Committed to excellence

RUTRONIK
ELECTRONICS WORLDWIDE

Passive Automotive Components

Capacitors | Resistors | Chokes & Ferrites
Acoustic Components | Timing Devices

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Committed to excellence

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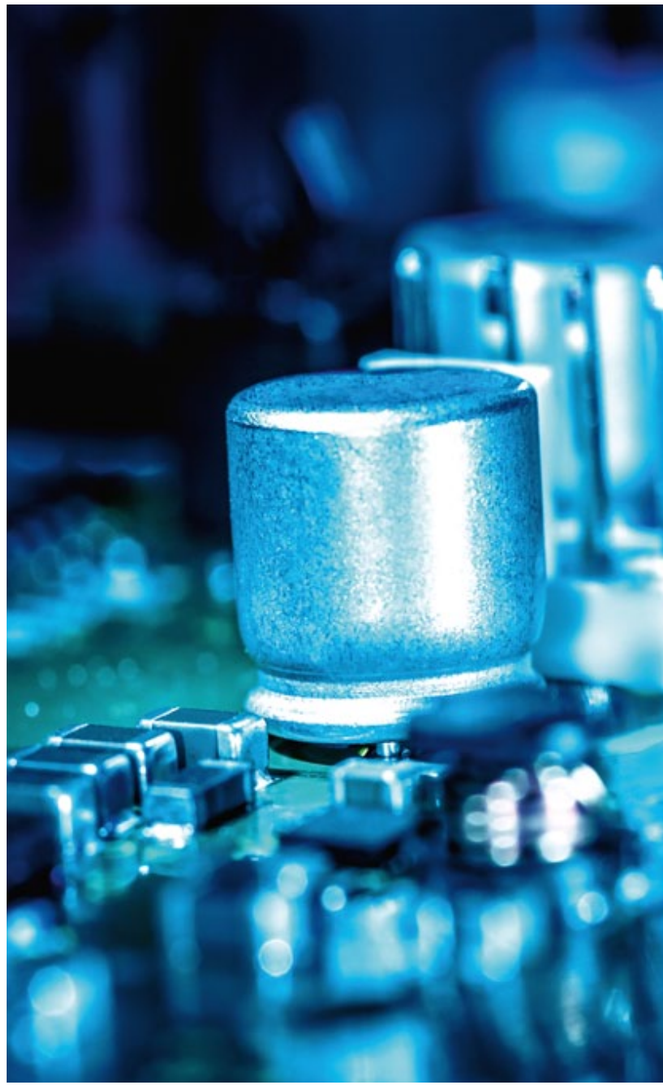
Quality management without compromise

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

Passive Automotive Components

RUTRONIK ELECTRONICS WORLDWIDE



RUTRONIK & Automotive

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, QS900 / 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.

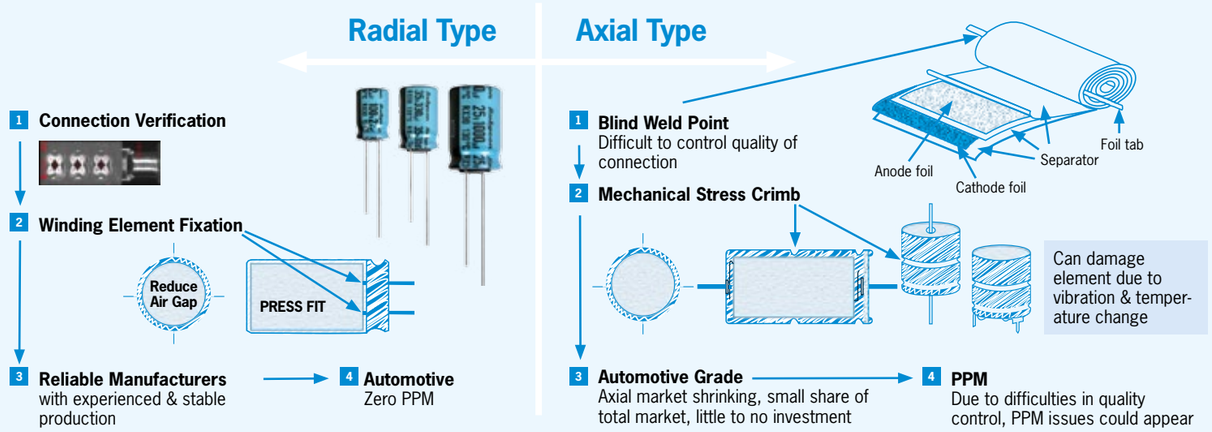
Introduction

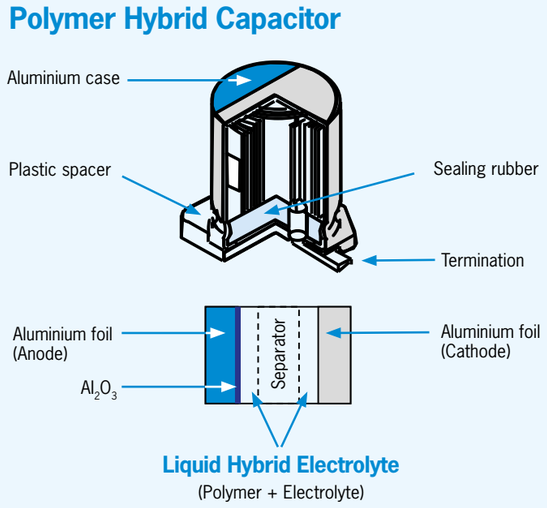
Today's automobiles include more electronic systems than ever before. Innovations in safety and environmental systems, as well as driver expectations of greater comfort, convenience and security are driving the trend towards more sophisticated on-board electronic applications.

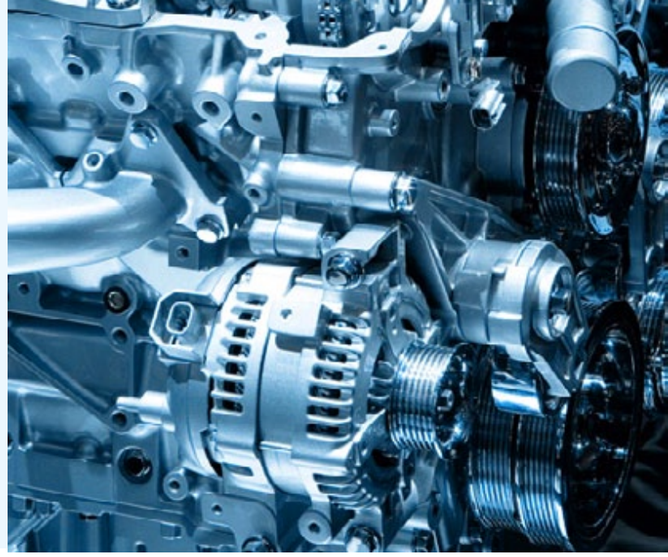
Many of these systems are critical to vehicle performance and passenger safety. For this reason, the accurate requirements for the components have to be considered.
Market requests like:
"...for automotive or for automotive application...",
"...Automotive suitable or capable...",
"...in accordance to, 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.

Applications, Functions	Recommended Parts
Information, comfort like: Navigation, audio, infotainment, power window, climatic control	Mostly commercial parts used and still allowed, but fast growing demand by customers for automotive specification
Safety like: ESC/EPS, ABS, Airbag, TPMS, HID, distance control	Automotive specified parts required
Powertrain like: Cruise and engine control, EPS/DSC, AT/CVT	Automotive specification strongly recommended, sometimes required
Clamp 30 (directly battery-connected): All functions where a failure / short circuit stops the car	Automotive specified parts required



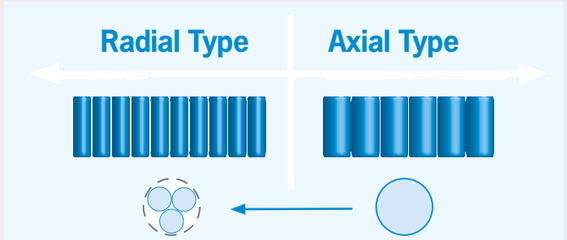




Replacement of Axial Aluminium Electrolytic Capacitors

Comparison of Radial and Axial Technology

Features	Radial	Axial
High Market Share	X	
Second Source Availability	X	
Size / Performance Ratio	X	
Vibration Resistance	X	X
Productivity Performance	X	
Design to cost	X	
Individual Capacitor Spec.		X



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

SMD Anti-Vibration Aluminium Electrolytic Capacitors

Benefits

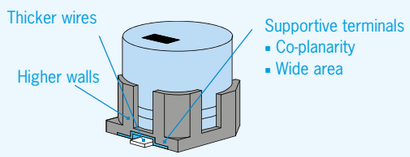
- High vibration and mechanical stress create demands on rugged and high reliable electronic components in automotive applications.
- Wherever inductive loads in vehicles are operated, a sufficient and stable power supply network is absolutely essential.
- With special created terminals, higher walls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

Features:

