
# Automotive lighting Protection Solution

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May 22, 2018

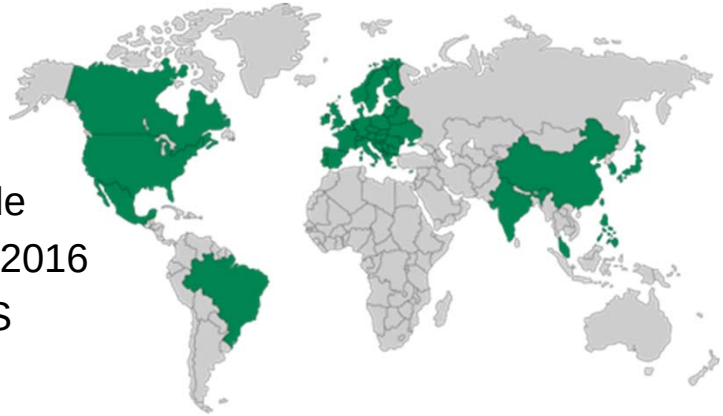
Littelfuse®
Expertise Applied | Answers Delivered

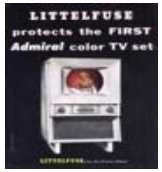
# From Small Beginnings

## Through decades of innovation

- Founded in 1927 inventing the first fast-acting protective fuse
- Introduced many industry-first technologies for circuit protection in automotive, aviation, consumer, communication, military and aero-space industries
- Broad Technology Portfolio
  - Passives
  - (Power) Semiconductors
  - Sensors
- Global Footprint
  - More than 10,000 employees worldwide
  - Exceeded $1 billion of annual sales in 2016
  - Publicly held — NASDAQ traded LFUS
  - More than 35 facilities worldwide:

    Americas | Europe | Asia





# The #1 Brand in Circuit Protection

## Expanding Player in Power Control and Sensing

### Electronics (51%)

- Passive Products
- Semiconductor Products
- Sensor Products

### Automotive (39%)

- Passenger Car Fuse Products
- Automotive Sensor Products
- Commercial Vehicle Products

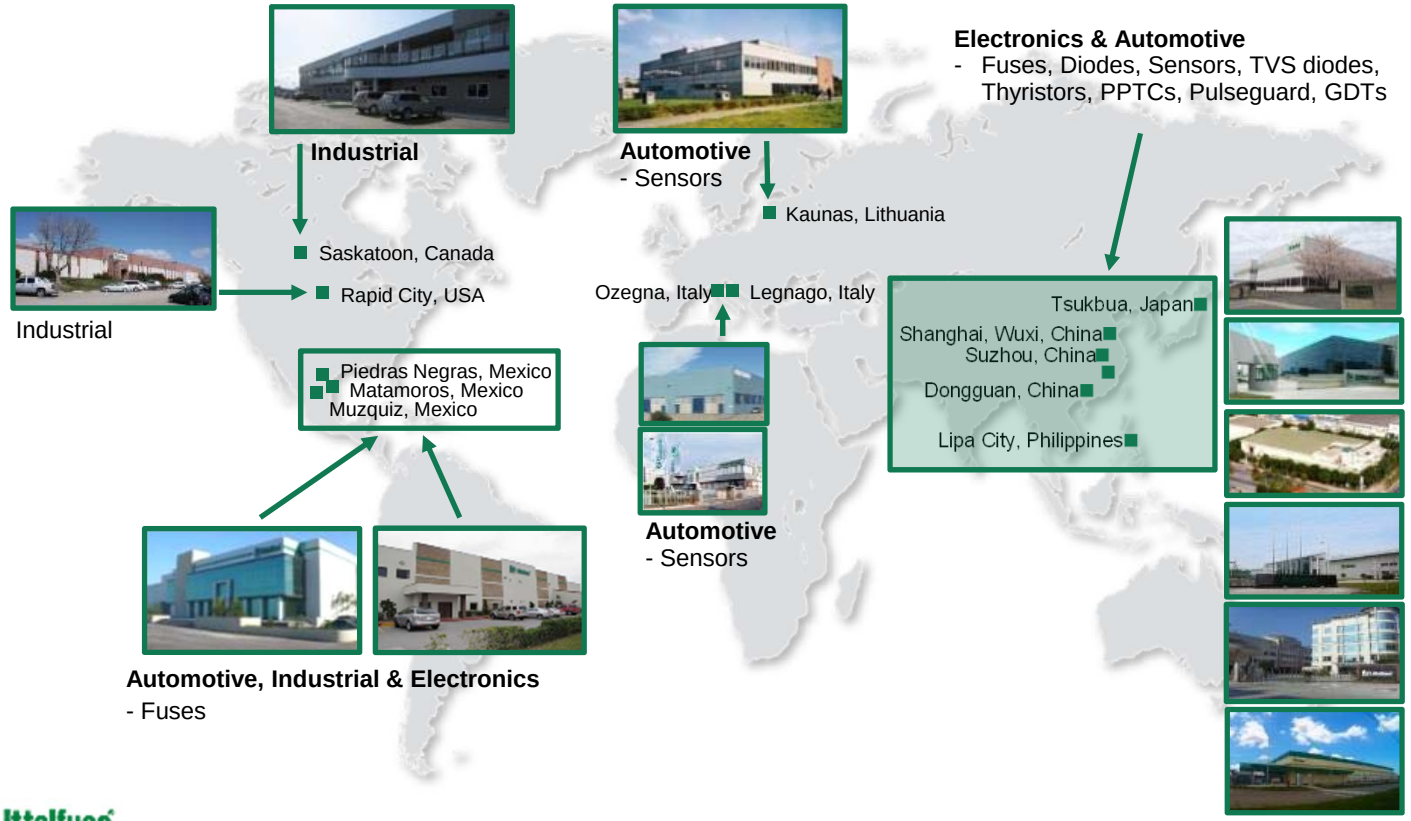
### Industrial (10%)

