CTVS®
Multilayer Varistors for Automotive

Automotive E series for ESD and transient protection
## CTVS* multilayer varistors: Contents

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* Ceramic Transient Voltage Suppressors
CTVS multilayer varistors: Product range

EPCOS CTVS (Ceramic Transient Voltage Suppressors) components feature excellent characteristics for a wide range of applications. ESD (Electro Static Discharge) and surge pulse protection is the key functionality.
CTVS multilayer varistors: just everywhere…

- High data rates for wireless communications
- High system integration in applications sensitive to ESD
- High safety and reliability, especially for automotive
- Reliable surge protection for telecom and industrial devices

ESD protection of phones, tablets & LEDs
Case size EIA 01005 … 0402

ESD/EMI protection of automotive ECUs
Case size EIA 01005 … 2220

Surge protection of telecom & industrial
Case size EIA 1812 … 2220
## CTVS multilayer varistors: Application fields

### Automotive

<table>
<thead>
<tr>
<th>Data bus systems</th>
<th>Infotainment</th>
<th>Safety</th>
<th>Body and comfort</th>
<th>Battery</th>
</tr>
</thead>
<tbody>
<tr>
<td>CAN bus, LIN, MOST</td>
<td>Mobile phone modules</td>
<td>Airbags</td>
<td>Air-conditioning</td>
<td>Load dump/jump-start protection</td>
</tr>
<tr>
<td>Ethernet, FlexRay</td>
<td>Navigation</td>
<td>ABS/ESP</td>
<td>Lighting (LED)</td>
<td>Battery control units</td>
</tr>
<tr>
<td>Audio systems</td>
<td></td>
<td></td>
<td></td>
<td>Electric drives (e.g. wipers, windows)</td>
</tr>
</tbody>
</table>

The range of CTVS components suitable for automotive applications includes the product series multilayer varistors (automotive E series) and leaded transient voltage/RFI suppressors (SHCV series).

- ESD protection according to ISO 10605/IEC 61000-4-2
- Load dump, jump start capability
- Reliability based on AEC-Q200, Rev. D

### Communication

<table>
<thead>
<tr>
<th>Mobile applications</th>
<th>Base stations</th>
<th>Interfaces</th>
<th>Reception tuners</th>
</tr>
</thead>
<tbody>
<tr>
<td>Smartphones, PDAs</td>
<td>Secondary surge protection</td>
<td>I/O and power keys</td>
<td>TV, radio, DAB, DVBT</td>
</tr>
<tr>
<td>Tablet PCs</td>
<td></td>
<td>Chargers, USB, HDMI</td>
<td>GPS, satellite radio</td>
</tr>
</tbody>
</table>

Due to their small size and high robustness, multilayer varistors, ESD/EMI filters and CeraDiode®s are being used e.g. for ESD protection in mobile devices.

- ESD protection to IEC 61000-4-2, level 4
- Ultra-low DC leakage current
- Low device capacitance

### Industrial

<table>
<thead>
<tr>
<th>Lighting</th>
<th>Building applications</th>
<th>Automation</th>
<th>Medical</th>
</tr>
</thead>
<tbody>
<tr>
<td>LED lighting</td>
<td>Smoke and fire detectors</td>
<td>Communication interfaces (e.g., USB 2.0, CAN bus, Ethernet)</td>
<td>Hearing aids</td>
</tr>
<tr>
<td>Control and security systems</td>
<td>Serial bus interfaces (e.g., RS-232)</td>
<td>Human interfaces (e.g., buttons, touchpads, PS/2)</td>
<td>Blood glucose meter</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Power supply units</td>
<td></td>
</tr>
</tbody>
</table>

Industrial electronics are sensitive to transients caused by both ESD and overvoltage. ESD can be caused by the human body (e.g., during handling stages) but also by the machine itself. Typical overvoltage transients are surge, burst, cable discharges and so-called electrical fast transients (EFT) often caused by switching of inductive loads.
CTVS multilayer varistors: Portfolio

