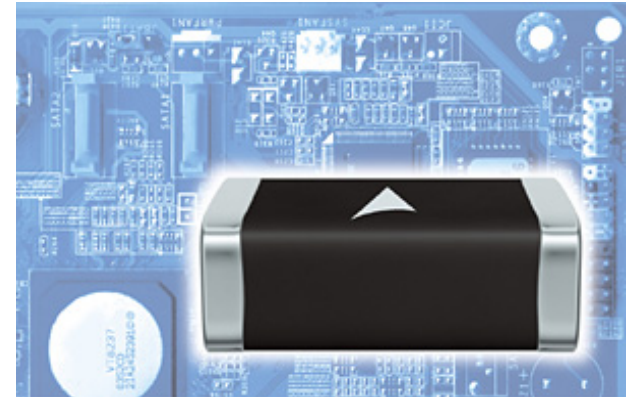
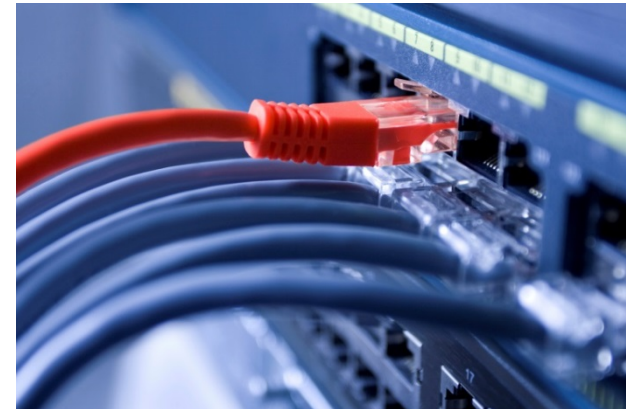


Ceramic Transient Voltage Suppressors (CTVS®)

Multilayer Varistors and CeraDiodes® for Industrial Use



EPCOS AG

A TDK Group Company
PPD Business Group • PD ML PM
Munich, Germany
May 15, 2017

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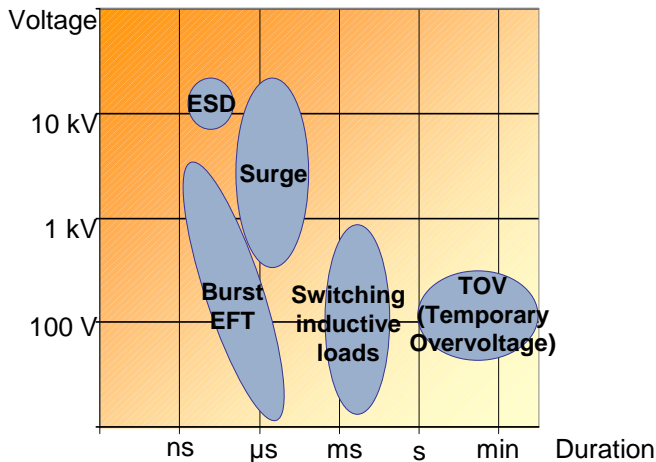
* **CTVS** = Ceramic Transient Voltage Suppressors

Transient environment

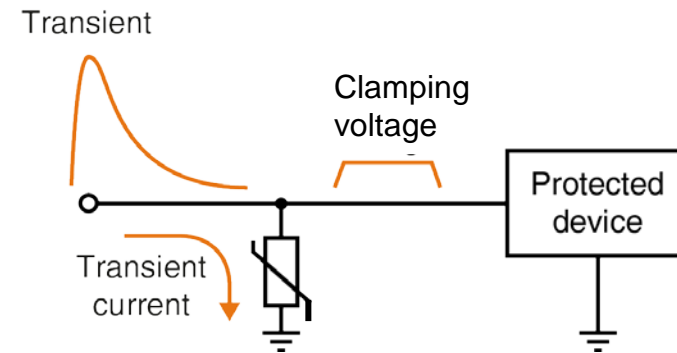
Transients and test standards

	ESD	Surge	Burst/ EFT (electrical fast transient)	Switching inductive loads	TOV (temporary overvoltage)
Phenomena	Electrostatic discharge	Lighting, switching of inductive loads	Transient interferences as single pulse (EFT) or pulse chain (burst)	Switching operations	Switching or fault clearing operations
Voltage	up to 25 kV	up to 4 kV	up to 4 kV	up to 600 V	up to 360 V
Pulse duration	ns	µs	ns (single pulse) µs (burst)	ms	min ... h
Standard	IEC 61000 4-2	IEC 61000 4-5	IEC 61000 4-4		

Pulse voltage/ duration



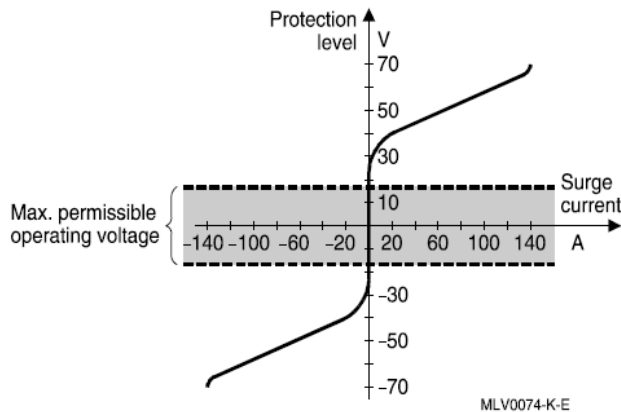
Protection principle



EPCOS CTVS® (Ceramic Transient Voltage Suppressors) and CeraDiodes® are ceramic multilayer components for reliable protection against electrical transients.

