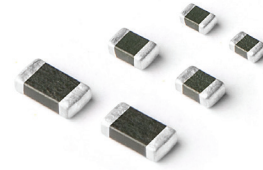


LOW CAPACITANCE & LOW ENERGY VARISTORS - ZVX SERIES

Description


The ZVX series are low-energy (0,1 J) varistor chips, designed specifically for the protection of I/O line drivers and other sensitive semiconductor gates from the damaging effects of high voltage, low energy transients such as ESD events. Unlike other competitive low-energy varistors, the ZVX series offers all the protecting features of standard varistor chips, and exceptionally low values of capacitance. In these applications, as the frequency of data transfer increases, lower capacitance is required to eliminate possible skewing of the data signals due to capacitive loading.

In most cases, the 1 KHz capacitance values of the ZVX series are less than one half of the competition. Furthermore, this series is offered in 0603, 0805 and 1206 sizes, with an extended range of voltages from 3V to 38 V_{dc}.



Features

- Operating voltage range V_{dc}.....3 V to 38 V.
- + 125 °C maximum continuous operating temperature
- 6 models sizes available... 0603, 0805, 1206.
- Exceptionally low capacitance ratings.
- Short response time.
- Inherent bi-directional clamping, low clamping voltages.
- Dimensional and weight savings on the board.
- Non-sensitive to mildly activated fluxes (see Soldering Recommendations, page 25).
- End termination: AgPd or barrier type suitable for Pb-free soldering process – barrier type and terminations solderable with Pb-free solders according to JEDEC J-STD-020C and IEC 60068-2-58.
- Non-plastic coating guaranties better flammability rating.

-  UL 1499, 3rd edition & CSA C22.2 File E326499 Section 8.
- RoHS 2 2011/65/EC, REACH, GADSL compliant.
- AEC-Q200 qualified Grade 1.

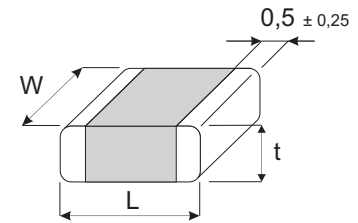
Applications

- Suppression of inductive switching or other transient events such as surge voltage at the circuit board level.
- Excellent for I/O line protection, operating at hi-speed data transfer rates, due to very low capacitance values.
- ESD protection for components sensitive to IEC 1000-4-2, MIL-STD 883C Method 3015.7, AEC-Q200-002 and other industry spec.
- Replace larger surface mount TVS Zeners in many applications.
- Used to achieve electromagnetic compliance of end products.
- Provides on-board transient voltage protection of ICs and transistors.

Absolute Maximum Ratings

	Units	Value
Continuous:		
Steady State Applied Voltage:		
DC Voltage Range (V _{dc})	V	3 to 38
AC Voltage Range (V _{rms})	V	2 to 30
Transient:		
Peak Single Pulse Surge Current, 8/20 μs Waveform (I _{max})	A	30 to 40
Single Pulse Surge Energy, 10/1000 μs Waveform (W _{max})	J	0,1
Operating Ambient Temperature	°C	-55 to +125
Storage Temperature Range	°C	-55 to +150
Threshold Voltage Temperature Coefficient	%/°C	< + 0,05
Response Time	ns	< 1
Climatic Category		55 / 125 / 56