Shapes 150 °C

Features
- Case sizes EIA 0402 … 2220 + SHCV
- Voltage range 14 … 60V
- Qualification according to AEC-Q200 (E series)
- ESD protection acc. to IEC61000-4-2
- Specified load dump & jump start
- Low leakage current
- High operating temperature up to 150 °C
- No temperature derating up to 150 °C
- High mechanical robustness
- Nickel barrier termination for lead-free soldering
- ROHS-compliant and 100% Pb-free

Temperature derating

CTVS® Multilayer Varistors for Automotive - E series
CTVS multilayer varistors: Functionality

Multilayer varistors or so-called Ceramic Transient Voltage Suppressors (CTVS) are voltage-dependent resistors with a symmetrical V/I characteristic curve whose resistance decreases with increasing voltage.

Because of their application as overvoltage protection devices, they are also often referred to as TVS (Transient Voltage Suppressors) on silicon basis. Connected in parallel with the electronic device or circuit that is to be guarded, CTVS threshold value and thus prevent any further rise in the transient overvoltage.

Circuit diagram symbol

Protection level (V/I characteristic curve)
● The chip of a CTVS multilayer consists of a stack of alternating ceramic/electrode layers. The thickness of the ceramic layers affects the protection level.

● In the active volume of the ceramic chip there are a number of internal electrode layers with an overlapping area affecting the pulse absorption capability. The internal electrodes are connected to the terminals or external electrodes.

● The nickel barrier termination is suitable for lead-free reflow soldering.
CTVS multilayer varistors: V/I characteristic curve

CTVS are operated in one of two modes. These modes concern two different segments of the CTVS V/I curve which lies within a well defined tolerance band:

- **“High-resistance” mode (<1 mA)**
  If the circuit is operated at normal operating voltage the CTVS has to be highly resistive. Here, the circuit designers may generally want to know about the largest possible leakage current at the given operating voltage. Therefore, the lower limit of the tolerance band is shown.

- **“Low-resistance” mode (>1 mA)**
  In an overvoltage event the CTVS has to be highly conductive. Here, the circuit designer’s primary concern is about the worst-case voltage drop across the CTVS. The upper limit of the tolerance band is shown. The clamping voltage $V_{\text{clamp}}$ is the voltage across the CTVS in an overvoltage event.

Example

CT0805K14G (max. AC operating voltage of $V_{\text{RMS, max}} = 14$ V and a varistor tolerance K of ±10%)

The CTVS V/I characteristic curve shows the mean value of the tolerance band between the limits indicated by dashed lines. The mean at 1 mA represents the varistor voltage ($V_V = V_{BR}$), in this case 22 V. The tolerance K ±10% refers to this value, so at this point the tolerance band ranges from 19.8 to 24.2 V (region). For the CT0805K14G MLV, a maximum permissible operating voltage of 18 $V_{\text{DC}}$ is specified. Depending on the actual value of the MLV in the tolerance band, you can derive a leakage current between $6 \times 10^{-6}$ A and $2 \times 10^{-4}$ A at room temperature (region) as well as an increase of the voltage across the MLV to between 65 V and 80 V (region) assuming a surge current of 100 A.
CTVS multilayer varistors: Transient environment

### Common automotive transients and test standards

<table>
<thead>
<tr>
<th>Phenomena</th>
<th>ESD</th>
<th>BURST/ EFT (electrical fast transients)</th>
<th>Surge</th>
<th>Surge</th>
<th>Load dump</th>
<th>Jump start</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cause</td>
<td>Electrostatic discharge</td>
<td>Switching processes</td>
<td>Lighting</td>
<td>Switching of inductive loads</td>
<td>Disconnected battery</td>
<td>Use case</td>
</tr>
<tr>
<td>Test voltage</td>
<td>up to 15 kV</td>
<td>up to 4 kV</td>
<td>up to 4 kV</td>
<td>up to 4 kV</td>
<td>up to 600 V</td>
<td>up to 36V</td>
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<tr>
<td>Test pulse duration</td>
<td>ns</td>
<td>ns (single pulse)</td>
<td>μs</td>
<td>ms</td>
<td>ms</td>
<td>s … min</td>
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<tr>
<td>Standard</td>
<td>IEC 61000-4-2</td>
<td>IEC 61000-4-4</td>
<td>IEC 61000-4-5</td>
<td>IEC 61000-4-5</td>
<td>ISO 16750-2</td>
<td>ISO 16750-2</td>
</tr>
</tbody>
</table>

