



## *Transformer Event Analysis*

### **Exercise 2: SEL-387 Trips on Energization**

#### **Customer Email**

We had an issue at one of our stations the other day and had some damage to a transformer's H3 bushing. We replaced the bushing and were closing up the high-side circuit switcher (Winding 1) when the transformer relay operated. The low-side secondary breaker (Winding 2) was open. We are trying to figure out if this was a valid operation and to help direct the testing crew's focus (more than the obvious answer of the H3 bushing). So far, we have tested the CTs and verified that they are correct to each relay. This unit had been energized with these settings before and did not trip.

#### **Available Resources**

- Event reports (Exercise 2 Filtered.CEV, Exercise 2 Differential.CEV, and Exercise 2 RAW.CEV)
- SEL-5601-2 SYNCHROWAVE® Event Software
- SEL-387 instruction manual
- "Using SYNCHROWAVE Event to Model Transformer Differential With Harmonic Restraint and Blocking" (AG2020-28) application guide
- "Considerations for Using Harmonic Blocking and Harmonic Restraint Techniques on Transformer Differential Relays" technical paper

#### **Questions and Answers**

**1. Open Exercise 2 Filtered.CEV. Is this a fault?**

**2. Open Exercise 2 RAW.CEV. Is this a fault?**

**3. Should the relay be tripping on this condition, and what features in the relay keep the 87 element secure during inrush?**

**4. Refer to Table 2 in AG2020-28. Which algorithm is this relay using to prevent tripping on inrush?**

**5. How does the harmonic restraint algorithm work?**

**6. Extract the contents of the AG2020-28.zip file into the following directory on your computer. Note that the AppData folder is hidden, so you must turn on the Show Hidden Files option in Microsoft Windows to see it.**

C:\Users\[username]\AppData\Roaming\SEL\SEL SynchroWAVE Event\Calculations

**Open the Exercise 2 Differential.CEV event report. Select the Import Calculations icon at the bottom right of the Custom Calculations window. Select the AG2020-28 SEL-387.txt file and select Open. The first line of the calculations (the import line) will flag red. Why is this, and how can you correct it? Hint: See the note at the bottom of Page 7 of AG2020-28.**

**7. Use Table 3 in AG2020-28 to identify which operating quantities and thresholds must be compared to analyze the operation of the harmonic restraint algorithm. Plot these quantities in SYNCHROWAVE Event. Is the assertion of the associated Relay Word bits for the harmonic restraint element as expected?**

**8. Could lowering the PCT2 setting have helped keep the relay secure? What value would it have to be lowered to in order to prevent misoperation?**

**9. The relay is not set to use the fourth harmonic content for inrush security (PCT4 = OFF). The SEL-387 instruction manual recommends using both second and fourth harmonic content for security. Would turning on the fourth harmonic help keep the relay secure?**

**10. Would using common harmonic blocking instead of harmonic restraint help keep the relay secure in this case? Use AG2020-28 to plot the harmonic blocking calculations to prove this one way or the other.**

**11. Are there any other elements in the relay that could have been turned on to prevent this operation?**