Understanding Earth Fault Loop Impedance

This document is intended to help existing users of CableCALC Pro software develop a better understanding of earth fault loop impedance.

The CableCALC Pro website (www.elek.com.au/cablecalc.htm) and documentation internal to the software environment has further information.

Contents

1. Introduction

The purpose of this document is to provide a better understanding of Fault Loop Impedance, also referred to as Earth Fault Loop Impedance so that the requirements of AS/NZS 3000 Wiring Rules for safety, design, installation and testing of electrical installation may be met.

This document provides:

1. The theoretical background behind fault loop impedance, leading to a better understanding.
2. A practical guide to performing the processes and procedures to meet the requirements of the Australian and New Zealand Standard AS/NZS 3000:2007.
3. Information about how the fault loop impedance is used by the CableCALC Pro software to calculate earth cable sizes.

Note: Whilst all efforts have been made to ensure details in this document are up-to-date, legal requirements may change as deemed necessary. It is therefore incumbent on the reader to be familiar with all current requirements.

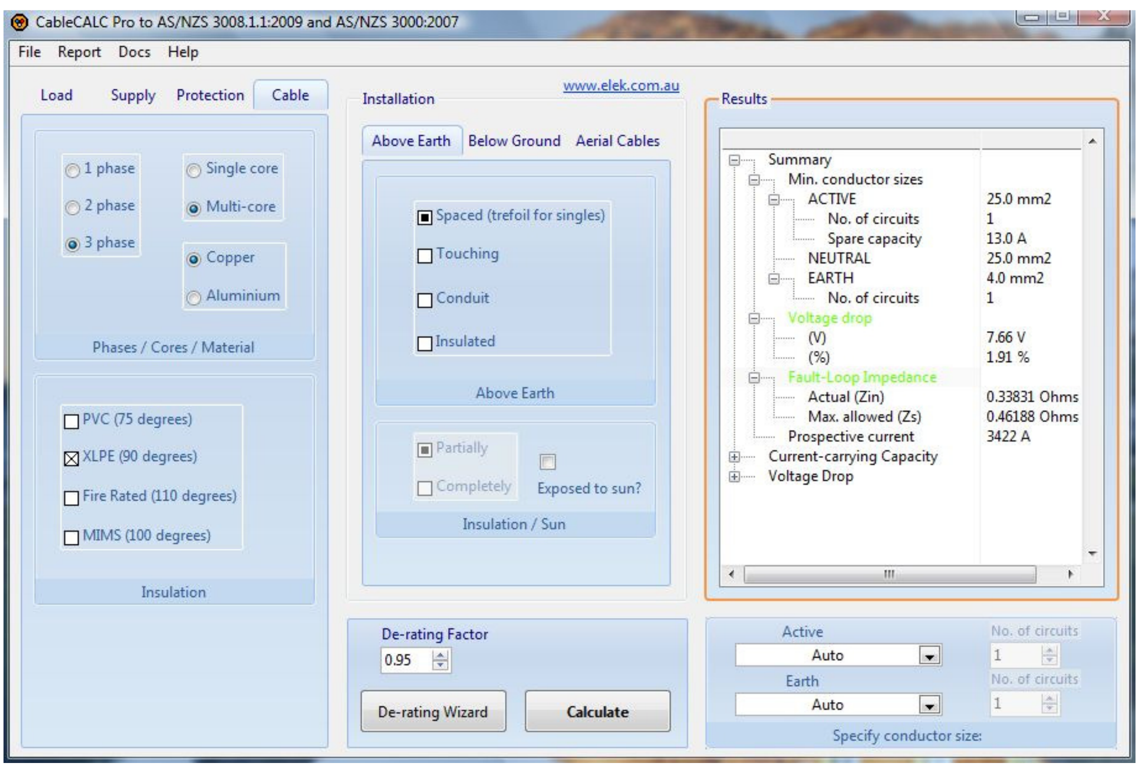

Figure 1. CableCALC Pro software for calculating earth fault loop impedance and earth cable size

2. Requirements of the Australian Standards

AS/NZS 3000 Wiring Rules applies throughout Australia and New Zealand and is references in whole or in part in legislation in all states of Australia and in New Zealand. Therefore the design and the installation of all electrical circuits in these regions must meet the minimum requirements of this Standard.

A basic safety requirement stated in AS/NZS 3000 is the protection of people from 'indirect contact' with live parts. Automatic disconnection of the power supply is the most common way of satisfying this requirement. However, there is a bit more to it than that.

