ENHANCED PROTECTION OF PHOTOVOLTAIC SYSTEMS

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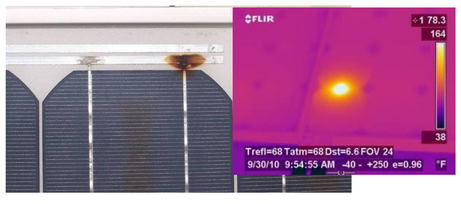
Abstract

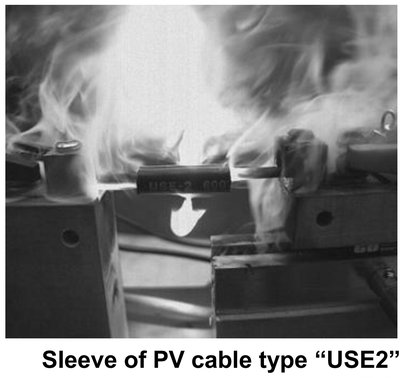
Photovoltaic (PV) systems have distributed DC power generation that requires multiple forms of fault protection to reduce the risk for PV related fires and shock hazard. Today, overcurrent protection (fuses) on strings provide protection only for reverse currents into a shorted string from parallel strings. Other electrical faults in distributed PV power systems include series and parallel arcing faults, ground faults, and shock hazards. Enhanced protection for each type of fault requires different detection and mitigation methods. We identify current mitigation practices, present test results that define enhanced protection and system requirements, and propose solutions for increased electrical safety.

Conclusions

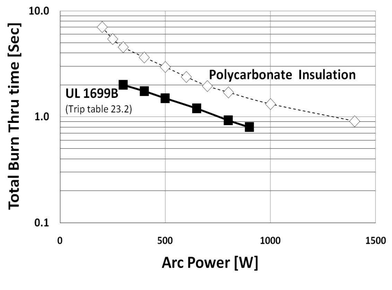
- **The 2011 National Electric Code® added requirement 690.11 for series DC arc fault circuit protection. Arc faults have been known to cause PV fires.**
- **Additional testing is being performed to assess ignition/burn thru times for In-module arcing with the close proximity to encapsulant and backsheet materials.**
- **PV on Fire testing at UL demonstrated the need for module level shutdown due to residual shock hazard and parallel arcing from compromised wiring and modules.**
- **NFPA Task Group on Firefighter Safety recommended and submitted 2014 NEC proposal: 690.12 PV Array Response to Emergency [Module] Shutdown for residential and commercial PV source circuits.**
- **A requirement for parallel DC arc fault protection has been proposed for 2014 NEC. Testing is being performed at higher arc wattages to determine ignition/burn through times, and for consideration of extending the trip time curve of UL1699B above 900 W.**
- **A requirement for AC Arc Fault Circuit Interrupters has been proposed for 2014 NEC to protect wire harness and exposed cable for PV systems with AC Modules and PV microinverters. Testing of AC AFCI being performed under reverse current conditions.**



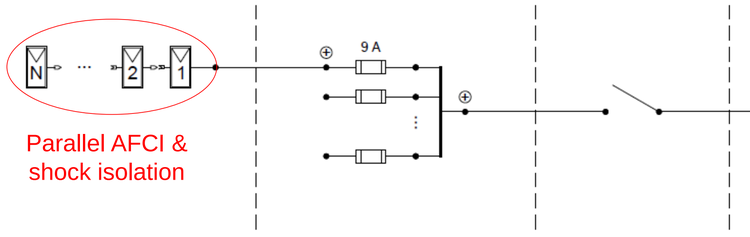
PV Module Failures



Sleeve of PV cable type "USE2" during burn-through test at 7 A

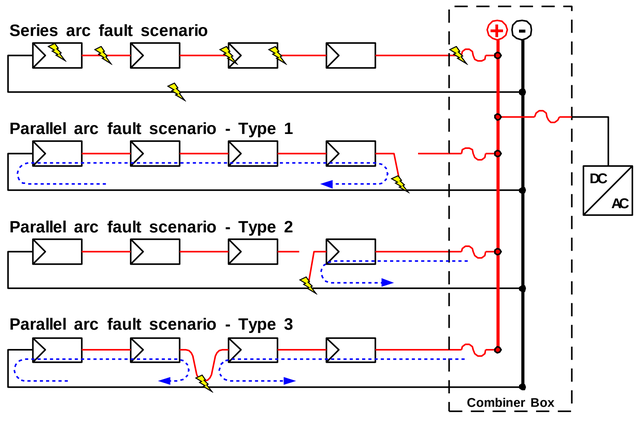


UL1699B trip curve established with safety margin below ignition/burn through times of PV insulation materials



Parallel AFCI & shock isolation

PV system with distributed DC power generation

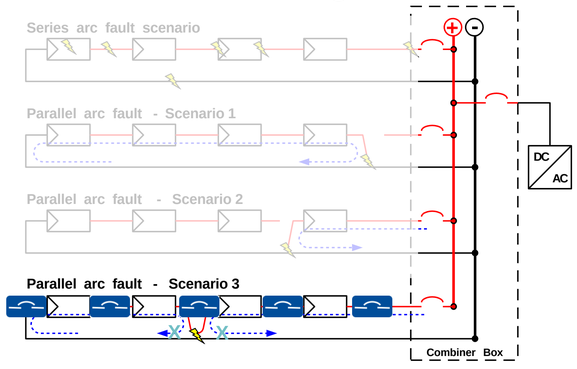


Arc Fault Detection and Mitigation

Arc Fault Detector

Single Module Arc Test

Shock Hazard (Ground Fault) Detection and Mitigation



Single Module Arc test demonstrated sufficient power to generate sustained arc fault and fire, and that **module shutdown must be an open DC switch** (to mitigate internal arc faults), not a shorting FET (as some have proposed to just reduce shock hazard).

Module Level Shutdown

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