



IEEE Guide for the Protection of Communication Installations from Lightning Effects

STANDARDS

IEEE Power and Energy Society

Developed by the
Power System Communications and Cybersecurity
Committee

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IEEE Guide for the Protection of Communication Installations from Lightning Effects

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of the
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Approved 6 December 2023

IEEE SA Standards Board

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Abstract: Methods and practices necessary to reduce the risk of damages to communications equipment within structures arising from lightning surges causing ground potential rise and similar potential differences are addressed in this guide.

Keywords: communications equipment, IEEE 1692™, lightning, protection, towers

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Introduction

This introduction is not part of IEEE Std 1692-2023, IEEE Guide for the Protection of Communication Installations from Lightning Effects.

This guide addresses methods and practices necessary to reduce the risk of damages to communications equipment within structures arising from lightning surges causing GPR (ground potential rise) and similar potential differences.

According to the National Lightning Safety Institute, accurate information about lightning-caused damage is elusive (see National Lightning Safety Institute [B32]).⁶ The U.S. Insurance Institute estimates the annual damages from lightning in the United States to be \$5 billion with the lightning strike claims, not including U.S. government property losses, paid per year being \$820 million (see Brashear [B7]). Other sources provide much higher values. Lightning damage to equipment results in losses exceeding \$26 billion annually in North America, and nearly three times that worldwide with more than 150 strikes per second (see Duckworth [B10]). Insurance payout resulting from lightning damage, accounts for approximately 7.5% of all U.S. insurance company distributions (see Brashear [B7]). Ironically, lightning damage to equipment could be all but totally prevented.

Special protection methods to minimize lightning damage are simple, very reliable, and inexpensive, particularly when compared to the cost of equipment repair and replacement, as well as the possible consequences of harm to personnel. However, methods for lightning special protection cannot be found in the code books, for example, the National Electrical Code® (NEC®) (NFPA 70®) or the National Electrical Safety Code® (NESC®) (Accredited Standards Committee C2) [B1]. Per the scopes of these two well-known codes, lightning protection is not covered, yet they are relied upon for practically all general construction in the United States. The Lightning Protection Standard (NFPA 780)^b should not be expected to provide guidance for the prevention of lightning damage to equipment. The scope of NFPA 780 covers the protection of structures only. NFPA 780 does contain requirements for the surge protection of all service entrance signal, data, and communication circuits as well as surge protection for all service entrance power circuits. Common grounding requirement for electric service, communications, and antenna system grounds as well as underground metallic piping systems is also included in NFPA 780.

Documented methods for the special protection of equipment from lightning cannot be found in the two main codes, NEC or NESC, or the Lightning Protection Standard that are systematically referred to for practically all general construction in the United States. This is in part the reason why there is so much needless lightning damage. This guide is dedicated to providing special lightning protection methods for equipment and filling the vacuum that currently exists today (see Duckworth [B10]).

Protection of the structure from lightning plays an important role in the protection of the equipment within the structure. While the protection of the equipment is the main objective of this document, the protection of the structure housing the equipment is also covered in this document. The equipment housed in the structure is often worth many times the value of the structure.

This guide was prepared by the Wire-Line Subcommittee of the IEEE Power System Communications Committee of the IEEE Power and Energy Society.

Acknowledgments

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⁶The numbers in brackets correspond to those of the bibliography in Annex A.

Contents

1. Overview	11
1.1 Scope	11
1.2 Purpose	11
1.3 Application	11
1.4 Word usage	11
2. Normative references	12
3. Definitions, acronyms, and abbreviations	12
3.1 Definitions	12
3.2 Acronyms and abbreviations	13
4. Overview and background.....	14
5. Lightning effects	14
5.1 General	14
5.2 Surge-protective devices and wire-line.....	15
5.3 Isolation techniques	16
5.4 Lightning—a major source of ground potential rise	17
6. Handling lightning strike current.....	19
7. Locating (siting) towers.....	19
8. Grounding (earthing) considerations.....	19
8.1 Grounding electrode system design.....	19
8.2 Grounding requirements.....	20
8.3 Radial counterpoises.....	21
8.4 Grounding conductor requirements in equipment buildings or EEEs.....	22
8.5 Interior equipment ground ring.....	22
8.6 Halo ground ring.....	23
8.7 AC service grounding.....	23
8.8 Coaxial cable, waveguide, and building entrance panel (BEP).....	24
8.9 Isolation of communications cables from a lightning induced GPR	25
8.10 Single point ground	25
8.11 Installation of ground rods and bonding requirements.....	25
9. Grounding (earthing) tower and equipment	26
9.1 Single point grounding	26
9.2 Ice bridge.....	26
9.3 Building entrance panel	26
10. Entrance communications cables	27
11. AC power surge protection	27
11.1 General	27
11.2 Protecting ac services entering and exiting the building	27
11.3 Surge-protective devices.....	28
12. Personnel safety considerations.....	28
13. Equipment building or EEE lightning protection system	29
Annex A (informative) Bibliography.....	30

Annex B (informative) Lightning protection guide checklist for risk management 33

Annex C (informative) Basic concepts for lightning protection of structures..... 35

IEEE Guide for the Protection of Communication Installations from Lightning Effects

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1. Overview

1.1 Scope

This document presents engineering design guidelines for the prevention of lightning damage to communications equipment within structures.

