A KYOCERA GROUP COMPANY

TPC
Zinc Oxide Varistors

Zinc Oxide Varistors

Contents

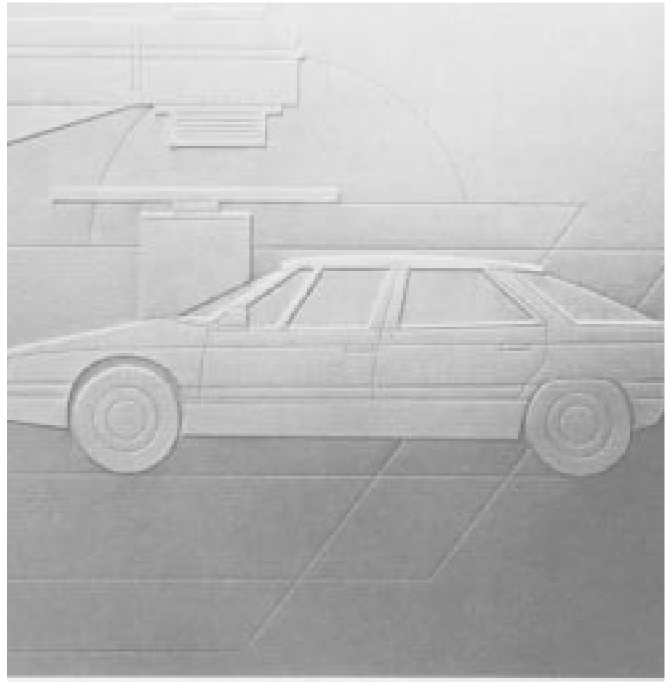
Zinc Oxide Varistors

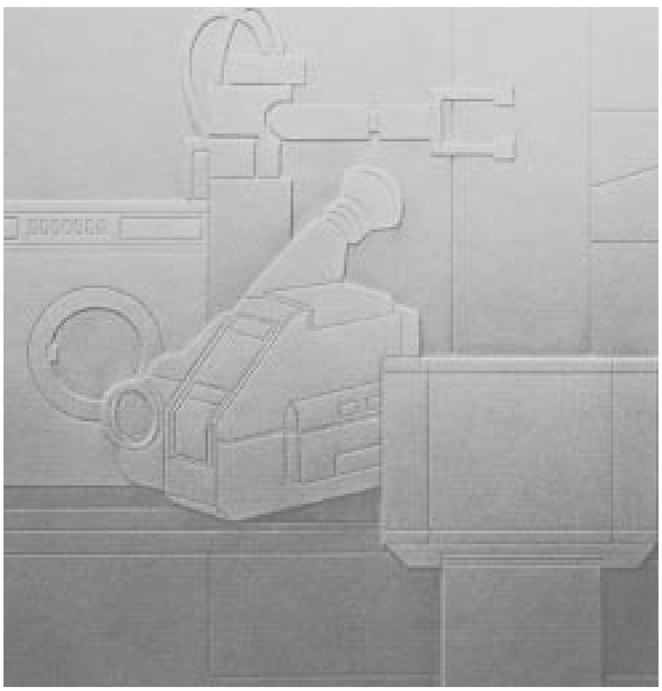
General

Metal Oxide Varistors are ceramic passive components made of zinc oxide sintered together with other metal oxide additives.

They provide an excellent protective device for limiting surge voltages and absorbing energy pulses.

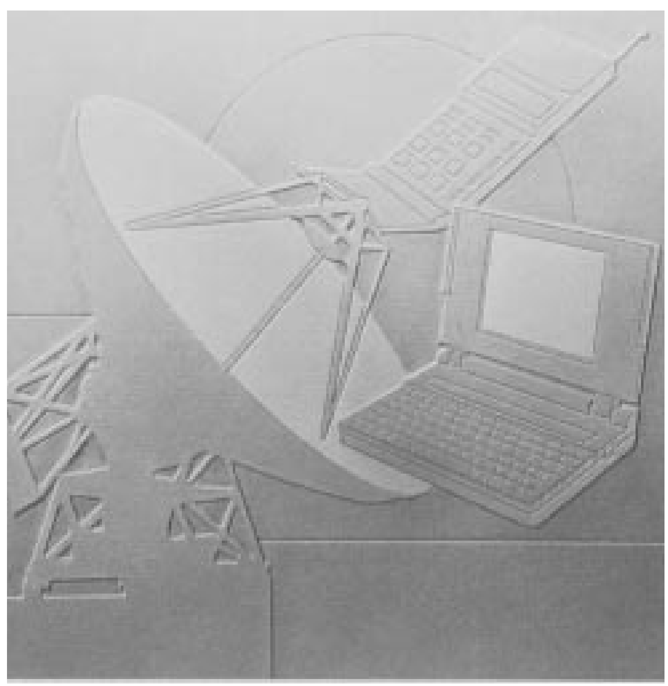
Their very good price / performance ratio enables designers to optimize the transient protection function when designing the circuits.





Varistors are Voltage Dependent Resistors whose resistance decreases drastically when voltage is increased.

When connected in parallel with the equipment to protect, they divert the transients and avoid any further overvoltage on the equipment.



Manufactured according to high level standards of quality and service, our Metal Oxide Varistors are widely used as protective devices in the telecommunications, industrial, automotive and consumer markets.

Zinc Oxide Varistors

Introduction

ZINC OXIDE VARISTORS. PROTECTION FUNCTION APPLICATION

Definition of the varistor effect

The varistor effect is defined as being the property of any material whose electrical resistance changes non-linearly with the voltage applied to its terminals.

In other words, within a given current range, the current-voltage relationship can be expressed by the equation:

$$I = KV^{\alpha}$$

In which K represents a constant depending on the geometry of the part and the technology used and α the non-linearity factor.

The higher the value of this factor, the greater the effect. The ideal (and theorical) case is shown in Figure1 where $\alpha = \infty$ whereas a linear material has an equation of I = f(V) obeying the well-known Ohm's law ($\alpha = 1$).

The relationship between these two extreme cases is shown in Figure 2. It should be pointed out that the I = f(V) curve is symmetrical with respect to zero in the case of zinc oxide varistors.

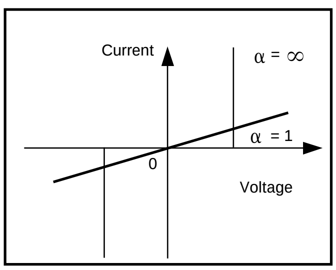


Figure 1

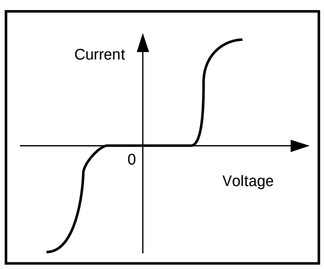


Figure 2

ZINC OXIDE VARISTORS

1-Composition of the material

Zinc oxide varistors are a polycrystalline structured material consisting of semiconducting zinc oxide crystals and a second phase located at the boundaries of the crystals.

This second phase consists of a certain number of metallic oxides (Bi_2O_3,MnO,Sb_2O_3, etc.). It forms the «heart»of the varistor effect since its electrical resistivity is a non-linear function of the applied voltage.

Thus, a zinc oxide varistor consists of a large number of boundaries (several millions) forming a series-parallel network of resistors and capacitors, appearing somewhat like a multijunction semiconductor.

Experimentally, it is found that the voltage drop (at 1mA) at each boundary is about 3V. The total voltage drop for the thickness of the material is proportional to the number N of boundaries.

$$V_{1mA} \approx 3 \text{ N where } N = \frac{t}{L}$$

in which L represents the average dimension of a zinc oxide grain and t the thickness of the material.

$$\text{In other words: } V_{1mA} \approx 3 \frac{t}{L}$$

Thus, with a thickness of 1 mm and average dimension of L = 20 µ, we obtain a voltage of 150 V for a current of 1mA.

The desired voltage at 1mA can thus be obtained either by changing the thickness of the disc or by controlling the average dimension of the zinc oxide grain through heat treatment or, yet again, by changing the chemical composition of the varistor.

The polycrystal is schematically represented in Figure 3. At room temperature the semiconducting grains have very low resistivity (a fews ohms/cm).

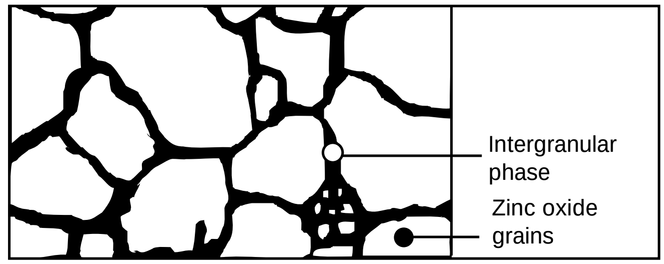


Figure 3

On the contrary, the resistivity of the second phase (or intergranular layer) basically depends on the value of the applied voltage.

If the voltage value is low, the phase is insulating (region I of the I = f(V) curve). As the voltage increases this phase becomes conductive (region II). At very high current values the resistivity of the grain can become preponderant and the I = f(V) curve tends towards a linear law (region III).

The curve I = f(V) for the different types can be found in corresponding data sheets.

2 - Equivalent electrical circuit diagram

Figure 4 explains the behavior of a zinc oxide varistor. r represents the equivalent resistance of all semiconducting grains and ρ that of the intergranular layer (the value of which basically varies with the applied voltage). Cp corresponds to the equivalent capacitance of the intergranular layers.

When the applied voltage is low, the resistivity of the intergranular layer is quite high and the current passing through the ceramic is low. When the voltage increases, the resistance ρ decreases (region II in Figure 5).

When a certain voltage value is reached, ρ becomes lower than r and the I = f(V) characteristic tends to become ohmic (region III).

The equivalent capacitance due to the insulating layers depends on their chemical types and geometries.

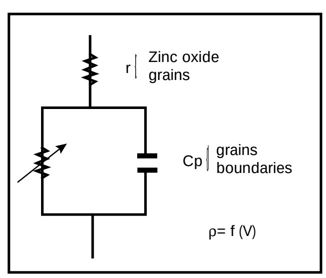


Figure 4

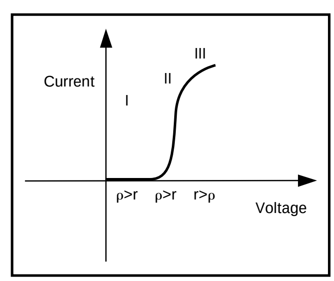


Figure 5

Values of a few hundred picofarads are usually found with commonly used discs.

Capacitance value decreases with the area of the ceramic. Consequently, this value is lower when maximum permissible energy and current values in the varistor are low, since these latter parameters are related to the diameter of the disc.

Capacitance values are not subject to outgoing inspection.

3 - Temperature influence on the I = f(V) characteristic

A typical I = f(V) curve is given in Figure 6.

Different distinct regions can be observed:

- The first one depends on the temperature and corresponds to low applied voltages (corresponding currents are in the range of the µA). Consequently, a higher leakage current is noticeable when temperature is increasing.
- The second one shows less variation and corresponds to the nominal varistor voltage region (Figure 7). The temperature coefficient of the varistor voltage at 1 mA is:

$$K = \frac{\Delta V/V}{\Delta T}$$ and has a negative value with $|K| < 9.10^{-4}/°C$

As the temperature coefficient decreases with increasing current density, this curve also depends on the type of the varistor.

- For higher voltages, the temperature has no significant influence. Practically the clamping voltages of the varistors are not affected by a temperature change.

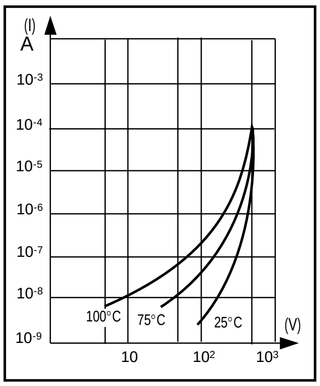


Figure 6

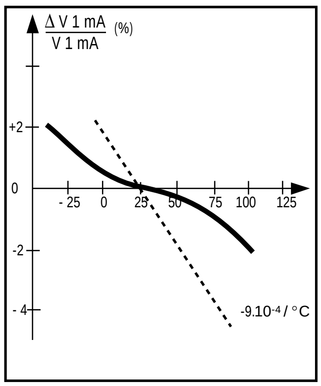


Figure 7

4 - Varistor characteristics

The choice of a varistor for a specific application should be guided by the following major characteristics:

1) Working or operating voltage (alternating or direct).
2) Leakage current at the working voltage.
3) Max. clamping voltage for a given current.
4) Maximum current passing through the varistor.
5) Energy of the pulse to be dissipated in the varistor.
6) Average power to be dissipated.

4.1 - Max. operating voltage and leakage current

The maximum operating voltage corresponds to the "rest" state of the varistor. This "rest" voltage offers a low leakage current in order to limit the power consumption of the protective device and not to disturb the circuit to be protected. The leakage currents usually have values in the range of a few micro-amperes.

$$P_A = AV\,.Ip = AKVp^{\alpha+1}$$

$$\text{with } \frac{P_A}{P_C} = A$$

in which: A = a constant f(α)

K = a constant

($I = KV^{\alpha}$).

P_C = dissipated power for a DC voltage Vp.

The A versus ∝ curve

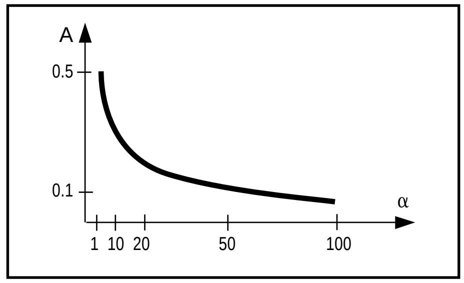


Figure 8

For usual values of ∝ (30 to 40), the continuously dissipated power is about 7 times greater than that dissipated by a sinusoidal signal having the same peak value. For example, a protective varistor operating at RMS voltage of 250 V has a power dissipation of a few mW.

4.2 - Non-linearity coefficient

The peak current and voltage values basically depend on the I = f(V) characteristic or, to be more precise, on the value of the coefficient defined by:

$$\alpha = \frac{\log (I_1/I_2)}{\log (V_1/V_2)}$$

In which I_1 and I_2 are the current values corresponding to voltage values V_1 and V_2.

The value of α depends on the technology used (chemical composition, heat synthesis, etc.). Nevertheless, the value is not constant over the entire current range (several decades). For example, Figure 9 shows the variation of this coefficient for currents ranging from 100 nA to 100 A. It can be seen that α passes through a maximum value and always stays at high values, even at high levels of current.

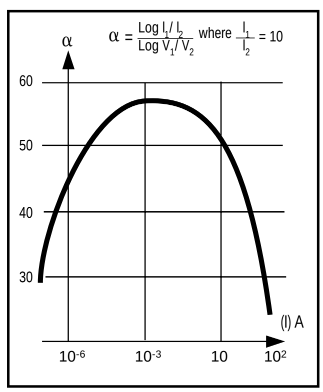


Figure 9

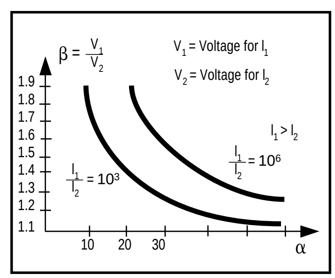


Figure 10

The non-lineary of the varistor can be expressed in another way by the ratio of the voltages corresponding to 2 current values.

$$\beta = \frac{V_1}{V_2}$$

Where:

V_1 voltage for current I_1

V_2 voltage for current I_2

The curve giving β versus the value of α is shown in Figure10 for 2 ratios of $I_1 / I_2 = 10^3$ and 10^6.

4.3 - Clamping voltage

It is the maximum residual voltage Vp across the varistor terminals for a through current Ip.

The voltage value gives an indication on the protective function of the varistor.

4.4 - Permissible peak current

The value of the permissible peak current depends upon the varistor model and waveform (8 x 20 µs, 10 x 1000 µs, etc.).

It can be seen that, as a first approximation, the permissible peak current is proportional to the area of the varistor electrodes.

By way of example, Table I gives the permissible peak current values for different diameters and for one current surge of waveform 8 x 20 µs.

It corresponds to a maximum permissible variation of ±10% in the voltage measured at 1 mA dc after the surges.

Overloads greater than specified values may result in a change in varistor voltage by more than ±10% and irreversible change in the electrical properties.

In case of heavy overload, surge currents beyond the specified ratings will puncture the varistor element. In extreme cases, the varistor will burst.

Table I

Operating Voltage (V)	Uncoated Disc ∅ (mm)	I max. (A)
250	5	400
250	7	1200
250	10	2500
250	14	4500
250	20	6500

Table II

Permissible Current (A)	Number of Current Surges (8 x 20 µs)
6500	1
4000	2
1000	10^2
200	10^4

The permissible peak current also depends on the number of current surges applied to the varistor. For example, Table II gives the permissible current values based on the number of consecutive surges of the same magnitude applied on varistor model VE24M00251K.

Thus, the smaller the number of surges, the higher the permissible current.

4.5 - Permissible energy

The notion of permissible energy relates much more to the "active" state of the varistor than to its "rest" state where the average power is the predominant notion.

Indeed, except in special cases, the overvoltages occur at random and not at a high repetition frequency.

Therefore, aging of the varistor will be related to energy of the transient defined by the current and peak voltage values as well as the pulse shape.

