NGR MONITORING WITH ISOLATED GROUND BEDS

The IEEE Guide for Safety in ac Substation Grounding (ANSI/IEEE Std 80-1986) defines ground potential rise as "the maximum voltage that a station grounding grid may attain relative to a distant grounding point assumed to be at the potential of remote earth." Ground potential rise (GPR) can be transferred to remote equipment by a ground conductor. This transferred voltage should not be confused with voltage drop in a ground conductor when a ground fault occurs. Figure 1 helps to illustrate GPR and ground-fault voltage. Disconnecting means and protection are not shown.

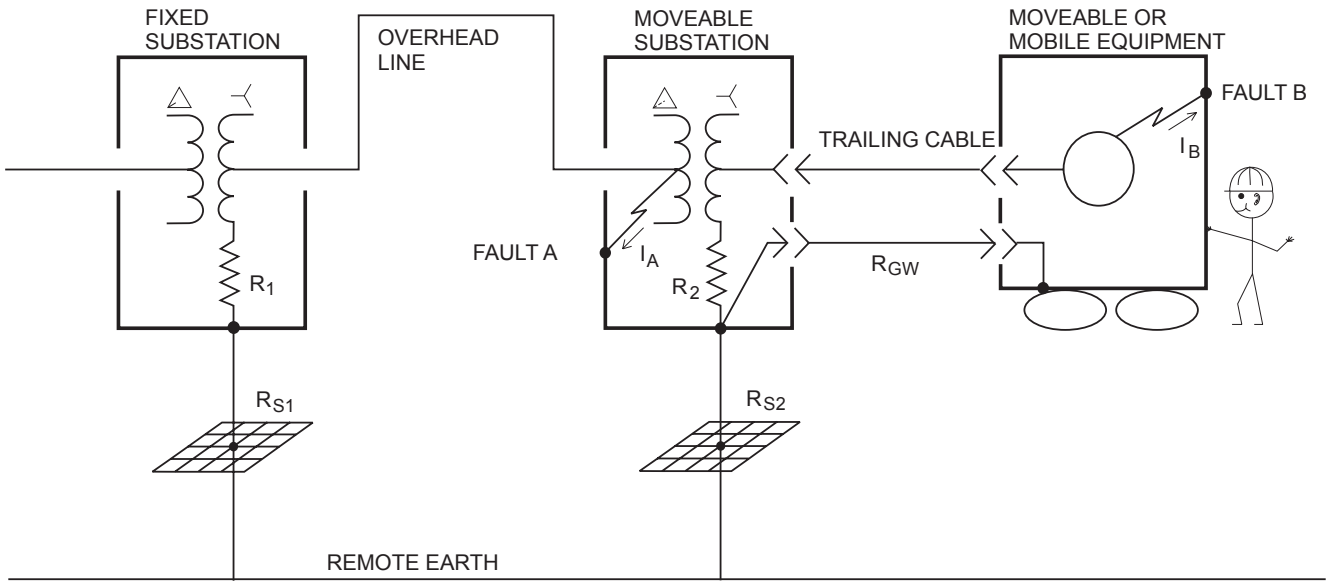


Figure 1: Ground Potential Rise and Ground-Fault Voltage

In resistance-grounded systems, it is standard practice to assume zero-impedance fault paths and consider only the neutral-grounding resistors (NGR's) to calculate prospective ground-fault currents. These values are used to calculate worst-case values of GPR and ground-fault voltage.

(a) Prospective ground-fault current I_A is equal to the line-to-neutral voltage of the fixed substation transformer divided by R_1—the resistance of the NGR.

(b) GPR at the moveable substation is equal to the product of I_A and R_{S2}—the resistance of the substation ground. This GPR is transferred to the frame of the trailing-cable-fed equipment.

(c) Prospective ground-fault current I_B is equal to the line-to-neutral voltage of the moveable substation transformer divided by R_2—the resistance of the NGR.

(d) Ground-fault voltage at the frame of the trailing-cable-fed equipment is equal to the product of I_B and R_{GW}—the resistance of the ground wire.