To comply with the Wiring Rules each circuit in an electrical installation must be designed such that automatic disconnection of the power supply occurs within a specified time when a short-circuit of negligible impedance occurs between the active and protective earth conductor or other exposed conductive part anywhere in the electrical installation.

To fulfil this requirement of AS/NZS 3000 when a fault occurs, and this is the important bit, the impedance of the fault current path (referred to in the Wiring Rules as the Fault Loop Impedance Path) must be low enough to allow sufficient current to flow to ensure the protective device will operate within the specified time.

3. Earth fault loop

The earth fault loop in an MEN system comprises the following components:

1. The protective earthing conductor (PE). The objective of the earth fault loop impedance calculation (see Section 4) is to properly determine earth cable size.
2. The neutral return path consisting of the neutral conductor (N) between the main neutral terminal and the transformer neutral point.
3. The path through the transformer winding.
4. The active conductor (A) as far as the point of the fault.

Figure 2 shows the earth fault loop for an active-earth short circuit. At the instant of the fault current will flow through the earth fault loop with its current magnitude limited by the total path impedance (Zin) which is obtained from the sum of impedances of the individual elements.

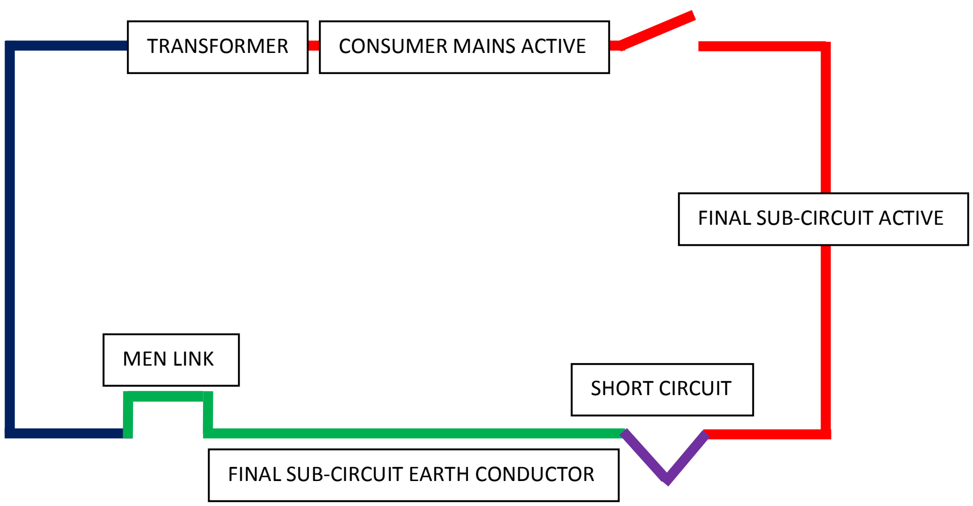

Figure 2. CableCALC Pro software for calculating earth fault loop impedance and earth cable size

Total earth fault loop impedance is approximately equal to the sum of impedances of all of the circuit components in the fault loop impedance current path shown in Figure 2. An accurate method of determining impedance of the conductors in the earth fault loop path is to use the resistance and reactance data given in AS/NZS 3008.1.1 – Electrical Installations – Selection of Cables.

4. Calculating earth fault loop impedance

Fault Loop Impedance compliance requires that if an active to earth fault occurs then the total impedance in the fault loop path (consisting of all conductors, connections and contacts as well as the transformer windings) must be low enough to generate sufficient fault current to operate the circuit protective device within an adequate time.

Therefore it must be ensured that the actual earth fault loop impedance (Zin) be less than the maximum permissible (Zs). The value of Zin is determined by summing the impedances of the earth fault loop described in Section 3. The maximum value Zs is calculated using:

$$Z_s = \frac{U_o}{I_a}$$

Where

Zs	=	Maximum earth fault loop impedance.
Uo	=	Nominal phase voltage.
Ia	=	Current ensuring automatic operation of the protective device.

Ia for circuit breakers is the mean tripping current as follows:

- Type B = 4 (typical)[1] x rated current
- Type C = 7.5 (typical) x rated current
- Type D = 12.5 (typical) x rated current

Ia for fuses are appropriate mean values from AS 60269.1

The value of maximum earth fault loop impedance (Zs) with respect to the actual (Zin) may be used to determine the appropriate earth cable size (explained in Section 5).

[1] Actual trip multiplier value may vary. In CableCALC Pro this value is changed to match actual or desired protective device setting.

5. Earth cable size

The earth cable size needs to be sufficient to ensure:

1. Appropriate earth fault loop impedance (Zin).
2. Adequate current-carrying capacity for prospective earth fault currents for a time at least equal to the tripping time of the associated circuit protection (adiabatic equation).
3. Adequate mechanical strength.

