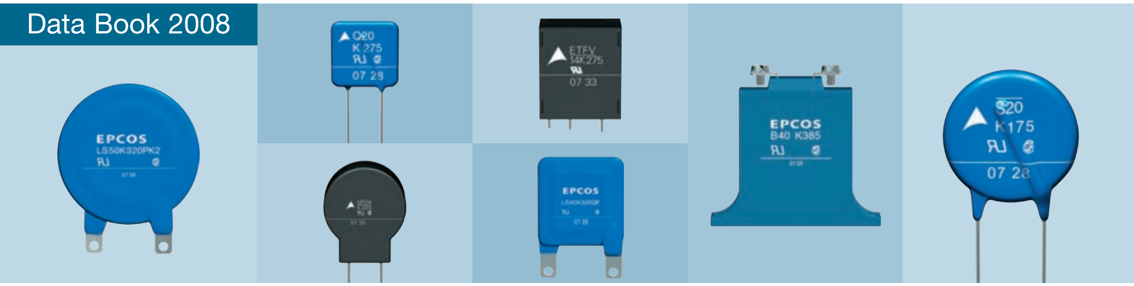
EPCOS

Data Book 2008



SIOV Metal Oxide Varistors

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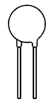
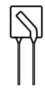
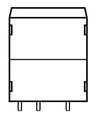
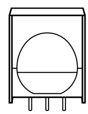
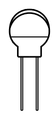
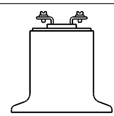
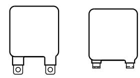
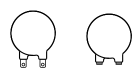
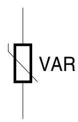
Leaded	Monolithic	Round disk, epoxy coating	Tinned copper wire	S	
		Square disk, epoxy coating	Tinned copper wire	Q	
Housed	Monolithic	Round disk, epoxy coating, thermoplastic housing	Tinned copper wire, metal compound wire	ETFV14K/ ETFV25K	
				ETFV20K	
		Round disk, epoxy coating	Tinned copper wire	SFS14	
Block	Monolithic	Round or square disk in housing	Screw terminals	B	
Strap	Monolithic	Square disk, epoxy coating	Bent or straight strap terminals for screw fixing or soldering	LS … QP(K2)	
		Round disk, epoxy coating	Bent or straight strap terminals for screw fixing or soldering	LS … P(K2)	

Disk varistors, monolithic, leaded

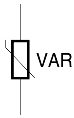
 VAR0017-R					
Nominal diameter	5 mm	5 mm	7 mm	7 mm	10 mm
	StandarD	**AdvanceD**	**StandarD**	**AdvanceD**	**StandarD**
	S05 page 99	**S05 … E2** page 131	**S07** page 99	**S07 … E2** page 131	**S10** page 99
Operating voltage V_{RMS}	11 … 460 V	130 … 300 V	11 … 460 V	130 … 320 V	11 … 680 V
Surge current (8/20 µs) i_{max}	100 … 400 A	800 A	250 … 1200 A	1750 A	500 … 2500 A
Energy absorption (2 ms) W_{max}	0.3 … 18 J	6.0 … 15 J	0.8 … 36 J	12.5 … 32 J	1.7 … 72 J
Automotive			**S07AUTO** page 193/205		**S10AUTO** page 193/205
Operating voltage V_{RMS}			14 V_{RMS} 48 V_{DC} 1)		14 … 17 V_{RMS} 48 V_{DC} 1)
Surge current (8/20 µs) i_{max}			250 A		500 A
Energy absorption (10 ×) W_{LD}			12.0 J		25.0 J
Telecom			**S07(TELE)** page 213		
Operating voltage V_{RMS}			60/95 V		
Surge current (8/20 µs) i_{max}			1200 A		
Energy absorption (2 ms) W_{max}			4.8/7.6 J		

PSpice simulation models for all types on the Internet at http://www.epcos.com/tools

1) Automotive series for 42 V

Overview of types

Disk varistors, monolithic, leaded

 VAR0017-R					
Nominal diameter	10 mm	10 mm	14 mm	14 mm	14 mm
	AdvanceD	**AdvanceD-MP**	**StandarD**	**AdvanceD**	**AdvanceD-MP**
	S10 … E2 page 131	**S10 … E2K1** page 151	**S14** page 99	**S14 … E2** page 131	**S14 … E2K1** page 151
Operating voltage V_{RMS}	130 … 680 V	275 … 460 V	11 … 1100 V	130 … 680 V	275 … 460 V
Surge current (8/20 µs) i_{max}	3.5 kA	3.5 kA	1.0 … 4.5 kA	5.0/6.0 kA	5.0/6.0 kA
Energy absorption (2 ms) W_{max}	25 … 110 J	55 … 70 J	3.2 … 230 J	50 … 220 J	110 … 150 J
Automotive			**S14AUTO** page 193/205		
Operating voltage V_{RMS}			14 … 30 V 48 V_{DC} 1)		
Surge current (8/20 µs) i_{max}			1.0 kA		
Energy absorption (10 ×) W_{LD}			50 J		

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1) Automotive series for 42 V

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Overview of types

Disk varistors, monolithic, leaded

 VAR VAR0017-R					
Nominal diameter	20 mm	20 mm	20 mm	20 mm	25 mm
	StandarD	**AdvanceD**	**SuperioR**	**SuperioR-MP**	**SuperioR**
	S20 page 99	**S20 … E2** page 131	**S20 … E3** page 161	**S20 … E3K1** page 169	**S25 … E4R12** page 175
Operating voltage V_{RMS}	11 … 1100 V	130 … 680 V	115 … 320 V	275 … 460 V	130 … 750 V
Surge current (8/20 µs) i_{max}	2.0 … 8 kA	10 kA	12 kA	12 kA	20 kA
Energy absorption (2 ms) W_{max}	10 … 410 J	100 … 440 J	110 … 320 J	260 … 370 J	185 … 1025 J
Automotive	**S20AUTO** page 193/205				
Operating voltage V_{RMS}	14 … 30 V 48 V_{DC} 1)				
Surge current (8/20 µs) i_{max}	2.0 kA				
Energy absorption (10 ×) W_{LD}	100 J				

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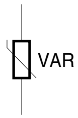
1) Automotive series for 42 V

Overview of types

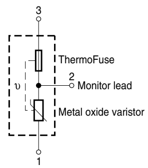
Disk varistors, monolithic, leaded

 VAR0017-R		
Nominal diameter	14 mm	20 mm
	EnergetiQ	
	Q14 page 183	**Q20** page 183
Operating voltage V_{RMS}	130 … 320 V	130 … 320 V
Surge current (8/20 μs) i_{max}	8.0 kA	15 kA
Energy absorption (2 ms) W_{max}	75 … 185 J	100 … 255 J

PSpice simulation models for all types on the Internet
at http://www.epcos.com/tools

Overview of types

Disk varistors in housing



Nominal diameter	14 mm	20 mm	25 mm	14 mm
	ThermoFuse varistor, AdvanceD			**Fail-safe varistor**
	ETFV14 … E2 page 235	**ETFV20 … E2** page 241	**ETFV25 … E4** page 247	**SFS14** page 253
Operating voltage V_{RMS}	130 … 420 V	130 … 420 V	115 … 420 V	385 V
Surge current (8/20 µs) i_{max}	6.0 kA	10 kA	20 kA	5.0 kA
Energy absorption (2 ms) W_{max}	50 … 136 J	100 … 273 J	170 … 700 J	136 J

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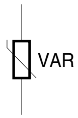
Overview of types

Block varistors, monolithic, screw terminals

 VAR0017-R				
Nominal diameter	32 mm	40 mm	60 mm	80 mm
	HighE			
	B32 page 259	**B40** page 259	**B60** page 259	**B80** page 259
Operating voltage V_{RMS}	130 … 750 V	75 … 750 V	130 … 1100 V	130 … 1100 V
Surge current (8/20 μs) i_{max}	25 kA	25/40 kA	70 kA	100 kA
Energy absorption (2 ms) W_{max}	210 … 800 J	190 … 1200 J	490 … 3000 J	660 … 6000 J

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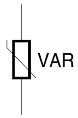
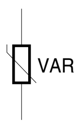
Overview of types

Strap varistors, monolithic, straight or bent strap terminals

 VAR0017-R					
Nominal diameter	40 mm	40 mm	40 mm	40 mm	40 mm
	HighE				
	LS40 … QP page 275	**LS40 … QPK2** page 275	**LS41 … QP** page 287	**LS42 … QP** page 293	**LS42 … QPK2** page 293
Operating voltage V_{RMS}	130 … 750 V	130 … 750 V	130 … 460 V	250 … 460 V	250 … 460 V
Surge current (8/20 µs) i_{max}	40 kA	40 kA	50 kA	65 kA	65 kA
Energy absorption (2 ms) W_{max}	310 … 1200 J	310 … 1200 J	310 … 960 J	490 … 960 J	490 … 960 J

 VAR0017-R		
Nominal diameter	50 mm	50 mm
	HighE	
	LS50 … P page 301	**LS50 … PK2** page 301
Operating voltage V_{RMS}	130 … 550 V	130 … 550 V
Surge current (8/20 µs) i_{max}	75 kA	75 kA
Energy absorption (2 ms) W_{max}	490 … 1820 J	490 … 1820 J

PSpice simulation models for all types on the Internet at http://www.epcos.com/tools

Ordering code system

For leaded and housed varistors

B722	10	S	2	271	K	1	0	1

B722 – Monolithic varistor

10 – Nominal disc diameter

Design:
S = Leaded varistor
T = ThermoFuse
F = Fail-safe varistor
Q = EnergetiQ

Series:
0 = StandarD
1 = Automotive
2 = AdvanceD
3 = SuperioR
4 = SuperioR

Max. AC operating voltage:
271 = $27 \cdot 10^1$ = 275 VAC
140 = $14 \cdot 10^0$ = 14 VAC
141 = $14 \cdot 10^1$ = 140 VAC

Tolerance of varistor voltage:
K = ±10%
J = ±5%
S = Special tolerance

Lead configuration:
1 = Straight leads,
2 thru 5 = Kinked form,
for further information please refer to chapter "Taping, packaging and lead configuration"

Packaging:
0 = Bulk,
1 thru 6 = Taping style,
for further information please refer to chapter "Taping, packaging and lead configuration"

Internal coding:
1 = Standard

EPCOS

Ordering code system

For block and strap varistors

B722	40	B	0	271	K	0	0	1

- **B722**: Monolithic varistor
- **40**: Nominal disc diameter
- **B**: **Design:**
  B = Block varistor
  L = Strap varistor
- **0**: Internal coding
- **271**: **Max. AC operating voltage:**
  271 = 27 · 10^1 = 275 VAC
  750 = 75 · 10^0 = 75 VAC
  141 = 14 · 10^1 = 140 VAC
- **K**: **Tolerance of varistor voltage:**
  K = ±10%
  J = ±5%
  S = Special tolerance
- **001**: Internal coding

1 General technical information

1.1 Introduction

Despite its many benefits, one of the few drawbacks of semiconductor technology is the vulnerability of solid-state devices to overvoltages. Even voltage pulses of very low energy can produce interference and damage, sometimes with far-reaching consequences. So, as electronics makes its way into more and more applications, optimum overvoltage or transient suppression becomes a design factor of decisive importance.

SIOV® varistors have proven to be excellent protective devices because of their application flexibility and high reliability. The metal oxide varistor, with its extremely attractive price/performance ratio, is an ideal component for limiting surge voltage and current as well as for absorbing energy.

The EPCOS product range includes radial-leaded disks, block varistors and strap varistors for power distribution applications. Special types for automotive electrical systems and for telecom applications round off the product range.

Overvoltage protection devices like SIOV varistors are often referred to in international publications as a TVSS (transient voltage surge suppressor).

1.2 Definition

Varistors (**var**iable res**istors**) are voltage-dependent resistors with a symmetrical V/I characteristic curve (figure 2) whose resistance decreases with increasing voltage. Connected in parallel with the electronic device or circuit that is to be guarded, they form a low-resistance shunt when voltage increases and thus prevent any further rise in the overvoltage.

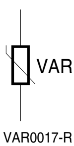


Figure 1 Circuit diagram symbol for a varistor

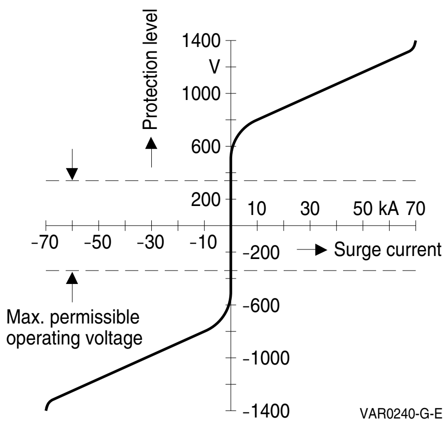


Figure 2 Typical V/I characteristic curve of a metal oxide varistor on a linear scale, using the SIOV-B60K250 as an example

® Registered trademark for EPCOS metal oxide varistors

The voltage dependence of varistors or VDRs (**v**oltage **d**ependent **r**esistors) may be approximately characterized by the formula $I = K \cdot V^{\alpha}$, where α denotes the “nonlinearity” exponent and in this way may be interpreted as a measure of the “steepness” of the V/I characteristic (more details will follow in section 1.6). In metal oxide varistors it has been possible to produce α figures of more than 30. This puts their protection levels in the same region as those of zener diodes and suppressor diodes. Exceptional current handling capability combined with response times of < 25 ns make them an almost perfect protective device. The principle of overvoltage protection by varistors is explained in chapter “Selection procedure” in section 1.2.

1.3 Microstructure and conduction mechanism

Sintering zinc oxide together with other metal oxide additives under specific conditions produces a polycrystalline ceramic whose resistance exhibits a pronounced dependence on voltage. This phenomenon is called the varistor effect.

Figure 3 shows the conduction mechanism in a varistor element in simplified form. The zinc oxide grains themselves are highly conductive, while the intergranular boundary formed of other oxides is highly resistive. Only at those points where zinc oxide grains meet does sintering produce “microvaristors”, comparable to symmetrical zener diodes (protection level approx. 3.5 V). The electrical behavior of the metal oxide varistor, as indicated by figure 3, results from the number of microvaristors connected in series or in parallel.

This implies that the electrical properties are controlled by the physical dimensions of the varistor:

- Twice the ceramic thickness produces twice the protection level because then twice the number of microvaristors are arranged in series.
- Twice the area produces twice the current handling capability because then twice the number of current paths are arranged in parallel.
- Twice the volume produces almost twice the energy absorption capability because then there are twice as many absorbers in the form of zinc oxide grains.

The series and parallel connection of the individual microvaristors in the sintered body of a SIOV also explains its high electrical load capacity compared to semiconductors. While the power in semiconductors is dissipated almost entirely in one thin p-n junction area, in a SIOV it is distributed over all the microvaristors, i.e. uniformly throughout the component’s volume. Each microvaristor is provided with energy absorbers in the form of zinc oxide grains with optimum thermal contact. This permits high absorption of energy and thus exceptionally high surge current handling capability.

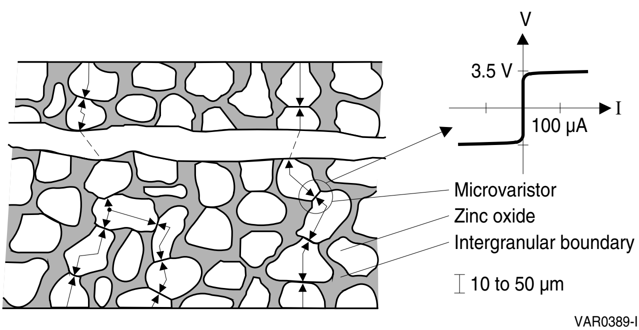


Figure 3 Conduction mechanism in a varistor element

Grain size

For matching very different levels of protection to ceramic thicknesses that are suitable for fabrication, SIOV varistors have to be produced from ceramics with different voltage gradients. The variation of raw materials and sintering process influence the growth of grain size (grain diameter approx. 10 to 100 µm) and thus produce the required specific ceramic voltage (approx. 30 to 250 V/mm). The V/I characteristic of the individual microvaristors is not affected by this.

Ceramics with a small specific voltage (low-voltage types ≤40 V) cannot handle the same current density as high-voltage types. That explains the differences in surge current, energy absorption and mechanical dimensions within the various type series. The effect of the different grain sizes is most apparent between the voltage classes K40 and K50. For example, the maximum permissible surge current is:

SIOV-S07K40	i_{max} = 250 A
SIOV-S07K50	i_{max} = 1200 A

1.4 Construction

Sintered metal oxide ceramics are processed on different production lines:

Disk types
Here the varistor disk is fitted with leads of tinned copper wire and then the ceramic body is coated with epoxy resin in a fluidized bed.

Disk varistors in housing

Here the disk varistors are fitted into a housing for special overvoltage fields application.

- ThermoFuse (ETFV) types
  These are designed for self-protection under abnormal overvoltage conditions.
- Fail-safe (SFS) types
  No flame or rupture under specified test conditions (see “Reliability data”, “Overvoltage test” in the data sheet).

Block types
The large electromagnetic forces involved in handling currents between 10 kA and 100 kA call for solid contacting with special electrodes and potting in a plastic housing. Block varistors are electrically and mechanically connected by screw terminals.

Strap types
After contacting of the varistor ceramics with special bolt-holed electrodes, these components are coated with epoxy resin in a fluidized bed.

For photos of all constructions see “Overview of types”.

1.5 Equivalent circuits

Figure 4 shows the simplified equivalent circuit of a metal oxide varistor. From this the behavior of the varistor can be interpreted for different current ranges.

Leakage current region (< 10^{-4} A)
In the leakage current region the resistance of an ideal varistor goes towards ∞, so it can be ignored as the resistance of the intergranular boundary will predominate. Therefore $R_B << R_{IG}$. This produces the equivalent circuit in figure 5:

The ohmic resistance R_{IG} determines behavior at low currents, the V/I curve goes from exponential to linear (downturn region).
R_{IG} shows a distinct temperature dependence, so a marked increase in leakage current must be expected as temperature increases.

Normal operating region (10^{-5} to 10^3 A)
With $R_V << R_{IG}$ and $R_B << R_V$, R_V determines the electrical behavior (figure 6). The V/I curve (figure 12) follows to a good approximation the simple mathematical description by an exponential function (equation 3 in 1.6.1) where $\alpha > 30$, i.e. the curve appears more or less as a straight line on a log-log scale.

High-current region (> 10^3 A)
Here the resistance of the ideal varistor approaches zero. This means that $R_V << R_{IG}$ and $R_V < R_B$ (figure 7). The ohmic bulk resistance of ZnO causes the V/I curve to resume a linear characteristic (upturn region).

Capacitance
Equivalent circuits 4 and 5 indicate the capacitance of metal oxide varistors (see product specifications for typical values).
In terms of overvoltage suppression, a high capacitance is desirable because, with its lowpass characteristic, it smooths steep surge voltage edges and consequently improves the protection level.

Lead inductance
The response time of the actual varistor ceramics is in the picosecond region. In the case of leaded varistors, the inductance of the connecting leads causes the response time to increase to values of several nanoseconds. For this reason, all attempts must be made to achieve a mounting method with the lowest possible inductance i.e. shortest possible leads.

Equivalent circuits

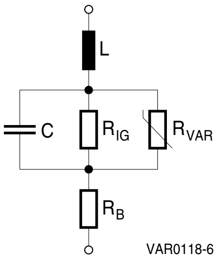


Figure 4

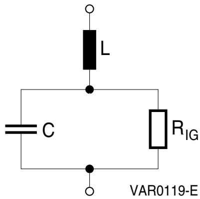


Figure 5

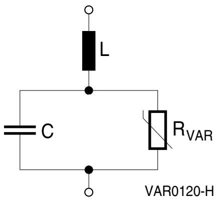


Figure 6

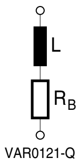


Figure 7

L	Lead inductance ($\approx$ 1 nH/mm)
C	Capacitance
R_{IG}	Resistance of intergranular boundary ($\rho \approx 10^{12}$ to 10^{13} Ωcm)
R_{VAR}	Ideal varistor (0 to ∞ Ω)
R_B	Bulk resistance of ZnO ($\rho \approx$ 1 to 10 Ωcm)

1.6 V/I characteristics

1.6.1 Forms of presentation

The V/I characteristics of metal oxide varistors are similar to those of power functions (odd exponents), so it is fairly obvious that the latter should be used to describe them. As the curves are symmetrical, only one quadrant is generally shown for reasons of simplification (figure 8):

$$I = K\,V^{\alpha} \qquad \alpha > 1 \qquad \text{(equ. 1)}$$

I	Current through varistor
K	Ceramic constant (depending on varistor type)
V	Voltage across varistor
α	Nonlinearity exponent (measure of nonlinearity of curve)

Another possible interpretation of the physical principle underlying these curves is that of a voltage-dependent resistance value, and particularly its rapid change at a predetermined voltage. This phenomenon is the basis of the varistor protection principle (figure 9):

$$R = \frac{V}{I} = \frac{V}{K\,V^{\alpha}} = \frac{1}{K}\,V^{1-\alpha} \qquad \text{(equ. 2)}$$

Equations 1 and 2 can be shown particularly clearly on a log-log scale, because power functions then appear as straight lines:

$$\log I = \log K + \alpha \log V \qquad \text{(equ. 3)}$$

$$\log R = \log\left(\frac{1}{K}\right) + (1-\alpha)\log V \qquad \text{(equ. 4)}$$

This is virtually the only form of presentation used for varistor characteristics (figures 10 and 11). A further advantage of the log-log format is the possibility of showing the wide range of the V/I curve (more than ten powers of 10).

It is evident that the simplified equations 1 to 4 cannot cover the downturn and upturn regions as described in section 1.5. Here, a mathematical description as shown in equation 21 in chapter “Application notes” is required.

Determining nonlinearity exponent α

Two pairs of voltage/current values (V_1/I_1 and V_2/I_2) are read from the V/I characteristic of the varistor and inserted into equation 3, solved for α:

$$\alpha = \frac{\log I_2 - \log I_1}{\log V_2 - \log V_1} \qquad \text{(equ. 5)}$$

Presentation of the V/I characteristics

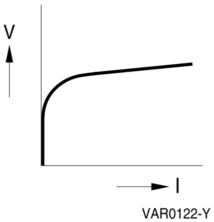


Figure 8

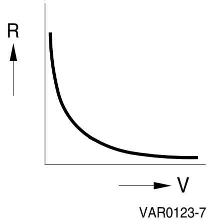


Figure 9

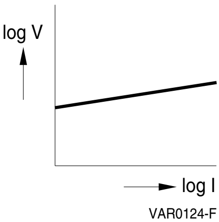


Figure 10

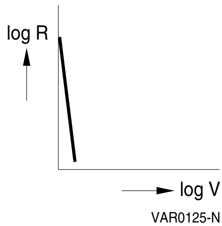


Figure 11

1.6.2 Real V/I characteristic and ohmic resistance

Figure 12 shows a typical V/I characteristic with SIOV-B60K250 taken as an example.

The downturn and upturn regions according to equivalent circuits 5 and 7 are easy to make out.

Calculating nonlinearity exponent α
Normally α is determined according to equation 5 from the pairs of values for 1 A and 1 mA of the V/I characteristic. For figure 12 this means:

$$\alpha = \frac{\log I_2 - \log I_1}{\log V_2 - \log V_1} = \frac{\log 1 - \log 10^{-3}}{\log 470 - \log 390} = \frac{0-(-3)}{2.67 - 2.59} = \frac{3}{0.08} \approx 38$$

The V/I curve of figure 12 is virtually a straight line between 10^{-4} and 10^{3} A, so it is described over a wide range to a good approximation by equation 3. The downturn and upturn regions may be adapted by inserting correction components in equation 3.

Another type of characteristic curve approximation is described in chapter “Application notes”, section 1.9.1.

Derived from figure 12, figure 13 shows the change in static resistance R = V/I for SIOV-B60K250. The resistance is > 1 MΩ in the range of the permissible operating voltage, whereas it can drop by as many as ten powers of 10 in case of overvoltage.

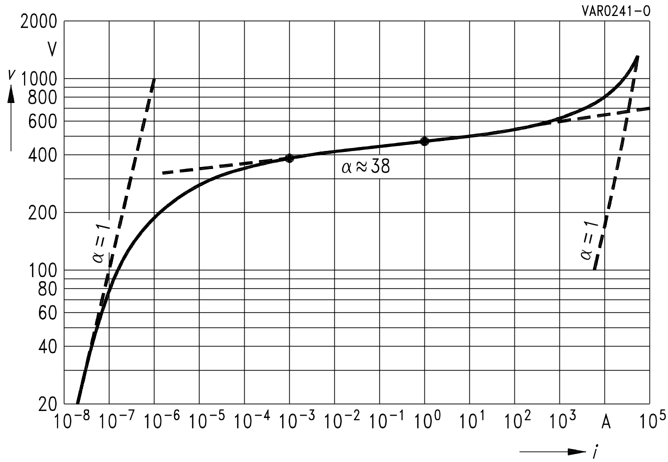


Figure 12 Real V/I characteristic of a metal oxide varistor as exemplified by SIOV-B60K250

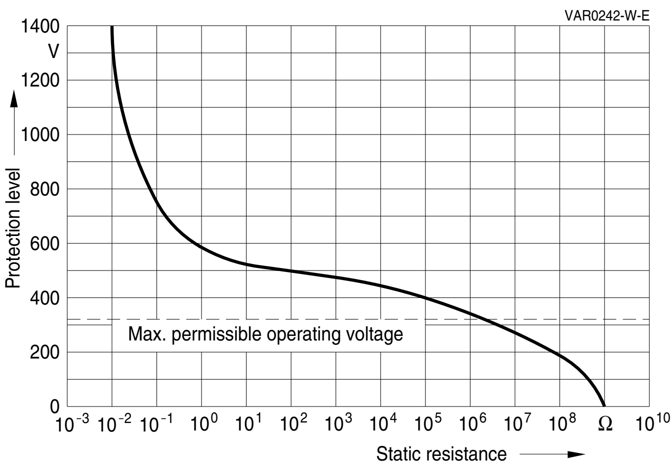


Figure 13 Static resistance of a metal oxide varistor versus protection level as exemplified by SIOV-B60K250

1.6.3 Presentation of tolerance band

The real V/I characteristic of individual varistors is subject to a certain deviation, which is primarily due to minor fluctuations in manufacturing and assembly process parameters. For varistors belonging to a certain type, their V/I curves are required to lie entirely within a well defined tolerance band. The tolerance band shown in figure 14 illustrates this in the case of SIOV-S14K14.

Varistors are operated at one of two conditions: If the circuit is operated at normal operating voltage, the varistor will be highly resistive. In an overvoltage event, it will be highly conductive.

These conditions concern two different segments of the V/I curve:

Lefthand part of curve (< 1 mA): This part of the curve refers to the "high-resistance" mode, where circuit designers may generally want to know about the largest possible leakage current at given operating voltage. Therefore the lower limit of the tolerance band is shown.

Righthand part of the curve (> 1 mA): This segment covers the "low-resistance" mode in an overvoltage event, where the circuit designer's primary concern is the worst-case voltage drop across the varistor. The upper limit of the tolerance band is shown.

The 1 mA "dividing line" between the two segments does not really have any electrophysical significance but it is generally used as a standard reference (varistor voltage – refer to section 1.7.5 for explanations).

Related branches are identified by the same maximum AC operating voltage (here "14").

V/I characteristic 1 in figure 14 shows the mean value of the tolerance band between the limits indicated by dashed lines. The mean at 1 mA represents the varistor voltage, in this case 22 V. The tolerance K $\triangleq \pm$ 10% refers to this value, so at this point the tolerance band ranges from 19.8 to 24.2 V.

Leakage current at operating voltage:
A maximum permissibe operating voltage of 18 V_{DC} is specified for SIOV-S14K14. For this, depending on where the varistor is in the tolerance band (figure 14), you can derive a leakage current between $6 \cdot 10^{-6}$ A and $2 \cdot 10^{-4}$ A (region 2). If the varistor is operated at a lower voltage, the figure for the maximum possible leakage current also drops (e.g. to max. $2 \cdot 10^{-6}$ A at 10 V_{DC}).

In the worst case, the peak value of the maximum permissible AC operating voltage ($v = \sqrt{2} \cdot 14$ V = 19.8 V) will result in an ohmic peak leakage current of 1 mA (see figure 14, point 3).

Protection level:
Assuming a surge current of 100 A, the voltage across SIOV-S14K14 will increase to between 35 V and 60 V (region 4), depending on where the varistor is in the tolerance band.

1.6.4 Overlapping V/I characteristics

As explained earlier (section 1.3) the differences in nonlinearity between voltage classes up to K40 and K50 and above lead to overlapping V/I curves.

In particular with SIOV disk varistors, before selecting voltage rating K40 you should always check whether K50 is not a more favorable solution. Firstly, the protection level is lower for higher surge currents, and secondly, the load capability of K50 is considerably higher for varistors of the same diameter.

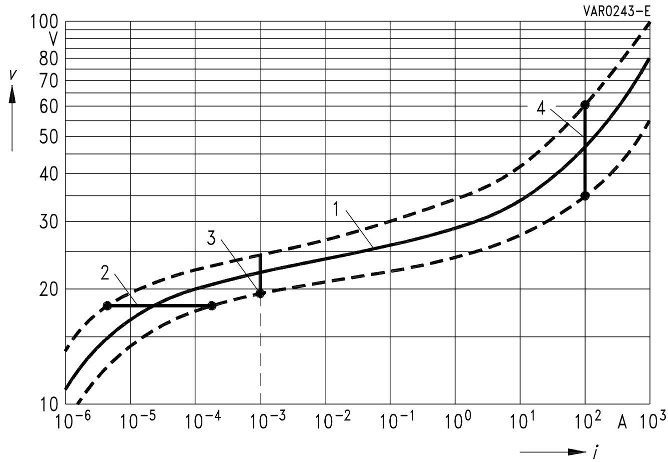


Figure 14 Tolerance limits of a metal oxide varistor as exemplified by SIOV-S14K14

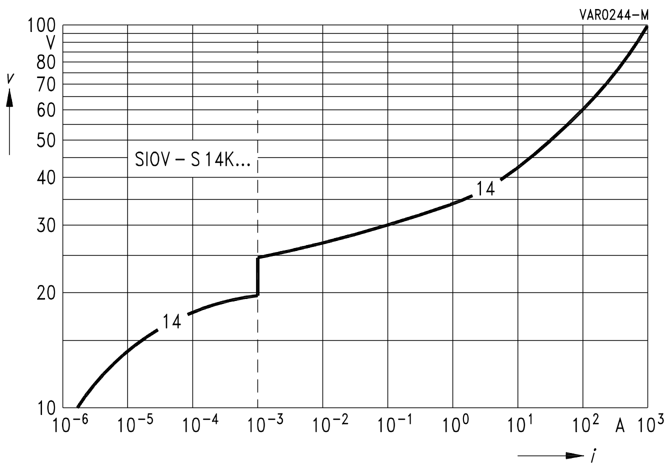


Figure 15 Tolerance limits of a metal oxide varistor as exemplified by SIOV-S14K14

1.7 Terms and descriptions

1.7.1 Operating voltage

The product tables specify maximum AC and DC operating voltages. These figures should only be exceeded by transients. Automotive types, however, are rated to withstand excessive voltage (jump start) for up to 5 minutes.

The leakage current at specified operating voltage is negligible.

The maximum permissible AC operating voltage is used to classify the individual voltage ratings within the type series.

In most applications the operating voltage is a given parameter, so the varistors in the product tables are arranged according to maximum permissible operating voltage to facilitate comparison between the individual varistor sizes.

1.7.2 Surge current, transient

Short-term current flow – especially when caused by overvoltage – is referred to as surge current or transient.

The maximum surge current that can be handled by a metal oxide varistor depends on amplitude, pulse duration and number of pulses applied over device lifetime. The ability of a varistor to withstand a single pulse of defined shape is characterized by the maximum non-repetitive surge current specified in the product tables (single pulse, $t_r \leq 20\ \mu s$).

If pulses of longer duration or multiple pulses are applied, the surge current must be derated as described in section 1.8.

Maximum surge current

The maximum non-repetitive surge current is defined by an 8/20 µs waveform (rise time 8 µs/decay time to half value 20 µs) according to IEC 60060 as shown in figure 16. This waveform approximates a rectangular wave of 20 µs. The derating curves of the surge current, defined for rectangular waveforms, consequently show a knee between horizontal branch and slope at 20 µs.

1.7.3 Energy absorption

The energy absorption of a varistor is correlated with the surge current by

$$W = \int_{t_0}^{t_1} v(t)i(t)dt \qquad \text{(equ. 6)}$$

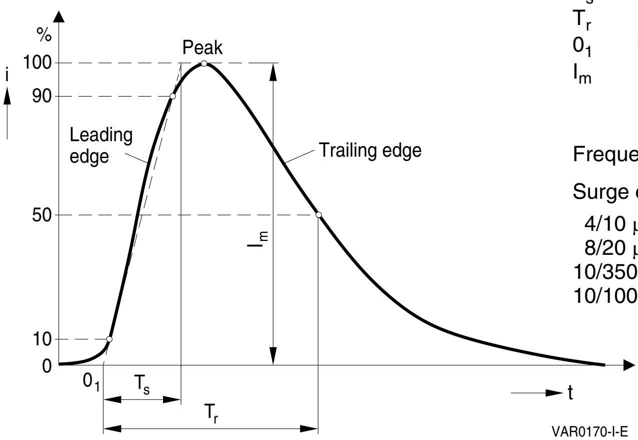
where v (t) is the voltage drop across the varistor during current flow.

Figure 13 in chapter "Application notes" illustrates the electrical performance for the absorption of 100 J in the case of SIOV-S20K14AUTO.

Maximum energy absorption

Surge currents of relatively long duration are required for testing maximum energy absorption capability. A rectangular wave of 2 ms according to IEC 60060 (figure 17) is commonly used for this test.

In the product tables the maximum energy absorption is consequently defined for a surge current of 2 ms.

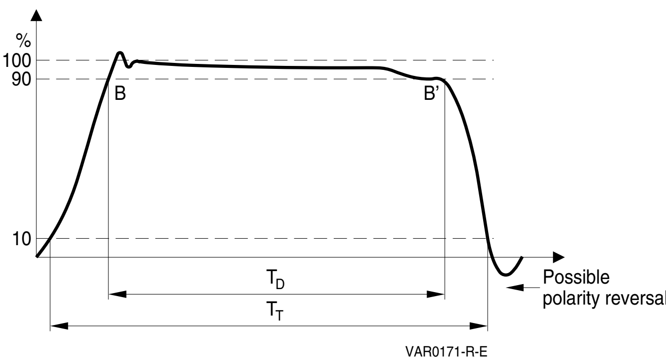


T_s	Rise time in µs
T_r	Decay time to half value in µs
0_1	Nominal start
I_m	Peak value

Frequently used T_s/T_r ratios:

Surge currents	Surge voltages
4/10 µs	1.2/50 µs
8/20 µs	10/700 µs
10/350 µs	
10/1000 µs	

Figure 16 Waveform to IEC 60060 standard



T_D	Duration of peak value (≈ 2 ms)
T_T	Total duration

Figure 17 Waveform to IEC 60060 standard

1.7.4 Average power dissipation

If metal oxide varistors are selected in terms of maximum permissible operating voltage, the resulting power dissipation will be negligible.

However, the rated maximum power dissipation must be taken into account if the varistor has not enough time to cool down between a number of pulses occurring within a specified isolated time period.

The examples in chapter “Calculation examples” show the calculation of the minimum time interval in periodic application of energy.

1.7.5 Varistor voltage

The varistor voltage is the voltage drop across the varistor when a current of 1 mA is applied to the device. It has no particular electrophysical significance but is often used as a practical standard reference in specifying varistors.

1.7.6 Tolerance

Tolerance figures refer to the varistor voltage at 25 °C. As shown in figure 14 the tolerance band for other current values can be larger.

Note:
When the tolerance is examined, the current of 1 mA must only be applied briefly so that the results are not corrupted by warming of the varistor (see temperature coefficient). The current should only flow for 0.2 up to 2.0 s, typical is a duration of 1 s.

1.7.7 Protection level (clamping voltage)

The protection level is the voltage drop across the varistor for surge currents > 1 mA.

The V/I characteristics show the maximum protection level as a function of surge current (8/20 μs waveform).

In the product tables the protection level for surge currents according to the R10 series (ISO 497) is additionally specified. This is also referred to as clamping voltage.

1.7.8 Capacitance

The product tables specify typical capacitance figures for 1 kHz.

The tabulated values show that metal oxide varistors behave like capacitors with a ZnO dielectric. The capacitance rises in proportion to disk area (and thus to current handling capability) and drops in proportion to the spacing of the electrodes, i.e. it decreases with increasing protection level.

Capacitance values are not subject to outgoing inspection.

1.7.9 Response behavior, response time

The response time of metal oxide varistor ceramics to transients is in the subnanosecond region, i.e. varistors are fast enough to handle even ESD transients with the extreme steep current rise of up to 50 A/ns.

You can find similar results for the silicon chip used in semiconductor protective devices like suppressor diodes.

However, when the chip is mounted in its package, the response time increases due to the series inductance of its package to values >1 ns.

The varistors specified in this data book have response times <25 ns.

Comparing the protection behavior of varistors with semiconductors, higher figures of protection level may be found for varistors. This cannot be explained by a higher response time of varistors – which definitely is not true – but rather it is due to slightly less nonlinearity of the V/I characteristics.

The V/I characteristics in this data book have been measured at currents >1 mA with the standard 8/20 μs waveform (figure 16). So they allow for the inductive voltage drop across the varistor for the particular di/dt.

If surge currents with steep edges are to be handled, one should always design the circuit layout for as low an inductance as possible.

1.7.10 Temperature coefficient

Metal oxide varistors show a negative temperature coefficient of voltage. Figure 18 shows the typical varistor behavior.

The temperature coefficient value drops markedly with rising currents and is completely negligible from roughly 1 mA upwards.

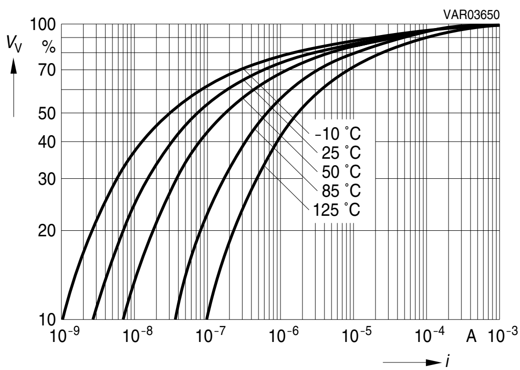


Figure 18 Typical temperature dependence of the V/I characteristic taking SIOV-S20K275 as an example.
(V_V = applied DC voltage in percentage of varistor voltage at +25 °C)

An increase in leakage current is consequently noticeable at higher temperatures, especially in the µA region.

Equation 7 describes the TC of varistor voltage (at 1 mA):

$$|TC| < 0.5 \cdot 10^{-3}/K = 0.05\%/K = 1\%/\Delta 20K \qquad \text{(equ. 7)}$$

Figure 19 shows results for SIOV-S20K275 as an example.

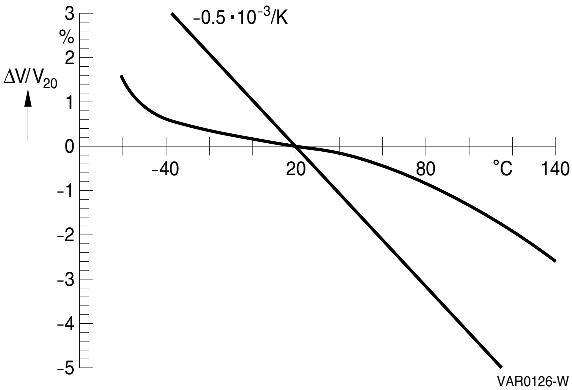


Figure 19 Temperature coefficient of voltage at 1 mA for SIOV-S20K275

1.8 Derating

Derating is the intentional reduction of maximum ratings in the application of a device. With metal oxide varistors derating is of particular interest under the following conditions:

- Derating for repetitive surge current and energy absorption
- Derating at increased operating temperatures

1.8.1 Derating for repetitive surge current

A typical feature of metal oxide varistors is the dependence of the maximum permissible ratings for surge current, and thus for energy absorption, on the pulse shape, pulse duration, and the number of times this load is repeated during the overall lifetime of the varistor.

The derating for a particular maximum permissible surge current can be derived from the curves for a type series in repetition figures graded 10^x. The surge derating curve is mainly dependent on the varistor size but also voltage rating. Such derating curves can be found for all individual varistors in this data book.

The maximum permissible energy absorption can also be calculated from the derating curves by

$W_{max} = v_{max}\, i_{max}\, t_{r\,max}$

1.8.2 Derating at increased operating temperatures

For operating temperatures exceeding 85 °C or 125 °C the following operating conditions of varistors have to be derated according to figure 20:

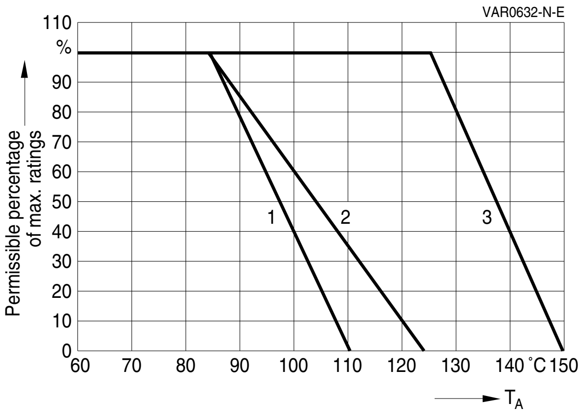
- Voltage
- Surge current
- Energy absorption
- Average power dissipation

1.9 Operating and storage temperature

The upper limits of the operating and storage temperature ranges for the individual type series can be deduced from the 100 % and 0 % values in figure 20, respectively. For lower ratings, refer to the product tables.

1.10 Climatic categories

The limit temperatures according to IEC 60068 are stated in the product tables as LCT (lower category temperature) and UCT (upper category temperature).



Derating curve 1	Derating curve 2	Derating curve 3
SIOV- B LS	SIOV- S…(AUTO)(E2)(E3) Q ETFV types SFS types	SIOV- S…AUTOD1

Figure 20 Temperature derating for operating voltage, surge current, energy absorption and average power dissipation

1.11 Overload response

1.11.1 Moderate overload

Surge currents or continuous overload of up to approx. one and a half times the specified figures can lead to a change in varistor voltage by more than ±10%. In most cases the varistor will not be destroyed, but there may be an irreversible change in its electrical properties. The thermal fuse in EPCOS ETFV may open in such a condition.

1.11.2 Heavy overload

Surge currents far beyond the specified ratings will puncture the varistor element. In extreme cases the varistor will burst.

Excessive steady-state overload fuses the ZnO grains and conducting paths are formed with the bulk resistance of ZnO, which is considerably lower than the resistance of the original varistor. The overload can overheat the varistor ceramic with the result that it becomes unsoldered from the electrodes.

1.12 Design notes

If steep surge current edges are to be expected, you must make sure that your design is as low-inductive as possible (cf 1.7.9).

1.12.1 Physical protection, fuses

Due to the unpredictable nature of transients a varistor may be overloaded although it was carefully selected. Overload may result in package rupture and expulsion of hot material. For this reason the varistor should be physically shielded from adjacent components, e.g. by a suitable metal case.

Fuse protection of varistors against excessive surge current is usually not possible because standard fuses are unable to quench surge currents. But fuses can offer protection against damage caused by follow-on currents. Such follow-on currents flow when a damaged varistor is in low-resistance mode and still connected to power.

When varistors are operated on standard line impedances, nominal fuse currents and varistor type series should be matched as follows:

Type	S05	S07	S10	S14/ SFS14	S20/ Q14	S25/ Q20
Nominal fuse current [A]	≤1	≤3	≤6	≤10	≤16	≤25

Type	ETFV14	ETFV20	ETFV25
Nominal fuse current [A]	≤10	≤16	≤25

Type	B32	B40/LS40/ LS41/LS42	B60/LS50	B80
Nominal fuse current [A]	≤50	≤80	≤125	≤160

In applications where the conditions deviate from standard power line impedances, better fuse protection of the varistor can be obtained using thermo-fuses. These thermo-fuses should be in direct thermal contact with the varistor. Better protection can be achieved with a thermal fuse or EPCOS ThermoFuse varistors series ETFV where the thermal coupling is matched with the varistors.

1.12.2 Potting and sealing, adhesion

Potting, sealing or adhesive compounds can produce chemical reactions in the varistor ceramic that will degrade its electrical characteristics. Information about this is available on inquiry.

1.12.3 Prior damage

The values specified only apply to varistors that have not been subjected to prior electrical, mechanical or thermal damage.

1.12.4 Environmental conditions

SIOV varistors are designed for indoor applications. On all accounts, prevent exposure to:

- Direct sunlight
- Rain or condensation
- Steam, saline spray
- Corrosive gases
- Atmospheres with reduced oxygen content

1.12.5 Mechanical strength of wire leads of disk-type varistors

The wire leads comply with the requirements of IEC 60068-2-2. They may only be bent at a minimum distance of 4 mm from the enamel coating end. When bending leads to shape, the lead-component junction must be supported. The minimum bend radius should be 0.75 mm.

1.13 Designation system

Varistor = **var**iable res**istor**
SIOV ® = registered tradename for EPCOS varistors

Table 1

SIOV	Design	Rated dimension	Tolerance	Max. AC oper. volt.	Additional specifications	Additional specifications

Design	**B**	Block type (HighE series)
	ETFV	Disk type in housing (ThermoFuse)
	LS … P	Strap type, round, epoxy coating, bent straps (HighE series)
	LS … PK2	Strap type, round, epoxy coating, straight straps (HighE series)
	LS … QP	Strap type, square, epoxy coating, bent straps (HighE series)
	LS … QPK2	Strap type, square, epoxy coating, straight straps (HighE series)
	Q	Disk type, square, leaded (EnergetiQ series)
	S	Disk type, round, leaded
	SFS	Disk type in housing

Rated diameters/length of disk varistors 5 up to 80 mm.

Table 1 (continued)

Tolerance of varistor voltage (1 mA)	K L M S…A/B/C	±10% ±15% ±20% Special tolerance A, B or C
Max. permissible AC operating voltage	11 … 1100 $V_{RMS,max}$	
Taping	G GA G.S.	Tape / reel Tape / Ammo pack Tape / reel, crimp style S, S2, S3, S4, S5 (see chapter “Taping, packaging and lead configuration”)
Appendix	AUTO AUTO … D1 E2 E3 E4 K2 M P Q R5 R7	Additional load dump and jump start specification Additional load dump, jump start and high-temperature specification AdvanceD series SuperioR series SuperioR series Suffix to define modifications Customer specific trimmed lead length (in mm) Standard coating (epoxy) Square shape = 5.0 Lead spacing differs from standard = 7.5 Lead spacing differs from standard

Production code: all coated varistors are marked with year/week code.
Example: 07 09 = 9th week of year 2007

Abbreviations for metal oxide varistors:

MOV metal oxide varistor
ZnO zinc oxide varistor
VDR voltage-dependent resistor

Abbreviation for overvoltage protection elements in general:
TVSS transient voltage surge suppressor

1.14 Marking of disk varistors

Disk-type varistors have printed markings as shown in figure 21. They are distinguished as follows: no underline under the "S" (Standard), an additional underline under the S… (for type series AdvanceD, E2) or a line above the S… (for type series SuperioR, E3) or a line above and under the S… (for SuperioR types, E4).

The lower section of the marking area contains the date code yy ww.

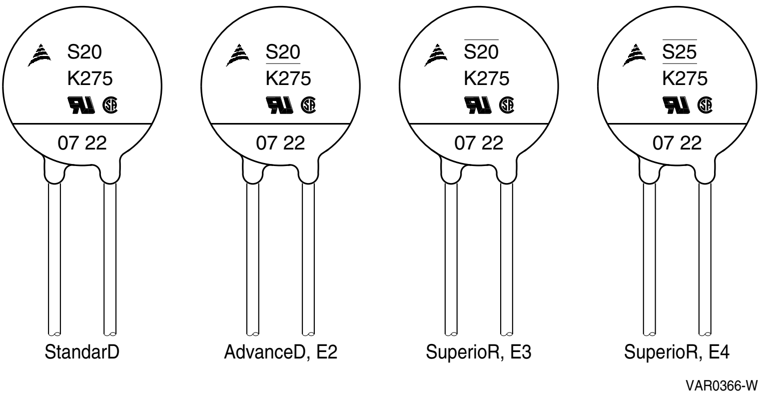


Figure 21 Various forms of printed markings of disk-type varistor series StandarD, AdvanceD and SuperioR, using S20K275 as an example.
Date code 07 09 ≙ yy ww ≙ 9th week of year 2007

1 Selection procedure

1.1 Overvoltage types and sources

Overvoltages are distinguished according to where they originate.

1.1.1 Internal overvoltages

Internal overvoltages originate in the actual system which is to be protected, e.g. through

- inductive load switching,
- arcing,
- direct coupling with higher voltage potential,
- mutual inductive or capacitive interference between circuits,
- electrostatic charge,
- ESD.

With internal overvoltages the worst-case conditions can often be calculated or traced by a test circuit. This enables the choice of overvoltage protective devices to be optimized.

1.1.2 External overvoltages

External overvoltages affect the system that is to be protected from the outside, e.g. as a result of

- line interference,
- strong electromagnetic fields,
- lightning.

In most cases the waveform, amplitude and frequency of occurrence of these transients are not known or, if so, only very vaguely. And this, of course, makes it difficult to design the appropriate protective circuitry.

There have been attempts to define the overvoltage vulnerability of typical supply systems (e.g. industrial, municipal, rural) so that the best possible protective device could be chosen for the purpose. But the scale of local differences makes such an approach subject to uncertainty. So, for reliable protection against transients, a certain degree of “overdesign” must be considered.

Therefore the following figures for overvoltage in 230 V power lines can only be taken as rough guidelines:

- Amplitude up to 6 kV
- Pulse duration 0.1 µs to 1 ms

Where varistors are operated directly on the line (i.e. without series resistor), normally the type series S20 should be chosen. In systems with high exposure to transients (industrial, mountain locations) block varistors are to be preferred.

Requirements are stipulated in IEC 61000-4-X. Severity levels are specified in the respective product standards.

Table 2 in chapter “Application notes” shows the selection of varistors for surge voltage loads according to IEC 61000-4-5 as an example.

1.2 Principle of protection and characteristic impedance

The principle of overvoltage protection by varistors is based on the series connection of voltage-independent and voltage-dependent resistance. Use is made of the fact that every real voltage source and thus every transient has a voltage-independent source impedance greater than zero. This voltage-independent impedance Z_{source} in figure 1 can be the ohmic resistance of a cable or the inductive reactance of a coil or the complex characteristic impedance of a transmission line.

If a transient occurs, current flows across Z_{source} and the varistor that, because $v_{source} = Z_{source} \cdot i$, causes a proportional voltage drop across the voltage-independent impedance. In contrast, the voltage drop across the SIOV is almost independent of the current that flows.

Because

$$v_{SIOV} = \left(\frac{Z_{SIOV}}{Z_{source} + Z_{SIOV}}\right) v \qquad \text{(equ. 8)}$$

the voltage division ratio is shifted so that the overvoltage drops almost entirely across Z_{source}. The circuit parallel to the varistor (voltage V_{SIOV}) is protected.

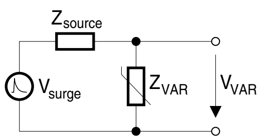


Figure 1 Equivalent circuit in which Z_{source} symbolizes the voltage-independent source impedance

Figure 2 shows the principle of overvoltage protection by varistors:

The intersection of the "load line" of the overvoltage with the V/I characteristic curve of the varistor is the "operating point" of the overvoltage protection, i.e. surge current amplitude and protection level.

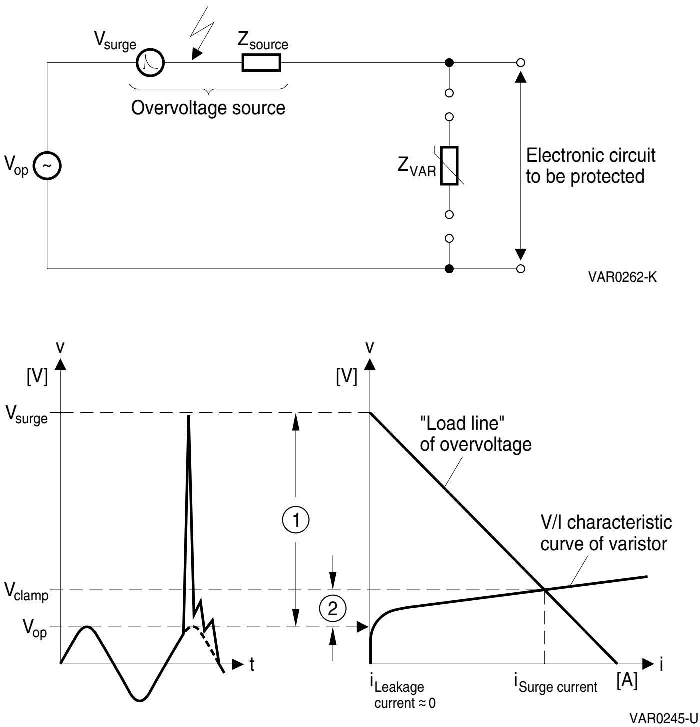


Figure 2 Principle of overvoltage protection by varistors

The overvoltage ① is clamped to ② by a varistor.

V_{op}	Operating voltage
V_{surge}	Superimposed surge voltage
V_{clamp}	Clamping voltage

For selection of the most suitable protective element, you must know the surge current waveform that goes with the transient. This is often, and mistakenly, calculated by way of the (very small) source impedance of the line at line frequency. This leads to current amplitudes of unrealistic proportions. Here you must remember that typical surge current waves contain a large portion of frequencies in the kHz and MHz range, at which the relatively high characteristic impedance of cables, leads, etc. determines the voltage/current ratio.

Figure 3 shows approximate figures for the characteristic impedance of a supply line when there are high-frequency overvoltages. For calculation purposes the characteristic impedance is normally taken as being 50 Ω. Artificial networks and surge generators are designed accordingly.

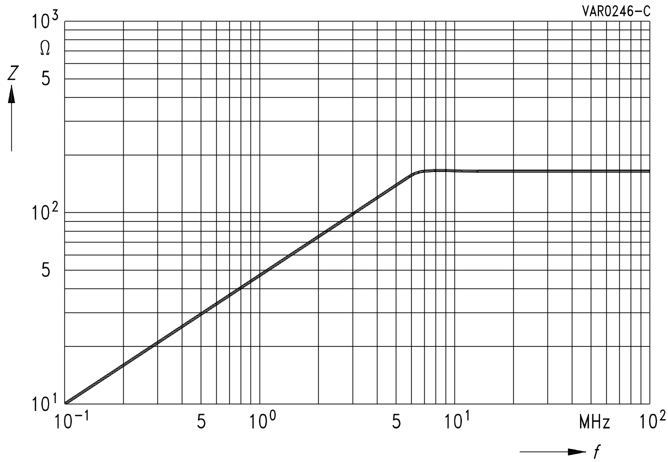


Figure 3 Impedance of a supply line for high-frequency overvoltages

1.3 Areas of application for varistors

A wide selection of types is available to cover very different requirements for protective level and load capability. Straightforward conditions of use and an attractive price/performance ratio have made SIOVs from EPCOS successful in just about every area of electrical engineering and electronics. The table below summarizes them:

Telecommunications
Private branch exchanges
Telephone subscriber sets
Telephone pushbutton modules
Teleprinters
Answering sets
Power supply units
Transmitting systems
Fax machines
Modems
Cellular (mobile) phones
Cordless phones
Chargers
Car kits

Industrial controls
Telemetering systems
Remote control systems
Machine controls
Elevator controls
Alarm systems
Proximity switches
Lighting controls
Power supply units
Ground fault interrupters
Gas heating electronics
Electronic ballasts
LCDs

Power electronics
Bridge rectifiers
Brake rectifiers
Electric welding
Electric vehicles
Switch-mode power supplies
High-power current converters
DC/AC converters
Power semiconductors

Power engineering
Transformers
Inductors
Motor and generator windings
Electrical power meter

Automotive electronics
Central protection of automotive electrical systems
Load-dump protection
Anti-skid brake systems
Trip recorders
Radios
Engine control units
Generator rectifiers
Central locking systems
Trip computers
Wiper motors
Power window systems
Airbag electronics
Carphones
Seat memories

Traffic lighting
Traffic signals
Runway lighting
Beacon lights

Medical engineering
Diagnostic equipment
Therapeutic equipment
Power supply units

Data systems
Data lines
Power supply units
Personal computers
Interfaces
ASIC resets
Microcontrollers
I/O ports
Keyboards
Handheld PCs

Stepped protection
Microelectronics
EMI/RFI suppression
EMP/NEMP protection

Entertainment electronics
Video sets
Television sets
Slide projectors
Power supply units
HIFI equipment
Set-top boxes

Household electronics
Washer controls
Dimmers
Lamps
Quartz clocks
Electric motor tools
Thermostats

Replacement of
Suppressor diodes
Diodes

If semiconductor devices like diodes, thyristors and triacs are paralleled with SIOVs for protection, they may do with lower reverse-voltage strength. This leads to a marked cost reduction and can be the factor that really makes a circuit competitive.

1.4 Series and parallel connection

1.4.1 Series connection

SIOV varistors can be connected in series for more precise matching to uncommon voltage ratings or for voltage ratings higher than those available. For this purpose the types selected should be of the same series (i.e. same diameter). The maximum permissible operating voltage in series configuration is produced by adding the maximum DC or AC voltages of the varistors.

1.4.2 Parallel connection

Metal oxide varistors can be connected in parallel to achieve higher current load capabilities or higher energy absorption than can be obtained with single components. To this end, the intended operating point in the surge current region (see chapter "General technical information", section 1.5) must be taken into account.

1.4.2.1 Medium current region

Since the surge current is well below its maximum permissible value in this region, parallel connection may only be used to increase energy absorption. The varistor has to absorb the energy of currents that have a relatively low amplitude, but a high energy content due to their duration.

Example surge current i* = 1 A in figure 4:

In the worst case, 2 varistors may have been chosen for parallel connection with the first having a V/I characteristic curve corresponding to the upper limits and the second having a V/I characteristic curve corresponding to the lower limits of the tolerance band. From the region boundary a) one can see that then a current of 1 mA flows through the first varistor and a current of 1 A flows through the second varistor. The energy absorptions of the two varistors are in the same ratio. This means that if unselected varistors are used in this current region, current distributions of up to 1000:1 may render the parallel connection useless. To achieve the desired results, it is necessary to match voltage and current to the intended operating point.

1.4.2.2 High-current region

In this region, the ohmic resistance of the zinc oxide causes a higher voltage drop across the varistor that carries the higher surge current. Thus, the current distribution is shifted to the varistor with the lower current. Region b) in figure 4 shows that in the worst case the current ratio is approx. 15 kA:40 kA, which is a considerably better result than in the medium operating region. Accordingly, parallel connection can increase the maximum permissible surge current for two block varistors, e.g. from 40 kA to 55 kA for B40K275 varistors.

The graphical method in accordance with figure 4 can only provide guideline values, since the deviation of the individual varistors from the standard nonlinear values is not taken into consideration. In practice, the individual varistors must be measured for the current region for which parallel operation is envisaged. If this region is within the two upper decades of the maximum surge current, the varistors should be measured at 1% of the maximum current to prevent the measurement itself reducing the service life of the varistor. Example: using B40K275, maximum permissible surge current 40 kA. The measurement should take place using 400 A with surge current pulse 8/20 µs.

The effort required for measurements of this kind will make parallel connection an exception. The possibility of using a single varistor with a higher load capacity should always be preferred, in this example it would be a type from the LS50, B60 or B80 series.

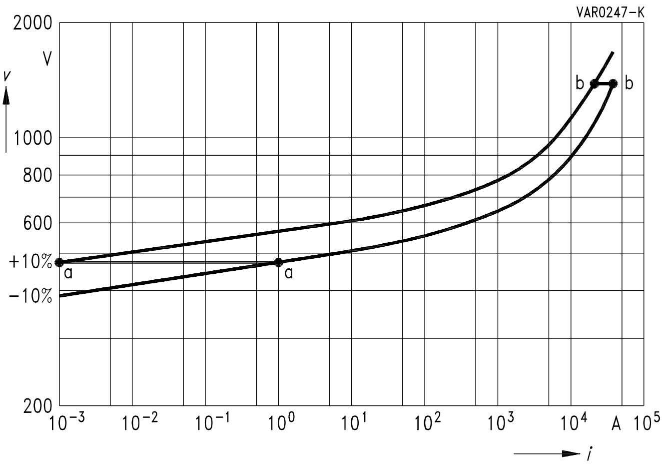


Figure 4 Tolerance band of the SIOV-B40K275

1.5 Selection guide

The choice of a varistor involves three main steps:

- Select varistors that are suitable for the operating voltage.
- Determine the varistor that is most suitable for the intended application in terms of
  a) surge current,
  b) energy absorption,
  c) average power dissipation,
  (for a and b also estimating the number of repetitions).
- Determine the maximum possible voltage rise on the selected varistor in case of overvoltage and compare this to the electric strength of the component or circuit that is to be protected.

To ensure proper identification of circuit and varistor data, the following distinction is made:

- Maximum possible loading of varistor that is determined by the electrical specifications of the intended location.
  Identification: *
- Maximum permissible loading of varistor that is given by its surge current and absorption capability.
  Identification: max

  (e.g. x^*, x_{max})

So the following must always apply:

$i^* \leq i_{max}$ (equ. 9)
$W^* \leq W_{max}$ (equ. 10)
$P^* \leq P_{max}$ (equ. 11)

1.5.1 Operating voltage

Maximum permissible AC and DC operating voltages are stated in the product tables for all varistors. To obtain as low a protection level as possible, varistors must be selected whose maximum permissible operating voltage equals or minimally exceeds the operating voltage of the application.

Nonsinusoidal AC voltages are compared with the maximum permissible DC operating voltages so that the peak or amplitude of the applied voltage does not exceed the maximum permissible DC voltage.

Note:
Of course, you may also select any varistor with a higher permissible operating voltage. This procedure is used, for example, when it is more important to have an extremely low leakage current than the lowest possible protection level. In addition, the service life of the varistor is increased. Also the type for the highest operating voltage may be selected to reduce the number of types being used for different voltages.

1.5.2 Surge current

Definition of the maximum possible operating voltage in the previous step will have narrowed down the choice of an optimum SIOV to the models of a voltage class (e.g. those whose designation ends in 275 for 230 V + 10% = 253 V). Then you check, with reference to the conditions of the application, what kind of load the SIOV can be subjected to.

Determining the load on the varistor when limiting overvoltage means that you have to know the surge current that is to be handled.

1.5.2.1 Predefined surge current

Often the surge current is predefined in specifications. After transformation into an equivalent rectangular wave (figure 8) the suitable varistor type can be selected by the derating curves.

1.5.2.2 Predefined voltage or network

If the voltage or a network is predefined, the surge current can be determined in one of the following ways:

Simulation

Using the PSpice simulation models of the SIOV varistors, the surge current, waveform and energy content can be calculated without difficulty. In these models, the maximum surge current is deduced for the lower limit of the tolerance band, i.e. setting TOL = –10.

Test circuit

The amplitude and waveform of the surge current can be determined with the aid of a test circuit. The dynamic processes for overvoltages require adapted measuring procedures.

Graphical method

As shown in figures 5 and 6, the overvoltage can be drawn into the V/I characteristic curve fields as a load line (open circuit voltage, short circuit current). At the intersection of this “load line” with the varistor curve selected to suit the operating voltage, the maximum protection level and the corresponding surge current can be read off. The waveform and thus the energy content cannot be determined by this method.
Since the V/I characteristic curves are drawn in a log-log representation, the “load line” in figure 6 is distorted to a curve.

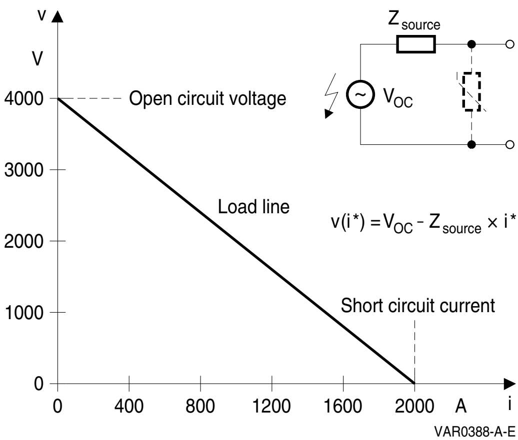


Figure 5 Load line on linear scale

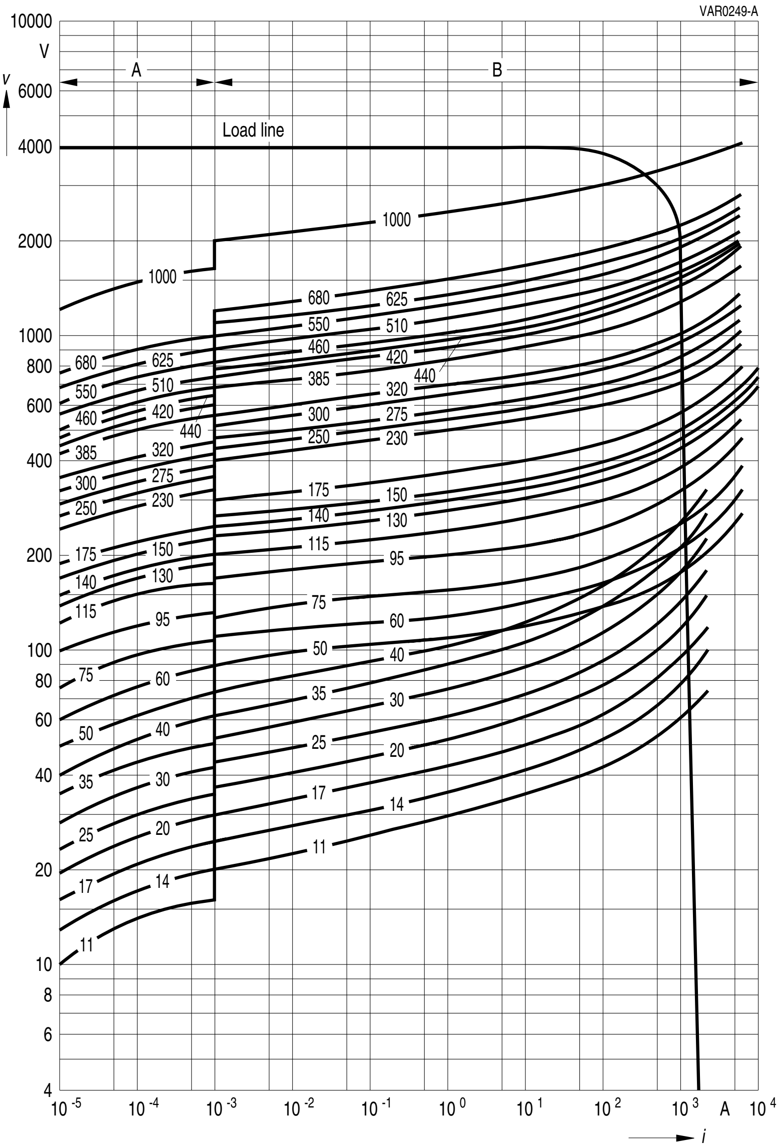


Figure 6 V/I characteristic curves SIOV-S20 with the load line drawn in for a surge current amplitude 4 kV with $Z_{source} = 2\ \Omega$

Mathematic approximation

The surge current is determined solely from the source impedance of the surge voltage (V_s). By subtracting the voltage drop across the varistor (from the V/I curve) you can approximate the maximum surge current as follows:

$$i^* = \frac{V_s - V_{SIOV}}{Z_{source}}$$

See 4.2 for an example. (equ. 12)

Switching off inductive loads

If the transient problems are caused by switching off an inductor, the "surge current" can be estimated as follows:

The current through an inductance cannot change abruptly, so, when switching off, a current of the order of the operating current must flow across the varistor as an initial value and then decay following an e function. The path taken by the current during this time is referred to as a flywheel circuit (refer to chapters "Calculation examples", "Switching off inductive loads").

The time constant $\tau = L/R$ that can be calculated from the inductance and the resistance of the flywheel circuit (including varistor resistance) shows how long the current requires to return to the 1/e part (approx. 37%) of its original value. According to theory, τ is also the time that the flywheel current must continue to flow at constant magnitude to transport the same charge as the decaying current.

So the amplitude of the "surge current" is known, and its duration is approximately τ (figure 7).

τ depends on the value of the inductance and the resistances of the flywheel circuit, generally therefore on the resistance of the coil and the varistor. The latter is, by definition, dependent on voltage and thus also current and so, for a given current, it has to be calculated from the voltage drop across the varistor (V/I characteristic).

$$\tau \approx \frac{L}{R_{Cu} + R_{SIOV}} \ [s]$$

(equ. 13)

L	[H]	Inductance
R_{Cu}	[Ω]	Coil resistance
R_{SIOV}	[Ω]	SIOV resistance at operating current

R_{SIOV} increases as current decreases. So τ is not constant either during a decay process.
This dependence can be ignored in such a calculation however.

For comparison with the derating curves of the current you can say that $\tau = t_r$ (refer to chapters "Calculation examples", "Switching off inductive loads").

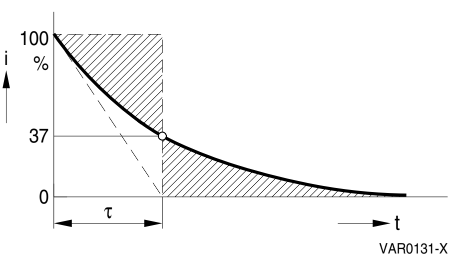


Figure 7 Time constant of flywheel circuit

1.5.2.3 Comparison: determined surge current / derating curve

The maximum permissible surge current of the SIOV depends on the duration of current flow and the required number of repetitions. Taking these two parameters, it can be read from the derating curves. It is compared to the maximum possible surge currents in the intended electrical environment of the varistor.

From the derating curves one can obtain maximum figures for rectangular surge current waves. For correct comparison with these maximum permissible values, the real surge current wave (any shape) has to be converted into an equivalent rectangular wave. This is best done graphically by the "rectangle method" illustrated in figure 8.

Keeping the maximum value, you can change the surge current wave into a rectangle of the same area. t^*_r is then the duration of the equivalent rectangular wave and is identical to the "pulse width" in the derating curves. (The period T* is needed to calculate the average power dissipation resulting from periodic application of energy.)

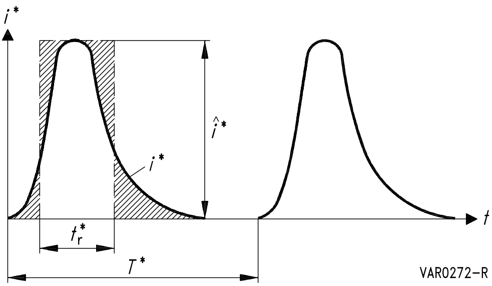


Figure 8 Rectangle method

If the pulse load $\int i^* dt$ is known, then t_r can be calculated using the following equation:

$$t^*_r = \frac{\int i^* d t}{\hat{i}^*} \qquad \text{(equ. 14)}$$

The duration of surge current waves is frequently specified using the 50% value of the trailing edge (ref. figure 16 in "General technical information"). The decay pattern of such waves can be represented by an exponential function.