ESD and high energy transient protection

Varistor = variable resistor



Features

- ESD protection up to 25 kV (ISO 10605)
- ESD protection min. 8 kV contact, 15 kV air (IEC 61000-4-2)
- High energy handling capability
- High surge current handling
- EMI/RFI attenuation
- Multi-strike capability
- Low parasitic inductance
- No derating up to +85 °C/ +125 °C (depending on type)
- Stable protection level
- **Available in EIA case sizes 0201... 2220** **NEW**
- Nickel barrier termination
- Bidirectional protection
- High reliability
- **Low leakage current** **NEW**
- For temperatures up to +125 °C
- Excellent long-term stability
- Short response time <0.5 ns
- PSpice simulation models available

Applications

- Automation engineering
- Interfaces, data lines, push buttons, serial ports
- Industrial PCs and monitoring systems
- Metering systems
- PoE (Power over Ethernet)
- Data capturing, e.g. barcode reader
- Comfort, control and security systems, e.g. heat and/ or smoke detectors
- Monitoring systems
- Medical equipment
- White goods
- Power supply
- LED

Filtering/ Protection on

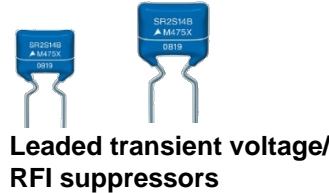
- Interface I/O lines
- Communication interfaces, e.g. bus systems
- Analog signal/ sensor lines
- Sensitive components, e.g. semiconductors

Portfolio CTVS (Ceramic Transient Voltage Suppressors)

Geometry



Multilayer Chip varistors (MLVs)



Leaded transient voltage/ RFI suppressors

Circuit diagram symbol

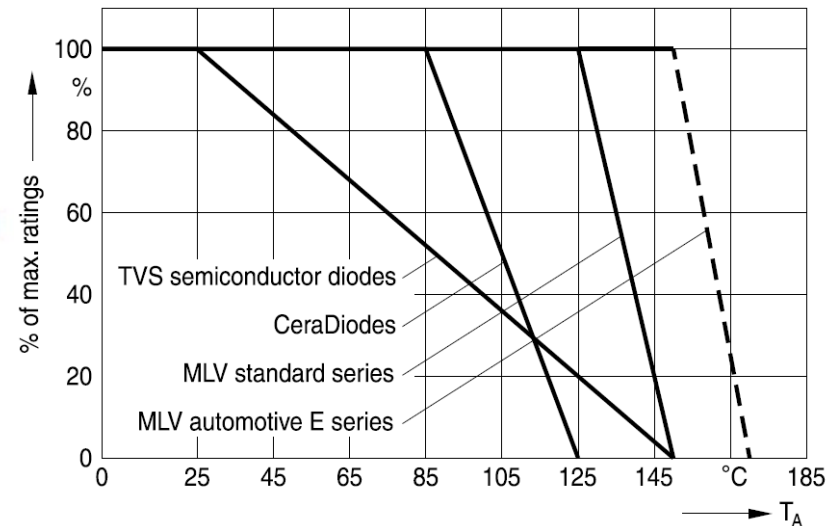
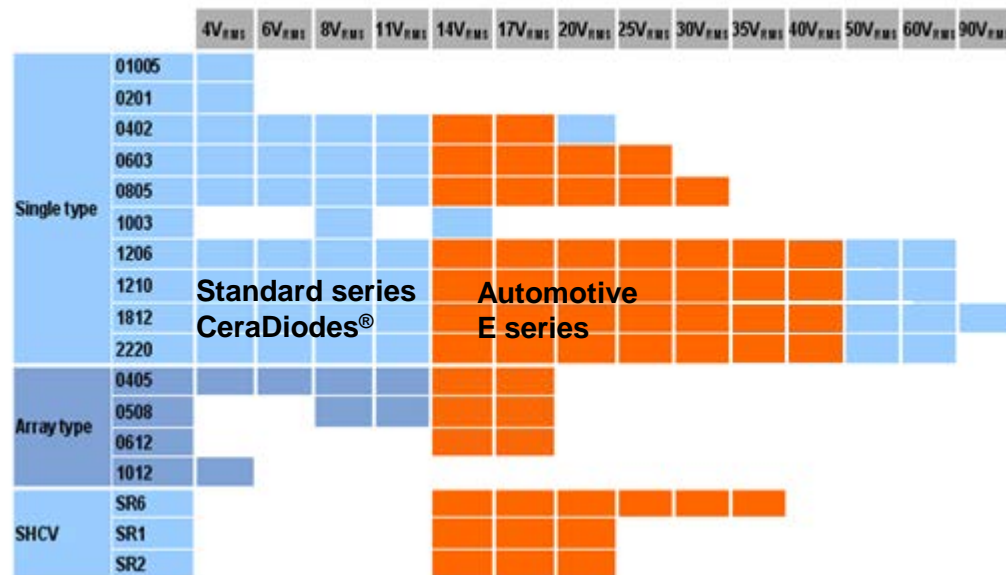


