of these in relation to earthing practices is given in clause 2.4.

(5) Methods of use of these filters are detailed in Parts B and C.

A2.4
Earthing Practices
Figures 1 - 3 detail the earthing practices involved for various situations. The variability of technique is dependent upon economic and technical constraints as follows:-

(a) The saturable earth choke filter has the earth choke wound on a toroid. This type normally becomes inoperable at approximately
0.2 Amps.

(b) Some small systems operate with no earth reference at all.

(c) Some PABX systems operate with phase to earth capacitance in excess of that permitted for portable devices.

- Special dispensation was granted to Telecom for these systems by the Ministry of Commerce, on condition that a telecommunications earth is provided. Similar dispensation would have to be sought on an individual basis by other parties before installing such arrangements.

- In all circumstances relating to a.c. mains earthing, the requirements of Electrical Wiring Regulation 152 must be complied with to operate sub-circuit protective devices.

- When the saturable earth choke filter is used, the telecommunications earth is connected to the primary side of the filter. The system should be

disconnected from the mains supply before disconnecting from the filter when undertaking any maintenance action (this instruction is normally detailed on the filter).

(d) Some telecommunications equipment modules are particularly static sensitive. If the normal maintenance techniques involve card changing, a telecommunications earth connection should always be provided to give static protection during times when the mains is disconnected.

A2.5
Notes relating to specific types of system
(1) Some small systems have no earth reference connection.

(2) Some loop working systems will operate with no internal mother board earth reference (not recommended as normal practice). If problems are encountered utilise filters as a first solution.

- On such systems the chassis earth must be maintained as a safety requirement.

- In such circumstances, the requirements of Electrical Wiring Regulation 152 must be complied with to operate sub-circuit protective devices.

(3) It is recommended that no separate telecommunications earth be applied to small systems which do not have separate replaceable cards for on-site maintenance and fault location purposes.

(4) In any installation where it is suspected that the system is likely to be susceptable to mains transients, use of a mains filter unit which includes an earth choke is recommended.

(5) Some systems are now being supplied with a mains filter inside the cabinet. The filter can normally be identified as a sealed metal box with numerous earth connections. Such a filter usually includes an earth choke (non-saturating) and should prove effective to a considerable extent. Further protection can be provided by the installation of an additional filter unit.

- Alternatively a Ferro-resonant Conditioner can be used, but there is evidence of occasional incompatibility between such Conditioners and any switched mode supplies.

(6) If no filter is fitted then it is recommended that the system telecommunications earth terminal within the cabinet be bonded to the a.c. mains earth and the system earthed as shown in Fig. 2 (a) - (c).

PART B
RADI0 FREQUENCY INTERFERENCE (RFI)

B1
Solving the problem
If RFI problems are experienced on a switching system then it is necessary to take corrective action. For assistance in the initial diagnosis, Table 1 details possible symptoms, likely sources of the interference and the mechanism by which that interference can occur.

B2
Corrective action

B2.1
Stage 1
(1) Try to determine the source of the interference. Co-ordinate with the New Zealand Radio Frequency Service (NZRFS) as necessary.

- All new equipment is required to comply with internationally recognised radio frequency interference standards (see Appendix 1 attached).

(2) By placing the system into night service, check whether the problem is being caused by:-

(a) the telephones,

(b) the PABX, or both.

Modify or change phones if necessary.

(3) Install a 230v mains RFI filter (see Part A) as an initial preventive measure.

- Always check local industry and trade sources to see what suitable hardware is available in the event of any problems. There are a few companies in New Zealand which specialise in RFI and transient protection and it is worthwhile referring to the technical publications and sales brochures produced by these companies.

(4) Consider changing the system type if necessary. For example some systems are basically immune to RFI, while others are extremely susceptible.

(5) Inform the customer of the nature of the problem. Enquire if the interference could be tolerated with some minor management of the environment as follows:-

(a) relocation of equipment,

(b) avoidance of VHF contact when vehicles are close to or on site.

B2.2
Stage 2

B2.2.1
If the interference is still intolerable after taking the action described in Stage 1 above, then proceed as follows in clause B2.2.2.

B2.2.2
(1) Install extension and trunk line filters as shown in Fig. 3.

