

Solar America Board for Codes and Standards



Photovoltaic Module Grounding: Issues and Recommendations

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Study Report Overview

This study report by the Solar America Board for Codes and Standards (Solar ABCs) investigates electrical grounding of photovoltaic (PV) modules. The Solar ABCs, with support from the U.S. Department of Energy, commissioned this study to provide the PV industry with practical guidelines and procedures for achieving reliable PV module frame grounding in the overall context of system grounding.

This report also makes recommendations for revising the technical standards that certify PV modules and related grounding components. Solar ABCs published an interim “[Lay of the Land](#)” report on this topic in the spring of 2011, which described the many issues facing industry stakeholders. This final report draws on feedback from the PV industry as well as on research performed at Underwriters Laboratories (UL) to develop guidelines and recommend changes to existing codes and standards.

Why the Report Is Important

The need for this study of PV module grounding issues was identified through a gap analysis completed by the Solar ABCs following a survey of U.S. stakeholders. Among stakeholders, there were concerns about several related issues involving module grounding. The list of stakeholder concerns and issues with PV module grounding included:

- unsatisfactory module grounding results,
- violations of the module’s UL 1703 listing when the installation does not comply with the installation manual’s prescribed method of grounding the module frame,
- incorporation of components listed to more general grounding equipment standards that may or may not be suitable for this application, and/or
- well-engineered grounding measures using methods or combinations of components that together are not listed and have no reasonable process for certification.

Issues

There are two fundamental module grounding issues discussed in the report. The first is that there are limited numbers of approved (listed) grounding methods, despite a variety of installation methods and components available for grounding module frames. This report discusses the substantial developmental activity on three UL standards that will clarify the listing issue for dedicated PV module frame grounding components.

The second is the lack of confidence in existing approved grounding methods, due largely to failures observed in the field from loss of mechanical integrity, installation error, and damage from corrosion. This report presents results of a recent UL study on accelerated aging tests of module grounding connections in which different types of PV grounding connectors were installed and tested in environmental chambers using both continuous damp heat and salt mist exposure. The effects of current cycling, variations in assembly force, and anti-oxidation coating application on grounding reliability were evaluated in conjunction with aging tests.



Key Findings

Results of the current tests described in this report reinforce the conclusions of a UL 1703 Standards Technical Panel (STP) subcommittee charged with developing new language for the Bonding and Grounding section. These tests combined existing low current tests with tests derived from UL 467 that are designed to ensure proper operation of overcurrent protection devices.

In addition, this report considers personnel safety. It explores various fault scenarios in conjunction with International Electrotechnical Commission data describing body impedances and harmful levels of current to provide generalized methods of evaluating ground resistance limits. It also discusses more generalized design criteria using National Electrical Code principles. From a listing standpoint, the current test regimes recommended here should adequately address safety issues such as touch safe voltages and currents.

The standards are still undergoing significant change, so this report concludes with general recommendations for ensuring proper grounds based on field experience and feedback received throughout the course of this study. These recommendations include:

- Complete the proposed changes to the existing standards to improve the method and quality of ground connections.
- Elicit additional industry feedback from the accelerated aging test study to determine if and how these or similar tests might be incorporated into standard testing.
- Be aware of and make use of the new and expanded set of channels for listing module grounding equipment.
- Be aware of the principles of module frame grounding, the type of faults that may occur, and the implications for safety and ground system design.
- Follow the specific design and installation recommendations enumerated in this report, such as using proper materials and components, following manufacturer instructions, using torque wrenches to ensure proper tightening of connections, and avoiding connections of dissimilar metals that lead to corrosion, among others.

Download the full report: www.solarabcs.org/grounding

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About Solar America Board for Codes and Standards

The Solar America Board for Codes and Standards (Solar ABCs) is a collaborative effort among experts to formally gather and prioritize input from the broad spectrum of solar photovoltaic stakeholders including policy makers, manufacturers, installers, and consumers resulting in coordinated recommendations to codes and standards making bodies for existing and new solar technologies. The U.S. Department of Energy funds Solar ABCs as part of its commitment to facilitate widespread adoption of safe, reliable, and cost-effective solar technologies. For more information, visit the Solar ABCs website: www.solarabcs.org

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