Ceramic Capacitors

NIC PRODUCT TRAINING
Topics: Lead and Surface Mount (SMT)

- Characteristics
- Ceramic Dielectrics
- Substitution Guides
- Styles - Appearance - Dimensions
- NIC Part Numbers
- Competition Cross Reference
- Use in Circuit Board Assembly
- Buzzwords & Technical Info
Capacitor Family Tree

CAPACITORS

ELECTROSTATIC
- FILM
- CERAMIC
  - DISC
  - MLC
    - SMT
    - MONO

ELECTROLYTIC
- ALUMINUM
- TANTALUM
Ceramic capacitors belong to the family of ELECTROSTATIC capacitors. They have the following characteristics:

- They are Non-Polar
- They dominate the lower range of capacitance values
- They are the most widely used style of capacitor (Largest Volume & Lowest Pricing)
- They are available in both leaded and surface mount styles
- The vast majority are fixed capacitance value (their value is not user variable)
Capacitance (Cap) Value Characteristic

Capacitance Value in...

\[ pF = \text{pico-Farad} = 1 \times 10^{-12} \text{ F} = 0.000000000001 \text{F} \]

NIC offers ceramic capacitors with values ranging from...

\[ 0.5pF \sim 22,000,000pF ( = 22\mu F) \]

Most call outs are from 10pF \sim 0.1\mu F
Cap Value Characteristic

Capacitance Value in...

\[\begin{align*}
pF &= \text{pico-Farad} = 1 \times 10^{-12} \text{ F} = 0.000000000001 \text{F} \\
nF &= \text{nano-Farad} = 1 \times 10^{-9} \text{ F} = 0.000000001 \text{F} \\
uF &= \text{micro-Farad} = 1 \times 10^{-6} \text{ F} = 0.000001 \text{F}
\end{align*}\]

\[1000 \text{pF} = 1 \text{nF}\]

\[1,000,000 \text{pF} = 1000 \text{nF} = 1 \text{uF}\]
Cap Value Characteristic

Capacitance Value Range

**Low End:** pF
Typical Values: 1pF, 4.7pF, 22pF, 100pF, 330pF, 1000pF, etc.

**Medium Range:** nF
Typical Values: 1nF, 10nF (0.01μF), 100nF (0.1μF), 220nF (0.22μF), etc.

**High End:** μF
Typical Values: 1μF, 2.2μF, 10μF and 22μF
Cap Value Characteristic

Standard Capacitance Values: (PER EIA-575 & RS 460)

E12
10 12 15 18 22 27 33 39 47 56 68 82

Examples:
1.0, 1.2, 1.5, ..., 10, 15, 22, ..., 100, 180, 270, ..., 1K, 3.3K, 4.7K, ...
10K, 33K, 56K, ..., 100K, 220K, 680K, ..., 1uF, 2.2uF, 4.7uF, ...
Cap Value Characteristic

Standard Capacitance Values: (PER EIA-575 & RS 460)

**E24**

10 11 12 13 15 16 18 20 22 24 27 30 33 36

39 43 47 51 56 62 68 75 82 91

In-between Values Shown In Red Are Considered “Odd” Non-Preferred Values
And As Such Are Not Stocked
And Should Be Discouraged From Being Selected...
Tolerance Characteristic

Capacitance Tolerance
Capacitance value will have tolerance value (+25°C):
±1% (F), ±2% (G), ±5% (J), ±10% (K), ±20% (M) and +80%/-20% (Z)
±0.1pF (B), ±0.25pF (C) and ±0.5pF (D)

These are the most commonly called out tolerances
This "Bell" curve illustrates product yield.

**Tolerance Characteristic**

**Capacitance Tolerance**

- Capacitance Tolerance Characteristic
- Target Value

- Capacitance (pF / nF / µF)
- Tolerance: -10% - 0% +10%

This “Bell” curve illustrates product yield.
Capacitance Tolerance Substitution

“A component with a tighter (better) tolerance can replace a looser (worst) tolerance component.”

i.e... ±1%(F) tolerance part can replace ±2%(G), ±5%(J) or ±10% (K) tolerance part
i.e... ±2%(G) tolerance part can replace ±5%(J), ±10% (K) or ±20% (M) tolerance part
i.e... ±5%(J) tolerance part can replace ± 10%(K) or ±20% (M) tolerance part
i.e... ±10%(K) tolerance part can replace ±20%(M) or +80%/-20%(Z) tolerance part
i.e... ±20%(M) tolerance part can replace +80%/-20%(Z) tolerance part
Voltage Characteristic

| 0.1uF ±20%(M) | 50VDC |

Voltage Rating

NIC offers ceramic capacitors with voltage ratings from...

