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.

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.

The delivery service from Rutronik
Innovative and flexible solutions: from supply chain management
to individual logistics systems.

The qualification drive from Rutronik
Technical support: through online services, seminars, PCNs,
quality management and much more.
Advantages of a strong partner
We are one of the leading distributors for electronic components on the world market. As we generate about one fourth of our total turnover with passive components, they represent an important business unit at Rutronik. Our focus is to provide a comprehensive product portfolio combined with high quality and technical standards.

Ceramic Capacitors with the widest range of capacity and voltage
Ceramic Capacitors have the highest electrical performance. Based on the function, the parts are more and more specialised with increased requests for automotive AEC-Q200 specifications and rising RFQ of High Cap / Voltage.

We offer you:
- Worldwide franchises with major manufacturers and world market leaders for electronic components
- High reliability due to multiple suppliers for the same products
- Competent product consulting and technical support based on exceptional expertise of product specialists with great market experience
- Complete supply chain with innovative inventory management via VMI and flexible DI solutions for calculation of processing costs

Our key customer list includes leading companies in the following sectors: Industrial, Automotive, Consumer, Telecommunications, Information, Communication and Medical.
### Overview. Quick Guide to Ceramic Capacitors.

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<thead>
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<th>Figure</th>
<th>Type</th>
<th>Ceramic Capacitors</th>
<th>Voltage</th>
<th>Capacity</th>
<th>Notice</th>
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<tbody>
<tr>
<td></td>
<td>Multilayer Chip, Type KC</td>
<td>AEC-Q200-Types</td>
<td>0402, 0603, 0805, 1206, 1210, 1808, 1812, 2211, 2220, 2225, 3640</td>
<td>0.47 pF - 220 μF</td>
<td>Also available with: Soft Termination, Open Mode, + 150°C Spec.</td>
</tr>
<tr>
<td></td>
<td>Multilayer Chip Array, Type KN</td>
<td>0612, 0508, 0405 (0203, 0306 in development) (2 or/and 4 caps)</td>
<td>Leadspace 2.5, 5.0, 7.5, 10</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Multilayer Leaded, Radial+Axial Type KV</td>
<td>NP0(COG), X5R/X7R, X8R, X8L, X8L, Y5V</td>
<td>NP0(COG), X5R/X7R, Y5V</td>
<td>NP0(COG), X7R, Z5U/Y5V</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Size / Leadspace</td>
<td>Ceramic</td>
<td>4.0 V ... 5 kV</td>
<td>6.3 V ... 100 V</td>
<td>25 V ... 630 V</td>
</tr>
<tr>
<td></td>
<td>Ceramic</td>
<td>NP0(COG), X5R/X7R/X8R, X8L, Y5V</td>
<td>0.47 pF - 47 μF</td>
<td>10 μF - 2.2 μF</td>
<td>1 pF - 10 μF</td>
</tr>
<tr>
<td>Figure</td>
<td>Type</td>
<td>Size / Leadspace</td>
<td>Ceramic</td>
<td>Voltage</td>
<td>Capacity</td>
</tr>
<tr>
<td>--------</td>
<td>------</td>
<td>------------------</td>
<td>---------</td>
<td>---------</td>
<td>----------</td>
</tr>
<tr>
<td></td>
<td>Multilayer Advanced, Type KVA</td>
<td>2-, 4- leads, Dual inline, Chip and leaded and several others</td>
<td>NPO (CQG), X7R, 25U</td>
<td>25V .... 5kV</td>
<td>10pf - 1300μf</td>
</tr>
<tr>
<td></td>
<td>Single Layer (Disc), Type KE</td>
<td>Leadspace 2.5, 5.0, 7.5, 10, 15</td>
<td>P100, NPO(CQG), .... N1500; 2B4, Y9E, ....YSV (B, C, .. F)</td>
<td>50V .... 15kV</td>
<td>1.0pf - 100nF</td>
</tr>
<tr>
<td></td>
<td>Suppression (Safety), Type KF</td>
<td>X-Y-Class X2, Y3, Y2, XIY2, XIY1; Leaded LSP 5.0, 7.5, 10, 12.5 &amp; Chip (1808 .... - 2220)</td>
<td>NPO, X7R, Y5F, Y5U, .... (B, E, ....)</td>
<td>250Vac (300Vac, 440Vac ....)</td>
<td>10pf - 56nF</td>
</tr>
<tr>
<td></td>
<td>Special Capacitors</td>
<td>„MegaCap“, Plate and cylindrical types; Pot-Caps; Feed-thru Array</td>
<td>High Frequency, RF Microwave; „Silicon“-SMD-Caps; Low Inductance</td>
<td>Tip&amp;Ring-Caps; „X2Y“-Filter; and others</td>
<td></td>
</tr>
</tbody>
</table>
### Overview. Quick Guide MLCC (MultiLayer Ceramic Chip).

