Modeling Blind Spot Ground Faults

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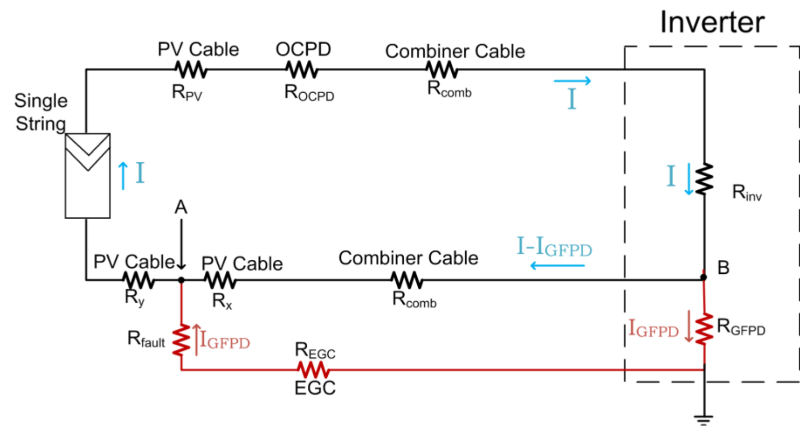
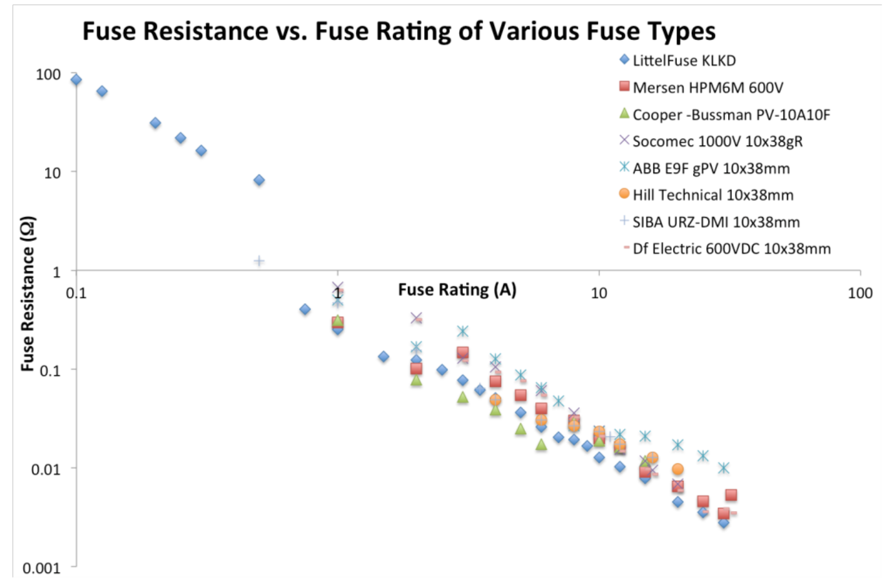
Sandia National Laboratories' Ground Fault Simulations

- 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

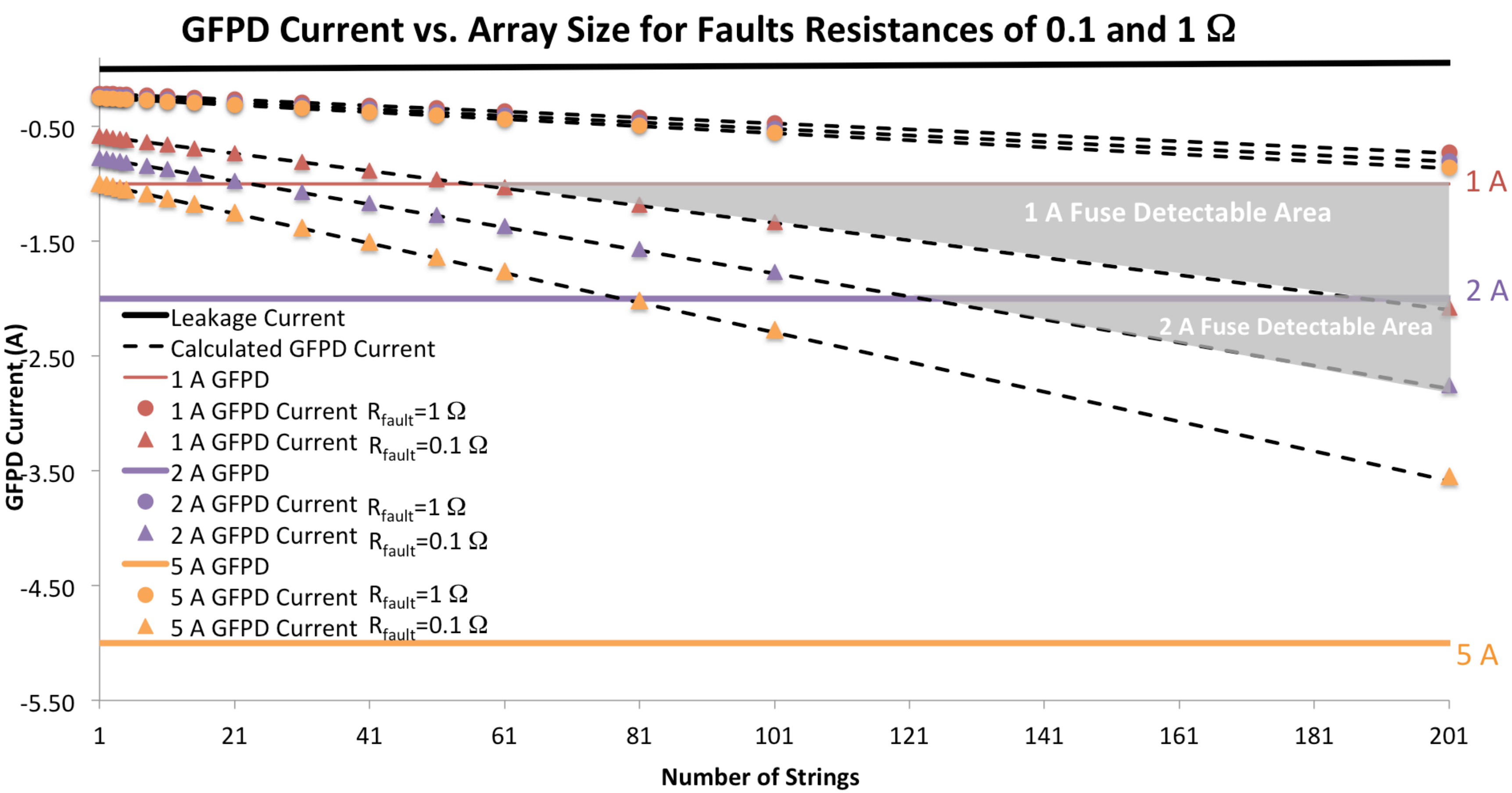
- Contrary to popular belief, continuously reducing the GFDI fuse rating does **NOT** increase the number of ground faults that are detected!
- **WHY?!** After the ground fault, there are two paths the current can take:
  - Normal PV conduction path
  - Fault path through the GFDI
- The high internal 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 my 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.

UL 1741 maximum allowable ground fault trip ranges

Device DC Rating (kW)	Max. Ground-Fault Current Detecting Setting (A)
0-25	1
25-50	2
50-100	3
100-250	4
>250	5