Approved & Proposed IEEE Smart Grid Standards
As of 5/2015

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1. **C62.11a-2008 IEEE Standard for Metal-Oxide Surge Arresters for AC Power Circuits (>1 kV) Amendment 1: Short-Circuit Tests for Station Intermediate and Distribution Arresters**

   Metal-oxide surge arresters designed to repeatedly limit the voltage surges on 48 Hz to 62 Hz power circuits (>1000 V) by passing surge discharge current and automatically limiting the flow of system power current applies to this amendment. This amendment covers devices for separate mounting and to those supplied integrally with other equipment. The tests demonstrate that an arrester can survive the rigors of reasonable environmental conditions and system phenomena, while, at the same time, protect equipment and/or the system from damaging overvoltages caused by lightning, switching, or other undesirable surges.

2. **C62.39-2012 - IEEE Standard for Test Methods and Preferred Values for Self-Restoring Current-Limiter Components Used in Telecommunication Surge Protection**

   This standard sets terms, test methods and measurement procedures for series connected, self-restoring current limiter components used in low-voltage telecommunication circuit surge protectors. It is only applicable for components in telecommunications circuits with voltages equal to or less than 1000 V rms or 1200 V dc. The self-restoring current limiters covered by this standard have the following properties: · Excessive current causes a transition from a low-resistance state to a high-resistance state · Reverts to a low-resistance state when the excessive current ends · Directly operated by the current flow through the component · Solid-state (no moving parts) · Withstands specified levels of impulse · Withstands specified AC voltage levels when in the high-resistance state Examples of this type of current limiter technology are positive temperature coefficient step-function thermistors of ceramic or polymeric material and silicon semiconductor based electronic circuits. This standard does not cover self-restoring current limiter components used in other applications, such as heaters, inrush-current limiters or sensing devices. Current interrupting type components, which reduce the current to zero by a mechanical circuit break, are not covered by this standard. In this standard, a telecommunications circuit is a circuit that uses metallic conductors to handle the remote transmission of information, such as data, communications and signalling.

3. **42010-2011 ISO/IEC/IEEE Standard for Systems and Software Engineering -- Architectural Description**

   The scope of this standard encompasses those products of system and software development that capture architectural information, referred to as "e;architectural descriptions"e;. This includes architectural descriptions that are used for the following: a) Expression of the system or software and its evolution b) Communication among the stakeholders c) Evaluation and comparison of architectures in a consistent manner d) Planning, managing, and executing the activities of development e) Expression of the persistent characteristics and supporting principles of a system or software to guide acceptable change f) Verification of an implementation's compliance with an architectural description g) Recording contributions to the body of knowledge of systems and software architecture

4. **IEC 61588 Ed.2 (2009-02) (IEEE Std 1588™-2008): Precision Clock Synchronization Protocol for Networked Measurement and Control Systems**

   A protocol to synchronize independent clocks running on separate nodes of a distributed measurement and control system to a high degree of accuracy and precision is specified. The protocol is independent of the networking technology, and the system topology is self-configuring.
   Outdoor ac substations, either conventional or gas-insulated, are covered in this guide. Distribution, transmission, and generating plant substations are also included. With proper caution, the methods described herein are also applicable to indoor portions of such substations, or to sub-stations that are wholly indoors. No attempt is made to cover the grounding problems peculiar to dc substations. A quantitative analysis of the effects of lightning surges is also beyond the scope of this guide.

5. **81-1983 IEEE Guide for Measuring Earth Resistivity Ground Impedance and Earth Surface Potentials of a Ground System Part 1: Normal Measurements**

   The technique of measuring ground resistance and impedance, earth resistivity, potential gradients from currents in the earth, and the prediction of the magnitudes of ground resistance and potential gradients from scale model tests are described and discussed. Factors influencing the choice of instruments and the techniques for various types of measurements are covered. These include the purpose of the measurement, the accuracy required, the type of instruments available, possible sources of error, and the nature of the ground or grounding system under test. Large power station ground grids and counterpoises of transmission lines are examples of such grounding systems. The standard is intended to assist the engineer or technician in obtaining and interpreting accurate, reliable data. It describes test procedures which promote the safety of personnel and property, and prevent interference with the operation of neighboring facilities.

6. **P81 - Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Grounding System**

   The test methods and techniques used to measure the electrical characteristics of the grounding system include the following topics: a) Establishing safe testing conditions. b) Measuring earth resistivity. c) Measuring the power system frequency resistance or impedance of the ground system to remote earth. d) Measuring the transient (surge) impedance of the ground system to remote earth. e) Measuring step and touch voltages. f) Verifying the integrity of the grounding system. g) Reviewing common methods and procedures for performing ground testing. h) Reviewing instrumentation characteristics and limitations. i) Reviewing various factors that can distort test measurements.

7. **81.2-1991 IEEE Guide for Measurement of Impedance and Safety Characteristics of Large Extended or Interconnected Grounding Systems**

   The purpose of this guide is to present practical instrumentation methods that may be used for the measurement of impedance to remote earth, step and touch potentials, and current distributions of large extended or interconnected grounding systems ranging in complexity from small grids (less than 900 m/sup 2/), with only a few connected overhead or direct burial bare concentric neutrals, to large grids (greater than 20 000 m/sup 2/), with many connected neutrals, overhead ground wires (sky wires), counterpoises, grid tie conductors, cable shields, and metallic pipes.

8. **367-1996 IEEE Recommended Practice for Determining the Electric Power Station Ground Potential Rise and Induced Voltage From a Power Fault**

   Guidance for the calculation of power station ground potential rise (GPR) and longitudinal induction (LI) voltages is provided, as well as guidance for their appropriate reduction from worst-case values, for use in metallic telecommunication protection design.

9. 487-2007 IEEE Recommended Practice for the Protection of Wire-Line Communication Facilities Serving Electric Supply Stations

Workable methods for protecting wire-line communication circuits entering electric supply locations are presented. This document covers: the electric supply location environment; protection apparatus; service types, reliability, service performance objective classifications, and transmission considerations; protection theory and philosophy; protection configurations; installation and inspection; and safety.

10. 644-1994 IEEE Standard Procedures for Measurement of Power Frequency Electric and Magnetic Fields from AC Power Lines

In this IEEE Standard uniform procedures for the measurement of power frequency electric and magnetic fields from alternating current (AC) overhead power lines and for the calibration of the meters used in these measurements are established. The procedures apply to the measurement of electric and magnetic fields close to ground level. The procedures can also be tentatively applied (with limitations, as specified in the standard) to electric fields near an energized conductor or structure

11. 656-1992 IEEE Standard for the Measurement of Audible Noise from Overhead Transmission Lines

In this standard uniform procedures are established for manual and automatic measurement of audible noise from overhead transmission lines. Their purpose is to allow valid evaluation and comparison of the audible noise performance of various overhead lines. Definitions are provided, and instruments are specified. Measurement procedures are set forth, and precautions are given. Supporting data that should accompany the measurement data are specified, and methods for presenting the latter are described.

12. P789 - Standard Performance Requirements for Communications and Control Cables for Application in High Voltage Environments

This standard applies to wires and cables, used principally for power system communications and control purposes, which are located within electric supply locations or are installed within the zone of influence (ZOI) of the power station ground potential rise (GPR), or which may be buried adjacent to electric power transmission and distribution lines. This standard covers the appropriate design requirements, electrical and mechanical parameters, the testing requirements, and the handling procedures for cables that are to be installed and operated in high voltage environments where they may be subjected to high voltages either by conduction, or induction coupling, or both. Coaxial and fiber optic cables, except for those used in Ethernet applications, are specifically excluded from this

standard.

13. 802-2001 IEEE Standard for Local and Metropolitan Area Networks: Overview and Architecture

IEEE Std 802-2001, IEEE Local and Metropolitan Area Networks: Overview and Architecture, provides an overview to the family of IEEE 802 standards. This amendment to IEEE Std 802-2001 specifies an Object Identifier hierarchy used within IEEE 802 for uniform allocation of Object Identifiers used in IEEE 802 standards.

14. P802 - Standard for Local and Metropolitan Area Networks: Overview and Architecture

This standard contains descriptions of the IEEE 802 Standards published by IEEE for Local Area Networks (LANs), Metropolitan Area Networks (MANs), and Personal Area Networks (PANs) networks considered as well as a reference model (RM) for protocol standards. Compliance with the family of IEEE 802 Standards is defined, and a standard for the identification of public, private, and standard protocols is included.

