Rutronik is one of the leading distributors for passive components in Europe, especially within the automotive market. We offer a complete product range with various technical and commercial solutions of major manufacturers and the world market leaders for automotive components.

All our suppliers have the relevant quality management certificates TS16949, QS9000/ISO9001 and offer automotive qualified passive components. The analysis reporting and standardized processes like PPAP, 8D-report, EOL-management/PCN’s, batch tracing are also available upon request.

Introduction

Today’s automobiles include more electronic systems than ever before. Innovations in safety and environmental systems, as well as driver expectations of greater comfort, convenience and security are driving the trend towards more sophisticated on-board electronic applications. Many of these systems are critical to vehicle performance and passenger safety. For this reason, the accurate requirements for the components have to be considered.

Market requests like:

- "...for automotive or for automotive application..."
- "...Automotive suitable or capable..."
- "...in accordance to, or compliant with AEC-Q200..."

are very "elastic" terms and they absolutely do not guarantee automotive specification.

Additionally, it is well known, that many commercial types are used in automotive applications. What to do?

The main point is to define the exact request, not only for which application but also the function.

### RUTRONIK & Automotive

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### Passive Automotive Components

### Content

- Aluminium Electrolytic & Polymer Hybrid Capacitors... 04 - 05
- Electric Double Layer Capacitors... 06 - 07
- Ceramic Capacitors... 08 - 11
- Film Capacitors... 12
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- Tantalum, Polymer Tantalum & Niobium Capacitors... 14 - 15
- Thin Film Resistors... 16
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### Committed to excellence

**Consult** – Know-how. Built-in.

The technical competence from Rutronik

Worldwide and individual consulting on the spot:

- by competent sales staff, application engineers and product specialists.

**Components** – Variety. Built-in.

The product portfolio from Rutronik

Wide product range of semiconductors, passive and electromechanical components, storage, displays & boards and wireless technologies for optimum coverage of your needs.

**Logistics** – Reliability. Built-in.

The delivery service from Rutronik

Innovative and flexible solutions: from supply chain management to individual logistics systems.


Quality management without compromise

The integrated management system (IMS) encompasses quality control, environmental protection and occupational health and safety.

### Our Product Portfolio

- Semiconductors
- Displays & Boards
- Passive Components
- Storage Technologies
- Electromechanical Components
- Wireless Technologies

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- Get it on Google Play

### Get your Rutronik App:
**Polymer Hybrid Capacitor Technology for 125°C**

**Advantages of Polymer Hybrid Technology**
- Long lifetime at high temperatures
- Stable over time / temperature / frequency
- High ripple current / low ESR
- Low leakage current
- THT and SMD solution available
- Possible to reduce part count on PCB
- Specifications based on customers' requirements are possible
- SMD Anti-Vibration solution for sizes ≥ size code E (Ø8 mm) available

**Applications**
- Fan control
- Pump control
- Gear box control
- Lighting
- EPS

**Comparison of related technologies, a Hybrid capacitor achieves 4 times the current and 1/6 of the ESR of an electrolytic capacitor**

<table>
<thead>
<tr>
<th>Type</th>
<th>Polymer Hybrid Capacitor</th>
<th>Solid Polymer Capacitor</th>
<th>Wet Electrolytic Capacitor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature range</td>
<td>55°C to +125°C</td>
<td>55°C to +125°C</td>
<td>40°C to +120°C</td>
</tr>
<tr>
<td>Size (WxHxD)</td>
<td>10x10.5</td>
<td>10x12</td>
<td>10x10.5</td>
</tr>
<tr>
<td>Rated Voltage</td>
<td>35V</td>
<td>35V</td>
<td>35V</td>
</tr>
<tr>
<td>Capacitance</td>
<td>270µF</td>
<td>56µF</td>
<td>225µF</td>
</tr>
<tr>
<td>Leakage Current (100kHz)</td>
<td>94.5µA (0.01CV)</td>
<td>392µA (0.01CV)</td>
<td>77.0µA (0.01CV)</td>
</tr>
<tr>
<td>Ripple Current (10ppm)</td>
<td>20mA</td>
<td>200mA</td>
<td>550mA</td>
</tr>
<tr>
<td>ESR (10kHz, 20°C)</td>
<td>20mΩ</td>
<td>35mΩ</td>
<td>120mΩ</td>
</tr>
<tr>
<td>Lifetime (125°C)</td>
<td>4000 Hrs</td>
<td>3000 Hrs</td>
<td>3000 Hrs</td>
</tr>
</tbody>
</table>

**High Temperature THT Aluminium Electrolytic Capacitors**

For various applications in the automotive industry electrolytic capacitors with THT mounting are still preferred (e.g. EPS, HV compressor). They can offer high voltage, high capacity and high ripple current while achieving a long lifetime and offering a good cost / performance ratio. Together with our manufacturers we would like to help you to choose the right capacitor for your design.

