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

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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)

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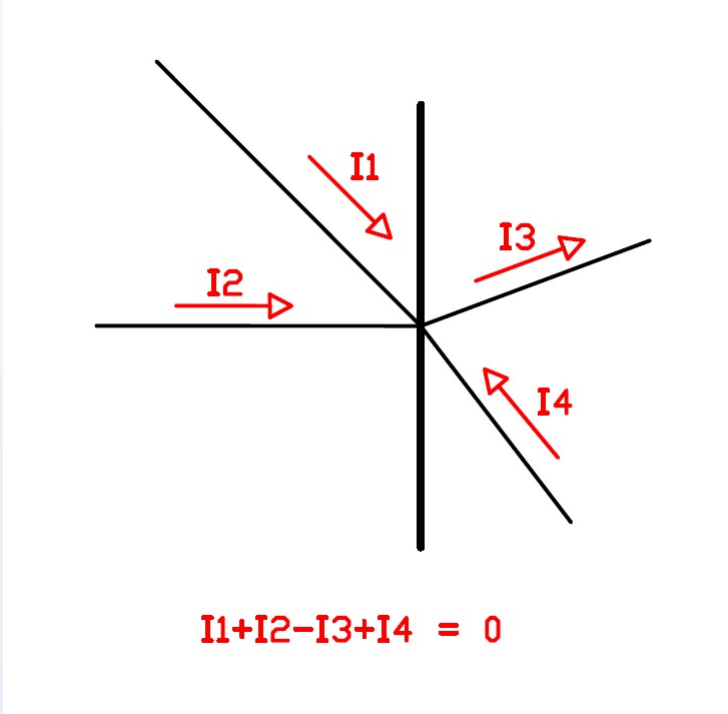
DIFFERENTIAL PROTECTION THEORY

- 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



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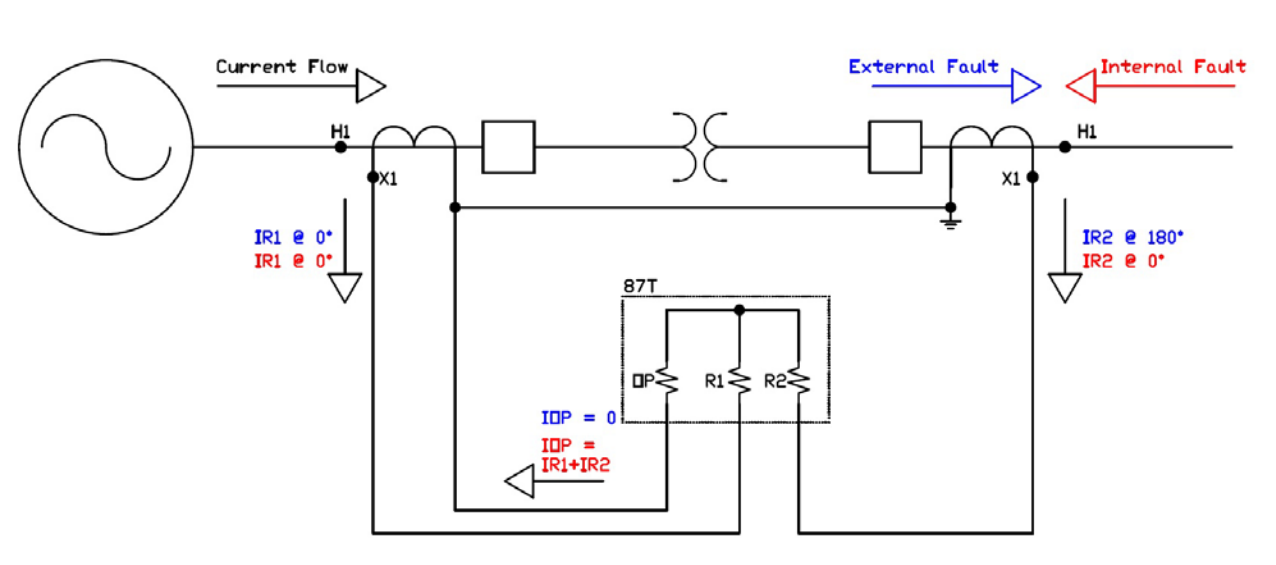
DIFFERENTIAL PROTECTION THEORY