Opposite, we have expressed energy W calculated for different pulse shapes, assuming that the value of the coefficient α equals 30.

a) Voltage surge
Figure 11 - 12 - 13 - 14

b) Current surge
Figure 15 - 16 - 17 - 18

If, for example, we take a current surge as shown in Figure 19, we demonstrate that the dissipated energy is given by the approximate expression:

$$W = Vp\ Ip\ (1.4\ \tau_2 - 0.88\ \tau_1)\ 10^{-6}$$

in which Vp is the peak voltage value and Ip the peak current value.

W is expressed in joules.

τ in µseconds.

Vp in volts.

Ip in amperes.

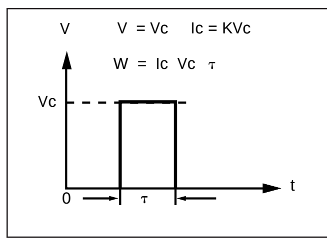


Figure 11

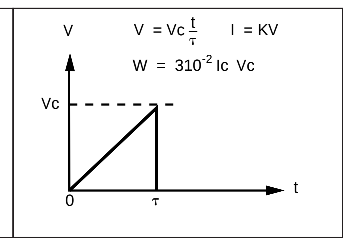


Figure 12

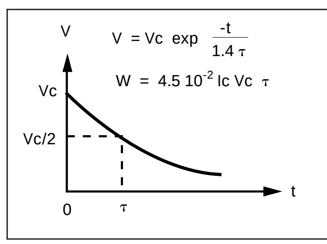


Figure 13

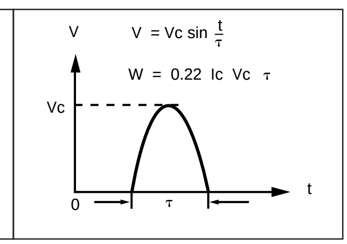


Figure 14

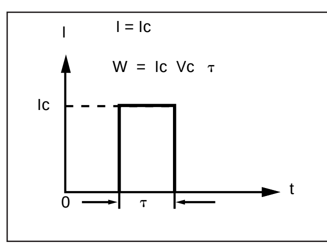


Figure 15

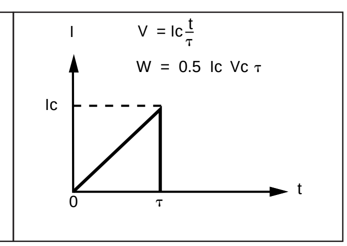


Figure 16

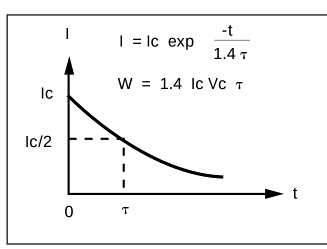


Figure 17

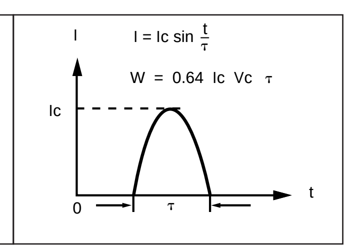


Figure 18

Table III gives the energies calculated according to waveform in Figure 19.

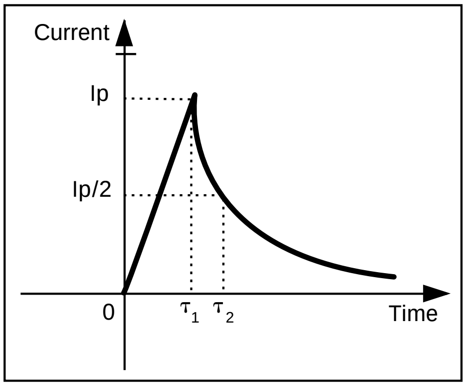


Figure 19

Table III

Vp (V)	Ip (A)	Waveform (µs)		Energy (J)
		τ_1	τ_2	
500	300	1.2	50	10
500	300	8	20	3
500	300	10	1000	210

The following changes are found when the varistor absorbs an energy greater than the maximum permissible value:

- Higher leakage current.
- Decrease in the voltage at 1 mA.
- Decrease in coefficient α.

If the energy increases well beyond the maximum value, the characteristics degrade to such an extent that, even at the rated voltage, the varistor has a very low resistance value.

The permissible energy for a given varistor is mainly related to the size of the part. For example, Table IV gives the permissible energy for different varistors sizes with an operating voltage of 250 V.

Table IV

Operating Voltage (V)	Uncoated Disc ø (mm)	Energy (J)
250	5	10
250	7	21
250	10	40
250	14	72
250	20	130

Table V

V– (V)	P (mW)
180	0.5
220	0.2
230	0.75

4.6 - Average dissipated power

a) Average power dissipated in the "rest" state

Considering the high values of the coefficient α, a special attention is required concerning the dissipated power value in case of possible changes in the operating voltage.

Indeed, starting with the equation:

$$I = KV^{\alpha}$$

the average power dissipated by the varistor is given by the equation:

$$PC = KV^{\alpha+1}$$

when a direct current voltage is applied, and

$$P_A = AP_C$$

in the case of a sinusoidal voltage having the same peak value and direct current voltage value.

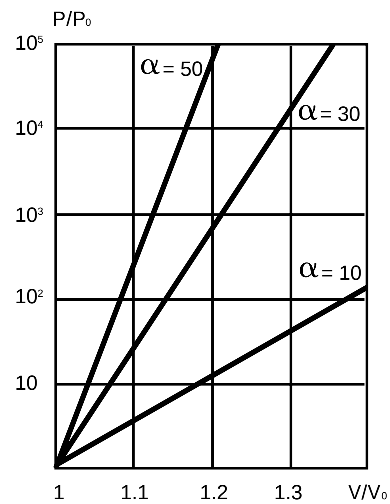


Figure 20

The A value as a function of α was given in Figure 8. A small change of the operating voltage can induce a dissipated power variation which is all the more greater since the value of exponent α is high (Figure 20).

It can be seen that a 10% change in the rated voltage increases the dissipated power by a factor of 20 when coefficient α equals 30, and by a factor of 150 when the coefficient equals 50.

Table V gives the power P dissipated at values of the applied direct current voltage when the value of α equals 30.

b) Average power dissipated during the transient state

If the transients to which the varistor is subjected are repeated at a sufficiently high frequency, there will be an increase ΔT in the average temperature of the part given by the expression:

$$\Delta T = P/\delta$$

in which P represents the average dissipated power which depends on the energy of the pulse and its repetition frequency and δ the dissipation factor in air of the unit.

This temperature rise should stay below the threshold indicated by the manufacturer or it may damage the component coating resin or even cause thermal runaway of the ceramic.

5 - Response time of zinc oxide varistors

5.1 - Intrinsic response time

This response time corresponds to the conduction mechanisms specific to semiconductors, therefore its value is quite low and is less than one nanosecond.

5.2 - Practical response time

However, the response time will be modified for several reasons:

- Parasitic capacitance of the component due to the insulation of the intergranular layers.
- Overshoot phenomenon occurring when the varistor is subjected to a voltage with a steep leading edge (Figure 21) and causing a dynamic voltage peak greater than the static voltage by a few percent.
- Impedance of the external circuit to the varistor.

In conclusion, the practical response time of a zinc oxide varistor usually stays below 50 nanoseconds.

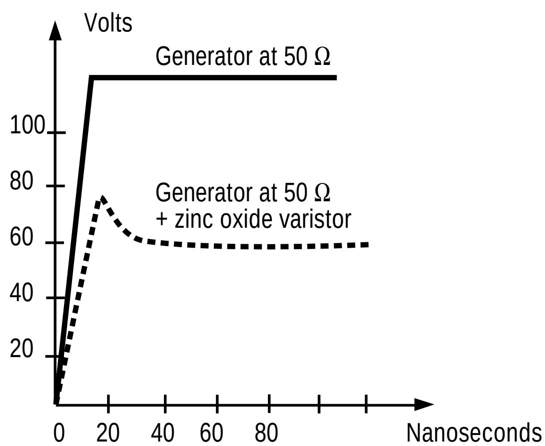


Figure 21

6 - Varistor voltage (V_{1mA})

6.1 - Nominal varistor voltage (V_{1mA})

The nominal voltage of a varistor (or "varistor" voltage) is defined as the voltage drop across the varistor when a dc test current of 1 mA is applied to the component.

It is defined at a temperature of 25°C.

This parameter is used as a standard to define the varistors but has no particular electrical or physical significance.

6.2 - Tolerance on the varistor voltage

The standard tolerance is ±10%. Other tolerances may be defined on custom design products.

To avoid any lack of understanding, different behaviors of Zn0 varistors should be noted when considering the measurement of V 1 mA.

- The measurement time must not be too short to allow a "break-in" stabilization of the varistor and not too long so the measurement is not affected by warming the varistor. The limits of V_{1mA} for our products are given for a measurement time comprised between 100 ms and 300 ms. For times comprised between 30 ms and 1s, the varistor voltage will differ typically by less than 2%.
- The value of the peak varistor voltage measured with ac current will be slightly higher than the dc value.
- When the varistor has been submitted to unipolar stresses (pulses, dc life test, ...) the voltage-current characteristic becomes asymmetrical in polarity.

1 - Principle of application

Zinc oxide varistors are essentially used as protective devices for components or items of equipment subjected to electrical interference whether accidental or otherwise. To be more specific, there are two types of interference: those which can be controlled (switching of resistive or capacitive circuits) and those which occur at random (high voltage surges change in the power supply network, etc.)

The "protection" function is related to the non-linear I = f(V) characteristic of the varistor. This component is always connected in parallel with the assembly E to be protected (Figure 22B).

The varistor's "rest" state has a very high impedance (several megohms) in relation to the component to be protected and does not change the characteristics or the electric circuit.

In the presence of a transient, the varistor then has a very low impedance (a few ohms) and short circuits the component E.

The "rest" and operating states are shown in Figure 22A and 22B. In case of a current surge of a peak value Ip, the higher the non-linear coefficient α is, the lower the voltage across the terminals of the component E will be:

$$Vp = (Ip/K)\ 1/\alpha$$

In case of a voltage surge Vs, the varistor limits the voltage across the terminals of component E to a value Vp via resistor Rc which can be the impedance of the source (Figure 23).

2 - Main applications

Varistors are widely used in the different electronic equipment:

- telecommunication and data systems
  - power supply units,
  - switching equipment,
  - answering sets, ...
- industrial equipment
  - control and alarm systems,
  - proximity switches,
  - transformers,
  - motors,
  - traffic lighting, ...
- consumer electronics
  - television and video sets,
  - washing machines,
  - electronic ballasts, ...
- automotive
  - all motor and electronic systems.

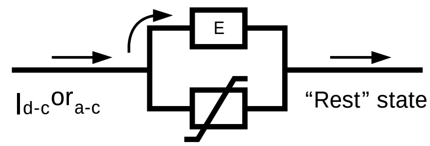


Figure 22A

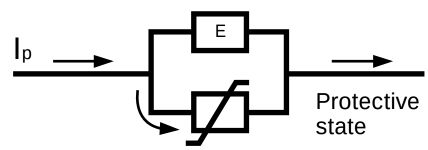


Figure 22B

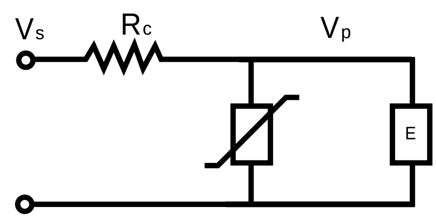


Figure 23

Three typical examples of applications are shown to illustrate the "protection" function of zinc oxide varistors.

1 - Protection of relay contacts

It is a well-known fact that a sudden break in an inductive circuit causes an overvoltage which can seriously damage the contacts of relay due to arcing. Overvoltages of several thousand volts can occur across the terminals of unprotected relay contacts. This disadvantage can be overcome by limiting the overvoltage due to opening an inductive circuit to a level such that it cannot generate an arc. Such limitation is achieved by wiring a zinc oxide varistor in parallel across the terminals of the relay characterized by the value of its inductance coil L and its resistor R (Figure 24).

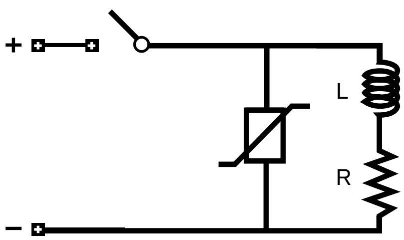


Figure 24

2 - Protection of a diode rectifier bridge

Semiconductor components (silicon diodes, thyristors, etc.) are especially sensitive to transients and must be protected so that the overvoltage value is limited to levels which are not dangerous.

An example of protection for a diode rectifier is schematically represented in Figure 25. The varistor is connected to the transformer secondary at the input of rectifier bridge.

If the transformer's magnetizing current is interrupted when it reaches its maximum value, a voltage ten times greater than the normal value can then appear at the terminals of the secondary winding in the absence of a load.

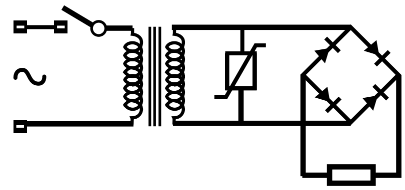


Figure 25

This overvoltage, which is excessive for the semiconductors, is limited by the presence of the varistor which absorbs the energy corresponding to the change of state of the primary circuit.

The same varistor can also protect the rectifier bridge against overvoltages coming from the mains and reaching the secondary circuit via the stray capacitance of the transformer.

Another practical case to be considered involves closing of the primary circuit. If the circuit is closed when the primary voltage reaches its maximum value, the secondary voltage can be two times greater than its steady-state value. Although this case is less dangerous than the preceding one, it still may cause damage to the rectifying diodes. Connection of a varistor in parallel limits this overvoltage to a value such that it does not cause any damage to the semiconductors.

3 - Opening of a resistive circuit supplied with AC current with a loadless rectifier

The diagram is given in Figure 26. When the circuit supplied with AC current is opened, an overvoltage appears across the rectifier terminals:

$$- L di/dt$$

The energy stored by the inductance coil (1/2 L I^2 rms) is transferred to the protective varistor wired in parallel to the inductance coil.

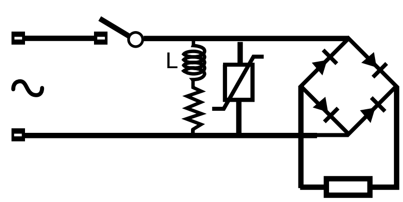
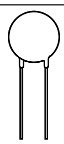
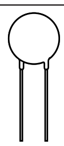
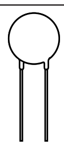
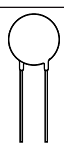
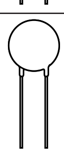
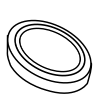
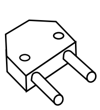


Figure 26

Zinc Oxide Varistors

Selection Guide

Maximum Operating RMS Voltage (V_{RMS})	V_{RMS}: 11, 14, 75, 150, 250, 300, 420, 625
Maximum Operating Steady State Voltage (V_{DC})	V_{DC}: 14, 18, 100, 200, 330, 385, 560, 825
Nominal Varistor Voltage (V_{1mA})	V_{1mA}: 18, 22, 120, 240, 390, 470, 680, 1000
Types	**Voltage range and admissible energy (J) (1 surge 10 x 1000 μs)**
VE 07 **VF 05** 	0.3, 0.4, 2, 5, 11
VE 09 **VF 07** 	0.8, 0.9, 6, 11, 23, 25
VE 13 **VF 10** 	2.0, 12, 24, 45, 68
VE 17 **VF 14** 	4.0, 20, 40, 75, 130
VE 24 **VF 20** 	40, 85, 140, 230
VN 32 	200, 550
VB 32 	200, 550

Zinc Oxide Varistors

Ordering Code

HOW TO ORDER

VE09	M	0	0251	K	– –
Type	**Series**	**Marking**	**AC Operating Voltage**	**Tolerance**	**Suffixes**

Type
VE 07
VE 09
VE 13
VE 17
VE 24
VF 05
VF 07
VF 10
VF 14
VF 20
VN 32
VB 32

Series
M: Varistors for general applications
P: Varistors for heavy duty applications

Marking
AC nominal voltage
VE:0

Nominal voltage at 1 mA dc
VF:1

AC Operating Voltage
(EIA coding)
VE

Nominal Voltage
at 1 mA dc
(EIA coding)
VF

Tolerance
at 1 mA
K: ±10%
(J: ±5% upon request)

Suffixes
See on page 32

1. Operating voltage expressed by 2 significant figures:
   1st digit: 0 (zero).
   2nd and 3rd digit: the two significant figures of the operating voltage.
   4th digit: the number of ZEROS to be added to the operating voltage value.

   Examples:
   75 V: 0750
   250 V: 0251
   300 V: 0301

2. Operating voltage expressed by 3 significant figures:
   1st, 2nd and 3rd digit: the 3 significant figures of the operating voltage.
   4th digit: the number of ZEROS to be added to the operating voltage value.

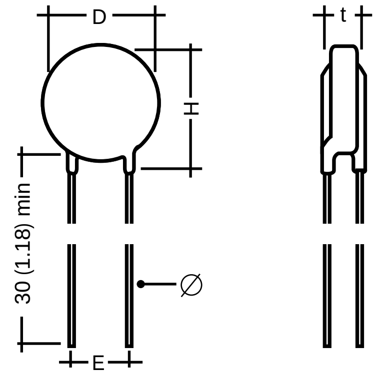
   Examples:
   205 V: 2050
   275 V: 2750

Zinc Oxide Varistors

VE 07/09/13/17/24 VF 05/07/10/14/20

FEATURES

- Radial lead varistors
- Wide operating voltage range from 11 V to 625 V (V_{rms} for VE types) or 18 V to 1000 V (V_{1mA} for VF types)
- Available in tape and reel for use with automatic insertion equipment (see pages 31 to 33 for details).