- Capacity: 4.7 to 8200 µF
- Voltage: 6.3 to 100 V
- ESR: down to 0,03 Ω
- Temp. range: -40 / -55 °C to +105 / +125 °C / +150°C
- Lifetime: 2000 to 10000 h
- Acceleration: 30 G (294 m/s2)
- Available for all case sizes ≥ size code E (Ø8 mm)
- High reflow soldering up to 260 °C available
- Co-planarity improved: due to supportive terminals the E-Cap is fixed on the PCB completely

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

Features	Anti-Vibration E-Cap	Standard E-Cap
Accelaration	30 G (294 m/s2)	not specified
Frequency	5 to 2000 Hz	10 to 55 Hz
Amplitude peak to peak	5 mm	1.5 mm
Duration	16 min / 1 cycle	1 min / 1 cycle
	2 hrs each of 3 axis (x, y and z)	



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

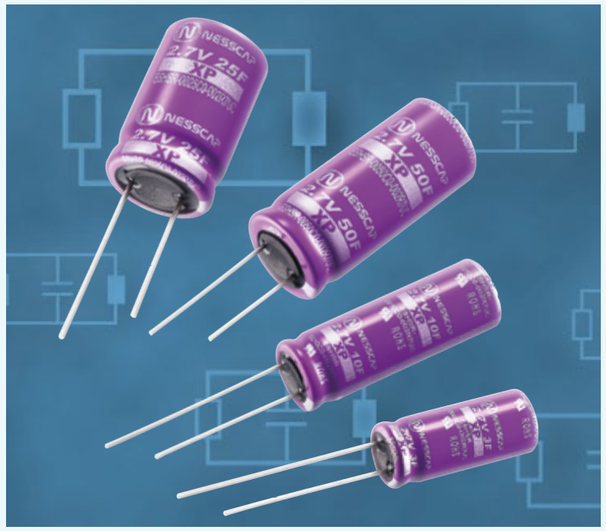
Type	Polymer Hybrid Capacitor	Solid Polymer Capacitor	Wet Electrolytic Capacitor
Temperature range	-55°C to +125°C	-55°C to +125°C	-40°C to +125°C
Size (øDXL)	10X10.5	10X12	10X10.5
Rated Voltage	35V	35V	35V
Capacitance	270µF	56µF	220µF
Leakage Current (WV 2min)	94.5µA (0.01CV)	392µA (0.2CV)	77.0µA (0.01CV)
Ripple Current (100kHz)	2000mA	2000mA	550mA
ESR(100kHz, 20°C)	20mΩ	31mΩ	120mΩ
Lifetime (125°C)	4000 Hrs	3000 Hrs	3000 Hrs

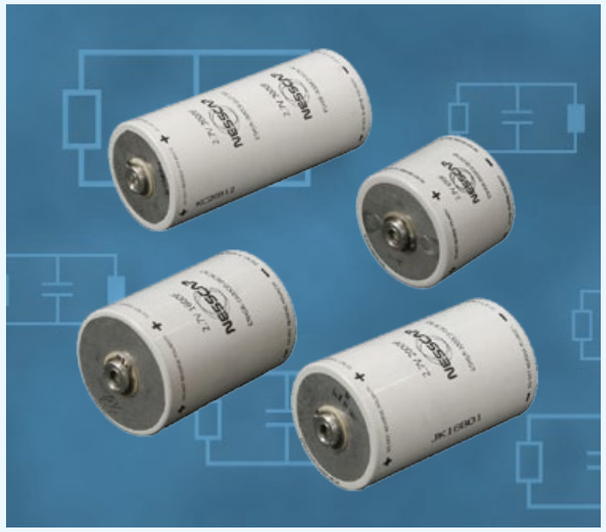
High Temperature THT Aluminium Electrolytic Capacitors

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.

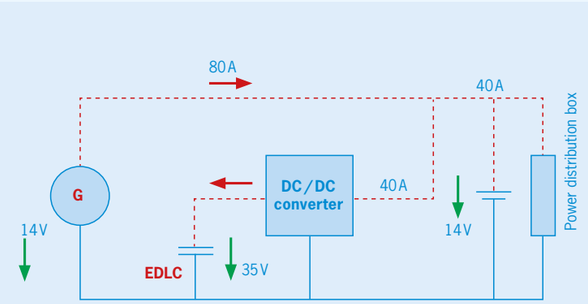
Below are some examples of typical applications and fitting THT capacitor types:

Type	Voltage	Temperature	Lifetime	Applications
Low ESR	6.3 - 100 V	105 °C	4000 - 10000 Hrs	Infotainment, DC/DC, body control
High temperature	10 - 400 V	up to 130 °C	1000 - 4000 Hrs	Drive control, EPS, body control, EV application
High temperature	25 - 70 V	135 to 150 °C	2000 - 3000 Hrs	EPS, EV applications
High voltage / high temp	250 - 275 V	125 to 135 °C	3000 Hrs	Drive control, E-compressor
Anti-vibration design	6.3 - 400 V	up to 150 °C	up to 7000 Hrs	Gear box control, EPS, drive control

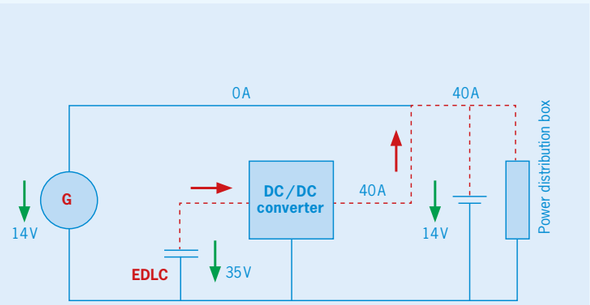




Overrun conditions → Ultracaps charging



Acceleration → Ultracaps powers board net
→ generator power available for acceleration



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 CO^2 emissions, a raft of new requirements is developing:

- Low fuel consumption
- Low CO2 emission
- High dynamic
- Low weight battery
- High efficiency
- Long life-time of battery
- High reliability of on board electronics

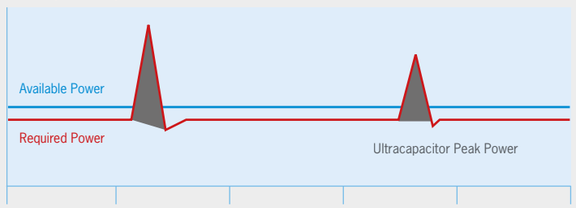
Positive results can be achieved by the use of Double-Layer Capacitors, also known as supercaps, in combination with conventional batteries. Supercapacitors – or supercaps – fill the energy density gap between conventional capacitors and batteries. Due to their extremely high power density, supercaps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

Comparison of different Energy Storage Technologies

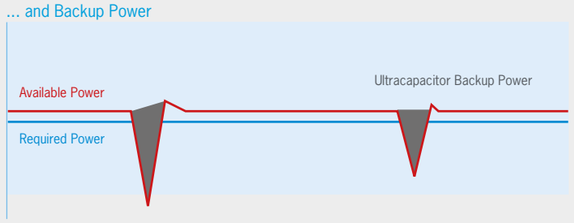
Type	Batteries	EDLC	Conv. Capacitors
			
Time of charge	1 to 5 h	0.3 to 30 s	10^{-3} to 10^{-6} s
Time of discharge	0.3 to 3 h	0.3 to 30 s	10^{-3} to 10^{-6} s
Spec. energy [Wh/kg]	20 to > 100	< 10	< 0.1
Lifetime [cycles]	1000	up to 1 Million	up to 1 Million
Spec. power [W/kg]	< 1000	> 10000	> 100000
Efficiency	0.7 to 0.85	0.9 to 0.98	> 0.95

Rutronik partner: Nesscap (others on request)

Ultracapacitors provide Peak Power ...



