Zig-Zag Transformer for Grounding System

Written for PSCAD v4.5 and v4.6.

Introduction

This example discusses the use of the zig-zag transformers in power systems to provide a high impedance ground system for the delta connected or ungrounded power systems. The zig-zag transformer is typically the least costly method that can be used as a high impedance ground system. It can be desined as a custom three-phase unit or as three individual single-phase units (which is the case in this example).

Figure 1 shows three single-phase transformers with one-to-one ratio that are connected as a grounding bank. The windings of the zig-zag transformer are connected such that under normal system operation, the magnetic flux in the three windings will cancel each other, and a negligible current (high impedance) will flow in the neutral (Ig ≈ 0).

During a single line to ground (SLG) fault, the magnetic flux in the zig-zag transformer coils are not equal in the faulted phase. Therefore, a zero sequence current flows through all the windings of the transformer, and at the neutral, they are added up.

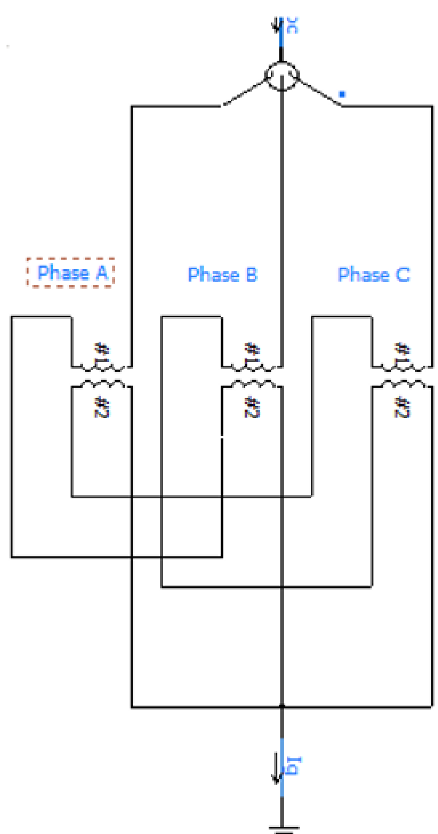

Figure 1: Three single-phase bank transformers to create a Zig-Zag transformer

The zero sequence impedance of the zig-zag transformer can contribute to limit the single line to ground (SLG) fault current.

If there is a zero sequence impedance of transformer, the power and leakage impedance rating of the transformer may be calculated.

For example, in the case, the zero sequence impedance of the zig-zag transformer can be calculated as:

$$Z_{base} = \frac{V_{phase}^2}{S_{phase}} = \frac{132.97kV^2}{50MVA} = 353.62 \text{ ohm}$$

$$Z_0 = Z_{base} \times X_l = 353.62 \times 0.08 = 28.21 \text{ ohm}$$

where Zbase, Z_0 and X_l are the base impedance, zero sequence impedance, and the leakage reactance of the transformer.

Simulation Results

Figure 2 shows the voltages on the healthy phases that are increased significantly without zig-zag transformer due to a SLG fault. The fault current is almost zero, and the protection system cannot see the fault in the system.