Single chip

Arrays

SHCV types

Temperature derating



CeraDiodes® & Arrays
Operating temp. -40°C/+85°C
or -40°C/+125°C

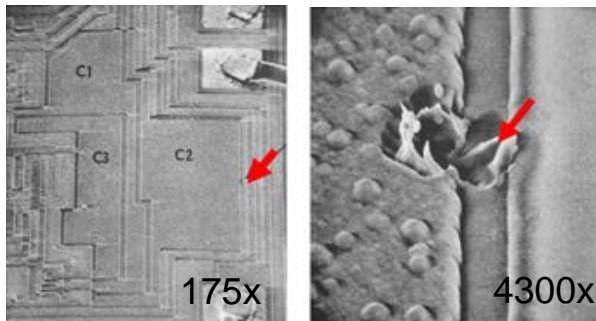
Automotive E series
acc. to AEC-Q200
Operating temp. -55°C/+150 °C

MLV standard series
Operating temp. -40°C/+85°C
or -55°C/+125°C

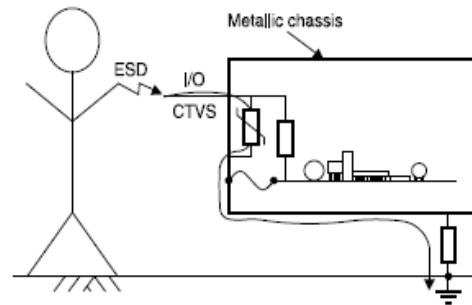
Electrostatic discharge (ESD) events

Electrostatic discharge (ESD) is a fast and high voltage transient. ESD transients are frequently caused by touching a device or contact with the fingers. More than 15 kV can be charged in a human body, thus a protection device for ESD requires a high voltage withstand and a very short response time. Industrial applications and automation equipment require reasonable ESD protection (e.g. on data line interfaces). EPCOS CeraDiodes® provide cost-efficient but reliable ESD protection up to 30 kV.

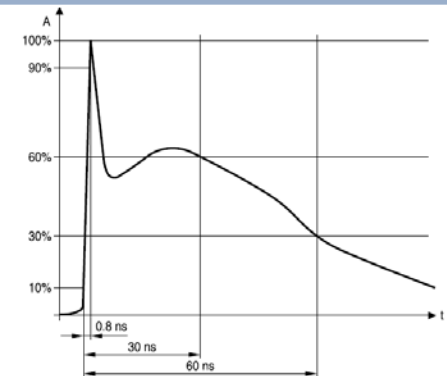
Micro destruction caused by ESD pulses



Human body model to simulate ESD events



ESD discharge current to IEC 61000-4-2



CTVS® and CeraDiode® from EPCOS fulfill at least **IEC 61000-4-2, level 4** (8 kV contact discharge, 15 kV air discharge). The response time is **<0.5 ns**.

ESD protection on interfaces: Product portfolio



CeraDiode®																													
3) Power line; 2) IEEE1394b						Analog video	DVI	HDMI 1.3 / Display port	Analog audio	Digital audio	USB 2.0	LCD dataline	UWB	IEEE 1284 parallel port	IEEE 1394 Firewire 400/800	Ethernet 10/100/1.000/fast	Serial RS-232 / RS-485	CANopen	UDF	WiFiMax 802.11	SATA	Memory card, SIM card	Bluetooth	ISDN	xDSL modem	WLAN 802.11 b/g	Key button, Push buttons, PS/2		
Product series	EIA case size	Type	Working voltage [V]	Capacitance 1) [pF]	Semi-diode package																								
Standard <single>	0201	CDS1C05GTH1	5.5	7.0 (typ.)	-				X																				
	0201	CDS1C05GTA1	5.5	15.0 (typ.)	-				X							X									X				
	0402	CDS2C05GTA	5.6	180.0 (typ.)	SOD-723				X							X									X				
		CDS2C15GTA	15.0	47.0 (typ.)				X	X ³⁾					X ³⁾		X								X					
	0603	CDS3C05GTA	5.6	470.0 (typ.)	SOD-523				X							X								X					
		CDS3C09GTA	9.0	220.0 (typ.)					X							X								X					
		CDS3C15GTA	15.0	160.0 (typ.)					X	X ³⁾					X ³⁾	X							X			X			
CDS3C20GTA		20.0	56.0 (typ.)					X							X							X	X		X				
1003	CDS4C12GTA	12.0	82.0 (typ.)	SOD-323			X	X ³⁾						X ³⁾	X							X			X				
Standard <array>	0508	CDA4C20GTA	22.0	33.0 (typ.)	-				X	X					X									X					
	0612	CDA5C20GTA	22.0	56.0 (typ.)	-				X	X					X								X	X		X			
High-speed <single>	0201	CDS1C05GTH2	5.5	3.0 (typ.)	-	X			X	X	X	X	X	X	X	X	X					X	X	X	X	X	X	X	
	0402	CDS2C05HDMI2	5.6	0.9 (max.)	SOD-723		X	X	X	X	X	X	X	X ²⁾	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
		CDS2C15GTH	15.0	15.0 (max.)			X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
		CDS2C20GTH	20	13.0 (max.)			X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
	0603	CDS3C05HDMI1	5.6	0.9 (max.)	SOD-523		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
		CDS3C16GTH	16.0	5.0 (max.)			X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
		CDS3C30GTH	30.0	15.0 (max.)			X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
1003	CDS4C16GTH	16.0	15.0 (max.)	SOD-323	X			X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		
High-speed <array>	0506	CDA3C05GTH	5.6	3.5 (max.)	SOT-666	X			X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
	0508	CDA4C16GTH	16.0	15.0 (max.)	-	X			X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
	0612	CDA5C16GTH	16.0	5.0 (max.)	-	X			X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
	1012	CDA6C05GTH	5.6	10.0 (max.)	SOT-23 6L	X			X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	