PARTICULAR CHARACTERISTICS

UL (USA and Canadian Standards)	VE Series P/N codification using (D_{max} , V_{rms})	VF Series P/N codification using ($d_{ceramic}$, V_{1mA})	Maximum operating voltage V_{rms}	V_{DC}	Nominal voltage at 1 mA dc $V_{1mA\ mini}$	$V_{1mA\ nominal}$	$V_{1mA\ maxi}$
	VE07M00110K _ _ VE09M00110K _ _	VF05M10180K _ _ VF07M10180K _ _	11	14	16.0	18	20.0
★ ★ ★ ★	VE07M00140K _ _ VE09M00140K _ _ VE13M00140K _ _ VE17M00140K _ _	VF05M10220K _ _ VF07M10220K _ _ VF10M10220K _ _ VF14M10220K _ _	14	18	19.8	22	24.2
★ ★ ★ ★	VE07M00170K _ _ VE09M00170K _ _ VE13M00170K _ _ VE17M00170K _ _	VF05M10270K _ _ VF07M10270K _ _ VF10M10270K _ _ VF14M10270K _ _	17	22	24.0	27	30.0
★ ★ ★ ★	VE07M00200K _ _ VE09M00200K _ _ VE13M00200K _ _ VE17M00200K _ _	VF05M10330K _ _ VF07M10330K _ _ VF10M10330K _ _ VF14M10330K _ _	20	26	29.5	33	36.5
★ ★ ★ ★	VE07M00250K _ _ VE09M00250K _ _ VE13M00250K _ _ VE17M00250K _ _	VF05M10390K _ _ VF07M10390K _ _ VF10M10390K _ _ VF14M10390K _ _	25	31	35	39	43
★ ★ ★ ★	VE07M00300K _ _ VE09M00300K _ _ VE13M00300K _ _ VE17M00300K _ _	VF05M10470K _ _ VF07M10470K _ _ VF10M10470K _ _ VF14M10470K _ _	30	38	42	47	52
★ ★ ★ ★	VE07M00350K _ _ VE09M00350K _ _ VE13M00350K _ _ VE17M00350K _ _	VF05M10560K _ _ VF07M10560K _ _ VF10M10560K _ _ VF14M10560K _ _	35	45	50	56	62
★ ★ ★ ★	VE07M00400K _ _ VE09M00400K _ _ VE13M00400K _ _ VE17M00400K _ _	VF05M10680K _ _ VF07M10680K _ _ VF10M10680K _ _ VF14M10680K _ _	40	56	61	68	75
★ ★ ★ ★	VE07M00500K _ _ VE09M00500K _ _ VE13M00500K _ _ VE17M00500K _ _	VF05M10820K _ _ VF07M10820K _ _ VF10M10820K _ _ VF14M10820K _ _	50	65	73	82	91

Zinc Oxide Varistors

VE 07/09/13/17/24 VF 05/07/10/14/20

DIMENSIONS millimeters (inches)

Type	Type	D: Ceramic diameter	D: Maximum coated diameter	H max.	t max.	ø +10% −0.05 (.002)	E ± 0.8
VE07	VF05	5 (.196)	7 (.275)	10 (.394)	see table	0.6 (.024)	5.08 (0.20)
VE09	VF07	7 (.275)	9 (.354)	12 (.472)		0.6 (.024)	5.08 (0.20)
VE13*	VF10*	10 (.393)	13* (.512)	16 (.630)		0.8* (.031)	7.62*(0.30)
VE17	VF14	14 (.551)	17 (.669)	20 (.787)		0.8 (.031)	7.62 (0.30)
VE24**	VF20**	20 (.787)	24 (.945)	27 (1.06)		0.8** (.031)	7.62 (0.30)

* VE13 / VF10: For models with V_{RMS} 320 V
other version/suffixes available with:
E = 5.08 (0.20) Suffix:
Ø = 0.6 (.024) Bulk: HB
D = 12.5 (.492) max Tape: DA, DB, DC, DD, DQ, ...

**VE24 / VF20: For lead diameter = 1.0 (.039), please consult us.

GENERAL CHARACTERISTICS

Storage temperature:	-40°C to +125°C
Max. operating temperature:	+85°C
Response time:	< 25 ns
Voltage coefficient temp.:	|K| < 0.09%/°C
Voltage proof:	2500 V
Epoxy coating:	Flame retardant UL94-VO

MARKING

Type
AC nominal voltage (EIA coding) for VE types
V_{1mA} varistor voltage (EIA coding) for VF types
Logo
UL logo (when approved)
Lot number (VE13/17/24 and VF10/14/20 only)

Max. clamping voltage (8 x 20 µs) Vp (V)	Ip (A)	Max. energy absorption (10 x 1000 µs) W (J) Number of surges: 1	10	Max. permissible peak current (8 x 20 µs) Ip (A): 1 surge	2 surges	Typical capacitance f = 1kHz pF	Mean power dissipation W	Maximum thickness t mm (inches)	V/I characteristic Page	Derating curves Page
36	1	0.3	0.15	100	50	1050	0.01	3.6 (.142)	22	24
36	2.5	0.8	0.5	250	125	1900	0.02	3.6 (.142)	22	25
43	1	0.4	0.2	100	50	1050	0.01	3.6 (.142)	22	24
43	2.5	0.9	0.6	250	125	1900	0.02	3.6 (.142)	22	25
43	5	2	1.3	500	250	4000	0.05	4.3 (.169)	22	26
43	10	4	2.6	1000	500	4000	0.10	4.3 (.169)	23	27
53	1	0.5	0.3	100	50	1050	0.01	3.7 (.146)	22	24
53	2.5	1.1	0.7	250	125	1900	0.02	3.7 (.146)	22	25
53	5	2.5	1.6	500	250	4000	0.05	4.3 (.169)	22	26
53	10	4.7	3.0	1000	500	6800	0.10	4.3 (.169)	23	27
65	1	0.6	0.3	100	50	750	0.01	3.9 (.154)	22	24
65	2.5	1.3	0.9	250	125	1500	0.02	3.9 (.154)	22	25
65	5	3.1	2.0	500	250	3100	0.05	4.5 (.177)	22	26
65	10	5.7	4.0	1000	500	5700	0.10	4.5 (.177)	23	27
77	1	0.7	0.4	100	50	660	0.01	3.6 (.142)	22	24
77	2.5	1.6	1.0	250	125	1250	0.02	3.6 (.142)	22	25
77	5	3.7	3	500	250	2800	0.05	4.4 (.173)	22	26
77	10	7	5	1000	500	4600	0.10	4.4 (.173)	23	27
93	1	0.9	0.4	100	50	580	0.01	3.8 (.150)	22	24
93	2.5	2.0	1	250	125	1050	0.02	3.8 (.150)	22	25
93	5	4.4	4	500	250	2150	0.05	4.4 (.173)	22	26
93	10	9.0	7	1000	500	3500	0.10	4.4 (.173)	23	27
110	1	1.1	0.4	100	50	460	0.01	3.9 (.154)	22	24
110	2.5	2.5	1	250	125	850	0.02	3.9 (.154)	22	25
110	5	5.4	4.4	500	250	1900	0.05	4.7 (.185)	22	26
110	10	10.0	8	1000	500	3100	0.10	4.7 (.185)	23	27
135	1	1.3	0.5	100	50	400	0.01	4.1 (.161)	22	24
135	2.5	3.0	1	250	125	720	0.02	4.1 (.161)	22	25
135	5	8.4	5.9	500	250	1700	0.05	4.9 (.193)	22	26
135	10	13.0	8.5	1000	500	2800	0.10	4.9 (.193)	23	27
135	5	1.8	0.6	400	200	300	0.1	3.5 (.138)	22	24
135	10	4.2	1.6	1200	600	530	0.2	3.5 (.138)	22	25
135	25	8.4	6	2500	1250	950	0.4	4.1 (.161)	22	26
135	50	15.0	11	4500	2500	1800	0.6	4.1 (.161)	23	27

UL (USA and Canadian Standards)	VE Series P/N codification using (D_{max}, V_{rms})	VF Series P/N codification using ($d_{ceramic}$, V_{1mA})	Maximum operating voltage		Nominal voltage at 1 mA dc		
			V_{rms}	V_{DC}	$V_{1mA\ mini}$	$V_{1mA\ nominal}$	$V_{1mA\ maxi}$
★	VE07M00600K _ _	VF05M10101K _ _	60	80	90	100	110
★	VE09M00600K _ _	VF07M10101K _ _					
★	VE13M00600K _ _	VF10M10101K _ _					
★	VE17M00600K _ _	VF14M10101K _ _					
★	VE07M00750K _ _	VF05M10121K _ _	75	100	108	120	132
★	VE09M00750K _ _	VF07M10121K _ _					
★	VE13M00750K _ _	VF10M10121K _ _					
★	VE17M00750K _ _	VF14M10121K _ _					
★	VE24M00750K _ _	VF20M10121K _ _					
★	VE07M00950K _ _	VF05M10151K _ _	95	125	135	150	165
★	VE09M00950K _ _	VF07M10151K _ _					
★	VE13M00950K _ _	VF10M10151K _ _					
★	VE17M00950K _ _	VF14M10151K _ _					
★	VE24M00950K _ _	VF20M10151K _ _					
★	VE07M01150K _ _	VF05M10181K _ _	115	150	162	180	198
★	VE09M01150K _ _	VF07M10181K _ _					
★	VE13M01150K _ _	VF10M10181K _ _					
★	VE17M01150K _ _	VF14M10181K _ _					
★	VE24M01150K _ _	VF20M10181K _ _					
★	VE07M00131K _ _	VF05M12050K _ _	130	170	184	205	226
★	VE09M00131K _ _	VF07M12050K _ _					
★	VE13M00131K _ _	VF10M12050K _ _					
★	VE17M00131K _ _	VF14M12050K _ _					
★	VE24M00131K _ _	VF20M12050K _ _					
★	VE07M00141K _ _	VF05M10221K _ _	140	180	198	220	242
★	VE09M00141K _ _	VF07M10221K _ _					
★	VE13M00141K _ _	VF10M10221K _ _					
★	VE17M00141K _ _	VF14M10221K _ _					
★	VE24M00141K _ _	VF20M10221K _ _					
★	VE07M00151K _ _	VF05M10241K _ _	150	200	216	240	264
★	VE09M00151K _ _	VF07M10241K _ _					
★	VE13M00151K _ _	VF10M10241K _ _					
★	VE17M00151K _ _	VF14M10241K _ _					
★	VE24M00151K _ _	VF20M10241K _ _					
★	VE07M01750K _ _	VF05M10271K _ _	175	225	243	270	297
★	VE09M01750K _ _	VF07M10271K _ _					
★	VE13M01750K _ _	VF10M10271K _ _					
★	VE17M01750K _ _	VF14M10271K _ _					
★	VE24M01750K _ _	VF20M10271K _ _					
★	VE07M00211K _ _	VF05M10331K _ _	210	275	297	330	363
★	VE09M00211K _ _	VF07M10331K _ _					
★	VE13M00211K _ _	VF10M10331K _ _					
★	VE17M00211K _ _	VF14M10331K _ _					
★	VE24M00211K _ _	VF20M10331K _ _					
★	VE07M00231K _ _	VF05M10361K _ _	230	300	324	360	396
★	VE09M00231K _ _	VF07M10361K _ _					
★	VE13M00231K _ _	VF10M10361K _ _					
★	VE17M00231K _ _	VF14M10361K _ _					
★	VE24M00231K _ _	VF20M10361K _ _					

Zinc Oxide Varistors

VE 07/09/13/17/24 VF 05/07/10/14/20

Max. clamping voltage (8 x 20 µs)		Max. energy absorption (10 x 1000 µs) W (J) Number of surges		Max. permissible peak current (8 x 20 µs) Ip (A)		Typical capacitance f = 1kHz	Mean power dissipation	Maximum thickness t	V/I characteristic	Derating curves
Vp (V)	Ip (A)	1	10	1 surge	2 surges	pF	W	mm (inches)	Page	Page
165	5	2.2	0.7	400	200	165	0.1	3.8 (.150)	22	24
165	10	4.8	1.7	1200	600	440	0.2	3.8 (.150)	22	25
165	25	10	7	2500	1250	870	0.4	4.5 (.177)	22	26
165	50	17	14	4500	2500	2200	0.6	4.5 (.177)	23	27
200	5	2.5	0.8	400	200	150	0.1	4.0 (.157)	22	24
200	10	5.9	1.8	1200	600	400	0.2	4.0 (.157)	22	25
200	25	12	8	2500	1250	700	0.4	4.4 (.173)	22	26
200	50	20	15	4500	2500	1900	0.6	4.4 (.173)	23	27
200	100	40	30	6500	4000	4200	0.8	4.8 (.189)	23	28
250	5	3.4	1	400	200	110	0.1	4.4 (.173)	22	24
250	10	7.6	3	1200	600	310	0.2	4.4 (.173)	22	25
250	25	15	9	2500	1250	560	0.4	5.0 (.197)	22	26
250	50	25	20	4500	2500	1200	0.6	5.0 (.197)	23	27
250	100	50	33	6500	4000	3400	0.8	5.4 (.213)	23	28
300	5	3.6	1.3	400	200	100	0.1	4.5 (.177)	22	24
300	10	8.4	3.3	1200	600	280	0.2	4.5 (.177)	22	25
300	25	18	10.6	2500	1250	500	0.4	5.1 (.201)	22	26
300	50	30	22	4500	2500	1100	0.6	5.1 (.201)	23	27
300	100	60	40	6500	4000	3000	0.8	5.5 (.217)	23	28
340	5	4.2	1.5	400	200	90	0.1	4.1 (.161)	22	24
340	10	9.5	4	1200	600	250	0.2	4.1 (.161)	22	25
340	25	19	11	2500	1250	450	0.4	4.7 (.185)	22	26
340	50	34	25	4500	2500	1000	0.6	4.7 (.185)	23	27
340	100	74	46	6500	4000	2500	0.8	5.1 (.201)	23	28
360	5	4.5	1.5	400	200	85	0.1	4.2 (.165)	22	24
360	10	10	4	1200	600	235	0.2	4.2 (.165)	22	25
360	25	22	12.5	2500	1250	425	0.4	4.8 (.189)	22	26
360	50	36	26.5	4500	2500	930	0.6	4.8 (.189)	23	27
360	100	78	50	6500	4000	2250	0.8	5.2 (.205)	23	28
400	5	4.9	1.8	400	200	80	0.1	4.3 (.169)	22	24
400	10	11	4.1	1200	600	220	0.2	4.3 (.169)	22	25
400	25	24	13	2500	1250	400	0.4	4.9 (.193)	22	26
400	50	40	30	4500	2500	850	0.6	4.9 (.193)	23	27
400	100	85	56	6500	4000	2000	0.8	5.3 (.209)	23	28
445	5	5.6	1.9	400	200	70	0.1	4.5 (.177)	22	24
445	10	13	4.5	1200	600	190	0.2	4.5 (.177)	22	25
445	25	28	13.5	2500	1250	340	0.4	5.1 (.201)	22	26
445	50	46	31	4500	2500	750	0.6	5.1 (.201)	23	27
445	100	98	56	6500	4000	2000	0.8	5.5 (.217)	23	28
545	5	7.2	2.2	400	200	60	0.1	4.9 (.193)	22	24
545	10	15	5.4	1200	600	155	0.2	4.9 (.193)	22	25
545	25	31	14.0	2500	1250	275	0.4	5.5 (.217)	22	26
545	50	54	35	4500	2500	600	0.6	5.5 (.217)	23	27
545	100	115	70	6500	4000	1650	0.8	5.9 (.232)	23	28
595	5	7.2	2.4	400	200	55	0.1	5.1 (.201)	22	24
595	10	17	6	1200	600	140	0.2	5.1 (.201)	22	25
595	25	36	14.3	2500	1250	250	0.4	5.7 (.224)	22	26
595	50	60	38	4500	2500	550	0.6	5.7 (.224)	23	27
595	100	130	75	6500	4000	1500	0.8	6.1 (.240)	23	28