(2) Check that other system interconnections are not the problem, for example:-

- console
- night bells
- V24/RS232 data port interface
- low voltage power connections.

If these connections are suspect then use screened cable and short runs, with the screen properly earthed. Filters may also be necessary. If screened cable is not available, spiral winding an earthed wire around the cable may suffice.

(3) Remember, it is unlikely that the problem is direct RF breakthrough to circuit board level. In most cases the RF enters via connecting leads acting as aerials.

IF THE INTERFERENCE IS STILL INTOLERABLE GO TO STAGE 3

B2.3
STAGE 3

B2.3.1
Outside help
Further RFI clearance techniques are likely to be time consuming and expensive. It is strongly recommended that more experienced assistance be involved at this stage.

B2.3.2
(1) Fig. 3 details the equipment layout necessary to eliminate RFI from a problem site.

(2) If very high field strengths are encountered (usually from close proximity to transmitter aerials) then system and filter earthing becomes critical.

(3) The length of the earth lead from the building earth electrode to the power, extension and trunk filters may have to be as short as 30 cm to be effective. It is advisable to experiment to find the required length.

(4) If the building earth electrode is suspect, a good telecommunications earth should be installed. A 2 metre driven earth rod should normally be sufficient. The telecommunications earth should be bonded to the power earth in the usual way. It may be necessary to use a 16 mm^2 earth cable bond if the power earth is not adequate.

- Further earthing system design techniques can be specified by a specialist engineer if appropriate (eg., multi-electrode).

(5) All filters must now be earthed to the telecommunications earth electrode with cable no longer than 30cm.

(6) The system earth lead should be as short as practicable and should go to the same earth point as the filters. Note that at this stage the system must be earthed on the secondary side of the power filter, and earth choke saturation is of no consequence.

(7) Wherever possible, co-locate the filters and the system right at the earth electrode.

(8) If the system cannot be moved to the earth electrode (and the filters prove to be ineffective without very short grounding leads) then the filter to system connecting cables must be as short as possible and, if necessary, screened. Earth the screens at the earth electrode.

PART C
ABNORMAL 230 VOLT A.C. MAINS CONDITIONS

C1
Conditions
Details of possible abnormal conditions on 230 V a.c. mains power supplies, together with associated symptoms, sources and likely interference mechanisms are given in Table 2.

- As explained in Specification PTC 101, faults in the a.c. mains power distribution system can lead to high voltages appearing on lines or, as rises in earth potential in the vicinity of the fault. The protection equipment provided by power distribution authorities is designed to shed any overloads within certain times, but the overall effect is that transients may be applied to the equipment of the following order (ref. Specification PTC 101, clause B3.5):-

430 V rms for ≤ 2 seconds
1000 V rms for ≤ 0.5 seconds
1500 V rms for ≤ 0.35 seconds

C2
Corrective action
(1) The actions necessary to correct the various abnormal a.c. mains conditions referred to above in clause C1 are given in Table 3.

(2) Particular attention is drawn to the references in Table 3 to use of small uninterruptible power supplies (UPS). These have been designed for personal computers but are very suitable for use on a.c. mains operated PABX's.

PART D
MISCELLANEOUS NOTES

Note 1
Line filters for use with telecommunications cabling are available and, typically, these should be installed in the trunk and extension cabling as shown:-

NOTE 2
Copper conductor sizes and resistances at 20° C

<----------Metric---------->		<----------AWG---------->		
Size (mm2)	d.c. Resistance (Ohms/km)	Gauge Size	Area (mm2)	d.c. Resistance (Ohms/km)
1	18.1	18	0.823	21.4
1.5	12.1	16	1.31	13.4
2.5	7.41	14	2.08	8.45
4	4.61	12	3.31	5.32
6	3.08	10	5.26	3.34
10	1.83	8	8.37	2.1
16	1.15	6	13.3	1.32
250.727	4	21.2	0.832	
35	0.524	2	33.6	0.523
50	0.387	1	42.4	0.415
70	0.268	1/0	53.5	0.329
95	0.193	3/0	85	0.207
120	0.153	4/0	107	0.164
150	0.124	250 MCM	127	0.139
185	0.0991	350 MCM	177	0.0992
240	0.0754	450 MCM	228	0.0771
300	0.0601	550 MCM	279	0.0631
400	0.047	700 MCM	355	0.0496
		750 MCM	380	0.0463

1 MCM = 1,000 circular mils (1 mm2 = 1973.52 circ. mils)

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2424

APPENDIX 1

RADIO FREQUENCY POLLUTION

New Zealand has adopted the internationally recognised CISPR 22 standards for defining the degree of radio frequency interference (RFI) that may be emitted by any appliance. Almost all electrically powered appliances emit some RFI if they are switching currents. This applies especially to devices like computers and microprocessors which work at high frequencies.