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

Application examples: Medical devices

CeraDiode, 0201 3 pF

- Ordering code: B72440C0050H260
- Description: CDS1C05GTH2
- Capacitance @ 1 MHz: 3 pF
- Working voltage $V_{DC,max}$: 5.5 V
- $V_{BR,min}$ @ 1 mA = 20 V
- V_{clamp} @ 1 A = 66 V
- Leakage current @ 3 V $\leq 0.1 \mu A$

CeraDiode, 0201 7 pF

- Ordering code: B72440C0050H160
- Description: CDS1C05GTH1
- Capacitance @ 1 MHz: 7 pF
- Working voltage $V_{DC,max}$: 5.5 V
- $V_{BR,min}$ @ 1 mA = 17 V
- V_{clamp} @ 1 A = 33 V
- Leakage current @ 3 V $\leq 0.1 \mu A$

CeraDiode, 0201 15 pF

- Ordering code : B72440C0050A160
- Description: CDS1C05GTA1
- Capacitance @ 1 MHz: 15 pF
- Working voltage $V_{DC,max}$: 5.5 V
- $V_{BR,min}$ @ 1 mA = 11 V
- V_{clamp} @ 1 A = 22 V
- Leakage current @ 3 V $\leq 0.1 \mu A$

Reliable ESD protection up to 15 kV air discharge, acc. to IEC 61000-4-2.

Blood glucose meter

- Sensor port
- Data port (RS-232, IrDA(s), RF, USB)
- Calibration port
- MCU

Hearing aids

- CeraDiodes® in support of a mechanical ESD protection
- Failure mode (reset) can be avoided.
- Low leakage current extends the life time of the battery.

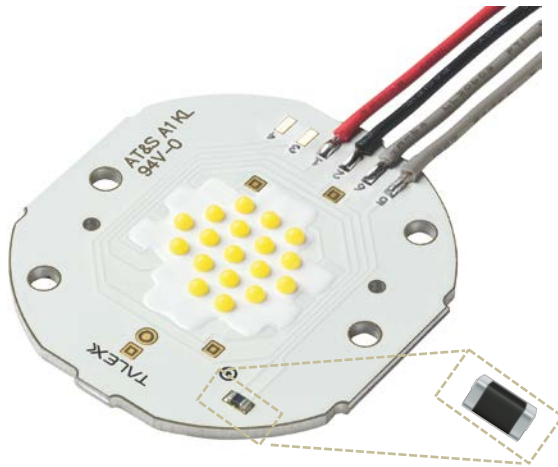
Wearable devices

- Key button 2 x
- SIM 3 x
- USB 3 x
- Audio 4 x
- Health interface 12 x

Application example: LED

LEDs are very ESD sensitive with a typical protection level of 100 to 500 V. EPCOS offers protection solutions for level 2 (L2) where the CeraDiode® is on the LED flash module and/ or the light engine.