According to figure 9 and the equation derived from this,

$$\frac{t_{37\%}}{t_{50\%}} = \frac{l_n 0.37}{l_n 0.50} = \frac{-0.994}{-0.693} = 1.43 = \frac{\tau}{T_r} \qquad \text{(equ. 15)}$$

the "equivalent rectangular wave" for such processes is found to be $t^*_r = 1.43\ T_r$

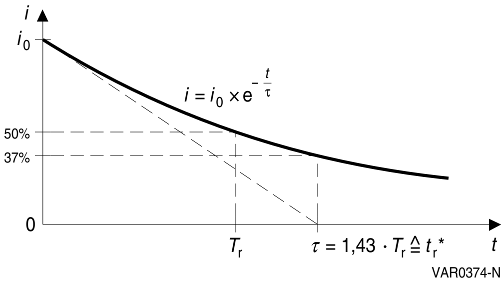


Figure 9 Equivalent rectangular wave of an e-function

1.5.3 Energy absorption

When a surge current flows across the varistor, there will be absorption of energy. The amount of energy to be absorbed by the varistor can generally be calculated by equation 6.

Calculation method

Often the energy absorption can be read directly from a storage oscilloscope or can be calculated from the voltage/current curve using numerical methods. An example for W* = 100 J is shown in figures 12 to 14 in chapter "Application notes").

Simulation

Determination of the energy absorption by simulation (PSpice) is even more convenient.

Graphic method

Otherwise equation 6 can be solved graphically with sufficient accuracy by using the rectangle method. i* (t) is converted as in figure 8 and multiplied by the highest voltage appearing on the varistor according to equation 16:

$$W^* = \hat{v}^*\ \hat{i}^*\ t^*_r \quad [J] \qquad \begin{array}{ll} \hat{v}^* & [V] \\ \hat{i}^* & [A] \\ t^*_r & [s] \end{array} \qquad \text{(equ. 16)}$$

$\hat{v}^*$ can either be derived from the V/I characteristic as the value matching $\hat{i}^*$, or likewise be determined with the aid of an oscilloscope as the maximum voltage drop across the varistor.

Switching off inductive loads

If transients are caused by interrupting the current supply of an inductor, the worst-case principle can be applied to calculate the necessary energy absorption of a varistor. The energy to be absorbed by the varistor cannot be greater than that stored in the inductor:

$W^* = {}^1/_2 \, L \, i^{*2}$ [J] L [H] (equ. 17)
i* [A]

This calculation will always include a safety margin because of losses in other components. Refer to chapter "Calculation examples", section 1.1.

Note:
When used for overvoltages caused by switching off inductive loads, varistors should always be applied in freewheeling circuits as shown in "Calculation examples", section 1.1 and figure 5 in chapter "Application notes").

Discharging of capacitors

The statements made for inductors also apply for capacitances. This means that the load placed on the varistors in many of the tests according to IEC 61000-4-X can be estimated.

Comparison: determined energy input / maximum permissible energy absorption

To check the selection requirement $W^* \leq W_{max}$ (equation 10), you have to determine the maximum permissible energy absorption for the intended varistor. This can be calculated by equation 18 as a function of the time the energy is applied (t_r) and the number of repetitions from the derating curves:

$W_{max} = v_{max} \, i_{max} \, t_{r\,max}$ (equ. 18)

v_{max} is derived from the V/I characteristic of the intended varistor type for the surge current i_{max}.
$t_{r\,max}$ can be taken as being the same as t^*_r, because W_{max} is to be calculated for the given time of current flow.

1.5.4 Average power dissipation

The actual power dissipation of a varistor is composed of the basic dissipation P_0 caused by the operating voltage and, possibly, the average of periodic energy absorption. If metal oxide varistors are chosen from the product tables in agreement with the maximum permissible operating voltages, P_0 will be negligible.

Periodic energy absorption produces an average power dissipation of:

$$P^* = \frac{W^*}{T^*} = \frac{v^* \, i^* \, t^*_r}{T^*} \text{ [W]} \qquad \text{(equ. 19)}$$

W*	[J]	i*	[A]
T*	[s]	t^*_r	[s]
v*	[V]	P*	[W]

W* takes the value of a single absorption of energy.
T* is the period of figure 8.

By solving this equation for T* it is possible to calculate the minimum time that must elapse before energy is applied again without exceeding the maximum permissible average power dissipation of the varistor:

$$T_{min} = \frac{W^*}{P_{max}} \text{ [s]} \qquad \text{(equ. 20)}$$

W*	[J]	T_{min}	[s]
P_{max}	[W]		

Note:
Metal oxide varistors are not to be “operated” at P_{max}. They are not suitable for “static” power dissipation, e.g. voltage stabilization. There are other kinds of components, like zener diodes, designed primarily for this kind of application, but with much lower surge current handling capability.

1.5.5 Maximum protection level

The maximum possible voltage rise in the event of a surge current is checked with the aid of the V/I curves or PSpice models. This figure can be read directly from the curve for a given surge current (for worst-case varistor tolerances). If the voltage value thus obtained is higher than acceptable, the following possibilities may assist in reducing the protection level:

- Choose a type with a larger disk diameter
  The protection level is lower for the same surge current because the current density is reduced.
- Better matching to the operating voltage by series connection
  Example: 340 V AC
  Here, according to the first step in selection, a standard SIOV with the end number “385” would normally be chosen. But if two SIOVs with the end number “175” are connected in series, the response of a 350 V varistor is obtained.
- Choose a tighter tolerance band
  A special type is introduced that only utilizes the bottom half of the standard tolerance band for example. This would mean a drop in the protection level by approx. 10%.
- Insert a series resistor
  This reduces the amplitude of the surge current and thus the protection level of the varistor.

Note:
If the protection level obtained from the V/I curve is **lower** than required, you can change to a varistor with a higher protection level, i.e. higher end number in its type designation. This has a favorable effect on load handling capability and operating life. The leakage current is further reduced.
If necessary, the number of different types used can be reduced.

1.5.6 Selection by test circuit

The maximum permissible ratings of varistors refer to the amount of energy that will cause the varistor voltage to change by maximum ±10%.

Figures 10 and 11 show typical curves for the change in varistor voltage of metal oxide varistors when energy is repeatedly applied through a bipolar or unipolar load. You often find an increase of a few percent to begin with, and for a unipolar load there are also polarization effects. This is seen in figure 11 for the leakage current. Such phenomena have to be considered when interpreting measured results.

So, in test circuits, you start by determining the varistor voltage for every single type as accurately as possible (at a defined temperature). It is advisable to check the change in varistor voltage from time to time, making sure the temperature is the same. By extrapolation of the measured results to the intersection with the –10% line, a guide value for the lifetime of varistors is obtained.

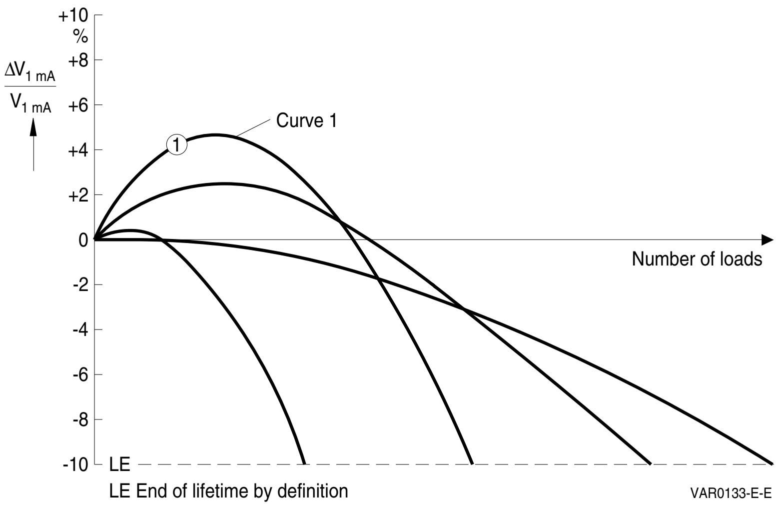


Figure 10 Typical curves for change in varistor voltage when metal oxide varistors are repeatedly loaded

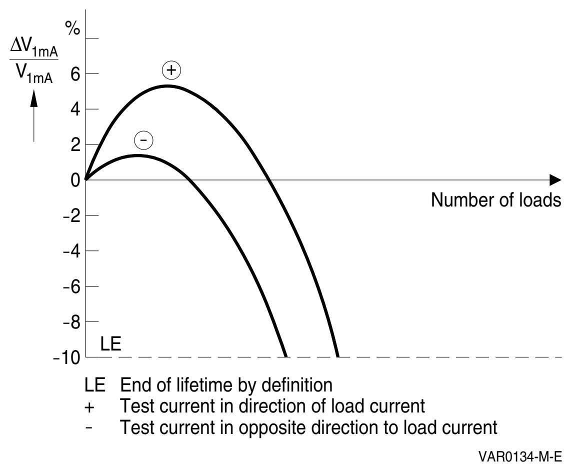
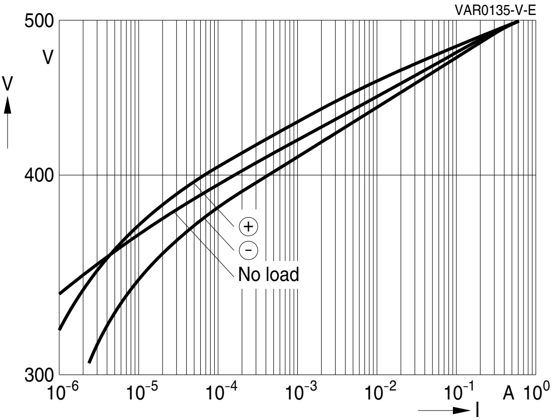


Figure 11 Typical polarization effect for unipolar loading of metal oxide varistors



\+ Test current in direction of load current
\- Test current in opposite direction to load current

Figure 12 Typical polarization effects of leakage current for unipolar loading of metal oxide varistors

1.6 Questionnaire for selecting SIOVs

Table 1

Date . . . .

Company . . . .

Project. . . . .

		Remarks
1. Max. operating voltage	… V_{AC} or … V_{DC}	Operating voltage including all +tolerances
2.1 Surge current amplitude	.... kA	
Waveform	.... s	e.g. 8/20 µs, 10/1000 µs, 2 ms
No. of repetitions through lifetime	.... times	
Minimum time between consecutive loads	.... s	
and / or		
2.2 Energy per load	.... J	
Duration of energy input	.... s	e.g. 8/20 µs, 10/1000 µs, 2 ms
No. of repetitions through lifetime	.... times	
Minimum time between consecutive loads	.... s	
and / or		
2.3 Test standard	....	e.g.: IEC 61000-4-5
Test severity	....	e.g.: 3
Protection class	....	e.g.: 4
3. Required protection level	… V	
Reference current	… A	
4. Desired package		Please mark
Disk type	☐	
Disk varistors in housing		
ThermoFuse varistor (ETFV)	☐	
Fail-safe varistor (SFS)	☐	
EnergetiQ type	☐	
Block type	☐	
Strap type	☐	

1 Applications

1.1 Protective circuits

The varistors must on all accounts be connected parallel to the electronic circuits to be protected.

Circuit concept, power supply line-to-line protection

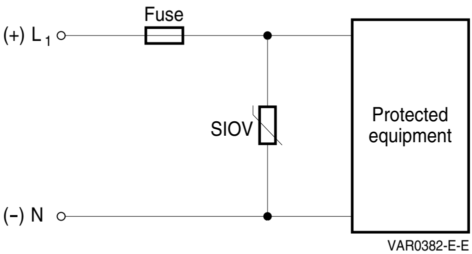


Figure 1 AC/DC single-phase protection

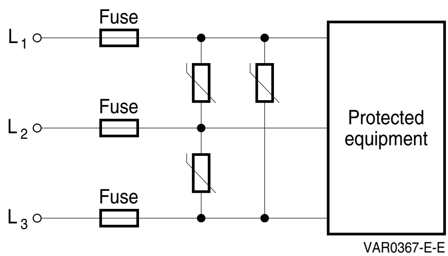


Figure 2 AC three-phase protection

When varistors are used in line-to-ground circuits (figures 3 and 4), the risk must be considered that a current type fuse may possibly not blow if the grounding resistance is too high and in this way the current is limited. With regard to such cases, various international and local standards do not allow the line-to-ground application of varistors without taking adequate safety countermeasures.

One possible solution is to use thermal fuses in series, which are thermally coupled with the varistor, as indicated in figures 3 and 4.

Circuit concept, power supply line-to-ground protection

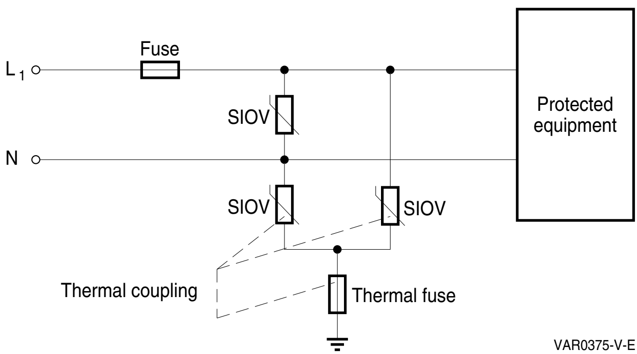


Figure 3 Single-phase protection including line-to-ground protection

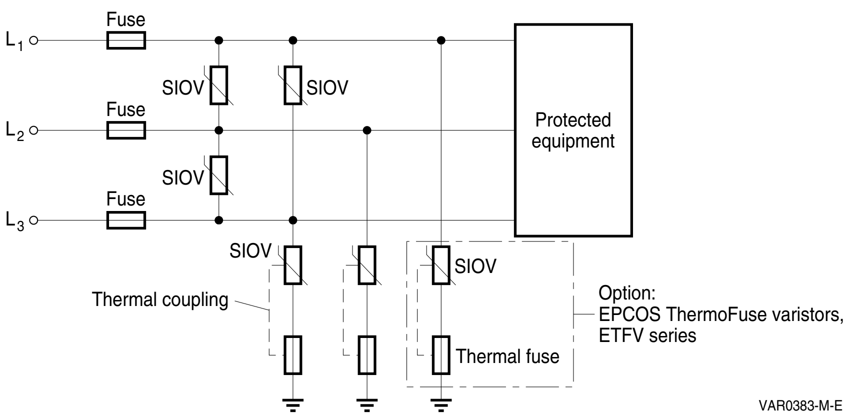


Figure 4 Three-phase protection including line-to-ground protection

Further typical applications of varistors used as a freewheeling circuit

Switching off protection

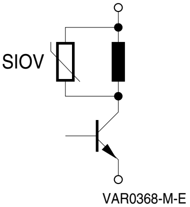


Figure 5

Semiconductor protection

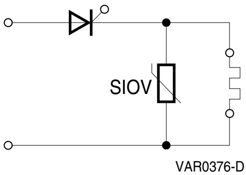


Figure 6

Contact spark suppression

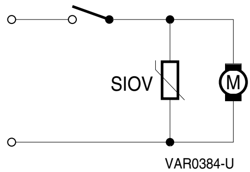


Figure 7

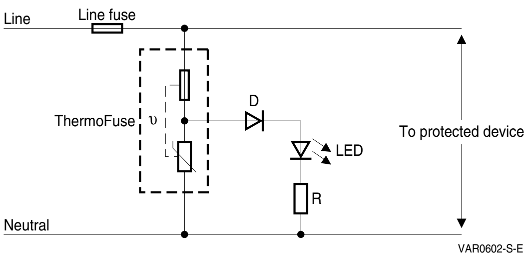


Figure 8 ETFV single-phase protection with working condition indicator

1.2 CE conformity

A wide range of legislation and of harmonized standards have come into force and been published in the field of electromagnetic compatibility (EMC) in the past few years. In the European Union, the EMC Directive 89/336/EEC of the Council of European Communities came into effect on the 1st of January 1996. As of this date, all electronic equipment must comply with the protective aims of the EMC Directive. Conformity with the respective standards must be guaranteed by the **manufacturer or importer** in the form of a declaration of conformity. A CE mark of conformity must be applied to all equipment [1].

As a matter of principle, all electrical or electronic equipment, installations and systems must meet the protection requirements of the EMC Directive and/or national EMC legislation. A declaration of conformity by the manufacturer or importer and a CE mark are required for most equipment. Exceptions to this rule and special rulings are described in detail in the EMC laws.

New, harmonized European standards have been drawn up in relation to the EMC Directive and national EMC laws. These specify measurement techniques and limit values or severity levels, both for interference emission and for interference susceptibility (or rather immunity to interference) of electronic devices, equipment and systems.

The subdivision of the European standards into various categories (cf. table 1) makes it easier to find the rules that apply to the respective equipment. The generic standards always apply to all equipment for which there is no specific product family standard or dedicated product standard.

Adherence to EMC standards is especially important.

[1] Kohling, Anton “CE Conformity Marking”; ISBN 3-89578-037-5, Ordering code: A19100-L531-B666

These are:

- Interference emission EN 61000-6-3 and EN 61000-6-4
- Immunity to interference EN 61000-6-1 and EN 61000-6-2

Whereas regulations concerning maximum interference emission have been in existence for some time, binding requirements concerning immunity to interference have only come into existence since 1996 for many types of equipment. In this respect, in addition to having an optimum price/performance ratio, SIOV varistors have proved themselves to be a reliable solution for all requirements concerning overvoltages:

- ESD (electrostatic discharge)
- Burst (fast transients)
- Surges, high-energy transients

The basic standards contain information on interference phenomena and general measuring methods.

The following standards and regulations form the framework of the conformity tests:

Table 1

EMC standards		Germany	Europe	International
Generic standards define the EMC environment in which a device is to operate according to its intended use				
Emission	residential	DIN EN 61000-6-3 (DIN EN 50081-1)[1]	EN 61000-6-3 (EN 50081-1)[1]	IEC 61000-6-3
	industrial	DIN EN 61000-6-4 (DIN EN 50081-2)[1]	EN 61000-6-4 (EN 50081-2)[1]	IEC 61000-6-4
Interference immunity	residential	DIN EN 61000-6-1 (DIN EN 50082-1)[1]	EN 61000-6-1 (EN 50082-1)[1]	IEC 61000-6-1
	industrial	DIN EN 61000-6-2	EN 61000-6-2	IEC 61000-6-2
Basic standards describe physical phenomena and measurement techniques				
Measuring equipment		DIN VDE 0876-16-1		CISPR 16-1
Measuring methods	emission	DIN VDE 0877-16-2		CISPR 16-2
	interference immunity	DIN EN 61000-4-1	EN 61000-4-1	IEC 61000-4-1
Harmonics		DIN EN 61000-3-2	EN 61000-3-2	IEC 61000-3-2
Flicker		DIN EN 61000-3-3	EN 61000-3-3	IEC 61000-3-3
Interference immunity parameters e.g.	ESD	DIN EN 61000-4-2	EN 61000-4-2	IEC 61000-4-2
	EM fields	DIN EN 61000-4-3	EN 61000-4-3	IEC 61000-4-3
	Burst	DIN EN 61000-4-4	EN 61000-4-4	IEC 61000-4-4
	Surge	DIN EN 61000-4-5	EN 61000-4-5	IEC 61000-4-5

1) The standards given in parentheses are earlier ones that will remain valid for a transition period.

Table 1 (continued)

EMC standards		Germany	Europe	International
Product family standards define limit values for emission and immunity				
ISM equipment	emission interference immunity	DIN EN 55011 1)	EN 55011 1)	CISPR 11 1)
Household appliances	emission interference immunity	DIN EN 55014-1 DIN EN 55014-2	EN 55014-1 EN 55014-2	CISPR 14-1 CISPR 14-2
Lighting	emission interference immunity	DIN EN 55015 DIN EN 61547	EN 55015 EN 61547	CISPR 15 IEC 1547
Radio and TV equipment	emission interference immunity	DIN EN 55013 DIN EN 55020	EN 55013 EN 55020	CISPR 13 CISPR 20
High-voltage systems	emission	DIN VDE 0873	—	CISPR 18
ITE equipment	emission interference immunity	DIN EN 55022 DIN EN 55024	EN 55022 EN 55024	CISPR 22 CISPR 24
Vehicles	emission interference immunity	DIN VDE 0879-2 —	2) 2)	CISPR 25 ISO 11451 ISO 11452

The following table shows the most important standards in the field of immunity to interference.

Standard	Test characteristics	Phenomena
Conducted interference		
EN 61000-4-4 IEC 61000-4-4	5/50 ns (single pulse) 2.5 or 5 kHz burst	Burst Cause: switching processes
EN 61000-4-5 IEC 61000-4-5	1.2/50 µs (open-circuit voltage) 8/20 µs (short circuit current)	Surge (high-energy transients) Cause: lightning strikes, power lines, switching processes
EN 61000-4-6 (ENV 50141) IEC 61000-4-6	1 V, 3 V, 10 V 150 kHz to 80 MHz	High-frequency coupling Narrow band interference
Radiated interference		
EN 61000-4-3 (ENV 50140) IEC 61000-4-3	3 V/m, 10 V/m 80 to 1000 MHz	High-frequency interference fields

The IEC 61000 or EN 61000 series of standards are planned as central EMC standards into which all EMC regulations (e.g. IEC 60801, IEC 60555) are to be integrated in the next few years.

1) Is governed by the safety and quality standards of the product families.
2) The EU Automotive Directive (95/54/EC) also covers limits and interference immunity requirements.

1.3 Burst

According to IEC 61000-4-4, burst pulses are low-energy transients with steep edges and high repetition rate. Thus, for equipment to pass burst testing successfully, design (line filter, grounding concept, case) is as critical as the choice of varistor. If IEC 61000-4-5 has been taken into account when selecting varistors, they will normally also handle the burst pulse energy without any problems. Due to the steepness of the pulse edges, the varistors must be connected in a way that keeps parasitic circuit inductance low. The EPCOS EMC laboratory will carry out tests upon request (cf. 1.6).

1.4 Surge voltages

Immunity to interference from surge voltages (high energy) is tested in accordance with IEC 61000-4-5. The transient is generated using a combination wave (hybrid) generator.

The severity level to be applied in the immunity test must be defined as a function of installation conditions.

In most cases the respective product standards demand five positive and five negative voltage pulses. Standard IEC 61000-4-5 specifies severity level 3 (line-to-line, 2 kV applied via 2 Ω) as being the highest energy load. Table 2 illustrates that even the small varistor size SIOV-S10 is suitable for absorbing this energy level.

The table also shows assessments for the other severity level. The maximum current and voltage values given were calculated using PSpice.

Table 2 has been supplemented by the 4 kV test level. The application of this test level has proven its worth in device protection for AC power supplies (without primary protection). Even this case can be dealt with using varistors of the standard series SIOV-S20, or, in case of space limitations, by using the decreased-size EnergetiQ series SIOV-Q14.

For the immunity testing line-to-earth of power supplies, IEC 61000-4-5 specifies 12 Ω as the internal resistance of the test generator. The energy content, which is considerably lowered due to this, permits use of the “small” type series SIOV-S05 and SIOV-S07.

For all other types of line, the internal resistance of the generator should be set to 42 Ω.

Note:
Connection of varistors to ground may be subject to restrictions. This must be clarified with the respective authorization offices.

Table 2

Application		2 Ω, 10 load cycles					
AC power supply line-to-line		230 V_{RMS}			400 V_{RMS}		
Severity level	kV	Type	I^*_{max} A	V^*_{max} V	Type	I^*_{max} A	V^*_{max} V
1	0.5	overvoltage protection not necessary					
2	1	S07K275	135	820	S05K460	3	1000
3	2	S10K275	590	920	S10K460	360	1430
4	4	S20K275 Q14K275	1560	900	S20K460	1300	1530

1.5 Interference emission

Switching off inductive loads can lead to overvoltages that may become sources of line interference as well as of inductively and/or capacitively coupled interference. This kind of interference can be suppressed using varistors connected as a flywheel circuit.

1.6 EMC systems engineering

EPCOS is your competent partner when it comes to solving EMC problems.

Our performance range covers:

- systems for measuring and testing EMC,
- shielded rooms for EMP measures,
- anechoic chambers,
- EMC consultation services and planning.

For further details, please refer to the “Chokes and Inductors” data book.

1.7 Protection of automotive electrical systems

1.7.1 Requirements

Electronic equipment must work reliably in its electromagnetic environment without, in turn, unduly influencing this environment. This requirement, known as electromagnetic compatibility (EMC), is especially important in automotive electrical systems, where energy of mJ levels is sufficient to disturb or destroy devices that are essential for safety. EPCOS has devised a wide range of special models matched to the particular demands encountered in automotive power supplies:

- extra high energy absorption (load dump),
- effective limiting of transients,
- low leakage current,
- jump-start capability (no varistor damage at double the car battery voltage),
- insensitivity to reverse polarity,
- wide range of operating temperature,
- high resistance to cyclic temperature stress.

EPCOS automotive varistors (SIOV-…AUTO) suit all these demands. They are specified separately in the product tables.

1.7.2 Transients

Standard ISO 7637 (DIN 40 839) details the EMC in automotive electrical systems. The toughest test for transient suppression is pulse 5, simulating load dump. This critical fault occurs when a battery is accidentally disconnected from the generator while the engine is running, e.g. because of a broken cable. Under this condition peak voltages up to 200 V can occur, lasting for few hundred ms, yielding energy levels up to 100 J. This worst case, as well as the other pulse loads, can be mastered reliably using SIOV-AUTO varistors.

1.7.3 Fine protection

Electronic components are often far apart, so EMC cannot be implemented with a central suppressor module alone. Instead you have to provide extra fine protection directly on the individual modules. Here energy absorption of a few Joules to some tens of Joules is adequate, meaning that lower rated and thus smaller components can be chosen. Figure 9 illustrates an EMC concept with varistors.

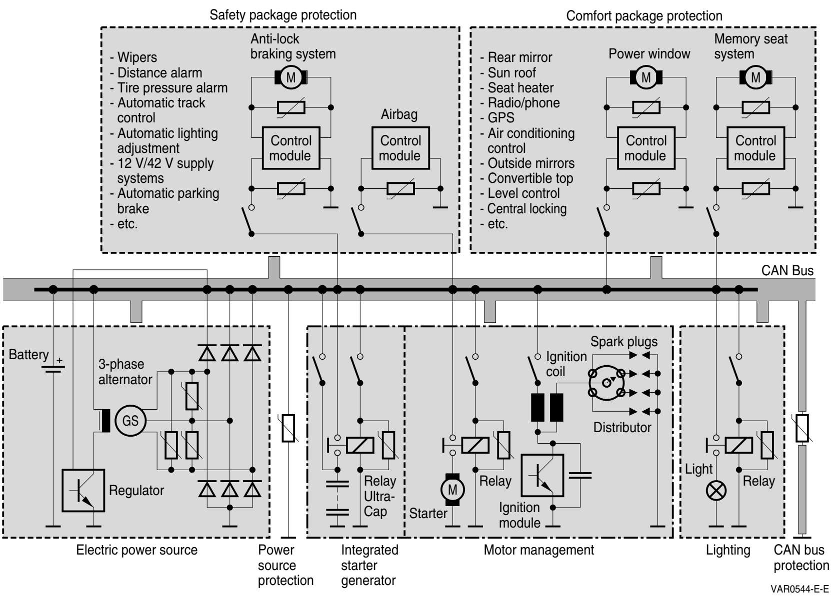
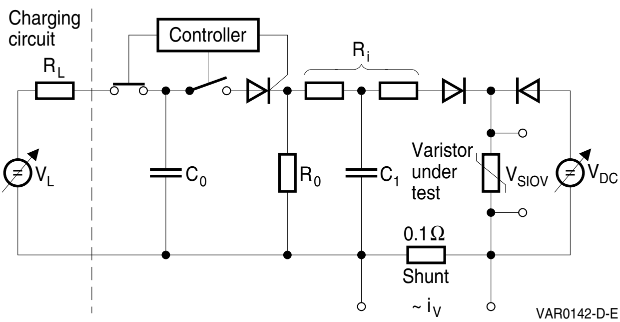


Figure 9 Automotive electrical system, complete EMC concept with varistors

1.7.4 Tests

Maintenance of EMC requirements can be checked with conventional test generators. Figures 10 and 11 show block diagrams for load dump tests with operating voltage applied. The electrical performance associated with a load dump of 100 J is illustrated in figures 12 to 14.

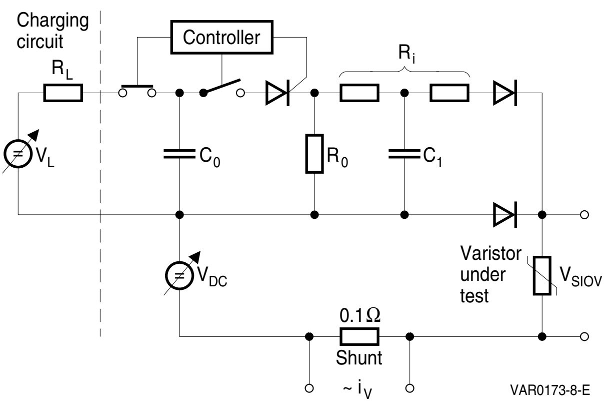
Note:
Circuit 11 produces test pulse 5 according to ISO 7637 (DIN 40 839); the 10% time constant t_d can be set independently of battery voltage. Note that the maximum discharge current is not limited by the source V_{DC}.



Typical values

C_0	20 … 35 mF
R_0	4 … 10 Ω
C_1	0 … 10 μF
R_i	0.5 … 4 Ω
V_L	0 … 200 V
V_{DC}	12 … 28 V
t_d	100 … 800 ms
V_{SIOV}	Protection level of varistor
i_v	Current through varistor

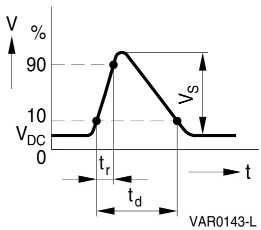
Figure 10 Principle of load dump generator with battery connected in parallel



Typical values

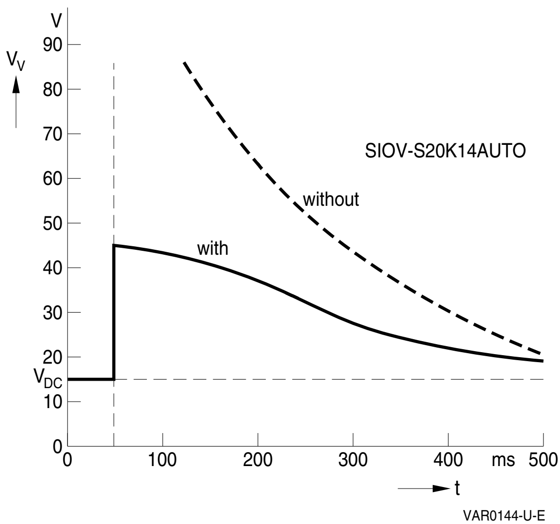
C_0	4.7 … 47 mF
R_0	4 … 5 Ω
C_1	47 … 470 μF
R_i	0.5 … 5 Ω
V_L	0 … 200 V
V_{DC}	12 … 28 V
t_d	40 … 500 ms
V_{SIOV}	Protection level of varistor
i_v	Current through varistor

Figure 11 Principle of load dump generator with battery connected in series



Test pulse 5
acc. to ISO 7637
(DIN 40 839)

Figure 12



Example:

C_0 = 37.6 mF
R_0 = 4.6 Ω
C_1 = 47 μF
V_S = 146 V
V_{DC} = 14 V
R_i = 2 Ω
t_d = 400 ms
t_r = 0.1 ms

Figure 13

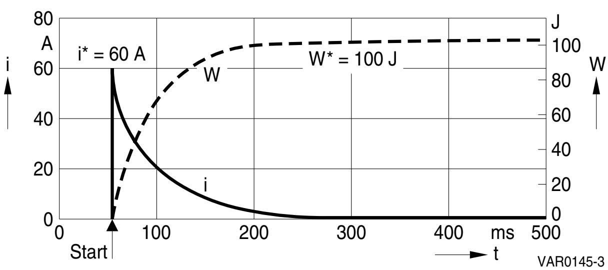


Figure 14

Voltage (figure 13), current and energy absorption (figure 14) on SIOV-S20K14AUTO with test pulse 5 (figure 12), load dump generator as in figure 11

1.7.5 Load dump simulation using PSpice software, e.g. PSpice simulation of the load dump energy

The time region of the varistor current derating graphs is only shown for up to 10 ms, whereas the load dump duration can be as long as 400 ms.

To cover also the load dump condition, the automotive product tables show supplementary maximum energy values for load dump absorption (10 ×).

In accordance with ISO 7637, the load dump pulse 5 is specified by the parameters

- Charge voltage (test level) V_s
- Internal resistance R_i
- Rise time t_r
- Duration t_d

(see figure 12).

The easiest way is to perform a software simulation (e.g. using PSpice) to determine the amount of energy dissipation by the varistor, which portion of the energy of this pulse the varistor absorbs. As stated in equation 10, the value calculated by this method must be lower than the value specified in the product tables.

ISO 7637 requires that at least one load dump absorption must be tolerated.

In other specifications repeated load dumps up to ten times are permissible. In coincidence with such regulations the automotive industry specifies load dump values for ten repetitions for their applications.

EPCOS offers to perform load dump simulations according to customers' specifications upon special request.

For such cases, we require information concerning:

V_s, R_i, t_r, t_d and the number of repetitions desired.

1.7.6 42 V vehicle power supply

For the 42 V vehicle on board power supply network, which will be of importance in the near future, EPCOS is offering the varistor type series SIOV-S..V42AUTO. For details, please refer to the automotive product tables.

Remark: PSpice is a registered trademark of MicroSim Corporation.
For this software we offer varistor simulation models.

1.8 Telecommunications

Electromagnetic interference on telecommunications, signal and control lines can be quite considerable as these lines tend to be long and exposed. So the requirements are correspondingly high when it comes to the electromagnetic compatibility of connected components or equipment.

1.8.1 Standard program

Disk-type SIOVs are used all over the world as reliable protection components in communications terminal devices (e.g. telephones) and in switching exchange systems (e.g. line cards).

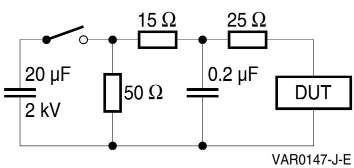
Depending on the test severity of the specifications, type series SIOV-S07, -S10, -S14, -S20 are used in such applications.

The easiest method of selecting a varistor is to use PSpice simulation to select a varistor for given requirements. In 1.9.2 the calculation shows if SIOV-S10K95 is acceptable.

1.8.2 Telecom varistors

According to the directives of Germany's Central Telecommunications Engineering Bureau (FTZ) the immunity of telecomms equipment must be tested with the increased surge voltage of 2 kV (ITU-T only specifies 1.0 and 1.5 kV). The wave shape is 10/700 μs according to ITU-T and IEC 61000-4-5. Figure 15 shows the simplified test circuit diagram.

To meet these more severe test conditions, EPCOS has developed special "Telecom" disk varistors that can absorb the energy of such 2 kV surge loads as specified in the test regulations (ten times; five times for each polarity).



DUT Device under test
e.g. telephone terminal device

Figure 15 Circuit for generating 10/700 μs test pulse to ITU-T and IEC 61000-4-5

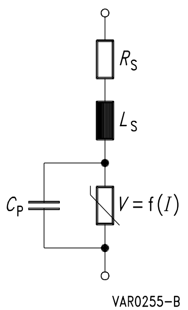
1.9 EPCOS PSpice simulation model

1.9.1 Varistor model

The development of a SIOV model for the “PSpice Design Center” circuit simulation program allows varistors to be integrated into the computer-assisted development of modern electronic circuitry.

In the PSpice modeling concept, the varistor is represented by its V/I characteristic curve, a parallel capacitance and a series inductance.

The structure of this equivalent circuit is shown in figure 16.



V = f (I)	V/I characteristic
C_p	Varistor capacitance
L_s	Series inductance
R_S = 100 μΩ	Series resistance

Figure 16 Varistor model, basic structure

In the model the V/I characteristic curve is implemented by a controlled voltage source V = f (I). An additional series resistance R_s = 100 μΩ has been inserted to prevent the impermissible state that would occur if ideal sources were to be connected in parallel or the varistor model were to be connected directly to a source.

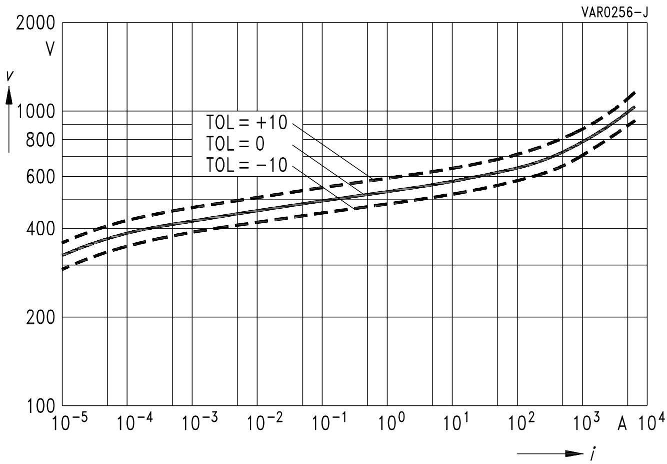
The following approximation is used for the mathematical description:

$$\log V = b1 + b2 \cdot \log(I) + b3 \cdot e^{-\log(I)} + b4 \cdot e^{\log(I)} \qquad I > 0 \qquad \text{(equ. 21)}$$

This means that the characteristic curve for any specific varistor can be described by the parameters b1 … b4. Figure 17 shows the typical V/I characteristic curve for the varistor SIOV-S20K275 and the corresponding parameters b1 … b4.

The tolerance bandwidth of the V/I characteristic curve can be shifted (cf. figures 14 and 15 in chapter “General technical information”) to include cases of

- upper tolerance bandwidth limit:
  highest possible protection level for a given surge current, and
- lower tolerance bandwidth limit:
  highest possible (leakage) current for a given voltage.



b1 = 2.7233755
b2 = 0.0258453
b3 = 0.0005746
b4 = 0.0046033

Figure 17 V/I characteristic curve of SIOV-S20K275 with tolerance band

In the model the capacitance values stated in the product tables are used. The dependence of the capacitance on the applied voltage and frequency is extremely low and can be neglected here.

It is not permissible to neglect the inductance of the varistor in applications with steep pulse leading edges. For this reason it is represented by a series inductance and essentially is determined by the lead inductance. As opposed to this, the internal inductance of the metal oxide varistor may be neglected. The inductance values in the model library are chosen for typical applications, e.g. approx. 13 nH for the S20K275. If longer leads are used, insertion of additional inductances must be considered if necessary. In the case of disk varistors the inductance of the leads is approx. 1 nH/mm.

The PSpice simulation models can be downloaded from the Internet (www.epcos.com/tools).

Limits of the varistor model

For mathematical reasons the V/I characteristic curves are extended in both directions beyond the current range (10 μA up to I_{max}) specified in this data book, and cannot be limited by the program procedure. The validity of the model breaks down if the specified current range is exceeded. For this reason it is imperative that the user consider these limits when specifying the task; the upper limit depends on the type of varistor. Values of < 10 μA may lead to incorrect results but do not endanger the component. In varistor applications it is only necessary to know the exact values for the leakage current in the < 10 μA range in exceptional cases. As opposed to this, values exceeding the type-specific surge current I_{max} may lead not only to incorrect results in actual practice but also to destruction of the component. Apart from this, the varistor model does not check adherence to other limit values such as maximum continuous power dissipation or surge current deratings. In addition to carrying out simulation procedures, adherence to such limits must always be ensured, observing the relevant spec given in the data book.

In critical applications the simulation result should be verified by a test circuit.

The model does not take into account the low temperature coefficient of the varistors (equ. 7).

1.9.2 Example for selection with PSpice

In this example the aim is to test whether selecting a standard varistor SIOV-S10K95 would meet the test conditions specified by the Germany's Central Telecommunications Engineering Bureau (FTZ):

Figure 15 shows the test circuit with a 2 kV charge voltage, figure 18 shows the corresponding model used in PSpice.

To achieve an open-circuit voltage of 2 kV, the charging capacitor must be charged to 2.05 kV.
To prevent an undefined floating of R_{m2}, an additional resistor R_1 = 10 MΩ is inserted at the output end.

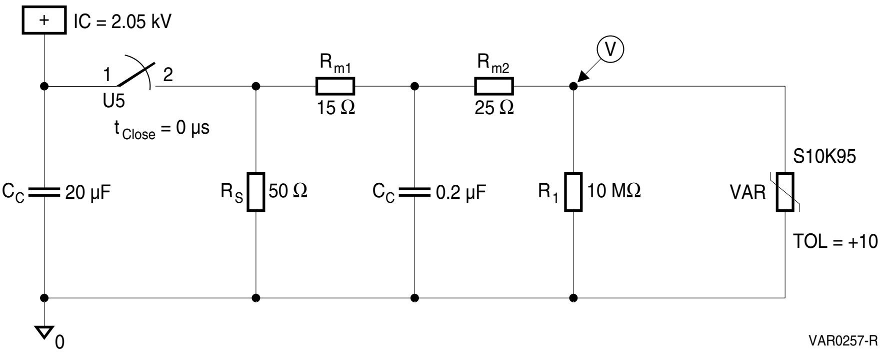


Figure 18 Simulation of the test pulse 10/700 µs applied to the device under test S10K95

For the varistor the upper characteristic curve tolerance (TOL = +10) limit is used to simulate the worst case, i.e. highest possible protection level. It is not considered necessary to model the device to be protected in this diagram since, in relation to the varistor, this is generally of higher resistance for pulse loads.

Figure 19 shows the curve of the open-circuit voltage (varistor disconnected) and the maximum protection level (with varistor).

Surge current

Figure 20 shows the voltage and current curves with the $\int i^* dt$ included in the drawing.

A maximum current of 44 A can be deduced from the curves.

Then, according to equation 14:

$$t^*_r = \frac{\int i^* dt}{\hat{i}^*} = \frac{17 \text{ mAs}}{44 \text{ A}} \approx 386 \ \mu\text{s}$$

According to figure 21, the resulting maximum surge current for 10 loads is i_{max} = 48 A > $\hat{i}^*$ = 44 A.

The selection criterion of equ. 9 is fulfilled.

Energy absorption

PSpice displays energy absorption directly as $W^* = \int v^* i^* dt = 4.2$ J.

The resulting permissible time interval between two pulses according to equation 20 is:

$$T_{min} = \frac{W^*}{P_{max}} = \frac{4.2\ J}{0.4\ W} = 10.5\ s$$

This means that the requirement of a minimum time interval between pulses of 60 s or more is fulfilled.

Highest possible protection level

Figure 19 shows the highest possible protection level to be 260 V. Thus it is possible to reduce the "overvoltage" of 2 kV to 13% of its value.

Note:
The specification stated above can also be met using the specially developed Telecom varistors (cf. section 1.8.2).

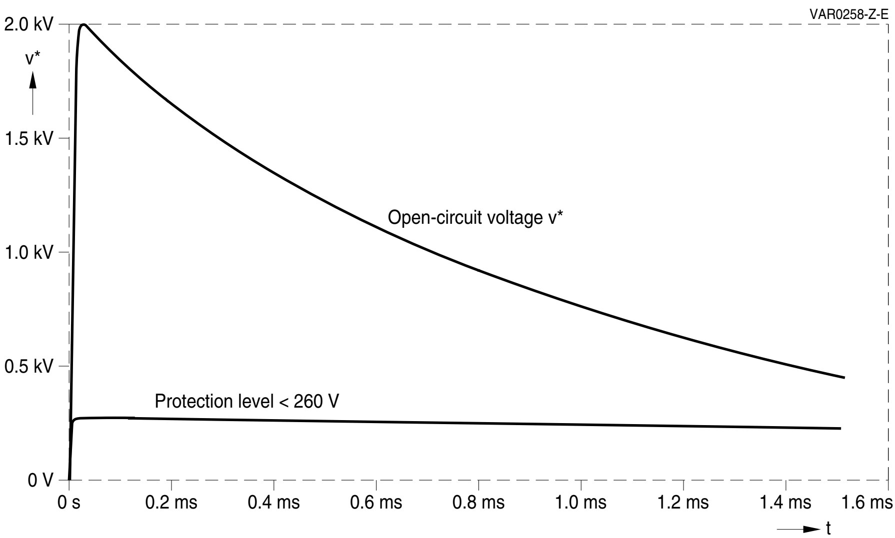


Figure 19 Open-circuit voltage (varistor disconnected) and maximum protection level (with varistor) achieved by the SIOV-S10K95 varistor

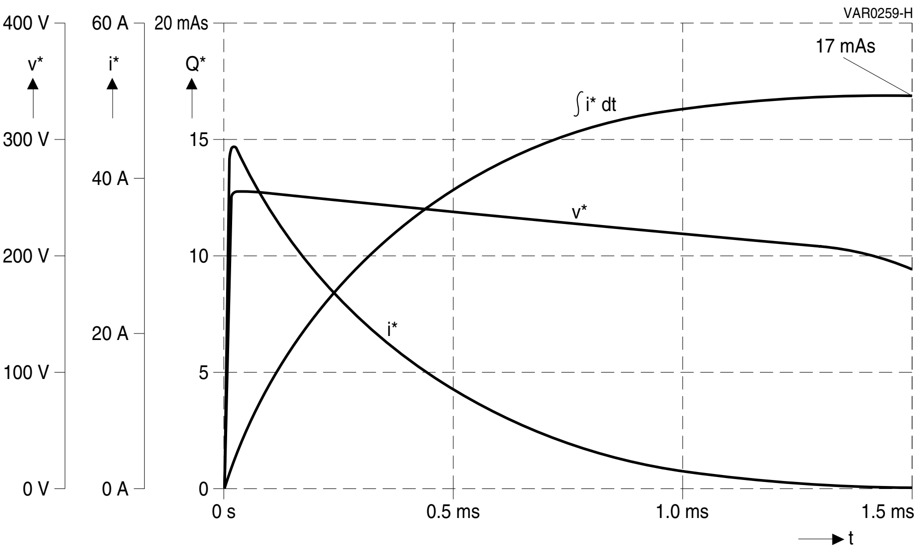


Figure 20 PSpice simulation: voltage, current and $\int i^* dt$ curves for the S10K95

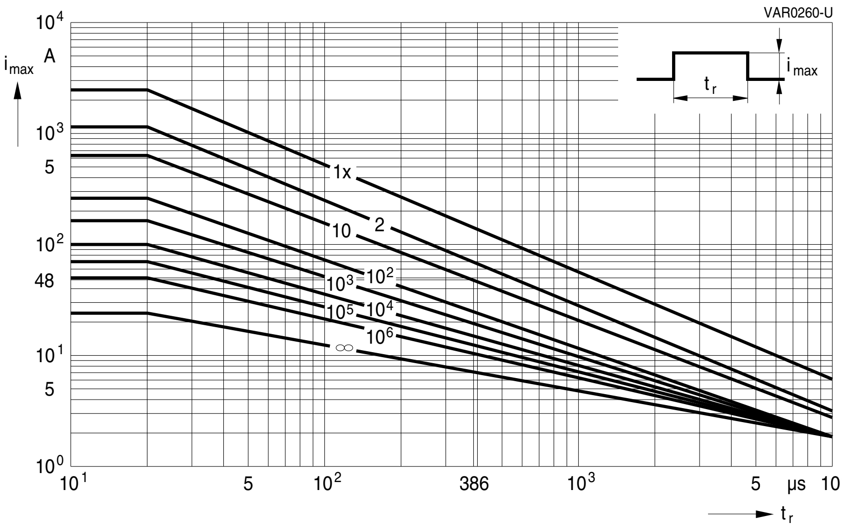


Figure 21 A maximum surge current i_{max} = 48 A (ten times) can be deduced for t^*_r = 386 µs from the derating curves for S10K50 … 320

1.10 Combined circuits

1.10.1 Stepped protection

If transient problems cannot be resolved with a single component like a varistor, it is always possible to combine different components and utilize their respective advantages. As an example, figure 22 illustrates the principle of stepped protection of a telemetry line with a gas-filled surge arrester[1)], a varistor and a CeraDiode or suppressor diode[2)]:

The voltage of 10 kV is limited in three stages

- "coarse" surge arrester
- "standard" varistor
- "fine" CeraDiode, suppressor diode[2)], zener diode[2)] or filter[3)]

to less than 50 V. The series inductors or resistors are necessary to decouple the voltage stages.

Note:
According to the specifications in the "Product Profile"[1)] gas-filled surge arresters may not be used on low-impedance supply lines.

1.10.2 Protective modules

Application-specific circuits for stepped protection assembled as modules, some incorporating overload protection and remote signaling, are available on the market.

Figures 23 and 24 show some practical examples.

1) Product Profile "Switching Spark Gaps", ordering no. EPC: 48003-7400
2) Not in the EPCOS product range
3) Data book "EMC Filters", ordering no. EPC: 32004-7600

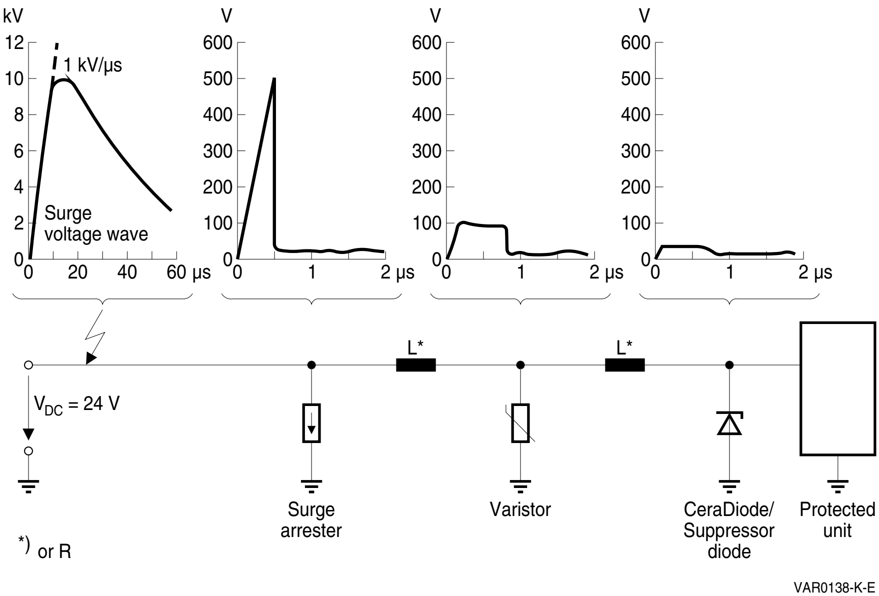


Figure 22 Principle of stepped protection with surge arrester, varistor and CeraDiode/suppressor diode

Examples of transient protective modules

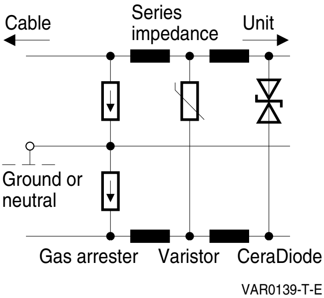


Figure 23 Circuit with coarse protection plus fine transverse voltage protection

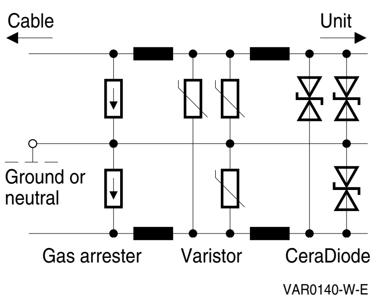


Figure 24 Circuit with coarse protection plus fine longitudinal voltage and transverse voltage protection

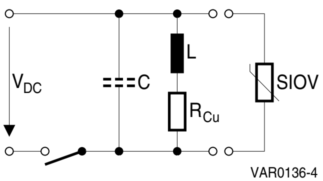
1 Calculation examples

1.1 Switching off inductive loads

The discharge of an inductor produces high voltages that endanger both the contact breaker (switching transistor and the like) and the inductor itself. According to equation 17 the energy stored in the coil is $W = {}^1/_2\, L\, i^2$. So, when the inductor is switched off, this energy charges a capacitor in parallel with the inductor (this capacitor can also be the intrinsic capacitance of the coil). Not allowing for the losses, and for ${}^1/_2\, C\, v^2 = {}^1/_2\, L\, i^2$, the values of figure 1 produce:

$$v^* = i^* \sqrt{\frac{L}{C}} = 1 \sqrt{\frac{0.1}{250 \cdot 10^{-12}}} = 20\,000 \text{ V}$$

To suppress this transient, a varistor is to be connected in parallel with the inductor as a flywheel circuit.



V_{DC} = 24 V
L = 0.1 H
R_{Cu} = 24 Ω
I = 1 A
C = 250 pF

Required switching rate = 10^6
Period = 10 s
Required protection level < 65 V

Figure 1 Limiting switching transients with a varistor as a flywheel circuit

Operating voltage

The DC operating voltage is given as 24 V (cf. figure 1). If the possible increase in operating voltage is no more than 2 V, types with a maximum permissible DC operating voltage of 26 V should be chosen from the product tables to achieve at as low a protection level as possible. Type S … K20 and S … K20E2 are available for this application.

Surge current

When it is cut off, the current through an inductor cannot change abruptly, so it flows across the varistor initially with the value of the operating current (here 1 A), then decaying towards zero following an exponential function.

The simplest ways of determining the current duration are simulation or measurement ($\tau = t^*_r$).

The time constant can also be calculated to an approximation with equation 13.
Here the varistor resistance of voltage class K20 is calculated for 1 A. As the protection levels of the various type series do not differ much, the S10K20 has been chosen arbitrarily to determine the resistance (the voltage is taken from the appropriate V/I characteristics).

$$R_{SIOV} = \frac{55\ V}{1\ A} = 55\ \Omega$$

So τ according to equation 13 is

$$\tau = t^*_r = \frac{0.1\ H}{24\ \Omega + 55\ \Omega} \approx 1.3\ ms$$

For S10K20 with $t^*_r = 1.3$ ms and 10^6 load repetitions, you obtain

$i_{max} = 3\ A > i^* = 1\ A$

from the derating curves.

Taking this result, you should check whether other types with lower current ratings satisfy the selection criterion:

S05K20: $i_{max} = 0.5\ A < i^* = 1\ A$
S07K20: $i_{max} = 1.4\ A > i^* = 1\ A$

For example, using a varistor of AdvanceD series S…K20E2 would not achieve any advantages at 10^6 load repetitions because in this region the derating fields of this series are not different from those of the StandarD series.

So the selection criterion of equation 9 is met by SIOV-S07K20 and all types with higher current ratings.

Energy absorption

The maximum energy absorption capacity of SIOV-S07K20 for $t^*_r = 1.3$ ms, $i_{max} = 1.4$ A and 10^6 repetitions according to equation 18 is

$W_{max} = v_{max} \cdot i_{max} \cdot t_{r\ max} = 60 \cdot 1.4 \cdot 0.0013 = 0.11\ J$ (with $t_{r\ max} = t^*_r$ according to chapter "Selection procedure", section 1.5.3)

According to equation 17 the varistor must in the worst case absorb energy of

$W^* = {}^1/_2\ L\ i^{*2} = {}^1/_2 \cdot 0.1\ H \cdot 1\ A^2 = 0.05\ J < W_{max} = 0.11\ J$

per switching cycle. Thus SIOV-S07K20 also satisfy the selection requirement of equation 10.

Average power dissipation

According to equation 19, applied energy of 0.05 J every 10 s produces average power dissipation of

$$P^* = \frac{W^*}{T^*} = \frac{0.05}{10} = 0.005\ W$$

The product table shows maximum dissipation capability of 0.02 W for SIOV-S07K20. So on this point too, the choice is correct (equation 11).

For the sake of completeness, the minimum permissible time between two applications of energy is calculated (equation 20):

$$T_{min} = \frac{W^*}{P_{max}} = \frac{0.05\ J}{0.02\ W} = 2.5\ s$$

Maximum protection level

The V/I curve for S07K20 shows a protection level of 60 V at 1 A for the worst-case position in the tolerance field (PSpice supplied by EPCOS: TOL = +10).
This means that type S07K20 meets the requirement for a protection level <65 V.

1.2 Ensuring EMC of equipment connected to 230 V line voltages

The example describes the selection procedure for a varistor that is to ensure the EMC of a device in accordance with IEC 61000-4-5 for 230 V operating voltage and a test voltage of 4 kV.

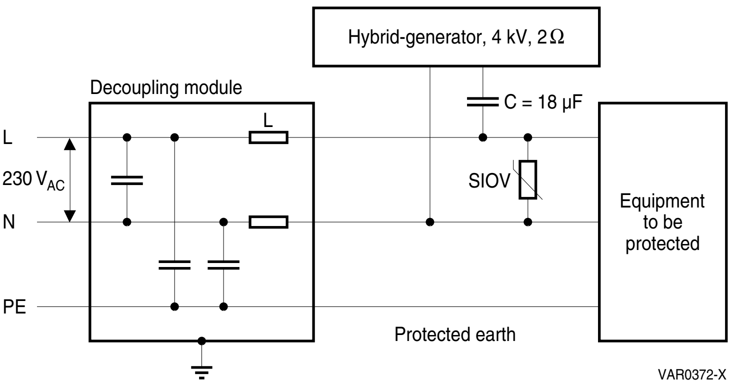


Figure 2 EMC test in accordance with IEC 61000-4-5 with $R_i = 2\ \Omega$, charge voltage 4 kV on a 230 V_{AC} line voltage

Line voltage:	230 V_{AC} ±10%
Hybrid test generator:	4 kV, 2 Ω
Number of repetitions:	10 (5 in each polarity)
Voltage endurance of equipment to be protected:	1 kV

Operating voltage

For European public AC power networks, IEC 60038 specifies that a line voltage tolerance of ±10% is to apply as from the year 2003. In this selection example we shall assume this tolerance to apply. This means that a maximum required operating voltage of 253 V_{AC} must be taken into account when selecting the varistor (the negative tolerance is of no significance for varistor selection).

To achieve the lowest possible protection level as described in chapter "Selection procedure", section 1.5.1, the varistor types with the voltage class closest to 253 V must be chosen, i.e. in this case the voltage class "K275".

For this voltage class the following EPCOS components are available:

■ disk types (StandarD, AdvanceD, SuperioR series)	SIOV-S…K275(E2)(E3)
■ disk types with housing (ThermoFuse (ETFV), fail-safe varistor (SFS))	SIOV-ETFV…K275(E2)(E4) SIOV-SFS…K275
■ block types (HighE series)	SIOV-B…K275
■ strap types (HighE series)	SIOV-L…K275…

Surge current

To determine surge current capability, the SIOV-S14K275 will be taken as an example.

For a given surge voltage, the maximum current will always be observed if the varistor operates at the lower limit of the tolerance range (refer to figure 14 in chapter "General technical information").

For this reason the clamping voltage reduced by the tolerance band width must be inserted in equation 12 instead of the value reduced by the tolerance (K = ±10%).

The surge generator's short circuit current would be:

$$i^* = \frac{4\,kV}{2\,\Omega} = 2\,kA$$

From the V/I characteristics of the SIOV-S14 you derive a protection level of 1000 V for an S14K275. Reducing this by the tolerance (±10%) produces $V_{SIOV} = 1000\,V \cdot \frac{0.9}{1.1} = 820\,V$.

By inserting this in equation 12, you obtain the surge current amplitude (worst case)

$$i^* = \frac{4000\,V - 820\,V}{2\,\Omega} = \frac{3180\,V}{2\,\Omega} = 1590\,A$$

The selected varistors must be able to handle a surge current of this amplitude ten times consecutively, regardless of polarity.

In accordance with IEC 61000-4-5, the hybrid generator is designed to supply surge current waveforms of type 8/20 µs (refer to figure 16 in chapter "General technical information") in the case of a short circuit. As the protection level of the varistor in this case is low in comparison to the no-load generator voltage, you can assume the 8/20 µs waveform to apply in this type of load as well. As shown in figure 8 in chapter "Selection procedure", this waveform can be transformed into an equivalent rectangular wave with $t_r^* = 20$ µs, which is to be used.

Look up this type in the derating diagram (drawing S14K50…320) to check whether or not an S14K275 can be subjected to the above surge current load. As a result of the investigation, a current of 1590 A (8/20 µs) is only permissible for two consecutive load cycles. For the required number of ten repetitions, the current i_{max} would be 1000 A only.

Since $i^* > i_{max}$, S14K275 is not a suitable choice for the given application conditions.

The type with the next highest surge current capability would be S14K275E2. The derating field yields i_{max} (10 ×) = 1500 A. For this reason this type is not suitable either.

As a result the selection check procedure must be repeated for the type series having the next highest power dissipation capability, SIOV-S20 series. In this case the type in question is the varistor type S20K275:

Here equation 12 results in

$$i^* = \frac{4000\ \text{V} - \left(950 \cdot \frac{0.9}{1.1}\right)\text{V}}{2\ \Omega} = \frac{4000\ \text{V} - 780\ \text{V}}{2\ \Omega} = \frac{3220\ \text{V}}{2\ \Omega} = 1610\,\text{A}$$

For ten load repetitions (at $t_r^* = t_r = 20\ \mu s$) the derating field of the S20K275 shows

$i_{max} = 2500$ A.

With this value the S20K275 meets the selection criterion of equation 9:

$i^* \leq i_{max}$.

Energy absorption

Since energy absorption, as calculated by equation 6, is directly correlated to surge current, the S20K275 also fulfils the selection criterion of equation 10:

$W^* \leq W_{max}$.

Power dissipation

In order to determine power dissipation, you must calculate the energy absorbed by the S20K275 when conducting the surge current. According to equation 16:

$W^* = v^* \cdot i^* \cdot t_r^* = 780\ \text{V} \cdot 1610\ \text{A} \cdot 20 \cdot 10^{-6}\ \text{s} = 25\ \text{J}$

As a pulse repetition rate, IEC 61000-4-5 specifies a maximum of one pulse/60 s. Inserting this in equation 19 results in:

$$P^* = \frac{W^*}{T^*} = \frac{25\ \text{J}}{60\ \text{s}} \approx 0.4\ \text{W}$$

From the product table the maximum permissible periodic load, i.e. average maximum power dissipation of an S20K275, is found to be 1 W. With this the selection criterion of equation 11,

$P^* \leq P_{max}$

is also met.

Protection level

The protection level is found to be 900 V (from the V/I characteristics for a value of 1610 A). In this case the 4 kV "overvoltage" is limited to 23%.

The protection level is lower than the voltage strength of the equipment to be protected, which is equal to 1000 V.

By fulfilling this final criterion, the StandarD SIOV-S20K275 is found to meet all selection criteria and can thus be considered suitable for the application.

Comparison to PSpice

Selection of the varistors for table 3 was carried out using PSpice calculations. The results for S20K275 correlate well with the values calculated here.

Other suitable types

If the physical dimensions of the chosen component SIOV-S20K275 are too large, similar selection calculations show that the EnergetiQ varistor SIOV-Q14K275, which requires less headroom, is also suitable.

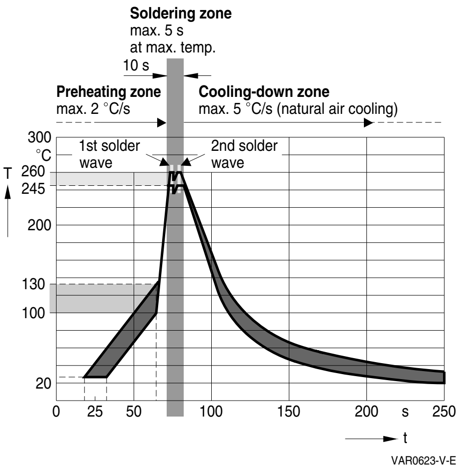
For comparison:

SIOV-S20K275 h_{max} = 25.5 mm
SIOV-Q14K275 h_{max} = 19.5 mm

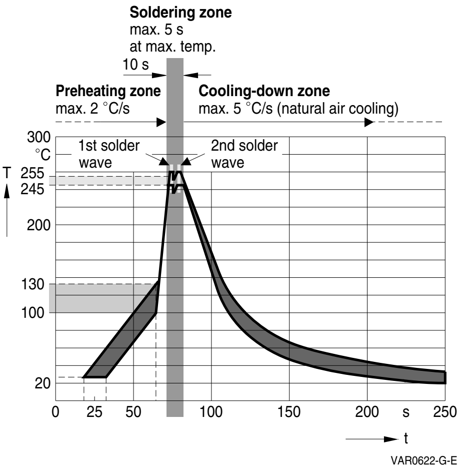
1 Soldering

Varistors with wire leads and versions with strap terminals as well as encapsulated varistors can be soldered using all conventional methods.

Recommended temperature profile in wave soldering (except ETFV series)



Recommended temperature profile in wave soldering for ETFV series



2 Storage

The SIOV type series should be soldered after shipment from EPCOS within the time specified:

SIOV-S, -Q, -LS	24 months
SIOV-ETFV, -SFS	12 months

The parts are to be left in the original packing to avoid any soldering problems caused by oxidized terminals. Storage temperature –25 to 45 °C.

Max. relative humidity (without condensation): <75% annual average,
<95% on max. 30 days per annum.

1 Reliability

1.1 Lifetime

The mean life (ML) of SIOV varistors as a function of

- voltage class (i.e. ceramic material),
- ambient temperature,
- applied voltage ratio (AVR)

can be derived from figure 1.

There is a marked difference between "low-voltage ceramics" (≤K40) and "high-voltage ceramics" (≥K50).

AVR is defined as the ratio between intended operating voltage and maximum permissible operating voltage.

$$AVR = \frac{v^*}{v_{max}} \qquad \text{(equ. 22)}$$

Reaching the maximum average power dissipation is defined as the end of useful life. But the varistor is still functional.

The increase in leakage current is, to a good approximation

$$i_L = A + k\sqrt{t} \qquad \text{(equ. 23)}$$

i_L = leakage current at constant voltage
A = factor, dependent on temperature, AVR, geometry, encapsulating material
k = slope coefficient of leakage current over $\sqrt{t}$

Investigations at different temperatures and AVRs show that the logarithm of lifetime is in a linear relation to reciprocal ambient temperature.The slope of this curve is virtually constant for zinc oxide. It can be attributed to activation energy.

The theoretical background of these relations is known as the Arrhenius model. Figure 1 shows evaluation for SIOV varistors.

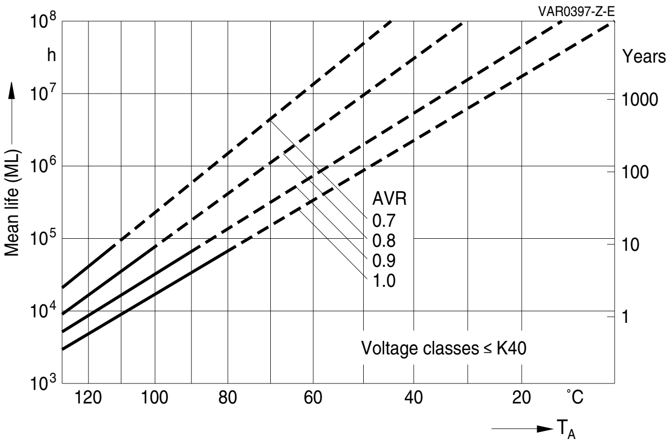
EPCOS lifetime tests extend over a period of several 10^4 hours. The higher lifetime figures are determined by extrapolation on the Arrhenius model.

1.2 Failure rate

The failure rate λ is the reciprocal of mean life in hours, the unit being fit (**f**ailures **i**n **t**ime) = 10^{-9}/h.

$$\lambda[\text{fit}] = \frac{10^9}{ML[h]} \qquad \text{(equ. 24)}$$

Accordingly, the fit rate can also be derived from the Arrhenius model.



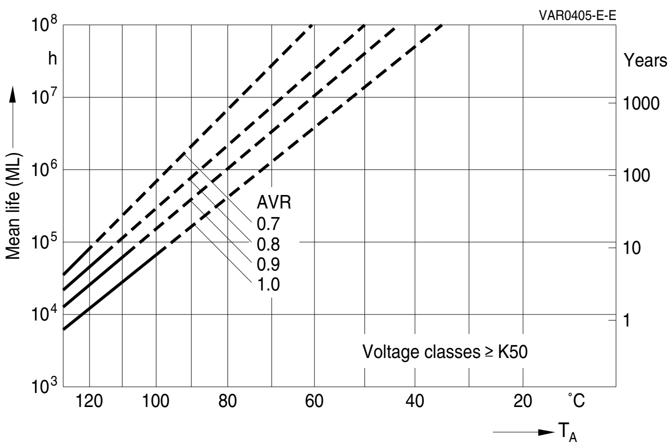


Figure 1 Mean life on Arrhenius model
Applied voltage ratio (AVR) referred to maximum permissible operating voltage

Failure rate figures refer to the average production status and are therefore to be understood as mean values (statistical expectations) for a large number of delivery lots of identical varistors. These figures are based on application experience and on data obtained from preceding tests under normal conditions, or – for purposes of accelerated aging – more severe conditions.

1.3 Tests

SIOV varistors are tested periodically. The relevant characteristics and test methods are described under reliability data for each series. These reliability test data are available on request.

Approvals

SIOV varistors have received the following certifications:

Underwriters Laboratories, Inc.

UL 1449 Transient voltage surge suppressors: File E97877

Disk types SIOV-S and SIOV-Q
Block types SIOV-B
Strap types SIOV-LS
Disk varistors in housing
ThermoFuse (ETFV) types
Fail-safe varistors (SFS types)

UL1414 Across-the-line components: File E63802

Type series S05/S07/S10/S14/S20, voltage classes K130 … K300; for S20 up to K680
Type series LS40K130 … K750

Note: For UL approvals please search for the EPCOS type designation at the UL website.

Canadian Standards Association

Class 2221 01 Accessories and Parts for Electronic Products
Metal oxide varistors, for use as across-the-line transient protectors: Master contract No. 175282

Disk types SIOV-S, voltage classes ≥K115, and SIOV-Q
Block types SIOV-B, voltage classes ≥K130
Strap types SIOV-LS
Fail-safe varistors (SFS types)

Schweizerischer Elektrotechnischer Verein SEV
(Swiss Electrotechnical Association)

Protection class 1
Degree of protection IP 00
Test requirement CECC 42 200

Test report no. 90.1 02484.02 (approved No. 96,5 51641,01)

Disk types SIOV-S

CECC approval of manufacturer in accordance with EN 100114-1

(includes the requirements of EN ISO 9001)

Qualification approval according to CECC 42201-004

Disk types (SIOV-S and SIOV-Q)

Qualification approval according to CECC 42201-008

Strap types LS40, voltage classes K150 … K385

Qualification approval IECQ-QA-1 according to IEC 61051-2-2, AT0001

Disk types (SIOV-S and SIOV-Q)

China Quality Certification Center
GB/T10193-1997, Varistors for use in electronic equipment

Part 1: Generic specification

Part 2: Sectional specification
S05K-(11 … 460) / (130E2 … 300E2)
S07K-(11 … 460) / (130E2 … 320E2)
S10K-(11 … 680) / (130E2 … 680E2)
S14K-(11 … 680) / (130E2 … 680E2)
S20K-(11 … 1000) / (130E2 … 680E2)

VDE marks license

Certification in accordance with CECC 42 000, CECC 42 200, CECC 42 201-004

Disk types (SIOV-S and SIOV-Q)

Corporate goals

Our aim is to play a leading role among the world's most competitive companies in the sector of electronic components. This aim is shared by the EPCOS quality and environment management system:

1 EPCOS quality system

1.1 Extract from EPCOS quality policy

- The quality of our products and services represents a key constituent of our corporate strategy, whose principal aim is customer satisfaction.
- Our quality management system is continuously oriented to the international standards that stipulate the highest requirements.