<table>
<thead>
<tr>
<th>Type</th>
<th>Standard</th>
<th>Automotive qualified AEC-Q200</th>
<th>Short circuit protection (Also AEC-Q200 qualified available)</th>
<th>High temp. +150°C spec. (Also AEC-Q200 qualified available)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Size-Range</td>
<td>01005 to 2220</td>
<td>01005 to 2220</td>
<td>0201 to 2220</td>
<td>0402 to 2220</td>
</tr>
<tr>
<td>Ceramic</td>
<td>NP0 (COG) X5R/X7R Y5V</td>
<td>NP0 (COG)/X7R X7R</td>
<td>X7R X8R X8L X8G</td>
<td></td>
</tr>
<tr>
<td>Temperature</td>
<td>-55 to +125°C</td>
<td>-55 to +85°C</td>
<td>-55 to +125°C</td>
<td>-55 to +125°C</td>
</tr>
<tr>
<td>Temperature Drift</td>
<td>±30 ppm/°C</td>
<td>±15%</td>
<td>±22/-45%</td>
<td>±15%</td>
</tr>
<tr>
<td>Tolerance (Std.)</td>
<td>±0.25 pf/±5%</td>
<td>±10%</td>
<td>±0.25 pf/±5%/±5%/±10%</td>
<td>±0.25 pf/±5%/±5%/±10%</td>
</tr>
<tr>
<td>E-Series</td>
<td>E-24 E-12 E-6</td>
<td>E-12/E-6 E-6</td>
<td>E-6</td>
<td>E-6</td>
</tr>
<tr>
<td>Voltage</td>
<td>10V to 5kV</td>
<td>4.0V to 5kV</td>
<td>4.0V to 250V</td>
<td>6.3V to 3kV</td>
</tr>
<tr>
<td>Preferred Range</td>
<td>1.0 pf to 1.0 nF</td>
<td>1.0 nF to 1.0 μF</td>
<td>1.0 μF to 47 μF E-3 values</td>
<td>On request</td>
</tr>
<tr>
<td>Comment</td>
<td>Also available: Arrays AEC-Q200 qualified</td>
<td>Soft Termination Open Mode Design Float Mode Design</td>
<td>Also available as leaded version</td>
<td></td>
</tr>
<tr>
<td>Supplier</td>
<td>AVX, Murata, Samsung, TDK, Vishay, Yageo (Phycomp)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Special Chips</td>
<td>250Vac types, with suppression-approval too = „Safety“ SMD; 2- and 4-Cap-Arrays; other sizes, e.g., 01005; Multi-Chip-Constructs; High Frequency, FR, Microwave; Feedthru; and several other specials on request</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Choose the right MLCC. Comparison of different versions.