- Fuse Products
- Protection Relays
- Custom Products

**Littelfuse serves more than 100,000 customers across three major market segments**

# Littelfuse Current Manufacturing Footprint

## All manufacturing locations are ISO/TS16949 certified

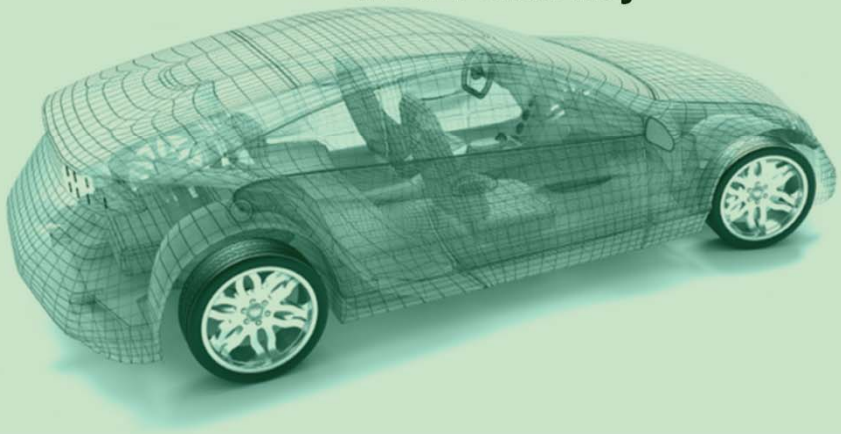


# Applications Focus Areas in Modern Vehicles

## Increasing number of ECUs

Technical Member of the AEC!

**Circuit protection is necessary to maintain functionality and enhance their reliability**



### Network Systems & Body

- CAN BUS
- LIN BUS
- FlexRay*
- MOST*
- Bluetooth*
- BroadR-Reach®
- Safe-By-Wire*
- Central Body Module
- Lighting Power Window
- Retracting Mirror
- Wiper
- Dashboard
- Climate Control
- Keyless Entry
- Seat Control
- Park Assistance

### Powertrain Systems

- Automatic Cruise Control (ACC)
- Electronics Control Unit (ECU)
- Turbo Charger
- Selespeed*
- Transmission Control Unit (TCU)
- Battery Charging
- Injection
- GDI

### Communication & Infotainment Systems

- Radio
- Power Audio
- GPS Module
- Satellite Navigation
- Portable Navigator
- Navigation System
- Telematics Box
- Car Multimedia

### Advanced Driver Assistance Systems

- Night Vision
- Pedestrian Avoidance
- Lane Departure Sensing
- Adaptive Cruise Control
- Vehicle to Vehicle (V2V) Communication
- Interior Camera – Driver Monitoring
- Exterior Camera – Front View
- Exterior Camera – Rear View Park Assist
- Blind Spot Detection
- Side Impact Assist
- Automated Head Light Control

### Chassis & Safety Systems

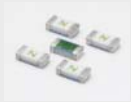
- Active Suspension
- Tire Pressure Monitoring System (TPMS)
- Electric Power Steering (EPS)
- Seat Belt Pretensioning
- Precrash
- Battery Disconnect
- Antirollover
- Stability Control
- Brake Control
- DC Power Supply
- Air Bag
- ABS
- Radar

### New Energy Car

- Gas Electric
- Fuel Cell Electric
- Diesel Electric
- Lilon and NiMH Battery Electric
- Ultracapacitors
- Battery Management System (BMS)