1.2 Quality management system

The quality management system to ISO/TS 16949:2002 is applied throughout the company and is used to implement the EPCOS quality policy. The implications include:

- As a rule, product and process developments follow the rules of APQP[1].
- Quality tools such as FMEA[2], DoE[3] and SPC[4] minimize risks and ensure continuous improvements in conjunction with regular internal audits and QM reviews.

1.3 Certification

The EPCOS quality management system forms the basis for the certification according to ISO 9001:2000 and ISO/TS 16949:2002. The certificates are posted on the EPCOS internet (www.epcos.com).

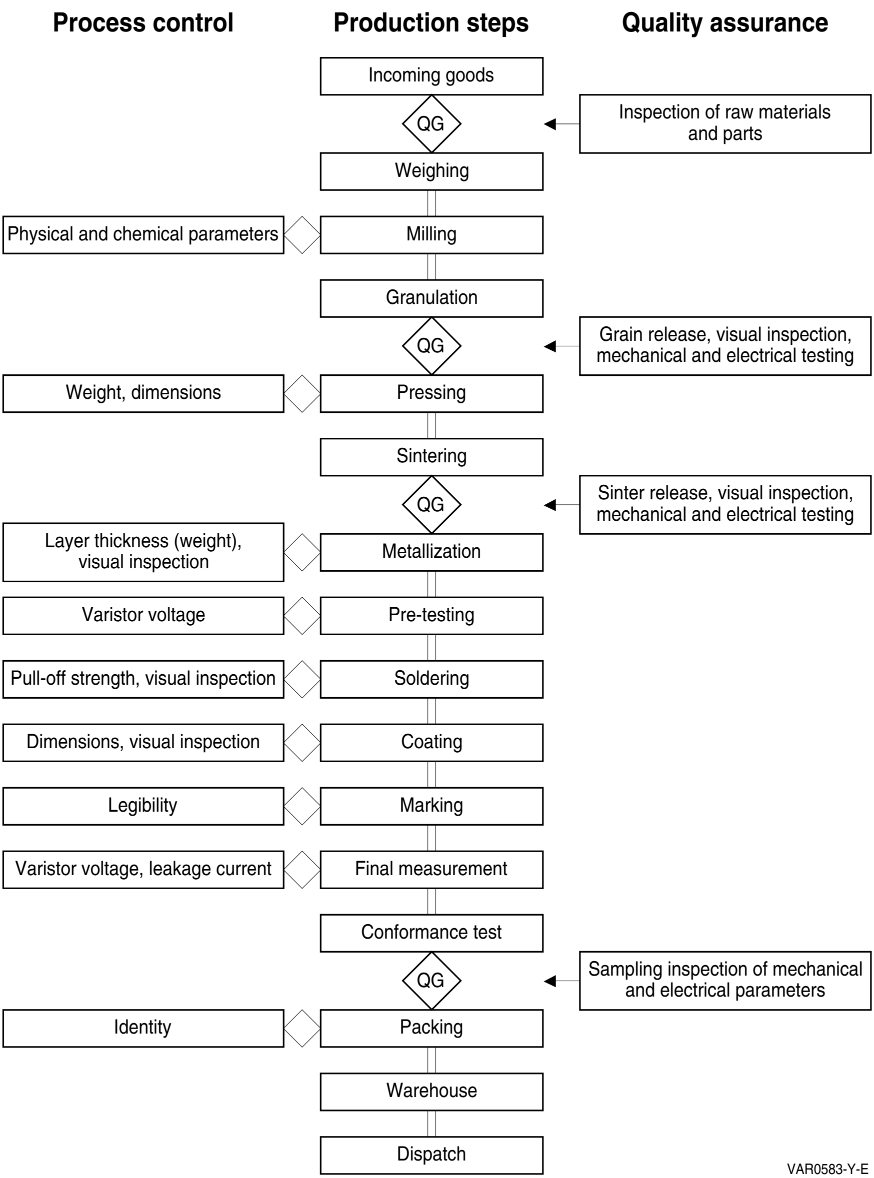
1.4 Production sequence and quality assurance

The business units implement the corporate specifications for quality management in procedural and work instructions referred to products and processes.

The following example shows quality assurance applied to the production sequence of disk, ThermoFuse (ETFV), fail-safe (SFS), strap and block varistors.

1) APQP = Advanced Product Quality Planning
2) FMEA = Failure Modes and Effects Analysis
3) DoE = Design of Experiments
4) SPC = Statistical Process Control

Manufacturing process and quality assurance of strap, block, leaded and housed varistors



1.5 Delivery quality

"Delivery quality" means compliance with the agreed data at the time of delivery.

1.6 Failure criteria

A component is defective if one of its features does not correspond to the specification of the data sheet or an agreed delivery specification.

1.7 Final inspection / approval for shipment

Final inspection verifies the major properties of the end products batch by batch, usually by means of fully automated selection tests.

Approval for shipment helps certify that products shipped comply with specifications. It includes

- testing of principal parameters,
- identification check and visual assessment,
- examination of papers accompanying the batch.

1.8 Duration of use

The duration of use in terms of reliability is the time period during which random failures occur, i.e. the range in the product operating life in which the failure rate remains largely constant (early failures and end of operating life excepted). The value depends strongly on conditions of use.

1.9 Reliability

A variety of endurance tests and environmental tests are conducted to assure the reliability of metal oxide varistors. These tests are derived from the extremes of expected application conditions, with test conditions intensified to obtain authoritative results within a reasonable period.

The reliability testing programs of EPCOS are based on the test plans of international standards and customer requirements.

EPCOS performs reliability tests to qualify new component families and for periodic requalification.

1.10 Bar code label

The packing of all EPCOS components bears a bar code label stating the type, ordering code, quantity, date of manufacture and batch number. This enables a component to be traced back through the production process, together with its batch and test report.

1.11 Conditions of use

EPCOS products may only be used in line with the technical specifications and assembly instructions and must comply with the state of the art. Non-observance of limits, operating conditions or handling guidelines can lead to disturbances in the circuit and other undesirable consequences such as a higher failure rate.

In this connection, please note the “Important notes” on page 2.

Should you have any application-referred questions, please contact our experts, who will be pleased to advise you.

1.12 Customer complaints

If a fault occurs in a product despite careful manufacture and testing, please contact your local sales organization. They will register your complaint as an RMA[5] process and forward it to the relevant technical departments for rapid handling.

5) RMA = Return of Material Authorization

EPCOS treats technical complaints according to the 8D methodology; i.e. with the use of interdisciplinary teams who aim to implement rapid countermeasures and sustained corrections and answer all complaints with an 8D report (8D = 8 disciplines).

In order to be able to deal quickly and smoothly with complaints, the following data is helpful:

- Number of components subject to complaint or returned
- Fault description
- How and when was the fault detected?
- Logistics data (date code, batch no., delivery note no.)
- Operating conditions
- Operating duration up to occurrence of the fault
- Measurement parameters in the case of divergent technical data

In the event of transport damage, we would ask you to describe this in more detail and if required to mark it so that it can be distinguished from any further damage sustained during the return shipment. The original package should also be checked and any damage to it described. In order to avoid further damage, the original packaging should also be used for the return shipment.

2 Environmental management system

2.1 Environmental policy

Our fundamental commitment to environmental protection is laid down in the EPCOS environmental policy.

EPCOS defines the following environmental protection principles:

- Above and beyond statutory and administrative requirements, we are continuously working to minimize the burden on the environment and to reduce consumption of energy and natural resources.
- We are taking all precautions necessary to protect our environment against damage.
- Potential impact on the environment is assessed and incorporated in product and process planning at the earliest possible stage.
- Our environmental management system ensures that our environmental protection principles are effectively put into practice. The technical and organizational procedures required are regularly monitored and updated.
- Each employee is required to act in an environmentally conscious manner. It is the constant duty of management to increase and encourage awareness of responsibility at all levels.
- We work with our business partners to promote conformity with similar objectives. We supply our customers with information on ways to minimize any potentially adverse environmental impacts of our products. We work in a spirit of cooperation with the relevant authorities.
- We inform the public of the impact on the environment caused by the company and our activities related to the environment.

2.2 Environmental management system

The EPCOS environmental management system according to ISO 14001 that is applied across the company is used to implement the EPCOS environmental policy. It is posted on the EPCOS intranet and is thus accessible to all employees.

2.3 Certification

The EPCOS environmental management system forms the basis for the ISO 14001 company certification in which all the plants are being successively integrated.

The company certificate is posted on the EPCOS internet (www.epcos.com).

2.4 RoHS

The term “RoHS-compatible” shall mean the following:

The components described as “RoHS-compatible” are compatible with the requirements of the regulations listed below (“Regulations”) and with the requirements of the provisions which will result from transformation of the Regulations into national law to the extent such provisions reflect the Regulations.

- Directive 2002/95/EC of the European Parliament and of the Council of 27 January 2003 on the restriction of the use of certain hazardous substances in electrical and electronic equipment ("Directive 2002/95/EC");
- Commission Decision of 18 August 2005 amending Directive 2002/95/EC (2005/618/EC); Directive 2005/618/EC;
- Commission Decision of 13 October 2005, of 21 October 2005 and of 21 April 2006 amending the Annex to Directive 2002/95/EC (2005/717/EC; 2005/747/EC; 2006/310/EC; 2006/690...692/EC).

2.5 Banned and hazardous substances in components

As a manufacturer of passive components, we develop our products on the basis of the relevant standards and laws and thus ensure that they remain free of materials and substances defined as banned and not exempted by the relevant legislation.

In order to guarantee a standardized procedure for EPCOS worldwide, a mandatory list of banned substances and substances of special interest is part of our environmental management system. The planning and development instructions include regulations and guidelines that aim to identify environmental aspects and to optimize products and processes with respect to material use and environmental compliance, to design them with sparing use of resources and to substitute hazardous substances as far as possible.

Consideration of the environmental aspects is checked and recorded in the design reviews: the environmental officer provides support in the assessment of the environmental impacts of a development project.

2.6 Material data sheets for product families

EPCOS posts material data sheets on the Internet (www.epcos.com/material) that show typical compositions of product groups by selected representatives. The materials are listed with their percentage weight distribution referred to the respective component.

As usual, all materials with a weight percentage exceeding 0.1 are listed. All specifications are typical data and may vary within a product class or production lot.

The material data sheets do not represent assured properties within the scope of the relevant legislation, but are merely given for purposes of information.

Please note in this connection the "Important notes" on page 2.

2.7 Disposal

The specifications given under the header of hazardous substances imply that all the components presented here can generally be disposed off or recycled together with customary electronic waste. However, as disposal is regulated by national law, the respective national provisions have to be observed.

Climatic category

Varistors are assigned to categories according to the climatic conditions under which they have been tested.

The IEC climatic category is specified for all varistors in the data sheets. In accordance with IEC 60068-1 (Appendix A) the climatic category is made up of three sets of digits, which are decoded as shown in the following example:

40 / 85 / 56

−40 °C

+85 °C

56 days

1st group:	Lower category temperature (temperature limit) denoting the test temperature for test A (cold) in accordance with IEC 60068-2-1.
2nd group:	Upper category temperature (temperature limit) denoting the test temperature for test B (dry heat) in accordance with IEC 60068-2-2.
3rd group:	Number of days, the duration of test Cab (damp heat, steady state) at a relative humidity of 93% +2/−3% and an ambient temperature of 40 °C, in accordance with IEC 60068-2-78.

General

1. EPCOS metal oxide varistors (SIOVs) are designed for specific applications and should not be used for purposes not identified in our specifications, application notes and data books unless otherwise agreed with EPCOS during the design-in-phase.
2. Ensure suitability of SIOVs through reliability testing during the design-in phase. SIOVs should be evaluated taking into consideration worst-case conditions.
3. For applications of SIOVs in line-to-ground circuits based on various international and local standards there are restrictions existing or additional safety measures required.

Storage

1. Store SIOVs only in original packaging. Do not open the package before storage.
2. Storage conditions in original packaging:

Storage temperature:	–25 °C … +45 °C
Relative humidity:	<75% annual average, <95% on maximum 30 days a year.
Dew precipitation:	Is to be avoided.

3. Avoid contamination of an SIOV's surface during storage, handling and processing.
4. Avoid storage of SIOVs in harmful environments that can affect the function during long-term operation (examples given under operation precautions).
5. The SIOV type series should be soldered within the time specified:

SIOV-S, -Q, -LS	24 months
ETFV and SFS types	12 months.

Handling

1. SIOVs must not be dropped.
2. Components must not be touched with bare hands. Gloves are recommended.
3. Avoid contamination of the surface of SIOV electrodes during handling, be careful of the sharp edge of SIOV electrodes.

Soldering (where applicable)

1. Use rosin-type flux or non-activated flux.
2. Insufficient preheating may cause ceramic cracks.
3. Rapid cooling by dipping in solvent is not recommended.
4. Complete removal of flux is recommended.

Mounting

1. Potting, sealing or adhesive compounds can produce chemical reactions in the SIOV ceramic that will degrade the component's electrical characteristics.
2. Overloading SIOVs may result in ruptured packages and expulsion of hot materials. For this reason SIOVs should be physically shielded from adjacent components.

Operation

1. Use SIOVs only within the specified temperature operating range.
2. Use SIOVs only within the specified voltage and current ranges.
3. Environmental conditions must not harm SIOVs. Use SIOVs only in normal atmospheric conditions. Avoid use in the presence of deoxidizing gases (chlorine gas, hydrogen sulfide gas, ammonia gas, sulfuric acid gas, etc), corrosive agents, humid or salty conditions. Avoid contact with any liquids and solvents.

Construction

- Round varistor element, leaded
- Coating: epoxy resin, flame-retardant to UL 94 V-0
- Terminals: tinned copper wire

Features

- Wide operating voltage range 11 … 1100 V_{RMS}
- High surge current ratings up to 8 kA
- No derating up to 85 °C ambient temperature
- PSpice models

Approvals

- UL
- CSA (all types ≥K115)
- SEV
- VDE
- CECC
- CQC S05/07 (K11 … K460), S10/S14 (K11 … K680), S20 (K11 … K1100)
- IEC

Delivery mode

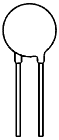
- Bulk (standard), taped versions on reel or in Ammo pack upon request.
- For further details refer to chapter "Taping, packaging and lead configuration" for leaded varistors.

Options

S10* types with lead spacing 5.0 mm and S20* types with lead spacing 7.5 mm are also available on request.

General technical data

Climatic category	to IEC 60068-1	40/85/56	
Operating temperature	to CECC 42 000	–40 … + 85	°C
Storage temperature		–40 … +125	°C
Electric strength	to CECC 42 000	≥2.5	kV_{RMS}
Insulation resistance	to CECC 42 000	≥10	MΩ
Response time		<25	ns



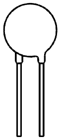
Maximum ratings (T_A = 85 °C)

Ordering code	Type (untaped) SIOV-	V_{RMS} V	V_{DC} V	i_{max} (8/20 µs) A	W_{max} (2 ms) J	P_{max} W
B72205S0110K101	S05K11	11	14	100	0.3	0.01
B72207S0110K101	S07K11	11	14	250	0.8	0.02
B72210S0110K101	S10K11	11	14	500	1.7	0.05
B72214S0110K101	S14K11	11	14	1000	3.2	0.10
B72220S0110K101	S20K11	11	14	2000	10.0	0.20
B72205S0140K101	S05K14	14	18	100	0.4	0.01
B72207S0140K101	S07K14	14	18[1]	250	0.9	0.02
B72210S0140K101	S10K14	14	18[1]	500	2.0	0.05
B72214S0140K101	S14K14	14	18[1]	1000	4.0	0.10
B72220S0140K101	S20K14	14	18[1]	2000	12.0	0.20
B72205S0170K101	S05K17	17	22	100	0.5	0.01
B72207S0170K101	S07K17	17	22	250	1.1	0.02
B72210S0170K101	S10K17	17	22	500	2.5	0.05
B72214S0170K101	S14K17	17	22	1000	5.0	0.10
B72220S0170K101	S20K17	17	22	2000	14.0	0.20
B72205S0200K101	S05K20	20	26	100	0.6	0.01
B72207S0200K101	S07K20	20	26	250	1.3	0.02
B72210S0200K101	S10K20	20	26	500	3.1	0.05
B72214S0200K101	S14K20	20	26	1000	6.0	0.10
B72220S0200K101	S20K20	20	26	2000	18.0	0.20
B72205S0250K101	S05K25	25	31	100	0.7	0.01
B72207S0250K101	S07K25	25	31	250	1.6	0.02
B72210S0250K101	S10K25	25	31	500	3.7	0.05
B72214S0250K101	S14K25	25	31	1000	7.0	0.10
B72220S0250K101	S20K25	25	31	2000	22.0	0.20
B72205S0300K101	S05K30	30	38	100	0.9	0.01
B72207S0300K101	S07K30	30	38	250	2.0	0.02
B72210S0300K101	S10K30	30	38	500	4.4	0.05
B72214S0300K101	S14K30	30	38	1000	9.0	0.10
B72220S0300K101	S20K30	30	38	2000	26.0	0.20

1) Jump-start strength (max. 24 V, 5 minutes)

Characteristics (T_A = 25 °C)

Ordering code	V_v (1 mA) V	ΔV_v (1 mA) %	$v_{c,\,max}$ (i_c) V	i_c A	C_{typ} (1 kHz) pF
B72205S0110K101	18	±10	36	1.0	1750
B72207S0110K101	18	±10	36	2.5	2750
B72210S0110K101	18	±10	36	5.0	6250
B72214S0110K101	18	±10	36	10.0	12100
B72220S0110K101	18	±10	36	20.0	23000
B72205S0140K101	22	±10	43	1.0	1450
B72207S0140K101	22	±10	43	2.5	2300
B72210S0140K101	22	±10	43	5.0	5200
B72214S0140K101	22	±10	43	10.0	9950
B72220S0140K101	22	±10	43	20.0	19000
B72205S0170K101	27	±10	53	1.0	1200
B72207S0170K101	27	±10	53	2.5	1900
B72210S0170K101	27	±10	53	5.0	4350
B72214S0170K101	27	±10	53	10.0	8200
B72220S0170K101	27	±10	53	20.0	15600
B72205S0200K101	33	±10	65	1.0	980
B72207S0200K101	33	±10	65	2.5	1600
B72210S0200K101	33	±10	65	5.0	3650
B72214S0200K101	33	±10	65	10.0	6800
B72220S0200K101	33	±10	65	20.0	13000
B72205S0250K101	39	±10	77	1.0	850
B72207S0250K101	39	±10	77	2.5	1400
B72210S0250K101	39	±10	77	5.0	3200
B72214S0250K101	39	±10	77	10.0	5850
B72220S0250K101	39	±10	77	20.0	11100
B72205S0300K101	47	±10	93	1.0	720
B72207S0300K101	47	±10	93	2.5	1200
B72210S0300K101	47	±10	93	5.0	2750
B72214S0300K101	47	±10	93	10.0	4950
B72220S0300K101	47	±10	93	20.0	9350

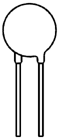


Maximum ratings (T_A = 85 °C)

Ordering code	Type (untaped) SIOV-	V_{RMS} V	V_{DC} V	i_{max} (8/20 μs) A	W_{max} (2 ms) J	P_{max} W
B72205S0350K101	S05K35	35	45	100	1.1	0.01
B72207S0350K101	S07K35	35	45	250	2.5	0.02
B72210S0350K101	S10K35	35	45	500	5.4	0.05
B72214S0350K101	S14K35	35	45	1000	10.0	0.10
B72220S0350K101	S20K35	35	45	2000	33.0	0.20
B72205S0400K101	S05K40	40	56	100	1.3	0.01
B72207S0400K101	S07K40	40	56	250	3.0	0.02
B72210S0400K101	S10K40	40	56	500	6.4	0.05
B72214S0400K101	S14K40	40	56	1000	13.0	0.10
B72220S0400K101	S20K40	40	56	2000	37.0	0.20
B72205S0500K101	S05K50	50	65	400	1.8	0.10
B72207S0500K101	S07K50	50	65	1200	4.2	0.25
B72210S0500K101	S10K50	50	65	2500	8.4	0.40
B72214S0500K101	S14K50	50	65	4500	15.0	0.60
B72220S0500K101	S20K50	50	65	6500	27.0	1.00
B72205S0600K101	S05K60	60	85	400	2.2	0.10
B72207S0600K101	S07K60	60	85	1200	4.8	0.25
B72210S0600K101	S10K60	60	85	2500	10.0	0.40
B72214S0600K101	S14K60	60	85	4500	17.0	0.60
B72220S0600K101	S20K60	60	85	6500	33.0	1.00
B72205S0750K101	S05K75	75	100	400	2.5	0.10
B72207S0750K101	S07K75	75	100	1200	5.9	0.25
B72210S0750K101	S10K75	75	100	2500	12.0	0.40
B72214S0750K101	S14K75	75	100	4500	20.0	0.60
B72220S0750K101	S20K75	75	100	6500	40.0	1.00
B72205S0950K101	S05K95	95	125	400	3.4	0.10
B72207S0950K101	S07K95	95	125	1200	7.6	0.25
B72210S0950K101	S10K95	95	125	2500	15.0	0.40
B72214S0950K101	S14K95	95	125	4500	25.0	0.60
B72220S0950K101	S20K95	95	125	6500	50.0	1.00

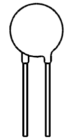
Characteristics (T_A = 25 °C)

Ordering code	V_v (1 mA) V	ΔV_v (1 mA) %	$v_{c, max}$ (i_c) V	i_c A	C_{typ} (1 kHz) pF
B72205S0350K101	56	±10	110	1.0	620
B72207S0350K101	56	±10	110	2.5	1050
B72210S0350K101	56	±10	110	5.0	2400
B72214S0350K101	56	±10	110	10.0	4200
B72220S0350K101	56	±10	110	20.0	8000
B72205S0400K101	68	±10	135	1.0	520
B72207S0400K101	68	±10	135	2.5	900
B72210S0400K101	68	±10	135	5.0	2100
B72214S0400K101	68	±10	135	10.0	3550
B72220S0400K101	68	±10	135	20.0	6750
B72205S0500K101	82	±10	135	5.0	300
B72207S0500K101	82	±10	135	10.0	530
B72210S0500K101	82	±10	135	25.0	950
B72214S0500K101	82	±10	135	50.0	1800
B72220S0500K101	82	±10	135	100.0	3800
B72205S0600K101	100	±10	165	5.0	250
B72207S0600K101	100	±10	165	10.0	480
B72210S0600K101	100	±10	165	25.0	870
B72214S0600K101	100	±10	165	50.0	1650
B72220S0600K101	100	±10	165	100.0	3600
B72205S0750K101	120	±10	200	5.0	210
B72207S0750K101	120	±10	200	10.0	430
B72210S0750K101	120	±10	200	25.0	720
B72214S0750K101	120	±10	200	50.0	1370
B72220S0750K101	120	±10	200	100.0	2900
B72205S0950K101	150	±10	250	5.0	135
B72207S0950K101	150	±10	250	10.0	260
B72210S0950K101	150	±10	250	25.0	530
B72214S0950K101	150	±10	250	50.0	870
B72220S0950K101	150	±10	250	100.0	1830



Maximum ratings (T_A = 85 °C)

Ordering code	Type (untaped) SIOV-	V_{RMS} V	V_{DC} V	i_{max} (8/20 μs) A	W_{max} (2 ms) J	P_{max} W
B72205S0111K101	S05K115	115	150	400	3.6	0.10
B72207S0111K101	S07K115	115	150	1200	8.4	0.25
B72210S0111K101	S10K115	115	150	2500	18.0	0.40
B72214S0111K101	S14K115	115	150	4500	30.0	0.60
B72220S0111K101	S20K115	115	150	6500	60.0	1.00
B72205S0131K101	S05K130	130	170	400	4.2	0.10
B72207S0131K101	S07K130	130	170	1200	9.5	0.25
B72210S0131K101	S10K130	130	170	2500	19.0	0.40
B72214S0131K101	S14K130	130	170	4500	34.0	0.60
B72220S0131K101	S20K130	130	170	8000	74.0	1.00
B72205S0141K101	S05K140	140	180	400	4.5	0.10
B72207S0141K101	S07K140	140	180	1200	10.0	0.25
B72210S0141K101	S10K140	140	180	2500	22.0	0.40
B72214S0141K101	S14K140	140	180	4500	36.0	0.60
B72220S0141K101	S20K140	140	180	8000	78.0	1.00
B72205S0151K101	S05K150	150	200	400	4.9	0.10
B72207S0151K101	S07K150	150	200	1200	11.0	0.25
B72210S0151K101	S10K150	150	200	2500	24.0	0.40
B72214S0151K101	S14K150	150	200	4500	40.0	0.60
B72220S0151K101	S20K150	150	200	8000	85.0	1.00
B72205S0171K101	S05K175	175	225	400	5.6	0.10
B72207S0171K101	S07K175	175	225	1200	13.0	0.25
B72210S0171K101	S10K175	175	225	2500	28.0	0.40
B72214S0171K101	S14K175	175	225	4500	46.0	0.60
B72220S0171K101	S20K175	175	225	8000	98.0	1.00
B72205S0231K101	S05K230	230	300	400	7.2	0.10
B72207S0231K101	S07K230	230	300	1200	17.0	0.25
B72210S0231K101	S10K230	230	300	2500	36.0	0.40
B72214S0231K101	S14K230	230	300	4500	60.0	0.60
B72220S0231K101	S20K230	230	300	8000	130.0	1.00
B72205S0251K101	S05K250	250	320	400	8.2	0.10
B72207S0251K101	S07K250	250	320	1200	19.0	0.25
B72210S0251K101	S10K250	250	320	2500	38.0	0.40
B72214S0251K101	S14K250	250	320	4500	65.0	0.60
B72220S0251K101	S20K250	250	320	8000	140.0	1.00

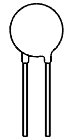


Characteristics (T_A = 25 °C)

Ordering code	V_v (1 mA) V	ΔV_v (1 mA) %	$v_{c,\,max}$ (i_c) V	i_c A	C_{typ} (1 kHz) pF
B72205S0111K101	180	±10	300	5.0	110
B72207S0111K101	180	±10	300	10.0	220
B72210S0111K101	180	±10	300	25.0	445
B72214S0111K101	180	±10	300	50.0	730
B72220S0111K101	180	±10	300	100.0	1520
B72205S0131K101	205	±10	340	5.0	100
B72207S0131K101	205	±10	340	10.0	200
B72210S0131K101	205	±10	340	25.0	400
B72214S0131K101	205	±10	340	50.0	650
B72220S0131K101	205	±10	340	100.0	1340
B72205S0141K101	220	±10	360	5.0	95
B72207S0141K101	220	±10	360	10.0	180
B72210S0141K101	220	±10	360	25.0	370
B72214S0141K101	220	±10	360	50.0	610
B72220S0141K101	220	±10	360	100.0	1240
B72205S0151K101	240	±10	395	5.0	90
B72207S0151K101	240	±10	395	10.0	170
B72210S0151K101	240	±10	395	25.0	350
B72214S0151K101	240	±10	395	50.0	570
B72220S0151K101	240	±10	395	100.0	1160
B72205S0171K101	270	±10	455	5.0	75
B72207S0171K101	270	±10	455	10.0	150
B72210S0171K101	270	±10	455	25.0	300
B72214S0171K101	270	±10	455	50.0	490
B72220S0171K101	270	±10	455	100.0	1000
B72205S0231K101	360	±10	595	5.0	60
B72207S0231K101	360	±10	595	10.0	115
B72210S0231K101	360	±10	595	25.0	230
B72214S0231K101	360	±10	595	50.0	380
B72220S0231K101	360	±10	595	100.0	760
B72205S0251K101	390	±10	650	5.0	55
B72207S0251K101	390	±10	650	10.0	105
B72210S0251K101	390	±10	650	25.0	215
B72214S0251K101	390	±10	650	50.0	350
B72220S0251K101	390	±10	650	100.0	700

Maximum ratings (T_A = 85 °C)

Ordering code	Type (untaped) SIOV-	V_{RMS} V	V_{DC} V	i_{max} (8/20 μs) A	W_{max} (2 ms) J	P_{max} W
B72205S0271K101	S05K275	275	350	400	8.6	0.10
B72207S0271K101	S07K275	275	350	1200	21.0	0.25
B72210S0271K101	S10K275	275	350	2500	43.0	0.40
B72214S0271K101	S14K275	275	350	4500	71.0	0.60
B72220S0271K101	S20K275	275	350	8000	151.0	1.00
B72205S0301K101	S05K300	300	385	400	9.6	0.10
B72207S0301K101	S07K300	300	385	1200	23.0	0.25
B72210S0301K101	S10K300	300	385	2500	47.0	0.40
B72214S0301K101	S14K300	300	385	4500	76.0	0.60
B72220S0301K101	S20K300	300	385	8000	173.0	1.00
B72210S0321K101	S10K320	320	420	2500	50.0	0.40
B72214S0321K101	S14K320	320	420	4500	84.0	0.60
B72220S0321K101	S20K320	320	420	8000	184.0	1.00
B72205S0381K101	S05K385	385	505	400	13.0	0.10
B72207S0381K101	S07K385	385	505	1200	28.0	0.25
B72210S0381K101	S10K385	385	505	2500	40.0	0.40
B72214S0381K101	S14K385	385	505	4500	80.0	0.60
B72220S0381K101	S20K385	385	505	8000	150.0	1.00
B72205S0421K101	S05K420	420	560	400	14.0	0.10
B72207S0421K101	S07K420	420	560	1200	32.0	0.25
B72210S0421K101	S10K420	420	560	2500	45.0	0.40
B72214S0421K101	S14K420	420	560	4500	90.0	0.60
B72220S0421K101	S20K420	420	560	8000	175.0	1.00
B72205S0441K101	S05K440	440	585	400	16.0	0.10
B72207S0441K101	S07K440	440	585	1200	34.0	0.25
B72210S0441K101	S10K440	440	585	2500	47.0	0.40
B72214S0441K101	S14K440	440	585	4500	95.0	0.60
B72220S0441K101	S20K440	440	585	8000	185.0	1.00
B72205S0461K101	S05K460	460	615	400	18.0	0.10
B72207S0461K101	S07K460	460	615	1200	36.0	0.25
B72210S0461K101	S10K460	460	615	2500	50.0	0.40
B72214S0461K101	S14K460	460	615	4500	100.0	0.60
B72220S0461K101	S20K460	460	615	8000	195.0	1.00



Characteristics (T_A = 25 °C)

Ordering code	V_v (1 mA) V	ΔV_v (1 mA) %	$v_{c,\,max}$ (i_c) V	i_c A	C_{typ} (1 kHz) pF
B72205S0271K101	430	±10	710	5.0	50
B72207S0271K101	430	±10	710	10.0	95
B72210S0271K101	430	±10	710	25.0	195
B72214S0271K101	430	±10	710	50.0	320
B72220S0271K101	430	±10	710	100.0	630
B72205S0301K101	470	±10	775	5.0	45
B72207S0301K101	470	±10	775	10.0	90
B72210S0301K101	470	±10	775	25.0	180
B72214S0301K101	470	±10	775	50.0	300
B72220S0301K101	470	±10	775	100.0	580
B72210S0321K101	510	±10	840	25.0	170
B72214S0321K101	510	±10	840	50.0	280
B72220S0321K101	510	±10	840	100.0	540
B72205S0381K101	620	±10	1025	5.0	40
B72207S0381K101	620	±10	1025	10.0	75
B72210S0381K101	620	±10	1025	25.0	150
B72214S0381K101	620	±10	1025	50.0	240
B72220S0381K101	620	±10	1025	100.0	450
B72205S0421K101	680	±10	1120	5.0	35
B72207S0421K101	680	±10	1120	10.0	65
B72210S0421K101	680	±10	1120	25.0	135
B72214S0421K101	680	±10	1120	50.0	220
B72220S0421K101	680	±10	1120	100.0	420
B72205S0441K101	715	±10	1180	5.0	32
B72207S0441K101	715	±10	1180	10.0	60
B72210S0441K101	715	±10	1180	25.0	125
B72214S0441K101	715	±10	1180	50.0	210
B72220S0441K101	715	±10	1180	100.0	400
B72205S0461K101	750	±10	1240	5.0	30
B72207S0461K101	750	±10	1240	10.0	55
B72210S0461K101	750	±10	1240	25.0	120
B72214S0461K101	750	±10	1240	50.0	200
B72220S0461K101	750	±10	1240	100.0	380

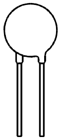
Maximum ratings (T_A = 85 °C)

Ordering code	Type (untaped) SIOV-	V_{RMS} V	V_{DC} V	i_{max} (8/20 µs) A	W_{max} (2 ms) J	P_{max} W
B72210S0511K101	S10K510	510	670	2500	55.0	0.40
B72214S0511K101	S14K510	510	670	4500	110.0	0.60
B72220S0511K101	S20K510	510	670	6500	190.0	1.00
B72210S0551K101	S10K550	550	745	2500	60.0	0.40
B72214S0551K101	S14K550	550	745	4500	120.0	0.60
B72220S0551K101	S20K550	550	745	6500	210.0	1.00
B72210S0621K101	S10K625	625	825	2500	68.0	0.40
B72214S0621K101	S14K625	625	825	4500	130.0	0.60
B72220S0621K101	S20K625	625	825	6500	230.0	1.00
B72210S0681K101	S10K680	680	895	2500	72.0	0.40
B72214S0681K101	S14K680	680	895	4500	140.0	0.60
B72220S0681K101	S20K680	680	895	6500	250.0	1.00
B72214S0102K101	S14K1000[1)]	1100	1465	4500	230.0	0.60
B72220S0102K101	S20K1000[1)]	1100	1465	6500	410.0	1.00

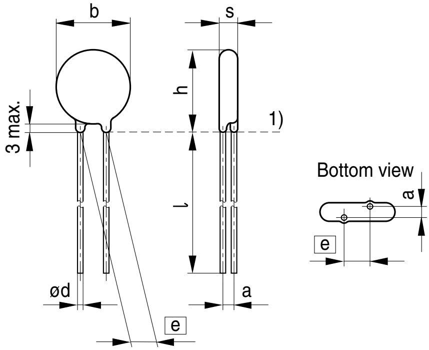
1) Operating voltage differs from type designation.

Characteristics (T_A = 25 °C)

Ordering code	V_v (1 mA) V	ΔV_v (1 mA) %	$v_{c,\,max}$ (i_c) V	i_c A	C_{typ} (1 kHz) pF
B72210S0511K101	820	±10	1355	25.0	110
B72214S0511K101	820	±10	1355	50.0	180
B72220S0511K101	820	±10	1355	100.0	340
B72210S0551K101	910	±10	1500	25.0	105
B72214S0551K101	910	±10	1500	50.0	170
B72220S0551K101	910	±10	1500	100.0	320
B72210S0621K101	1000	±10	1650	25.0	90
B72214S0621K101	1000	±10	1650	50.0	150
B72220S0621K101	1000	±10	1650	100.0	280
B72210S0681K101	1100	±10	1815	25.0	85
B72214S0681K101	1100	±10	1815	50.0	140
B72220S0681K101	1100	±10	1815	100.0	250
B72214S0102K101	1800	±10	2970	50.0	100
B72220S0102K101	1800	±10	2970	100.0	170



Dimensional drawing



1) Seating plane to IEC 60717

VAR0408-C

Weight

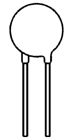
Nominal diameter mm	V_{RMS} V	Weight g
5	11 … 460	0.3 … 0.7
7	11 … 460	0.4 … 1.1
10	11 … 680	1.0 … 3.0
14	11 … 1000	1.4 … 7.6
20	11 … 1000	2.7 … 15.7

The weight of varistors in between these voltage classes can be interpolated.

Dimensions

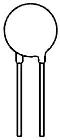
Ordering code	e ±1 mm	a ±1 mm	b_{max} mm	s_{max} mm	h_{max} mm	l_{min} mm	d ±0.05 mm
B72205S0110K101	5.0	1.2	7.0	3.3	8.5	25.0	0.6
B72207S0110K101	5.0	1.2	9.0	3.4	11.0	25.0	0.6
B72210S0110K101	7.5	1.4	12.0	4.0	14.5	25.0	0.8
B72214S0110K101	7.5	1.4	15.5	4.0	18.5	25.0	0.8
B72220S0110K101	10.0	1.5	21.5	4.5	25.5	25.0	1.0
B72205S0140K101	5.0	1.3	7.0	3.4	8.5	25.0	0.6
B72207S0140K101	5.0	1.3	9.0	3.5	11.0	25.0	0.6
B72210S0140K101	7.5	1.5	12.0	4.2	14.5	25.0	0.8
B72214S0140K101	7.5	1.5	15.5	4.2	18.5	25.0	0.8
B72220S0140K101	10.0	1.6	21.5	4.6	25.5	25.0	1.0
B72205S0170K101	5.0	1.4	7.0	3.5	8.5	25.0	0.6
B72207S0170K101	5.0	1.4	9.0	3.6	11.0	25.0	0.6
B72210S0170K101	7.5	1.6	12.0	4.4	14.5	25.0	0.8
B72214S0170K101	7.5	1.7	15.5	4.4	18.5	25.0	0.8
B72220S0170K101	10.0	1.8	21.5	4.8	25.5	25.0	1.0
B72205S0200K101	5.0	1.2	7.0	3.5	8.5	25.0	0.6
B72207S0200K101	5.0	1.2	9.0	3.6	11.0	25.0	0.6
B72210S0200K101	7.5	1.8	12.0	4.5	14.5	25.0	0.8
B72214S0200K101	7.5	1.9	15.5	4.6	18.5	25.0	0.8
B72220S0200K101	10.0	2.1	21.5	5.1	25.5	25.0	1.0

EPCOS



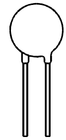
Dimensions

Ordering code	e ±1 mm	a ±1 mm	b_{max} mm	s_{max} mm	h_{max} mm	l_{min} mm	d ±0.05 mm
B72205S0250K101	5.0	1.3	7.0	3.6	8.5	25.0	0.6
B72207S0250K101	5.0	1.3	9.0	3.7	11.0	25.0	0.6
B72210S0250K101	7.5	1.6	12.0	4.2	14.5	25.0	0.8
B72214S0250K101	7.5	1.7	15.5	4.2	18.5	25.0	0.8
B72220S0250K101	10.0	1.8	21.5	4.7	25.5	25.0	1.0
B72205S0300K101	5.0	1.5	7.0	3.6	8.5	25.0	0.6
B72207S0300K101	5.0	1.5	9.0	3.7	11.0	25.0	0.6
B72210S0300K101	7.5	1.7	12.0	4.4	14.5	25.0	0.8
B72214S0300K101	7.5	1.8	15.5	4.4	18.5	25.0	0.8
B72220S0300K101	10.0	2.0	21.5	4.9	25.5	25.0	1.0
B72205S0350K101	5.0	1.6	7.0	3.7	8.5	25.0	0.6
B72207S0350K101	5.0	1.6	9.0	3.9	11.0	25.0	0.6
B72210S0350K101	7.5	1.8	12.0	4.4	14.5	25.0	0.8
B72214S0350K101	7.5	2.0	15.5	4.5	18.5	25.0	0.8
B72220S0350K101	10.0	2.2	21.5	5.1	25.5	25.0	1.0
B72205S0400K101	5.0	1.8	7.0	3.9	8.5	25.0	0.6
B72207S0400K101	5.0	1.8	9.0	4.1	11.0	25.0	0.6
B72210S0400K101	7.5	2.1	12.0	4.8	14.5	25.0	0.8
B72214S0400K101	7.5	2.2	15.5	4.9	18.5	25.0	0.8
B72220S0400K101	10.0	2.4	21.5	5.4	25.5	25.0	1.0
B72205S0500K101	5.0	1.2	7.0	3.3	8.5	25.0	0.6
B72207S0500K101	5.0	1.2	9.0	3.3	11.0	25.0	0.6
B72210S0500K101	7.5	1.4	12.0	3.9	14.5	25.0	0.8
B72214S0500K101	7.5	1.4	15.5	3.9	18.5	25.0	0.8
B72220S0500K101	10.0	1.5	21.5	4.3	25.5	25.0	1.0
B72205S0600K101	5.0	1.2	7.0	3.3	8.5	25.0	0.6
B72207S0600K101	5.0	1.2	9.0	3.3	11.0	25.0	0.6
B72210S0600K101	7.5	1.4	12.0	4.0	14.5	25.0	0.8
B72214S0600K101	7.5	1.5	15.5	4.0	18.5	25.0	0.8
B72220S0600K101	10.0	1.6	21.5	4.4	25.5	25.0	1.0
B72205S0750K101	5.0	1.3	7.0	3.4	8.5	25.0	0.6
B72207S0750K101	5.0	1.3	9.0	3.6	11.0	25.0	0.6
B72210S0750K101	7.5	1.5	12.0	4.2	14.5	25.0	0.8
B72214S0750K101	7.5	1.5	15.5	4.2	18.5	25.0	0.8
B72220S0750K101	10.0	1.6	21.5	4.6	25.5	25.0	1.0



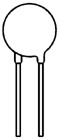
Dimensions

Ordering code	e ±1 mm	a ±1 mm	b_{max} mm	s_{max} mm	h_{max} mm	l_{min} mm	d ±0.05 mm
B72205S0950K101	5.0	1.3	7.0	3.4	8.5	25.0	0.6
B72207S0950K101	5.0	1.3	9.0	3.4	11.0	25.0	0.6
B72210S0950K101	7.5	1.5	12.0	4.0	14.5	25.0	0.8
B72214S0950K101	7.5	1.5	15.5	4.0	18.5	25.0	0.8
B72220S0950K101	10.0	1.6	21.5	4.5	25.5	25.0	1.0
B72205S0111K101	5.0	1.5	7.0	3.6	8.5	25.0	0.6
B72207S0111K101	5.0	1.5	9.0	3.6	11.0	25.0	0.6
B72210S0111K101	7.5	1.6	12.0	4.2	14.5	25.0	0.8
B72214S0111K101	7.5	1.7	15.5	4.2	18.5	25.0	0.8
B72220S0111K101	10.0	1.8	21.5	4.6	25.5	25.0	1.0
B72205S0131K101	5.0	1.6	7.0	3.6	8.5	25.0	0.6
B72207S0131K101	5.0	1.6	9.0	3.6	11.0	25.0	0.6
B72210S0131K101	7.5	1.8	12.0	4.2	14.5	25.0	0.8
B72214S0131K101	7.5	1.9	15.5	4.2	18.5	25.0	0.8
B72220S0131K101	10.0	2.0	21.5	4.7	25.5	25.0	1.0
B72205S0141K101	5.0	1.7	7.0	3.7	8.5	25.0	0.6
B72207S0141K101	5.0	1.7	9.0	3.7	11.0	25.0	0.6
B72210S0141K101	7.5	1.9	12.0	4.3	14.5	25.0	0.8
B72214S0141K101	7.5	2.0	15.5	4.3	18.5	25.0	0.8
B72220S0141K101	10.0	2.1	21.5	4.8	25.5	25.0	1.0
B72205S0151K101	5.0	1.8	7.0	3.8	8.5	25.0	0.6
B72207S0151K101	5.0	1.8	9.0	3.8	11.0	25.0	0.6
B72210S0151K101	7.5	2.0	12.0	4.4	14.5	25.0	0.8
B72214S0151K101	7.5	2.1	15.5	4.4	18.5	25.0	0.8
B72220S0151K101	10.0	2.2	21.5	4.9	25.5	25.0	1.0
B72205S0171K101	5.0	2.0	7.0	3.9	8.5	25.0	0.6
B72207S0171K101	5.0	2.0	9.0	4.0	11.0	25.0	0.6
B72210S0171K101	7.5	2.2	12.0	4.6	14.5	25.0	0.8
B72214S0171K101	7.5	2.2	15.5	4.6	18.5	25.0	0.8
B72220S0171K101	10.0	2.3	21.5	5.0	25.5	25.0	1.0
B72205S0231K101	5.0	1.8	7.0	4.0	8.5	25.0	0.6
B72207S0231K101	5.0	1.8	9.0	4.0	11.0	25.0	0.6
B72210S0231K101	7.5	2.0	12.0	4.7	14.5	25.0	0.8
B72214S0231K101	7.5	2.0	15.5	4.7	18.5	25.0	0.8
B72220S0231K101	10.0	2.1	21.5	5.1	25.5	25.0	1.0



Dimensions

Ordering code	e ±1 mm	a ±1 mm	b_{max} mm	s_{max} mm	h_{max} mm	l_{min} mm	d ±0.05 mm
B72205S0251K101	5.0	1.8	7.0	4.2	8.5	25.0	0.6
B72207S0251K101	5.0	1.8	9.0	4.2	11.0	25.0	0.6
B72210S0251K101	7.5	2.0	12.0	4.8	14.5	25.0	0.8
B72214S0251K101	7.5	2.0	15.5	4.8	18.5	25.0	0.8
B72220S0251K101	10.0	2.2	21.5	5.3	25.5	25.0	1.0
B72205S0271K101	5.0	2.0	7.0	4.3	8.5	25.0	0.6
B72207S0271K101	5.0	2.0	9.0	4.4	11.0	25.0	0.6
B72210S0271K101	7.5	2.2	12.0	5.0	14.5	25.0	0.8
B72214S0271K101	7.5	2.2	15.5	5.0	18.5	25.0	0.8
B72220S0271K101	10.0	2.3	21.5	5.4	25.5	25.0	1.0
B72205S0301K101	5.0	2.1	7.0	4.5	8.5	25.0	0.6
B72207S0301K101	5.0	2.1	9.0	4.5	11.0	25.0	0.6
B72210S0301K101	7.5	2.3	12.0	5.1	14.5	25.0	0.8
B72214S0301K101	7.5	2.3	15.5	5.2	18.5	25.0	0.8
B72220S0301K101	10.0	2.4	21.5	5.6	25.5	25.0	1.0
B72210S0321K101	7.5	2.4	12.0	5.4	15.0	25.0	0.8
B72214S0321K101	7.5	2.4	15.5	5.4	19.0	25.0	0.8
B72220S0321K101	10.0	2.6	21.5	5.8	25.5	25.0	1.0
B72205S0381K101	5.0	2.5	7.0	5.1	9.0	25.0	0.6
B72207S0381K101	5.0	2.5	9.0	5.2	11.5	25.0	0.6
B72210S0381K101	7.5	2.7	12.0	5.8	15.0	25.0	0.8
B72214S0381K101	7.5	2.7	15.5	5.9	19.0	25.0	0.8
B72220S0381K101	10.0	2.8	21.5	6.3	26.0	25.0	1.0
B72205S0421K101	5.0	2.8	7.0	5.4	9.0	25.0	0.6
B72207S0421K101	5.0	2.8	9.0	5.4	11.5	25.0	0.6
B72210S0421K101	7.5	2.9	12.0	6.1	15.0	25.0	0.8
B72214S0421K101	7.5	2.9	15.5	6.1	19.0	25.0	0.8
B72220S0421K101	10.0	3.1	21.5	6.5	26.0	25.0	1.0
B72205S0441K101	5.0	2.8	7.0	5.5	9.0	25.0	0.6
B72207S0441K101	5.0	2.8	9.0	5.5	11.5	25.0	0.6
B72210S0441K101	7.5	3.0	12.0	6.2	15.0	25.0	0.8
B72214S0441K101	7.5	3.0	15.5	6.3	19.0	25.0	0.8
B72220S0441K101	10.0	3.1	21.5	6.7	26.0	25.0	1.0



Dimensions

Ordering code	e ±1 mm	a ±1 mm	b_{max} mm	s_{max} mm	h_{max} mm	l_{min} mm	d ±0.05 mm
B72205S0461K101	5.0	3.0	7.0	5.7	9.0	25.0	0.6
B72207S0461K101	5.0	3.0	9.0	5.7	11.5	25.0	0.6
B72210S0461K101	7.5	3.1	12.0	6.3	15.0	25.0	0.8
B72214S0461K101	7.5	3.1	15.5	6.4	19.0	25.0	0.8
B72220S0461K101	10.0	3.3	21.5	6.8	26.0	25.0	1.0
B72210S0511K101	7.5	3.4	12.0	6.7	15.0	25.0	0.8
B72214S0511K101	7.5	3.4	15.5	6.8	19.0	25.0	0.8
B72220S0511K101	10.0	3.5	21.5	7.1	26.0	25.0	1.0
B72210S0551K101	7.5	3.7	12.0	7.1	15.0	25.0	0.8
B72214S0551K101	7.5	3.7	15.5	7.2	19.0	25.0	0.8
B72220S0551K101	10.0	3.9	21.5	7.5	26.0	25.0	1.0
B72210S0621K101	7.5	4.0	12.0	7.5	15.0	25.0	0.8
B72214S0621K101	7.5	4.0	15.5	7.5	19.0	25.0	0.8
B72220S0621K101	10.0	4.2	21.5	7.9	26.0	25.0	1.0
B72210S0681K101	7.5	4.4	12.0	7.9	15.0	25.0	0.8
B72214S0681K101	7.5	4.4	15.5	8.0	19.0	25.0	0.8
B72220S0681K101	10.0	4.5	21.5	8.4	26.0	25.0	1.0
B72214S0102K101	7.5	6.7	15.5	11.0	20.5	25.0	0.8
B72220S0102K101	10.0	6.9	21.5	11.4	28.5	25.0	1.0

Reliability data

Test	Test methods/conditions	Requirement
Varistor voltage	The voltage between two terminals with the specified measuring current applied is called V_v (1 mA_{DC} @ 0.2 … 2 s).	To meet the specified value.
Clamping voltage	The maximum voltage between two terminals with the specified standard impulse current (8/20 µs) applied.	To meet the specified value.
Max. AC operating voltage	CECC 42 000, test 4.20 1000 h at UCT After having continuously applied the maximum allowable voltage at UCT ±2 °C for 1000 h, the specimen shall be stored at room temperature and normal humidity for 1 to 2 h. Thereafter, the change of V_v shall be measured.	$\|\Delta V/V$ (1 mA)$\| \leq 10\%$
Surge current derating, 8/20 µs	CECC 42 000, test C 2.1 100 surge currents (8/20 µs), unipolar, interval 30 s, amplitude corresponding to derating curve for 100 impulses at 20 µs	$\|\Delta V/V$ (1 mA)$\| \leq 10\%$ (measured in direction of surge current) No visible damage
Surge current derating, 2 ms	CECC 42 000, test C 2.1 100 surge currents (2 ms), unipolar, interval 120 s, amplitude corresponding to derating curve for 100 impulses at 2 ms	$\|\Delta V/V$ (1 mA)$\| \leq 10\%$ (measured in direction of surge current) No visible damage
Electric strength	CECC 42 000, test 4.7 Metal balls method, 2500 V_{RMS}, 60 s The varistor is placed in a container holding 1.6 ±0.2 mm diameter metal balls such that only the terminations of the varistor are protruding. The specified voltage shall be applied between both terminals of the specimen connected together and the electrode inserted between the metal balls.	No breakdown

Reliability data

Test	Test methods/conditions	Requirement
Climatic sequence	CECC 42 000, test 4.16 The specimen shall be subjected to: a) dry heat at UCT, 16 h b) damp heat, 1st cycle: 55 °C, 93% r. H., 24 h c) cold, LCT, 2 h d) damp heat, additional 5 cycles: 55 °C/25 °C, 93% r. H., 24 h/cycle. Then the specimen shall be stored at room temperature and normal humidity for 1 to 2 h. Thereafter, the change of V_v shall be measured. Thereafter, insulation resistance R_{ins} shall be measured according to CECC 42 000, test 4.8 at V = 500 V.	$\|\Delta V/V\ (1\ mA)\| \leq 10\%$ $R_{ins} \geq 1\ M\Omega$
Fast temperature cycling	IEC 60068-2-14, test Na, LCT/UCT, dwell time 30 min, 5 cycles	$\|\Delta V/V\ (1\ mA)\| \leq 5\%$ No visible damage
Damp heat, steady state	The specimen shall be subjected to 40 ±2 °C, 90 to 95% r. H. for 56 days without load / with 10% of the maximum continuous DC operating voltage V_{DC}. Then stored at room temperature and normal humidity for 1 to 2 h. Thereafter, the change of V_v shall be measured. Thereafter, insulation resistance R_{ins} shall be measured according to CECC 42 000, test 4.8 at V = 500 V.	$\|\Delta V/V\ (1\ mA)\| \leq 10\%$ $R_{ins} \geq 1\ M\Omega$
Solderability	IEC 60068-2-20, test Ta, method 1 with modified conditions for lead-free solder alloys: 245 °C, 3 s: After dipping the terminals to a depth of approximately 3 mm from the body in a soldering bath of 245 °C for 3 s, the terminals shall be visually examined.	The inspection shall be carried out under adequate light with normal eyesight or with the assistance of a magnifier capable of giving a magnification of 4 to 10 times. The dipped surface shall be covered with a smooth and bright solder coating with no more than small amounts of scattered imperfections such as pinholes or un-wetted or de-wetted areas. These imperfections shall not be concentrated in one area.

Reliability data

Test	Test methods/conditions	Requirement
Resistance to soldering heat	IEC 60068-2-20, test Tb, method 1A, 260 °C, 10 s: Each lead shall be dipped into a solder bath having a temperature of 260 ±5 °C to a point 2.0 to 2.5 mm from the body of the specimen, be held there for 10 ±1 s and then be stored at room temperature and normal humidity for 1 to 2 h. The change of V_v shall be measured and the specimen shall be visually examined.	$\lvert\Delta V/V\ (1\ mA)\rvert \leq 5\%$ No visible damage
Tensile strength	IEC 60068-2-21, test Ua1 After gradually applying the force specified below and keeping the unit fixed for 10 s, the terminal shall be visually examined for any damage. Force for wire diameter: 0.6 mm = 10 N 0.8 mm = 10 N 1.0 mm = 20 N	$\lvert\Delta V/V\ (1\ mA)\rvert \leq 5\%$ No break of solder joint, no wire break
Vibration	IEC 60068-2, test Fc Frequency range: 10 … 55 Hz Amplitude: 0.75 mm or 98 m/s² Duration: 6 h (3 · 2 h) Pulse: sine wave After repeatedly applying a single harmonic vibration according to the table above. The change of V_v shall be measured and the specimen shall be visually examined.	$\lvert\Delta V/V\ (1\ mA)\rvert \leq 5\%$ No visible damage
Bump	IEC 60068-2-29, test Eb Pulse duration: 6 ms Max. acceleration: 400 m/s² Number of bumps: 4000 Pulse: half sine	$\lvert\Delta V/V\ (1\ mA)\rvert \leq 5\%$ No visible damage
Flammability	IEC 60695-2-2 (needle flame test) Severity: vertical 10 s	5 s max.

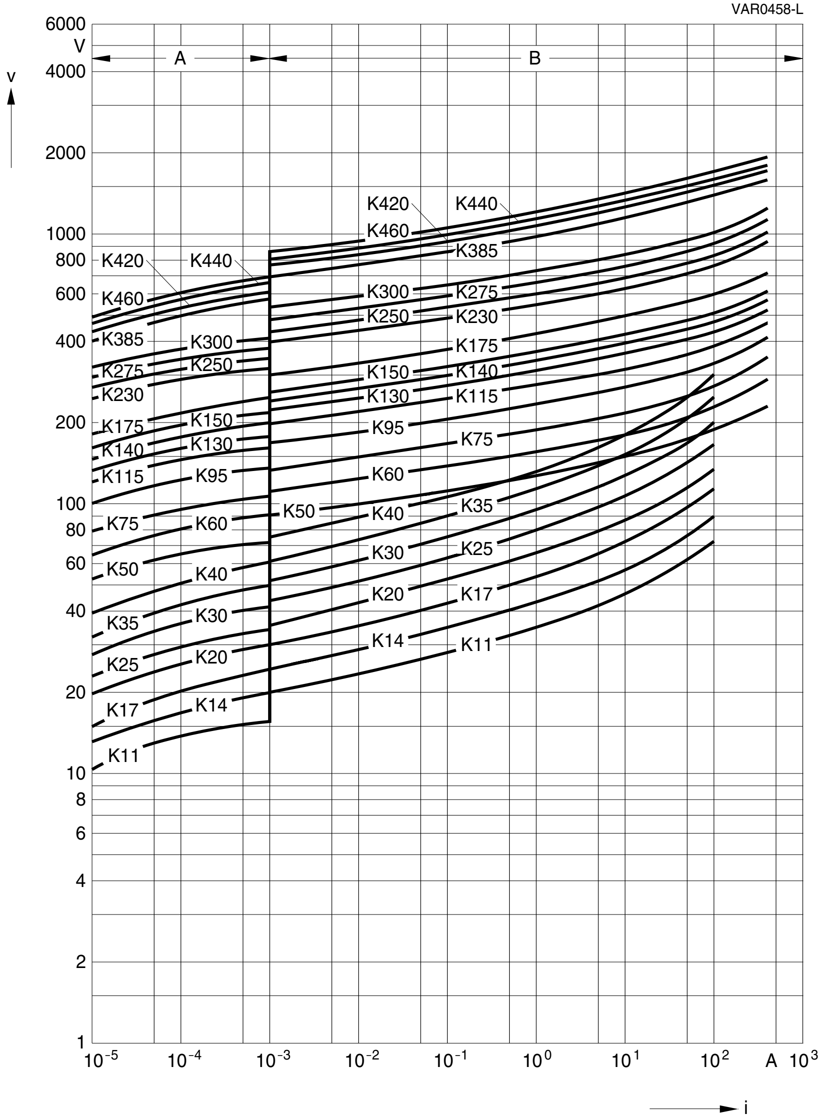
Note:

UCT = Upper category temperature / LCT = Lower category temperature / R_{ins} = Insulation resistance to CECC 42 000, test 4.8

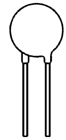
v/i characteristics

v = f (i) – for explanation of the characteristics refer to "General technical information", 1.6.3

A = Leakage current } for worst-case varistor tolerances
B = Protection level } for worst-case varistor tolerances



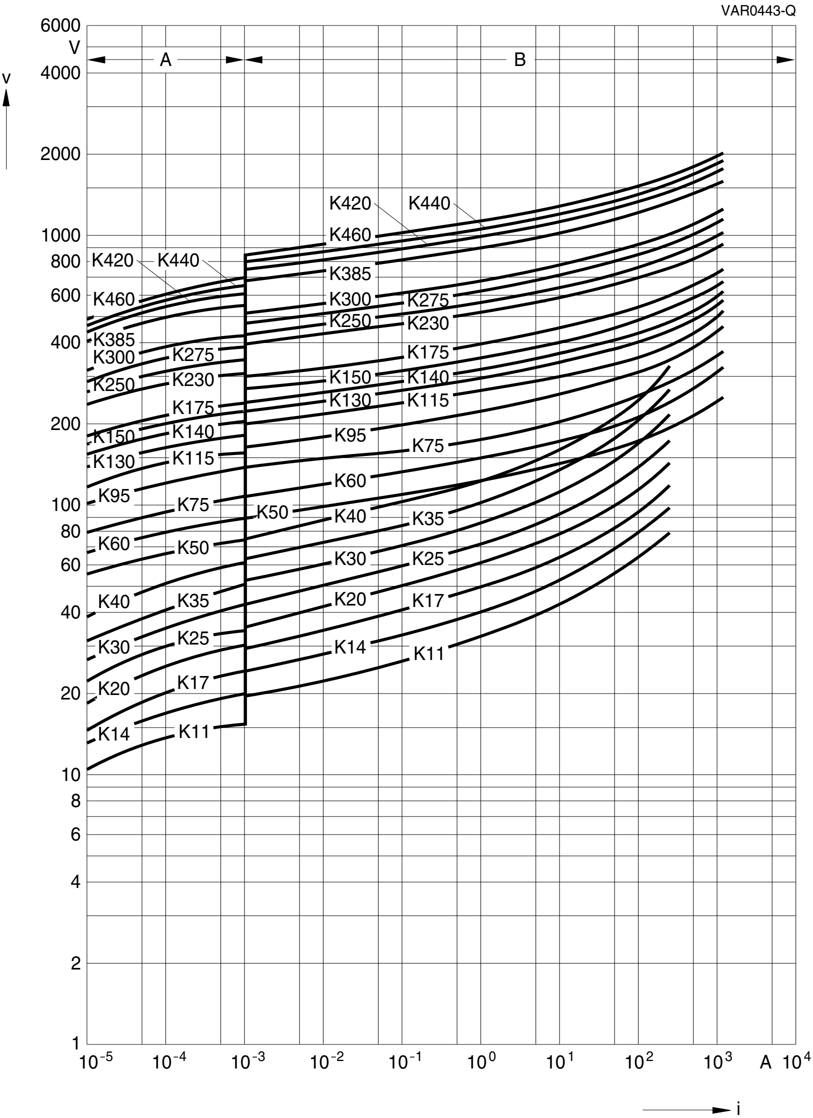
SIOV-S05 …



v/i characteristics

v = f (i) – for explanation of the characteristics refer to "General technical information", 1.6.3

A = Leakage current } for worst-case varistor tolerances
B = Protection level } for worst-case varistor tolerances

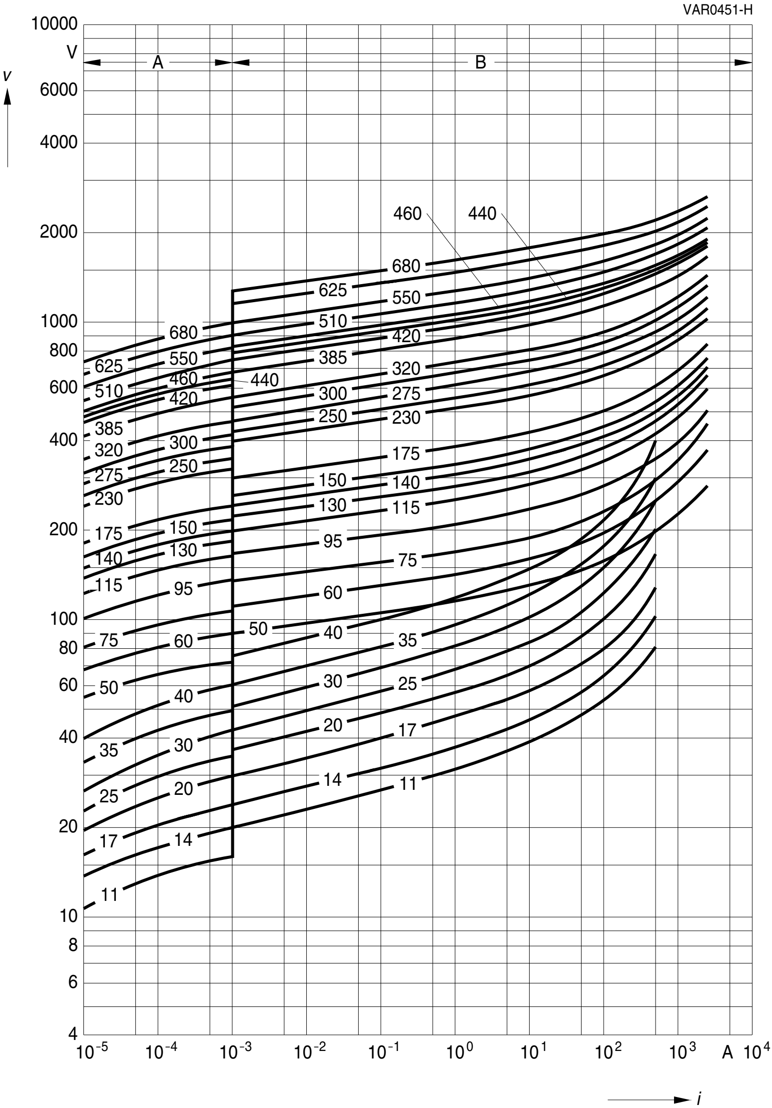


SIOV-S07 …

v/i characteristics

v = f (i) – for explanation of the characteristics refer to "General technical information", 1.6.3

A = Leakage current, B = Protection level: for worst-case varistor tolerances

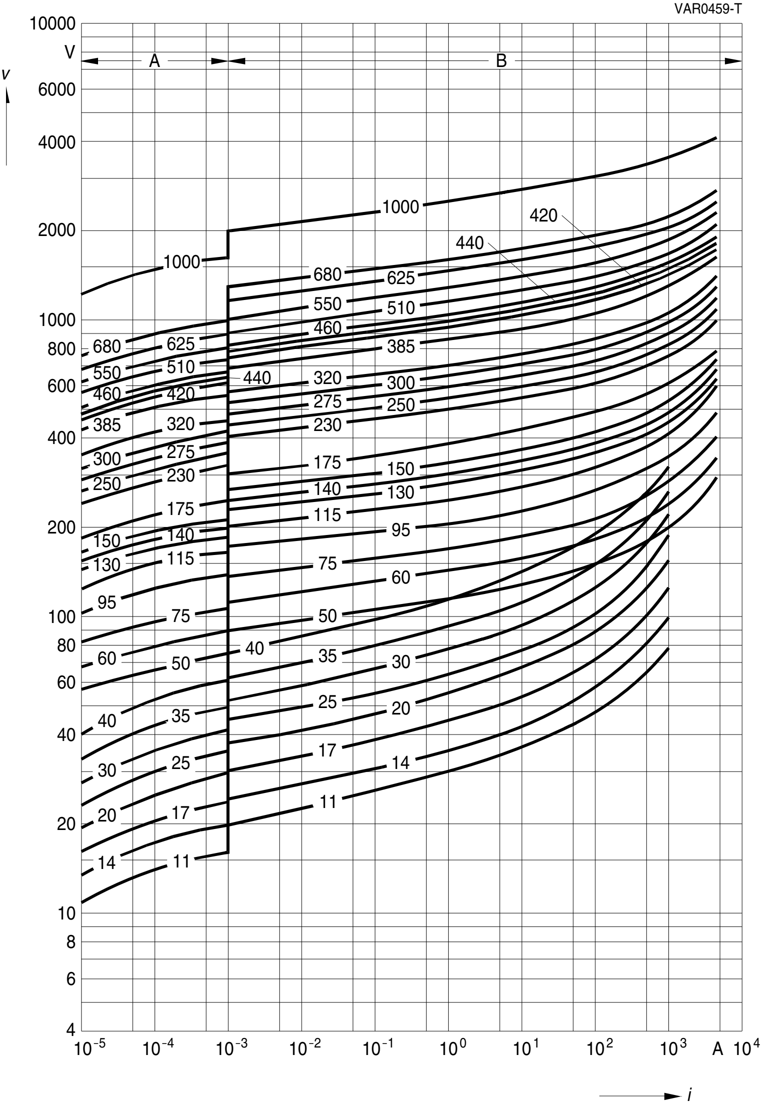


SIOV-S10 …

v/i characteristics

v = f (i) – for explanation of the characteristics refer to "General technical information", 1.6.3

A = Leakage current, B = Protection level (for worst-case varistor tolerances)

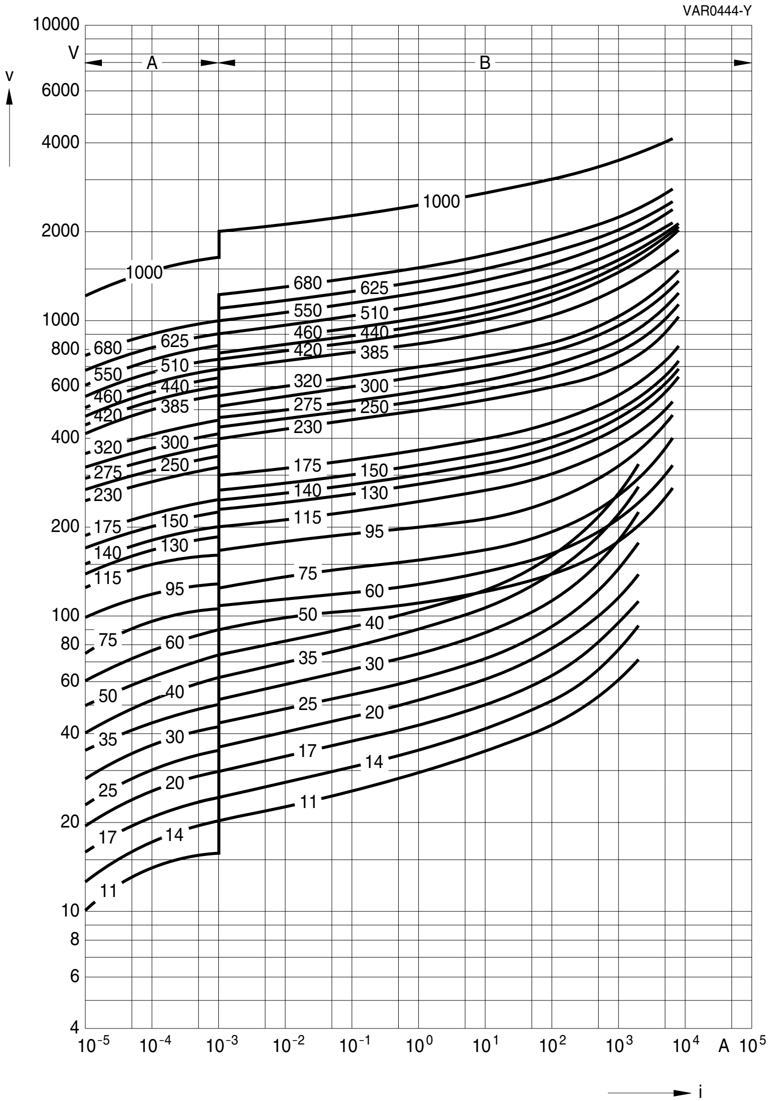


SIOV-S14 …

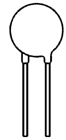
v/i characteristics

v = f (i) – for explanation of the characteristics refer to “General technical information”, 1.6.3

A = Leakage current, B = Protection level (for worst-case varistor tolerances)