15. 802.1AB-2009 - IEEE Standard for Local and Metropolitan Area Networks - Station and Media Access Control Connectivity Discovery

This document defines a protocol and a set of managed objects that can be used for discovering the physical topology from adjacent stations in IEEE 8020 LANs

16. 802.2-1998 Standard for Information Technology - Telecommunications and Information Exchange Between Systems - Local and Metropolitan Area Networks - Specific Requirements - Part 2: Logcal Link Control

This standard is part of a family of standards for local area networks (LANs) and metropolitan area networks (MANs) that deals with the physical and data link layers as defined by the ISO Open Systems Interconnection Basic Reference Model. The functions, features, protocol, and services of the Logical Link Control (LLC) sublayer, which constitutes the top sublayer in the data link layer of the ISO/IEC 8802 LAN protocol, are described. The services required of, or by, the LLC sublayer at the logical interfaces with the network layer, the medium access control (MAC) sublayer, and the LLC sublayer management function are specified. The protocol data unit (PDU) structure for data communication systems is defined using bit-oriented procedures, as are three types of operation for data communication between service access points. In the first type of operation, PDUs are exchanged between LLCs without the need for the establishment of a data link connection. In the second type of operation, a data link connection is established between two LLCs prior to any exchange of information-bearing PDUs. In the third type of operation, PDUs are exchanged between LLCs without the need for the establishment of a data link connection, but stations are permitted to both send data and request the return of data simultaneously.

17. 802.3-2005 - IEEE Standard for Information Technology - Telecommunications and Information Exchange Between Systems - Local and Metropolitan Area Networks - Specific Requirements Part 3: Carrier Sense Multiple Access with Collision Detection (CSMA/CD) Acc

Corrigendum to IEEE Std 802.3-2005 This corrigendum clarifies and corrects isolation text including harmonization for both powered and unpowered Medium Dependent Interfaces.

18. 802.11-2012 IEEE Standard for Information Technology - Telecommunications and Information Exchange Between Systems - Local and Metropolitan Area Networks - Specific Requirements - Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (P

The scope of this standard is to define one medium access control (MAC) and several physical layer (PHY) specifications for wireless connectivity for fixed, portable, and moving stations (STAs) within a local area.

19.   802.11-2007 IEEE Standard for Information Technology - Telecommunications and Information Exchange Between Systems - Local and Metropolitan Area Networks - Specific Requirements - Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY)

This amendment specifies the extensions to IEEE Std 802.11-2007 for wireless local area networks (WLANs) providing mechanisms for fast basic service set (BSS) transition.

20.   802.15.1-2005 IEEE Standard for Information Technology - telecommunications and information exchange Systems between systems - Local and metropolitan area networks-Specific requirements - Part 15.1a: Wireless Medium Access Control (MAC) and Physical Layer

Methods for communicating devices in a personal area network (PAN) are covered in this standard.

21.   802.15.4-2006 IEEE Standard for Information Technology - Telecommunications and Information Exchange Between Systems - Local and Metropolitan Area Networks - Specific Requirements - Part 15.4: Wireless Medium Access Control (MAC) and Physical Layer (PHY)

This standard defines the protocol and compatible interconnection for data communication devices using low-data-rate, low-power and low-complexity, short-range radio frequency (RF) transmissions in a wireless personal area network (WPAN).

22.   802.15.4e-2012 - IEEE Standard for Local and metropolitan area networks--Part 15.4: Low-Rate Wireless Personal Area Networks (LR-WPANs) Amendment 1: MAC sublayer

IEEE Std 802.15.4-2011 is amended by this standard. The intention of this amendment is to enhance and add functionality to the IEEE 802.15.4 MAC to (a) better support the industrial markets and (b) permit compatibility with modifications being proposed within the Chinese WPAN.

23.   802.15.4g-2012 IEEE Standard for Information Technology - Telecommunications and Information Exchange Between Systems - Local and Metropolitan Area Networks - Specific Requirements - Part 15.4: Wireless Medium Access Control (MAC) and Physical Layer (PHY)

(See explanatory notes in Secton 8.1) This Standard defines an amendment to IEEE 802.15.4. It addresses principally outdoor Low Data Rate Wireless Smart Metering Utility Network requirements. It defines an alternate PHY and only those MAC modifications needed to support its implementation. Specifically, the amendment supports all of the following: • Operation in any of the regionally available license exempt frequency bands, such as 700MHz to 1GHz, and the 2.4 GHz band. • Data rate of at least 40 kbits per second but not more than 1000 kbits per second • . Achieve the optimal energy efficient link margin given the environmental conditions encountered in Smart Metering deployments. • Principally outdoor communications • PHY frame sizes up to a minimum of 1500 octets • Simultaneous operation for at least 3 co-located orthogonal networks • Connectivity to at least one thousand direct neighbors characteristic of dense urban deployment Provides mechanisms that enable coexistence with other systems in the same band(s) including IEEE 802.11, 802.15 and 802.16 systems.

24.   802.16-2012 IEEE Approved Draft Standard for local and metropolitan area networks Part 16: Air Interface for Broadband Wireless Access Systems

This standard specifies the air interface, including the medium access control layer (MAC) and physical layer (PHY), of combined fixed and mobile point-to-multipoint broadband wireless access (BWA) systems providing multiple services. The MAC is structured to support multiple physical layer (PHY) specifications, each suited to a particular operational environment. The standard enables rapid worldwide deployment of innovative, cost effective, and interoperable multivendor broadband wireless access products, facilitates competition in broadband access by providing alternatives to wireline broadband access, encourages consistent worldwide spectrum allocations, and accelerates the commercialization of broadband wireless access systems. The standard is a revision of IEEEE Std 02.16-2004, and consolidates material from IEEE Std 802.16eTM-2005, IEEE 802.16 004/Cor1-2005, IEEE 02.16fTM-2005, and IEEE Std 802.16gTM-2007, along with additional maintenance items and enhancements to the management information base specifications. This revision supersedes nd makes obsolete IEEE Std 802.16-2004 and all of its subsequent amendments and corrigenda.

25.   802.16.1a-2013 - Standard for WirelessMAN-Advanced Air Interface for Broadband Wireless Access Systems - Amendment: Higher Reliability Networks

This amendment specifies protocol enhancements to the medium access control layer (MAC) for enabling increased robustness and alternate radio path establishment in degraded network conditions. Limited WirelessMAN-Advanced physical layer extensions are included for enabling operation with radio path redundancy and direct communication between subscriber stations. Also mobile base stations and mobile relay stations are supported.

26.   802.16.1b-2012 - IEEE Standard for WirelessMAN-Advanced Air Interface for Broadband Wireless Access Systems Amendment 1: Enhancements to Support Machine-to-Machine Applications

This amendment specifies medium access control (MAC) enhancements and minimal WirelessMAN-Advanced physical layer (PHY) modifications in licensed bands to support lower power consumption at the device, support by the base station of significantly larger numbers of devices, efficient support for small burst transmissions, and improved device authentication.

27.   802.20-2008 - IEEE Standard for Local and Metropolitan Area Networks - Part 20: Air Interface for Mobile Broadband Wireless Access Systems Supporting Vehicular Mobility -- Physical and Media Access Control Layer Specification

The technical requirements of this standard form a compatibility standard for mobile broadband wireless access systems. The standard ensures that a compliant access terminal (AT) or user terminal (UT) can obtain service through any access node (AN) or base station (BS) conforming to properly selected modes of this standard, consistent with equipment and operator requirements, thus providing a framework for the rapid development of cost-effective, multivendor mobile broadband wireless access systems. This compatibility standard is targeted for use in a wide variety of licensed frequency bands and regulatory environments. This standard provides for future standardized extension capabilities. The architecture defined by this standard permits such expansion without the loss of backward compatibility.

28.   802.20.2-2010 - IEEE Standard for Conformance to IEEE 802.20 Systems--Protocol Implementation Conformance Statement (PICS) Proforma

The technical requirements of this standard form a compatibility standard for mobile broadband wireless access systems. The standard ensures that a compliant access terminal (AT) or user terminal (UT) can obtain service through any access node (AN) or base station (BS) conforming to properly selected modes of this standard, consistent with equipment and operator requirements, thus providing a framework for the rapid development of cost-effective, multivendor mobile broadband wireless access systems. This compatibility standard is targeted for use in a wide variety of licensed frequency bands and regulatory environments.This standard provides for future standardized extension capabilities. The architecture defined by this standard permits such expansion without the loss of backward compatibility.

29.   P802.21d - IEEE Standard for Local and metropolitan area networks -- Part 21: Media Independent Handover Services Amendment: Multicast Group Management

To add support in Media-Independent Handover (MIH) framework for management of multicast groups.

30.   1020-2011 IEEE Guide for Control of Small (100 kVA to 5 MVA) Hydroelectric Power Plants

This guide describes the electrical control and monitoring requirements for equipment and systems associated with small (100 kVA to 5 MVA) hydroelectric power plants.

31.   1031-2011 IEEE Guide for the Functional Specification of Transmission Static Var Compensators

This guide assists users in specifying the functional requirements for transmission static Var compensators (SVCs) using conventional thyristor technology. It will not serve for SVCs primarily associated with DC converters nor with the correction of load disturbances or phase unbalance. Nevertheless many sections will be useful for compensator systems using gate turn-off (GTO) thyristor technology [static compensator (STATCOM)] or other semiconductor devices, or SVCs associated with high-voltage dc (HVDC) converter stations, or industrial and distribution applications. General terms and conditions forming the commercial part of a specification for a particular project are outside the scope of this document.

