

Field Guide for Testing Existing PV Systems for Ground Faults

PRESENTED BY

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U.S. DEPARTMENT OF
ENERGY



AGENDA FOR WEBINAR

- Background on Previous Work and Ongoing Project
- Purpose of the Field Guide
- Testing for Known Ground Faults
- Testing for Unknown Ground Faults
- Installing Equipment to Monitor Residual Current
- Other Equipment to Mitigate Fires

Background on Previous Work and Ongoing Project

- Known fire hazards exist with PV systems
 - Ground faults in older systems (no blind spot necessary)
 - Ground fault blind spot fires
 - Arcing fires (connection, connector, or conductor failures)
- SolarABCs research project outlines ground fault blind spot concerns.
 - <http://solarabcs.org/about/publications/reports/blindspot/index.html>
- The National Renewable Energy Laboratory (NREL) is continuing work in this area. Field Guide is first project under this contract.
- The Field Guide is in draft form and ready for initial review.

Purpose of the Field Guide

- Provide practical guidance to field technicians on how best to perform testing on PV systems with known and unknown ground faults.
- Discuss need for residual current monitors on grounded PV systems to improve ground fault detection to a safe level.
- Discuss equipment and methods of installation for residual current monitors that can be retrofitted to any grounded PV system.
- Discuss need for arc fault detection equipment to complete the safety hardware necessary to cover remaining known fire hazards.

Testing for Known Ground Faults

- Premise of Field Guide is that field technicians are qualified and authorized to do the work.
 - Qualified--*"One who has skills and knowledge related to the construction and operation of the electrical equipment and installations and has received safety training to recognize and avoid the hazards involved."* NEC
 - Authorized--*"One who has been granted permission to work on the PV system by the system owner."*
- Several articles have been written describing how to locate ground faults in a PV array when a ground fault detector has tripped. (SolarPro SP2.5)
- This guide is intended to provide a step-by-step field procedure to find and rectify a known ground fault.

Phase 1: Initial Testing

- Record the information shown on the display of the inverter or ground fault detector.
- Consult data acquisition system to understand when the system shut down (if shut down)
- Allow for capacitors to drain
- Test for voltage
- Test for current on the equipment grounding conductor
- For circuit breaker ground fault detectors, check whether circuit breaker in on, tripped, or off position.

Phase 2a: No current in Grounding Circuit Phase 2b: Current in Grounding Circuit

- These two sections describe what to do when there is and is not current in the grounding circuit.
- When current is still present in the grounding conductor after the inverter is shut down, several additional steps are necessary to locate the fault.

Phase 3: Testing of Source Circuit Combiner Box

- Test for current on all circuits in source circuit combiner (aka string combiner).
- Open all fuse holders that have no current.
- Procedure explains how to approach circuits with current—this requires decisions related to time, cost, hazard, etc.... Circuits may need to be opened that have current flowing. This is hazardous, requires proper PPE, and requires some company position on whether technicians are allowed to work in these conditions. Night work may be the only other option.
- Unplugging faulted circuit.
- Replacing faulted conductors or modules.

Phase 4: Final Verification and Startup

- Testing to make sure ground fault fuse can be replaced or circuit breaker reset without tripping immediately.
- Starting up system.
- Testing for no current on the grounding conductor

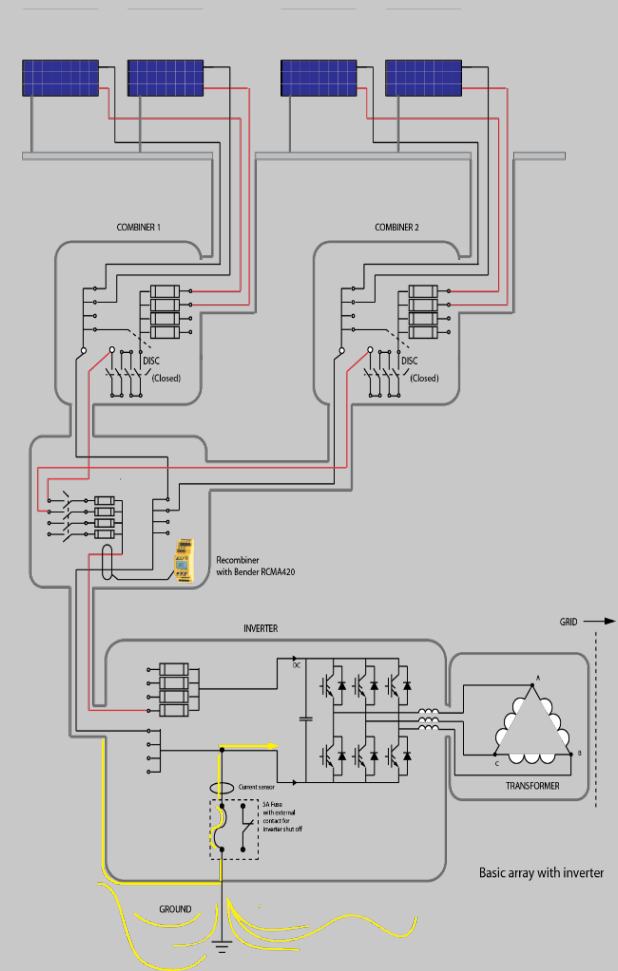
Testing PV Systems with No Known Ground Faults

