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Codes for Photovoltaic Arc-Fault Protection

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http://pvarcfault.sandia.gov

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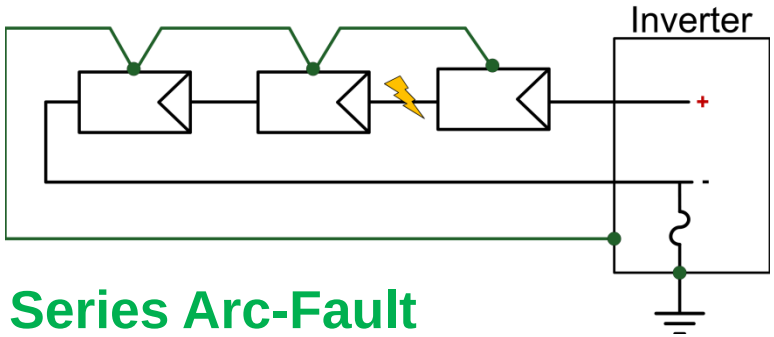
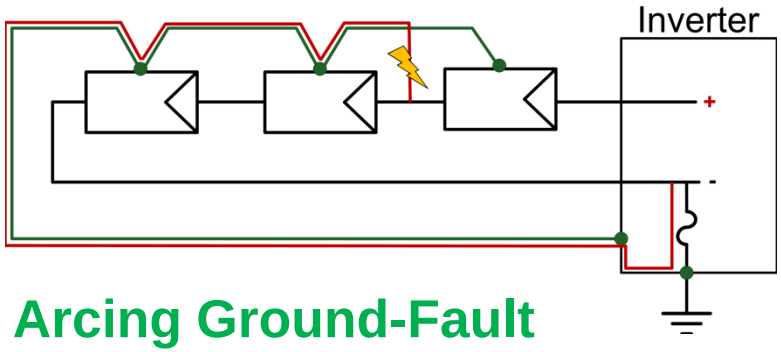
PV Arc-Fault Types



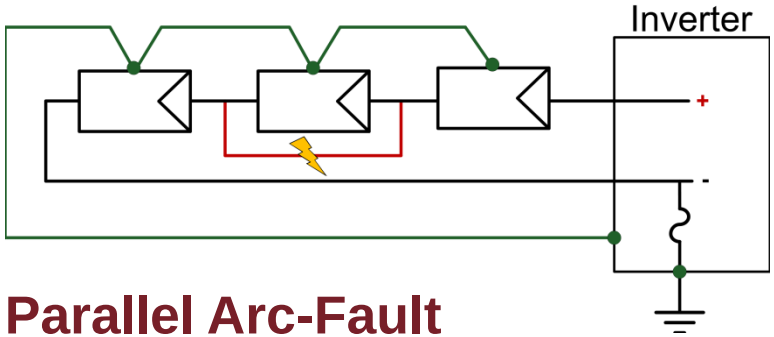
Series Arc-Fault

Single failure in intended conduction path.
Covered in *NEC* 690.11



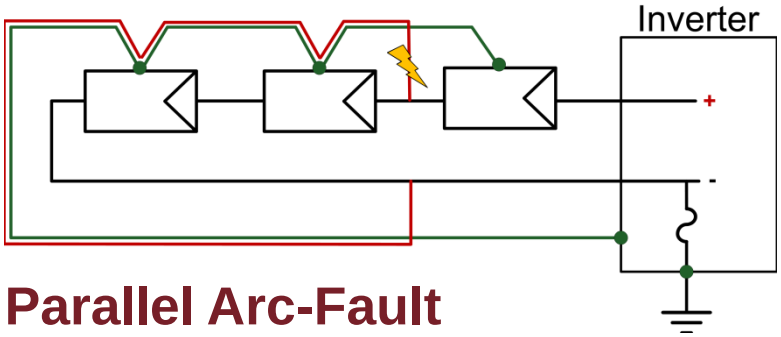
Arcing Ground-Fault

Single failure to equipment ground.
(Fault current passes through GFPD)
Covered in *NEC* 690.5