The selection of the earth cable size is determined from either:

(a) Tables in AS/NZS 3000 which provide conservative earth cable sizes with relation to the largest active cable size (or summation where there are parallel circuits).

(b) By calculation – this requires the protective device details to be known.

**Note: Appropriate earth fault loop impedance must always be ensured.

The CableCALC Pro software performs both (a) or (b). When the protective device details are not entered the program uses the conservative earth cable sizes given in AS/NZS 3000. On the other hand when the protective information is entered it will use the more accurate calculation methods to determine earth cable size (see Figure 3).

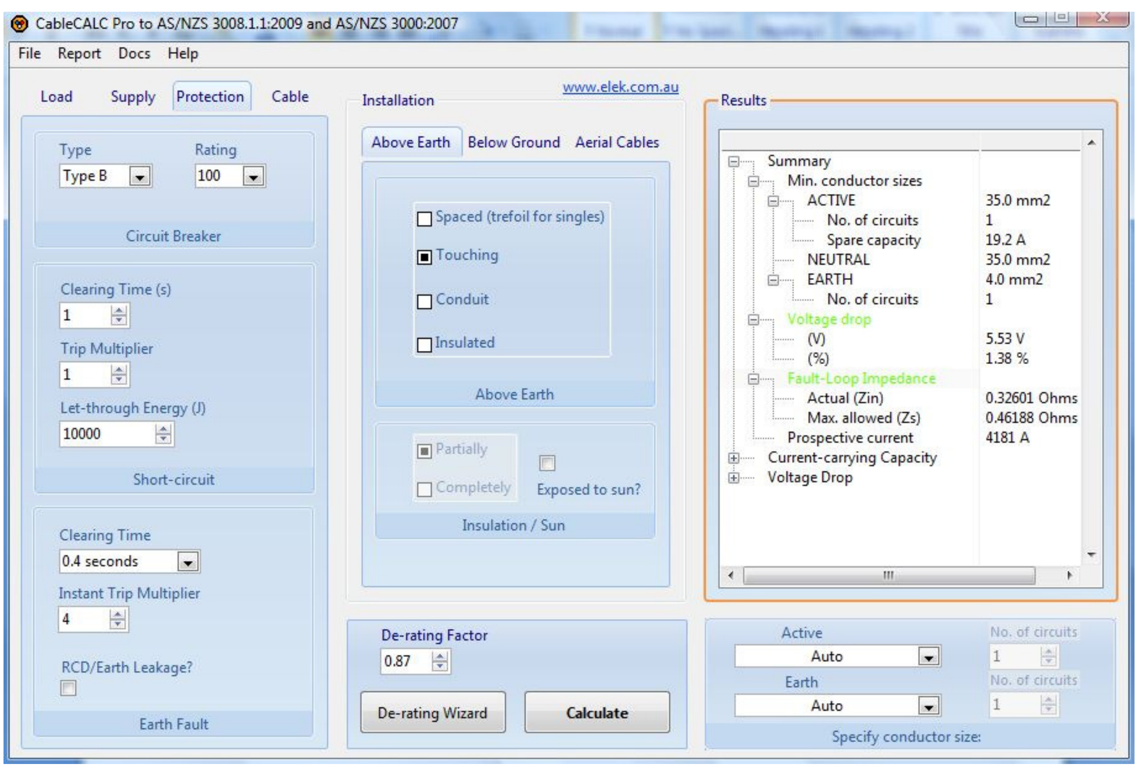

Figure 3. Protective device details entered into CableCALC Pro software for calculating earth cable size

6. Summary

The AS/NZS 3000 Wiring Rules mandate that the Earth Fault Loop Impedance of a circuit within an electrical installation must comply with specific requirements to ensure safety.

Fault Loop Impedance compliance requires that if an active to earth fault occurs then the total impedance in the fault loop path (consisting of all conductors, connections and contacts as well as the transformer windings) must be low enough to generate sufficient fault current to operate the circuit protective device within an adequate time.

The actual earth fault loop impedance (Zin) (either measured or calculated) must be less than the maximum permissible (Zs). This is determined from knowledge about the earth fault protective device and applying an appropriate equation. The earth cable size is determined with respect to earth fault loop impedance but also adequate short-circuit performance must be ensured b y employing the adiabatic equation method from AS/NZS 3008.1.1.

CableCALC Pro software is used to quickly and accurately calculate earth fault loop impedance and earth cable sizes in full compliance with the latest Australian Standards.

For resources and information or if you have questions visit our website www.elek.com.au.