Considering Touch & Step Voltage Hazards at Utility Scale Photovoltaic Power Plant

Overcome challenges from soil data, impacts of physical and electrical design, and software limitations with engineering knowledge and advanced software tools

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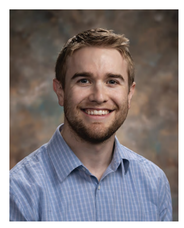
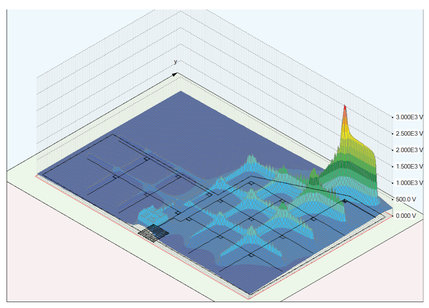


Photovoltaic Power Plant Grounding Challenges

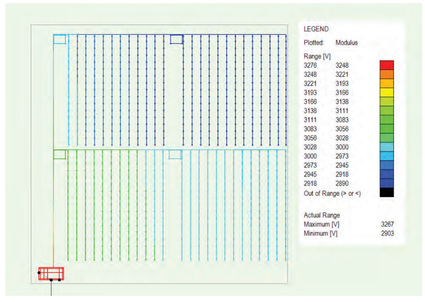
PV Design

Variation in solar physical design affect grounding system design. Stationary, single axis, or dual axis tracker dictate the complexity of ground continuity. Piers and supports can offer auxiliary grounding, however in high corrosion areas may use coated or non-conductive materials. Additionally congregated sites may use all cables for electrical connections, while dispersed or very large sites may use overhead lines.



Software Limitation

Simple software tools based on smaller substation grounding system may omit key properties of the physics of a grounding system during fault conditions.



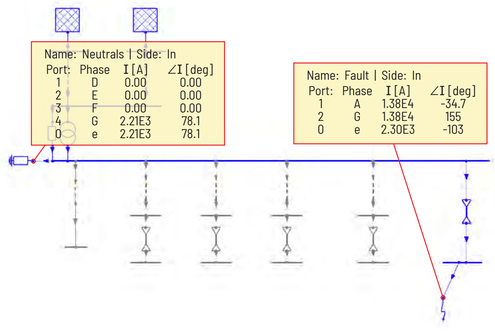
Metallic Voltage Drop

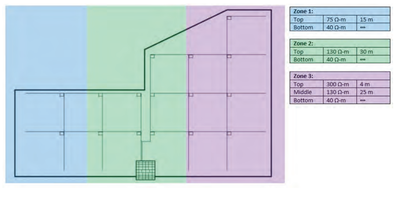
Simple software ignores the voltage drop of the ground conductor, driving inaccurate results. Advanced software considers this voltage drop, and resulting variation in touch voltage references.

Fault Current Paths

Fault current from a remote fault source produces earth current, but utility scale PV may require detailed fault current calculation.

OH Length (ft)	Cable Length (ft)	Phase Current (A)	Neutral Current (A)	Earth Current (A)	Current to Earth (%)
5280	0	8790	1010	7780	89%
3960	1320	8730	1480	7250	83%
2640	2640	8870	2300	6590	74%
1320	3960	9570	4160	5440	57%
80	5200	13100	11700	2390	18%
0	5280	13800	13100	2300	17%

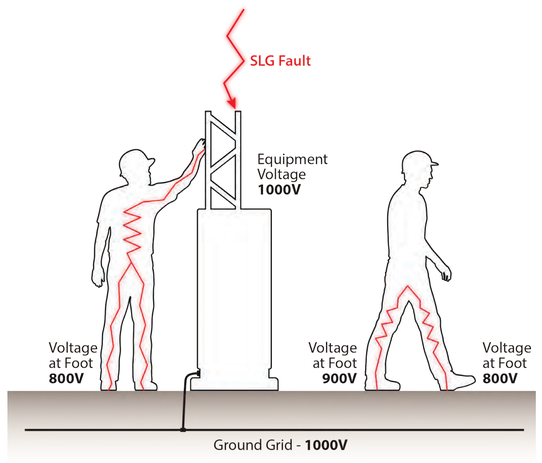




Soil Challenges

Soil electrical characteristics are a significant driver for grounding system performance. The size of solar facilities allows changes is soil characteristics along the width of the system.

Grounding System Design



A grounding system supports several purposes:

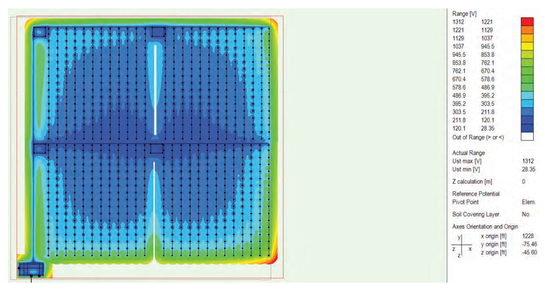
- Ensure personnel and public safety
- Facilitate proper equipment
- Prevent & reduce damage from fault escalation
- Prevent & reduce damage from lightning effects

Refer to IEEE Std 80 & IEEE Std 2778

Solutions to Grounding Analysis Challenges

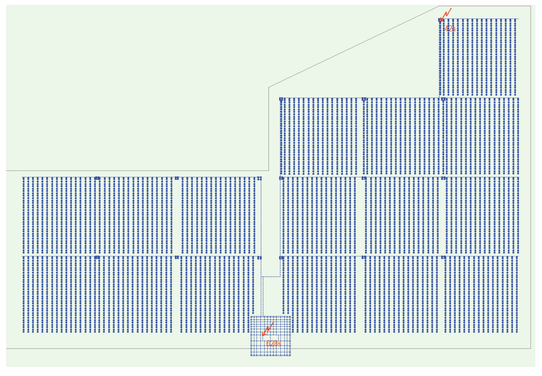
Utilize Advanced Software

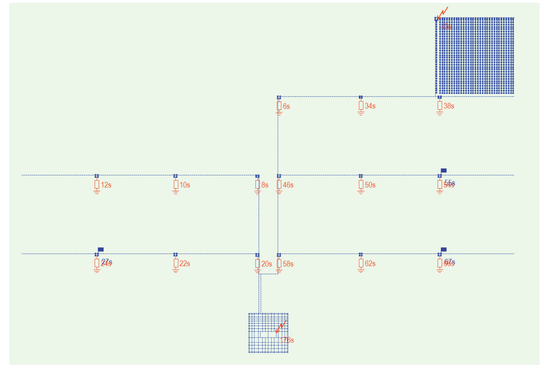
Tools that consider the self and mutual impedance of grounding conductors provide the capability to accurately analyze the touch and step voltages. These consider voltage drop, overcoming 'equipotential plane' assumption and allow regional touch voltage references as pertinent for accurate touch voltage



Detailed & Approximated Modeling Methods

Some software and hardware allow for all ground components to be modeled that reduce the ground potential rise, and reduce soil surface voltage gradients. Approximation methods are typically uses when user limits occur and generally categorized as a sampled approximation or lumped approximation. Additionally modeling the overhead line or cables with concentric neutrals significantly aides in an accurate analysis.





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