**Below are some examples of typical applications and fitting THT capacitor types:**

<table>
<thead>
<tr>
<th>Type</th>
<th>Voltage</th>
<th>Temperature</th>
<th>Lifetime</th>
<th>Applications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low ESR</td>
<td>6.3 - 10.0V</td>
<td>105°C</td>
<td>4000 - 10000 Hrs</td>
<td>Infotainment, DC/DC, body control</td>
</tr>
<tr>
<td>High temperature</td>
<td>10 - 40V</td>
<td>up to 130°C</td>
<td>1000 - 4000 Hrs</td>
<td>Drive control, EPS, body control, EV application</td>
</tr>
<tr>
<td>High temperature</td>
<td>25 - 70V</td>
<td>135 to 150°C</td>
<td>2000 - 3000 Hrs</td>
<td>EPS, EV applications</td>
</tr>
<tr>
<td>High voltage / high temp</td>
<td>250 - 275V</td>
<td>125 to 135°C</td>
<td>3000 Hrs</td>
<td>Drive control, E-compressor</td>
</tr>
<tr>
<td>Anti-vibration design</td>
<td>8.3 - 400V</td>
<td>up to 150°C</td>
<td>up to 7000 Hrs</td>
<td>Gear box control, EPS, drive control</td>
</tr>
</tbody>
</table>

**SMD Anti-Vibration Aluminium Electrolytic Capacitors**

**Benefits**
- High vibration and mechanical stress create demands on rugged and high reliable electronic components in automotive applications.
- Wherever inductive loads in vehicles are operated, a sufficient and stable power supply network is absolutely essential.
- With special created terminals, higher walls and thicker wires the SMD Anti-Vibration Aluminium Electrolytic Capacitors are more rugged than standard SMD Aluminium Electrolytic Capacitors.

**Anti-Vibration E-Caps Compared to Standard E-Caps**

<table>
<thead>
<tr>
<th>Features</th>
<th>Anti-Vibration E-Cap</th>
<th>Standard E-Cap</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acceleration</td>
<td>30G (294 m/s²)</td>
<td>not specified</td>
</tr>
<tr>
<td>Frequency</td>
<td>5 to 2000Hz</td>
<td>10 to 55Hz</td>
</tr>
<tr>
<td>Amplitude peak to peak</td>
<td>5mm</td>
<td>1.5mm</td>
</tr>
<tr>
<td>Duration</td>
<td>16mm / 1 cycle</td>
<td>1mm / 1 cycle</td>
</tr>
<tr>
<td>2 hrs each of 3 axes x, y and z</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Replacement of Axial Aluminium Electrolytic Capacitors**

**Comparison of Radial and Axial Technology**

<table>
<thead>
<tr>
<th>Features</th>
<th>Radial</th>
<th>Axial</th>
</tr>
</thead>
<tbody>
<tr>
<td>High-Market Share</td>
<td>√</td>
<td></td>
</tr>
<tr>
<td>Second Source Availability</td>
<td></td>
<td>√</td>
</tr>
<tr>
<td>Size / Performance Ratio</td>
<td>√</td>
<td></td>
</tr>
<tr>
<td>Wear-Resistance</td>
<td>√</td>
<td></td>
</tr>
<tr>
<td>Productivity Performance</td>
<td>√</td>
<td></td>
</tr>
<tr>
<td>Design to cost</td>
<td>√</td>
<td></td>
</tr>
<tr>
<td>Individual Capacitor Spec.</td>
<td></td>
<td>√</td>
</tr>
</tbody>
</table>

The drawing shows an example of space consumption when a single axial capacitor is replaced by 3 radial capacitors.

**Features:**
- Capacity: 4.7 to 8200 µF
- Voltage: 6.3 to 100 V
- ESR: down to 0.03 Ω
- Temp. range: -40°C to +125°C / +150°C
- Lifetime: 2000 to 10000h
- Acceleration: 30G (294 m/s²)
- Available for all case sizes ≥ size code E (Ø8 mm) available
- High reflow soldering up to 260°C available
- Can damage element due to vibration & temperature change
- Due to difficulties in quality control, PPM issues could appear

**Connections Verification**
- PRESS FIT
- Shrinkable sleeves
- Adhesive tape
- AI 2 hrs each of 3 axis (x, y and z)
- 16 min / 1 cycle

**Connection Verification**
- Zero PPM
- Mechanical Stress Crimp
- Blind Weld Point
- Difficult to control quality of connection
- Can damage element due to vibration & temperature change

**Automotive Grade**
- Axial market shrinking, small share of total market, little to no investment
- Axial Type
- Axial market shrinking, small share of total market, little to no investment
- Axial Type
Electric Double Layer Capacitors (EDLC)

Future demands in the automotive sector make innovative power supply technologies a market of the future. In times of scarce resources, increasing oil prices and growing awareness of the damage caused by CO₂ emissions, a raft of new requirements is developing:

Positive results can be achieved by the use of Double-Layer Capacitors, also known as supercaps, in combination with conventional batteries. Supercapacitors – or supercaps – fill the energy density gap between conventional capacitors and batteries. Due to their extremely high power density, supercaps are ideal for handling short power peaks.

