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Grounding Issues for Utility Telecom

As the practice of utilizing high voltage environments as locations for communications towers and switch sites becomes commonplace, it is critical to understand the hazards posed to personnel and equipment by high voltage fault conditions. Telecommunication sites installed within high voltage environments are exposed to the same fault conditions as the towers and substations, therefore, the protection of personnel and equipment at these sites is a critical consideration when designing a proper grounding system. Safety, reliability and cost effectiveness are major goals for properly designed installations.

Copper wire communications cables within high voltage environments such as substations, power plants and transmission towers, can be exposed to thousands of volts during a power system fault. In that instant, the entire site will experience a Ground Potential Rise (GPR) and a dangerous voltage difference will occur between the power station and the remote ground (zero potential zone) of the telecommunications cable. Any voltage differences will trigger a current flow, which as the potentials equalize, may have destructive consequences for personnel or sensitive electronics.

The increase in “shared” teleco/utility locations has greatly increased the need for these critical issues to be remedied. Close coordination and cooperation are needed from all parties involved (utility, communication company and engineering firm) beginning with the earliest design stages. Strict adherence to industry practices and standards, such IEEE Standard 80, Standard 487 and Standard 367, is highly recommended.

Unfortunately, many communication site providers are simply unaware of the hazards of installing equipment in these high voltage environments. Many utilities take for granted that the site’s installers have met the proper design considerations for safety. This process of designing adequate protection for telecommunications facilities must take into considerations both a stable low impedance earth grounding and proper bonding:

- Standards for personnel protection mandate rigorous bonding and the utilization of the necessary insulating materials to allow for safe Step and Touch voltage levels.
- Standards for equipment performance mandate installation of a stable ground reference, which will facilitate long-term successful site operation.
- Equipment surge protection can effectively operate only if proper grounding is provided.

The parameters of interest (as defined in IEEE Std. 367) for telecommunications sites located within the utility property are:

- Ground Potential Rise (GPR) - the product of a ground electrode impedance, referenced to remote earth, and the current that flows through that electrode impedance. In a 3-phase 4-wire electric power system some current will flow into the earth due to load unbalance. This current will generally create small values of GPR which does not constitute a concern. However, in the case of power system faults, the currents involved are of considerable magnitude and the resulting GPR becomes a problem in need of a solution.
- 300 Volt (peak) Line - the area around a grounding electrode representative of a 300 volts (peak) potential resulting from the voltage drop through the earth between the grounding electrode and remote earth. When GPR values exceed a certain threshold, it is necessary to install isolation equipment on metallic, non-power carrying conductors, such as phone lines. Sometimes the only solution is to utilize fiber optic lines or a microwave link. Standard communications circuit protectors usually fire at nominal 300 volts peak.
- Step Voltage - the difference in surface potential between a person’s feet (bridging a distance of 1 meter).
- Touch Voltage - the voltage difference between the GPR and the surface potential (over a distance of 1 meter).
- X/R ratio - the ratio of the power system inductive reactance to resistance. It is proportional to the time constant L/R and is therefore, indicative of the rate of decay of any DC offset. A small X/R ratio will facilitate a fast fault clearance.

The first and most critical step in grounding design is building an accurate soil resistivity model. The high voltage environment includes either large surface substation grids or miles of transmission lines, both with extensive zones of influence. The typical soil testing for telecommunications sites, which usually does not exceed a 40-foot depth, is not extensive enough to offer an adequate soil image, which is critical, especially in the evaluation of the 300 Volt line.

IEEE standards often use three soil configurations as starting points for various calculation examples. They are:

- Two-layer soil, 100/20 ohm (top layer is 20ft in depth)
- Single-layer soil, 100 ohm-m
- Two-layer soil, 100/1000 ohm-m (top layer is 20 ft in depth)

These scenarios should not be taken as the only three possible soil configurations. Site-by-site soil resistivity testing is a necessity because it is the key factor in proper grounding design.