Example



Protection concept: 1 CeraDiode® per LED string

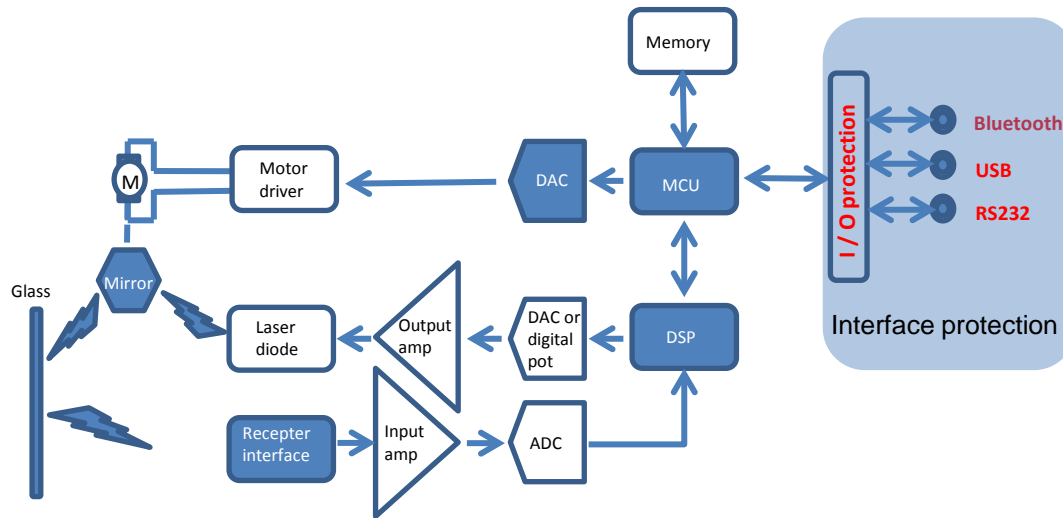
Number of LEDs per system	Type	EIA case size	Working voltage [V]	Min. breakdown voltage (@1mA) [V]	Max. clamping voltage (@ 1 A, 8/20 μs) [V]
1	CDS1C04GTB	0201	4	9	33
1	CDS2C04GTB	0402	4	6	20
2 ... 3	CDS2C12GTB	0402	12	14,5	40
4	CDS2C18GTB	0402	18	24	66
5 ... 6	CDS2C20GTB	0402	20	30	80
7 ... 10	CDS2C36GTB	0402	36	45	130
11 ... 14	CDS2C48GTB	0402	48	65	200
15 ... 20	CDS2C70GTB	0402	70	100	290
21 ... 26	CDS2C90GTB	0402	90	125	350
27 ... 48	CDS2C200GTB	0402	200	230	600

Features

- Broad portfolio for protection of 1 to 48 LEDs available (low to high voltage)
- High ESD robustness up to 15 kV contact discharge

Application example: Bar code scanner

ESD can occur when touching a bar code scanner. The unwanted pulse may damage the components inside and thus its function. Multilayer ESD protection devices are used to protect ESD sensitive components preventing damage to the board.



Recommended parts

EIA case size	Type	Working voltage [V]	Max. capacitance (@ 1 MHz, 1 V) [pF]
0402	CDS2C05HDMI2	5.6	0.9
	CDS2C15GTH	15.0	15.0
	CDS2C16GTH	16.0	3.0
0603	CDS3C05HDMI1	5.6	0.9
	CDS3C16GTH	16.0	5.0
	CDS3C30GTH	30.0	15.0

Features

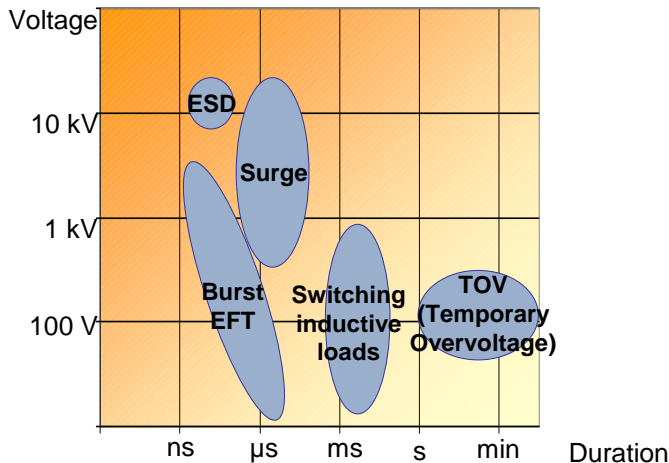
- Ultra-low DC leakage current
- Low device capacitance
- Small package

CeraDiode® provide reliable ESD performance in smaller packages than TVS!

Protection against high energy transients

Industrial applications and automation equipment require protection against various transients, such as ESD, Electrical Fast Transients (EFT) or burst, but also against high energy transients, so called surges. Surges are caused by switching of large capacitive or inductive loads. EPCOS CTVS® surge protection series can be applied for such a variety of transients. They provide protection against high surge currents up to 5.000 A acc. to IEC 61000-4-5. Due to the high energy level of these transients, EIA case sizes 0805... 2220 are recommended.

Pulse voltage/ duration



Applications

- Automation engineering
- Industrial PCs and monitoring systems
- Metering systems
- PoE (Power over Ethernet)
- Data capturing, e.g. barcode reader
- Comfort, control and security systems, e.g. heat and/ or smoke detectors
- Monitoring systems
- Medical equipment
- White goods
- Power supply
- LED

Surge (high energy transients) IEC 61000-4-5

Transient length up to 700 μ s
Surge current up to 5000 A
Voltage amplitude up to 4 kV

Burst/ EFT (electrical fast transient) IEC 61000-4-4

Transient length up to 50 ns
Current protection up to 10 A
Voltage amplitude up to 4 kV

Switching inductive loads

Transient length up to 10 ms
Current protection up to 10 A
Voltage amplitude up to 600 V