UL (USA and Canadian Standards)	VE Series P/N codification using (D_{max}, V_{rms})	VF Series P/N codification using ($d_{ceramic}$, V_{1mA})	Maximum operating voltage V_{rms}	V_{DC}	Nominal voltage at 1 mA dc $V_{1mA\ mini}$	$V_{1mA\ nominal}$	$V_{1mA\ maxi}$
★	VE07M00251K _ _	VF05M10391K _ _	250	320	351	390	429
★	VE09M00251K _ _	VF07M10391K _ _					
★	VE13M00251K _ _	VF10M10391K _ _					
★	VE17M00251K _ _	VF14M10391K _ _					
★	VE24M00251K _ _	VF20M10391K _ _					
★	VE07M02750K _ _	VF05M10431K _ _	275	350	387	430	473
★	VE09M02750K _ _	VF07M10431K _ _					
★	VE13M02750K _ _	VF10M10431K _ _					
★	VE17M02750K _ _	VF14M10431K _ _					
★	VE24M02750K _ _	VF20M10431K _ _					
	VE07M00301K _ _	VF05M10471K _ _	300	385	423	470	517
★	VE09M00301K _ _	VF07M10471K _ _					
★	VE13M00301K _ _	VF10M10471K _ _					
★	VE17M00301K _ _	VF14M10471K _ _					
★	VE24M00301K _ _	VF20M10471K _ _					
★	VE09M00321K _ _	VF07M10511K _ _	320	420	459	510	561
★	VE13M00321K _ _	VF10M10511K _ _					
★	VE17M00321K _ _	VF14M10511K _ _					
★	VE24M00321K _ _	VF20M10511K _ _					
★	VE09M00351K _ _	VF07M10561K _ _	350	460	504	560	616
★	VE13M00351K _ _	VF10M10561K _ _					
★	VE17M00351K _ _	VF14M10561K _ _					
★	VE24M00351K _ _	VF20M10561K _ _					
★	VE09M03850K _ _	VF07M10621K _ _	385	505	558	620	682
★	VE13M03850K _ _	VF10M10621K _ _					
★	VE17M03850K _ _	VF14M10621K _ _					
★	VE24M03850K _ _	VF20M10621K _ _					
★	VE09M00421K _ _	VF07M10681K _ _	420	560	612	680	748
★	VE13M00421K _ _	VF10M10681K _ _					
★	VE17M00421K _ _	VF14M10681K _ _					
★	VE24M00421K _ _	VF20M10681K _ _					
★	VE13M00441K _ _	VF10M17150K _ _	440	585	643	715	787
★	VE17M00441K _ _	VF14M17150K _ _					
★	VE24M00441K _ _	VF20M17150K _ _					
★	VE13M00461K _ _	VF10M10751K _ _	460	615	675	750	825
★	VE17M00461K _ _	VF14M10751K _ _					
★	VE24M00461K _ _	VF20M10751K _ _					
★	VE13M00511K _ _	VF10M10821K _ _	510	670	738	820	902
★	VE17M00511K _ _	VF14M10821K _ _					
★	VE24M00511K _ _	VF20M10821K _ _					
★	VE13M00551K _ _	VF10M10861K _ _	550	715	774	860	946
★	VE17M00551K _ _	VF14M10861K _ _					
★	VE24M00551K _ _	VF20M10861K _ _					
★	VE13M05750K _ _	VF10M10911K _ _	575	730	819	910	1001
★	VE17M05750K _ _	VF14M10911K _ _					
★	VE24M05750K _ _	VF20M10911K _ _					
★	VE13M06250K _ _	VF10M10102K _ _	625	825	900	1000	1100
★	VE17M06250K _ _	VF14M10102K _ _					
★	VE24M06250K _ _	VF20M10102K _ _					

Zinc Oxide Varistors

VE 07/09/13/17/24   VF 05/07/10/14/20

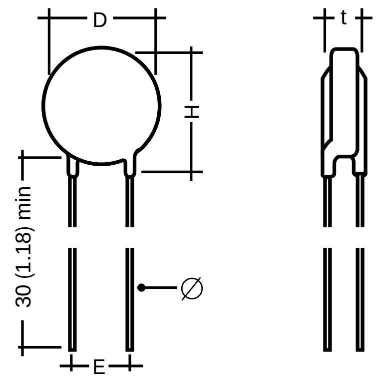
Max. clamping voltage (8 x 20 µs) Vp (V)	Ip (A)	Max. energy absorption (10 x 1000 µs) W (J) Number of surges 1	10	Max. permissible peak current (8 x 20 µs) Ip (A) 1 surge	2 surges	Typical capacitance f = 1kHz pF	Mean power dissipation W	Maximum thickness t mm (inches)	V/I characteristic Page	Derating curves Page
645	5	8.2	2.8	400	200	50	0.1	5.4 (.213)	22	24
645	10	19	7.3	1200	600	130	0.2	5.4 (.213)	22	25
645	25	38	19	2500	1250	230	0.4	5.9 (.232)	22	26
645	50	65	39	4500	2500	500	0.6	5.9 (.232)	23	27
645	100	140	100	6500	4000	1300	0.8	6.3 (.248)	23	28
710	5	8.6	3	400	200	45	0.1	5.7 (.224)	22	24
710	10	21	7.4	1200	600	120	0.2	5.7 (.224)	22	25
710	25	43	20	2500	1250	210	0.4	6.3 (.248)	22	26
710	50	71	40	4500	2500	450	0.6	6.3 (.248)	23	27
710	100	151	105	6500	4000	1200	0.8	6.7 (.264)	23	28
775	5	9	3.3	400	200	40	0.1	6.0 (.236)	22	24
775	10	25	7.5	1200	600	100	0.2	6.0 (.236)	22	25
775	25	45	20	2500	1250	180	0.4	6.6 (.260)	22	26
775	50	80	42	4500	2500	400	0.6	6.6 (.260)	23	27
775	100	150	107	6500	4000	1000	0.8	7.0 (.276)	23	28
840	10	25	7.5	1200	600	100	0.2	6.4 (.252)	22	25
840	25	45	20	2500	1250	170	0.4	7.0 (.276)	22	26
840	50	82	42	4500	2500	380	0.6	7.0 (.276)	23	27
840	100	150	107	6500	4000	950	0.8	7.5 (.276)	23	28
910	10	25	7.5	1200	600	95	0.2	6.6 (.260)	22	25
910	25	45	20	2500	1250	160	0.4	7.3 (.287)	22	26
910	50	85	42	4500	2500	365	0.6	7.3 (.287)	23	27
910	100	155	107	6500	4000	900	0.8	7.8 (.307)	23	28
1025	10	25	7.5	1200	600	95	0.2	7.0 (.276)	22	25
1025	25	45	20	2500	1250	150	0.4	7.7 (.303)	22	26
1025	50	88	42	4500	2500	350	0.6	7.7 (.303)	23	27
1025	100	155	107	6500	4000	850	0.8	8.1 (.319)	23	28
1120	10	25	7.5	1200	600	80	0.2	7.4 (.291)	22	25
1120	25	45	20	2500	1250	120	0.4	8.2 (.323)	22	26
1120	50	90	42	4500	2500	300	0.6	8.2 (.323)	23	27
1120	100	160	107	6500	4000	700	0.8	8.6 (.339)	23	28
1180	25	45	20	2500	1250	115	0.4	8.4 (.331)	22	26
1180	50	95	44	4500	2500	275	0.6	8.4 (.331)	23	27
1180	100	165	115	6500	4000	650	0.8	8.8 (.346)	23	28
1240	25	45	20	2500	1250	110	0.4	8.5 (.335)	22	26
1240	50	100	47	4500	2500	250	0.6	8.5 (.335)	23	27
1240	100	175	120	6500	4000	600	0.8	9.0 (.354)	23	28
1350	25	55	22	2500	1250	100	0.4	9.0 (.354)	22	26
1350	50	110	57	4500	2500	220	0.6	9.0 (.354)	23	27
1350	100	190	150	6500	4000	550	0.8	9.4 (.370)	23	28
1420	25	57	24	2500	1250	90	0.4	9.3 (.366)	22	26
1420	50	113	57	4500	2500	200	0.6	9.3 (.366)	23	27
1420	100	200	150	6500	4000	500	0.8	9.7 (.382)	23	28
1500	25	60	25	2500	1250	80	0.4	9.7 (.382)	22	26
1500	50	120	60	4500	2500	180	0.6	9.7 (.382)	23	27
1500	100	210	160	6500	4000	450	0.8	10.1 (.398)	23	28
1650	25	68	25	2500	1250	74	0.4	10.5 (.413)	22	26
1650	50	130	60	4500	2500	165	0.6	10.5 (.413)	23	27
1650	100	230	160	6500	4000	410	0.8	11.0 (.433)	23	28

Zinc Oxide Varistors

VE/VF Types for Heavy Duty Applications ("P Series")

FEATURES

- "P Series" are especially dedicated to heavy duty applications encountered in the AC power network. Higher surge current and energy ratings provide an improved protection and a better reliability
- Radial lead varistors
- Operating voltage range from 130 V to 625 V (V_{rms} for VE types) or 205 V to 1000 V (V_{1mA} for VF types)
- Available in tape and reel for use with automatic insertion equipment (see pages 31 to 33 for details).



PARTICULAR CHARACTERISTICS

UL (USA and Canadian Standards)	VE Series P/N codification using (D_{max} , V_{rms})	VF Series P/N codification using ($d_{ceramic}$, V_{1mA})	Maximum operating voltage		Nominal voltage at 1 mA dc		
			V_{rms}	V_{DC}	$V_{1mA\ mini}$	$V_{1mA\ nominal}$	$V_{1mA\ maxi}$
★	VE07P00131K _ _	VF05P12050K _ _	130	170	184	205	226
★	VE09P00131K _ _	VF07P12050K _ _					
★	VE13P00131K _ _	VF10P12050K _ _					
★	VE17P00131K _ _	VF14P12050K _ _					
★	VE24P00131K _ _	VF20P12050K _ _					
★	VE07P00141K _ _	VF05P10221K _ _	140	180	198	220	242
★	VE09P00141K _ _	VF07P10221K _ _					
★	VE13P00141K _ _	VF10P10221K _ _					
★	VE17P00141K _ _	VF14P10221K _ _					
★	VE24P00141K _ _	VF20P10221K _ _					
★	VE07P00151K _ _	VF05P10241K _ _					
★	VE09P00151K _ _	VF07P10241K _ _	150	200	216	240	264
★	VE13P00151K _ _	VF10P10241K _ _					
★	VE17P00151K _ _	VF14P10241K _ _					
★	VE24P00151K _ _	VF20P10241K _ _					
★	VE07P01750K _ _	VF05P10271K _ _	175	225	243	270	297
★	VE09P01750K _ _	VF07P10271K _ _					
★	VE13P01750K _ _	VF10P10271K _ _					
★	VE17P01750K _ _	VF14P10271K _ _					
★	VE24P01750K _ _	VF20P10271K _ _					
★	VE07P00211K _ _	VF05P10331K _ _	210	275	297	330	363
★	VE09P00211K _ _	VF07P10331K _ _					
★	VE13P00211K _ _	VF10P10331K _ _					
★	VE17P00211K _ _	VF14P10331K _ _					
★	VE24P00211K _ _	VF20P10331K _ _					
★	VE07P00231K _ _	VF05P10361K _ _	230	300	324	360	396
★	VE09P00231K _ _	VF07P10361K _ _					
★	VE13P00231K _ _	VF10P10361K _ _					
★	VE17P00231K _ _	VF14P10361K _ _					
★	VE24P00231K _ _	VF20P10361K _ _					

Zinc Oxide Varistors

VE/VF Types for Heavy Duty Applications (“P Series”)

DIMENSIONS millimeters (inches)

Type	Type	D: Ceramic diameter	D: Maximum coated diameter	H max.	t max.	ø +10% –0.05 (.002)	E ± 0.8
VE07	VF05	5 (.196)	7 (.275)	10 (.394)	see table	0.6 (.024)	5.08 (0.20)
VE09	VF07	7 (.275)	9 (.354)	12 (.472)		0.6 (.024)	5.08 (0.20)
VE13*	VF10*	10 (.393)	13* (.512)	16 (.630)		0.8* (.031)	7.62*(0.30)
VE17	VF14	14 (.551)	17 (.669)	20 (.787)		0.8 (.031)	7.62 (0.30)
VE24**	VF20**	20 (.787)	24 (.945)	27 (1.06)		0.8** (.031)	7.62 (0.30)

* VE13 / VF10: For models with $V_{RMS} \leq 320$ V
other version/suffixes available with:
E = 5.08 (0.20) Suffix:
Ø = 0.6 (.024) Bulk: HB
D = 12.5 (.492) max Tape: DA, DB, DC, DD, DQ, ...

**VE24 / VF20: For lead diameter = 1.0 (.039), please consult us.

GENERAL CHARACTERISTICS

Storage temperature:	-40°C to +125°C
Max. operating temperature:	+85°C
Response time:	< 25 ns
Voltage coefficient temp.:	$\lvert K \rvert$ < 0.09%/°C
Voltage proof:	2500 V
Epoxy coating:	Flame retardant UL94-VO

MARKING

Type
AC nominal voltage (EIA coding) for VE types
V_{1mA} varistor voltage (EIA coding) for VF types
Logo
UL logo (when approved)
Lot number (VE13/17/24 and VF10/14/20 only)

Max. clamping voltage (8 x 20 µs) Vp (V)	Max. clamping voltage (8 x 20 µs) Ip (A)	Max. energy absorption (10 x 1000 µs) W (J) Number of surges 1 surge	Max. permissible peak current (8 x 20 µs) Ip (A) 1 surge	Max. permissible peak current (8 x 20 µs) Ip (A) 2 surges	Typical capacitance f = 1kHz pF	Mean power dissipation W	Maximum thickness t mm (inches)	V/I characteristic Page	Derating curves Page
340	5	8.5	800	600	90	0.1	4.1 (.161)	34	24
340	10	17.5	1750	1250	250	0.2	4.1 (.161)	34	25
340	25	35	3500	2500	450	0.4	4.7 (.185)	34	26
340	50	70	6000	4500	1000	0.6	4.7 (.185)	35	27
340	100	140	10000	7000	2500	0.8	5.1 (.201)	35	28
360	5	9	800	600	85	0.1	4.2 (.165)	34	24
360	10	19	1750	1250	235	0.2	4.2 (.165)	34	25
360	25	39	3500	2500	425	0.4	4.8 (.189)	34	26
360	50	78	6000	4500`	930	0.6	4.8 (.189)	35	27
360	100	155	10000	7000	2250	0.8	5.2 (.205)	35	28
400	5	10.5	800	600	80	0.1	4.3 (.169)	34	24
400	10	21	1750	1250	220	0.2	4.3 (.169)	34	25
400	25	42	3500	2500	400	0.4	4.9 (.193)	34	26
400	50	85	6000	4500	850	0.6	4.9 (.193)	35	27
400	100	170	10000	7000	2000	0.8	5.3 (.209)	35	28
445	5	11	800	600	70	0.1	4.5 (.177)	34	24
445	10	24	1750	1250	190	0.2	4.5 (.177)	34	25
445	25	50	3500	2500	340	0.4	5.1 (.201)	34	26
445	50	100	6000	4500	750	0.6	5.1 (.201)	35	27
445	100	190	10000	7000	2000	0.8	5.5 (.217)	35	28
545	5	13	800	600	60	0.1	4.9 (.193)	34	24
545	10	28	1750	1250	155	0.2	4.9 (.193)	34	25
545	25	60	3500	2500	275	0.4	5.5 (.217)	34	26
545	50	115	6000	4500	600	0.6	5.5 (.217)	35	27
545	100	230	10000	7000	1650	0.8	5.9 (.232)	35	28
595	5	16	800	600	55	0.1	5.1 (.201)	34	24
595	10	32	1750	1250	140	0.2	5.1 (.201)	34	25
595	25	65	3500	2500	250	0.4	5.7 (.224)	34	26
595	50	130	6000	4500	550	0.6	5.7 (.224)	35	27
595	100	250	10000	7000	1500	0.8	6.1 (.240)	35	28

Zinc Oxide Varistors

VE/VF Types for Heavy Duty Applications ("P Series")

UL (USA and Canadian Standards)	VE Series P/N codification using (D_{max} , V_{rms})	VF Series P/N codification using ($d_{ceramic}$, V_{1mA})	Maximum operating voltage V_{rms}	V_{DC}	Nominal voltage at 1 mA dc $V_{1mA\ mini}$	$V_{1mA\ nominal}$	$V_{1mA\ maxi}$
★ ★ ★ ★ ★	VE07P00251K _ _ VE09P00251K _ _ VE13P00251K _ _ VE17P00251K _ _ VE24P00251K _ _	VF05P10391K _ _ VF07P10391K _ _ VF10P10391K _ _ VF14P10391K _ _ VF20P10391K _ _	250	320	351	390	429
★ ★ ★ ★ ★	VE07P02750K _ _ VE09P02750K _ _ VE13P02750K _ _ VE17P02750K _ _ VE24P02750K _ _	VF05P10431K _ _ VF07P10431K _ _ VF10P10431K _ _ VF14P10431K _ _ VF20P10431K _ _	275	350	387	430	473
★ ★ ★ ★ ★	VE07P00301K _ _ VE09P00301K _ _ VE13P00301K _ _ VE17P00301K _ _ VE24P00301K _ _	VF05P10471K _ _ VF07P10471K _ _ VF10P10471K _ _ VF14P10471K _ _ VF20P10471K _ _	300	385	423	470	517
★ ★ ★ ★	VE09P00321K _ _ VE13P00321K _ _ VE17P00321K _ _ VE24P00321K _ _	VF07P10511K _ _ VF10P10511K _ _ VF14P10511K _ _ VF20P10511K _ _	320	420	459	510	561
★ ★ ★ ★	VE09P00351K _ _ VE13P00351K _ _ VE17P00351K _ _ VE24P00351K _ _	VF07P10561K _ _ VF10P10561K _ _ VF14P10561K _ _ VF20P10561K _ _	350	460	504	560	616
★ ★ ★ ★	VE09P03850K _ _ VE13P03850K _ _ VE17P03850K _ _ VE24P03850K _ _	VF07P10621K _ _ VF10P10621K _ _ VF14P10621K _ _ VF20P10621K _ _	385	505	558	620	682
★ ★ ★ ★	VE09P00421K _ _ VE13P00421K _ _ VE17P00421K _ _ VE24P00421K _ _	VF07P10681K _ _ VF10P10681K _ _ VF14P10681K _ _ VF20P10681K _ _	420	560	612	680	748
★ ★ ★	VE13P00441K _ _ VE17P00441K _ _ VE24P00441K _ _	VF10P17150K _ _ VF14P17150K _ _ VF20P17150K _ _	440	585	643	715	787
★ ★ ★	VE13P00461K _ _ VE17P00461K _ _ VE24P00461K _ _	VF10P10751K _ _ VF14P10751K _ _ VF20P10751K _ _	460	615	675	750	825
★ ★ ★	VE13P00511K _ _ VE17P00511K _ _ VE24P00511K _ _	VF10P10821K _ _ VF14P10821K _ _ VF20P10821K _ _	510	670	738	820	902
★ ★ ★	VE13P00551K _ _ VE17P00551K _ _ VE24P00551K _ _	VF10P10861K _ _ VF14P10861K _ _ VF20P10861K _ _	550	715	774	860	946
★ ★ ★	VE13P05750K _ _ VE17P05750K _ _ VE24P05750K _ _	VF10P10911K _ _ VF14P10911K _ _ VF20P10911K _ _	575	730	819	910	1001
★ ★ ★	VE13P06250K _ _ VE17P06250K _ _ VE24P06250K _ _	VF10P10102K _ _ VF14P10102K _ _ VF20P10102K _ _	625	825	900	1000	1100