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The person touching the frame of the trailing-cable-fed equipment will be exposed to a transferred GPR when fault A occurs and to a ground-fault voltage when fault B occurs.

A monitored, adequately sized ground conductor will ensure that the ground-fault voltage will be less than 100 volt. However, the GPR will be excessive if either I^A or R^{S2} are large. The preferred method of achieving a tolerable GPR is to reduce I^A by increasing R^1. Increasing R^1 is not an option at many sites and the isolated-ground-bed design shown in Figure 2 is frequently used to reduce the GPR transferred to trailing-cable-fed equipment. This method is effective if the ground beds are sufficiently separated and precautions are taken to prevent the ground beds from being inadvertently coupled by fences, buried pipes, or other conductive equipment.

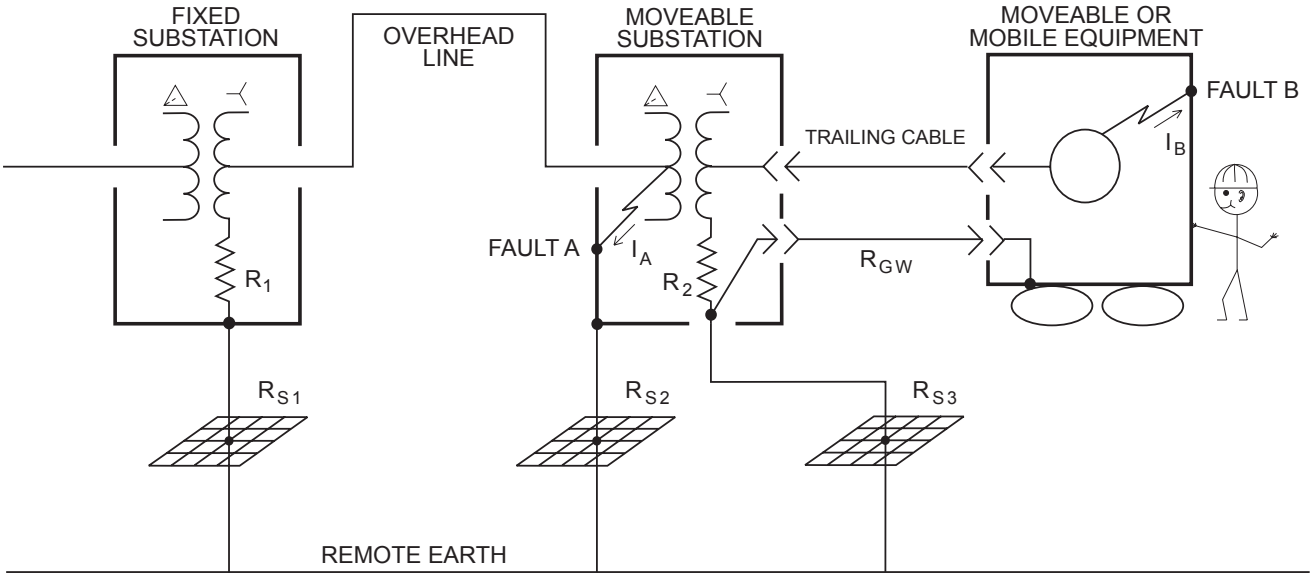


Figure 2: Isolated -Ground-Bed Design to Reduce Transferred GPR

In an isolated-ground-bed design, GPR develops between the isolated ground and the substation ground instead of being transferred to the trailing-cable-fed equipment. The bottom of the NGR and the cable to the isolated ground must be insulated to withstand this voltage. Similarily, any monitoring equipment resident in the substation and connected to the isolated ground must either withstand the GPR or be insulated for it.

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If only the NGR is to be monitored in an isolated-ground-bed design, the NGR monitor and its external resistor (ER) must be connected to the bottom of the NGR. Typically, GPR is larger than an NGR monitor's terminal-block rating and its internal power-supply transformer's (T4) primary-to-secondary rating. Consequently, both the NGR monitor and its external resistor (ER) must be insulated from the substation ground and connected to the isolated ground as shown in Figure 3. Precautions must be taken with respect to personnel and the GPR which can develop between the monitoring equipment and the substation ground.

