CTVS –
Ceramic transient voltage suppressors

SMD multilayer varistors (MLVs),
automotive G series

Series/Type:

Date: December 2019

EPCOS type designation system for automotive G series, single chips

CT	1210	S	14	B	AUTO	G2	_G

Construction:
CT ≙ Single chip with nickel barrier termination (AgNiSn)

EAI case sizes:
0402
0603
0805
1206
1210
1812
2220

Varistor voltage tolerance:
K ≙ ±10%, standard
L ≙ ±10%, standard
S ≙ Special tolerance

Maximum RMS operating voltage (V_{RMS}):
14 ≙ 14 V
V_{RMS} < 25 V are suitable for 12 V DC supply systems
V_{RMS} ≥ 25 V are suitable for 24 V DC supply systems

Special tolerance for the varistor voltage:
– ≙ Standard tolerance
A or B ≙ Special tolerance

– ≙ Standard series
AUTO ≙ specified for load-dump/ jump-start protection

Taping mode:
G ≙ Taped, 180-mm reel, 7"
G2 ≙ Taped, 330-mm reel, 13"

_G ≙ Automotive G series

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Features

- Reliable ESD protection up to 30 kV acc. to IEC 61000-4-2, level 4 (8 kV contact, 15 kV air)
- High energy absorption capability
- Low leakage current
- Long-term ESD stability
- Bidirectional protection
- No temperature derating up to 150 °C
- RoHS-compatible, lead-free
- Nickel barrier suitable for lead-free soldering
- Qualification based on AEC-Q200
- PSpice simulation models available

Applications

- Transient overvoltage protection in automotive applications: battery lines, body control units, ABS/ESP, EPS, DC motors

Design

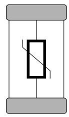
- Multilayer technology
- Lead-free glass coating
- Flammability rating better than UL 94 V-0
- Termination (see “Soldering directions”):
  - CT types with nickel barrier terminations (AgNiSn), recommended for lead-free reflow and wave soldering, and compatible with tin/lead solder.

V/I characteristics and derating curves

V/I and derating curves are attached to the data sheet. The curves are sorted by V_{RMS} and then by case size, which is included in the type designation.

Single chip

Internal circuit



MLV0006-H

Available case sizes:

EIA	Metric
0603	1608
0805	2012
1206	3216
1210	3225
2220	5750

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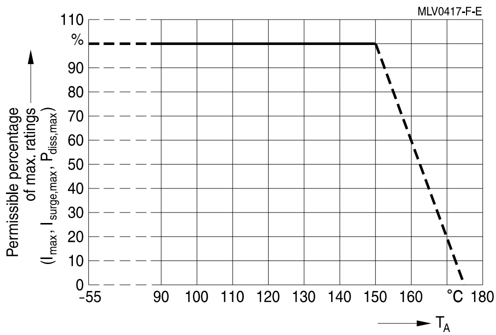
General technical data

Maximum RMS operating voltage		$V_{RMS,max}$	14 ... 40	V
Maximum DC operating voltage		$V_{DC,max}$	16 ... 56	V
Maximum surge current	(8/20 µs)	$I_{surge,max}$	30 ... 1200	A
Maximum load dump energy	(10 pulses)	W_{LD}	1 ... 12	J
Maximum jump-start voltage	(5 min)	V_{jump}	24.5 ... 45	V
Maximum clamping voltage		$V_{clamp,max}$	38 ... 110	V
Operating temperature		T_{op}	−55/+150	°C
Storage temperature		LCT/UCT	−55/+150	°C
Response time		t_{resp}	< 0.5	ns

Temperature derating

Climatic category: −55/+150 °C
for all single chips



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Electrical specifications and ordering codes
Maximum ratings ($T_{op,max}$)
Automotive standard series[1)]

Type	Ordering code	$V_{RMS,max}$ V	$V_{DC,max}$ V	W_{max} (2 ms) mJ	$P_{diss,max}$ mW	V_V (1 mA) V	ΔV_V %
CT0603K14G_G	B72500G0140K060	14	18	200	3	22	±10
CT1206K14G_G	B72520G0140K062	14	18	500	8	22	±10
CT1210K14G_G	B72530G0140K062	14	18	1500	10	22	±10
CT1206K17G_G	B72520G0170K062	17	22	600	8	27	±10
CT1210K17G_G	B72530G0170K062	17	22	1700	10	27	±10
CT1206K20G_G	B72520G0200K062	20	26	700	8	33	±10
CT1210K20G_G	B72530G0200K062	20	26	1900	10	33	±10
CT0603K25G_G	B72500G0250K060	25	31	300	3	39	±10
CT0805K25G_G	B72510G0250K062	25	31	300	5	39	±10
CT1206K25G_G	B72520G0250K062	25	31	1000	8	39	±10
CT1210K25G_G	B72530G0250K062	25	31	1700	10	39	±10
CT0805K30G_G	B72510G0300K062	30	38	300	5	47	±10
CT1206K30G_G	B72520G0300K062	30	38	1100	8	47	±10
CT1210K30G_G	B72530G0300K062	30	38	2000	10	47	±10
CT2220K30G_G	B72540G0300K062	30	38	12000	20	47	±10
CT1206K35G_G	B72520G0350K062	35	45	400	8	56	±10
CT1210K35G_G	B72530G0350K062	35	45	2000	10	56	±10
CT1206K40G_G	B72520G0400K062	40	56	500	8	68	±10

1) W_{LD} and V_{jump} values are not specified for automotive standard series.

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Characteristics (T_A = 25 °C)

Type	$V_{clamp,max}$ V	$I_{surge,max}$ (8/20 µs) A	I_{clamp} (8/20 µs) A	C_{max} 2) pF	$I_{leak,max}$ µA
CT0603K14G_G	40	30	1	220	20@18 V
CT1206K14G_G	38	200	1	1500	70@18 V
CT1210K14G_G	38	400	2.5	3000	70@18 V
CT1206K17G_G	44	200	1	1500	70@22 V
CT1210K17G_G	44	400	2.5	2200	50@22 V
CT1206K20G_G	54	200	1	1500	10@26 V
CT1210K20G_G	54	400	2.5	2200	20@26 V
CT0603K25G_G	67	30	1	100	10@31 V
CT0805K25G_G	67	80	1	330	25@31 V
CT1206K25G_G	65	200	1	1200	10@31 V
CT1210K25G_G	65	300	2.5	2200	25@31 V
CT0805K30G_G	77	80	1	270	40@38 V
CT1206K30G_G	77	200	1	1000	25@38 V
CT1210K30G_G	77	300	2.5	1500	20@38 V
CT2220K30G_G	77	1200	10	6000	50@38 V
CT1206K35G_G	90	100	1	820	20@45 V
CT1210K35G_G	90	250	2.5	1000	20@45 V
CT1206K40G_G	110	100	1	470	20@56 V

2) Measurement frequency: f = 1 MHz for C < 100 pF, f = 1 KHz for C ≥ 100 pF

Electrical specifications and ordering codes

Maximum ratings ($T_{op,max}$)

Automotive series with load-dump/ jump-start protection[1)]

Type	Ordering code	$V_{RMS,max}$ V	$V_{DC,max}$ V	$I_{surge,max}$ (8/20 µs) A	W_{max} (2 ms) mJ	W_{LD} (10 pulses) J	$P_{diss,max}$ mW
CT1206S14BAUTOG_G	B72520G1140S262	14	16	200	600	1.5	8
CT1210S14BAUTOG_G	B72530G1140S262	14	16	400	1600	3	10
CT1210K17AUTOG_G	B72530G1170K062	17	22	400	1700	3	10
CT1206K20AUTOG_G	B72520G1200K062	20	26	200	700	1.5	8
CT1210K20AUTOG_G	B72530G1200K062	20	26	400	1900	3	10
CT0805K25AUTOG_G	B72510G1250K062	25	31	80	300	1	5
CT1206K25AUTOG_G	B72520G1250K062	25	31	200	1000	1.5	8
CT1210K25AUTOG_G	B72530G1250K062	25	31	300	1700	3	10
CT2220K30AUTOG_G	B72540G1300K062	30	34	1200	12000	12	30

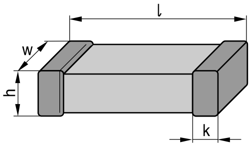
Characteristics (T_A = 25 °C)

Type	V_V (1 mA) V	ΔV_V %	V_{jump} (5 min) V	$V_{clamp,max}$ V	I_{clamp} (8/20 µs) A	C_{max} (1 kHz) pF	$I_{leak,max}$ µA
CT1206S14BAUTOG_G	24.5	±15	24.5	40	1	1500	5@16 V
CT1210S14BAUTOG_G	24.5	±15	24.5	40	2.5	3000	5@16 V
CT1210K17AUTOG_G	27	±10	26.5	44	2.5	2200	50@22 V
CT1206K20AUTOG_G	33	±10	27	54	1	1500	10@26 V
CT1210K20AUTOG_G	33	±10	27	54	2.5	2200	20@26 V
CT0805K25AUTOG_G	39	±10	29	67	1	330	25@22 V
CT1206K25AUTOG_G	39	±10	29	65	1	1200	10@31 V
CT1210K25AUTOG_G	39	±10	29	65	2.5	2200	25@31 V
CT2220K30AUTOG_G	47	±10	45	77	10	6000	20@34 V

1) C_{min} and C_{max} values are not specified for standard automotive series with load dump/ jump start specification.

Dimensional drawings

Single chip



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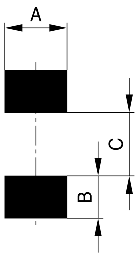
Case size EIA / mm	l	w	h	k
0402 / 1005	1.0 ±0.15	0.50 ±0.10	0.6 max.	0.10 ... 0.30
0603 / 1608	1.6 ±0.15	0.80 ±0.10	0.9 max.	0.10 ... 0.40
0805 / 2012	2.0 ±0.20	1.25 ±0.15	1.4 max.	0.13 ... 0.75
1206 / 3216	3.2 ±0.30	1.60 ±0.20	1.7 max.	0.25 ... 0.75
1210 / 3225	3.2 ±0.30	2.50 ±0.25	1.7 max.	0.25 ... 0.75
1812 / 4532	4.5 ±0.40	3.20 ±0.30	2.5 max.	0.25 ... 1.00
2220 / 5750	5.7 ±0.40	5.00 ±0.40	2.5 max.	0.25 ... 1.00

Recommended solder pad layout

Single chip



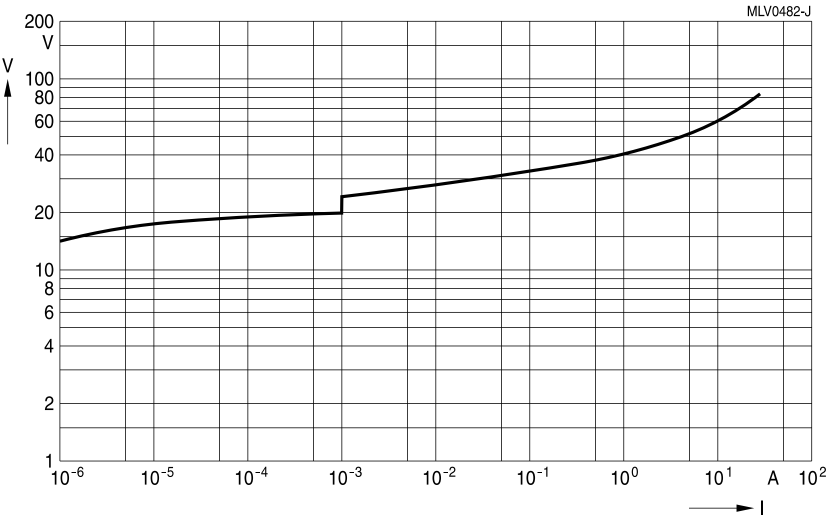
Dimensions in mm

Case size EIA / mm	A	B	C
0402 / 1005	0.60	0.60	0.50
0603 / 1608	1.00	1.00	1.00
0805 / 2012	1.40	1.20	1.00
1206 / 3216	1.80	1.20	2.10
1210 / 3225	2.80	1.20	2.10
1812 / 4532	3.60	1.50	3.00
2220 / 5750	5.50	1.50	4.20