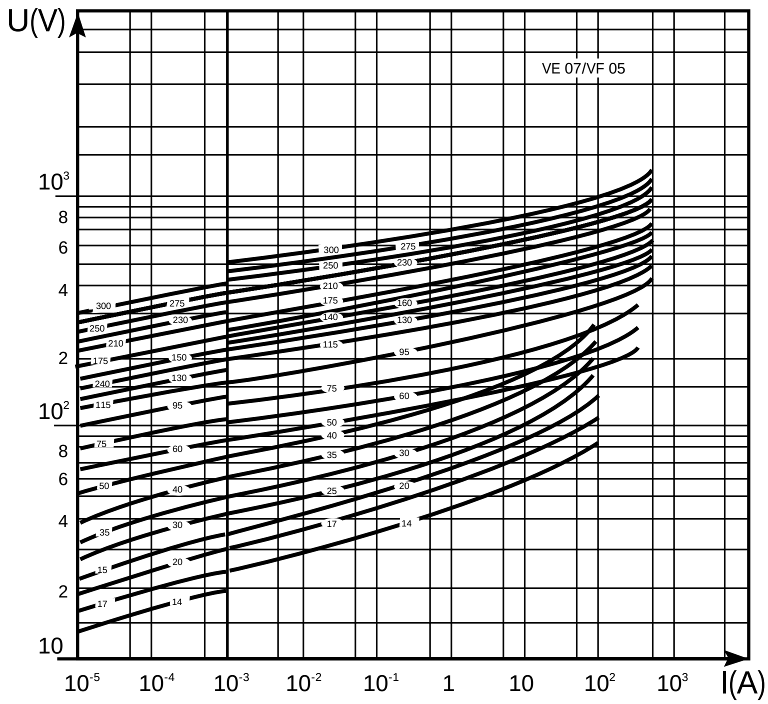
Zinc Oxide Varistors

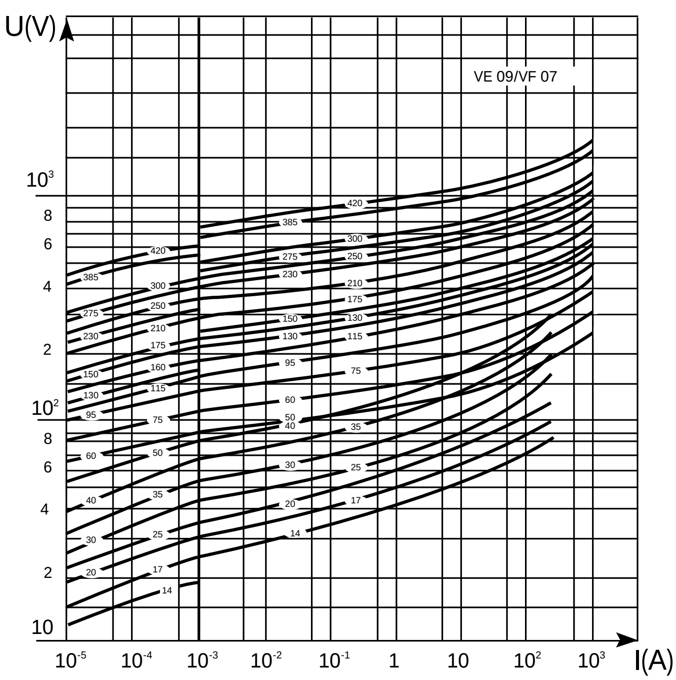
VE/VF Types for Heavy Duty Applications ("P Series")

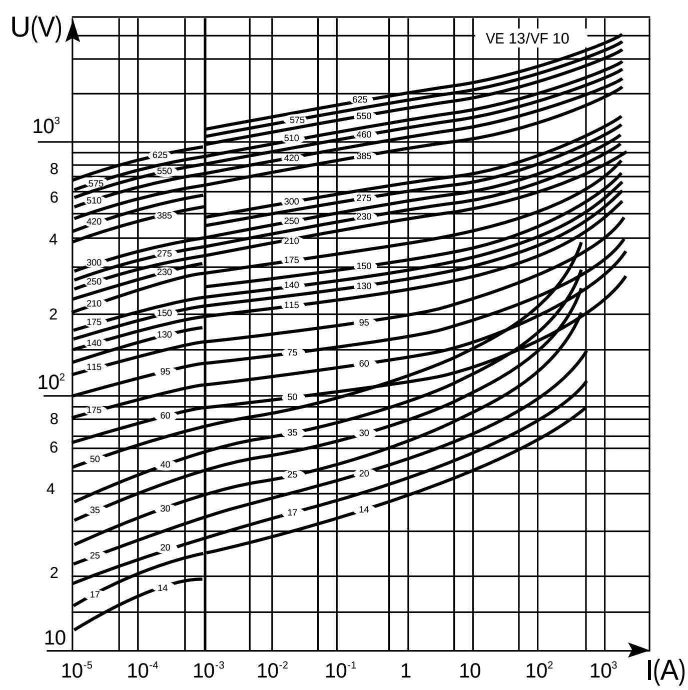
Max. clamping voltage (8 x 20 µs) Vp (V)	Ip (A)	Max. energy absorption (10 x 1000 µs) W (J) Number of surges 1 surge	Max. permissible peak current (8 x 20 µs) Ip (A) 1 surge	2 surges	Typical capacitance f = 1kHz pF	Mean power dissipation W	Maximum thickness t mm (inches)	V/I characteristic Page	Derating curves Page
645	5	17	800	600	50	0.1	5.4 (.213)	34	24
645	10	35	1750	1250	130	0.2	5.4 (.213)	34	25
645	25	70	3500	2500	230	0.4	5.9 (.232)	34	26
645	50	140	6000	4500	500	0.6	5.9 (.232)	35	27
645	100	280	10000	7000	1300	0.8	6.3 (.248)	35	28
710	5	20	800	600	45	0.1	5.7 (.224)	34	24
710	10	40	1750	1250	120	0.2	5.7 (.224)	34	25
710	25	80	3500	2500	210	0.4	6.3 (.248)	34	26
710	50	160	6000	4500	450	0.6	6.3 (.248)	35	27
710	100	310	10000	7000	1200	0.8	6.7 (.264)	35	28
775	5	21	800	600	40	0.1	6.0 (.236)	34	24
775	10	42	1750	1250	100	0.2	6.0 (.236)	34	25
775	25	85	3500	2500	180	0.4	6.6 (.260)	34	26
775	50	170	6000	4500	400	0.6	6.6 (.260)	35	27
775	100	340	10000	7000	1000	0.8	7.0 (.276)	35	28
840	10	45	1750	1250	100	0.2	6.4 (.252)	34	25
840	25	90	3500	2500	170	0.4	7.0 (.276)	34	26
840	50	180	5000	4000	380	0.6	7.0 (.276)	35	27
840	100	360	8000	6000	950	0.8	7.5 (.295)	35	28
910	10	47	1750	1250	95	0.2	6.6 (.260)	34	25
910	25	95	3500	2500	160	0.4	7.3 (.287)	34	26
910	50	190	5000	4000	365	0.6	7.3 (.287)	35	27
910	100	380	8000	6000	900	0.8	7.8 (.307)	35	28
1025	10	50	1750	1250	95	0.2	7.0 (.276)	34	25
1025	25	100	3500	2500	150	0.4	7.7 (.303)	34	26
1025	50	200	5000	4000	350	0.6	7.7 (.303)	35	27
1025	100	400	8000	6000	850	0.8	8.1 (.319)	35	28
1120	10	52	1750	1250	80	0.2	7.4 (.291)	34	25
1120	25	105	3500	2500	120	0.4	8.2 (.323)	34	26
1120	50	210	5000	4000	300	0.6	8.2 (.323)	35	27
1120	100	420	8000	6000	700	0.8	8.6 (.339)	35	28
1180	25	105	3500	2500	115	0.4	8.4 (.331)	34	26
1180	50	210	5000	4000	275	0.6	8.4 (.331)	35	27
1180	100	420	8000	6000	650	0.8	8.8 (.346)	35	28
1240	25	105	3500	2500	110	0.4	8.5 (.335)	34	26
1240	50	210	5000	4000	250	0.6	8.5 (.335)	35	27
1240	100	420	8000	6000	600	0.8	9.0 (.354)	35	28
1350	25	110	3500	2500	100	0.4	9.0 (.354)	34	26
1350	50	225	5000	4000	220	0.6	9.0 (.354)	35	27
1350	100	450	7500	6000	550	0.8	9.4 (.370)	35	28
1420	25	120	3500	2500	90	0.4	9.3 (.366)	34	26
1420	50	240	5000	4000	200	0.6	9.3 (.366)	35	27
1420	100	480	7500	6000	500	0.8	9.7 (.382)	35	28
1500	25	125	3500	2500	80	0.4	9.7 (.382)	34	26
1500	50	250	5000	4000	180	0.6	9.7 (.382)	35	27
1500	100	500	7500	6000	450	0.8	10.1 (.398)	35	28
1650	25	140	3500	2500	74	0.4	10.5 (.413)	34	26
1650	50	230	5000	4000	165	0.6	10.5 (.413)	35	27
1650	100	560	7500	6000	410	0.8	11.0 (.433)	35	28

VOLTAGE-CURRENT CHARACTERISTICS

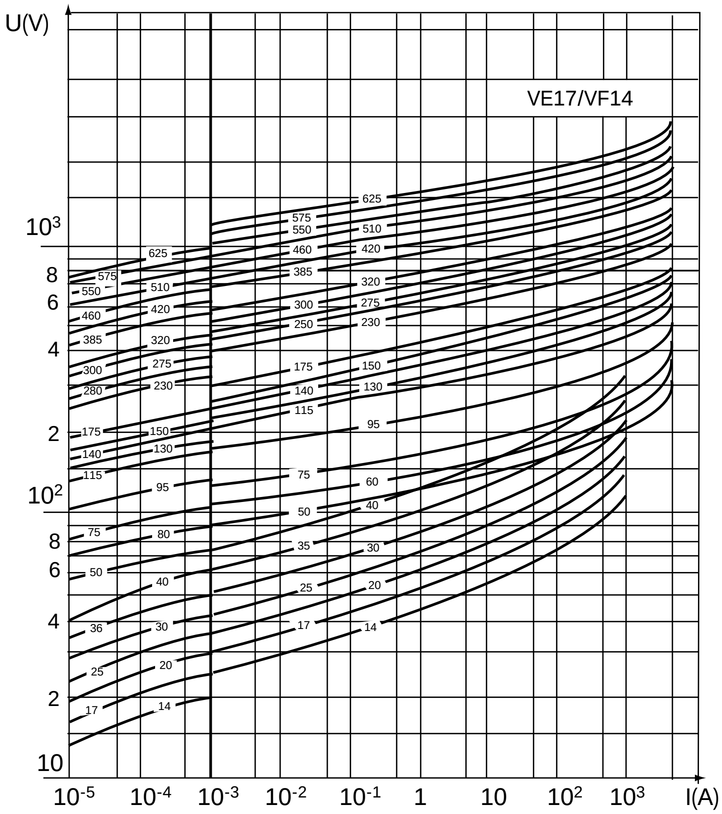
V/I characteristics give:
- for I below 1 mA the maximum leakage current under V_{dc}
- for I above 1 mA the maximum clamping voltage

