**SLOVENSKI STANDARD**
**oSIST prEN IEC 61643-332:2023**

**01-marec-2023**

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**Sestavni deli za nizkonapetostne naprave za zaščito pred prenapetostnimi udari - 332. del: Izbira in načini uporabe za kovinsko-oksidne varistorje (MOV)**

Components for low-voltage surge protection - Part 332: Selection and application principles for metal oxide varistors (MOV)



Composants de protection contre les surtensions basse tension - Partie 332 : Principes de sélection et d'application pour les varistances à oxyde métallique (MOV)



**Ta slovenski standard je istoveten z:** **prEN IEC 61643-332:2022**

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**ICS:**

| | | |
|---|---|---|
| 29.120.50 | Varovalke in druga nadtokovna zaščita | Fuses and other overcurrent protection devices |
| 31.040.20 | Potenciometri, spremenljivi upori | Potentiometers, variable resistors |

**oSIST prEN IEC 61643-332:2023** **en**

# 37B/230/CDV

COMMITTEE DRAFT FOR VOTE (CDV)

| | |
|---|---|
| PROJECT NUMBER: **IEC 61643-332 ED1** | |
| DATE OF CIRCULATION: **2022-12-30** | CLOSING DATE FOR VOTING: **2023-03-24** |
| SUPERSEDES DOCUMENTS: **37B/226/CD, 37B/229/CC** | |

| | |
|---|---|
| IEC SC 37B : COMPONENTS FOR LOW-VOLTAGE SURGE PROTECTION | |
| SECRETARIAT: United States of America | SECRETARY: Mr Casey Granata |
| OF INTEREST TO THE FOLLOWING COMMITTEES: SC 37A,TC 40,TC 108 | PROPOSED HORIZONTAL STANDARD: ☐ Other TC/SCs are requested to indicate their interest, if any, in this CDV to the secretary. |
| FUNCTIONS CONCERNED: ☒ EMC ☐ ENVIRONMENT ☐ QUALITY ASSURANCE ☐ SAFETY | |
| ☒ SUBMITTED FOR CENELEC PARALLEL VOTING<br>**Attention IEC-CENELEC parallel voting**<br>The attention of IEC National Committees, members of CENELEC, is drawn to the fact that this Committee Draft for Vote (CDV) is submitted for parallel voting.<br>The CENELEC members are invited to vote through the CENELEC online voting system. | ☐ NOT SUBMITTED FOR CENELEC PARALLEL VOTING |



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TITLE:

**Components for low-voltage surge protection – Part 332: Selection and application principles for metal oxide varistors (MOV)**

PROPOSED STABILITY DATE: 2025

NOTE FROM TC/SC OFFICERS:

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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# COMPONENTS FOR LOW-VOLTAGE SURGE PROTECTION –

# Part 332: Selection and application principles for metal oxide varistors (MOV)

## FOREWORD

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International Standard IEC 61643 has been prepared by subcommittee 37B: Components for low voltage surge protection, of IEC technical committee 37: Surge arresters.

The text of this International Standard is based on the following documents:

| FDIS | Report on voting |
|---|---|
| XX/XX/FDIS | XX/XX/RVD |

Full information on the voting for the approval of this International Standard can be found in the report on voting indicated in the above table.

This document has been drafted in accordance with the ISO/IEC Directives, Part 2.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under "http://webstore.iec.ch" in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

# COMPONENTS FOR LOW-VOLTAGE SURGE PROTECTION –

# Part 332: Selection and application principles for metal oxide varistors (MOV)

## 1 Scope

This part of IEC 61643 presents a description, theory of operation, test characteristics, and application principles for MOVs, which are used for applications up to 1 000 V AC or 1 500 V DC in power line, or telecommunication, or signalling circuits. They are designed to protect apparatus or personnel, or both, from high transient voltages.

This specification applies to MOVs having two electrodes and overvoltage protection components with or without disconnectors. This specification also does not apply to mountings and their effect on the MOV's characteristics. Characteristics given apply solely to the MOV mounted only in the ways described for the tests.

This standard specifically discusses the zinc-oxide type of MOVs.

## 2 Normative references



The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.