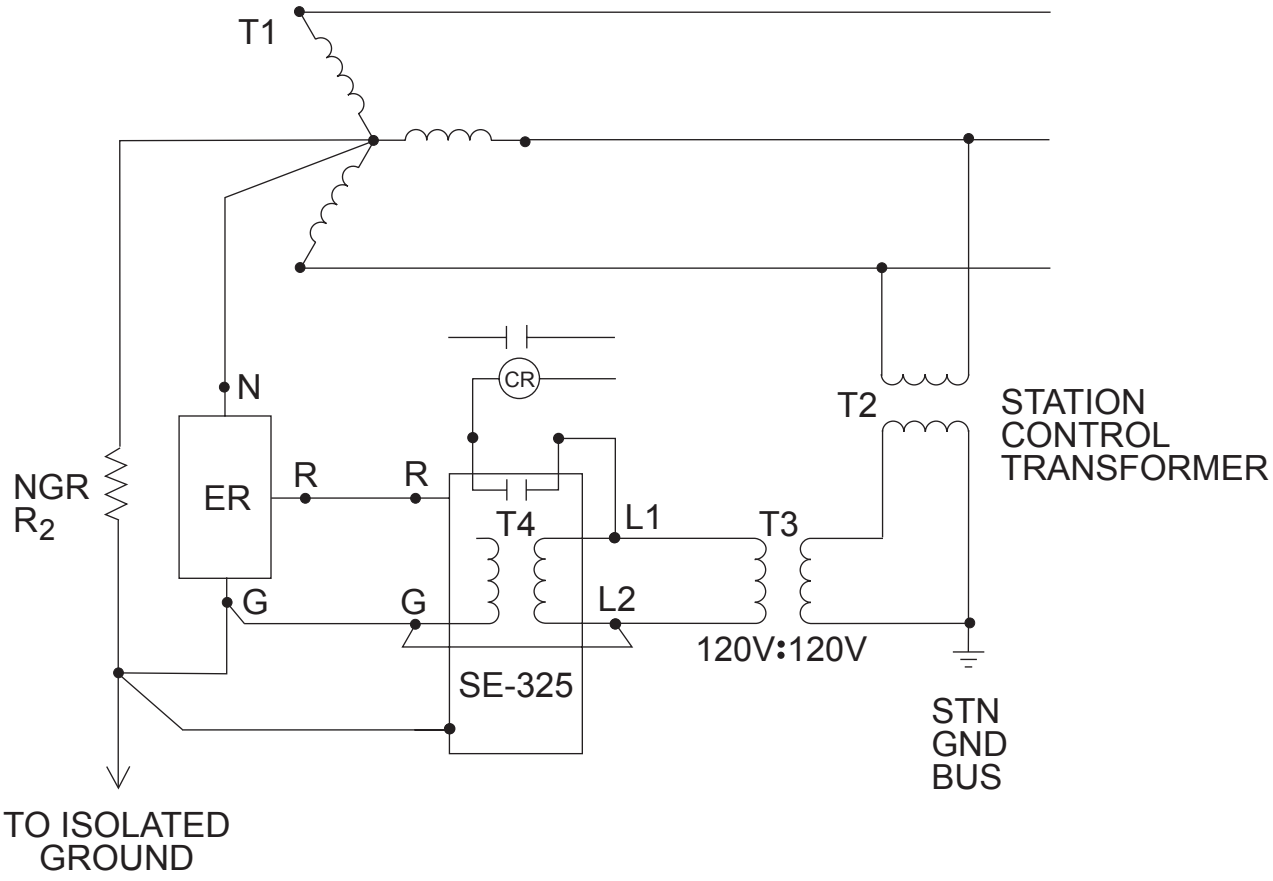


Figure 3: NGR Monitor Grounding in an Isolated-Ground-Bed Design

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The NGR-monitor-grounding scheme shown in Figure 4 does not require an isolation transformer, an interposing relay, or an insulated external resistor (ER) and SE-325 chassis. In this design, the SE 325 monitors the series combination of the NGR and the two ground beds. This configuration is acceptable provided stray dc currents are not present and the ground-bed resistances are small with respect to the resistance of the NGR.