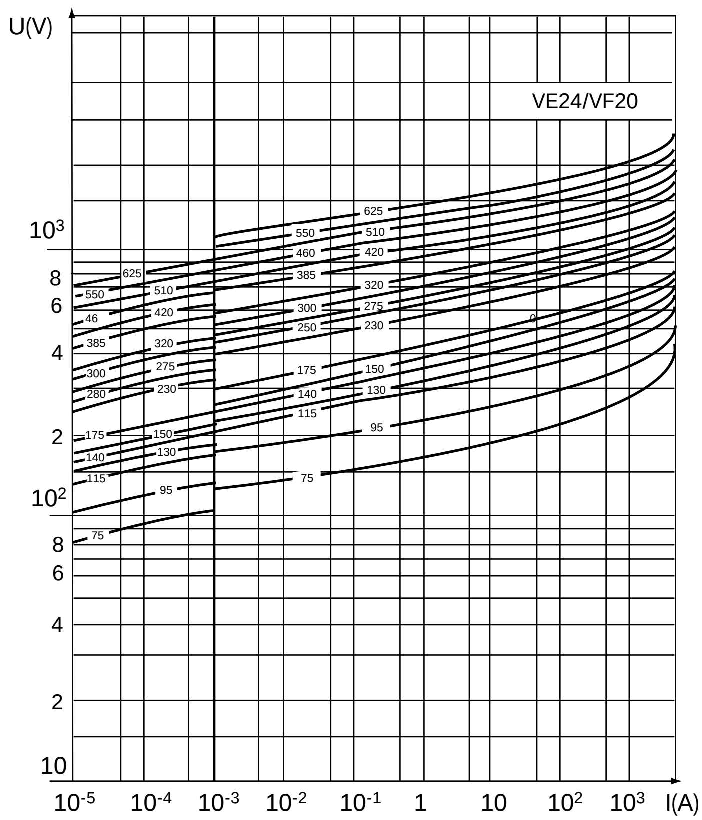




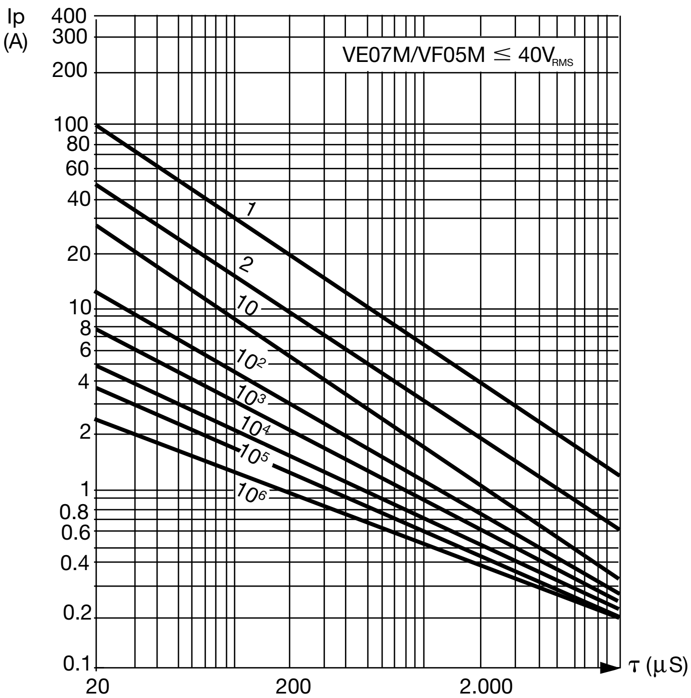


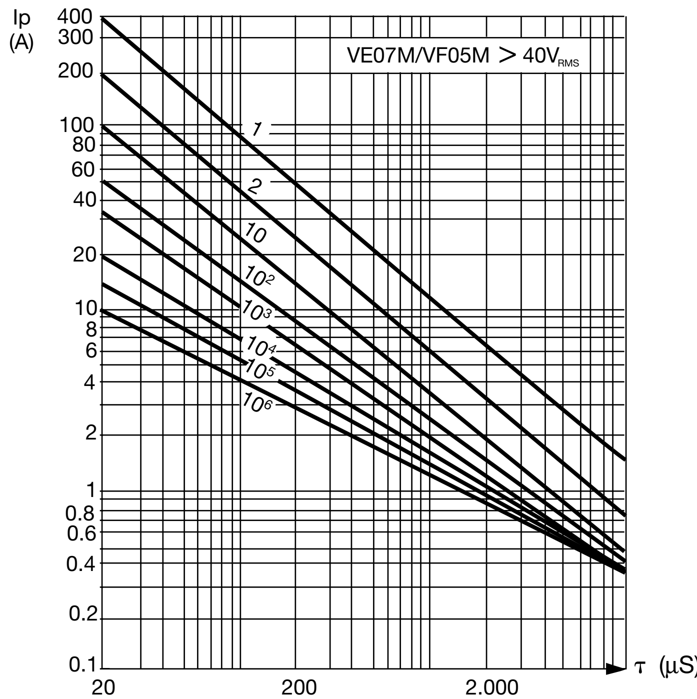
VOLTAGE-CURRENT CHARACTERISTICS

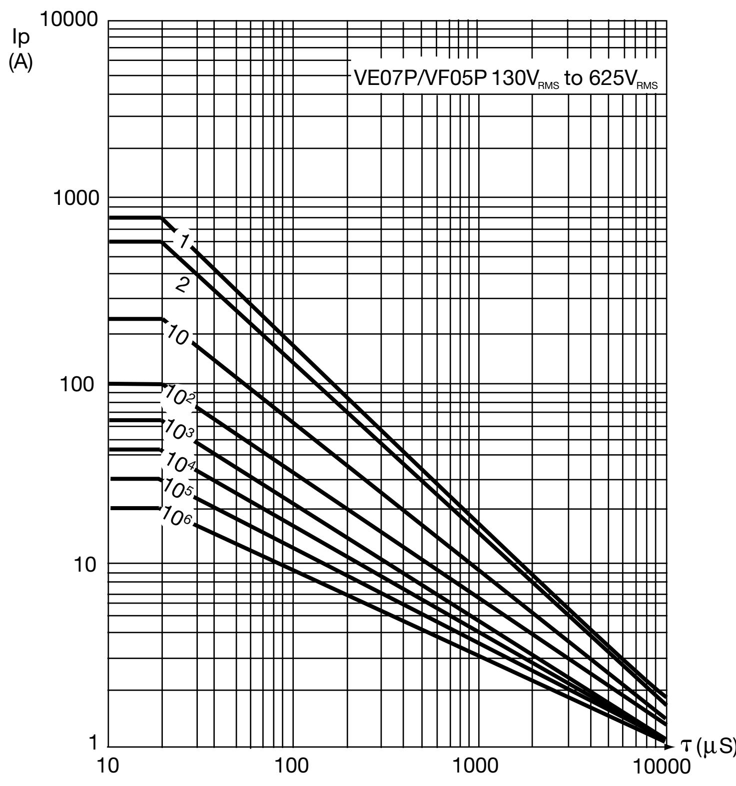




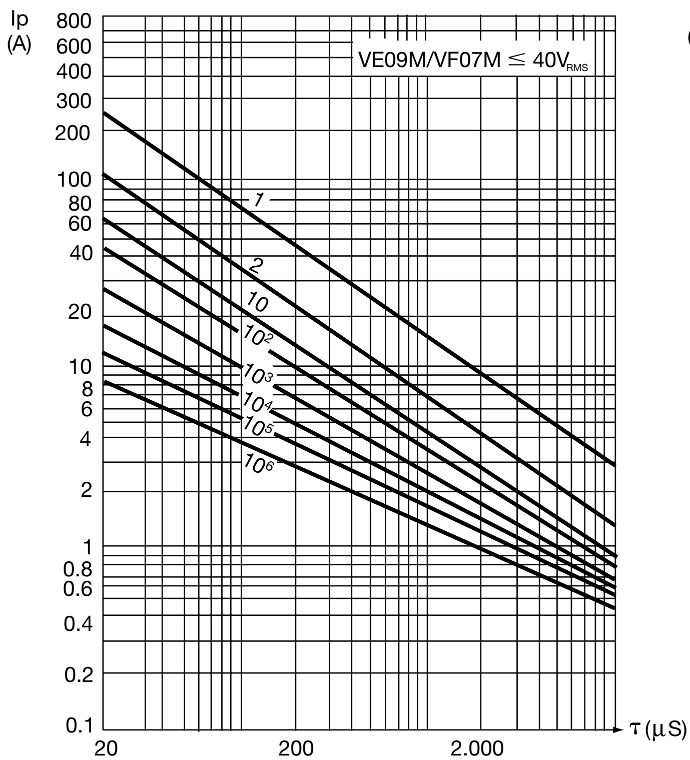
MAXIMUM SURGE CURRENT (Ip)
DERATING CURVES WITH PULSE WIDTH (τ) AND FREQUENCY

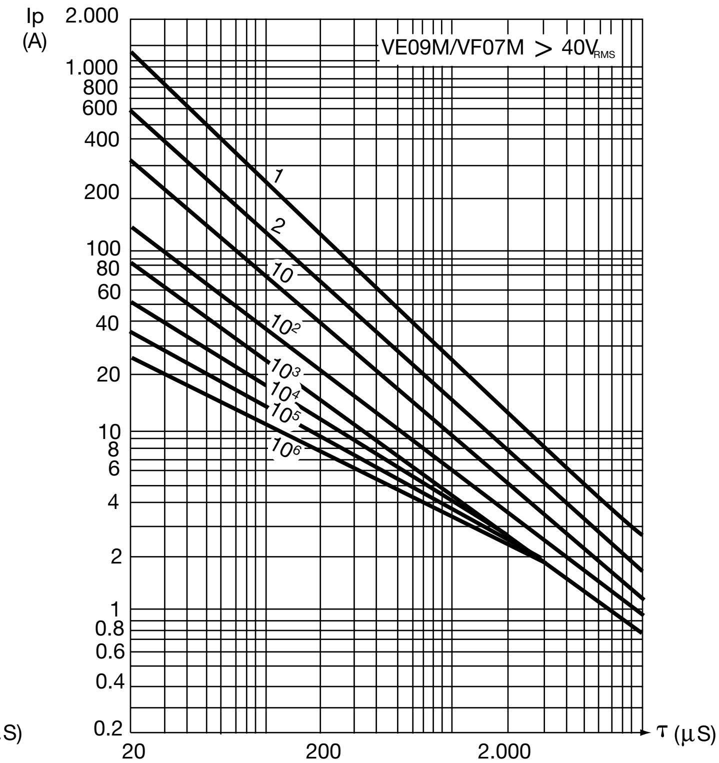


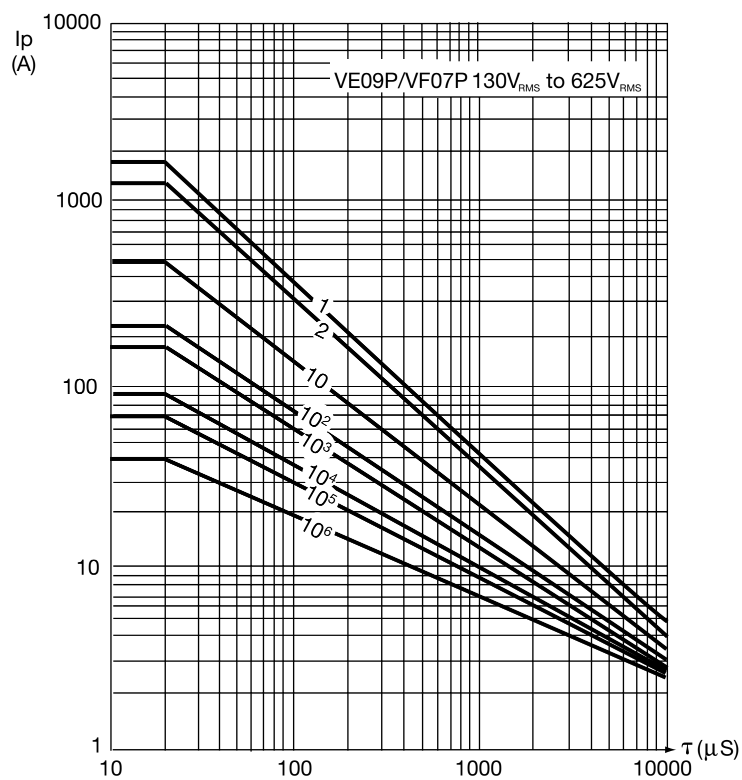




MAXIMUM SURGE CURRENT (Ip)
DERATING CURVES WITH PULSE WIDTH (τ) AND FREQUENCY

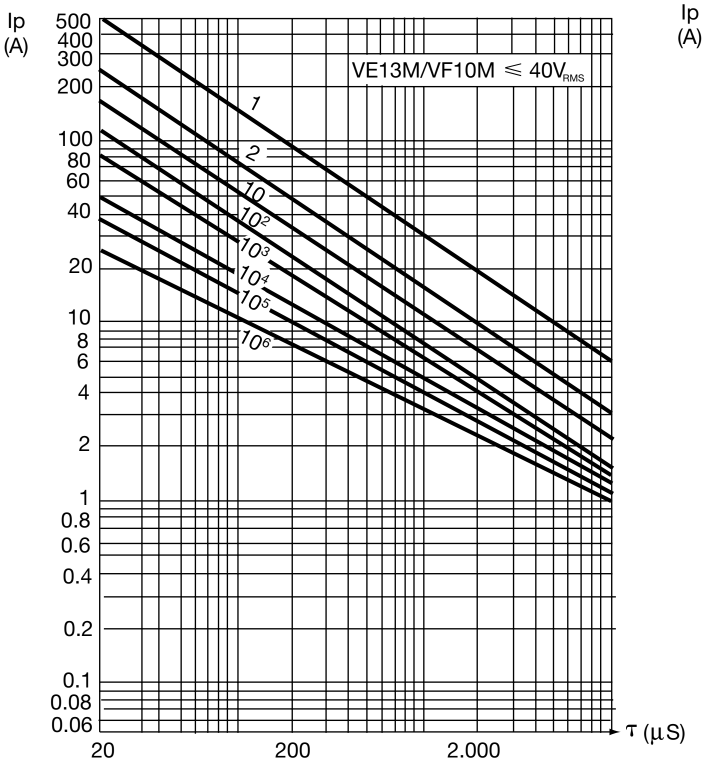


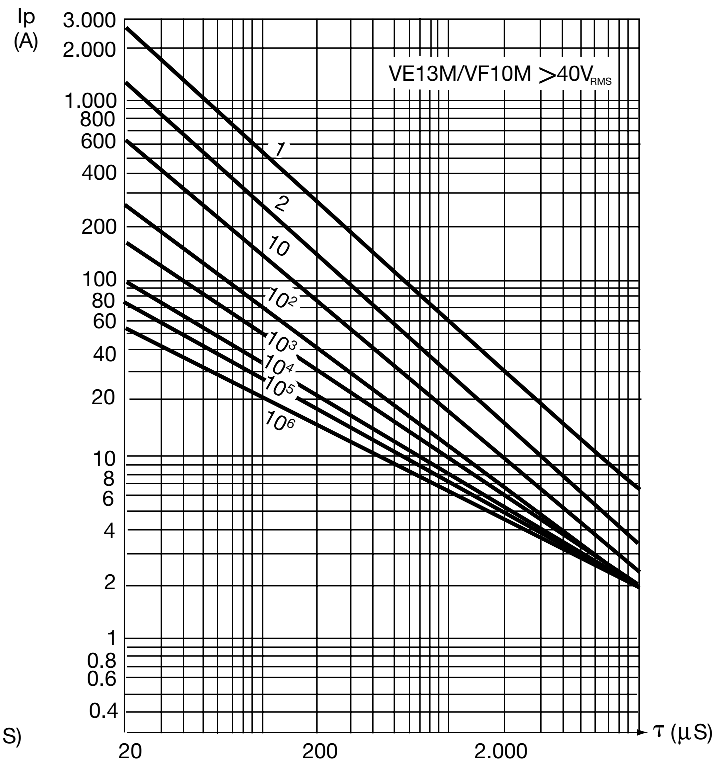


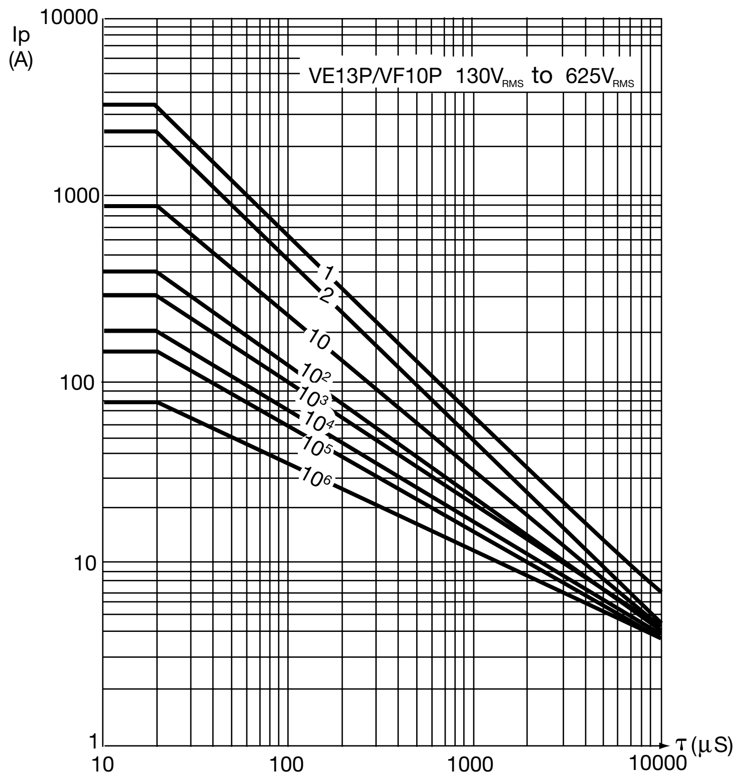


Electrical Characteristics VE / VF Types

MAXIMUM SURGE CURRENT (Ip)
DERATING CURVES WITH PULSE WIDTH (τ) AND FREQUENCY

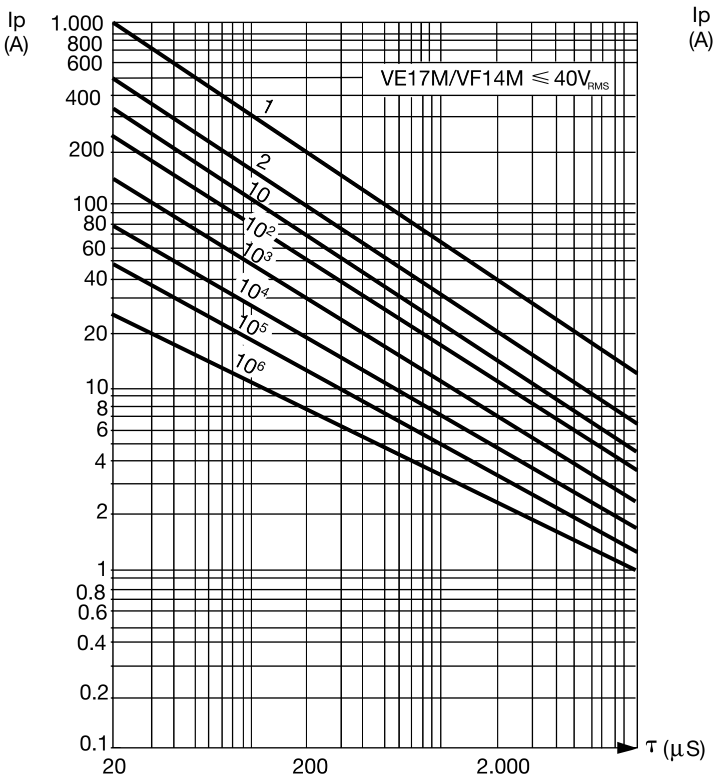


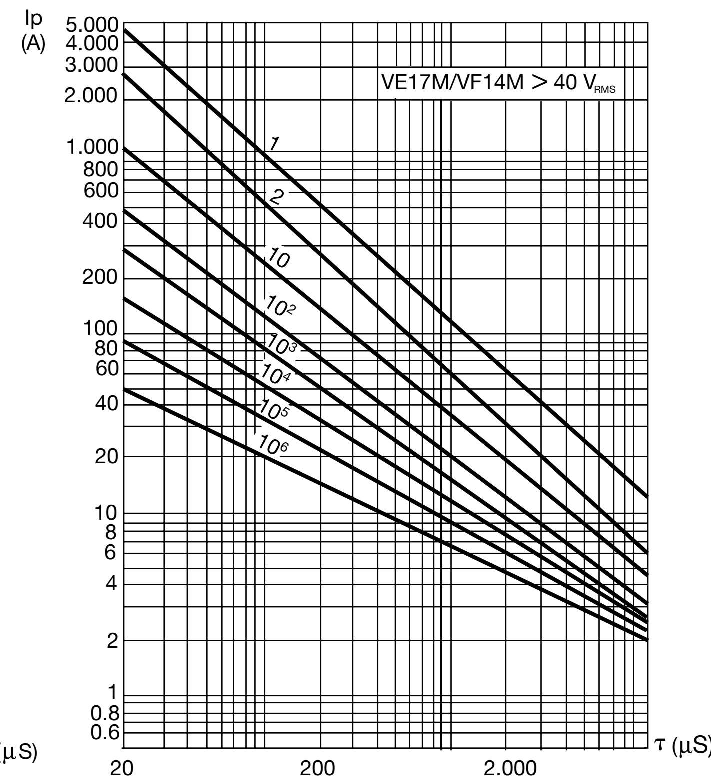


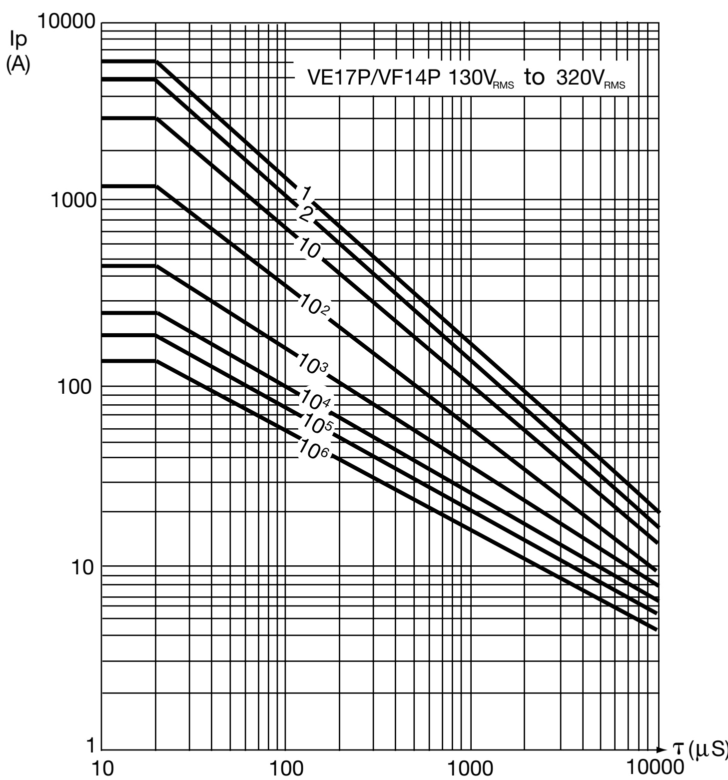


TPC

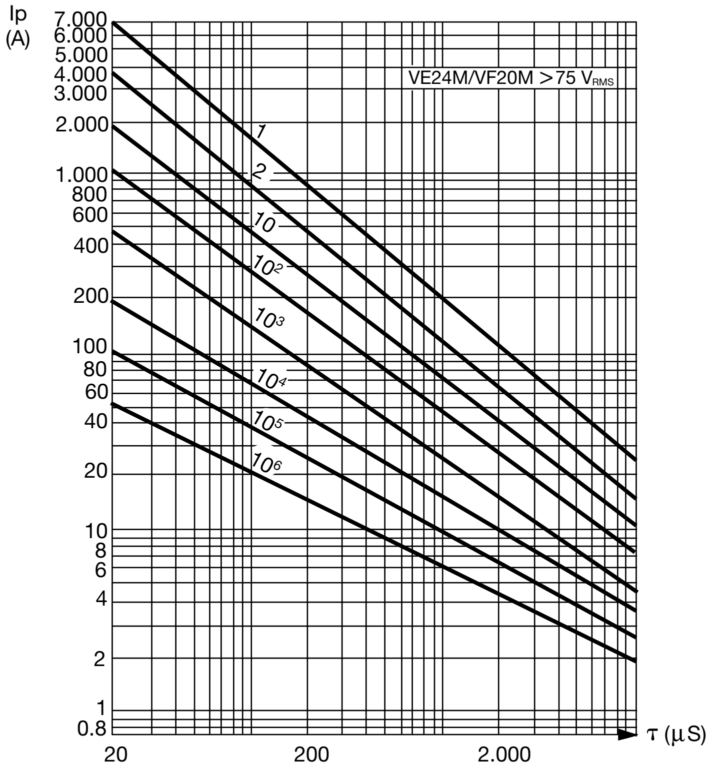
MAXIMUM SURGE CURRENT (Ip)
DERATING CURVES WITH PULSE WIDTH (τ) AND FREQUENCY

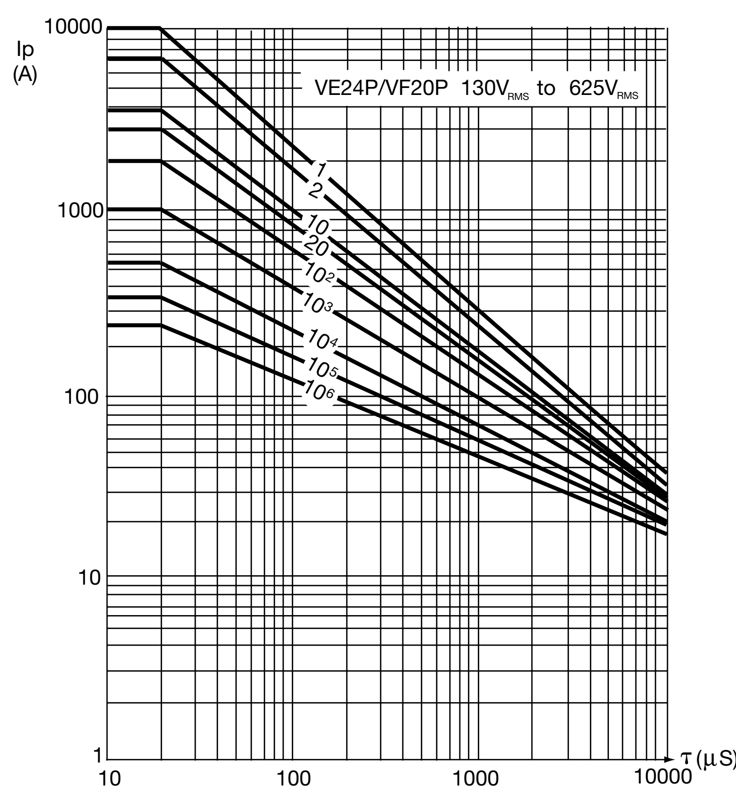






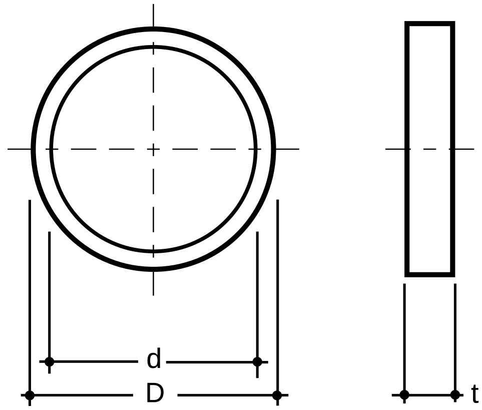
MAXIMUM SURGE CURRENT (Ip)
DERATING CURVES WITH PULSE WIDTH (τ) AND FREQUENCY





Zinc Oxide Varistors

VN 32 Uncoated Discs



DIMENSIONS: millimeters (inches)

Type	D ±1.5	d ±1	t max.
VN32M00251K- -	32 (1.26)	28 (1.10)	2.8 (.110)
VN32M02750K- -	32 (1.26)	28 (1.10)	3.1 (.122)
VN32M00321K- -	32 (1.26)	28 (1.10)	3.7 (.146)
VN32M00381K- -	32 (1.26)	28 (1.10)	4.4 (.173)
VN32M00421K- -	32 (1.26)	28 (1.10)	4.9 (.193)
VN32M00461K- -	32 (1.26)	28 (1.10)	5.5 (.217)
VN32M00511K- -	32 (1.26)	28 (1.10)	6.0 (.236)
VN32M00750K- -	32 (1.26)	28 (1.10)	6.6 (.260)

HOW TO ORDER

VN32	M	0	0461	K	– –
Type	Material		RMS Operating Voltage	Tolerance	Suffix

GENERAL CHARACTERISTICS

Max. operating temperature: +85°C
Storage temperature: -40°C to +125°C
Ceramic discs with silver layer on each face

MARKING

On packaging only

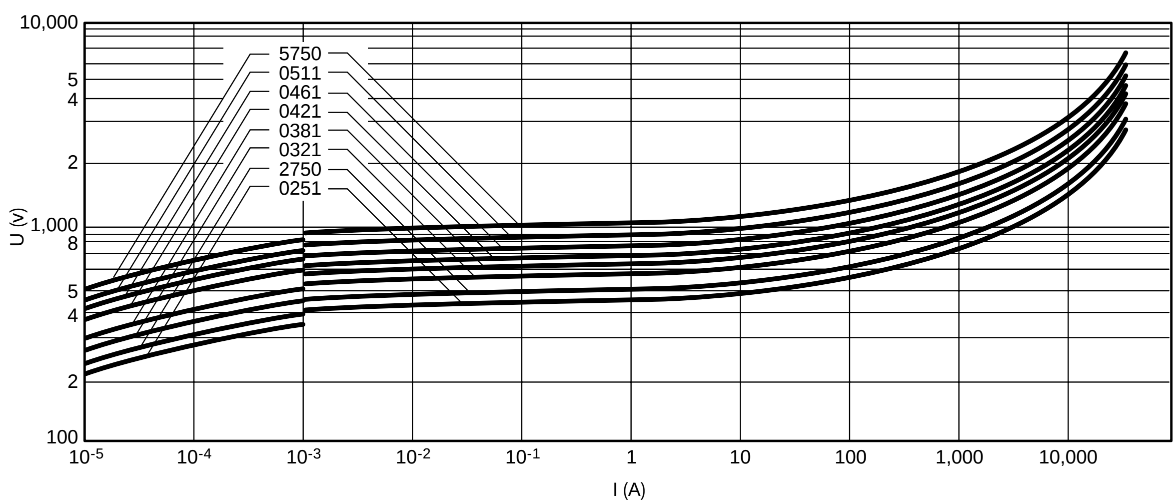
REMARK

Discs of 14 mm and 20 mm available upon request

PARTICULAR CHARACTERISTICS

Type	Max. operating voltage V_{RMS} (V)	V_{DC} (V)	Nominal voltage at 1 mA DC V_R (V)	Clamping voltage Vp(V) at 2.5 kA	at 2.5 kA	Energy 1 surge (10 x 1000 μs) W (J)	Max. peak current with insulating coating (8 x 20 μs) Ip (kA) 1 pulse	2 pulses
VN32M00251K- -	250	330	390	970	1100	200	25	15
VN32M02750K- -	275	369	430	1075	1230	260	25	15
VN32M00321K- -	320	420	510	1200	1380	300	25	15
VN32M00381K- -	380	500	610	1350	1550	350	25	15
VN32M00421K- -	420	560	680	1500	1700	400	25	15
VN32M00461K- -	460	615	750	1650	1900	450	25	15
VN32M00511K- -	510	675	820	1800	2070	500	25	15
VN32M00750K- -	575	730	910	2000	2300	550	25	15

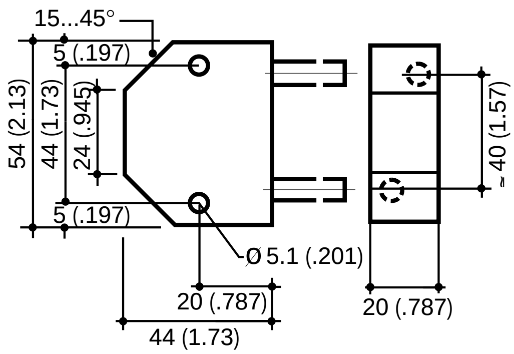
VOLTAGE-CURRENT CHARACTERISTICS



Zinc Oxide Varistors

VB 32 Blocks

