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Ground Fault Protection Improvements to Prevent Fires

Description of problem and potential solutions

Presented by

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Ground-Fault Protection Blindspot

Recent fires on large PV Systems have had similar origins

- April 5, 2008 – Bakersfield, California
- April 16, 2011 – Mount Holly, North Carolina
- May be others (several)

Common Elements in Fires

- Undetected fault in a grounded conductor that can continue indefinitely. Undetected fault becomes new “normal” and the ground fault fuse does not blow.
- Ungrounded conductor fault occurs some time after grounded conductor fault. This fault blows the ground fault fuse but instead of interrupting the fault, short circuit current persists in the array.

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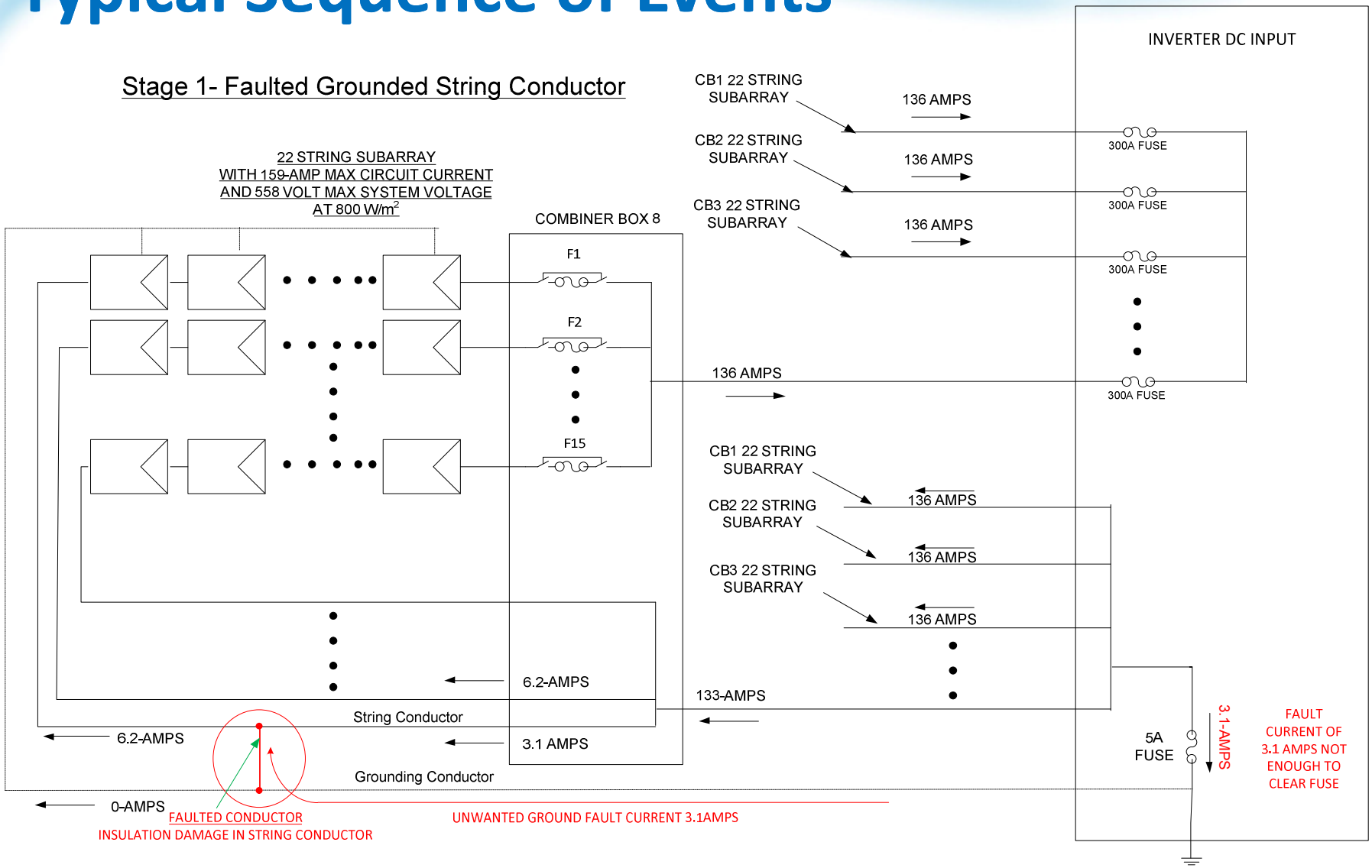
Typical Sequence of Events