Device Ratings and Characteristics



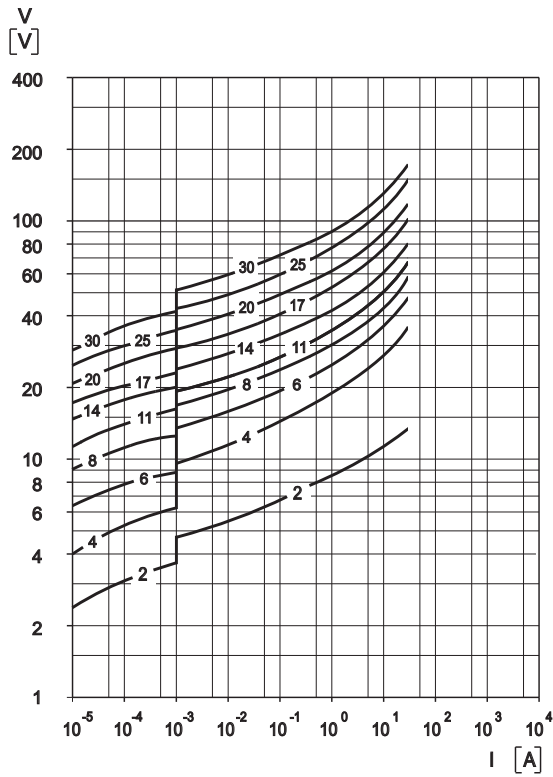
ZVX 2 S 0603 300....ZVX 30 S 1206 400

Type	V _{rms}	V _{dc}	V _n 1 mA	V _c	I _c 8/20 μs	W _{max} 10/1000 μs	P max	I _{max} 8/20 μs	C _{typ} @ 1 kHz	L _{typ} 100 mA/ns	L	W	t max
	V	V	V	V	A	J	W	A	pF	nH	mm	mm	mm
ZVX 2 S 0603 300	2	3,3	4,1 - 6,0	10	1	0,1	0,003	30	200	1,0	1,6 ± 0,20	0,80 ± 0,10	0,9
ZVX 2 S 0805 400	2	3,3	4,1 - 6,0	10	1	0,1	0,005	40	500	1,5	2,0 ± 0,25	1,25 ± 0,20	1,0
ZVX 2 S 1206 400	2	3,3	4,1 - 6,0	10	1	0,1	0,008	40	840	1,8	3,2 ± 0,30	1,60 ± 0,20	1,0
ZVX 4 S 0606 300	4	5,6	7,6 - 9,3	15,5	1	0,1	0,003	30	165	1,0	1,6 ± 0,20	0,80 ± 0,10	0,9
ZVX 4 S 0805 400	4	5,6	7,6 - 9,3	15,5	1	0,1	0,005	40	340	1,5	2,0 ± 0,25	1,25 ± 0,20	1,0
ZVX 4 S 1206 400	4	5,6	7,6 - 9,3	15,5	1	0,1	0,008	40	720	1,8	3,2 ± 0,30	1,60 ± 0,20	1,0
ZVX 6 S 0603 300	6	9	11,0 - 14,0	20	1	0,1	0,003	30	145	1,0	1,6 ± 0,20	0,80 ± 0,10	0,9
ZVX 6 S 0805 400	6	9	11,0 - 14,0	20	1	0,1	0,005	40	290	1,5	2,0 ± 0,25	1,25 ± 0,20	1,0
ZVX 6 S 1206 400	6	9	11,0 - 14,0	20	1	0,1	0,008	40	620	1,8	3,2 ± 0,30	1,60 ± 0,20	1,0
ZVX 8 S 0603 300	8	12	14,0 - 18,3	25	1	0,1	0,003	30	135	1,0	1,6 ± 0,20	0,80 ± 0,10	0,9
ZVX 8 S 0805 400	8	12	14,0 - 18,3	25	1	0,1	0,005	40	275	1,5	2,0 ± 0,25	1,25 ± 0,20	1,0
ZVX 8 S 1206 400	8	12	14,0 - 18,3	25	1	0,1	0,008	40	540	1,8	3,2 ± 0,30	1,60 ± 0,20	1,0
ZVX 11 S 0603 300	11	14	16,5 - 20,3	30	1	0,1	0,003	30	120	1,0	1,6 ± 0,20	0,80 ± 0,10	0,9
ZVX 11 S 0805 400	11	14	16,5 - 20,3	30	1	0,1	0,005	40	200	1,5	2,0 ± 0,25	1,25 ± 0,20	1,0
ZVX 11 S 1206 400	11	14	16,5 - 20,3	30	1	0,1	0,008	40	500	1,8	3,2 ± 0,30	1,60 ± 0,20	1,0
ZVX 14 S 0603 300	14	18	22,9 - 28,0	40	1	0,1	0,003	30	110	1,0	1,6 ± 0,20	0,80 ± 0,10	0,9
ZVX 14 S 0805 400	14	18	22,9 - 28,0	40	1	0,1	0,005	40	165	1,5	2,0 ± 0,25	1,25 ± 0,20	1,0
ZVX 14 S 1206 400	14	18	22,9 - 28,0	40	1	0,1	0,008	40	250	1,8	3,2 ± 0,30	1,60 ± 0,20	1,0
ZVX 17 S 0603 300	17	22	25,2 - 31,3	48	1	0,1	0,003	30	100	1,0	1,6 ± 0,20	0,80 ± 0,10	0,9
ZVX 17 S 0805 400	17	22	25,2 - 31,3	48	1	0,1	0,005	40	145	1,5	2,0 ± 0,25	1,25 ± 0,20	1,0
ZVX 17 S 1206 400	17	22	25,2 - 31,3	48	1	0,1	0,008	40	210	1,8	3,2 ± 0,30	1,60 ± 0,20	1,0
ZVX 20 S 0603 300	20	26	31,0 - 38,0	58	1	0,1	0,003	30	100	1,0	1,6 ± 0,20	0,80 ± 0,10	0,9
ZVX 20 S 0805 400	20	26	31,0 - 38,0	58	1	0,1	0,005	40	140	1,5	2,0 ± 0,25	1,25 ± 0,20	1,0
ZVX 20 S 1206 400	20	26	31,0 - 38,0	58	1	0,1	0,008	40	200	1,8	3,2 ± 0,30	1,60 ± 0,20	1,0
ZVX 25 S 0603 300	25	30	37,0 - 46,9	65	1	0,1	0,003	30	100	1,0	1,6 ± 0,20	0,80 ± 0,10	0,9
ZVX 25 S 0805 400	25	30	37,0 - 46,9	65	1	0,1	0,005	40	140	1,5	2,0 ± 0,25	1,25 ± 0,20	1,0
ZVX 25 S 1206 400	25	30	37,0 - 46,9	65	1	0,1	0,008	40	200	1,8	3,2 ± 0,30	1,60 ± 0,20	1,0
ZVX 30 S 0603 300	30	38	42,3 - 51,7	77	1	0,1	0,003	30	80	1,0	1,6 ± 0,20	0,80 ± 0,10	0,9
ZVX 30 S 0805 400	30	38	42,3 - 51,7	77	1	0,1	0,005	40	100	1,5	2,0 ± 0,25	1,25 ± 0,20	1,0
ZVX 30 S 1206 400	30	38	42,3 - 51,7	77	1	0,1	0,008	40	165	1,8	3,2 ± 0,30	1,60 ± 0,20	1,0

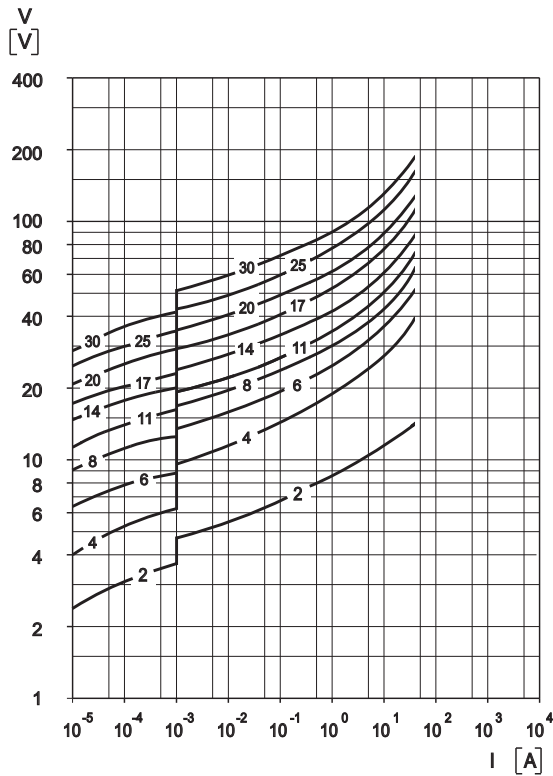
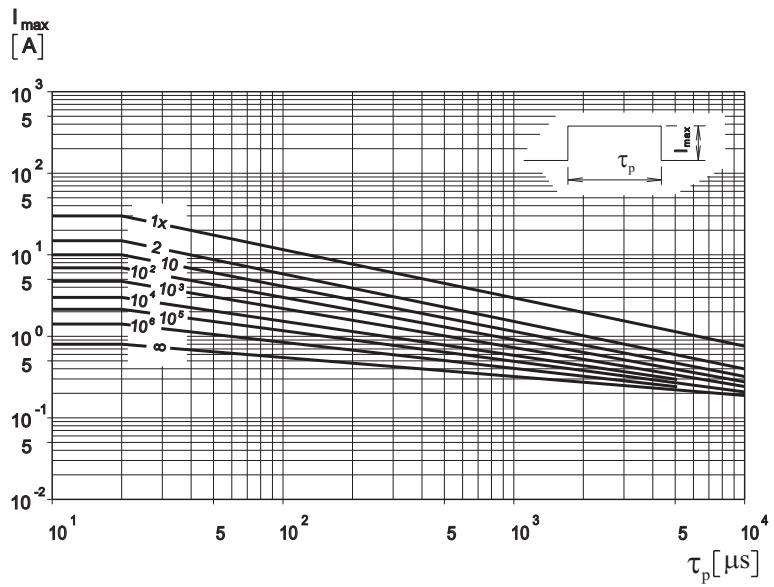
Protection Level

