Substation Insulation Coordination

Document Number: 1-11-FR-10

VERSON 1.1 June 2024

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Contents

1. Purpose

This document details the principals for insulation coordination.

2. Scope

This specification is applicable to the insulation coordination design for substations connected to ElectraNet's South Australian transmission network.

3. Products, terms, acronyms, and initialisms

3.1 Products

Product	Definition
PSCAD	Is a software application used model a power system and run simulations of power system events. PSCAD is a product of the engineering department within Manitoba Hydro International Ltd. Further information is available at: https://www.pscad.com/software/pscad/overview.
SAP ERP	Is a software application used by ElectraNet for asset management and other business functions. SAP ERP is a product of SAP. Further information is available at: https://www.sap.com/australia/products/erp.html

3.2 Terms

Terms	Definition
Arcing horn	Is a projecting conductor used to protect insulators from damage during flashover by diverting the high voltage away from the insulator using air as the conductive medium.
Brownfield	A previously developed site that is to be expanded or modified.
Bushing	Is a device that enables one or several conductors to pass through a partition such as a wall or a tank and insulate the conductors from it.
Cable termination	Is a device fitted to the end of a cable to ensure electrical connection with other parts of the system and to maintain the insulation up to the point of connection
Capacitor bank	Is a number of capacitor units connected so as to act together.
Designer	Is the person or organisation concerned with the design of systems, devices, and processes.
Disconnector	Is a mechanical switching device which provides, in the open position, an isolating distance in accordance with specified requirements. *Informative: A disconnector is capable of opening and closing a circuit when either negligible current is broken or made, or when no significant change in the voltage across the terminals of each of the poles of the disconnector occurs. It is also capable of carrying currents under normal circuit conditions and carrying for a specified time currents under abnormal conditions such as those of short circuit.*
Reactor	Is a large inductor that is connected to the power system to improve power system stability.

3.3 Acronyms and initialisms

Acronym or initialism	Definition
CVT	Capacitor Voltage Transformer(s), is a voltage transformer comprising a capacitor divider unit and an electromagnetic unit so designed and interconnected that the secondary voltage of the electromagnetic unit is substantially proportional to the primary voltage and differs in phase from it by an angle which is approximately zero for an appropriate direction of the connections.
DMS	Drawing Management System, is a generic term for the software application used by ElectraNet to manage engineering information.
HV	High-Voltage, is a voltage greater than 1000 V AC or 1500 V DC.
SA	Surge Arrester(s), is a surge protective device designed to limit the duration and frequently the amplitude of the follow current.

4. Insulation coordination requirements

4.1 General

1. Insulation coordination must be in accordance with:
   a. IEC 60071-1
   b. IEC 60071-2
   c. IEC TR 60071-4
2. The design must identify the insulation coordination requirements between the transmission line and substation assets.
3. Design and safety clearances must be in accordance with AS 2067:
   a. AS 2067, table 3.1 Design and safety clearances rod to structure/plate geometry (voltage range I and voltage range II)
   b. AS 2067, table 3.2 Design and safety clearances conductor to structure geometry U_m > 245 kV (voltage range II).
4. Where AS 2067, tables 3.1 and 3.2, provide several options, the values selected for design and safety clearances as well as withstand voltages must correspond to those that would apply for the highest listed impulse and withstand voltages at that nominal voltage. As an example, for 132 kV applications all designs must be based upon the use of 275 kV as the short duration power frequency withstand voltage and 650 kV as the rated lightning impulse withstand voltage.
5. Equipment clearances must maintain electrical safety and maintenance requirements. Minimum air clearance requirements to meet ElectraNet maintenance requirements are provided in 1-11-ADM-09.

4.2 Design

4.2.1 Introduction

Substation insulation coordination must ensure that surge protection devices such as SAs are adequately rated and correctly positioned within a substation to limit transient over voltages to the levels specified within this document.

4.2.2 Study

1. The Designer must undertake an insulation coordination assessment of the site unless the site-specific documentation indicates that it is not required.
2. Lightning impulse and short duration power frequency withstand assessments must be undertaken for IEC 60071 range I voltages (U_m up to 245 kV). Lightning and switching impulse assessments must be undertaken for range II voltages (U_m greater than 245 kV). In special cases ElectraNet may specify that switching studies will be required at lower voltages.
3. PSCAD software must be used where computer modelling is required.
4. ElectraNet will make existing technical documentation available to the Designer for the purposes of the insulation coordination study. The information will include:
   a. When plant data is unavailable IEC TR 60071-4, 7.6, provides equipment capacitances that must be used for conventional HV equipment in the model. manufacturers' plant data sheets shall be used when modelling the capacitance to ground for the CVT.

b. SAs must be modelled according to the VI characteristics for period contract SAs. If other types of SAs are required, then the studies must be based on the VI characteristics supplied by the manufacturer.