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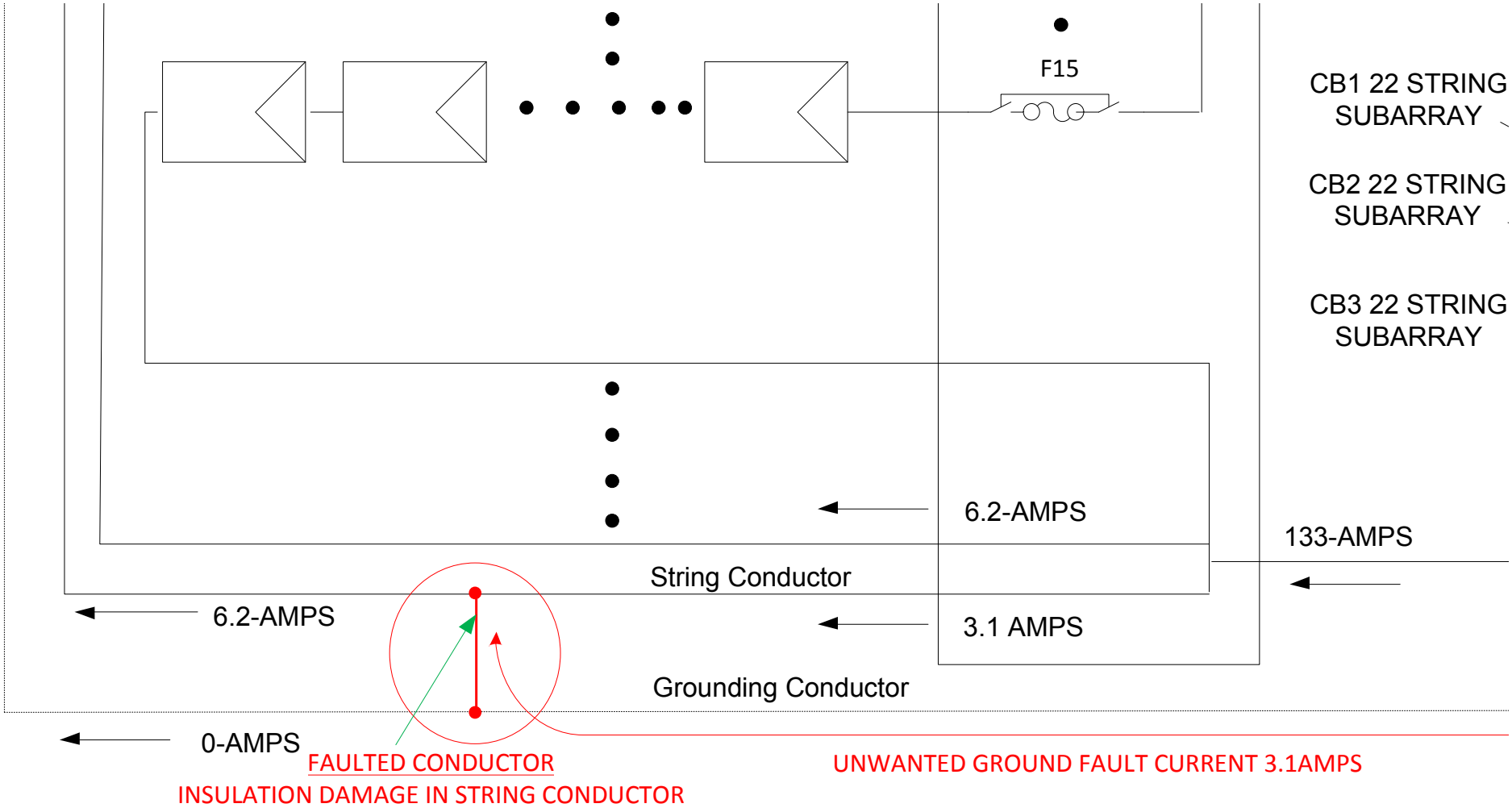

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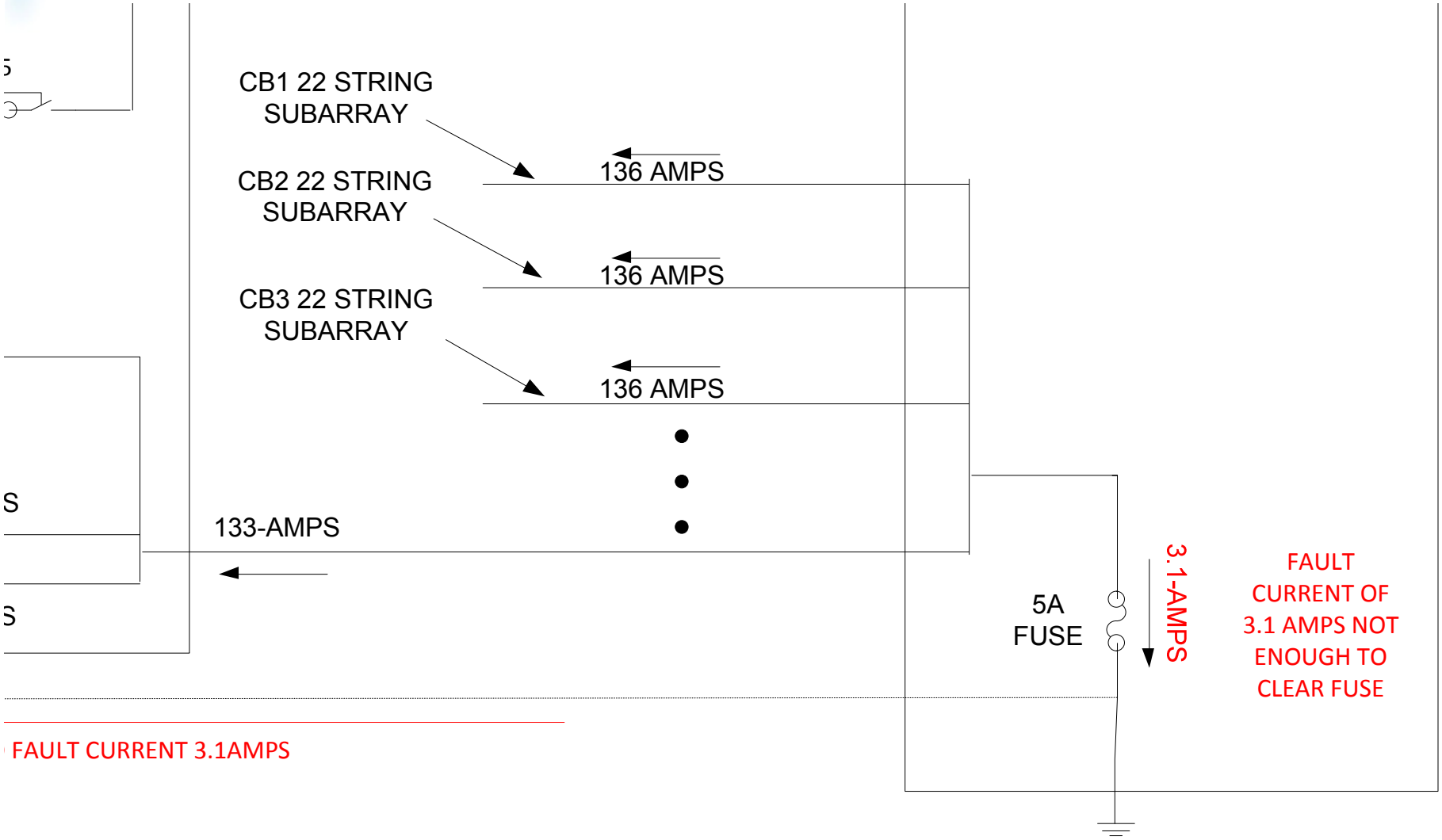