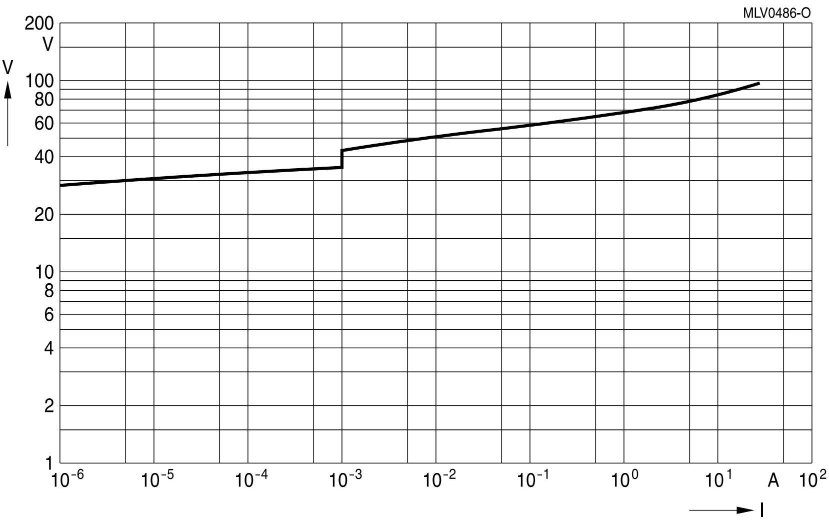
Delivery mode

EIA case size	Taping	Reel size mm	Packing unit pcs.	Type	Ordering code
Single chip					
0603	Cardboard	180	4000	CT0603K14G_G	B72500G0140K060
0603	Cardboard	180	4000	CT0603K25G_G	B72500G0250K060
0805	Blister	180	3000	CT0805K25AUTOG_G	B72510G1250K062
0805	Blister	180	3000	CT0805K25G_G	B72510G0250K062
0805	Blister	180	3000	CT0805K30G_G	B72510G0300K062
1206	Blister	180	2000	CT1206K25AUTOG_G	B72520G1250K062
1206	Blister	180	2000	CT1206K25G_G	B72520G0250K062
1206	Blister	180	2000	CT1206K30G_G	B72520G0300K062
1206	Blister	180	2000	CT1206K35G_G	B72520G0350K062
1206	Blister	180	2000	CT1206K40G_G	B72520G0400K062
1206	Blister	180	3000	CT1206K14G_G	B72520G0140K062
1206	Blister	180	3000	CT1206K17G_G	B72520G0170K062
1206	Blister	180	3000	CT1206K20AUTOG_G	B72520G1200K062
1206	Blister	180	3000	CT1206K20G_G	B72520G0200K062
1206	Blister	180	3000	CT1206S14BAUTOG_G	B72520G1140S262
1210	Blister	180	2000	CT1210K20AUTOG_G	B72530G1200K062
1210	Blister	180	2000	CT1210K20G_G	B72530G0200K062
1210	Blister	180	2000	CT1210K25AUTOG_G	B72530G1250K062
1210	Blister	180	2000	CT1210K25G_G	B72530G0250K062
1210	Blister	180	2000	CT1210K30G_G	B72530G0300K062
1210	Blister	180	2000	CT1210K35G_G	B72530G0350K062
1210	Blister	180	3000	CT1210K14G_G	B72530G0140K062
1210	Blister	180	3000	CT1210K17AUTOG_G	B72530G1170K062
1210	Blister	180	3000	CT1210K17G_G	B72530G0170K062
1210	Blister	180	3000	CT1210S14BAUTOG_G	B72530G1140S262
2220	Blister	180	1000	CT2220K30AUTOG_G	B72540G1300K062
2220	Blister	180	1000	CT2220K30G_G	B72540G0300K062

V/I characteristics for automotive standard series



CT0603K14G_G



CT0603K25G_G

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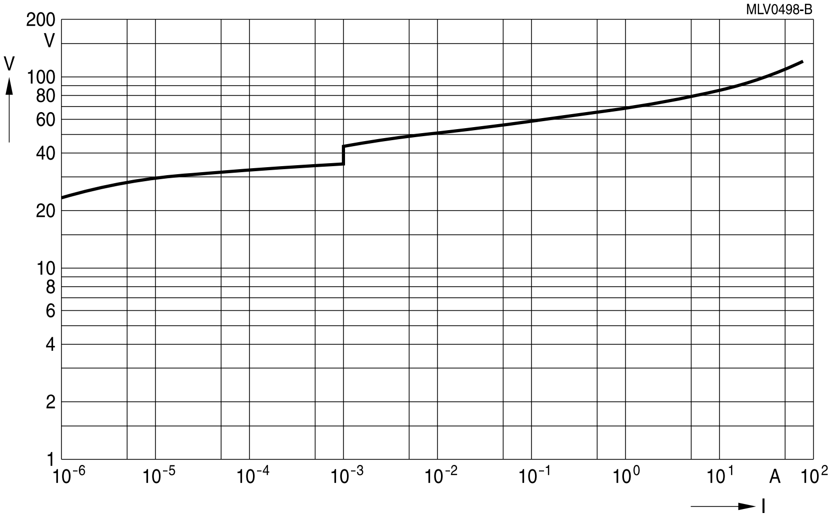
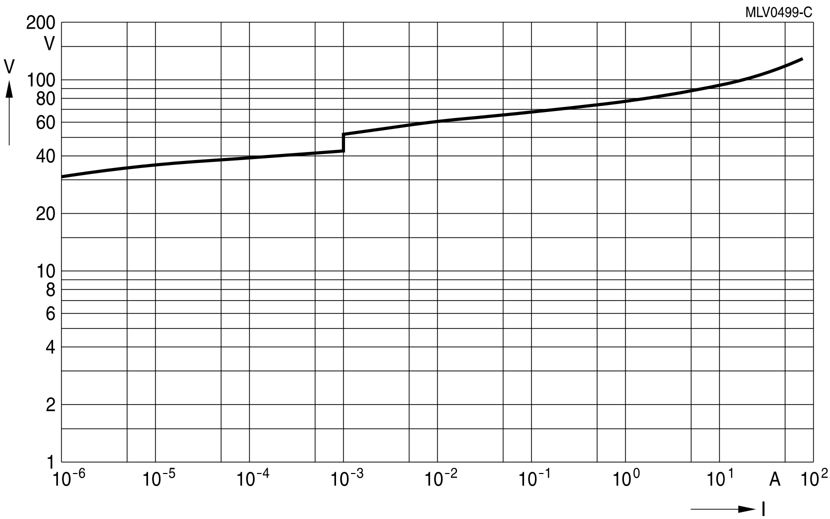
V/I characteristics for automotive standard series