- Electrical Insulation (Megger) Testing is the common method to locate ground faults when faults are not obvious and the methods in Phase 1-3 will not work.
- Several testers allow testing at 50V. This avoids concerns about removing surge arrestors prior to testing and avoids concerns by PV module manufacturers about applying higher voltages to their modules.
- Field guide provides procedures to test the whole array and test subarray sections at source circuit combiners.
- Guide also differentiates for negative and positive grounded systems.

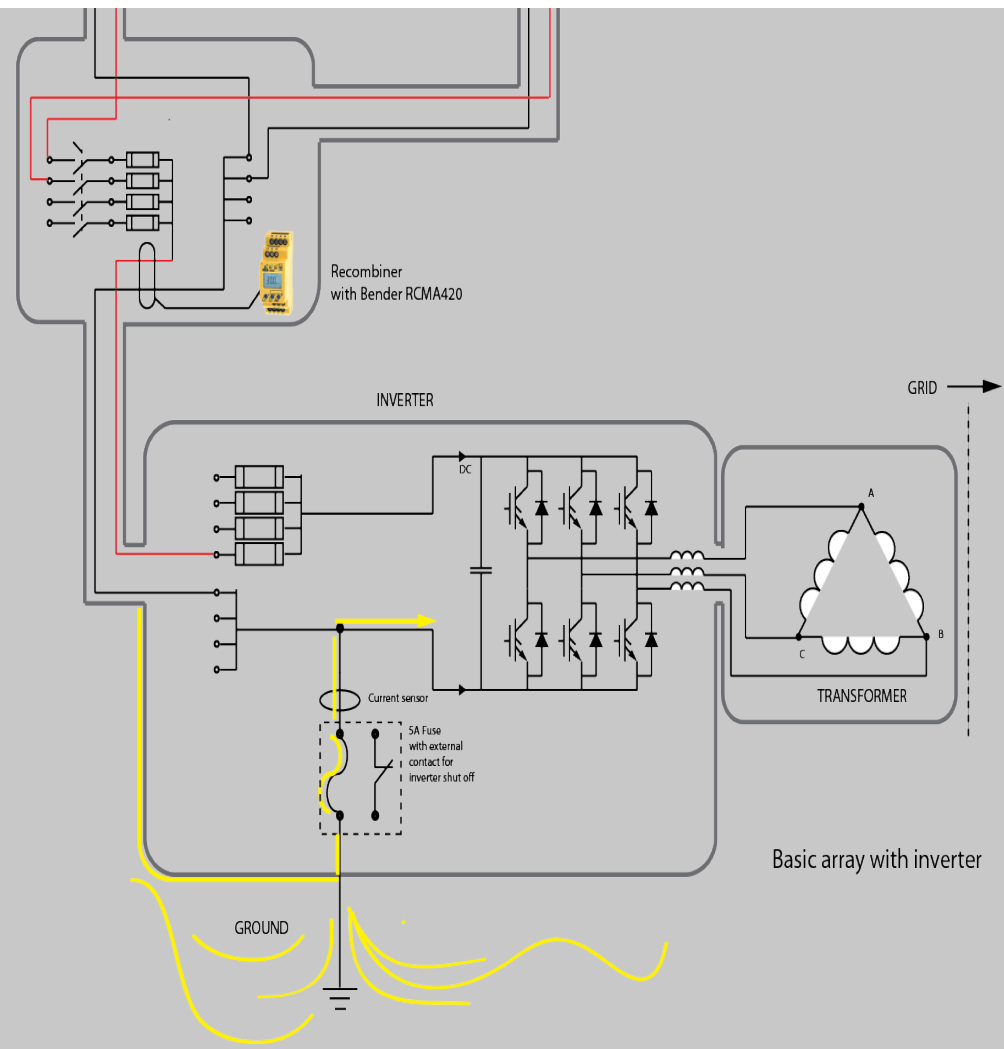
Installing Equipment to Monitor Residual Current

- Permanent solution is installing high resolution ground fault monitoring equipment.
- Does not interfere with listed equipment set a much higher detection levels.
- Provides an early warning system to alarm the PV system owner or field technician that wiring damage has occurred that could eventually develop into a catastrophic failure.