... and Backup Power



General Key Features

- Clean energy-source
- Fast charge-/discharge cycles (only a few seconds)
- High charge-/discharge currents (up to hundreds of A)
- Long life-time (up to over 1 billion cycles)
- Wide operating temperature range
- No replacement necessary – maintenance free
- Series- and parallel-connection possible
- Typical voltage range 2.1 V-3.0 V per single cell

Combination with Batteries in Hybrid and Electric Cars

Recuperation of braking energy / power boost

- Supercap unit stores energy generated by braking and releases it within a short-time for acceleration

Peak-load levelling

- Supercap unit supports battery by covering power-peaks
  - smaller size
  - lower weight

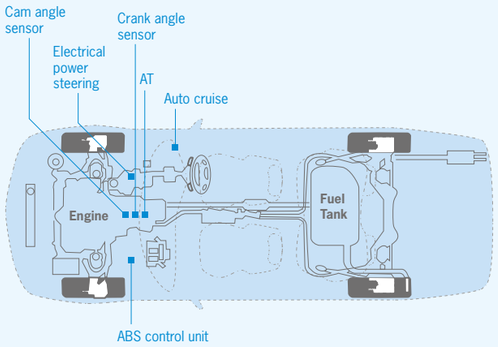
Local power supply

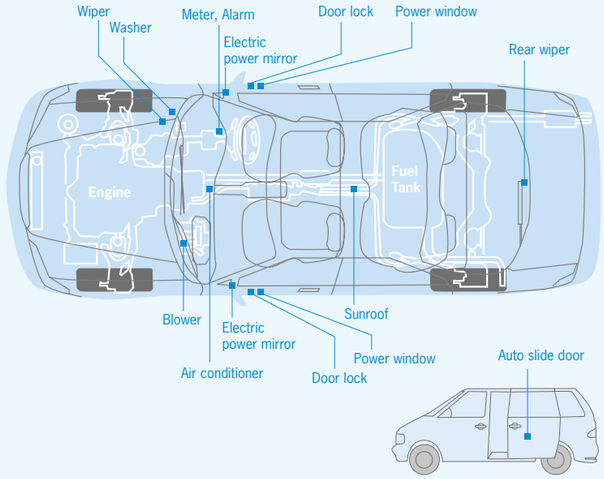
- Supercap unit supplies local electric systems which need peak power within a short time

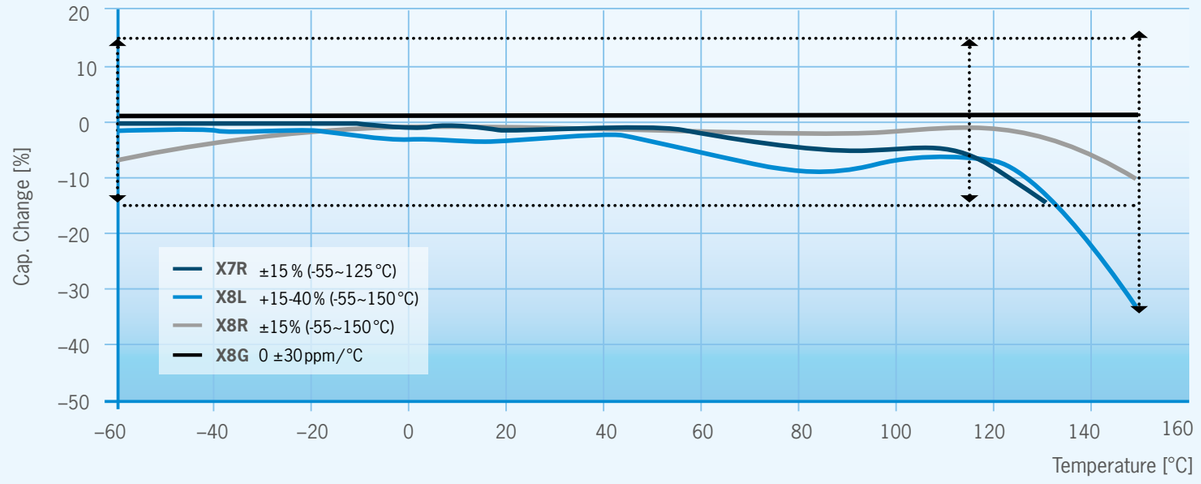
Boardnet stabilisation

- Safety back-up for security relevant on-board electronic system

Examples for several Automotive Applications

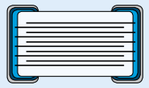
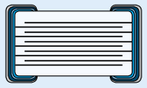
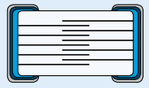






Ceramic Capacitors

Choose the right MLCC. Comparison of different versions.

Figure						
Type version	Standard	AEC-Q200	+150°C - specified	Flexiterm/ Soft Termination	OpenMode/ FR-Design	Combined Design
	Commercial Parts	Automotive qualified	High Temperature	Other names are e.g. Soft, Polymer, Flexible Termination, Softelectrode, FlexiCap		Flexiterm/Softterminati-on with Cascade-Design (Floating-, Serial- Elec-trode) or Open Mode Design
Generally	Standard Specs and qualifications	Increased sample plans with more and higher criteria	Standard Specs and qualifications, but speci-fied up to +150°C	Standard Specs and qualifications, but: - bending strength ≥ 3mm - tendency to open beyond	Standard Specs and qualifications, but construction avoids a short circuit caused by typical bending cracks	AEC-Q200- Spec. Highest protection against short circuit
Bending strength	1mm (some 2mm)	NPO 3mm, X7R 2mm	1 mm (some 2mm)	X7R ≥ 3mm	1 mm	X7R ≥ 3mm
Temp.-Cycles	5 cycles	1000 cycles	5 cycles	3000 cycles (AVX)	5 cycles	3000 cycles (AVX)
Thermal shock	no	yes	no	no	no	yes
Visual check	by sample plan	100%	by sample plan	by sample plan	by sample plan	100%
Other differences see detailed specifications supplier by supplier, e.g. vibration, ESD, high temperature exposure (storage), moisture resistance, etc.						
Ceramic	NP0 (COG), X5R/ X7R/X8R, Y5V	NP0 (COG), X7R, X8R (L)	X8G, X8R, X8L	X7R	X7R, X8R, X5R	X7R
Voltage	4.0V ... 5kV	6.3V ... 3kV	10V ... 100V	10V ... 3kV	16V ... 630V	16V - 100V
Capacitance	0.47pF ... 220µF	0.47pF ... 47µF	100pF ... 10µF	200pF ... 22µF	220pF ... 22µF	1.0nF ... 1.0µF
Note		Many items also available as Soft Termination / Open Mode / +150°C	Also available as AEC-Q200 or/and Soft Termination	Also available as +150°C or/ and AEC-Q200	Also available as AEC-Q200	AEC-Q200- Spec. Highest protection against short circuit

AEC-Q200 is an international standard with enhanced stress test qualification.

High Temperature. 150 °C.

MLCC 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.

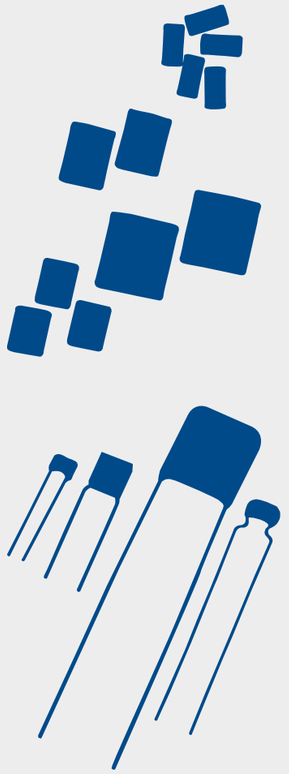
Available from AVX, Murata, TDK, Vishay.
AVX also as Flexiterm® (with Soft Termination), Vishay with derating for usage up to 175°C.

MLC Radial Automotive & 150 °C – new leaded types

Based on strong increase of sensors, both in automotive applications and for mounting on lead-frames instead of pcb's, leaded multilayer capacitors (MLC) become more and more interesting.

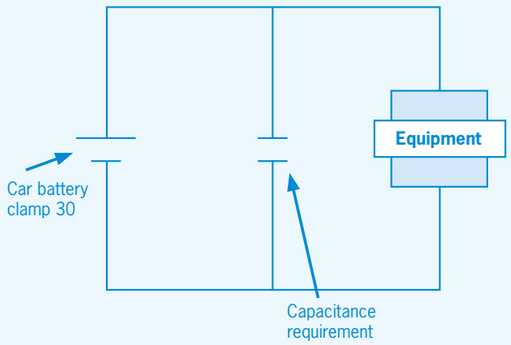
To fulfil automotive and high temperature requirements these MLC have been created with AEC-Q200 qualification and additionally with some values specified up to 150 °C. One of the best-known functions are the suppression capacitors for Hall Sensors.

Besides AVX and Murata, Vishay also launched a new programm 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.



Ceramic	NPO	X7R	X8L	X8R
TC / Temp.	±30ppm/°C -55 to +125 °C	±15% -55 to +125°C	+15-40% -55 to +150 °C	±15% -55 to +150 °C
Tolerance	±5% / ±10%	±10% / ±20%	±10% / ±20%	±10 % / ±20%
Voltage	50V - 200V	50V - 3kV	50V - 100V	25V - 50V
Capacitance-Range radial	1.0pF - 10 nF	330pF - 4.7µF	1.0nF - 10µF	1nF / 10nF / 100n - 330nF
Capacitance-Range axial	100pF - 10nF	330pF - 1µF		470pF - 330nF

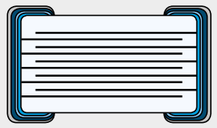
Available from AVX, Murata, TDK, Vishay.