Comparison of different Energy Storage Technologies

<table>
<thead>
<tr>
<th>Type</th>
<th>Batteries</th>
<th>EDLC</th>
<th>Conv. Capacitors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time of charge</td>
<td>1 to 5h</td>
<td>0.3 to 30 s</td>
<td>10-3 to 10-6 s</td>
</tr>
<tr>
<td>Time of discharge</td>
<td>0.3 to 3h</td>
<td>0.3 to 30 s</td>
<td>10-3 to 10-6 s</td>
</tr>
<tr>
<td>Spec. energy (Wh/kg)</td>
<td>20 to &gt; 100</td>
<td>&lt; 10</td>
<td>&lt; 0.1</td>
</tr>
<tr>
<td>Lifetime (cycles)</td>
<td>1000</td>
<td>up to 1 Million</td>
<td>up to 1 Million</td>
</tr>
<tr>
<td>Spec. power (W/kg)</td>
<td>&lt; 1000</td>
<td>&gt; 10000</td>
<td>&gt; 100000</td>
</tr>
<tr>
<td>Efficiency</td>
<td>0.7 to 0.85</td>
<td>0.9 to 0.96</td>
<td>&gt; 0.95</td>
</tr>
</tbody>
</table>

Ultracapacitors provide Peak Power ...

Available Power

Required Power

Ultracapacitor Peak Power

... and Backup Power

Available Power

Required Power

Ultracapacitor Backup Power

Rutronik partner: Nesscap (others on request)

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</tr>
<tr>
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</tr>
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<td>up to 1 Million</td>
</tr>
<tr>
<td>Spec. power (W/kg)</td>
<td>&lt; 1000</td>
<td>&gt; 10000</td>
<td>&gt; 100000</td>
</tr>
<tr>
<td>Efficiency</td>
<td>0.7 to 0.85</td>
<td>0.9 to 0.96</td>
<td>&gt; 0.95</td>
</tr>
</tbody>
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Ultracapacitors provide Peak Power ...

Available Power

Required Power

Ultracapacitor Peak Power

... and Backup Power

Available Power

Required Power

Ultracapacitor Backup Power

Rutronik partner: Nesscap (others on request)
Examples for several Automotive Applications

Ceramic Capacitors
Choose the right MLCC. Comparison of different versions.

<table>
<thead>
<tr>
<th>Figure</th>
<th>Type version</th>
<th>Standard</th>
<th>AEC-Q200</th>
<th>±15°C - specified</th>
<th>Flexibility/ Soft Termination</th>
<th>OpenMode/ FRDesign</th>
<th>Combined Design</th>
</tr>
</thead>
<tbody>
<tr>
<td>Commercial Parts</td>
<td>Automotive qualified</td>
<td>High Temperature</td>
<td>Other names are e.g. Soft, Polymer, Flexible Termination, SoftElectrode, FlexCap</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Generally</td>
<td>Standard Spec. and qualifications</td>
<td>Increased sample plans with more and higher criteria</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bending-strength</td>
<td>1mm (some 2mm)</td>
<td>NPO 3mm, X7R 2mm</td>
<td>1mm (some 2mm)</td>
<td>X7R ≥ 3mm</td>
<td>1mm</td>
<td>X7R ≥ 3mm</td>
<td></td>
</tr>
<tr>
<td>Temp.-Cycles</td>
<td>5 cycles</td>
<td>1000 cycles</td>
<td>5 cycles</td>
<td>3000 cycles (AVX)</td>
<td>5 cycles</td>
<td>3000 cycles (AVX)</td>
<td></td>
</tr>
<tr>
<td>Thermal shock</td>
<td>no</td>
<td>yes</td>
<td>no</td>
<td>no</td>
<td>no</td>
<td>yes</td>
<td></td>
</tr>
<tr>
<td>Visual check</td>
<td>by sample plan</td>
<td>100%</td>
<td>by sample plan</td>
<td>by sample plan</td>
<td>by sample plan</td>
<td>100%</td>
<td></td>
</tr>
<tr>
<td>Other differences see detailed specifications supplier by supplier, e.g. vibration, ESD, high temperature exposure (storage), moisture resistance, etc.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

High Temperature. 150°C.

MLC specified up to 150°C

Their electrostatic capacity temperature response is stable at 15 % even in high temperature ranges (up to 150°C). Provides high-precision performance because their electrostatic capacity temperature response is ±7.5 % in semi-high temperature ranges (up to 125°C). Mostly used in automotive applications in the engine bay.

Available from AVX, Murata, TDK, Vishay. AVX also as Flexiterm® (with Soft Termination), Vishay with derating for usage up to 175°C.

MLC Radial Automotive & 150°C – new leaded types

Based on strong increase of sensors, both in automotive applications and for mounting on leadframes instead of PCBs, leaded multilayer capacitors (MLC) become more and more interesting.

To fulfil automotive and high temperature requirements these MLC have been created with AEC-Q200 qualification and additionally with some values specified up to 150°C. One of the best-known functions are the suppression capacitors for Hall Sensors.

Besides AVX and Murata, Vishay also launched a new program of leaded automotive Ceramic Capacitors. Vishay not only offers radial but also axial types up to 150°C, with derating for usage up to 160°C and even up to 175°C.

