OVERVIEW GUIDE

POWER CO-ORDINATION OVERVIEW GUIDE

NZCCPTS

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The New Zealand Committee for the Co-ordination of Power and Telecommunication Systems Inc. (NZCCPTS)

The New Zealand Committee for the Co-ordination of Power and Telecommunication Systems was established in 1985 following the increasing need to implement efficient cost-effective measures for the limitation of hazard and interference to Power and Telecommunications Systems and Personnel.

Such measures not only require the determination of optimum engineering solutions consistent with minimum national cost, but also necessitate clear guide-lines covering the equitable allocation of responsibilities during all work phases from planning through to in-service operation.

The objective of the New Zealand Committee for the Co-ordination of Power and Telecommunication Systems is to meet these needs and, by means of publications and seminars, promote a greater awareness and understanding of the actions that must be taken to ensure that Power and Telecommunication Systems coexist satisfactorily.

Membership of the Committee and its Working Parties currently comprises representatives from each of the following organizations:

- Electricity Engineers' Association of New Zealand (Inc.)
- Energy Safety, WorkSafe NZ, Ministry of Business Innovation and Employment (MBIE)
- Chorus New Zealand Ltd
- Transpower New Zealand Ltd
- KiwiRail (KiwiRail Holdings Ltd)

For further information concerning this Committee and its published guides, contact the Secretary of NZCCPTS via email to secretary@nzccpts.co.nz, or via his contact details on the 'Contact Us' page of the NZCCPTS website (www.nzccpts.co.nz).

GUIDE FOR EVALUATING AND ADDRESSING ADVERSE INTERACTIONS BETWEEN POWER AND TELECOMMUNICATIONS SYSTEMS

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Foreword

This guide provides a summary of the various mechanisms by which interaction can occur between Power and Telecommunication Systems, and provides reference to NZCCPTS Guides and related documents available for detailed advice and mitigation possibilities.

Acknowledgements

NZCCPTS is indebted to the Electricity Engineers' Association of New Zealand, Chorus, Transpower, KiwiRail and Energy Safety (WorkSafe NZ), for their contributions in the formation of this guide.

Comments for revision of this guide are welcomed. Any comments or information that may be useful for inclusion in this guide should be forwarded to the Secretary of NZCCPTS via email to secretary@nzccpts.co.nz, or via his contact details on the ‘Contact Us’ page of the NZCCPTS website (www.nzccpts.co.nz).

A brief description of the objectives and organization of the New Zealand Committee for the Co-ordination of Power and Telecommunication Systems Inc. is printed inside the back cover of this publication.

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1 Introduction

Power Co-ordination is a process to identify, analyse and, where necessary, mitigate adverse interactions between Power and Telecommunications networks. These typically include:

(1) Hazardous voltages coupled onto a telecommunications cable network from a nearby power network.
(2) Interference voltages coupled onto a telecommunications cable network from a nearby power network, that cause excessive electrical noise and/or mal-operation of telecommunications equipment.
(3) Electrolytic corrosion of metallic telecommunications network plant in direct contact with the ground, due to AC or DC currents flowing through the earth. [For more information on ac corrosion, refer to the CIGRE TB 290 and CEN 15280 guides detailed in the section 14 ‘References’.]

Adverse impacts typically include:

- Hazard to humans.
- Damage to telecommunications network plant and telecommunications network customer’s plant.
- Mal-operation, or substandard operation, of telecommunications cable network circuits.
- Corrosion of metallic telecommunications network plant in direct contact with the ground.

Any of the above impacts could be an issue during normal operation of the power network. However during power network faults that are tripped by protection, typically much higher voltages can be impressed onto the telecommunications network for very brief periods of time. In these situations, only the hazard and damage impacts normally need to be considered.

The New Zealand Committee for the Co-ordination of Power and Telecommunication Systems (NZCCPTS) was established in 1985 following the increasing need to implement efficient cost-effective measures for the limitation of hazard and interference to power and telecommunications systems and personnel. Since then the NZCCPTS has published a number of guides on specific aspects of Power Co-ordination. See website www.nzccpts.co.nz for details of these guides, and how to obtain them. Together with other relevant New Zealand industry standards, regulations and Electrical Codes of Practice (ECPs), AS/NZS standards and international standards, these now cover most aspects of Power Co-ordination.

This Power Co-ordination Overview Guide attempts to tie all these guides, standards and regulations together, and to put them all into context.

This guide may be updated from time to time to reflect progress and advancement of current legislation, codes of practice, international standards and other industry documentation.

2 Interpretation

2.1 Definitions

In this guide, unless the context otherwise requires, the following definitions apply:

earth potential rise (EPR) means the potential with respect to remote earth of any earthing electrode or soil, due to the flow of current through the earth electrode and soil, whether continuous, or short duration under fault conditions.

earthing system means an arrangement of conductors and earth electrodes buried in the earth, that provide an electrical connection to earth. Examples include:

(a) a buried mesh,
(b) a number of interconnected driven electrodes,
(c) a single driven electrode.

electrical size of an earthing system means the radius of the equivalent hemispherical electrode that will have the same earth resistance as the earthing system.

hazard means a potential cause of harm to any person or a possible cause of damage to property, including telecommunications plant and equipment.

impressed means (in respect of voltages impressed onto telecommunication conductors) either:
(a) induced onto parallel telecommunications conductors; or
(b) transferred onto telecommunication conductors either:
  (i) from EPR in the ground surrounding telecommunication network plant if insulation breakdown of the plant occurs; or
  (ii) from EPR in the ground coupling directly onto the earthing system of earthed telecommunications plant (e.g. roadside electronic cabinets); or
  (iii) from EPR on the LV neutral and earth conductors within an electrical installation if insulation breakdown within a customer's mains-powered telecommunication equipment occurs.

interference (to telecommunication circuits) means any unacceptable interaction, causing a nuisance to either equipment or persons in the form of impressed noise voltages.

longitudinal psophometric voltage means the psophometrically weighted value of the voltage impressed on a telecommunication circuit, measured between any wire of the telecommunications line and earth at the termination of the telecommunication line.

psophometrically weighted voltage means the calculated value of voltage resulting from multiplying the measured voltage spectrum by weighting factors that recognise the way that the human ear responds to sounds within the speech frequency range. These weighting factors are specified for a range of frequencies in the psophometric weighting table in Appendix I of ITU-T Recommendation K.68. A copy of this table is included in Appendix A. The psophometrically weighted value of an induced voltage comprising fundamental and harmonic components is given by the expression:

$$W_p = \frac{1}{1000}\sum_f \left[V_f \times P_f\right]$$

where V_f = the measured value of the voltage component at harmonic frequency f
P_f = the psophometric weighting factor at harmonic frequency f.

step voltage means the difference in surface voltages experienced by a person bridging a distance of 1 metre with the person's feet apart without contacting any other earthed object.

touch voltage means the voltage that will appear between any point of hand contact with uninsulated metal work and any point on the surface of the ground within a horizontal distance of 1 metre from the vertical projection of the point of contact with the uninsulated metalwork.

transferred earth potential rise means the potential of the earth at a remote location, due to either:
1. EPR from a power network earthing system, indirectly coupled through the ground, or
2. EPR directly coupled via a conductor (e.g. LV MEN conductor).

transverse noise voltage means the psophometrically weighted value of the voltage between the two legs of a telecommunication circuit, measured across a 600 ohm resistor terminating the line when the other end of the line is terminated on a standard telephone line termination.

2.2 Glossary of Abbreviations

AS/NZS	Joint Standards Australia/Standards New Zealand Standard
NZECP	New Zealand Electrical Code of Practice
EPR	Earth potential rise
ESRs	Electricity (Safety) Regulations 2010. ESR Y is regulation Y of those regulations.
HV	High Voltage
ITU	International Telecommunication Union
LV	Low Voltage
MEN	Multiple earthed neutral system
NZCCPTS	New Zealand Committee for the Co-ordination of Power and Telecommunication Systems Inc.
SAA	Standards Association of Australia
SWER	Single wire earth-return

3 Background

Power Co-ordination adverse effects almost always result from the impact of High Voltage (HV) power and railway networks on widespread telecommunications copper multi-pair or coax cable networks.