### Peak voltage/ pulse duration

- **ESD**: Voltage up to 15 kV, Pulse duration up to 4 ns
- **Surge**: Voltage up to 4 kV, Pulse duration up to 4 μs
- **Load dump**: Voltage up to 600 V, Pulse duration up to 4 ms
- **Jump start**: Voltage up to 36 V, Pulse duration up to 36 s

### Protection principle

- **Transient current**
- **Clamp voltage**
- **Protected device**
CTVS multilayer varistors: Package vs. TVS

CTVS multilayer varistor

No leads on the component
- Low parasitic inductance
- No influence on clamping voltage
- Less space consumption on PCB

Semiconductor diode (TVS)

Long leads on the component
- Causes a high parasitic inductance
- Influences the clamping voltage level at very fast transients (e.g. first peak of an ESD spike)
- Higher space consumption on PCB
CTVS multilayer varistors: Construction vs. TVS

CTVS multilayer varistor

- Ceramic body
- Internal electrodes
- External electrodes
- B$_2$O$_3$ phase
- ZnO
- Internal electrode
- Energy absorption takes place inside the ZnO grains and is provided nearly over the entire volume of the component.

Semiconductor diode (TVS)

- Epoxy molding
- Lead frame
- Silicon chip
- Plating and solder
- One "P-N junction"
- Energy absorption only in the relative small area of the pn junction possible.

Millions of “P-N junctions”

Energy absorption takes place inside the ZnO grains and is provided nearly over the entire volume of the component.
CTVS multilayer varistors: V/I characteristics vs. TVS

CTVS multilayer varistor

Semiconductor diode (TVS)

Bidirectional

Unidirectional
Tests acc. to IEC61000-4-2 method

Y: Mean value of the clamping voltage between 30 and 100 ns, calculated by

\[ Y = \frac{\int_{30\text{ns}}^{100\text{ns}} x \, dx}{n} \]

Multilayer varistors can significantly clamp the ESD peak pulse lower than TVS diodes, especially for high voltage >> 6 kV.
CTVS multilayer varistors: Signal integrity vs. TVS

**CTVS multilayer varistor**

CTVS MLVs have typically a higher clamping voltage
- The V/I curve is steep
- The V/I curve does not touch the RF signal
- No signal distortion

**Semiconductor diode (TVS)**

TVS have typically a lower clamping voltage
- The V/I curve is less steep
- The diode does clip the RF signal
- Error in signal transmission

CTVS ML varistors offer a low non-linearity which leads to a higher signal integrity.
CTVS multilayer varistors: RF filtering vs. TVS

DPI method (Direct Power Injection): Continuous RF disturbance power (from 1 MHz to 1 GHz, yellow line) delivered by a generator is fed into a pin of a test board. By coupling out of interference power, a characterization of the immunity of the integrated circuit is possible. Due to impedance mismatch, most of the RF power delivered by the generator is reflected towards the source and only a small amount enters the PCB and IC under test (red line).

CTVS multilayer varistor

By putting a CTVS MLV on the PCB, the coupling out signal shows no affect due to the varistor.

The MLV have an excellent immunity to RF disturbances. MLVs are working like an EMC filter (Electro Magnetic Compatibility) by using the internal capacitance for RFI suppression and RF filtering.

Semiconductor diode (TVS)

After putting a TVS diode on the PCB, the coupling out signal is affected by the TVS.

The semiconductor diode has a bad immunity to RF disturbances.
CTVS ML varistors: Advantages vs. TVS diodes

● Surge current handling capability
The interleaved electrode arrangement of multilayer ceramic devices allows surge currents of over 1 kA to be handled, whereas semiconductors can often withstand only a few amperes. This characteristic enables multilayer products to be used not only for protection against ESD, but also for dealing with surge loads of much higher energy levels to IEC 61000-4-5.