TOV (temporary overvoltage)

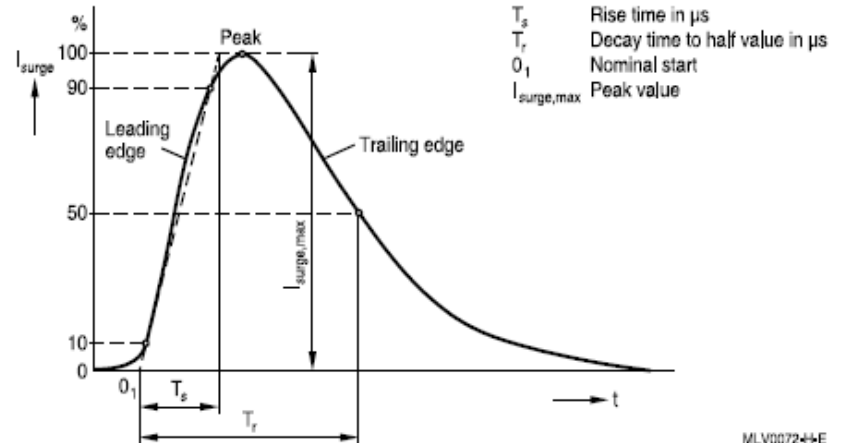
Transient length up to hours
Voltage amplitude up to 360 V

Surge current protection

Pulse energy

- Very high current flows caused by surge voltages or spikes, like lightning coupled over network are referred as surge currents. Such surge currents deposit much more energy than ESD pulses and thus requires much higher energy absorption capability of the protection device, usually in the range of joules.
- For CTVS® the max. surge current $I_{\text{surge, max}}$ is specified acc. to IEC 60060-01 (within IEC 61000-4-5).

Waveform



Waveform acc. to IEC 60060-01:
 $I_{\text{surge, max}}$ for CTVS® is specified for T_s / T_r ratio of 8/20 μs

MLV00724+E

Additional features of MLV surge protection series

- High surge current protection up to 5.000 A
- Surge load capability up 4 kV for 8/20 μs acc. to IEC 61000-4-5
- Surge voltage capability up to 2 kV for 10/700 μs acc. to IEC 61000-4-5
- High energy handling capability
- Max. energy absorption up to 15 J
- No derating up to +125 °C
- Stable protection level
- Available in EIA case sizes 0805... 2220

Surge current protection: Product portfolio

Surge protection series (acc. to IEC 61000-4-5)

