

IEEE Guide for the Interconnection of User-Owned Substations to Electric Utilities

Sponsor
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of the
IEEE Power Engineering Society**

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Abstract: IEEE Std 1109-1990, *IEEE Guide for the Interconnection of User-Owned Substations to Electric Utilities*, provides a checklist and selected guidance, for persons not normally practicing in this specialized field, of major technical design areas that should be considered when interconnecting user-owned and utility-owned facilities at substations. Only medium- and high-voltage purchased-power interconnections are addressed. This guide does not discuss the considerable implications of interactive power systems design and operation, nor does it present criteria or directions for the design of substations.

Keywords: high-voltage purchased-power interconnections, interconnections, medium-voltage purchased-power interconnections, non-utility generation, substations, user-owned and utility-owned facilities at substations

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Foreword

(This Foreword is not a part of IEEE Std 1109-1990 , IEEE Guide for the Interconnection of User-Owned Substations to Electric Utilities.)

This guide provides a “checklist” and selected guidance, for persons not normally practicing in this specialized field, on topics that should be considered when developing the interconnection of user-owned and electric-utility-owned electric power facilities, particularly substations. This guide is concerned with large substations for purchased-power-only service and also with substations of all sizes associated with the interconnection of user-owned generating (interactive power, dispersed power, cogeneration, or small-power-producer) facilities.

This guide is concerned with generation (interactive electrical system) interconnections of all magnitudes to the degree that the substation facilities are affected. However, it is not within the scope of this guide to discuss in detail the considerable implications of interactive power systems design and operations, since these are covered in other documents.

A listing of code and standard agencies relevant to substation design is included in the Appendix.

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IEEE Guide for the Interconnection of User-Owned Substations to Electric Utilities

1. Introduction and Scope

This guide presents a “checklist” of major technical design areas that should be considered when interconnecting user-owned and utility-owned facilities at substations. Guidance is presented in selected areas of particular importance.

This guide principally provides guidance for the interconnection of user-owned substations. In this regard only medium- and high-voltage purchased-power interconnections are addressed, since low-voltage (and some medium-voltage) interconnections for typical residential, commercial, and small industrial energy purchase are adequately covered by existing electric utility practices and standards.

Historically, most utilities with a significant industrial base load have established technical guidelines for large purchasers of electric energy when the user’s demand mandates the construction of a medium- or high-voltage substation having a capacity greater than 500 kVA and connected to a three-phase power interconnection with a voltage greater than 15 kV. These substation and interconnection facilities were usually for the user purchase of electric power only. The presence of a user’s own in-house generation facility was uncommon enough to be handled on a case-by-case basis.

The advent of the Public Utilities Regulatory Policies Act (PURPA) of 1978, as well as other public laws, has precipitated the development of numerous new electric power generating facilities that are necessarily interconnected to established electric utilities. It is common for these “dispersed” facilities to be fostered by entrepreneurial organizations that may or may not be cognizant of the complexities associated with connecting to and interacting with a large electric system by means of a dedicated substation facility, such as is addressed by this document. Therefore, this guide does address in general the interconnection of interactive (dispersed generation, cogeneration, and small-power producer) facilities of all sizes with electric utilities, to the degree that the interconnection substation design is affected. However, the subject of interactive power systems is addressed in greater detail in the publications of other agencies or committees.

It is not the intent of this guide to present detailed design criteria or directions. And it is beyond the scope of this document to discuss commercial or contractual issues, which are covered by other existing industry codes, standards, and practices. Also, detailed discussions of the design and operation of interactive power systems (cogeneration, dispersed power, small power producers; and user-owned generation) are not included, since it would be beyond the scope of this document and since these topics are covered by other existing or forthcoming documents.

A listing of related code and standard agencies is included as an appendix to aid the users of this guide in finding other codes and standards applicable to the design, operation, and equipment selection of proposed interconnection substations.

2. Definitions and References

2.1 Definitions

cogeneration: The generation of electric energy and commercial or industrial quality heat or steam from a single facility.

dispersed power: An electric power generation source (or sources) not directly under established electric utility ownership and control.

electrical system: The existing utility network consisting of interconnected and synchronized generation, transmission, and distribution facilities.

generation: The production or storage, or both, of electric energy with the intent of enabling practical use of commercial sale of the available energy. This includes photovoltaic, wind-farm, hydro, etc., as well as normal commercial and industrial thermal sources.

interactive electrical systems: Two or more interconnected and compatible electrical systems with appropriate protection and measuring provisions at their interconnection point(s).

interconnection: The physical plant and equipment required to facilitate the transfer of electric energy between two or more entities. It can consist of a substation and an associated transmission line and communications facilities or only a simple electric power feeder.

small-power producer: A non-utility generation source that is a qualifying small-power production facility under PURPA and the Federal Energy Regulatory Commission (FERC).

user (or customer): The independent party that may be a purchaser of utility electric power or a producer of electric energy for sale to an electric utility or both.

