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IEEE Guide for the Application of Surge Protective Components in Surge Protective Devices and Equipment Ports—Part 3: Silicon PN-Junction

IEEE Power and Energy Society

Sponsored by the
Surge Protective Devices Committee

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Abstract: Surge protective components (SPCs) used in power and telecom surge protective devices (SPDs) and equipment ports are covered in the IEEE C62.42™ guide series. This part, Part 3 of the series, describes silicon PN-Junction clamping diode SPCs and covers technology variants, including forward biased semiconductor diodes, Zener breakdown semiconductor diodes, avalanche breakdown semiconductor diodes, punch-through semiconductor bipolar junction transistor diodes, and fold-back semiconductor bidirectional transistor diodes, as well as component construction; characteristics; ratings; and application examples.

Keywords: avalanche breakdown, clamping, diode, fold back, forward biased, IEEE C62.42.3™, PN-junction, punch-through, silicon, Zener breakdown

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Introduction

This introduction is not part of IEEE Std C62.42.3-2017, IEEE Guide for the Application of Surge Protective Components in Surge Protective Devices and Equipment Ports—Part 3: Silicon PN-Junction.

PN-junction voltage clamping diodes have one or more PN junctions in a silicon chip. Depending on the PN-junction arrangement the clamping characteristic can be one of five types: forward-biased, Zener, avalanche, punch-through, or fold-back. The chosen component technology for a given application depends on the required clamping voltage. Clamping voltages above 10 V dictate the use of avalanche or fold-back technologies. Clamping voltages of 6 V and below are best suited to punch-through or forward-biased technologies. To lower the capacitance, these clamping components are integrated with series diodes or diode bridges. Making the diode bridge a multi-phase diode bridge allows the protection of multiple conductors with a single clamping protection component.

Clause 3 of this document gives the terms used to describe the different types of P-N-junction voltage clamping component and Clause 4 covers the various physical PN-junction constructions. Clause 5 deals with the characteristics of the different PN-junction structures and Clause 6 details the component ratings. Clause 7 describes application examples for the protection of ac, dc, or signal circuits and component series and parallel combinations.

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IEEE Guide for the Application of Surge Protective Components in Surge Protective Devices and Equipment Ports—Part 3: Silicon PN-Junction

1. Scope

The IEEE C62.42™ guide series covers surge protective components (SPCs) used in power and telecom surge protective devices (SPDs) and equipment ports. This part, Part 3 of the series, describes Silicon PN-Junction Clamping Diode SPCs and covers:

- Technology variants
  - Forward biased semiconductor diodes
  - Zener breakdown semiconductor diodes
  - Avalanche breakdown semiconductor diodes
  - Punch-through semiconductor bipolar junction transistor diodes
  - Fold-back semiconductor bidirectional transistor diodes
- Component construction
- Characteristics
- Ratings
- Application examples

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.

IEEE Std C62.42.0™, IEEE Guide for the Application of Surge Protective Components in Surge Protective Devices and Equipment Ports—Overview.[1,2]

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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* should be consulted for terms not defined in this clause.[3]

acceptor: Imperfection in a crystal lattice that, when predominant, permits hole conduction by the acceptance of electrons. (IEC 60050-521 [B5][4])

avalanche breakdown (of a PN-junction): Breakdown that is caused by the cumulative multiplication of charge carriers in a semiconductor under the action of a strong electric field, which causes some carriers to gain enough energy to liberate new hole-electron pairs by ionization. (IEC 60050-521 [B5])

bidirectional breakdown diode: Diode that has substantially the same electrical breakdown characteristic for both voltage polarities.

bidirectional transistor: Transistor that has substantially the same electrical characteristics when the terminals normally designated as emitter and collector are interchanged. (IEC 60050-521 [B5])

bipolar junction transistor: Transistor having at least two junctions and whose functioning depends on both majority carriers and minority carriers. (IEC 60050-521 [B5])

breakdown (of a reverse-biased PN-junction): Phenomenon, the initiation of which is observed as a transition from a state of high dynamic resistance to a state of substantially lower dynamic resistance for increasing magnitude of reverse current. (IEC 60050-521 [B5])

common mode conversion: Process by which a differential-mode electrical signal is produced in response to a common-mode electrical signal. (IEC 60050-161 [B3])

common-mode surge: Surge appearing equally on all conductors of a group at a given location.

NOTE 1—The reference point for common-mode surge voltage measurement can be a chassis terminal or a local earth/ground point.[5]

NOTE 2—Also known as *longitudinal surge* or *asymmetrical surge*.

depletion layer (of a semiconductor): Region in which the mobile charge carrier concentration is insufficient to neutralize the net fixed charge density of ionized donors and acceptors. (IEC 60050-521 [B5])

differential-mode surge: Surge occurring between any two conductors or two groups of conductors at a given location.

NOTE 1—The surge source may be floating, without a reference point or connected to reference point, such as a chassis terminal or a local earth/ground point.

NOTE 2—Also known as *metallic surge, transverse surge, symmetrical surge,* or *normal surge*.

[3] *IEEE Standards Dictionary Online* is available at: http://dictionary.ieee.org.
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