Long Term Development Statement (LTDS)

Appendix 8: Equivalent Infeed Impedance Calculations

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This document outlines the Equivalent Infeed Impedance Calculations for the data exchanges of the proposed LTDS Common Information Model (CIM) revision.

It is part of the supporting artefacts that accompany the package of technical documentation setting out the outputs delivered by the LTDS reforms working group. We are publishing these documents to ensure all interested parties have full visibility of the outcomes of this programme of work, which is intended to form the basis of a future consultation on a proposed implementation of the CIM for the LTDS data. As such, the guidance offered in this package of documentation is not mandatory at this stage and will be subject to consultation before any changes to this data requirement are mandated.

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1 Introduction

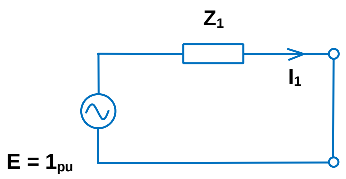
In the current version of LTDS the positive and zero sequence impedance parameters (R1, X1, R0 and X0) are explicitly specified. In the proposed revision of the LTDS these values can be calculated using the single and three phase fault current magnitudes and angles. The equations are presented below.

Note that the equations can produce negative zero sequence parameters. This is acceptable as the zero sequence parameters are not used in isolation, they are always combined with at least the positive sequence impedance in sequence networks analysis.

The following parameters are used by the equations:

- $I_{3\emptyset}$ – three phase fault current magnitude, in kA (exchanged using gb:ShortCircuitResult.symmetricalBreakingCurrent for gb:ShortCircuitResult.faultKind with value gb:ShortCircuitFaultKind.threePhase)
- $\theta_{3\emptyset}$ – three phase fault current angle, in degrees (exchanged using gb:ShortCircuitResult.symmetricalBreakingCurrentAngle for gb:ShortCircuitResult.faultKind with value gb:ShortCircuitFaultKind.threePhase)
- $I_{1\emptyset}$ – single phase fault current magnitude, in kA (exchanged using gb:ShortCircuitResult.symmetricalBreakingCurrent for gb:ShortCircuitResult.faultKind with value gb:ShortCircuitFaultKind.singlePhase)
- $\theta_{1\emptyset}$ – single phase fault current angle, in degrees (exchanged using gb:ShortCircuitResult.symmetricalBreakingCurrentAngle for gb:ShortCircuitResult.faultKind with value gb:ShortCircuitFaultKind.singlePhase)

2 Three phase fault



The following equations apply for three phase fault:

$$Z_1 = \frac{E}{I_1} \quad where\ I_1 = I_{3\emptyset(pu)} = \frac{I_{3\emptyset}}{I_B}\ ;\ \ I_B = \frac{MVA_B}{\sqrt{3}.V_L};\ \ MVA_B\ is\ base\ MVA;\ V_L\ is\ the\ line\ to\ line\ voltage$$

$$I_1 = \frac{I_{3\emptyset}}{\frac{MVA_B}{\sqrt{3}.V_L}} = \frac{\sqrt{3}.V_L.I_{3\emptyset}}{MVA_B};\ \ Z_1 = \frac{1}{\frac{\sqrt{3}.V_L.I_{3\emptyset}}{MVA_B}};$$

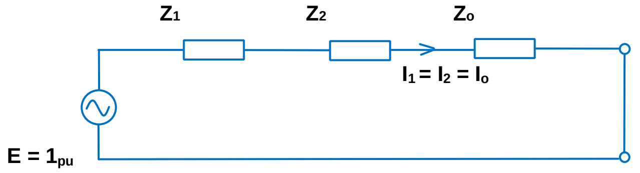
$$Z_{1(pu)} = \frac{MVA_B}{\sqrt{3}.V_L.I_{3\theta}};$$

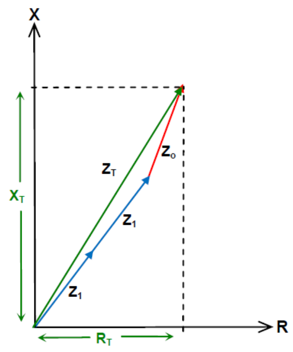
$$Z_1 = R_1 + jX_1 = \frac{E\angle 0^o}{I_1\angle\theta_{3\emptyset}} = Z_1\angle(-\theta_{3\emptyset});$$

$$R_{1(pu)} = \frac{MVA_B}{\sqrt{3}.V_L.I_{3\emptyset}}cos(\theta_{3\emptyset});$$

$$X_{1(pu)} = \frac{MVA_B}{\sqrt{3}.V_L.I_{3\emptyset}}sin(-\theta_{3\emptyset});$$

3 Single phase fault





The following equations apply for single phase fault:

$$I_1 = \frac{E}{Z_1 + Z_2 + Z_3}; \quad I_1 = I_2 = I_0 = \frac{1}{3}I_{1\emptyset(pu)};$$

$$Assume\ Z_1 = Z_2, i.e. positive\ and\ negative\ sequence\ impedance\ are\ equal$$

$$I_{1\emptyset(pu)} = \frac{3E}{2Z_1 + Z_0} = \frac{3E}{Z_T}; \quad Z_T = \frac{3E}{I_{1\emptyset(pu)}}; \quad I_{1\theta(pu)} = \frac{I_{1\emptyset}}{I_B} = \frac{\sqrt{3}.V_L.I_{1\emptyset}}{MVA_B}; \quad I_B = \frac{MVA_B}{\sqrt{3}.V_L}$$

$$Z_T = \frac{3MVA_B}{\sqrt{3}.V_L.I_{1\emptyset}};$$

$$R_T = \frac{3MVA_B}{\sqrt{3}.V_L.I_{1\emptyset}}cos(\emptyset_{1\emptyset});$$

$$X_T = \frac{3MVA_B}{\sqrt{3}.V_L.I_{1\emptyset}}sin(-\emptyset_{1\emptyset});$$

$$R_0 = R_T - 2R_1;$$

$$X_0 = X_T - 2X_1;$$

$$R_{0(pu)} = \frac{3MVA_B}{\sqrt{3}.V_L.I_{1\emptyset}}cos\emptyset_{1\emptyset} - \frac{2MVA_B}{\sqrt{3}.V_L.I_{3\emptyset}}cos\emptyset_{3\emptyset} = \frac{MVA_B}{\sqrt{3}.V_L}\left[\frac{3cos\emptyset_{1\emptyset}}{I_{1\emptyset}} - \frac{2cos\emptyset_{3\emptyset}}{I_{3\emptyset}}\right];$$

$$Similarly,$$

$$X_{0(pu)} = \frac{MVA_B}{\sqrt{3}.V_L}\left[\frac{3\sin(-\emptyset_{1\emptyset})}{I_{1\emptyset}} - \frac{2sin(-\emptyset_{3\emptyset})}{I_{3\emptyset}}\right]$$