5. ElectraNet will provide the input data needed to carry out the insulation coordination study. The Designer must identify missing or site-specific parameters and must seek additional information from ElectraNet prior to commencement of the study.
6. For the modelling of shielding failure within the substation, the lightning protection design must be utilised to determine the stroke current magnitude. If this is unavailable, then the Designer must seek guidance from ElectraNet confirming what stroke current magnitude should be used for the studies. Typically for a 275 kV substation a magnitude of 6.5 kA must be used. This corresponds to the minimum interception current for a lightning protection system based on a rolling sphere radius of 27 m. For lower operating voltages the stroke current magnitude may need to be even lower.
7. The lighting strike model peak current shall be 130 kA for the first stroke peak current and 40 kA for the subsequent stroke peak current based on the 1% probability values in AS/NZS 1768, Table B1.
8. For the modelling of lightning surges, a CIGRE concave waveshape current source impulse model must be used, as per IEC 60071-4, C.2.1.1.
9. Lightning wave shape parameters must be calculated utilising the log-normal representation in CIGRE TB 063. The first negative downstroke must be according to the parameters in Table 4. Subsequent stroke(s) must be according to the parameters in Table 5.
10. Insulators flashover trigger must be modelled in accordance with IEC 60071-4, 7.6.5, using the area criterion method for air gaps less than one metre. The leader propagation method must be used to represent air gaps greater than or equal to one metre.
11. Lighting over voltages in the substation must be limited to 75% of the rated equipment withstand voltages. Sufficient points in the substation must be monitored during simulations to ensure that over voltages do not exceed this requirement.
12. Switching surge wave shape parameters must be automatically generated because of switching operations within the PSCAD software.
13. Switching over voltages in the substation must be limited to 80% of the rated equipment withstand voltages. Sufficient points in the substation must be monitored during simulations to ensure that over voltages do not exceed this requirement.

4.2.3 Requirements

1. The insulation levels of the equipment must be provided in accordance with AS 2067 and IEC 60071 for all ElectraNet voltage levels.
2. Pollution levels of the substation equipment must be provided in accordance with IEC/TS 60815-1. Category d) and e) pollution levels must be used for the substation equipment insulation levels. Category d) can be considered as 25 mm/kV according to AS 4436. Category e) can be considered as 31 mm/kV according to AS 4436. ElectraNet will define the pollution levels to be applied for each substation in the specification.
3. The substation equipment must be protected from all forms of over-voltages that are likely to be experienced by the equipment including continuous and temporary over-voltages, slow front and fast front over-voltages.
4. SAs must be installed at the transmission line entries to the substation and in the yard in front of the critical substation equipment for the protection of the internal insulation, such as near transformer bushings, HV cable terminations, reactors and capacitor banks.

5. SAs must have a minimum 10 kA rating, unless the insulation coordination study indicates higher kA ratings are required.
6. Arcing horns are not acceptable for over voltage protection of equipment in new substation designs.
7. Arcing horns must be removed whenever SAs are installed in proximity at brownfield sites. Examples of this include the removal of arcing horns on line disconnectors following the installation of SAs in the line exit position as well as the removal arcing horns mounted on transformer HV bushings when there are SAs in close proximity.
8. SAs must be connected in the vicinity of primary plant such that through design, the surge would arrive at the SA prior to the primary plant. Where this is not the case system studies/calculations may be performed to justify or otherwise the position of the SA.

4.3 Data Capture Requirements

1. The following information will be stored in SAP ERP associated with insulation coordination:
    a. Functional location
    b. Number
    c. serial number
    d. physical parameters of the SA.
2. The Insulation Coordination design report and associated software model, reflecting the as-built status, will be stored as separate objects under the same placeholder in ElectraNet's DMS.

City West Substation

Appendices

ElectraNet

References

Standards

Name	Title
AS 2067 ⚖	Substation and high voltage installations exceeding 1 kV ac
AS 4436	Guide for the selection of insulators in respect of polluted conditions
AS/NZS 1768	Lightning protection
CIGRE TB 063	Guide to procedures for estimating the lightning performance of transmission lines
IEC 60071-1	Insulation co-ordination - Part 1: Definitions, principles and rules
IEC 60071-2	Insulation co-ordination - Part 2: Application guidelines
IEC TR 60071-4	Insulation co-ordination - Part 4: Computational guide to insulation co-ordination and modelling of electrical networks
IEC/TS 60815-1	Selection and dimensioning of high-voltage insulators intended for use in polluted conditions - Part 1: Definitions, information and general principles
⚖, *Electricity (General) Regulations 2012*	

ElectraNet documents

Name	Title
1-11-ADM-09	Substation Configurations

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