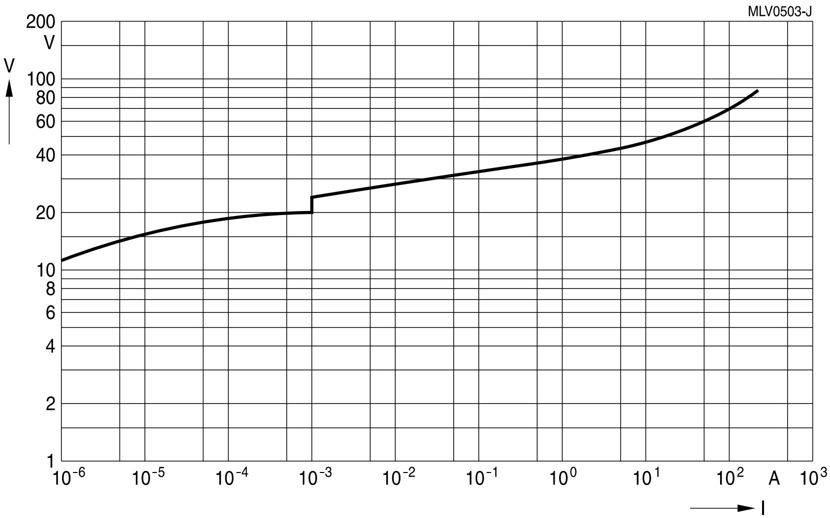


CT0805K25G_G

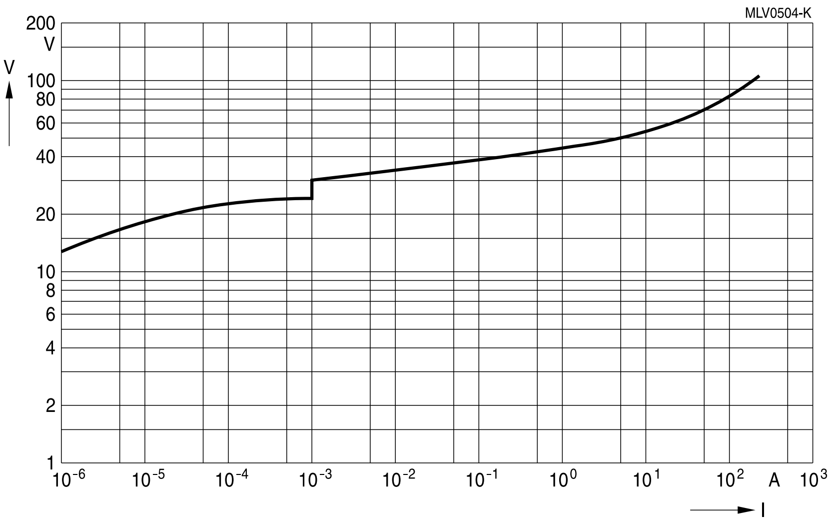


CT0805K30G_G

V/I characteristics for automotive standard series

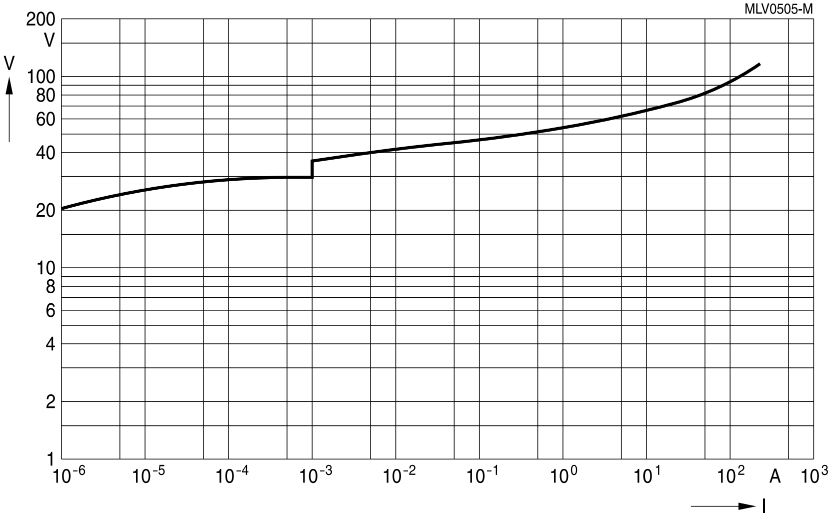


CT1206K14G_G

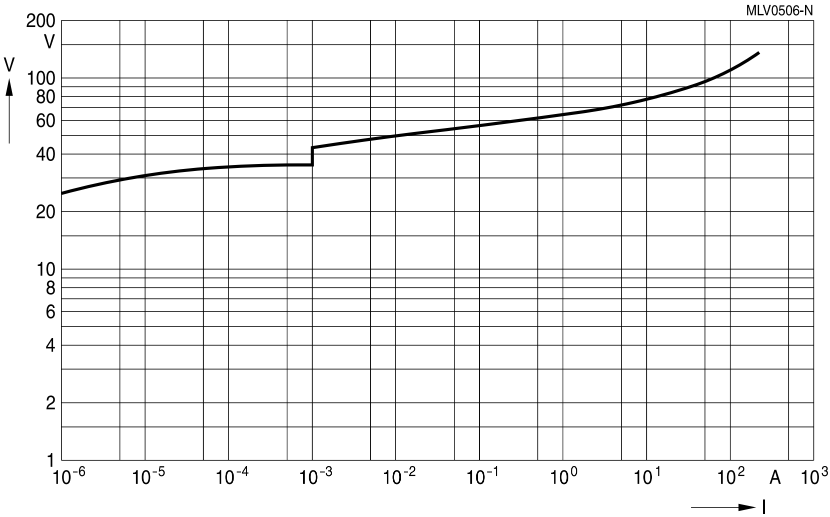


CT1206K17G_G

V/I characteristics for automotive standard series

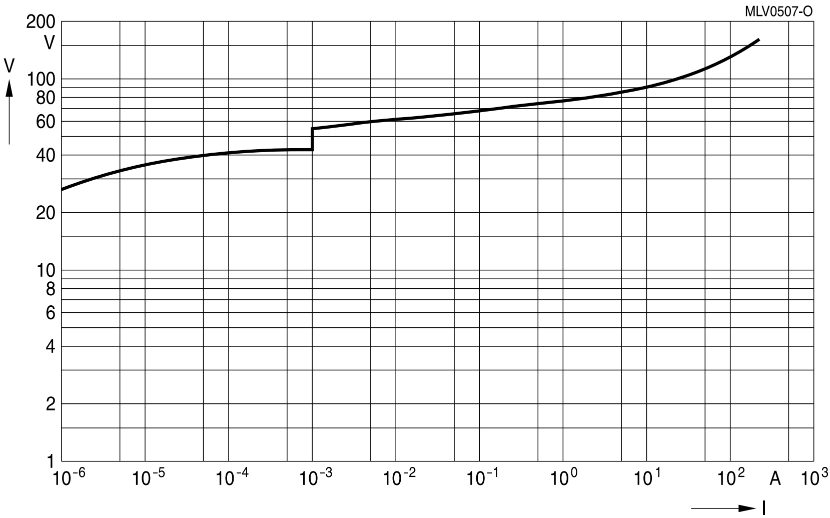


CT1206K20G_G

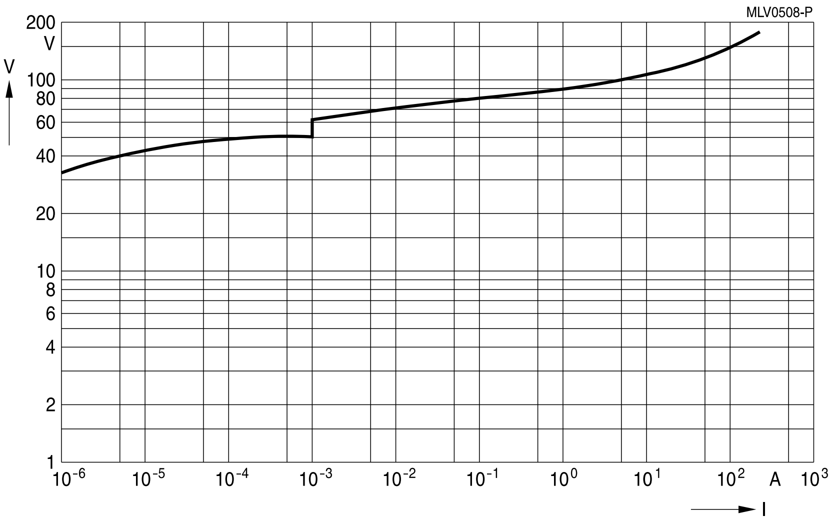


CT1206K25G_G

V/I characteristics for automotive standard series

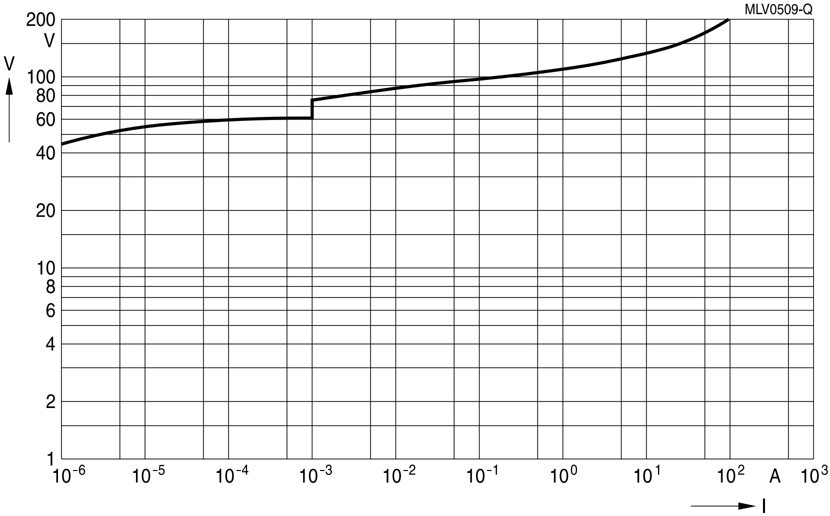


CT1206K30G_G

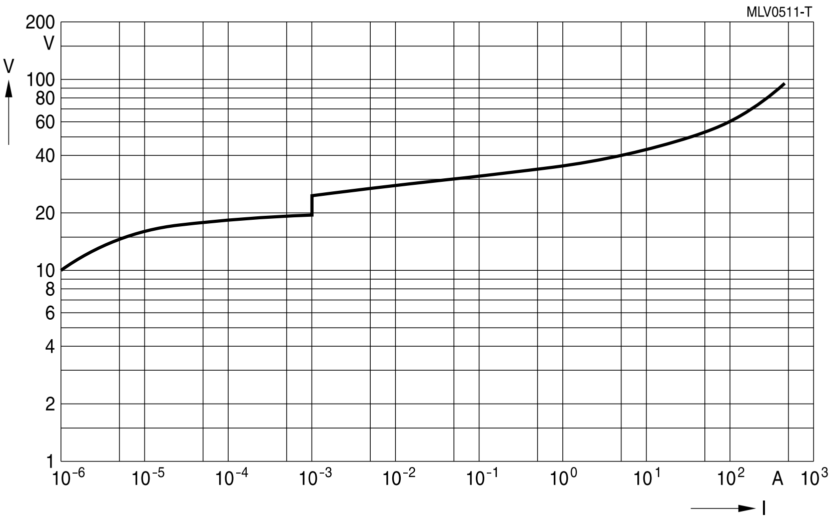


CT1206K35G_G

V/I characteristics for automotive standard series



CT1206K40G_G



CT1210K14G_G

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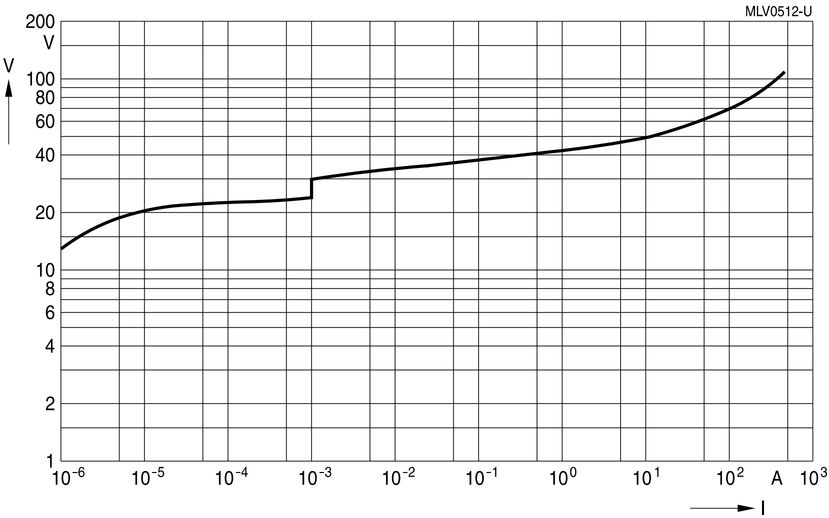
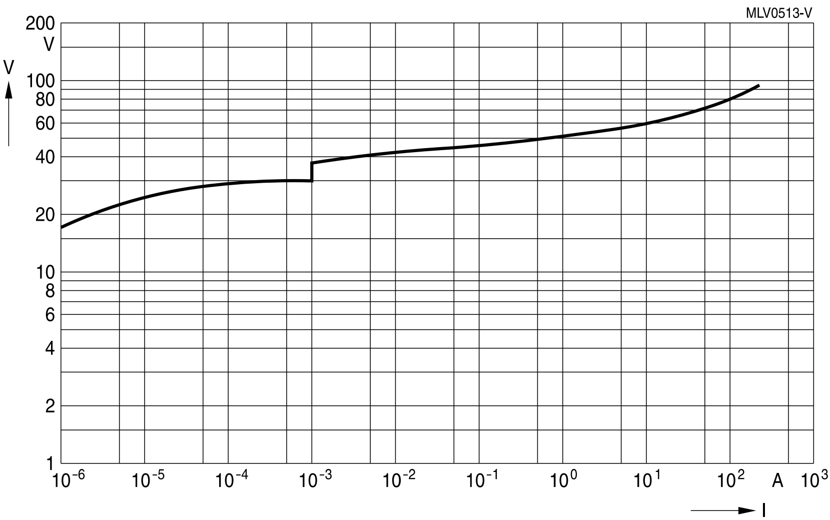
V/I characteristics for automotive standard series