New Zealand HV Power and Railway Networks

New Zealand HV power and railway networks include:

- The Transpower National Grid (typically 66 kV and higher AC voltages, plus the 350 kV DC HVDC link).
- Power Line Companies' sub transmission networks (typically 33 kV and 66 kV AC) – these link their Zone Substations.
- Power Lines Companies' HV distribution networks (typically 6.6 kV, 11 kV and 22 kV AC).
- KiwiRail's 25 kV electrified railways (Palmerston North to Hamilton on the North Island Main Trunk (NIMT) railway from Wellington to Auckland, and the Auckland suburban railways).
- KiwiRail's 1500 V DC Wellington suburban area commuter lines.

New Zealand Telecommunications Networks

The main 'at risk' telecommunications networks in New Zealand are:

- The Chorus copper multi-pair cable network – installed down one or both sides of most roads in New Zealand.
- The Vodafone coax and copper multi-pair networks in urban Wellington, Hutt Valley, Kapiti Coast and Christchurch.

Working pairs in telecommunications network copper multi-pair cables are insulated copper conductors which have an AC earth reference on them provided by the source Telephone Exchange earthing system. This is normally considered to be at remote earth potential.

Fibre Optic Telecommunications Cables

- Fibre optic cables with no metallic parts are immune from Power Co-ordination impacts.
- Fibre optic cables or blown fibre microduct assemblies with a metallic strength member or metallic moisture barrier, and no other metallic parts, have only a minor exposure to Power Co-ordination impacts. These are easily mitigated.
- Fibre optic cables containing insulated copper pairs must be treated essentially the same as other copper multi-pair cables when considering Power Co-ordination issues.
- Aerial fibre optic cables installed along a power line, which contain a metallic moisture barrier, or are supported under the power conductors by an integral metal strength member or an

external metal catenary wire, can cause hazards to staff working on the power line. This is explained in more detail in Section 4.5 'Voltages Impressed onto Any Moisture Barrier, Metal Strength Member or Metal Catenary Wire Associated with Aerial Fibre Optic Cables Installed along Power Lines'.

- Optical fibres contained in an overhead earth wire should pose no Power Co-ordination issues, since the earth wire should be earthed regularly, and bonded to any conductive tower/pole supporting it (which establishes equipotential bonding at that conductive tower/pole).

4 Mechanisms of Adverse Interactions

4.1 Direct Contact between Power Network Conductors and Telecommunications Network Conductors

(1) Between Overhead Power Lines and Overhead Telecommunications Lines (or Cables)
This is covered by the requirements, including minimum separations, in NZECP 34 'Electrical Safe Distances' Section 6. The requirements in NZECP 34 are made mandatory by the Electricity (Safety) Regulations 2010.

(2) In the Ground
Electrical contact between conductors in a power network cable and conductors in a nearby telecommunications network cable, can occur during digging operations if a metal digger slices through and/or contacts both simultaneously. This risk is addressed by the NZCCPTS Cable Separations Guide, which specifies minimum separations that should be maintained between buried power and telecommunication cables.

This Guide can be downloaded free as a PDF file from
http://www.nzccpts.co.nz/publications.html.

4.2 EPR Impressed onto Telecommunications Network Conductors

This will normally occur via one of the following mechanisms:

(1) EPR coupled through the ground onto a telecommunications network earthing system, that provides the earth reference for the local telecommunications network

Examples of telecommunications network earthing systems that provide the earth reference for a local telecommunications network include the earthing systems of a telephone exchange, or a roadside telecommunications electronic cabinet.

The magnitude of EPR coupled onto the telecommunications network earthing system due to EPR on a nearby power network earthing system will depend on:

(i) The magnitude of the EPR on the power network earthing system;

This is dependent on the power network source voltage and the earth loop impedances, including the earth resistance of the power earthing system (which is in turn dependent on the soil resistivity).

(ii) The separation between the power and telecommunications network earthing systems; and

(iii) The 'electrical size' of the power network earthing system.

The **electrical size of an earthing system** is defined in this guide as the radius of the equivalent hemispherical electrode (r_e) that has the same earth resistance as the earthing system.

The resistance to remote earth (R) of a hemispherical electrode has the following relationship to its radius (r_e)

$$R = \frac{\rho}{2\pi r_e} \qquad (1)$$

For any given earthing system in a homogeneous earth of resistivity ρ, R can be expressed as R = ρ.K, where K is a constant which is a function of the dimensions and "shape" of the earthing system. This means we can calculate r_e according to the below equation, without knowing what the earth resistivity (ρ) is (i.e. r_e is independent of ρ). The equivalent hemispherical radius (r_e) of an earthing system is a constant number which is a function of the dimensions and "shape" of the earthing system.

$$r_e = \frac{1}{2\pi K} \qquad (2)$$

For this hemispherical electrode, it can further be shown that the earth potential at any point in the soil with respect to remote earth (E_d), is inversely proportional to its distance 'd' from the centre of the earth electrode.

i.e. $E_d \;\alpha\; \frac{1}{d}$ for $d > r$

Hence the proportion of the EPR on the power network earthing system (E_r) that will be present in the soil at distance 'd' from the centre of the power network earthing system (E_d) is given by the expression

$$\frac{E_d}{E_r} = \frac{r_e}{d} \qquad (3)$$

or

$$E_d = \frac{r_e \times E_r}{d} \qquad (4)$$

where

E_d = EPR at distance 'd'
E_r = EPR on power network earthing system

If a nearby telecommunications network earthing system is at distance 'd' from the centre of the power network earthing system, and this earthing system is isolated (i.e. NOT bonded to any other 'remote' earthing system (e.g. extensive MEN)), then the EPR transferred onto the telecommunications network earthing system will be E_d.

If the 'electrical size' of the power network earthing system (r_e) doubles, this will result in:

- Its resistance to remote earth (R) halving (see equation (1));
- Any EPR on the power network earthing system (E_r) reducing to between 50% and 100% of its former EPR (since while R has reduced by 50%, the total fault loop impedance must have reduced by a lesser amount); and
- The proportion of the EPR on the power network earthing system that is coupled onto the nearby telecommunications network earthing system (= E_d/E_r) doubling (see equation (3)).

The nett effect of this is the EPR coupled onto the telecommunications network earthing system (E_d) will increase to between 100% and 200% of its former value, regardless of soil resistivity, if the 'electrical size' of the power network earthing system doubles.

So long as the power network earthing system and the telecommunications network earthing system are not bonded together, any increase in the 'electrical size' of the power network earthing system will cause an increase in the EPR coupled onto any nearby telecommunications network earthing system. Similarly, any decrease in the 'electrical size' of the power network earthing system will cause a decrease in the EPR coupled onto any nearby telecommunications network earthing system. [Please note that this applies if the power network earthing system is enlarged locally, but does not apply if a 'remote' earth electrode is bonded to the power network earthing system.]