## Overcurrent protection

SMD Fuses



PPTC

## Overvoltage protection

TVS Diodes

Diode Arrays

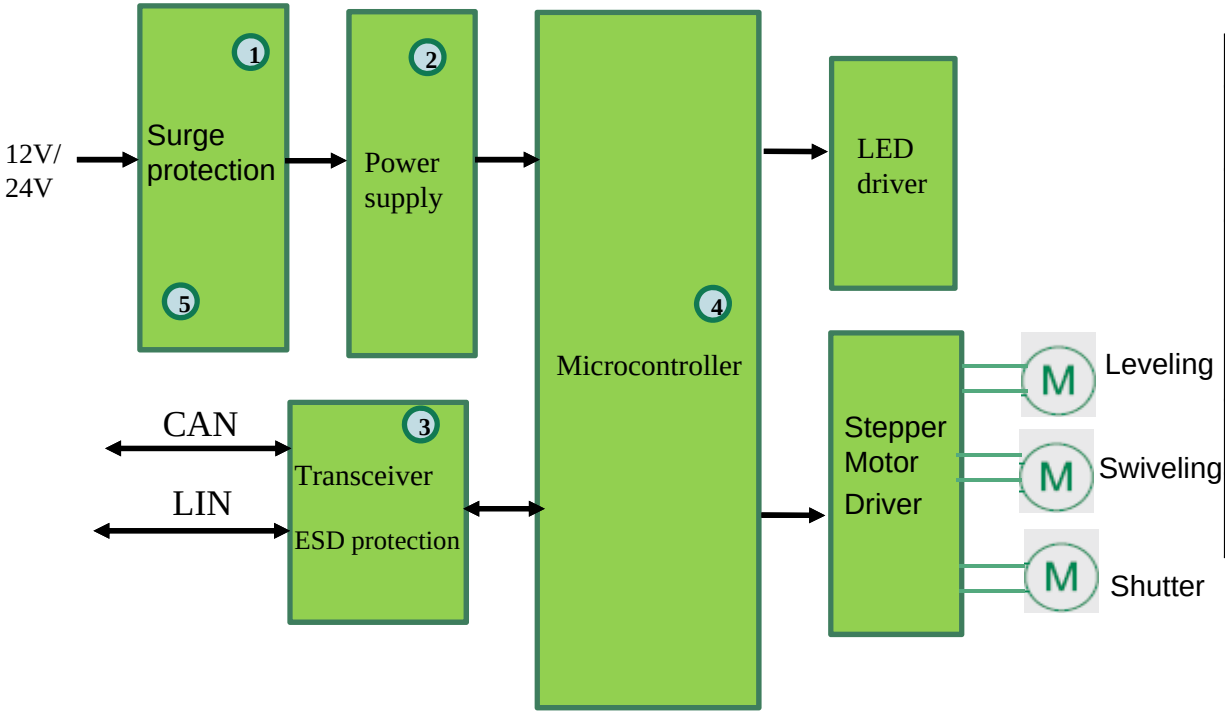
Varistors

XTREME-GUARD™

## Power

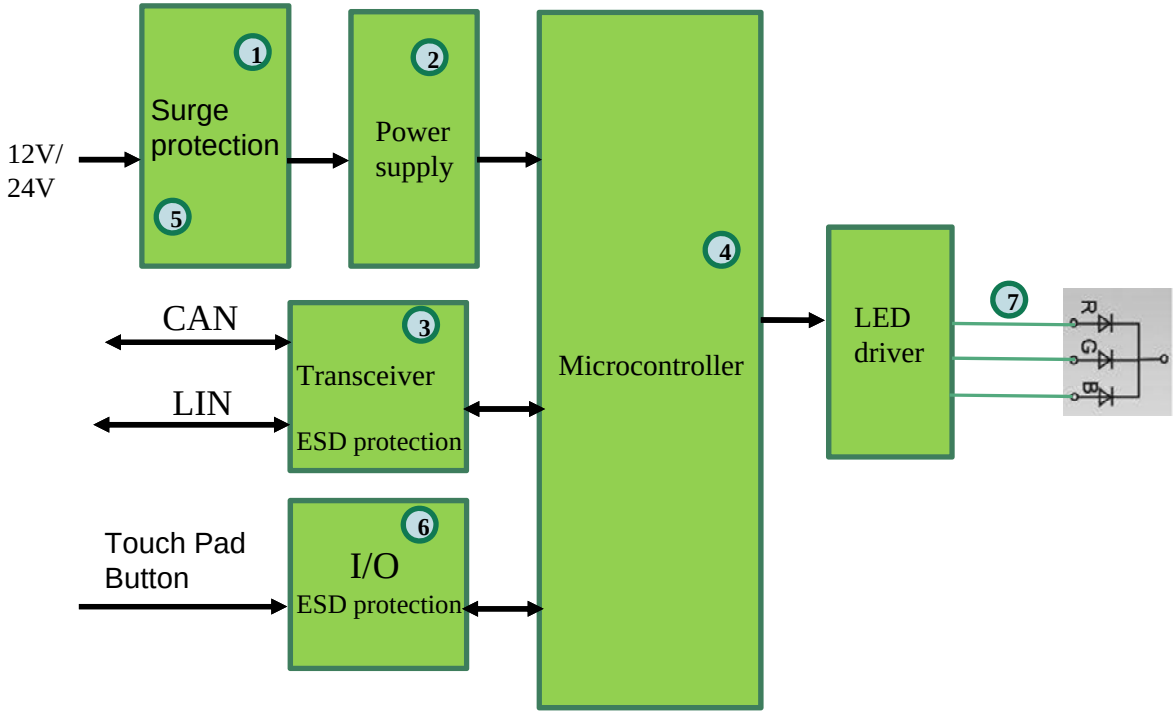
Thyristors, IGBTs, Sc[illegible]y Diodes

# Auto head lamp protection solution




| | Technology | Series |
|---|---|---|
| 1 | TVS diode/MOV | SLD8S/TPSMX/AUML /AUMOV |
| 2 | Schottky Diode | DST |
| 3 | TVS array | SM24CANA-02HTG<br>SM24CANB-02HTG<br>AQ24CANFD-02HTG<br>SD24C-01FTG/<br>AQ24C-01FTG |
| 4 | TVS diode | TPSMX |
| 5 | Schottky Diode/PPTC | DST/SMD PPTC |

# Auto Interior Lighting solution

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| 2 | Schottky Diode | DST |
| 3 | TVS array | SM24CANA-02HTG SM24CANB-02HTG AQ24CANFD-02HTG SD24C-01FTG/ AQ24C-01FTG |
| 4 | TVS diode | TPSMX |
| 5 | Schottky Diode/PPTC | DST/SMD PPTC |
| 6 | TVS array | AQ1 |
| 7 | PPTC | SMD PPTC |

# Why is circuit protection so important?

## Electrostatic discharge (ESD)

| | Simulator Model | | Test Voltage (max) | Environmental focus | |
|---|---|---|---|---|---|
| | Charging Capacitor | Discharge Resistor | | | |
| Human Body Model | 100 pF | 1,500Ω | 0.5V to 2kV | Simulates the environment inside the factory environment (wafer fab/assembly | ESD capability on component level |
| IEC 61000-4-2 | 150 pF | 330Ω | 8 to 30kV contact discharge | Simulates the field level ESD to which applications will be subjected in the field | Gap to be filled by ESD protection |
| ISO 10605, interior | 330 pF | 330Ω | 15kV contact discharge | Simulates ESD environment inside the automobile; also used for electronic modules | System ESD requirements |
| ISO 10605, exterior | 150 pF | 330Ω | 25kV air discharge | Simulates ESD environment around the exterior of the automobile | |

**Main ESD standards for Automotive Applications**

## Transient surges

**Major Transients defined in ISO 7637-2***

Automotive EMC transient requirements from ISO 7637:

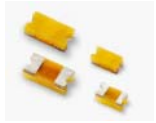
| | | |
|---|---|---|
| Standard Surge Protection | Pulse 1 | Interruption of inductive load – refers to disconnection of the power supply from an inductive load while the device under test (DUT) is in parallel with the inductive load |
| | Pulse 2 | Interruption of series inductive load – refers to the interruption of current and causes load switching |
| | Pulse 3 | Switching spikes<br>3a negative transient burst<br>3b positive transient burst<br>Refers to the unwanted transients in the switching events |
| | Pulse 4 | Starter crank – refers battery voltage drop during motor start. This always happens in cold weather |
| Loaddump Protection | Pulse 5 | Load dump – refers to the battery being disconnected when it is charged by the alternator. |
| | Pulse 6 | Ignition coil interruption |
| | Pulse 7 | Alternator field decay |
| | Pulses 1, 2, 3a, 3b, 5, 6, 7 | Related to high voltage transient getting into the supply line; Pulse 4 defines minimum battery voltage. |