Ceramic Capacitors

MLCC crack and short circuit protection. Higher reliability with our manufacturer‘s solutions

Soft Termination + Standard Design

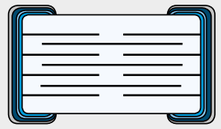


In addition to the standard chip design with its high volumetric efficiency a conductive epoxy coat between first termination layer and the NiSn plating is used. Through this flexible epoxy coat the MLCC withstands much higher bending stresses. Beyond this in case of too high mechanical stress instead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

Soft Termination + Float Mode Design

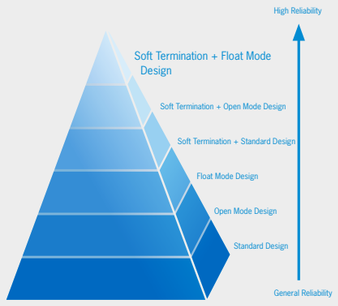


Combines the feature of a flexible conductive epoxy coat with an internal serial construction of two caps.
Maximum capacity is about a third compared to a standard design based both on series connection and the gap between the two active areas. Double insurance: in the improbable case of a crack almost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

Supplier Overview

Supplier	Flexiterm / Soft- / Polymer- / Termination	Combined Designs Flexiterm / Soft Termination with		AEC-Q200
		Open Mode Design	Cascade Design	
AVX	■		■	■
Murata	■		■	■
Samsung	■	■	■	■
TDK	■		■	■
Vishay	■			■

■ available

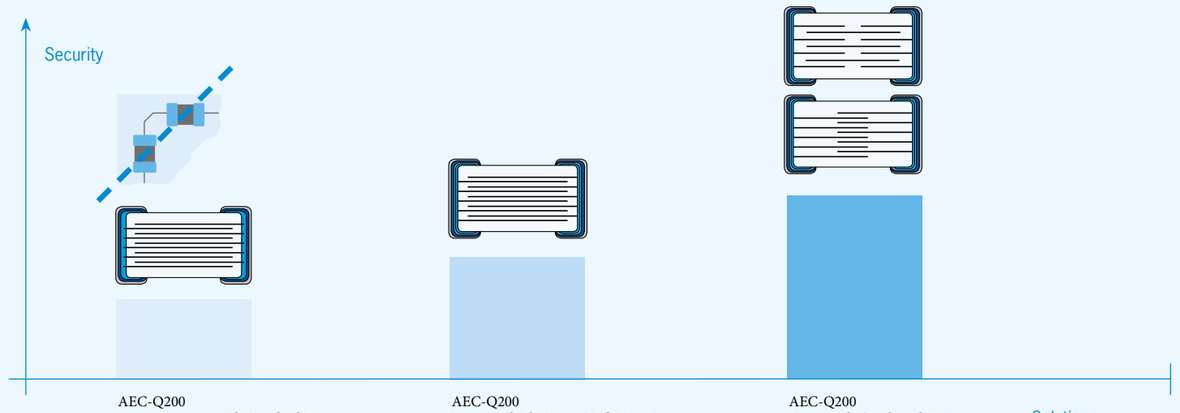


Clamp 30 solutions

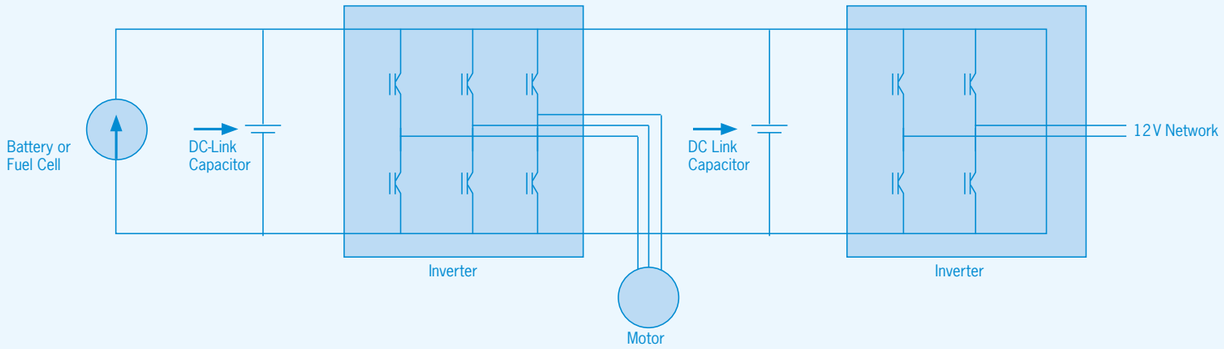
More than 95% of defect components sent back to the supplier for analysis are damaged mechanically by bending stress. Based on this fact the typical recommendation of automotive customers for connections directly across the battery is to use two parts connected in series and mounted in a 90° angle to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

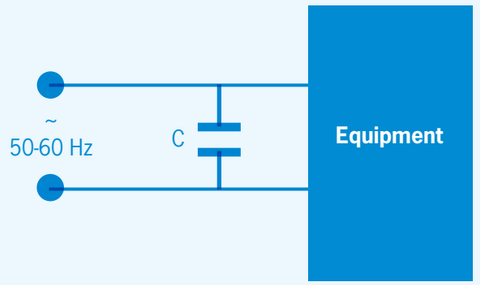
The highest level of security can be reached by using an automotive MLCC with a combined design, i.e. a Flexiterm / Soft-/ Polymer-termination together with Open Mode or cascade design.



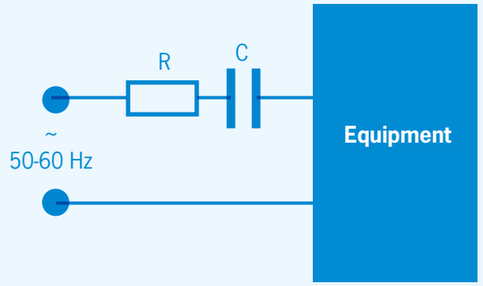
DC-Link Capacitor



Capacitors connected in parallel with the mains



Capacitors connected in series with the mains



Film Capacitors

DC-Link Capacitors in EV/HEV Applications

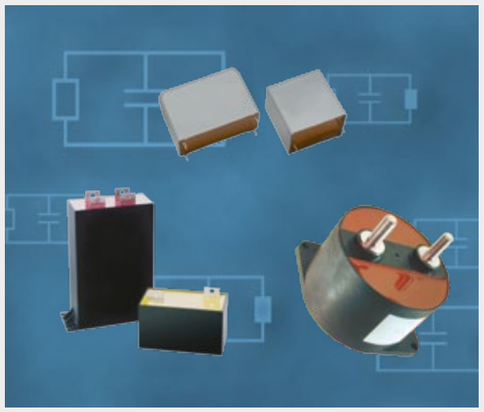
The DC-Link capacitors prevent ripple currents from reaching back to the power source and serve to smooth out DC-bus voltage variations. That means the capacitor acts as a „buffer“ between the power source and the inverter and in more complex systems also between different inverters. EV/HEV platforms 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. Urated >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 densitiy
- 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

	DC-Link Capacitors
Capacitance range	0.47 µF to 4920 µF
Rated DC voltage	400 Vdc to 3900 Vdc
Capacitance tolerance	5%, 10%, 20%
Operating temperature range	-55 °C to +85 °C / 105 °C
Dielectric	Polypropylene, Polyester
Component shape	rectangular or cylindrical case, modules
Mounting	2-leads, 4-leads, screw connectors, customized

Available from AVX, Panasonic, Vishay, Wima.



High Reliabilty 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.

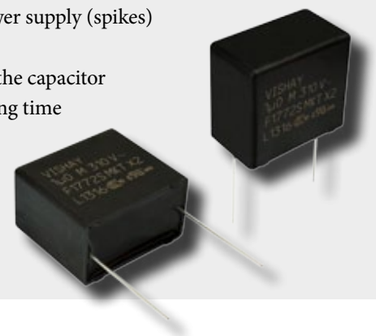
The capacitance decrease is caused by ionization, which means that the air enclosed in the winding element becomes ionized and consequently more conductive.

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 use of capacitors parallel to the mains results in a reduction in the component's ability to suppress interference. When they are used in series, the result is usually complete failure of the application.