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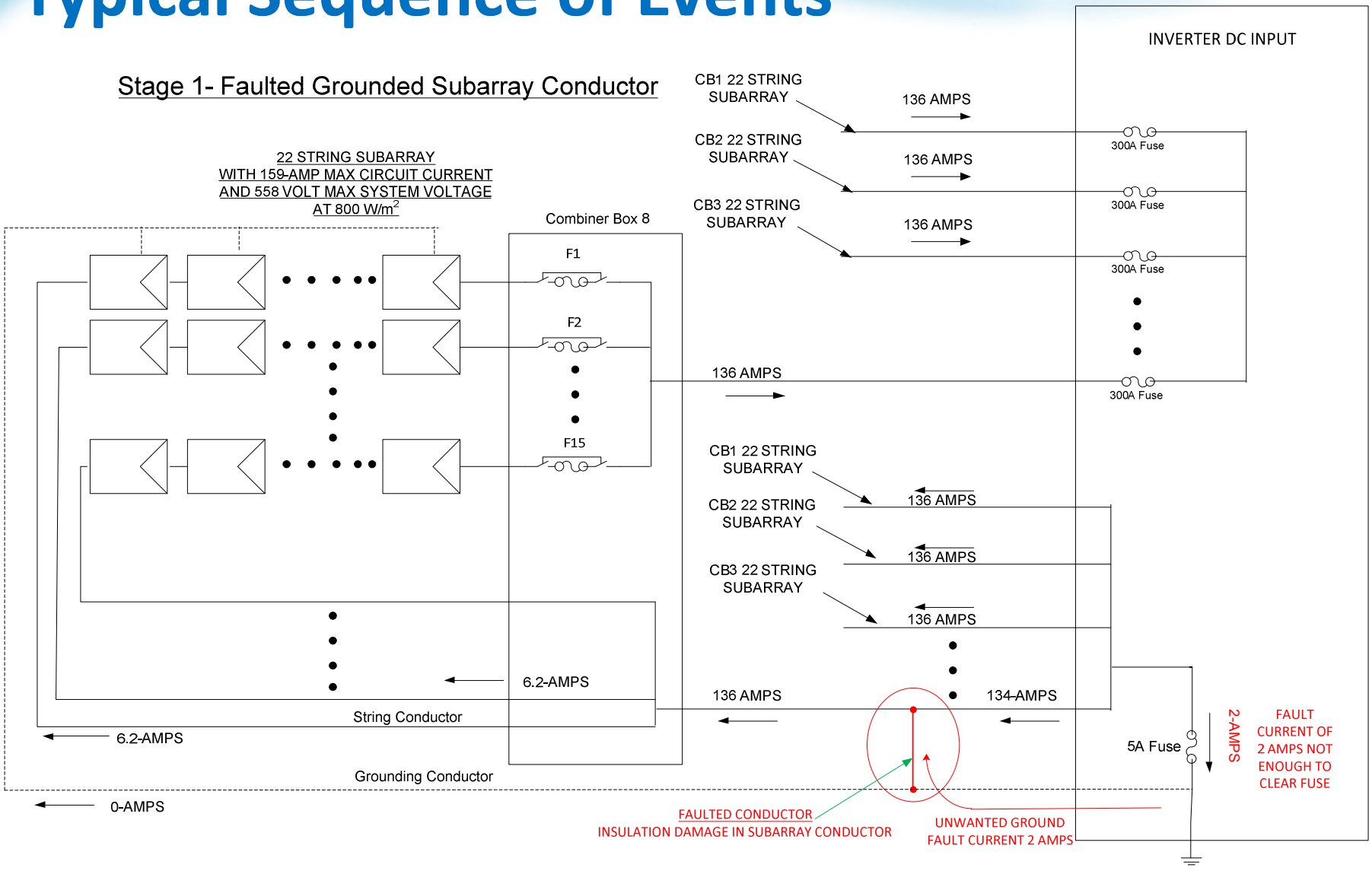