*ISO 16750-2 has updated requirements on the load dump (Pulse 5) test conditions

**Surge wave of different pulses and its magnitude**

# Littelfuse offers 3 ESD Protection Technologies

## Ceramic, Silicon and Polymer

| Technology | Data Rate | Relative Cost | Typical Applications | Characteristic | Main Advantage |
|---|---|---|---|---|---|
| MLA Auto<br>**Ceramic**<br>  | Up to<br>125 Mbps | Best | Keypad<br>Switch<br>Audio<br>Analog video<br>USB 1.1<br>Power buses | $V_{M(DC)}$= **3.5V to 120V**<br><br>**0603, 0805, 1206 and 1210 packages** | **Lowest cost**<br>Broad discrete offering<br>**AEC-Q200** |
| ESD Diodes<br>**Silicon**<br>  | Up to<br>10 Gbps | Good | USB 2.0/3.0/3.1<br>HDBaseT<br>HDMI<br>Ethernet/BroadR Reach<br>CAN bus/LIN bus<br>MMC interface<br>LCD module | **Uni- and bidirectional** devices with leakage current < 100nA<br>upto ±30kV ESD rating for up to 4 channels<br>SD24C-01FTG for LIN<br>SM24CANA-02HTG for CAN | **Lowest $R_{dyn}$**<br>For lower clamping voltage range<br>**AEC-Q101** |
| XGD/PESD<br>**Polymer**<br>  | More than<br>20 Gbps | Good | RF antenna<br>  | Ultra low capacitance of<br>0.04 / 0.09 pF | **Lowest capacitance**<br>For highest data rates<br>**AEC-Q200** |

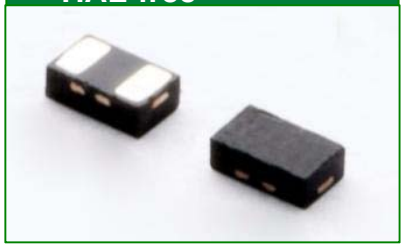
# TVS Diode Arrays (SPA®)

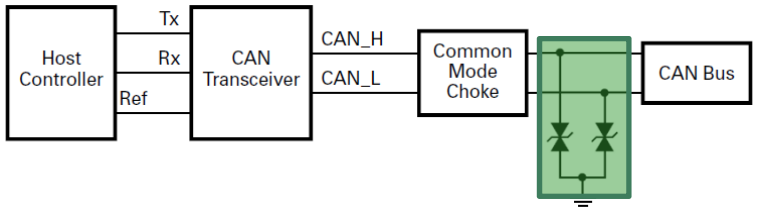
## ESD Protection for Communication Buses according ISO 10605

**AQ, SM and SD Automotive Series offer protection of data lines against ESD, EFT and lightning surges**

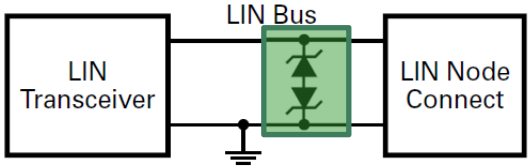
- **Uni- and bidirectional** devices with leakage current < 100nA
- ESD absorption capability of upto±30kV for up to 4 channels
- Low loading capacitance for high data rates of USB, GPS, LTE and many more

**All AQ products are**
- **AEC-Q101**
- **RoHS compliant**
- **HAL-free**






**SM24CANA-02HTG**
**SM24CANB-02HTG**
**AQ24CANFD-02HTG**




SD24C-01F/ AQ24C-01FTG

# Multi Layer Varistors (MLV)

## ESD Protection for Automotive Electronics according IEC 61000-4-2

**MLA Automotive Series offers best flexibility by its**

- Scalability over a wide operating range **$V_{M(DC)}$= 3.5V to 48V**
- Different leadless **0603, 0805, 1206 and 1210 packages**
- **Rubustness** even in harsh automotive environments

**All MLA products out of Dongguan Fab are**
**-AEC-Q200**
**-RoHS compliant**
**-HAL-free**

**Examples of Success Stories with varistors in automotive**

**Car Lighting**
**-** ESD protection with V18AUMLA1210H

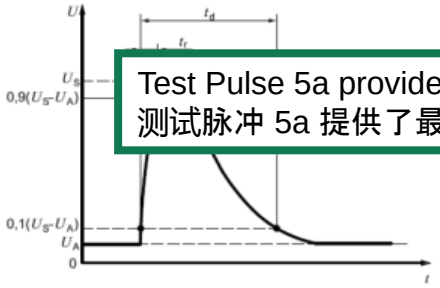
**Keyless entry**
**-** ESD protection with V18AUMLA1206H

**Infotainment**
**-** ESD protection with V18MLA0603NHAUTO

# Important Standards for Reliability and Protection

ISO 16750-2 Test Pulses 5a and 5b

Pulso 5a




Test Pulse 5a provides worst case scenario
测试脉冲 5a 提供了最坏的情况

Table 5 — Pulse for test A in systems with 12 V and 24 V nominal voltage

| Parameter | Type of system | | Minimum test requirements |
|---|---|---|---|
| | $U_N$ – 12 V | $U_N$ – 24 V | |
| $U_S$ [a] | $79 \leqslant U_S \leqslant 101$ | $151 \leqslant U_S \leqslant 202$ V | 10 pulses at intervals of 1 min |
| $R_i$ | $\leqslant 4$ | $1 \leqslant R_i \leqslant 8$ | |
| $t_d$ ms | 400 | $100 \leqslant t_d \leqslant 350$ | |
| $t_r$ ms | $10\left(\frac{0}{-5}\right)$ | $10\left(\frac{0}{-5}\right)$ | |

[a] If not otherwise agreed, use the higher voltage level with the higher value for internal resistance, or use the lower voltage level with the lower value for internal resistance.