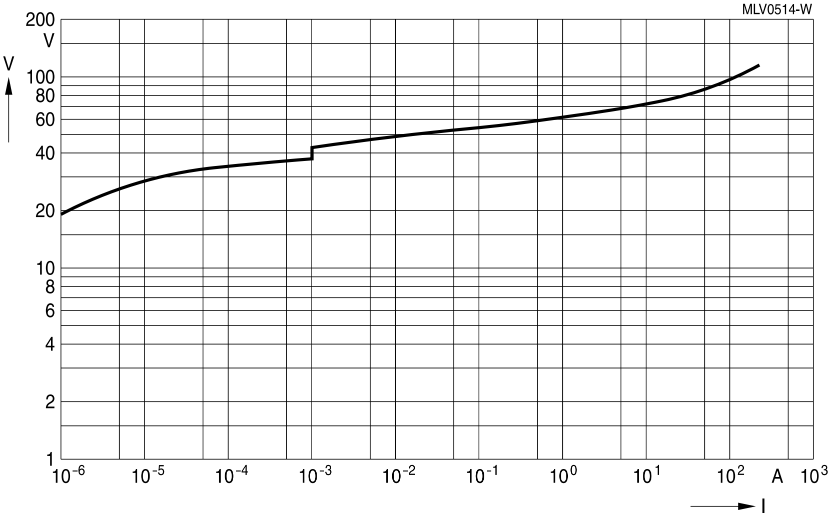


CT1210K17G_G

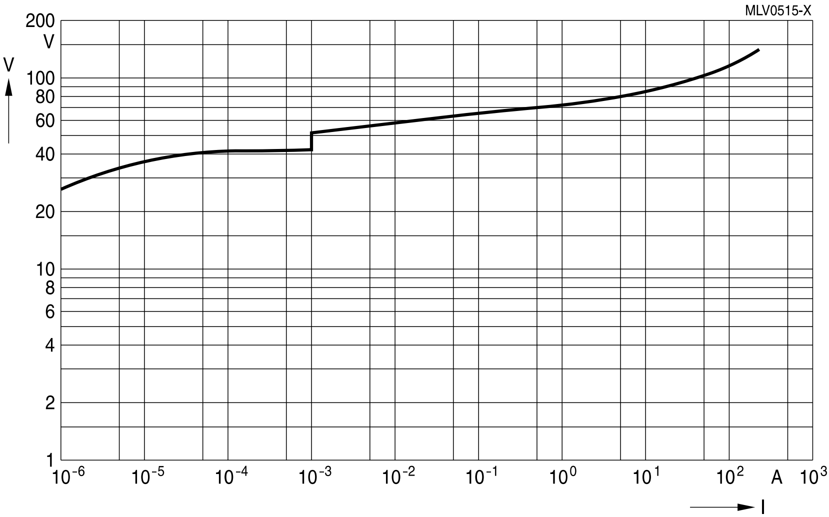


CT1210K20G_G

V/I characteristics for automotive standard series

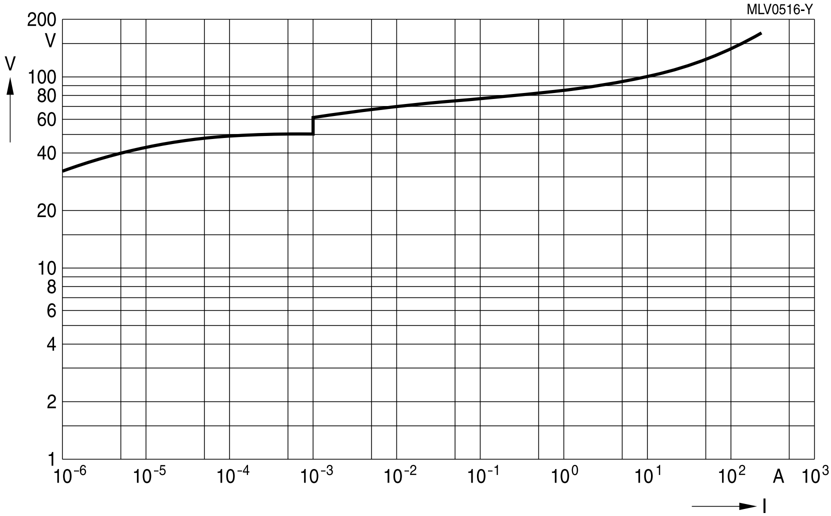


CT1210K25G_G

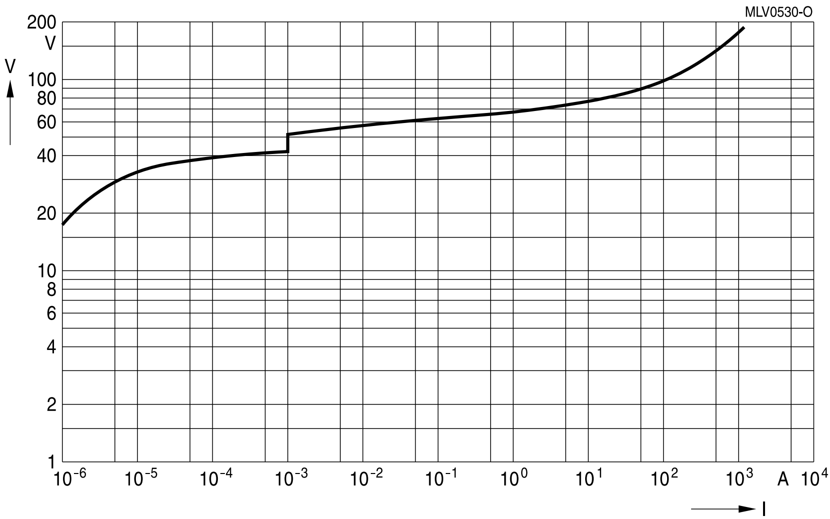


CT1210K30G_G

V/I characteristics for automotive standard series

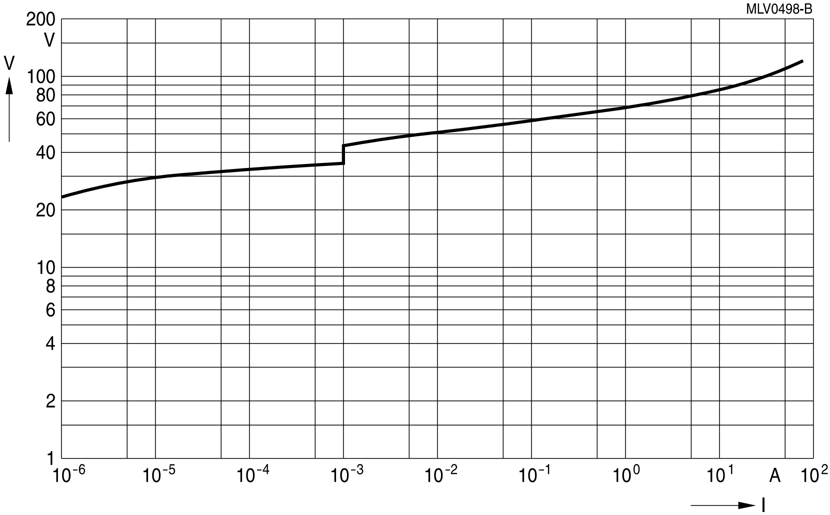


CT1210K35G_G

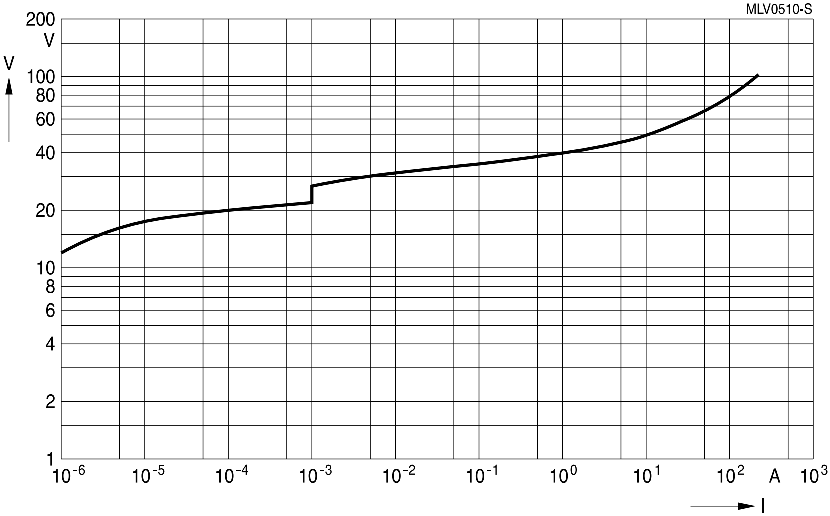


CT2220K30G_G

V/I characteristics for automotive series with load dump/ jump-start protection

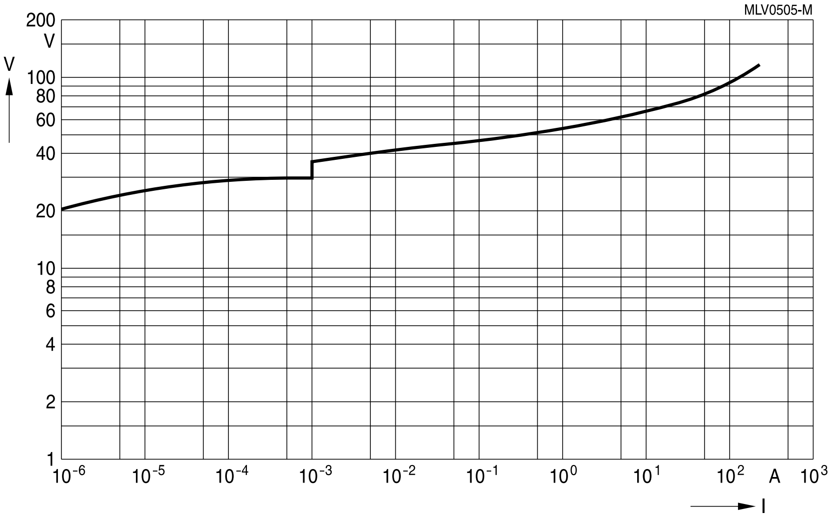


CT0805K25AUTOG_G

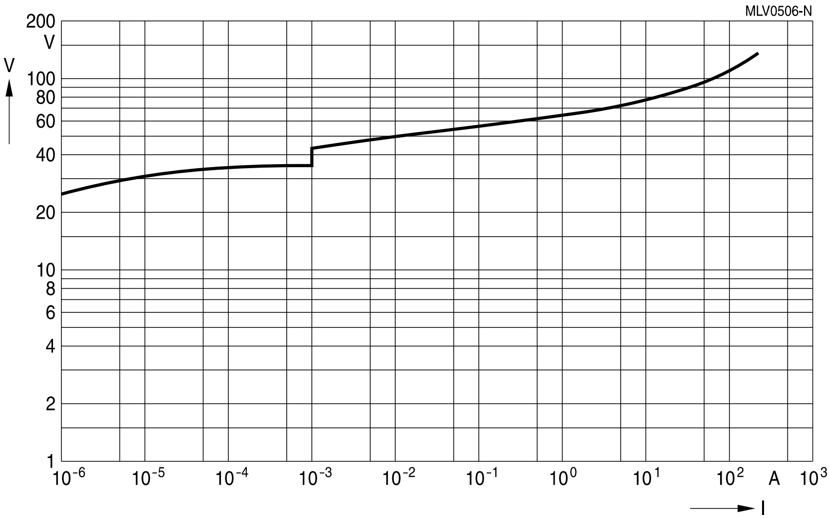


CT1206S14BAUTOG_G

V/I characteristics for automotive series with load dump/ jump-start protection

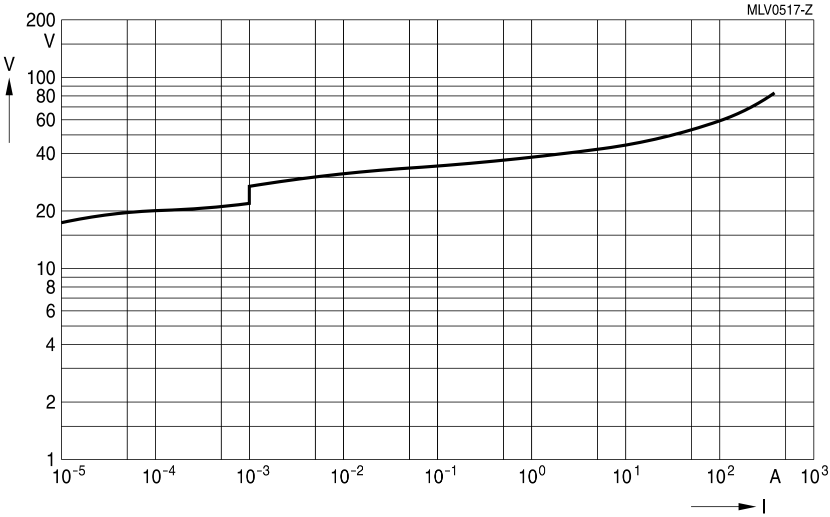


CT1206K20AUTOG_G

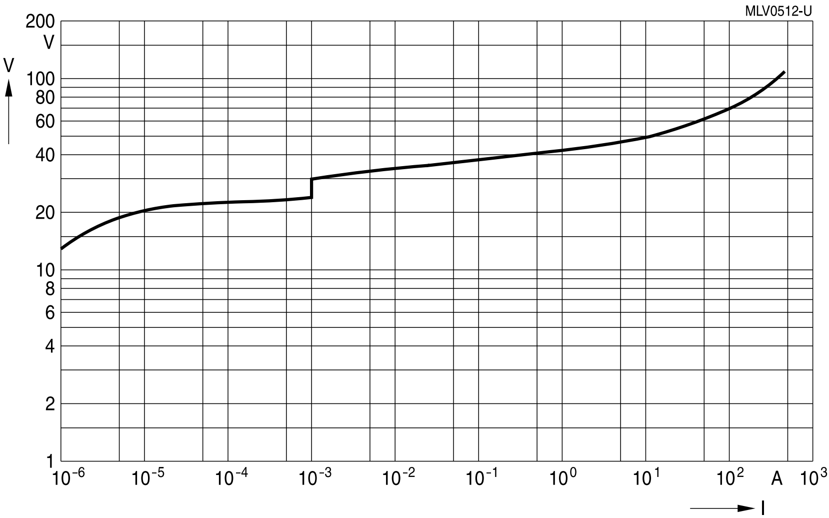


CT1206K25AUTOG_G

V/I characteristics for automotive series with load dump/ jump-start protection

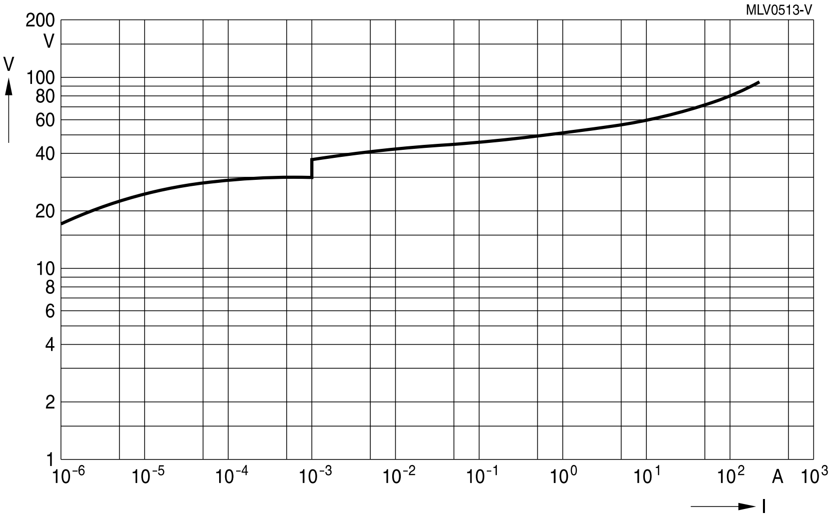


CT1210S14BAUTOG_G

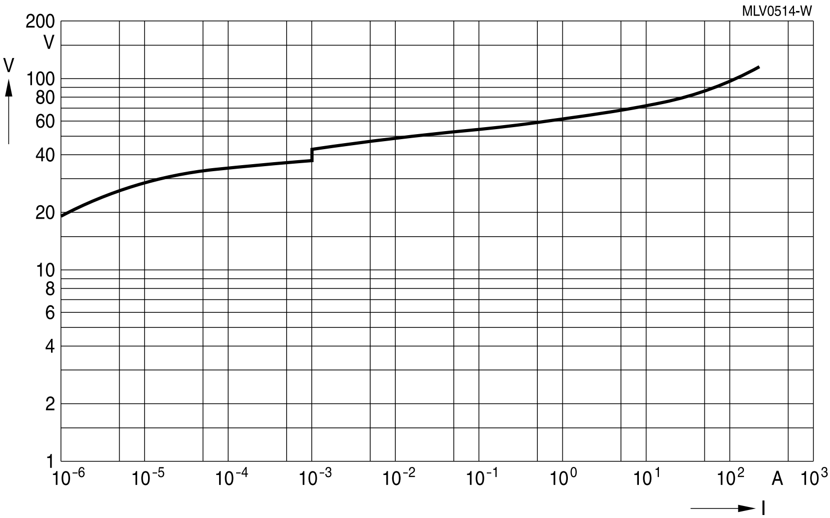


CT1210K17AUTOG_G

V/I characteristics for automotive series with load dump/ jump-start protection



CT1210K20AUTOG_G



CT1210K25AUTOG_G

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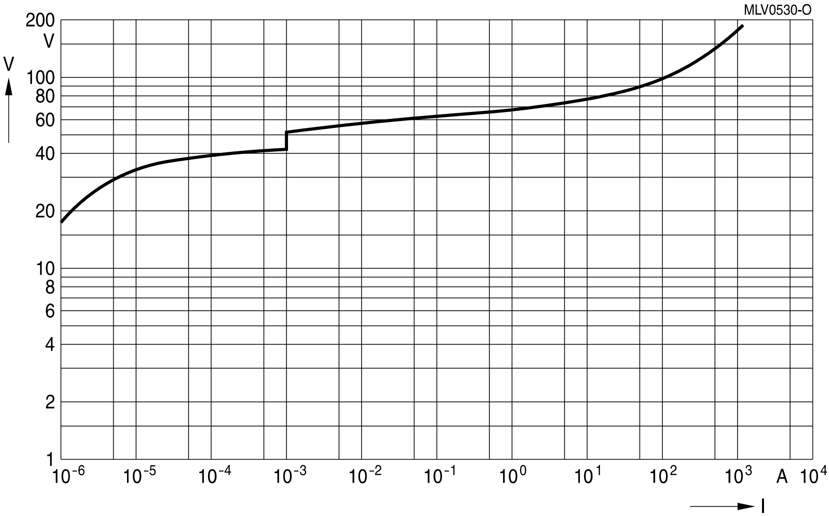
V/I characteristics for automotive series with load dump/ jump-start protection