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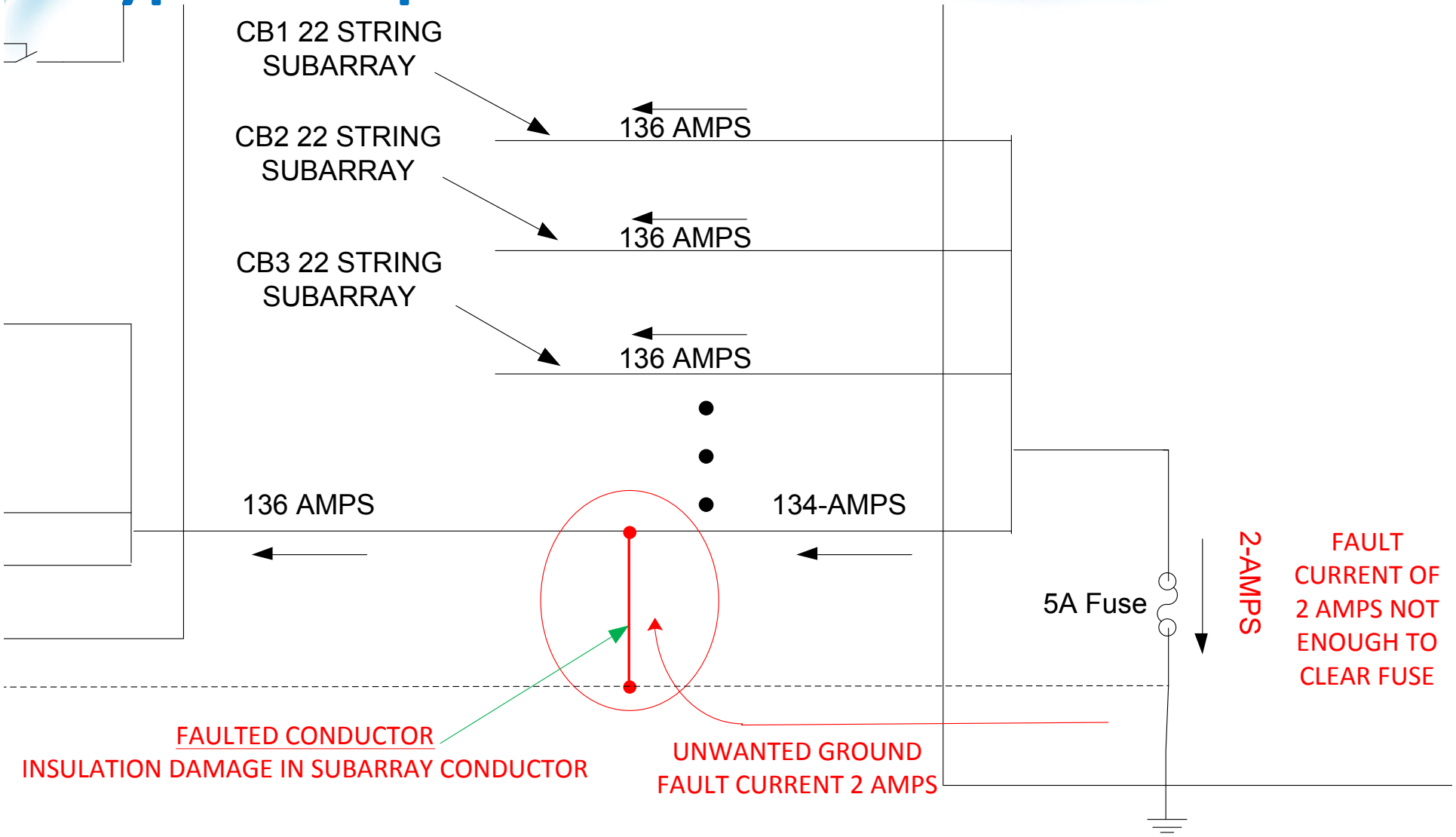