<table>
<thead>
<tr>
<th>Ceramic</th>
<th>NPO</th>
<th>X7R</th>
<th>X8R</th>
<th>X8L</th>
</tr>
</thead>
<tbody>
<tr>
<td>TC / Temp.</td>
<td>±530 ppm/°C</td>
<td>±10 %</td>
<td>±15 %</td>
<td>±10%</td>
</tr>
<tr>
<td></td>
<td>-55 to +150 °C</td>
<td>-55 to +125 °C</td>
<td>-55 to +150 °C</td>
<td>-55 to +150 °C</td>
</tr>
<tr>
<td>Tolerance</td>
<td>±5 %/ ±10%</td>
<td>±10% / ±20%</td>
<td>±15% / ±20%</td>
<td>±10% / ±20%</td>
</tr>
<tr>
<td>Voltage</td>
<td>50 V - 300V</td>
<td>50 V - 30V</td>
<td>50 V - 100V</td>
<td>25 V - 10V</td>
</tr>
<tr>
<td>Capacitance/Rage radial</td>
<td>3.0pF - 10nF</td>
<td>330pF - 4.7pF</td>
<td>1.0nF - 10UF</td>
<td>3.0µF - 10nF / 100nF - 330nF</td>
</tr>
<tr>
<td>Capacitance Range axial</td>
<td>100pF - 10nF</td>
<td>330pF - 4.7pF</td>
<td>1.0nF - 10UF</td>
<td>470µF - 330nF</td>
</tr>
</tbody>
</table>

Available from AVX, Murata, TDK, Vishay.
AEC-Q200
1 part with Combined Design

AEC-Q200
1 part with Flexiterm / Soft Termination

AEC-Q200
2 parts in series with Standard Design

Security

Solutions

More than 95% of defect components sent back to the supplier for analysis are damaged mechanically by bending stress. Based on this fact the typical recommendation of automotive customers for connections directly across the battery is to use two parts connected in series and mounted in a 90° angle to each other on the PCB.

The problem is that this solution assumes that board bending happens only in rectangular directions and always effects just one of the two components. But what happens at diagonal stress-directions on the pcb? Based on our experience and according to supplier information both of these automotive MLCC crack with this solution in the majority of cases. To date parts with features like Flexiterm-/Soft-/Polymer-termination don't show bending cracks. This results in better reliability and higher security by using only one part with such a special feature than with two parts connected in series orientated at 90°. Additionally the suppression performance of two serial connected parts decreases and the total capacitance is only half of one part.

The highest level of security can be reached by using an automotive MLCC with a combined design, i.e. a Flexiterm / Soft / Polymer-termination together with Open Mode or cascade design.

Ceramic Capacitors
MLCC crack and short circuit protection. Higher reliability with our manufacturer’s solutions

Soft Termination + Standard Design

In addition to the standard chip design with its high volumetric efficiency a conductive epoxy coat between first termination layer and the NiSn plating is used. Through this flexible epoxy coat the MLCC withstands much higher bending stresses. Beyond this in case of too high mechanical stress instead of the chip the layer tends to brake.

Soft Termination + Open Mode Design

Combines the feature of flexible conductive epoxy coat with an OpenMode/FR Design. But: this construction results in lower cap.-values in comparison to standard chip design. Additional assurance to avoid a short circuit in the improbable case of a typical bending crack.

Soft Termination + Float Mode Design

Combines the feature of a flexible conductive epoxy coat with an internal serial construction of two caps. Maximum capacity is about a third compared to a standard design based both on series connection and the gap between the two active areas. Double insurance: in the improbable case of a crack almost no short circuit is possible!

Supplier Overview

<table>
<thead>
<tr>
<th>Supplier</th>
<th>Flexiterm / Soft / Polymer- Termination</th>
<th>Combined Designs</th>
<th>AEC-Q200</th>
</tr>
</thead>
<tbody>
<tr>
<td>AVX</td>
<td>–</td>
<td>Soft Termination with Open Mode Design</td>
<td>–</td>
</tr>
<tr>
<td>Murata</td>
<td>–</td>
<td>Cascade Design</td>
<td>–</td>
</tr>
<tr>
<td>Samsung</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>TDK</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Vishay</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
</tbody>
</table>

available

Car battery clamp 30

Clamp 30 solutions

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The highest level of security can be reached by using an automotive MLCC with a combined design, i.e. a Flexiterm / Soft / Polymer-termination together with Open Mode or cascade design.
DC-Link capacitors prevent ripple currents from reaching back to the power source and serve to smooth out DC-bus voltage variations. That means the capacitor acts as a “buffer” between the power source and the inverter and in more complex systems also between different inverters. EV/HEV platforms require higher and higher operating temperatures, switching frequencies and RMS current handling. Therefore, film capacitors become more and more interesting. The generally higher performance compared to electrolytic capacitors (i.e. $U_{\text{rated}} > 500$ Vdc, almost unlimited life time, peak voltage, better energy density, lower ESR and ripple) tends to use film capacitors in automotive applications.

**Special Features of DC-Link Capacitors**
- Self-healing properties
- High capacitance density
- Very low dissipation factor (ESR and ESL)
- Very high insulation resistance
- High ripple current
- High contact reliability
- Suitable for high frequency applications
- Long life time expectancy

### Capacitors connected in parallel with the mains

1. DC-Link Capacitor
2. Inverter
3. Battery or Fuel Cell
4. Motor
5. 12V Network

### Capacitors connected in series with the mains

1. Equipment
2. $R$
3. $C$
4. 50-60 Hz

---

**Film Capacitors**

**DC-Link Capacitors in EV/HEV Applications**

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### Film Capacitors

**DC-Link Capacitors in EV/HEV Applications**

The DC-Link capacitors prevent ripple currents from reaching back to the power source and serve to smooth out DC-bus voltage variations. That means the capacitor acts as a „buffer“ between the power source and the inverter and in more complex systems also between different inverters. EV/HEV platforms require higher and higher operating temperatures, switching frequencies and RMS current handling. Therefore, film capacitors become more and more interesting. The generally higher performance compared to electrolytic capacitors (i.e. $U_{\text{rated}} > 500$ Vdc, almost unlimited life time, peak voltage, better energy density, lower ESR and ripple) tends to use film capacitors in automotive applications.

