Modeling Blind Spot Ground Faults

25 June, 2013

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Sandia National Laboratories’ Ground Fault Simulations

- Research question: Does reducing the ground fault detector and interrupter (GFDI) fuse rating improve the PV system safety without causing additional nuisance trips?
- Sandia created a SPICE model of multiple PV systems.
  - Simulated up to 201 string (200 kW) arrays, varying irradiance conditions, leakage currents, and fault locations and fault resistances.
- Ground faults were simulated as constant resistance faults to the equipment grounding conductor (EGC).
- Model limitations include:
  - Steady state conditions, e.g., no DC current ripple, changing leakage currents, MPPT algorithms. etc.
  - Inverter modeled using a constant resistance.
- Ground fault and blind spot results will also be presented in:
  - Blind spot-specific Solar ABCs report, “Photovoltaic Blind Spot Electrical Simulations”
  - Comprehensive Sandia Technical Report, “Photovoltaic Ground Fault and Blind Spot Electrical Simulations”
Fuse Internal Resistance

• Contrary to popular belief, continuously reducing the GFDI fuse rating does **NOT** increase the number of ground faults that are detected!

• **WHY?!** After the ground fault, there are two paths the current can take:
  - Normal PV conduction path
  - Fault path through the GFDI

• The high internal resistance of the fuse reduces the current through the GFDI path and it does not clear!
Detection Ranges for GFDI Fuses

- Only 1 A and 2 A fuses can detect blind spot faults.
  - The 1 A fuse needs 56 strings to trip and the 2 A fuse needs 124 strings to trip.
Modeling Recommendations

- Based on the modeling results, reducing GFDI fuses to 1 A for all 600 V installations below 250 kW will increase the detection window for blind spot ground faults.
  - Higher voltage and power installations may require a 2 A fuse.
  - Note: It is likely a 1 A GFDI fuse at Bakersfield and Mt. Holly would have tripped on the first blind spot ground fault.
- More research is needed to verify fuse rating reductions do not cause nuisance trip issues in the case of lightning or array transients.

<table>
<thead>
<tr>
<th>Device DC Rating (kW)</th>
<th>Max. Ground-Fault Current Detecting Setting (A)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-25</td>
<td>1</td>
</tr>
<tr>
<td>25-50</td>
<td>2</td>
</tr>
<tr>
<td>50-100</td>
<td>3</td>
</tr>
<tr>
<td>100-250</td>
<td>4</td>
</tr>
<tr>
<td>&gt;250</td>
<td>5</td>
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</tbody>
</table>

**UL 1741 maximum allowable ground fault trip ranges**

**GFPD Trip Point vs. Size of Various Inverter Manufacturers**

- SMA larger inverters use external GFDI
- Power-one, Solaredge, and OMRON use differential measurements @300mA
- ABB uses insulation monitoring

**Suggested Max. GFDI Current Ratings**

**Maximum Leakage allowed by IEC 61215**

**Solar America Board for Codes and Standards**