Transformer Event Analysis

Exercise 3: SEL-487E Trips on External Fault

Introduction

A utility has a 6.9 kV generator connecting to a 40 MVA, 6.8/115/230 kV, generator step-up (GSU) transformer, as seen in Figure 1. An SEL-487E Transformer Protection Relay is used as the differential protection for the GSU transformer. The CTs are connected in wye with differential polarity and connected to the S, T, U, and W current channel inputs on the SEL-487E. The utility reports that there was an external fault on the station service (SS) transformer and the SEL-487E tripped unexpectedly. This exercise helps us determine why the relay operated, if there are any problems, and propose solutions.

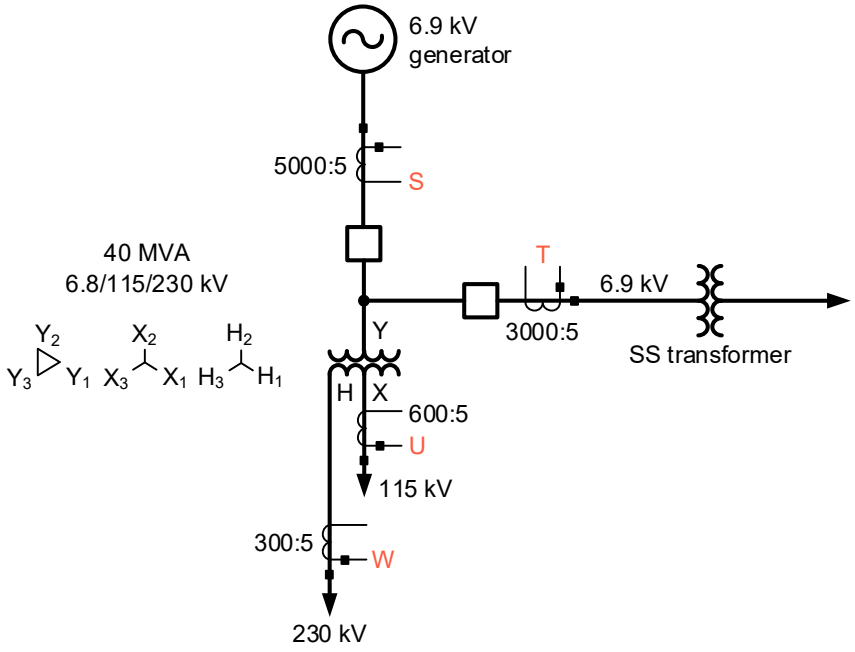

Figure 1 Transformer Installation

Resources available for this example:

- Event reports (Exercise 3 Filtered.CEV)
- SEL-5601-2 SYNCHROWAVE® Event Software
- SEL-487E instruction manual
- "Using Custom Calculations in SYNCHROWAVE Event to Apply Transformer Compensation Matrices" (AG2015-26) application guide
- "Beyond the Nameplate – Selecting Transformer Compensation Settings for Secure Differential Protection" technical paper

Questions and Answers

1. Open Exercise 3 Filtered.CEV. Is this a fault? Did the relay trip?

2. What operating characteristic does the 87R element use in the SEL-487E? What signals will we need to determine if the relay operated correctly based on this characteristic? What settings will we need, and what are they set to in the relay?

3. Was the relay in high-security mode? Which slope was the relay using for the 87R?

4. Plot and compare the operate and restraint quantities for each phase. Does the operation of 87RA make sense?

5. Do the IOP and IRT quantities look correct for an external fault on the station service transformer?

6. Are the winding compensation settings correct for the installation? Use AG2015-26 to plot the compensated current phasors and confirm. Hint: Terminals W and T do not have pre-fault current, so they cannot be used to validate compensation before the fault. Compare Terminal S and Terminal U only; determine what Terminal W and Terminal T should be by comparing them to S and U.

7. Since we were not able to use pre-fault current to verify the angles of Terminal T or Terminal W, we need to ensure that these angles look correct during the fault. Compare the angle of Terminal T to Terminal S during the fault, using the faulted phases. What should this angle be? What is it actually?

8. Use AG2015-26 to plot the calculated operate and restraint currents for each phase (IOPnCALC vs. IRTnCALC). These should match your results from Question 4. Simulate a polarity swap on Terminal T CTs by adding a negative sign where the phasor signals for Terminal T are defined (shown in Figure 7). Are the new IOPnCALC vs. IRTnCALC plots correct?

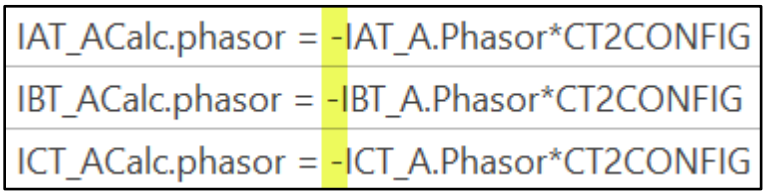

Figure 2 Phasor Signals for Terminal T in Custom Calculations

9. What is the proposed solution?