**Special Features of DC-Link Capacitors**

- Self-healing properties
- High capacitance density
- Very low dissipation factor (ESR and ESL)
- Very high insulation resistance
- High ripple current
- High contact reliability
- Suitable for high frequency applications
- Long life time expectancy

### Capacitors connected in parallel with the mains

1. DC-Link Capacitor
2. Inverter
3. Battery or Fuel Cell
4. Motor
5. 12V Network

### Capacitors connected in series with the mains

1. Equipment
2. $R$
3. $C$
4. 50-60 Hz

---

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**High Reliability X2 RFI Capacitors**

**Against Corona Effect**

### Corona Effect

Time and time again, after a relatively short life span of 1 to 2 years, increased capacitance decrease is recorded in modern X2 capacitors caused by the so-called corona effect.

The capacitance decrease is caused by ionization, which means that the air enclosed in the winding element becomes ionized and consequently more conductive.

This allows partial discharges on the metallized surface of the film, which in turn results in local vaporization of the metallization. If this process is repeated significantly, the result is a measurable loss of capacitance.

### The Solution

In order to preclude the Corona Effect our suppliers offer a wide range of suitable products. These special parts have a different capacitor construction. One example: two capacitors sections are internally connected in series.

- Ionization is not possible.

Furthermore, a combination of several methods is used to counteract the Corona Effect, for example:

- Resilient foil
- Resilient cases
- Aluminum metallization
- Different potting compounds
- Metalized paper

These products are suitable for applications where a high capacitance stability over time is required.

- Energy meters
- Control boards for white goods and home appliances e.g. timer applications
- Relays and switching gears for industrial applications
- Applications where the capacitor is used to store energy or to divide the main voltage

### Available manufacturers

Panasonic, Vishay, Wima
(AEC-Q200 available on request)

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Tantalum & Conductive Polymer Tantalum Capacitor Solutions

Higher Reliability with our Manufacturer’s Solutions

For high reliability and optimal performances in automotive applications tantalum capacitors have to achieve special requirements:

- High continuous operating temperature
- High basic reliability
- More robust against more severe working conditions
- High endurance

Example for Several Automotive Applications

- Exterior systems
- Powertrain
- EC glasses
- Electronics
- Mirrors
- Vehicle assembly
- All-wheel drive
- Interior systems
- Metal forming

Benefits

- Highest level of reliability
- Highest operation temperature
- Optimal current 
- Lower profile & weight
- Lower ESR values
- Smaller in size

Conductive Polymer Tantalum Capacitors

Applications

- e.g. CAN/LIN vehicle networking, tire pressure monitoring system, brake & steering control, airbag system, engine control unit
- e.g. HD headlamps, air conditioning, brake & steering control, engine control unit, fan control
- e.g. vapor systems, tire pressure monitoring system, audio & video systems, air conditioning, power module, GPS, Dashboard, seat control
- e.g. DC/DC converters, battery management systems, power supply

Capacitance

0.1 - 680 µF

Tolerance

10 %, 20 %

Rated voltage

6.3 – 50 Vdc

Applications

- Body electronic applications, comfort & convenience, drive train, sensor, engine control unit, parking assistant, keyless system
- Body electronic applications, comfort & convenience, drive train, sensor, engine control unit, parking assistant, keyless system
- Dashboard systems, car alarm, LED driver, rain sensor, engine control unit, parking assistant, keyless system
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Tantalum capacitors SMD

Safety & security, body electronic applications, comfort & convenience, drive train

More robust against more severe working conditions

- 3x Reflow 260 °C
- Moisture penetration

Reliability

0.1% per 1000 hours at 85 °C, Vr with 0.1 Ω/Vr series impedance, 60% confidence level

EC glasses

- e.g. HID headlamps, air conditioning, brake & steering control, engine control unit
- e.g. HD headlamps, air conditioning, brake & steering control, engine control unit
- e.g. vapor systems, tire pressure monitoring system, audio & video systems, air conditioning, power module, GPS, Dashboard, seat control
- e.g. DC/DC converters, battery management systems, power supply

Capacitance

0.1 - 220 µF

Tolerance

10 %, 20 %

Rated voltage

6.3 – 50 Vdc

Applications

- Body electronic applications, comfort & convenience, drive train, sensor, engine control unit, parking assistant, keyless system
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Example for Several Automotive Applications

- Exterior systems
- Powertrain
- EC glasses
- Electronics
- Mirrors
- Vehicle assembly
- All-wheel drive
- Interior systems
- Metal forming

Benefits

- Moisture penetration barrier
- Thicker electrolytic layer & modified manufacturing process
- 6 case sizes with dimensions identical to standard SMD capacitors
- Low ESR parts released