Since microprocessors are now used in a wide variety of telecommunications terminal equipment, most equipment is subject to the requirements of the New Zealand Radio Frequency Service (NZRFS) Regulations.

In view of the importance of this subject, the following information has been prepared by the NZRFS:-

"Our lives are being constantly changed due to changes in technology. New radio, electrical and electronic products are continuously appearing on the market, offering new features, improved productivity, or the ability to do things that cannot easily be done otherwise.

Unfortunately, many of these products generate radio frequency energy as a by-product, and this has the potential to cause radio interference.
In effect this by-product is a form of pollution.

Whilst the effect of the pollution from an individual product may be small, the accumulative effect of emissions from all products is rapidly turning into a serious problem for all industrialised countries, including New Zealand.

For example, emissions from FM broadcast receivers create interference on a land mobile radio band, which disrupts services such as taxis, trucking companies and many others. Increasing emission levels due to the increasing use of these types of products mean that the reception of radio frequencies for entertainment, business and safety purposes, among others, is adversely affected.

The effects of this pollution have been recognised worldwide, and limits are set to keep interference to an acceptable level. This problem is considered serious enough that developed countries control these pollution levels by regulation. In New Zealand, the Radio Regulations 1987 currently provide this control.

The limits set by the international standards body IEC (based in Europe) have been adopted in New Zealand. These standards are commonly called "CISPR Standards", and they cover most electrical and electronic products, including telecommunications terminal equipment. For

products intentionally designed to use radio frequencies, the standards are similar to those used overseas and are mainly European in origin. Examples of these products are shown in Table 1 below.

The Radio Frequency Service is presently running a nationwide awareness campaign informing you of your legal obligation to ensure that pollution levels from these products do not prevent or impair the use of the radio frequency spectrum by everyone in New Zealand.

Products which you may be importing or manufacturing could be causing hazardous or annoying radio interference.

It is an offence to install, use, sell, or manufacture any products that exceed the New Zealand interference limits!

If a product you deal with falls within a class for which interference limits have been set (such as those listed in Tables 1 and 2 below), and a certificate of compliance has not been issued under the Radio Regulations 1987, you may well be breaking the law. If so, you may be liable for a fine and this could be up to $200,000 for a corporate body.

There are currently two methods of obtaining the necessary certificate of compliance. You can either send NZRFS a test report prepared by a reputable independent test laboratory; or you can send NZRFS the necessary number of samples of the product for testing in their laboratory.

For further enquiries about how to obtain a certificate or whether a certificate is needed, the likely costs involved, etc, please contact :-

Radio Frequency Service
PO Box 2847
WELLINGTON

Phone: (04) 732 200
Facsimile: (04) 732 489

Tables 1 & 2 follow

TABLE 1
PRODUCTS WHICH INTENTIONALLY USE RADIO FREQUENCIES

VHF and UHF radios
VHF marine radios
CB radios
SSB radios for ship, land and mobile use
TV and radio broadcast transmitters
Automatic garage door openers
Baby minders
Wireless door chimes
Radio microphones
Wireless burglar alarms
Cordless telephones
Radio controls for models

TABLE 2
PRODUCTS WHICH ARE UNINTENTIONAL EMITTERS OF RADIO FREQUENCY ENERGY

Telephones and telecommunications equipment
Computers and associated equipment
Information technology equipment
Electrical and electronic household appliances
Portable electrically-powered tools
Fluorescent lights
Broadcast sound and TV receivers
Microwave ovens
Industrial, scientific and medical RF equipment
Office machines
Recording apparatus
Light dimmers
Motor speed controllers
Electronic transformers (UPS, inverters and converters)"