<table>
<thead>
<tr>
<th>Type version</th>
<th>Standard</th>
<th>AEC-Q200</th>
<th>+150°C - specified</th>
<th>Flexiterm/ Soft Termination</th>
<th>OpenMode / FR-Design</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, FlexiCap</td>
<td>Flexiterm/Softtermination with Cascade-Design (Floating, Serial Electrode) or Open Mode Design</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Generally</td>
<td>Standard Specs and qualifications</td>
<td>Increased sample plans with more and higher criteria</td>
<td>Standard Specs and qualifications, but specified up to +150°C</td>
<td>Standard Specs and qualifications, but: bending strength &gt; 5mm - tendency to open beyond</td>
<td>Standard Specs and qualifications, but construction avoids a short circuit caused by typical bending cracks</td>
<td></td>
</tr>
<tr>
<td>Bending strength</td>
<td>1mm (some 2mm)</td>
<td>NPO 3mm, X7R 2mm</td>
<td>1 mm (some 2mm) X7R &gt; 5mm</td>
<td>1 mm X7R &gt; 5mm</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Temp.-Cycles</td>
<td>5 cycles</td>
<td>1000 cycles</td>
<td>5 cycles 3000 cycles (AVX)</td>
<td>5 cycles 3000 cycles (AVX)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thermal shock</td>
<td>no</td>
<td>yes</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 100%</td>
<td></td>
</tr>
</tbody>
</table>

Other differences see detailed specifications supplier by supplier, e.g. vibration, ESD, high temperature exposure (storage), moisture resistance, etc.

- Voltage: 4.0 V ... 5kV / 10V ... 3kV / 10V ... 100V / 10V ... 3kV / 16V ... 630V / 16V ... 100V
- Capacitance: 0.47pf ... 220µF / 0.47pf ... 47µF / 100µF ... 4.7µF (up to 10µF dev) / 200µF ... 22µF / 150µF ... 22µF / 1.0nF ... 1.0µF
- Notice: 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.
Increase Capacitance. High Cap MLCC.

<table>
<thead>
<tr>
<th>Definition</th>
<th>Types</th>
</tr>
</thead>
<tbody>
<tr>
<td>Size Dimensions</td>
<td>Ceramic X5R</td>
</tr>
<tr>
<td>Temperature</td>
<td>-55 to +85 °C</td>
</tr>
<tr>
<td>Tolerance</td>
<td>±10% / ±20%</td>
</tr>
<tr>
<td>Voltage</td>
<td>25 V</td>
</tr>
<tr>
<td>0402 1.0 x 0.5 mm</td>
<td>Capacitance</td>
</tr>
<tr>
<td>0603 1.0 x 0.5 mm</td>
<td>Capacitance</td>
</tr>
<tr>
<td>0805 2.0 x 1.25 mm</td>
<td>Capacitance</td>
</tr>
<tr>
<td>1206 3.2 x 1.6 mm</td>
<td>Capacitance</td>
</tr>
<tr>
<td>1210 3.2 x 2.5 mm</td>
<td>Capacitance</td>
</tr>
</tbody>
</table>

For highest volumetric efficiency and also for replacements against higher nominal cap. values in tantalum or electrolytic caps Rutronik offers together with the world's leading MLCC-manufacturers a wide range of High-CV-Chips including world's top values in „materials“ X5R and X7R.

Available from: AVX, Murata, Samsung, TDK, Yageo.
Advanced. Leadframe and stacked MLCC.

To improve power handling with large chips there exists a wide program of MLCC with „J“-leadframe for surface mounting. The leadframe provides higher robustness against thermal and mechanical shocks as well as excellent performance on aluminium circuit substrates. These capacitors are specifically designed for applications requiring high reliability performance in harsh environments. They have very low ESR (Equivalent Series Resistance) and ESL (Equivalent Series Inductance).

In addition to that more capacitance is obtainable on one single capacitor space with two or more MLCC stacked. Furthermore, there is a possibility of vertical stacking of the ceramic elements, which allows very high capacitance in a small volume (TurboCap).

Another possibility for using large chips with less concerns on handling stress is a MLCC with size 2220 in a molded leadframe tantalum style case (MH Series).