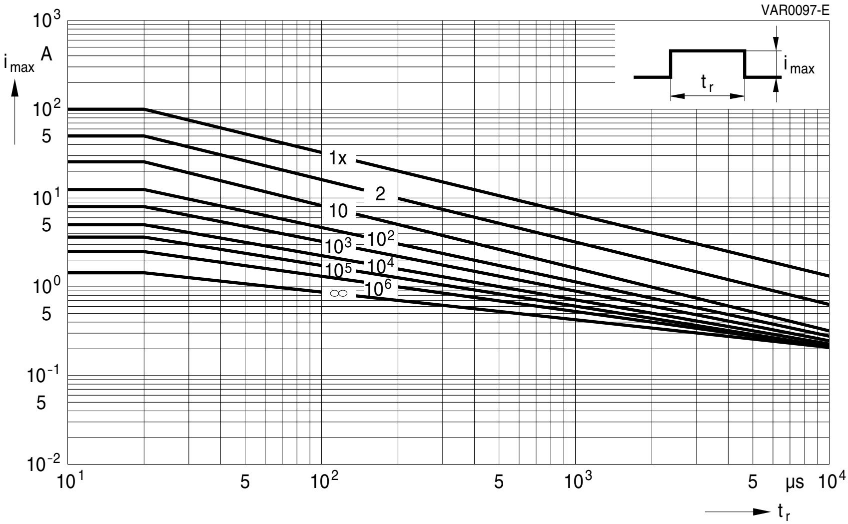
SIOV-S20 …



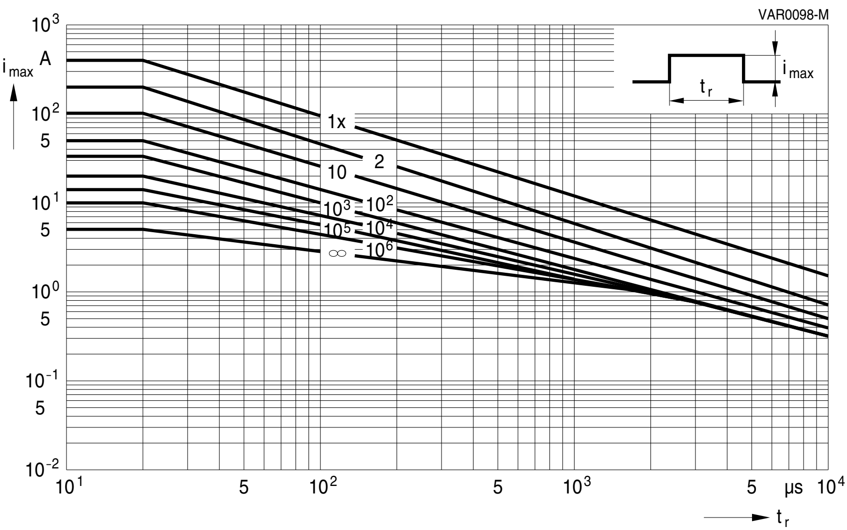
Derating curves

Maximum surge current $i_{max} = f\,(t_r$, pulse train)

For explanation of the derating curves refer to “General technical information”, section 1.8.1



SIOV-S05K11 … K40

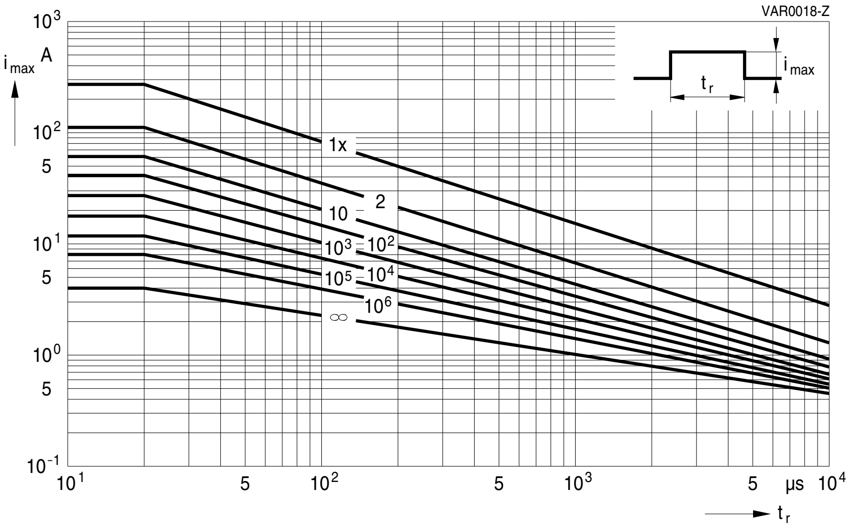


SIOV-S05K50 … K460

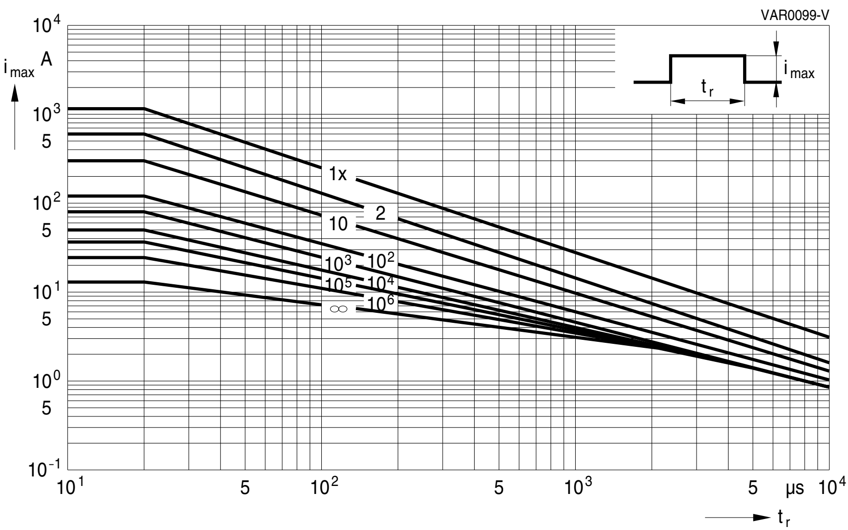
Derating curves

Maximum surge current $i_{max} = f$ (t_r, pulse train)

For explanation of the derating curves refer to “General technical information”, section 1.8.1



SIOV-S07K11 … K40

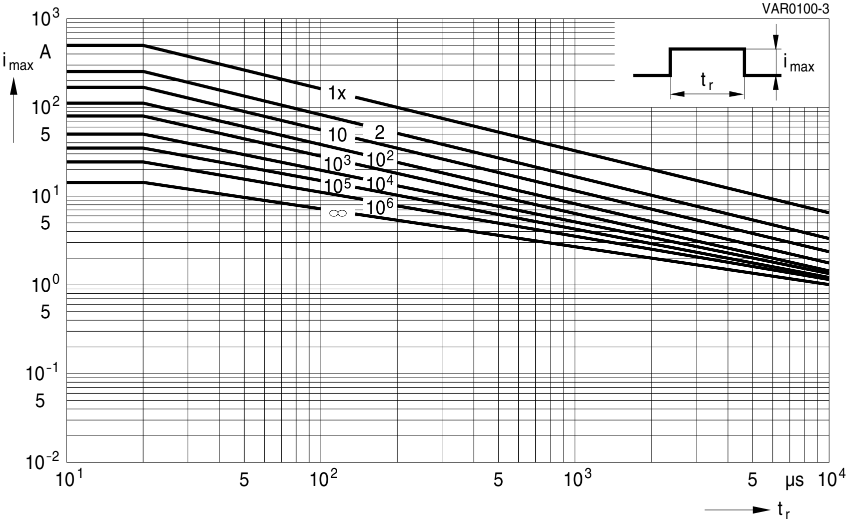


SIOV-S07K50 … K460

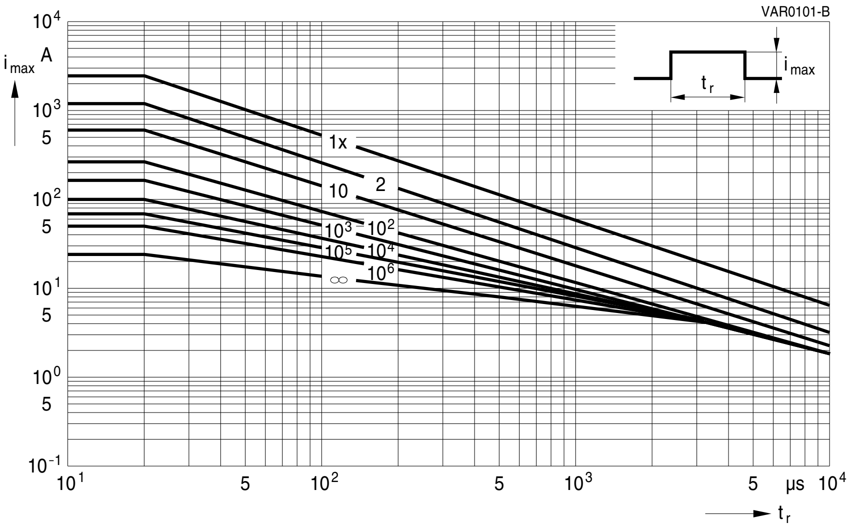
Derating curves

Maximum surge current $i_{max} = f(t_r, \text{pulse train})$

For explanation of the derating curves refer to “General technical information”, section 1.8.1



SIOV-S10K11 … K40

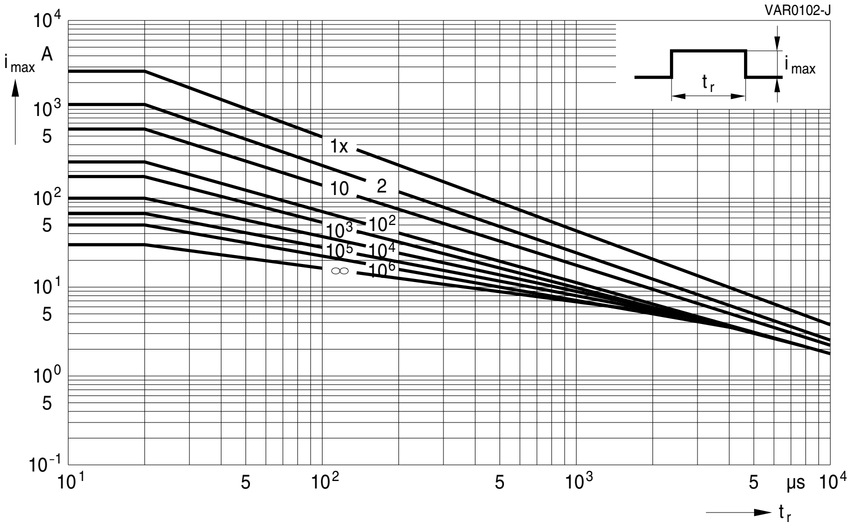


SIOV-S10K50 … K320

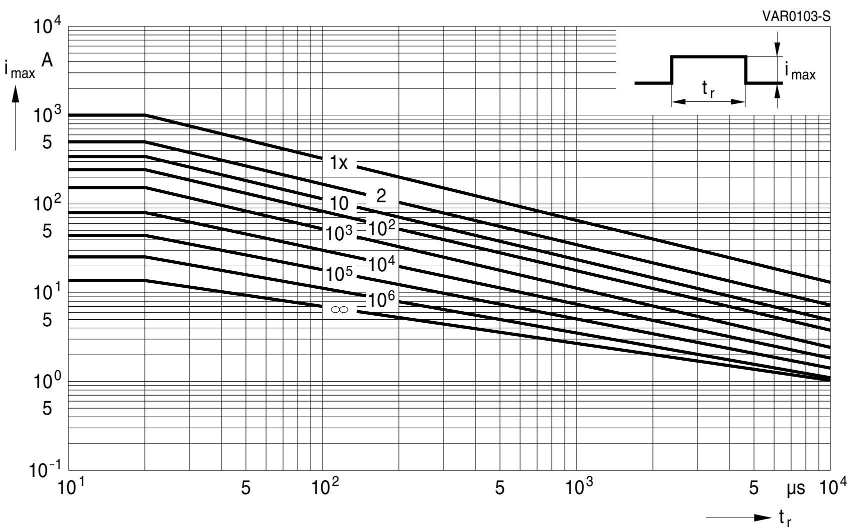
Derating curves

Maximum surge current i_{max} = f (t_r, pulse train)

For explanation of the derating curves refer to “General technical information”, section 1.8.1



SIOV-S10K385 … K680

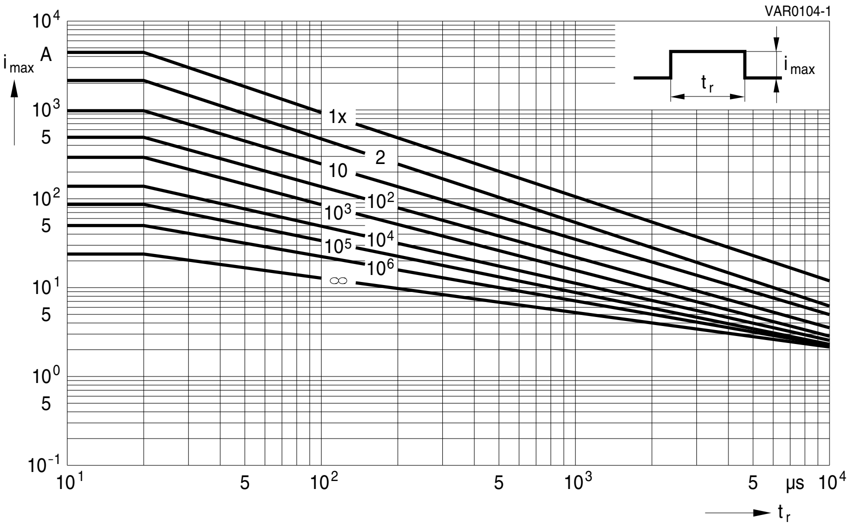


SIOV-S14K11 … K40

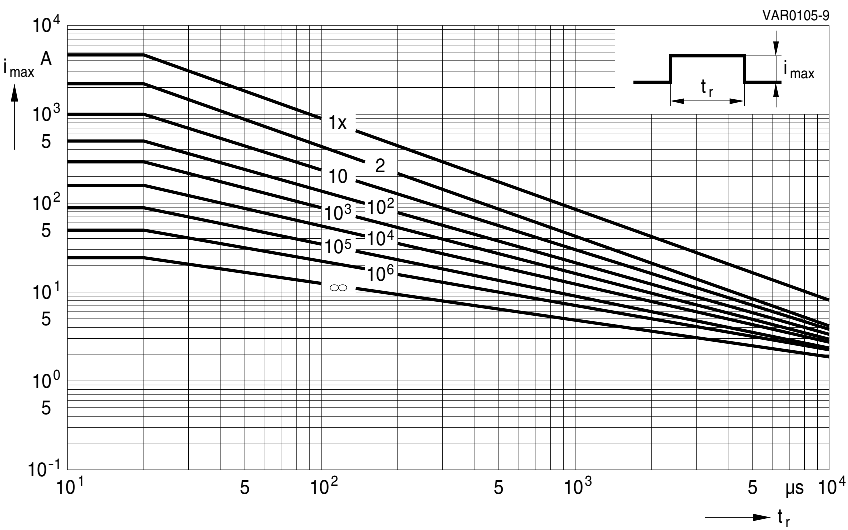
Derating curves

Maximum surge current $i_{max} = f(t_r$, pulse train)

For explanation of the derating curves refer to “General technical information”, section 1.8.1



SIOV-S14K50 … K320

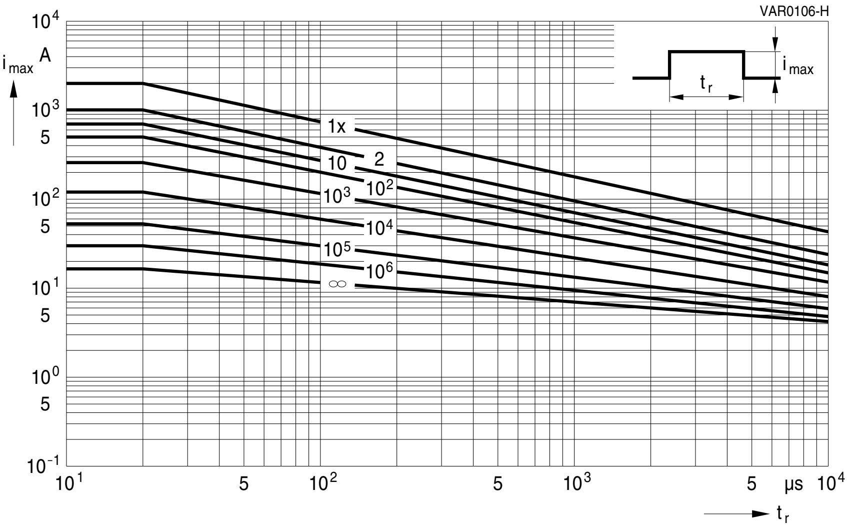


SIOV-S14K385 … K1000

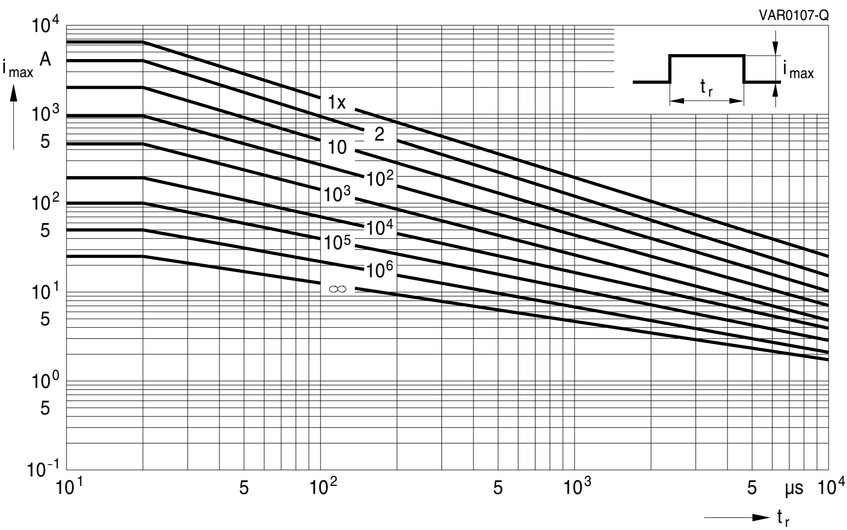
Derating curves

Maximum surge current $i_{max} = f(t_r, \text{pulse train})$

For explanation of the derating curves refer to “General technical information”, section 1.8.1



SIOV-S20K11 … K40

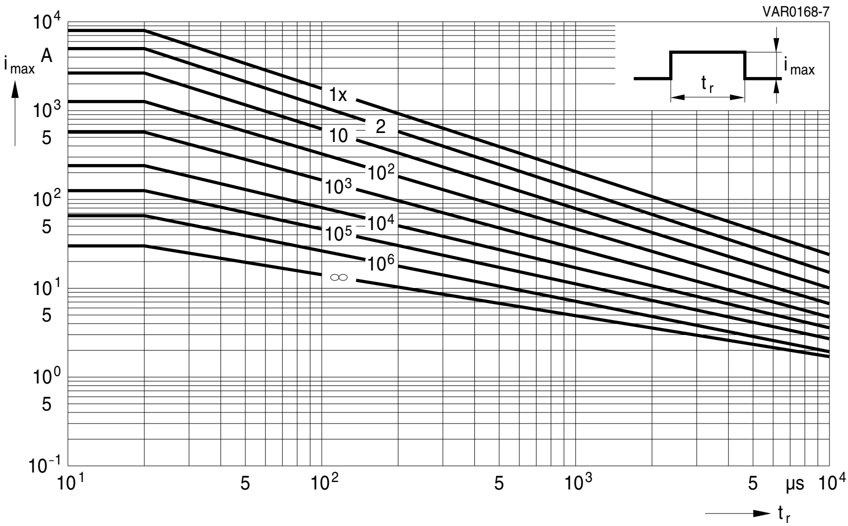


SIOV-S20K50 … K115

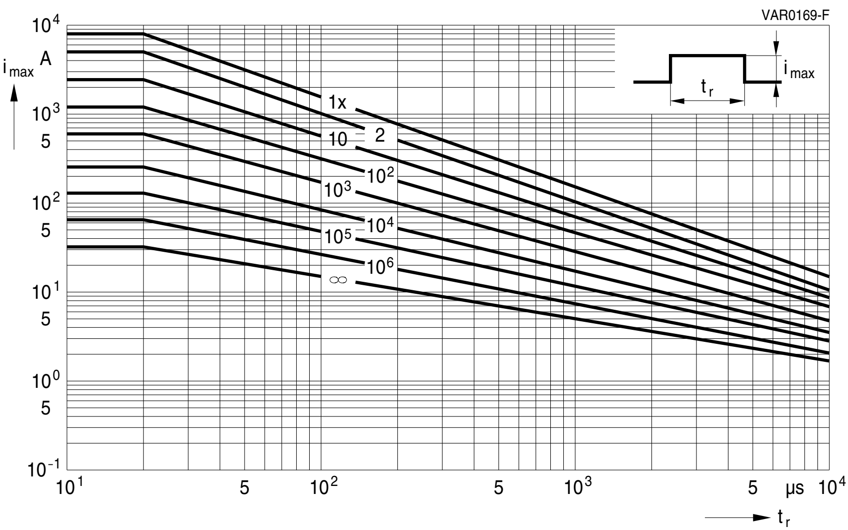
Derating curves

Maximum surge current $i_{max} = f(t_r$, pulse train)

For explanation of the derating curves refer to “General technical information”, section 1.8.1



SIOV-S20K130 … K320

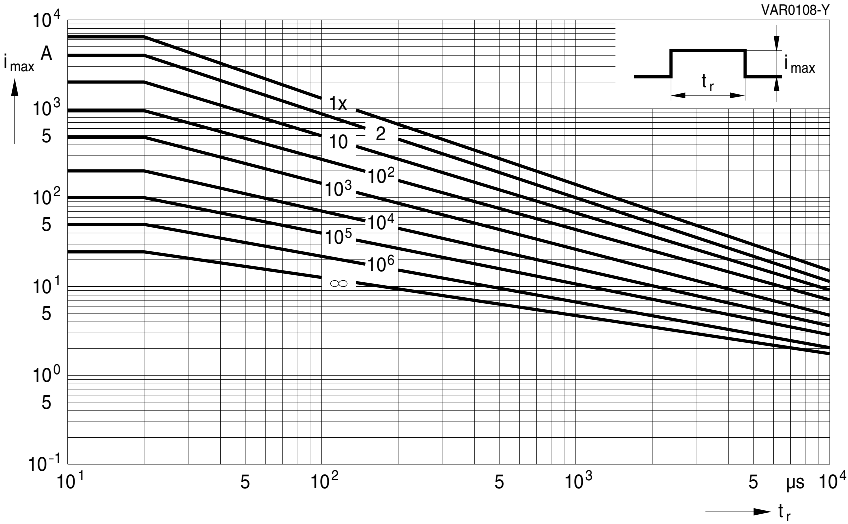


SIOV-S20K385 … K460

Derating curves

Maximum surge current $i_{max} = f$ (t_r, pulse train)

For explanation of the derating curves refer to “General technical information”, section 1.8.1



SIOV-S20K510 … K1000

EPCOS

Construction

- Round varistor element, leaded
- Coating: epoxy resin, flame-retardant to UL 94 V-0
- Terminals: tinned copper wire

Features

- High-energy AdvanceD series E2
- High surge current ratings up to 10 kA
- High energy ratings up to 440 J
- Wide operating voltage range 130 … 680 V_{RMS}
- PSpice models

Approvals

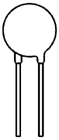
- UL
- CSA
- VDE
- CECC
- CQC S05/07 (K11 … K460), S10/S14 (K11 … K680), S20 (K11 … K1100)
- IEC

Delivery mode

- Bulk (standard), taped versions on reel or in Ammo pack upon request.
- For further details refer to chapter “Taping, packaging and lead configuration” for leaded varistors.

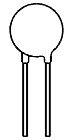
General technical data

Climatic category	to IEC 60068-1	40/85/56	
Operating temperature	to CECC 42 000	– 40 … + 85	°C
Storage temperature		– 40 … +125	°C
Electric strength	to CECC 42 000	≥2.5	kV_{RMS}
Insulation resistance	to CECC 42 000	≥10	MΩ
Response time		<25	ns



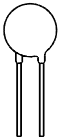
Maximum ratings (T_A = 85 °C)

Ordering code	Type (untaped) SIOV-	V_{RMS} V	V_{DC} V	i_{max} (8/20 µs) A	W_{max} (2 ms) J	P_{max} W
B72205S2131K101	S05K130E2	130	170	800	6.0	0.10
B72207S2131K101	S07K130E2	130	170	1750	12.5	0.25
B72210S2131K101	S10K130E2	130	170	3500	25.0	0.40
B72214S2131K101	S14K130E2	130	170	6000	50.0	0.60
B72220S2131K101	S20K130E2	130	170	10000	100.0	1.00
B72205S2141K101	S05K140E2	140	180	800	6.5	0.10
B72207S2141K101	S07K140E2	140	180	1750	13.5	0.25
B72210S2141K101	S10K140E2	140	180	3500	27.5	0.40
B72214S2141K101	S14K140E2	140	180	6000	55.0	0.60
B72220S2141K101	S20K140E2	140	180	10000	110.0	1.00
B72205S2151K101	S05K150E2	150	200	800	7.5	0.10
B72207S2151K101	S07K150E2	150	200	1750	15.0	0.25
B72210S2151K101	S10K150E2	150	200	3500	30.0	0.40
B72214S2151K101	S14K150E2	150	200	6000	60.0	0.60
B72220S2151K101	S20K150E2	150	200	10000	120.0	1.00
B72205S2171K101	S05K175E2	175	225	800	8.0	0.10
B72207S2171K101	S07K175E2	175	225	1750	17.0	0.25
B72210S2171K101	S10K175E2	175	225	3500	35.0	0.40
B72214S2171K101	S14K175E2	175	225	6000	70.0	0.60
B72220S2171K101	S20K175E2	175	225	10000	135.0	1.00
B72205S2211K101	S05K210E2	210	270	800	9.5	0.10
B72207S2211K101	S07K210E2	210	270	1750	20.0	0.25
B72210S2211K101	S10K210E2	210	270	3500	42.0	0.40
B72214S2211K101	S14K210E2	210	270	6000	80.0	0.60
B72220S2211K101	S20K210E2	210	270	10000	160.0	1.00



Characteristics (T_A = 25 °C)

Ordering code	V_v (1 mA) V	ΔV_v (1 mA) %	$v_{c,\,max}$ (i_c) V	i_c A	C_{typ} (1 kHz) pF
B72205S2131K101	205	±10	340	5.0	100
B72207S2131K101	205	±10	340	10.0	200
B72210S2131K101	205	±10	340	25.0	400
B72214S2131K101	205	±10	340	50.0	650
B72220S2131K101	205	±10	340	100.0	1340
B72205S2141K101	220	±10	360	5.0	95
B72207S2141K101	220	±10	360	10.0	180
B72210S2141K101	220	±10	360	25.0	370
B72214S2141K101	220	±10	360	50.0	610
B72220S2141K101	220	±10	360	100.0	1240
B72205S2151K101	240	±10	395	5.0	90
B72207S2151K101	240	±10	395	10.0	170
B72210S2151K101	240	±10	395	25.0	350
B72214S2151K101	240	±10	395	50.0	570
B72220S2151K101	240	±10	395	100.0	1160
B72205S2171K101	270	±10	455	5.0	75
B72207S2171K101	270	±10	455	10.0	150
B72210S2171K101	270	±10	455	25.0	300
B72214S2171K101	270	±10	455	50.0	490
B72220S2171K101	270	±10	455	100.0	1000
B72205S2211K101	330	±10	545	5.0	65
B72207S2211K101	330	±10	545	10.0	125
B72210S2211K101	330	±10	545	25.0	250
B72214S2211K101	330	±10	545	50.0	410
B72220S2211K101	330	±10	545	100.0	835

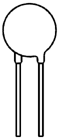


Maximum ratings (T_A = 85 °C)

Ordering code	Type (untaped) SIOV-	V_{RMS} V	V_{DC} V	i_{max} (8/20 µs) A	W_{max} (2 ms) J	P_{max} W
B72205S2231K101	S05K230E2	230	300	800	11.0	0.10
B72207S2231K101	S07K230E2	230	300	1750	23.0	0.25
B72210S2231K101	S10K230E2	230	300	3500	45.0	0.40
B72214S2231K101	S14K230E2	230	300	6000	90.0	0.60
B72220S2231K101	S20K230E2	230	300	10000	180.0	1.00
B72205S2251K101	S05K250E2	250	320	800	12.0	0.10
B72207S2251K101	S07K250E2	250	320	1750	25.0	0.25
B72210S2251K101	S10K250E2	250	320	3500	50.0	0.40
B72214S2251K101	S14K250E2	250	320	6000	100.0	0.60
B72220S2251K101	S20K250E2	250	320	10000	195.0	1.00
B72205S2271K101	S05K275E2	275	350	800	13.5	0.10
B72207S2271K101	S07K275E2	275	350	1750	27.5	0.25
B72210S2271K101	S10K275E2	275	350	3500	55.0	0.40
B72214S2271K101	S14K275E2	275	350	6000	110.0	0.60
B72220S2271K101	S20K275E2	275	350	10000	215.0	1.00
B72205S2301K101	S05K300E2	300	385	800	15.0	0.10
B72207S2301K101	S07K300E2	300	385	1750	30.0	0.25
B72210S2301K101	S10K300E2	300	385	3500	60.0	0.40
B72214S2301K101	S14K300E2	300	385	6000	125.0	0.60
B72220S2301K101	S20K300E2	300	385	10000	250.0	1.00
B72207S2321K101	S07K320E2	320	420	1750	32.0	0.25
B72210S2321K101	S10K320E2	320	420	3500	67.0	0.40
B72214S2321K101	S14K320E2	320	420	6000	136.0	0.60
B72220S2321K101	S20K320E2	320	420	10000	273.0	1.00

Characteristics (T_A = 25 °C)

Ordering code	V_v (1 mA) V	ΔV_v (1 mA) %	$v_{c,\,max}$ (i_c) V	i_c A	C_{typ} (1 kHz) pF
B72205S2231K101	360	±10	595	5.0	60
B72207S2231K101	360	±10	595	10.0	115
B72210S2231K101	360	±10	595	25.0	230
B72214S2231K101	360	±10	595	50.0	380
B72220S2231K101	360	±10	595	100.0	760
B72205S2251K101	390	±10	650	5.0	55
B72207S2251K101	390	±10	650	10.0	105
B72210S2251K101	390	±10	650	25.0	215
B72214S2251K101	390	±10	650	50.0	350
B72220S2251K101	390	±10	650	100.0	700
B72205S2271K101	430	±10	710	5.0	50
B72207S2271K101	430	±10	710	10.0	95
B72210S2271K101	430	±10	710	25.0	195
B72214S2271K101	430	±10	710	50.0	320
B72220S2271K101	430	±10	710	100.0	630
B72205S2301K101	470	±10	775	5.0	45
B72207S2301K101	470	±10	775	10.0	90
B72210S2301K101	470	±10	775	25.0	180
B72214S2301K101	470	±10	775	50.0	300
B72220S2301K101	470	±10	775	100.0	580
B72207S2321K101	510	±10	840	10.0	85
B72210S2321K101	510	±10	840	25.0	170
B72214S2321K101	510	±10	840	50.0	280
B72220S2321K101	510	±10	840	100.0	540

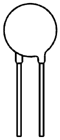


Maximum ratings (T_A = 85 °C)

Ordering code	Type (untaped) SIOV-	V_{RMS} V	V_{DC} V	i_{max} (8/20 µs) A	W_{max} (2 ms) J	P_{max} W
B72210S2381K101	S10K385E2	385	505	3500	67.0	0.40
B72214S2381K101	S14K385E2	385	505	5000	136.0	0.60
B72220S2381K101	S20K385E2	385	505	10000	273.0	1.00
B72210S2421K101	S10K420E2	420	560	3500	67.0	0.40
B72214S2421K101	S14K420E2	420	560	5000	136.0	0.60
B72220S2421K101	S20K420E2	420	560	10000	273.0	1.00
B72210S2461K101	S10K460E2	460	615	3500	70.0	0.40
B72214S2461K101	S14K460E2	460	615	5000	150.0	0.60
B72220S2461K101	S20K460E2	460	615	10000	300.0	1.00
B72210S2511K101	S10K510E2	510	670	3500	80.0	0.40
B72214S2511K101	S14K510E2	510	670	5000	165.0	0.60
B72220S2511K101	S20K510E2	510	670	10000	325.0	1.00
B72210S2551K101	S10K550E2	550	745	3500	90.0	0.40
B72214S2551K101	S14K550E2	550	745	5000	180.0	0.60
B72220S2551K101	S20K550E2	550	745	10000	360.0	1.00
B72210S2621K101	S10K625E2	625	825	3500	100.0	0.40
B72214S2621K101	S14K625E2	625	825	5000	200.0	0.60
B72220S2621K101	S20K625E2	625	825	10000	400.0	1.00
B72210S2681K101	S10K680E2	680	895	3500	110.0	0.40
B72214S2681K101	S14K680E2	680	895	5000	220.0	0.60
B72220S2681K101	S20K680E2	680	895	10000	440.0	1.00

Characteristics (T_A = 25 °C)

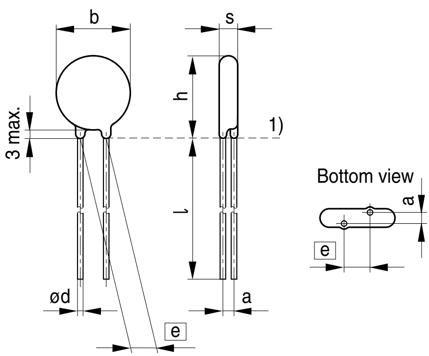
Ordering code	V_v (1 mA) V	ΔV_v (1 mA) %	$v_{c,\,max}$ (i_c) V	i_c A	C_{typ} (1 kHz) pF
B72210S2381K101	620	±10	1025	25.0	150
B72214S2381K101	620	±10	1025	50.0	240
B72220S2381K101	620	±10	1025	100.0	450
B72210S2421K101	680	±10	1120	25.0	135
B72214S2421K101	680	±10	1120	50.0	220
B72220S2421K101	680	±10	1120	100.0	420
B72210S2461K101	750	±10	1240	25.0	120
B72214S2461K101	750	±10	1240	50.0	200
B72220S2461K101	750	±10	1240	100.0	380
B72210S2511K101	820	±10	1355	25.0	110
B72214S2511K101	820	±10	1355	50.0	180
B72220S2511K101	820	±10	1355	100.0	340
B72210S2551K101	910	±10	1500	25.0	105
B72214S2551K101	910	±10	1500	50.0	170
B72220S2551K101	910	±10	1500	100.0	320
B72210S2621K101	1000	±10	1650	25.0	90
B72214S2621K101	1000	±10	1650	50.0	150
B72220S2621K101	1000	±10	1650	100.0	280
B72210S2681K101	1100	±10	1815	25.0	85
B72214S2681K101	1100	±10	1815	50.0	140
B72220S2681K101	1100	±10	1815	100.0	250



Leaded varistors

AdvanceD series

Dimensional drawing



1) Seating plane to IEC 60717

VAR0408-C

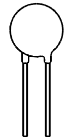
Weight

Nominal diameter mm	V_{RMS} V	Weight g
5	130 … 300	0.4 … 0.5
7	130 … 320	0.6 … 0.8
10	130 … 680	1.2 … 2.8
14	130 … 680	1.8 … 4.8
20	130 … 680	3.3 … 9.6

The weight of varistors in between these voltage classes can be interpolated.

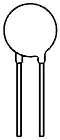
Dimensions

Ordering code	e ±1 mm	a ±1 mm	b_{max} mm	s_{max} mm	h_{max} mm	l_{min} mm	d ±0.05 mm
B72205S2131K101	5.0	1.6	7.0	3.9	8.5	25.0	0.6
B72207S2131K101	5.0	1.6	9.0	3.9	11.0	25.0	0.6
B72210S2131K101	7.5	1.8	12.0	4.5	14.5	25.0	0.8
B72214S2131K101	7.5	1.9	15.5	4.6	18.5	25.0	0.8
B72220S2131K101	10.0	2.0	21.5	5.0	25.5	25.0	1.0
B72205S2141K101	5.0	1.7	7.0	4.0	8.5	25.0	0.6
B72207S2141K101	5.0	1.7	9.0	4.0	11.0	25.0	0.6
B72210S2141K101	7.5	1.9	12.0	4.6	14.5	25.0	0.8
B72214S2141K101	7.5	2.0	15.5	4.7	18.5	25.0	0.8
B72220S2141K101	10.0	2.1	21.5	5.1	25.5	25.0	1.0
B72205S2151K101	5.0	1.8	7.0	4.1	8.5	25.0	0.6
B72207S2151K101	5.0	1.8	9.0	4.1	11.0	25.0	0.6
B72210S2151K101	7.5	2.0	12.0	4.7	14.5	25.0	0.8
B72214S2151K101	7.5	2.1	15.5	4.8	18.5	25.0	0.8
B72220S2151K101	10.0	2.2	21.5	5.2	25.5	25.0	1.0
B72205S2171K101	5.0	2.0	7.0	4.3	8.5	25.0	0.6
B72207S2171K101	5.0	2.0	9.0	4.3	11.0	25.0	0.6
B72210S2171K101	7.5	2.2	12.0	4.9	14.5	25.0	0.8
B72214S2171K101	7.5	2.2	15.5	4.9	18.5	25.0	0.8
B72220S2171K101	10.0	2.3	21.5	5.3	25.5	25.0	1.0



Dimensions

Ordering code	e ±1 mm	a ±1 mm	b_{max} mm	s_{max} mm	h_{max} mm	l_{min} mm	d ±0.05 mm
B72205S2211K101	5.0	1.7	7.0	4.2	8.5	25.0	0.6
B72207S2211K101	5.0	1.7	9.0	4.2	11.0	25.0	0.6
B72210S2211K101	7.5	1.9	12.0	5.0	14.5	25.0	0.8
B72214S2211K101	7.5	1.9	15.5	5.0	18.5	25.0	0.8
B72220S2211K101	10.0	2.2	21.5	5.4	25.5	25.0	1.0
B72205S2231K101	5.0	1.8	7.0	4.4	8.5	25.0	0.6
B72207S2231K101	5.0	1.8	9.0	4.4	11.0	25.0	0.6
B72210S2231K101	7.5	2.0	12.0	5.0	14.5	25.0	0.8
B72214S2231K101	7.5	2.0	15.5	5.1	18.5	25.0	0.8
B72220S2231K101	10.0	2.3	21.5	5.5	25.5	25.0	1.0
B72205S2251K101	5.0	1.9	7.0	4.5	8.5	25.0	0.6
B72207S2251K101	5.0	1.9	9.0	4.5	11.0	25.0	0.6
B72210S2251K101	7.5	2.1	12.0	5.2	14.5	25.0	0.8
B72214S2251K101	7.5	2.1	15.5	5.2	18.5	25.0	0.8
B72220S2251K101	10.0	2.4	21.5	5.7	25.5	25.0	1.0
B72205S2271K101	5.0	2.0	7.0	4.6	8.5	25.0	0.6
B72207S2271K101	5.0	2.0	9.0	4.6	11.0	25.0	0.6
B72210S2271K101	7.5	2.2	12.0	5.4	14.5	25.0	0.8
B72214S2271K101	7.5	2.2	15.5	5.4	18.5	25.0	0.8
B72220S2271K101	10.0	2.6	21.5	5.8	25.5	25.0	1.0
B72205S2301K101	5.0	2.1	7.0	4.7	8.5	25.0	0.6
B72207S2301K101	5.0	2.1	9.0	4.7	11.0	25.0	0.6
B72210S2301K101	7.5	2.3	12.0	5.6	14.5	25.0	0.8
B72214S2301K101	7.5	2.3	15.5	5.6	18.5	25.0	0.8
B72220S2301K101	10.0	2.8	21.5	6.1	25.5	25.0	1.0
B72207S2321K101	5.0	2.3	9.0	4.6	11.0	25.0	0.6
B72210S2321K101	7.5	2.4	12.0	5.8	15.0	25.0	0.8
B72214S2321K101	7.5	2.4	15.5	5.8	19.0	25.0	0.8
B72220S2321K101	10.0	2.9	21.5	6.2	25.5	25.0	1.0
B72210S2381K101	7.5	3.3	12.0	7.1	15.0	25.0	0.8
B72214S2381K101	7.5	3.4	15.5	7.1	19.0	25.0	0.8
B72220S2381K101	10.0	3.9	21.5	7.6	26.0	25.0	1.0
B72210S2421K101	7.5	3.5	12.0	7.4	15.0	25.0	0.8
B72214S2421K101	7.5	3.6	15.5	7.5	19.0	25.0	0.8
B72220S2421K101	10.0	4.2	21.5	7.9	26.0	25.0	1.0



Dimensions

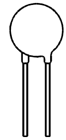
Ordering code	e ±1 mm	a ±1 mm	b_{max} mm	s_{max} mm	h_{max} mm	l_{min} mm	d ±0.05 mm
B72210S2461K101	7.5	3.7	12.0	7.7	15.0	25.0	0.8
B72214S2461K101	7.5	3.8	15.5	7.8	19.0	25.0	0.8
B72220S2461K101	10.0	4.5	21.5	8.2	26.0	25.0	1.0
B72210S2511K101	7.5	4.0	12.0	8.0	15.0	25.0	0.8
B72214S2511K101	7.5	4.0	15.5	8.1	19.0	25.0	0.8
B72220S2511K101	10.0	4.6	21.5	8.6	26.0	25.0	1.0
B72210S2551K101	7.5	4.3	12.0	8.4	15.0	25.0	0.8
B72214S2551K101	7.5	4.7	15.5	8.5	19.0	25.0	0.8
B72220S2551K101	10.0	4.8	21.5	9.0	26.0	25.0	1.0
B72210S2621K101	7.5	5.0	12.0	8.8	15.0	25.0	0.8
B72214S2621K101	7.5	5.1	15.5	8.9	19.0	25.0	0.8
B72220S2621K101	10.0	5.4	21.5	9.4	26.0	25.0	1.0
B72210S2681K101	7.5	5.4	12.0	9.2	15.0	25.0	0.8
B72214S2681K101	7.5	5.5	15.5	9.3	19.0	25.0	0.8
B72220S2681K101	10.0	5.8	21.5	9.8	26.0	25.0	1.0

Reliability data

Test	Test methods/conditions	Requirement
Varistor voltage	The voltage between two terminals with the specified measuring current applied is called V_v (1 mA_{DC} @ 0.2 … 2 s).	To meet the specified value.
Clamping voltage	The maximum voltage between two terminals with the specified standard impulse current (8/20 µs) applied.	To meet the specified value.
Max. AC operating voltage	CECC 42 000, test 4.20 1000 h at UCT After having continuously applied the maximum allowable voltage at UCT ±2 °C for 1000 h, the specimen shall be stored at room temperature and normal humidity for 1 to 2 h. Thereafter, the change of V_v shall be measured.	$\|\Delta V/V$ (1 mA)$\| \leq 10\%$
Surge current derating, 8/20 µs	CECC 42 000, test C 2.1 100 surge currents (8/20 µs), unipolar, interval 30 s, amplitude corresponding to derating curve for 100 impulses at 20 µs	$\|\Delta V/V$ (1 mA)$\| \leq 10\%$ (measured in direction of surge current) No visible damage
Surge current derating, 2 ms	CECC 42 000, test C 2.1 100 surge currents (2 ms), unipolar, interval 120 s, amplitude corresponding to derating curve for 100 impulses at 2 ms	$\|\Delta V/V$ (1 mA)$\| \leq 10\%$ (measured in direction of surge current) No visible damage
Electric strength	CECC 42 000, test 4.7 Metal balls method, 2500 V_{RMS}, 60 s The varistor is placed in a container holding 1.6 ±0.2 mm diameter metal balls such that only the terminations of the varistor are protruding. The specified voltage shall be applied between both terminals of the specimen connected together and the electrode inserted between the metal balls.	No breakdown

Reliability data

Test	Test methods/conditions	Requirement
Climatic sequence	CECC 42 000, test 4.16 The specimen shall be subjected to: a) dry heat at UCT, 16 h b) damp heat, 1st cycle: 55 °C, 93% r. H., 24 h c) cold, LCT, 2 h d) damp heat, additional 5 cycles: 55 °C/25 °C, 93% r. H., 24 h/cycle. Then the specimen shall be stored at room temperature and normal humidity for 1 to 2 h. Thereafter, the change of V_v shall be measured. Thereafter, insulation resistance R_{ins} shall be measured according to CECC 42 000, test 4.8 at V = 500 V.	$\lvert\Delta V/V\ (1\ mA)\rvert \leq 10\%$ $R_{ins} \geq 1\ M\Omega$
Fast temperature cycling	IEC 60068-2-14, test Na, LCT/UCT, dwell time 30 min, 5 cycles	$\lvert\Delta V/V\ (1\ mA)\rvert \leq 5\%$ No visible damage
Damp heat, steady state	The specimen shall be subjected to 40 ±2 °C, 90 to 95% r. H. for 56 days without load / with 10% of the maximum continuous DC operating voltage V_{DC}. Then stored at room temperature and normal humidity for 1 to 2 h. Thereafter, the change of V_v shall be measured. Thereafter, insulation resistance R_{ins} shall be measured according to CECC 42 000, test 4.8 at V = 500 V.	$\lvert\Delta V/V\ (1\ mA)\rvert \leq 10\%$ $R_{ins} \geq 1\ M\Omega$
Solderability	IEC 60068-2-20, test Ta, method 1 with modified conditions for lead-free solder alloys: 245 °C, 3 s: After dipping the terminals to a depth of approximately 3 mm from the body in a soldering bath of 245 °C for 3 s, the terminals shall be visually examined.	The inspection shall be carried out under adequate light with normal eyesight or with the assistance of a magnifier capable of giving a magnification of 4 to 10 times. The dipped surface shall be covered with a smooth and bright solder coating with no more than small amounts of scattered imperfections such as pinholes or un-wetted or de-wetted areas. These imperfections shall not be concentrated in one area.



Reliability data

Test	Test methods/conditions	Requirement
Resistance to soldering heat	IEC 60068-2-20, test Tb, method 1A, 260 °C, 10 s: Each lead shall be dipped into a solder bath having a temperature of 260 ±5 °C to a point 2.0 to 2.5 mm from the body of the specimen, be held there for 10 ±1 s and then be stored at room temperature and normal humidity for 1 to 2 h. The change of V_v shall be measured and the specimen shall be visually examined.	|ΔV/V (1 mA)| ≤5% No visible damage
Tensile strength	IEC 60068-2-21, test Ua1 After gradually applying the force specified below and keeping the unit fixed for 10 s, the terminal shall be visually examined for any damage. Force for wire diameter: 0.6 mm = 10 N 0.8 mm = 10 N 1.0 mm = 20 N	|ΔV/V (1 mA)| ≤5% No break of solder joint, no wire break
Vibration	IEC 60068-2, test Fc Frequency range: 10 … 55 Hz Amplitude: 0.75 mm or 98 m/s² Duration: 6 h (3 · 2 h) Pulse: sine wave After repeatedly applying a single harmonic vibration according to the table above. The change of V_v shall be measured and the specimen shall be visually examined.	|ΔV/V (1 mA)| ≤5% No visible damage
Bump	IEC 60068-2-29, test Eb Pulse duration: 6 ms Max. acceleration: 400 m/s² Number of bumps: 4000 Pulse: half sine	|ΔV/V (1 mA)| ≤5% No visible damage
Flammability	IEC 60695-2-2 (needle flame test) Severity: vertical 10 s	5 s max.

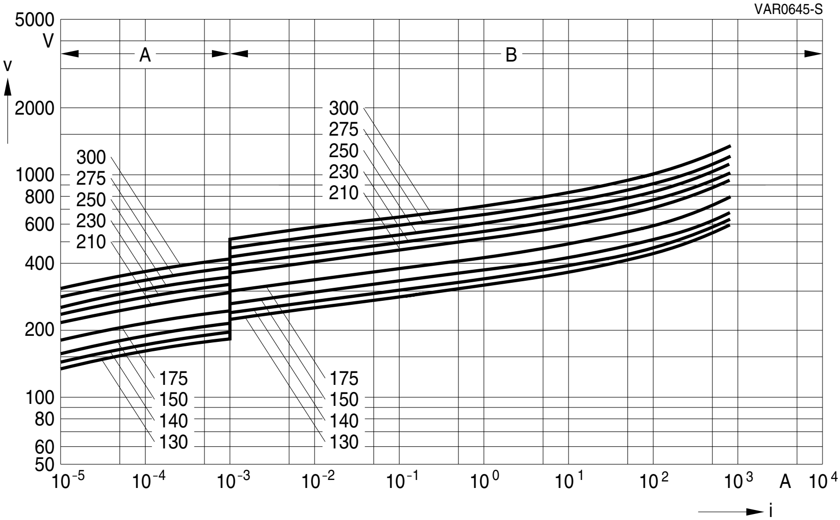
Note:

UCT = Upper category temperature / LCT = Lower category temperature / R_{ins} = Insulation resistance to CECC 42 000, test 4.8

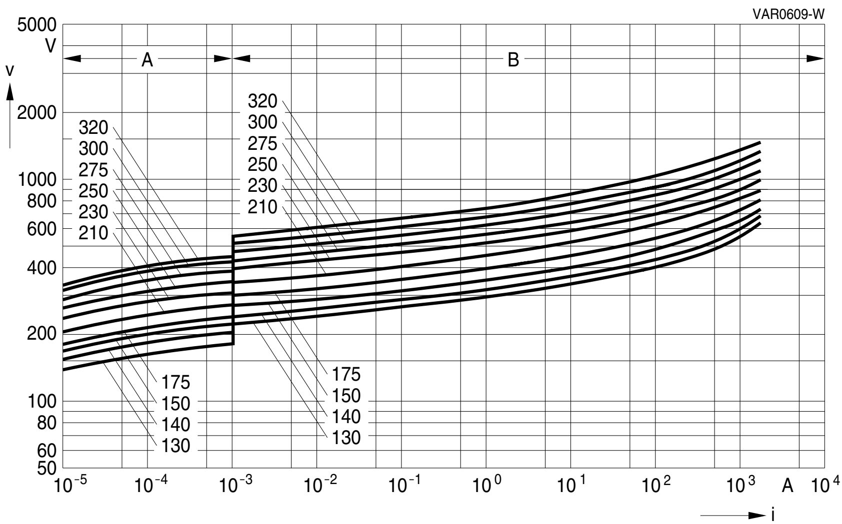
v/i characteristics

v = f (i) – for explanation of the characteristics refer to “General technical information”, 1.6.3

A = Leakage current, B = Protection level: for worst-case varistor tolerances



SIOV-S05 … E2

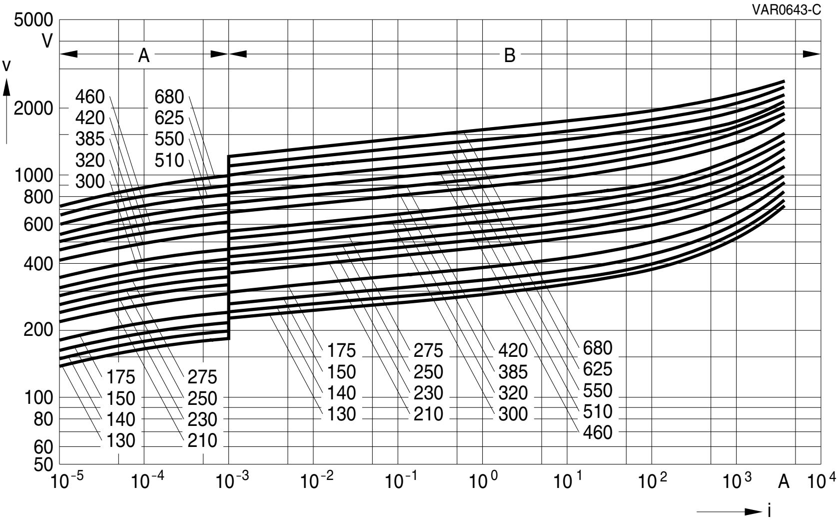


SIOV-S07 … E2

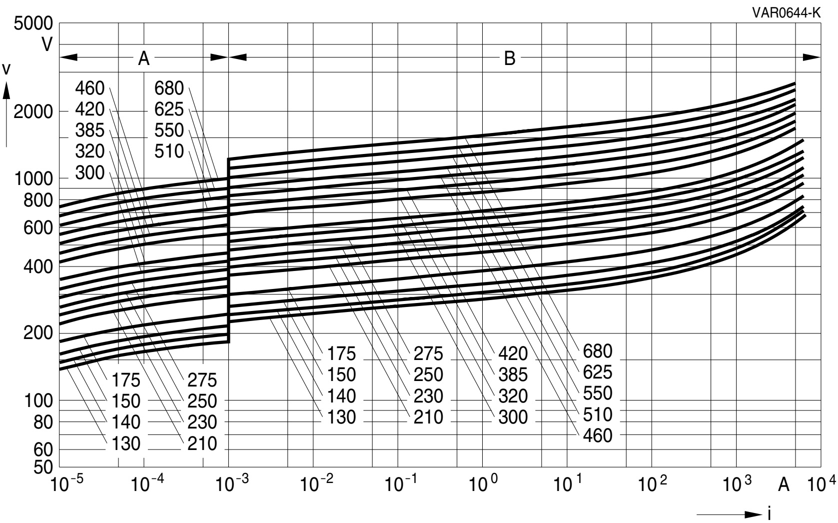
v/i characteristics

v = f (i) – for explanation of the characteristics refer to "General technical information", 1.6.3

A = Leakage current } for worst-case varistor tolerances
B = Protection level



SIOV-S10 … E2

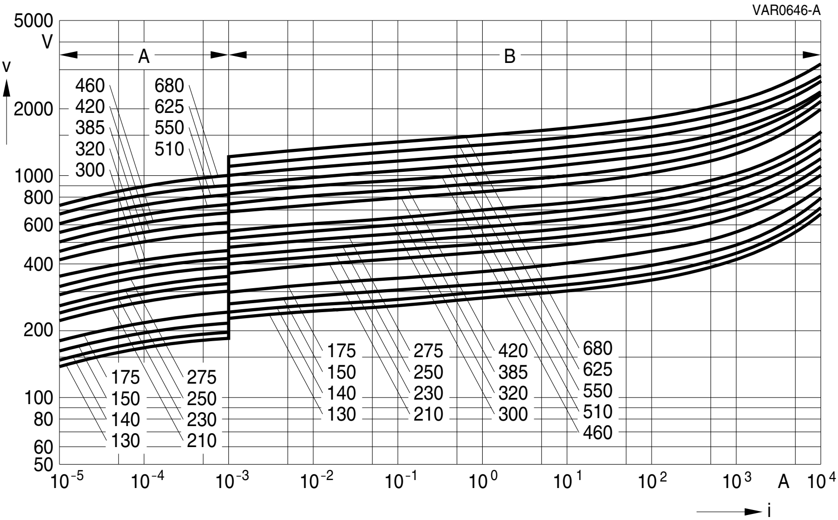


SIOV-S14 … E2

v/i characteristics

v = f (i) – for explanation of the characteristics refer to "General technical information", 1.6.3

A = Leakage current, B = Protection level } for worst-case varistor tolerances

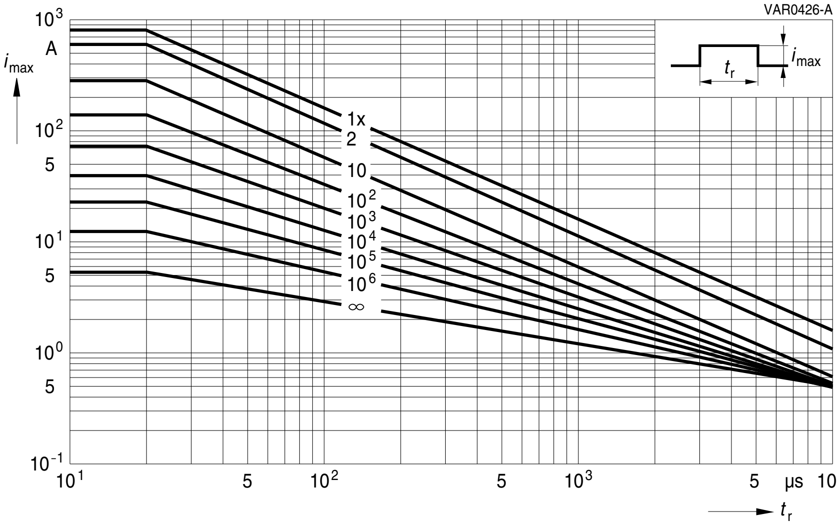


SIOV-S20 … E2

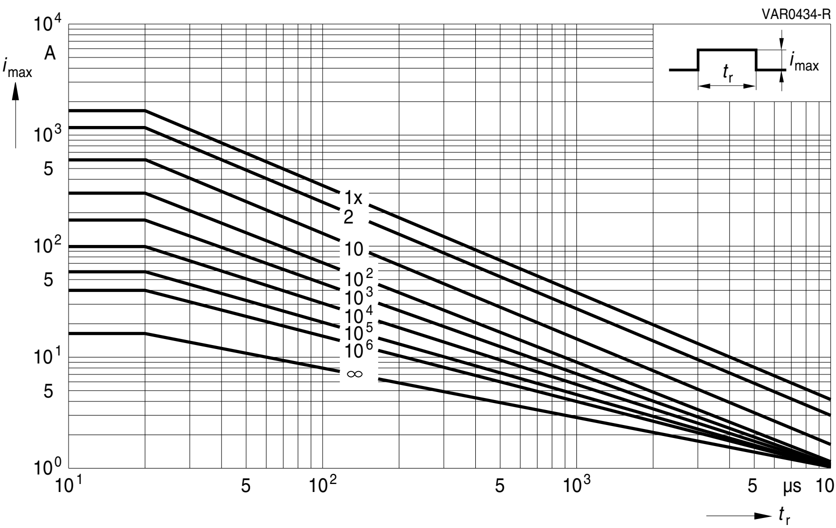
Derating curves

Maximum surge current i_{max} = f (t_r, pulse train)

For explanation of the derating curves refer to “General technical information”, section 1.8.1



SIOV-S05K130 … K300E2

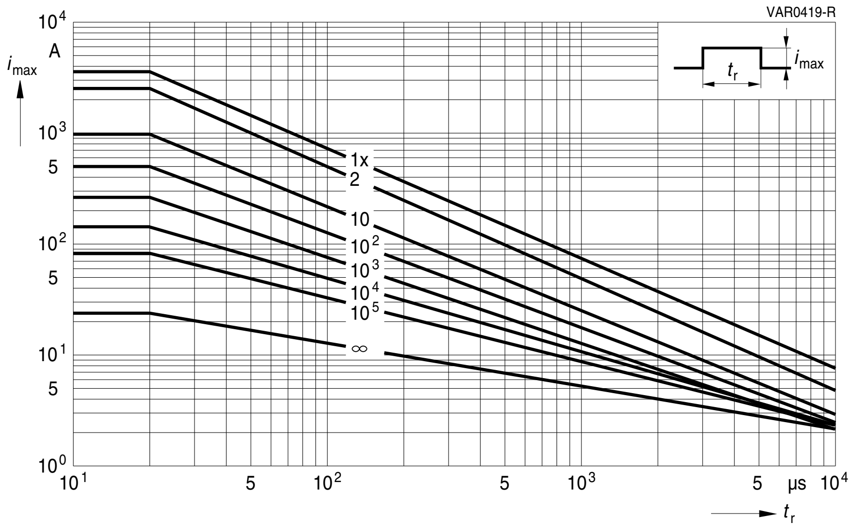


SIOV-S07K130 … K320E2

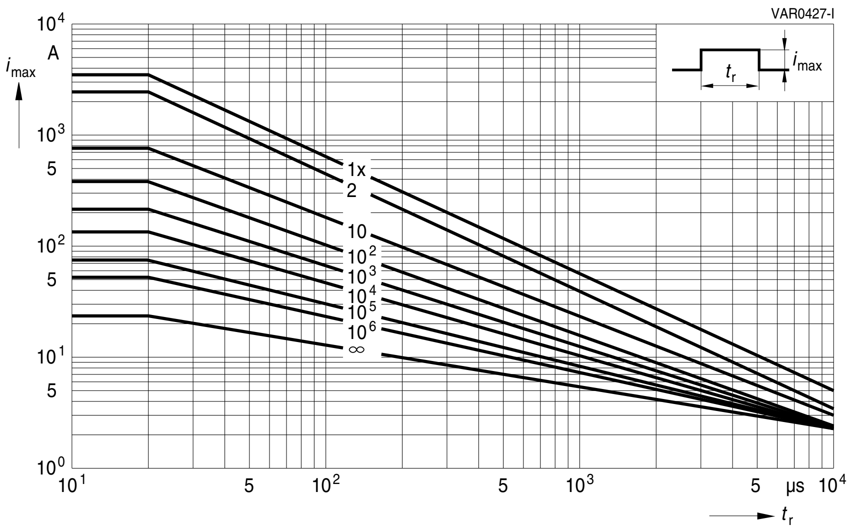
Derating curves

Maximum surge current i_{max} = f (t_r, pulse train)

For explanation of the derating curves refer to “General technical information”, section 1.8.1



SIOV-S10K130 … K320E2

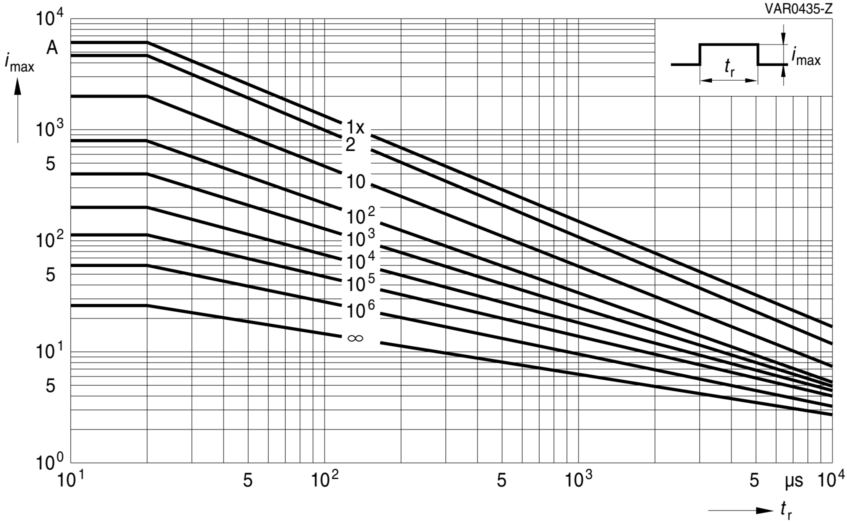


SIOV-S10K385 … K680E2

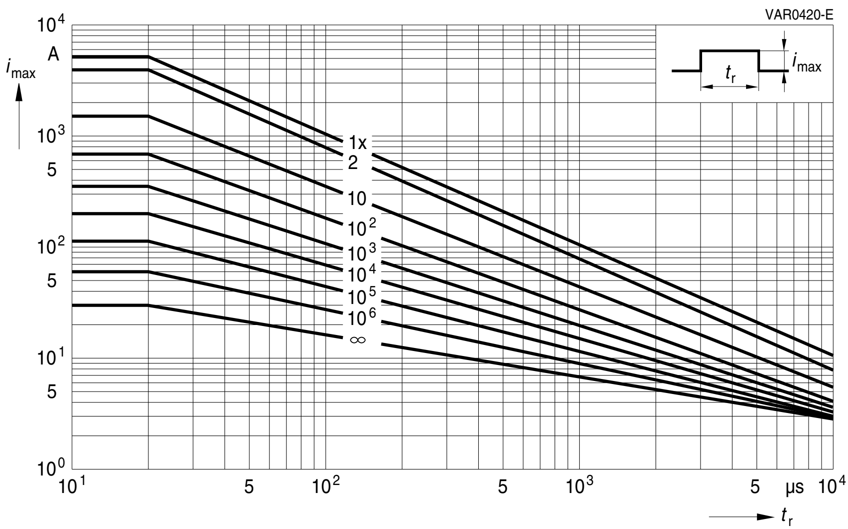
Derating curves

Maximum surge current i_{max} = f (t_r, pulse train)

For explanation of the derating curves refer to “General technical information”, section 1.8.1



SIOV-S14K130 … K320E2

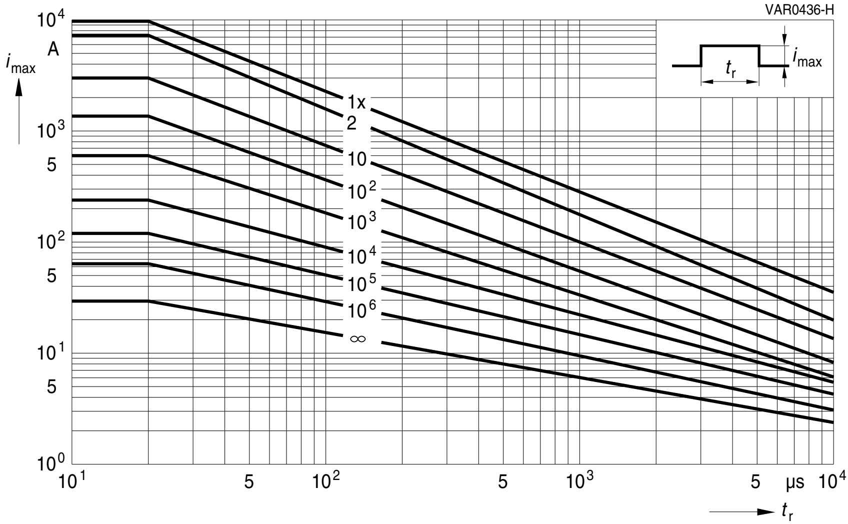


SIOV-S14K385 … K680E2

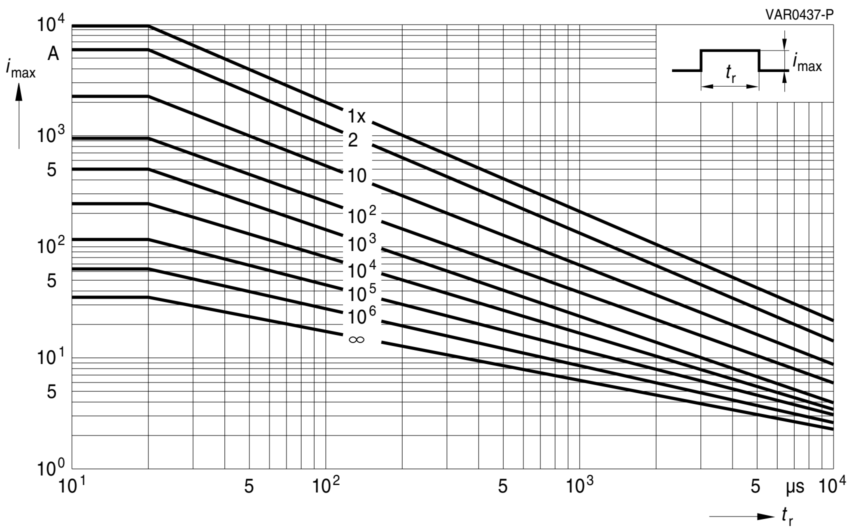
Derating curves

Maximum surge current $i_{max} = f(t_r$, pulse train)

For explanation of the derating curves refer to “General technical information”, section 1.8.1



SIOV-S20K130 … K320E2



SIOV-S20K385 … K680E2

Construction

- Round varistor element, leaded
- Coating: epoxy resin, flame-retardant to UL 94 V-0
- Terminals: tinned copper wire

Features

- Wide operating voltage range 275 … 460 V_{RMS}
- Multiple pulse handling capability

  Detailed surge current specification (8/20 µs) is indicated as below:

Amplitude	Interval	Quantity
I_{nom}	60 s	15
0.10 I_{max}	30 min	1
0.25 I_{max}	30 min	1
0.50 I_{max}	30 min	1
0.75 I_{max}	30 min	1
1.00 I_{max}	30 min	1

Remarks		
S10K … E2K1	I_{nom} = 1.5 kA	I_{max} = 3 kA
S14K … E2K1	I_{nom} = 3 kA	I_{max} = 6 kA

Approvals

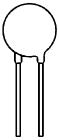
- UL
- CSA
- VDE
- CECC

Delivery mode

- Bulk (standard), taped versions on reel or in Ammo pack upon request.
- For further details refer to chapter "Taping, packaging and lead configuration" for leaded varistors.

General technical data

Climatic category	to IEC 60068-1	40/85/56	
Operating temperature	to CECC 42 000	–40 … + 85	°C
Storage temperature		–40 … +125	°C
Electric strength	to CECC 42 000	≥2.5	kV_{RMS}
Response time		<25	ns

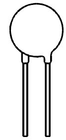


Maximum ratings (T_A = 85 °C)

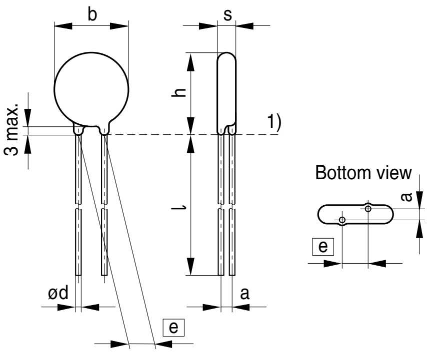
Ordering code	Type (untaped) SIOV-	V_{RMS} V	V_{DC} V	i_{max} (8/20 µs) A	W_{max} (2 ms) J	P_{max} W
B72210S2271K105	S10K275E2K1	275	350	3500	55.0	0.40
B72214S2271K105	S14K275E2K1	275	350	6000	110.0	0.60
B72210S2301K105	S10K300E2K1	300	385	3500	60.0	0.40
B72214S2301K105	S14K300E2K1	300	385	6000	125.0	0.60
B72210S2321K105	S10K320E2K1	320	420	3500	67.0	0.40
B72214S2321K105	S14K320E2K1	320	420	6000	136.0	0.60
B72210S2381K105	S10K385E2K1	385	505	3500	67.0	0.40
B72214S2381K105	S14K385E2K1	385	505	5000	136.0	0.60
B72210S2421K105	S10K420E2K1	420	560	3500	67.0	0.40
B72214S2421K105	S14K420E2K1	420	560	5000	136.0	0.60
B72210S2461K105	S10K460E2K1	460	615	3500	70.0	0.40
B72214S2461K105	S14K460E2K1	460	615	5000	150.0	0.60

Characteristics (T_A = 25 °C)

Ordering code	Type (untaped) SIOV-	V_v (1 mA) V	ΔV_v (1 mA) %	$v_{c,\,max}$ (i_c) V	i_c A	C_{typ} (1 kHz) pF
B72210S2271K105	S10K275E2K1	430	±10	710	25.0	235
B72214S2271K105	S14K275E2K1	430	±10	710	50.0	375
B72210S2301K105	S10K300E2K1	470	±10	775	25.0	215
B72214S2301K105	S14K300E2K1	470	±10	775	50.0	355
B72210S2321K105	S10K320E2K1	510	±10	840	25.0	205
B72214S2321K105	S14K320E2K1	510	±10	840	50.0	330
B72210S2381K105	S10K385E2K1	620	±10	1025	25.0	170
B72214S2381K105	S14K385E2K1	620	±10	1025	50.0	285
B72210S2421K105	S10K420E2K1	680	±10	1120	25.0	155
B72214S2421K105	S14K420E2K1	680	±10	1120	50.0	260
B72210S2461K105	S10K460E2K1	750	±10	1240	25.0	135
B72214S2461K105	S14K460E2K1	750	±10	1240	50.0	235



Dimensional drawing



1) Seating plane to IEC 60717

VAR0408-C

Weight

Nominal diameter mm	V_{RMS} V	Weight g
10	275 … 460	1.7 … 2.7
14	275 … 460	2.8 … 4.7

The weight of varistors in between these voltage classes can be interpolated.