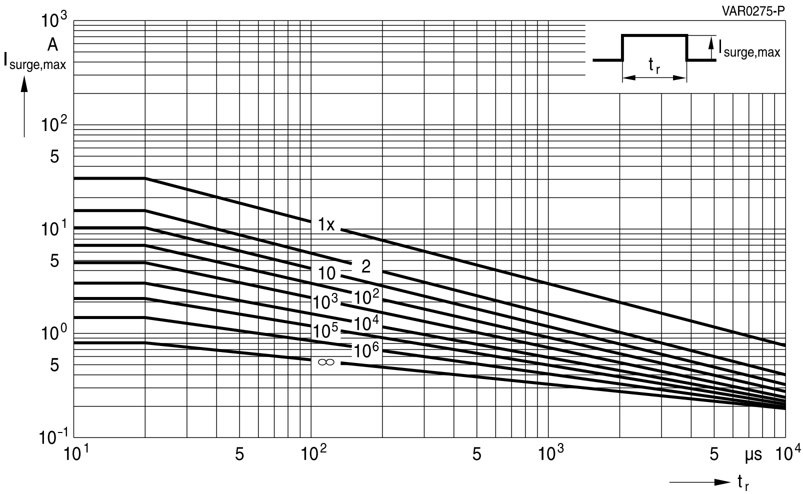


CT2220K30AUTOG_G

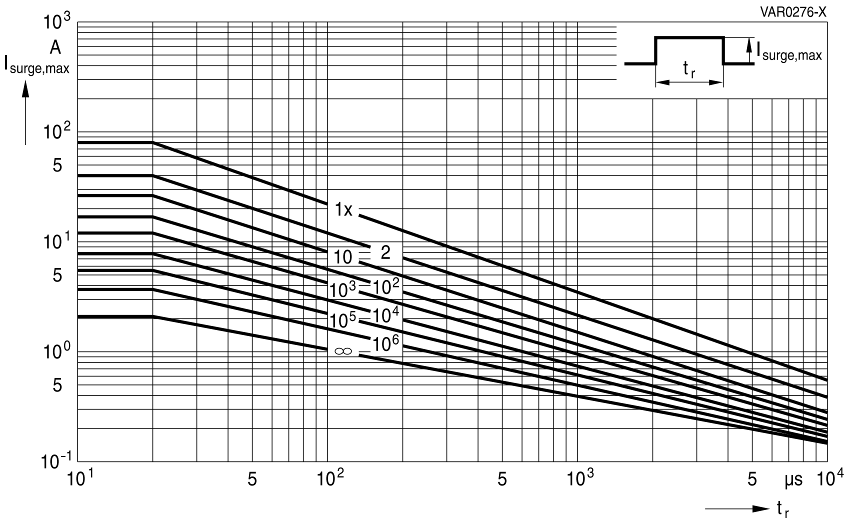
Derating curves for automotive standard series

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

For explanation of the derating curves refer to "General technical information", chapter 2.7.1



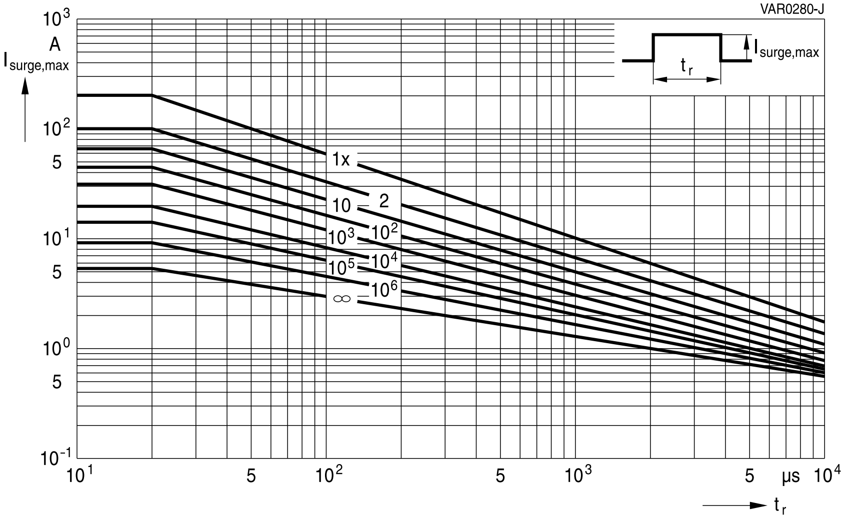
CT0603K14G_G ... K25G_G



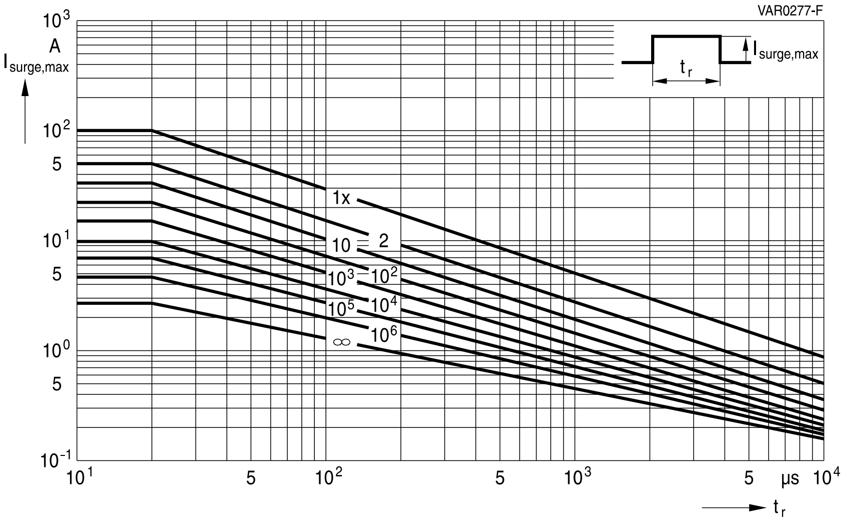
CT0805K25G_G ... K30G_G

Derating curves for automotive standard series

Maximum surge current $I_{surge,max} = f(t_r$, pulse train)
For explanation of the derating curves refer to "General technical information", chapter 2.7.1



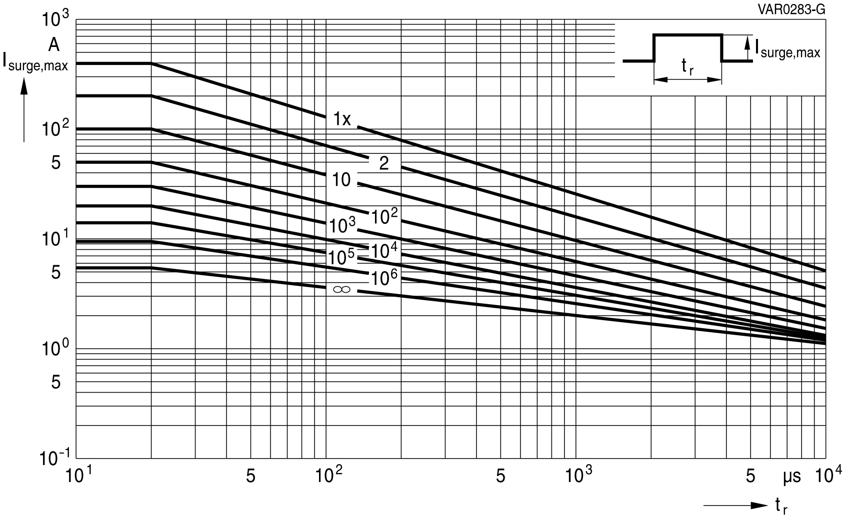
CT1206K14G_G ... K30G_G



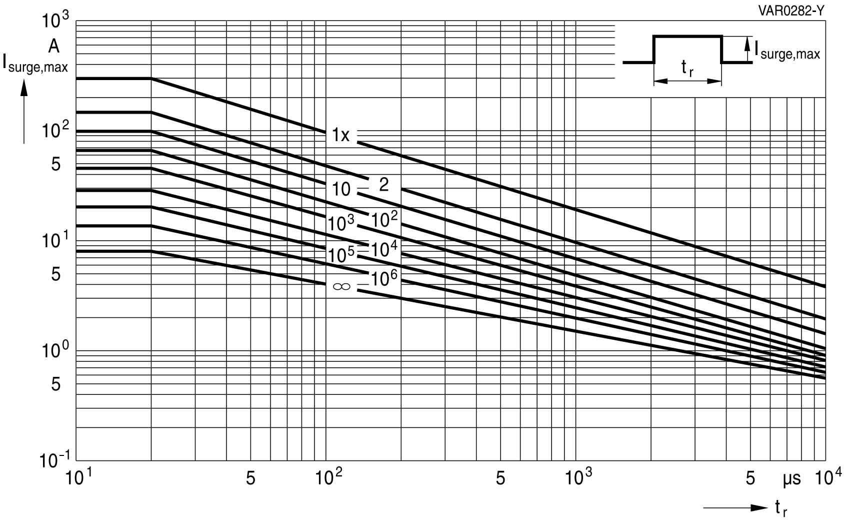
CT1206K35G_G ... K40G_G

Derating curves for automotive standard series

Maximum surge current $I_{surge,max}$ = f (t_r, pulse train)
For explanation of the derating curves refer to "General technical information", chapter 2.7.1



CT1210K14G_G ... K20G_G

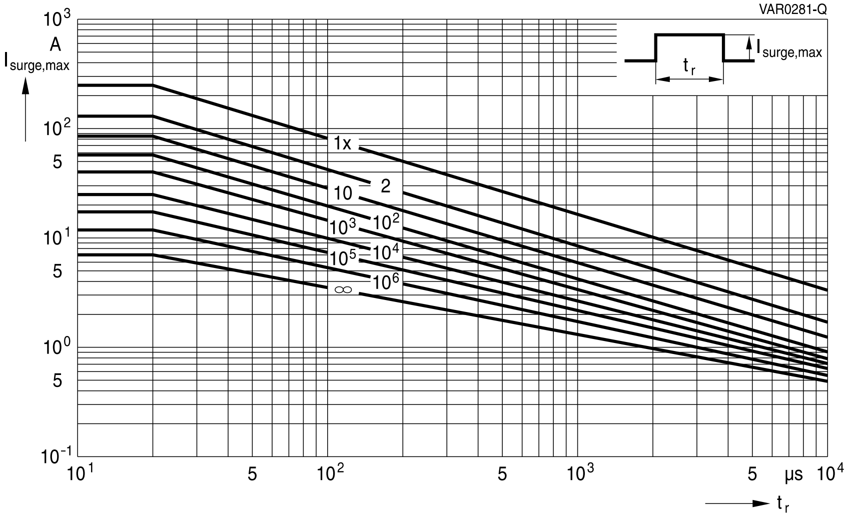


CT1210K25G_G ... K30G_G

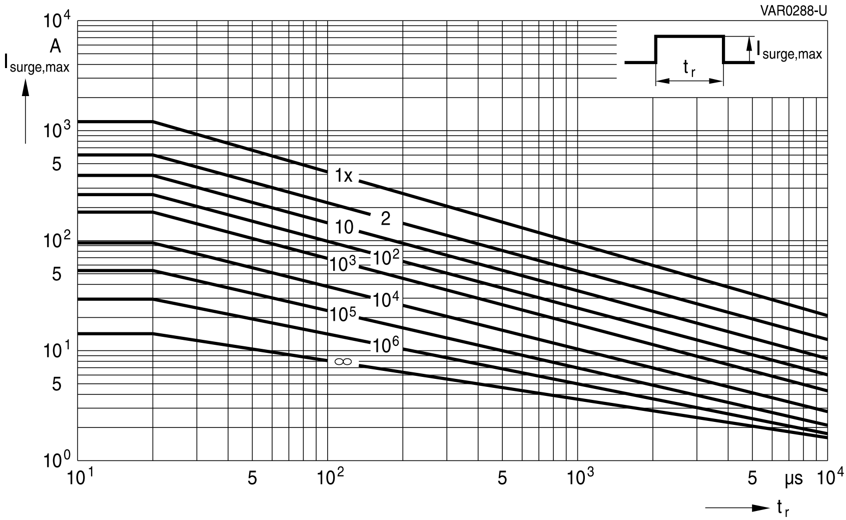
Derating curves for automotive standard series

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

For explanation of the derating curves refer to "General technical information", chapter 2.7.1



CT1210K35G_G

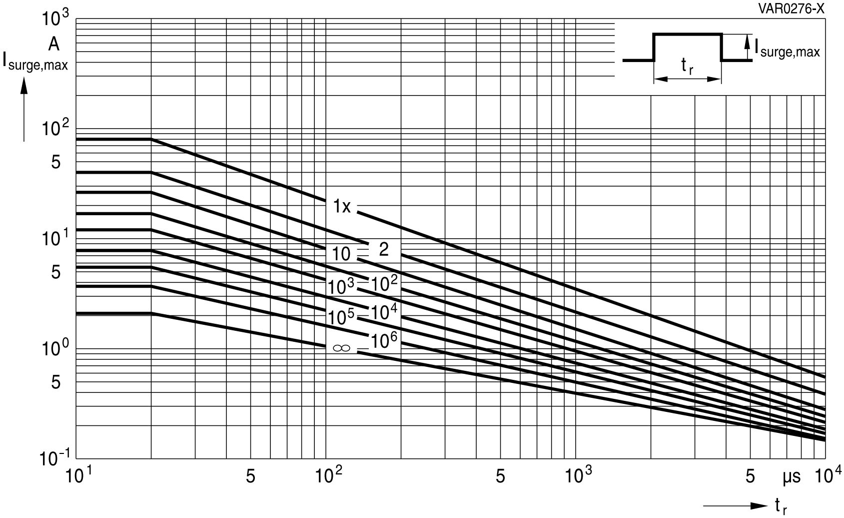


CT2220K30G_G

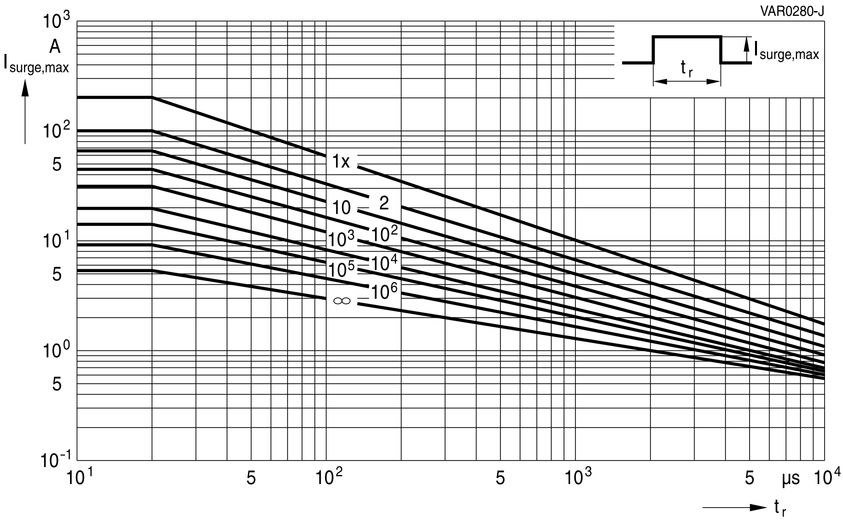
SMD

Derating curves for automotive series with load dump/ jump-start protection

Maximum surge current $I_{surge,max}$ = f (t_r, pulse train)
For explanation of the derating curves refer to "General technical information", chapter 2.7.1