This effect is influenced by factors including:

- the climatic ambient conditions such as humidity and temperature
- the status of the power supply (spikes)
- the voltage
- the construction of the capacitor
- the effective operating time



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.
The voltage on the capacitor is divided by two.
→ **Ionization is not possible.**

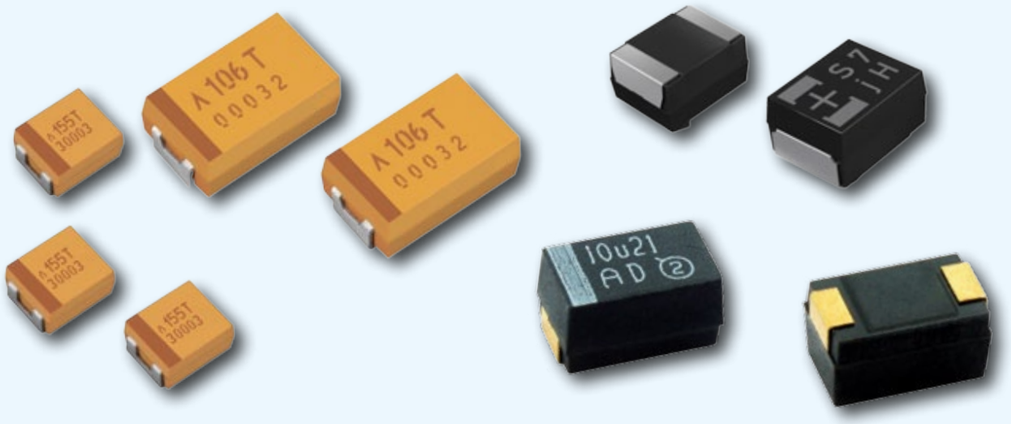
Furthermore, a combination of several methods is used to counteract the Corona Effect, for example:

- Resilient foil
- Resilient cases
- Aluminum metallization
- Different potting compounds
- Metallized 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)



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

Type	High Performance		Standard Automotive		Conductive Polymer Tantalum Capacitors
Tantalum capacitors SMD	Safety & security, body electronic applications, comfort & convenience, drive train		Body electronic applications, comfort & convenience, drive train		Body electronic applications, drive train, comfort & convenience
	High Reliability	High Temperature	Standard	Low ESR	High Reliability
Applications	e.g. CAN/LIN vehicle networking, tire pressure monitoring system, brake & steering control, airbag system, engine control unit	e.g. HID headlamps, air conditioning, brake & steering control, engine control unit, fan controller unit	e.g. wiper systems, tire pressure monitoring system, audio & video systems, air conditioning, power module,GPS, Dashboard, seat control	e.g. DC/DC converters, battery management systemes, power supply	Dashboard systems, car alarm, LED driver, rain sensor, engine control unit, parking assistant, keyless system
Capacitance	0.1 - 680 µF	0.1 - 220 µF	0.22 - 680 µF	0.22 - 680 µF	10 -680
ESR values	–	–	–	ESR readings measured at 100 kHz, +25 °C from 100 mΩ to 7000 mΩ	ESR readings measured at 100 kHz, +25 °C from 23 mΩ to 2200 mΩ
Tolerance	10%, 20%	10%, 20%	10%, 20%	10%, 20%	20%
Rated voltage	4-50 Vdc for continuous operation at +85 °C	6.3-50 Vdc for continuous operation at +85 °C	6.3 – 50 Vdc for continous operation at + 85°C	6.3 to 50 Vdc for continuous operation at + 85 °C	1.8-8 Vdc for continous operation at +85 °C (0.66DC to 105 °C / 0.5DC to 125 °C)
Operating temp.	-55 to + 85 °C (to + 125 °C with voltage derating)	Up to 200 °C	-55 to +85 °C (to +125 °C with voltage derating)	-55 to + 85 °C (to +125 °C with voltage derating)	-55 to +105 °C
Reliability	0.5 % per 1000 hours at 85 °C, Vr with 0.1 Ω/Vr series impedance, 60 % confidence level	0.5 % per 1000 hours at 85°C, Vr with 0.1 Ω/Vr series impedance, 60 % confidence level, 3.5 fits at 40 °C, 0.5 Vr	1 % per 1000 hours at 85 °C, Vr with 0.1 Ω/Vr series impedance, 60 % confidence level	1 % per 1000 hours at 85 °C, Vr with 0.1 Ω/Vr series impedance, 60 % confidence level	0.2 % per 1000 hours at 85 °C, Vr, 0.1 Ω/Vr series impedance, 60% confidence level
Benefits	▪ Moisture penetration barrier ▪ Thicker dielectric layer & modified manganising process ▪ 6 case sizes with dimensions identical to standard SMD capacitors ▪ Low ESR parts released	▪ High temperature operation and higher basic reliability for optimal performance ▪ 5 case sizes with dimensions identical to standard SMD capacitors ▪ Low ESR parts released	▪ High temperature operation and higher basic reliability for optimal performance ▪ 5 case sizes with dimensions identical to standard SMD capacitors ▪ 3x Reflow 260 °C compatible	▪ 5 case sizes with dimensions identical to standard SMD capacitors ▪ Excellent line and field performance	▪ Surge resistant ▪ Benign failure mode under recommended conditions ▪ Roadmaps to 150 °C, 63V and Lower ESR

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.

Engine control unit

Infotainment

Dashboard systems

Keyless entry

LED Lighting

Air conditioning

Tyre pressure monitoring system

Parking assistant

Car applications requirements

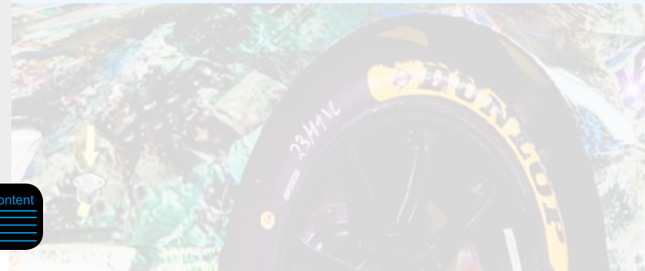
1. Harsh environment conditions
- Wide temperature range
- High humidity, dust

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

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

4. Production certified to TS16949 and ISO 9001

5. All capacitors certified to AECQ-200



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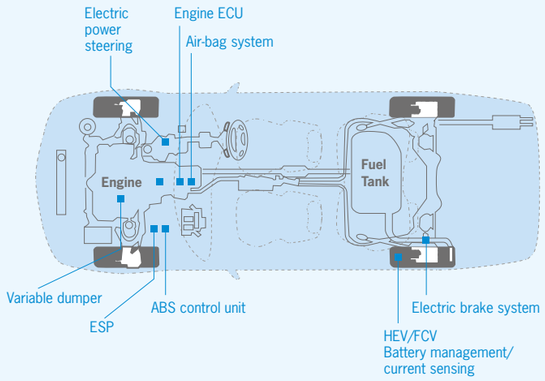
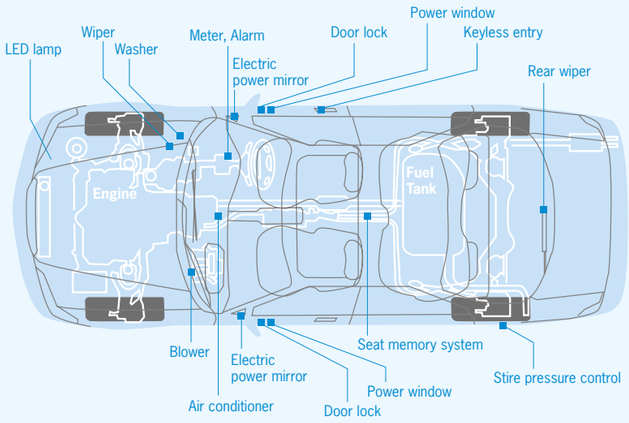
Examples for Several Automotive Applications





Thin Film Resistors

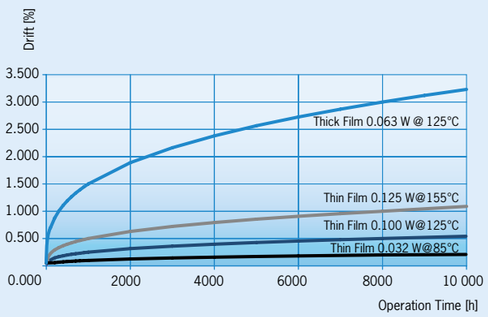
Braking and safety systems, engine management, gearbox control and power supply are systems which depend on a high degree of reliability and long-term stability of all components.

Thin Film Resistors are precise, reliable, temperature-resistant and unsusceptible to moisture. These characteristics make them ideal for recording, evaluating and processing measured variables that are hardly distorted by the resistance.

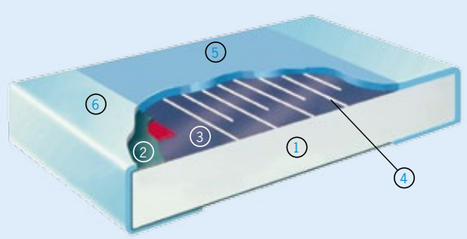
Rutronik cooperates with innovative manufacturers of Thin Film Resistors.