<table>
<thead>
<tr>
<th>Series</th>
<th>Structure</th>
<th>Capacitance</th>
<th>Voltage</th>
<th>Number of Stacked MLCC</th>
</tr>
</thead>
<tbody>
<tr>
<td>MegaCap (TDK)</td>
<td><img src="image1.png" alt="Image" /></td>
<td>47nF - 100µF</td>
<td>16V - 630V</td>
<td>1 - 2</td>
</tr>
<tr>
<td>KRM + KCM</td>
<td><img src="image2.png" alt="Image" /></td>
<td>330nF - 47µF</td>
<td>25V - 630V</td>
<td>1 - 2</td>
</tr>
<tr>
<td>RH (AVX)</td>
<td><img src="image3.png" alt="Image" /></td>
<td>47nF - 47µF</td>
<td>50V - 500V</td>
<td>1 - 2</td>
</tr>
<tr>
<td>Stacked MLC SM + RM (AVX)</td>
<td><img src="image4.png" alt="Image" /></td>
<td>10nF - 1300µF</td>
<td>50V - 500V</td>
<td>1 - 5</td>
</tr>
<tr>
<td>TurboCap (AVX)</td>
<td><img src="image5.png" alt="Image" /></td>
<td>820nF - 220µF</td>
<td>25V - 100V (500V in dev.)</td>
<td>3, 5, 10</td>
</tr>
<tr>
<td>MH (AVX)</td>
<td><img src="image6.png" alt="Image" /></td>
<td>1.0µF - 22µF</td>
<td>25V - 100V</td>
<td>1</td>
</tr>
</tbody>
</table>

Available from: AVX (RH, RM, SM, MH Series & TurboCap), TDK (MegaCaps), Murata (KRM + KCM)
Due to various motivations more and more customers are replacing their tantalum caps with ceramic caps for new designs. Reasons can be:
- Price stability of ceramic chips, price increase of tantalums
- Common shortage of tantalums, longer lead times
- Higher reliability
- Less required space
- Better interference suppression
- Less heating
- No voltage derating (at Tantalum up to 50%)

There are several aspects which have to be considered when replacing a tantalum with a ceramic capacitor. In the following you will find main criteria.

Compared to a tantalum capacitor the MLCC is much more stable especially at higher frequency. As a result of this, depending on the frequency you can reduce the capacity of a MLCC when replacing a tantalum.

Generally:
- Frequency \( \geq 100 \text{ kHz} \)
  - \( >10 \text{ to } 20\% \) of the original value
- \( 10 \text{ kHz} \geq \) Frequency \( \leq 100 \text{ kHz} \)
  - \( >50\% \) of the original value
- Frequency \( \leq 10 \text{ kHz} \)
  - \( >100\% \) of the original value

Considering the function of the capacitor:
- Decoupling: 10% to 50% of the original value
- Smoothing: 10% to 100% of the original value
- Time constant: Same capacitance level needed like tantalum
Observing the Break Down Voltage the MLCC is clearly safer than tantalum. The BDV of MLCC is multiple higher than at tantalum. For this reason ceramic capacitors are more reliable over lifetime.

Regarding DC Bias, the capacity of a tantalum stays much more stable over the voltage in comparison to a MLCC. Especially High Cap MLCC show considerable fluctuations by increasing voltage.

Also temperature is important for the calculation. At rising temperature the tantalum is normally more stable than MLCC.
Be on the safe side.
Avoid cracks and short circuits.

**Introduction**

A crack generates a conductive path leading to a dropping down of the insulation-resistance accelerated by humidity and temperature. Frequently this causes almost a short circuit. Based on the fact that most of the problems with failed MLCC (>90%) are caused by bending-cracks, the first aim usually should be to avoid too high mechanical stresses by sufficient and optimized handling in the electronic production. But nevertheless for higher reliability and security of the device against blowing up and burning, there exist several special versions of ceramic chip capacitors to minimize the risk of cracks and short circuits. These solutions mostly include also the automotive specification AEC-Q200.

**Mode of cracking**

The mode of cracking changes in the direction from A to B by the thickness of the capacitor and the amount of solder.

- **Crack mode A**: (1) Thick capacitor
  (2) Small amount of solder
- **Crack mode B**: (1) Thin capacitor
  (2) Excessive amount of solder
Cautions for prevention of crack

1. Direction of chip placement vs. Direction of PCB breaking line:

   ![Diagram showing good and bad cases for chip placement and PCB breaking line]

2. Distance & direction between chip and breaking line:

   ![Diagram showing the distance and direction between chip and breaking line]

3. Direction of PCB Bending:

   ![Diagram showing good and bad cases for PCB bending]

4. Over-press during chip placement makes PCB bent:

   ![Diagram showing good and bad cases for over-press during chip placement]

5. By putting connectors and so on:

   ![Diagram showing the insertion of a connector into a socket]

   [Set the suitable clearance to the hole for setting.]