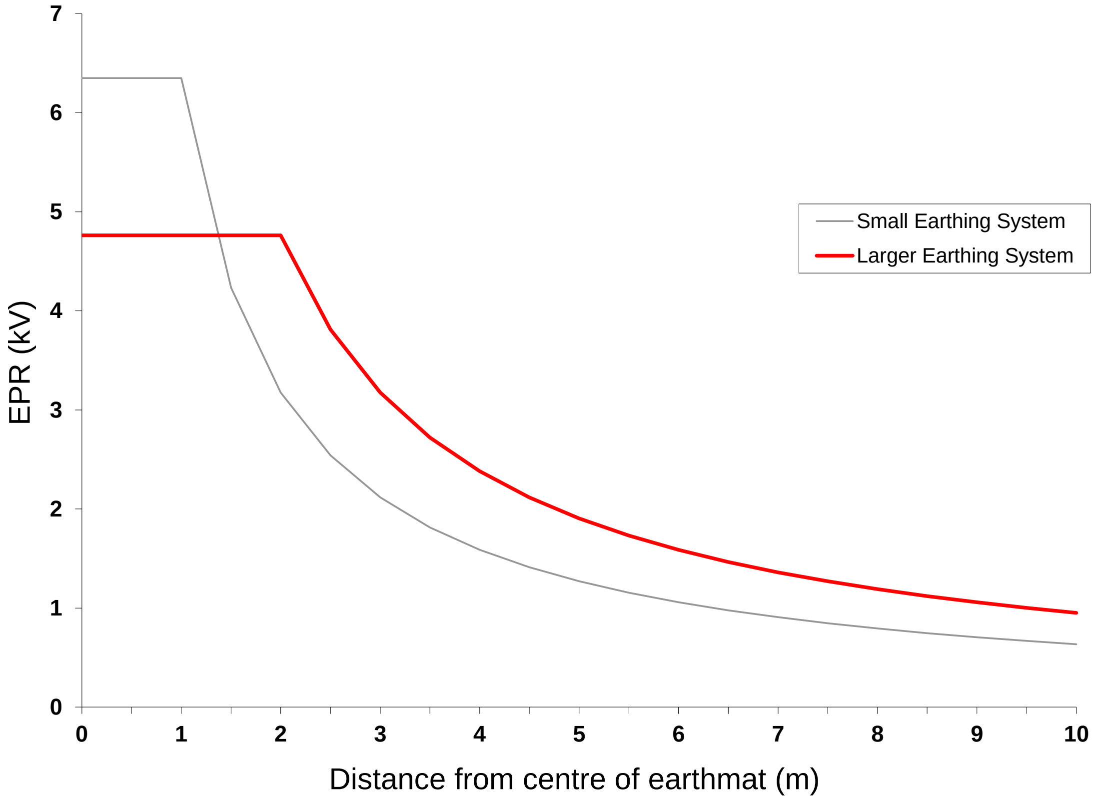

Figure 1 Impact of 'Size' of Earthing system on the EPR (in the Soil) Dropoff Curve

(2) EPR coupled onto telecommunications network conductors via insulation breakdown of telecommunications cable network plant

If the EPR in the ground in contact with telecommunications cable network plant is high enough, insulation breakdown will occur to the working copper conductors in the telecommunications network cables (which are typically at remote earth potential, via their connection to the remote Telephone Exchange earthing system). The EPR impressed onto these conductors will then travel down the telecommunications network cable pair in both directions, to the Telephone Exchange and to other customers' premises. This is likely to present a hazard to any telecommunications staff working on the cable, and possibly to customers using their telecommunications circuits, as well as damaging telecommunications network equipment and telecommunications customers' equipment.

Note that if no insulation breakdown of telecommunications cable network plant occurs, no hazard will exist via this mechanism. Typical telecommunications cable network plant insulation levels are given below in Table 1.

Telecommunications Cable Network Plant	Assumed Minimum Insulation Level (kV_{rms})	When Chorus Cables of These Types were Installed
Buried telecommunications cables with paper insulated conductors (PCUT, PCUB, PCQL, etc.)	1.0	Before about 1970
Buried telecommunications cables with plastic insulated conductors, that are both unfilled and unpressurised (PEUT).	1.5	About 1970 to mid 1970s
Network cabling ready access points (e.g. pillars, pedestals, plastic openable joints in pits (BD[2]))	1.5	Since about 1970
Buried grease-filled or pressurised telecommunications cables with plastic insulated conductors (PEFUT, CPUB, PEUB cables)	2.5	Since mid 1970s
Grease-filled or pressurised telecommunications cables with plastic insulated conductors (PEFUT, CPUB, PEUB cables) installed in buried pipe	4.0	Since mid 1970s

Table 1 Typical Minimum Insulation Levels of Telecommunications Cable Network Plant

(3) EPR coupled onto telecommunications network conductors via insulation breakdown within mains-powered customers' telecommunications equipment

In rural areas, an 11 kV phase-to-earth fault at a distribution transformer will typically impress an EPR of over 3 kV_{rms} onto the distribution transformer earthing system. Since the LV MEN system is bonded to this earthing system, this means over 3 kV_{rms} EPR will appear virtually in full on the LV neutral throughout any premises supplied by this distribution transformer.

Any mains-powered customers' telecommunications equipment in these premises will be stressed by the difference between two incoming potential references. The incoming LV neutral and LV earth will have over 3 kVrms EPR, while the incoming telecommunications network line will have the earth potential of the telephone exchange earthing system, which will normally effectively be at remote earth potential.

Mains-powered customers' telecommunications equipment in New Zealand is required by AS/NZS 60950.1 (virtually an exact copy of the international standard IEC 60950.1) to have a minimum insulation of 1.5 kVrms between its LV neutral/earth and its telecommunications network line connections. [This is considered ample to survive typical impressed EPRs in Europe.]

However AS/NZS 60950.1 then permits this 1.5 kVrms minimum insulation between the LV neutral/earth and the telecommunications network line connections to be bridged by internal surge arrestors. These are commonly included in the equipment to protect it from lightning surges. AS/NZS 60950.1 requires these surge arrestors to have a minimum DC sparkover voltage of 1.6 times the upper RMS voltage of the equipment's rated supply voltage range. For the most common 'rated voltage range' of 220 - 240 V_{rms}, this results in a minimum DC sparkover voltage of 384 V_{DC}. Working telecommunications network cable pairs normally have the Exchange battery (nominally 50 V_{DC}, maximum 54 V_{DC}) across them, and one leg of each cable pair is referenced to the Exchange earth. This means that the minimum additional EPR on the LV earth that could cause these internal surge arrestors to fire, is 384 V_{DC} – 54 V_{DC} = 330 V_{DC}. If this EPR results from a 50 Hz power fault, this is equivalent to 330 V_{peak}, or 233 V_{rms}.

For brief periods of time, a telephone cable circuit could also have a ringing voltage of 80 V_{rms} +/- 10%, 25 Hz across it. So if the power fault coincides with one of these brief periods of ringing, the minimum additional EPR on the LV earth that could cause these internal surge arrestors to fire could be as low as 233 – 88 = 145 V_{rms}.

These internal surge arrestors are designed to handle very brief lightning surge currents only. They are not designed to handle 50 Hz fault currents. If any 50 Hz fault EPR on the LV earth is sufficient to cause the surge arrestors to 'fire', the surge arrestors will almost certainly be destroyed. However, prior to being destroyed, they will conduct the EPR on the LV neutral/earth onto the telecommunications network line connections. This impressed voltage will then travel down the telecommunications network cable pair in both directions, to the Telephone Exchange and to other customers' premises. This is likely to present a hazard to any telecommunications staff working on the cable, and possibly to customers using their telecommunications circuits, as well as damaging telecommunications network equipment and telecommunications customers' equipment.

During normal operation of a power network, the EPRs on the power network earthing systems would usually be insufficient to cause insulation breakdown to occur in telecommunications cable network plant or mains-powered customers' telecommunications equipment (mechanisms (2) and (3) above). Normally a power network HV phase-to-earth fault will be required to generate sufficient EPR for this to occur.

The most relevant standards covering the above EPR mechanisms are:

AS/NZS 3835:2006	EPR – Protection of Telecommunications Network Users, Personnel and Plant Part 1 - Code of Practice Part 2 - Application Guide
AS/NZS HB 219:2006	EPR – Protection of Telecommunications Network Users, Personnel and Plant Handbook - Worked Examples for the Application Guide

Excel spreadsheets of the EPR Calculation Worked Examples in the above AS/NZS HB 219:2006 can be freely downloaded from the 'Tools' webpage of the NZCCPTS website (www.nzccpts.co.nz). These facilitate customised EPR calculations, and enable easy 'what if' repeat calculations (e.g. what if a 38 Ω NER were installed?).

The New Zealand power industry standard 'EEA Guide to Power System Earthing Practice – June 2009' is also relevant. This covers the design of HV power earthing systems, assessment of the consequential EPR, and the possible employment of a risk analysis approach to deciding when to install mitigation (e.g. the provision of separate HV and LV earths).