IEC 60068-1:2013, *Environmental testing – Part 1: General and guidance*

IEC 60068-2-20:2021, *Environmental testing - Part 2-20: Tests - Test Ta and Tb: Test methods for solderability and resistance to soldering heat of devices with leads*

IEC 60068-2-21:2021, *Environmental testing – Part 2-21: Tests – Test U: Robustness of terminations and integral mounting devices*

IEC 60068-2-78:2012, *Environmental testing - Part 2-78: Tests - Test Cab: Damp heat, steady state*

IEC 60664-1:2020, *Insulation coordination for equipment within low-voltage supply systems - Part 1: Principles, requirements and tests*

IEC 61051-1:2018, *Varistors for use in electronic equipment - Part 1: Generic specification*

IEC 61051-2:1991/AMD1:2009, *Ammendment 1- Varistors for use in electronic equipment - Part 2: Sectional specification for surge suppression varistors*

IEC 61643-11:2011, *Low-voltage surge protective devices – Part 11: Surge protective devices connected to low-voltage power systems – Requirements and test methods*

IEC 61643-331:2020, *Components for low-voltage surge protection - Part 331: Performance requirements and test methods for metal oxide varistors (MOV)*

IEC 62368-1:2018, *Audio/video, information and communication technology equipment - Part 1: Safety requirements*

# 3 Terms, definitions, symbols and abbreviated terms

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at http://www.electropedia.org/
- ISO Online browsing platform: available at http://www.iso.org/obp

## 3.1 Terms and definitions

### 3.1.1 Ratings

**3.1.1.1**
**rating**

either a limiting capability or a limiting condition beyond which damage to the MOV may occur

Note 1 to entry: A limiting condition may be either a maximum or a minimum.

**3.1.1.2**
**nominal discharge current**
$I_n$
crest value of the current through the MOV having a current waveshape of 8/20

[SOURCE: IEC 61643-331:2020, 3.1.1.3]

**3.1.1.3**
**maximum continuous voltage**
$V_M$
voltage that may be applied continuously at a specified temperature



Note 1 to entry: May also be called $U_C$ or MCOV (Maximum continuous operating voltage).

Note 2 to entry: See Figure 1.



[SOURCE: IEC 61643-331:2020, 3.1.1.7, modified (addition of "Maximum continuous operating voltage" to Note 1 to entry)]

**3.1.1.4**
**maximum continuous AC voltage**
$V_{M(AC)}$
value of r.m.s. power frequency voltage (less than 5 % total harmonic distortion) that may be applied continuously at a specified temperature

[SOURCE: IEC 61643-331:2020, 3.1.1.8]

**3.1.1.5**
**maximum continuous DC voltage**
$V_{M(DC)}$
DC voltage that may be applied continuously at a specified temperature

[SOURCE: IEC 61643-331:2020, 3.1.1.9]

**3.1.1.6**
**maximum discharge current**
$I_{max}$
crest value of a current through the SPD having an 8/20 waveshape and magnitude according to the manufacturers specification.

Note 1 to entry: $I_{max}$ is equal to or greater than $I_n$

[SOURCE: IEC 61643-11:2011, 3.1.48]

**3.1.1.7**
**impulse discharge current for class I test**
$I_{imp}$

crest value of a discharge current through the SPD with specified charge transfer *Q* and specified energy *W/R* in the specified time

[SOURCE: definition 3.1.10 of IEC 61643-11:2011]

**3.1.1.8**
**rated average dissipation power**

$P_M$
maximum average dissipation power of repetitive pulses allowed to be applied to the varistors at ambient temperature of 25 °C

[SOURCE: definition of IEC 61051-1:2018, 3.23]

### 3.1.2 Characteristics

**3.1.2.1**

**characteristics**
inherent and measurable properties of an MOV

[SOURCE: IEC 61643-331:2020, 3.1.2.1]

**3.1.2.2**

**standby current**
$I_D$
current passing through MOV at maximum continuous voltage $V_M$

Note 1 to entry: The current passing through the MOV at less than $V_M$ is called leakage current

[SOURCE: IEC 61643-331:2020, 3.1.2.2]

**3.1.2.3**

**varistor voltage**
$V_V$
voltage across the MOV measured at a specified current (typically 1 mA) for a specific duration

Note 1 to entry: The MOV manufacturer specifies the current. Otherwise, 1 mA DC for a duration of 20 to 100 ms is normally used.