● Bipolar characteristics
ESD can occur with any polarity, which poses no problems for multilayer ceramic products with their symmetrical protection characteristics, whereas two components are often required to achieve the required bipolar characteristic with semiconductor suppressor diodes.

● Operating temperatures
CTVS products can be subjected to full load at temperatures of up to 150 °C, whereas the load capacity of semiconductor suppressor diodes derates from temperatures of 25 °C upwards and is frequently reduced to 25% of the rated value at 125 °C.

● EIA case size
The ceramic material for CTVS serves as an insulator on the exterior surfaces; the terminal electrodes are available as direct contact surfaces. By comparison, semiconductor components most times require a casing. This makes them correspondingly bulky and they require more mounting space.

● Response time
Due to their extremely low parasitic inductances, CTVS are fast enough to handle ESD pulses with very short rise times. One can find similar results for the die of the silicon used in semiconductor protective devices like suppressor diodes. However, when the die is mounted in its package, the response time often increases to values >1 ns due to the series inductance of its package.
CTVS multilayer varistors: Automotive E series

- No temperature derating up to 150 °C
- Very high life time robustness up to 150 °C
- Voltage range 14 … 40 V with low leakage current (typ. <1 µA)
- Reliable ESD protection up to 30 kV acc. to IEC 61000-4-2 (8 kV contact, 15 kV air)
- Broad product range with case size EIA 0402 … 2220
- 100% lead-free
- High electrical/ mechanical robustness over time
- Electrical characteristics are stable against repeated ESD (level 4 of IEC 61000-4-2), and high-energy transient pulses (jump start and load dump protection according to ISO 16750-2)
- Qualification based on AEC-Q200 and with extended stress tests

<table>
<thead>
<tr>
<th>Automotive series</th>
<th>Application</th>
<th>Case size [EIA]</th>
<th>$V_{DC, \text{max}}$ [V]</th>
<th>Capacitance [pF]</th>
</tr>
</thead>
<tbody>
<tr>
<td>E series</td>
<td>ESD protection for bus systems</td>
<td>0402 … 0805</td>
<td>14 … 40</td>
<td>10 … 10000</td>
</tr>
<tr>
<td></td>
<td>Load dump &amp; jump start protection</td>
<td>0805 … 2220</td>
<td>16 … 34</td>
<td>100 … 15000</td>
</tr>
<tr>
<td>ESD/ EMI filter array (2-fold MCV array)</td>
<td>EMI filtering &amp; ESD protection</td>
<td>0508</td>
<td>12 … 16</td>
<td>10 … 100</td>
</tr>
</tbody>
</table>
CTVS ML varistors: Automotive E series applications

CTVS multilayer varistors for automotive applications are generally used for:

- ESD protection (e.g. acc. to ISO 10605/IEC 61000-4-2) for bus interfaces (e.g. CAN, LIN, MOST, Ethernet, FlexRay)
- Protection against high-energy transients (e.g. jump start and load dump protection) acc. to ISO 7637-2 and ISO 16750-2) occurring at e.g. battery lines.
# CTVS ML varistors: E series application examples 1/3

<table>
<thead>
<tr>
<th>Convenience</th>
<th>Top column module (TCM)</th>
<th>ESD protection for CAN bus interfaces</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td><strong>Type</strong></td>
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<tr>
<td></td>
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<td></td>
<td>CT0603K25G</td>
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<td></td>
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<td>CT0603K17LCG</td>
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<tr>
<td></td>
<td></td>
<td>CT0603S20ACCG</td>
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</table>

<table>
<thead>
<tr>
<th>Convenience</th>
<th>Body controller</th>
<th>ESD protection for CAN bus interfaces</th>
</tr>
</thead>
<tbody>
<tr>
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<td><strong>Type</strong></td>
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<td></td>
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</table>