4.3 Voltages Induced along Telecommunications Network Conductors by Parallel HV Power Lines

If a power current returns to source through the body of earth (i.e. not via an earth wire or cable sheath), this earth return current will induce by means of inductive coupling a voltage in any parallel, or part parallel, insulated telecommunications circuits. Normally, mutual impedance effects mean that the vast majority of this earth return current will return in the soil directly under the route of the power line (or cable), even if this is not the most direct route back to the source. Note that no insulation breakdown is required for this voltage to be coupled onto the telecommunications circuits by this mechanism. All that is needed is a parallel earth return current.

This means that often very low voltages are induced onto the telecommunications conductors, that have no, or minimal, impact on the telecommunications circuits.

Significant power network earth return currents (through the body of earth) are most commonly caused by earth faults. Normally these need to be HV earth faults to generate sufficient voltage to have a significant impact.

Some situations are exposed to both the EPR and induced voltage effects of the same earth fault current. In these cases, if the phase relationship between the impressed EPR and induced voltages is not known, the voltage impressed onto the telecommunications network conductors should be calculated as the vector sum of the impressed EPR and induced voltage.

There are no New Zealand standards that directly deal with this issue. The most relevant international standards on this issue are the following Standards Australia Handbooks:

(1)	SAA HB101 – 1997	Code of Practice for the mitigation of hazardous voltages induced into telecommunications lines (also known as the 'LFI Code').
(2)	SAA HB102 – 1997	Application Guide to the LFI (Low Frequency Interference) Code.

4.4 Voltages Impressed on Telecommunications Network Metal Pipelines that Parallel Power Lines

If a power current returns to source through the body of earth (i.e. not via an earth wire or cable sheath), any nearby buried uninsulated metal pipeline following the same direction will carry some part of this earth return current. This current could present a hazard to staff working on the metal pipe. AC corrosion of the pipe may also be an issue. For more information on ac corrosion, refer to the CIGRE TB 290 and CEN 15280 guides detailed in section 14.

In addition, a power current returning to source through the body of earth (i.e. not via an earth wire or cable sheath) can induce a voltage along any parallel buried insulated metal pipeline.

These issues are covered by AS/NZS 4853:2000 'Electrical Hazards on Metallic Pipelines'.

4.5 Voltages Impressed onto Any Moisture Barrier, Metal Strength Member or Metal Catenary Wire Associated with Aerial Fibre Optic Cables Installed along Power Lines

If aerial fibre optic cables installed along a power line contain a metallic moisture barrier, or are supported under the power conductors by an integral metal strength member or via an external metal catenary wire, the metallic moisture barrier/metal strength member/metal catenary wire can have a voltage impressed on it by:

1. induction,
2. capacitive coupling, or
3. direct contact with a bare power conductor (e.g. if a power conductor breaks and falls down onto the metal strength member/catenary).

Even if this voltage is relatively low, it may still be sufficient to cause a physiological reaction that could directly or indirectly injure staff working on the fibre optic cables or the power lines, while up a ladder at the pole (e.g. staff could receive a shock, causing them to fall off the ladder).

These risks are best addressed by following the advice on earthing and equipotential bonding in the EEA 'Guide to Work on De-energised Overhead Distribution Lines', Section 6.9 'Inclusion of

Conductive Items Within Equipotential Zones' and Appendix D 'Precautions When Working Near Aerial Catenary Wires'.

This guide can be downloaded free as a PDF file from the http://www.eea.co.nz website.

5 Procedures for Evaluating Situations for Possible Power Co-ordination Hazard Issues

5.1 When New Power, Electrified Railway or Telecommunications Network Construction or Alteration Proposals should be Evaluated for Possible Power Co-ordination Hazard or Damage Issues

Any significant Power, Electrified Railway or Telecommunications Network construction or alteration works should be referred to the appropriate Power Co-ordination specialist for initial comments on possible Power Co-ordination hazard or damage issues, at the earliest possible stage in the project. **This should normally be at the planning stage, long before the specific details of the proposed works have been finalised.**

This enables possible major future problems to be identified at a stage where the proposal can usually be easily modified to avoid the problems. For example, the proposal may involve locating a major HV earthing system and a large telecommunications roadside electronic cabinet earthing system very close to one another. Shifting the proposed location of the new plant may be a simple issue, while still in the planning phase.

If notification of the proposal details is left until the design is finalised, and Power Co-ordination hazard or damage problems are only identified at this late stage, then:

1. the simplest and cheapest mitigation option(s) may no longer be viable,
2. the detailed design of the proposal may need to be redone, with the associated significant delays and extra costs this will involve,
3. this could involve some very unwelcome last minute delays and budget 'surprises'.

5.2 Procedures for Evaluating New or Existing Situations for Possible Power Co-ordination Hazard Issues

Discussions are currently under way between the NZ Power, Telecommunications and Railways Industries on recommended procedures for evaluating situations for possible Power Co-ordination hazard issues.

The results of these discussions will be covered in detail in either a new NZCCPTS Application Guide, or a new section in an existing or future NZCCPTS Application Guide.

5.3 Expertise Required

Industry experience shows that the following aspects of Power Co-ordination EPR hazard are not generally well understood in either the Power or Telecommunications Industries:

1. The impact of extensive inter-bonded MENs on urban EPR levels.
2. The impact of HV cable sheath bonding on (urban) EPR levels.
3. The use of segregated HV and LV earthing systems at rural distribution transformers to minimise the maximum EPR on the LV MEN.
4. The impact of the 'electrical size' of the power network earthing system on the EPR in the soil at the location of nearby telecommunications plant (see section 4.2 (1)).
5. The impact of multiple soil resistivity layers on the resultant EPR contours in the soil around a HV earthing system.

Similarly, the mechanism of Induced Voltage hazard is not generally well understood in either the Power or Telecommunications Industries. In particular, the impacts of the following on the resultant induced voltage levels is not generally well understood:

(i) Shielding from other metallic infrastructure (e.g. wire fences, metal pipes, reinforced concrete).
(ii) Multiple soil resistivity levels (down to kilometres deep).
(iii) Earthed metal sheaths and/or armouring on the HV cables.
(iv) Earthed metal sheaths and/or armouring on the telecommunication cables.

For these reasons NZCCPTS recommends that skilled industry power/telecommunication co-ordination specialists are used to analyse proposed new construction or alteration work for possible power/telecommunication co-ordination hazards, for all but the most simple of work proposals.

If necessary, the Secretary of NZCCPTS can advise on suitable specialists.

6 Methods of Determining Levels of Impressed EPR and/or Induced Voltage

6.1 Use of Simple Calculations

Accurately calculating expected maximum EPR levels in the vicinity of telecommunications network plant, or expected maximum voltages induced along parallel telecommunications cables, is usually a relatively complex exercise.

However accurate values of EPR or induced voltage are normally not strictly needed. Instead, all that is usually required is confidence that:

1. the maximum EPR in the vicinity of telecommunications network plant will be less than the assumed minimum insulation level of that type of telecommunications network plant (i.e. insulation breakdown will not occur), and/or
2. the maximum voltage impressed onto telecommunications network conductors is less than the limits in Table 7 (typical situation) or Table 8 (severe situation) in section 10.2.3, for both normal operation, and for all types of power faults that could reasonably be expected to occur.

This can usually be quickly established by simple calculations, where conservative ‘worst case’ values are initially assumed for all unknown or ‘difficult to quantify’ parameters. This will give a conservative maximum impressed voltage. In the few cases where these calculated voltage levels indicate a possible problem, better quantifying these parameter values to enable a more accurate calculation of the maximum impressed voltage may then be warranted.

6.2 Use of Computer Modelling

Where good computer modelling software is available, more accurate calculations of expected maximum EPR in the vicinity of telecommunications network plant, or expected maximum voltages induced along parallel telecommunications cables, can often be readily done at little extra cost.