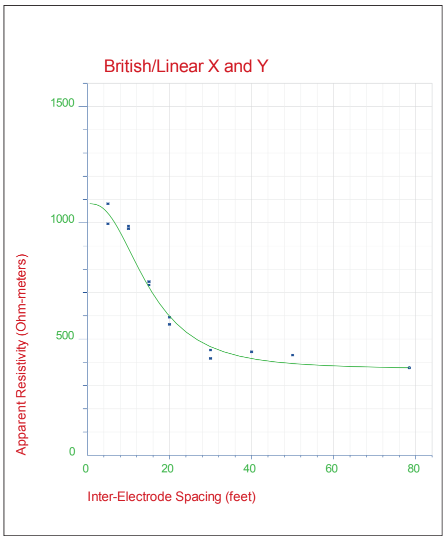


Figure 1

Figure 1 - Soil Model Based on Average Field Data, illustrates actual soil resistivity data collected by field testing of up to a 150-foot depth. The computer model consists of two-layer configurations: 17 ohm-m for the top 75 feet, followed by 53 ohm-m. It is evident that if the soil measurements stopped at a 40-foot depth, any subsequent changes in soil conductivity would have been missed.

The grounding system of a communications site operating within a high voltage environment must always be connected to the high voltage ground (substation grid or transmission tower footings). Maintaining the entire facility at the same potential by proper bonding is necessary to avoid destructive circulating currents. All protective devices rely on the grounding system as the path to dissipate energy from any fault. If the grounding system is not well designed and maintained, a fault will cause equipment damage and failure.

Manufacturers often require that grounding systems achieve a certain resistance to ground (usually five ohms or less) in order to validate equipment warranties. The need to provide a final test report, after installation, brings in another frequently overlooked question: has the grounding design process considered the need for periodical future resistance measurements as part of the maintenance schedules? A Single Point Grounding (SPG) concept remains a valid solution to the problem.

Figure 2 - Communications Equipment Grounding Configuration, illustrates a typical grounding configuration for a communications site located adjacent to a transmission tower. The equipment shelter is installed under the tower and a chain link fence protects it. The antennas are solidly mounted on the tower structure.

Typical grounding system layouts include buried conductors of at least #2 bare tinned copper around the concrete equipment pad or shelter and ground rods as per the National Electrical Code (NEC) Section 250. An additional ground ring positioned 3 to 4 feet outside the fence line or the tower perimeter, often supplements the buried ring around the equipment. This additional ring ensures personnel safety in fault conditions. If non-conductive soils and high fault current conditions concur, the outer ground ring must be replaced by a ground copper mesh (1 to 2ft center to center), as illustrated in **Figure 3** - Equipotential Mesh. Geographical and geological particulars are also important in the design process. Frost line depth, water table level, bedrock existence, soil resistivity data, as well as the available space, will dictate the specifics of the grounding system including lengths of rods and burial depth.

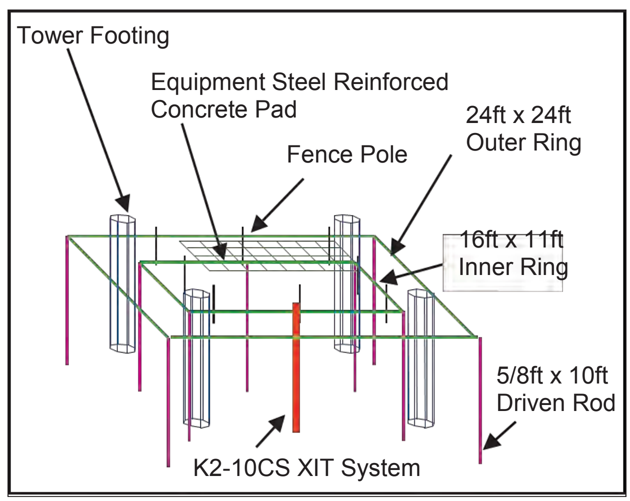
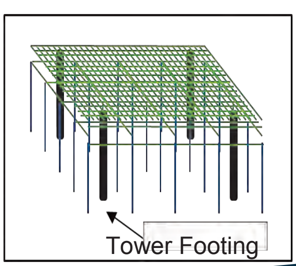


Figure 2



For optimum protection, an electrolytic grounding system, such as Lyncole's XIT Ground Rod is recommended. The 2 inch copper pipe has better energy handling capability than conventional driven rods. The system is warranted for 30 years and provides unmatched performance and stable resistance throughout the changing seasons. Unfortunately, unrealistic project deadlines, budgetary restrictions and lack of information often compromise the communications equipment investments by limiting the protection options available.