32.   1127-1998 IEEE Guide for the Design, Construction, and Operation of Electric Power Substations for Community Acceptance and Environmental Compatibility

Significant community acceptance and environmental compatibility items to be considered during the planning and design phases, the construction period, and the operation of electric supply substations are identified, and ways to address these concerns to obtain community acceptance and environmental compatibility are documented. On-site generation and telecommunication facilities are not considered.

33.   P1127a - Guide for the Design, Construction, and Operation of Electric Power Substations for Community Acceptance and Environmental Compatibility

This guide identifies significant community acceptance and environmental compatibility items to be considered during the planning and design phases, the construction period, and the operation of electric supply substations, and documents ways to address these concerns to obtain community acceptance and environmental compatibillity. On-site generation and telecommunication facilities are not considered.

34.   1138-2009 IEEE Standard for Testing and Performance for Optical Ground Wire (OPGW) for Use on Electric Utility Power Lines

The performance, test requirements, procedures, and acceptance criteria for a transmission line overhead ground wire (a.k.a. shield wire, static wire, earth wire, skywire) with optical fibers commonly known as optical ground wire (OPGW) are covered. Functional requirements, such as electrical, mechanical, optical fiber, environmental, and packaging, and test requirements related to design, installation, in-service, and maintenance, including routine tests, are covered.

35.   1159.3-2003 IEEE Recommended Practice for the Transfer of Power Quality Data

This recommended practice defines a file format suitable for exchanging power quality related measurement and simulation data in a vendor independent manner. The format is designed to represent all power quality phenomena identified in IEEE Std 1159 TM -1995, IEEE Recommended Practice on Monitoring Electric Power Quality, other power related measurement data, and is extensible to other data types as well. The recommended file format utilizes a highly compressed storage scheme to minimize disk space and transmission times. The utilization of globally unique identifiers (GUID) to represent each element in the file permits the format to be extensible without the need for a central registration authority.

36.   1222-2003 IEEE Standard for All-Dielectric Self-Supporting Fiber Optic Cable

Construction, mechanical, electrical, and optical performance, installation guidelines, acceptance criteria, test requirements, environmental considerations, and accessories for an all-dielectric, nonmetallic, self-supporting fiber optic (ADSS) cable are covered in this standard. The ADSS cable is designed to be located primarily on overhead utility facilities. This standard provides both construction and performance requirements that ensure within the guidelines of the standard that the dielectric capabilities of the cable components and maintenance of optical fiber integrity and optical transmissions are proper. This standard may involve hazardous materials, operations, and equipment. It does not purport to address all of the safety issues associated with its use, and it is the responsibility of the user to establish appropriate safety and health practices and to determine the applicability of regulatory limitations prior to use.

37.   1247-2005 IEEE Standard for Interrupter Switches for Alternating Current Rated Above 1000 Volts

The basic requirements of interrupter switches used indoors, outdoors, and in enclosures are covered. This standard does not apply to load-break separable insulated connectors.

38.   1250-2011 IEEE Guide for Identifying and Improving Voltage Quality in Power Systems

The reader of this guide will find discussions of ways to identify and improve voltage quality in power systems, as well as references to publications in this area. More specifically, this guide includes: a) Voltage quality levels from benchmarking studies b) Factors that affect power system performance c) Mitigation measures that improve power system performance d) References to current relevant in-depth IEEE standards and other documents. This guide only addresses subjects in depth where no other power quality reference does so. It is a "e;gateway"e; document for power quality that points the way to other documents in this field.

39.   1250-1995 IEEE Recommended Practice for Measurement and Limits of Voltage Fluctuations and Associated Light Flicker on AC Power Systems

Voltage fluctuations on electric power systems sometimes give rise to noticeable illumination changes from lighting equipment. This phenomenon is often referred to as flicker, lamp flicker, and sometimes voltage flicker. This recommended practice provides specifications for measurement of this phenomenon and recommends acceptable levels for 120 V, 60 Hz and 230 V, 50 Hz AC electric power systems. It does not make any flicker emission specifications for certification of individual products manufactured for use on these systems.

40.   1325-1996 IEEE Recommended Practice for Reporting Field Failure Data for Power Circuit Breakers

A format is presented that provides a concise and meaningful method for recording pertinent information on power circuit breaker field failures. It is recommended that this format be utilized in record keeping and directing corrective action to improve field reliability of power circuit breakers.

41.   1366-2012 IEEE Guide for Electric Power Distribution Reliability Indices

This guide identifies distribution reliability indices and factors that affect their calculation. It includes indices, which are useful today, as well as ones that may be useful in the future. The indices are intended to apply to distribution systems, substations, circuits, and defined regions.

42.   1377 - IEEE Standard for Utility Industry Metering Communication Protocol Application Layer (End Device Data Tables)

This Standard defines a Table structure for utility application data to be passed between an End Device and any other device. It neither defines device design criteria nor specifies the language or protocol used to transport that data. The Tables defined in this standard represent data structure that shall be used to transport the data, not necessarily the data storage format used inside the End Device.

43.   1379-2000 IEEE Recommended Practice for Data Communications Between Remote Terminal Units and Intelligent Electronic Devices in a Substation

A uniform set of guidelines for communications and interoperations of remote terminal units (RTUs) and intelligent electronic devices (IEDs) in an electric utility substation is provided. A mechanism for adding data elements and message structures to this recommended practice is described.

44.   1402-2000 IEEE Guide for Electric Power Substation Physical and Electronic Security

Security issues related to human intrusion upon electric power supply substations are identified and discussed. Various methods and techniques presently being used to mitigate human intrusions are also presented in this guide.

45.   1409-2012 IEEE Guide for the Application of Power Electronics for Power Quality Improvement on Distribution Systems Rated 1 kV Through 38 kV

This guide introduces and defines the emerging technology of custom power. This technology involves devices and circuit configurations of power electronic equipment used in utility power distribution systems rated 1 kV through 38 kV for the purposes of mitigating problems associated with power quality. This guide also includes definitions, general need guidelines, performance objectives, electrical environments, input/output criteria, performance measurements, case studies, bibliography, and engineering trade-offs. The proposed document addresses power assessment techniques as specified by IEEE Std 1250-1005, which defines power quality terms and phenomena, and IEEE Std 1159-1995 which provides a recommended practice for measuring power quality.

46.   1453-2004 IEEE Recommended Practice for Measurement and Limits of Voltage Fluctuations and Associated Light Flicker on AC Power Systems

Voltage fluctuations on electric power systems sometimes give rise to noticeable illumination changes from lighting equipment. This phenomenon is often referred to as flicker, lamp flicker, and sometimes voltage flicker. This recommended practice provides specifications for measurement of this phenomenon and recommends acceptable levels for 120 V, 60 Hz and 230 V, 50 Hz AC electric power systems. It does not make any flicker emission specifications for certification of individual products manufactured for use on these systems.

47.   1459–2010 IEEE Standard Definitions for the Measurement of Electric Power Quantities under Sinusoidal Non-Sinusoidal Balanced or Unbalanced Conditions

Definitions used for measurement of electric power quantities under sinusoidal, nonsinusoidal, balanced, or unbalanced conditions are provided in this standard. Mathematical expressions that were used in the past, as well as new expressions, are listed, as well as explanations of the features of the new definitions.

48.   1471-2000 IEEE Recommended Practice for Architectural Description for Software- Intensive Systems

This recommended practice addresses the activities of the creation, analysis, and sustainment of architectures of software-intensive systems, and the recording of such architectures in terms of architectural descriptions . A conceptual framework for architectural description is established. The content of an architectural description is defined. Annexes provide the rationale for key concepts and terminology, the relationships to other standards, and examples of usage.

49.   1547-2003 IEEE Standard for Interconnecting Distributed Resources with Electric Power Systems

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, 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. This standard is written considering that the DR is a 60 Hz source.

50.   1547.1-2005 IEEE Standard Conformance Test Procedures for Equipment Interconnecting Distributed Resources with Electric Power Systems

In this paper, technical background and application details to support understanding of IEEE Std 1547-2003 are provided. The guide facilitates the use of IEEE Std 1547-2003 by characterizing various forms of distributed resource (DR) technologies and their associated interconnection issues. It provides background and rationale of the technical requirements of IEEE Std 1547-2003. It also provides tips, techniques, and rules of thumb, and it addresses topics related to DR project implementation to enhance the user's understanding of how IEEE Std 1547-2003 may relate to those topics. This guide is intended for use by engineers, engineering consultants, and knowledgeable individuals in the field of DR. The IEEE 1547 series of standards is cited in the Federal Energy Policy Act of 2005, and this guide is one document in the IEEE 1547 series.

