# Dielectric characteristics

## Class I Dielectrics

Multilayer Ceramic Capacitors are generally divided into classes which are defined by the capacitance temperature characteristics over specified temperature ranges. These are designated by alpha numeric codes. Code definitions are summarised below and are also available in the relevant national and international specifications.

Capacitors within this class have a dielectric constant range from 10 to 100. They are used in applications which require ultra stable dielectric characteristics with negligible dependence of capacitance and dissipation factor with time, voltage and frequency. They exhibit the following characteristics:-

a) Time does not significantly affect capacitance and dissipation factor (Tan δ) – no ageing.
b) Capacitance and dissipation factor are not affected by voltage.
c) Linear temperature coefficient.

| | | Class I Dielectrics | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | C0G/NP0 (Porcelain) | P90 (Porcelain) | C0G/NP0 | | X8G | Class I High Temperature | |
| Dielectric classifications | | Ultra stable | Ultra stable | Ultra stable | | Ultra stable | Ultra stable | |
| | IECQ-CECC | - | - | 1B/CG | | - | - | - |
| | EIA | C0G/NP0 | P90 | C0G/NP0 | | X8G | - | - |
| | MIL | - | - | CG (BP) | | - | - | - |
| Ordering code | DLI | CF | AH | - | - | - | - | - |
| | Novacap | - | - | - | N | - | F | D, RD |
| | Syfer | - | - | Q, U | C | H | - | G |
| | Voltronics | F | H | Q | - | - | - | - |
| Rated temperature range | | -55ºC to +125ºC | -55ºC to +125ºC | -55ºC to +125ºC | -55ºC to +125ºC | -55ºC to +150ºC | -55ºC to +160ºC | -55ºC to +200ºC |
| Maximum capacitance change over temperature range | No DC voltage applied | 0 ± 15 ppm/ºC | ± 20 ppm/ºC | 0 ± 30 ppm/ºC | ± 30 ppm/ºC | 0 ± 30 ppm/ºC | 0 ± 30 ppm/ºC | 0 ± 30 ppm/ºC |
| | Rated DC voltage applied | - | | | | | | |
| Tangent of loss angle (tan δ) | | ≤0.05 | | ≤0.0005 @1MHz | >50pF ≤0.0015<br>≤50pF 0.0015 $(\frac{15}{Cr} + 0.7)$ | | ≤0.001 | |
| Insulation resistance (Ri) | Time constant (Ri x Cr) | @25ºC = $10^6$ MΩ min<br>@125ºC = $10^5$ MΩ min | | 100GΩ or 1000s (whichever is the least) | | | @25ºC = 100GΩ or 1000ΩF<br>@160ºC & 200ºC = 1GΩ or 10ΩF<br>(whichever is the least) | |
| Capacitance Tolerance | Cr <4.7pF | ±0.05pF, ±0.10pF, ±0.25pF, ±0.5pF | | | | | | |
| | Cr ≥4.7 to <10pF | ±0.10pF, ±0.25pF, ±0.5pF | | | | | | |
| | Cr ≥10pF | ±1%, ±2%, ±5%, ±10% | | | | | | |
| Dielectric strength Voltage applied for 5 seconds. Charging current limited to 50mA maximum. | ≤200V | 2.5 times | 2.5 times | 2.5 times | | 2.5 times | 2.5 times | |
| | >200V to <500V | | | Rated voltage + 250V | | | Rated voltage + 250V | |
| | 500V to ≤1kV | | | 1.5 times | | | 1.5 times | |
| | >1kV to ≤1.2kV | | N/A | 1.25 times | | | 1.25 times | |
| | >1.2kV | | | 1.2 times | | | 1.2 times | |
| Climatic category (IEC) | Chip | 55/125/56 | 55/125/56 | 55/125/56 | | - | - | |
| | Dipped | - | - | - | 55/125/21 | - | - | |
| | Discoidal | - | - | - | 55/125/56 | - | - | |
| Ageing characteristic (Typical) | | Zero | | | | | | |
| Approvals | Syfer Chip | - | - | - | QC-32100 | - | - | |

# Dielectric characteristics

## Class II Dielectrics

Capacitors of this type have a dielectric constant range of 1000-4000 and also have a non-linear temperature characteristic which exhibits a dielectric constant variation of less than ±15% (2R1) from its room temperature value, over the specified temperature range. Generally used for by-passing (decoupling), coupling, filtering, frequency discrimination, DC blocking and voltage transient suppression with greater volumetric efficiency than Class I units, whilst maintaining stability within defined limits.