Conductive Polymer Tantalum Capacitors

Applications

- e.g. CAN/LIN vehicle networking, tire pressure monitoring system, brake & steering control, airbag system, engine control unit
- e.g. HD headlamps, air conditioning, brake & steering control, engine control unit, fan control
- e.g. vapor systems, tire pressure monitoring system, audio & video systems, air conditioning, power module, GPS, Dashboard, seat control
- e.g. DC/DC converters, battery management systems, power supply

Capacitance

0.1 - 220 µF

Tolerance

10 %, 20 %

Rated voltage

6.3 – 50 Vdc

Applications

- Body electronic applications, comfort & convenience, drive train, sensor, engine control unit, parking assistant, keyless system
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Reliability

0.1% per 1000 hours at 85 °C, Vr with 0.1 Ω/Vr series impedance, 60% confidence level

Car applications requirements

1. Harsh environment conditions
   - High humidity, dust

2. Harsh electrical requirements
   - Voltage & current spikes
   - High electrostatic voltage

3. Increasingly strict requirements
   - 10 years guarantee
   - 150,000 miles
   - <1 ppm failures
   - Lead-free

4. Production certified to TSI6949 and ISO 9001

5. All capacitors certified to AECQ-200

All series of our manufacturer meet the requirements of AEC-Q200. (an international standard with enhanced stress test qualifications)

We can also offer AEC-Q200 qualified Niobium Capacitors. For more details, please do not hesitate to contact us.
**Benefits**

- High heat resistance
- Operating temperature range up to 155°C
- Typical drift below 0.05% after 1000 h
- Rated ambient temperature +85°C with rated power
- Pulse stability
- High reliability
- Moisture resistance
- Low drift at 85°C, 85% relative humidity 1000 h
- High precision
- Resistance tolerance down to ±0.05%
- T.C.R. down to ±5 ppm/K
- High stability
- Resistance change max. ±0.1%

**Features & Benefits**

- Resistance range from 0.2 mΩ to 1 Ω
- Exact measurement with low tolerances
- Wide temperature range from -65°C to +275°C
- Power rating up to 9 watt, depending on version
- Practically unaffected by temperature fluctuations
- SMD component, but also available to customer requirements
- Low thermal EMF
- Excellent frequency behaviour

---

**Current Sensing Resistors**

**Use of a Shunt Resistor for Battery Management**

Customer demands for comfort, convenience and safety in the automotive sector will continue to grow in the coming years. Implementing developments to meet these demands require a dependable vehicle electrical system that reliably delivers the power needed by each load at all times. The only way of achieving this is with comprehensive vehicle energy management.

The shunt resistor is always used when a particular application needs exact current measurements. With its high accuracy in recording and processing measured data, combined with the reliability and durability, the precision resistor is ideal for use in the vehicle.

This high degree of electronic equipment requires a dependable power supply with high energy efficiency and durability. This will be achieved by a comprehensive battery management system (BMS). The BMS is monitoring the state of the battery as represented by various items, such as:

- **Voltage**: total voltage or voltages of individual cells
- **Temperature**: average temperature, coolant intake temperature, coolant output temperature, or temperatures of individual cells
- **State of charge (SOC) / depth of discharge (DOD)**: to indicate the charge level of the battery
- **State of health (SOH)**: a variously-defined measurement of the overall condition of the battery
- **Current**: current in or out of the battery

The BMS is monitoring the state of the battery, calculating secondary data, reporting that data, protecting the battery, controlling its environment, and / or balancing it.
Automotive NTC Thermistors

In the automotive industry the importance of engine management, safety, fuel economy and control of exhaust emissions is growing rapidly. For optimal control of the various engine parameters, more precise knowledge of the various states is necessary. Nowadays sensors detect temperature changes more quickly, whereas they are exposed to higher temperatures. Rutronik’s focus in the automotive industry are (assembled) thermistor cables, which allow the engineer to bridge longer distances from the PCB to measured locations underhood. Here, a precise SMD or THT NTC is coated with epoxy, metal pipe or screw connection and assembled with cables. The length of the cables is up to engineer demands.

Requirements for the automotive market
- Short reaction time
- Small sizes
- Special coating (protecting against electrical, mechanical, climatic impacts)
- Climatic category IEC 60068-1
- High accuracy over a wide temperature range
- High stability over a long life
- Exceptional thermal shock withstanding performance
- High voltage sector

Typical automotive applications
- Inside temperature
- Outside temperature
- Air condition
- Air intake
- Cooling water
- Motor oil
- Transmission oil
- Brake fluid
- Water heater
- Battery management

MLVs have long time been an ideal solution for low power circuit and sensor applications due to their inherent low current leakage characteristics, which can be as low as a few nanoamps. MLV off-state capacitance is also a compelling advantage to designers since it provides a broad range of EMI filtering. Automobile designers are some of the most stringent in the world. Recently two technology developments have broadened the MLV family of products:

- The operating temperature range of MLVs has been expanded to a range of -55°C to +150°C.
- The capacitance of an MLV has been reduced to <1 pF. This results in MLVs with self-resonant frequencies in the 9000 MHz range.

Expanding the range of available capacitance down to <1 pF and upwards to 16 nF is of particular interest to the automobile community.