Dimensions

Ordering code	e ±1 mm	a ±1 mm	b_{max} mm	s_{max} mm	h_{max} mm	l_{min} mm	d ±0.05 mm
B72210S2271K105	7.5	2.8	12.0	5.9	16.0	25.0	0.8
B72214S2271K105	7.5	2.8	16.0	5.9	20.0	25.0	0.8
B72210S2301K105	7.5	2.9	12.0	6.1	16.0	25.0	0.8
B72214S2301K105	7.5	2.9	16.0	6.1	20.0	25.0	0.8
B72210S2321K105	7.5	3.0	12.0	6.3	16.0	25.0	0.8
B72214S2321K105	7.5	3.0	16.0	6.3	20.0	25.0	0.8
B72210S2381K105	7.5	4.0	12.5	7.7	16.5	25.0	0.8
B72214S2381K105	7.5	4.1	16.5	7.7	20.5	25.0	0.8
B72210S2421K105	7.5	4.2	12.5	8.1	16.5	25.0	0.8
B72214S2421K105	7.5	4.3	16.5	8.2	20.5	25.0	0.8
B72210S2461K105	7.5	4.4	12.5	8.4	16.5	25.0	0.8
B72214S2461K105	7.5	4.5	16.5	8.5	20.5	25.0	0.8

Reliability data

Test	Test methods/conditions	Requirement
Varistor voltage	The voltage between two terminals with the specified measuring current applied is called V_v (1 mA_{DC} @ 0.2 … 2 s).	To meet the specified value.
Clamping voltage	The maximum voltage between two terminals with the specified standard impulse current (8/20 μs) applied.	To meet the specified value.
Max. AC operating voltage	CECC 42 000, test 4.20 1000 h at UCT After having continuously applied the maximum allowable voltage at UCT ±2 °C for 1000 h, the specimen shall be stored at room temperature and normal humidity for 1 to 2 h. Thereafter, the change of V_v shall be measured.	$\lvert\Delta V/V$ (1 mA)$\rvert \leq$10%
Surge current derating, 8/20 μs	CECC 42 000, test C 2.1 100 surge currents (8/20 μs), unipolar, interval 30 s, amplitude corresponding to derating curve for 100 impulses at 20 μs	$\lvert\Delta V/V$ (1 mA)$\rvert \leq$10% (measured in direction of surge current) No visible damage
Surge current derating, 2 ms	CECC 42 000, test C 2.1 100 surge currents (2 ms), unipolar, interval 120 s, amplitude corresponding to derating curve for 100 impulses at 2 ms	$\lvert\Delta V/V$ (1 mA)$\rvert \leq$10% (measured in direction of surge current) No visible damage
Electric strength	CECC 42 000, test 4.7 Metal balls method, 2500 V_{RMS}, 60 s The varistor is placed in a container holding 1.6 ±0.2 mm diameter metal balls such that only the terminations of the varistor are protruding. The specified voltage shall be applied between both terminals of the specimen connected together and the electrode inserted between the metal balls.	No breakdown

Reliability data

Test	Test methods/conditions	Requirement
Climatic sequence	CECC 42 000, test 4.16 The specimen shall be subjected to: a) dry heat at UCT, 16 h b) damp heat, 1st cycle: 55 °C, 93% r. H., 24 h c) cold, LCT, 2 h d) damp heat, additional 5 cycles: 55 °C/25 °C, 93% r. H., 24 h/cycle. Then the specimen shall be stored at room temperature and normal humidity for 1 to 2 h. Thereafter, the change of V_v shall be measured. Thereafter, insulation resistance R_{ins} shall be measured according to CECC 42 000, test 4.8 at V = 500 V.	$\lvert\Delta V/V\ (1\ mA)\rvert \leq 10\%$ $R_{ins} \geq 1\ M\Omega$
Fast temperature cycling	IEC 60068-2-14, test Na, LCT/UCT, dwell time 30 min, 5 cycles	$\lvert\Delta V/V\ (1\ mA)\rvert \leq 5\%$ No visible damage
Damp heat, steady state	The specimen shall be subjected to 40 ±2 °C, 90 to 95% r. H. for 56 days without load / with 10% of the maximum continuous DC operating voltage V_{DC}. Then stored at room temperature and normal humidity for 1 to 2 h. Thereafter, the change of V_v shall be measured. Thereafter, insulation resistance R_{ins} shall be measured according to CECC 42 000, test 4.8 at V = 500 V.	$\lvert\Delta V/V\ (1\ mA)\rvert \leq 10\%$ $R_{ins} \geq 1\ M\Omega$
Solderability	IEC 60068-2-20, test Ta, method 1 with modified conditions for lead-free solder alloys: 245 °C, 3 s: After dipping the terminals to a depth of approximately 3 mm from the body in a soldering bath of 245 °C for 3 s, the terminals shall be visually examined.	The inspection shall be carried out under adequate light with normal eyesight or with the assistance of a magnifier capable of giving a magnification of 4 to 10 times. The dipped surface shall be covered with a smooth and bright solder coating with no more than small amounts of scattered imperfections such as pinholes or un-wetted or de-wetted areas. These imperfections shall not be concentrated in one area.

Reliability data

Test	Test methods/conditions	Requirement
Resistance to soldering heat	IEC 60068-2-20, test Tb, method 1A, 260 °C, 10 s: Each lead shall be dipped into a solder bath having a temperature of 260 ±5 °C to a point 2.0 to 2.5 mm from the body of the specimen, be held there for 10 ±1 s and then be stored at room temperature and normal humidity for 1 to 2 h. The change of V_v shall be measured and the specimen shall be visually examined.	$\lvert \Delta V/V$ (1 mA)$\rvert \leq 5\%$ No visible damage
Tensile strength	IEC 60068-2-21, test Ua1 After gradually applying the force specified below and keeping the unit fixed for 10 s, the terminal shall be visually examined for any damage. Force for wire diameter: 0.8 mm = 10 N	$\lvert \Delta V/V$ (1 mA)$\rvert \leq 5\%$ No break of solder joint, no wire break
Vibration	IEC 60068-2, test Fc Frequency range: 10 … 55 Hz Amplitude: 0.75 mm or 98 m/s² Duration: 6 h (3 · 2 h) Pulse: sine wave After repeatedly applying a single harmonic vibration according to the table above. The change of V_v shall be measured and the specimen shall be visually examined.	$\lvert \Delta V/V$ (1 mA)$\rvert \leq 5\%$ No visible damage
Bump	IEC 60068-2-29, test Eb Pulse duration: 6 ms Max. acceleration: 400 m/s² Number of bumps: 4000 Pulse: half sine	$\lvert \Delta V/V$ (1 mA)$\rvert \leq 5\%$ No visible damage
Flammability	IEC 60695-2-2 (needle flame test) Severity: vertical 10 s	5 s max.

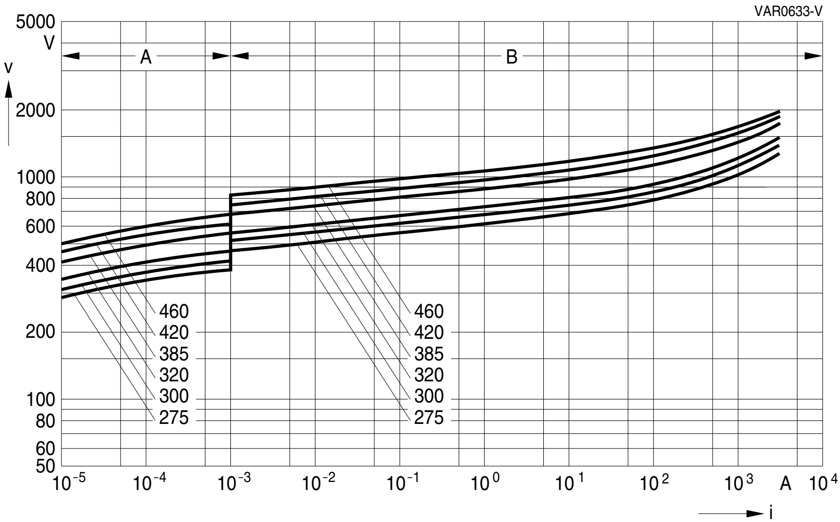
Note:

UCT = Upper category temperature
LCT = Lower category temperature
R_{ins} = Insulation resistance to CECC 42 000, test 4.8

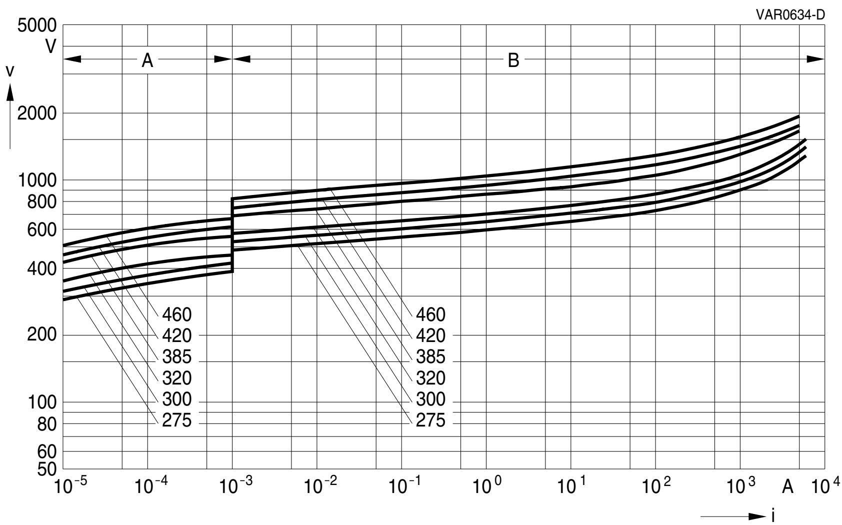
v/i characteristics

v = f (i) – for explanation of the characteristics refer to "General technical information", 1.6.3

A = Leakage current, B = Protection level (for worst-case varistor tolerances)



SIOV-S10 … E2K1

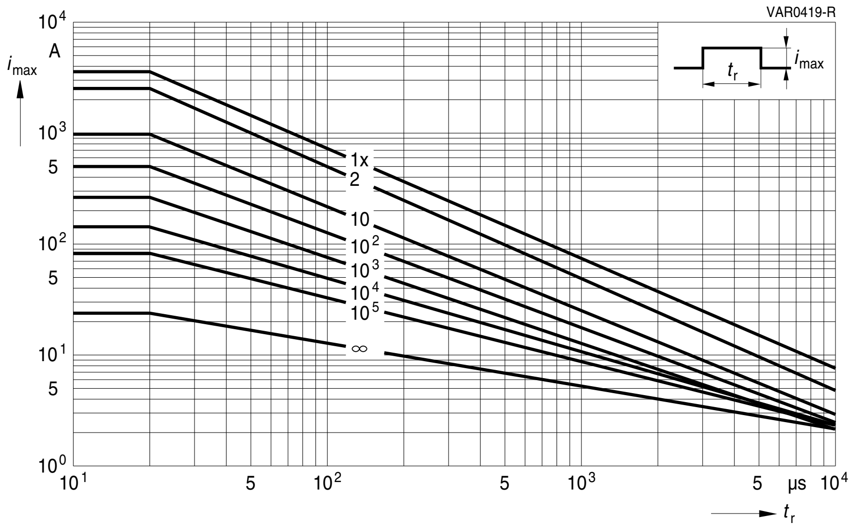


SIOV-S14 … E2K1

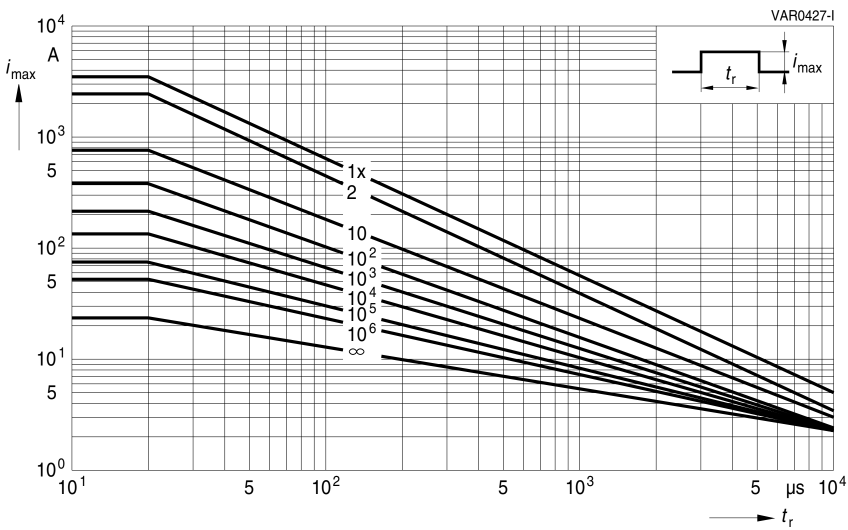
Derating curves

Maximum surge current $i_{max} = f(t_r, \text{pulse train})$

For explanation of the derating curves refer to “General technical information”, section 1.8.1



SIOV-S10K275 … K320E2K1

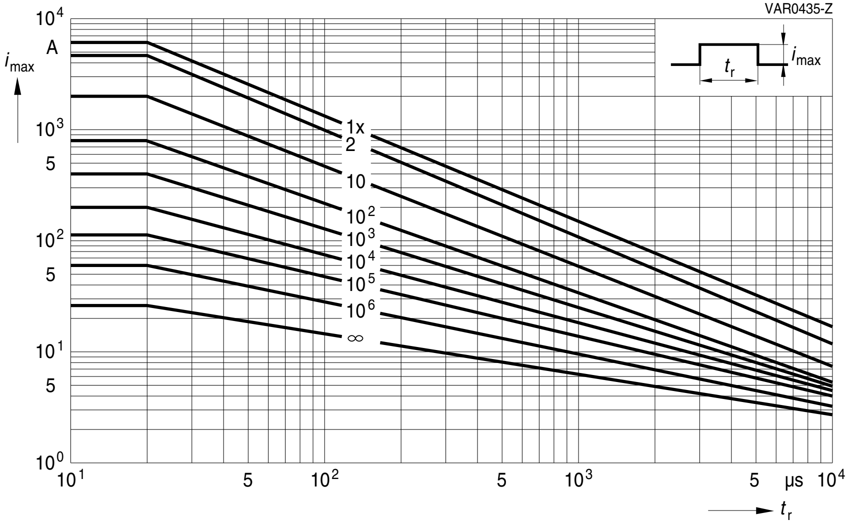


SIOV-S10K385 … K460E2K1

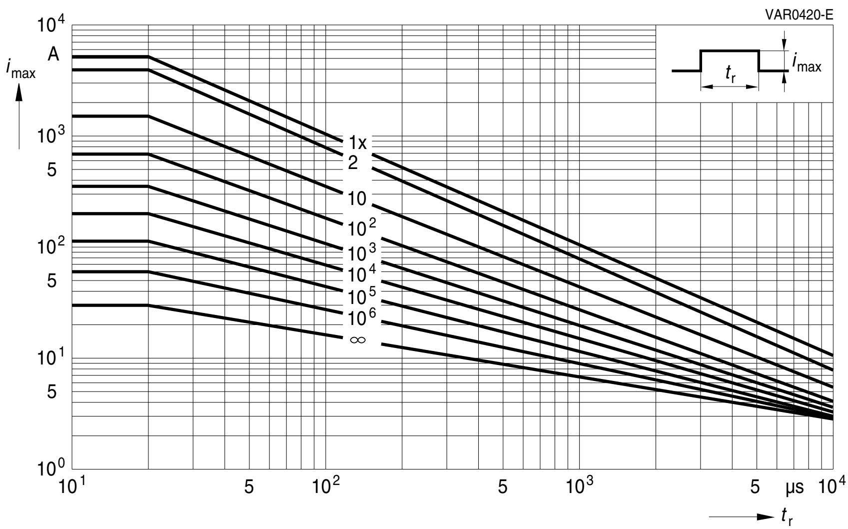
Derating curves

Maximum surge current $i_{max} = f(t_r$, pulse train)

For explanation of the derating curves refer to “General technical information”, section 1.8.1



SIOV-S14K275 … K320E2K1



SIOV-S14K385 … K460E2K1

Construction

- Round varistor element, leaded
- Coating: epoxy resin, flame-retardant to UL 94 V-0
- Terminals: tinned copper wire

Features

- High-energy SuperioR series E3
- Very high surge current ratings of 12 kA
- High energy ratings up to 320 J
- PSpice models

Approvals

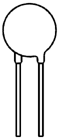
- UL
- CSA
- CECC
- VDE
- IEC

Delivery mode

- Bulk (standard), taped versions on reel or in Ammo pack upon request.
- For further details refer to chapter "Taping, packaging and lead configuration" for leaded varistors.

General technical data

Climatic category	to IEC 60068-1	40/85/56	
Operating temperature	to CECC 42 000	–40 … + 85	°C
Storage temperature		–40 … +125	°C
Electric strength	to CECC 42 000	≥2.5	kV_{RMS}
Insulation resistance	to CECC 42 000	≥10	MΩ
Response time		<25	ns



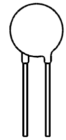
EPCOS

Maximum ratings (T_A = 85 °C)

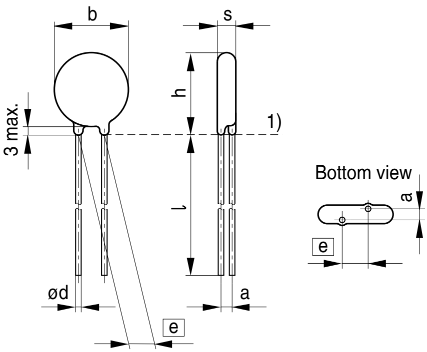
Ordering code	Type (untaped) SIOV-	V_{RMS} V	V_{DC} V	i_{max} (8/20 µs) A	W_{max} (2 ms) J	P_{max} W
B72220S3111K101	S20K115E3	115	150	12000	110	1.0
B72220S3131K101	S20K130E3	130	170	12000	130	1.0
B72220S3141K101	S20K140E3	140	180	12000	140	1.0
B72220S3151K101	S20K150E3	150	200	12000	150	1.0
B72220S3171K101	S20K175E3	175	225	12000	180	1.0
B72220S3211K101	S20K210E3	210	270	12000	210	1.0
B72220S3231K101	S20K230E3	230	300	12000	220	1.0
B72220S3251K101	S20K250E3	250	320	12000	250	1.0
B72220S3271K101	S20K275E3	275	350	12000	260	1.0
B72220S3301K101	S20K300E3	300	385	12000	290	1.0
B72220S3321K101	S20K320E3	320	420	12000	320	1.0

Characteristics (T_A = 25 °C)

Ordering code	Type (untaped) SIOV-	V_v (1 mA) V	ΔV_v (1 mA) %	$v_{c,\,max}$ (i_c) V	i_c A	C_{typ} (1 kHz) pF
B72220S3111K101	S20K115E3	180	±10	300	100	1520
B72220S3131K101	S20K130E3	205	±10	340	100	1340
B72220S3141K101	S20K140E3	220	±10	360	100	1240
B72220S3151K101	S20K150E3	240	±10	395	100	1160
B72220S3171K101	S20K175E3	270	±10	455	100	1000
B72220S3211K101	S20K210E3	330	±10	550	100	830
B72220S3231K101	S20K230E3	360	±10	595	100	760
B72220S3251K101	S20K250E3	390	±10	650	100	700
B72220S3271K101	S20K275E3	430	±10	710	100	630
B72220S3301K101	S20K300E3	470	±10	775	100	580
B72220S3321K101	S20K320E3	510	±10	840	100	540



Dimensional drawing



1) Seating plane to IEC 60717

VAR0408-C

Weight

Nominal diameter mm	V_{RMS} V	Weight g
20	115 … 320	4.0 … 7.0

The weight of varistors in between these voltage classes can be interpolated.

Dimensions

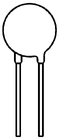
Ordering code	e ±1 mm	a ±1 mm	b_{max} mm	s_{max} mm	h_{max} mm	l_{min} mm	d ±0.05 mm
B72220S3111K101	10.0	1.8	22.5	4.8	26.0	25.0	1.0
B72220S3131K101	10.0	2.0	22.5	5.0	26.0	25.0	1.0
B72220S3141K101	10.0	2.1	22.5	5.1	26.0	25.0	1.0
B72220S3151K101	10.0	2.2	22.5	5.2	26.0	25.0	1.0
B72220S3171K101	10.0	2.3	22.5	5.3	26.0	25.0	1.0
B72220S3211K101	10.0	2.4	22.5	5.4	26.0	25.0	1.0
B72220S3231K101	10.0	2.9	22.5	5.9	26.0	25.0	1.0
B72220S3251K101	10.0	3.1	22.5	6.1	27.0	25.0	1.0
B72220S3271K101	10.0	3.3	22.5	6.3	27.0	25.0	1.0
B72220S3301K101	10.0	3.6	22.5	6.6	27.0	25.0	1.0
B72220S3321K101	10.0	3.8	22.5	6.8	27.0	25.0	1.0

Reliability data

Test	Test methods/conditions	Requirement
Varistor voltage	The voltage between two terminals with the specified measuring current applied is called V_v (1 mA_{DC} @ 0.2 … 2 s).	To meet the specified value.
Clamping voltage	The maximum voltage between two terminals with the specified standard impulse current (8/20 μs) applied.	To meet the specified value.
Max. AC operating voltage	CECC 42 000, test 4.20 1000 h at UCT After having continuously applied the maximum allowable voltage at UCT $\pm$2 °C for 1000 h, the specimen shall be stored at room temperature and normal humidity for 1 to 2 h. Thereafter, the change of V_v shall be measured.	$\lvert\Delta V/V$ (1 mA)$\rvert \leq$10%
Surge current derating, 8/20 μs	CECC 42 000, test C 2.1 100 surge currents (8/20 μs), unipolar, interval 30 s, amplitude corresponding to derating curve for 100 impulses at 20 μs	$\lvert\Delta V/V$ (1 mA)$\rvert \leq$10% (measured in direction of surge current) No visible damage
Surge current derating, 2 ms	CECC 42 000, test C 2.1 100 surge currents (2 ms), unipolar, interval 120 s, amplitude corresponding to derating curve for 100 impulses at 2 ms	$\lvert\Delta V/V$ (1 mA)$\rvert \leq$10% (measured in direction of surge current) No visible damage
Electric strength	CECC 42 000, test 4.7 Metal balls method, 2500 V_{RMS}, 60 s The varistor is placed in a container holding 1.6 $\pm$0.2 mm diameter metal balls such that only the terminations of the varistor are protruding. The specified voltage shall be applied between both terminals of the specimen connected together and the electrode inserted between the metal balls.	No breakdown

Reliability data

Test	Test methods/conditions	Requirement
Climatic sequence	CECC 42 000, test 4.16 The specimen shall be subjected to: a) dry heat at UCT, 16 h b) damp heat, 1st cycle: 55 °C, 93% r. H., 24 h c) cold, LCT, 2 h d) damp heat, additional 5 cycles: 55 °C/25 °C, 93% r. H., 24 h/cycle. Then the specimen shall be stored at room temperature and normal humidity for 1 to 2 h. Thereafter, the change of V_v shall be measured. Thereafter, insulation resistance R_{ins} shall be measured according to CECC 42 000, test 4.8 at V = 500 V.	$\lvert\Delta V/V\ (1\ mA)\rvert \leq 10\%$ $R_{ins} \geq 1\ M\Omega$
Fast temperature cycling	IEC 60068-2-14, test Na, LCT/UCT, dwell time 30 min, 5 cycles	$\lvert\Delta V/V\ (1\ mA)\rvert \leq 5\%$ No visible damage
Damp heat, steady state	The specimen shall be subjected to 40 ±2 °C, 90 to 95% r. H. for 56 days without load / with 10% of the maximum continuous DC operating voltage V_{DC}. Then stored at room temperature and normal humidity for 1 to 2 h. Thereafter, the change of V_v shall be measured. Thereafter, insulation resistance R_{ins} shall be measured according to CECC 42 000, test 4.8 at V = 500 V.	$\lvert\Delta V/V\ (1\ mA)\rvert \leq 10\%$ $R_{ins} \geq 1\ M\Omega$
Solderability	IEC 60068-2-20, test Ta, method 1 with modified conditions for lead-free solder alloys: 245 °C, 3 s: After dipping the terminals to a depth of approximately 3 mm from the body in a soldering bath of 245 °C for 3 s, the terminals shall be visually examined.	The inspection shall be carried out under adequate light with normal eyesight or with the assistance of a magnifier capable of giving a magnification of 4 to 10 times. The dipped surface shall be covered with a smooth and bright solder coating with no more than small amounts of scattered imperfections such as pinholes or un-wetted or de-wetted areas. These imperfections shall not be concentrated in one area.



Reliability data

Test	Test methods/conditions	Requirement
Resistance to soldering heat	IEC 60068-2-20, test Tb, method 1A, 260 °C, 10 s: Each lead shall be dipped into a solder bath having a temperature of 260 ±5 °C to a point 2.0 to 2.5 mm from the body of the specimen, be held there for 10 ±1 s and then be stored at room temperature and normal humidity for 1 to 2 h. The change of V_v shall be measured and the specimen shall be visually examined.	$\lvert \Delta V/V\ (1\ mA) \rvert \leq 5\%$ No visible damage
Tensile strength	IEC 60068-2-21, test Ua1 After gradually applying the force specified below and keeping the unit fixed for 10 s, the terminal shall be visually examined for any damage. Force for wire diameter: 1.0 mm = 20 N	$\lvert \Delta V/V\ (1\ mA) \rvert \leq 5\%$ No break of solder joint, no wire break
Vibration	IEC 60068-2, test Fc Frequency range: 10 … 55 Hz Amplitude: 0.75 mm or 98 m/s² Duration: 6 h (3 · 2 h) Pulse: sine wave After repeatedly applying a single harmonic vibration according to the table above. The change of V_v shall be measured and the specimen shall be visually examined.	$\lvert \Delta V/V\ (1\ mA) \rvert \leq 5\%$ No visible damage
Bump	IEC 60068-2-29, test Eb Pulse duration: 6 ms Max. acceleration: 400 m/s² Number of bumps: 4000 Pulse: half sine	$\lvert \Delta V/V\ (1\ mA) \rvert \leq 5\%$ No visible damage
Flammability	IEC 60695-2-2 (needle flame test) Severity: vertical 10 s	5 s max.

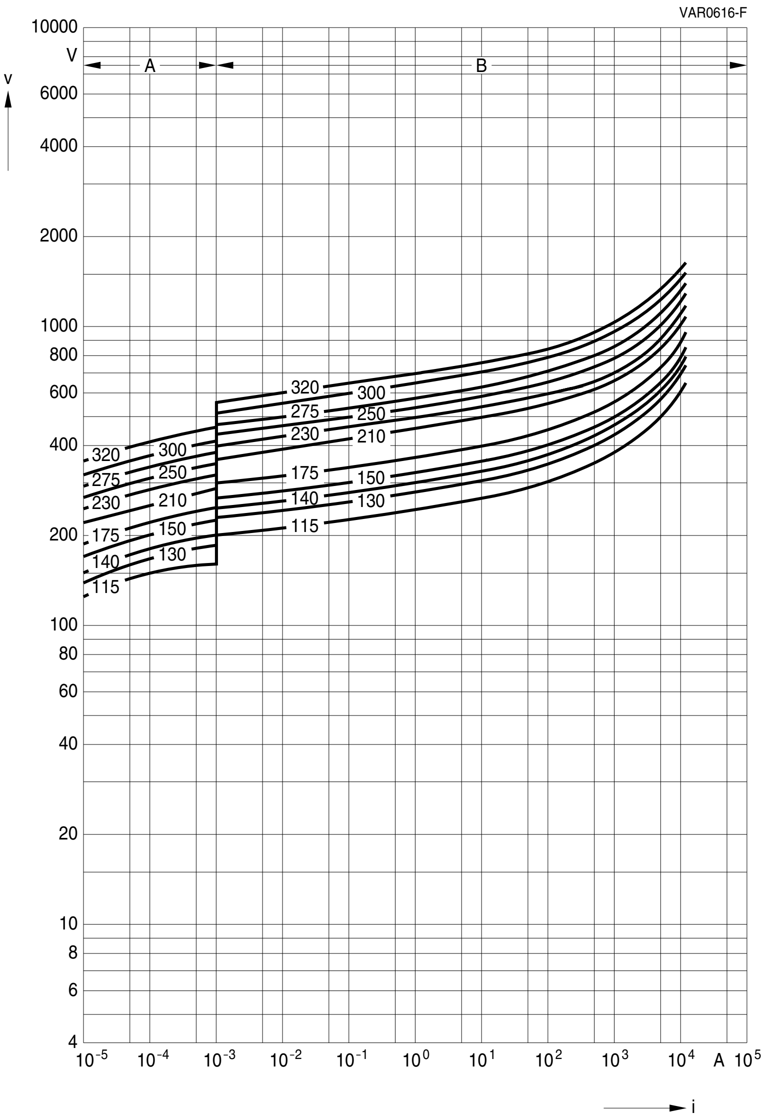
Note:

UCT = Upper category temperature
LCT = Lower category temperature
R_{ins} = Insulation resistance to CECC 42 000, test 4.8

v/i characteristics

v = f (i) – for explanation of the characteristics refer to “General technical information”, 1.6.3

A = Leakage current } for worst-case varistor tolerances
B = Protection level } for worst-case varistor tolerances

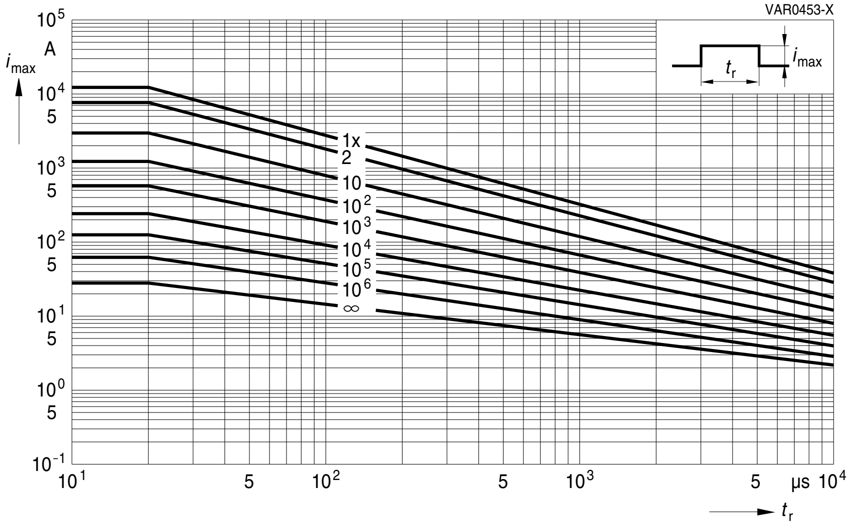


SIOV-S20 … E3

Derating curves

Maximum surge current i_{max} = f (t_r, pulse train)

For explanation of the derating curves refer to “General technical information”, section 1.8.1



SIOV-S20 … E3

Construction

- Round varistor element, leaded
- Coating: epoxy resin, flame-retardant to UL 94 V-0
- Terminals: tinned copper wire

Features

- Wide operating voltage range 275 … 460 V_{RMS}
- Multiple pulse handling capability

  Detailed surge current specification (8/20 µs) is indicated as below:

Amplitude	Interval	Quantity
I_{nom}	60 s	15
0.10 I_{max}	30 min	1
0.25 I_{max}	30 min	1
0.50 I_{max}	30 min	1
0.75 I_{max}	30 min	1
1.00 I_{max}	30 min	1

Remark		
S20K … E3K1	I_{nom} = 5 kA	I_{max} = 10 kA

Approvals

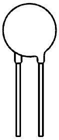
- UL

Delivery mode

- Bulk (standard), taped versions on reel upon request.
- For further details refer to chapter “Taping, packaging and lead configuration” for leaded varistors.

General technical data

Climatic category	to IEC 60068-1	40/85/56	
Operating temperature	to CECC 42 000	–40 … + 85	°C
Storage temperature		–40 … +125	°C
Electric strength	to CECC 42 000	≥2.5	kV_{RMS}
Response time		<25	ns

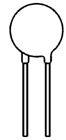


Maximum ratings (T_A = 85 °C)

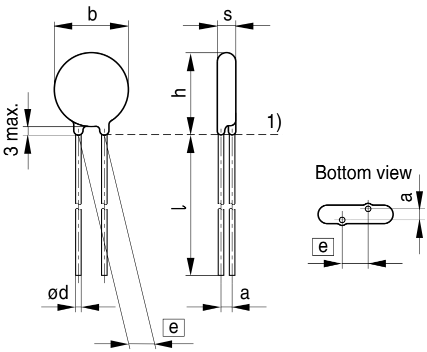
Ordering code	Type (untaped) SIOV-	V_{RMS} V	V_{DC} V	i_{max} (8/20 µs) A	W_{max} (2 ms) J	P_{max} W
B72220S3271K105	S20K275E3K1	275	350	12000	260	1.00
B72220S3301K105	S20K300E3K1	300	385	12000	290	1.00
B72220S3321K105	S20K320E3K1	320	420	12000	320	1.00
B72220S3381K105	S20K385E3K1	385	505	12000	320	1.00
B72220S3421K105	S20K420E3K1	420	560	12000	320	1.00
B72220S3461K105	S20K460E3K1	460	615	12000	370	1.00

Characteristics (T_A = 25 °C)

Ordering code	Type (untaped) SIOV-	V_v (1 mA) V	ΔV_v (1 mA) %	$v_{c,\,max}$ (i_c) V	i_c A	C_{typ} (1 kHz) pF
B72220S3271K105	S20K275E3K1	430	±10	710	100	750
B72220S3301K105	S20K300E3K1	470	±10	775	100	690
B72220S3321K105	S20K320E3K1	510	±10	840	100	640
B72220S3381K105	S20K385E3K1	620	±10	1025	100	510
B72220S3421K105	S20K420E3K1	680	±10	1120	100	475
B72220S3461K105	S20K460E3K1	750	±10	1240	100	430



Dimensional drawing



1) Seating plane to IEC 60717

VAR0408-C

Weight

Nominal diameter mm	V_{RMS} V	Weight g
20	275 … 460	5.5 … 8.8

The weight of varistors in between these voltage classes can be interpolated.

Dimensions

Ordering code	e ±1 mm	a ±1 mm	b_{max} mm	s_{max} mm	h_{max} mm	l_{min} mm	d ±0.05 mm
B72220S3271K105	10.0	3.5	22.5	6.5	27.0	25.0	1.0
B72220S3301K105	10.0	3.8	22.5	6.8	27.0	25.0	1.0
B72220S3321K105	10.0	3.9	22.5	6.9	27.0	25.0	1.0
B72220S3381K105	10.0	4.8	22.5	8.3	27.5	25.0	1.0
B72220S3421K105	10.0	5.0	22.5	8.6	27.5	25.0	1.0
B72220S3461K105	10.0	5.3	22.5	8.9	27.5	25.0	1.0

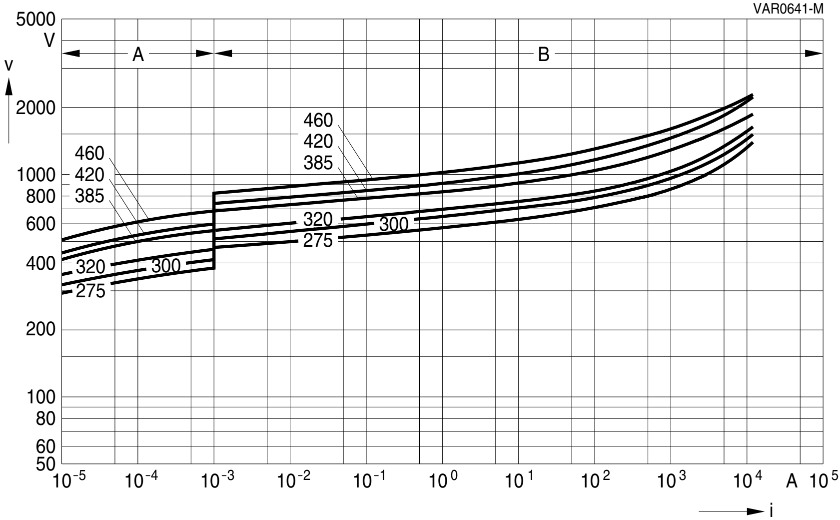
Reliability data

Test	Test methods/conditions	Requirement
Varistor voltage	The voltage between two terminals with the specified measuring current applied is called V_v (1 mA_{DC} @ 0.2 … 2 s).	To meet the specified value.
Clamping voltage	The maximum voltage between two terminals with the specified standard impulse current (8/20 µs) applied.	To meet the specified value.
Surge current derating, 8/20 µs	CECC 42 000, test C 2.1 100 surge currents (8/20 µs), unipolar, interval 30 s, amplitude corresponding to derating curve for 100 impulses at 20 µs	$\lvert\Delta V/V$ (1 mA)$\rvert \leq 10\%$ (measured in direction of surge current) No visible damage
Surge current derating, 2 ms	CECC 42 000, test C 2.1 100 surge currents (2 ms), unipolar, interval 120 s, amplitude corresponding to derating curve for 100 impulses at 2 ms	$\lvert\Delta V/V$ (1 mA)$\rvert \leq 10\%$ (measured in direction of surge current) No visible damage

v/i characteristics

v = f (i) – for explanation of the characteristics refer to "General technical information", 1.6.3

A = Leakage current } for worst-case
B = Protection level } varistor tolerances

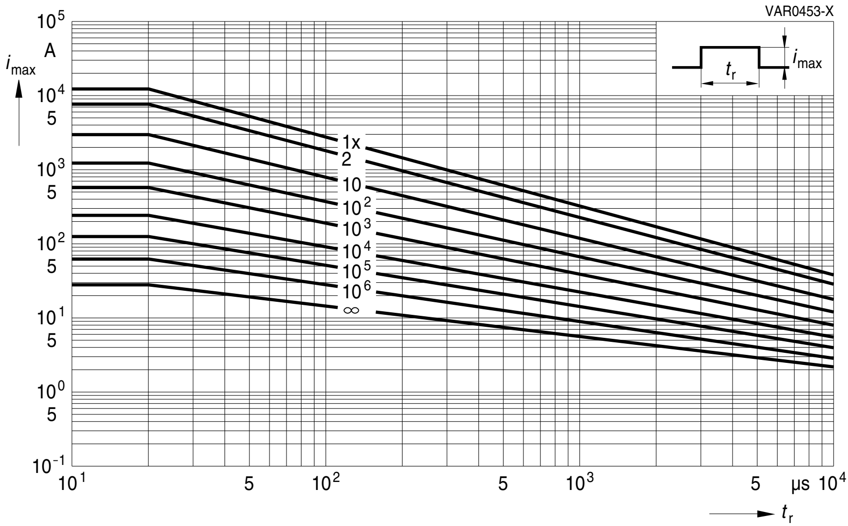


SIOV-S20 … E3K1

Derating curves

Maximum surge current i_{max} = f (t_r, pulse train)

For explanation of the derating curves refer to “General technical information”, section 1.8.1



SIOV-S20 … E3K1

Construction

- Round varistor element, leaded
- Coating: epoxy resin, flame-retardant to UL 94 V-0
- Terminals: tinned copper wire

Features

- High-energy SuperioR series E4
- Wide operating voltage range 130 … 750 V_{RMS}
- UL approval to UL 1449 (file number E97877 – exception 580 V)
- Very high surge current rating up to 20 kA

Approvals

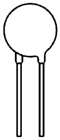
- UL
- CSA

Delivery mode

- Bulk (standard)
- For further details refer to chapter "Taping, packaging and lead configuration" for leaded varistors.

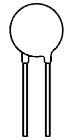
General technical data

Climatic category	to IEC 60068-1	40/85/56	
Operating temperature	to CECC 42 000	–40 … + 85	°C
Storage temperature		–40 … +125	°C
Electric strength	to CECC 42 000	≥2.5	kV_{RMS}
Insulation resistance	to CECC 42 000	≥10	MΩ
Response time		<25	ns



Maximum ratings (T_A = 85 °C)

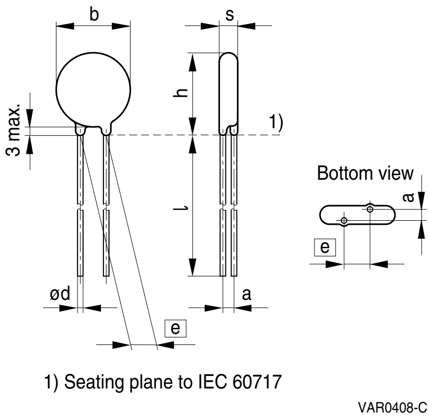
Ordering code	Type (untaped) SIOV-	V_{RMS} V	V_{DC} V	i_{max} (8/20 µs) A	W_{max} (2 ms) J	P_{max} W
B72225S4131K101	S25K130E4R12	130	170	20000	185	1.0
B72225S4141K101	S25K140E4R12	140	180	20000	195	1.0
B72225S4151K101	S25K150E4R12	150	200	20000	215	1.0
B72225S4171K101	S25K175E4R12	175	225	20000	245	1.0
B72225S4231K101	S25K230E4R12	230	300	20000	315	1.0
B72225S4251K101	S25K250E4R12	250	320	20000	345	1.0
B72225S4271K101	S25K275E4R12	275	350	20000	375	1.0
B72225S4301K101	S25K300E4R12	300	385	20000	410	1.0
B72225S4321K101	S25K320E4R12	320	420	20000	445	1.0
B72225S4381K101	S25K385E4R12	385	505	20000	600	1.0
B72225S4421K101	S25K420E4R12	420	560	20000	700	1.0
B72225S4441K101	S25K440E4R12	440	585	20000	710	1.0
B72225S4461K101	S25K460E4R12	460	615	20000	720	1.0
B72225S4511K101	S25K510E4R12	510	670	20000	750	1.0
B72225S4551K101	S25K550E4R12	550	745	20000	780	1.0
B72225S4581K101	S25K580E4R12	580	780	20000	800	1.0
B72225S4621K101	S25K625E4R12	625	825	20000	855	1.0
B72225S4681K101	S25K680E4R12	680	895	20000	940	1.0
B72225S4751K101	S25K750E4R12	750	1060	20000	1025	1.0



Characteristics (T_A = 25 °C)

Ordering code	V_v (1 mA) V	ΔV_v (1 mA) %	$v_{c,\,max}$ (i_c) V	i_c A	C_{typ} (1 kHz) pF
B72225S4131K101	205	±10	340	150	2780
B72225S4141K101	220	±10	360	150	2550
B72225S4151K101	240	±10	395	150	2370
B72225S4171K101	270	±10	455	150	2080
B72225S4231K101	360	±10	595	150	1560
B72225S4251K101	390	±10	650	150	1430
B72225S4271K101	430	±10	710	150	1320
B72225S4301K101	470	±10	775	150	1180
B72225S4321K101	510	±10	840	150	1090
B72225S4381K101	620	±10	1025	150	900
B72225S4421K101	680	±10	1120	150	830
B72225S4441K101	715	±10	1180	150	780
B72225S4461K101	750	±10	1240	150	740
B72225S4511K101	820	±10	1355	150	680
B72225S4551K101	910	±10	1500	150	630
B72225S4581K101	940	±10	1580	150	605
B72225S4621K101	1000	±10	1650	150	565
B72225S4681K101	1100	±10	1815	150	515
B72225S4751K101	1200	±10	2000	150	480

Dimensional drawing



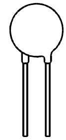
Weight

Nominal diameter mm	V_{RMS} V	Weight g
25	130 … 750	5.4 … 16.8

The weight of varistors in between these voltage classes can be interpolated.

Dimensions

Ordering code	e ±1 mm	a ±1 mm	b_{max} mm	s_{max} mm	h_{max} mm	l_{min} mm	d ±0.05 mm
B72225S4131K101	12.7	2.2	27.5	5.1	31.0	25.0	1.0
B72225S4141K101	12.7	2.3	27.5	5.2	31.0	25.0	1.0
B72225S4151K101	12.7	2.4	27.5	5.3	31.0	25.0	1.0
B72225S4171K101	12.7	2.6	27.5	5.4	31.0	25.0	1.0
B72225S4231K101	12.7	3.2	27.5	6.0	31.0	25.0	1.0
B72225S4251K101	12.7	3.4	27.5	6.2	31.0	25.0	1.0
B72225S4271K101	12.7	3.6	27.5	6.4	31.0	25.0	1.0
B72225S4301K101	12.7	3.9	27.5	6.7	31.0	25.0	1.0
B72225S4321K101	12.7	4.1	27.5	6.9	31.0	25.0	1.0
B72225S4381K101	12.7	4.8	27.5	7.6	31.0	25.0	1.0
B72225S4421K101	12.7	5.1	27.5	7.9	31.0	25.0	1.0
B72225S4441K101	12.7	5.4	27.5	8.1	31.0	25.0	1.0
B72225S4461K101	12.7	5.6	27.5	8.3	31.0	25.0	1.0
B72225S4511K101	12.7	6.0	27.5	8.7	31.0	25.0	1.0
B72225S4551K101	12.7	6.5	27.5	9.2	31.0	25.0	1.0
B72225S4581K101	12.7	6.7	27.5	9.4	31.0	25.0	1.0
B72225S4621K101	12.7	7.1	27.5	9.8	31.0	25.0	1.0
B72225S4681K101	12.7	7.7	27.5	10.4	31.0	25.0	1.0
B72225S4751K101	12.7	8.2	27.5	10.9	31.0	25.0	1.0



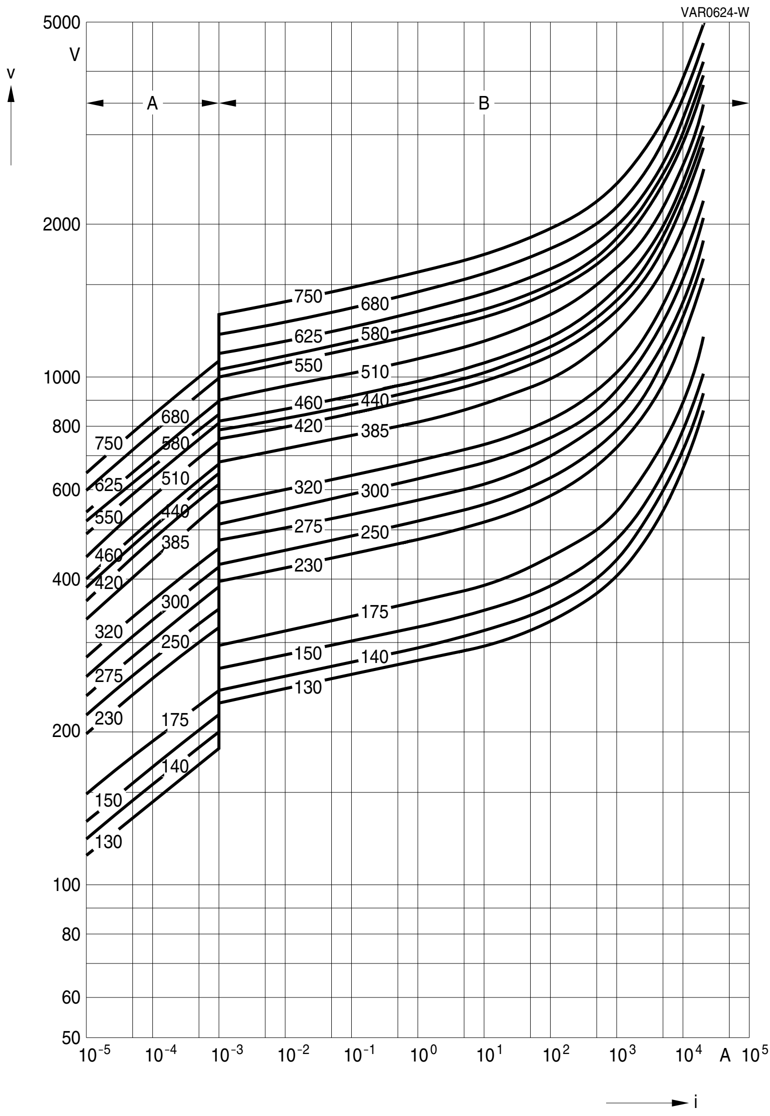
Reliability data

Test	Test methods/conditions	Requirement
Varistor voltage	The voltage between two terminals with the specified measuring current applied is called V_v (1 mA_{DC} @ 0.2 … 2 s).	To meet the specified value.
Clamping voltage	The maximum voltage between two terminals with the specified standard impulse current (8/20 µs) applied.	To meet the specified value.
Surge current derating, 8/20 µs	CECC 42 000, test C 2.1 100 surge currents (8/20 µs), unipolar, interval 30 s, amplitude corresponding to derating curve for 100 impulses at 20 µs	$\lvert \Delta V/V \text{ (1 mA)} \rvert \leq 10\%$ (measured in direction of surge current) No visible damage
Surge current derating, 2 ms	CECC 42 000, test C 2.1 100 surge currents (2 ms), unipolar, interval 120 s, amplitude corresponding to derating curve for 100 impulses at 2 ms	$\lvert \Delta V/V \text{ (1 mA)} \rvert \leq 10\%$ (measured in direction of surge current) No visible damage

v/i characteristics

v = f (i) – for explanation of the characteristics refer to "General technical information", 1.6.3

A = Leakage current } for worst-case varistor tolerances
B = Protection level } for worst-case varistor tolerances

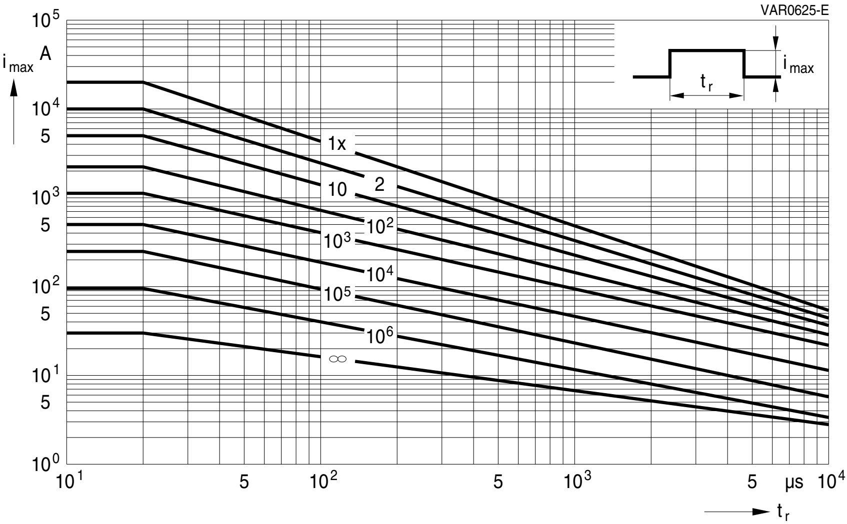


SIOV-S25 … E4R12

Derating curves

Maximum surge current i_{max} = f (t_r, pulse train)

For explanation of the derating curves refer to “General technical information”, section 1.8.1



SIOV-S25 … E4R12

Construction

- Square varistor element, leaded
- Coating: epoxy resin, flame-retardant to UL 94 V-0
- Terminals: tinned copper wire

Features

- High-EnergetiQ series Q14/Q20
- Maximum load capacity at minimum component height
- Very high surge current ratings up to 15 kA
- PSpice models

Approvals

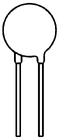
- UL
- CSA
- CECC
- VDE
- IEC

Delivery mode

- Bulk (standard), taped versions on reel or in Ammo pack upon request.
- For further details refer to chapter "Taping, packaging and lead configuration" for leaded varistors.

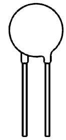
General technical data

Climatic category	to IEC 60068-1	40/85/56	
Operating temperature	to CECC 42 000	–40 … + 85	°C
Storage temperature		–40 … +125	°C
Electric strength	to CECC 42 000	≥2.5	kV_{RMS}
Insulation resistance	to CECC 42 000	≥10	MΩ
Response time		<25	ns



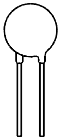
Maximum ratings (T_A = 85 °C)

Ordering code	Type (untaped) SIOV-	V_{RMS} V	V_{DC} V	i_{max} (8/20 μs) A	W_{max} (2 ms) J	P_{max} W
B72214Q0131K101	Q14K130	130	170	8000	75	0.80
B72220Q0131K101	Q20K130	130	170	15000	100	1.20
B72214Q0141K101	Q14K140	140	180	8000	80	0.80
B72220Q0141K101	Q20K140	140	180	15000	110	1.20
B72214Q0151K101	Q14K150	150	200	8000	85	0.80
B72220Q0151K101	Q20K150	150	200	15000	120	1.20
B72214Q0171K101	Q14K175	175	225	8000	100	0.80
B72220Q0171K101	Q20K175	175	225	15000	135	1.20
B72214Q0211K101	Q14K210	210	270	8000	115	0.80
B72220Q0211K101	Q20K210	210	270	15000	165	1.20
B72214Q0231K101	Q14K230	230	300	8000	130	0.80
B72220Q0231K101	Q20K230	230	300	15000	180	1.20
B72214Q0251K101	Q14K250	250	320	8000	140	0.80
B72220Q0251K101	Q20K250	250	320	15000	195	1.20
B72214Q0271K101	Q14K275	275	350	8000	150	0.80
B72220Q0271K101	Q20K275	275	350	15000	215	1.20
B72214Q0301K101	Q14K300	300	385	8000	175	0.80
B72220Q0301K101	Q20K300	300	385	15000	235	1.20
B72214Q0321K101	Q14K320	320	420	8000	185	0.80
B72220Q0321K101	Q20K320	320	420	15000	255	1.20

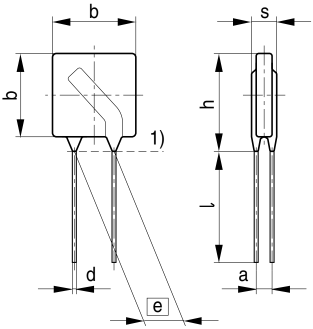


Characteristics (T_A = 25 °C)

Ordering code	V_v (1 mA) V	ΔV_v (1 mA) %	$v_{c, max}$ (i_c) V	i_c A	C_{typ} (1 kHz) pF
B72214Q0131K101	205	±10	340	65	980
B72220Q0131K101	205	±10	340	130	1950
B72214Q0141K101	220	±10	360	65	900
B72220Q0141K101	220	±10	360	130	1800
B72214Q0151K101	240	±10	395	65	830
B72220Q0151K101	240	±10	395	130	1650
B72214Q0171K101	270	±10	455	65	750
B72220Q0171K101	270	±10	455	130	1500
B72214Q0211K101	330	±10	550	65	600
B72220Q0211K101	330	±10	550	130	1200
B72214Q0231K101	360	±10	595	65	550
B72220Q0231K101	360	±10	595	130	1100
B72214Q0251K101	390	±10	650	65	500
B72220Q0251K101	390	±10	650	130	1000
B72214Q0271K101	430	±10	710	65	470
B72220Q0271K101	430	±10	710	130	930
B72214Q0301K101	470	±10	775	65	430
B72220Q0301K101	470	±10	775	130	850
B72214Q0321K101	510	±10	840	65	390
B72220Q0321K101	510	±10	840	130	780



Dimensional drawing



1) Seating plane to IEC 60717

VAR0393-T

Weight

Nominal diameter mm	V_{RMS} V	Weight g
14	130 … 320	2.4 … 3.6
20	130 … 320	4.1 … 6.5

The weight of varistors in between these voltage classes can be interpolated.

Dimensions

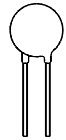
Ordering code	e ±1 mm	a ±1 mm	b_{max} mm	s_{max} mm	h_{max} mm	l_{min} mm	d ±0.05 mm
B72214Q0131K101	10.0	1.9	16.5	5.0	19.5	25.0	1.0
B72220Q0131K101	10.0	1.9	22.5	5.0	27.0	25.0	1.0
B72214Q0141K101	10.0	2.0	16.5	5.1	19.5	25.0	1.0
B72220Q0141K101	10.0	2.0	22.5	5.1	27.0	25.0	1.0
B72214Q0151K101	10.0	2.1	16.5	5.2	19.5	25.0	1.0
B72220Q0151K101	10.0	2.1	22.5	5.2	27.0	25.0	1.0
B72214Q0171K101	10.0	2.2	16.5	5.3	19.5	25.0	1.0
B72220Q0171K101	10.0	2.2	22.5	5.3	27.0	25.0	1.0
B72214Q0211K101	10.0	2.2	16.5	5.4	19.5	25.0	1.0
B72220Q0211K101	10.0	2.2	22.5	5.4	27.0	25.0	1.0
B72214Q0231K101	10.0	2.3	16.5	5.5	19.5	25.0	1.0
B72220Q0231K101	10.0	2.3	22.5	5.5	27.0	25.0	1.0
B72214Q0251K101	10.0	2.4	16.5	5.7	19.5	25.0	1.0
B72220Q0251K101	10.0	2.4	22.5	5.7	27.0	25.0	1.0
B72214Q0271K101	10.0	2.6	16.5	5.8	19.5	25.0	1.0
B72220Q0271K101	10.0	2.6	22.5	5.8	27.0	25.0	1.0
B72214Q0301K101	10.0	2.8	16.5	6.1	19.5	25.0	1.0
B72220Q0301K101	10.0	2.8	22.5	6.1	27.0	25.0	1.0
B72214Q0321K101	10.0	2.9	16.5	6.3	19.5	25.0	1.0
B72220Q0321K101	10.0	2.9	22.5	6.3	27.0	25.0	1.0

Reliability data

Test	Test methods/conditions	Requirement
Varistor voltage	The voltage between two terminals with the specified measuring current applied is called V_v (1 mA_{DC} @ 0.2 … 2 s).	To meet the specified value.
Clamping voltage	The maximum voltage between two terminals with the specified standard impulse current (8/20 µs) applied.	To meet the specified value.
Max. AC operating voltage	CECC 42 000, test 4.20 1000 h at UCT After having continuously applied the maximum allowable voltage at UCT ±2 °C for 1000 h, the specimen shall be stored at room temperature and normal humidity for 1 to 2 h. Thereafter, the change of V_v shall be measured.	|ΔV/V (1 mA)| ≤10%
Surge current derating, 8/20 µs	CECC 42 000, test C 2.1 100 surge currents (8/20 µs), unipolar, interval 30 s, amplitude corresponding to derating curve for 100 impulses at 20 µs	|ΔV/V (1 mA)| ≤10% (measured in direction of surge current) No visible damage
Surge current derating, 2 ms	CECC 42 000, test C 2.1 100 surge currents (2 ms), unipolar, interval 120 s, amplitude corresponding to derating curve for 100 impulses at 2 ms	|ΔV/V (1 mA)| ≤10% (measured in direction of surge current) No visible damage
Electric strength	CECC 42 000, test 4.7 Metal balls method, 2500 V_{RMS}, 60 s The varistor is placed in a container holding 1.6 ±0.2 mm diameter metal balls such that only the terminations of the varistor are protruding. The specified voltage shall be applied between both terminals of the speci-men connected together and the elec-trode inserted between the metal balls.	No breakdown

Reliability data

Test	Test methods/conditions	Requirement
Climatic sequence	CECC 42 000, test 4.16 The specimen shall be subjected to: a) dry heat at UCT, 16 h b) damp heat, 1st cycle: 55 °C, 93% r. H., 24 h c) cold, LCT, 2 h d) damp heat, additional 5 cycles: 55 °C/25 °C, 93% r. H., 24 h/cycle. Then the specimen shall be stored at room temperature and normal humidity for 1 to 2 h. Thereafter, the change of V_v shall be measured. Thereafter, insulation resistance R_{ins} shall be measured according to CECC 42 000, test 4.8 at V = 500 V.	$\|\Delta V/V\ (1\ mA)\| \leq 10\%$ $R_{ins} \geq 1\ M\Omega$
Fast temperature cycling	IEC 60068-2-14, test Na, LCT/UCT, dwell time 30 min, 5 cycles	$\|\Delta V/V\ (1\ mA)\| \leq 5\%$ No visible damage
Damp heat, steady state	The specimen shall be subjected to 40 ±2 °C, 90 to 95% r. H. for 56 days without load / with 10% of the maximum continuous DC operating voltage V_{DC}. Then stored at room temperature and normal humidity for 1 to 2 h. Thereafter, the change of V_v shall be measured. Thereafter, insulation resistance R_{ins} shall be measured according to CECC 42 000, test 4.8 at V = 500 V.	$\|\Delta V/V\ (1\ mA)\| \leq 10\%$ $R_{ins} \geq 1\ M\Omega$
Solderability	IEC 60068-2-20, test Ta, method 1 with modified conditions for lead-free solder alloys: 245 °C, 3 s: After dipping the terminals to a depth of approximately 3 mm from the body in a soldering bath of 245 °C for 3 s, the terminals shall be visually examined.	The inspection shall be carried out under adequate light with normal eyesight or with the assistance of a magnifier capable of giving a magnification of 4 to 10 times. The dipped surface shall be covered with a smooth and bright solder coating with no more than small amounts of scattered imperfections such as pinholes or un-wetted or de-wetted areas. These imperfections shall not be concentrated in one area.



Reliability data

Test	Test methods/conditions	Requirement
Resistance to soldering heat	IEC 60068-2-20, test Tb, method 1A, 260 °C, 10 s: Each lead shall be dipped into a solder bath having a temperature of 260 ±5 °C to a point 2.0 to 2.5 mm from the body of the specimen, be held there for 10 ±1 s and then be stored at room temperature and normal humidity for 1 to 2 h. The change of V_v shall be measured and the specimen shall be visually examined.	$\vert\Delta V/V\ (1\ mA)\vert \leq 5\%$ No visible damage
Tensile strength	IEC 60068-2-21, test Ua1 After gradually applying the force specified below and keeping the unit fixed for 10 s, the terminal shall be visually examined for any damage. Force for wire diameter: 1.0 mm = 20 N	$\vert\Delta V/V\ (1\ mA)\vert \leq 5\%$ No break of solder joint, no wire break
Vibration	IEC 60068-2, test Fc Frequency range: 10 … 55 Hz Amplitude: 0.75 mm or 98 m/s² Duration: 6 h (3 · 2 h) Pulse: sine wave After repeatedly applying a single harmonic vibration according to the table above. The change of V_v shall be measured and the specimen shall be visually examined.	$\vert\Delta V/V\ (1\ mA)\vert \leq 5\%$ No visible damage
Bump	IEC 60068-2-29, test Eb Pulse duration: 6 ms Max. acceleration: 400 m/s² Number of bumps: 4000 Pulse: half sine	$\vert\Delta V/V\ (1\ mA)\vert \leq 5\%$ No visible damage
Flammability	IEC 60695-2-2 (needle flame test) Severity: vertical 10 s	5 s max.

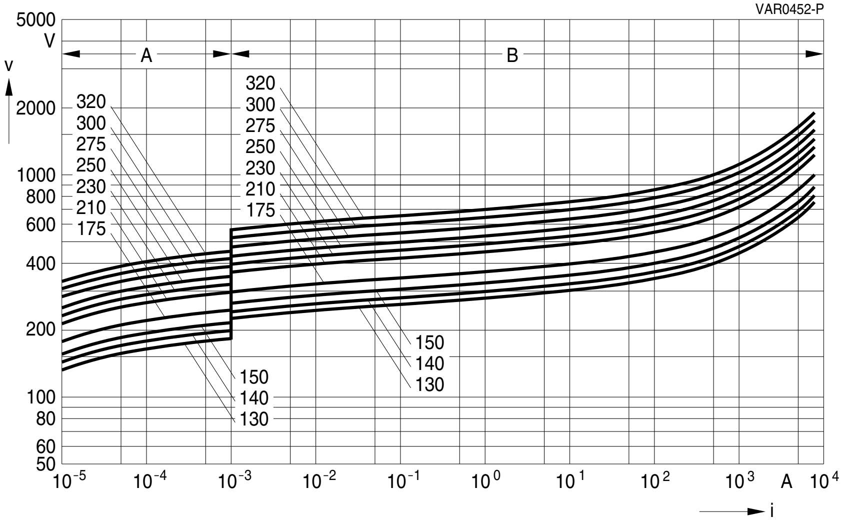
Note:

UCT = Upper category temperature
LCT = Lower category temperature
R_{ins} = Insulation resistance to CECC 42 000, test 4.8

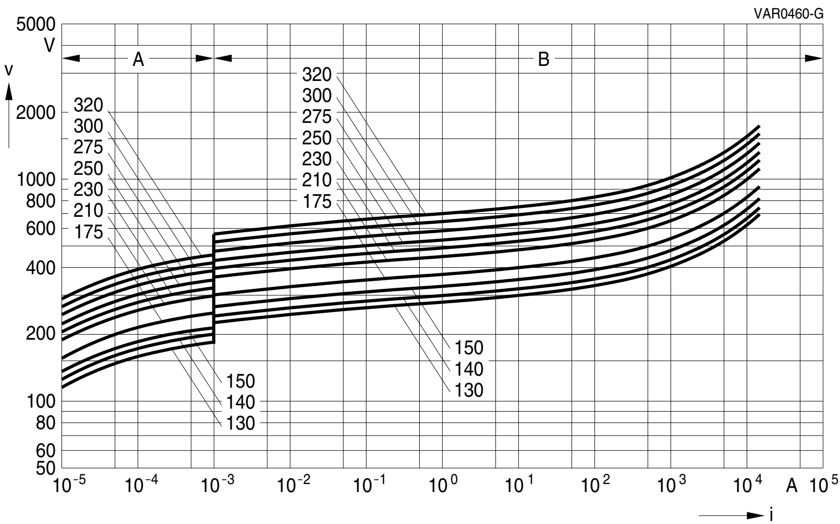
v/i characteristics

v = f (i) – for explanation of the characteristics refer to "General technical information", 1.6.3

A = Leakage current } for worst-case varistor tolerances
B = Protection level }



SIOV-Q14 …

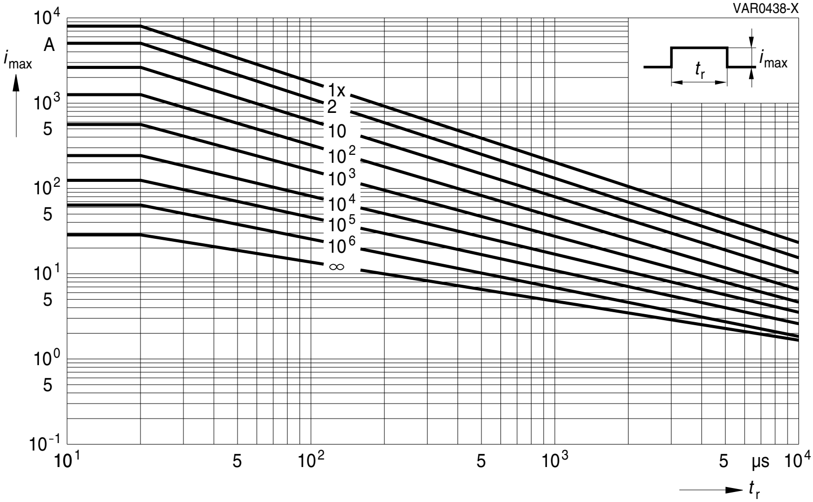


SIOV-Q20 …

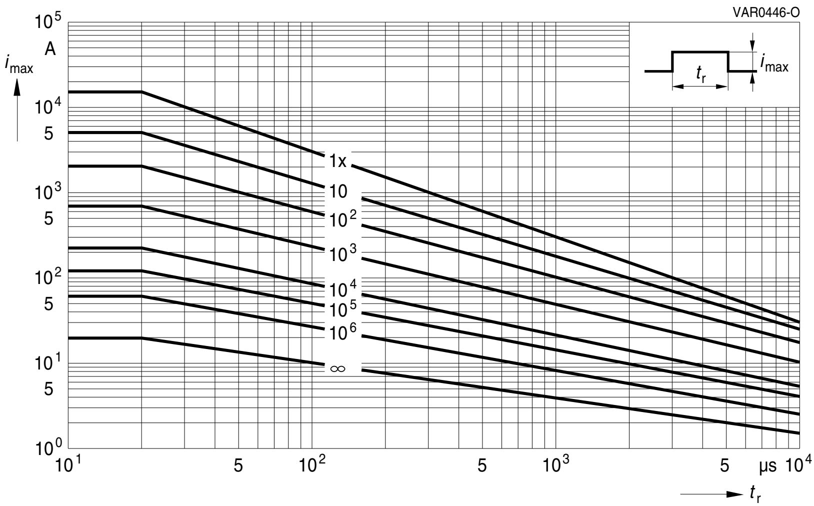
Derating curves

Maximum surge current $i_{max} = f(t_r$, pulse train)

For explanation of the derating curves refer to “General technical information”, section 1.8.1



SIOV-Q14K130 … K320



SIOV-Q20K130 … K320

Construction

- Round varistor element, leaded
- Coating: epoxy resin (D1: phenolic resin), flame-retardant to UL 94 V-0
- Terminals: tinned copper wire

Features

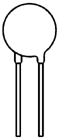
- High energy absorption, particularly for load dump
- Jump-start strength
- Stable protection level, minimum leakage current
- High resistance to cyclic temperature stress
- PSpice models
- High operating temperature range up to 125 °C

Delivery mode

- Bulk (standard), taped versions on reel or in Ammo pack upon request.
- For further details refer to chapter "Taping, packaging and lead configuration" for leaded varistors.

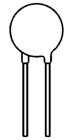
General technical data

Climatic category	to IEC 60068-1	40/85/56	
	for …D1 types	40/125/56	
Operating temperature	to CECC 42 000	– 40 … + 85	°C
	for …D1 types	– 40 … +125	
Storage temperature		– 40 … +125	°C
	for …D1 types	– 40 … +150	
Electric strength	to CECC 42 000	≥2.5 (not D1 types)	kV_{RMS}
Insulation resistance	to CECC 42 000	≥10 (not D1 types)	MΩ
Response time		<25	ns



Maximum ratings (T_A = 85 °C, T_A = 125 °C for S…D1 types)

Ordering code	Type (untaped) SIOV-	V_{RMS} V	V_{DC} V	i_{max} (8/20 μs) A	W_{max} (2 ms) J	P_{max} W	W_{LD} (10x) J
12-V supply systems							
B72207S1140K201	S07K14AUTOS2D1	14	16	250	0.9	0.02	12
B72210S1140K102	S10K14AUTO	14	16	500	2.0	0.05	25
B72210S1140K501	S10K14AUTOS5D1	14	16	500	2.0	0.05	25
B72214S1140K102	S14K14AUTO	14	16	1000	4.0	0.10	50
B72214S1140K501	S14K14AUTOS5D1	14	16	1000	4.0	0.10	50
B72220S1140K102	S20K14AUTO	14	16	2000	12.0	0.20	100
B72210S1170K102	S10K17AUTO	17	20	500	2.5	0.05	25
B72214S1170K102	S14K17AUTO	17	20	1000	5.0	0.10	50
B72220S1170K102	S20K17AUTO	17	20	2000	14.0	0.20	100
24-V supply systems							
B72220S1250K102	S20K25AUTO	25	28	2000	22.0	0.20	100
B72214S1300K102	S14K30AUTO	30	34	1000	9.0	0.10	50
B72220S1300K102	S20K30AUTO	30	34	2000	26.0	0.20	100

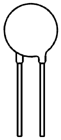


Characteristics (T_A = 25 °C)

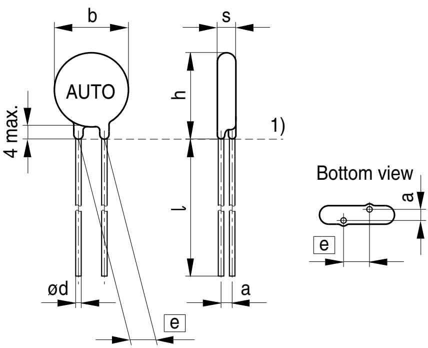
Ordering code	V_{Jump} (5 min) V	V_v (1 mA) V	ΔV_v (1 mA) %	$v_{c,\,max}$ (i_c) V	i_c A	C_{typ} (1 kHz) nF
12-V supply systems						
B72207S1140K201	25	22	±10	43	2.5	2.3
B72210S1140K102	25	22	±10	43	5.0	5.2
B72210S1140K501	25	22	±10	43	5.0	5.2
B72214S1140K102	25	22	±10	43	10.0	10.0
B72214S1140K501	25	22	±10	43	10.0	10.0
B72220S1140K102	25	22	±10	43	20.0	19.0
B72210S1170K102	30	27	±10	53	5.0	4.4
B72214S1170K102	30	27	±10	53	10.0	8.2
B72220S1170K102	30	27	±10	53	20.0	15.6
24-V supply systems						
B72220S1250K102	40	39	±10	77	20.0	11.1
B72214S1300K102	45	47	±10	93	10.0	5.0
B72220S1300K102	45	47	±10	93	20.0	9.4

Notes

- If the maximum loads specified for load dump and jump start are fully utilized, subsequent polarity reversal of the AUTO varistors is inadmissible.
- If the load remains under the maximum ratings, polarity reversal may be admissible. Contact EPCOS for consultancy on this kind of problem.
- Load dump or jump start can decrease the varistor voltage in load direction by max. 15%.
- Load dump: min. time of energy input 40 ms, interval 60 s.