Note 2 to entry: See Figure 1

[SOURCE: IEC 61643-331:2020, 3.1.2.3]

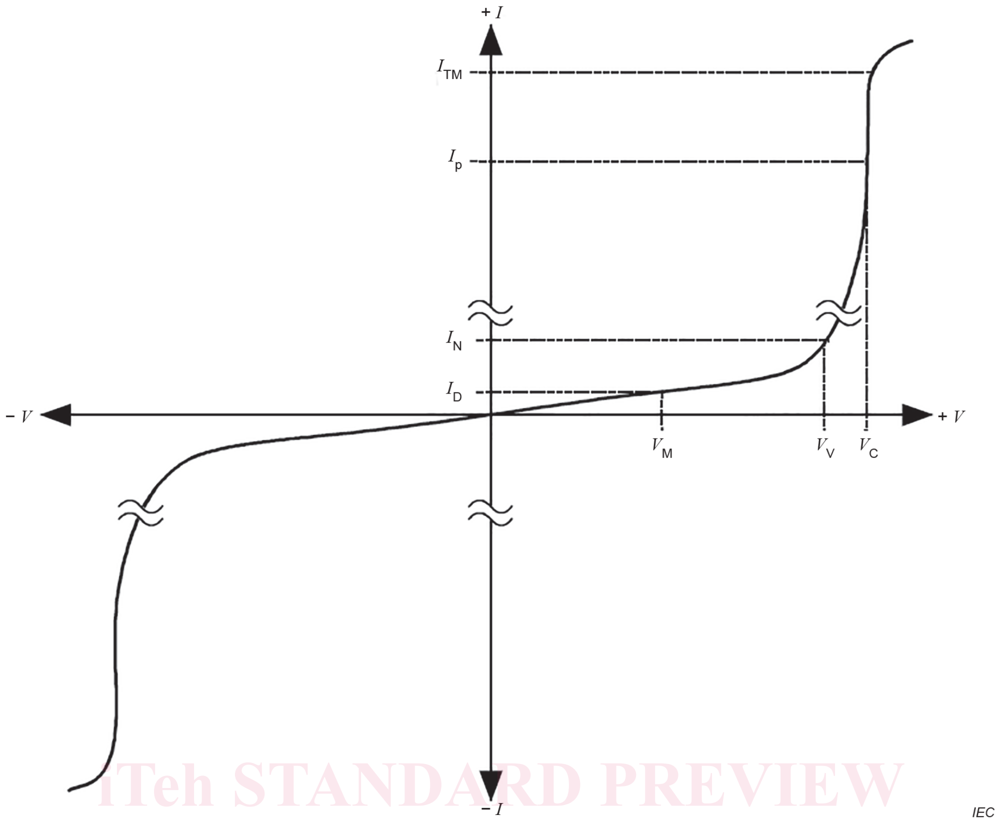


**Figure 1 – *V-I* characteristic of an MOV**



**3.1.2.4**

**Clamping voltage**

$V_C$

peak voltage across the MOV measured under conditions of a specified peak pulse current ($I_p$) and specified waveform

[SOURCE: IEC 61643-331:2020, 3.1.2.5]

**3.1.2.5**

**Capacitance**

$C_V$

capacitance across the MOV measured at a specified frequency, voltage and time

[SOURCE: IEC 61643-331:2020, 3.1.2.6]

**3.1.2.6**

**metal oxide varistor (MOV)**

non-linear resistor made of a sintered mixture of metal oxides whose conductance, at a given temperature, increases rapidly with voltage

Note 1 to entry: This is also known as a voltage dependant resistor (VDR).