51. 1547.2-2008 IEEE Application Guide for IEEE Std 1547, IEEE Standard for Interconnecting Distributed Resources with Electric Power Systems

In this paper, technical background and application details to support understanding of IEEE Std 1547-2003 are provided. The guide facilitates the use of IEEE Std 1547-2003 by characterizing various forms of distributed resource (DR) technologies and their associated interconnection issues. It provides background and rationale of the technical requirements of IEEE Std 1547-2003. It also provides tips, techniques, and rules of thumb, and it addresses topics related to DR project implementation to enhance the user's understanding of how IEEE Std 1547-2003 may relate to those topics. This guide is intended for use by engineers, engineering consultants, and knowledgeable individuals in the field of DR. The IEEE 1547 series of standards is cited in the Federal Energy Policy Act of 2005, and this guide is one document in the IEEE 1547 series.

52. 1547.3-2007 IEEE Guide For Monitoring, Information Exchange, and Control of Distributed Resources Interconnected With Electric Power Systems

This guide is intended to facilitate the interoperability of distributed resources (DR) and help DR project stakeholders implement monitoring, information exchange, and control (MIC) to support the technical and business operations of DR and transactions among the stakeholders. The focus is on MIC between DR controllers and stakeholder entities with direct communication interactions. This guide incorporates information modeling, use case approaches, and a proforma information exchange template and introduces the concept of an information exchange interface. The concepts and approaches are compatible with historical approaches to establishing and satisfying MIC needs. The IEEE 1547trade series of standards is cited in the U.S. Federal Energy Policy Act of 2005, and this guide is one document in the IEEE 1547 series. This guide is primarily concerned with MIC between the DR unit controller and the outside world. However, the concepts and methods should also prove helpful to manufacturers and implementers of communications systems for loads, energy management systems, SCADA, electric power system and equipment protection, and revenue metering. The guide does not address the economic or technical viability of specific types of DR. It provides use case methodology and examples (e.g., examples of DR unit dispatch, scheduling, maintenance, ancillary services, and reactive supply). Market drivers will determine which DR applications become viable. This document provides guidelines rather than mandatory requirements or prioritized preferences.

53. 1547.4-2011 IEEE Guide for Design, Operation, and Integration of Distributed Resource Island Systems with Electric Power Systems

This document provides alternative approaches and good practices for the design, operation, and integration of distributed resource (DR) island systems with electric power systems (EPS). This includes the ability to separate from and reconnect to part of the area EPS while providing power to the islanded local EPSs. This guide includes the distributed resources, interconnection systems, and participating electric power systems.

54. 1547.6-2011 IEEE Recommended Practice For Interconnecting Distributed Resources With Electric Power Systems Distribution Secondary Networks

This standard builds upon IEEE Standard 1547 for the interconnection of distributed resources (DR) to distribution secondary network systems. This standard establishes recommended criteria, requirements and tests, and provides guidance for interconnection of distribution secondary network system types of area electric power systems (Area EPS) with distributed resources (DR) providing electric power generation in local electric power systems (Local EPS).

55. P1547.7 - Guide to Conducting Distribution Impact Studies for Distributed Resource Interconnection

This guide describes criteria, scope, and extent for engineering studies of the impact on area electric power systems of a distributed resource or aggregate distributed resource interconnected to an area electric power distribution system.

56. P1547.8 - Recommended Practice for Establishing Methods and Procedures that Provide Supplemental Support for Implementation Strategies for Expanded Use of IEEE Standard 1547

This recommended practice applies to the requirements set forth in IEEE Std 1547 and provides recommended methods that may expand the usefulness and utilization of IEEE Std 1547 through the identification of innovative designs, processes, and operational procedures.

57. 1590-2009 IEEE Recommended Practice for the Electrical Protection of Communication Facilities Serving Electric Supply Locations Using Optical Fiber Systems

The main emphasis of this recommended practice is the engineering design of optical fiber communication facilities serving, or connected to, electric supply locations. This recommended practice includes methods for providing telecommunication facilities serving electric supply locations using optical fiber cables, and their related electronic systems, extending across the zone of influence (ZOI).

58. 1591.1-2012 IEEE Standard for Testing and Performance of Hardware for Optical Groundwire (OPGW)

This standard covers the construction, mechanical and electrical performance, test requirements, environmental considerations, and acceptance criteria for qualifying hardware for use with optical ground wire (OPGW).

59. P1591.2 - Standard for Testing and Performance of Hardware for All-Dielectric Self-Supporting (ADSS) Fiber Optic Cable

This standard covers the construction, mechanical and electrical performance, test requirements, environmental considerations, and acceptance criteria for qualifying hardware for use with all-dielectric self-supporting (ADSS) fiber optic cable.

60. 1591.3-2011 IEEE Standard for Qualifying Hardware for Helically-Applied Fiber Optic Cable Systems (WRAP Cable)

This standard covers hardware for use with all-dielectric fiber optic (WRAP) cable designed to be helically wrapped around a conductor or other messenger on overhead power facilities. This covers mechanical, and electrical performance, test requirements, environmental considerations, and acceptance criteria for qualification of the hardware.

61. P1595 - Standard for Quantifying Greenhouse Gas Emission Credits from Small Hydro and Wind Power Projects, and for Grid Baseline Conditions

The Standard is intended to cover the measurement and quantification of CO_2 reductions for emissions credits for specific renewable generation projects in the electricity supply industry, namely Wind Power and Small Hydro. This requires a "cradle to grave" project life-cycle approach and also the consideration of the Grid Base-line conditions to assess the reduction in emissions from the grid generation displaced by the "clean" power and energy from the project. Natural Resources Canada have agreed to share documents they have developed for Wind Power; Small Hydro and Grid Base-line conditions in a cooperative effort for the development of the Standards, courtesy of an agreement reached between IEEE-SA and Natural Resources Canada. The Natural Resources Canada documents are based on a "cradle to grave" life cycle approach.

62.   P1613 - Standard for Environmental and Testing Requirements for Communications Networking Devices Installed in Electric Power Substations

This document specifies standard service conditions, standard ratings, environmental performance requirements, and testing requirements for communications networking devices and communications ports in protective relays installed in electric power substations. It does not cover such equipment designed for operation in other environments, such as office locations. Other than their communications ports, it does not cover such equipment used in protective relaying applications, for which IEEE Std C37.90,IEEE Std C37.90.1, IEEE Std C37.90.2, and IEEE Std C37.90.3 shall apply.

63.   1615-2007 IEEE Recommended Practice for Network Communication in Electric Power Substations

Recommended practices for communication and interoperation of devices connected on an electric power substation Internet protocol (IP) network are provided. For the power engineer new to IP networking, this document provides an introduction to the concepts that need to be mastered as well as specific recommendations to follow when deploying the technologies. For equipment manufacturers and system integrators, it provides direction and requirements to facilitate interoperable electric utility information networks.

64.   P1646 - Standard Communication Delivery Time Performance Requirements for Electric Power Substation Automation

This standard defines communication delivery times of information to be exchanged within and external to substation integrated protection, control, and data acquisition systems.

65.   1646-2004 IEEE Standard Communication Delivery Time Performance Requirements for Electric Power Substation Automation

A standard defining communication delivery times of information to be exchanged within and external to substation integrated protection, control, and data acquisition systems is described. Communication capabilities and system capabilities to deliver data on time are also specified.

66.   1675-2008 IEEE Standard for Broadband over Power Line Hardware

Testing and verification standards for the commonly used hardware, primarily couplers, and enclosures, for broadband over power line (BPL) installations, and installation methods to enable compliance with applicable codes and standards are provided in this standard.

67.   P1686 - Standard for Intelligent Electronic Devices (IEDs) Cyber Security Capabilities

The standard defines the functions and features to be provided in intelligent electronic devices (IEDs) to accommodate critical infrastructure protection (CIP) programs. The standard addresses security regarding the access, operation, configuration, firmware revision, and data retrieval from an IED. Encryption of communications to and from the IED is also addressed.

68.   1686-2007 IEEE Standard for Substation Intelligent Electronic Devices (IEDs) Cyber Security Capabilities

The functions and features to be provided in substation intelligent electronic devices (IEDs) to accommodate critical infrastructure protection programs are defined in this standard. Security regarding the access, operation, configuration, firmware revision, and data retrieval from an IED is addressed in this standard. Communications for the purpose of power system protection (teleprotection) is not addressed. Encryption for the secure transmission of data both within and external to the substation, including supervisory control and data acquisition, is not part of this standard as this is addressed in other efforts.

69.   1701-2011 IEEE Standard for Optical Port Communication Protocol to Complement the Utility Industry End Device Data Tables

This document is identified by three numbers, MC1218-2009, ANSI C12.18-2006 and IEEE 1701-200X. The standard details the criteria required for communications with a Utility End Device by another device via an optical port. The other device could be a hand held reader, a laptop or portable computer, a master station system, or some other electronic communications device. It shall provide the optical port lower layers communication protocol for the Utility metering Industry including specifically Water, Gas, and Electric. The Standard provides details for a complete implementation of an OSI 7-layer model in accordance with ISO/IEC 7498-1. The protocol specified in this document was designed to transport data in Table format. The Table definitions are in ANSI C12.19-2008 (MC1219-2009, IEEE 1377) Utility Industry End Device Data Tables.

