Evaluating PV Field Grounding Performance with Simulations for Lightning Transient Energy Time Domain Analysis of Lightning Current Distribution

- Lightning discharge near to or within a PV field creates a Ground Potential Rise (GPR) and transient current dissipating through the PV arrays, grounding conductors and the inverter ground electrode.
- Without effective means of distribution and dispersion, potentially harmful energy values (A²s) of lightning current are diverted through the power trenches and inverter electrodes to other low impedance parts of the PV field.
- When large parts of the PV fields are not interconnected at specific points, the distributed energy through the inverter ground electrode could result in operational issues and equipment damage.

Modeling of the Solar Power Plant

Modeling of the PV field structure layout, DC / AC trench grounding conductor installations, messenger/CAB bonding conductor and inverter grounding electrodes.

Simulation scenarios:
1. Scenario 1: The initial scenario to consider the PV field grounding system design. (Initial Condition)
2. Scenario 2: Recommended grounding and bonding solution implemented. (Improved Condition)

The modeled elements and their conductor representation is summarized:

Soil Resistivity Modeling

Soil resistivity models influence the dissipation of current and energy. Accurate field soil resistivity measurements is required to increase accuracy of the analysis.

- Soil conditions influence existing earthing and are a factor to determine how much additional bonding is required.
- Soil resistivity can vary across large plants and different depths, especially where the power blocks are disjointed due to complex terrain and site allocation.

Lightning Injection Time Domain Analysis

To model lightning current as an impulse, the analysis should be conducted in the frequency domain and converted back to the time domain. The lightning transient impulse will consist of multiple frequencies.

The characteristics of the First Negative Stroke for LPL III is extracted from IEC 62305-1:

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Simultaneous waveforms can be used for calculating and illustrating the GPR during a lightning strike condition. Bonding recommendations that create additional conductive paths within the area are simulated for comparison to the initial condition.

For each simulation scenario the lightning current impulse waveform is calculated at critical locations in the PV field to compare the peak magnitude and specific energy contributed by the lightning injection. Bonding recommendations that create additional conductive paths within the area are simulated for comparison to the initial condition.

Sinusoidal waveforms can be used for calculating and illustrating the GPR during a lightning strike condition. This frequency domain analysis will illustrate the localized GPR with a high rate of rise and peak value to be expected by lightning striking the PV field (sinusoidal waveform with frequency of 250 kHz).

Table 1: Lightning Impulse Parameters of First Negative Stroke for Simulation Purposes (IEC 62305-1)

<table>
<thead>
<tr>
<th>Parameters</th>
<th>First Negative Stroke</th>
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<tbody>
<tr>
<td>I (kA)</td>
<td>50</td>
</tr>
<tr>
<td>T1 (μs)</td>
<td>1.82</td>
</tr>
<tr>
<td>T2(T)</td>
<td>289</td>
</tr>
<tr>
<td>k</td>
<td>0.586</td>
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</tbody>
</table>

Table 2: Summary of Calculations for Area 1 (Scenario 1 vs. Scenario 2)

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