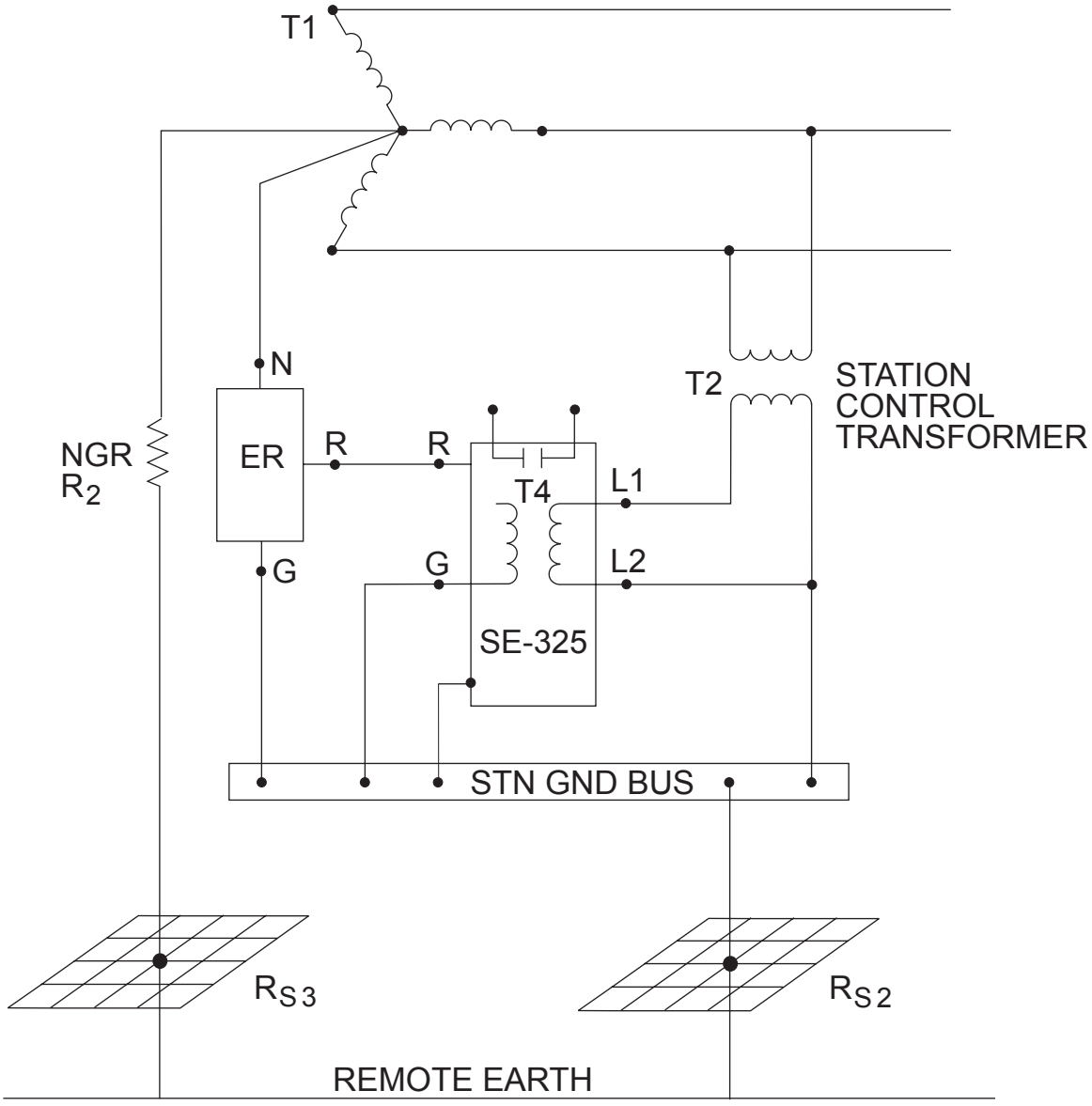


Figure 4: NGR Monitor Grounding with Ground Beds Included in the NGR Monitored Loop

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