Pulse Rating Curves

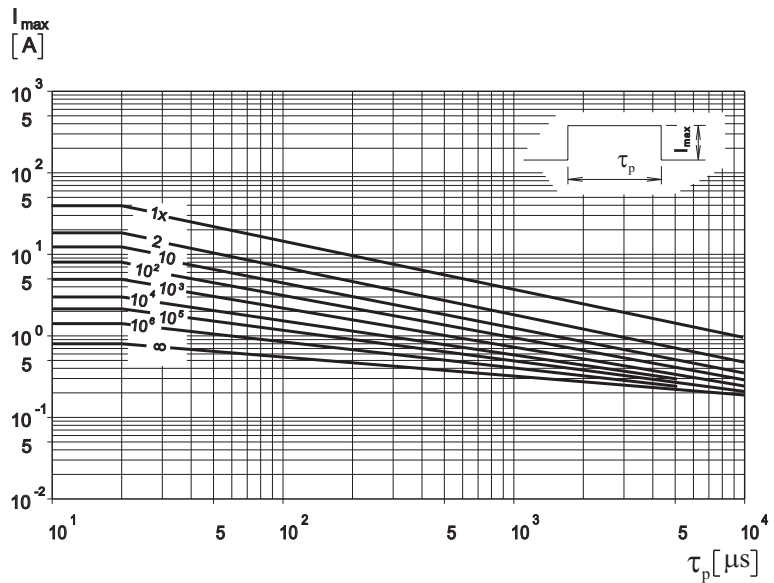
* With the worst-case condition in the tolerance region



Model Size 0603
ZVX 2 ... 30 S



Model Size 0805
ZVX 2 ... 30 S



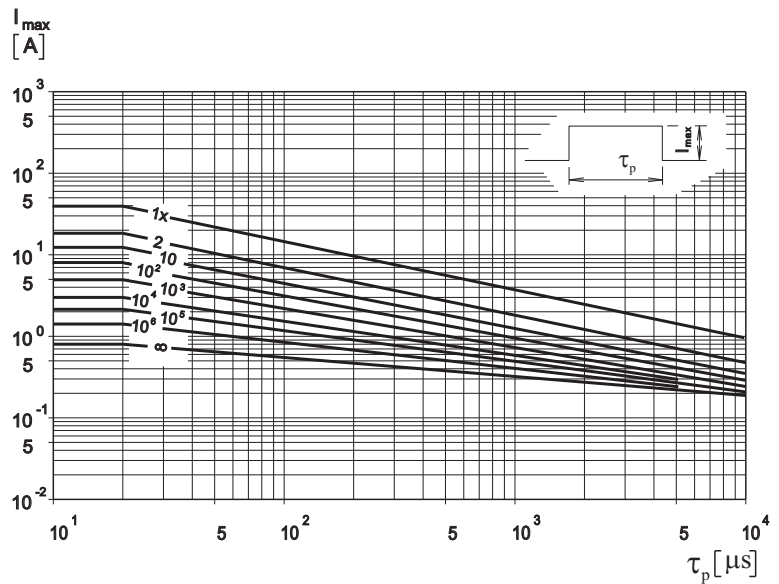
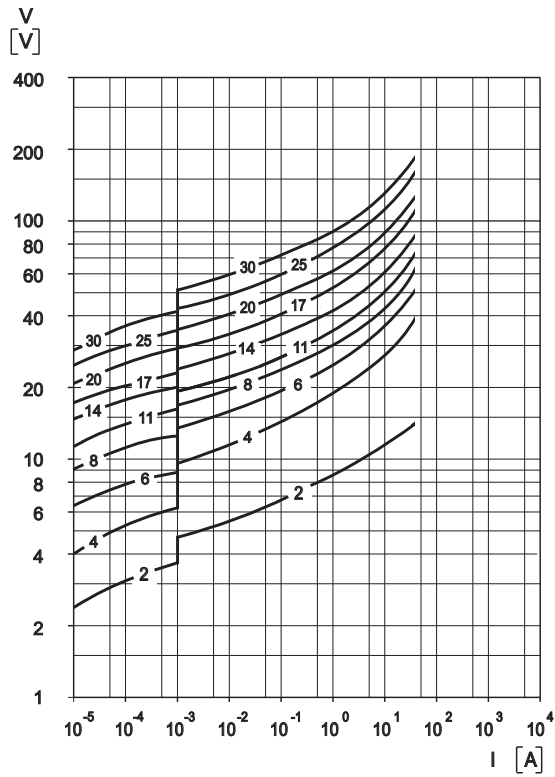
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Protection Level

Pulse Rating Curves

* With the worst-case condition in the tolerance region

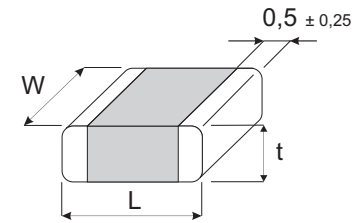
Model Size 1206
ZVX 2 ... 30 S



Device Ratings and Characteristics

Dimensions

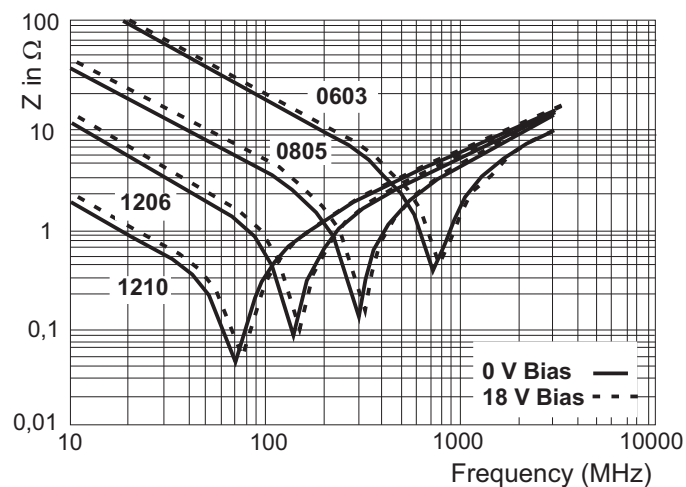
	L mm	W mm	t _{max} mm
ZVE 14 S 0603	1,6 ± 0,20	0,80 ± 0,10	0,95
ZVE 14 S 0805	2,0 ± 0,25	1,25 ± 0,20	0,95
ZVE 14 S 1206	3,2 ± 0,30	1,60 ± 0,20	1,20
ZVE 14 S 1210	3,2 ± 0,30	2,50 ± 0,25	1,30