6.3 Measurement of EPR and/or Induced Voltages during a Current Injection Test

The most accurate way of establishing the expected maximum EPR in the vicinity of telecommunications network plant, or expected maximum voltages induced along parallel telecommunications cables, is by conducting a current injection test and measuring the actual voltage levels that result. Since the injected current will be substantially less than the ‘worst case’ fault current, normal practice is to multiply the measured voltage levels by the ratio of the ‘worst case’ earth fault current divided by the actual (measured) injected current, to establish the expected ‘worst case’ EPR and/or induced voltage levels.

The best power network injection circuit to use, if practicable, is the actual ‘worst case’ fault current (or normal operation) circuit. This is because this inherently includes any (usually unknown) soil resistivity variations and shielding along the route of this circuit. These ‘usually not accurately known’ parameters can result in a substantial difference between calculated or computer modelled voltage levels, and the actual voltage levels. The calculated levels are almost always a conservative approximation, with the calculated or computer modelled voltage levels substantially higher than the actual voltage levels.

7 Noise Interference Voltages Impressed onto Telecommunications Network Conductors by Power Networks or Electrified Railways

‘Noise’ currents and voltages in power distribution networks are predominantly caused by customer’s appliances. A common source of this noise is customer’s appliances with an internal power supply that uses half-wave rectifiers. In rare cases, these currents and voltages can be greatly magnified by the power distribution network if one of the noise frequencies produced by the customer’s appliances matches an inherent resonant frequency of the power distribution network. Some high frequency RFI (Radio Frequency Interference) noise can be caused by power distribution networks (primarily due to partial discharge on the surface of insulators (corona)), but this has not caused significant noise problems for telecommunications networks as at the date of publication of Version 1 of this guide.

Noise interference problems on telecommunications networks normally appear as either:

(1) loud noise on analogue telephone circuits operating in the audible frequency band (typically 250 Hz to 4 kHz), or
(2) higher frequency noise causing mal-operation, or substandard operation, of telecommunications digital transmission circuits. This can simultaneously shut down multiple broadband circuits, or slow down the maximum speed available on the broadband circuits.

In the foreseeable future, noise interference in the audible frequency band (typically 250 Hz to 4 kHz) will become less relevant, as an increasing number of telephone circuits are migrated from the analogue ‘voice’ frequency band onto internet telephony – known as Voice over Internet Protocol (VoIP). Internet telephony is a service offered via a digital broadband circuit.

While the mechanisms for a power network or electrified railway to impress noise voltages onto telecommunications network conductors are virtually identical to those previously discussed for impressing 50 Hz hazard or damage voltages, it is almost always impractical to attempt to calculate these voltage levels before a proposed change to the power network or electrified railway takes place. This is because:

1. Estimating future power noise current levels is generally impractical. It is unknown, and subject to wide variation as new customers’ equipment is connected or disconnected from the power network (something that is largely beyond the control of the power company).
2. The effect of shielding is usually largely unknown.

Instead levels of impressed noise can only really be established by measurement after the change to the power network or electrified railway takes place.

While the potential for significant noise interference issues exists with virtually all proposed changes to a power network or electrified railway, only a tiny fraction of these situations ever results in a significant noise problem. Also, noise interference problems do not present a direct hazard to humans, or damage telecommunications plant or equipment.

As a result, the best approach to addressing possible noise problems is almost always a ‘reactive’ one, which involves:

1. No analysis of proposed changes to the power network or electrified railway for possible noise interference problems.
2. Both parties accepting that in a tiny fraction of cases a noise problem may eventuate, and that this will then need to be addressed. Also, that this noise problem may not eventuate until well after the change to the power network or electrified railway has been completed.

3. Waiting for any significant, ongoing noise problems to occur.
4. Only investigating and mitigating these problems after they occur.

The most relevant standard covering noise voltages impressed onto telecommunications networks by power networks (including electrified railways) is:

NZCCPTS Noise Interference Investigation Guide, September 1999

This Guide can be downloaded free as a PDF file from http://www.nzccpts.co.nz/publications.html.

The recommended 'acceptable' noise voltage limits in this standard are copied from Chapter 6 'Permissible voltage and current levels to limit disturbance' in the ITU-T "Directives concerning the protection of telecommunication lines against harmful effects from electric power and electrified railway lines", Volume VI "Danger, damage and disturbance" :2008. These are detailed in 10.2.4.

8 Hazard and Noise Interference Interactions with SWER HV Power Lines

SWER stands for Single Wire Earth Return. SWER HV power lines comprise a single phase conductor, with the return current returning to source via the earth. SWER HV lines have been constructed in NZ as a means to provide electricity to remote rural consumers at an affordable cost.

Conventional NZ HV distribution lines normally only produce significant earth return currents in the soil, with the associated possible EPR and induced voltage issues, during earth faults. SWER HV lines differ, in that a significant earth return current in the soil is an intrinsic feature of their normal operation (as well as during earth faults).

With SWER HV lines, relatively low magnitude but very long duration ('continuous') EPRs and induced voltages need to be assessed for potential Power Co-ordination issues. Also, since these EPRs and induced voltages are continuously present, noise interference becomes a major consideration.

Refer to the following Guides:

NZCCPTS Application Guide for SWER HV Power Lines, September 1999

EEA Guide for HV SWER Systems, October 2010

The EEA Guide for HV SWER Systems was developed as an electricity industry standard, from NZECP 41 'Single Wire Earth Return Systems'.

These Guides can be downloaded free as PDF files from the
http://www.nzccpts.co.nz/publications.html and http://www.eea.co.nz websites respectively.

9 Relevant New Zealand Statutory Legislation and Electrical Codes of Practice

9.1 Electricity Act 1992

Section 24: Construction or maintenance of works on roads
This section gives an electricity operator the statutory right to install works in the road reserve, but only in accordance with such reasonable conditions as may be prescribed by the local authority or other body having jurisdiction over the road.

Section 25: Notice to be given before work undertaken
Before an electricity operator can start any works under section 24, they must first give written notice of details of their proposed work to the local authority or other body having jurisdiction over the road, and the owners of any affected water or gas pipe, telecommunications line or works.

9.2 Telecommunications Act 2001

Section 135: Construction or repair of lines or wireless works on roads
This section gives an telecommunications network operator the statutory right to install works in the road reserve, but only in accordance with such reasonable conditions as may be prescribed by the local authority or other body having jurisdiction over the road.

Section 25: Notice to be given before work undertaken
Before a telecommunications network operator can start any works under section 135, they must first give written notice of details of their proposed work to the local authority or other body having jurisdiction over the road, and any utility operator whose pipe, lines or other structures might be affected by the works.

9.3 Electricity (Safety) Regulations 2010

Regulation 33 Requirements relating to construction of, or work in vicinity of, telecommunications equipment

Any telecommunications equipment being constructed in the vicinity of any electrical works or installation, or any electrical works or installation being constructed in the vicinity of any telecommunications equipment, must be constructed so as to ensure that any induced voltage or earth potential rise (EPR) that is capable of being created by the electricity works or installation is not likely to cause:

(a) Serious harm to any person, or
(b) Significant damage to the telecommunications equipment.

[Note – ‘telecommunications equipment’ in this context includes telecommunications lines, cables, plant and equipment.]

Voltages impressed onto telecommunications equipment by induction or earth potential rise are deemed not to be likely to cause a serious harm to persons if:

(1) In respect of faults on an AC system of supply of electricity
  - (a) the magnitude and duration of any resulting shock currents cannot exceed: curve c2 of Fig 20 of IEC/TS 60479-1,
  - (b) the impressed voltages do not exceed:
    - (i) 430 V_{rms} for AC fault durations exceeding 0.5 seconds but not exceeding 5 seconds,
    - (ii) 650 V_{rms} for AC fault durations not exceeding 0.5 seconds;

(2) In respect of faults on a DC system of supply of electricity
  - (a) the magnitude and duration of any resulting shock currents cannot exceed curve c2 of Fig 22 of IEC/TS 60479-1,
  - (b) the impressed voltages do not exceed 1,000 V_{peak}.