Figure 3

Regardless of the grounding system layout, resistance testing is mandatory after installation. This final step will validate the design efforts, provide the written statement necessary to obtain the manufacturer's warranty and establish a "baseline" value for future maintenance checks.

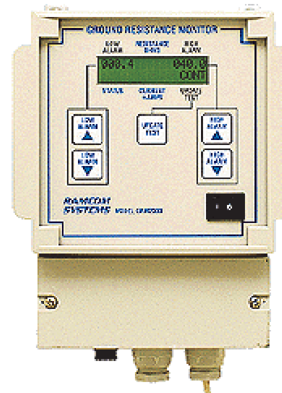


Figure 4

The most common testing procedures are:

- The Fall-of-Potential (3 Point) method, used only if the grounding system is completely isolated from any other grounds (utility, water, pipe networks, building metallic structure, tower, fence, etc.)
- The Clamp-on methodology which is applicable only if the grounding system is bonded to electrical utility (or other large effectively grounded networks).

If permanent monitoring of the grounding system performance is desired, the Lyncole Ground Resistance Monitor GRM 2000 RS - **Figure 4**, is highly recommended. Any unwanted changes in the system components (conductor cuts, illegal bonds triggering loop conditions) will be remotely alarmed and monitored via the Internet, a local network or an RS232 port.

Once the grounding system configuration is established, the GPR, 300 Volt Line and the safety calculations can be performed. They are based on the worst-case phase-to-ground fault current and the fault clearing time provided by the utility company. Only the earth return component of the fault currents will be used. Accurate configuration of the entire power system involved (connected substation grids and transmission lines if overhead ground wires are present) is critical to avoid over design.

Step and Touch Voltage calculations verify that safety thresholds for personnel operating on site are not exceeded, **Figure 5** - Step Voltage and **Figure 6** - Step Voltage using Crushed Rock. ANSI/IEEE Standard 80 is used to determine the acceptable values for these two safety parameters. Recent publications emphasize the conservativeness of these assumptions.

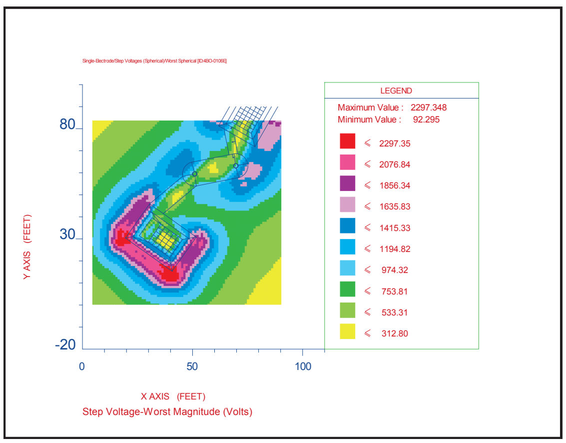


Figure 5

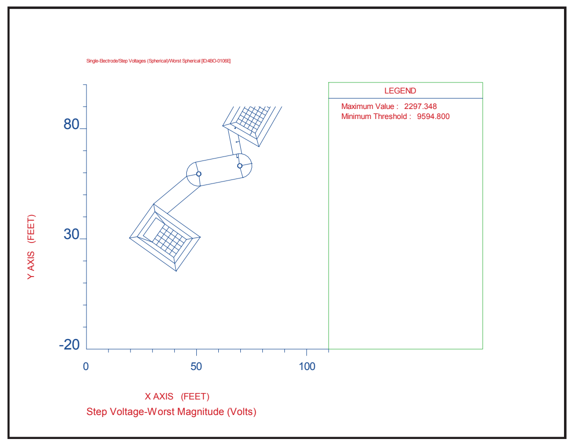


Figure 6

Once Step and Touch voltages have been calculated, additional methods can be utilized to address dangerous potentials. If necessary, insulating layers of crushed rock (3000 ohms-meters) or asphalt (10,000 ohm-meters) are recommended to ensure personnel safety within the high voltage site, **Figure 7** - Touch Voltage and **Figure 8 -** Touch Voltage using Crushed Rock.

