EIA TEMPERATURE COEFFICIENTS: CERAMIC CAPACITORS

All ceramic capacitors are specified (and guaranteed) with regards to their capacitance value and tolerance at +25°C (Room Temperature; 77°F)

All capacitors will change in capacitance value if their temperature departs from room temperature, as normally will occur through heating or cooling within an electronic circuit.

THE GRAPH BELOW, SHOWS EXAMPLE OF CAPACITANCE VALUE CHANGE OVER TEMPERATURE RANGE

CAPACITANCE VALUE CHANGE OVER TEMPERATURE

The maximum allowable change in capacitance value over a specified operating temperature range is the Temperature Coefficient (TC) of the capacitor.

THE TABLE BELOW, SHOWS THE BREAKDOWN OF THE EIA THREE DIGIT “TC” CODES

<table>
<thead>
<tr>
<th>Low Temperature Limit</th>
<th>High Temperature Limit</th>
<th>Maximum Allowable Capacitance Change From +25°F (0 VDC)</th>
</tr>
</thead>
<tbody>
<tr>
<td>X = -55°C</td>
<td>5 = +85°C</td>
<td>F = ±7.5%</td>
</tr>
<tr>
<td>Y = -30°C</td>
<td>6 = +105°C</td>
<td>P = ±10%</td>
</tr>
<tr>
<td>Z = +10°C</td>
<td>7 = +125°C</td>
<td>R = ±15%</td>
</tr>
<tr>
<td>8 = +150°C (SPECIAL)</td>
<td></td>
<td>S = ±22%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>T = +22% / -33%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>U = +22% / -56%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>V = +22% / -82%</td>
</tr>
</tbody>
</table>

X7R = ±15% ΔC over -55°C ~ +125°C
EIA Temperature Coefficients: Ceramic Capacitors

Common "TC" designations include:

- **X5R** = ±15% change over -55°C~+85°C Standard Tolerance: K = ±10%
- **X7R** = ±15% change over -55°C~+125°C Standard Tolerance: K = ±10%
- **Y5V** = +22%/-82% change over -30°C~+85°C Standard Tolerance: Z = -20%/+80%
- **Z5U** = +22%/−56% change over -10°C~+85°C Standard Tolerance: M = ±20%

Exception to the above system is Ultra-Stable "TC": **COG = NPO**

- **NPO** = 0±30PPM/°C over -55°C ~ +125°C ...Standard Tolerance: J = ±5%
- **NPO** = Negative Positive Zero  [Originated from Military Standards]

Component Characteristics Substitution Guide:

- "TC" - Temperature Coefficient: (Ceramic Capacitors)
- Substitution Rule: A component with a more stable (better) temperature coefficient (TC) can replace a less temperature stable TC component.
  - i.e...an **X7R** ceramic can replace **X5R, Z5U** or **Y5V** ceramic part
  - i.e...an **NPO** ceramic can replace a **X5R, X7R, Z5U** or **Y5V** ceramic

Temperature Characteristic Curves:

![Typical NPO Temperature Coefficient Curve](image-url)
EIA Temperature Coefficients: Ceramic Capacitors

**X7R**
±15% over -55°C ~ +125°C

**Y5V**
+22% to -82% change over -30°C ~ +85°C
EIA Temperature Coefficients: Ceramic Capacitors

- **Z5U**: +22%/-56% change over -10°C ~ +85°C

**Typical Z5U Temperature Coefficient**

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**Additional Information & Resources:**
- EIA-521... APPLICATION GUIDE FOR MULTILAYER CERAMIC CAPACITORS - ELECTRICAL
- EIA-198-2-E ... TEST METHODS CERAMIC CAPACITORS
- NIC MLCC GUIDELINES:
  - Measurement of High Capacitance MLCC
  - Voltage Coefficients: NPO, X7R, Y5V
  - Aging Characteristics
  - Test Conditions