ZVE 14 S 0603.....ZVE 14 S 1210

Type	V _{rms} V	V _{dc} V	V _n 1 mA V	V _c 8/20 μs V	I _c 8/20 μs A	W _{max} 10/1000 μs J	P max W	C _{max} 1 MHz pF	L _{typ} 100 mA/μs nH
ZVE 14 S 0603	14	18	22 - 28	50	2	0,05	0,003	75	< 1,0
ZVE 14 S 0805	14	18	22 - 28	50	2	0,10	0,004	100	< 1,5
ZVE 14 S 1206	14	18	22 - 28	50	2	0,10	0,004	200	< 1,8
ZVE 14 S 1210	14	18	22 - 28	50	2	0,10	0,004	400	< 3,5

Capacitance - Frequency Characteristics



Reliability – Lifetime

In general, **reliability** is the ability of a component to perform and maintain its functions in routine circumstances, as well as in hostile or unexpected circumstances.

The Mean life of ZVE/ZVX series components is a function of:

- Factor of Applied Voltage
- Ambient temperature.

Mean life is closely related to Failure rate (formula).

Mean life (ML) is the arithmetic mean (average) time to failure of a component.

Failure rate is the frequency with which an engineered system or component fails, expressed for example in failures per hour. Failure rate is usually time dependent, and an intuitive corollary is that the rate changes over time versus the expected life cycle of a system.

Failure rate formula – calculation

$$\Lambda = \frac{10^9}{ML [h]} \text{ [fit]}$$

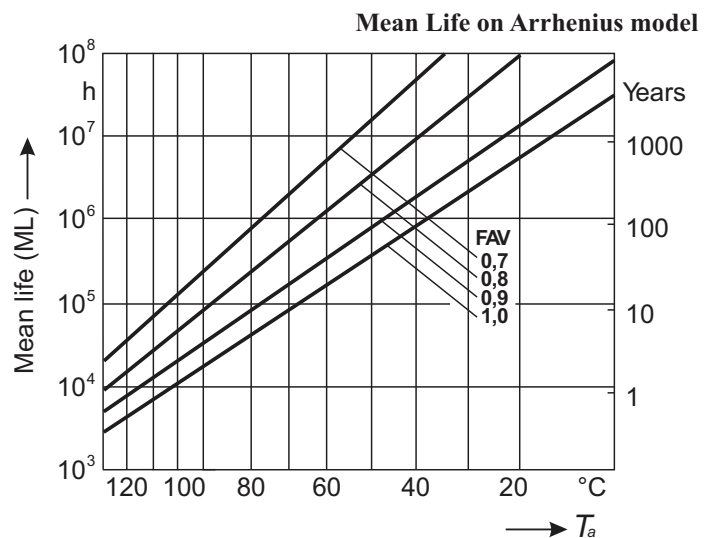
FAV – Factor of Applied Voltage

$$FAV = \frac{V_{apl}}{V_{max}}$$

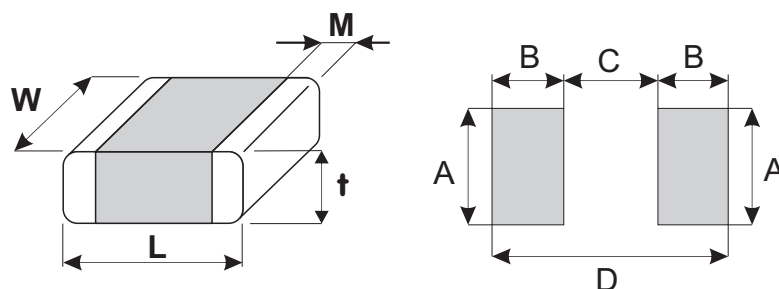
V_{apl} ... applied voltage

V_{max} ... maximum operating voltage

ZVE/ZVX 2 ... 40 Dimension 0603 ... 2220



Soldering Pad Configuration

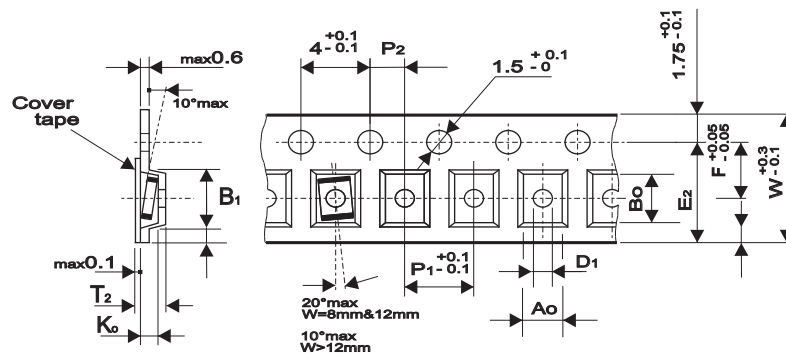


Size	L (mm)	W (mm)	M (mm)	t_{\max} (mm)	A (mm)	B (mm)	C (mm)	D (mm)
0603	1,6 ± 0,20	0,80 ± 0,10	0,5 ± 0,25	1,0	1,0	1,0	0,6	2,6
0805	2,0 ± 0,25	1,25 ± 0,20	0,5 ± 0,25	1,1	1,4	1,2	1,0	3,4
1206	3,2 ± 0,30	1,60 ± 0,20	0,5 ± 0,25	1,6	1,8	1,2	2,1	4,5
1210	3,2 ± 0,30	2,50 ± 0,25	0,5 ± 0,25	1,8	2,8	1,2	2,1	4,5
1812	4,7 ± 0,40	3,20 ± 0,30	0,5 ± 0,25	1,9	3,6	1,5	3,2	6,2
2220	5,7 ± 0,50	5,00 ± 0,40	0,5 ± 0,25	1,9	5,5	1,5	4,2	7,2
3225	8,0 ± 0,50	6,30 ± 0,40	0,5 ± 0,25	2,0	6,8	1,5	6,5	9,5