Dimensional drawing



1) Seating plane to IEC 60717

VAR0401-Y

Weight

Nominal diameter mm	V_{RMS} V	Weight g
7	14	0.6 … 0.8
10	14; 17	1.0 … 2.0
14	14; 17; 30	2.0 … 4.0
20	14; 17; 25; 30	3.0 … 6.0

Dimensions

Ordering code	e ±1 mm	a ±1 mm	b_{max} mm	s_{max} mm	h_{max} mm	l_{min} mm	d ±0.05 mm
B72207S1140K201	5.0	1.3	9.0	3.5	12.5	25.0	0.6
B72210S1140K102	7.5	1.5	13.0	5.0	16.5	25.0	0.8
B72210S1140K501	7.5	1.5	12.0	4.0	16.0	25.0	0.8
B72214S1140K102	7.5	1.5	17.0	5.0	20.5	25.0	0.8
B72214S1140K501	7.5	1.5	16.0	4.0	20.0	25.0	0.8
B72220S1140K102	10.0	1.6	23.0	5.4	27.5	25.0	1.0
B72210S1170K102	7.5	1.6	13.0	5.1	16.5	25.0	0.8
B72214S1170K102	7.5	1.7	17.0	5.1	20.5	25.0	0.8
B72220S1170K102	10.0	1.6	23.0	5.6	27.5	25.0	1.0
B72220S1250K102	10.0	2.9	23.0	6.2	27.5	25.0	1.0
B72214S1300K102	7.5	1.8	17.0	5.3	20.5	25.0	0.8
B72220S1300K102	10.0	3.2	23.0	6.5	27.5	25.0	1.0

For crimp styles S2 and S5 refer to chapter “Taping, packaging and lead configuration”.

Reliability data

Test	Test methods/conditions	Requirement
Varistor voltage	The voltage between two terminals with the specified measuring current applied is called V_v (1 mA_{DC} @ 0.2 … 2 s).	To meet the specified value.
Clamping voltage	The maximum voltage between two terminals with the specified standard impulse current (8/20 µs) applied.	To meet the specified value.
Max. DC operating voltage	MIL STD 202F, method 108A, UCT, V_{DC}, 1000 h	$\|\Delta V/V$ (1 mA)$\| \leq 10\%$ No visible damage
Load dump	ISO 7637-1, test pulse 5 (“load dump”) (DIN 40 839 Part 1; impulse 5) 7 mm varistors (S07K…AUTO…): 10 × 12 J 10 mm varistors (S10K…AUTO…): 10 × 25 J 14 mm varistors (S14K…AUTO…): 10 × 50 J 20 mm varistors (S20K…AUTO…): 10 × 100 J (minimum 40 ms time of energy input, 60 s interval)	$\Delta V/V$ (1 mA) $\leq 15\%$ No visible damage
Jump start	$V_{DC,\ load} = V_{jump}$; 5 min duration 14 V (S…K14AUTO…); V_{jump} = 25 V 17 V (S…K17AUTO…); V_{jump} = 30 V 25 V (S…K25AUTO…); V_{jump} = 40 V 30 V (S…K30AUTO…); V_{jump} = 45 V	$\Delta V/V$ (1 mA) $\leq 15\%$ No visible damage
Fast temperature cycling	IEC 60068-2-14, test Na, LCT/UCT, dwell time 15 min, 100 cycles for SIOV…AUTO types and dwell time 15 min, 1000 cycles for SIOV…AUTOD1 types	$\|\Delta V/V$ (1 mA)$\| \leq 5\%$ No visible damage
Damp heat, steady state	IEC 60068-2-67, test Cy, 85% r. H., V_{DC}, 1000 h	$\|\Delta V/V$ (1 mA)$\| \leq 10\%$ No visible damage

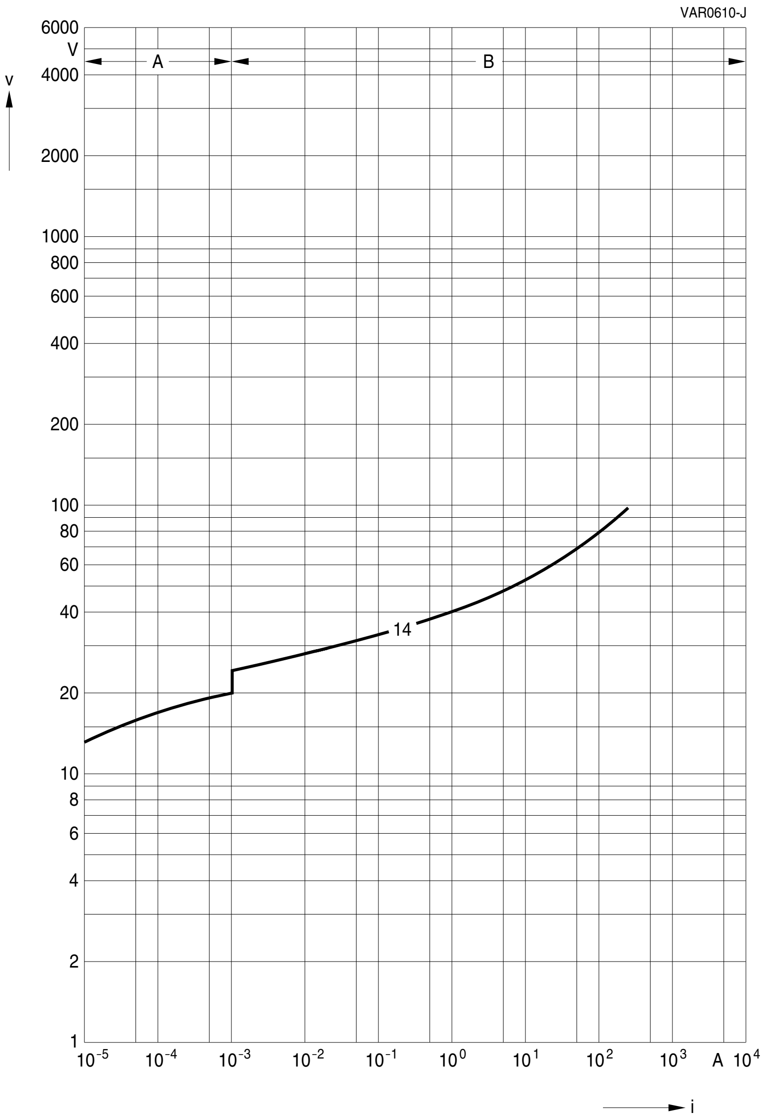
Note:

UCT = Upper category temperature
LCT = Lower category temperature

v/i characteristics

v = f (i) – for explanation of the characteristics refer to “General technical information”, 1.6.3

A = Leakage current, B = Protection level – for worst-case varistor tolerances

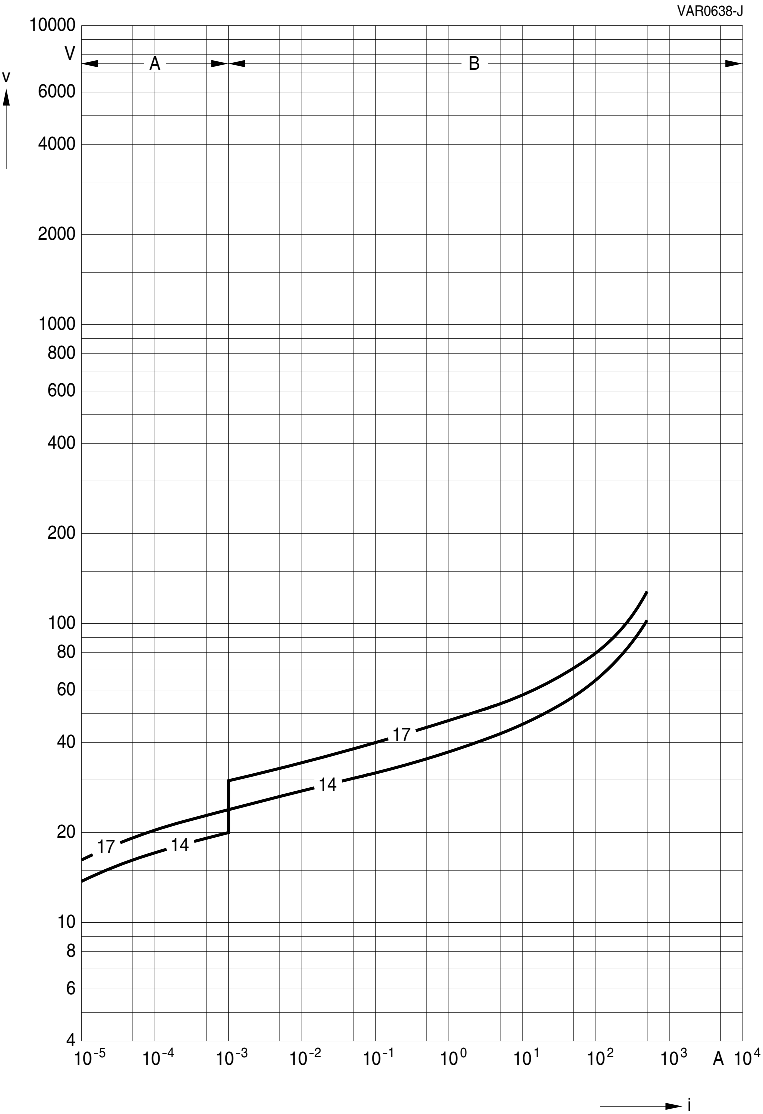


SIOV-S07 … D1

v/i characteristics

v = f (i) – for explanation of the characteristics refer to "General technical information", 1.6.3

A = Leakage current } for worst-case
B = Protection level } varistor tolerances

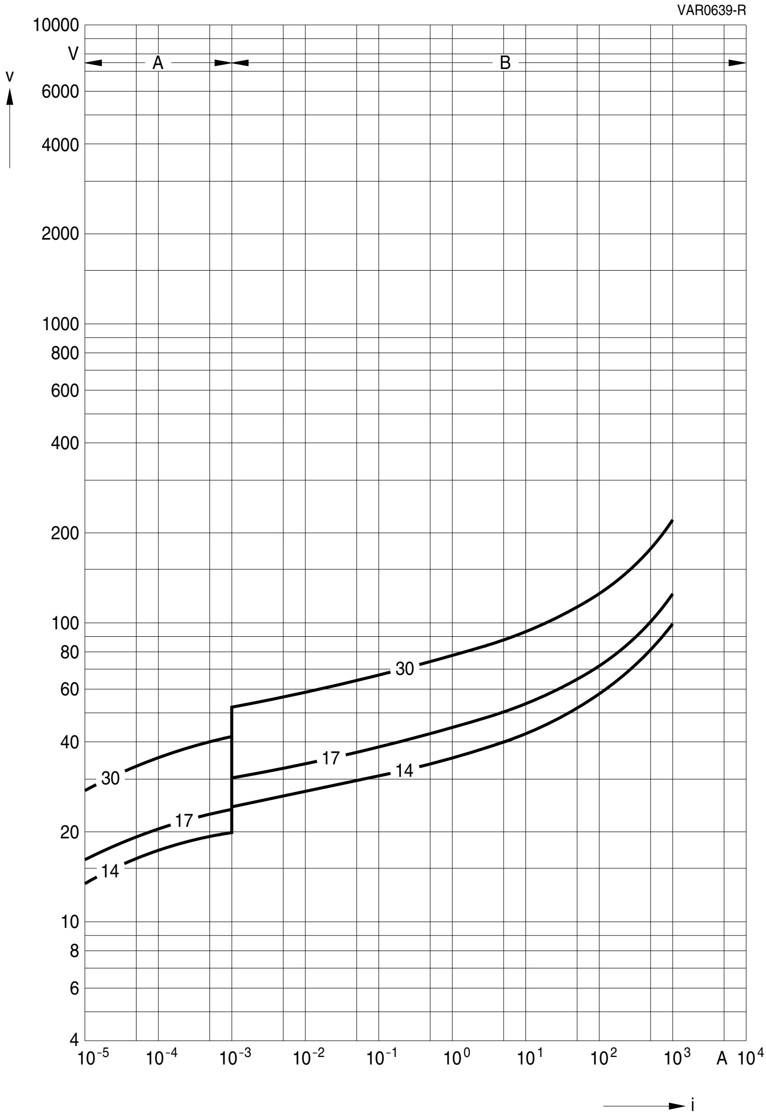


SIOV-S10 … (AUTO)(D1)

v/i characteristics

v = f (i) – for explanation of the characteristics refer to “General technical information”, 1.6.3

A = Leakage current } for worst-case varistor tolerances
B = Protection level } for worst-case varistor tolerances

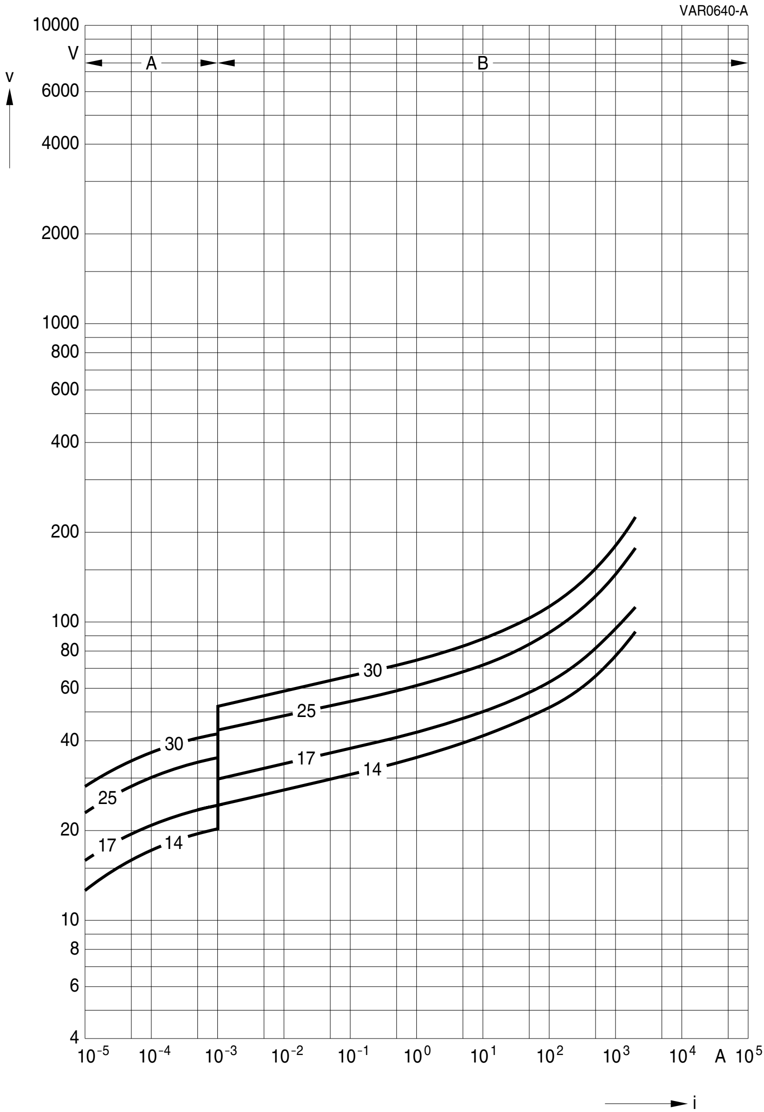


SIOV-S14 … (AUTO)(D1)

v/i characteristics

v = f (i) – for explanation of the characteristics refer to "General technical information", 1.6.3

A = Leakage current, B = Protection level – for worst-case varistor tolerances

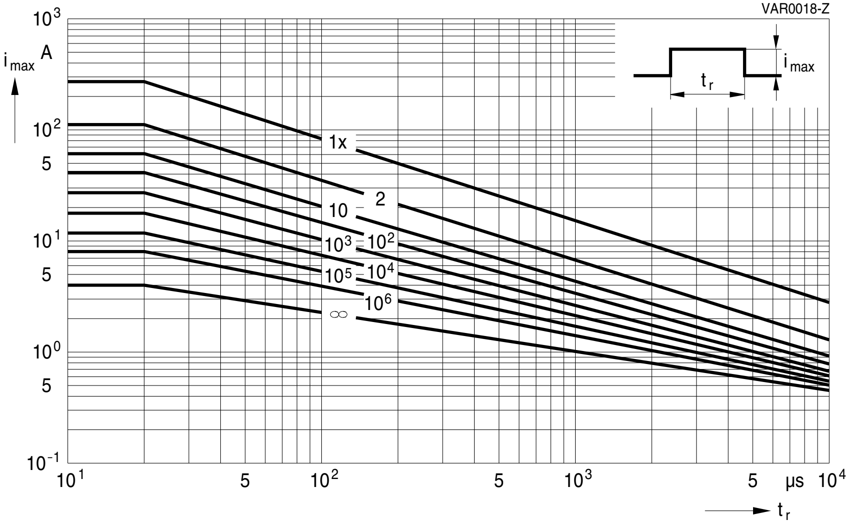


SIOV-S20 … AUTO

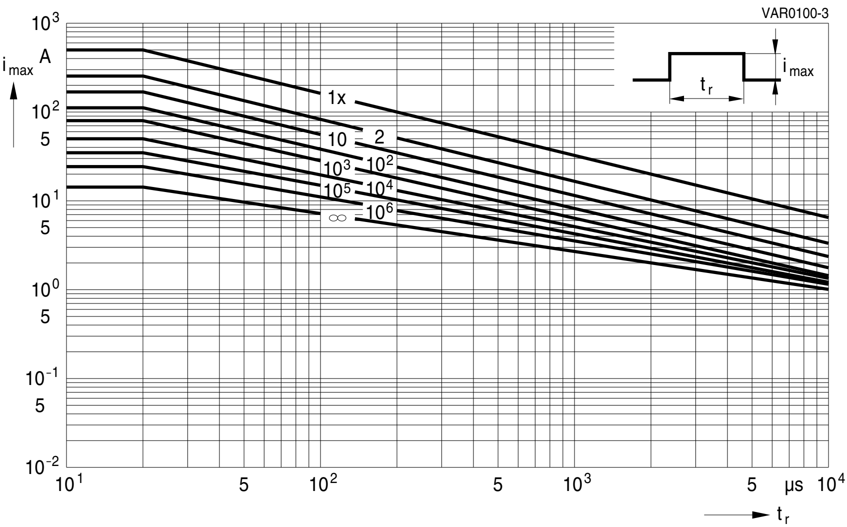
Derating curves

Maximum surge current $i_{max} = f(t_r$, pulse train)

For explanation of the derating curves refer to “General technical information”, section 1.8.1



SIOV-S07K14AUTOS2D1

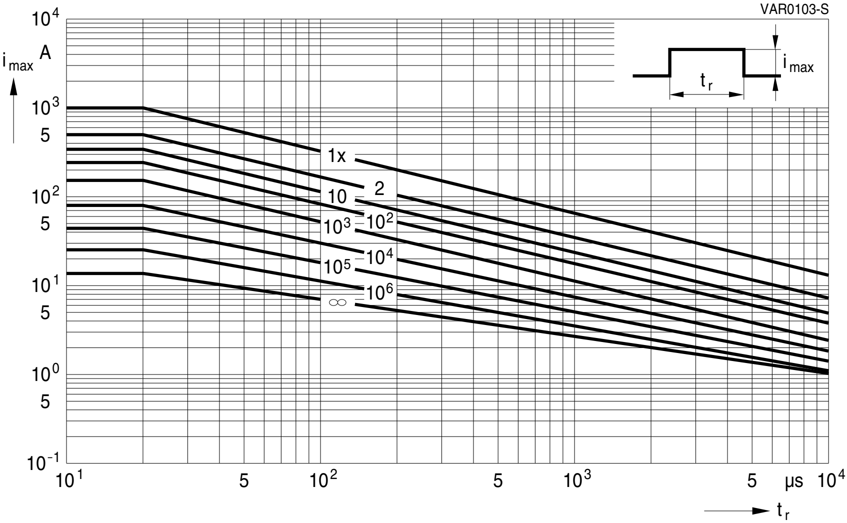


SIOV-S10K14AUTO … K17AUTO **SIOV-S10K14AUTOS5D1**

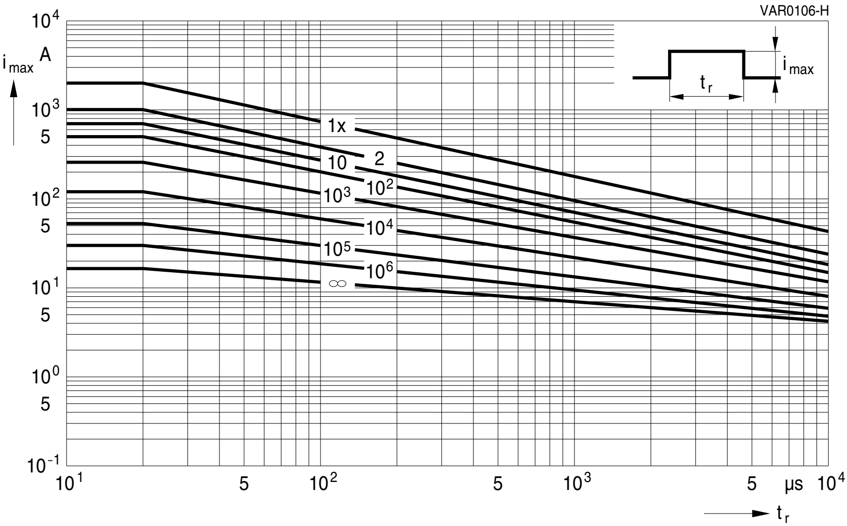
Derating curves

Maximum surge current $i_{max} = f(t_r$, pulse train)

For explanation of the derating curves refer to “General technical information”, section 1.8.1



SIOV-S14K14AUTO … K30AUTO **SIOV-S14K14AUTOS5D1**



SIOV-S20K14AUTO … K30AUTO

Construction

- Round varistor element, leaded
- Coating: phenolic resin
- Terminals: tinned copper wire

Features

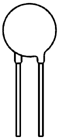
- Automotive series for 42 V supply systems
- This series complies with the electrical requirements for the new 42 V board net as specified in draft standard ISO/TC22 WD42V-1E
- Stable protection level, minimum leakage current
- High resistance to cyclic temperature stress: 1000 cycles
- High operating temperature up to 125 °C

Delivery mode

- Bulk (standard), taped versions on reel or in Ammo pack upon request.
- For further details refer to chapter "Taping, packaging and lead configuration" for leaded varistors.

General technical data

Climatic category	to IEC 60068-1	40/125/56	
Operating temperature	to CECC 42 000	– 40 … +125	°C
Storage temperature		– 40 … +150	°C
Response time		<25	ns



EPCOS

Maximum ratings (T_A = 125 °C)

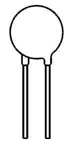
Ordering code	Type (untaped) SIOV-	$V_{RMS, op, max}$ 1) V_{DC}	$V_{op, max}$ 2) V_{DC}	$V_{max, dyn}$ 3) V_{DC}	W_{max} (2 ms) J	P_{max} W
42 V supply systems						
B72207S1390K201	S07V42AUTOS2D1	48	50	58	3.0	0.02
B72210S1390K501	S10V42AUTOS5D1	48	50	58	6.4	0.05
B72214S1390K501	S14V42AUTOS5D1	48	50	58	13.0	0.10
B72220S1390K501	S20V42AUTOS5D1	48	50	58	37.0	0.20

Note:

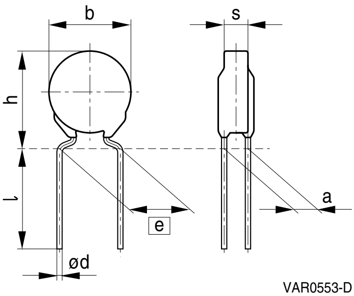
1) Root-mean-square value of max. DC operating voltage incl. ripple
2) Peak value of max. DC operating voltage incl. ripple
3) Max. dynamic overvoltage as per ISO/TC22 WD24V-1E, $t_s \leq$ 400 ms

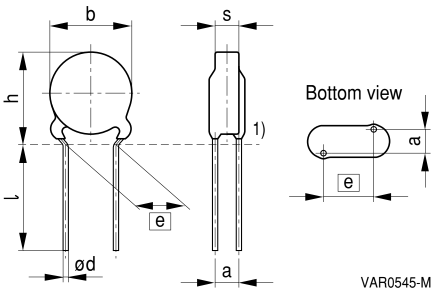
Characteristics (T_A = 25 °C)

Ordering code	Type (untaped) SIOV-	V_v (1 mA) V	ΔV_v (1 mA) %	$v_{c, max}$ (i_c) V	i_c A	C_{typ} (1 kHz) pF
42 V supply systems						
B72207S1390K201	S07V42AUTOS2D1	68	±10	135	2.5	0.90
B72210S1390K501	S10V42AUTOS5D1	68	±10	135	5.0	2.10
B72214S1390K501	S14V42AUTOS5D1	68	±10	135	10.0	3.55
B72220S1390K501	S20V42AUTOS5D1	68	±10	135	20.0	6.75



Dimensional drawings





1) Seating plane in accordance with IEC 60717

S07V42AUTOS2D1 **S10, S14, S20V42AUTOS5D1**

Dimensions

Ordering code	e ±1 mm	a ±1 mm	b_{max} mm	s_{max} mm	h_{max} mm	l_{min} mm	d ±0.05 mm
B72207S1390K201	5.0	1.7	9.0	4.1	12.0	25.0	0.6
B72210S1390K501	7.5	2.0	12.0	4.8	15.5	25.0	0.8
B72214S1390K501	7.5	2.1	16.0	4.9	20.0	25.0	0.8
B72220S1390K501	10.0	2.3	22.0	5.5	27.0	25.0	1.0

Weight

Nominal diameter mm	$V_{RMS, op, max}$ V	Weight g
7	48	0.5
10	48	1.0
14	48	2.5
20	48	5.0

Reliability data

Test	Test methods/conditions	Requirement
Varistor voltage	The voltage between two terminals with the specified measuring current applied is called V_v (1 mA_{DC} @ 0.2 … 2 s).	To meet the specified value.
Clamping voltage	The maximum voltage between two terminals with the specified standard impulse current (8/20 µs) applied.	To meet the specified value.
Max. DC operating voltage	MIL STD 202F, method 108A, UCT, V_{DC}, 1000 h	$\|\Delta V/V$ (1 mA)$\| \leq 10\%$ No visible damage
Fast temperature cycling	IEC 60068-2-14, test Na, LCT/UCT, dwell time 15 min, 100 cycles for SIOV…AUTO types and dwell time 15 min, 1000 cycles for SIOV…AUTOD1 types	$\|\Delta V/V$ (1 mA)$\| \leq 5\%$ No visible damage
Damp heat, steady state	IEC 60068-2-67, test Cy, 85% r. H., V_{DC}, 1000 h	$\|\Delta V/V$ (1 mA)$\| \leq 10\%$ No visible damage

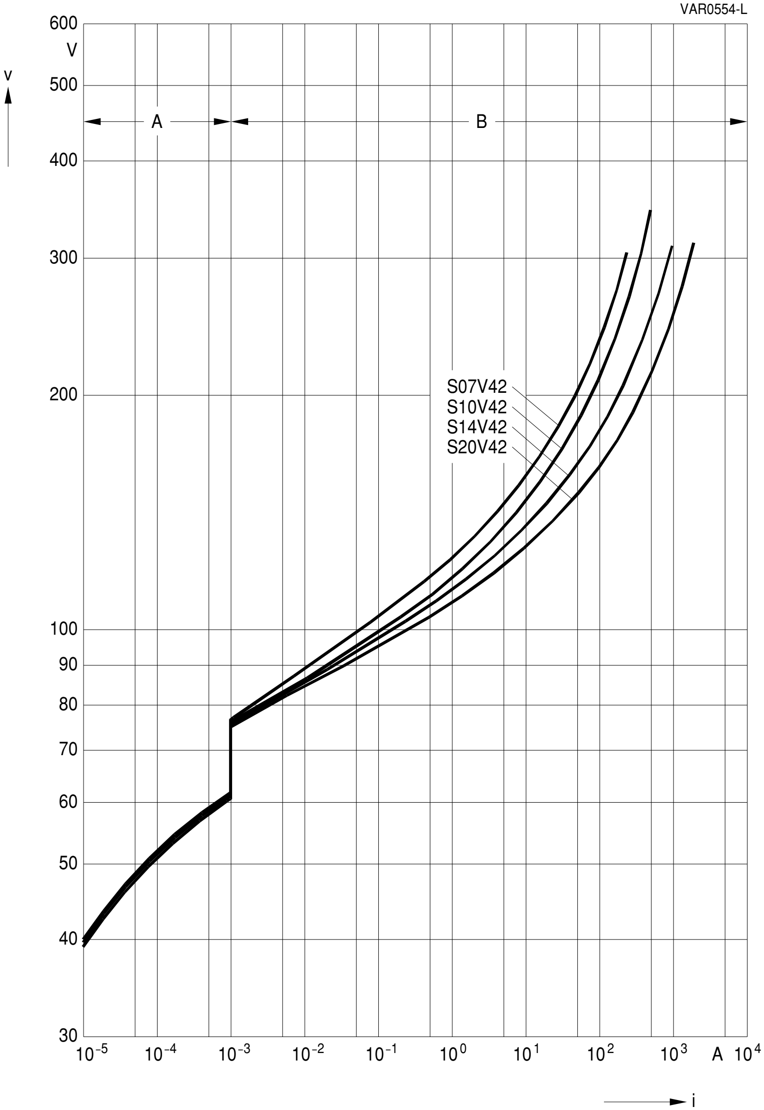
Note:

UCT = Upper category temperature
LCT = Lower category temperature

v/i characteristics

v = f (i) – for explanation of the characteristics refer to “General technical information”, 1.6.3

A = Leakage current } for worst-case varistor tolerances
B = Protection level } for worst-case varistor tolerances

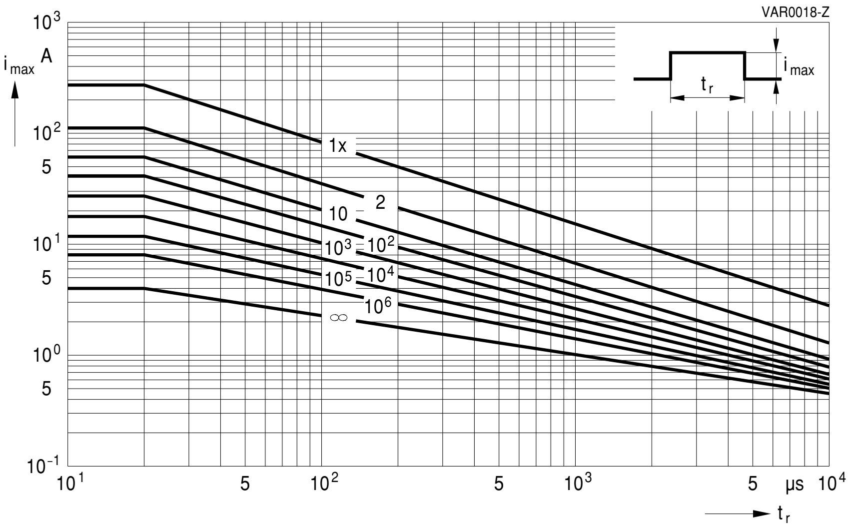


SIOV-S07V42AUTOS2D1 **SIOV-S10(-S14)(-S20)V42AUTOS5D1**

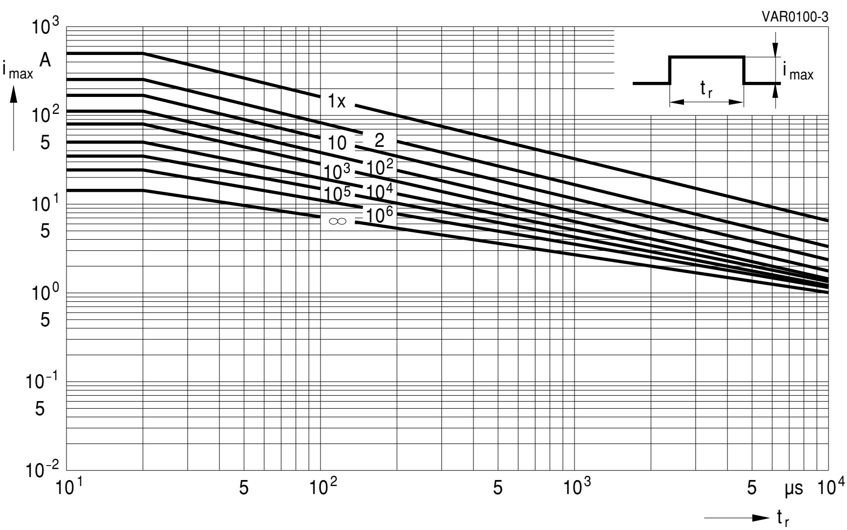
Derating curves

Maximum surge current $i_{max} = f(t_r, \text{pulse train})$

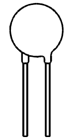
For explanation of the derating curves refer to “General technical information”, section 1.8.1



SIOV-S07V42AUTOS2D1



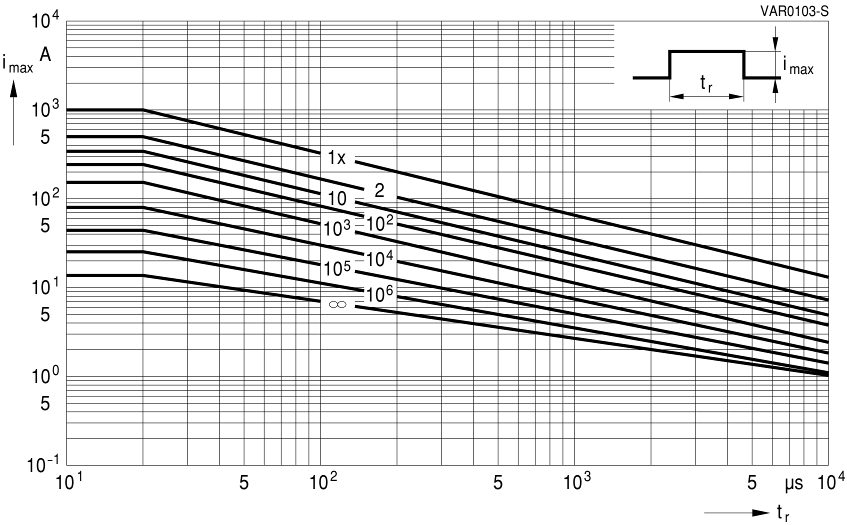
SIOV-S10V42AUTOS5D1



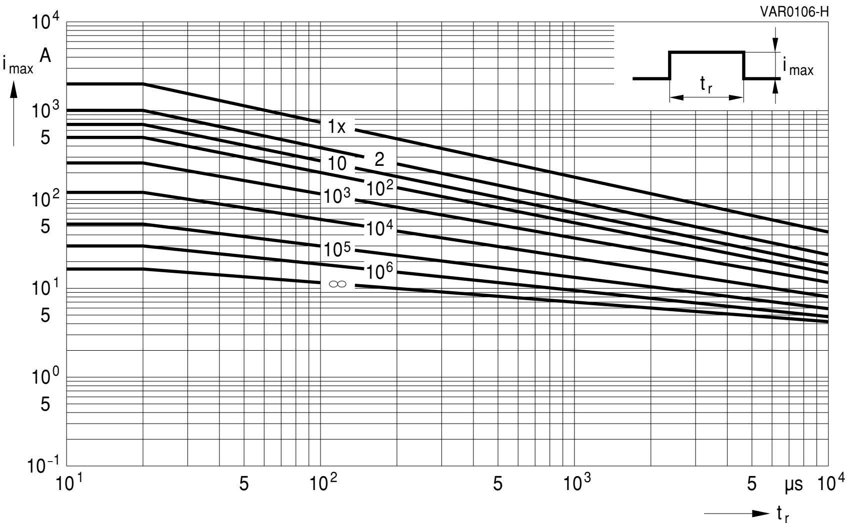
Derating curves

Maximum surge current i_{max} = f (t_r, pulse train)

For explanation of the derating curves refer to "General technical information", section 1.8.1



SIOV-S14V42AUTOS5D1



SIOV-S20V42AUTOS5D1

Leaded varistors

Telecom series

Construction

- Round varistor element, leaded
- Coating: epoxy resin, flame-retardant to UL 94 V-0
- Terminals: tinned copper wire

Features

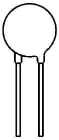
- Suitable for handling the surge current of the 10/700 µs pulse to ITU-T and IEC 1000-4-5
- Suitable for handling the increased surge voltage according to the directives of Germany's Central Telecommunications Engineering Bureau (FTZ)
- Matched to line conditions with or without superimposed ringing voltage
- PSpice models

Delivery mode

- Bulk (standard), taped versions on reel or in Ammo pack upon request.
- For further details refer to chapter "Taping, packaging and lead configuration" for leaded varistors.

General technical data

Climatic category	to IEC 60068-1	40/85/56	
Operating temperature	to CECC 42 000	– 40 … + 85	°C
Storage temperature		– 40 … +125	°C
Electric strength	to CECC 42 000	≥2.5	kV_{RMS}
Insulation resistance	to CECC 42 000	≥10	MΩ
Response time		<25	ns



Maximum ratings (T_A = 85 °C)

Ordering code	Type SIOV-	V_{RMS} V	V_{DC} V	i (10 × 10/700 µs) A 1)	i_{max} (8/20 µs) A	W_{max} (2 ms) J	P_{max} W
B72207S0600S212	S07S60AGS2	60	85	45	1200	4.8	0.25
B72207S0950S212	S07S95AGS2	95	125	45	1200	7.6	0.25

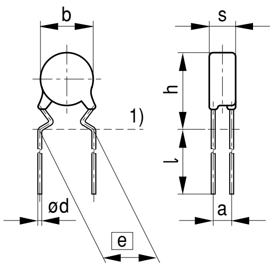
Characteristics (T_A = 25 °C)

Ordering code	Type SIOV-	V_v (1 mA) V	ΔV_v (1 mA) %	$v_{c,\,max}$ (i_c) V	i_c A	C_{typ} (1 kHz) pF
B72207S0600S212	S07S60AGS2	100	+18/−1	200	45	480
B72207S0950S212	S07S95AGS2	150	+10/−2	270	45	260

Note

In addition to the telecom varistors listed above, all varistors of the standard series can be used for telecom applications if the selection criteria are considered.

Dimensional drawing



1) Seating plane to IEC 60717

VAR0409-K

Weight

Nominal diameter mm	V_{RMS} V	Weight g
7	60; 95	0.6 … 0.8

The weight of varistors in between these voltage classes can be interpolated.

Dimensions

Ordering code	e +0.6/-0.1 mm	a ±1 mm	b_{max} mm	s_{max} mm	h_{max} mm	l_{min} mm	d mm
B72207S0600S212	5.0	1.2	9.0	3.3	12.0	(*)	0.6
B72207S0950S212	5.0	1.3	9.0	3.4	12.0	(*)	0.6

For (*) see chapter “Taping, packaging and lead configuration”.

1) The test circuit according to figure 15 in chapter “Application notes” yields a surge current amplitude of approx. 45 A.

Reliability data

Test	Test methods/conditions	Requirement
Varistor voltage	The voltage between two terminals with the specified measuring current applied is called V_v (1 mA_{DC} @ 0.2 … 2 s).	To meet the specified value.
Clamping voltage	The maximum voltage between two terminals with the specified standard impulse current (8/20 µs) applied.	To meet the specified value.
Max. AC operating voltage	CECC 42 000, test 4.20 1000 h at UCT After having continuously applied the maximum allowable voltage at UCT ±2 °C for 1000 h, the specimen shall be stored at room temperature and normal humidity for 1 to 2 h. Thereafter, the change of V_v shall be measured.	$\vert\Delta V/V$ (1 mA)$\vert \leq$10%
Surge current derating, 8/20 µs	CECC 42 000, test C 2.1 100 surge currents (8/20 µs), unipolar, interval 30 s, amplitude corresponding to derating curve for 100 impulses at 20 µs	$\vert\Delta V/V$ (1 mA)$\vert \leq$10% (measured in direction of surge current) No visible damage
Surge current derating, 2 ms	CECC 42 000, test C 2.1 100 surge currents (2 ms), unipolar, interval 120 s, amplitude corresponding to derating curve for 100 impulses at 2 ms	$\vert\Delta V/V$ (1 mA)$\vert \leq$10% (measured in direction of surge current) No visible damage
Surge current derating, 10/700 µs	IEC 61000-4-5 Pulse current testing: 10/700 µs, open circuit voltage = 2 kV. Number of pulses: 10 (5 times for each polarity). Pulse interval 60 s.	$\vert\Delta V/V$ (1 mA)$\vert \leq$10% No visible damage
Electric strength	CECC 42 000, test 4.7 Metal balls method, 2500 V_{RMS}, 60 s The varistor is placed in a container holding 1.6 ±0.2 mm diameter metal balls such that only the terminations of the varistor are protruding. The specified voltage shall be applied between both terminals of the specimen connected together and the electrode inserted between the metal balls.	No breakdown

Reliability data

Test	Test methods/conditions	Requirement
Climatic sequence	CECC 42 000, test 4.16 The specimen shall be subjected to: a) dry heat at UCT, 16 h b) damp heat, 1st cycle: 55 °C/25 °C, 93% r. H., 24 h c) cold, LCT, 2 h d) damp heat, additional 5 cycles: 55 °C/25 °C, 93% r. H., 24 h/cycle. Then the specimen shall be stored at room temperature and normal humidity for 1 to 2 h. Thereafter, the change of V_v shall be measured. Thereafter, insulation resistance R_{ins} shall be measured according to CECC 42 000, test 4.8 at V = 500 V.	$\|\Delta V/V\ (1\ mA)\| \leq 10\%$ $R_{ins} \geq 1\ M\Omega$
Fast temperature cycling	IEC 60068-2-14, test Na, LCT/UCT, dwell time 30 min, 5 cycles: The temperature cycle shown below shall be repeated 5 times. Then the specimen shall be stored at room temperature and normal humidity for 1 to 2 h. The change of V_v and mechanical damage shall be examined. Step / Temperature / Period 1 / LCT ±3 °C / 30 ±3 min 2 / transition time / <10 s 3 / UCT ±2 °C / 30 ±3 min	$\|\Delta V/V\ (1\ mA)\| \leq 5\%$ No visible damage
Damp heat, steady state	The specimen shall be subjected to 40 ±2 °C, 90 to 95% r. H. for 56 days without load / with 10% of the maximum continuous DC operating voltage V_{DC}. Then stored at room temperature and normal humidity for 1 to 2 h. Thereafter, the change of V_v shall be measured. Thereafter, insulation resistance R_{ins} shall be measured according to CECC 42 000, test 4.8 at V = 500 V.	$\|\Delta V/V\ (1\ mA)\| \leq 10\%$ $R_{ins} \geq 1\ M\Omega$

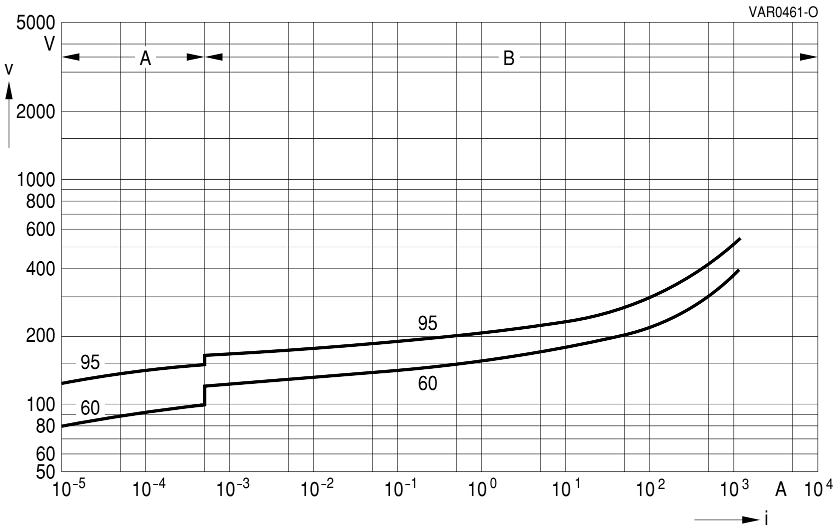
Note:

UCT = Upper category temperature
LCT = Lower category temperature
R_{ins} = Insulation resistance to CECC 42 000, test 4.8

v/i characteristics

v = f (i) – for explanation of the characteristics refer to “General technical information”, 1.6.3

A = Leakage current } for worst-case varistor tolerances
B = Protection level }

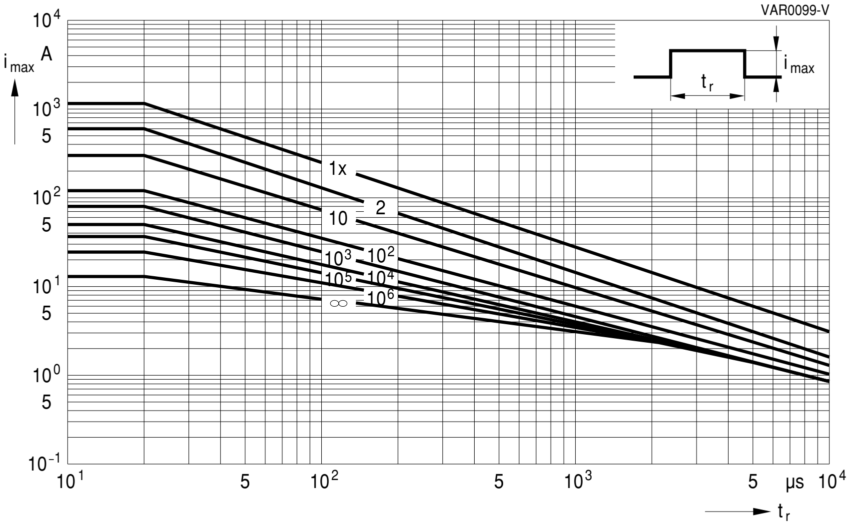


SIOV-S07S60AGS2, SIOV-S07S95AGS2

Derating curves

Maximum surge current i_{max} = f (t_r, pulse train)

For explanation of the derating curves refer to “General technical information”, section 1.8.1



SIOV-S07S60AGS2, SIOV-S07S95AGS2

1 EPCOS ordering code system

B722	10	S	2	271	K	1	0	1
Digit 1 2 3 4	…	…	…	…	12	13	14	15

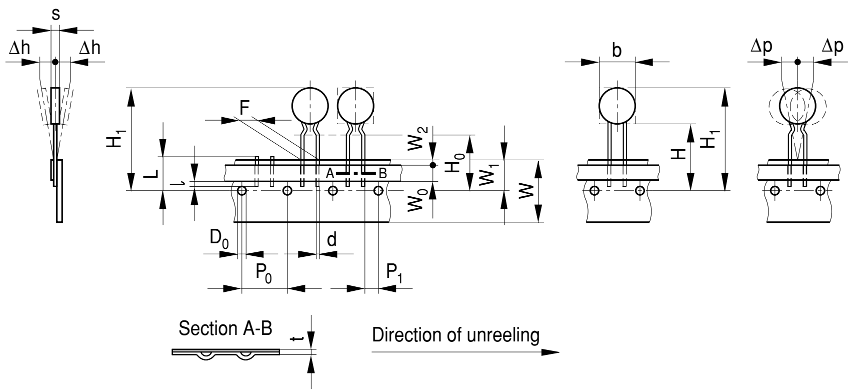
- **B722** – Monolithic varistor
- **10** – Nominal disc diameter
- **S** – **Design:**
  S = Leaded varistor
  T = ThermoFuse
  F = Fail-safe varistor
  Q = EnergetiQ
- **2** – **Series:**
  0 = StandarD
  1 = Automotive
  2 = AdvanceD
  3 = SuperioR
  4 = SuperioR
- **271** – **Max. AC operating voltage:**
  271 = 27 · 10^1 = 275 VAC
  140 = 14 · 10^0 = 14 VAC
  141 = 14 · 10^1 = 140 VAC
- **K** – **Tolerance of varistor voltage:**
  K = ±10%
  J = ±5%
  S = Special tolerance
- **1** – **Lead configuration:**
  1 = Straight leads,
  2 thru 5 = Kinked form
- **0** – **Packaging:**
  0 = Bulk,
  1 thru 6 = Taping style
- **1** – Internal coding:
  1 = Standard

2 Taping and packaging of leaded varistors

Tape packaging for lead spacing e = 5 fully conforms to IEC 60286-2, while for lead spacings e = 7.5 and 10 the taping mode is based on this standard.

The overview of delivery mode on pages 228 ff lists disk types available on tape in detail, i.e. with complete ordering code and type designation. Taping mode and, if relevant, crimp style and lead spacing are coded in the type designation. For types not listed please contact EPCOS. Upon request parts with lead spacing e = 5 mm are also available in Ammo pack too.

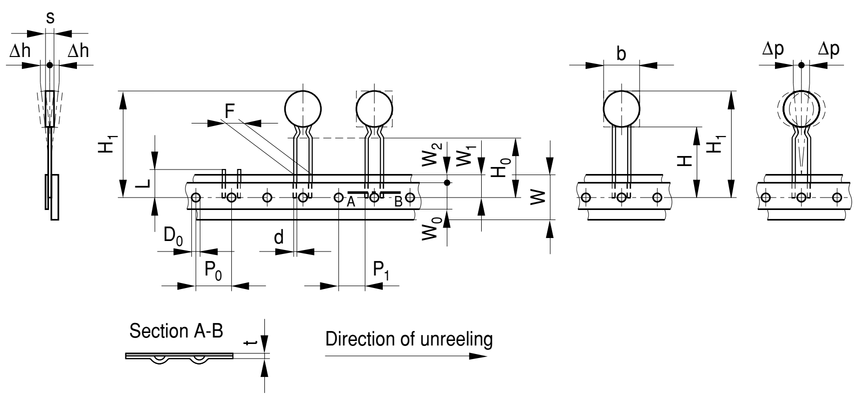
2.1 Taping in accordance with IEC 60286-2 for lead spacing 5.0 mm



F ≙ e = 5.0 mm (except S ... R5)

VAR0410-X

2.2 Taping based on IEC 60286-2 for lead spacing 7.5 and 10 mm



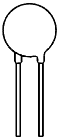
F ≙ e = 7.5 mm (including S ... R5)
F ≙ e = 10 mm (including S ... R5)

VAR0395-J

2.3 Tape dimensions (in mm)

Symbol	e = 5.0	Tolerance	e = 7.5	Tolerance	e = 10.0	Tolerance	Remarks
b		max.		max.		max.	see tables
s		max.		max.		max.	on pages 110 ff
d	0.6	±0.05	0.8	±0.05	1.0	±0.05	
P_0	12.7	±0.3	12.7 [1]	±0.3	12.7	±0.3	±1 mm/20 sprocket holes
P_1	3.85	±0.7	8.95	±0.8	7.7	±0.8	
F	5.0	+0.6/–0.1	7.5	±0.8	10.0	±0.8	
Δh	0	±2.0	depends on s		depends on s		measured at
Δp	0	±1.3	0	±2.0	0	±2.0	top of compo-nent body
W	18.0	±0.5	18.0	±0.5	18.0	±0.5	
W_0	5.5	min.	11.0	min.	11.0	min.	Peel-off force ≥ 5 N
W_1	9.0	±0.5	9.0	+0.75/–0.5	9.0	+0.75/–0.5	
W_2	3.0	max.	3.0	max.	3.0	max.	
H	18.0	+2.0/–0	18.0	+2.0/–0	18.0	+2.0/–0	[2]
H_0	16.0 (18.0)	±0.5	16.0 (18.0)	±0.5	16.0	±0.5	[3]
H_1	32.2	max.	45.0	max.	45.0	max.	
D_0	4.0	±0.2	4.0	±0.2	4.0	±0.2	
t	0.9	max.	0.9	max.	0.9	max.	without lead
L	11.0	max.	11.0	max.	11.0	max.	
l	4.0	max.					

1) Taping with P_0 = 15.0 mm upon request
2) Applies only to uncrimped types
3) Applies only to crimped types (H_0 = 18 upon request)



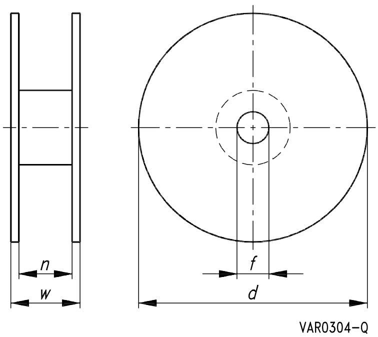
2.4 Taping mode

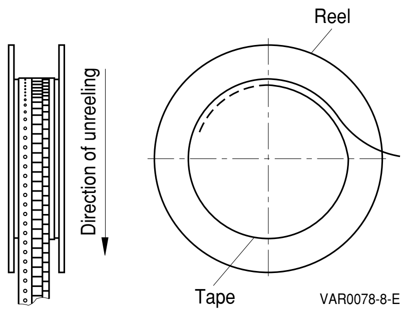
Example: B72210S0271K1 [5] 1

Digit 14

Digit 14	Taping mode	Reel type	Seating plane height H_0 for crimped types mm	Seating plane height H for uncrimped types mm	Pitch distance P_0 mm
1	G	I	16	18	12.7
2	G2	I	18	–	12.7
3	G3	II	16	18	12.7
4	G4	II	18	–	12.7
5	G5	III	16	18	12.7
6	GA	Ammo pack	16	18	12.7
7	G2A	Ammo pack	18	–	12.7
Internal coding for special taping					
	G6	III	18	–	12.7
	G10	II	16	18	15.0
	G11	II	18	–	15.0
	G10A	Ammo pack	16	18	15.0
	G11A	Ammo pack	18	–	15.0

2.5 Reel dimensions



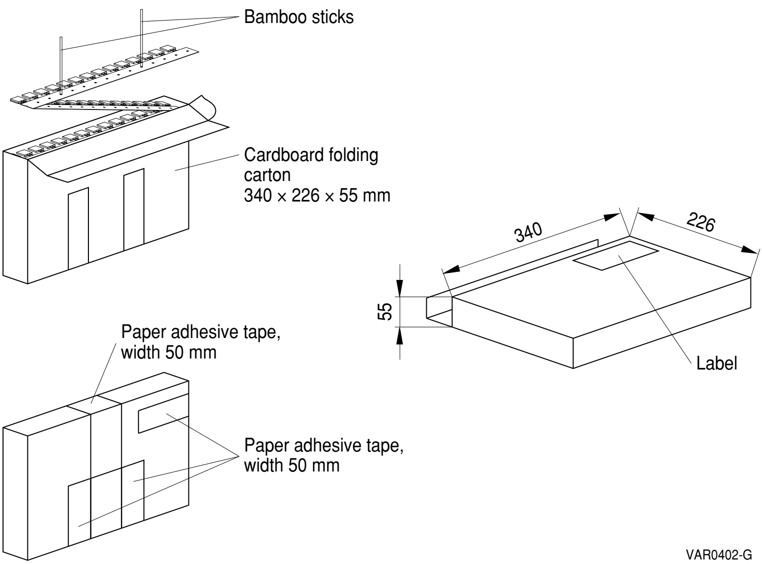


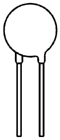
Dimensions (in mm)

Reel type	d	f	n	w
I	360 max.	31 ±1	approx. 45	54 max.
II	360 max.	31 ±1	approx. 55	64 max.
III	500 max.	23 ±1	approx. 59	72 max.

If reel type III is not compatible with insertion equipment because of its large diameter, nominal disk diameter 10 mm and 14 mm can be supplied on reel II upon request (taping mode G3).

2.6 Ammo pack dimensions





3 Lead configuration

Both crimped and straight leads are standard for taped disk varistors. The leads are differently crimped for technical reasons; the individual crimp styles are denoted by consecutive numbers (S, S2 through S5) as shown in the dimensional drawings on page 224.

The crimp styles of the individual types can be seen from the type designation in the ordering tables.

3.1 Crimp style mode

Example: B72210S0271K 5 01

Digit 13

Digit 13 of ordering code	Crimp style	Figure
1	Standard, straight leads	1
2	S2	2
3	S3	3
4	S4	4
5	S5	5
Available upon request		
Internal coding	S9	6
Internal coding	S11	7
Internal coding	—	8

3.2 Standard crimp styles

Standard, straight leads

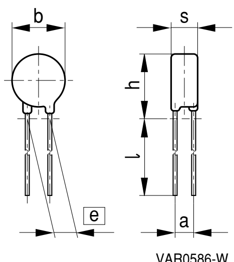


Figure 1

Crimp style S2

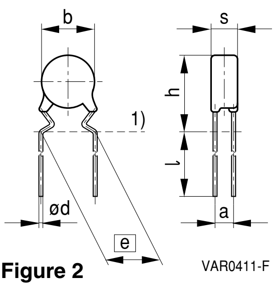


Figure 2

Crimp style S3

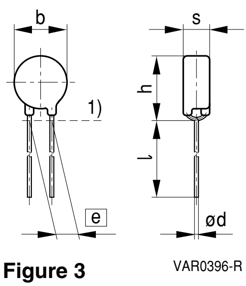


Figure 3

Crimp style S4

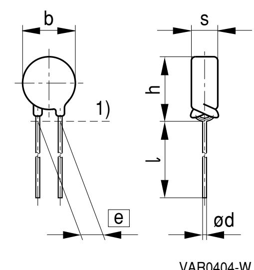


Figure 4

Crimp style S5

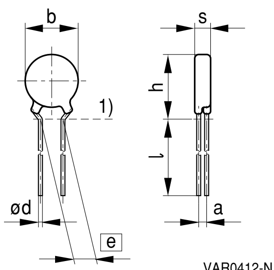
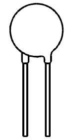


Figure 5

1) Seating plane to IEC 60717



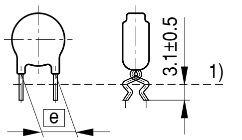
3.3 Component height (h_{max}) for crimped versions

Due to technical reasons the component height (hmax) increases if a crimp is added. The maximum height of the crimped component can be found in the table below.

Nominal diameter mm	V_{RMS} V	Crimp style	$\boxed{e}$ mm	h_{max} mm
5	11 … 175	S2	5.0	10.0
5	210 … 460	S3	5.0	10.0
7	11 … 175	S2	5.0	12.0
7	210 … 460	S3	5.0	12.0
10	11 … 300	S5	7.5	15.5
10	320 … 460	S3/S5	7.5	16.5
10	510	S3/S5	7.5	17.5
10	Automotive	S5	7.5	17.0
10	Automotive (D1 types)	S5	7.5	16.0
10	11 … 175	S4	5.0	16.5
10	210 … 460	S3	5.0	16.5
14	11 … 300	S5	7.5	20.0
14	320 … 460	S3/S5	7.5	20.0
14	510	S3/S5	7.5	21.5
14	Automotive	S5	7.5	21.0
14	Automotive (D1 types)	S5	7.5	20.0
20	11 … 320	S5	10.0	27.0
20	385 … 510	S5	10.0	27.5

3.4 Crimp style S9, lock-in crimps (for lead spacing [e] = 5 mm)

These crimp styles provide automatic lock-in function on the printed circuit board for simplified assembly.

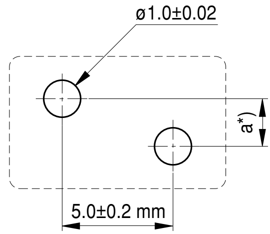


1) Seating plane to IEC 60717

VAR0413-V

Figure 6

Layout recommendation



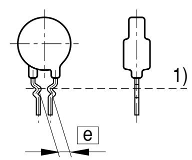
*) Set-off "a" depending on voltage ratings

VAR0421-M-E

Recommended PCB thickness: 1.5 +0.2 mm

Example: SIOV-S07K275S9

3.5 Crimp style S11, lock-in crimps (for lead spacing [e] = 7.5 mm)

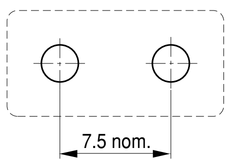


1) Seating plane to IEC 60717

VAR0429-Y

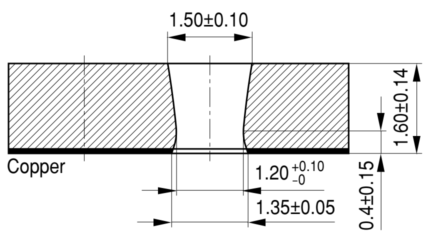
Figure 7

Layout recommendation



VAR0414-D

Recommended PCB thickness: 1.6 ±0.14 mm



VAR0549-S

Recommended hole pattern

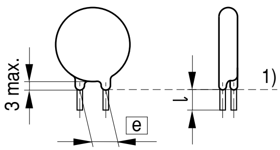
Example: SIOV-S14K275S11

3.6 Trimmed leads

Varistors with cut leads available upon request.