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 %

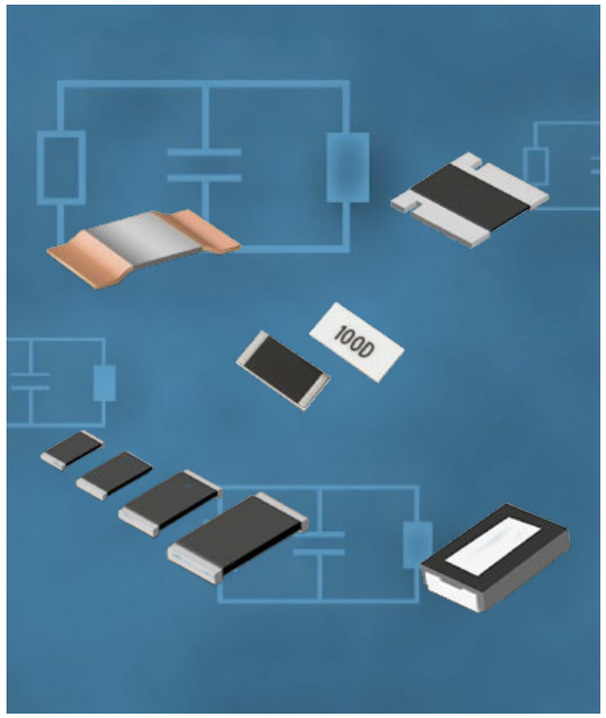


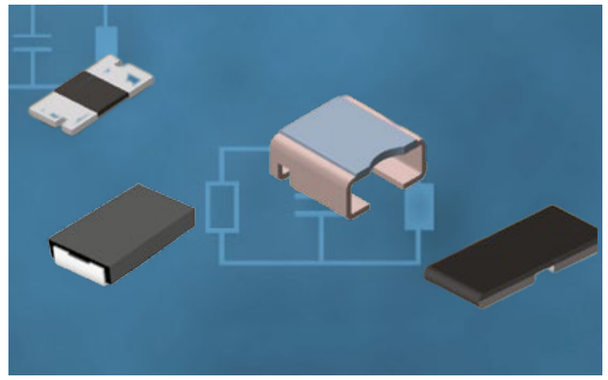
Resistance drift – Thin Film compared to Thick Film



1. Ceramic Substrate
2. Ceramic Substrate
3. Resistive Layer
4. Laser Trimming
5. Lacquer
6. Electroplated Termination

Construction





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

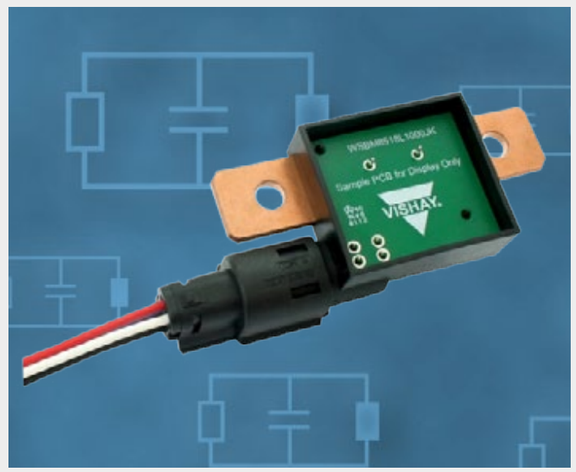
Current Sensing Resistors

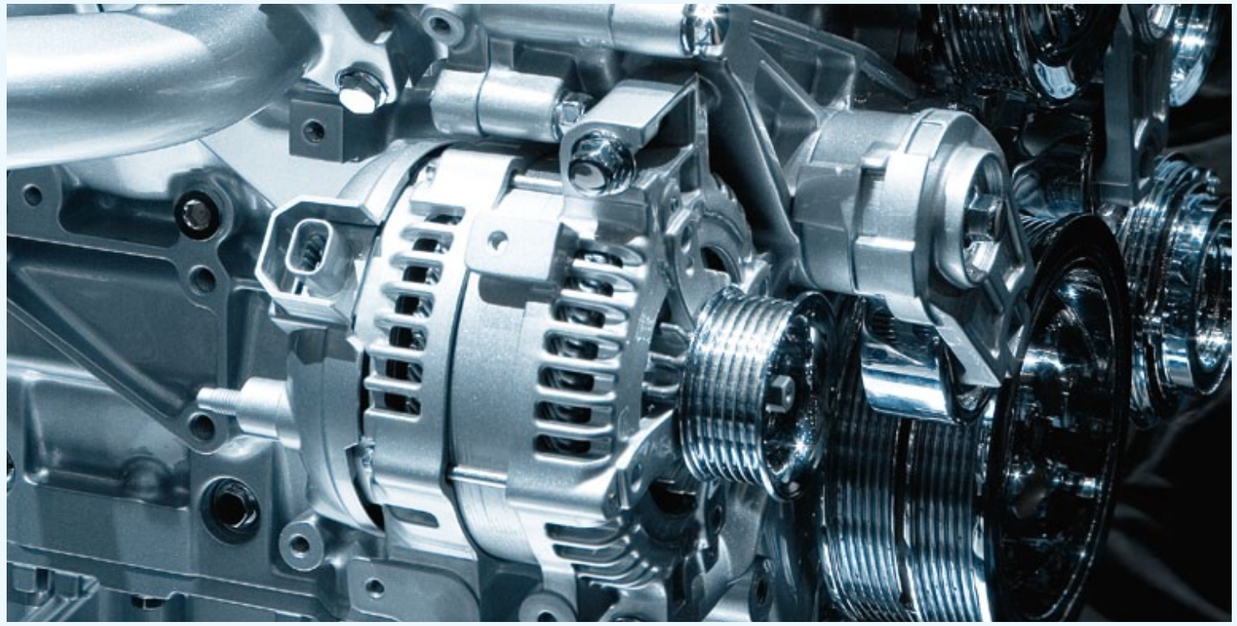
Use of a Shunt Resistor for Battery Management

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 electrical system and battery management and also in hybrid and electric vehicles.

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

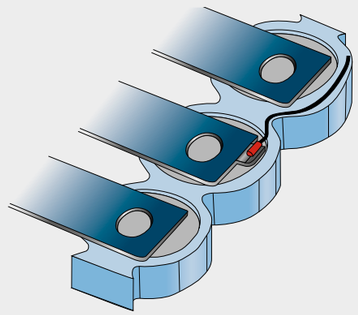
In the automotive industry the importance of engine management, safety, fuel economy and control of exhaust emissions is growing rapidly. For optimal control of the various engine parameters, more precise knowledge of the various states is necessary. Nowadays sensors detect temperature changes more quickly, 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

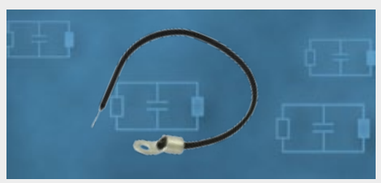
- Short reaction time
- Small sizes
- Special coating (protecting against electrical, mechanical, climatic impacts)
- Climatic category IEC 60068-1
- High accuracy over a wide temperature range
- High stability over a long life
- Exceptional thermal shock withstanding performance
- High voltage sector

Typical automotive applications

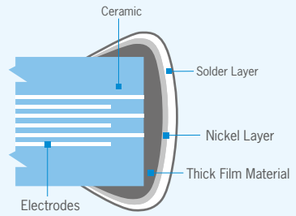
- Inside temperature
- Outside temperature
- Air condition
- Air intake
- Cooling water
- Motor oil
- Transmission oil
- Brake fluid
- Water heater
- Battery management



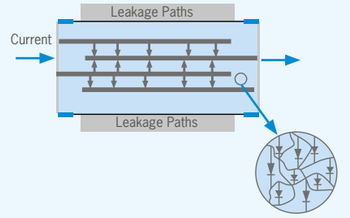
Smart battery pack for hybrid car



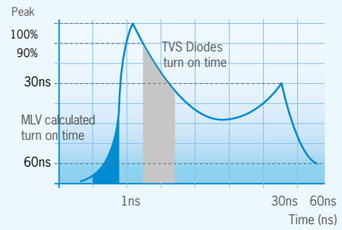
Structure



Construction



Turn on time comparison: MLV vs TVS diodes



Multilayer Varistors (MLVs)

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 beed 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

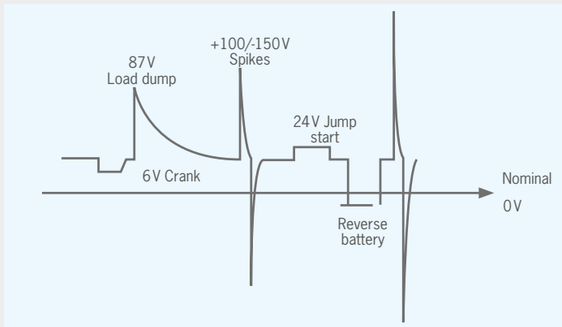
- EMI filter response
- Highly rugged on extreme thermal cycles and repetitive pulses
- Reliable ESD protection acc. to ISO 10605 and IEC 61000-4-2 Level 4 up to 25 kV for high-speed data buses
- Bidirectional clamping
- Fast response time: < 0.5 ns due to small case inductance
- Repetitive strike capability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

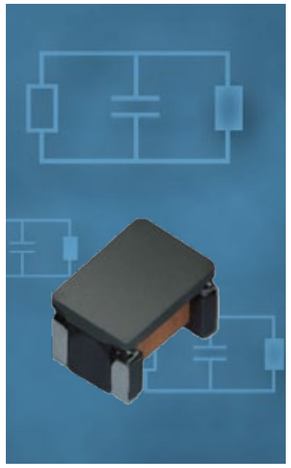
- Ni-barrier termination with tin alloy plated finish for lead-free soldering acc. to IEC 60068-2-59 and acc. to JEDEC J-STD 020C
- Operating temperature up to +125 °C for lead-free soldering or +150 °C for hybrid mounting