- 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



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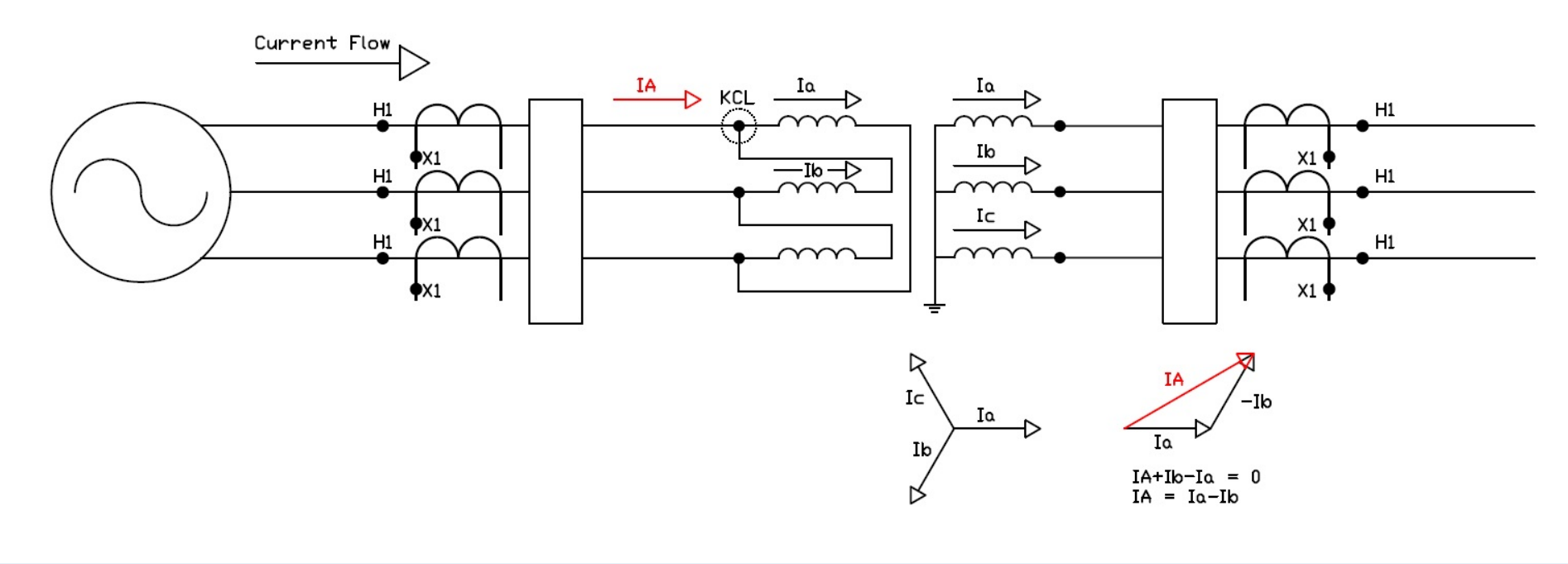
DIFFERENTIAL PROTECTION THEORY