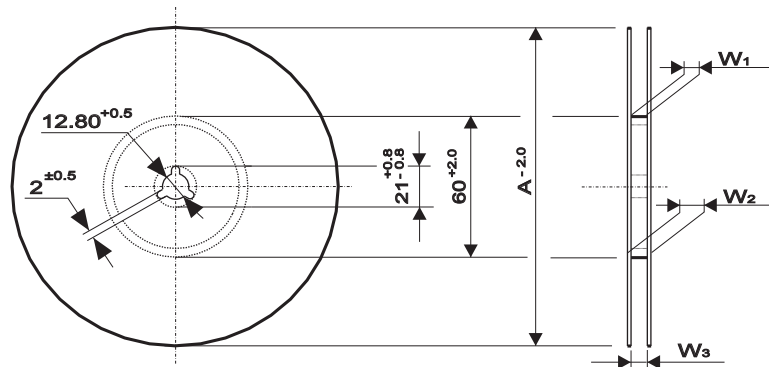
Tape and Reel Specification

Conforms to IEC Publication 286 - 3 Ed.4: 2007-06

Tape



Reel



Variable dimensions

Tape Size		8 mm				12 mm		16 mm	
Size	Units	0603	0805	1206	1210	1812	2220	3225	4032
Ao	(mm)	1,2	1,6	1,9	2,9	3,75	5,6	7	8,6
Bo	(mm)	1,9	2,4	3,75	3,7	5	6,25	8,7	10,8
Ko max	(mm)	1,1	1,1	1,8	2	2	2	3,7	3,7
B1 max	(mm)	4,35	4,35	4,35	4,35	8,2	8,2	12,1	12,1
D1 min	(mm)	0,3	0,3	0,3	0,3	1,5	1,5	1,5	1,5
E2 min	(mm)	6,25	6,25	6,25	6,25	10,25	10,25	14,25	14,25
P1	(mm)	4	4	4	4	8	8	12	12
F	(mm)	3,5	3,5	3,5	3,5	5,5	5,5	7,5	7,5
W	(mm)	8,0	8,0	8,0	8,0	12,0	12,0	16,0	16,0
T2 max	(mm)	3,5	3,5	3,5	3,5	6,5	6,5	9,5	9,5
W1	(mm)	8,4+1,5	8,4+1,5	8,4+1,5	8,4+1,5	12,4+2	12,4+2	16,4+2	16,4+2
W2 max	(mm)	14,4	14,4	14,4	14,4	18,4	18,4	22,4	22,4
W3	(mm)	7,9...10,9	7,9...10,9	7,9...10,9	7,9...10,9	11,9...15,4	11,9...15,4	15,9...19,4	15,9...19,4
A	(mm)	180/330	180/330	180/330	180/330	180/330	180/330	330	330

Package units

Series	Voltage range (V)	Chip Size													
		0603 Reel size		0805 Reel size		1206 Reel size		1210 Reel size		1812 Reel size		2220 Reel size		3225 Reel size	4032 Reel size
		180	330	180	330	180	330	180	330	180	330	180	330	330	330
ZVE	14	4000	15000	4000	15000	4000	15000	4000	15000						
ZV / ZVX	2 to 14	4000	15000	4000	15000	4000	15000	4000	15000	1500	6000	1500	5000		
	17	3500	14000	3500	14000	2500	14000	2500	14000	1500	6000	1500	5000		
	20 to 40	3500	14000	3500	14000	2500	10000	2500	9000	1000	4000	1000	4000		
AV	50 to 130					2000	8000	2000	8000	1000	4000	1000	4000		
	14			3500	15000	2500	15000	2500	15000	1000	6000	1000	4000	2500	2500
	17			3500	14000	2500	14000	2500	14000	1000	6000	1000	4000	2500	2500
	20 to 40				14000	2500	10000	2500	9000	1000	4000	1000	4000	2500	2500

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Ordering Information

AV 20 K 1210 401 N R1 yy

AV 20 K 1210 401 Ni R1 yy

- AV** - Series Name: AV, ZV, ZVE, ZVX
- 20** - Maximum Continuous Working Voltage - V_{rms}
- K** - V_n Tolerance: K = $\pm 10\%$, L = $\pm 15\%$, M = $\pm 20\%$
- 1210** - Chip Size: 0603, 0805, 1206, 1210, 1812, 2220, 3225
- 401** - Maximum Surge Current: 400 = 40 A; 401 = 400 A
- N** - Barrier type end terminations suitable for Pb-free reflow soldering
- (no letter) AgPd end terminations suitable for Pb reflow soldering
- Ni** - Ni Sn barrier type end terminations - suitable for Pb and Pb-Free reflow soldering
- R1** - Packaging: R1 = Reel 180 mm, R2 = Reel 330 mm, R3 = 180 mm-1000 pcs
- yy** - Special requirements

SOLDERING RECOMMENDATIONS

Popular soldering techniques used for surface mounted components are Wave and Infrared Reflow processes. Both processes can be performed with Pb-containing or Pb-free solders. The termination options available for these soldering techniques are AgPd and Barrier Type End Terminations.

End termination	Designation	Recommended and Suitable for	Component RoHS Compliant
Ag/Pd	Series (ZV, AV, DV, C, ...)..... R1	Pb-containing soldering	Yes
Barrier Type End Termination	Series (ZV, AV, DV, C, ...)..... N R1	Pb-containing and Pb-free soldering	Yes
Ni Sn End Termination	Series (ZV, AV, ...) ...Ni R1	Pb-containing and Pb-free soldering v	Yes

Wave Soldering – this process is generally associated with discrete components mounted on the underside of printed circuit boards, or for large top-side components with bottom-side mounting tabs to be attached, such as the frames of transformers, relays, connectors, etc. SMD varistors to be wave soldered are first glued to the circuit board, usually with an epoxy adhesive. When all components on the PCB have been positioned and an appropriate time is allowed for adhesive curing, the completed assembly is then placed on a conveyor and run through a single, double wave process.

Infrared Reflow Soldering – these reflow processes are typically associated with top-side component placement. This technique utilizes a mixture of adhesive and solder compounds (and sometimes fluxes) that are blended into a paste. The paste is then screened onto PCB soldering pads specifically designed to accept a particular sized SMD component. The recommended solder paste wet layer thickness is 100 to 300 μm . Once the circuit board is fully populated with MD components, it is placed in a reflow environment, where the paste is heated to slightly above its eutectic temperature. When the solder paste reflows, the SMD components are attached to the solder pads.