Voltages impressed onto telecommunications equipment by induction or earth potential rise are deemed not to be likely to cause significant damage to any telecommunications equipment if they do not exceed:

- (a) In respect of faults on an AC system of supply of electricity,
  - (i) 430 V_{rms} for AC fault durations exceeding 0.5 seconds but not exceeding 5 seconds,
  - (ii) 650 V_{rms} for AC fault durations not exceeding 0.5 seconds;
- (b) In respect of faults on a DC system of supply of electricity, 1,000 V_{peak}.

So for faults on the AC system of supply, these 430/650 V_{rms} voltage limits are an ‘acceptable means of compliance’ with all the serious harm and significant damage requirements in ESR 33.

Alternatively, compliance with the ESR 33 requirement to 'not be **likely** to cause serious harm to any person, or significant damage to telecommunications equipment', could be justified by:

(1) a Risk Analysis (see section 11 of this guide); or

(2) a different set of authoritative hazard voltage limits calculated using the body current curves in IEC/TS 60479-1:2005 (see Fig. 2), and agreed between the power and telecommunications industries in NZ.

IEC/TS 60479-1:2005 is also published as AS/NZS 60479.1:2010.

Regulation 33A Limits of operation of SWER systems in relation to telecommunications

This regulation applies only to AC HV SWER systems, other than an AC electrified railway traction system.

During normal operation, the SWER system must not impress on a telecommunication line:

(a) a transverse psophometrically weighted noise voltage, measured at the user's end of the telecommunication line, greater than 0.5mV; or

(b) an induced voltage greater than 35 V_{rms}.

During any normal or fault-related operation, the SWER system must not cause earth potential rises coupled to the neutral conductor of a MEN system, or voltages impressed on a telecommunication line, that exceed the maximum voltages in the voltage limit tables of the ITU-T 'Directives concerning the protection of telecommunication lines against harmful effects from electric power and electrified railway lines', Volume VI 'Danger, damage and disturbance':2008.

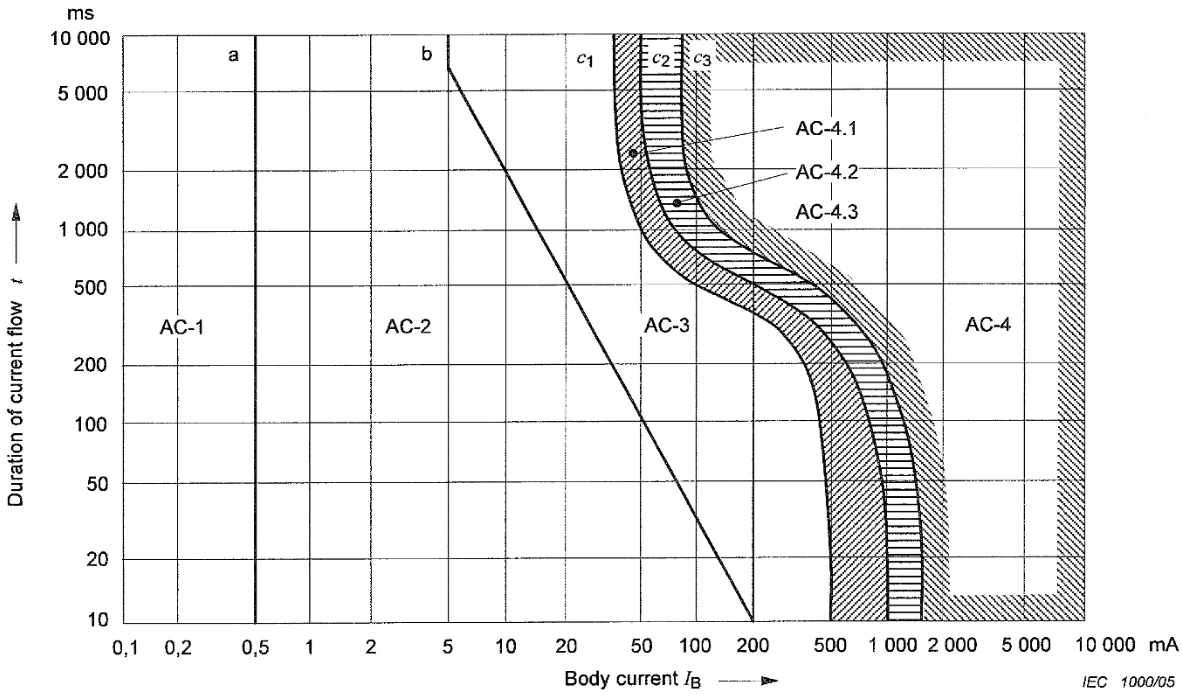

Figure 2 **Conventional time/current zones of effects of a.c. currents (15 Hz to 100 Hz) on persons for a current path corresponding to left hand to feet (for explanation see Table 2)**

Zones	Boundaries	Physiological effects
AC-1	Up to 0,5 mA curve a	Perception possible but usually no 'startled' reaction
AC-2	0,5 mA up to curve b	Perception and involuntary muscular contractions likely but usually no harmful electrical physiological effects
AC-3	Curve b and above	Strong involuntary muscular contractions. Difficulty in breathing. Reversible disturbances of heart function. Immobilization may occur. Effects increasing with current magnitude. Usually no organic damage to be expected
AC-4 [1)]	Above curve c_1	Patho-physiological effects may occur such as cardiac arrest, breathing arrest, and burns or other cellular damage. Probability of ventricular fibrillation increasing with current magnitude and time
	c_1-c_2	AC-4.1 Probability of ventricular fibrillation increasing up to about 5 %
	c_2-c_3	AC-4.2 Probability of ventricular fibrillation up to about 50 %
	Beyond curve c_3	AC-4.3 Probability of ventricular fibrillation above 50 %

[1)] For durations of current flow below 200 ms, ventricular fibrillation is only initiated within the vulnerable period if the relevant thresholds are surpassed. As regards ventricular fibrillation, this figure relates to the effects of current which flows in the path left hand to feet. For other current paths, the heart current factor has to be considered.

Table 2 Time/current zones for a.c. 15 Hz to 100 Hz for hand to feet pathway – Summary of zones of Figure 2

9.4 New Zealand Electrical Codes of Practice

NZECP 34:2001 Electrical Safe Distances

Electricity (Safety) Regulation 17 (1) makes it mandatory for anyone working near an overhead power line (other than an overhead rail electrification line) to comply with NZECP 34.

NZECP 34 specifies:

(1) Minimum safe distances between overhead power lines and overhead telecommunications lines (Section 6).

(2) Minimum safe distances for excavation and construction near overhead power line supports (Section 2).

(3) Minimum safe distances for the operation of mobile plant near overhead power lines (Section 5).

(4) Minimum safe approach distances for persons working near overhead power lines (Section 9).

Note:
Electricity (Safety) Regulation 17 (1) makes it mandatory for anyone working near an overhead rail electrification line to comply with the minimum separations in IEC 62128-1. However KiwiRail still requires compliance with NZECP 34 for mobile plant working near an overhead rail electrification line, unless special agreed conditions for reduced minimum approach distances apply.

EEA Guide for HV SWER Systems

The EEA Guide for HV SWER Systems was developed as an electricity industry standard, from NZECP 41 'Single Wire Earth Return Systems'.

This Guide can be downloaded free as a PDF file from the http://www.eea.co.nz website.

NZECP 36:1993 Harmonic Levels

NZECP 36 sets limits for:

(1) the equivalent disturbing voltage for a system voltage of 66 kV or above, at any point of common coupling.
(2) the equivalent disturbing current for a system voltage of 66 kV, 110 kV or 220 kV, at any point of common coupling.

The equivalent disturbing voltages and equivalent disturbing currents are psophometrically weighted voltages and currents for the harmonic frequencies from 100 Hz to 2,500 Hz inclusive. As such they are only a very indirect indication of likely levels of noise voltage that could be induced onto parallel telecommunications circuits.

Psophometric weighting simulates the effect on the human ear of harmonic voltages in the audible frequency range (typically 300 Hz to 3.4 kHz). Harmonics outside this range can impact on high frequency communication circuits (e.g. broadband bearer circuits).

