ELECTROMECHANICAL DIFFERENTIAL RELAYS
MISOPERATION AND INVESTIGATION

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OBJECTIVES

• Introduction
• Differential protection theory
• Power system description
• Phase to Ground fault
• Troubleshooting
• Lessons learned
INTRODUCTION

- Transformer differential protection (87T) is very common on large transformers
- Complex method, especially when used on Delta-Wye transformers
- Without proper commissioning, mistakes will lead to misoperations (from seconds to months or years)
Kirchhoff’s Current Law (KCL): The algebraic sum of the currents entering a node (or a closed boundary) is zero.

If the sum is not equal to zero, an unintended path (e.g. fault) is present.
DIFFERENTIAL PROTECTION THEORY

• Electromechanical (EM) relays have existed for 100+ years. Many are still in service.

• 87T EM relays use **operate** and **restraint** currents to determine fault location.

• Opposite restraint currents (180° degrees apart) cancel each other during normal operation.
DIFFERENTIAL PROTECTION THEORY

- Protecting Delta-Wye transformers is challenging due to 30° shift.

- ANSI standard shown below, but this is not always the case.
DIFFERENTIAL PROTECTION THEORY

• Opposite polarities between CTs, as well as delta-connected CTs on the Wye side is used to achieve 180° between restraint currents
PHASE TO GROUND FAULT

- C-phase to ground fault downstream of feeder 5
- Digital relay recently installed captured the event data
- This fault tripped both 87T relays…
TROUBLESHOOTING

• Using a power system simulator, 1 A was injected from the feeder 5 CT wiring back into the 87T relay.

• Using a clamp meter, 0.6 A were metered into the 87T restraint channel.

• Where did the other 0.4 A went to?
TROUBLESHOOTING

• Site personnel remembered that the tie breaker had been replaced some time ago.

• Because the breaker would not be used, it was isolated via switches and the CTs were **shorted out**.

• The CTs are delta connected, which means that a new path for current flow was created by the shorting screws. The 0.4 A were found!
LESSONS LEARNED

• When replacing substation apparatus, auxiliary devices (CTs, VTs, etc.) must be fully tested and commissioned.

• The application of electromechanical relays on Delta-Wye transformers is complex. Never short out delta-connected CTs.

• Protection systems must be recommissioned anytime that they are modified. Current metering is a simple check that must be performed (meter command if digital, clamp meter if electromechanical).
QUESTIONS?