70.   71702-2011 IEEE Standard for Telephone Modem Communication Protocol to Complement the Utility Industry End Device Data Tables

This Standard details the criteria required for communication between a device and a client conforming to ANSI C12.21 via a modem connected to the switched telephone network. The C12.21 Client could be a laptop or portable computer, a master station system or some other electronic communications device. This Standard does not specify the implementation requirements of the telephone switched network to the modem, nor does it include definitions for the establishment of the communication channel. This document provides details for an implementation of the OSI 7-layer model in accordance with ISO/IEC 7498-1. The protocol specified in this Standard was designed to transport data in Table format. The Table definitions are in ANSI C12.19, and Annex D of this document. This Standard specifies the differences between ANSI C12.18-2006, Protocol Specification for ANSI Type 2 Optical Port and ANSI C12.19-1997, Utility Industry End Device Data Tables, and those features and services required to describe a protocol specification for Telephone Modem Communications.

71.   1703-2012 - IEEE Standard for Local Area Network/Wide Area Network (LAN/WAN) Node Communication Protocol to Complement the Utility Industry End Device Data Tables

This standard provides a set of application layer messaging services that are applicable for the enterprise and End Device ends of an Advanced Metering Infrastructure (AMI). The application services include those useful for managing the AMI network assets defined by this standard. These messages may be transported over a wide range of underlying network transports such as TCP/IP, UDP, IEEE 802.11, IEEE 802.15.4 IEEE 802.16, PLC and SMS over GSM, over a wide range of physical media. Additionally, interfaces are defined for a Communication Module and a Local Port (e.g. an IEEE 1701 optical port). The described protocol is tailored for, but not limited to, the transport of IEEE 1377 Table data. The standard also provides a means by which information can be sent in a secure manner using AES-128 and the EAX mode. This standard was developed jointly with ANSI (published asANSI C12.22) and Measurement Canada (published as MC12.22).

72.   P1704 - Standard for Utility Industry End Device Communications Module

This document defines the hardware physical interface and interface signals between IEEE 1703 Devices (such as IEEE 1377 meters or distribution automation devices) and IEEE 1703 communication modules. The communication modules are described as being attachable and removable to/from the IEEE 1703 Devices, and are not intended to be internal to the metering devices. Included in this standard are the physical dimensions, electrical connections, communication hardware interface signals, and module positioning which involves the secure physical mounting, weather elements, and communications propagation considerations. This standard serves as the extension of (but not limited to) IEEE 1703, MC1222, and ANSI C12.22 standards in regard to the communications module hardware interfaces, reference signals, their description and specification.

73. **P1705 - Standard for Compliance Testing Standard for Utility Industry Metering Communications Protocol Standards**

This standard provides requirements for building and testing for compliance to the following Utility Industry Metering Communications protocols: 1. The Utility Industry Metering Communication Protocol Application Layer Std (Proposed congruent standards, IEEE P1377, ANSI C12.19-2006 and MC12.19-2006) 2. Optical Port Communication Protocol (Proposed congruent standards, IEEE P1701, MC12.18-2006 and ANSI C12.18-2006) to complement The Utility Industry Metering Communication Protocol Application Layer Std. 3. Telephone Port Communication Protocol (Proposed congruent standards, IEEE P1702, MC12.21-2006 and ANSI C12.21-2006) to complement the Utility Industry Metering Communication Protocol Application Layer Std. 4. Local Area Network/Wide Area Network (LAN/WAN) Communication Protocol (Proposed congruent standards, IEEE P1703, MC12.22-2006 and ANSI C12.22-2006) to complement the Utility Industry Metering Communication Protocol Application Layer Std.

74. **1711-2010 IEEE Trial Use Standard for a Cryptographic Protocol for Cyber Security of Substation Serial Links**

This trial use standard defines a cryptographic protocol to provide integrity, and optional confidentiality, for cyber security of serial links. It does not address specific applications or hardware implementations, and is independent of the underlying communications protocol.

75. **1775-2010 IEEE Standard for Powerline Communication Equipment - Electromagnetic Compatibility (EMC) Requirements - Testing and Measurement Methods**

The scope of this standard will be electromagnetic compatibility (EMC) criteria, and consensus test and measurements procedure for broadband Power Line Communication (also known as BPL) equipment and installations. The standard will reference existing national and international standards for BPL equipment and installations. It will not include the specific emission limits, which are subject to national regulations.

76. **P1797 - Guide for Design and Application of Solar Technology in Commercial Power Generating Stations**

This document will summarize current electrical engineering methods and practices for applying photovoltaic technology for Solar Power Generation Stations. It will describe analytical methods, preferred parameters and performance characteristics from a common frame of reference for grid connected power systems.

77. **1808-2011 - IEEE Guide for Collecting and Managing Transmission Line Inspection and Maintenance Data**

Reference information to assist electric utilities and their contractors with the development of computer-based means for collecting and managing transmission line inspection and maintenance data and associated asset information is provided. The guide provides a high level overview of key principles and considerations learned through experience that will help ensure common pitfalls are avoided and enhance the usability of systems. It is not intended to provide an exhaustive discussion of the many details and specifics that must be accounted for when designing and developing a system for an individual utility's application and needs.

78. **1815-2012 IEEE Standard for Electric Power Systems Communications -- Distributed Network Protocol (DNP3)**

The DNP3 protocol structure, functions, and application alternatives and the corresponding conformance test procedures are specified. In addition to defining the structure and operation of DNP3, three application levels that are interoperable are defined. The simplest application is for low-cost distribution feeder devices, and the most complex is for full-featured master stations. The intermediate application level is for substation and other intermediate devices. The protocol is suitable for operation on a variety of communication media consistent with the makeup of most electric power communication systems. Keywords: Distributed Network Protocol (DNP3), distribution automation, distribution feeder, electric power communication systems, master station, substation automation

79. **P1815.1 - Standard for Exchanging Information Between Networks Implementing IEC 61850 and IEEE Std 1815 (Distributed Network Protocol - DNP3)**

This document specifies the standard approach for mapping between IEEE Std 1815 (Distributed Network Protocol (DNP3)) and IEC 61850 (Communications Networks and Systems for Power Utility Automation). Two primary use cases are addressed; A) Mapping between an IEEE Std 1815 based master and an IEC 61850 based remote site and B) Mapping between an IEC 61850 based master and an IEEE Std 1815 based remote site. Mapping aspects included in the standard are: conceptual architecture; general mapping requirements; the mapping of Common Data Classes, Constructed Attribute Classes and Abstract Communication Service Interface (ASCI); cyber security requirements, the architecture of a gateway used for translation and requirements for embedding mapping configuration information into IEC 61850 System Configuration Language (SCL) and DNP3 Device Profile. This specification addresses a selection of features, data classes and services of the two standards.

80. **P1854 - Guide for Smart Distribution Applications Guide**

This guide categorizes important smart distribution applications, develops descriptions of the critical functions involved, defines important components of these systems, and provides examples of the systems that can be considered as part of distribution management systems or other smart distribution systems.

81. **1901-2010 IEEE Standard for Broadband over Power Line Networks: Medium Access Control and Physical Layer Specifications**

A standard for high-speed communication devices via electric power lines, so called broadband over power line (BPL) devices, is defined. Transmission frequencies below 100 MHz are used. All classes of BPL devices can use this standard, including BPL devices used for the first-mile/last-mile connection to broadband services as well as BPL devices used in buildings for local area networks (LANs), Smart Energy applications, transportation platforms (vehicle) applications, and other data distribution. The balanced and efficient use of the power line communications channel by all classes of BPL devices is the main focus of this standard, defining detailed mechanisms for coexistence and interoperability between different BPL devices, and ensuring that desired bandwidth and quality of service may be delivered. The necessary security questions are addressed to ensure the privacy of communications between users and to allow the use of BPL for security sensitive services.

82. **P1901.2 - Standard for Low Frequency (less than 500 kHz) Narrow Band Power Line Communications for Smart Grid Applications**

This standard specifies communications for low frequency (less than 500 kHz) narrowband power line devices via alternating current and direct current electric power lines. This standard supports indoor and outdoor communications over low voltage line (line between transformer and meter, less than 1000 V), through transformer low-voltage to medium-voltage (1000 V up to 72 kV) and through transformer medium-voltage to low-voltage power lines in both urban and in long distance (multi- kilometer) rural communications. The standard uses transmission frequencies less than 500 kHz. Data rates will be scalable to 500 kbps depending on the application requirements. This standard addresses grid to utility meter, electric vehicle to charging station, and within home area networking communications scenarios. Lighting and solar panel power line communications are also potential uses of this communications standard. This standard focuses on the balanced and efficient use of the power line communications channel by all classes of low frequency narrow band (LF NB) devices, defining detailed mechanisms for coexistence between different LF NB standards developing organizations (SDO) technologies, assuring that desired bandwidth may be delivered. This standard assures coexistence with broadband power line (BPL) devices by minimizing out-of-band emissions in frequencies greater than 500 kHz. The standard addresses the necessary security requirements that assure communication privacy and allow use for security sensitive services. This standard defines the physical layer and the medium access sub-layer of the data link layer, as defined by the International Organization for Standardization (ISO) Open Systems Interconnection (OSI) Basic Reference Model.