Single Bender Monitor Setup



Single Bender Monitor Setup

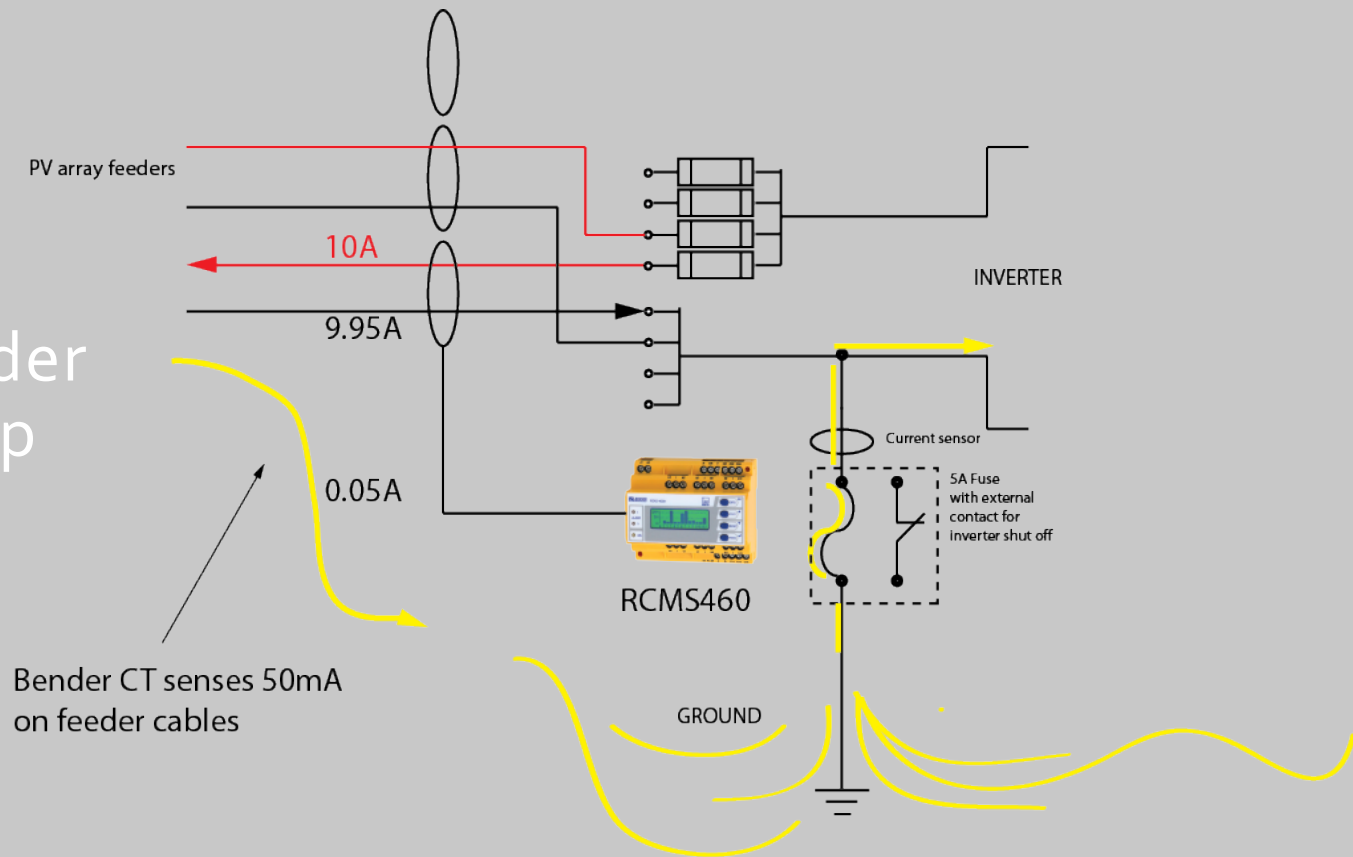


Single Monitor Installation



Bender WAB60
Current Transducer
around the String 1
Pos (blk) and Neg (wht)
conductors

Multiple Bender Monitor Setup



Bender CT senses 50mA on feeder cables

Bender RCMS460 on feeder cables measuring differential current

Multiple Monitor Installation



Factory-Installed Monitor



Other Equipment to Mitigate Fires

- Arc fault detectors are available in several string inverters.
- Arc fault products that are independent of inverters are slow in coming. Products must be evaluated with each inverter.
- The combination of high resolution ground fault detection and arc fault detection will effectively reduce the probability of a PV system fire to nearly zero.

Next Steps

- Need experienced technicians to review the draft field guide and provide solid feedback to make it better.
- If you or someone you know are interested in providing feedback on the guide, please contact me at billbrooks7@yahoo.com