CIRCUIT PROTECTION IN AUTOMOTIVE APPLICATIONS

The following applications and schematic diagrams show where TransGuards® might be used to suppress various transient voltages:

- Automotive Transients
- LIN Bus
- CAN Bus and FlexRay
- Electric Power Steering
- Seat Motor Circuit
- LED Door Lamp
- Drive by Wire
- Keyless Entry
- Voltage Regulator
- Bluetooth
- LED Driver
AUTOMOTIVE TRANSIENTS

Today's automobiles are using new technologies based on electronics systems connected by a wide variety of networks to provide increased safety, convenience, and comfort, to reduce emissions, increase fuel efficiency and more.

During the lifetime these systems are subjected to many overvoltage transient surges. To ensure safe and reliable function it is necessary to protect these sensitive systems against overvoltage surges.

Automotive Power Rail Transients

The transients on automotive power rails are usually medium to high energy transients and are caused by engine start such as Jump start (connecting other car's battery to jump start the engine), Load Dump (sudden load disconnect from alternator) or inductive switching (caused by DC motors on/off switching - e.g. window lifter, wipers, adaptive headlights). These transients are typically bi-directional.

AVX MULTILAYER VARISTORS

The EMC requirements of today's automotive electronics are a natural fit for the use of AVX MultiLayer Varistors (MLVs).

AVX Automotive Series Varistors provide reliable protection against automotive related transients - such as Load Dump, Jump Start and ESD to protect the growing number of electronics systems used in automotive applications.

Transient examples:
- Load dump (ISO 7637-2-5) • AEC-Q200-002 • CI-220
- Jump Start • ISO 10605 • CI-260
- ISO 7637 Pulse 1-3 • ISO 16750-2
- IEC 61000-4-2, etc.

The parts offer fast turn on time, bi-directional protection, excellent multiple strikes capability and in addition also EMI/RFI filtering in the off-state that can improve overall system EMC performance.

High power MLV designs have been revised and miniaturized to allow efficient protection of today's most widely used communication bus designs.

When used in communication bus designs, MLVs can save approximately 90% of the board area involved with diode/EMC cap solutions. In addition, MLVs offer a FIT rate <0.1, an ability to be used at temperatures up to 150°C and a fast turn on time.

AVX MULTILAYER VARISTORS ADVANTAGES

- AEC-Q200 qualified
- Bi-directional protection
- Compact footprint
- Very fast response - sub ns
- EMI/RFI filtering in the off state
- Multiple strikes capability
- No derating over operating temperature range (-55°C to +125°C, 150°C available)
- RoHS compliant
- Optional hybrid termination (Pd/Ag) available

Automotive Data Line Transients

Data lines connecting the automotive systems need to be protected against various ESD pulses to ensure sensitive electronics protection. These transients are mainly caused by human interaction with the electronics systems (controls, buttons, ports) or by interaction between systems due to different charge build up. These transients are typically bi-directional and very fast.
MLVs have traditionally been used in inductively generated automotive transient suppression applications such as motors, relays and latches. MLVs offer a large in rush current capability in a small package, high-energy transient suppression and a broad and definable off state bulk EMC capacitance. These, coupled with an extremely low FIT rate and excellent process capability makes MLVs a common device in today’s intermediate to high power automotive circuit protection.

**AUTOMOTIVE COMMUNICATION BUS**

AVX varistors are ideal choice for automotive circuit protection thanks to wide range of automotive qualified parts covering wide range of applications from low capacitance components for high speed data lines/RF circuits up to high energy varistors for load dump and jump start requirements on power lines or low speed data lines such as LIN Bus. AVX also offers automotive varistors for targeted and enhanced EMI filtering that help to improve overall EMC system performance.

Automotive electronic systems are connected by various network systems depending on the data speed requirements. Most common networks include:

**LIN (LOCAL INTERCONNECT NETWORK)**

LIN Bus operates at slower data speeds up to 20kbps and provides reliable low cost automotive networking. Typical applications are e.g. window lifter, door lock, seat controls, mirror controls, wipers, rain sensors etc.

**CAN (CONTROLLER AREA NETWORK)**

CAN Bus is a vehicle bus standard designed to allow microcontrollers and devices to communicate with each other within a vehicle without a host computer. CAN Bus supports data speeds up to 1Mbps. Typical applications are ECU connection to transmission, door locks, adaptive headlights, climate control, etc.