Capacitance and dissipation factor are affected by:-

a) Time (Ageing)
b) Voltage (AC or DC)
c) Frequency

| Class II Dielectrics | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **X5R** | **X7R** | | | **X8R** | **Class II High Temperature** | | | |
| Stable | Stable | | | Stable | Stable | | | Dielectric classifications |
| - | 2C1 | 2R1 | 2X1 | - | - | - | IECQ-CECC | |
| X5R | - | X7R | - | X8R | - | - | EIA | |
| - | BZ | - | BX | - | - | - | MIL | |
| - | - | - | - | - | - | - | DLI | Ordering code |
| BW | - | B | X | S | G | E, RE | Novacap | |
| P | R | X | B | N | - | X | Syfer | |
| - | - | X | - | - | - | - | Voltronics | |
| -55ºC to +85ºC | -55ºC to +125ºC | | | -55ºC to +150ºC | -55ºC to +160ºC | -55ºC to +200ºC | | Rated temperature range |
| ±15% | ±15% | ±15% | ±15% | ±15% | +15 -40% | +15 -65% | No DC voltage applied | Maximum capacitance change over temperature range |
| - | +15 -45% | - | +15 -25% | - | - | - | Rated DC voltage applied | |
| ≤ 0.025 Typical* | >25V ≤0.025<br>≤25V ≤0.035 | | | ≤0.025 | ≤0.025 | | | Tangent of loss angle (tan δ) |
| 100GΩ or 1000s (whichever is the least) | | | | | | | Time constant (Ri x Cr) | Insulation resistance (Ri) |
| ±5%, ±10%, ±20% | | | | | | | | Capacitance Tolerance |
| 2.5 times | 2.5 times | | | 2.5 times | 2.5 times | | ≤200V | Dielectric strength Voltage applied for 5 seconds. Charging current limited to 50mA maximum. |
| | Rated voltage + 250V | | | | Rated voltage + 250V | | >200V to <500V | |
| | 1.5 times | | | | 1.5 times | | 500V to <1kV | |
| | 1.2 times | | | | 1.2 times | | ≥1kV | |
| 55/85/56 | 55/125/56 | | | 55/150/56 | - | | Chip | Climatic category (IEC) |
| - | 55/125/21 | | | - | - | | Dipped | |
| - | 55/125/56 | | | - | - | | Discoidal | |
| 5% Typical | <2% per time decade | | | | | | | Ageing characteristic (Typical) |
| - | QC-32100 | - | - | - | QC-32100 | - | Syfer Chip | Approvals |

* Refer to page 34 for details of Dissipation Factor.