83. **P1909.1 - Recommended Practice for Smart Grid Communication Equipment -Test methods and installation requirements**

This document includes Recommended Practice for testing and installing different types of smart grid communication equipment according to national and international standards available for equipment to be used in the smart grid. The Recommended Practice includes Safety[1], EMC, Environmental and Mechanical battery of tests but excludes the interoperability testing. This document captures Recommended Practice for communication equipment to be installed in various domains of the smart grid such as generation, transmission and distribution.

84. **2030-2011 IEEE Guide for Smart Grid Interoperability of Energy Technology and Information Technology Operation with the Electric Power System (EPS), and End-Use Applications and Loads**

This document provides guidelines for smart grid interoperability. This guide provides a knowledge base addressing terminology, characteristics, functional performance and evaluation criteria, and the application of engineering principles for smart grid interoperability of the electric power system with end use applications and loads. The guide discusses alternate approaches to good practices for the smart grid.

85. **P2030.1 - Guide for Electric-Sourced Transportation Infrastructure**

This document provides guidelines that can be used by utilities, manufacturers, transportation providers, infrastructure developers and end users of electric-sourced vehicles and related support infrastructure in addressing applications for road-based personal and mass transportation. This guide provides a knowledge base addressing terminology, methods, equipment, and planning requirements for such transportation and its impacts on commercial and industrial systems including, for example, generation, transmission, and distribution systems of electrical power. This guide provides a roadmap for users to plan for short, medium, and long-term systems.

86. **P2030.2 - Guide for the Interoperability of Energy Storage Systems Integrated with the Electric Power Infrastructure**

This document provides guidelines for discrete and hybrid energy storage systems that are integrated with the electric power infrastructure, including end-use applications and loads. This guide builds upon IEEE Standard 2030 Guide for Smart Grid Interoperability of Energy Technology and Information Technology Operation With The Electric Power System (EPS), and End-Use Applications and Loads.

87. **P2030.3 - Standard for Test Procedures for Electric Energy Storage Equipment and Systems for Electric Power Systems Applications**

This standard establishes test procedures for electric energy storage equipment and systems for electric power systems (EPS) applications. It is recognized that an electric energy storage equipment or systems can be a single device providing all required functions or an assembly of components, each having limited functions. Components having limited functions shall be tested for those functions in accordance with this standard. Conformance may be established through combination of type, production, and commissioning tests. Additionally, requirements on installation evaluation and periodic tests are included in this standard.

88. **P2030.4 - Guide for Control and Automation Installations Applied to the Electric Power Infrastructure**

This document is a guide to users of IEEE Std 2030-2011, Guide for Smart Grid Interoperability of Energy Technology and Information Technology Operation with the Electric Power System (EPS), and End-Use Applications and Loads. It provides guidance in applying the smart grid interoperability reference model (SGIRM) of IEEE Std 2030 in the development of control and automation components. This guide outlines approaches to defining the requirements for control and automation applications within the electric power infrastructure, and describing their design, while adhering to a common open architecture.

89. **P2030.100 - Recommended Practice for Implementing an IEC 61850 Based Substation Communications, Protection, Monitoring and Control System**

This recommended practice outlines the necessary steps and procedures a utility should undertake to implement an IEC 61850 substation in a multi-vendor equipment environment. The document addresses equipment configuration, equipment procurement specification, documentation procedures and general design philosophy that will condense the IEC61850 standard into a practical working implementation guide. The recommended practice also defines baseline information sets and functionality for IEC 61850 devices to allow users to implement similar design philosophies between vendors of IEC 61850 equipment.

90. **C37.1-2007 IEEE Standard for SCADA and Automation Systems**

The requirements for SCADA and automation systems in substations are defined. This standard defines the process of substation integration as the design process that is the foundation for substation automation. Functional and environmental requirements are provided for all IEDs located in the system. Tutorial material is included in the annexes to address common issues with systems without introducing requirements. Information is also presented in the annexes regarding SCADA masters.

91. **C37.2-2008 IEEE Standard Electrical Power System Device Function Numbers Acronyms and Contact Designations**

The definition and application of function numbers and acronyms for devices and functions used in electrical substations and generating plants and in installations of power utilization and conversion apparatus are covered. The purpose and use of the numbers and acronyms is discussed, and 95 numbers and 17 acronyms are assigned. Function numbers or function acronyms for arc fault detection, high impedance fault detection, human machine interface, communications devices, digital fault and sequence of event recorders, power quality recorders, substation time sources and synchrophasor devices are among those that have been added. The use of prefixes and suffixes to provide a more specific definition of a function is defined. Device contact designations are also covered.

92. **C37.13-2008 IEEE Standard for Low-Voltage AC Power Circuit Breakers Used in Enclosures**

The following enclosed low-voltage ac power circuit breakers are covered in this standard: a) stationary or draw-out type of two-, three-, or four-pole construction, with one or more rated maximum voltages of 635 V (600 V for units incorporating fuses), 508 V, and 254 V for application on systems having nominal voltages of 600 V, 480 V, and 240 V; b) unfused or fused circuit breakers; c) manually or power operated; and d) with or without electromechanical or electronic trip devices. Service conditions, ratings, functional components, temperature limitations and classifications of insulating materials, insulation (dielectric) withstand voltage requirements, test procedures, and application are discussed in this standard.

93. **C37.90.2-2004 IEEE Standard for Withstand Capability of Relay Systems to Radiated Electromagnetic Interference from Transceivers**

Design tests for relays and relay systems that relate to the immunity of this equipment to Radiated Electromagnetic Interference from Transceivers are specified. Field strength, test frequencies, modulation, sweep rates, equipment setup and connection, test procedures, criteria for acceptance, and documentation for test results are described. This standard has been harmonized with IEC standards where consensus could be reached.

94.   C37.91-2008 IEEE Guide for Protecting Power Transformers

This guide is intended to provide protection engineers and other readers with guidelines for protecting three-phase power transformers of more than 5 MVA rated capacity and operating at voltages exceeding 10 kV. In some cases, a user may apply the techniques described in this guide for protecting transformers of less than 5 MVA ratings or operating at voltages less than 10 kV. Information to assist protection engineers in applying properly relays and other devices to protect transformers used in transmission and distribution systems is provided in this guide. General philosophy, practical applications, and economic considerations involved in power transformer protection are discussed. Emphasis is placed on practical applications. Types of faults in transformers are described. Technical problems with the protection systems, including the behaviour of current transformers during system faults, are discussed. Associated problems, such as fault clearing and reenergization, are discussed as well.

95.   C37.92-2005 IEEE Standard for Analog Inputs to Protective Relays From Electronic Voltage and Current Transducers

This standard is part of a family of local area network (LAN) standards dealing with the physical and data link layers as defined by the ISO Open Systems Interconnection Reference Model. It describes the functions, features, protocol, and services of the logical link control (LLC) sublayer, which constitutes the top sublayer in the data link layer of the ISO 8802 Local Area Network Protocol. The services required of, or by, the LLC sublayer at the logical interfaces with the network layer, the MAC sublayer, and the LLC sublayer management function are specified. The protocol data unit (PDU) structure for data communication systems is defined using bit-oriented procedures, as are two types of operation for data communication between service access points. In one type of operation, PDUs are exchanged between LLCs without the need for the establishment of a data link connection. In the other, a data link connection is established between two LLCs prior to any exchange of information-bearing PDUs.

96.   C37.93-2004 IEEE Guide for Power System Protective Relay Applications of Audio Tones Over Voice Grade Channels

Guidelines for applying audio tones over voice grade channels for power system relaying are provided in this document, including transmitting and receiving equipment, leased voice grade channels, application principles, installation, and testing. The primary purpose of this document is to guide the power system user in applying, installing, and operating audio-tone protective relaying systems over voice grade channels. Secondly, it is to provide a reference for equipment manufacturers engaged in the design and application of relaying equipment and for telephone personnel engaged in providing telecommunications channels for audio-tone protective relay schemes.

97.   C37.94-2002 IEEE Standard for N Times 64 Kilobit Per Second Optical Fiber Interfaces Between Teleprotection and Multiplexer Equipment

An optical interface for use between teleprotection and digital multiplexer equipment that can operate at a data rate of N times 64 kilobit per second where N = 1, 2... 12 is described. Requirements for both physical connection and the communications timing are also included.