1.2 Purpose

~~The purpose of~~ This guide provides ~~is to provide reliable engineering~~ methods and practices that have proven reliable in industry application for minimizing lightning-related ~~to minimize~~ damages to communications equipment located within structures, including those co-located with radio transmission towers or in other challenging environments, with consideration for preserving compliance with applicable codes ~~a structure~~.

1.3 Application

The protection of the structure plays an important role in the protection of the equipment within the structure. While the protection of the equipment is the main objective of this document, the protection of the structure housing the equipment is also covered in this document.

1.4 Word usage

The word shall indicates mandatory requirements strictly to be followed in order to conform to the standard and from which no deviation is permitted (*shall equals is required to*).^{7,8}

The word should indicates that among several possibilities one is recommended as particularly suitable, without mentioning or excluding others; or that a certain course of action is preferred but not necessarily required (*should equals is recommended that*).

The word may is used to indicate a course of action permissible within the limits of the standard (*may equals is permitted to*).

The word can is used for statements of possibility and capability, whether material, physical, or causal (*can equals is able to*).

2. Normative references

The following referenced documents are indispensable for the application of this document (i.e., they must be understood and used, so each referenced document is cited in text and its relationship to this document is explained). For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments or corrigenda) applies.

⁷ The use of the word must is deprecated when stating mandatory requirements; must is used only to describe unavoidable situations.

⁸ The use of will is deprecated when stating mandatory requirements; will is only used in statements of fact.

~~Accredited Standards Committee C2-2007, National Electrical Safety Code® (NESC®).~~¹

IEEE Std 487TM ~~2007~~, IEEE Standard Recommended Practice for the Electrical Protection of Communications ~~Wire-Line Communication~~ Facilities Serving Electric Supply Locations—General Considerations.^{9,10} ~~2,3~~

IEEE Std 487.2TM ~~1590~~ ~~2009~~, IEEE Standard Recommended Practice for the Electrical Protection of Communication Facilities Serving Electric Supply Locations through the Use of ~~Using~~ Optical Fiber Systems.

IEEE Std 487.3TM, IEEE Standard for the Electrical Protection of Communication Facilities Serving Electric Supply Locations Through the Use of Hybrid Facilities.

NFPA 70®, ~~2008 Edition~~, National Electrical Code® (NEC®).^{11,12} ~~4~~

NFPA 780®, ~~2000 Edition~~, Standard for the Installation of Lightning Protection Systems.

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3. Definitions, acronyms, and abbreviations

3.1 Definitions

For the purposes of this document, the following terms and definitions apply. The *IEEE Standards Dictionary Online* ~~:-Glossary of Terms & Definitions~~ should be consulted for terms not defined in this clause.^{13 5}

all-dielectric optical fiber cable: An optical fiber cable containing no metallic or conductive components.

electronic equipment enclosure (EEE): An enclosure containing communications electronic equipment. The equipment contained in an EEE might be switches, carrier electronics, or remote terminals. The EEE usually consists of a weatherproof enclosure. The EEE may be located remotely from a central office and may be either above or below ground.

ground potential rise (GPR): The product of a ground electrode impedance, referenced to remote earth, and the current that flows through that electrode impedance.

ground ring: A buried grounding electrode, in the form of a conductor in direct contact with the earth, encircling the structure being grounded.

halo ground: An internal closed loop metallic ring typically ground. ~~Usually a 6 AWG sized conductor that is routed around the room approximately 2 to 2.4 m (6 to 8 feet) above the floor. This ground is used in communications building equipment areas to dissipate unwanted electromagnetic energy from off of metallic surfaces. This ground is used to bond and ground metal objects such as metal doors, door frames or casings, window frames or casings, air handling ducts, and air conditioning housings (except fire suppression equipment). It is not to be used to ground communication equipment or equipment supporting hardware.~~