Advantages of MLV technology

Electrical
- EMI filter response
- Highly rugged on extreme thermal cycles and repetitive pulses
- Reliable ESD protection acc. to ISO 10605 and IEC 61000-4-2 Level 4 up to 25 kV for high-speed data buses
- Bidirectional clamping
- Fast response time: <0.5 ns due to small case inductance
- Repetitive strike capability
- Operating voltage varies from 3.3 V up to 385 V
- Energy absorbency depends on MLV size, typical values between 50 mJ (only ESD protection) up to 50 J (inductive voltage peaks)
- Custom-designed MLVs for CAN-Bus, LIN, Flexray, USB and other applications

Physical
- SMD sizes from 0402 to 2220
- Single MLV takes place of back-to-back diode plus an EMC capacitor thereby saving up to 90% of the board space that zener & capacitor solutions demand
- Lead free (RoHS compliant)

Termination
- Ni-barrier termination with tin alloy plated finish for lead-free soldering acc. to IEC 60068-2-59 and acc. to JEDEC J-STD-020C
- Operating temperature up to +125°C for lead-free soldering or +150°C for hybrid mounting

Dangers in automotive applications
- ESD spikes
- EMI
- Load dump
- Inductive switching
- Jump start
Our continuously improved product range of magnetic products are not only compatible with today’s systems – we offer designers the flexibility to incorporate the technology of tomorrow and support you to bring cutting-edge systems to market first.

RUTRONIK has extended its range of common mode filters for automotive networking applications by introducing filters from our wide portfolio of manufacturers. The chokes achieve a common-mode impedance up to high frequencies and inductive-coupling coefficient. These devices maximize signal integrity as well as noise immunity and ensure a great reliability. This is achieved through advanced adhesives, internal constructions and technologies.

Can-Bus Chokes

- Ferrite Bead
  - 20 dB suppression
  - Easy to use
  - Low price
  - Large selection

3-terminal Filter

- High performance
- 60 dB suppression
- LC/RC-combinations

Noise Reduction Solutions

- Low signal distortion
- High noise suppression
- High frequency
- Flexible usage
- Good mechanical strength

Examples for Several Automotive Applications

- Electric power steering
- Door lock
- Door lock/Keyless entry
- Airbag
- Door lock
- Air conditioner
- Sunroof
- Rear wiper

Common mode chokes effectively reduce noise levels

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<td>500.0</td>
<td>200</td>
<td>0</td>
<td>50</td>
<td>40 to 125</td>
<td>4.5x3.2x3.8</td>
<td>ACT45B-1102P</td>
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<tr>
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<td>1000.0</td>
<td>200</td>
<td>1</td>
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<td>40 to 150</td>
<td>4.5x3.2x2.8</td>
<td>ACT45B-2202P</td>
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<td>ACT45B-5102P</td>
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<td>ACT45B-1012P</td>
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Noise Level [dBuµ/m]

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Noise Reduction Solutions

- Insertion Loss [dB]
- Noise Reduction [dB]

Benefits
- Low signal distortion
- High noise suppression
- High frequency
- Flexible usage
- Good mechanical strength
Timing Devices in Automotive Applications

Timing Devices such as quartz crystals, oscillators, real-time-clock modules and resonators provide accurate clock frequency for all automotive key applications. To produce reliable components the factories are certified according to ISO9001 TS16949 ISO 14001. Automotive parts have to fulfill AEC-Q200 standard. For safety applications special materials are used to guarantee the operation in harsh environment. PPAP documents of submission level 1 to 5 can be provided on request.

Key Features
- Accuracy over a wide temperature range
- Robust designs for reliable products
- Special packages with special terminals to avoid cracks
- Seam-sealed ceramics with grounded lid, EMI solutions
- High reliable glass sealed 2 pad crystals

Benefits
- Board evaluation with manufacturer, to
  - Shorten development time
  - Ensure enough safety oscillation margin
  - Achieve specified tolerance by frequency matching

Robust Package Portfolio

<table>
<thead>
<tr>
<th>Crystals</th>
<th>TCXO</th>
<th>SPXO</th>
<th>Real Time Clock</th>
<th>Ceramic Resonator</th>
<th>SAW Resonator/Filter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Body electric control</td>
<td>GPS navigation</td>
<td>Information system</td>
<td>Camera</td>
<td>Instrument cluster clock</td>
<td>Car navigation</td>
</tr>
<tr>
<td>ABS, airbag, engine control</td>
<td>Telematics</td>
<td>ABS, airbag</td>
<td>Wireless, wiper control</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Display control</td>
<td></td>
<td></td>
<td></td>
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</table>

32.768 kHz Tuning Fork Products

Applications
- Remote keyless entry
- Infotainment & telematics
- Advanced driver assistance system
- Connected car

MHz Crystals

Applications
- Advanced driving assistance system
- ECU
- High-speed automotive network
- TPMS

Real Time Clock Modules

Applications
- Battery control
- Board diagnostic
- Car audio
- GPS

Oscillators

Applications
- Navigation
- Front / Rear camera
- Multi media interface
Purpose

Crystal offers more precise tolerances (20ppm to 250ppm) but for many applications a resonator is the right choice, because it is cheaper than a quartz crystal.

### Resonators

#### Purpose

**Circuit stability**
To evaluate the combination of IC and ceramic resonator to seek optimum circuit conditions, preventing oscillation failure such as stop oscillation and irregular oscillation.