**MOST (MEDIA ORIENTED SYSTEMS TRANSPORT)**

MOST is standard for high-bandwidth automotive multimedia networking. This network provides excellent Quality of Service and seamless connectivity for audio/video streaming through variety of multimedia interfaces such as DVD player, head set, voice control.

**FLEXRAY**

FlexRay is an automotive network communications protocol to govern on-board automotive computing. It is designed to be faster and more reliable than CAN and TTP intended for drive-by-wire applications.

Example of suitable AVX series based on data speed and line type is shown below:

<table>
<thead>
<tr>
<th>SERIES</th>
<th>BUS</th>
<th>DATA SPEED</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sub pF AntennaGuard Automotive Series</td>
<td>HDMI</td>
<td>3.2 Gbps</td>
</tr>
<tr>
<td>AG/Sub pF AG Automotive Series, Miniature AC</td>
<td>MOST</td>
<td>400 Mbps</td>
</tr>
<tr>
<td>FlexRay</td>
<td>TTP</td>
<td>25 Mbps</td>
</tr>
<tr>
<td>CAN, FlexRay, AG Series</td>
<td>FlexRay</td>
<td>10 Mbps</td>
</tr>
<tr>
<td>CAN, FlexRay, AG Series, TransGuard® Automotive Series, StaticGuard Automotive Series, Radial Varistor</td>
<td>TTCAN</td>
<td>1 Mbps</td>
</tr>
<tr>
<td>CAN, FlexRay, AG Series, TransGuard® Automotive Series, StaticGuard Automotive Series, Radial Varistor</td>
<td>CAN</td>
<td>1 Mbps - 50 Mbps</td>
</tr>
<tr>
<td>TransGuard® Automotive Series, Safe-by-Wire, StaticGuard Automotive Series, Radial Varistor</td>
<td>Safe-by-Wire</td>
<td>150 Kbps</td>
</tr>
<tr>
<td>TransGuard® Automotive Series, StaticGuard Automotive Series, Radial Varistor, Miniature MAC, TransFeed Automotive Series, Controlled Capacitance</td>
<td>ALL</td>
<td>&lt;20 Kbps</td>
</tr>
<tr>
<td>TransFeed Automotive Series</td>
<td>LIN</td>
<td>10-100 Mbps</td>
</tr>
</tbody>
</table>

**CONTROLLED CAPACITANCE**

Cutoff Frequency
TransGuard® Automotive Series
AVX Multilayer Transient Voltage Protection
Circuit Protection in Automotive Applications

LIN BUS

Component | Product          | AVX Part number | Specification
-----------|------------------|-----------------|------------------
V1         | Multilayer Varistor | VCAS080518C400RP | 0805, 18Vdc, 0.3J, 120A, 550pF typ
**CAN BUS**

![CAN BUS Diagram]

<table>
<thead>
<tr>
<th>Component</th>
<th>Product</th>
<th>AVX Part number</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>V1, V2</td>
<td>Multilayer Varistor</td>
<td>CAN0001RP</td>
<td>0603, 18Vdc, 0.015J, 4A, 22pF max</td>
</tr>
<tr>
<td>(V1+V2)</td>
<td>Multilayer Varistor</td>
<td>CAN0002RP</td>
<td>0405 Dual Array, 0.015J, 4A, 22pF max</td>
</tr>
</tbody>
</table>

**FLEXRAY**

![FLEXRAY Diagram]

<table>
<thead>
<tr>
<th>Component</th>
<th>Product</th>
<th>AVX Part number</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>V1, V2</td>
<td>Multilayer Varistor</td>
<td>FLX0005WP</td>
<td>0402, 18Vdc, 0.02J, 4A, 17pF max</td>
</tr>
</tbody>
</table>
**ELECTRIC POWER STEERING**

![Schematic Diagram]

<table>
<thead>
<tr>
<th>Component</th>
<th>Product</th>
<th>AVX Part number</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>V1</td>
<td>Multilayer Varistor</td>
<td>VCAS121018J390RP</td>
<td>1210, 18Vdc, 1.5J, 500A, 3100pF typ</td>
</tr>
</tbody>
</table>
### SEAT MOTOR CIRCUIT

![SEAT MOTOR CIRCUIT Diagram](image)