<table>
<thead>
<tr>
<th>Convenience</th>
<th>Seat actuator and window lift</th>
<th>Protection against high-energy transients (inductive loads)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td><strong>Type</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td>CT1210S14BAUTOG</td>
</tr>
</tbody>
</table>
# CTVS ML varistors: E series application examples 2/3

## Infotainment

ESD protection for CAN bus interfaces and protection against high-energy transients (battery lines)

<table>
<thead>
<tr>
<th>Type</th>
<th>Ordering code</th>
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</thead>
<tbody>
<tr>
<td>CT0603V150RFG</td>
<td>B72500E7151V060</td>
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<tr>
<td>CT2220S14BAUTOE2G2</td>
<td>B72540E3140S272</td>
</tr>
</tbody>
</table>

## Rain & light sensor

ESD protection for CAN bus interfaces

<table>
<thead>
<tr>
<th>Type</th>
<th>Ordering code</th>
</tr>
</thead>
<tbody>
<tr>
<td>CT0402L14G</td>
<td>B72590E0140L060</td>
</tr>
<tr>
<td>CT0402S14AHSG</td>
<td>B72590E8140S160</td>
</tr>
</tbody>
</table>

## Engine control unit

ESD protection for CAN bus interfaces and protection against high-energy transients (battery lines)

<table>
<thead>
<tr>
<th>Type</th>
<th>Ordering code</th>
</tr>
</thead>
<tbody>
<tr>
<td>CT0603L25HSG</td>
<td>B72500E8250L060</td>
</tr>
<tr>
<td>CT2220S14BAUTOE2G2</td>
<td>B72540E3140S272</td>
</tr>
</tbody>
</table>
# CTVS ML varistors: E series application examples 3/3

## Headlight

### ESD protection for CAN bus interfaces

<table>
<thead>
<tr>
<th>Type</th>
<th>Ordering code</th>
</tr>
</thead>
<tbody>
<tr>
<td>CT0603K20G</td>
<td>B72500E0200K060</td>
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<tr>
<td>CT0603K25G</td>
<td>B72500E0250K060</td>
</tr>
<tr>
<td>CT0603S20ACCG</td>
<td>B72500E5200S160</td>
</tr>
</tbody>
</table>

## Airbag

### ESD protection for CAN bus interfaces & protection against high-energy transients (inductive loads & battery lines)

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<thead>
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<th>Ordering code</th>
</tr>
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<tbody>
<tr>
<td>CT0603L25HSG</td>
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<tr>
<td>CT0805K25G</td>
<td>B72510E0250K062</td>
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<tr>
<td>CT1210K20AUTOG</td>
<td>B72530E1200K062</td>
</tr>
</tbody>
</table>

## Parking assistance

### ESD protection for CAN bus interfaces & protection against high-energy transients (inductive loads)

<table>
<thead>
<tr>
<th>Type</th>
<th>Ordering code</th>
</tr>
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<tbody>
<tr>
<td>CT0603K17LCG</td>
<td>B72500E2170K060</td>
</tr>
<tr>
<td>CT0805S14BAUTOG</td>
<td>B72510E1140S262</td>
</tr>
<tr>
<td>CT1210K20AUTOG</td>
<td>B72530E1200K062</td>
</tr>
</tbody>
</table>
Varistors: ESD protection for bus interfaces - basics

Electrostatic discharge (ESD) are fast and high voltage transients. 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 high voltage withstand and very short response time.

<table>
<thead>
<tr>
<th>Micro destruction caused by ESD pulses</th>
<th>Human body model to simulate ESD events</th>
<th>ESD discharge current to IEC 61000-4-2</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="175X" alt="Image" /></td>
<td><img src="4300X" alt="Image" /></td>
<td>![Image](ESD discharge current)</td>
</tr>
</tbody>
</table>

EPCOS CTVS multilayer varistors E series for automotive provide highly reliable ESD protection up to 30 kV according to IEC 61000-4-2, level 4 (8 kV contact, 15 kV air). The response time is <0.5 ns.
Varistors: ESD protection for bus interfaces/ data lines