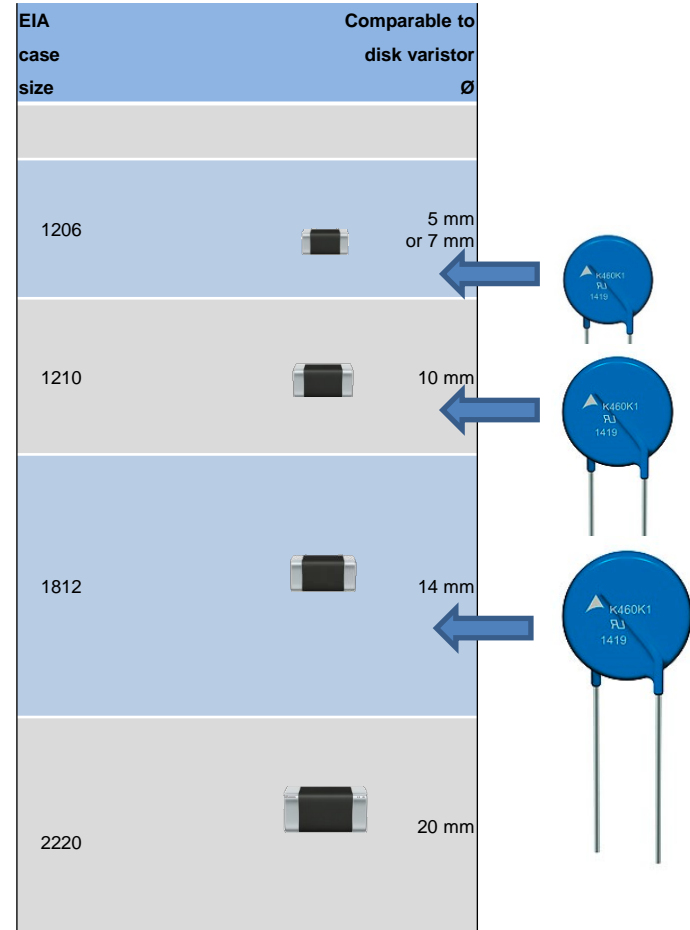
NEW

Type	EIA case size	V _{DC, max} [V]	V _v @ 1mA [V]	I _{surge, max} 8/20 μs [A]	W _{max} 2 ms [mJ]
CT0805K30G	0805	38	47	80	300
CT0805K35G	0805	45	47	80	300
CT1206K30G	1206	38	47	200	1.100
CT1206K35G	1206	45	56	100	400
CT1206K40G	1206	56	68	100	500
CT1206K50G	1206	65	82	100	600
CT1206K60G	1206	85	100	100	700
CT1210K30G	1210	38	47	300	2.000
CT1210K35G	1210	45	56	250	2.000
CT1210K40G	1210	56	68	250	2.300
CT1210K50G	1210	65	82	200	1.600
CT1210K60G	1210	85	100	200	2.000
CT1812K30G	1812	38	47	800	4.200
CT1812K35G	1812	35	56	500	4.000
CT1812K40G	1812	40	68	500	4.800
CT1812K50G	1812	65	82	200	4.500
CT1812K60G	1812	85	100	400	5.800
CT1812K75TELEG2	1812	100	120	400 ²⁾	2.500
CT1812S95AG2	1812	125	165	250	2.800
CT1812K130G2	1812	170	205	250	3.500
CT1812K115TELEG2	1812	150	180	250 ²⁾	3.200
CT2220K30G	2220	38	47	1.200	12.000
CT2220K30E2G	2220	38	47	5.000	15.000
CT2220K40G	2220	56	68	1.000	9.000
CT2220K50G	2220	65	82	800	5.600
CT2220K50E2G	2220	65	82	4.500	15.000
CT2220S50E3G	2220	63	82	4.500	15.000
CT2220K60G	2220	85	100	800	6.800

NEW

low clamping

²⁾ I_{surge, max} for 10/700 μs = 45 A (acc. to IEC 61000-4-5)



For the selection of suitable CTVS® for surge current refer to the I_{surge, max} ratings.

Application example: Cabled fire detectors

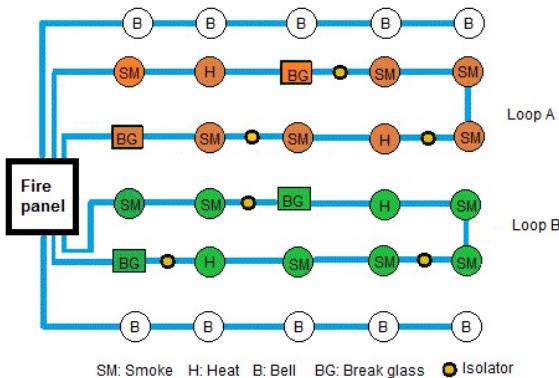
Fire detectors are obligatory in many countries. Modern and intelligent fire security systems with a working voltage of 30 V DC to 40V (from power connection 230 V) have up to 200 smoke detectors in a loop. Therefore components with a low leakage current are required.



Recommended SMD varistor parts

Type	EIA case size	$V_{RMS,max}$ [V]	V_{DC} [V]	$V_V @ 1\text{ mA}$ [V]	$V_{clamp,max}$ [V]	$I_{surge,max}$ [A]	$W_{max} (2\text{ ms})$ [mJ]	$I_{leak} @ V_{RMS,max}$ [μA]
CT0805K35G	0805	35	45	47	77	80	300	1 max
CT1206K40G	1206	40	56	68	110	100	500	1 max
CT1812K60G	1812	60	85	100	165	400	5,800	1 max
CT2220K40G	2220	40	56	68	110	1,000	9,000	1 max

UL available !



Detection system

- Motion/ vibration detector
- Opening detector
- Breakage of glass detector
- Smoke detector
- Heat detector
- Water detector

Sender

- Emergency call sender
- Assault sender

Communication modules

- ISDN module
- GSM module
- IP module, Info module

EPCOS CTVS® are reliable solutions with very low leakage current.

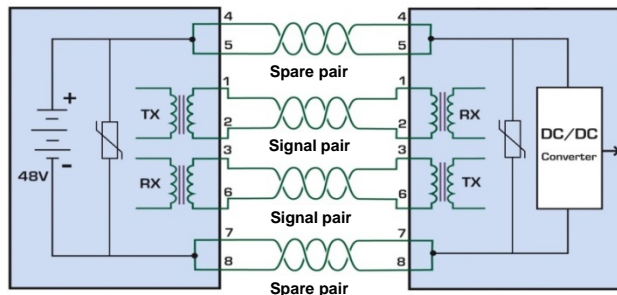
Application example: Power over Ethernet (PoE)

Power over Ethernet (PoE) does use the same copper cable for supply 48 V DC and the Ethernet data signal. This is an existing possibility how to transport data and supply voltage to Ethernet device by already existing net of cabling for computer networks (10 Mbit/s and 100 Mbit/s).

This standard is authorized as IEEE 802.3af.