98.   C37.95-2002 IEEE Guide for Protective Relaying of Utility-Consumer Interconnections

Protective relay applications involving electric service to consumers that requires a transformation between the utility's supply voltage and the consumer's utilization voltage are covered in this guide. This guide describes the factors that need to be considered in the design of adequate protection facilities, outlines modern relay practices, and provides several examples of the protection of typical utility-consumer interconnections.

99.   PC37.95 - Guide for Protective Relaying of Utility-Consumer Interconnections

This guide contains information on a number of different protective relaying practices for the utility-consumer interconnection. It is intended to cover applications involving service to a consumer that normally requires a transformation between the utility's supply voltage and the consumer's utilization voltage. Interconnections supplied at the utilization voltage are not covered. This guide is not intended to supplant specific utility or consumer practices, procedures, requirements, or any contractual agreement between the utility and the consumer. The examples in Clause 7 are used for illustrative purposes only and do not necessarily represent the preferred protection under all conditions. This guide addresses consumers, with or without generation, that are connected to utility subtransmission or transmission circuits. The specific control schemes associated with generation are not addressed. It is not intended to apply necessarily to consumer generation connected to utility distribution circuits.

100.   C37.100-1992 IEEE Standard Definitions for Power Switchgear

In this standard, terms that encompass the products with the scope of the C37 project are defined. These include power switchgear for switching, interrupting, metering, protection and regulating purposes as used primarily in connection with generation, transmission, distribution, and conversion of electric power. The definitions do not purport to embrace other meanings that the terms may properly have when used in connection with other subjects.

101.   C37.101-2006 IEEE Guide for Generator Ground Protection

The guide is intended to assist protection engineers in applying relays and relaying schemes for protection against stator ground faults on various generator grounding schemes. The existing guide is outdated due to rapid technology development. Hence, the revised guide includes new stator ground protection principles that have evolved with the use of new technologies in relay designs. Additional application examples are included, and other issues raised by the users are also addressed. The guide is not intended for the selection of generator or ground connection schemes.

102.   C37.101-2006/Cor 1-2007 - IEEE Guide for Generator Ground Protection - Corrigendum 1: Annex A.2 Phasor Analysis (Informative)

Errors identified in IEEE Std C37.101-2006 are addressed in this corrigendum.

103.   C37.102-2006 IEEE Guide for AC Generator Protection

A review of the generally accepted forms of relay protection for the synchronous generator and its excitation system is presented. This guide is primarily concerned with protection against faults and abnormal operating conditions for large hydraulic, steam, and combustion turbine generators.

104.   C37.104-2012 - IEEE Guide for Automatic Reclosing of Circuit Breakers for AC Distribution and Transmission Lines

Current reclosing practices for transmission and distribution lines are described. Application considerations and coordination practices of reclosing are also discussed.

105.   C37.106-2003 IEEE Guide for Abnormal Frequency Protection for Power Generating Plants

This guide has been prepared to assist the protection engineer in applying relays for the protection of generating plant equipment from damage caused by operation at abnormal frequencies including overexcitation.

106.   C37.111-1999 IEEE Standard Common Format for Transient Data Exchange (COMTRADE) for Power Systems

A common format for data files and exchange medium used for the interchange of various types of fault, test, or simulation data for electrical power systems is defined. Sources of transient data are described, and the case of diskettes as an exchange medium is recommended. Issues of sampling rates, filters, and sample rate conversions for transient data being exchanged are discussed. Files for data exchange are specified, as is the organization of the data. A sample file is given.

107. PC37.111 - Standard for Common Format for Transient Data Exchange (COMTRADE) for Power Systems

This standard defines a format for files containing transient waveform and event data collected from power systems or power system models. The format is intended to provide an easily interpretable form for use in exchanging data. The standard is for files stored on currently used physical media such as portable external hard drives, USB drives, flash drives, CD, DVD. It is not a standard for transferring data files over communication networks.

108. C37.112-1996 IEEE Standard Inverse-Time Characteristic Equations for Overcurrent Relays

The inverse-time characteristics of overcurrent relays are defined in this standard. Operating equations and allowances are provided in the standard. The standard defines an integral equation for microprocessor relays that ensures coordination not only in the case of constant current input but for any current condition of varying magnitude. Electromechanical inverse-time overcurrent relay reset characteristics are defined in the event that designers of microprocessor based relays and computer relays want to match the reset characteristics of the electromechanical relays.

109. C37.114-2004 IEEE Guide for Determining Fault Location on AC Transmission and Distribution Lines

Electrical faults on transmission and distribution lines are detected and isolated by system protective devices. Once the fault has been cleared, outage times can be reduced if the location of the fault can be determined more quickly. This guide outlines the techniques and application considerations for determining the location of a fault on ac transmission and distribution lines. The document reviews traditional approaches and the primary measurement techniques used in modern devices: one-terminal and two-terminal impedance-based methods and traveling wave methods. Application considerations include: two- and three-terminal lines, series-compensated lines, parallel lines, untransposed lines, underground cables, fault resistance effects, and other power system conditions, including those unique to distribution systems.

110. C37.115-2003 IEEE Standard Test Method for Use in the Evaluation of Message Communications Between Intelligent Electronic Devices in an Integrated Substation Protection Control and Data Acquisition System

A standard test method, including evaluation criteria and performance measures, test scenarios for communication between intelligent electronic devices (IEDs) that implement substation integrated protection, control, and data acquisition is defined. Test scenarios are used to describe what data is exchanged between IEDs to perform a specified function that may be distributed between IEDs. All test scenarios use a standard Unified Modelling Language (UML) and a core reference model to build out an implementation.

111. C37.116-2007 IEEE Guide for Protective Relay Application to Transmission-Line Series Capacitor Banks

The application of protective relays on transmission-line series capacitor banks is covered. The purpose of this guide is to provide the reader with ample discussion of the protection and control issues related to series capacitor bank installations. Specific examples related to protective functions and testing procedures are provided. Keywords: bypass gap, bypass switch, externally fused capacitor, fuseless capacitor, harmonic protection, internally fused capacitor, metal oxide varistor, MOV, series capacitor, unbalance protection

112. C37.117-2007 IEEE Guide for the Application of Protective Relays Used for Abnormal Frequency Load Shedding and Restoration

Information on the application of underfrequency load shedding and restoration to ac power systems is compiled in this guide. Various system conditions that may require the use of underfrequency load shedding and the application of protective relays to various methods of performing underfrequency load shedding are described in this guide. Some practical examples of underfrequency load shedding applications are also provided.

113. C37.118-2005 IEEE Standard for Synchrophasors for Power Systems

This standard defines synchronized phasor measurements used in power system applications. It provides a method to quantify the measurement, tests to be sure the measurement conforms to the definition, and error limits for the test. It also defines a data communication protocol, including message formats for communicating this data in a real-time system. Explanation, examples, and supporting information are also provided.

114. C37.118.1-2011 IEEE Standard for Synchrophasor Measurements for Power Systems

This standard is for synchronized phasor measurement systems in power systems. It defines a synchronized phasor (synchrophasor), frequency and rate of change of frequency measurements. It describes timetag and synchronization requirements for measurement of all three of these quantities. It specifies methods for evaluating these measurements, and requirements for compliance with the standard under both static and dynamic conditions. It defines a Phasor Measurement Unit (PMU) which can be a stand-alone physical unit or a functional unit within another physical unit. This standard does not specify hardware, software or a method for computing phasors, frequency, or rate of change of frequency.

115. C37.118.2-2011 IEEE Standard for Synchrophasor Data Transfer for Power Systems

This standard defines a method for exchange of synchronized phasor measurement data between power system equipment. It specifies messaging including types, use, contents, and data formats for real-time communication between Phasor Measurement Units (PMU), Phasor Data Concentrators (PDC), and other applications.

116. C37.230-2007 IEEE Guide for Protective Relay Applications to Distribution Lines

A review of generally accepted applications and coordination of protection for radial power system distribution lines is presented. The advantages and disadvantages of schemes presently being used in protecting distribution lines are examined in this guide. Identification of problems with the methods used in distribution line protection and the solutions for those problems is included.

117. C37.231-2006 IEEE Recommended Practice for Microprocessor-Based Protection Equipment Firmware Control

This recommended practice deals with the implications surrounding the use and administration of firmware revisions for protection-related equipment. In general, the number of firmware revisions have become prolific since the introduction of microprocessor-based protection related equipment and no standard means of dealing with the issues surrounding this situation has been addressed. This recommended practice attempts to provide guidelines for the effective communication of firmware-related issues with the intent of helping to maximize the security and reliability of the power system.

118. C37.232-2011 - IEEE Standard for Common Format for Naming Time Sequence Data Files (COMNAME)

A standard procedure for naming time sequence data (TSD) files, such as files produced by digital fault recorders, power swing recorders, power quality monitors, and so on, is specified. The sources of TSD files are described, and a survey of current naming techniques is provided. The advantages of using a common naming procedure are highlighted, and the limitations and applications are identified. Issues of compatibility across operating systems and various vintages, and adaptability to other types of files, are also discussed. The required and optional portions of the naming procedure are described in detail, and many examples are provided.