2.2 References

This guide shall be used in conjunction with the following publications. When the following standards are superseded by an approved revision, the revision shall apply.

[1] ANSI C2-1990 National Electrical Safety Code.¹

[2] ANSI C84.1-1989 Voltage Ratings for Electric Power Systems and Equipment (60 Hz).

[3] IEEE Std C37.1-1987 IEEE Standard Definition, Specification, and Analysis of Systems Systems Used for Supervisory Control, Data Acquisition, and Automatic Control (ANSI).²

[4] IEEE Std C37.2-1987 IEEE Standard Electrical Power System Device Function Numbers (ANSI).

[5] IEEE Std C37.122-1983 IEEE Standard Gas-Insulated Substations (ANSI).

[6] IEEE Std 80-1986 IEEE Guide for Safety in AC Substation Grounding (ANSI).

¹ANSI publications are available from the Sales Department, American National Standards Institute, 1430 Broadway, New York, NY 10018, USA.

²IEEE publications are available from the Institute of Electrical and Electronics Engineers, Service Center, 445 Hoes Lane, Piscataway, NJ 08855-1331, USA.

- [7] IEEE Std 81-1983 IEEE Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System (ANSI).
- [8] IEEE Std 525-1987 IEEE Guide for the Design and Installation of Cable Systems in Substations (ANSI).
- [9] IEEE Std 605-1987 IEEE Guide for Design of Substation Rigid-Bus Structures (ANSI).
- [10] IEEE Std 979-1984 IEEE Guide for Substation Fire Protection (ANSI).
- [11] IEEE Std 980-1987 IEEE Guide for Containment and Control of Oil Spills in Substations (ANSI).
- [12] IEEE P998 (Draft) Guide for Direct Lighting Stroke Shielding of Substations.³
- [13] IEEE Std 1001-1988 IEEE Guide for Interfacing Dispersed Storage and Generation Facilities With Electric Utility Systems (ANSI).
- [14] IEEE Std 1119-1988 IEEE Guide for Fence Safety Clearances in Electric-Supply Stations (ANSI).
- [15] IEEE P1127 (Draft) Guide for the Design, Construction, and Operation of Safe and Reliable Substations for Environmental Acceptance.⁴
- [16] NFPA 70-1990, National Electrical Code (ANSI).⁵

3. System Interconnection Considerations

Whether a proposed interconnection is for an interactive (i.e., including user-owned generation) or purchased-energy-only facility, the following significant design factors should be considered for the high-voltage electric power interface. Care should be taken to ensure that each party of the interconnection uses a comparable basis for ratings (i.e., temperature rise) and the same formulas for calculations (e.g., transformer loss-of-life or no-loss-of-life for overloading) to avoid wasteful overbuilding on the one hand or potentially destructive overloading on the other.

3.1 Voltage, Voltage Range, Frequency, and Frequency Range

Interconnection facility ratings should be selected to operate satisfactorily with the utility's nominal and normal operating voltage and frequency. Further, the design of the interconnection facility should consider the anticipated minimum and maximum voltage ranges below and above nominal, respectively. Typical permissible voltage ranges are up to $\pm 5\%$ of nominal voltage and can be higher. It is particularly important to determine the impact of starting large motors and other major equipment under low-voltage conditions. Standard nominal system voltages and voltage ranges can be found in ANSI C84.1-1987 [2].⁶ The nominal operating frequency in the United States is 60 Hz. Under normal conditions, the instantaneous operating frequency may range from 59.970 to 60.030 Hz. For interconnected utility operation, frequency is usually discussed, measured, and displayed with a resolution of 0.001 Hz. In other parts of the world, other nominal operating frequencies (for example, 50 Hz) and other ranges of instantaneous operating frequency may be used.

³This draft document is currently in production; when it is completed, approved, and published, it will become a part of the references of this guide.

⁴See footnote 3.

⁵NFPA publications are available from Publications Sales, National Fire Protection Association, Battery-march Park, Quincy, MA 02269, USA.

⁶The numbers in brackets correspond to those of the references in 2.2.