Lead length tolerances:

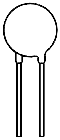
Straight leads	+/–1.0 mm
Crimped leads	+/–0.8 mm
Minimum lead length	3.5 mm



1) Seating plane to IEC 60717

VAR0642-U-E

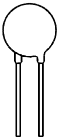
Figure 8



Overview of standard varistors

Ordering code	Type SIOV-	Crimp style	Taping mode	Pieces/reel I
Nominal disk diameter 5 mm, straight leads, $\boxed{e}$ = 5 mm				
B72205S0110K111	S05K11G	–	G	1500
B72205S0140K111	S05K14G	–	G	1500
B72205S0170K111	S05K17G	–	G	1500
B72205S0200K111	S05K20G	–	G	1500
B72205S0250K111	S05K25G	–	G	1500
B72205S0300K111	S05K30G	–	G	1500
B72205S0350K111	S05K35G	–	G	1500
B72205S0400K111	S05K40G	–	G	1500
B72205S0500K111	S05K50G	–	G	1500
B72205S0600K111	S05K60G	–	G	1500
B72205S0750K111	S05K75G	–	G	1500
B72205S0950K111	S05K95G	–	G	1500
B72205S0111K111	S05K115G	–	G	1500
B72205S0131K111	S05K130G	–	G	1500
B72205S0141K111	S05K140G	–	G	1500
B72205S0151K111	S05K150G	–	G	1500
B72205S0171K111	S05K175G	–	G	1500
B72205S0231K111	S05K230G	–	G	1500
B72205S0251K111	S05K250G	–	G	1500
B72205S0271K111	S05K275G	–	G	1500
B72205S0301K111	S05K300G	–	G	1000
Nominal disk diameter 5 mm, crimped leads, $\boxed{e}$ = 5 mm				
B72205S0110K211	S05K11GS2	S2	G	1500
B72205S0140K211	S05K14GS2	S2	G	1500
B72205S0170K211	S05K17GS2	S2	G	1500
B72205S0200K211	S05K20GS2	S2	G	1500
B72205S0250K211	S05K25GS2	S2	G	1500
B72205S0300K211	S05K30GS2	S2	G	1500
B72205S0350K211	S05K35GS2	S2	G	1500
B72205S0400K211	S05K40GS2	S2	G	1500
B72205S0500K211	S05K50GS2	S2	G	1500
B72205S0600K211	S05K60GS2	S2	G	1500
B72205S0750K211	S05K75GS2	S2	G	1500
B72205S0950K211	S05K95GS2	S2	G	1500

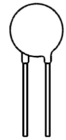
Ordering code	Type SIOV-	Crimp style	Taping mode	Pieces/reel I
Nominal disk diameter 5 mm, crimped leads, [e] = 5 mm (continued)				
B72205S0111K211	S05K115GS2	S2	G	1500
B72205S0131K211	S05K130GS2	S2	G	1500
B72205S0141K211	S05K140GS2	S2	G	1500
B72205S0151K211	S05K150GS2	S2	G	1500
B72205S0171K211	S05K175GS2	S2	G	1500
B72205S0231K311	S05K230GS3	S3	G	1500
B72205S0251K311	S05K250GS3	S3	G	1500
B72205S0271K311	S05K275GS3	S3	G	1500
B72205S0301K311	S05K300GS3	S3	G	1000
B72205S0381K311	S05K385GS3	S3	G	1000
B72205S0421K311	S05K420GS3	S3	G	1000
B72205S0441K311	S05K440GS3	S3	G	1000
B72205S0461K311	S05K460GS3	S3	G	1000
Nominal disk diameter 7 mm, straight leads, [e] = 5 mm				
B72207S0110K111	S07K11G	–	G	1500
B72207S0140K111	S07K14G	–	G	1500
B72207S0170K111	S07K17G	–	G	1500
B72207S0200K111	S07K20G	–	G	1500
B72207S0250K111	S07K25G	–	G	1500
B72207S0300K111	S07K30G	–	G	1500
B72207S0350K111	S07K35G	–	G	1500
B72207S0400K111	S07K40G	–	G	1500
B72207S0500K111	S07K50G	–	G	1500
B72207S0600K111	S07K60G	–	G	1500
B72207S0750K111	S07K75G	–	G	1500
B72207S0950K111	S07K95G	–	G	1500
B72207S0111K111	S07K115G	–	G	1500
B72207S0131K111	S07K130G	–	G	1500
B72207S0141K111	S07K140G	–	G	1500
B72207S0151K111	S07K150G	–	G	1500
B72207S0171K111	S07K175G	–	G	1500
B72207S0231K111	S07K230G	–	G	1500
B72207S0251K111	S07K250G	–	G	1500
B72207S0271K111	S07K275G	–	G	1000
B72207S0301K111	S07K300G	–	G	1000



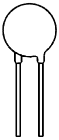
Taping, packaging and lead configuration

For leaded varistors

Ordering code	Type SIOV-	Crimp style	Taping mode	Pieces/reel I
Nominal disk diameter 7 mm, crimped leads, e = 5 mm				
B72207S0110K211	S07K11GS2	S2	G	1500
B72207S0140K211	S07K14GS2	S2	G	1500
B72207S0170K211	S07K17GS2	S2	G	1500
B72207S0200K211	S07K20GS2	S2	G	1500
B72207S0250K211	S07K25GS2	S2	G	1500
B72207S0300K211	S07K30GS2	S2	G	1500
B72207S0350K211	S07K35GS2	S2	G	1500
B72207S0400K211	S07K40GS2	S2	G	1500
B72207S0500K211	S07K50GS2	S2	G	1500
B72207S0600K211	S07K60GS2	S2	G	1500
B72207S0600S212	S07S60AGS2	S2	G	1500
B72207S0750K211	S07K75GS2	S2	G	1500
B72207S0950K211	S07K95GS2	S2	G	1500
B72207S0950S212	S07S95AGS2	S2	G	1500
B72207S0111K211	S07K115GS2	S2	G	1500
B72207S0131K211	S07K130GS2	S2	G	1500
B72207S0141K211	S07K140GS2	S2	G	1500
B72207S0151K211	S07K150GS2	S2	G	1500
B72207S0171K211	S07K175GS2	S2	G	1500
B72207S0231K311	S07K230GS3	S3	G	1000
B72207S0251K311	S07K250GS3	S3	G	1000
B72207S0271K311	S07K275GS3	S3	G	1000
B72207S0301K311	S07K300GS3	S3	G	1000
B72207S0381K311	S07K385GS3	S3	G	1000
B72207S0421K311	S07K420GS3	S3	G	1000
B72207S0441K311	S07K440GS3	S3	G	1000
B72207S0461K311	S07K460GS3	S3	G	1000



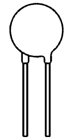
Ordering code	Type SIOV-	Crimp style	Taping mode	Pieces/reel III
Nominal disk diameter 10 mm, straight leads, e = 7.5 mm				
B72210S0110K151	S10K11G5	–	G5	1500
B72210S0140K151	S10K14G5	–	G5	1500
B72210S0170K151	S10K17G5	–	G5	1500
B72210S0200K151	S10K20G5	–	G5	1500
B72210S0250K151	S10K25G5	–	G5	1500
B72210S0300K151	S10K30G5	–	G5	1500
B72210S0350K151	S10K35G5	–	G5	1500
B72210S0400K151	S10K40G5	–	G5	1500
B72210S0500K151	S10K50G5	–	G5	1500
B72210S0600K151	S10K60G5	–	G5	1500
B72210S0750K151	S10K75G5	–	G5	1500
B72210S0950K151	S10K95G5	–	G5	1500
B72210S0111K151	S10K115G5	–	G5	1500
B72210S0131K151	S10K130G5	–	G5	1500
B72210S0141K151	S10K140G5	–	G5	1500
B72210S0151K151	S10K150G5	–	G5	1500
B72210S0171K151	S10K175G5	–	G5	1500
B72210S0231K151	S10K230G5	–	G5	1000
B72210S0251K151	S10K250G5	–	G5	1000
B72210S0271K151	S10K275G5	–	G5	1000
B72210S0301K151	S10K300G5	–	G5	1000
Nominal disk diameter 10 mm, crimped leads, e = 7.5 mm				
B72210S0110K551	S10K11G5S5	S5	G5	1500
B72210S0140K551	S10K14G5S5	S5	G5	1500
B72210S0170K551	S10K17G5S5	S5	G5	1500
B72210S0200K551	S10K20G5S5	S5	G5	1500
B72210S0250K551	S10K25G5S5	S5	G5	1500
B72210S0300K551	S10K30G5S5	S5	G5	1500
B72210S0350K551	S10K35G5S5	S5	G5	1500
B72210S0400K551	S10K40G5S5	S5	G5	1500
B72210S0500K551	S10K50G5S5	S5	G5	1500
B72210S0600K551	S10K60G5S5	S5	G5	1500
B72210S0750K551	S10K75G5S5	S5	G5	1500
B72210S0950K551	S10K95G5S5	S5	G5	1500
B72210S0111K551	S10K115G5S5	S5	G5	1500
B72210S0131K551	S10K130G5S5	S5	G5	1500
B72210S0141K551	S10K140G5S5	S5	G5	1500



Ordering code	Type SIOV-	Crimp style	Taping mode	Pieces/reel III
Nominal disk diameter 10 mm, crimped leads, e = 7.5 mm (continued)				
B72210S0151K551	S10K150G5S5	S5	G5	1500
B72210S0171K551	S10K175G5S5	S5	G5	1500
B72210S0231K551	S10K230G5S5	S5	G5	1000
B72210S0251K551	S10K250G5S5	S5	G5	1000
B72210S0271K551	S10K275G5S5	S5	G5	1000
B72210S0301K551	S10K300G5S5	S5	G5	1000

S10K320 … 460G.S. upon request

Ordering code	Type SIOV-	Crimp style	Taping mode	Pieces/reel III
Nominal disk diameter 14 mm, straight leads, e = 7.5 mm				
B72214S0110K151	S14K11G5	–	G5	1500
B72214S0140K151	S14K14G5	–	G5	1500
B72214S0170K151	S14K17G5	–	G5	1500
B72214S0200K151	S14K20G5	–	G5	1500
B72214S0250K151	S14K25G5	–	G5	1500
B72214S0300K151	S14K30G5	–	G5	1500
B72214S0350K151	S14K35G5	–	G5	1500
B72214S0400K151	S14K40G5	–	G5	1500
B72214S0500K151	S14K50G5	–	G5	1500
B72214S0600K151	S14K60G5	–	G5	1500
B72214S0750K151	S14K75G5	–	G5	1500
B72214S0950K151	S14K95G5	–	G5	1500
B72214S0111K151	S14K115G5	–	G5	1500
B72214S0131K151	S14K130G5	–	G5	1500
B72214S0141K151	S14K140G5	–	G5	1500
B72214S0151K151	S14K150G5	–	G5	1500
B72214S0171K151	S14K175G5	–	G5	1500
B72214S0231K151	S14K230G5	–	G5	1000
B72214S0251K151	S14K250G5	–	G5	1000
B72214S0271K151	S14K275G5	–	G5	1000
B72214S0301K151	S14K300G5	–	G5	1000



Ordering code	Type SIOV-	Crimp style	Taping mode	Pieces/reel III
Nominal disk diameter 14 mm, crimped leads, e = 7.5 mm				
B72214S0110K551	S14K11G5S5	S5	G5	1500
B72214S0140K551	S14K14G5S5	S5	G5	1500
B72214S0170K551	S14K17G5S5	S5	G5	1500
B72214S0200K551	S14K20G5S5	S5	G5	1500
B72214S0250K551	S14K25G5S5	S5	G5	1500
B72214S0300K551	S14K30G5S5	S5	G5	1500
B72214S0350K551	S14K35G5S5	S5	G5	1500
B72214S0400K551	S14K40G5S5	S5	G5	1500
B72214S0500K551	S14K50G5S5	S5	G5	1500
B72214S0600K551	S14K60G5S5	S5	G5	1500
B72214S0750K551	S14K75G5S5	S5	G5	1500
B72214S0950K551	S14K95G5S5	S5	G5	1500
B72214S0111K551	S14K115G5S5	S5	G5	1500
B72214S0131K551	S14K130G5S5	S5	G5	1500
B72214S0141K551	S14K140G5S5	S5	G5	1500
B72214S0151K551	S14K150G5S5	S5	G5	1500
B72214S0171K551	S14K175G5S5	S5	G5	1500
B72214S0231K551	S14K230G5S5	S5	G5	1000
B72214S0251K551	S14K250G5S5	S5	G5	1000
B72214S0271K551	S14K275G5S5	S5	G5	1000
B72214S0301K551	S14K300G5S5	S5	G5	1000

Construction

- Round varistor element, leaded
- Coating: epoxy resin, flame-retardant to UL 94 V-0
- Terminals: tinned copper wire, metal compound wire
- Housing: thermoplastic, flame-retardant to UL 94 V-0

Features

- Wide operating voltage range 130 … 420 V_{RMS}
- Self-protected under abnormal overvoltage conditions
- High-energy AdvanceD series E2

Approvals

- UL

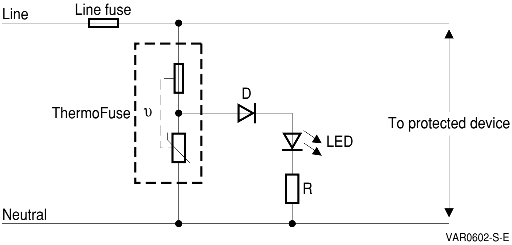
Applications

- Air conditioner, refrigerator, TV, etc.
- Power meter, inverter, telecom equipment, etc.
- Transient voltage surge suppressors (TVSS)

Delivery mode

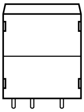
- Bulk (standard)

Typical applications



General technical data

Climatic category	to IEC 60068-1	40/85/56	
Operating temperature	to CECC 42 000	–40 … + 85	°C
Storage temperature		–40 … +125	°C
Electric strength	to CECC 42 000	≥2.5	kV_{RMS}
Response time		<25	ns



Housed varistors

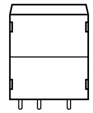
ThermoFuse varistors, ETFV14 series

Maximum ratings (T_A = 85 °C)

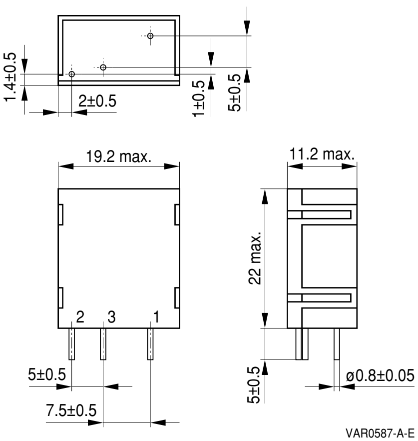
Ordering code	Type (untaped) SIOV-	V_{RMS} V	V_{DC} V	i_{max} (8/20 µs) A	W_{max} (2 ms) J	P_{max} W
B72214T2131K101	ETFV14K130E2	130	170	6000	50	0.6
B72214T2141K101	ETFV14K140E2	140	180	6000	55	0.6
B72214T2151K101	ETFV14K150E2	150	200	6000	60	0.6
B72214T2171K101	ETFV14K175E2	175	225	6000	70	0.6
B72214T2211K101	ETFV14K210E2	210	270	6000	80	0.6
B72214T2231K101	ETFV14K230E2	230	300	6000	90	0.6
B72214T2251K101	ETFV14K250E2	250	320	6000	100	0.6
B72214T2271K101	ETFV14K275E2	275	350	6000	110	0.6
B72214T2301K101	ETFV14K300E2	300	385	6000	125	0.6
B72214T2321K101	ETFV14K320E2	320	420	6000	136	0.6
B72214T2351K101	ETFV14K350E2	350	460	6000	136	0.6
B72214T2381K101	ETFV14K385E2	385	505	6000	136	0.6
B72214T2421K101	ETFV14K420E2	420	560	6000	136	0.6

Characteristics (T_A = 25 °C)

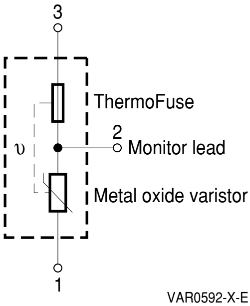
Ordering code	Type (untaped) SIOV-	V_v (1 mA) V	ΔV_v (1 mA) %	$v_{c,\,max}$ (i_c) V	i_c A	C_{typ} (1 kHz) pF
B72214T2131K101	ETFV14K130E2	205	±10	340	50	650
B72214T2141K101	ETFV14K140E2	220	±10	360	50	610
B72214T2151K101	ETFV14K150E2	240	±10	395	50	570
B72214T2171K101	ETFV14K175E2	270	±10	455	50	490
B72214T2211K101	ETFV14K210E2	330	±10	545	50	410
B72214T2231K101	ETFV14K230E2	360	±10	595	50	380
B72214T2251K101	ETFV14K250E2	390	±10	650	50	350
B72214T2271K101	ETFV14K275E2	430	±10	710	50	320
B72214T2301K101	ETFV14K300E2	470	±10	775	50	300
B72214T2321K101	ETFV14K320E2	510	±10	840	50	280
B72214T2351K101	ETFV14K350E2	560	±10	910	50	260
B72214T2381K101	ETFV14K385E2	620	±10	1025	50	240
B72214T2421K101	ETFV14K420E2	680	±10	1120	50	220



Dimensional drawing



Lead configuration



Weight

Nominal diameter mm	V_{RMS} V	Weight g
14	130 … 420	4.3 … 5.3

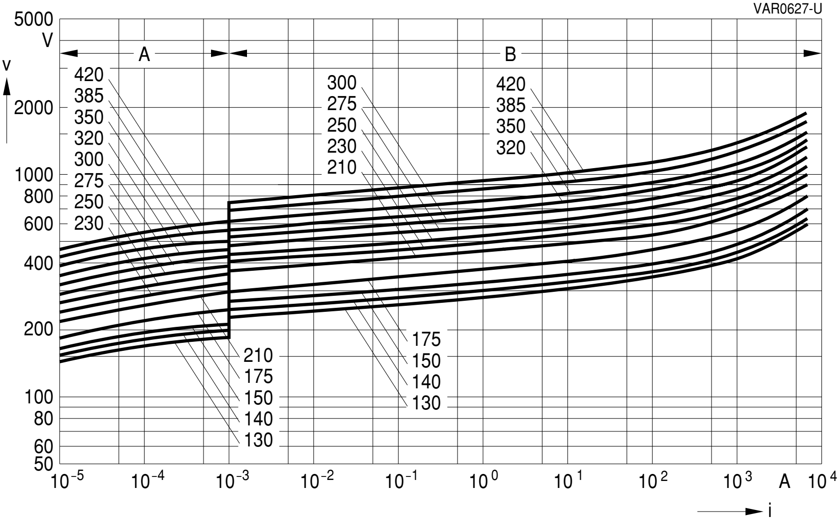
Reliability data

Test	Test methods/conditions	Requirement
Varistor voltage	The voltage between two terminals with the specified measuring current applied is called V_v (1 mA_{DC} @ 0.2 … 2 s).	To meet the specified value.
Clamping voltage	The maximum voltage between two terminals with the specified standard impulse current (8/20 μs) applied.	To meet the specified value.
Surge current derating, 8/20 μs	CECC 42 000, test C 2.1 100 surge currents (8/20 μs), unipolar, interval 30 s, amplitude corresponding to derating curve for 100 impulses at 20 μs	$\lvert\Delta V/V$ (1 mA)$\rvert \leq 10\%$ (measured in direction of surge current) No visible damage
Surge current derating, 2 ms	CECC 42 000, test C 2.1 100 surge currents (2 ms), unipolar, interval 120 s, amplitude corresponding to derating curve for 100 impulses at 2 ms	$\lvert\Delta V/V$ (1 mA)$\rvert \leq 10\%$ (measured in direction of surge current) No visible damage
Abnormal overvoltage test	UL1449, limited current abnormal overvoltage test. Apply a high AC voltage to ThermoFuse varistor, the amplitude of overvoltage and current limit will be adopted from UL1449 general instruction in section 37. The specimen will be tested on a softwood surface covered with a double layer of white tissue paper. The specimen is to be loosely draped with a double layer of cheesecloth. The cheesecloth shall cover openings where flame, molten or other particles may be expelled as a result of the test. The test result will be visually inspected.	Any of these phenomena shall not be observed, or this specimen will be judged as failed part. 1. Emission of flame, molten metal, glowing or flaming particles through any openings (pre-existed or created as a result of the test) in the product. 2. Charring, glowing, or flaming of the supporting surface, tissue paper, or cheesecloth. 3. Ignition of the enclosure. 4. Creation of any openings in the enclosure that result in accessibility of live parts, when judged in accordance with accessibility of live parts, UL1449 section 13.

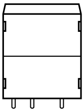
v/i characteristics

v = f (i) – for explanation of the characteristics refer to “General technical information”, 1.6.3

A = Leakage current, B = Protection level — for worst-case varistor tolerances



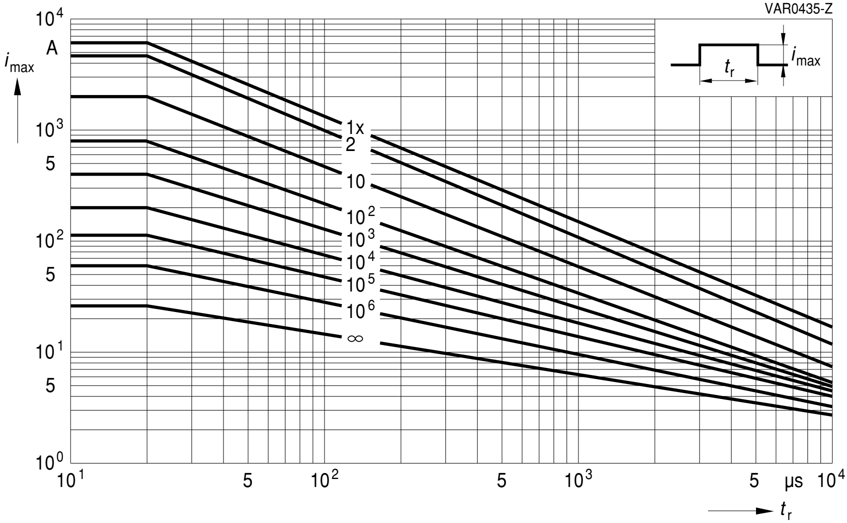
SIOV-ETFV14 … E2



Derating curves

Maximum surge current i_{max} = f (t_r, pulse train)

For explanation of the derating curves refer to “General technical information”, section 1.8.1



SIOV-ETFV14 … E2

Housed varistors

ThermoFuse varistors, ETFV20 series

Construction

- Round varistor element, leaded
- Coating: epoxy resin, flame-retardant to UL 94 V-0
- Terminals: tinned copper wire, metal compound wire
- Housing: thermoplastic, flame-retardant to UL 94 V-0

Features

- Wide operating voltage range 130 … 420 V_{RMS}
- Self-protected under abnormal overvoltage conditions
- High-energy AdvanceD series E2

Approvals

- UL

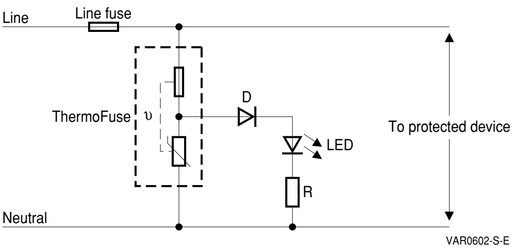
Applications

- Air conditioner, refrigerator, TV, etc.
- Power meter, inverter, telecom equipment, etc.
- Transient voltage surge suppressors (TVSS)

Delivery mode

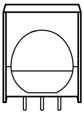
- Bulk (standard)

Typical applications



General technical data

Climatic category	to IEC 60068-1	40/85/56	
Operating temperature	to CECC 42 000	–40 … + 85	°C
Storage temperature		–40 … +125	°C
Electric strength	to CECC 42 000	≥2.5	kV_{RMS}
Response time		<25	ns

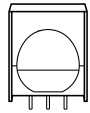


Maximum ratings (T_A = 85 °C)

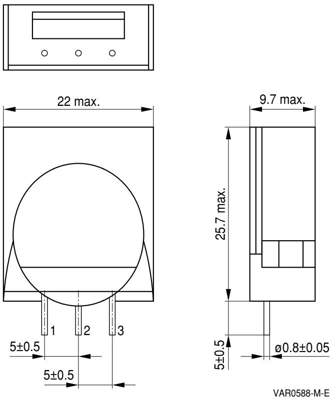
Ordering code	Type (untaped) SIOV-	V_{RMS} V	V_{DC} V	i_{max} (8/20 μs) A	W_{max} (2 ms) J	P_{max} W
B72220T2131K101	ETFV20K130E2	130	170	10000	100	1.0
B72220T2141K101	ETFV20K140E2	140	180	10000	110	1.0
B72220T2151K101	ETFV20K150E2	150	200	10000	120	1.0
B72220T2171K101	ETFV20K175E2	175	225	10000	135	1.0
B72220T2211K101	ETFV20K210E2	210	270	10000	160	1.0
B72220T2231K101	ETFV20K230E2	230	300	10000	180	1.0
B72220T2251K101	ETFV20K250E2	250	320	10000	195	1.0
B72220T2271K101	ETFV20K275E2	275	350	10000	215	1.0
B72220T2301K101	ETFV20K300E2	300	385	10000	250	1.0
B72220T2321K101	ETFV20K320E2	320	420	10000	273	1.0
B72220T2351K101	ETFV20K350E2	350	460	10000	273	1.0
B72220T2381K101	ETFV20K385E2	385	505	10000	273	1.0
B72220T2421K101	ETFV20K420E2	420	560	10000	273	1.0

Characteristics (T_A = 25 °C)

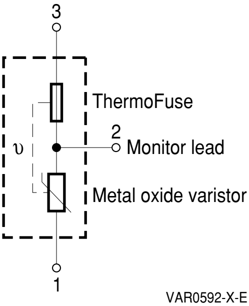
Ordering code	Type (untaped) SIOV-	V_v (1 mA) V	ΔV_v (1 mA) %	$v_{c,\ max}$ (i_c) V	i_c A	C_{typ} (1 kHz) pF
B72220T2131K101	ETFV20K130E2	205	±10	340	100	1340
B72220T2141K101	ETFV20K140E2	220	±10	360	100	1240
B72220T2151K101	ETFV20K150E2	240	±10	395	100	1160
B72220T2171K101	ETFV20K175E2	270	±10	455	100	1000
B72220T2211K101	ETFV20K210E2	330	±10	545	100	835
B72220T2231K101	ETFV20K230E2	360	±10	595	100	760
B72220T2251K101	ETFV20K250E2	390	±10	650	100	700
B72220T2271K101	ETFV20K275E2	430	±10	710	100	630
B72220T2301K101	ETFV20K300E2	470	±10	775	100	580
B72220T2321K101	ETFV20K320E2	510	±10	840	100	540
B72220T2351K101	ETFV20K350E2	560	±10	910	100	500
B72220T2381K101	ETFV20K385E2	620	±10	1025	100	450
B72220T2421K101	ETFV20K420E2	680	±10	1120	100	420



Dimensional drawing



Lead configuration

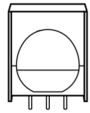


Weight

Nominal diameter mm	V_{RMS} V	Weight g
20	130 … 420	6.7 … 8.3

Reliability data

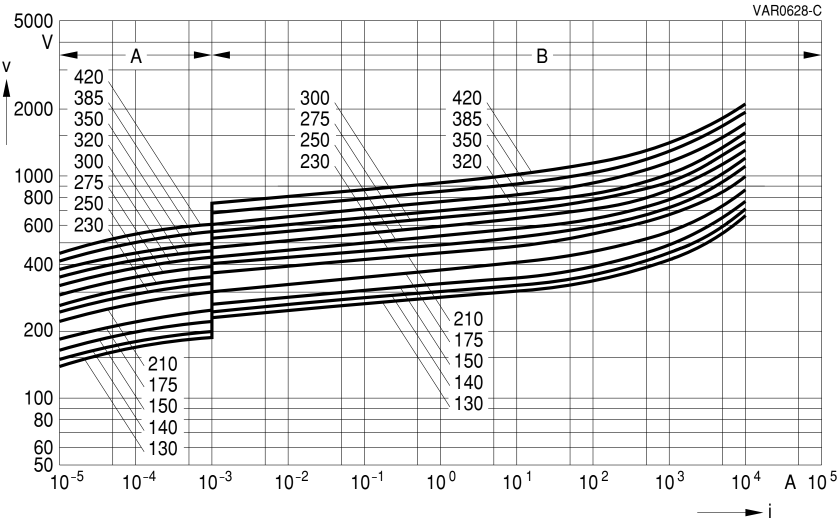
Test	Test methods/conditions	Requirement
Varistor voltage	The voltage between two terminals with the specified measuring current applied is called V_v (1 mA_{DC} @ 0.2 … 2 s).	To meet the specified value.
Clamping voltage	The maximum voltage between two terminals with the specified standard impulse current (8/20 µs) applied.	To meet the specified value.
Surge current derating, 8/20 µs	CECC 42 000, test C 2.1 100 surge currents (8/20 µs), unipolar, interval 30 s, amplitude corresponding to derating curve for 100 impulses at 20 µs	$\lvert \Delta V/V$ (1 mA)$\rvert \leq 10\%$ (measured in direction of surge current) No visible damage
Surge current derating, 2 ms	CECC 42 000, test C 2.1 100 surge currents (2 ms), unipolar, interval 120 s, amplitude corresponding to derating curve for 100 impulses at 2 ms	$\lvert \Delta V/V$ (1 mA)$\rvert \leq 10\%$ (measured in direction of surge current) No visible damage
Abnormal overvoltage test	UL1449, limited current abnormal overvoltage test. Apply a high AC voltage to ThermoFuse varistor, the amplitude of overvoltage and current limit will be adopted from UL1449 general instruction in section 37. The specimen will be tested on a softwood surface covered with a double layer of white tissue paper. The specimen is to be loosely draped with a double layer of cheesecloth. The cheesecloth shall cover openings where flame, molten or other particles may be expelled as a result of the test. The test result will be visually inspected.	Any of these phenomena shall not be observed, or this specimen will be judged as failed part. 1. Emission of flame, molten metal, glowing or flaming particles through any openings (pre-existed or created as a result of the test) in the product. 2. Charring, glowing, or flaming of the supporting surface, tissue paper, or cheesecloth. 3. Ignition of the enclosure. 4. Creation of any openings in the enclosure that result in accessibility of live parts, when judge in accordance with accessibility of live parts, UL1449 section 13.



v/i characteristics

v = f (i) – for explanation of the characteristics refer to “General technical information”, 1.6.3

A = Leakage current } for worst-case varistor tolerances
B = Protection level

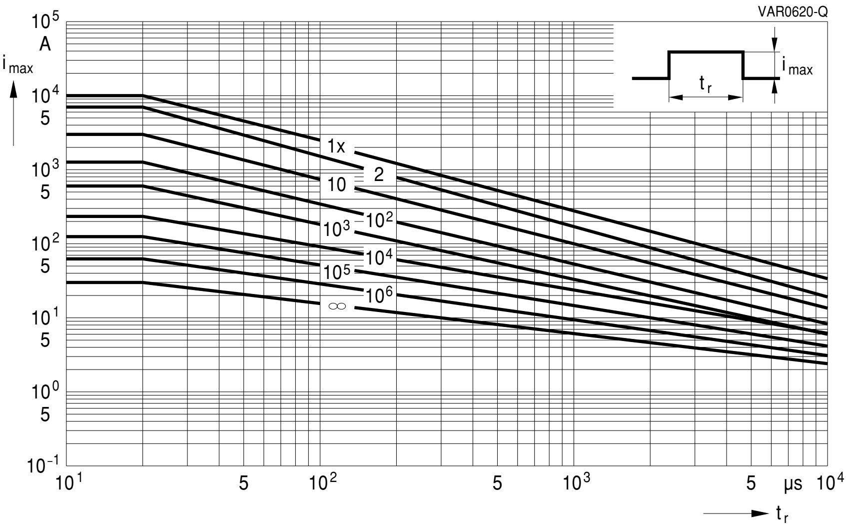


SIOV-ETFV20 … E2

Derating curves

Maximum surge current i_{max} = f (t_r, pulse train)

For explanation of the derating curves refer to “General technical information”, section 1.8.1



SIOV-ETFV20 … E2

ThermoFuse varistors, ETFV25 series

Construction

- Round varistor element, leaded
- Coating: epoxy resin, flame-retardant to UL 94 V-0
- Terminals: tinned copper wire, metal compound wire
- Housing: thermoplastic, flame-retardant to UL 94 V-0

Features

- Wide operating voltage range 115 … 420 V_{RMS}
- Self-protected under abnormal overvoltage conditions
- Very high surge current ratings of 20 kA

Approvals

- UL

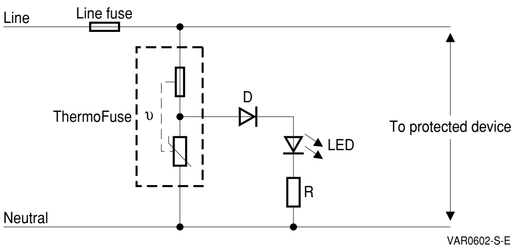
Applications

- Air conditioner, refrigerator, TV, etc.
- Power meter, inverter, telecom equipment, etc.
- Transient voltage surge suppressors (TVSS)

Delivery mode

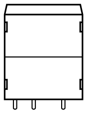
- Bulk (standard)

Typical applications



General technical data

Climatic category	to IEC 60068-1	40/85/56	
Operating temperature	to CECC 42 000	–40 … + 85	°C
Storage temperature		–40 … +125	°C
Electric strength	to CECC 42 000	≥2.5	kV_{RMS}
Response time		<25	ns

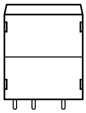


Maximum ratings (T_A = 85 °C)

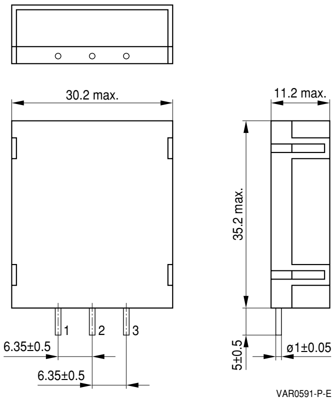
Ordering code	Type (untaped) SIOV-	V_{RMS} V	V_{DC} V	i_{max} (8/20 µs) A	W_{max} (2 ms) J	P_{max} W
B72225T4111K101	ETFV25K115E4	115	150	20000	170	1.0
B72225T4131K101	ETFV25K130E4	130	170	20000	185	1.0
B72225T4141K101	ETFV25K140E4	140	180	20000	195	1.0
B72225T4151K101	ETFV25K150E4	150	200	20000	215	1.0
B72225T4171K101	ETFV25K175E4	175	225	20000	245	1.0
B72225T4211K101	ETFV25K210E4	210	270	20000	290	1.0
B72225T4231K101	ETFV25K230E4	230	300	20000	315	1.0
B72225T4251K101	ETFV25K250E4	250	320	20000	345	1.0
B72225T4271K101	ETFV25K275E4	275	350	20000	375	1.0
B72225T4301K101	ETFV25K300E4	300	385	20000	410	1.0
B72225T4321K101	ETFV25K320E4	320	420	20000	445	1.0
B72225T4351K101	ETFV25K350E4	350	460	20000	495	1.0
B72225T4381K101	ETFV25K385E4	385	505	20000	600	1.0
B72225T4421K101	ETFV25K420E4	420	560	20000	700	1.0

Characteristics (T_A = 25 °C)

Ordering code	Type (untaped) SIOV-	V_v (1 mA) V	ΔV_v (1 mA) %	$v_{c,\,max}$ (i_c) V	i_c A	C_{typ} (1 kHz) pF
B72225T4111K101	ETFV25K115E4	180	±10	300	150	2280
B72225T4131K101	ETFV25K130E4	205	±10	340	150	2010
B72225T4141K101	ETFV25K140E4	220	±10	360	150	1860
B72225T4151K101	ETFV25K150E4	240	±10	395	150	1740
B72225T4171K101	ETFV25K175E4	270	±10	455	150	1500
B72225T4211K101	ETFV25K210E4	330	±10	545	150	1245
B72225T4231K101	ETFV25K230E4	360	±10	595	150	1140
B72225T4251K101	ETFV25K250E4	390	±10	650	150	1050
B72225T4271K101	ETFV25K275E4	430	±10	710	150	945
B72225T4301K101	ETFV25K300E4	470	±10	775	150	870
B72225T4321K101	ETFV25K320E4	510	±10	840	150	810
B72225T4351K101	ETFV25K350E4	560	±10	910	150	750
B72225T4381K101	ETFV25K385E4	620	±10	1025	150	675
B72225T4421K101	ETFV25K420E4	680	±10	1120	150	630



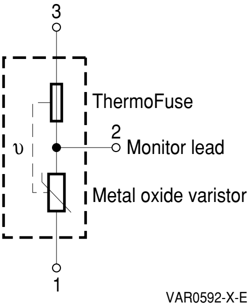
Dimensional drawing

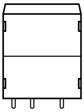


Weight

Nominal diameter mm	V_{RMS} V	Weight g
25	115 … 420	13.3 … 16.3

Lead configuration





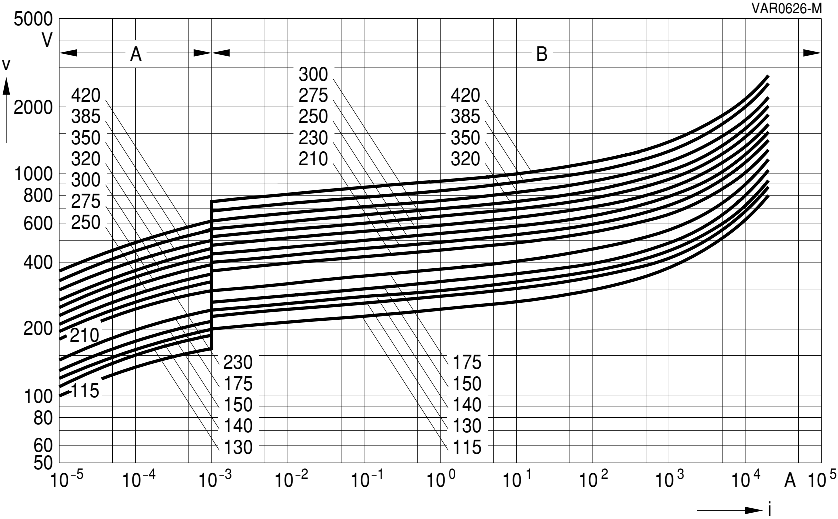
Reliability data

Test	Test methods/conditions	Requirement
Varistor voltage	The voltage between two terminals with the specified measuring current applied is called V_v (1 mA_{DC} @ 0.2 … 2 s).	To meet the specified value.
Clamping voltage	The maximum voltage between two terminals with the specified standard impulse current (8/20 µs) applied.	To meet the specified value.
Surge current derating, 8/20 µs	CECC 42 000, test C 2.1 100 surge currents (8/20 µs), unipolar, interval 30 s, amplitude corresponding to derating curve for 100 impulses at 20 µs	$\lvert\Delta V/V$ (1 mA)$\rvert \leq 10\%$ (measured in direction of surge current) No visible damage
Surge current derating, 2 ms	CECC 42 000, test C 2.1 100 surge currents (2 ms), unipolar, interval 120 s, amplitude corresponding to derating curve for 100 impulses at 2 ms	$\lvert\Delta V/V$ (1 mA)$\rvert \leq 10\%$ (measured in direction of surge current) No visible damage
Abnormal overvoltage test	UL1449, limited current abnormal overvoltage test. Apply a high AC voltage to ThermoFuse varistor, the amplitude of overvoltage and current limit will be adopted from UL1449 general instruction in section 37. The specimen will be tested on a softwood surface covered with a double layer of white tissue paper. The specimen is to be loosely draped with a double layer of cheesecloth. The cheesecloth shall cover openings where flame, molten or other particles may be expelled as a result of the test. The test result will be visually inspected.	Any of these phenomena shall not be observed, or this specimen will be judged as failed part. 1. Emission of flame, molten metal, glowing or flaming particles through any openings (pre-existed or created as a result of the test) in the product. 2. Charring, glowing, or flaming of the supporting surface, tissue paper, or cheesecloth. 3. Ignition of the enclosure. 4. Creation of any openings in the enclosure that result in accessibility of live parts, when judge in accordance with accessibility of live parts, UL1449 section 13.

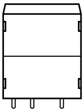
v/i characteristics

v = f (i) – for explanation of the characteristics refer to "General technical information", 1.6.3

A = Leakage current, B = Protection level — for worst-case varistor tolerances



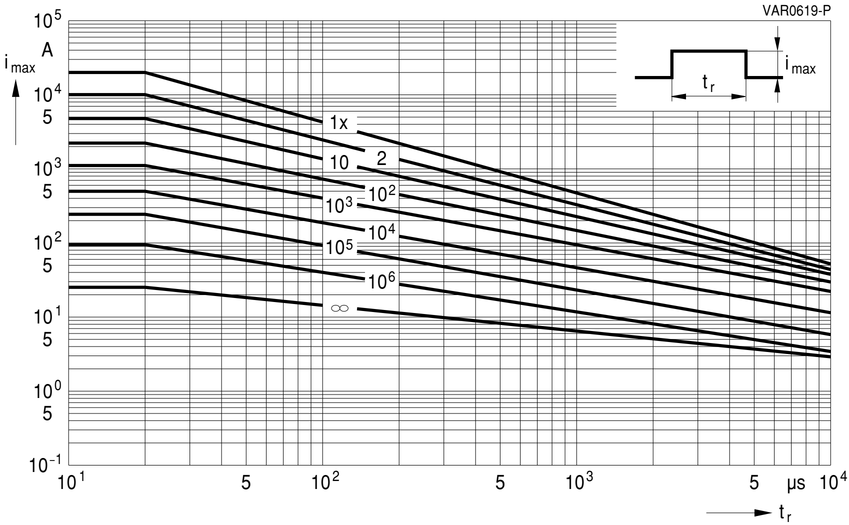
SIOV-ETFV25 … E4



Derating curves

Maximum surge current $i_{max} = f(t_r$, pulse train)

For explanation of the derating curves refer to “General technical information”, section 1.8.1



SIOV-ETFV25 … E4

Construction

- Plastic housing protected varistor
- Terminals: tinned copper wire
- Housing: heat-resistant and flame-retardant to UL 94 V-0

Features

- No flame or rupture under specified test conditions
  (see “Reliability data”, “Overvoltage test”)
- No harm to other components nearby on printed circuit board (PCB)

Approvals

- UL
- CSA

Applications

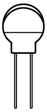
- Consumer electronics
- Power supply

Delivery mode

- Bulk (standard)

General technical data

Climatic category	to IEC 60068-1	40/85/56	
Operating temperature	to CECC 42 000	– 40 … + 85	°C
Storage temperature		– 40 … +125	°C
Electric strength	to CECC 42 000	≥2.5	kV_{RMS}
Insulation resistance	to CECC 42 000	≥10	MΩ
Response time		<25	ns



Housed varistors

Fail-safe varistor, SFS14 series

Maximum ratings (T_A = 85 °C)

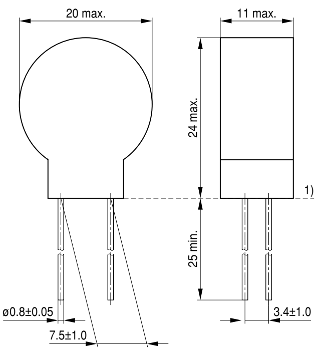
Ordering code	Type (untaped) SIOV-	V_{RMS} V	V_{DC} V	i_{max} (8/20 µs) A	W_{max} (2 ms) J	P_{max} W
B72214F2381K101	SFS14K385E2	385	505	5000	136	0.6

Characteristics (T_A = 25 °C)

Ordering code	Type (untaped) SIOV-	V_v (1 mA) V	ΔV_v (1 mA) %	$v_{c,\,max}$ (i_c) V	i_c A	C_{typ} (1 kHz) pF
B72214F2381K101	SFS14K385E2	620	±10	1025	50	240

Other types are available on request.

Dimensional drawing



1) Seating plane in accordance with IEC 60717

VAR0593-F-E

Weight

Nominal diameter mm	V_{RMS} V	Weight g
14	385	5.5

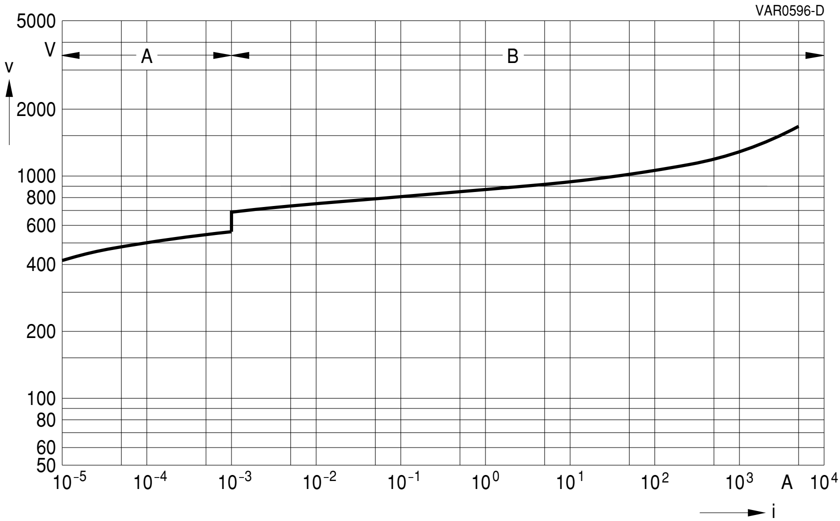
Reliability data

Test	Test methods/conditions	Requirement
Varistor voltage	The voltage between two terminals with the specified measuring current applied is called V_v (1 mA_{DC} @ 0.2 … 2 s).	To meet the specified value.
Clamping voltage	The maximum voltage between two terminals with the specified standard impulse current (8/20 µs) applied.	To meet the specified value.
Surge current derating, 8/20 µs	CECC 42 000, test C 2.1 100 surge currents (8/20 µs), unipolar, interval 30 s, amplitude corresponding to derating curve for 100 impulses at 20 µs	$\lvert\Delta V/V$ (1 mA)$\rvert \leq 10\%$ (measured in direction of surge current) No visible damage
Surge current derating, 2 ms	CECC 42 000, test C 2.1 100 surge currents (2 ms), unipolar, interval 120 s, amplitude corresponding to derating curve for 100 impulses at 2 ms	$\lvert\Delta V/V$ (1 mA)$\rvert \leq 10\%$ (measured in direction of surge current) No visible damage
Overvoltage test	The varistor should be subjected to V_{RMS} test (V_{RMS} = 0.85 V_v (1 mA)) until it failed, in series with 5 A fuse and 5 Ω resistor (based on S14 series).	No flame, no rupture

v/i characteristics

v = f (i) – for explanation of the characteristics refer to "General technical information", 1.6.3

A = Leakage current, B = Protection level — for worst-case varistor tolerances

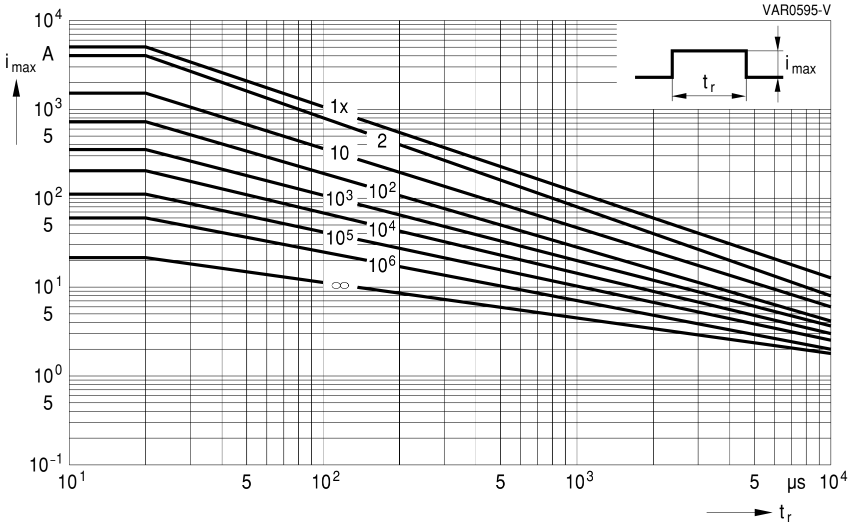


SIOV-SFS14K385E2

Derating curves

Maximum surge current $i_{max} = f(t_r$, pulse train)

For explanation of the derating curves refer to “General technical information”, section 1.8.1



SIOV-SFS14K385E2

Construction

- Disk-shaped varistor element,
  potted in plastic housing
- Housing and potting flame-retardant to UL 94 V-0
- Screw terminals M4 (SIOV-B32 … 40)
  Screw terminals M5 (SIOV-B60 … 80)

Features

- Heavy-duty varistors (surge current capability up to 100 kA)
- Wide operating voltage range 75 … 1100 V_{RMS}
- SIOV-B40 also available without housing (LS40 series)
- PSpice models

Approvals

- UL
- CSA (≥ K130)

Delivery mode

- Cardboard box

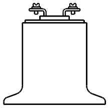
General technical data

Climatic category	to IEC 60068-1	40/85/56	
Operating temperature	to CECC 42 000	– 40 … + 85	°C
Storage temperature		– 40 … +110	°C
Electric strength	to CECC 42 000	≥2.5	kV_{RMS}
Insulation resistance	to CECC 42 000	≥10	MΩ
Response time		<25	ns
Max. torque			
B32/B40		1.0	Nm
B60/B80		2.5	Nm

Maximum ratings (T_A = 85 °C)

Ordering code	Type SIOV-	V_{RMS} V	V_{DC} V	i_{max} (8/20 µs) A	W_{max} (2 ms) J	P_{max} W
B72240B0750K001	B40K75	75	100	25000	190	1.4
B72232B0131K001	B32K130	130	170	25000	210	1.2
B72240B0131K001	B40K130	130	170	40000	310	1.4
B72260B0131K001	B60K130	130	170	70000	490	1.6
B72280B0131K001	B80K130	130	170	100000	660	2.0
B72232B0151K001	B32K150	150	200	25000	240	1.2
B72240B0151K001	B40K150	150	200	40000	360	1.4
B72260B0151K001	B60K150	150	200	70000	570	1.6
B72280B0151K001	B80K150	150	200	100000	800	2.0
B72232B0231K001	B32K230	230	300	25000	300	1.2
B72240B0231K001	B40K230	230	300	40000	460	1.4
B72260B0231K001	B60K230	230	300	70000	730	1.6
B72280B0231K001	B80K230	230	300	100000	1200	2.0
B72232B0251K001	B32K250	250	320	25000	330	1.2
B72240B0251K001	B40K250	250	320	40000	490	1.4
B72260B0251K001	B60K250	250	320	70000	800	1.6
B72280B0251K001	B80K250	250	320	100000	1300	2.0
B72232B0271K001	B32K275	275	350	25000	360	1.2
B72240B0271K001	B40K275	275	350	40000	550	1.4
B72260B0271K001	B60K275	275	350	70000	860	1.6
B72280B0271K001	B80K275	275	350	100000	1400	2.0
B72232B0321K001	B32K320	320	420	25000	430	1.2
B72240B0321K001	B40K320	320	420	40000	640	1.4
B72260B0321K001	B60K320	320	420	70000	1000	1.6
B72280B0321K001	B80K320	320	420	100000	1600	2.0
B72232B0381K001	B32K385	385	505	25000	550	1.2
B72240B0381K001	B40K385	385	505	40000	800	1.4
B72260B0381K001	B60K385	385	505	70000	1200	1.6
B72280B0381K001	B80K385	385	505	100000	2000	2.0

Varistor elements without plastic housing (suitable for soldering) are available upon request.



Characteristics (T_A = 25 °C)

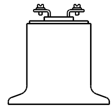
Ordering code	V_v (1 mA) V	ΔV_v (1 mA) %	$v_{c, max}$ (i_c) V	i_c A	C_{typ} (1 kHz) pF
B72240B0750K001	120	±10	220	300	11000
B72232B0131K001	205	±10	340	200	4400
B72240B0131K001	205	±10	340	300	5600
B72260B0131K001	205	±10	340	500	15000
B72280B0131K001	205	±10	340	800	28000
B72232B0151K001	240	±10	395	200	3700
B72240B0151K001	240	±10	395	300	4800
B72260B0151K001	240	±10	395	500	12000
B72280B0151K001	240	±10	395	800	23000
B72232B0231K001	360	±10	595	200	2500
B72240B0231K001	360	±10	595	300	3200
B72260B0231K001	360	±10	595	500	7900
B72280B0231K001	360	±10	595	800	16000
B72232B0251K001	390	±10	650	200	2200
B72240B0251K001	390	±10	650	300	2900
B72260B0251K001	390	±10	650	500	7100
B72280B0251K001	390	±10	650	800	14000
B72232B0271K001	430	±10	710	200	2000
B72240B0271K001	430	±10	710	300	2700
B72260B0271K001	430	±10	710	500	6600
B72280B0271K001	430	±10	710	800	13000
B72232B0321K001	510	±10	840	200	1700
B72240B0321K001	510	±10	840	300	2300
B72260B0321K001	510	±10	840	500	5600
B72280B0321K001	510	±10	840	800	11000
B72232B0381K001	620	±10	1025	200	1400
B72240B0381K001	620	±10	1025	300	1900
B72260B0381K001	620	±10	1025	500	4600
B72280B0381K001	620	±10	1025	800	9000

Maximum ratings (T_A = 85 °C)

Ordering code	Type SIOV-	V_{RMS} V	V_{DC} V	i_{max} (8/20 µs) A	W_{max} (2 ms) J	P_{max} W
B72232B0421K001	B32K420	420	560	25000	600	1.2
B72240B0421K001	B40K420	420	560	40000	910	1.4
B72260B0421K001	B60K420	420	560	70000	1500	1.6
B72280B0421K001	B80K420	420	560	100000	2200	2.0
B72232B0441K001	B32K440	440	585	25000	630	1.2
B72240B0441K001	B40K440	440	585	40000	950	1.4
B72260B0441K001	B60K440	440	585	70000	1580	1.6
B72280B0441K001	B80K440	440	585	100000	2350	2.0
B72232B0461K001	B32K460	460	615	25000	660	1.2
B72240B0461K001	B40K460	460	615	40000	1000	1.4
B72260B0461K001	B60K460	460	615	70000	1650	1.6
B72280B0461K001	B80K460	460	615	100000	2500	2.0
B72232B0551K001	B32K550	550	745	25000	620	1.2
B72240B0551K001	B40K550	550	745	40000	960	1.4
B72260B0551K001	B60K550	550	745	70000	1500	1.6
B72280B0551K001	B80K550	550	745	100000	3100	2.0
B72232B0681K001	B32K680	680	895	25000	760	1.2
B72240B0681K001	B40K680	680	895	40000	1100	1.4
B72260B0681K001	B60K680	680	895	70000	1800	1.6
B72280B0681K001	B80K680	680	895	100000	3600	2.0
B72232B0751K001	B32K750	750	970	25000	800	1.2
B72240B0751K001	B40K750	750	970	40000	1200	1.4
B72260B0751K001	B60K750	750	970	70000	2000	1.6
B72280B0751K001	B80K750	750	970	100000	4000	2.0
B72260B0102K001	B60K1000[1)]	1100	1465	70000	3000	1.6
B72280B0112K001	B80K1100	1100	1465	100000	6000	2.0

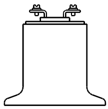
Varistor elements without plastic housing (suitable for soldering) are available upon request.

1) Operating voltage differs from type designation



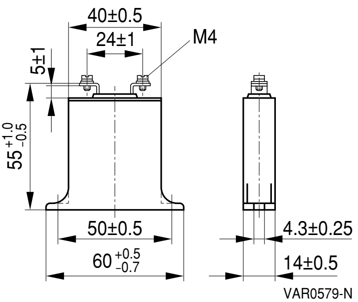
Characteristics (T_A = 25 °C)

Ordering code	V_v (1 mA) V	ΔV_v (1 mA) %	$v_{c, max}$ (i_c) V	i_c A	C_{typ} (1 kHz) pF
B72232B0421K001	680	±10	1120	200	1300
B72240B0421K001	680	±10	1120	300	1800
B72260B0421K001	680	±10	1120	500	4300
B72280B0421K001	680	±10	1120	800	8500
B72232B0441K001	715	±10	1180	200	1250
B72240B0441K001	715	±10	1180	300	1700
B72260B0441K001	715	±10	1180	500	4100
B72280B0441K001	715	±10	1180	800	8100
B72232B0461K001	750	±10	1240	200	1200
B72240B0461K001	750	±10	1240	300	1600
B72260B0461K001	750	±10	1240	500	3900
B72280B0461K001	750	±10	1240	800	7700
B72232B0551K001	910	±10	1500	200	1000
B72240B0551K001	910	±10	1500	300	1400
B72260B0551K001	910	±10	1500	500	3300
B72280B0551K001	910	±10	1500	800	6500
B72232B0681K001	1100	±10	1815	200	830
B72240B0681K001	1100	±10	1815	300	1100
B72260B0681K001	1100	±10	1815	500	2600
B72280B0681K001	1100	±10	1815	800	5200
B72232B0751K001	1200	±10	2000	200	800
B72240B0751K001	1200	±10	2000	300	1000
B72260B0751K001	1200	±10	2000	500	2400
B72280B0751K001	1200	±10	2000	800	4800
B72260B0102K001	1800	±10	2970	500	1600
B72280B0112K001	1800	±10	2970	800	3200

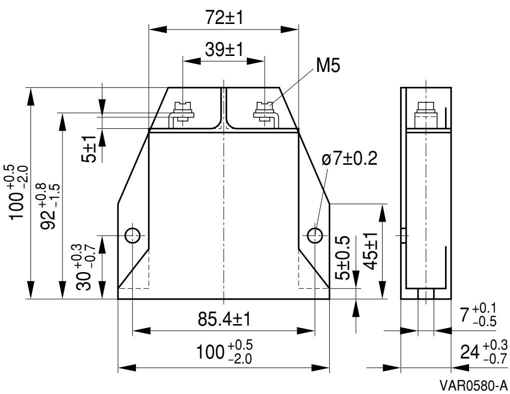


Dimensions

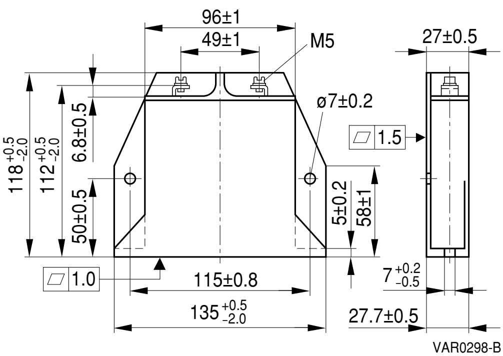
SIOV-B32/-B40



SIOV-B60



SIOV-B80



Weight

Nominal diameter mm	V_{RMS} V	Weight g
32	130 … 750	45
40	75 … 750	50
60	130 … 1100	250
80	130 … 1100	650

Dimensions in mm

Reliability data

Test	Test methods/conditions	Requirement
Varistor voltage	The voltage between two terminals with the specified measuring current applied is called V_v (1 mA_{DC} @ 0.2 … 2 s).	To meet the specified value.
Clamping voltage	The maximum voltage between two terminals with the specified standard impulse current (8/20 µs) applied.	To meet the specified value.
Max. DC operating voltage	The maximum allowable DC operating voltage V_{DC} at UCT +5/–0 °C is applied for 1000 ±48 h. The leakage current I_{leak} (t) during test is recorded. Then the specimen shall be stored at room temperature and normal humidity for 1 to 2 h. Thereafter, the change of V_v shall be measured.	I_{leak} (t = 1000 h) ≤ I_{leak} (t = 0 h) |ΔV/V (1 mA)| ≤10%
Surge current derating, 8/20 µs	10 surge currents (8/20 µs), unipolar, interval ≥60 s, amplitude corresponding to derating curve for 10 impulses at 20 µs	|ΔV/V (1 mA)| ≤10% (measured in direction of surge current) No visible damage
Fast temperature cycling	IEC 60068-2-14, test Na, LCT/UCT, dwell time 120 min, 5 cycles	|ΔV/V (1 mA)| ≤10% No visible damage
Damp heat, steady state	IEC 60068-2-78 The specimen shall be subjected to 40 ±2 °C, 90 to 95% r. H. for 56 ±2 days with 10% of the maximum continuous DC operating voltage V_{DC}. Then stored at room temperature and normal humidity for 1 to 2 h. Thereafter, the change of V_v shall be measured.	|ΔV/V (1 mA)| ≤10%

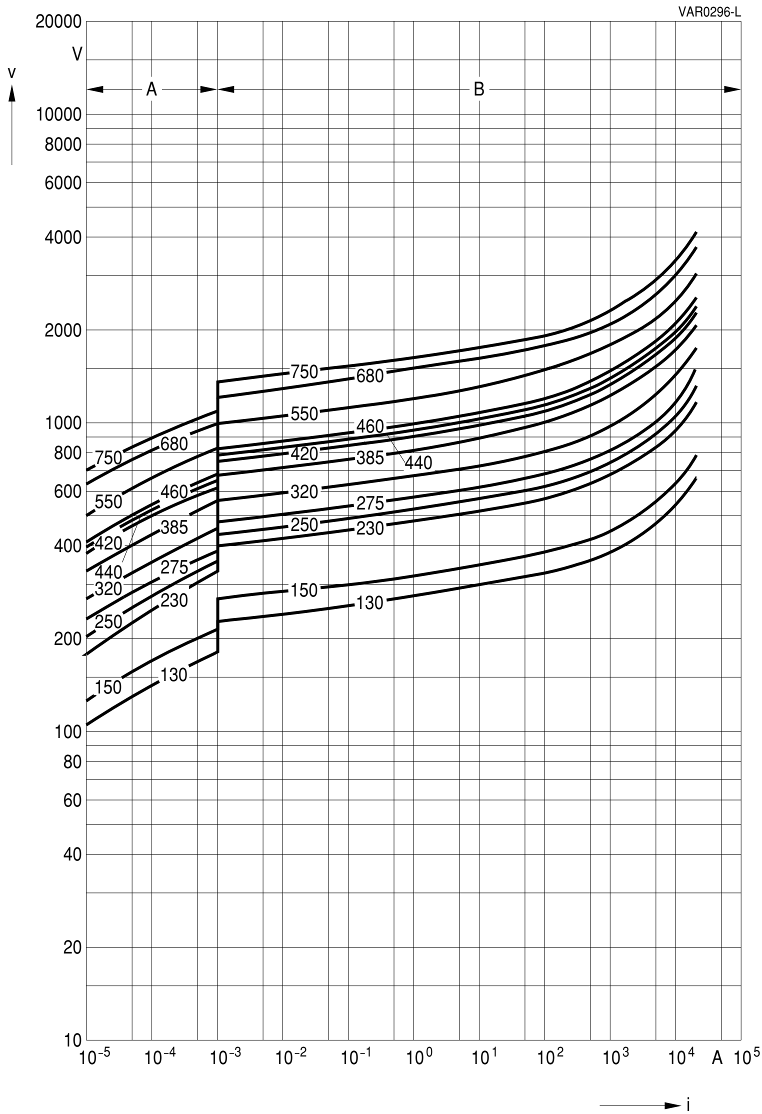
Note:

UCT = Upper category temperature
LCT = Lower category temperature

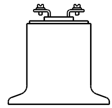
v/i characteristics

v = f (i) – for explanation of the characteristics refer to “General technical information”, 1.6.3

A = Leakage current, B = Protection level — for worst-case varistor tolerances



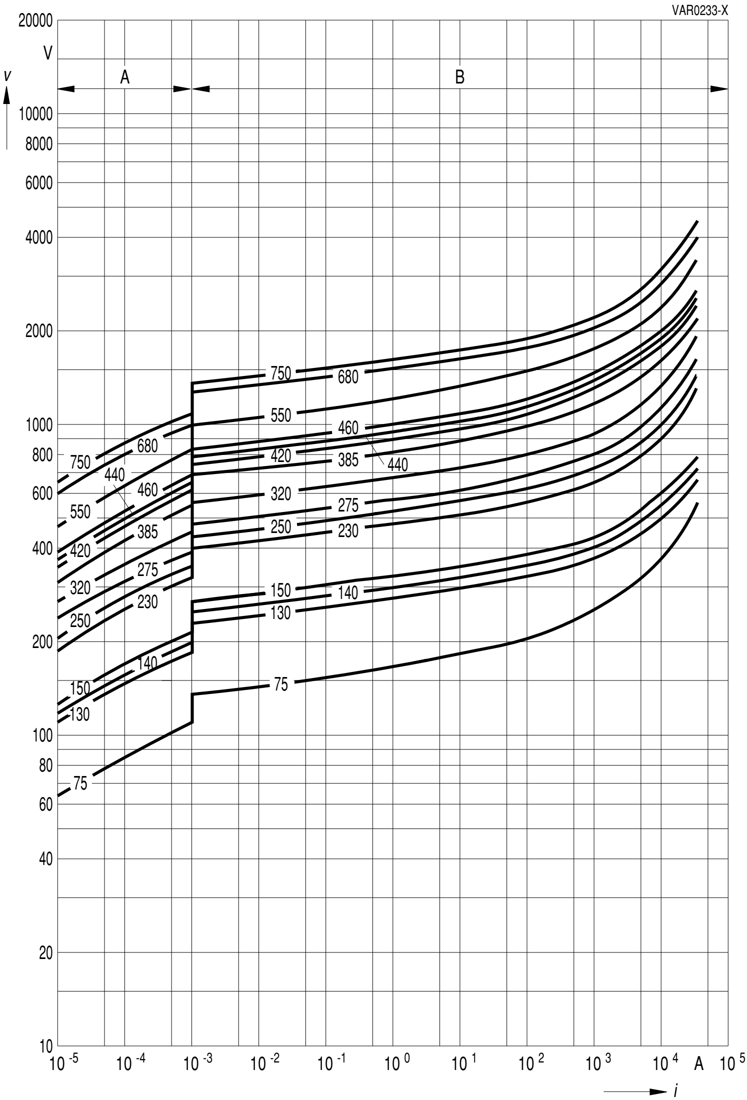
SIOV-B32K130 … K750



v/i characteristics

v = f (i) – for explanation of the characteristics refer to “General technical information”, 1.6.3

A = Leakage current, B = Protection level: for worst-case varistor tolerances

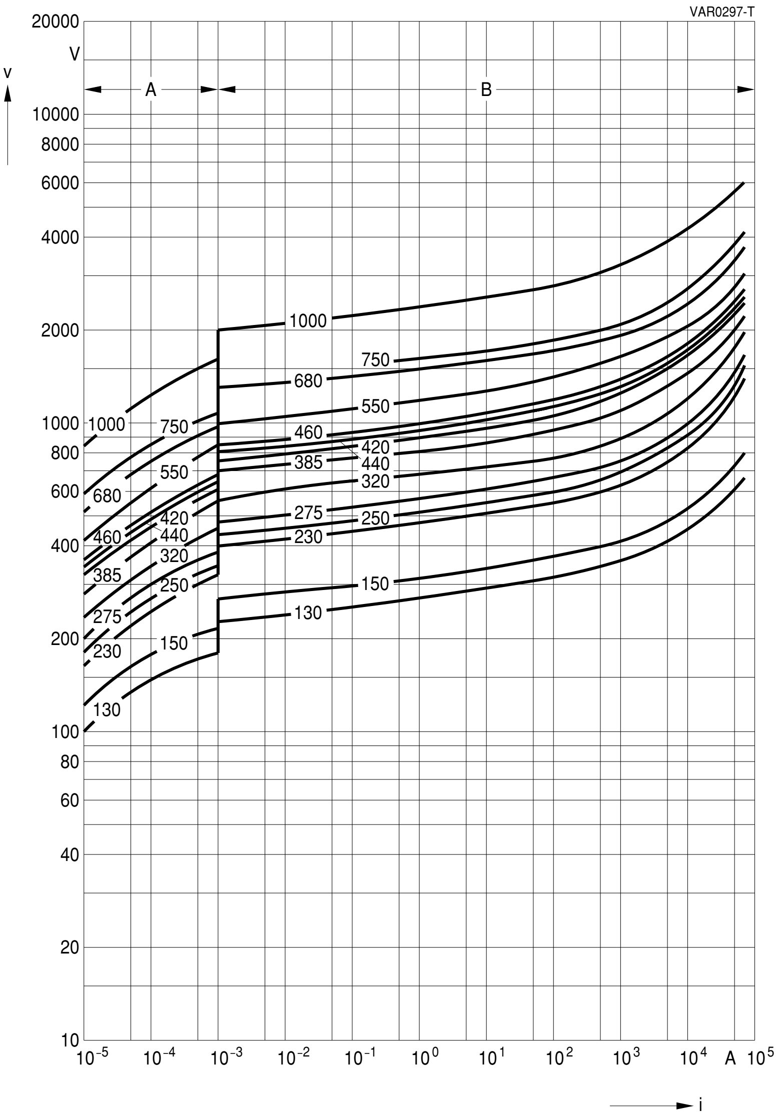


SIOV-B40K75 … K750

v/i characteristics

v = f (i) – for explanation of the characteristics refer to "General technical information", 1.6.3

A = Leakage current } for worst-case varistor tolerances
B = Protection level } for worst-case varistor tolerances

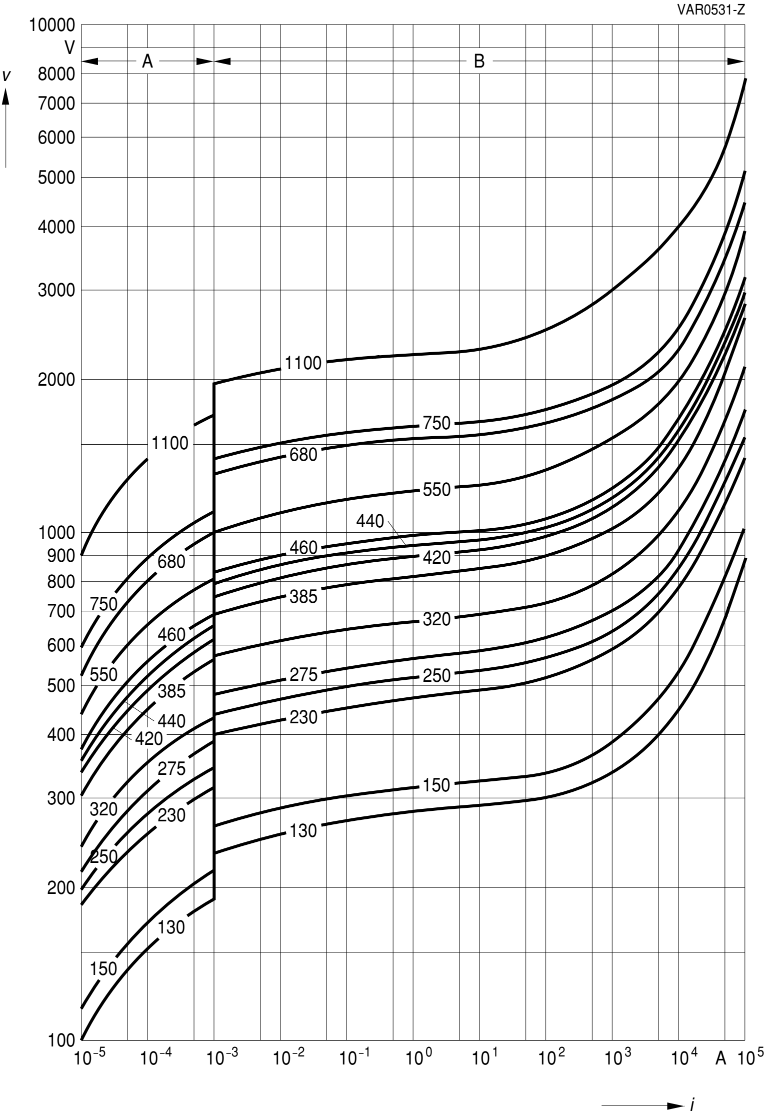


SIOV-B60K130 … K1000

v/i characteristics

v = f (i) – for explanation of the characteristics refer to "General technical information", 1.6.3

A = Leakage current, B = Protection level — for worst-case varistor tolerances

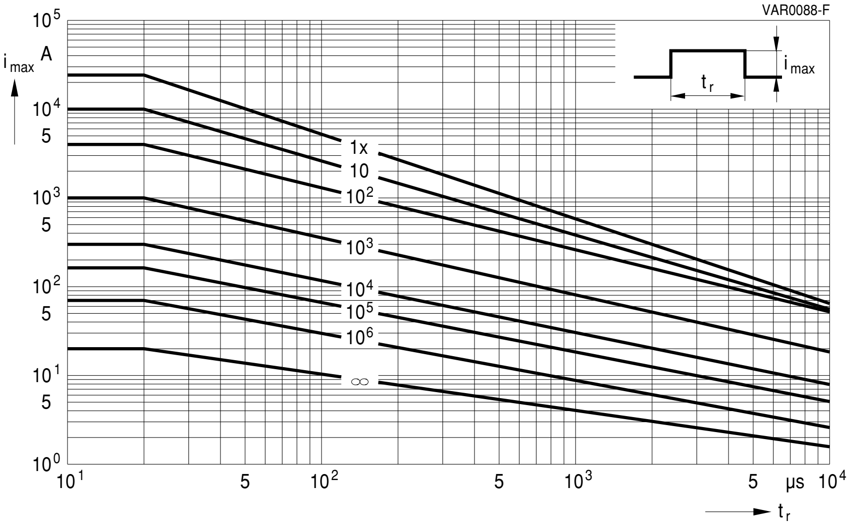


SIOV-B80K130 … K1100

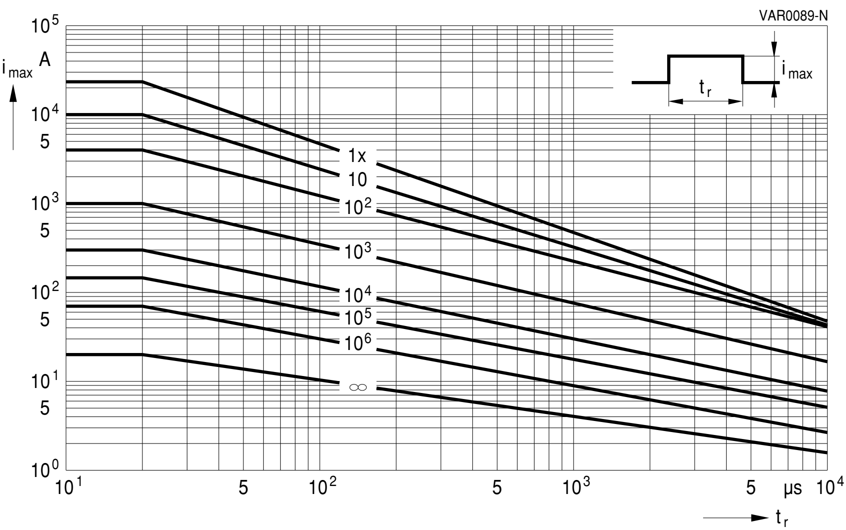
Derating curves

Maximum surge current $i_{max} = f(t_r$, pulse train)

For explanation of the derating curves refer to “General technical information”, section 1.8.1



SIOV-B32K130 … K150 **SIOV-B40K75**

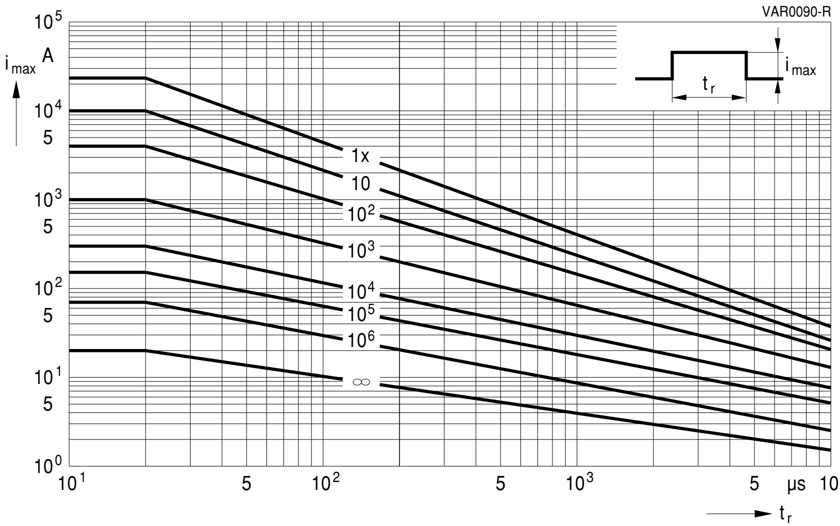


SIOV-B32K230 … K460

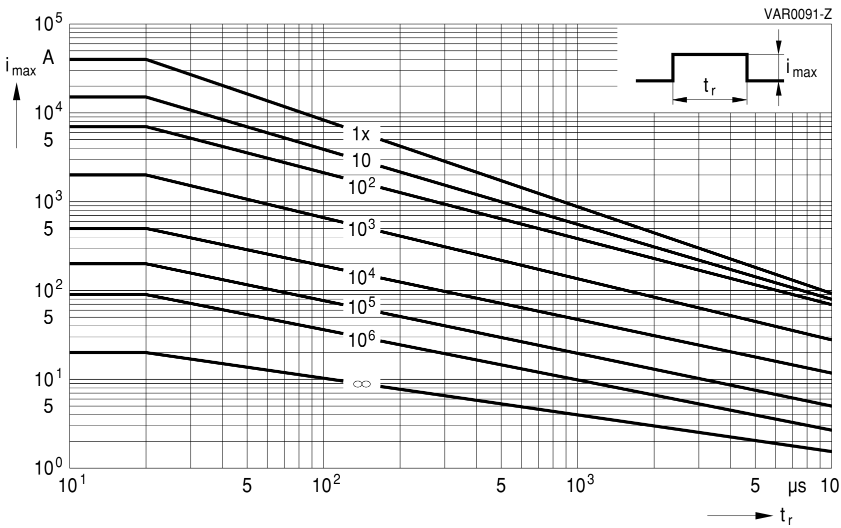
Derating curves

Maximum surge current $i_{max} = f(t_r$, pulse train)

For explanation of the derating curves refer to “General technical information”, section 1.8.1



SIOV-B32K550 … K750

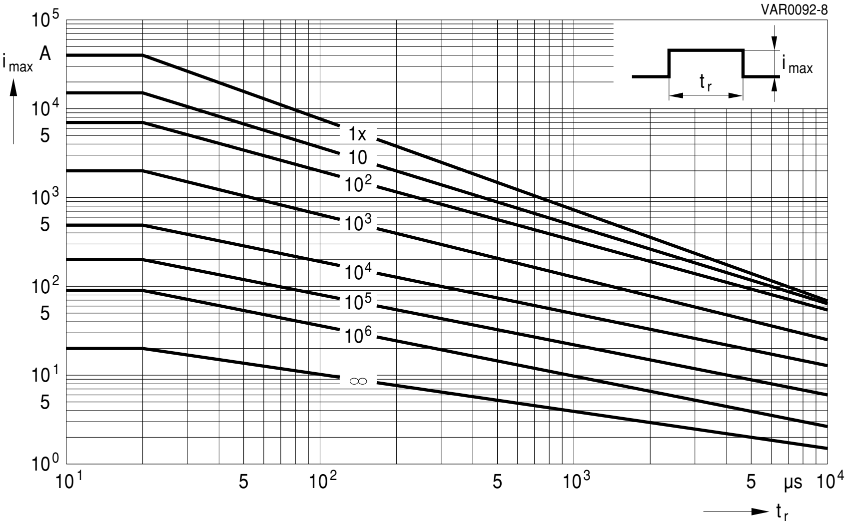


SIOV-B40K130 … K150

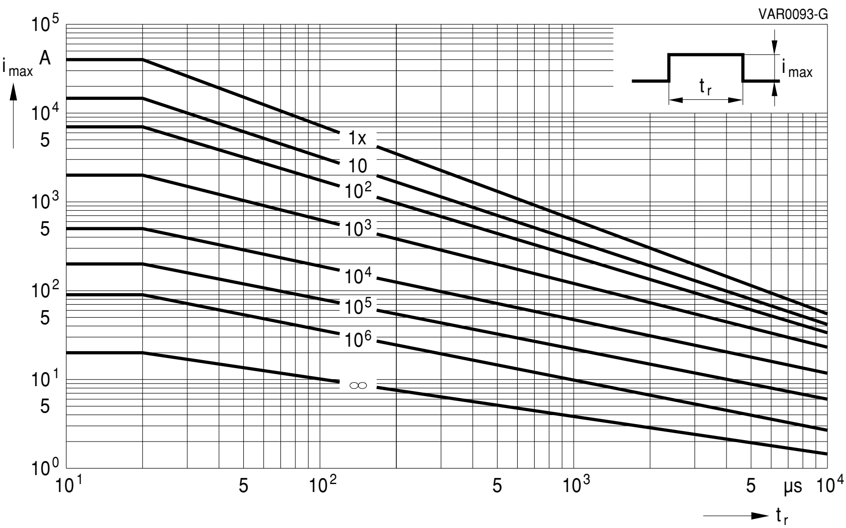
Derating curves

Maximum surge current i_{max} = f (t_r, pulse train)

