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## Interconnecting distributed resources with electric power systems

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# INTERCONNECTING DISTRIBUTED RESOURCES WITH ELECTRIC POWER SYSTEMS

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It is based on IEEE Std 1547™-2003. It is published as a double-logo PAS.

| The text of this PAS is based on the following document: | This PAS was approved for publication by the P-members of the committee concerned as indicated in the following document: |
|---|---|
| **Draft PAS** | **Report on voting** |
| 8/1296/PAS | 8/1299/RVD |

Following publication of this PAS the technical committee or subcommittee concerned may transform it into an International Standard.

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**IEEE Std 1547™-2003**

# IEEE Standard for Interconnecting Distributed Resources with Electric Power Systems

Sponsor

**Standards Coordinating Committee 21**
**(Fuel Cells, Photovoltaics, Dispersed Generation, and Energy Storage)**

Approved 12 June 2003 **IEEE-**

**SA Standards Board**

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**Abstract:** This standard is the first in the 1547 series of interconnection standards and is a benchmark milestone demonstrating the open consensus process for standards development. Traditionally, utility electric power systems (EPS--grid or utility grid) were not designed to accommodate active generation and storage at the distribution level. As a result, there are major issues and obstacles to an orderly transition to using and integrating distributed power resources with the grid. The lack of uniform national interconnection standards and tests for interconnection operation and certification, as well as the lack of uniform national building, electrical, and safety codes, are understood. IEEE Std 1547 and its development demonstrate a model for ongoing success in establishing additional interconnection agreements, rules, and standards, on a national, regional, and state level. IEEE Std 1547 has the potential to be used in federal legislation and rule making and state public utilities commission (PUC) deliberations, and by over 3000 utilities in formulating technical requirements for interconnection agreements for distributed generators powering the electric grid.

This standard focuses on the technical specifications for, and testing of, the interconnection itself. It provides requirements relevant to the performance, operation, testing, safety considerations, and maintenance of the interconnection. It includes general requirements, response to abnormal conditions, power quality, islanding, and test specifications and requirements for design, production, installation evaluation, commissioning, and periodic tests. The stated requirements are universally needed for interconnection of distributed resources (DR), including synchronous machines, induction machines, or power inverters/converters and will be sufficient for most installations. The criteria and requirements are applicable to all DR technologies, [IEC IN SOME COUNTRIES CLAUSE: with aggregate capacity of 10 MVA or less at the point of common coupling], interconnected to electric power systems at typical primary and/or secondary distribution voltages. Installation of DR on radial primary and secondary distribution systems is the main emphasis of this document, although installation of DR on primary and secondary network distribution systems is considered. [IEC IN SOME COUNTRIES CLAUSE: This standard is written considering that the DR is a 60 Hz source].

**Keywords:** certification; codes; commissioning, dc injection; design, field, installation, production tests; communications; diesel generators; distributed generation, power; resources; electric distribution systems; dispersed generation, storage; energy storage; faults; flicker; fuel cells; generators; grid; harmonics; IEEE; induction machines; inverters; interconnection requirements and specifications; islanding; microturbines; monitoring and control; paralleling; power converters, networks, quality; photovoltaic power systems; point of common coupling; public utility commissions; reclosing coordination; regulations; rule making, federal, national, regional, state; standards; synchronous machines; testing; utilities; wind energy systems.

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# IEEE INTRODUCTION

(This introduction is not part of IEEE Std 1547-2003, IEEE Standard for Interconnecting Distributed Resources with Electric Power Systems.)

IEEE Std 1547-2003 is the first of a series of standards being developed by Standards Coordinating Committee 21 on Fuel Cells, Photovoltaics, Dispersed Generation, and Energy Storage (SCC21) concerning distributed resources interconnection. The titles of the additional documents in that series follow.

– IEEE P1547. 1™ Draft Standard For Conformance Test Procedures for Equipment Interconnecting Distributed Resources with Electric Power Systems
– IEEE P1 547.2™ Draft Application Guide for IEEE Std 1547-2003, IEEE Standard for Interconnecting Distributed Resources with Electric Power Systems
– IEEE P1 547.3™ Draft Guide for Monitoring, Information Exchange, and Control of Distributed Resources Interconnected with Electric Power Systems

This first publication of IEEE Std 1547-2003 is an outgrowth of the changes in the environment for production and delivery of electricity and builds on prior IEEE recommended practices and guidelines developed by SCC21 [IEC IN SOME COUNTRIES CLAUSE: e.g., IEEE Std 929™-2000, IEEE Recommended Practice for Utility Interface of Photovoltaic (PV) Systems], and Standards Coordinating Committee 23 on Dispersed Storage and Generation (e.g., IEEE Std 1001™-1988, Guide for Interfacing Dispersed Storage and Generation Facilities with Electric Utility Systems).