6. By inserting or pulling out the socket:

   ![Diagram showing the insertion or pulling out of a socket]

   [Set the work not to bend the substrate.]

7. By tightening the machine screw:

   ![Diagram showing the tightening of a machine screw]

   [Set the work setting that substrate does not bend. Use suitable and torque screwdriver which does not tighten screws too much.]
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.

Combines the feature of a 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 bendingcrack.

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>Flexiterm / Soft Termination with Open Mode Design</td>
<td>Cascade Design</td>
</tr>
<tr>
<td>Murata</td>
<td></td>
<td></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>
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, Vishay, TDK.
AVX also as Flexiterm® (with Soft Termination)

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 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 programme of leaded automotive Ceramic Capacitors. Vishay not only offers radial but also axial types up to 150°C.

<table>
<thead>
<tr>
<th>Ceramic</th>
<th>NPO</th>
<th>X7R</th>
<th>X8L</th>
<th>X8R</th>
</tr>
</thead>
<tbody>
<tr>
<td>TCC/Temp.</td>
<td>±30 ppm/°C -55 to +125 °C</td>
<td>±15% -55 to +125 °C</td>
<td>±1540% -55 to +150 °C</td>
<td>±15% -55 to +150 °C</td>
</tr>
<tr>
<td>Tolerance</td>
<td>±5% / ±10%</td>
<td>±10% / ±20%</td>
<td>±10% / ±20%</td>
<td>±10% / ±20%</td>
</tr>
<tr>
<td>Voltage</td>
<td>50V - 200V</td>
<td>50V - 100V</td>
<td>50V</td>
<td>25V - 50V</td>
</tr>
<tr>
<td>Capacitance-Range radial</td>
<td>1.0 pF - 10 nF</td>
<td>330 pF - 1 μF</td>
<td>--</td>
<td>1 nF / 10 nF / 100 nF / 470 nF</td>
</tr>
<tr>
<td>Capacitance-Range axial</td>
<td>100 pF - 10 nF</td>
<td>330 pF - 1 μF</td>
<td>1.0 nF - 1.0 μF</td>
<td>470 pF - 330 nF</td>
</tr>
</tbody>
</table>

Available from AVX, Murata, Vishay.
Nowadays the electronic market requires:
- that more and more applications are getting smaller or
- that more functions are integrated within the existing device sizes.

As a result of this the space for electronic components on the pcb is limited. Therefore the market trend leads to capacitors with smaller sizes to save space on the pcb area. Further advantages could be:

- less thickness
- less weight
- less solder amount
- less storage space

Besides 0402 (1.0x0.5mm) well-known is case size 0201 (0.6x0.3mm). The smallest ceramic capacitor 01005 (0.4x0.2mm) is also already in production.

Available from: AVX, Murata, Samsung, TDK, Vishay, Yageo.
Higher efficiency to save space can be provided by Arrays, means 2 or 4 caps included in one part. Available sizes are 0405 (1.0x1.37mm) including 2 caps, 0508 (1.25x2.0mm) including 2 or 4 caps and 0612 (1.6x3.2mm) with 4 caps. Upon request special versions like „Multivalue“, „Feedthru“ or „Filter“ are possible. Smaller sizes 0306 (0.8x1.6mm) and 0204 (0.6x0.9mm) are both in development as 2-Cap version.

The 0612 4-element capacitor array gives a PCB space saving of over 50% vs four 0603 discretes and over 70% vs four 0805 discrete capacitors.