**Frequency matching**
To measure the frequency correlation between your PCB and standard test circuit. This is important for tight tolerance (±0.1% and ±0.2% initial tolerance) resonators.

#### Benefits

**Save time and effort**
Customers can save engineering time and effort in evaluating oscillation circuits in terms of preventing oscillation failures.

**Guaranteed oscillation**
Guaranteed resonator oscillation with optimum resonator part number and circuit conditions.

**Assumption:** No changes have been made to the IC and/or PCB.

#### Known performance

Customers know the performance and frequency correlation. If required, resonator frequency can be adjusted to the IC/PCB based on customers frequency tolerance requirement.

<table>
<thead>
<tr>
<th>Series PN</th>
<th>Size</th>
<th>Frequency range</th>
</tr>
</thead>
<tbody>
<tr>
<td>PM0VHR1</td>
<td>7.4 x 3.4 x 2.0 mm</td>
<td>2 to 20 MHz</td>
</tr>
<tr>
<td>PM0VHR1</td>
<td>4.5 x 2.0 x 1.2 mm</td>
<td>4 to 20 MHz</td>
</tr>
<tr>
<td>P0QQV</td>
<td>3.2 x 1.3 x 1.0 mm</td>
<td>8 to 20 MHz</td>
</tr>
</tbody>
</table>

#### Key Specifications

- **Save space and components:** 3.2 x 1.3 mm
- **Built in capacitor**
- **Shorter start-up time**
- **Contribute to cost reduction**
- **Less influenced by foreign particles**
- **Tight frequency tolerance ±0.25%**
- **High temperature -40 + 150ºC**

#### Automotive Graded Resonators

<table>
<thead>
<tr>
<th>Test Condition</th>
<th>Test Item</th>
<th>Acceptable</th>
</tr>
</thead>
<tbody>
<tr>
<td>High temperature exposure</td>
<td>125ºC, 1000h</td>
<td>Acceptable</td>
</tr>
<tr>
<td>Temperature cycling</td>
<td>1000 cycles</td>
<td>Acceptable</td>
</tr>
<tr>
<td>Moisture resistance</td>
<td>MIL-STD-202 Method 106</td>
<td>Acceptable</td>
</tr>
<tr>
<td>Bias (Max)</td>
<td>85ºC/85% RH, 6V, 1000h</td>
<td>Acceptable</td>
</tr>
<tr>
<td>Mechanical shock</td>
<td>10G, 6ms, 6 sides</td>
<td>Acceptable</td>
</tr>
<tr>
<td>Thermal shock</td>
<td>300 cycles</td>
<td>Acceptable</td>
</tr>
<tr>
<td>ESD</td>
<td>Level depends on the series</td>
<td>Acceptable</td>
</tr>
<tr>
<td>Board Flex</td>
<td>2mm</td>
<td>Acceptable</td>
</tr>
</tbody>
</table>

#### Acoustic Components in Automotive Vehicles

- **Instrument cluster**
  - Seat belt warning sound
  - Head light reminder sound
  - Key reminder sound
  - Flat tyre warning sound
  - Reverse warning sound
  - Turn signal operation sound

- **ETC (Electronic Toll Collection)**
  - Confirmation sound of operation
  - Car audio / navigation
  - Confirmation sound of button / an operation
  - TPMS (for after market)
  - Confirmation sound of tyure pressure warning

- **Burglar alarm**
  - Car siren
  - RKE Transmitter
  - Answer back

#### Piezoelectric Sounder for Turn Signal

Piezoelectric sounders can create the tick-tack sound of a turn signal as shown in the following example.
Five good reasons for choosing Rutronik24

Order online and receive personalised on-site support. We offer Catalog, Procurement, Mass Quotation and Product Change Notifications.

1. Personal support
   You got it.
   With Rutronik24 we have created a modular platform that significantly simplifies your business processes. The advantages of rapid online orders are combined with a personal advisory service, tailored to your needs. This has not replaced our personal service; on the contrary: We are adding to it.

2. Catalog
   All roads lead to us.
   Are you looking for a particular electronic component? Our Rutronik24 catalog will guide you reliably to the right choice: Our Product Groups Search will enable you to find the product you are looking for in a maximum of three steps. The product groups are divided into semiconductors, passive and electromechanical components, storage technologies, displays & boards as well as wireless technologies. Using the full-text and part number search, you can select results after entering parts of the product or manufacturer’s name.

3. Procurement
   Everything at a glance.
   The Rutronik24 "Procurement" module provides you with a complete overview of your orders, item lists, stocks, contracts and delivery times. You can conveniently download all the lists in Excel format and import them into your inventory control system, for example. Take the opportunity to save time.

4. Mass quotation
   Everything in just a few seconds.
   Rutronik24 offers you the opportunity to access all the information about our products very quickly. We have developed the "Mass quotation" tool for the fast and simple evaluation of your individual material. Upload your comprehensive item lists to our system in one file and this will then be returned to you, complete with current prices and additional information, just a few moments later.

5. PCN
   Everything from a single source.
   Be fully informed of changes. Our Rutronik24 "PCN" module keeps you up-to-date with current product changes from our manufacturers. Not only do you have access to an extensive PCN database, but the product changes are also linked directly to the respective product. This gives you the opportunity to react in good time to the changes.
Please note, there could be some limitations for some franchised product lines in several countries. For more information, please contact our sales team.