Parallel Arc-Fault

Two failures create new conduction path.
Not Covered in *NEC*



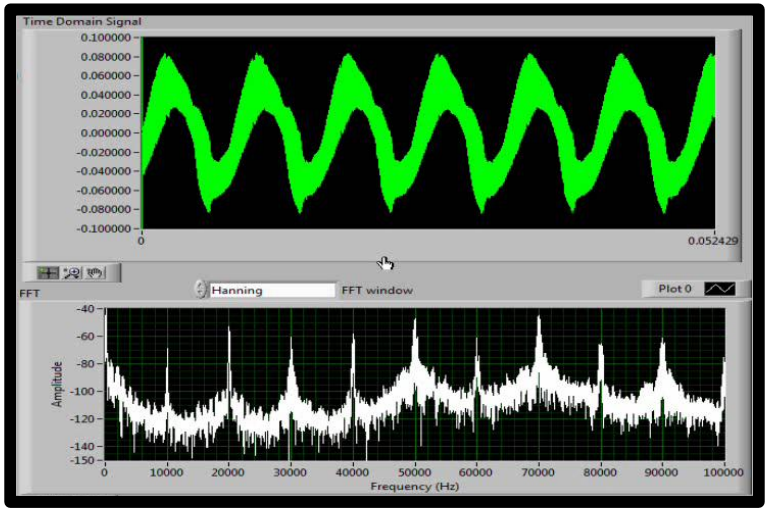
Parallel Arc-Fault

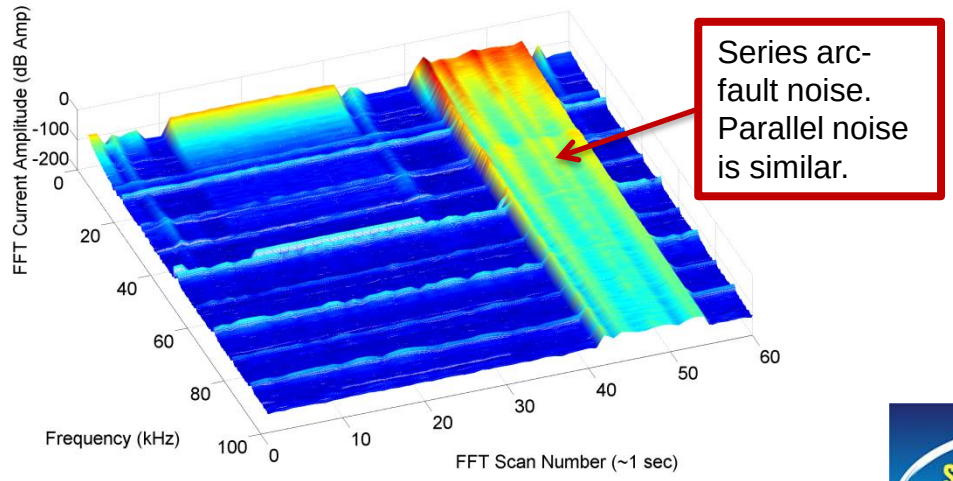
Two failures create new conduction path.
(Fault current passes through equipment ground but not GFPD)
Not Covered in *NEC*

GFPD = Ground-Fault Protection Device.

Arc-Fault Detection and Mitigation

Arc-fault noise propagation (movie)

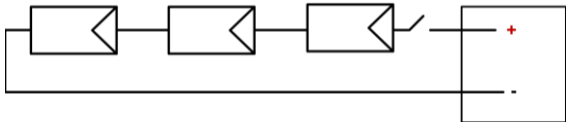




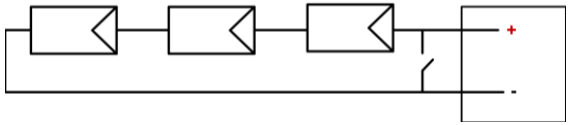
Series arc-fault noise. Parallel noise is similar.

Mitigation (De-energization) Measures

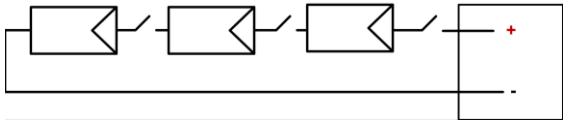
- **Series**: Open the faulted conduction path



- **Parallel**: No consensus
  - Option A: Short the system



  - Option B: Open connections between all modules



Summary of 2011 NEC and 2014 Proposals

	2011 *NEC*	2014 *NEC* Report of Proposals	2014 *NEC* 690.11 Task Force Suggestion	Ideal Protection (with Appropriate Mitigation Technology)
Series arc-faults	✓	✓	✓	✓
Parallel arc-faults		✓		✓
Rooftop systems	✓	✓	✓	✓
Ground mount systems		✓	✓	✓

Parallel Arc-Fault Challenges

- **Parallel arc-fault protection** is needed for 100% safe, fire-free PV systems so **why didn't the *NEC* 690.11 task subcommittee recommend it** for this code cycle?
- Detection and differentiation of series and parallel arc-faults is **technically feasible** and not the issue.
- The subcommittee hesitation is because the current mitigation options have **limitations**!
  - **Shorting** the array has caused at least one **fire** on a rooftop system.
  - A **shorted** system is also **difficult to repair**: either covering the modules or waiting for night is necessary to de-energize the array to begin work.
  - **Opening connections** between each module **does not eliminate parallel arc-faults** in the modules, junction boxes, or module leads.
  - **Opening** between each module adds **communication and control complexity**.
- **Mitigation methodologies need additional testing** and **parallel arc-faults are rare***, so it will likely be 2017 before there are requirements for parallel arc-fault protection in PV systems.
- **Stay tuned for the NEC Code Making Panel's decision!**

*Based on http://www.pv-brandsicherheit.de/ results and SEIA data.