^{13 5} The IEEE Standards Dictionary *Online* ~~:-Glossary of Terms & Definitions~~ is available at: <https://dictionary.ieee.org>. An IEEE Account is required for access to the dictionary, and one can be created at no charge on the dictionary sign-in page <http://shop.ieee.org/>.

high-voltage interface (HVI): Protective apparatus that provides electrical isolation of wire-line communications conductive paths.

lightning ground potential rise (LGPR): A ground potential rise condition caused by a lightning strike to the earth or object attached to the earth. Characteristics include rise times in the [microsecond](#) ~~µs~~ and sub-[microsecond](#) ~~µs~~ time frame, current flow nominally radial from the strike point, and high differential ground potentials created over extended distances (subject to local soil resistivity).

primary (or extrinsic) [communications surge-protective device](#) ~~communication~~ SPD: [A](#) ~~An~~ surge-protective device capable of diverting or arresting a considerable portion of the surge current away from the system it is protecting. They are generally installed at the cable entrance to a [structure building](#), on the main distributing frame, or at the equipment/cable interface.

radial counterpoise: A conductor or system of conductors located on, above, or most frequently below the surface of the earth; and connected to the grounding system of towers or poles.

[remote earth:](#) [That distant point on the earth's surface where an increase in the distance from a ground electrode will not measurably increase the impedance between that ground electrode and the new distant point.](#)

[structure:](#) [A building, hut, cabinet, shelter, or electronic equipment enclosure \(EEE\) that contains communications equipment such as radio, microwave, or other electronic equipment.](#)

3.2 Acronyms and abbreviations

ABD avalanche breakdown diodeac

ac alternating current

[AHJ](#) [authority having jurisdiction](#)

AWG American wire gauge

BEP building entrance panel

dc	direct current
EEE	electronic equipment enclosure
~~EMP~~	~~electro-magnetic pulse~~
GDT	gas discharge tube
GPR	ground potential rise
HVI	high-voltage interface
IEGR	interior equipment ground ring
LGPR	lightning ground potential rise
MBJ	main bonding jumper
MCOV	maximum continuous operating voltage
~~MDF~~	~~main distributing frame~~
MGB	master ground bar
MGN	multigrounded neutral
MOV	metal oxide varistor
~~MTBF~~	~~mean time between failures~~
NEC	National Electrical Code
PGP	principal ground point
~~NESC~~	~~National Electrical~~
PSAP	Public Safety Answering Point
~~NFPA~~	~~National Fire Protection Association~~

PVC	polyvinyl chloride
SAD	silicon avalanche diode
SAS	silicon avalanche suppressor
SBTC	solid bare tinned copper
SCR	silicon controlled rectifier
SPD	surge-protective device
SPG	single point ground
~~TVSS~~	~~transient voltage surge suppression (see SPD)~~
UPS	uninterruptible power system

4. Overview and background

This guide presents recommended engineering design practices to reduce the risk of lightning damages to communications equipment within structures. If equipment is protected from damage by lightning, then personnel using, or associated with, the equipment may also be protected. Specific measures for the protection of personnel are not covered in this guide.

This guide includes discussion on the following topics:

- Lightning effects on grounded towers, buildings [or EEE](#), and equipment (Clause 5)
- Lightning—a major source of ground potential rise (Clause 5)
- Divide and control lightning strike current (Clause 6)
- Tower location with respect to equipment building [or EEE](#), electromagnetic radiation, need for Faraday cage (Clause 7)
- Grounding (earthing) considerations (Clause 8)

- Voltage divider circuit from lightning traveling down a tower (Clause 9)
- Single point ground location (Clause 9)
- Coordinate the coaxial cable entry with building [or EEE](#) equipment grounding (Clause 10)
- Entrance panel, bulkhead, or wave guide hatch (Clause 10)
- Isolate wire-line communications from remote earth (Clause 10)
- AC power surge protection and uninterruptible power system ([UPS](#)) at the power entrance facility (Clause 11)
- ~~AC disconnect isolation~~

5. Lightning effects

5.1 General

Lightning is an electrical discharge. The cloud-to-cloud or cloud-to- [earth](#) ~~ground~~ discharge generates electric, magnetic, and electromagnetic fields. The most significant field is the magnetic one. The magnetic field induces voltages in conductors. [The magnetic field also induces](#) ~~and, if~~ currents in conductive loops [When](#) a loop is formed. Cloud-to-[earth](#) ~~ground~~ or grounded structure discharges will cause a localized ground potential rise (GPR). Currents flowing in structures will cause localized voltage differences in structure grounding and the currents will create localized magnetic fields.

~~Electrical~~ Equipment damage from lightning may be placed into [the following](#) three major categories:

- Improper or insufficient grounding
- Lack of protection from GPR
- Lack of protection from lightning transients