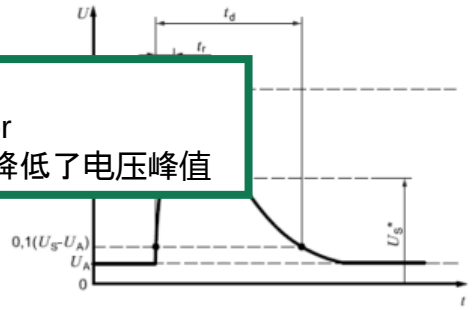
Table 6 — Pulse for test B in systems with 12 V and 24 V nominal voltage

| Parameter | Type of system | | Minimum test requirements |
|---|---|---|---|
| | $U_N$ = 12 V | $U_N$ = 24 V | |
| $U_S$ [a] V | $79 \leqslant U_S \leqslant 101$ | $151 \leqslant U_S \leqslant 202$ V | |
| $U_S^*$ V | | | |
| $R_i$ [a] Ω | | | |
| $t_d$ ms | | | |
| $t_r$ ms | $10\left(\frac{0}{-5}\right)$ | $10\left(\frac{0}{-5}\right)$ | |

[a] If not otherwise agreed, use the higher voltage level with the higher value for internal resistance, or use the lower voltage level with the lower value for internal resistance.

Test Pulse 5b with reduced voltage peak
due to clamping device installed within alternator
测试脉冲 5b 因交流发电机内安装的钳位器件而降低了电压峰值

Pulso 5b



# Transient surges hazards

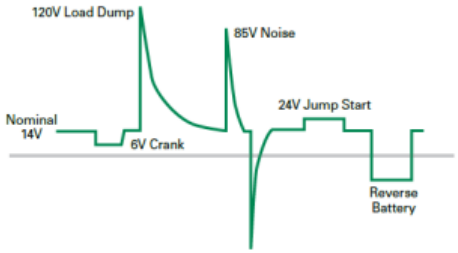
## Threats acc. ISO 7637-2 and Typical Application Schemes

### Major Transients defined in ISO 7637-2*

Automotive EMC transient requirements from ISO 7637:

| | | |
|---|---|---|
| Standard Surge Protection | Pulse 1 | Interruption of inductive load – refers to disconnection of the power supply from an inductive load while the device under test (DUT) is in parallel with the inductive load |
| | Pulse 2 | Interruption of series inductive load – refers to the interruption of current and causes load switching |
| | Pulse 3 | Switching spikes<br>3a negative transient burst<br>3b positive transient burst<br>Refers to the unwanted transients in the switching events |
| | Pulse 4 | Starter crank – refers battery voltage drop during motor start. This always happens in cold weather |
| Load dump Protection | Pulse 5 | Load dump – refers to the battery being disconnected when it is charged by the alternator. |
| | Pulse 6 | Ignition coil interruption |
| | Pulse 7 | Alternator field decay |
| | Pulses 1, 2, 3a, 3b, 5, 6, 7 | Related to high voltage transient getting into the supply line; Pulse 4 defines minimum battery voltage. |

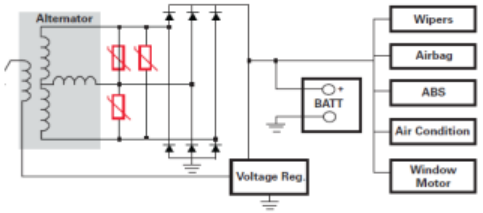
*ISO 16750-2 has updated requirements on the load dump (Pulse 5) test conditions



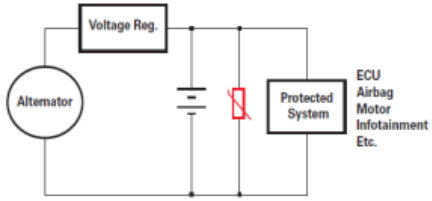

Surge wave of different pulses and its magnitude

### Typ. Applications for Protection Elements

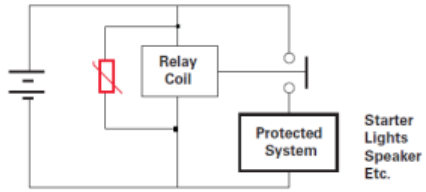
System Protection against Alternator Transients




Vehicle subsystem module transient protection




Automotive Relay Surge Protection

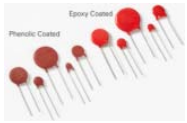
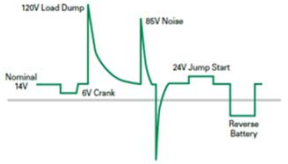



Littelfuse

Expertise Applied | Answers Delivered

# Littelfuse offers 3 Surge Protection Technologies

## Ceramic, Plasma Arrestor and Silicon

| Technology | Operating Voltage | Package | Peak Surge Capability | Typical Application | Main Advantages |
|---|---|---|---|---|---|
| **AUMOV**  | 14V – 625Vac 825Vdc | Radial leaded 5mm-20mm | 400A – 10kA | **surge protection** | **Hi-Pot Encapsulation 2500V @ 125°C** AEC-Q200 |
| **AUML**  | 18, 24, 48, 68Vdc | 1206, 1210, 1812, 2220 | 1.5A – 10A | **Standard Surge protection** **Active Clamping**   Surge wave of different pulses and its magnitude | **Load Dump rated up to 25J** AEC-Q200 |
| **TVS Diodes**  | 5V – 495Vdc | SMA SMB SMC SMD Axial Leaded | 75 – 350A | | **Load Dump rated up to 8kW** AEC-Q101 |

# Littelfuse TVS Diodes

## Automotive product series ( AEC-Q101)

Automotive TVS Diode App Note
Automotive TVS Diode Selection Guide

| Littelfuse Series (preferred for new design) | Aquired Series | Package | Directional | Power rating (by 10x1000us) | Reverse Standoff Voltage (VR) |
|---|---|---|---|---|---|
| TP6KE | | DO-15 | Uni & Bi | 600W | 11-78 |
| TPSMF4L | SZSMF ( 200W) | SOD-123FL | Uni | 400W | 5-85 |
| | SZ1SMA | DO-214AC | Uni & Bi | | 5-85 |
| TPSMA6L | | DO-221AC | Uni | 600W | 5-85 |
| TPSMB | SZ1SMB/SZP6SMB | DO-214AA | Uni & Bi | | 6.4 -650 |
| TP1.5KE | | DO-201 | | 1500W | 11-78 |
| TPSMC | SZ1.5SMC | DO-214AB | | | 10.2-78 |
| TPSMDJ | | DO-214AB | | 3000 W | 10-43 |
| **SLD8S** | | SMTO-263 | | 8000 W | 10-57 |
| SLD | | P600 | | | 10-60 |