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

- ANSI standard shown below, but this is not always the case



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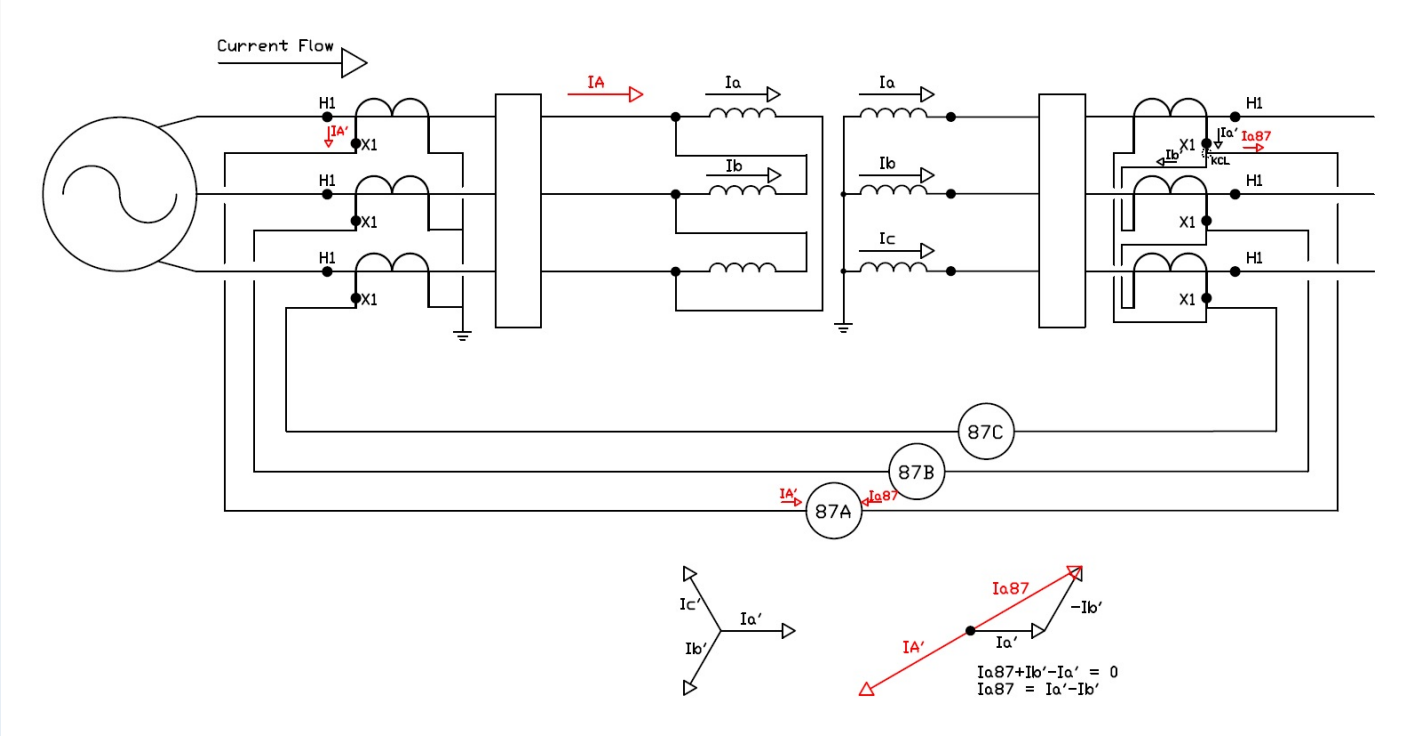
DIFFERENTIAL PROTECTION THEORY