**Save space. Multilayer Chip Arrays.**

<table>
<thead>
<tr>
<th>Size Dimensions No of caps</th>
<th>Ceramic</th>
<th>NPO</th>
<th>X5R</th>
<th>X7R</th>
<th>Y5V</th>
<th>NP0</th>
<th>X7R</th>
<th>X8R</th>
</tr>
</thead>
<tbody>
<tr>
<td>Voltage</td>
<td>16V - 50V</td>
<td>6.3V - 16V</td>
<td>6.3V - 50V</td>
<td>5.0V</td>
<td>6.3V - 16V</td>
<td>25V</td>
<td>10V</td>
<td></td>
</tr>
<tr>
<td>Capacitance</td>
<td>10pF - 1.0nF</td>
<td>22nF - 1µF</td>
<td>100pF - 150nF</td>
<td>22nF - 1µF</td>
<td>100nF - 220pF</td>
<td>22nF - 1µF</td>
<td>100nF - 220pF</td>
<td></td>
</tr>
<tr>
<td>Voltage</td>
<td>16V - 100V</td>
<td>6.3V - 16V</td>
<td>6.3V - 100V</td>
<td>25V</td>
<td>16V - 100V</td>
<td>10V</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Capacitance</td>
<td>10pF - 470pF</td>
<td>120nF - 2.2µF</td>
<td>220pF - 100nF</td>
<td>10nF - 1µF</td>
<td>220pF - 100nF</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Voltage</td>
<td>16V - 100V</td>
<td>6.3V - 16V</td>
<td>6.3V - 100V</td>
<td>25V</td>
<td>16V - 100V</td>
<td>10V</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Capacitance</td>
<td>10pF - 470pF</td>
<td>1.0µF (120nF - 820nF)*</td>
<td>220pF - 100nF</td>
<td>10nF - 1µF</td>
<td>220pF - 100nF</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Available from: AVX (also with AEC-Q200), Murata, Samsung, Yageo.

* in development
High Voltage MLCC. 250 V – 5 kV.

A lot of well-known leaded high voltage capacitors (discs) can be replaced by chips (MLCC). In particular nowadays they are mostly used for applications like LCD backlight converters.

To avoid arc-over problems, Vishay offers a special solution with the HV Arc Guard Capacitors. This series provides in comparison to standard or competitor components:

- Increased voltage breakdown ratings
- Reduced body sizes
- Extended capacitor ranges
- No need to coat the parts or the pcb

Above you find preferred sizes, also available in 1808 / 1825 / 2225 / 3640 with voltages up to 5 kV. Several parts from AVX and Vishay (HV Arc Guard) are available with Flexiterm- / Polymer-Termination.

Available from: AVX, Murata, Samsung, TDK, Vishay, Yageo.
Safety and Suppression. „X-“ & „Y-“ Capacitors.

Electrical equipment belongs to protection class I, their case is in connection to potential earth (PE). Any failure at Y-capacitors causes no danger of electric shock if connection to potential earth is not interrupted.

Electrical equipment belongs to protection class II, it has no electrical connection to potential earth. Any failure at Y-capacitors could endanger a person touching the device if casing insulation is damaged.

In most applications the usage of such types is regulated by law. These capacitors are components with approvals like:

Also available for several years: Safety-Capacitors as SMD (MLCC): Save space of about 70%

<table>
<thead>
<tr>
<th>X/Y-Class</th>
<th>Y3-SMD</th>
<th>X2Y3-SMD</th>
<th>Y2-SMD</th>
<th>XIY2-SMD</th>
<th>X2-SMD</th>
<th>XIY2</th>
<th>XIY2</th>
<th>XIY1</th>
<th>XI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test-Voltage</td>
<td>1.5k Vac</td>
<td>1.5k Vac</td>
<td>1.5k Vac</td>
<td>1.5k Vac</td>
<td>1075 Vac</td>
<td>2.0k Vac</td>
<td>2.6k Vac</td>
<td>4.0k Vac</td>
<td>3.5k Vac</td>
</tr>
<tr>
<td>Cap.-Range</td>
<td>10pf - 1.5nF / 1.8nF - 4.7nF</td>
<td>10pf - 2.2nF / 10pf - 4.7nF</td>
<td>10pf - 330pF</td>
<td>10pf - 4.7nF</td>
<td>10pf - 56nF</td>
<td>10pf - 12nF</td>
<td>10pf - 10nF</td>
<td>10pf - 4.7nF</td>
<td>4.7nF - 22nF</td>
</tr>
<tr>
<td>Size / Leadspace</td>
<td>1808 / 1812</td>
<td>1808 / 1812</td>
<td>1808</td>
<td>1808...2220</td>
<td>2220</td>
<td>5.0 (7.5)</td>
<td>7.5 (10)</td>
<td>10 (12.5)</td>
<td>7.5</td>
</tr>
</tbody>
</table>

Available from: Murata (also SMD), Vishay (also SMD), Yageo (only SMD)
Always the right frequency.
High Frequency/RF Microwave Chips.