Solder Fluxes – solder fluxes are generally applied to populated circuit boards to lean oxides form forming during the heating process and to facilitate the flowing of the solder. Solder fluxes can be either a part of the solder paste compound or can be separate materials, usually fluids. Recommended fluxes are:

- non-activated (R) fluxes, whenever possible
- mildly activated (RMA) fluxes of class L3CN
- class ORLO

Activated (RA), water soluble or strong acidic fluxes with a chlorine content > 0.2 wt. % are NOT RECOMMENDED. The use of such fluxes could create high leakage current paths along the body of the varistor components.

When a flux is applied prior to wave soldering, it is important to completely dry any residual flux solvents prior to the soldering process.

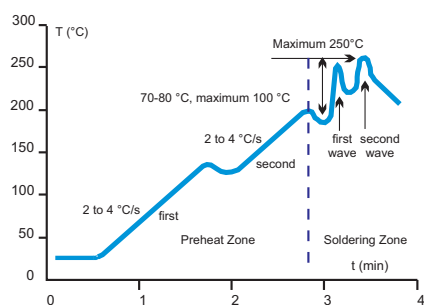


Fig. 1. Wave Soldering Temperature Profile for Pb-free and Pb-containing Soldering

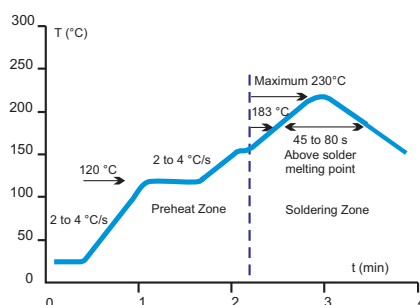


Fig. 2. Infrared Reflow Temperature Profile for Pb-containing Soldering

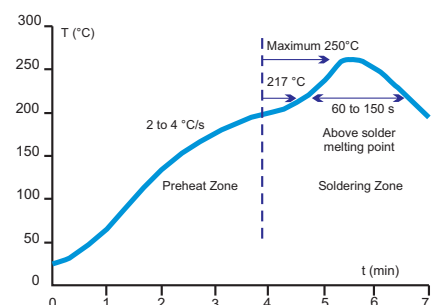


Fig. 3. Reflow Temperature Profile for Pb-free Soldering

Thermal Shock – to avoid the possibility of generating stresses in the varistor chip due to thermal shock, a preheat stage to within 100 °C of the peak soldering process temperature is recommended. Additionally, SMD varistors should not be subjected to a temperature gradient greater than 4 °C/sec., with an ideal gradient being 2 °C/sec. Peak temperatures should be controlled. Wave and Reflow soldering conditions for SMD varistors with Pb-containing solders are shown in Fig. 1 and 2 respectively, while Wave and Reflow soldering conditions for SMD varistors with Pb-free solders are shown in Fig. 1 and 3.

Whenever several different types of SMD components are being soldered, each having a specific soldering profile, the soldering profile with the least heat and the minimum amount of heating time is recommended. Once soldering has been completed, it is necessary to minimize the possibility of thermal shock by allowing the hot PCB to cool to less than 50 °C before cleaning.

Inspection Criteria – the inspection criteria to determine acceptable solder joints, when Wave or Infrared Reflow processes are used, will depend on several key variables, principally termination material process profiles.

Pb-containing Wave and IR Reflow Soldering – typical “before” and “after” soldering results for Silver/Palladium (AgPd) and Barrier Type End Terminations can be seen in Fig. 4. Both barrier type and silver/palladium terminated varistors form a reliable electrical contact and metallurgical bond between the end terminations and the solder pads. The bond between these two metallic surfaces is exceptionally strong and has been tested by both vertical pull and lateral (horizontal) push tests. The results, in both cases, exceed established industry standards for adhesion.

The solder joint appearance of a barrier type terminated versus a silver/palladium terminated varistor will be slightly different. Solder forms a metallurgical junction with the thin tin-alloy (over the barrier layer), and due to its small volume “climbs” the outer surface of the terminations, the meniscus will be slightly lower. This optical appearance difference should be taken into consideration when programming visual inspection of the PCB after soldering.