[SOURCE: IEC 61643-331:2020, 3.1.2.7]

**3.1.2.7**

**thermally protected metal oxide varistor**

varistor which includes a series non-resettable element that will disconnect the MOV when it is overheated due to excessive dissipation

[SOURCE: IEC 61643-331:2020, 3.1.2.8]

**3.1.2.8**

**non-linear exponent**

α

a measure of varistor non-linearity between a given current range of ($I_1$, $I_2$), it is expressed as $\alpha_{12}=\log (I_2 / I_1) / \log (V_2 / V_1)$

## 3.2 Symbols and abbreviated terms used in this document

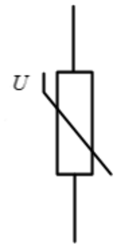


**Figure 2 – Symbol for an MOV**

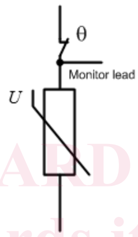




**Figure 3 – Symbol for a thermally protected MOV**

Note 1 to entry: IEC 60027 recommends the letters *V* and *v* only as reserve symbols for voltage; however, in the field of MOV components, these are so widely used that in this publication they are preferred to *U* and *u*.



### 3.2.1 Abbreviated terms

| | |
|---|---|
| ESD | Electrostatic Discharge |
| GDT | Gas Discharge Tube |
| IC | Integrated Circuit |
| IT | Information Technology |
| IT | Isole-Terre (French for Isolated-Earth) |
| MCOV | Maximum Continuous Operating Voltage |
| MOV | Metal Oxide Varistor |
| SMD | Surface Mount Device |
| SMT | Surface Mount Technology |
| SPC | Surge Protective Component |
| SPD | Surge Protective Device |
| TCO | Thermal Cut off |
| TOV | Temporary Overvoltage |
| TN | Terre-Neutral (French for Earth-Neutral) |
| TT | Terre-Terre (French for Earth-Earth) |
| VDR | Voltage Dependent Resistor |

# 4 General

Due to the high complexity of the ceramics on which the functioning of the MOV is based, the performance of the MOV depends on the technology and processes used. Thus the electrical properties and characteristics (tolerances, impulse withstand capability, etc.) may vary among manufacturers. The explanations of terms related to electrical properties and characteristics are described in Annex A.

# 5 Construction

Typically, MOVs consist of a round disc-shaped body of sintered zinc-oxide with suitable additives. Other types in use include rectangular and tubular shapes and multilayer structures. MOVs have metal particle electrodes consisting of a silver alloy or other metal. The electrodes may have been applied to the body by screening and sintering or by other processes depending on the metal used. MOVs also often have wire leads or some other type of termination that may have been soldered to the electrode.

The basic conduction mechanism of MOVs results from semiconductor barriers at the boundary of the zinc-oxide grains formed during a sintering process. The MOV may be considered a multi-barrier component with many grains acting in series-parallel combination between the terminals. A schematic cross-sectional view of a typical MOV is shown in Figure 4.

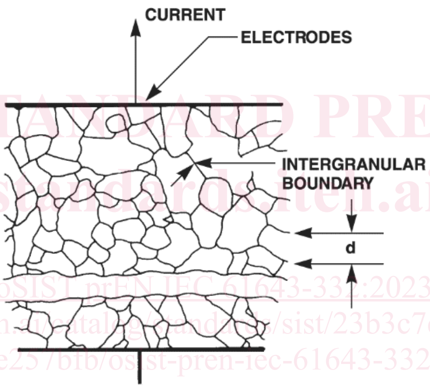




**Figure 4 – Schematic depiction of microstructure of MOV**

# 6 Function

## 6.1 Theory of operation

MOVs have the property of maintaining a relatively small voltage change across their terminals while the surge current flowing through them varies over several decades. This non-linear action allows them to divert the current of a surge when connected in shunt across the line, and hold the voltage across the line to values that protect the equipment connected to that line. Since the voltage across the MOV is held at some level higher than the normal circuit voltage (but still protecting) while surge current flows, there will be energy dissipated in the MOV during its surge diversion function.

The MOV material consists of zinc-oxide grains separated by a thin intergranular material. Bismuth oxide and other metal oxides comprise the boundary between grains, and these form semiconducting barriers with the grains. A fundamental property of the material is that the voltage drop across a single interface between the grains is nearly constant, and is independent of the grain size. Figure 5 shows a typical $V$-$I$ characteristic of an MOV in one direction of conduction, and the opposite direction would be similar.

The voltage and current values of the curve in Figure 5 were measured by using DC current when the current being less than $10^{-2}$ A, or by using 8/20 current when the current being greater than 100 A.