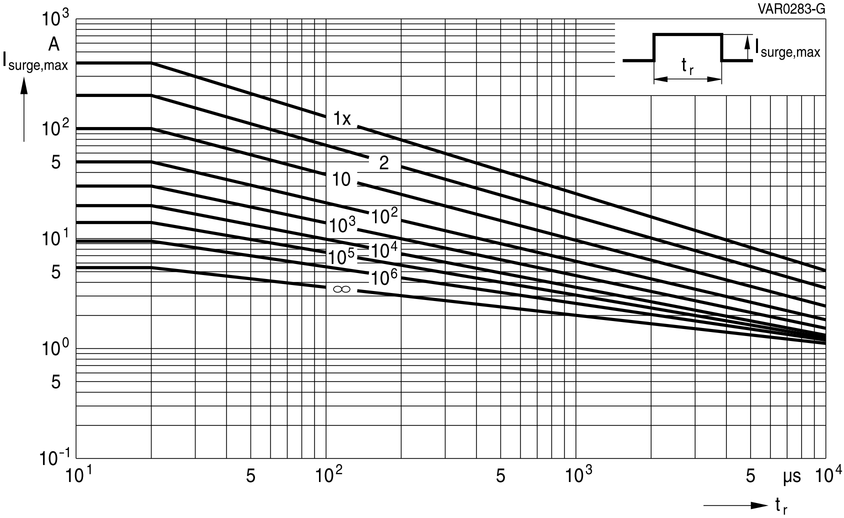
CT0805K25AUTOG_G



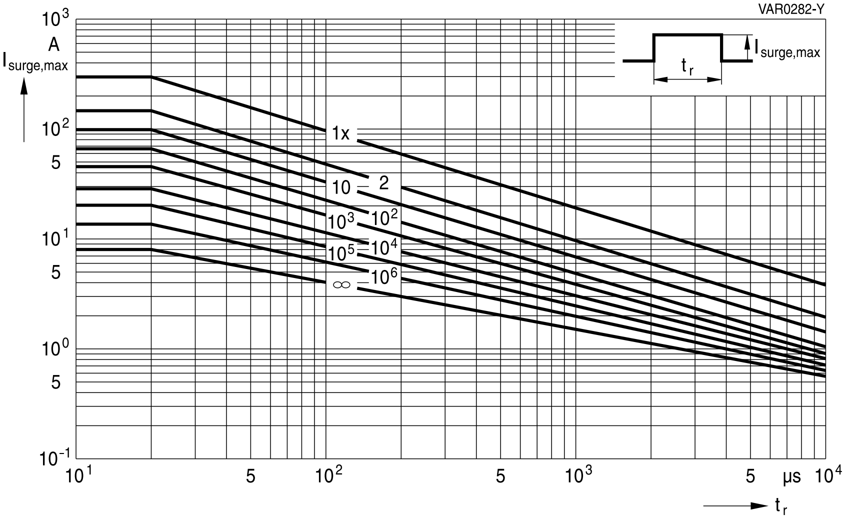
CT1206K20AUTOG_G CT1206K25AUTOG_G CT1206S14BAUTOG_G

Derating curves for automotive series with load dump/ jump-start protection

Maximum surge current $I_{surge,max}$ = f (t_r, pulse train)
For explanation of the derating curves refer to "General technical information", chapter 2.7.1



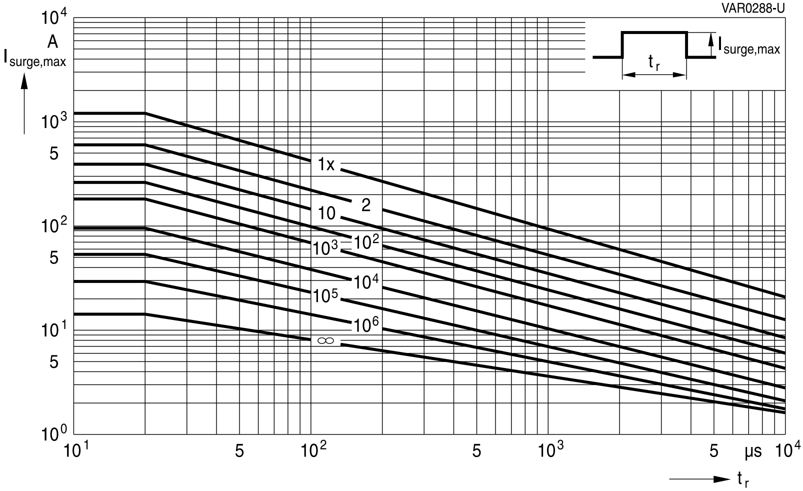
CT1210K17AUTOG_G CT1210K20AUTOG_G CT1210S14BAUTOG_G



CT1210K25AUTOG_G

Derating curves for automotive series with load dump/ jump-start protection

Maximum surge current $I_{surge,max}$ = f (t_r, pulse train)
For explanation of the derating curves refer to "General technical information", chapter 2.7.1



CT2220K30AUTOG_G

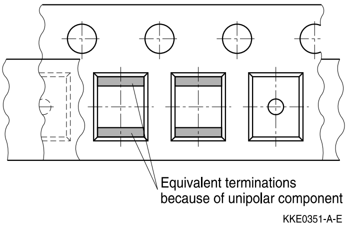
Taping and packing

1 Taping and packing for SMD components

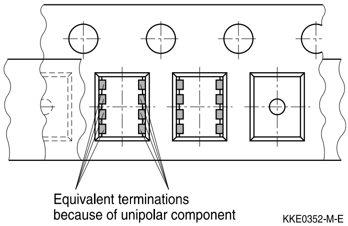
1.1 Blister tape (taping to IEC 60286-3)

Part orientation in tape pocket for blister tape

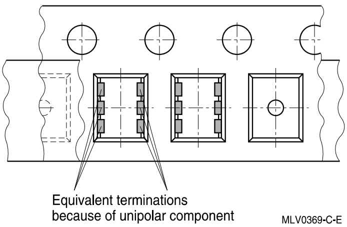
For discrete chip, EIA case sizes 0603, 0805, 1206, 1210, 1812 and 2220



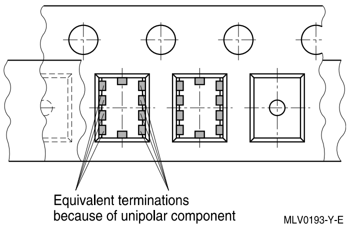
For array, EIA case size 0612



For arrays, EIA case sizes 0506 and 1012



For filter array, EIA case size 0508



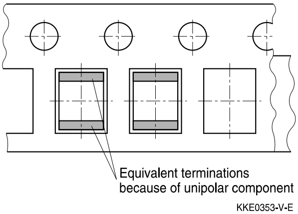
Additional taping information

Reel material	Polystyrol (PS)
Tape material	Polystyrol (PS) or Polycarbonat (PC) or PVC
Tape break force	min. 10 N
Top cover tape strength	min. 10 N
Top cover tape peel force	0.1 to 1.0 N for 8-mm tape and 0.1 to 1.3 N for 12-mm tape at a peel speed of 300 mm/min
Tape peel angle	Angle between top cover tape and the direction of feed during peel off: 165° to 180°
Cavity play	Each part rests in the cavity so that the angle between the part and cavity center line is no more than 20°

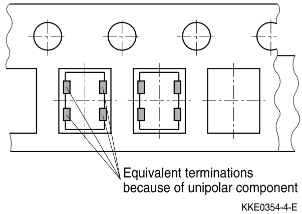
1.2 Cardboard tape (taping to IEC 60286-3)

Part orientation in tape pocket for cardboard tape

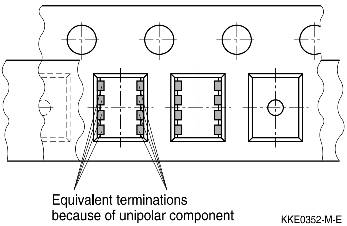
For discrete chip, EIA case sizes 0201, 0402, 0603 and 1003



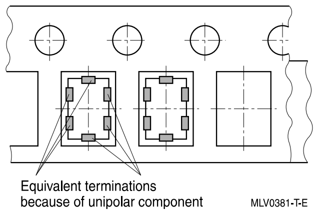
For array, EIA case size 0405



For array, EIA case size 0508



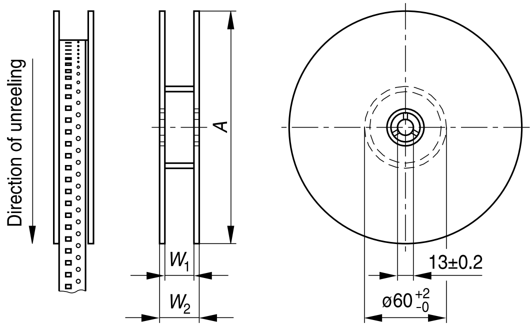
For filter array, EIA case size 0405



Additional taping information

Reel material	Polystyrol (PS)
Tape material	Cardboard
Tape break force	min. 10 N
Top cover tape strength	min. 10 N
Top cover tape peel force	0.1 to 1.0 N at a peel speed of 300 mm/min
Tape peel angle	Angle between top cover tape and the direction of feed during peel off: 165° to 180°
Cavity play	Each part rests in the cavity so that the angle between the part and cavity center line is no more than 20°

1.3 Reel packing



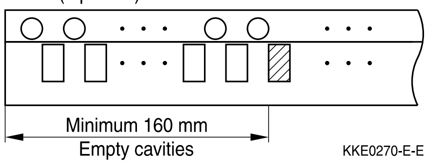
KKE0058-I-E

Dimensions in mm

	8-mm tape		12-mm tape	
	180-mm reel	330-mm reel	180-mm reel	330-mm reel
A	180 +0/−3	330 +0/−2.0	180 +0/−3	330 +0/−2.0
W_1	8.4 +1.5/−0	8.4 +1.5/−0	12.4 +1.5/−0	12.4 +1.5/−0
W_2	14.4 max.	14.4 max.	18.4 max.	18.4 max.