ESD protection of bus interfaces/ data line  |  ESD pulses (acc. to IEC 61000-4-2/ ISO 10605)

Key product data
- No temperature derating up to 150 °C
- High life time robustness up to 150 °C
- Low clamping voltage
- Low leakage current <1 μA
- Reliable ESD protection up to 15 kV air discharge acc. to IEC 61000-4-2
- Bidirectional protection
- Stable protection level
- 100% lead-free
- Low parasitic inductance
- Extremely fast response time <0.5 ns
- Qualification based on AEC-Q200 with extended stress tests
- PSpice simulation models available
- Test board available

Product overview

<table>
<thead>
<tr>
<th>CTVS series</th>
<th>Bus system</th>
<th>Benefit</th>
</tr>
</thead>
<tbody>
<tr>
<td>E series</td>
<td>LIN CAN B</td>
<td>Ideal cost-effective solution for low-speed buses.</td>
</tr>
<tr>
<td>High-speed series</td>
<td>CAN C</td>
<td>No signal distortion on high-speed data lines.</td>
</tr>
<tr>
<td>ESD/ EMI filter array (2-fold MCV array)</td>
<td>FlexRay Ethernet</td>
<td>Protection of 2 lines with one component. Combination of EMI filtering and ESD protection.</td>
</tr>
</tbody>
</table>
CTVS MLV for ESD protection: Selection guide

CVS multilayer varistors **E series** for automotive for different data rates:
From 20 kbit/s to 100 Mbit/s

<table>
<thead>
<tr>
<th>Type</th>
<th>Ordering code</th>
<th>Size</th>
<th>LIN</th>
<th>CAN A/B</th>
<th>CAN C</th>
<th>FlexRay</th>
<th>MOST</th>
<th>Ethernet</th>
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</table>
Protection against high-energy transients: Basics

Transients are divided into several pulses

- **Transient voltages** in automotive supply lines occur due to disconnection of inductive load, sudden interruption of currents or switching processes. These transients may damage components connected to the supply lines. Typical automotive transients are defined in ISO 7637-2.

- **Load dump** in automotive electronics refers to a sudden disconnection of the vehicle battery from the alternator while the battery is being charged (e.g. break of a battery cable). Other loads connected to the alternator will be exposed to a high voltage surge (transient voltage) in the power line in case of such a disconnection of the battery. A load dump represents the most severe transient voltage in a vehicle. It is defined in ISO 16750-2.

- **Jump start** is a method of starting a vehicle with an external starter battery. If the external battery exceeds the voltage rating of the vehicle system, the electronic components must withstand this higher jump start voltage to avoid damage. Automotive specifications often require a 24 V jump start capability for 12 V systems.

Our CTVS multilayer varistors E series for automotive provide highly reliable transient suppression according to ISO 7637-2 and ISO 16750-2.
Protection against high-transients in automotive

Central load dump protection

ISO 16750-2: Load dump pulse

Key product data

- No temperature derating up to 150 °C
- High life time robustness up to 150 °C
- Low clamping voltage
- Low leakage current <1 μA
- Reliable ESD protection up to 15 kV air discharge acc. to IEC 61000-4-2
- Bidirectional protection
- Stable protection level
- 100% lead-free
- Low parasitic inductance
- Extremely fast response time <0.5 ns
- Qualification based on AEC-Q200 with extended stress tests
- PSpice simulation models available

Test pulse A

Test pulse B

Minimum test requirement 5 pulses at intervals of 1 min.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>UA = 12 V</th>
<th>UA = 24 V</th>
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<tbody>
<tr>
<td>Us (V)</td>
<td>79 to 101</td>
<td>151 to 202</td>
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<tr>
<td>Ri (Ohm)</td>
<td>0.5 to 4</td>
<td>1 to 8</td>
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<tr>
<td>td (ms)</td>
<td>40 to 400</td>
<td>100 to 360</td>
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<tr>
<td>tr (ms)</td>
<td>10 / +0 / -5</td>
<td>10 / +0 / -5</td>
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Product overview

<table>
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<tr>
<th>Type</th>
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Protection against transient pulses: Product range

Load dump transients occur
- Cable corrosion
- Poor or loose connection
- Intentional disconnection with the engine running

Load dump specified in ISO 16750-2
A severe transient voltage, caused by disconnection of the vehicle battery from the alternator while the battery is being charged.