# Dielectric termination combinations

| | | Palladium Silver | Palladium Silver | Nickel Barrier (100% matte tin plating). Lead free | Nickel Barrier 90/10% tin/lead | Nickel Barrier Gold flash | FlexiCap™ with Nickel Barrier 100% tin | FlexiCap™ with Nickel Barrier 90/10% tin/lead | FlexiCap™ with Copper Barrier 100% tin | FlexiCap™ Ag Layer, 400-u-in Cu barrier 200-u-in Sn Plate | FlexiCap™ with Copper Barrier 90/10% tin/lead | Copper Barrier 100% tin | Ag Layer, 400-500u-in Cu barrier, 200-u-in 90/10 Sn Plate | Copper Barrier 90/10% tin/lead | Solderable Silver | Solderable Palladium Silver |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | RoHS | RoHS | | RoHS | RoHS | | RoHS | | | RoHS | | | RoHS | RoHS |
| Recommended for Solder Attachment | | | | ● | ● | | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● |
| Recommended for Conductive Epoxy Attachment | | ● | ● | | | ● | | | | | | | | | | |
| **Termination ordering code:** | **DLI** | - | - | Z | U | S | - | - | - | - | - | - | - | - | - | - |
| | **Novacap** | P | PR | N | Y | NG | C | D | - | - | - | B | - | E | S | K |
| | **Syfer** | - | F | J | A | - | Y | H | 3 | - | 5 | 2 | - | 4 | - | - |
| **Dielectric** | **Code** | | | | | | | | | | | | | | | |
| C0G - Hi Q/Low ESR | DLI - UL | | | ● | ● | ● | | | | | | | | | | |
| | Syfer - Q, U | | | ● | ● | | | | | | | | | | | |
| C0G - Hi Q/Low ESR BME | Syfer - H | | | ● | | | | | | | | | | | | |
| C0G/NP0 | Novacap - N/RN | ● | ● | ● | ● | ● | ● | ● | | | | | | | ● | ● |
| | Syfer - A | | | ● | | | ● | | | | | | | | | |
| | Syfer - C, F | | ● | ● | ● | | ● | ● | | | | | | | | |
| C0G/NP0 - BME | Syfer - G, K | | | ● | | | | | | | | | | | | |
| C0G/NP0 - Non-Mag | Novacap - M | ● | ● | | | | | | | | | ● | | ● | | ● |
| | Syfer - C, Q | | | | | | | | ● | | ● | ● | | ● | | |
| | Voltronics - Q | | ● | | | | | | | ● | | ● | ● | | | |
| X5R | Syfer - P | | ● | ● | ● | | ● | ● | | | | | | | | |
| | Novacap - BW | | | ● | ● | ● | | | | | | | | | | |
| X7R | Novacap - B/RB | ● | ● | ● | ● | ● | ● | ● | | | | | | | ● | ● |
| | Syfer - E | | | | | | ● | | | | | | | | | |
| | Syfer - X, D | | ● | ● | ● | | ● | ● | | | | | | | | |
| X7R - BME | Novacap - BB | | | ● | ● | ● | | | | | | | | | | |
| | Syfer - J | | | ● | | | ● | | | | | | | | | |
| | Syfer - S | | | | | | ● | | | | | | | | | |
| BX | Novacap - X | ● | ● | ● | ● | ● | ● | ● | | | | | | | ● | ● |
| | Syfer - B | | ● | ● | ● | | ● | ● | | | | | | | | |
| R2D (Pulse Energy) | Novacap - R | ● | ● | | | | | | | | | | | | | ● |
| BZ | Syfer - R | | ● | ● | ● | | ● | ● | | | | | | | | |
| X7R - Non-Mag | Novacap - C | ● | ● | | | | | | | | | ● | | ● | | ● |
| | Syfer - X | | | | | | | | ● | | ● | | | | | |
| | Voltronics - X | | ● | | | | | | ● | ● | | | ● | | | |
| X8R | Novacap - S | ● | ● | ● | ● | | ● | ● | | | | | | | ● | ● |
| | Syfer - N | | | | | | ● | | | | | | | | | |
| | Syfer - T | | | | | | ● | | | | | | | | | |
| C0G/NP0 (160°C) | Novacap - F | ● | ● | ● | ● | | ● | ● | | | | | | | ● | ● |
| C0G/NP0 (200°C) | Novacap - D | | | | | | | | | | | | | | ● | ● |
| C0G/NP0 (200°C) | Novacap - RD | | | ● | | | | | | | | | | | | |
| | Syfer - G | | | ● | | | | | | | | | | | | |
| Class II (160°C) | Novacap - G | ● | ● | ● | ● | | ● | ● | | | | | | | ● | ● |
| Class II (200°C) | Novacap - E | | | | | | | | | | | | | | ● | ● |
| | Novacap - RE | | | ● | | | | | | | | | | | | |

Dielectric codes in **Red** - AEC-Q200 qualified. Dielectric codes in **Green** - IECQ-CECC.