

## VOLTAGE METERING IN RESISTANCE-GROUNDED SYSTEMS

### Background

A high-resistance-grounded system is similar to an ungrounded system in that it is not used to supply line-to-ground loads. Protection and monitoring equipment connected from line to ground must not jeopardize the protection system and must have little or no impact on system performance.

If line-to-ground potential transformers (PTs) are used to measure line-to-ground voltages, the PTs create a Y-Y transformer connection:

- 1) Any unbalance in PT-secondary loading will cause neutral-grounding-resistor (NGR) current to flow even though the system is not faulted. In most cases the current will be below ground-fault relay pick-up levels; however, this system ramification should be considered if line-to-ground PTs are used in a high-resistance-grounded system.
- 2) An open NGR will result in the system being grounded through the PTs. The PT circuit should be evaluated for stability and ferroresonance effects in order to prevent overvoltage.

### NGR Monitoring with Grounded PTs

Littelfuse NGR monitors (SE-325 and SE-330) continuously measure NGR resistance by injecting a sensing signal through the NGR. The measured resistance must increase by a threshold amount for an open NGR to be detected. With this measurement method, primary-grounded PT windings are in parallel with the NGR and are included in the resistance measurement. This can prevent failure detection when an NGR opens, unless a ground fault is present.

Neutral voltage and current are also measured to allow detection of resistor failure during a ground fault, and to provide ground-fault protection. When a ground fault is present, this feature enables NGR-failure detection when the resistance-measurement detection method is disabled by a parallel path.

### SE-325 NGR Monitoring with Grounded PTs

The SE-325 NGR-continuity circuit is not compatible with grounded-PT connections and an SE-325 will not detect an open NGR unless neutral voltage exceeds the RES TRIP LEVEL setting as a result of a ground fault.

### SE-330 NGR Monitoring with Grounded PTs

#### 20K Sensing Resistors (ER-600VC, ER-5KV, ER-5WP)

In some applications, the parallel PT-winding resistance can be increased sufficiently with the addition of a PT-grounding resistor (PTGR) to ground the PT-primary "Y" point. The PTGR resistance must be greater than the sum of the SE-330 trip resistance (500 ohms) and the resistance of the system NGR. In cases where multiple PT installations are used on the same system, the PTGR resistance values must be increased so that when the system NGR opens there is at least a 500-ohm increase in neutral-to-ground resistance.

The PTGR resistance has little impact on voltage-measurement accuracy during normal operation but will affect accuracy during a ground fault. Expect a voltage-measurement error in the range of a few percent in the presence of a ground fault.

The PTGR is not used to ground the power system and need not meet the design criteria specific to NGRs.

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### **100K and 200K Sensing Resistors (ER-15KV, ER-25KV, ER-35KV, ER-72KV)**

In some cases, PT-winding impedance is high enough to allow SE-330 NGR-failure detection. The criterion that must be met is that the impedance measured by the SE-330 must increase by at least 2,500 ohms when the NGR opens (5,000-ohm increase for a 200-kohm sensing resistor). When the PT data sheet shows that primary-winding resistance is suitable, the systems are compatible. When the resistance is not high enough, winding impedance might still be suitable. Winding impedance needs to be evaluated at a frequency of 0.4 Hz. It is recommended to use field or bench testing to verify compatibility.

The parallel PT-winding resistance can be increased with the addition of a PT-grounding resistor (PTGR) to ground the PT-primary “Y” point. The sum of PTGR resistance and PT-winding resistance must be greater than the sum of the SE-330 trip resistance (2,500 ohms) and the resistance of the system NGR. In cases where multiple PT installations are used on the same system, the PTGR resistance values must be increased so that when the system NGR opens there is at least a 2,500-ohm increase in neutral-to-ground resistance.

The PTGR resistance has little impact on voltage-measurement accuracy during normal operation but will affect accuracy during a ground fault. Expect a voltage-measurement error in the range of a few percent in the presence of a ground fault.

The PTGR is not used to ground the power system and need not meet the design criteria specific to NGRs.

If non-compatible PTs must be used, an SE-330 will still detect an NGR failure when a ground fault occurs. A Resistor-Fault trip will occur when neutral voltage is above the VN Trip Level setting and neutral current is less than 5% of the CT-primary rating—this is the condition when the NGR is open and a ground fault is present. If neutral voltage persists after a Resistor-Fault trip, a Ground-Fault trip will also occur.

### **THE CVT Solution**

Capacitor voltage transformers (CVT's) are compatible with NGR monitors and are recommended for high-voltage applications.

A CVT is an ideal solution for voltage measurement in resistance-grounded systems. Since the CVT uses a coupling capacitor, the DC sensing signal used for NGR monitoring is blocked by the CVT and its presence has no impact on the NGR monitor's continuity circuit. Unfortunately, CVTs are not readily available in the 4160-V to 25-kV range.