The non-ideal characteristics of a real capacitor can be ignored at low frequencies.

Physical size imparts inductance to the capacitor and dielectric and metal electrodes result in resistive losses, but these often are of negligible effects on the circuit. At the very high frequencies of radio communication (>100MHz) and satellite systems (>1GHz), these effects become important.

Recognizing that a real capacitor will exhibit inductive and resistive impedances in addition to capacitance, the ideal capacitor for these high frequencies is an ultra low loss component which can be fully characterized in all parameters with total repeatability from unit to unit.

Application examples are:
- Wireless systems (e.g. keyless entry system, alarm system, etc.)
- Communication market (Mobile Phones, Telephone Networks, etc.)
- Navigation systems
- TV systems (Satellite, Cable)
- Test & Measurement Equipment
- Radar systems
- GPS, GSM
- SMART Metering

Typical series from our suppliers are:
AVX: SLC, U, Accu-P, SQ (former AQ) and HQ Series
Murata: GJM, GQM, ERB, GMA Series
Vishay: VJ HiFreq RF Serie
Samsung: High Frequency Series
Yageo: Microwave

Series:
U, Accu-P, GJM, GQM, ERB, VJ HiFreq RF, High Frequency, Microwave

SQ, HQ

SLC, GMA
Low inductance.

Low inductance products are specially designed with lower inductance than standard MLCC. In general, there are three factors that drive the need for these parts:
- Speed: the higher the operating frequency, the greater the need for Low Inductance MLCC (typically 300MHz and more)
- Power: the higher the power demand of the IC, the greater the need for Low Inductance MLCC
- Voltage: the lower the voltage, the lower the voltage drop minimum to keep the IC operating

Application examples are:
- High end battery powered devices
- Lightweight military systems
- Harsh environment CPU applications

Available from AVX, Murata, Samsung, Yageo, TDK.
EMI Filtering. Feedthru & X2Y.

The X2Y and Feedthru are special designed devices performing as a broadband filter enabling better EMC compliance for electrical equipment in a wide range of applications.

Feedthru
The construction of a feedthru capacitor provides low parallel inductance and offers excellent decoupling capability for all high di/dt environments and provides significant noise reduction in digital circuits up to 5 GHz.

Available from AVX, Murata, TDK.

X2Y
New design of X2Y® series comprises two identical Y-capacitors and one X-capacitor. Thanks to the construction the device provides noise cancellation within the device, reducing ESL and offering superior decoupling and filtering.

Available from Yageo, Samsung.
Capacitors in general. Main functions.

**Decoupling**

![Decoupling Diagram](image)

**Backup**

**Without Capacitor**

- Power
- Logic IC
- Without Capacitor

**With Capacitor**

- Power
- Logic IC
- With Capacitor

MLCC Discharge Current

**Filtering**

**Low Pass Filter**

- V in
- L: Low Freq. Signal Pass
- C: V out
- Low Frequency Pass

**High Pass Filter**

- V in
- L: High Freq. Signal Pass
- C: V out
- High Frequency Pass

---

<table>
<thead>
<tr>
<th>Polarity</th>
<th>High Cap Range</th>
<th>Impedance / ESR characteristics</th>
<th>Temperature characteristics</th>
<th>High Voltage Resistance (overload)</th>
<th>Reliability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electrolytic</td>
<td></td>
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<tr>
<td>Polymer</td>
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<td>Ceramic</td>
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<td>Film</td>
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<td>Tantalum</td>
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<td>Niobium</td>
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</tbody>
</table>

Capacitor technology comparison

- Excellent
- Good
- Normal
- Bad