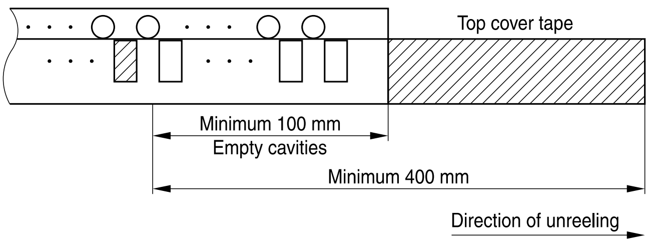
Leader, trailer

Trailer (tape end)



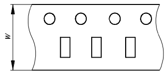
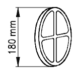
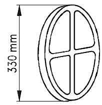
KKE0270-E-E

Leader



KKE0289-Q-E

1.4 Packing units for discrete chip and array chip

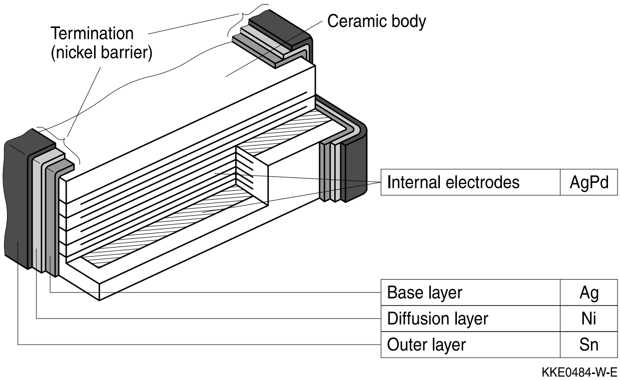
					
Case size	Chip thickness	Cardboard tape	Blister tape	∅ 180-mm reel	∅ 330-mm reel
inch/mm	th	W	W	pcs.	pcs.
0201/0603	0.33 mm	8 mm	–	15000	–
0402/1005	0.6 mm	8 mm	–	10000	50000
0405/1012	0.7 mm	8 mm	–	5000	–
0506/1216	0.5 mm	–	8 mm	4000	–
0508/1220	0.9 mm	8 mm	8 mm	4000	–
0603/1608	0.9 mm	8 mm	8 mm	4000	16000
0612/1632	0.7 mm	–	8 mm	3000	–
0805/2012	0.7 mm	–	8 mm	3000	–
	0.9 mm	–	8 mm	3000	12000
	1.3 mm	–	8 mm	3000	12000
1003/2508	0.9 mm	8 mm	–	4000	–
1012/2532	1.0 mm	–	8 mm	2000	–
1206/3216	0.9 mm	–	8 mm	3000	–
	1.3 mm	–	8 mm	3000	12000
	1.4 mm	–	8 mm	2000	8000
	1.6 mm	–	8 mm	2000	8000
1210/3225	0.9 mm	–	8 mm	3000	–
	1.3 mm	–	8 mm	3000	12000
	1.4 mm	–	8 mm	2000	8000
	1.6 mm	–	8 mm	2000	8000
1812/4532	1.3 mm	–	12 mm	1500	–
	1.4 mm	–	12 mm	1000	–
	1.6 mm	–	12 mm	1000	4000
	2.0 mm	–	12 mm	–	3000
	2.3 mm	–	12 mm	–	3000
2220/5750	1.3 mm	–	12 mm	1500	–
	1.4 mm	–	12 mm	1000	–
	1.6 mm	–	12 mm	1000	–
	2.0 mm	–	12 mm	–	3000
	2.3 mm	–	12 mm	–	3000
	2.7 mm	–	12 mm	600	–
	3.0 mm	–	12 mm	600	–

Soldering directions

1 Terminations and soldering methods

1.1 Nickel barrier termination

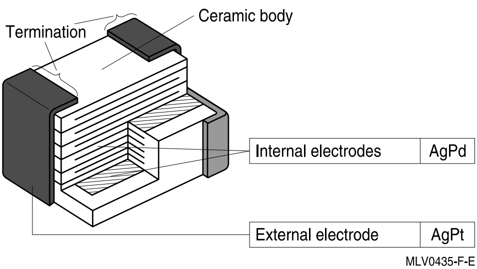
The nickel barrier layer of the silver/nickel/tin termination prevents leaching of the silver base metallization layer. This allows great flexibility in the selection of soldering parameters. The tin prevents the nickel layer from oxidizing and thus ensures better wetting by the solder. The nickel barrier termination is suitable for lead-free soldering, as well as for other commonly-used soldering methods.



Multilayer CTVS: Structure of nickel barrier termination

1.2 Silver-platinum termination

Silver-platinum terminations are mainly used for the large EIA case sizes 1812 and 2220. The silver-platinum termination is approved for reflow soldering, SnPb soldering and lead-free soldering with a silver containing solder paste. In case of SnPb soldering, a solder paste Sn62Pb36Ag2 is recommended. For lead-free reflow soldering, a solder paste SAC, e.g. Sn95.5Ag3.8Cu0.7, is recommended.



Multilayer varistor: Structure of silver-platinum termination

1.3 Silver-palladium termination

Silver-palladium terminations are designed for the use of conductive adhesivs. Lead-free reflow soldering does not form a proper solder joint. In general reflow or wave soldering is not recommended.

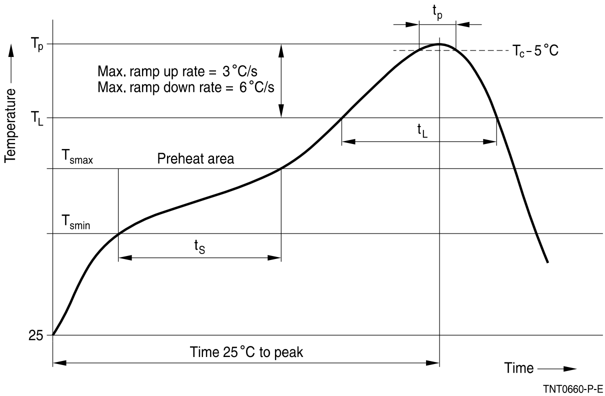
1.4 Tinned iron wire

All SHCV types with tinned terminations are suitable for lead-free and SnPb soldering.

2 Recommended soldering temperature profiles

2.1 Reflow soldering temperature profile

Temperature ranges for reflow soldering acc. to IEC 60068-2-58 recommendations.



Profile feature		Sn-Pb eutectic assembly	Pb-free assembly
Preheat and soak - Temperature min - Temperature max - Time	 T_{smin} T_{smax} t_{smin} to t_{smax}	 100 °C 150 °C 60 ... 120 s	 150 °C 200 °C 60 ... 120 s
Average ramp-up rate	T_{smax} to T_p	3 °C/ s max.	3 °C/ s max.
Liquidous temperature Time at liquidous	T_L t_L	183 °C 40 ... 150 s	217 °C 40 ... 150 s
Peak package body temperature	T_p	215 °C ... 260 °C[1)]	235 °C ... 260 °C
Time above (T_P –5 °C)	t_p	10 ... 40 s	10 ... 40 s
Average ramp-down rate	T_p to T_{smax}	6 °C/ s max.	6 °C/ s max.
Time 25 °C to peak temperature		max. 8 minutes	max. 8 minutes

1) Depending on package thickness.

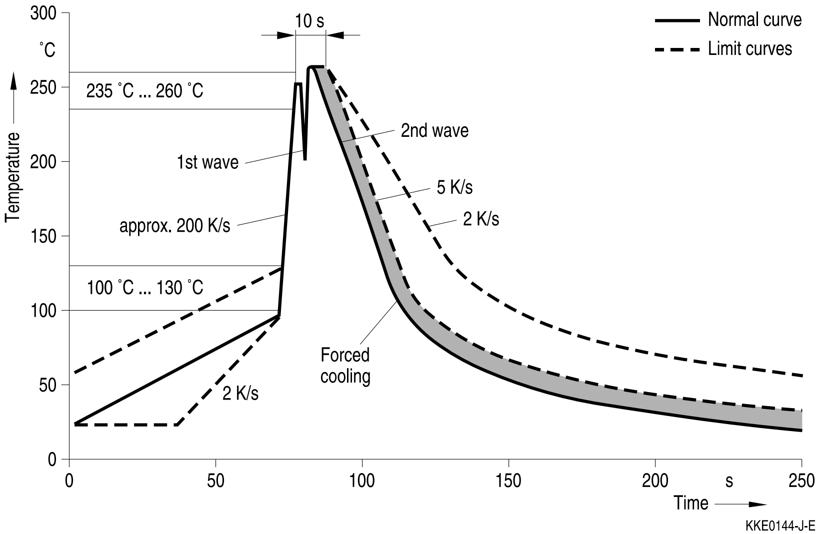
Notes: All temperatures refer to topside of the package, measured on the package body surface.

Number of reflow cycles: 3

Iron soldering should be avoided, hot air methods are recommended for repair purposes.

2.2 Wave soldering temperature profile

Temperature characteristics at component terminal with dual-wave soldering



3 Solder joint profiles / solder quantity

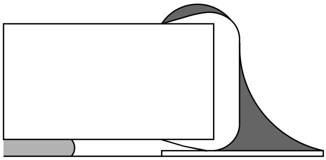
3.1 Nickel barrier termination

If the meniscus height is too low, that means the solder quantity is too low, the solder joint may break, i.e. the component becomes detached from the joint. This problem is sometimes interpreted as leaching of the external terminations.

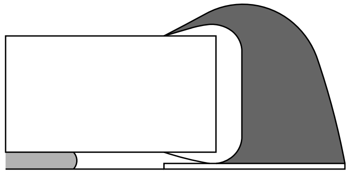
If the solder meniscus is too high, i.e. the solder quantity is too large, the vise effect may occur. As the solder cools down, the solder contracts in the direction of the component. If there is too much solder on the component, it has no leeway to evade the stress and may break, as in a vise.

The figures below show good and poor solder joints for dual-wave and infrared soldering.

3.1.1 Solder joint profiles for nickel barrier termination - dual-wave soldering



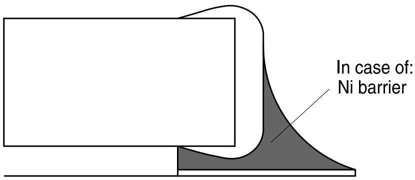
Good solder joint KKE0287-9-E



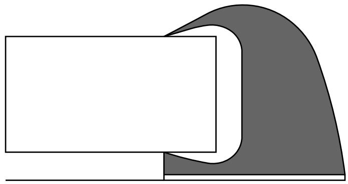
Too much solder
Pad geometry too large,
not soldered in preferred direction KKE0288-H-E

Good and poor solder joints caused by amount of solder in dual-wave soldering.

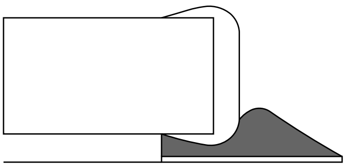
3.1.2 Solder joint profiles for nickel barrier termination / silver-platinum termination - reflow soldering



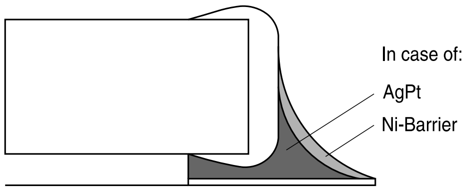
Good solder joint MLV0196-B-E



Too much solder
Pad geometry too large KKE0071-A-E



Poor wetting KKE0072-I-E



Good solder joint MLV0549-M-E

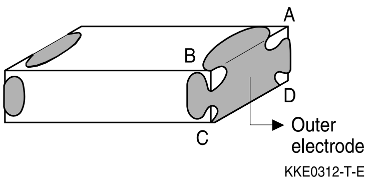
Good and poor solder joints caused by amount of solder in reflow soldering.

4 Solderability tests

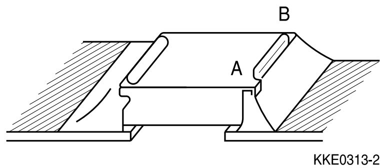
Test	Standard	Test conditions Sn-Pb soldering	Test conditions Pb-free soldering	Criteria/ test results
Wettability	IEC 60068-2-58	Immersion in 60/40 SnPb solder using non-activated flux at 215 ±3 °C for 3 ±0.3 s	Immersion in Sn96.5Ag3.0Cu0.5 solder using non- or low activated flux at 245 ±5 °C for 3 ±0.3 s	Covering of 95% of end termination, checked by visual inspection
Leaching resistance	IEC 60068-2-58	Immersion in 60/40 SnPb solder using mildly activated flux without preheating at 260 ±5 °C for 10 ±1 s	Immersion in Sn96.5Ag3.0Cu0.5 solder using non- or low activated flux without preheating at 255 ±5 °C for 10 ±1 s	No leaching of contacts
Thermal shock (solder shock)		Dip soldering at 300 °C/5 s	Dip soldering at 300 °C/5 s	No deterioration of electrical parameters. Capacitance change: $\|\Delta C/C_0\| \leq 15\%$
Tests of resistance to soldering heat for SMDs	IEC 60068-2-58	Immersion in 60/40 SnPb for 10 s at 260 °C	Immersion in Sn96.5Ag3.0Cu0.5 for 10 s at 260 °C	Change of varistor voltage: $\|\Delta V/V$ (1 mA)$\| \leq 5\%$
Tests of resistance to soldering heat for radial leaded components (SHCV)	IEC 60068-2-20	Immersion of leads in 60/40 SnPb for 10 s at 260 °C	Immersion of leads in Sn96.5Ag3.0Cu0.5 for 10 s at 260 °C	Change of varistor voltage: $\|\Delta V/V$ (1 mA)$\| \leq 5\%$ Change of capacitance X7R: $\leq -5/+10\%$

Note:
Leaching of the termination

Effective area at the termination might be lost if the soldering temperature and/or immersion time are not kept within the recommended conditions. Leaching of the outer electrode should not exceed 25% of the chip end area (full length of the edge A-B-C-D) and 25% of the length A-B, shown below as mounted on substrate.



As a single chip



As mounted on substrate

5 Notes for proper soldering

5.1 Preheating and cooling

- According to IEC 60068-2-58. Please refer to section 2 of this chapter.

5.2 Repair/ rework

Manual soldering with a soldering iron must be avoided, hot-air methods are recommended for rework purposes.

5.3 Cleaning

All environmentally compatible agents are suitable for cleaning. Select the appropriate cleaning solution according to the type of flux used. The temperature difference between the components and cleaning liquid must not be greater than 100 °C. Ultrasonic cleaning should be carried out with the utmost caution. Too high ultrasonic power can impair the adhesive strength of the metallized surfaces.

5.4 Solder paste printing (reflow soldering)

An excessive application of solder paste results in too high a solder fillet, thus making the chip more susceptible to mechanical and thermal stress. Too little solder paste reduces the adhesive strength on the outer electrodes and thus weakens the bonding to the PCB. The solder should be applied smoothly to the end surface.

5.5 Selection of flux

Used flux should have less than or equal to 0.1 wt % of halogenated content, since flux residue after soldering could lead to corrosion of the termination and/or increased leakage current on the surface of the component. Strong acidic flux must not be used. The amount of flux applied should be carefully controlled, since an excess may generate flux gas, which in turn is detrimental to solderability.