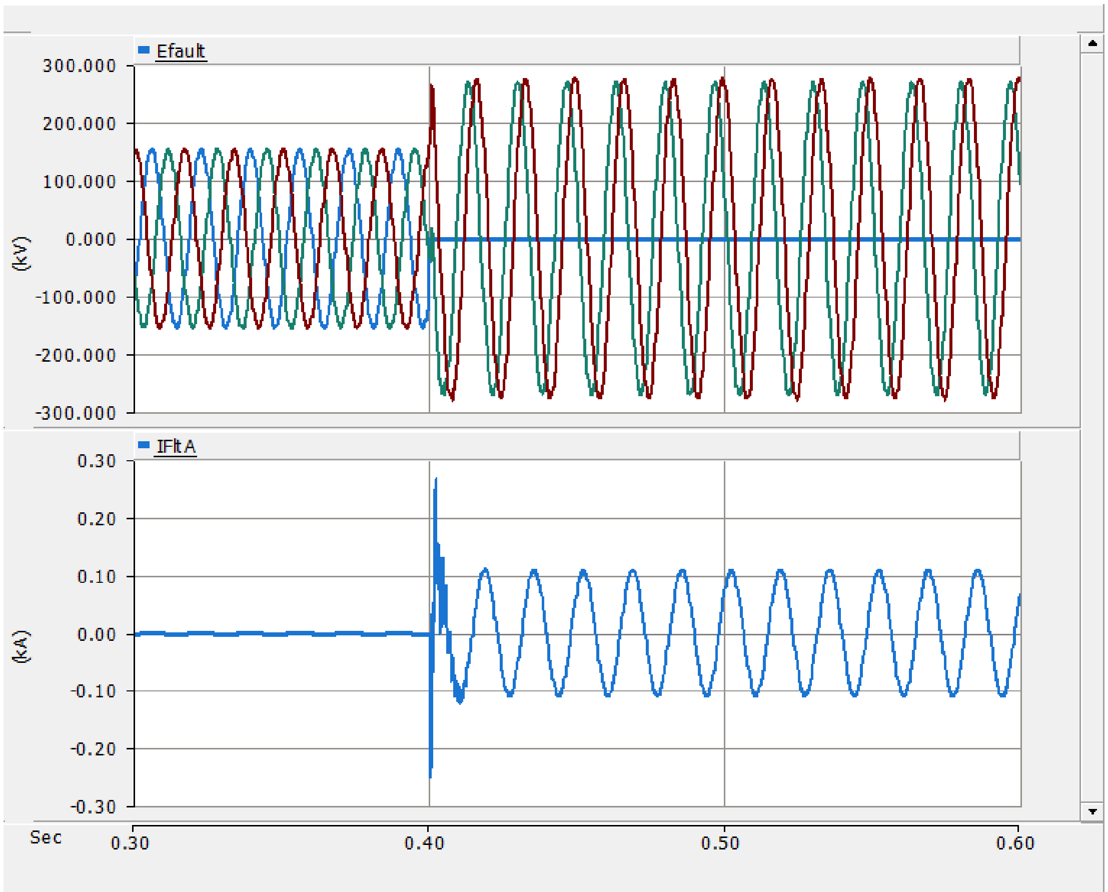

Figure 2: Swell of phase voltages due to SLG fault and the fault current

Figure 3 shows the voltages on the healthy phases are not increased significantly because the zig-zag transformer distributes the SLG fault current between the phases. Therefore, the fault current can be detected by the protection system.