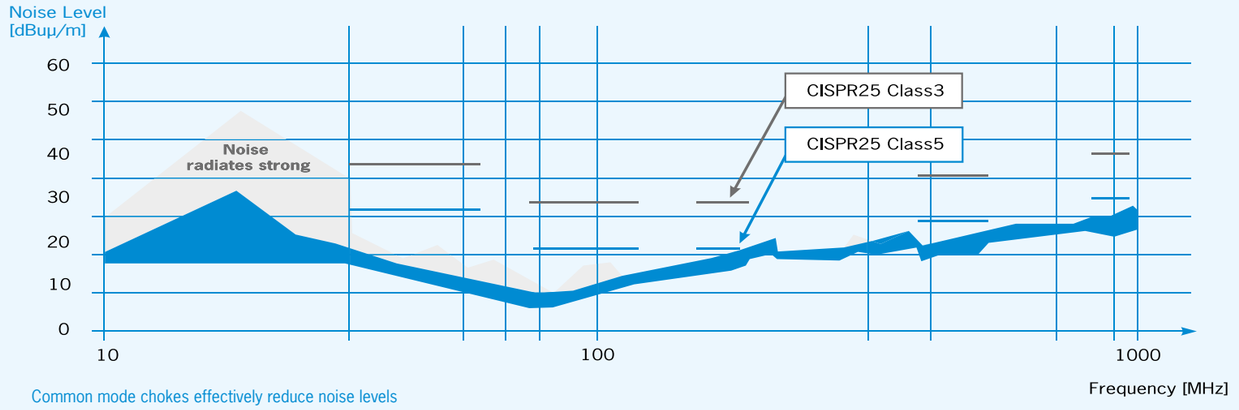


Dangers in automotive applications

- ESD spikes
- EMI
- Load dump
- Inductive switching
- Jump start

Content





Common mode chokes effectively reduce noise levels

Chokes, Inductors, Filters & Ferrites

Power Transmission, Signal Transmission, Filtering, EMI and Noise Reduction Solutions

Our continuous 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 offers considerable advantages by means of a well-balanced supplier mix. Therefore we are able to cover the broad product range for almost all automotive applications with competitive price levels. Our long-standing strong partnership has formed the basis for a high availability of parts, technical support and procurement of samples. All parts are RoHS compliant and comply with the AEC-Q200 for automotive suppliers.

Rutronik has extended its range of magnetic components together with our strong manufacturer partners over the last years.

We can offer you optimised products. In some cases the devices are specified for operating temperatures up to 150 °C and ensure a great reliability. This matches equivalent industry standard devices to deliver a high reliability, high performance second source for developers of automotive subsystems such as safety equipment, lighting, security systems and telematics.

RUTRONIK offers dedicated know-how from specially trained FAEs and Product Marketing Managers along with state-of-the-art product portfolios from leading suppliers around the globe.

Our Focus AUTOMOTIVE Products

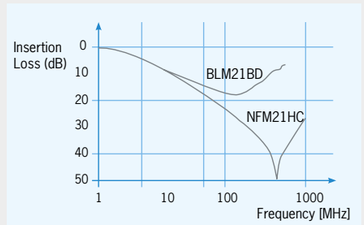
- Filter for CAN and FlexRay networks for Automotive Applications
- Metal Composite Power Inductor for Automotive Applications
- Ethernet Magnetics and Common Mode Chokes for Automotive Applications
- Ferrite beads for Automotive Applications

Our Focus AUTOMOTIVE Applications

- Safety
- Body electronics
- Drive train
- Comfort & Convenience
- eMobility

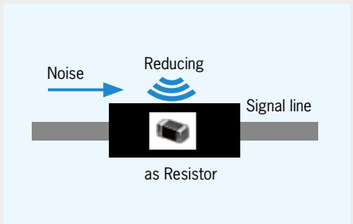
L [uH]	Impedance [at 10MHz]	IN [mA]	R [mΩ]	U [V]	Operating Temp. Range [°C]	Dimensions [mm]	Part No.
11	500Ω	250	0	50	-40 to +125	4.5x3.2x2.8	ACT45B-110-2P
22	1000Ω	200	1	50	-40 to +150	4.5x3.2x2.8	ACT45B-220-2P
51	1000Ω	200	1	50	-40 to +150	4.5x3.2x2.9	ACT45B-510-2P
100	2000Ω	100	3	50	-40 to +150	4.5x3.2x2.8	ACT45B-101-2P
100	5000Ω	200	2	50	-40 to +125	4.5x3.2x2.9	DLW43SH101XK2
51	2000Ω	230	1	50	-40 to +125	4.5x3.2x2.9	DLW43SH510XK2
100	3000Ω	170	2	50	-40 to +125	4.5x3.2x2.9	DLW43SH101XP2

Noise Reduction Solutions



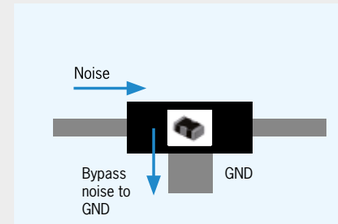
Benefits

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



Ferrite Bead

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



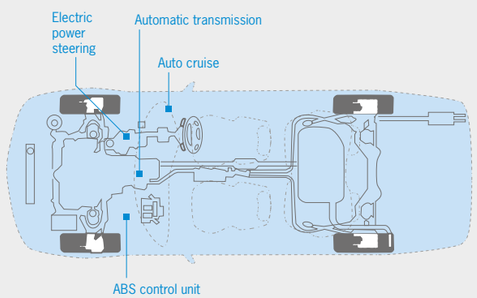
3-terminal Filter

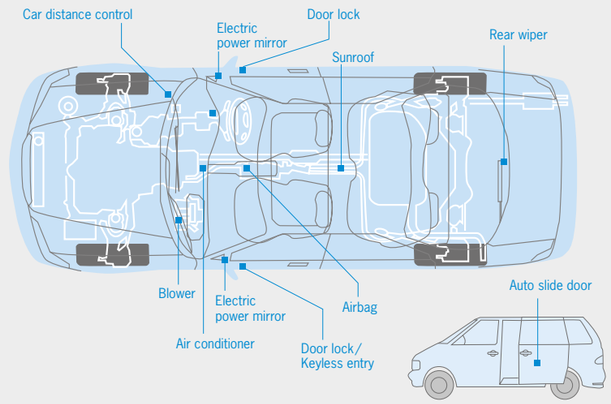
- High performance
- 60 dB suppression
- LC/RC-combinations

Can-Bus Chokes

RUTRONIK has extended its range of common mode filters for automotive networking applications by introducing filters from our wide portfolio of manufactures. 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.

Examples for Several Automotive Applications





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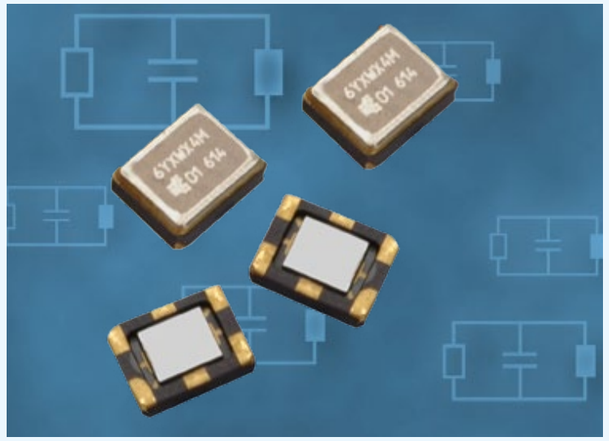
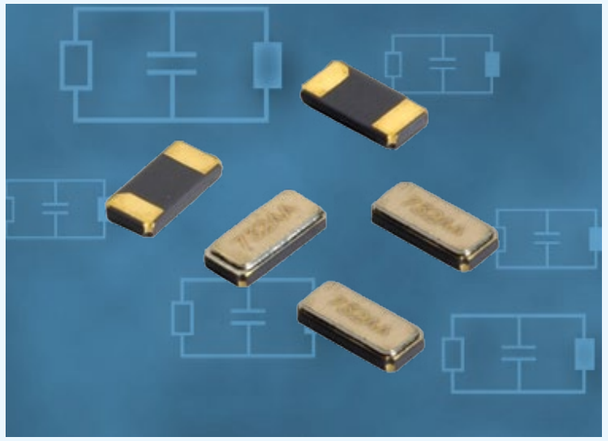
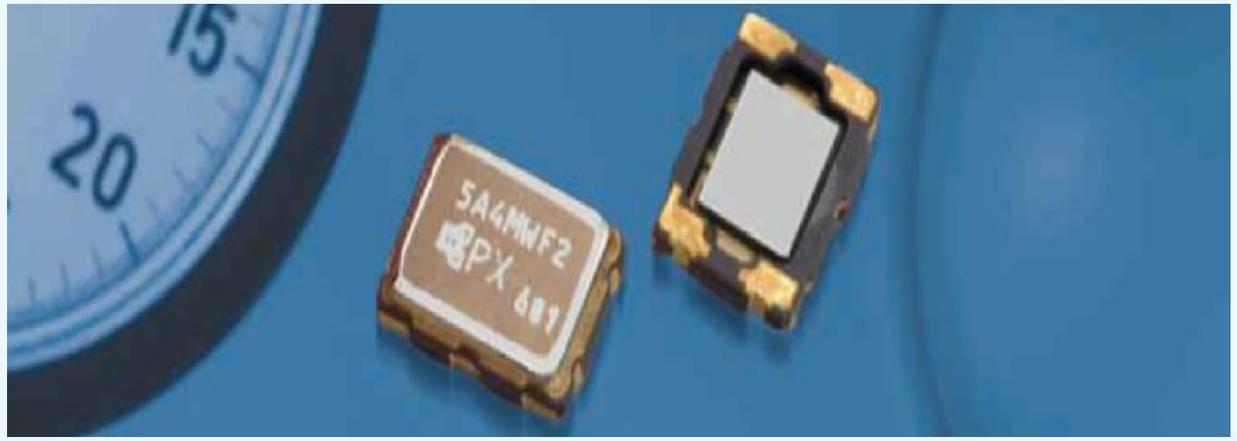