For explanation of the derating curves refer to “General technical information”, section 1.8.1



SIOV-B40K230 … K460

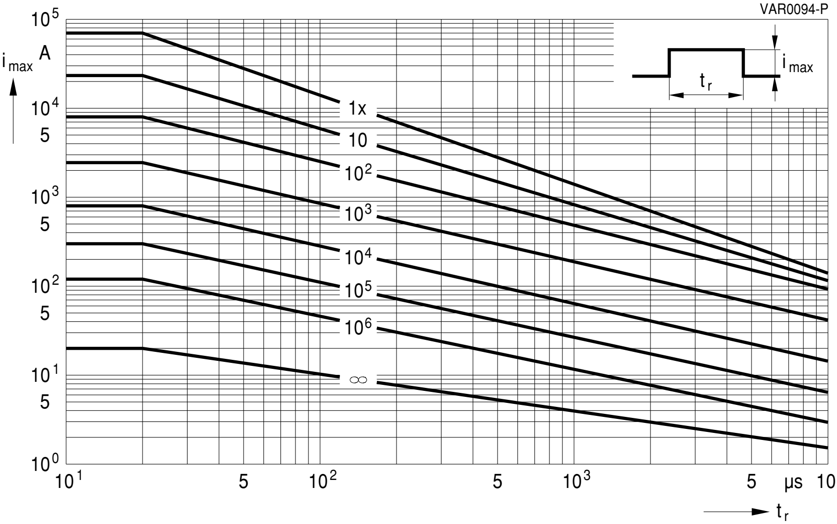


SIOV-B40K550 … K750

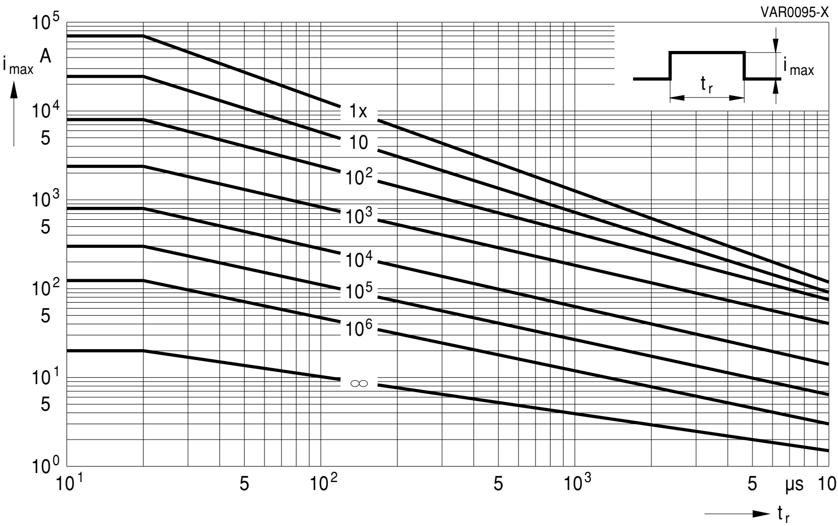
Derating curves

Maximum surge current $i_{max} = f(t_r$, pulse train)

For explanation of the derating curves refer to “General technical information”, section 1.8.1



SIOV-B60K130 … K150

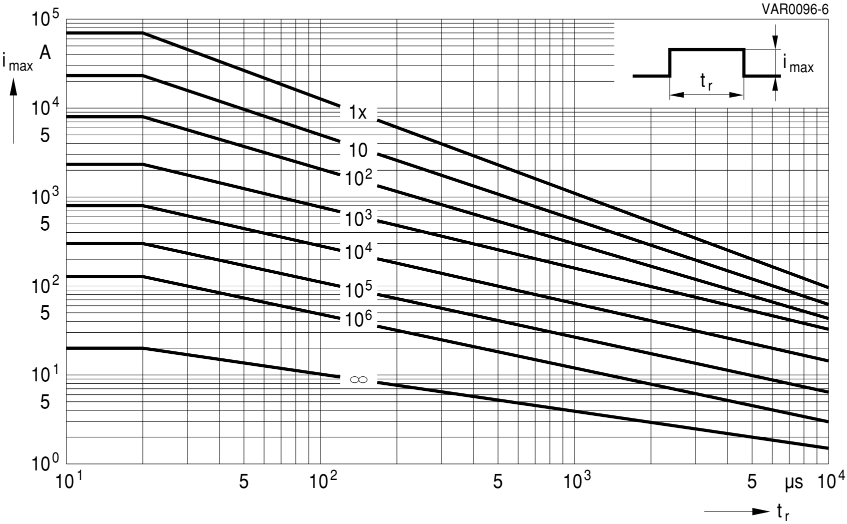


SIOV-B60K230 … K460

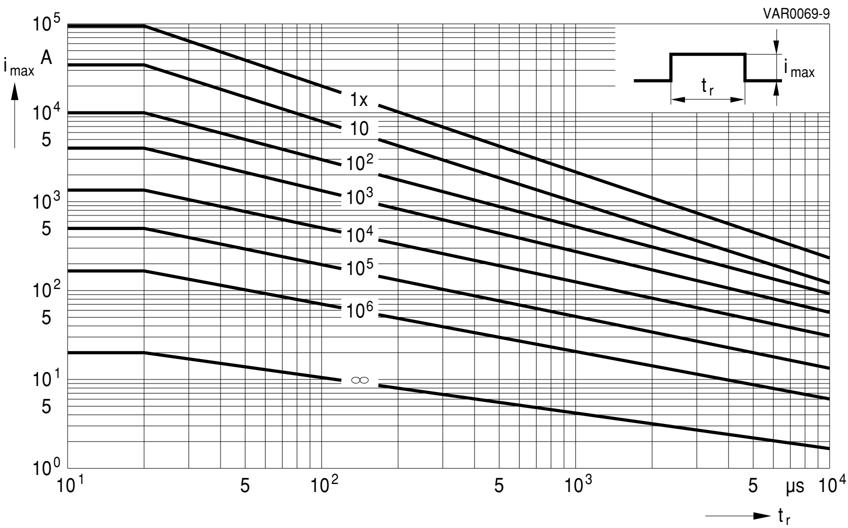
Derating curves

Maximum surge current $i_{max} = f$ (t_r, pulse train)

For explanation of the derating curves refer to “General technical information”, section 1.8.1



SIOV-B60K550 … K1000



SIOV-B80K130 … K1100

EPCOS

Construction

- Rectangular varistor element as in SIOV-B40
- Coating: epoxy resin, flame-retardant to UL 94 V-0
- Bolt-holed strap terminals for screw fixing or soldering
- Bent or straight strap terminals

Features

- High surge current up to 40 kA
- Wide operating voltage range 130 … 750 V_{RMS}
- PSpice models

Approvals

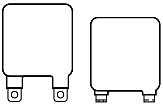
- UL
- CSA
- CECC (K150 … K385)

Delivery mode

- Vacuum-packed styrofoam box

General technical data

Climatic category	to IEC 60068-1	40/85/56	
Operating temperature	to CECC 42 000	−25 … + 85	°C
Storage temperature		−25 … +110	°C
Electric strength	to CECC 42 000	≥2.5	kV_{RMS}
Insulation resistance	to CECC 42 000	≥10	MΩ
Response time		<25	ns

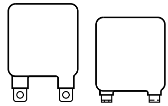


Strap varistors

HighE, standard, LS40 series

Maximum ratings (T_A = 85 °C)

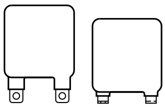
Ordering code	Type SIOV-	V_{RMS} V	V_{DC} V	i_{max} (8/20 µs) A	W_{max} (2 ms) J	P_{max} W
Bent strap terminals						
B72240L0131K100	LS40K130QP	130	170	40000	310	1.4
B72240L0141K100	LS40K140QP	140	180	40000	340	1.4
B72240L0151K100	LS40K150QP	150	200	40000	360	1.4
B72240L0231K100	LS40K230QP	230	300	40000	460	1.4
B72240L0251K100	LS40K250QP	250	320	40000	490	1.4
B72240L0271K100	LS40K275QP	275	350	40000	550	1.4
B72240L0321K100	LS40K320QP	320	420	40000	640	1.4
B72240L0381K100	LS40K385QP	385	505	40000	800	1.4
B72240L0421K100	LS40K420QP	420	560	40000	910	1.4
B72240L0441K100	LS40K440QP	440	585	40000	950	1.4
B72240L0461K100	LS40K460QP	460	615	40000	960	1.4
B72240L0551K100	LS40K550QP	550	745	40000	960	1.4
B72240L0681K100	LS40K680QP	680	895	40000	1100	1.4
B72240L0751K100	LS40K750QP	750	970	40000	1200	1.4
Straight strap terminals						
B72240L0131K102	LS40K130QPK2	130	170	40000	310	1.4
B72240L0141K102	LS40K140QPK2	140	180	40000	340	1.4
B72240L0151K102	LS40K150QPK2	150	200	40000	360	1.4
B72240L0231K102	LS40K230QPK2	230	300	40000	460	1.4
B72240L0251K102	LS40K250QPK2	250	320	40000	490	1.4
B72240L0271K102	LS40K275QPK2	275	350	40000	550	1.4
B72240L0321K102	LS40K320QPK2	320	420	40000	640	1.4
B72240L0381K102	LS40K385QPK2	385	505	40000	800	1.4
B72240L0421K102	LS40K420QPK2	420	560	40000	910	1.4
B72240L0441K102	LS40K440QPK2	440	585	40000	950	1.4
B72240L0461K102	LS40K460QPK2	460	615	40000	960	1.4
B72240L0551K102	LS40K550QPK2	550	745	40000	960	1.4
B72240L0681K102	LS40K680QPK2	680	895	40000	1100	1.4
B72240L0751K102	LS40K750QPK2	750	970	40000	1200	1.4



Characteristics (T_A = 25 °C)

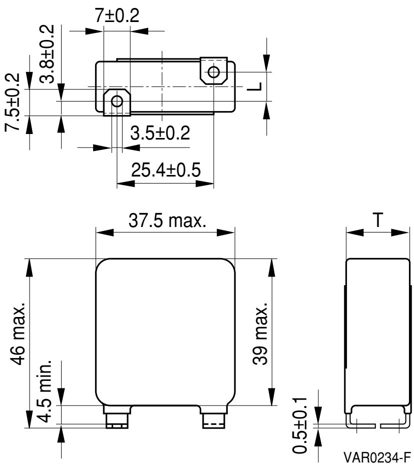
Ordering code	V_V (1 mA) V	ΔV_V (1 mA) %	$v_{c, max}$ (i_c) V	i_c A	C_{typ} (1 kHz) pF
Bent strap terminals					
B72240L0131K100	205	±10	340	300	5600
B72240L0141K100	220	±10	365	300	5200
B72240L0151K100	240	±10	395	300	4800
B72240L0231K100	360	±10	595	300	3200
B72240L0251K100	390	±10	650	300	2900
B72240L0271K100	430	±10	710	300	2700
B72240L0321K100	510	±10	840	300	2300
B72240L0381K100	620	±10	1025	300	1900
B72240L0421K100	680	±10	1120	300	1800
B72240L0441K100	715	±10	1180	300	1700
B72240L0461K100	750	±10	1240	300	1600
B72240L0551K100	910	±10	1500	300	1400
B72240L0681K100	1100	±10	1815	300	1100
B72240L0751K100	1200	±10	2000	300	1000
Straight strap terminals					
B72240L0131K102	205	±10	340	300	5600
B72240L0141K102	220	±10	365	300	5200
B72240L0151K102	240	±10	395	300	4800
B72240L0231K102	360	±10	595	300	3200
B72240L0251K102	390	±10	650	300	2900
B72240L0271K102	430	±10	710	300	2700
B72240L0321K102	510	±10	840	300	2300
B72240L0381K102	620	±10	1025	300	1900
B72240L0421K102	680	±10	1120	300	1800
B72240L0441K102	715	±10	1180	300	1700
B72240L0461K102	750	±10	1240	300	1600
B72240L0551K102	910	±10	1500	300	1400
B72240L0681K102	1100	±10	1815	300	1100
B72240L0751K102	1200	±10	2000	300	1000

Varistor elements without coating (suitable for soldering) are available upon request.
Designation: B72240D****K***



Dimensional drawings

Bent strap terminals

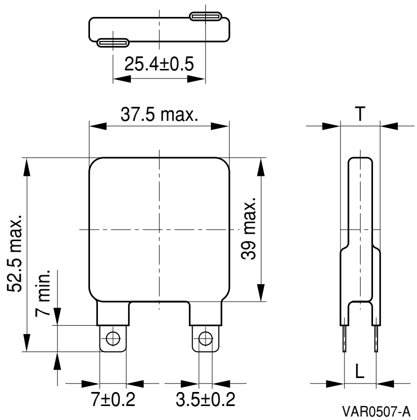


Ordering code	T_{max} mm	L ±1.0 mm
B72240L0131K100	8.1	–3.5
B72240L0141K100	8.2	–3.3
B72240L0151K100	8.3	–3.2
B72240L0231K100	9.0	–2.0
B72240L0251K100	9.2	–1.8
B72240L0271K100	9.4	–1.6
B72240L0321K100	9.9	–1.1
B72240L0381K100	10.6	–0.4
B72240L0421K100	10.9	0.0
B72240L0441K100	11.1	0.2
B72240L0461K100	11.4	0.4
B72240L0551K100	12.3	1.2
B72240L0681K100	13.5	2.4
B72240L0751K100	14.1	3.0

SIOV-LS40K … QP

Weight: 20 … 50 g

Straight strap terminals



Ordering code	T_{max} mm	L ±1.0 mm
B72240L0131K102	8.1	4.4
B72240L0141K102	8.2	4.5
B72240L0151K102	8.3	4.6
B72240L0231K102	9.0	5.4
B72240L0251K102	9.2	5.6
B72240L0271K102	9.4	5.8
B72240L0321K102	9.9	6.3
B72240L0381K102	10.6	6.9
B72240L0421K102	10.9	7.3
B72240L0441K102	11.1	7.6
B72240L0461K102	11.4	7.8
B72240L0551K102	12.3	8.8
B72240L0681K102	13.5	9.9
B72240L0751K102	14.1	10.5

SIOV-LS40K … QPK2

Weight: 20 … 50 g

Reliability data

Test	Test methods/conditions	Requirement
Varistor voltage	The voltage between two terminals with the specified measuring current applied is called V_v (1 mA_{DC} @ 0.2 … 2 s).	To meet the specified value.
Clamping voltage	The maximum voltage between two terminals with the specified standard impulse current (8/20 µs) applied.	To meet the specified value.
Max. DC operating voltage	The maximum allowable DC operating voltage V_{DC} at UCT +5/–0 °C is applied for 1000 ±48 h. The leakage current I_{leak} (t) during test is recorded. Then the specimen shall be stored at room temperature and normal humidity for 1 to 2 h. Thereafter, the change of V_v shall be measured.	I_{leak} (t = 1000 h) ≤ I_{leak} (t = 0 h) |ΔV/V (1 mA)| ≤10%
Surge current derating, 8/20 µs	10 surge currents (8/20 µs), unipolar, interval ≥60 s, amplitude corresponding to derating curve for 10 impulses at 20 µs	|ΔV/V (1 mA)| ≤10% (measured in direction of surge current) No visible damage
Fast temperature cycling	IEC 60068-2-14, test Na, LCT/UCT, dwell time 30 min, 5 cycles	|ΔV/V (1 mA)| ≤10% No visible damage
Damp heat, steady state	IEC 60068-2-78 The specimen shall be subjected to 40 ±2 °C, 90 to 95% r. H. for 56 ±2 days with 10% of the maximum continuous DC operating voltage V_{DC}. Then stored at room temperature and normal humidity for 1 to 2 h. Thereafter, the change of V_v shall be measured.	|ΔV/V (1 mA)| ≤10%

Note:

UCT = Upper category temperature
LCT = Lower category temperature

Reliability data for CECC approved types

Test	Test methods/conditions	Requirement
Varistor voltage	The voltage between two terminals with the specified measuring current applied is called V_v (1 mA_{DC} @ 0.2 … 2 s).	To meet the specified value.
Clamping voltage	The maximum voltage between two terminals with the specified standard impulse current (8/20 µs) applied.	To meet the specified value.
Max. AC operating voltage	CECC 42 000, test 4.20 1000 h at UCT After having continuously applied the maximum allowable voltage at UCT ±2 °C for 1000 h, the specimen shall be stored at room temperature and normal humidity for 1 to 2 h. Thereafter, the change of V_v shall be measured. Thereafter, insulation resistance R_{ins} shall be measured according to CECC 42 000, test 4.8 at V = 500 V.	$\lvert\Delta V/V$ (1 mA)$\rvert \leq$10% $R_{ins} \geq$10 MΩ
Surge current derating, 8/20 µs	CECC 42 000, test C 2.1 100 surge currents (8/20 µs), unipolar, interval 30 s, amplitude corresponding to derating curve for 100 impulses at 20 µs	$\lvert\Delta V/V$ (1 mA)$\rvert \leq$10% (measured in direction of surge current) No visible damage
Surge current derating, 2 ms	CECC 42 000, test C 2.1 100 surge currents (2 ms), unipolar, interval 120 s, amplitude corresponding to derating curve for 100 impulses at 2 ms	$\lvert\Delta V/V$ (1 mA)$\rvert \leq$10% (measured in direction of surge current) No visible damage
Electric strength	CECC 42 000, test 4.7 Metal balls method, 2500 V_{RMS}, 60 s The varistor is placed in a container holding 1.6 ±0.2 mm diameter metal balls such that only the terminations of the varistor are protruding. The specified voltage shall be applied between both terminals of the specimen connected together and the electrode inserted between the metal balls.	No breakdown

Reliability data for CECC approved types

Test	Test methods/conditions	Requirement
Climatic sequence	CECC 42 000, test 4.16 The specimen shall be subjected to: a) dry heat at UCT, 16 h b) damp heat, 1st cycle: 55 °C/25 °C, 93% r. H., 24 h c) cold, LCT, 2 h d) damp heat, additional 5 cycles: 55 °C/25 °C, 93% r. H., 24 h/cycle. Then the specimen shall be stored at room temperature and normal humidity for 1 to 2 h. Thereafter, the change of V_v shall be measured. Thereafter, insulation resistance R_{ins} shall be measured according to CECC 42 000, test 4.8 at V = 500 V.	$\|\Delta V/V\ (1\ mA)\| \leq 10\%$ $R_{ins} \geq 1\ M\Omega$
Fast temperature cycling	IEC 60068-2-14, test Na, LCT/UCT, dwell time 30 min, 5 cycles	$\|\Delta V/V\ (1\ mA)\| \leq 5\%$ No visible damage
Damp heat, steady state	The specimen shall be subjected to 40 ±2 °C, 90 to 95% r. H. for 56 days without load / with 10% of the maximum continuous DC operating voltage V_{DC}. Then stored at room temperature and normal humidity for 1 to 2 h. Thereafter, the change of V_v shall be measured. Thereafter, insulation resistance R_{ins} shall be measured according to CECC 42 000, test 4.8 at V = 500 V.	$\|\Delta V/V\ (1\ mA)\| \leq 10\%$ $R_{ins} \geq 1\ M\Omega$
Solderability	IEC 60068-2-20, test Ta, method 1 with modified conditions for lead-free solder alloys: 245 °C, 3 s: After dipping the terminals to a depth of approximately 3 mm from the body in a soldering bath of 245 °C for 3 s, the terminals shall be visually examined.	The inspection shall be carried out under adequate light with normal eyesight or with the assistance of a magnifier capable of giving a magnification of 4 to 10 times. The dipped surface shall be covered with a smooth and bright solder coating with no more than small amounts of scattered imperfections such as pinholes or un-wetted or de-wetted areas. These imperfections shall not be concentrated in one area.

Reliability data for CECC approved types

Test	Test methods/conditions	Requirement
Resistance to soldering heat	IEC 60068-2-20, test Tb, method 1A, 260 °C, 10 s: Each lead shall be dipped into a solder bath having a temperature of 260 ±5 °C to a point 2.0 to 2.5 mm from the body of the unit, be held there for 10 ±1 s and then be stored at room temperature and normal humidity for 1 to 2 h. The change of V_v and mechanical damages shall be examined.	$\|\Delta V/V\ (1\ mA)\| \leq 5\%$ No visible damage
Tensile strength	IEC 60068-2-21, test Ua1 After gradually applying the force specified below and keeping the unit fixed for 10 s, the terminal shall be visually examined for any damage. Force = 20 N	$\|\Delta V/V\ (1\ mA)\| \leq 5\%$ No break of solder joint, no wire break
Vibration	IEC 60068-2, test Fc frequency range: 10 … 55 Hz amplitude: 0.75 mm or 98 m/s² duration: 6 h (3 · 2 h) pulse: sine wave After repeatedly applying a single harmonic vibration according to the table below. The change of V_v and mechanical damages shall be examined.	$\|\Delta V/V\ (1\ mA)\| \leq 5\%$ No visible damage
Shock	IEC 60068-2-27, test Ea pulse duration: 11 ms max. acceleration: 490 m/s² number of shocks: 6 · 3 pulse: half sine	$\|\Delta V/V\ (1\ mA)\| \leq 5\%$ No visible damage
Flammability	IEC 60695-2-2 (needle flame test) Severity: vertical 10 s	5 s max.

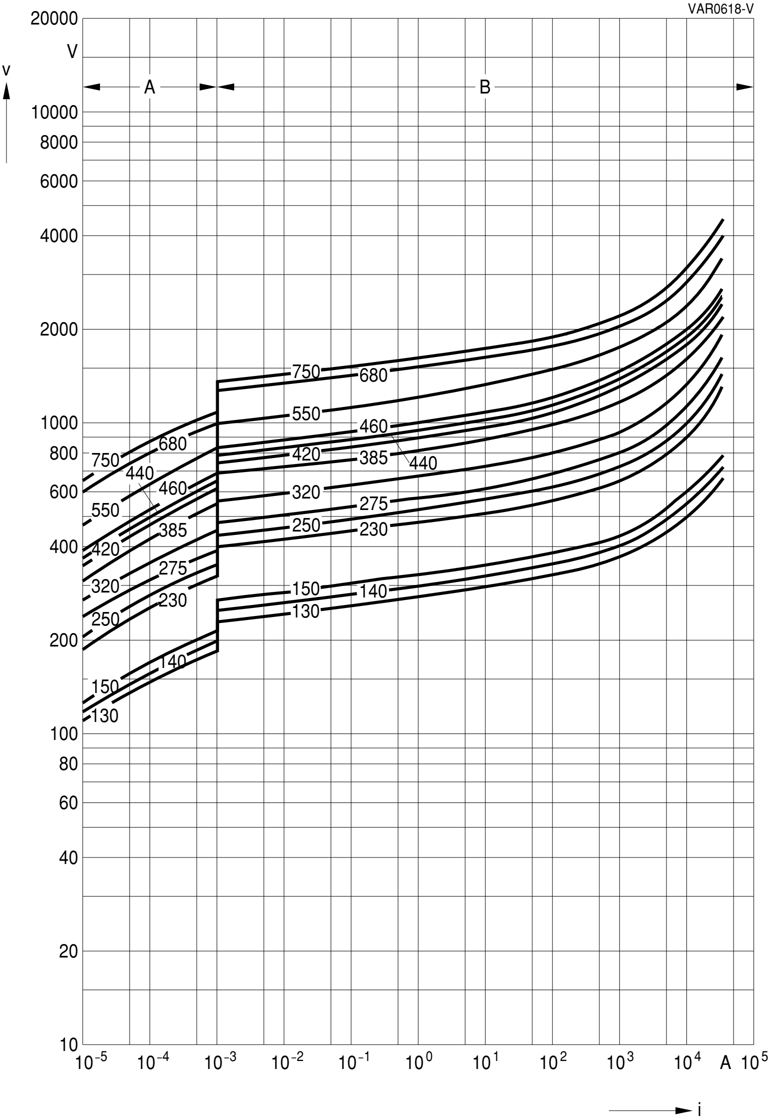
Note:

UCT = Upper category temperature
LCT = Lower category temperature
R_{ins} = Insulation resistance to CECC 42 000, test 4.8

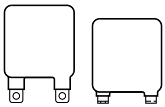
v/i characteristics

v = f (i) – for explanation of the characteristics refer to “General technical information”, 1.6.3

A = Leakage current } for worst-case varistor tolerances
B = Protection level



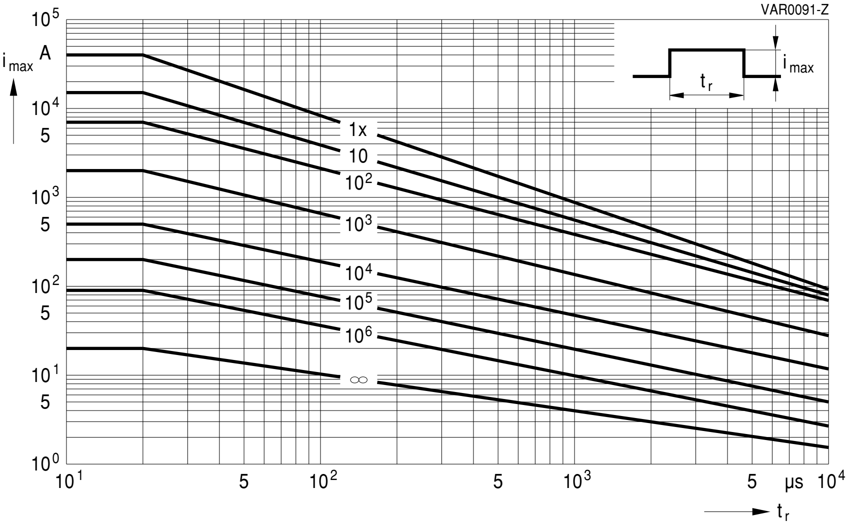
SIOV-LS40K130QP(K2) … K750QP(K2)



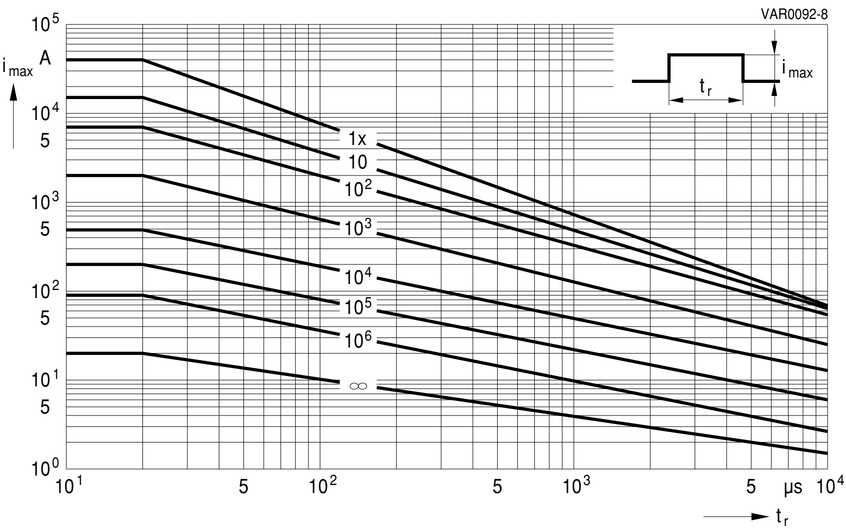
Derating curves

Maximum surge current i_{max} = f (t_r, pulse train)

For explanation of the derating curves refer to “General technical information”, section 1.8.1



SIOV-LS40K130QP(K2) … K150QP(K2)

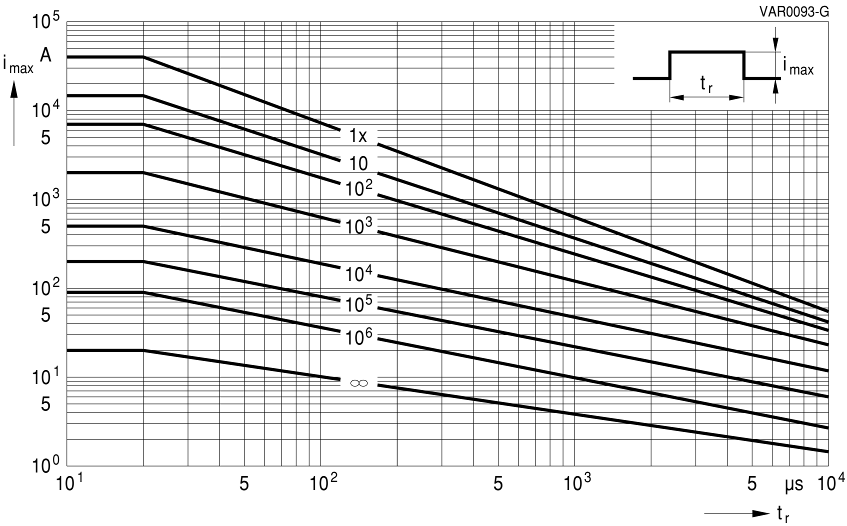


SIOV-LS40K230QP(K2) … K460QP(K2)

Derating curves

Maximum surge current $i_{max} = f(t_r$, pulse train)

For explanation of the derating curves refer to “General technical information”, section 1.8.1



SIOV-LS40K550QP(K2) … K750QP(K2)

Strap varistors

HighE, AdvanceD, LS41 series

Construction

- Rectangular varistor element
- Coating: epoxy resin, flame-retardant to UL 94 V-0
- Bolt-holed strap terminals for screw fixing or soldering
- Bent strap terminals

Features

- Dimensions equivalent to SIOV-LS40
- High surge current up to 50 kA
- Wide operating voltage range 130 … 460 V_{RMS}
- Designed in accordance with the requirements of IEC 61643-1, class II, for low-voltage surge protection devices

Approvals

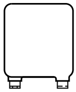
- UL
- CSA

Delivery mode

- Vacuum-packed styrofoam box

General technical data

Climatic category	to IEC 60068-1	40/85/56	
Operating temperature	to CECC 42 000	–25 … + 85	°C
Storage temperature		–25 … +110	°C
Electric strength	to CECC 42 000	≥2.5	kV_{RMS}
Insulation resistance	to CECC 42 000	≥10	MΩ
Response time		<25	ns



Strap varistors

HighE, AdvanceD, LS41 series

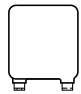
Maximum ratings (T_A = 85 °C)

Ordering code	Type SIOV-	V_{RMS} V	V_{DC} V	i_{max} (8/20 µs) A	I_{max}[1] (8/20 µs) A	I_{nom}[2] (8/20 µs) A	W_{max} (2 ms) J	P_{max} W
B72241L0131K100	LS41K130QP	130	170	50000	45000	20000	310	1.4
B72241L0141K100	LS41K140QP	140	180	50000	45000	20000	340	1.4
B72241L0151K100	LS41K150QP	150	200	50000	45000	20000	360	1.4
B72241L0231K100	LS41K230QP	230	300	50000	45000	20000	460	1.4
B72241L0251K100	LS41K250QP	250	320	50000	45000	20000	490	1.4
B72241L0271K100	LS41K275QP	275	350	50000	45000	20000	550	1.4
B72241L0321K100	LS41K320QP	320	420	50000	45000	20000	640	1.4
B72241L0381K100	LS41K385QP	385	505	50000	45000	20000	800	1.4
B72241L0421K100	LS41K420QP	420	560	50000	45000	20000	910	1.4
B72241L0441K100	LS41K440QP	440	585	50000	45000	20000	950	1.4
B72241L0461K100	LS41K460QP	460	615	50000	45000	20000	960	1.4

Characteristics (T_A = 25 °C)

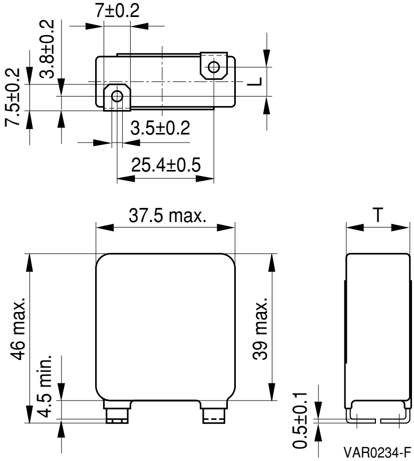
Ordering code	Type SIOV-	V_v (1 mA) V	ΔV_v (1 mA) %	$v_{c, max}$ (i_c) V	i_c A	C_{typ} (1 kHz) pF
B72241L0131K100	LS41K130QP	205	±10	340	300	5600
B72241L0141K100	LS41K140QP	220	±10	365	300	5200
B72241L0151K100	LS41K150QP	240	±10	395	300	4800
B72241L0231K100	LS41K230QP	360	±10	595	300	3200
B72241L0251K100	LS41K250QP	390	±10	650	300	2900
B72241L0271K100	LS41K275QP	430	±10	710	300	2700
B72241L0321K100	LS41K320QP	510	±10	840	300	2300
B72241L0381K100	LS41K385QP	620	±10	1025	300	1900
B72241L0421K100	LS41K420QP	680	±10	1120	300	1800
B72241L0441K100	LS41K440QP	715	±10	1180	300	1700
B72241L0461K100	LS41K460QP	750	±10	1240	300	1600

1) I_{max} = Maximum discharge current to IEC 61643-1, class II
2) I_{nom} = Nominal discharge current to IEC 61643-1, class II



Dimensional drawings

Bent strap terminals



Ordering code	T_{max} mm	L ±1.0 mm
B72241L0131K100	8.1	–3.5
B72241L0141K100	8.2	–3.3
B72241L0151K100	8.3	–3.2
B72241L0231K100	9.0	–2.0
B72241L0251K100	9.2	–1.8
B72241L0271K100	9.4	–1.6
B72241L0321K100	9.9	–1.1
B72241L0381K100	10.6	–0.4
B72241L0421K100	10.9	0.0
B72241L0441K100	11.1	0.2
B72241L0461K100	11.4	0.4

SIOV-LS41K … QP

Weight: 20 … 40 g

Reliability data

Test	Test methods/conditions	Requirement
Varistor voltage	The voltage between two terminals with the specified measuring current applied is called V_v (1 mA_{DC} @ 0.2 … 2 s).	To meet the specified value.
Clamping voltage	The maximum voltage between two terminals with the specified standard impulse current (8/20 μs) applied.	To meet the specified value.
Max. DC operating voltage	The maximum allowable DC operating voltage V_{DC} at UCT +5/–0 °C is applied for 1000 ±48 h. The leakage current I_{leak} (t) during test is recorded. Then the specimen shall be stored at room temperature and normal humidity for 1 to 2 h. Thereafter, the change of V_v shall be measured.	I_{leak} (t = 1000 h) ≤ I_{leak} (t = 0 h) |ΔV/V (1 mA)| ≤10%
Surge current derating, 8/20 μs	10 surge currents (8/20 μs), unipolar, interval ≥60 s, amplitude corresponding to derating curve for 10 impulses at 20 μs	|ΔV/V (1 mA)| ≤10% (measured in direction of surge current) No visible damage
Fast temperature cycling	IEC 60068-2-14, test Na, LCT/UCT, dwell time 30 min, 5 cycles	|ΔV/V (1 mA)| ≤10% No visible damage
Damp heat, steady state	IEC 60068-2-78 The specimen shall be subjected to 40 ±2 °C, 90 to 95% r. H. for 56 ±2 days with 10% of the maximum continuous DC operating voltage V_{DC}. Then stored at room temperature and normal humidity for 1 to 2 h. Thereafter, the change of V_v shall be measured.	|ΔV/V (1 mA)| ≤10%

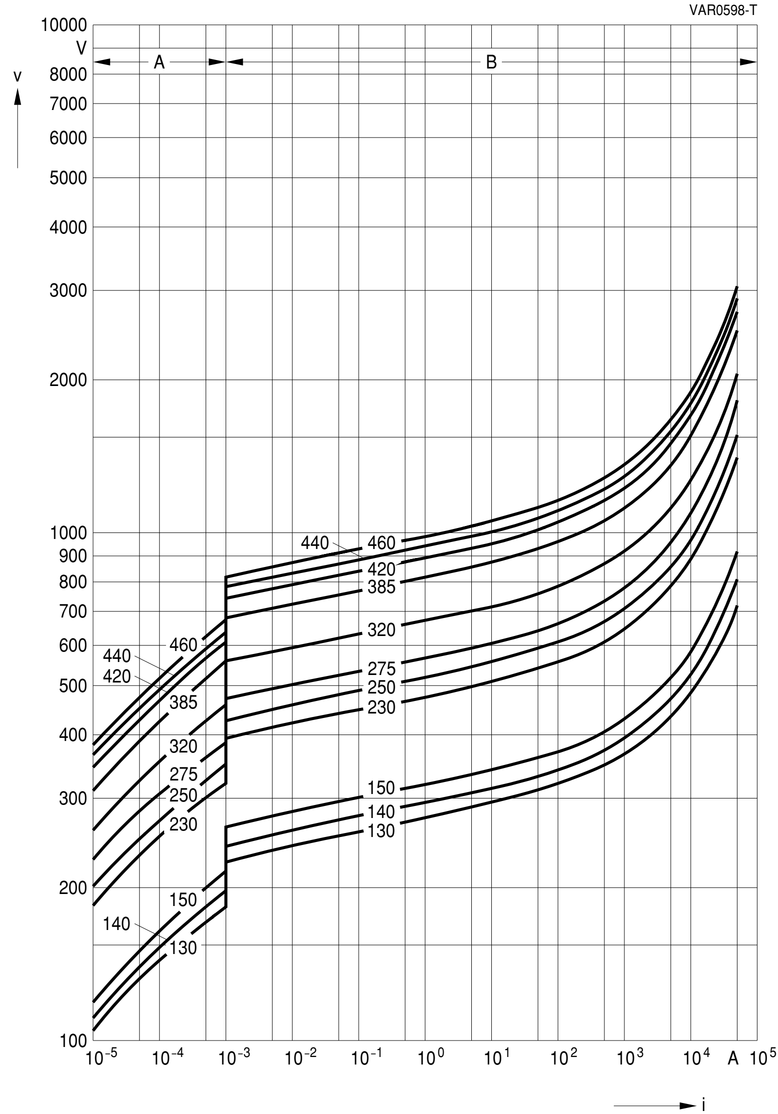
Note:

UCT = Upper category temperature
LCT = Lower category temperature

v/i characteristics

v = f (i) – for explanation of the characteristics refer to “General technical information”, 1.6.3

A = Leakage current, B = Protection level — for worst-case varistor tolerances

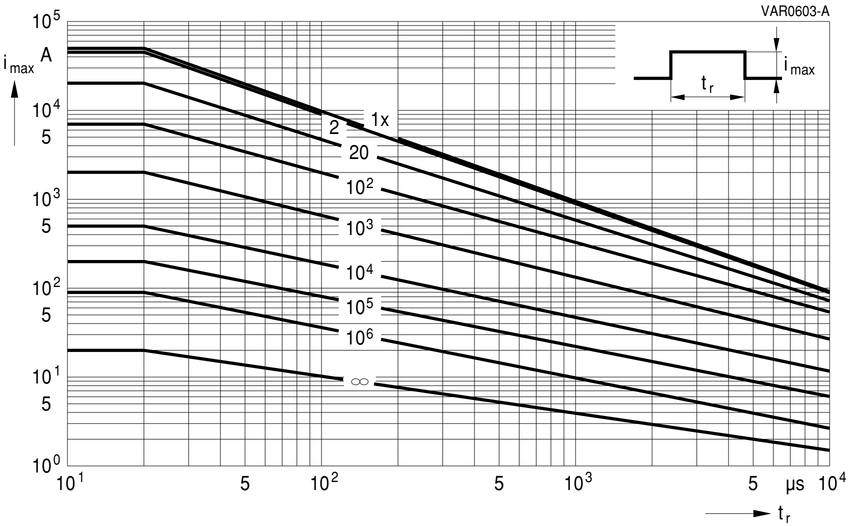


SIOV-LS41K130QP … K460QP

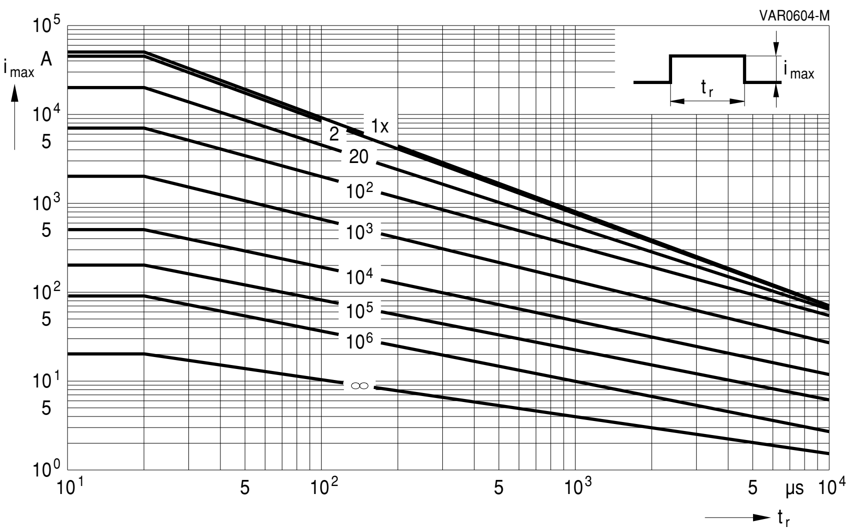
Derating curves

Maximum surge current i_{max} = f (t_r, pulse train)

For explanation of the derating curves refer to “General technical information”, section 1.8.1



SIOV-LS41K130QP … K150QP



SIOV-LS41K230QP … K460QP

Strap varistors

HighE, SuperioR, LS42 series

Construction

- Rectangular varistor element
- Coating: epoxy resin, flame-retardant to UL 94 V-0
- Bolt-holed strap terminals for screw fixing or soldering
- Bent or straight strap terminals

Features

- Dimensions equivalent to SIOV-LS40
- Very high surge current up to 65 kA
- Wide operating voltage range 250 … 460 V_{RMS}
- Designed in accordance with the requirements of IEC 61643-1, class II, for low-voltage surge protection devices

Approvals

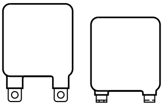
- UL
- CSA

Delivery mode

- Vacuum-packed styrofoam box

General technical data

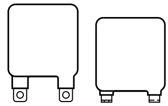
Climatic category	to IEC 60068-1	40/85/56	
Operating temperature	to CECC 42 000	–25 … + 85	°C
Storage temperature		–25 … +110	°C
Electric strength	to CECC 42 000	≥2.5	kV_{RMS}
Insulation resistance	to CECC 42 000	≥10	MΩ
Response time		<25	ns



Maximum ratings (T_A = 85 °C)

Ordering code	Type SIOV-	V_{RMS} V	V_{DC} V	i_{max} (8/20 µs) A	I_{max}[1)] (8/20 µs) A	I_{nom}[2)] (8/20 µs) A	W_{max} (2 ms) J	P_{max} W
Bent strap terminals								
B72242L0251K100	LS42K250QP	250	320	65000	65000	20000	490	1.4
B72242L0271K100	LS42K275QP	275	350	65000	65000	20000	550	1.4
B72242L0321K100	LS42K320QP	320	420	65000	65000	20000	640	1.4
B72242L0381K100	LS42K385QP	385	505	65000	65000	20000	800	1.4
B72242L0421K100	LS42K420QP	420	560	65000	65000	20000	910	1.4
B72242L0441K100	LS42K440QP	440	585	65000	65000	20000	950	1.4
B72242L0461K100	LS42K460QP	460	615	65000	65000	20000	960	1.4
Straight strap terminals								
B72242L0251K102	LS42K250QPK2	250	320	65000	65000	20000	490	1.4
B72242L0271K102	LS42K275QPK2	275	350	65000	65000	20000	550	1.4
B72242L0321K102	LS42K320QPK2	320	420	65000	65000	20000	640	1.4
B72242L0381K102	LS42K385QPK2	385	505	65000	65000	20000	800	1.4
B72242L0421K102	LS42K420QPK2	420	560	65000	65000	20000	910	1.4
B72242L0441K102	LS42K440QPK2	440	585	65000	65000	20000	950	1.4
B72242L0461K102	LS42K460QPK2	460	615	65000	65000	20000	960	1.4

1) I_{max} = Maximum discharge current to IEC 61643-1, class II
2) I_{nom} = Nominal discharge current to IEC 61643-1, class II

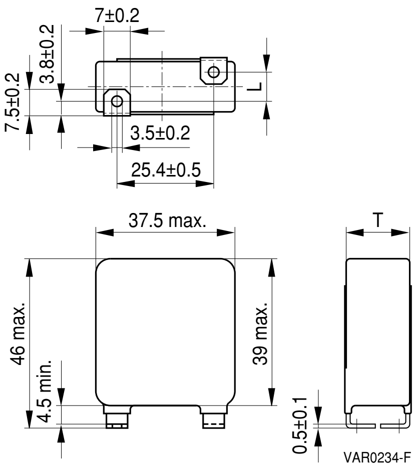


Characteristics (T_A = 25 °C)

Ordering code	Type SIOV-	V_V (1 mA) V	ΔV_V (1 mA) %	$v_{c,\,max}$ (i_c) V	i_c A	C_{typ} (1 kHz) pF
Bent strap terminals						
B72242L0251K100	LS42K250QP	390	±10	650	300	2900
B72242L0271K100	LS42K275QP	430	±10	710	300	2700
B72242L0321K100	LS42K320QP	510	±10	840	300	2300
B72242L0381K100	LS42K385QP	620	±10	1025	300	1900
B72242L0421K100	LS42K420QP	680	±10	1120	300	1800
B72242L0441K100	LS42K440QP	715	±10	1180	300	1700
B72242L0461K100	LS42K460QP	750	±10	1240	300	1600
Straight strap terminals						
B72242L0251K102	LS42K250QPK2	390	±10	650	300	2900
B72242L0271K102	LS42K275QPK2	430	±10	710	300	2700
B72242L0321K102	LS42K320QPK2	510	±10	840	300	2300
B72242L0381K102	LS42K385QPK2	620	±10	1025	300	1900
B72242L0421K102	LS42K420QPK2	680	±10	1120	300	1800
B72242L0441K102	LS42K440QPK2	715	±10	1180	300	1700
B72242L0461K102	LS42K460QPK2	750	±10	1240	300	1600

Dimensional drawings

Bent strap terminals

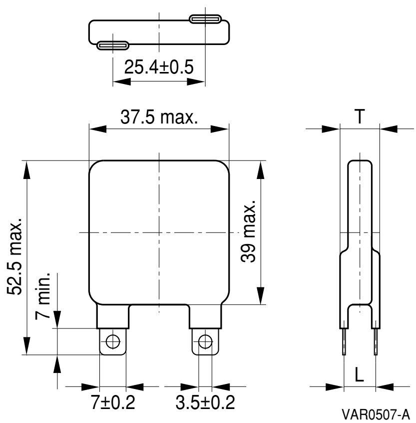


Ordering code	T_{max} mm	L ±1.0 mm
B72242L0251K100	9.2	–2.1
B72242L0271K100	9.4	–1.9
B72242L0321K100	9.9	–1.5
B72242L0381K100	10.6	–0.8
B72242L0421K100	10.9	–0.5
B72242L0441K100	11.1	–0.4
B72242L0461K100	11.4	–0.2

SIOV-LS42K … QP

Weight: 25 … 40 g

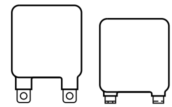
Straight strap terminals



Ordering code	T_{max} mm	L ±1.0 mm
B72242L0251K102	9.2	5.3
B72242L0271K102	9.4	5.5
B72242L0321K102	9.9	5.9
B72242L0381K102	10.6	6.5
B72242L0421K102	10.9	6.8
B72242L0441K102	11.1	7.0
B72242L0461K102	11.4	7.2

SIOV-LS42K … QPK2

Weight: 25 … 40 g



Reliability data

Test	Test methods/conditions	Requirement
Varistor voltage	The voltage between two terminals with the specified measuring current applied is called V_v (1 mA_{DC} @ 0.2 … 2 s).	To meet the specified value.
Clamping voltage	The maximum voltage between two terminals with the specified standard impulse current (8/20 µs) applied.	To meet the specified value.
Max. DC operating voltage	The maximum allowable DC operating voltage V_{DC} at UCT +5/–0 °C is applied for 1000 ±48 h. The leakage current I_{leak} (t) during test is recorded. Then the specimen shall be stored at room temperature and normal humidity for 1 to 2 h. Thereafter, the change of V_v shall be measured.	I_{leak} (t = 1000 h) ≤ I_{leak} (t = 0 h) |ΔV/V (1 mA)| ≤10%
Surge current derating, 8/20 µs	10 surge currents (8/20 µs), unipolar, interval ≥60 s, amplitude corresponding to derating curve for 10 impulses at 20 µs	|ΔV/V (1 mA)| ≤10% (measured in direction of surge current) No visible damage
Fast temperature cycling	IEC 60068-2-14, test Na, LCT/UCT, dwell time 30 min, 5 cycles	|ΔV/V (1 mA)| ≤10% No visible damage
Damp heat, steady state	IEC 60068-2-78 The specimen shall be subjected to 40 ±2 °C, 90 to 95% r. H. for 56 ±2 days with 10% of the maximum continuous DC operating voltage V_{DC}. Then stored at room temperature and normal humidity for 1 to 2 h. Thereafter, the change of V_v shall be measured.	|ΔV/V (1 mA)| ≤10%

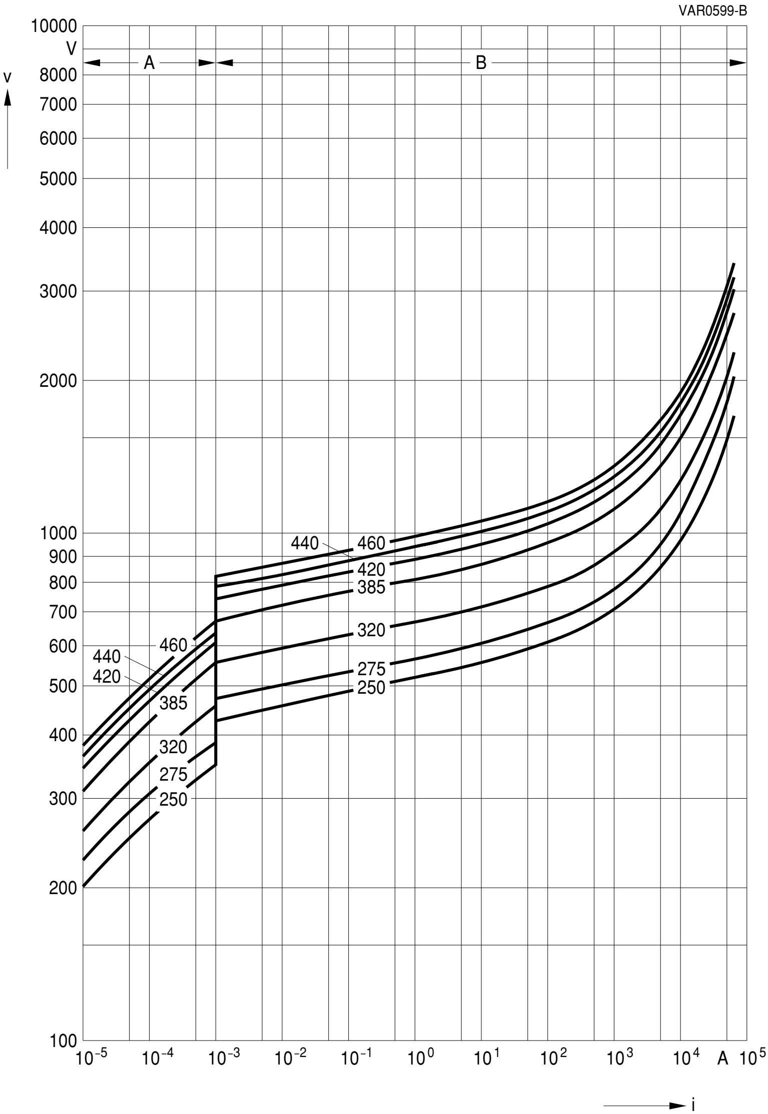
Note:

UCT = Upper category temperature
LCT = Lower category temperature

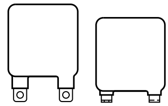
v/i characteristics

v = f (i) – for explanation of the characteristics refer to "General technical information", 1.6.3

A = Leakage current, B = Protection level – for worst-case varistor tolerances



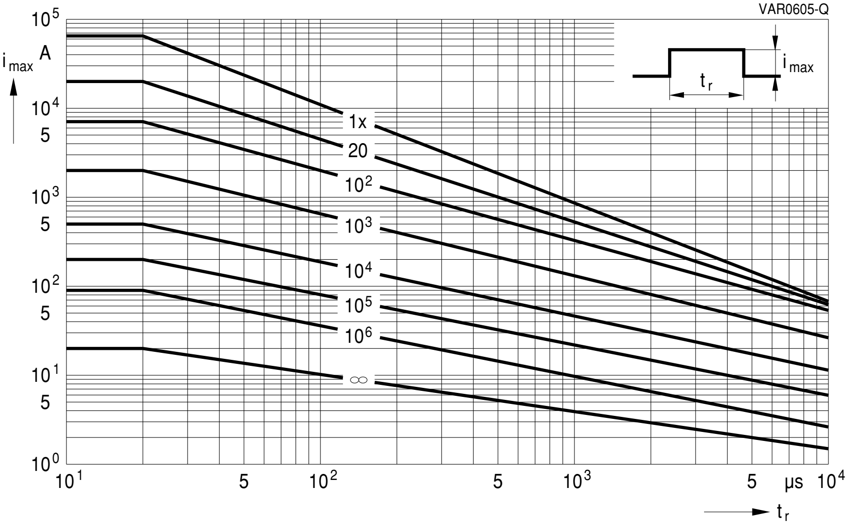
SIOV-LS42K250QP(K2) … K460QP(K2)



Derating curves

Maximum surge current i_{max} = f (t_r, pulse train)

For explanation of the derating curves refer to “General technical information”, section 1.8.1



SIOV-LS42K250QP(K2) … K460QP(K2)

Strap varistors

HighE, standard, LS50 series

Construction

- Round varistor element
- Coating: epoxy resin, flame-retardant to UL 94 V-0
- Bolt-holed strap terminals for screw fixing or soldering
- Bent or straight strap terminals

Features

- Maximum load capacity with minimum size
- High surge current up to 75 kA
- Wide operating voltage range 130 … 550 V_{RMS}

Approvals

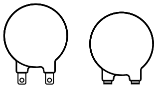
- UL
- CSA

Delivery mode

- Vacuum-packed styrofoam box

General technical data

Climatic category	to IEC 60068-1	40/85/56	
Operating temperature	to CECC 42 000	−25 … + 85	°C
Storage temperature		−25 … +110	°C
Electric strength	to CECC 42 000	≥2.5	kV_{RMS}
Insulation resistance	to CECC 42 000	≥10	MΩ
Response time		<25	ns

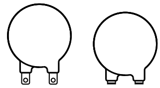


Strap varistors

HighE, standard, LS50 series

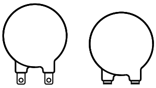
Maximum ratings (T_A = 85 °C)

Ordering code	Type SIOV-	V_{RMS} V	V_{DC} V	i_{max} (8/20 µs) A	W_{max} (2 ms) J	P_{max} W
Bent strap terminals						
B72250L0131K100	LS50K130P	130	170	75000	490	1.5
B72250L0151K100	LS50K150P	150	200	75000	570	1.5
B72250L0231K100	LS50K230P	230	300	75000	730	1.5
B72250L0251K100	LS50K250P	250	320	75000	800	1.5
B72250L0271K100	LS50K275P	275	350	75000	860	1.5
B72250L0321K100	LS50K320P	320	420	75000	1000	1.5
B72250L0381K100	LS50K385P	385	505	75000	1200	1.5
B72250L0421K100	LS50K420P	420	560	75000	1500	1.5
B72250L0441K100	LS50K440P	440	585	75000	1580	1.5
B72250L0461K100	LS50K460P	460	615	75000	1650	1.5
B72250L0551K100	LS50K550P	550	745	75000	1820	1.5
Straight strap terminals						
B72250L0131K102	LS50K130PK2	130	170	75000	490	1.5
B72250L0151K102	LS50K150PK2	150	200	75000	570	1.5
B72250L0231K102	LS50K230PK2	230	300	75000	730	1.5
B72250L0251K102	LS50K250PK2	250	320	75000	800	1.5
B72250L0271K102	LS50K275PK2	275	350	75000	860	1.5
B72250L0321K102	LS50K320PK2	320	420	75000	1000	1.5
B72250L0381K102	LS50K385PK2	385	505	75000	1200	1.5
B72250L0421K102	LS50K420PK2	420	560	75000	1500	1.5
B72250L0441K102	LS50K440PK2	440	585	75000	1580	1.5
B72250L0461K102	LS50K460PK2	460	615	75000	1650	1.5
B72250L0551K102	LS50K550PK2	550	745	75000	1820	1.5



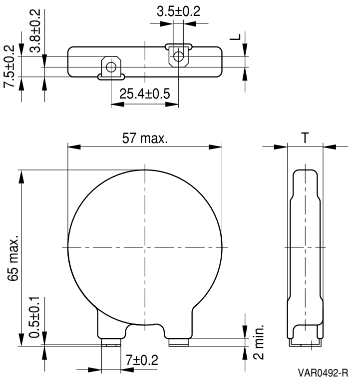
Characteristics (T_A = 25 °C)

Ordering code	V_V (1 mA) V	ΔV_V (1 mA) %	$v_{c,\,max}$ (i_c) V	i_c A	C_{typ} (1 kHz) pF
Bent strap terminals					
B72250L0131K100	205	±10	340	500	10500
B72250L0151K100	240	±10	395	500	9500
B72250L0231K100	360	±10	595	500	6000
B72250L0251K100	390	±10	650	500	5600
B72250L0271K100	430	±10	710	500	5500
B72250L0321K100	510	±10	840	500	4300
B72250L0381K100	620	±10	1025	500	3500
B72250L0421K100	680	±10	1120	500	3300
B72250L0441K100	715	±10	1180	500	3000
B72250L0461K100	750	±10	1240	500	2900
B72250L0551K100	910	±10	1500	500	2400
Straight strap terminals					
B72250L0131K102	205	±10	340	500	10500
B72250L0151K102	240	±10	395	500	9500
B72250L0231K102	360	±10	595	500	6000
B72250L0251K102	390	±10	650	500	5600
B72250L0271K102	430	±10	710	500	5500
B72250L0321K102	510	±10	840	500	4300
B72250L0381K102	620	±10	1025	500	3500
B72250L0421K102	680	±10	1120	500	3300
B72250L0441K102	715	±10	1180	500	3000
B72250L0461K102	750	±10	1240	500	2900
B72250L0551K102	910	±10	1500	500	2400



Dimensional drawings

Bent strap terminals

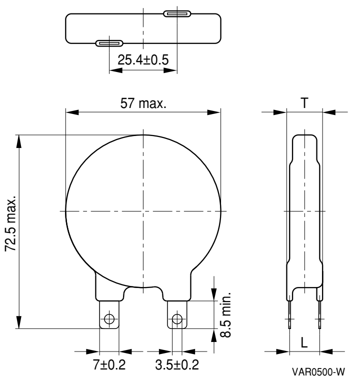


SIOV-LS50K … P

Weight: 30 … 90 g

Ordering code	T_{max} mm	L ±1.0 mm
B72250L0131K100	8.1	–3.5
B72250L0151K100	8.3	–3.2
B72250L0231K100	9.0	–2.0
B72250L0251K100	9.2	–1.8
B72250L0271K100	9.4	–1.6
B72250L0321K100	9.9	–1.1
B72250L0381K100	10.6	–0.4
B72250L0421K100	10.9	0.0
B72250L0441K100	11.1	0.2
B72250L0461K100	11.4	0.4
B72250L0551K100	12.3	1.2

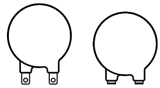
Straight strap terminals



SIOV-LS50K … PK2

Weight: 30 … 90 g

Ordering code	T_{max} mm	L ±1.0 mm
B72250L0131K102	8.1	4.4
B72250L0151K102	8.3	4.6
B72250L0231K102	9.0	5.3
B72250L0251K102	9.2	5.5
B72250L0271K102	9.4	5.8
B72250L0321K102	9.9	6.3
B72250L0381K102	10.6	6.9
B72250L0421K102	10.9	7.3
B72250L0441K102	11.1	7.5
B72250L0461K102	11.4	7.8
B72250L0551K102	12.3	8.7



Reliability data

Test	Test methods/conditions	Requirement
Varistor voltage	The voltage between two terminals with the specified measuring current applied is called V_v (1 mA_{DC} @ 0.2 … 2 s).	To meet the specified value.
Clamping voltage	The maximum voltage between two terminals with the specified standard impulse current (8/20 µs) applied.	To meet the specified value.
Max. DC operating voltage	The maximum allowable DC operating voltage V_{DC} at UCT +5/–0 °C is applied for 1000 ±48 h. The leakage current I_{leak} (t) during test is recorded. Then the specimen shall be stored at room temperature and normal humidity for 1 to 2 h. Thereafter, the change of V_v shall be measured.	I_{leak} (t = 1000 h) ≤ I_{leak} (t = 0 h) |ΔV/V (1 mA)| ≤10%
Surge current derating, 8/20 µs	10 surge currents (8/20 µs), unipolar, interval ≥60 s, amplitude corresponding to derating curve for 10 impulses at 20 µs	|ΔV/V (1 mA)| ≤10% (measured in direction of surge current) No visible damage
Fast temperature cycling	IEC 60068-2-14, test Na, LCT/UCT, dwell time 30 min, 5 cycles	|ΔV/V (1 mA)| ≤10% No visible damage
Damp heat, steady state	IEC 60068-2-78 The specimen shall be subjected to 40 ±2 °C, 90 to 95% r. H. for 56 ±2 days with 10% of the maximum continuous DC operating voltage V_{DC}. Then stored at room temperature and normal humidity for 1 to 2 h. Thereafter, the change of V_v shall be measured.	|ΔV/V (1 mA)| ≤10%

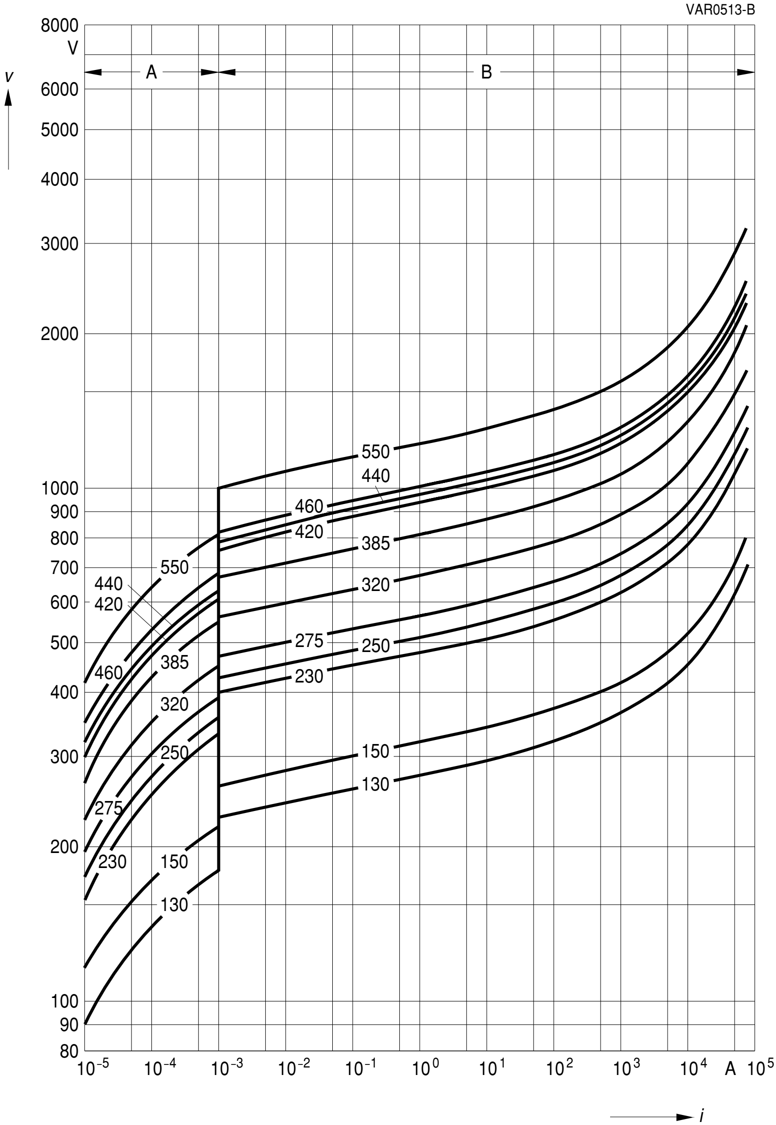
Note:

UCT = Upper category temperature
LCT = Lower category temperature

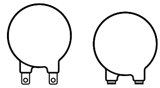
v/i characteristics

v = f (i) – for explanation of the characteristics refer to "General technical information", 1.6.3

A = Leakage current } for worst-case varistor tolerances
B = Protection level



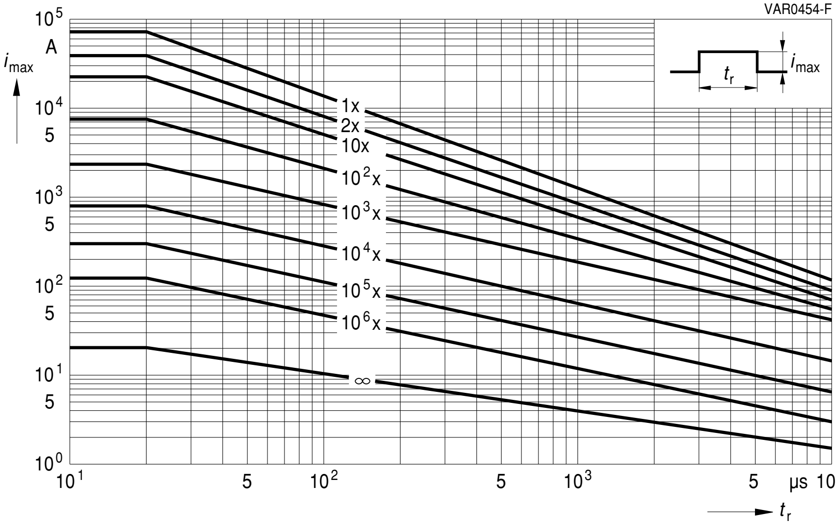
SIOV-LS50K130P(K2) … K550P(K2)



Derating curves

Maximum surge current i_{max} = f (t_r, pulse train)

For explanation of the derating curves refer to “General technical information”, section 1.8.1



SIOV-LS50K130P(K2) … K550P(K2)

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Symbols and terms

Symbol	Term
C	Capacitance
C_{typ}	Typical capacitance
i	Current
i_c	Current at which $v_{c,\,max}$ is measured
I_{leak}	Leakage current
i_{max}	Maximum surge current (also termed peak current)
I_{max}	Maximum discharge current to IEC 61643-1
I_{nom}	Nominal discharge current to IEC 61643-1
LCT	Lower category temperature
L_{typ}	Typical inductance
P_{max}	Maximum average power dissipation
R_{ins}	Insulation resistance
R_{min}	Minimum resistance
T_A	Ambient temperature
t_r	Duration of equivalent rectangular wave
UCT	Upper category temperature
v	Voltage
V_{clamp}	Clamping voltage
$v_{c,\,max}$	Maximum clamping voltage at specified current i_c
V_{DC}	DC operating voltage
V_{jump}	Maximum jump start voltage
v_{max}	Maximum voltage
V_{op}	Operating voltage
V_{RMS}	AC operating voltage, root-mean-square value
$V_{RMS,\,op,\,max}$	Root-mean-square value of max. DC operating voltage incl. ripple current
V_{surge}	Super imposed surge voltage
V_V	Varistor voltage
ΔV_V	Tolerance of varistor voltage
W_{LD}	Maximum load dump
W_{max}	Maximum energy absorption
$\boxed{e}$	Lead spacing

All dimensions are given in mm.
The commas used in numerical values denote decimal points.

EPCOS

Equation overview

Equation no.		Page
1	$I = K\,V^{\alpha} \qquad \alpha > 1$ I Current through varistor V Voltage across varistor K Ceramic constant (depending on varistor type) α Nonlinearity exponent (measure of nonlinearity of curve)	22
2	$R = \frac{V}{I} = \frac{V}{K\,V^{\alpha}} = \frac{1}{K}V^{1-\alpha}$	22
3	$\log I = \log K + \alpha \log V$	22
4	$\log R = \log\left(\frac{1}{K}\right) + (1-\alpha)\log V$	22
5	$\alpha = \frac{\log I_2 - \log I_1}{\log V_2 - \log V_1}$	22
6	$W = \int_{t_0}^{t_1} v(t)\,i(t)\,dt$	27
7	$\lvert TC\rvert < 0.5 \cdot 10^{-3}/K = 0.05\%/K = 1\%/\Delta 20K$	31
8	$v_{SIOV} = \left(\frac{Z_{SIOV}}{Z_{source} + Z_{SIOV}}\right) v$	38
9	$i^* \leq i_{max}$	44
10	$W^* \leq W_{max}$	44
11	$P^* \leq P_{max}$	44
12	$i^* = \frac{V_s - V_{SIOV}}{Z_{source}}$	47
13	$\tau \approx \frac{L}{R_{Cu} + R_{SIOV}}\ [s]$ L [H] Inductance R_{Cu} [Ω] Coil resistance R_{SIOV} [Ω] SIOV resistance at operating current	47
14	$t^*_r = \frac{\int i^*\,dt}{\hat{i}^*}$	48
15	$\frac{t_{37\%}}{t_{50\%}} = \frac{I_n 0.37}{I_n 0.50} = \frac{-0.994}{-0.693} = 1.43 = \frac{\tau}{T_r}$	49
16	$W^* = \hat{v}^*\,\hat{i}^*\,t^*_r$ [J] $\hat{v}^*$ [V] $\hat{i}^*$ [A] t^*_r [s]	49
17	$W^* = {}^1/_2\,L\,i^{*2}$ [J] L [H] i* [A]	50
18	$W_{max} = v_{max}\,i_{max}\,t_{r\,max}$	50

Equation no.			Page
19	$P^* = \frac{W^*}{T^*} = \frac{v^*\ i^*\ t^*_r}{T^*}\ [W]$	W^* [J] i^* [A] T^* [s] t^*_r [s] v^* [V]	50
20	$T_{min} = \frac{W^*}{P_{max}} [s]$	W^* [J] P_{max} [W]	50
21	$\log V = b1 + b2 \cdot \log(I) + b3 \cdot e^{-\log(I)} + b4 \cdot e^{\log(I)}$	$I > 0$	67
22	$AVR = \frac{v^*}{v_{max}}$		83
23	$i_L = A + k\sqrt{t}$		83
24	$\lambda[fit] = \frac{10^9}{ML[h]}$		83

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