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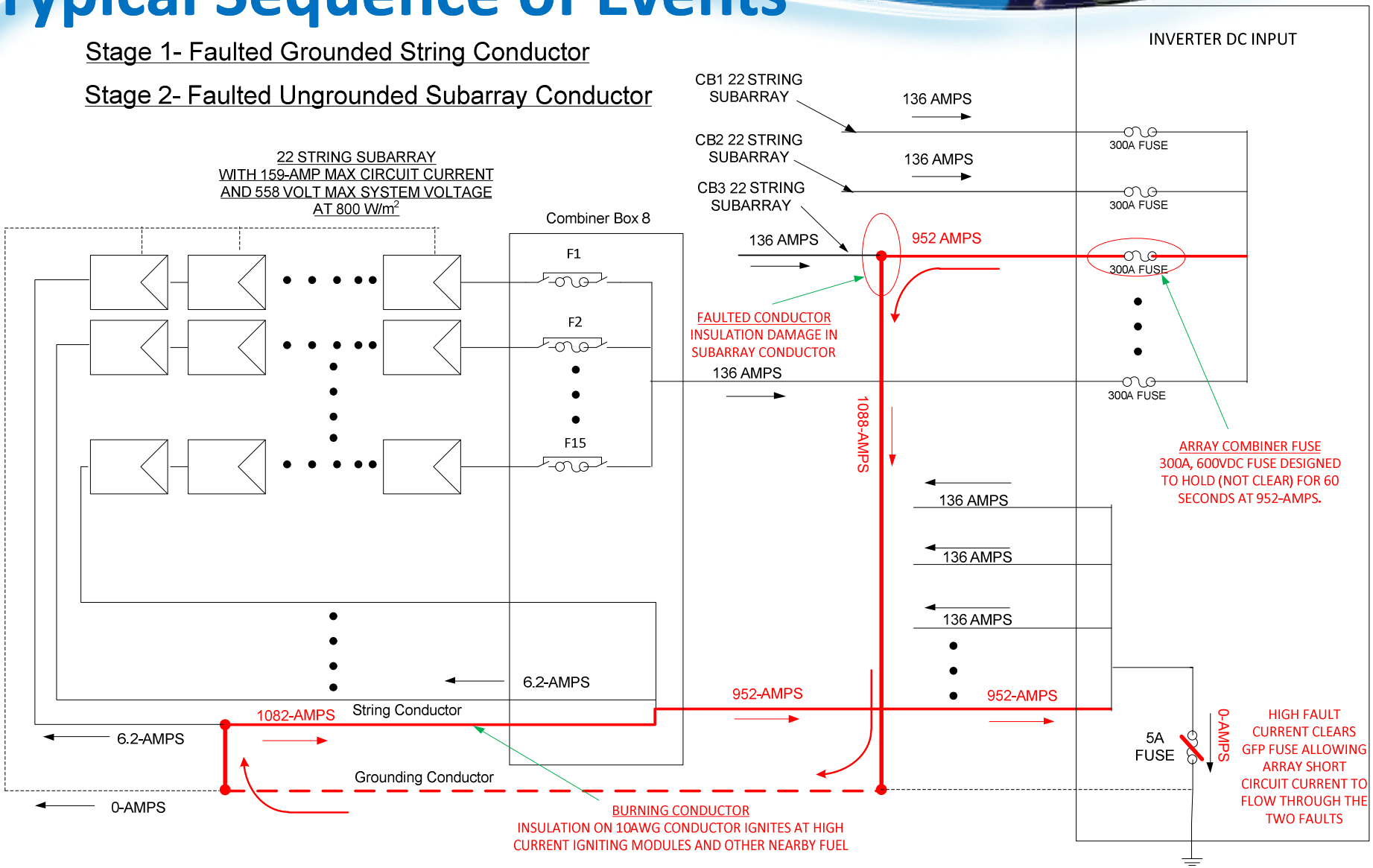
Typical Sequence of Events

Stage 1- Faulted Grounded String Conductor

Stage 2- Faulted Ungrounded Subarray Conductor



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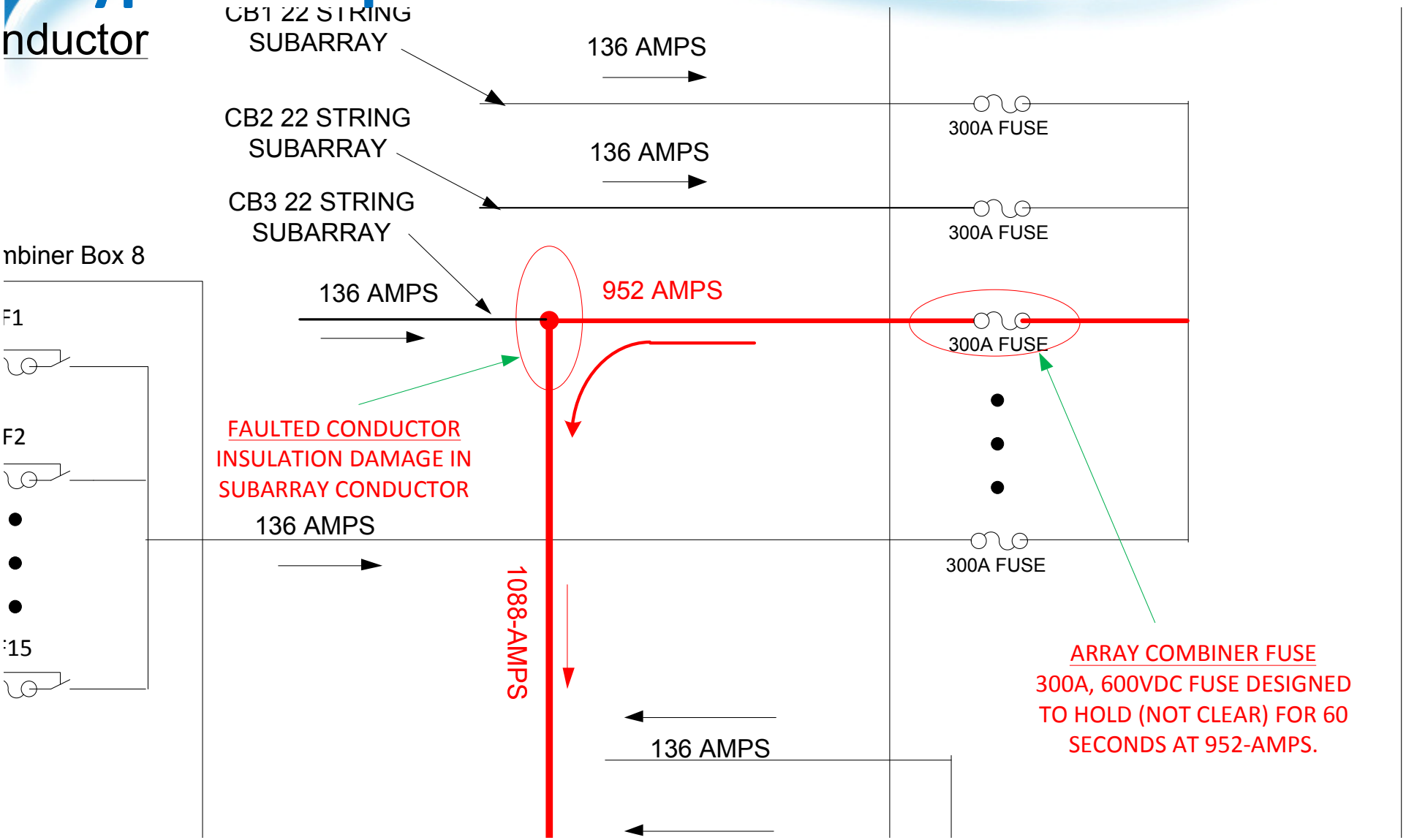