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



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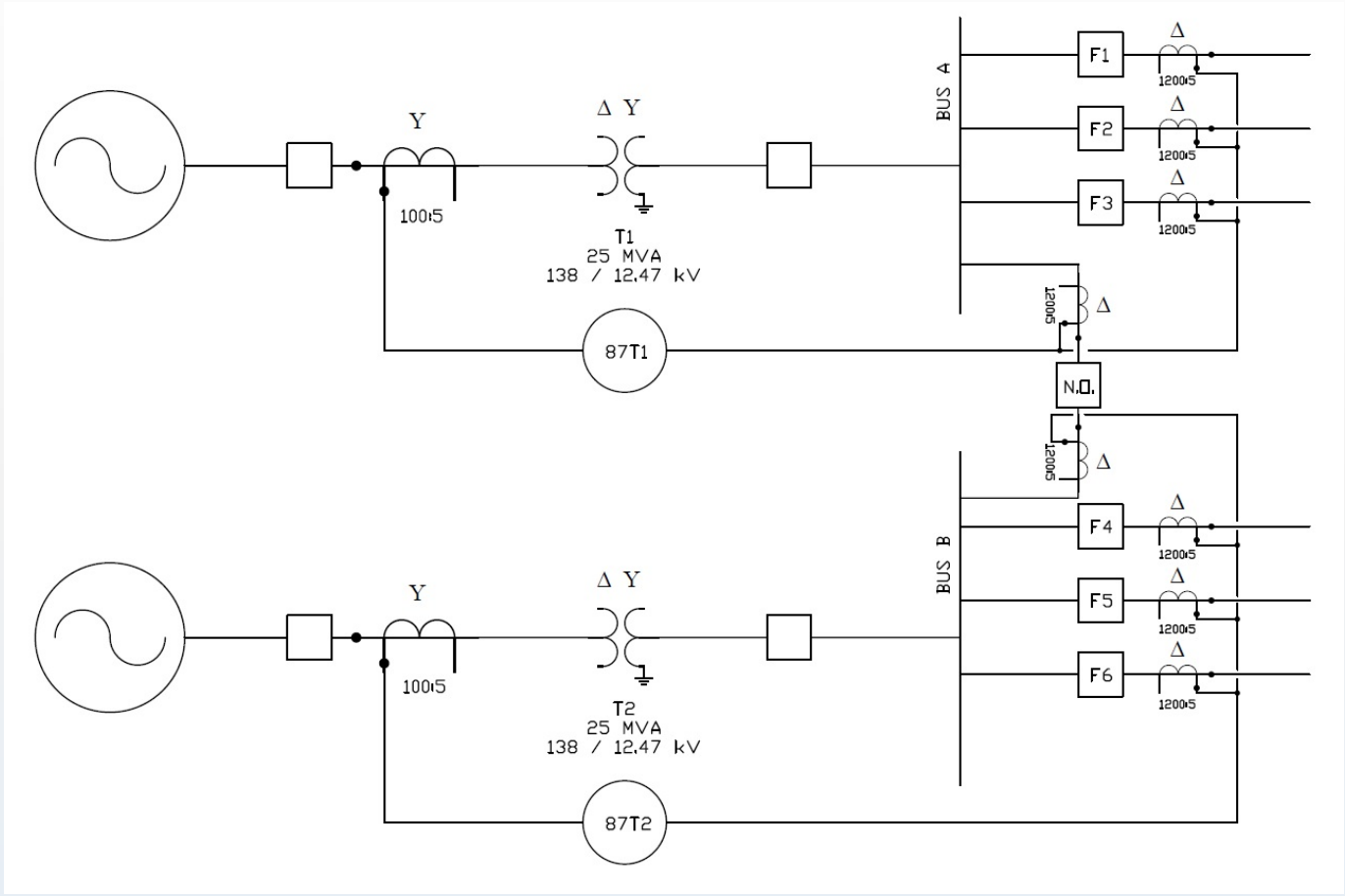
POWER SYSTEM DESCRIPTION