Compliance with NZECP 36 is deemed to be compliance with Electricity (Safety) Regulation 31 (1) ‘Quality of supply’, in terms of harmonic interference to another person’s electricity supply.

10 Limits for Voltages Impressed onto Telecommunications Network Conductors by Power Networks or Electrified Railways

10.1 Electricity (Safety) Regulations 2010

Electricity (Safety) Regulation 33 specifies voltage limits of:

(i) 430 V_{rms} for fault durations > 0.5 s, and
(ii) 650 V_{rms} for fault durations ≤ 0.5 s,

as an acceptable means of complying, in respect of faults in an AC system of supply, with the requirement in this regulation that any new construction must not cause voltages impressed onto telecommunications equipment by induction or earth potential rise that are likely to cause serious harm to any person or significant damage to any telecommunications equipment.

It also specifies that demonstrating that ‘the magnitude and duration of any resultant shock currents cannot exceed curve c2 of Fig 20 of IEC/TS 60479-1’ (in respect of faults in an AC system of supply) is an acceptable alternative means of complying, with the requirement in this regulation that any new construction must not cause voltages impressed onto telecommunications equipment by induction or earth potential rise that are likely to cause serious harm to any person.

Alternatively, compliance with the ESR 33 requirement to ‘not be **likely** to cause serious harm to any person, or significant damage to telecommunications equipment’, could be justified by:
(1) a Risk Analysis (see section 11 of this guide); or
(2) a different set of authoritative hazard voltage limits calculated using the body current curves in IEC/TS 60479-1:2005 (see Fig. 2), and agreed between the power and telecommunications industries in NZ.

No voltage limits for either hazard or noise are specified in the Electricity (Safety) Regulations for voltages impressed onto telecommunications network conductors by a power system or electrified railway system during normal operation (i.e. no faults) of that power system or electrified railway system .

10.2 NZCCPTS Hazard Assessment Guide

The NZCCPTS Hazard Assessment Guide – "Assessment of Risk of Earth Potential Rise and Induced Voltage Hazard to Telecommunication Networks" was still being written at the time of publication of this guide. This will specify recommended human hazard and telecommunications equipment damage limits for New Zealand.

It will also outline the alternative approach of addressing human hazard and telecommunications plant and equipment damage issues by means of a risk assessment. Under this approach, a situation where the maximum possible impressed voltages exceed the above recommended human hazard and/or equipment damage voltage limits, may still be deemed to be an 'acceptable risk' if the risk of the adverse combination of events happening is sufficiently low.

Once published, this guide will be able to be downloaded free as a PDF file from http://www.nzccpts.co.nz/publications.html.

11 Risk Assessments

Even if the EPR and/or induced voltages impressed onto telecommunication network circuits are well in excess of the hazard and damage voltage limits given above in Section 6, this may still be considered an 'acceptably safe' situation if the probability of the situation arising in the first place is sufficiently small.

An indication of how small this probability needs to be, is given below in Table 9, which is an exact copy of the Risk Management Matrix table in the EEA "Guide to Power System Earthing Practice – June 2009". [The term ALARP in this table stands for 'As Low As Reasonably Practicable'.]

Equivalent Probability (per annum)	Risk Classification for Individual Death	Resulting Implication for Hazard Mitigation
> 10^{-4}	High	Intolerable Must prevent occurrence regardless of costs.
10^{-4} - 10^{-6}	Intermediate	ALARP for Intermediate Risk Must minimise occurrence unless risk reduction is impractical and costs are grossly disproportionate to safety gained.
< 10^{-6}	Low	ALARP for Low Risk Minimise occurrence if reasonably practical and cost of reduction is reasonable given project costs.

Table 9 Risk Management Matrix

Legislation has directly supported this option since 1993, via Regulation 50 in the 1993 Electricity Regulations, Regulation 58 in the 1997 Electricity Regulations, and Regulation 33 in the 2010 Electricity (Safety) Regulations. Specifically, these regulations have required that EPR or induced voltages impressed onto telecommunications circuits ***not be likely*** to cause a hazard to persons, or damage to telecommunications plant.

While this option has existed since 1993, it has hardly ever been used because of the lack of a robust, authoritative method of doing risk assessments. This has changed recently, with the publication of the new New Zealand power industry standard 'EEA Guide to Power System Earthing Practice – June 2009'. This standard covers the design of HV power earthing systems, assessment of the consequential EPR, and how to employ a risk analysis approach for deciding when to install mitigation.

The future NZCCPTS Hazard assessment Guide will also include discussion on, and worked example(s) of, risk analyses.

12 Mitigation Options for Addressing Hazardous Situations

The following mitigation options may be used to reduce levels of EPR and/or induced voltage impressed onto telecommunications network conductors.

12.1 Power Industry Mitigation Options

Power Industry mitigation options include the following. These options either:

(1) Reduce the earth fault current returning through the soil – this reduces both EPR and induced voltages;
(2) Reduce the EPR; or
(3) Reduce the transferred EPR.

12.1.2 Neutral Earthing Resistors or Reactors (NERs)

The installation of a NER between the star point of a HV transformer and the local substation earthing system can substantially reduce the maximum earth return currents that flow through the body of earth (via the substation earthing system) during both normal operation and earth faults on the HV system. This will in turn substantially reduce levels of EPR and/or induced voltage impressed onto telecommunications network conductors.

In recent years there has been a gradual increase in the number of resonant earthed systems installed in New Zealand, with most of these systems being operated in such a way that any faulted circuit is usually left energised until the fault has been located and isolated. The voltage at, and the current flowing into, the point of fault, will generally be very low and largely confined to harmonic currents and voltages not exceeding approximately 100 volts. As a result they should have a beneficial impact on telecommunications systems relative to solidly earthed distribution systems.

The most relevant standard covering the use of NERs is:

> NZCCPTS Neutral Earthing Resistors or Reactors (including resonant reactance earthing) Application Guide, September 2010

This Application Guide was recently updated to include details on the use of Petersen coils/resonant reactance earthing in New Zealand. This guide can be downloaded free as a PDF file from http://www.nzccpts.co.nz/publications.html.

12.1.3 Cable Sheath Bonding

The use of cable sheath bonding on HV cables can substantially reduce the maximum earth return currents that flow through the body of earth (via the substation earthing systems) during both normal operation and earth faults on the HV system. This will in turn substantially reduce levels of EPR and/or induced voltage impressed onto telecommunications network conductors.

The most relevant standard covering the use of Cable Sheath Bonding is:

> NZCCPTS Cable Sheath Bonding Application Guide, September 1999

A companion paper on “Fundamentals of Calculation of EPR in the Underground Power Distribution Cable Network” by Ashok Parsotam (1997) is supplied free by the NZCCPTS with the NZCCPTS Cable Sheath Bonding Application Guide. This paper explains how to calculate levels of EPR in an urban cable sheath bonded network.

Both this guide and the companion paper can be downloaded free as PDF files from http://www.nzccpts.co.nz/publications.html.

12.1.4 Connecting Power Network Earthing Systems to an Urban Extensive Interconnected MEN System

Connecting power HV earthing systems to an urban extensive interconnected power MEN system will substantially reduce the maximum EPR that could otherwise occur on that earthing system. This is because urban extensive interconnected MEN systems typically have resistances to earth of less than 0.5 Ω.

This is discussed in Section 6.6.1 (b) and (c) of the New Zealand power industry standard 'EEA Guide to Power System Earthing Practice – June 2009', which states the following:

"In urban areas with an extensive inter-bonded MEN network, the maximum EPR on the MEN, and on any HV earthing system bonded to the MEN network, is highly likely to be less than 430 V_{rms}, and may well be less than 280 V_{rms}. This is supported by Telecom's experience of an almost total lack of damage history from power network faults in urban areas to power plant bonded to an extensive inter-bonded MEN network. Therefore, no mitigation of transferred voltages is expected to be required for power plant bonded to an extensive inter-bonded MEN network in these areas."