Test A* Pulse shape without centralized load dump suppression
Test B* Pulse shape with a centralized load dump suppression

* Previously known as test pulse 5a and 5b in ISO 7637-2, 2004

CTVS multilayer varistors E series for automotive against different transient pulses and load dump pulses up to 25 J.

<table>
<thead>
<tr>
<th>CTVS E series automotive</th>
<th>Size</th>
<th>$V_{RMS/V_{DC, \text{max}}}$ [V]</th>
<th>$I_{\text{surge, max}}$ [8/20 μs]</th>
<th>$W_{\text{max}}$ [mJ]</th>
<th>$W_{LD}$ [J]</th>
<th>$P_{\text{diss, max}}$ [mW]</th>
<th>$V_{\text{jump}}$ [V]</th>
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CTVS ML varistors for automotive: Design support

Product brief
● Ceramic Transient Voltage Suppressors: Combined EMI filtering and ESD protection for high-speed bus systems
   Ordering no. EPC:63005-7600

Sample kits
● Ceramic Transient Voltage Suppressors: E Series of Multilayer Varistors for ESD and High-Energy Transient Protection in Automotive Applications
   Ordering no. B72499A9999K099

Data book
● CTVS - Ceramic Transient Voltage Suppressors
   Ordering no. EPC:62023-7600

Application support
● PSpice libraries
● Data sheets
● Contact sheet to get further support by our technical experts
Annex
Multilayer varistors: Important terms

- **Operating voltage** $V_{op}$
  Specified by maximum AC and DC operating voltages. These figures should only be exceeded by transients. Our multilayer varistor automotive E series is rated to withstand excessive voltage (jump start) up to 5 minutes.

- **Varistor voltage** $V_v/V_{BR}$
  The varistor voltage is the voltage drop across the CTVS when a current of 1 mA is applied to the device. It has no particular electrophysical significance but is often used as a practical standard reference in specifying overvoltage protection components. The tolerance of the varistor voltage refers to 25 °C.

- **Protection level** (clamping voltage) $V_{clamp}$
  The protection level is the voltage drop across the CTVS for surge currents $>1$ mA. The V/I characteristics show the maximum protection level as a function of surge current (8/20 ms waveform).

- **Maximum surge current** $I_{surge,\ max}$
  The maximum non-repetitive surge current is usually defined by an 8/20 ms waveform (rise time 8 ms/ decay time to half value 20 ms) to IEC 62475.

- **Electrostatic discharge** (ESD)
  A rapid and short lasting surge of electric current that flows between two different objects when they come together and an excess of electric charge is transferred between them. At the component level there are three standards for passive electronic components: IEC 61000-4-2 level 4, AEC-Q200, Rev. D, ISO 10605 (2008).

- **Automotive high-energy transient pulses**
  The standards ISO 7637-2 and ISO 16750-2 detail EMC testing for automotive electrical systems, including test pulses 1, 2a/ 2b and 3a/ 3b (acc. to ISO 7637-2), and test pulses A and B according to ISO 16750-2, which simulate load dump. Load dump occurs when a battery is accidentally disconnected from the generator while the engine is running, e.g. because of a broken cable.
Multilayer varistors: Microstructure

Sintering zinc oxide (ZnO) together with other metal oxide additives under specific conditions produces a polycrystalline ceramic whose grain boundary resistance exhibits a non-linear dependence on voltage. This phenomenon is called the **varistor effect**. At those points where zinc oxide grains are connected by an intergranular layer, sintering produces a microscopic structure of ‘**microvaristors**’. The electrical behavior of the CTVS multilayer results from the number of microvaristors connected in series or in parallel.

**Varistor effect**  

**Microvaristor**
**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®**s are specific products 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 Zener and 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.