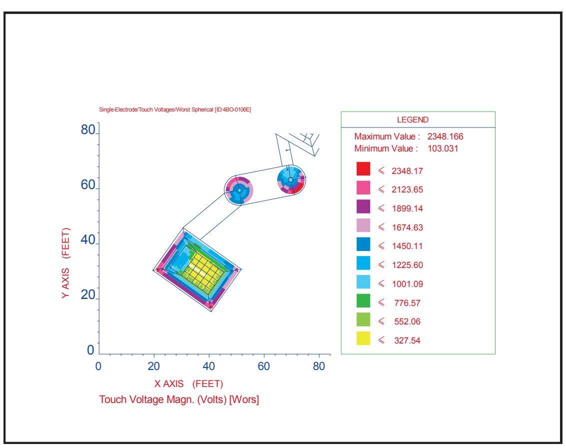


Figure 7

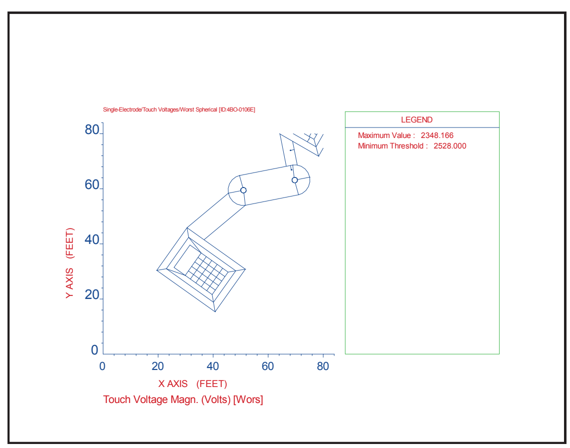


Figure 8

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Similar calculations (GPR, 300 Volt line, Step and Touch Voltages) must be performed for all sources of GPR within the same high voltage right-of-way. Power transmission facilities, even not directly bonded, may have a significant effect on sensitive equipment and personnel, **Figure 9 -** Transmission Tower in the same Right-of-Way.

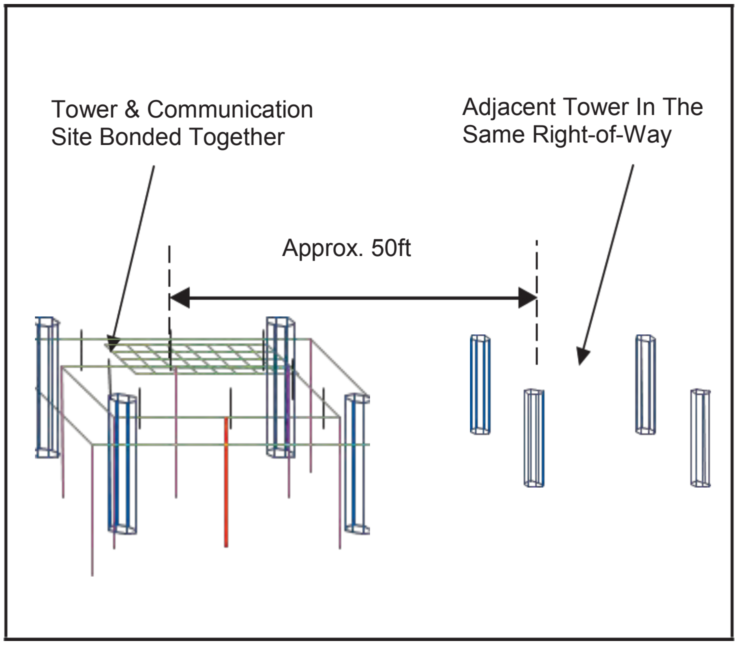

Figure 9

A properly designed and installed grounding system is the foundation upon which all protection systems are dependent. Understanding and developing a proper plan for the safe installation of communications sites within the high voltage environments is, and will continue to be, a critical design component in the future of the utilities and the communications companies.

Lyncole provides a complete unmatched range of products and services in electrical protection and grounding. Lyncole engineers have tested, designed and implemented grounding systems and upgrades in a variety of projects including telecommunications, broadcasting, recording, office environments, manufacturing facilities, military applications and more.

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