12.1.5 Segregating HV and LV Earthing systems at Distribution Transformers

Separate HV and LV earthing systems at distribution transformers can be suitably designed and installed to limit the EPR transferred onto the neutral of the LV supply to customers' homes during a HV earth fault at the distribution transformer, to below the insulation withstand level of customers' mains-powered telecommunications equipment. This will stop any hazardous EPR voltages being coupled onto a telecommunications network via customers' mains-powered telecommunications equipment.

This is discussed in Section 6.7 of the New Zealand power industry standard 'EEA Guide to Power System Earthing Practice – June 2009'.

12.2 Telecommunication Industry Mitigation Options

12.2.1 EPR Hazard Mitigation Options

Telecommunications Industry mitigation options include:

(1) Shift any telecommunication cable network plant within an EPR hazard zone, which has an insulation rating less than the EPR it could be stressed by, to outside the EPR contour corresponding to its insulation rating.

(2) Replace any telecommunication cable network plant within an EPR hazard zone, which has an insulation rating less than the EPR it could be stressed by, with plant with a suitably higher insulation rating.

(3) Shift any locally earthed telecommunication cable network plant (e.g. gaseous arrestor installation, roadside electronics (MUX) cabinet) within an EPR hazard zone, to outside the relevant EPR hazard zone.

(4) Install isolation units on the incoming telecommunication network circuits at point of entry to buildings in an EPR hazard zone.

(5) Replace the incoming copper multipair telecommunication cable to buildings in an EPR hazard zone, with a fibre optic cable.

(6) Special safety practices and associated safety equipment (e.g. insulating mats) for telecommunications staff working in EPR hazard zones.

12.2.2 Induced Voltage Hazard Mitigation Options

Telecommunications Industry mitigation options include:

(1) Rerouting the parallel telecommunication cables to either
- (i) Reduce the maximum lengths of parallel; or
- (ii) Increase the separation from the power line; or
- (iii) Both of the above.

(2) Installing a fibre optic cable fed roadside electronic (MUX) cabinet at approximately 2/3 of the way along the parallel. This enables the maximum length of any parallel to be reduced to 1/3 of its former length.

12.2.3 Fibre-to-the-home (FTTH)

When all existing copper telecommunications network cables are fully replaced by a fibre to the home network, all the above hazards and interference issues will largely cease to apply. Minor Power Co-ordination hazard issues may still apply if the fibre optic cables contain any metallic parts (e.g. a metallic strength member or metallic moisture barrier).

However, it would be unrealistic to expect that there will not be a large number of urban and rural customers in New Zealand still connected to copper telecommunications network cables for a considerable time yet.

12.2.4 Electrified railway installations

Electrified railway traction systems are segregated electrically from power and utility systems and this may need to be taken into account when assessing mitigation options. IEC62128-1 defines the general principles adopted and is cited in ESR 42 as a means of compliance for railway earthing systems.

13 Apportionment of Mitigation Costs

Refer to the following Guide:

NZCCPTS Cost Apportioning Guide – Cost Apportioning Principles for the Mitigation of Hazards and/or Interference between Power and Telecommunication Networks, March 2002

This guide recommends the following general principles:

(1) For ‘hazard’ situations resulting from a new power or telecommunications works
- The party installing the new works pays 100% of the cost of the ‘minimum overall cost’ mitigation option

(2) For ‘hazard’ situations found in an ‘existing’ situation
- The two parties split the cost of the ‘minimum overall cost’ mitigation option 50:50.

It also sets out a basis for resolving disputes.

This guide can be downloaded free as a PDF file from http://www.nzccpts.co.nz/publications.html.

14 References

NZECP 34:2001 Electrical Safe Distances

NZECP36:1993	Harmonic Levels
AS/NZS 60950.1:2011	Information technology equipment – Safety, Part 1: General requirements (IEC 60950.1:2005)
AS/NZS 3835:2006	EPR – Protection of Telecommunications Network Users, Personnel and Plant Part 1 - Code of Practice Part 2 - Application Guide
AS/NZS HB 219:2006	Handbook: EPR - Protection of Telecommunications Network Users, Personnel and Plant - Worked Examples for the Application Guide
AS/NZS 4853:2012	Electrical Hazards on Metallic Pipelines
AS/NZS 60479.1:2010	Effects of current on humans and livestock, Part 1: General aspects (IEC/TS 60479-1:2005)
IEC/TS 60479-1:2005	Effects of current on humans and livestock, Part 1: General aspects
ITU-T DIRECTIVES	Concerning the protection of telecommunication lines against harmful effects from electric power and electrified railway lines, Volume VI:2008 Danger, damage and disturbance
CIGRE TB 290	Guide for ac corrosion on metallic pipelines due to the influence from ac power lines
CEN 15280	Evaluation of a.c. corrosion likelihood of buried pipelines – Application to cathodically protected pipelines

NZCCPTS Guides

All the below NZCCPTS guides (and companion document) can be downloaded free as PDF files from http://www.nzccpts.co.nz/publications.html.

Cable Separations Guide – Minimum Separations between Buried Power and Telecommunication Cables, March 2003

Noise Interference Investigation Guide – Guide for Investigating and Mitigating Power System – Telecommunication System Noise Interference, September 1999

Neutral Earthing Resistors or Reactors (including resonant reactance earthing) Application Guide – for the control of earth fault currents in power systems operating at 33 kV or less, September 2010

Cable Sheath Bonding Application Guide – for the control of earth potential rise and for the limitation of hazardous induction into telecommunication circuits, September 1999

Companion document to the NZCCPTS Cable Sheath Bonding Application Guide – Fundamentals of Calculation of Earth Potential Rise in the Underground Power Distribution Cable Network, Ashok Parsotam, March 1997

Cost Apportioning Guide – Cost Apportioning Principles for the Mitigation of Hazards and/or Interference between Power and Telecommunications Networks, March 2002

Hazard Assessment Guide – Assessment of Risk of Earth Potential Rise and Induced Voltage Hazard to Telecommunication Networks, Draft 2011

Single Wire Earth Return HV Power Lines Application Guide – for the control of interference to telecommunication circuits, September 1999

EEA Guides

EEA Guide to Power System Earthing Practice, June 2009

EEA Guide for HV SWER Systems, October 2010
- This guide can be downloaded free as a PDF file from http://www.eea.co.nz.

EEA Guide to Work on De-energised Overhead Distribution Lines, July 2008
- This guide can be downloaded free as a PDF file from http://www.eea.co.nz.

Standards Published by Standards Australia for Standards Australia Committee ET/7, the Australia/New Zealand Coordinating Committee for Power and Telecommunications (CCPT)

SAA HB101 – 1997	Code of Practice for the mitigation of hazardous voltages induced into telecommunications lines (also known as the ‘LFI Code’).
SAA HB102 – 1997	Application Guide to the LFI Code.

APPENDIX A Psophometric Weighting Factors

Copied from ITU-T Recommendation K.68 'Management of electromagnetic interference on telecommunication systems due to power systems', Appendix 1 *(courtesy of ITU)*

Frequency [Hz]	Psophometric Weighting Factor
16.66	0.056
50	0.71
100	6.91
150	35.5
200	89.1
250	178
300	295
350	376
400	484
450	582
500	661
550	733
600	794
650	851
700	902
750	955
800	1000
850	1035
900	1072
950	1109
1000	1122
1050	1109
1100	1072
1150	1035
1200	1000
1250	977
1300	955
1350	928
1400	905
1450	881
1500	861
1550	842
1600	824
1650	807
1700	791
1750	775
1800	760
1850	745
1900	732
1950	720
2000	708
2050	698
2100	689
2150	679
2200	670
2250	661

Frequency [Hz]	**Psophometric Weighting Factor**
2300	652
2350	643
2400	634
2450	626
2500	617
2550	607
2600	598
2650	590
2700	580
2750	571
2800	562
2850	553
2900	543
2950	534
3000	525
3100	501
3200	473
3300	444
3400	412
3500	376
3600	335
3700	292
3800	251
3900	214
4000	178
4100	144.5
4200	116
4300	92.3
4400	72.4
4500	56.2
4600	43.7
4700	33.9
4800	26.3
4900	20.4
5000	15.9
> 6000	< 7.1