- **SLD and SLD8S** dedicated for Load Dump application (ISO 7637-2 5a/b and ISO 16750-2 5a/b)
- **TPSMF4L/TPSMA6L** low profile and small package
- **TPSMB Hi-Vol (400V+)** for IGBT active clamping application in Automotive, Bi-Directional is our unique AECQ101 product

# Mission Critical Applications – Protection Solutions

Auto TVS Diodes - Transient and Load Dump Capabilities

## AEC-Q101 Qualified TVS Diode (Meets ISO7637-2 and ISO16750-2)

| Series Name | Package Type | Power Rating (10/1000µs) | 12V SYSTEM | | | | | | | | | | | | | 24V SYSTEM | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 1 | 2a | 2b | 3a | 3b | 5a | 5b | 1 | 2a | 2b | 3a | 3b | 5a | 5b | 1 | 2a | 2b | 3a | 3b | 5a | 5b | 1 | 2a | 2b | 3a | 3b | 5a | 5b |
| | | | -75v | 37v | 10v | -112v | 75v | 65v | 65v | -100v | 112v | 10v | -220v | 150v | 87v | 87v | -300v | 37v | 20v | -150v | 150v | 123v | 123v | -600v | 112v | 20v | -300v | 300v | 173v | 173v |
| **Automotive Transient Surge Including Load Dump Protection** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **TPSMA6L** | DO-221AC | 600W | Pass | Pass | Pass | Pass | Pass | | | Pass | Pass | Pass | Pass | Pass | | | Pass | Pass | Pass | Pass | Pass | | | Pass | Pass | Pass | Pass | Pass | | |
| **TPSMB** | DO-214AA (SMB) | 600W | Pass | Pass | Pass | Pass | Pass | | | Pass | Pass | Pass | Pass | Pass | | | Pass | Pass | Pass | Pass | Pass | | | Pass | Pass | Pass | Pass | Pass | | |
| **TPSMC** | DO-214AB (SMC) | 1500W | Pass | Pass | Pass | Pass | Pass | | | Pass | Pass | Pass | Pass | Pass | | | Pass | Pass | Pass | Pass | Pass | | | Pass | Pass | Pass | Pass | Pass | | |
| **TPSMD** | DO-214AB (SMC) | 3000W | Pass | Pass | Pass | Pass | Pass | | *Pass | Pass | Pass | Pass | Pass | Pass | | *Pass | Pass | Pass | Pass | Pass | Pass | | *Pass | Pass | Pass | Pass | Pass | Pass | | *Pass |
| **TP6KE** | DO-15 | 600W | Pass | Pass | Pass | Pass | Pass | | | Pass | Pass | Pass | Pass | Pass | | | Pass | Pass | Pass | Pass | Pass | | | Pass | Pass | Pass | Pass | Pass | | |
| **SLD (or Load Dump)** | P600 | 2200W Load Dump | | | | | | Pass | Pass | | | | | | Pass | Pass | | | | | | Pass | Pass | | | | | | Pass | Pass |

Note: * denotes the conditional pass which depends on the value of the Us as required by the customer requirement. If Us value is high, then it may not pass the 5b test. Please contact Littelfuse Tech support team regarding the test condition.

- Selection of suitable TVS Diodes depends on expected transients, placement (distance) and routing, other voltage limiting (Inductance) or energy absorbing (Capacitors) devices, sensitivity of protected element, reliability requirements (number of pulses over lifetime), operating conditions (e.g. temperature), cost targets

- Load Dump Capability depends in addition on internal resistance of alternator and if alternator has already a voltage limiting device integrated (5b test case)