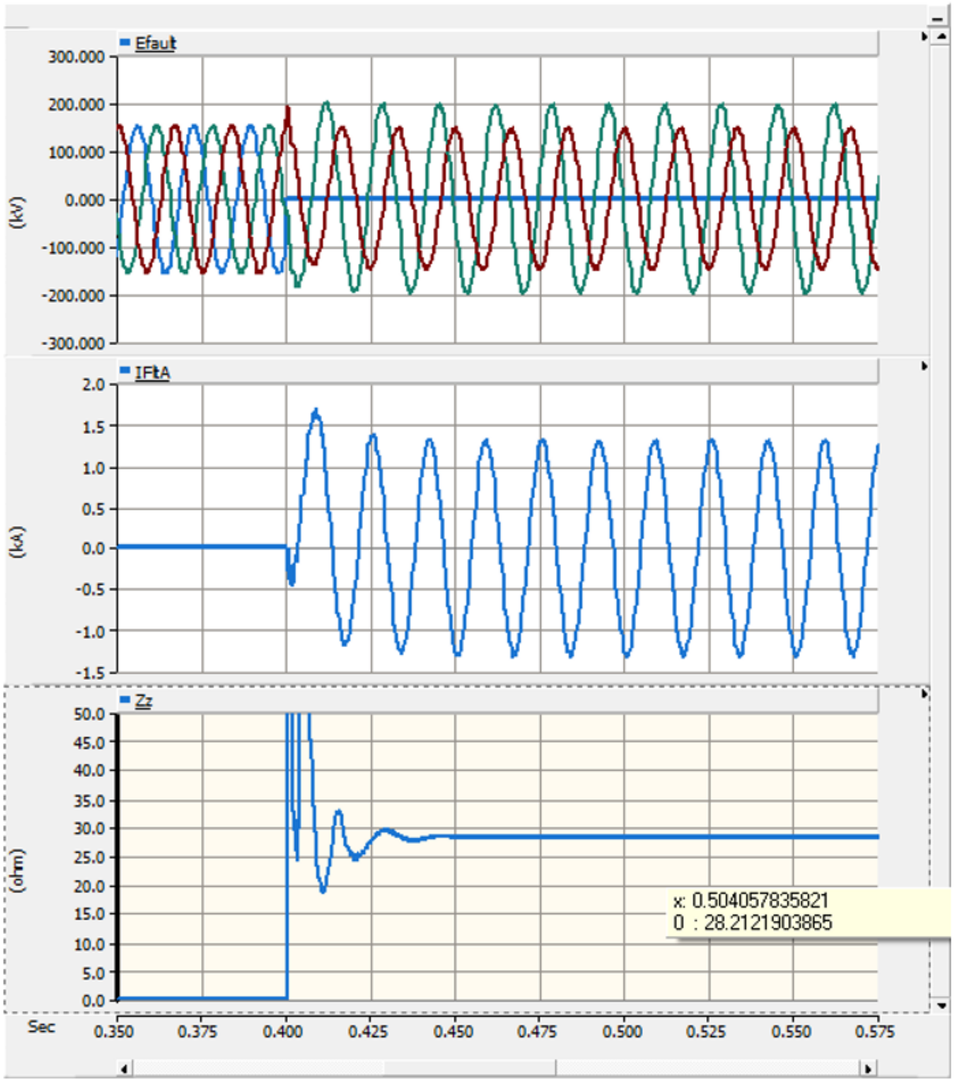

Figure 3: Phase voltages, fault current and zero sequence impedance

Figure 4 shows that during an SLG fault, the zero sequence current that flows through all the windings are added up at the nuteral, i.e. Ig =Ia+Ib+Ic . Therefore, the fault current has a much higher magnitude compared to when the zig-zag transformer is not connected to the system.

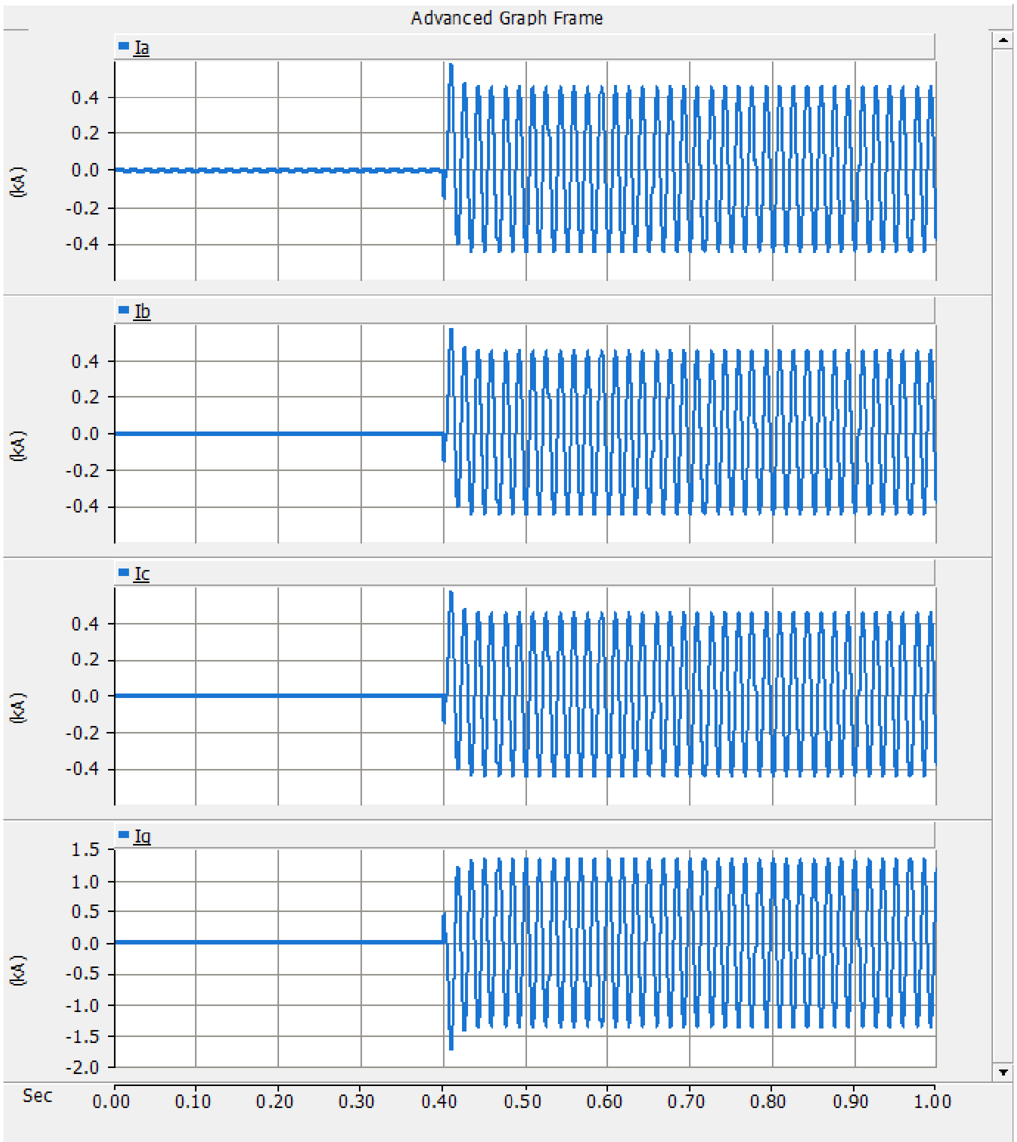

Figure 4: The three windings share the same magnitude with the entire fault current that flows through the neutral