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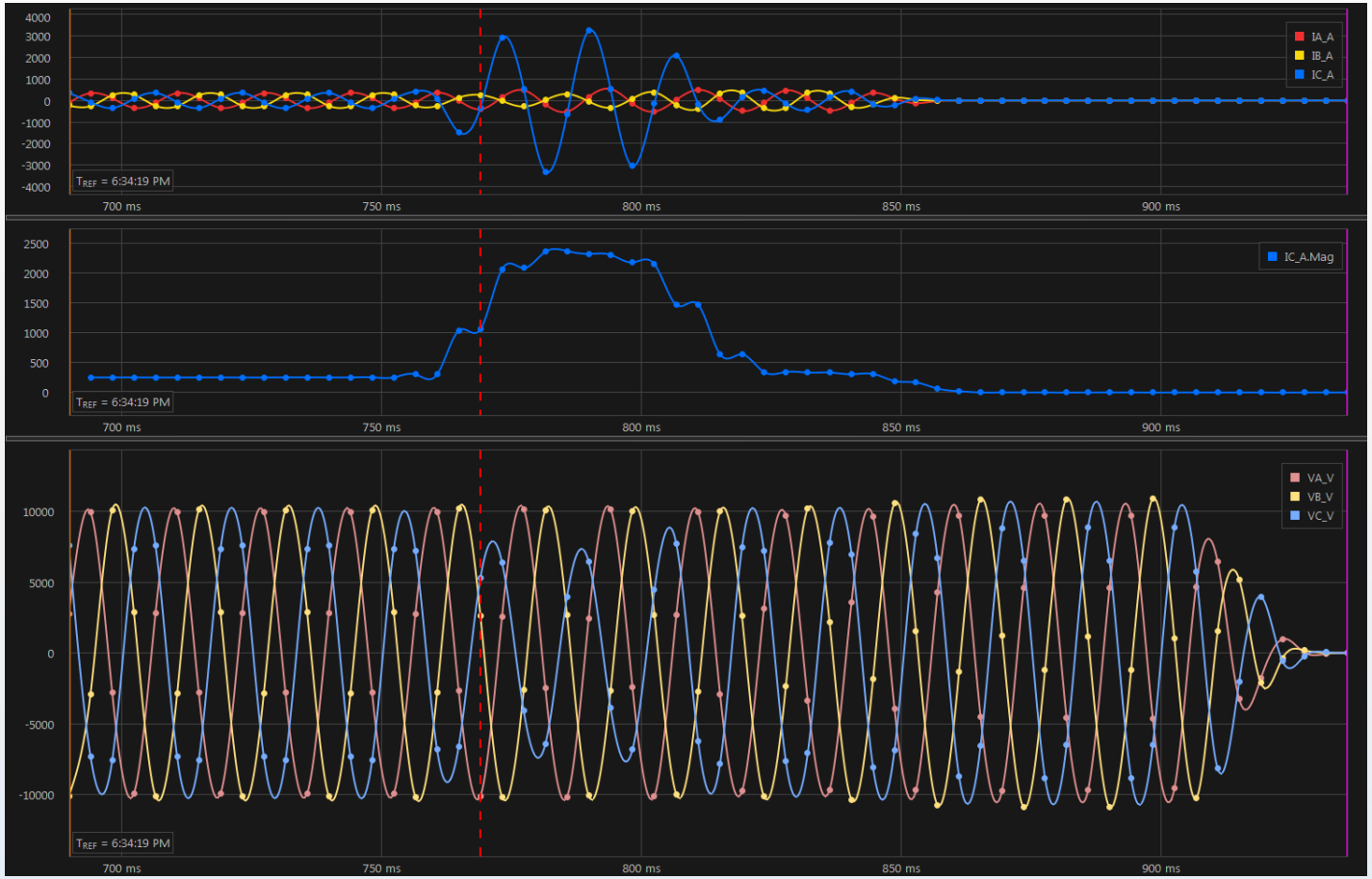
PHASE TO GROUND FAULT