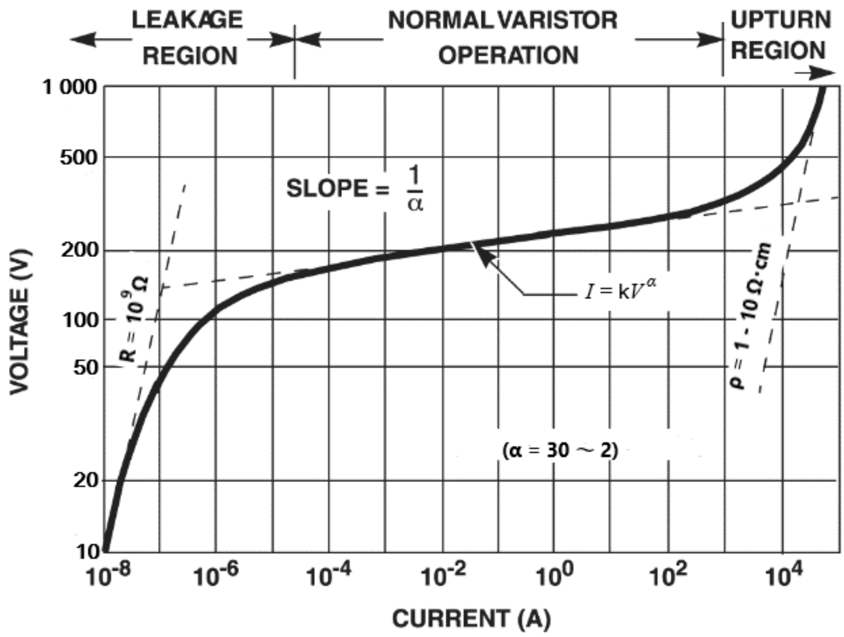


**Figure 5 – Typical varistor $V$-$I$ curve plotted log-log scale**

The electrical behaviour of an MOV can be understood by reference to the $V$-$I$ characteristic of Fig.5 and the equivalent circuit components of Fig.6 as follows:

1) Leakage Region: When the voltage across the MOV is below its varistor voltage ($V_V$), the non-linear resistance $R_x$ approaches a high ohmic state and can be disregarded, hence the parallel resistance $R_{off}$, is the prevailing component. In the example of Fig. 6, $R_{off}$ is such a high value that the MOV is essentially in a nearly open-circuit state.
2) Normal Varistor Operation Region: The non-linear resistance $R_x$ becomes so small that it is much lower than the linear leakage resistance $R_{off}$, so that the $R_{off}$ is ignored but $R_x$ remains larger than $R_{on}$. The variable resistance $R_x$ takes on continuously decreasing values, according to the power law relating current and voltage. During this region, current increases in several orders of magnitude as $V_V$ remains rather constant.
3) Upturn Region: At large currents, the series resistance $R_{on}$ becomes a significant part of the total device resistance, causing an upturn with the value of $R_{on}$ as an asymptote. The MOV is essentially in a short-circuit state during this region.

The parametric values given in Figure 5 and Figure 6 are shown for illustration purposes only.

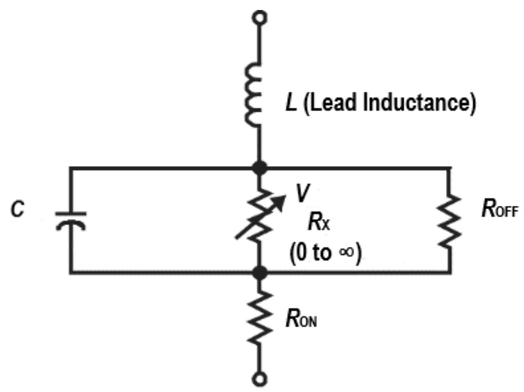


**Figure 6 – MOV equivalent circuit model**

Under AC or signal operating conditions as well as under surge conditions the reactive components ($L$ and $C$) of Figure 6 may significantly affect the behaviour of the MOV. The parallel capacitance $C$ can pass a current that may be larger than the DC standby current. The series inductance $L$, resulting from the leads can increase the voltage appearing across the component