Timing Devices in Automotive Applications

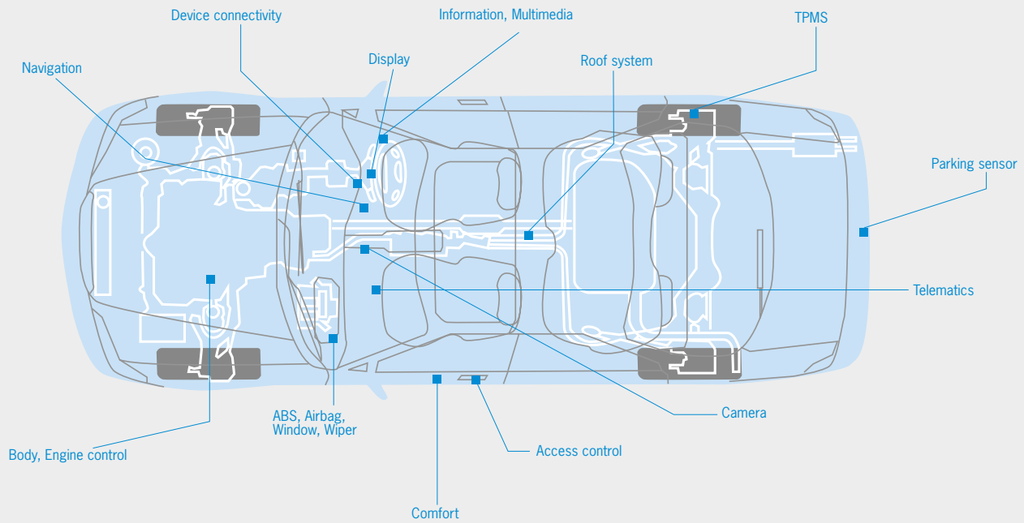
Timing Devices such as quartz crystals, oscillators, real-time-clock modules and resonators provide accurate clock frequency for all automotive key applications. To produce reliable components the factories are certified according to ISO9001 TS16949 ISO 14001. Automotive parts have to fulfil AEC-Q200 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

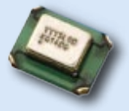
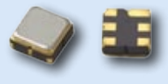
- Accuracy over a wide temperature range
- Robust designs for reliable products
- Special packages with special terminals to avoid cracks
- Seam-sealed ceramics with grounded lid, EMI solutions
- High reliable glass sealed 2 pad crystals

Benefits

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



Robust Package Portfolio

					
Crystals	**TCXO**	**SPXO**	**Real Time Clock**	**Ceramic Resonator**	**SAW Resonator/Filter**
▪ Body electric control ▪ ABS, airbag, engine control ▪ Display control	▪ GPS navigation ▪ Telematics	▪ Information system ▪ Camera	▪ Instrument cluster/clock ▪ Car navigation	▪ ABS, airbag ▪ Window, wiper control	▪ RKE ▪ TPMS

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

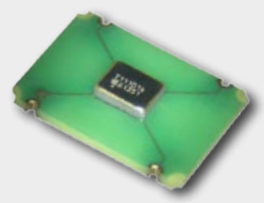
Applications

- Battery control
- Board diagnostic
- Car audio
- GPS

Oscillators

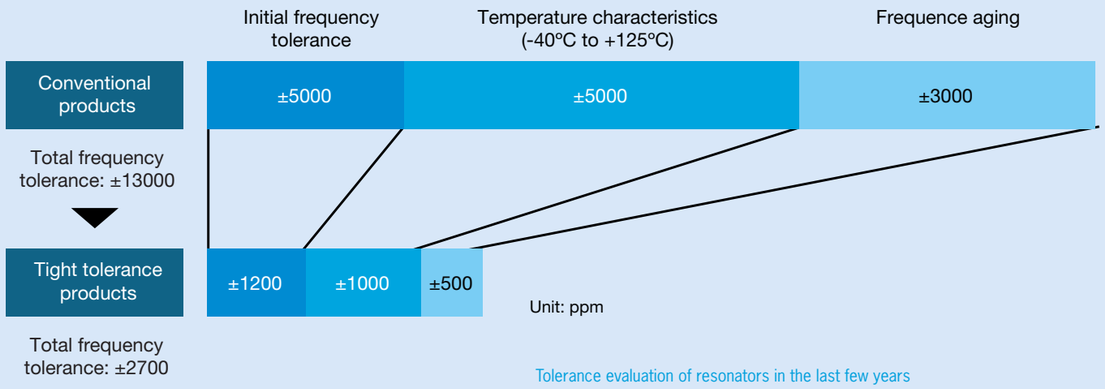
Applications

- 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.



Tolerance evaluation of resonators in the last few years

Resonators

Purpose

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.

Series PN	Size	Frequency range
PBRV-HR	7.4 x 3.4 x 2.0 mm	2 to 20 MHz
PBRV-MR	4.5 x 2.0 x 1.2 mm	4 to 20 MHz
PRQV	3.2 1.3 x 1.0 mm	8 to 20 MHz

Automotive Graded Resonators

AEC-Q200 test item	Test Condition	Judgement
High temperature exposure	125 °C, 1000 h	Acceptable
Temperature cycling	1000 cycles	Acceptable
Moisture resistance	MIL-STD-202 Method 106	Acceptable
Biased humidity	85 °C/85 % RH, 6 V, 1000 h	Acceptable
Mechanical shock	100 G, 6 ms, 6 sides	Acceptable
Thermal shock	300 cycles	Acceptable
ESD	Level depends on the series	Acceptable Test condition depends on the series
Board Flex	2 mm	Acceptable

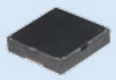
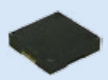
Criteria: Oscillating frequency: +/-0.15 % max. Resonant impendance: Meet initial spec.

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 + 150°C

Acoustic Components in Automotive Vehicles

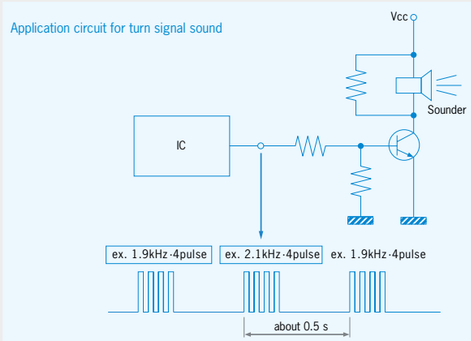
- Instrument cluster
  - Seat belt warning sound
  - Head light reminder sound
  - Key reminder sound
  - Flat tyre warning sound
  - Reverse warning sound
  - Turn signal operation sound
- ETC (Electronic Toll Collection)
  - Confirmation sound of operation
- Car audio / navigation
  - Confirmation sound of button / an operation
- TPMS (for after market)
  - Confirmation sound of tyre pressure warning
- Burglar alarm
  - Car siren
- RKE Transmitter
  - Answer back

Piezoelectric Sounder External Drive					Piezoelectric Diaphragm
					
4kHz SMD Type	2.4kHz SMD Type	High Sound Pressure Level Type	2kHz Small Type	Automatic Insertion 4 kHz Small Type	
PKLCS1212E40A1-R1	PKLCS1212E24A0-R1	PKM22EPPH4007-B0	PKM17EPP-2002-B0 PKM22EPPH2001-B0	PKM13EPYH4000-A0	7BB-20-6

Piezo Sounder for Turn Signal

Piezoelectric sounders can create the tick-tack sound of a turn signal as shown in the following example:

Application circuit for turn signal sound



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