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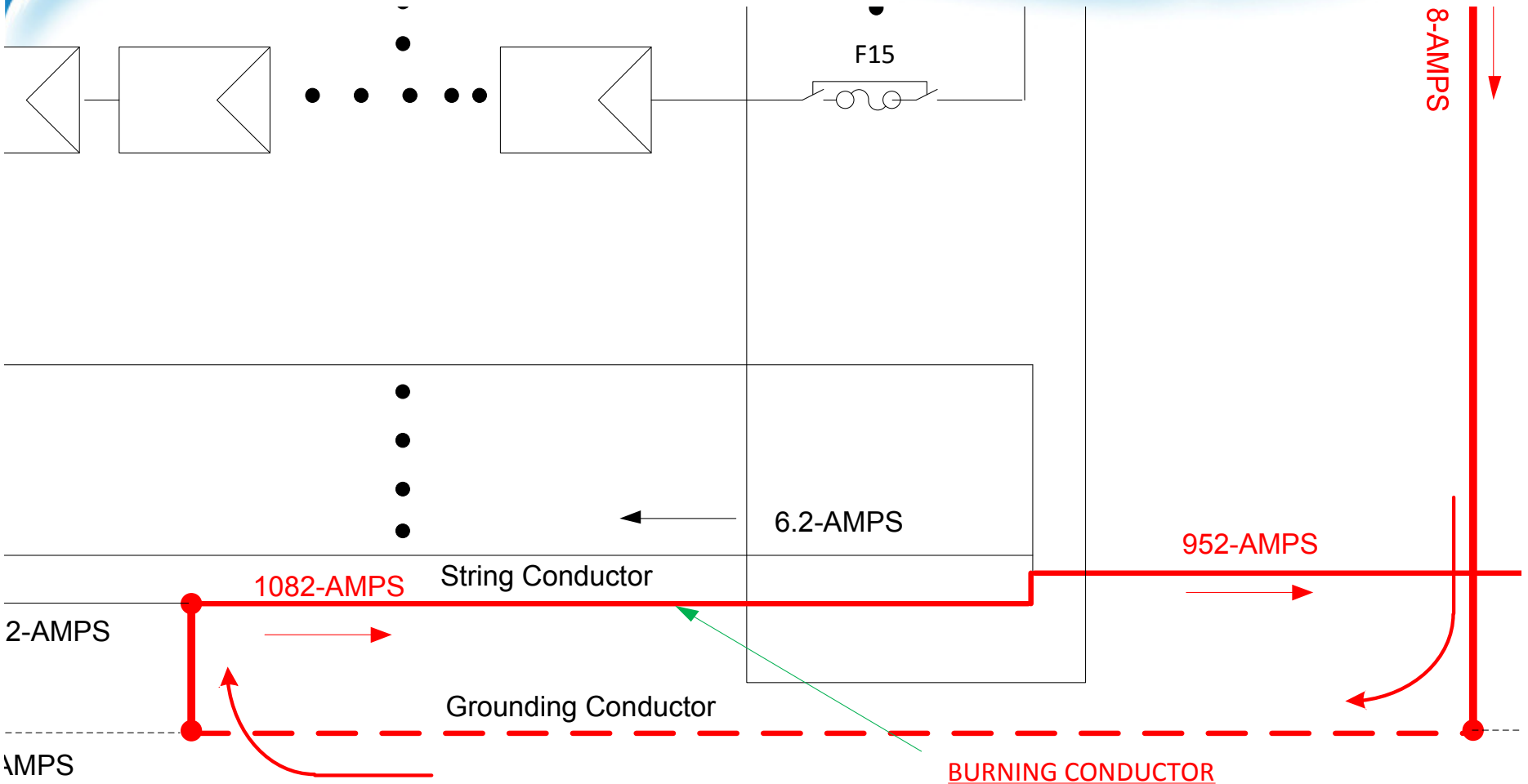