# TVS selection guidance

- TPSMX for load dump 5b test

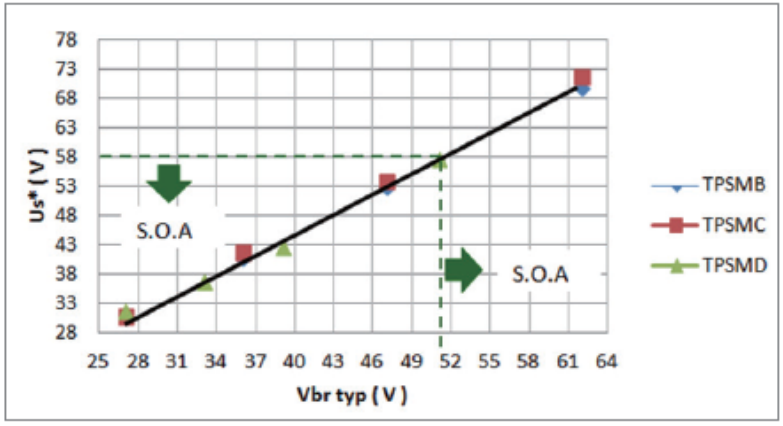



Figure 5. 12v 5b Vbr vs. US*

- SLD8 for load dump 5a test

**Figure 4 - Typical SOA Chart**

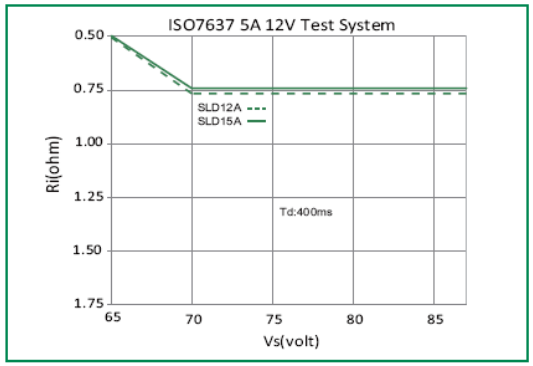
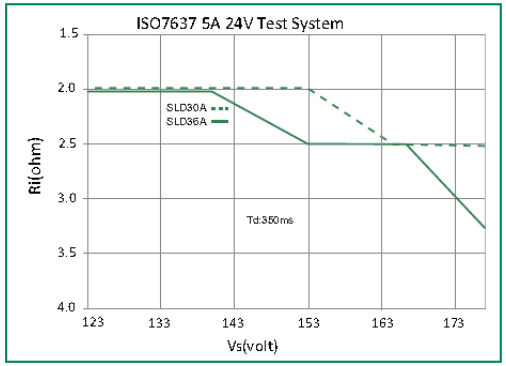
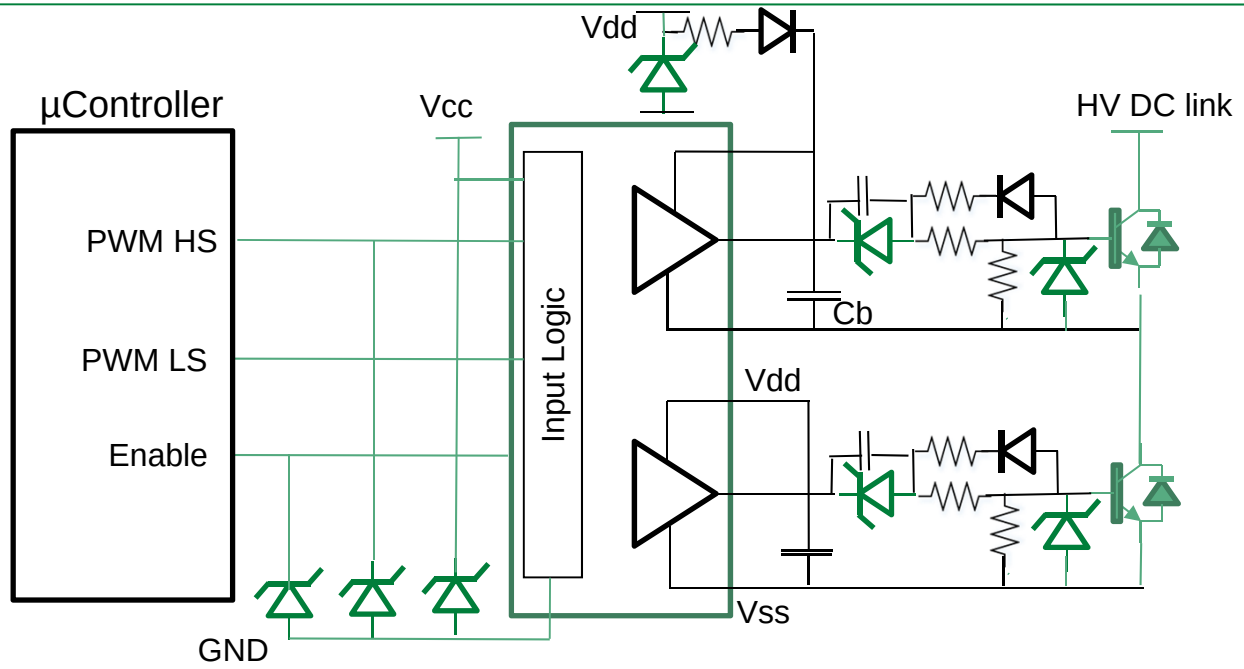



**Figure 3 - SOA Chart**



# MOSFET Driver Protection




| | |
|---|---|
| Input Logic: | Diode Array SPx Series |
| Power Supply: | MLA & AUML Series, TVS TPSMx Series |
| Gate Protection: | TVS TPSMx Series |

# AUMOV Automotive High Surge Varistors

## Surge Protection for Automotive Applications

- **AUMOV Series Key Features**
  - High Surge Ceramic Varistors, **up to 3x higher surge current capability at same disc size compared to competition**
  - Transient overvoltage protection in automotive applications
  - Operating voltage range **$V_{M(DC)}$= 16V to 825V**
  - Disc sizes **5mm ($I_{TM\ (8x20\mu s)}$ = 400A) up to 20mm ($I_{TM\ (8x20\mu s)}$ = 10kA)**
  - Typical Applications: Body Electronics, Powertrain, Infotainment, etc.
  - **AEC-Q200 compliant**
  - Operating Temperature Range -40˚ C to +125˚ C (Phenolic+Silicone)
  - RoHS compliant & Halogen Free & Lead Free
- **AUMOV Automotive Series Maximum Ratings**

**Absolute Maximum Ratings**

| | Low Voltage Series | Units |
|---|---|---|
| Continuous: | | |
| Steady State Applied Voltage: | | |
| AC Voltage Range ($V_{M(AC)rms}$) | 14 to 575 | V |
| DC Voltage Range ($V_{M(DC)}$) | 16 to 825 | V |
| Transient: | | |
| Non-Repetitive Surge Current 8/20µs Waveform ($I_{TM}$) | 400 to 6,000 | A |
| Non-Repetitive Energy Capability 2ms Waveform ($W_{TM}$) | 10 to 100 | J |
| Operating Ambient Temperature Range ($T_A$) for Epoxy coated | -40 to +85 | °C |
| Operating Ambient Temperature Range ($T_A$) for Phenolic coated and Silicone coated | -40 to +125 | °C |
| Storage Temperature Range ($T_{STG}$) for Epoxy coated | -40 to +125 | °C |
| Storage Temperature Range ($T_{STG}$) for Phenolic coated and Silicone coated | -40 to +150 | °C |
| Temperature Coefficient (αV) or Clamping Voltage ($V_C$) at Specified Test Current | < 0.01% | °C |
| Hi-Pot Encapsulation Isolation Voltage Capability for Epoxy coated | 2500 | V |
| Hi-Pot Encapsulation Isolation Voltage Capability for Phenolic coated | 500 | V |
| Hi Pot Encapsulation Isolation Voltage Capability for Silicone coated | 2500 | V |
| Temperature Cycling (-40C to +25C) for Epoxy coated | 5 | Cycles |
| Temperature Cycling (-40C to +25C) for Phenolic and Silicone coated | 100 | Cycles |

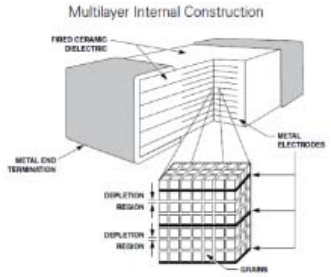
**All AUMOV products are**
- **AEC-Q200**
- **RoHS compliant**
- **HAL-free**
- **ISO/TS 16949**