Silver Palladium (AgPd) End Terminations

Barrier Type End Terminations and Ni Sn End Terminations

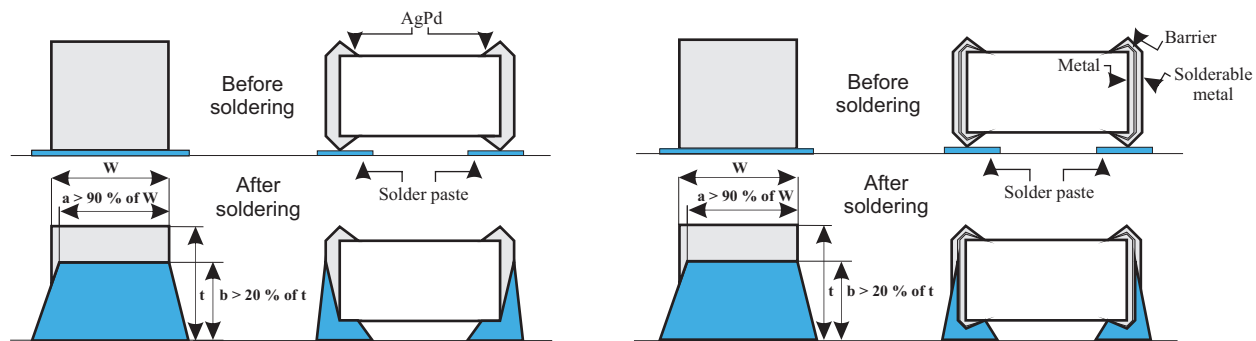


Fig. 4 Soldering Criterion in case of Wave and IR Reflow Pb-containing Soldering

Silver Palladium (AgPd) End Terminations

Barrier Type End Terminations and Ni Sn End Terminations

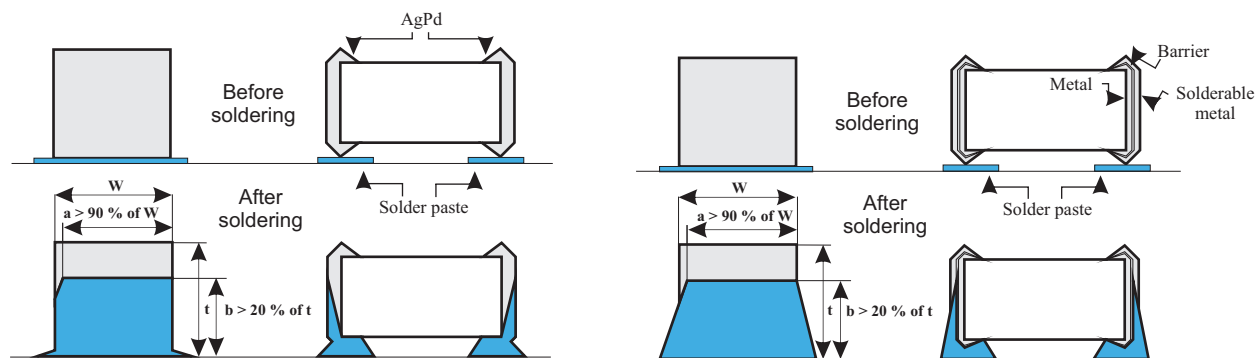


Fig. 5 Soldering Criterion in case of Wave and IR Reflow Pb-free Soldering

Pb-free Wave and IR Reflow Soldering – typical “before” and “after” soldering results for Silver/Palladium (AgPd) and Barrier Type End Terminations are given in A phenomenon known as “mirror” or “negative” meniscus results will appear in the case of Silver/Palladium terminated varistors. Solder forms a metallurgical junction with the entire volume of the end termination, i.e. it diffuses from pad to end termination across the inner side, forming a “mirror” or “negative meniscus. The height of the solder penetration can be clearly seen on the end termination and is always 30% higher than the chip height.

Since barrier type terminations on KEKO-VARICON chips do not require the use of problematic nickel and tin-alloy electroplating processes, these varistors are truly considered environmentally friendly.

Solder Test and Retained Samples – reflow soldering test based on J-STD-020D.1 and soldering test by dipping based on IEC 60068-2 for Pb-free solders are performed on each production lot as shown in the following chart. Test results and accompanying samples are retained for a minimum of two (2) years. The solderability of a specific lot can be checked at any time within this period should a customer require this information.

Test	Resistance to flux	Solderability	Static leaching (simulation of Reflow Soldering)	Dynamic leaching (simulation of Wave Soldering)
Parameter				
Soldering method	dipping	dipping	dipping	dipping with agitation
Flux	L3CN, ORLO	L3CN, ORLO, R	L3CN, ORLO, R	L3CN, ORLO, R
Pb Solder	62Sn / 36Pb / 2 Ag			
Pb Soldering temperature (°C)	235 ± 5	235 ± 5	260 ± 5	235 ± 5
Pb-FREE Solder	Sn96 / Cu0,4-0,8 / 3-4Ag			
Pb-FREE Soldering temperature (°C)	250 ± 5	250 ± 5	280 ± 5	250 ± 5
Soldering time (s)	2	210	10	> 15
Burn-in conditions	V _{dcmax} , 48 h	-	-	-
Acceptance criterion	dVn < 5 %, i _{dc} must stay unchanged	> 95 % of end termination must be covered by solder	> 95 % of end termination must be intact and covered by solder	> 95 % of end termination must be intact and covered by solder

Rework Criteria Soldering Iron – unless absolutely necessary, the use of soldering irons is NOT recommended for reworking varistor chips. If no other means of rework is available, the following criteria must be strictly followed:

- Do not allow the tip of the iron to directly contact the top of the chip
- Do not exceed the following soldering iron specifications:
 - Output Power: 30 Watts maximum
 - Temperature of Soldering Iron Tip: 280 °C maximum
 - Soldering Time: 10 Seconds maximum

Storage Conditions – SMD varistors should be used within 1 year of purchase to avoid possible soldering problems caused by oxidized terminals. The storage environment should be controlled, with humidity less than 40% and temperature between -25 and 45 °C. Varistor chips should always be stored in their original packaged unit.

Where varistor chips have been in storage for more than 1 year, and where there is evidence of solderability difficulties, KEKO-VARICON can “refresh” the terminations to eliminate these problems.

Reliability Testing Procedures

Varistor testing procedures comply with CECC 42200, IEC 1051-1/2 and AEC-Q200.

Testing results are available upon customer request. Special tests can be performed upon customer request.