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



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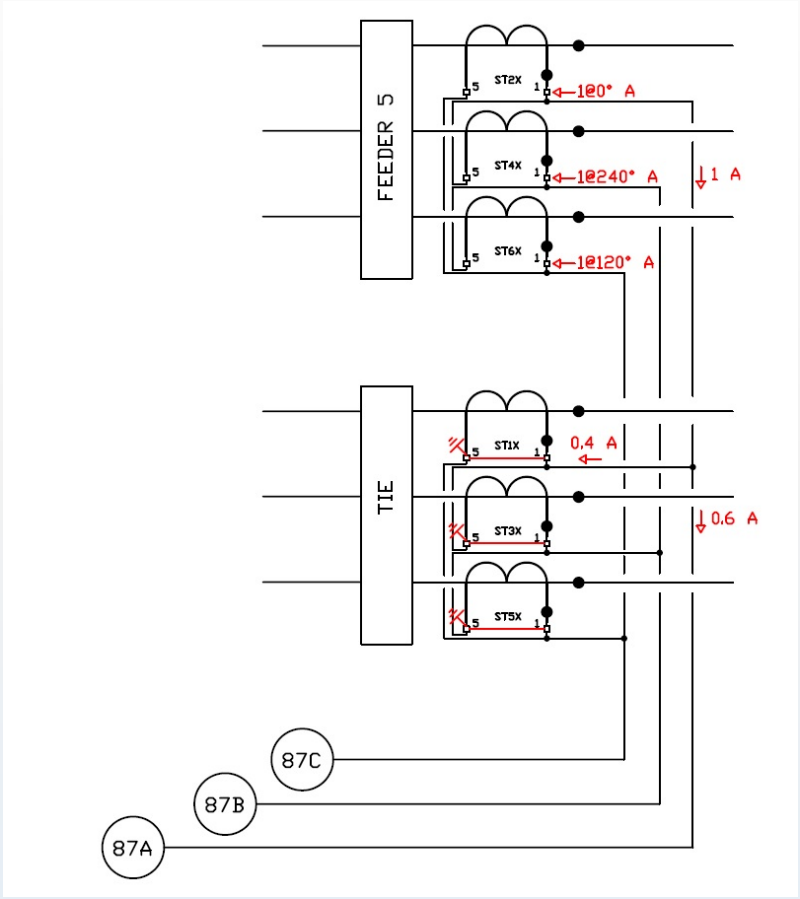
TROUBLESHOOTING

- 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?



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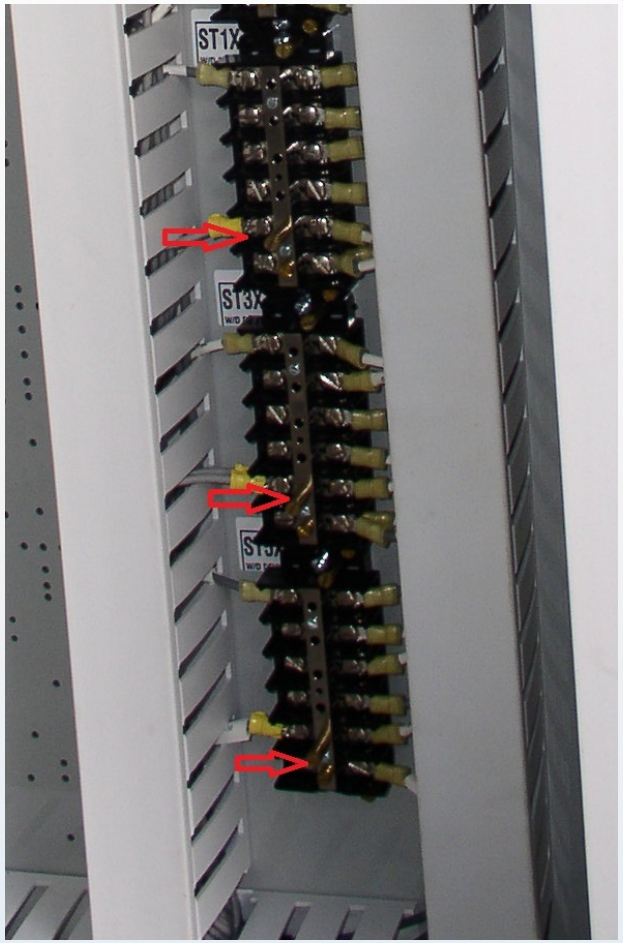
TROUBLESHOOTING

- 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 !



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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).

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QUESTIONS?

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