DIMENSIONS millimeters (inches)



HOW TO ORDER

VB32	M	0	0421	K	– –
Type	Material		RMS Operating Voltage	Tolerance	Suffix

GENERAL CHARACTERISTICS

Max. operating temperature: +85°C
Storage temperature: -40°C to +85°C

MOUNTING

Ø 5 mm holes for screwing
500 mm long, 6 mm² insulated copper cables

PACKAGING

Bulk or three units per box (one for each phase)

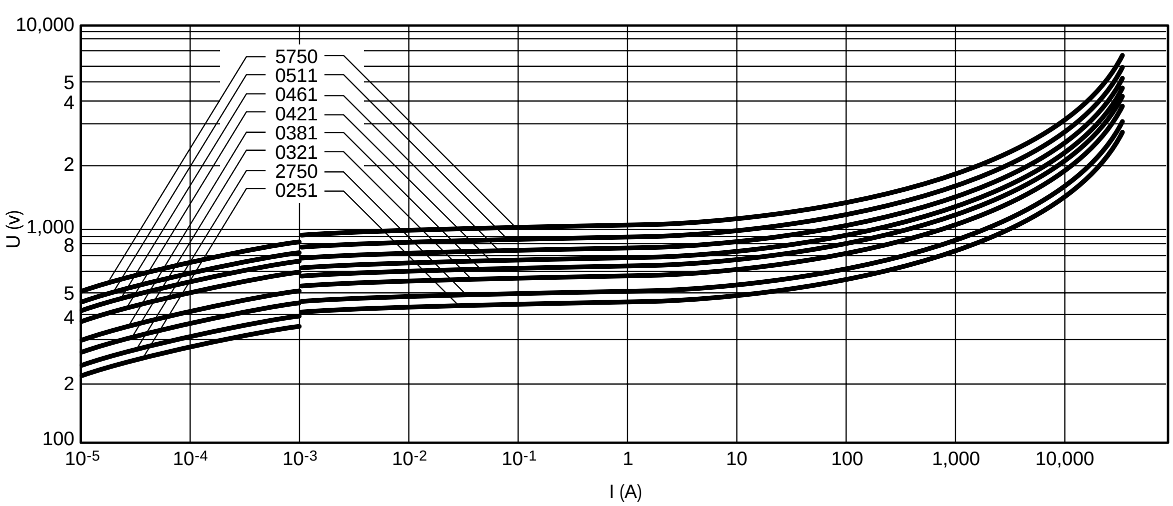
MARKING

Type
AC nominal voltage (EIA code)
Logo

PARTICULAR CHARACTERISTICS

Type	Max. operating voltage V_{RMS} (V)	Max. operating voltage V_{DC} (V)	Nominal voltage at 1 mA DC V_R (V)	Clamping voltage at 2.5 kA Vp (V)	Energy 1 surge (10 x 1000 µs) W (J)	Max. peak current with insulating coating (8 x 20 µs) Ip (kA) 1 pulse	Ip (kA) 2 pulses
VB32M00251K- -	250	330	390	970	200	25	15
VB32M02750K- -	275	369	430	1075	260	25	15
VB32M00321K- -	320	420	510	1200	300	25	15
VB32M00381K- -	380	500	610	1350	350	25	15
VB32M00421K- -	420	560	680	1500	400	25	15
VB32M00461K- -	460	615	750	1650	450	25	15
VB32M00511K- -	510	675	820	1800	500	25	15
VB32M00750K- -	575	730	910	2000	550	25	15

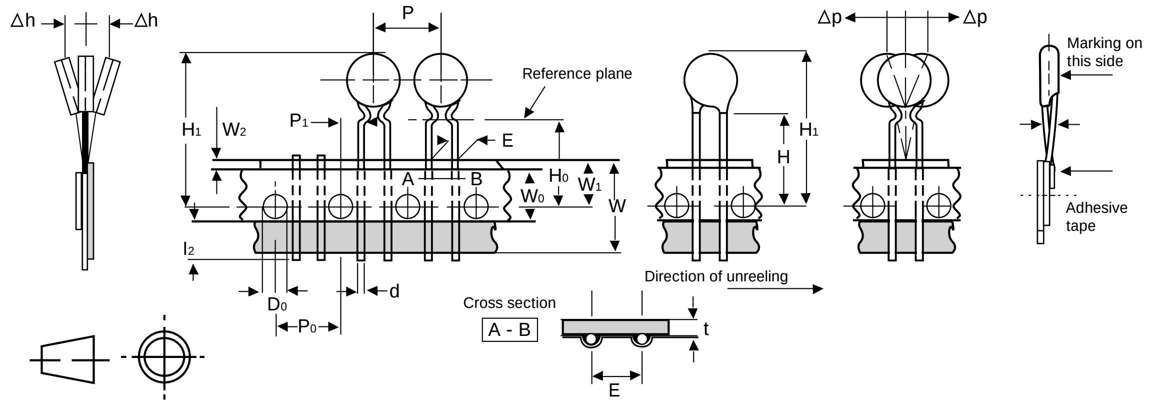
VOLTAGE-CURRENT CHARACTERISTICS



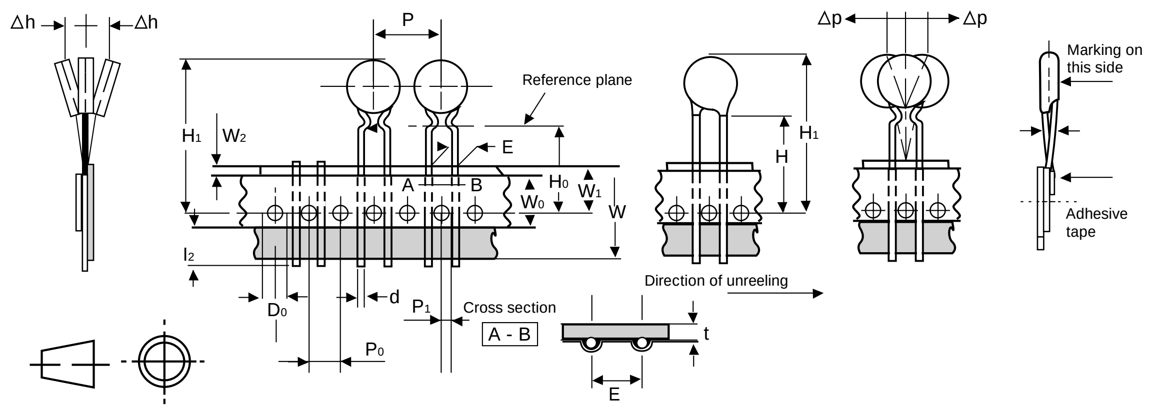
TPC

TAPING OF OUR VARISTORS IS MADE ACCORDING TO IEC 286-2

Types: VE07/09 - VF05/07



Types: VE13/17 - VF10/14



DIMENSIONS: millimeters (inches)

Dimension Characteristics	Value		Tolerance	
Leading tape width	18 (.709)		+1/-0.5	W
Adhesive tape width	The hold down tape shall not protrude beyond the carrier tape			W_0
Sprocket hole position	9 (.354)		+0.75/-0.5	W_1
Distance between the tops of the tape and the adhesive	3 (.118) max			W_2
Diameter of sprocket hole	4 (.157)		±0.2	D_0
Distance between the tape axis and the bottom plane of component body	16/ (.630)/ or 18 (.709)		±0.5/ -0/+2	H
Distance between the tape axis and the kink	16/ (.630)/ or 18 (.709)		±0.5/ -0/+2	H_0
Distance between the tape axis and the top of component body VE 07/09 - VF 05/07 VE 13/17 - VF 10/14	33.0 (1.30) max 45.0 (1.77) max			H_1
Lead diameter	0.6 (.024)	0.8 (.031)	+10% -0.05	d
Protrusions beyond the lower side of the hold down tape	5 (.197) max			l_2
Lead spacing	5.08 (0.20)	7.62 (0.30)	±0.8	E
Components pitch	12.7 (0.50)	25.4 (0.10)	±0.3	p

DIMENSIONS: millimeters (inches)

Dimension Characteristics	Value	Tolerance	
Sprocket holes pitch	12.7 (0.50)	±0.3	P_0
Distance between the sprocket hole axe and the lead axe	3.8 (.150)	±0.7	P_1
Total thickness of tape	0.9 (.035) max		t
Verticality of components	0	±2	Δp
Alignment of components	0	±2	Δh

Zinc Oxide Varistors

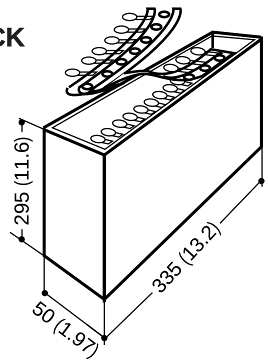
Taping Characteristics

PACKAGING

For automatic insertion, the following types can be ordered on tape either in AMMOPACK (fan folder) or on REEL in accordance to IEC 286-2.