BURNING CONDUCTOR

INSULATION ON 10AWG CONDUCTOR IGNITES AT HIGH CURRENT IGNITING MODULES AND OTHER NEARBY FUEL

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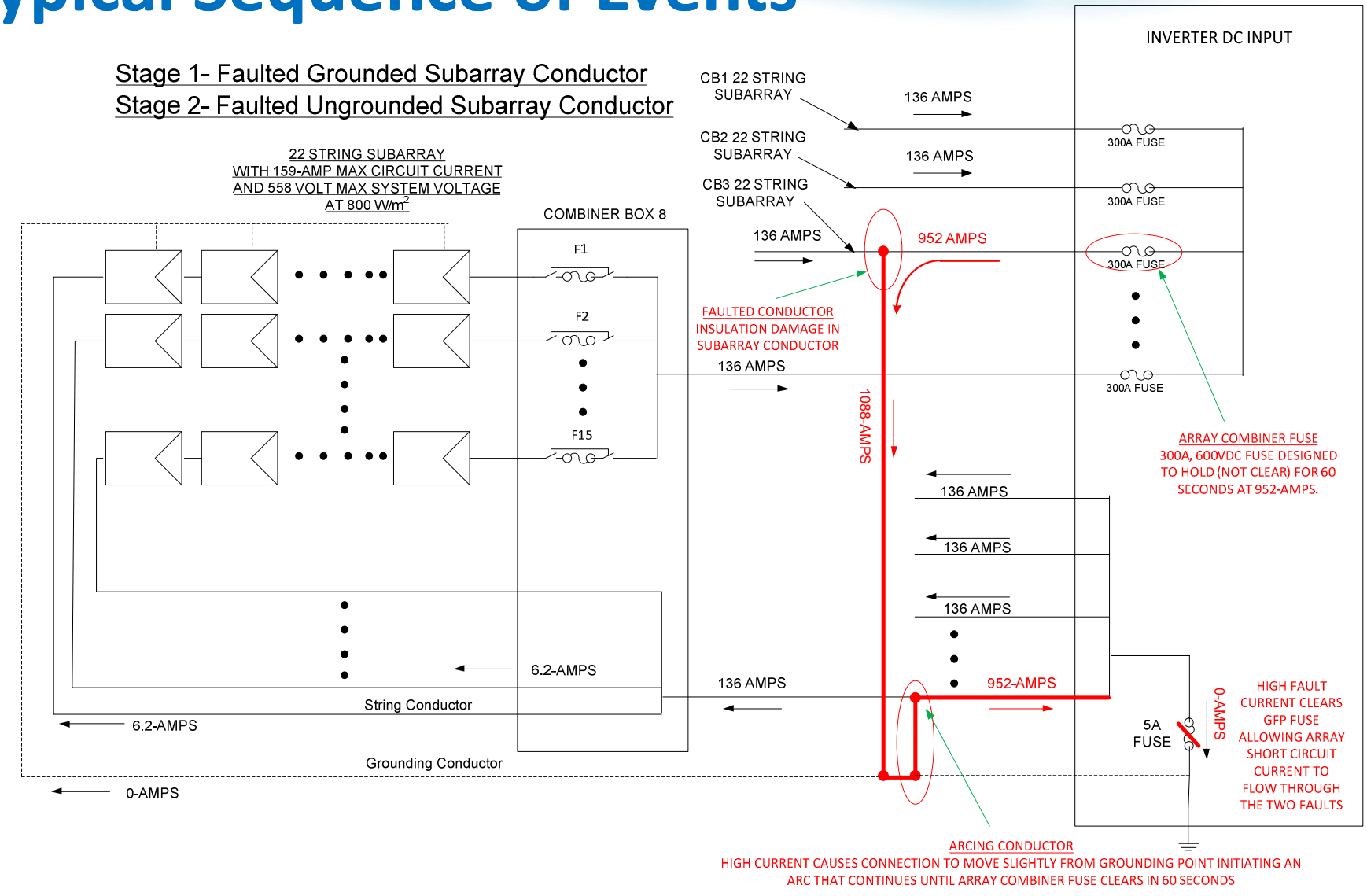
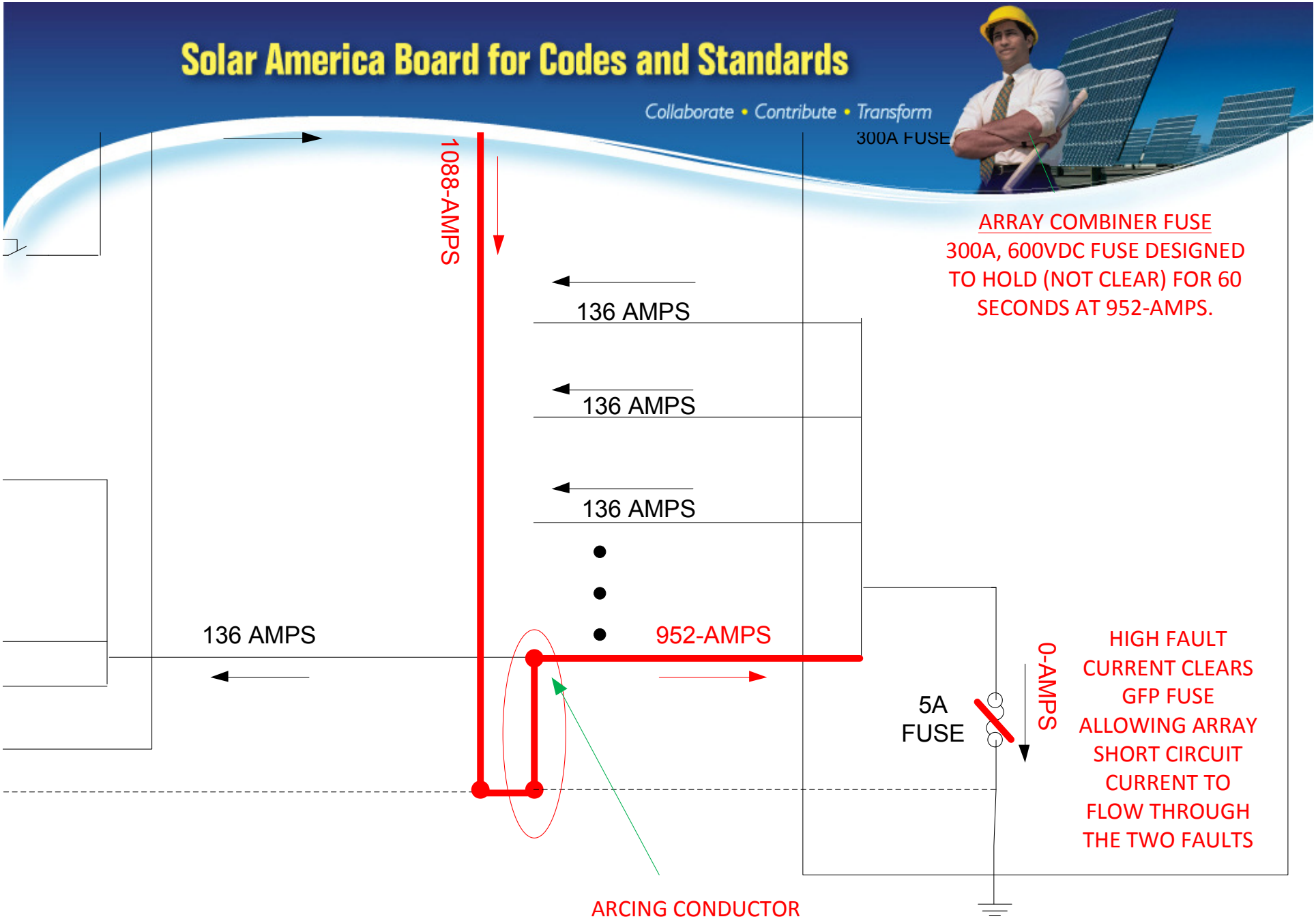
Typical Sequence of Events