119. C37.232-2007 IEEE Recommended Practice for Naming Time Sequence Data Files

A procedure for naming time sequence data (TSD) files, such as files produced by digital fault recorders, power swing recorders, power quality monitors, and so on is recommended. The sources of TSD files are described, and a survey of current naming techniques is provided. The advantages of using a common naming procedure are highlighted, and the limitations and applications are identified. Issues of compatibility across operating systems and various vintages, and adaptability to other types of files are also discussed. The required and optional portions of the naming procedure are described in detail, and many examples are provided.

120. C37.236-2013 - IEEE Guide for Power System Protective Relay Applications over Digital Communication Channels

This document is a a guide for the application of digital communication for protective relaying systems and schemes, including transmitting and receiving equipment, digital channels, application principals, performance, installation, troubleshooting, testing and maintenance. Reflected in this guide is the knowledge and experience of equipment manufacturers and power utility users. This guide is not intended to supplant specific or general instructions contained in manufacturers' instruction books or any contractual agreement.

121. PC37.237 - Recommended Practice for Time Tagging of Power System Protection Events

This is a recommended practice for time tagging protection events and associated analog and derived measurements in electric power systems. It defines the meaning of a time tag, and defines reference times for common events and time-varying quantities. It provides methods to describe measurement and transport delays, and the overall accuracy of time tagging. Potential problems caused by delays in ancillary equipment and the use of different time scales in different locations (local time zones, for example) are identified and addressed.

122. C37.238-2011 IEEE Standard Profile for Use of IEEE Std. 1588 Precision Time Protocol in Power System Applications

This standard specifies a common profile for use of IEEE 1588-2008 Precision Time Protocol (PTP) in power system protection, control, automation and data communication applications utilizing an Ethernet communications architecture. The profile specifies a well-defined subset of IEEE 1588-2008 mechanisms and settings aimed at enabling device interoperability, robust response to network failures, and deterministic control of delivered time quality. It specifies the preferred physical layer (Ethernet), higher level protocol used for PTP message exchange and the PTP protocol configuration parameters. Special attention is given to ensuring consistent and reliable time distribution within substations, between substations, and across wide geographic areas.

123. C37.239-2010 IEEE Standard Common Format for Event Data Exchange (COMFEDE) for Power Systems

A common format for data files used for the interchange of various types of event data collected from electrical power systems or power system models is defined. Extensibility, extension mechanisms, and compatibility of future versions of the format are discussed. An XML schema is defined. A sample file is given.

124. PC37.240 - Standard for Cyber Security Requirements for Substation Automation, Protection and Control Systems

This document provides technical requirements for substation cyber security. It presents sound engineering practices that can be applied to achieve high levels of cyber security of automation, protection and control systems independent of voltage level or criticality of cyber assets. Cyber security includes trust and assurance of data in motion, data at rest and incident response.

125. C37.242-2013 - IEEE Guide for Synchronization, Calibration, Testing, and Installation of Phasor Measurement Units (PMUs) for Power System Protection and Control

The document provides guidance for Synchronization, Calibration, Testing, and Installation of Phasor Measurement Units (PMU) applied in Power System Protection and Control. The following are addressed in this Guide: * Considerations for the installation of PMU devices based on application requirements and typical bus configurations. * Techniques focusing on the overall accuracy and availability of the time synchronization system. * Test and calibration procedures for phasor measurement units (PMUs) for laboratory and field applications. * Communication testing for connecting PMUs to other devices including Phasor Data Concentrators (PDC).

126. PC37.243 - Guide for Application of Digital Line Current Differential Relays Using Digital Communication

This guide presents practical line current differential schemes using digital communication. Operating principles, synchronization methods, channel requirements, current transformer requirements, external time reference requirements, backup considerations, testing considerations and troubleshooting are included. It also provides specific guidelines for various application aspects including multi-terminal lines, series compensated lines, mutual coupled lines, line charging current, in-zone transformers and reactors, single-pole tripping and reclosing as well as channel and external time sources requirements.

127. C37.244-2013 - Guide for Phasor Data Concentrator Requirements for Power System Protection, Control, and Monitoring

This guide describes performance, functional and communication needs of Phasor Data Concentrators (PDC) for power system protection, control and monitoring applications. The guide covers synchrophasor system needs and testing procedures for PDC. It includes functional requirements for associated interfaces with Phasor Measurement Units (PMU) to PDC and PDC systems. In particular, it includes requirements for synchronization, synchrophasor data processing, real-time access and historical data access.

128. C57.120-1991 IEEE Loss Evaluation Guide for Power Transformers and Reactors

In this standard a method for establishing the dollar value of the electric power needed to supply the losses of a transformer or reactor is provided. Users can use this loss evaluation to determine the relative economic benefit of a high-first-cost, low-loss unit versus one with a lower first cost and higher losses, and to compare the offerings of two or more manufacturers to aid in making the best purchase choice. Manufacturers can use the evaluation to optimize the design and provide the most economical unit to bid and manufacture. The various types of losses are reviewed.<>

129. C57.123-2002 IEEE Guide for Transformer Loss Measurement

Information and general recommendations of instrumentation, circuitry, calibration, and measurement techniques of no-load losses (excluding auxiliary losses), excitation current, and load losses of power and distribution transformers are provided. The guide is intended as a complement to the test code procedures given in Clause 8 and Clause 9 of IEEE Std C57.12.90-1999.

130. C62.11-2012 - IEEE Standard for Metal-Oxide Surge Arresters for AC Power Circuits (> 1 kV)

This standard applies to metal-oxide surge arresters (MOSAs) designed to repeatedly limit the voltage surges on 48 Hz to 62 Hz power circuits (>1000 V) by passing surge discharge current and automatically limiting the flow of system power current. This standard applies to devices for separate mounting and to devices supplied integrally with other equipment. The tests demonstrate that an arrester can survive the rigors of reasonable environmental conditions and system phenomena while protecting equipment and/or the system from damaging overvoltages caused by lightning, switching, and other undesirable surges.

131. C62.11a-2008 IEEE Standard for Metal-Oxide Surge Arresters for AC Power Circuits (>1 kV) Amendment 1: Short-Circuit Tests for Station Intermediate and Distribution Arresters

Metal-oxide surge arresters designed to repeatedly limit the voltage surges on 48 Hz to 62 Hz power circuits (>1000 V) by passing surge discharge current and automatically limiting the flow of system power current applies to this amendment. This amendment covers devices for separate mounting and to those supplied integrally with other equipment. The tests demonstrate that an arrester can survive the rigors of reasonable environmental conditions and system phenomena, while, at the same time, protect equipment and/or the system from damaging overvoltages caused by lightning, switching, or other undesirable surges.

132. C62.39-2012 - IEEE Standard for Test Methods and Preferred Values for Self-Restoring Current-Limiter Components Used in Telecommunication Surge Protection

This standard sets terms, test methods and measurement procedures for series connected, self-restoring current limiter components used in low-voltage telecommunication circuit surge protectors. It is only applicable for components in telecommunications circuits with voltages equal to or less than 1000 V rms or 1200 V dc. The self-restoring current limiters covered by this standard have the following properties: · Excessive current causes a transition from a low-resistance state to a high-resistance state · Reverts to a low-resistance state when the excessive current ends · Directly operated by the current flow through the component · Solid-state (no moving parts) · Withstands specified levels of impulse · Withstands specified AC voltage levels when in the high-resistance state Examples of this type of current limiter technology are positive temperature coefficient step-function thermistors of ceramic or polymeric material and silicon semiconductor based electronic circuits. This standard does not cover self-restoring current limiter components used in other applications, such as heaters, inrush-current limiters or sensing devices. Current interrupting type components, which reduce the current to zero by a mechanical circuit break, are not covered by this standard. In this standard, a telecommunications circuit is a circuit that uses metallic conductors to handle the remote transmission of information, such as data, communications and signalling.

133. 42010-2011 ISO/IEC/IEEE Standard for Systems and Software Engineering -- Architectural Description

The scope of this standard encompasses those products of system and software development that capture architectural information, referred to as "e;architectural descriptions"e;. This includes architectural descriptions that are used for the following: a) Expression of the system or software and its evolution b) Communication among the stakeholders c) Evaluation and comparison of architectures in a consistent manner d) Planning, managing, and executing the activities of development e) Expression of the persistent characteristics and supporting principles of a system or software to guide acceptable change f) Verification of an implementation's compliance with an architectural description g) Recording contributions to the body of knowledge of systems and software architecture

134. IEC 61588 Ed.2 (2009-02) (IEEE Std 1588™-2008): Precision Clock Synchronization Protocol for Networked Measurement and Control Systems

A protocol to synchronize independent clocks running on separate nodes of a distributed measurement and control system to a high degree of accuracy and precision is specified. The protocol is independent of the networking technology, and the system topology is self-configuring.