Reliability Parameter	Test	Tested according to	Condition to be satisfied after testing
AC/DC Bias Reliability	AC/DC Life Test	CECC 42200, Test 4.20 or IEC 1051-1, Test 4.20., AEC-Q200 Test8 - 1000 h at UCT	$ \delta_{Vn} (1 \text{ mA}) < 10 \%$
Pulse Current Capability	$I_{\text{max}} 8/20 \mu\text{s}$	CECC 42200, Test C 2.1 or IEC 1051-1, Test 4.5. 10 pulses in the same direction at 2 pulses per minute at maximum peak current for 10 pulses	$ \delta_{Vn} (1 \text{ mA}) < 10 \%$ no visible damage
Pulse Energy Capability	$W_{\text{max}} 10/1000 \mu\text{s}$	CECC 42200, Test C 2.1 or IEC 1051-1, Test 4.5. 10 pulses in the same direction at 1 pulse every 2 minutes at maximum peak current for 10 pulses	$ \delta_{Vn} (1 \text{ mA}) < 10 \%$ no visible damage
WLD Capability	WLD x 10	ISO 7637, Test pulse 5, 10 pulses at rate 1 per minute	$ \delta_{Vn} (1 \text{ mA}) < 15 \%$ no visible damage
V_{jump} Capability	$V_{\text{jump}} 5 \text{ min}$	Increase of supply voltage to $V \geq V_{\text{jump}}$ for 1 minute	$ \delta_{Vn} (1 \text{ mA}) < 15 \%$ no visible damage
Environmental and Storage Reliability	Climatic Sequence	CECC 42200, Test 4.16 or IEC 1051-1, Test 4.17. a) Dry heat, 16h, UCT, Test Ba, IEC 68-2-2 b) Damp heat, cyclic, the first cycle: 55 °C, 93 % RH, 24 h, Test Db 68-2-4 c) Cold, LCT, 2 h, Test Aa, IEC 68-2-1 d) Damp heat cyclic, remaining 5 cycles: 55 °C, 93 % RH, 24 h/cycle, Test Bd, IEC 68-2-30	$ \delta_{Vn} (1 \text{ mA}) < 10 \%$
	Thermal Shock	CECC 42200, Test 4.12, Test Na, IEC 68-2-14, AEC-Q200 Test16, 5 cycles UCT/LCT, 30 minutes	$ \delta_{Vn} (1 \text{ mA}) < 10 \%$ no visible damage
	Steady State Damp Heat	CECC 42200, Test 4.17, Test Ca, IEC 68-2-3, AEC-Q200 Test 6, 56 days, 40 °C, 93% RH. AEC-Q200 Test7: Bias, Rh, T all at 85.	$ \delta_{Vn} (1 \text{ mA}) < 10 \%$
	Storage Test	IEC 68-2-2, Test Ba, AEC-Q200 Test 3, 1000 h at maximum storage temperature	$ \delta_{Vn} (1 \text{ mA}) < 5 \%$
Mechanical Reliability	Solderability	CECC 42200, Test 4.10.1, Test Ta, IEC 68-2-20 solder bath and reflow method	Solderable at shipment and after 2 year of storage, criteria > 95% must be covered by solder for reflow meniscus
	Resistance to Soldering Heat	CECC 42200, Test 4.10.2, Test Tb, IEC 68-2-20 solder bath nad reflow method	$ \delta_{Vn} (1 \text{ mA}) < 5 \%$
	Terminal Strength	JIS-C-6429, App. 1, 18N for 60 s - same for AEC-Q200 Test 22	no visual damage
	Board Flex	JIS-C-6429, App. 2, 2 mm min. AEC-Q200 test 21 - Board flex: 2 mm flex min.	$ \delta_{Vn} (1 \text{ mA}) < 2 \%$ no visible damage
	Vibration	CECC 42200, Test 4.15, Test Fc, IEC 68-2-6, AEC-Q200 Test 14. Frequency range 10 to 55 Hz (AEC: 10-2000Hz) Amplitude 0.75 m/s ² or 98 m/s ² (AEC: 5 g's for 20 minutes) Total duration 6 h (3x2h) (AEC: 12 cycles each of 3 directions) Waveshape - half sine	$ \delta_{Vn} (1 \text{ mA}) < 10 \%$ no visible damage
Mechanical Shock	CECC 42200, Test 4.14, Test Ea, IEC 68-2-27, AEC-Q200 Test 13. Acceleration = 490 m/s ² (AEC: MIL-STD-202-Method 213), Pulse duration = 11 ms, Waveshape - half sine; Number of shocks = 3x6	$ \delta_{Vn} (1 \text{ mA}) < 10 \%$ no visible damage	
Electrical Transient Conduction	ISO-7637-1 Pulses	AEC-Q200 Test 30: Test pulses 1 to 3. Also other pulses - freestyle.	$ \delta_{Vn} (1 \text{ mA}) < 10 \%$ no visible damage

Terminology

Term	Symbol	Definition
Rated AC Voltage	V_{rms}	Maximum continuous sinusoidal AC voltage (<5% total harmonic distortion) which may be applied to the component under continuous operation conditions at 25 °C
Rated DC Voltage	V_{dc}	Maximum continuous DC voltage (<5% ripple) which may be applied to the component under continuous operating conditions at 25 °C
Supply Voltage	V	The voltage by which the system is designated and to which certain operating characteristics of the system are referred; $V_{rms} = 1,1 \times V$
Leakage Current	I_{dc}	The current passing through the varistor at V_{dc} and at 25 °C or at any other specified temperature
Varistor Voltage	V_n	Voltage across the varistor measured at a given reference current I_n
Reference Current	I_n	Reference current = 1 mA DC
Clamping Voltage Protection Level	V_c	The peak voltage developed across the varistor under standard atmospheric conditions, when passing an 8/20 μ s class current pulse
Class Current	I_c	A peak value of current which is 1/10 of the maximum peak current for 100 pulses at two per minute for the 8/20 μ s pulse
Voltage Clamping Ratio	V_c/V_{app}	A figure of merit measure of the varistor clamping effectiveness as defined by the symbols V_c/V_{app} , where ($V_{app} = V_{rms}$ or V_{dc})
Jump Start Transient	V_{jump}	The jump start transient results from the temporary application of an overvoltage in excess of the rated battery voltage. The circuit power supply may be subjected to a temporary overvoltage condition due to the voltage regulation failing or it may be deliberately generated when it becomes necessary to boost start the car.
Rated Single Pulse Transient Energy	W_{max}	Energy which may be dissipated for a single 10/1000 μ s pulse of a maximum rated current, with rated AC voltage or rated DC voltage also applied, without causing device failure
Load Dump Transient	WLD	Load Dump is a transient which occurs in automotive environment. It is an exponentially decaying positive voltage which occurs in the event of a battery disconnect while the alternator is still generating charging current with other loads remaining on the alternator circuit at the time of battery disconnect.
Rated Peak Single Pulse Transient Current	I_{max}	Maximum peak current which may be applied for a single 8/20 μ s pulse, with, rated line voltage also applies, without causing device failure
Rated Transient Average Power Dissipation	P	Maximum average power which may be dissipated due to a group of pulses occurring within a specified isolated time period, without causing device failure at 25 °C
Capacitance	C	Capacitance between two terminals of the varistor measured at @ 1 kHz
Non-linearity Exponent	α	A measure of varistor nonlinearity between two given operating currents, I_n and I_1 , as described by $I = k V \exp(a)$, where: - k is a device constant, - $I_1 < I < I_n$ and - $a = 0 \log(I_1/I_n) / \log(V_1/V_n) = 1 / \log(V_1/V_n)$, where: - I_n is reference current (1 mA) and V_n is varistor voltage - $I_1 = 10 I_n$, V_1 is the voltage measured at I_1
Response Time	t_r	The time lag between application of a surge and varistor's "turn-on" conduction action
Varistor Voltage Temperature Coefficient	TC	$(V_n \text{ at } 85 \text{ °C} - V_n \text{ at } 25 \text{ °C}) / (V_n \text{ at } 25 \text{ °C}) \times 60 \text{ °C} \times 100$
Insulation Resistance	IR	Minimum resistance between shorted terminals and varistor surface
Isolation Voltage		The maximum peak voltage which may be applied under continuous operating conditions between the varistor terminations and any conducting mounting surface
Operating Temperature		the range of ambient temperature for which the varistor is designed to operate continuously as defined by the temperature limits of its climatic category
Climatic Category	LCT/UCT/DHD	UCT = Upper Category Temperature - the maximum ambient temperature for which a varistor has been designed to operate continuously, LCT = Lower Category Temperature - the minimum ambient temperature at which a varistor has been designed to operate continuously DHD = Dump Heat Test Duration
Storage Temperature		Storage temperature range without voltage applied
Current/Energy Derating		Derating of maximum values when operated above UCT (85 °C for PV and 125 °C for DV)

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