5.6 Storage of CTVSs

Solderability is guaranteed for one year from date of delivery for multilayer varistors, CeraDiodes and ESD/EMI filters (half a year for chips with AgPt terminations) and two years for SHCV components, provided that components are stored in their original packages.

Storage temperature:	−25 °C to +45 °C
Relative humidity:	≤75% annual average, ≤95% on 30 days a year

The solderability of the external electrodes may deteriorate if SMDs and leaded components are stored where they are exposed to high humidity, dust or harmful gas (hydrogen chloride, sulfurous acid gas or hydrogen sulfide).

Do not store SMDs and leaded components where they are exposed to heat or direct sunlight. Otherwise the packing material may be deformed or SMDs/ leaded components may stick together, causing problems during mounting.

After opening the factory seals, such as polyvinyl-sealed packages, it is recommended to use the SMDs or leaded components as soon as possible.

Solder CTVS components after shipment from TDK Electronics within the time specified:

CTVS with Ni barrier termination:	12 months
CTVS with AgPt termination:	6 months
SHCV (leaded components):	24 months

5.7 Placement of components on circuit board

Especially in the case of dual-wave soldering, it is of advantage to place the components on the board before soldering in that way that their two terminals do not enter the solder bath at different times.
Ideally, both terminals should be wetted simultaneously.

5.8 Soldering cautions

An excessively long soldering time or high soldering temperature results in leaching of the outer electrodes, causing poor adhesion and a change of electrical properties of the varistor due to the loss of contact between electrodes and termination.
Keep the recommended down-cooling rate.

5.9 Standards

CECC 00802

IEC 60068-2-58

IEC 60068-2-20

Symbols and terms

For ceramic transient voltage suppressors (CTVS)

Symbol	Term
$C_{line,max}$	Maximum capacitance per line
$C_{line,min}$	Minimum capacitance per line
$C_{line,typ}$	Typical capacitance per line
C_{max}	Maximum capacitance
C_{min}	Minimum capacitance
C_{nom}	Nominal capacitance
ΔC_{nom}	Tolerance of nominal capacitance
C_{typ}	Typical capacitance
$f_{cut\text{-}off,max}$	Maximum cut-off frequency
$f_{cut\text{-}off,min}$	Minimum cut-off frequency
$f_{cut\text{-}off,typ}$	Typical cut-off frequency
$f_{res,typ}$	Typical resonance frequency
I	Current
I_{clamp}	Clamping current
I_{leak}	Leakage current
$I_{leak,max}$	Maximum leakage current
$I_{leak,typ}$	Typical leakage current
I_{PP}	Peak pulse current
$I_{surge,max}$	Maximum surge current (also termed peak current)
LCT	Lower category temperature
L_{typ}	Typical inductance
$P_{diss,max}$	Maximum power dissipation
P_{PP}	Peak pulse power
R_{ins}	Insulation resistance
R_{min}	Minimum resistance
R_S	Resistance per line
$R_{S,typ}$	Typical resistance per line
T_A	Ambient temperature
T_{op}	Operating temperature
$T_{op,max}$	Maximum operating temperature
T_{stg}	Storage temperature

Symbol	Term
t_r	Duration of equivalent rectangular wave
t_{resp}	Response time
$t_{resp,max}$	Maximum response time
UCT	Upper category temperature
V	Voltage
$V_{BR,min}$	Minimum breakdown voltage
$V_{clamp,max}$	Maximum clamping voltage
$V_{DC,max}$	Maximum DC operating voltage (also termed working voltage)
$V_{ESD,air}$	Air discharge ESD capability
$V_{ESD,contact}$	Contact discharge ESD capability
V_{jump}	Maximum jump-start voltage
$V_{RMS,max}$	Maximum AC operating voltage, root-mean-square value
V_V	Varistor voltage (also termed breakdown voltage)
V_{LD}	Maximum load dump voltage
V_{leak}	Measurement voltage for leakage current
$V_{V,min}$	Minimum varistor voltage
$V_{V,max}$	Maximum varistor voltage
ΔV_V	Tolerance of varistor voltage
W_{LD}	Maximum load dump energy
W_{max}	Maximum energy absorption (also termed transient energy)
α_{typ}	Typical insertion loss
tan δ	Dissipation factor
e	Lead spacing
≪*≫	Maximum possible application conditions

All dimensions are given in mm.
The commas used in numerical values denote decimal points.

Cautions and warnings

General

Some parts of this publication contain statements about the suitability of our ceramic transient voltage suppressor (CTVS) components (multilayer varistors (MLVs)), CeraDiodes, ESD/EMI filters, leaded transient voltage/ RFI suppressors (SHCV types)) for certain areas of application, including recommendations about incorporation/design-in of these products into customer applications. The statements are based on our knowledge of typical requirements often made of our CTVS devices in the particular areas. We nevertheless expressly point out that such statements cannot be regarded as binding statements about the suitability of our CTVS components for a particular customer application. As a rule, EPCOS is either unfamiliar with individual customer applications or less familiar with them than the customers themselves. For these reasons, it is always incumbent on the customer to check and decide whether the CTVS devices with the properties described in the product specification are suitable for use in a particular customer application.

- Do not use EPCOS CTVS components for purposes not identified in our specifications, application notes and data books.
- Ensure the suitability of a CTVS in particular by testing it for reliability during design-in. Always evaluate a CTVS component under worst-case conditions.
- Pay special attention to the reliability of CTVS devices intended for use in safety-critical applications (e.g. medical equipment, automotive, spacecraft, nuclear power plant).

Design notes

- Always connect a CTVS in parallel with the electronic circuit to be protected.
- Consider maximum rated power dissipation if a CTVS has insufficient time to cool down between a number of pulses occurring within a specified isolated time period. Ensure that electrical characteristics do not degrade.
- Consider derating at higher operating temperatures. Choose the highest voltage class compatible with derating at higher temperatures.
- Surge currents beyond specified values will puncture a CTVS. In extreme cases a CTVS will burst.
- If steep surge current edges are to be expected, make sure your design is as low-inductance as possible.
- In some cases the malfunctioning of passive electronic components or failure before the end of their service life cannot be completely ruled out in the current state of the art, even if they are operated as specified. In applications requiring a very high level of operational safety and especially when the malfunction or failure of a passive electronic component could endanger human life or health (e.g. in accident prevention, life-saving systems, or automotive battery line applications such as clamp 30), ensure by suitable design of the application or other measures (e.g. installation of protective circuitry or redundancy) that no injury or damage is sustained by third parties in the event of such a malfunction or failure. Only use CTVS components from the automotive series in safety-relevant applications.

- Specified values only apply to CTVS components that have not been subject to prior electrical, mechanical or thermal damage. The use of CTVS devices in line-to-ground applications is therefore not advisable, and it is only allowed together with safety countermeasures like thermal fuses.

Storage

- Only store CTVS in their original packaging. Do not open the package prior to processing.
- Storage conditions in original packaging: temperature −25 to +45°C, relative humidity ≤75% annual average, maximum 95%, dew precipitation is inadmissible.
- Do not store CTVS devices where they are exposed to heat or direct sunlight. Otherwise the packaging material may be deformed or CTVS may stick together, causing problems during mounting.
- Avoid contamination of the CTVS surface during storage, handling and processing.
- Avoid storing CTVS devices in harmful environments where they are exposed to corrosive gases for example (SO_x, Cl).
- Use CTVS as soon as possible after opening factory seals such as polyvinyl-sealed packages.
- Solder CTVS components after shipment from EPCOS within the time specified:
  - CTVS with Ni barrier termination, 12 months
  - CTVS with AgPt termination, 6 months
  - SHCV, 24 months

Handling

- Do not drop CTVS components and allow them to be chipped.
- Do not touch CTVS with your bare hands - gloves are recommended.
- Avoid contamination of the CTVS surface during handling.
- Washing processes may damage the product due to the possible static or cyclic mechanical loads (e.g. ultrasonic cleaning). They may cause cracks to develop on the product and its parts, which might lead to reduced reliability or lifetime.

Mounting

- When CTVS devices are encapsulated with sealing material or overmolded with plastic material, electrical characteristics might be degraded and the life time reduced.
- Make sure an electrode is not scratched before, during or after the mounting process.
- Make sure contacts and housings used for assembly with CTVS components are clean before mounting.
- The surface temperature of an operating CTVS can be higher. Ensure that adjacent components are placed at a sufficient distance from a CTVS to allow proper cooling.
- Avoid contamination of the CTVS surface during processing.

Soldering

- Complete removal of flux is recommended to avoid surface contamination that can result in an instable and/or high leakage current.
- Use resin-type or non-activated flux.
- Bear in mind that insufficient preheating may cause ceramic cracks.
- Rapid cooling by dipping in solvent is not recommended, otherwise a component may crack.

Operation

- Use CTVS only within the specified operating temperature range.
- Use CTVS only within specified voltage and current ranges.
- Environmental conditions must not harm a CTVS. Only use them in normal atmospheric conditions. Reducing the atmosphere (e.g. hydrogen or nitrogen atmosphere) is prohibited.
- Prevent a CTVS from contacting liquids and solvents. Make sure that no water enters a CTVS (e.g. through plug terminals).
- Avoid dewing and condensation.
- EPCOS CTVS components are mainly designed for encased applications. Under all circumstances avoid exposure to:
  - direct sunlight
  - rain or condensation
  - steam, saline spray
  - corrosive gases
  - atmosphere with reduced oxygen content
- EPCOS CTVS devices are not suitable for switching applications or voltage stabilization where static power dissipation is required.

This listing does not claim to be complete, but merely reflects the experience of EPCOS AG.

Display of ordering codes for EPCOS products

The ordering code for one and the same EPCOS product can be represented differently in data sheets, data books, other publications, on the EPCOS website, or in order-related documents such as shipping notes, order confirmations and product labels. **The varying representations of the ordering codes are due to different processes employed and do not affect the specifications of the respective products**. Detailed information can be found on the Internet under www.epcos.com/orderingcodes

Important notes

The following applies to all products named in this publication:

1. Some parts of this publication contain **statements about the suitability of our products for certain areas of application**. These statements are based on our knowledge of typical requirements that are often placed on our products in the areas of application concerned. We nevertheless expressly point out **that such statements cannot be regarded as binding statements about the suitability of our products for a particular customer application**. As a rule, we are either unfamiliar with individual customer applications or less familiar with them than the customers themselves. For these reasons, it is always ultimately incumbent on the customer to check and decide whether a product with the properties described in the product specification is suitable for use in a particular customer application.
2. We also point out that **in individual cases, a malfunction of electronic components or failure before the end of their usual service life cannot be completely ruled out in the current state of the art, even if they are operated as specified**. In customer applications requiring a very high level of operational safety and especially in customer applications in which the malfunction or failure of an electronic component could endanger human life or health (e.g. in accident prevention or lifesaving systems), it must therefore be ensured by means of suitable design of the customer application or other action taken by the customer (e.g. installation of protective circuitry or redundancy) that no injury or damage is sustained by third parties in the event of malfunction or failure of an electronic component.
3. **The warnings, cautions and product-specific notes must be observed.**
4. In order to satisfy certain technical requirements, **some of the products described in this publication may contain substances subject to restrictions in certain jurisdictions (e.g. because they are classed as hazardous)**. Useful information on this will be found in our Material Data Sheets on the Internet (www.tdk-electronics.tdk.com/material). Should you have any more detailed questions, please contact our sales offices.
5. We constantly strive to improve our products. Consequently, **the products described in this publication may change from time to time**. The same is true of the corresponding product specifications. Please check therefore to what extent product descriptions and specifications contained in this publication are still applicable before or when you place an order. We also **reserve the right to discontinue production and delivery of products**. Consequently, we cannot guarantee that all products named in this publication will always be available. The aforementioned does not apply in the case of individual agreements deviating from the foregoing for customer-specific products.
6. Unless otherwise agreed in individual contracts, **all orders are subject to our General Terms and Conditions of Supply**.

Important notes

7. **Our manufacturing sites serving the automotive business apply the IATF 16949 standard.** The IATF certifications confirm our compliance with requirements regarding the quality management system in the automotive industry. Referring to customer requirements and customer specific requirements ("CSR") TDK always has and will continue to have the policy of respecting individual agreements. Even if IATF 16949 may appear to support the acceptance of unilateral requirements, we hereby like to emphasize that **only requirements mutually agreed upon can and will be implemented in our Quality Management System.** For clarification purposes we like to point out that obligations from IATF 16949 shall only become legally binding if individually agreed upon.
8. The trade names EPCOS, CeraCharge, CeraDiode, CeraLink, CeraPad, CeraPlas, CSMP, CTVS, DeltaCap, DigiSiMic, ExoCore, FilterCap, FormFit, LeaXield, MiniBlue, MiniCell, MKD, MKK, MotorCap, PCC, PhaseCap, PhaseCube, PhaseMod, PhiCap, PowerHap, PQSine, PQvar, SIFERRIT, SIFI, SIKOREL, SilverCap, SIMDAD, SiMic, SIMID, SineFormer, SIOV, ThermoFuse, WindCap are **trademarks registered or pending** in Europe and in other countries. Further information will be found on the Internet at www.tdk-electronics.tdk.com/trademarks.

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