Traditionally, utility electric power systems (EPS) were not designed to accommodate active generation and storage at the distribution level. The technologies and operational concepts to properly integrate distributed resources (DR) into the existing EPS continue to be further developed to fully realize benefits and to avoid negative impacts on system reliability and safety.

There is a critical need to have a single document of consensus standard technical requirements for DR interconnection rather than having to conform to numerous local practices and guidelines. This standard addresses that critical need by providing uniform criteria and requirements relevant to the performance, operation, testing, safety considerations, and maintenance of the interconnection.

The intent of this standard is to define the technical requirements in a manner that can be universally adopted. The universality relates not only to the technical aspects, but also to the adoption of this standard as being pertinent across a number of industries and institutions, e.g., hardware manufacturers, utilities, energy service companies, codes and standards organizations, regulators and legislators, and other interested entities.

This standard focuses on the technical specifications for, and testing of, the interconnection itself, and not on the types of the DR technologies. This standard aims to be technology neutral, although cognizant that the technical attributes of DR and the types of EPSs do have a bearing on the interconnection requirements. The addition of DR to an EPS will change the system and its response in some manner. Although this standard establishes criteria and requirements for interconnection, this standard is not a design handbook nor is it an application guideline. This standard provides the minimum functional technical requirements that are universally needed to help assure a technically sound interconnection. Any additional local requirements should not be implemented to the detriment of the functional technical requirements of this standard.

It is beyond the scope of this standard to address the methods used for performing EPS impact studies, mitigating limitations of the Area EPS, or for addressing the business or tariff issues associated with interconnection.

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# INTERCONNECTING DISTRIBUTED RESOURCES WITH ELECTRIC POWER SYSTEMS

## 1 Overview

This standard provides interconnection technical specifications and requirements, and test specifications and requirements. Additionally, there is a bibliography included as Annex A that lists citations referred to in this standard for informative purposes, but that are not required to be used in conjunction with this standard.

### 1.1 Scope

This standard establishes criteria and requirements for interconnection of distributed resources (DR) with electric power systems (EPS).

### 1.2 Purpose

This standard provides a uniform standard for interconnection of distributed resources with electric power systems. It provides requirements relevant to the performance, operation, testing, safety considerations, and maintenance of the interconnection.

The requirements shall be met at the point of common coupling (PCC), although the devices used to meet these requirements can be located elsewhere. This standard applies to interconnection based on the aggregate rating of all the DR units that are within the Local EPS. The functions of the interconnection system hardware and software that affect the Area EPS are required to meet this standard regardless of their location on the EPS.

The stated specifications and requirements, both technical and testing, are universally needed for interconnection of DR, including synchronous machines, induction machines, or power inverters/converters, and will be sufficient for most installations.[1]

### 1.3 Limitations

The criteria and requirements in this document are applicable to all distributed resource technologies, [IEC IN SOME COUNTRIES CLAUSE: with aggregate capacity of 10 MVA or less at the PCC], interconnected to EPSs at typical primary and/or secondary distribution voltages. Installation of DR on radial primary and secondary distribution systems is the main emphasis of this standard, although installation of DR on primary and secondary network distribution systems is considered. [IEC IN SOME COUNTRIES CLAUSE: This standard is written considering that the DR is a 60 Hz source].

– This standard does not define the maximum DR capacity for a particular installation that may be interconnected to a single PCC or connected to a given feeder.

– This standard does not prescribe DR self-protection or all operating requirements for DR units.

– This standard does not address planning, designing, operating, or maintaining the Area EPS.

– This standard does not apply to automatic transfer schemes in which load is transferred between the DR and the EPS in a momentary make-before-break

[1] Additional technical requirements and/or tests may be necessary for some limited situations.

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operation provided the duration of paralleling the sources is less than 100 ms, except as noted in 4.1.4.

## 2 References

[IEC IN SOME COUNTRIES CLAUSE: The following standards shall be used in conjunction with this standard. When the stated version of the following standards is superseded by an approved revision, then that revision shall apply.

The applicability of the following standards is determined by the specific requirements stated in this standard, such as requiring certain sections.

ANSI C84.1-1995, *Electric Power Systems and Equipment –Voltage Ratings (60 Hz).*[2]

IEEE Std C37.90.1™-2002, *IEEE Standard Surge Withstand Capability (SWC) Tests for Relays and Relay Systems Associated with Electric Power Apparatus*[3,4]

IEEE Std C37.90.2™-1995, *IEEE Standard Withstand Capability of Relay Systems to Radiated Electromagnetic Interference from Transceivers*

IEEE Std C62.41.2™-2002, *IEEE Recommended Practice on Characterization of Surges in Low Voltage (1000 V and less) AC Power Circuits*

IEEE Std C62.45™-2002, *IEEE Recommended Practice on Surge Testing for Equipment Connected to Low-Voltage (1000 V and Less) AC Power Circuits*

NEMA MG 1-1998, *Motors and Generators,* Revision 2.[5] ]

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