May 12, 2000

With the new PowlVac-AT Model ATSB outdoor substation circuit breakers recently introduced by Powell Electrical Manufacturing Company, several questions should be addressed regarding the ground point for the Current Transformer (CT) circuits. This Powell Technical Brief investigates the preferred ground location of typical CT circuits such as transformer and bus differential relays.

IEEE standard C57.13.3 serves as the ANSI guide to standardize instrument transformer grounding practices. The grounding of current transformers is important to both safety and the proper operation of the protective relays. To assure the safe and reliable operation, the neutral of the current transformer secondary should have a single ground location for each circuit. The single ground is irrespective of the number of current transformers or the chosen grounding location. Utilizing a single ground eliminates the risk of redundant ground loops and associated problems.

During normal operation more than one ground on a CT circuit is not an obvious problem other than the difficulties it may cause during testing. However during a fault condition, multiple grounds allow a different ground potential rise for each current transformer. The result is a significant current flow through the CT circuit that is not representative of the primary current. This ground loop typically creates a potential across the operating coil of the differential relay causing the relay to pick up as though a fault exists in the relay’s protective zone. Tripping a differential relay due to a fault external to the zone of protection, is one of the more popular nuisance trips. These nuisance trips may not only shut down the load, but may require a maintenance crew to spend days in testing to determine that no real problem exists in the differential zone. Further, the actual problem may go uncovered until the system is re-energized into the original fault.

![Diagram](attachment:image.png)

**Figure 1**
To demonstrate what happens with a second ground on the current transformer circuit, Figure 1 shows a typical differential relay with two current transformers. The recommended method of grounding is to install a single ground point at the “first point of application (switchboard or relay panel) of the current transformer secondary circuit.
A substation circuit breaker should have the wye or delta connections made-up at the CT terminal blocks in the equipment. If the protective relay is mounted in the breaker the wye connection is grounded at the circuit breaker. If the protective relays are mounted in a separate building, then the wye connection is in the breaker but is grounded at the relay house. The same applies for current transformers in the transformer tank. The CTs are grounded at the place where the metering or relaying is located (see Figure 2).

**Figure 2**

For a fault, external to the protective zone, insufficient voltage develops across the operating relay to pick up the coil.

**Figure 3**

*Note: For a fault, external to the protective zone, insufficient voltage develops across the operating relay to pick up the coil.*
For an external fault (see Figure 3), this allows the current flowing through the current transformer on the line side of the protected zone and the current flowing through the load side current transformers to develop a voltage of opposite polarities. The result is a voltage of very small magnitude across the operating coil of the relay. The relay coil does will not operate without sufficient applied voltage.

In the case of a fault internal to the protective zone, the voltage developed by the current transformers is of the same polarity. The magnitude of voltage drop across the operating coil is sufficient to operate the relay (see Figure 4).

In the final example (Figure 5) there is a second ground is on a current transformer mounted near where a ground fault occurs. If the fault creates a ground potential rise of 100 volts, then the protective relay will experience sufficient voltage across the operating coil to cause the relay to nuisance trip even though the fault was outside the fault zone.

Just as with any other event there is an exception to this standard. Many of the new multifunction relays (ABB, Schweitzer, GE/Multilin, and Basler) are designed to connect all current transformers coming into the relay in a wye connection. Each wye has to be grounded. The most desirable way to do this is to bus the wye points together at the relay panel and have a single conductor to ground, to make certain the relay has but one ground potential.

As you can see, there are significant considerations in the proper grounding of current transformer circuits.
EXTERNAL FAULT - WITH SECOND GROUND

Figure 5
Note: With a second ground at a remote location, the voltage across the operating coil is sufficient to result in a miss-operation for an external fault and cause a nuisance trip situation.

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