<table>
<thead>
<tr>
<th>Component</th>
<th>Product</th>
<th>AVX Part number</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>V1</td>
<td>Multilayer Varistor</td>
<td>VCAS040218X400WP</td>
<td>0402, 18Vdc, 0.05J, 20A, 65pF typ</td>
</tr>
<tr>
<td>V2</td>
<td>Multilayer Varistor</td>
<td>VCAS121018J390RP</td>
<td>1210, 18Vdc, 1.5J, 500A, 3100 pF typ</td>
</tr>
</tbody>
</table>

### LED DOOR LAMP

![LED DOOR LAMP Diagram](image)

<table>
<thead>
<tr>
<th>Component</th>
<th>Product</th>
<th>AVX Part number</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>V1</td>
<td>Multilayer Varistor</td>
<td>VCAS120618D400RP</td>
<td>1206, 18Vdc, 0.4J, 150A, 900pF typ</td>
</tr>
</tbody>
</table>
DRIVE BY WIRE – THROTTLE

Supply Voltage PAAT
V1
C1
VDD1
Power Control Chip
V2
C5
VDD2
V4
Throttle Drive
C4
Throttle Sensor
C3
VCC
C7
C8
VCCPAAT
Vreg
V3
Accelerator Sensor
CLK- CLK+
XTAL 13MHz

<table>
<thead>
<tr>
<th>Component</th>
<th>Product</th>
<th>AVX Part number</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>V1, V2</td>
<td>Multilayer Varistor</td>
<td>VCAS080518C400DP</td>
<td>0805, 18Vdc, 0.3J, 120A, 550pF typ</td>
</tr>
<tr>
<td>V3, V4</td>
<td>TransFeed</td>
<td>V2AF118X500Y3DDP</td>
<td>0805, 18Vdc, 0.05J, 20A, 75pF typ</td>
</tr>
</tbody>
</table>
TRANSGUARD® AUTOMOTIVE SERIES
AVX MULTILAYER TRANSIENT VOLTAGE PROTECTION
CIRCUIT PROTECTION IN AUTOMOTIVE APPLICATIONS

KEYLESS ENTRY

Vehicle

125kHz Inductive Transmitter

V1

μC

UHF Receiver

VDD1

14V/24V

C1

Vreg

μC

UHF Receiver

ID Device

125kHz LF Frontend (3-dimensional)

V2

V3

V4

V6

Vreg

VDD2

Vbat

Up-link: wake-up data (inductive)

Up to 2.5m

Downlink: data (UHF)

Component | Product | AVX Part number | Specification
--- | --- | --- | ---
V1, V2, V3, V4 | Multilayer Varistor | MAV0010DP | 0603, 52Vac, 110 Pk-Pk @ 125kHz, 0.015J, 2A, 22pF Max
V5, V6 | Multilayer Varistor | VCAS04AG183R0YATWA | 0402, 18Vdc, 3pF Max

VOLTAGE REGULATOR

Component | Product | AVX Part number | Specification
--- | --- | --- | ---
V1 | Multilayer Varistor | VCAS080518C400DP | 0805, 18Vdc, 0.3J, 120A, 550pF typ
BLUETOOTH

![Diagram of BLUETOOTH circuit](image)

<table>
<thead>
<tr>
<th>Component</th>
<th>Product</th>
<th>AVX Part number</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>V1</td>
<td>Multilayer Varistor</td>
<td>VCAS080518C400DP</td>
<td>0805, 18Vdc, 0.3J, 120A, 550pF typ</td>
</tr>
<tr>
<td>V2, V3</td>
<td>Multilayer Varistor</td>
<td>VCAS060314A300DP</td>
<td>0603, 14Vdc, 0.1J, 30A, 350pF typ</td>
</tr>
<tr>
<td>V4</td>
<td>Multilayer Varistor</td>
<td>VCAS06AG183R0YAT3A</td>
<td>0603, 18Vdc, 3pF max</td>
</tr>
<tr>
<td>V5</td>
<td>Multilayer Varistor</td>
<td>VCAS040218X400WP</td>
<td>0402, 18Vdc, 0.05J, 20A, 65pF typ</td>
</tr>
</tbody>
</table>
LED DRIVER

Component | Product     | AVX Part number     | Specification 
--- | --- | --- | --- 
V1 | Multilayer Varistor | VCAS120618E380 | 1206, 18Vdc, 0.5J, 200A, 930pF 
V2 | Multilayer Varistor | VCAS060318A400 | 0603, 18Vdc, 0.1J, 30A, 150pF 
V3 | Multilayer Varistor | VCAS06LC18X500 | 0603, 18Vdc, 0.05J, 30A, 50pF