AMMOPACK

millimeters (inches)

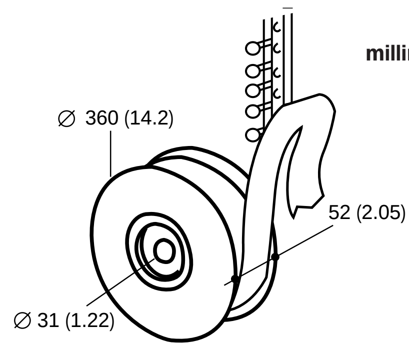


MISSING COMPONENTS

A maximum of 3 consecutive components may be missing from the bandolier, surrounded by at least 6 filled positions. The number of missing components may not exceed 0.5% of the total per packing module.

REEL

millimeters (inches)



LEADS CONFIGURATION AND PACKAGING SUFFIXES

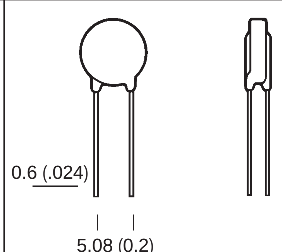
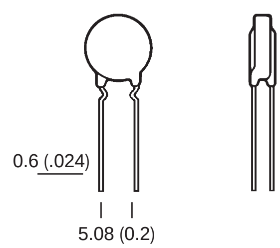
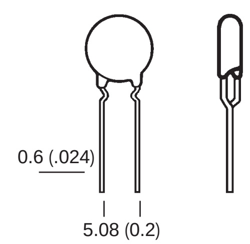
The tables below indicate the suffixes to be specified when ordering kink and packaging types. For devices on tape, it is necessary to specify the height (H or Ho) which is the distance between the tape axis (sprocket holes) and the sitting plane on the printed circuit board.

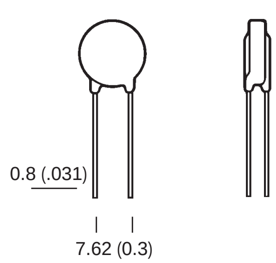
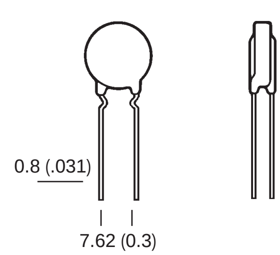
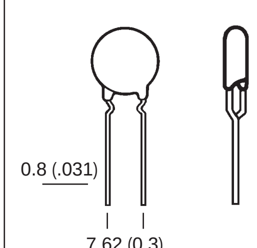
– Straight leads

H represents the distance between the sprocket holes axis and the bottom plane of component body (base of resin or base of stand off).

– Kinked leads

Ho represents the distance between the sprocket holes axis and the base of the knee.

Types	**VE 07/09 - VF 05/07 (VE13 - VF10 ≤ 320 V_{rms} upon request)**					
Leads	**Straight**		**Kinked (type 1)**		**Kinked (type 2)**	
Dimensions						
Packaging	AMMOPACK	REEL	AMMOPACK	REEL	AMMOPACK	REEL
H/Ho = 16 ± 0.5	DA(*)	DB(*)	DQ(**)	DR(**)	D7(**)	D5(**)
H/Ho = 18 -0/+2	DC(**)	DD(**)	DS	DT	D8	D6

Types	**VE 13/17 - VF 10/14**					
Leads	**Straight**		**Kinked (type 1)**		**Kinked (type 2)**	
Dimensions						
Packaging	AMMOPACK	REEL	AMMOPACK	REEL	AMMOPACK	REEL
H/Ho = 16 ± 0.5	EA(*)	EN(*)	EC(**)	EF(**)	EQ(**)	ER(**)
H/Ho = 18 -0/+2	EB(**)	ED(**)	EG	EH	ES	ET

(*) DA, DB, EA, EN suffixes are not available for varistors with V_{RMS} 300V are available only upon request for other types.
(**) Preferred versions according to IEC 286-2

> 300 VRMS

Zinc Oxide Varistors

Packaging

PACKAGING QUANTITIES

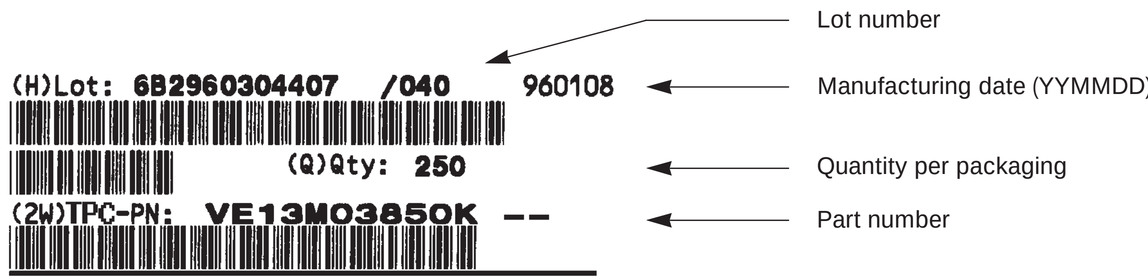
Type	Bulk	AMMOPACK	REEL
VE07 - VF05 all	1500	1500	1500
VE09 - VF07 < 230 V_{RMS}	1000	1500	1500
VE09 - VF07 ≥ 230 V_{RMS} ≤ 300 V_{RMS}	1000	1000	1000
VE09 - VF07 > 300 V_{RMS}	750	1000	1000
VE13 - VF10 ≤ 230 V_{RMS}	500	750	750
VE13 - VF10 > 230 V_{RMS} ≤ 300 V_{RMS}	500	500	500
VE13 - VF10 > 300 V_{RMS}	500	—	—
VE17 - VF14 ≤ 230 V_{RMS}	500	750	750
VE17 - VF14 > 230 V_{RMS} ≤ 300 V_{RMS}	500	500	500
VE17 - VF14 > 300 V_{RMS}	500	—	—
VE24 - VF20	250	—	—

IDENTIFICATION - TRACEABILITY

On the packaging of all shipped varistors, you will find a bar code label.

This label gives systematic information on the type of product, part number, lot number, manufacturing date and quantity.

An example is given below:



This information allows complete traceability of the entire manufacturing process, from raw materials to final inspection.

This is extremely useful for any information request.

QUALITY SYSTEM

A high level of performance, quality and service has been achieved in setting up a quality system based on the ISO 9000 standard.

The system includes:

- A quality manual ensuring the proper organization
- Incoming inspection
- Manufacturing process control and final inspection as described on page 35
- Reliability tests according to IEC 68 and CECC 42000 standards as described on page 36
- Continuous improvement programs

APPROVALS

The quality of our products and organization has been recognized by the following approvals:

ISO 9002

Certificate of approval n° 928373

CECC, EN100114-1

Certificate of approval of manufacturer n° 004-96

CECC 42201-005

Qualification approval certificate N° 96-024
All VE/VF types

VDE

Certificate of approval n° 94763E
All VE/VF types with V_{RMS} from 25V to 575V

Underwriters Laboratories, Inc./Canadian Standards Association

- UL 1449 Transient Voltage Surge Suppressors
  File E 84108 (S)
- UL 1414 - Across the line components
  File 184 051
  All types VE/VF with V_{RMS} from 130V to 275V

List GAM T1

Types VB1 (VE09) to VB4 (VE24)

List LNZ 44004

Types EPV-7A (VE09) to EPV-20A (VE24)

Zinc Oxide Varistors

Manufacturing Process and Quality Assurance

Raw material incoming	Weight: every batch
Grinding	Grinding time: every batch
Mixing	Density and viscosity: 1 time per batch
Spray drying	Temperature, pressure, particle size: every batch
Mixing	Weight, mixing time, moist: every batch
Electrical test	Every batch by sampling - Voltage/current characteristics degradation, physical characteristics
Pressing	Weight, thickness, visual inspection: every batch by sampling
Binder burn out	Thermal cycle: every batch
Stacking	Visual inspection 100%
Sintering	Thermal cycle: every batch
Electrical test	Every batch by sampling: physical characteristics, capacitance, V1mA, leakage current, clamping voltage, degradation
Silvering	Visual inspection: every batch 100%
Silver firing	Thermal cycle: every batch
Soldering	Temperature, visual inspection: every batch 100%. Every batch by sampling: spacing between leads
Cleaning	Thermal cycle: every batch
Coating	Thermal cycle, visual inspection: every batch by sampling
Marking	Visual inspection: every batch 100%
Polymerization	Thermal cycle: every batch
Cutting leads	Visual inspection lead length: every batch by sampling
Final control	Electrical: every batch 100%: V1mA; leakage current: sampling. Visual: every batch 100%, aspect, marking
Quality control	Every batch by sampling. AQL: V1mA, leakage current clamping voltage, visual inspection, dimensions, solderability
Packaging	Bulk: every batch pieces quantity. On tape: batch by sampling, visual inspection of taping
Packaging Quality Control	Every batch, taping dimensions, missing parts, taping defects, label check
Shipping consignment	
Outgoing shipping - Verification	Every batch, every shipment, packaging, documentation

PRODUCT QUALITY ASSURANCE

TPC has a Quality System that complies with the ISO & CECC quality requirements.

All products are tested and released by the quality department based on the compliance to established customer specifications. Critical raw materials are inspected for dimensional, electrical and physical properties prior to releasing to the production floor.

Routine checks are carried out at crucial processes. The finished products are submitted to Quality Control for inspection on electrical, dimensional, physical & visual conformance to relevant specifications, based on established AQLs.

The average outgoing quality level is < 10ppm on TPC varistors. The low ppm value is applicable for total functional failures, i.e. short circuit and open circuit.

RELIABILITY

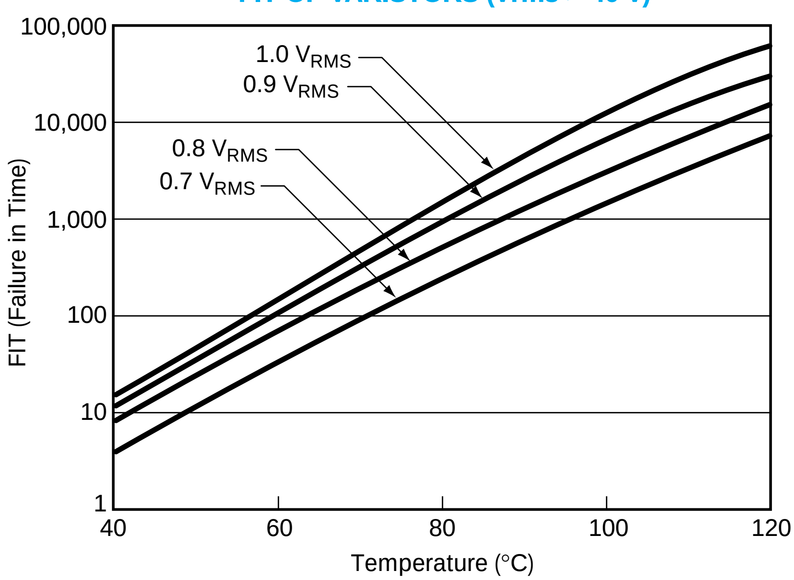
TPC varistors are subjected to reliability tests stated in page 37 (per CECC 42000).

Life test is conducted to determine the life time of varistors. The test conditions used are stated in page 00. The varistors are subjected to these conditions for a minimum period of 1000 hours.

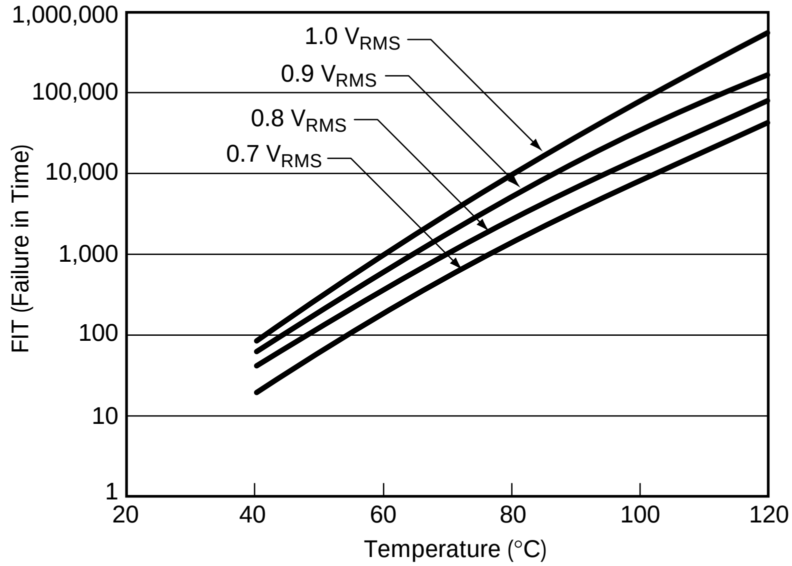
Failure in time (FIT) is computed for all tested parts based on Arrhenius equation. The definition of failure is a shift in the nominal voltage exceeding ± 10%. The FIT calculation is computed in units of 10^{-9}/h.

Figures below give the FIT for low and high voltage varistors. The FIT values at various stresses are extrapolated based on Arrhenius equation.

FIT OF VARISTORS (Vrms > 40 V)



FIT OF VARISTORS (Vrms </= 40 V)



Zinc Oxide Varistors

Reliability

Test Description	Test Condition	Test Requirement
SURGE CURRENT DERATING 8/20 MICRO SECONDS	CECC 42000, Test C 2.1 100 surge currents (8/20 µs), unipolar, interval 30 s, amplitude corresponding to derating curve for 20 µs.	• I Delta V/V (1 mA) I max 10% Measured in the direction of the surge current • No visible damage
SURGE CURRENT DERATING 10/1000 MICRO SECONDS	CECC 42000, Test C 2.1 100 surge currents (10/1000 µs), unipolar, interval 120 s, amplitude corresponding to derating curve for 1000 µs.	• I Delta V/V (1 mA) I max 10% Measured in the direction of the surge current • No visible damage
RESISTANCE TO SOLDERING HEAT	IEC 68-2-20, Test Tb Method 1A 260°C, 5 s	• I Delta V/V (1 mA) I max 5%
RAPID CHANGE IN TEMPERATURE	IEC 68-2-14, Test Na Ta = -40°C; Tb = +85°C Duration: 1 Hr/cycle Total: 5 cycles	• I Delta V/V (1 mA) I max 5% • No visible damage
SHOCK	IEC 68-2-27, Test Ea Pulse shape: half sine Acceleration: 490 m/s/s Pulse duration: 11 ms 3 x 6 shocks	• I Delta V/V (1 mA) I max 5% • No visible damage
VIBRATION	IEC 68-2-6, Test Fc Method B4 Freq. range: 10 Hz ... 55 Hz Amplitude: 0.75 mm or 98 m/s/s Duration: 6 h (3 x 2 h)	• I Delta V/V (1 mA) I max 5% • No visible damage
CLIMATIC SEQUENCE	CECC 42000, Test 4.16 a) Dry heat - Test Ba Temperature / Duration: 125°C / 2 h b) Damp heat cyclic 1st cycle - Test Db Temperature / Duration: 55°C / 24 h Humidity: 95-100% RH c) Cold - Test Aa Temperature / Duration: -40°C / 2 h d) Damp heat cyclic test remaining 5 humidity cycles - Test Db Duration: 24 h/cycle	• I Delta V/V (1 mA) I max 10% • Insulation Resistance min 1 Mohm
LIFE TEST	CECC 42000, Test 4.20 Applied voltage: max continuous a.c. Voltage, continuous application Temperature / Duration: 85°C / 1000 h	• I Delta V/V (1 mA) I max 10% • Insulation Resistance min 10 Mohm
DAMP HEAT, STEADY STATE	IEC 68-2-3 Temperature / Duration: 40°C / 56 days Humidity: 93%	• I Delta V/V (1 mA) I max 10% • Insulation Resistance min 1 Mohm
FLAMMABILITY - NEEDLE FLAME TEST	IEC 695-2-2 Vertical application: 10 s	• Burning max 10 s
TEMPERATURE COEFFICIENT OF VOLTAGE	Current: 1 mA Temperature: -40°C / +25°C / +85°C	• - (0.09%/K) max

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