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300A FUSE
1088-AMPS
136 AMPS
136 AMPS
136 AMPS
136 AMPS
952-AMPS
0-AMPS
5A
FUSE
ARRAY COMBINER FUSE
300A, 600VDC FUSE DESIGNED TO HOLD (NOT CLEAR) FOR 60 SECONDS AT 952-AMPS.
HIGH FAULT CURRENT CLEARS GFP FUSE ALLOWING ARRAY SHORT CIRCUIT CURRENT TO FLOW THROUGH THE TWO FAULTS
ARCING CONDUCTOR
HIGH CURRENT CAUSES CONNECTION TO MOVE SLIGHTLY FROM GROUNDING POINT INITIATING AN ARC THAT CONTINUES UNTIL ARRAY COMBINER FUSE CLEARS IN 60 SECONDS

"Blindspot"

- Established GFDI limits are larger for larger PV systems
- Current examination of the evidence suggests faults on the grounded array conductor can exist without tripping the ground fault fuse
- Higher ground-fault trip threshold also yields a larger blind-spot

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Solar ABCs Project

- White Paper
- Research
- Report with Recommendations

White Paper

- Describe Problem
- Describe planned research to identify possible causes
- Discuss tests to determine if specific installations can detect faults on the grounded conductor
- Identify possible solutions

Research

- Characterize the conditions where the existing ground-fault protection may be inadequate
- Develop mitigation proposals
  - –Implement through changes to NEC and UL Standards
  - –Working proposal is a combination of a morning check and measurement of differential current.

What about Existing PV Systems with Blindspot?

- Current evidence suggests the need for the following:
  1. proper installation techniques with close attention to wire management,
  2. annual preventative maintenance actions to identify and resolve progressive system damage,
  3. detailed data acquisition to monitor the operation of all PV systems at a level sufficient to determine if unscheduled maintenance is required, and,

What about Existing PV Systems with Blindspot?

4. Possible need to add additional ground fault and PV array isolation sensing devices

- Possible options to be confirmed through research:
  - Retrofit large systems with more sensitive Residual Current Monitors (300mA or less)
  - Where possible, apply daily array insulation test before starting the inverter.

Possible Design Recommendations for Future PV Systems

- Possible options based on future research:
  - Employ retrofit recommendations up front for grounded PV arrays.
  - UNGROUND the array
  - Employ segmenting contactors to reduce current during faults.
  - Arc Fault Detectors (2011 NEC)
  - Module level control to react to faults

Ongoing Codes and Standards Efforts

- UL 1741 that governs PV inverters is being revised to address the blind spot in inverters
- The 2014 National Electrical Code has several proposals that address code concerns related to the blind spot.
- CMP4 Task Group on firefighter safety submitted a proposal to the 2014 NEC that would require all PV systems on buildings to have module-level control.