Littelfuse
Expertise Applied | Answers Delivered

# AUML Automotive Multi Layer Varistors

## Transient Protection for Automotive Applications

- **AUML Automotive Series Key Features**
  - Multilayer Ceramic Varistor Technology
  - Transient overvoltage protection in automotive applications
  - ESD protection according IEC 61000-4-2
  - Operating Voltage: 18V
  - **Low Clamping Voltage of 40V @ $I_P$**
  - Leadless **1206, 1210, 1812 and 2220 chip sizes**
  - Typical Applications: On-Board Transient Protection
  - **AEC-Q200 compliant**
  - **Repetitive High Energy Load dump & Jump start capability**
  - RoHS compliant




**All AUML products are**
- **AEC-Q200**
- **RoHS compliant**
- **HAL-free**
- **ISO/TS 16949**

- **AUML Automotive Series Maximum Ratings**

| Continuous | AUML Series | Units |
|---|---|---|
| Steady State Applied Voltage: | | |
| DC Voltage Range ($V_{MDC}$) | 18 | V |
| Transient: | | |
| Load Dump Energy, ($W_{LD}$) | 1.5 to 25 | J |
| Jump Start Capability (5 minutes), ($V_{JUMP}$) | 24.5 | V |
| Operating Ambient Temperature Range ($T_A$) | -55 to +125 | °C |
| Storage Temperature Range ($T_{STG}$) | -55 to +150 | °C |
| Temperature Coefficient ($\alpha V$) of Clamping Voltage ($V_C$) at Specified Test Current | <0.01 | %/°C |

# Potential fault origins fall under 3 categories

## Functions to Protect

- PCB traces: power line trace and signal line trace
- Other sensitive Electronic Components: BJT, FET, ICs
  - Overcurrent components:

**PPTC or Fuse ?**

| | SMD Fuse | SMD PPTC |
|---|---|---|
| Failure Types | Permanent failure | Occasional failure |
| Examples | Components fail short, Crash event , last defense on board, Accessible Control Unit… | Install/Service Fault/After Market Intermittent short failures due to connector or harness damage, abnormal loads, connector Metallic intrusion, Moisture, fluid ingress, salted water , thermal event Software issue, IC malfunction Buried control Unit , load Protection … |

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Expertise Applied | Answers Delivered

## Potential Fault Origins fall under 3 categories

- **Install/Service Fault/After Market**
  - Mis-Wiring
  - Short to ground and +V Bat
  - Reverse Battery
  - ESD
- **Operational Defect/Fault in the field**
  - Cross to Higher Voltage
  - Signal Ground/Power Ground
  - Switch/Relay contact failure
  - Thermal Runaway
  - Resistive short circuit (Components, PCB..)
  - Transient spikes
  - Load dump
  - Jump Start
  - ESD
  - Software issue
  - Load protection
- **Meet Regulatory Spec Test : ISO7637-2 / LV124/ Internal Spec**
  - Transient spikes
  - Load dump
  - Jump Start
  - Short to ground and to +V Bat
  - Reverse Polarity
  - Isolation

# Resettable PPTCs

## - AEC-Q200

**Overcurrent protection in Car electronics and Motor protection**

- Circuit Protection Devices for:
- Audio
- Video
- Navigation
- I/O Ports (USB)
- Circuit Protection Devices for:
- ECU, BCM & Junction Box Applications
- Communication Systems
- Climate Control Systems
- Sensor Circuit Applications
- Safety & Security Applications
- LED Lighting Applications
- Interior & Cluster Applications
- Thermal Protection Applications
- Harness Protection

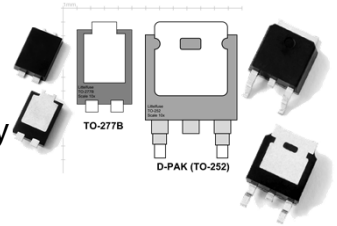
| Series | Form Factor | Voltage Rating | Current rating |
|---|---|---|---|
| SMD | 0603, 0805, 1206, 1210, 1812, 2016, 2920, 2018, 3425 | 6 – 60Vdc | 0.05 – 5A |
| Leaded | 7 – 24mm | 16Vdc<br>30Vdc<br>32Vdc | 0.5 – 15A |

AEC-Q200 Parts

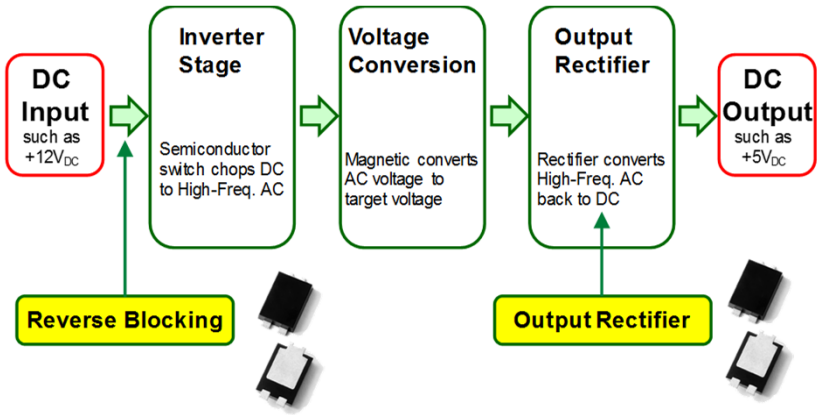
# Schottky Barrier Rectifier

## DC-DC converter

- 1/3 of footprint of comparable D-PAK product
- Trench-MOS design: Lower VF than conventional MBR Schottky




**D-PAK replacement with smaller package**




Low $V_F$ of Schottky rectifier >>> reverse blocking at input
Zero $T_{RR}$ & Low $V_F$ of Schottky rectifier >>> output rectifier

| $IF_{AV}$ | $V_{RR}$ | Part number |
|---|---|---|
| Average forward current | Reverse Voltage | AEC-Q101 |
| 5A | 60V | DST560S-A |
| | 80V | DST580S-A |
| | 100V | DST5100S-A |
| 8A | 60A | DST860S-A |
| | 100V | DST8100S-A |
| 10A | 40V | DST1040S-A |
| | 45V | DST1045S-A |
| | 50V | DST1050S-A |
| | 100V | DST10100S-A |