Power sourcing equipment (PSE)

Powered device (PD)




2 types of IEEE 802.3

PoE 48 V; 350 mA; 15.4 W

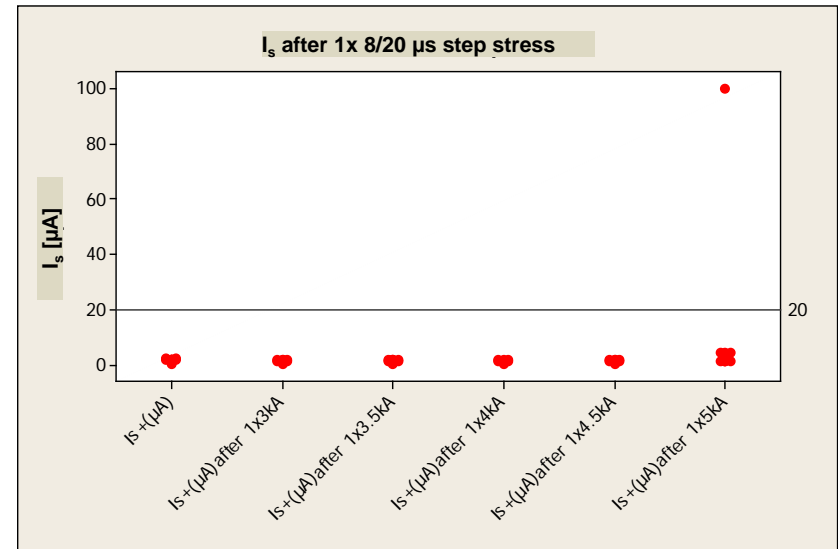
PoE plus 48 V; 600 mA; 25.5 W

Recommended parts

Type		EIA case size	V _{DC} [V]	V _V @ mA [V]	V _{clamp, max} [V] @ 10A	I _{surge, max} [A]	P _{diss, max} [mW]
CT2220K50G		2220	65	82	135	1 x 800	20
CT2220K50E2G		2220	65	82	135	1 x 4.500	20
CT2220S50E3G		2220	63	77.5	115	1 x 4.500	20

NEW

8/20 μs step stress test

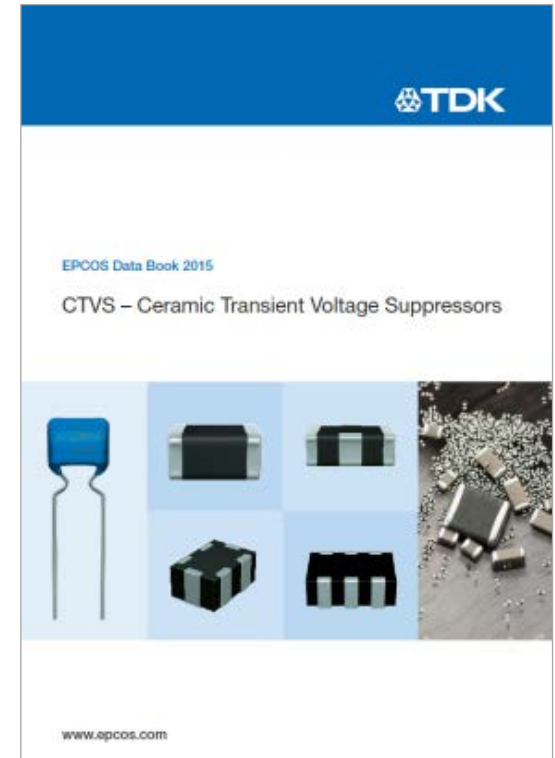


High level of reliability: Increased 8/20 μs EoL for high fail-safe level. 100% passed ✓

CTVS[®] multilayer varistors: Design support

Sample kits

- **Ceramic Transient Voltage Suppressors
CTVS[®] Multilayer Varistors for Surge Protection**
Ordering no. B72499H9999K199
- **Ceramic Transient Voltage Suppressors
CTVS[®] Multilayer Varistors and CeraDiodes[®] for General Use**
Ordering no. B72499S9999K199
- **Ceramic Transient Voltage Suppressors
CTVS[®] Multilayer Varistors and CeraDiodes[®] for Industrial Applications**
Ordering no. B72499I9999K199
- **Ceramic Transient Voltage Suppressors
E Series of Multilayer Varistors in Automotive Applications**
Ordering no. B72499A9999K199



Data book

- **CTVS[®] - Ceramic Transient Voltage Suppressors**
Ordering no. EPC:62023-7600

Application support

Detailed technical information can be found in the TDK product center:
<https://product.tdk.com/info/en/index.html>

Annex

CTVS[®] multilayer varistors: Product series at a glance

- **Multilayer varistors (MLV)** are components designed for circuit protection in automotive, industrial, communication and consumer electronics.
 - **Standard** For general protection purpose
 - **Automotive E series** AEC-Q200 qualified
 - **Low clamping voltage** For sensitive IC protection
 - **Surge protection** For high energies
 - **High-speed** For data line protection

- **CeraDiode[®]** is a specific product for ESD protection of data, audio and video lines, analog and digital interfaces, ICs and I/O ports as alternative to semiconductor-based devices such as TVS diodes.
 - **Standard** For general protection purpose
 - **High-speed** For data line protection
 - **LED** For protection of LED systems

- **ESD/EMI filters** present two functions in one component, ESD protection and EMI filtering. They protect audio lines (microphone and speaker) of a mobile phone from radio frequency noise generated by the phone itself.

- **Leaded transient voltage/ RFI suppressors (SHCV)** are leaded components consisting of a multilayer varistor and multilayer ceramic capacitor for combined protection against transients and RFI suppression in a single component.



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