16VDC ~ 15,000VDC

Most call outs are from 25V ~ 100VDC
Voltage Rating Substitution

“A component with a higher voltage rating may be used in place of, or as a substitute for, a lower voltage rated component.”

i.e… 1000V rated part can replace 500V, 250V or 100V rated part.
i.e… 500V rated part can replace 250V, 100V or 50V rated part.
i.e… 250V rated part can replace 100V, 50V or 25V rated part.
i.e… 100V rated part can replace 50V or 25V rated part.
i.e… 50V rated part can replace 25V or 16V rated part.
i.e… 25V rated part can replace 16V or 10V rated part.
TC Characteristic

Unfortunately not all capacitance values can be produced from one ceramic dielectric formulation…

A wide range of ceramic dielectrics are needed, and have been developed, to cover a broad range of capacitance values. The EIA (Electronics Industries Alliance) established industry classifications for ceramic dielectrics that are agreed to and met by all ceramic capacitor producers.

These ceramic dielectric classifications are identified by their temperature coefficient (TC) code.

- Y5P
- NPO
- X7R
- Z5U
- Y5F
Room Temperature is +25°C (77°F)

All capacitors are specified (and guaranteed) with regards to their capacitance value and tolerance at +25°C

All capacitors will change in capacitance value if their temperature departs from room temperature (through heating or cooling within an electronic circuit). Blue line shown on above graph illustrates capacitance change over -50°C to +100°C temperature range.

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

Standard Temperature Coefficients (TC) of ceramic capacitors:

<table>
<thead>
<tr>
<th>Low Temperature Limit</th>
<th>High Temperature Limit</th>
<th>Maximum Allowable Capacitance Change From +25°C (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></td>
<td>8 = +150°C (SPECIAL)</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
TC Characteristic

Industry standard Temperature Coefficients (TC) of ceramic capacitors:

**X5R** = ±15% ∆C over -55°C ~ +85°C

**X7R** = ±15% ∆C over -55°C ~ +125°C  
*Standard Tolerance: K = ±10%*

**Y5F** = ±7.5% ∆C over -30°C ~ +85°C

**Y5P** = ±10% ∆C over -30°C ~ +85°C

**Y5R** = ±15% ∆C over -30°C ~ +85°C

**Y5S** = ±22% ∆C over -30°C ~ +85°C

**Y5T** = +22% / -33% ∆C over -30°C ~ +85°C

**Y5U** = +22% / -56% ∆C over -30°C ~ +85°C

**Y5V** = +22% / -82% ∆C over -30°C ~ +85°C  
*Standard Tolerance: Z = -20%+/80%*

**Z5U** = +22% / -56% ∆C over -10°C ~ +85°C  
*Standard Tolerance: M = ±20%*

**Z5V** = +22% / -82% ∆C over -10°C ~ +85°C

**COG = NPO** = 0±30PPM/ °C over -55°C ~ +125°C  
*Standard Tolerance: J = ±5%*

*MLC = Multi-Layer Ceramic*
TC Characteristics

**SPECIAL TEMPERATURE COMPENSATING TC’S**
(linear capacitance value change over temperature)

- **N150** = -150PPM ±60PPM/ °C over -30°C ~ + 85°C
- **N470** = -470PPM ±60PPM/ °C over -30°C ~ + 85°C
- **N750** = -750PPM ±120PPM/ °C over -30°C ~ + 85°C
- **N1500** = -1500PPM ±250PPM/ °C over -30°C ~ + 85°C
- **N3300** = -3300PPM ±500PPM/ °C over -30°C ~ + 85°C
- **SL** = -330PPM±500PPM/ °C over -30°C ~ + 85°C

These temperature compensating TC’s are available in **CERAMIC DISC CAPACITOR** styles...
Component Substitution Guideline

- **Temperature Coefficient**
  "A component with a more stable (better) temperature characteristic (TC) can replace a less temperature stable (worse) component.

  i.e… an X7R ceramic can replace Z5U or Y5V ceramic parts.
  i.e… an NPO ceramic can replace a X7R or Z5U or Y5V ceramic.
Styles - Appearance (Leaded)

Radial Leaded Ceramic Disc

Monolithic Multi-layer Ceramic (MLC)

Axial Leaded “Mono”

Packaged on tape for auto insertion
Single Layer Disc Capacitor (Radial)

Nippon Ceramic Disc Y5F 102K 1KV

SINGLE LAYER CERAMIC DIELECTRIC DISC

LEADS ATTACHED TO EACH ELECTRODE

SILVER ELECTRODE PRINTED AND FIRED ON BOTH SIDES

PROCETIVE COATING APPLIED AND COMPONENT MARKED
Ceramic Disc Capacitor (Radial)

Body Diameter
From 4mm to 25mm (0.15”~1.0”)

Lead Spacing
6.35mm (0.25”) is standard (bulk packaged)
5.0mm (0.2”) is standard (Tape and Reeled “T/R”)
7.5mm (0.30”) and 10mm(0.39”) are options

NCD Series
- Disc
- Ceramic
- Nippon
Ceramic Disc Capacitor (Radial)

**Body Thickness**
From 2mm to 7mm (0.079” ~ 0.276”)

**Lead Diameter** 0.6mm (0.024”)
is standard…

On larger body diameters 0.8mm (0.031”) lead diameter is available as option. It is also standard on 5KVDC and higher voltage ratings.

**NCD Series**
- Disc
- Ceramic
- Nippon
Ceramic Disc Capacitor (Radial)

Cap Value
102 = 1000pF

Dielectric
Y5F

Cap Tolerance
C = +/-25pF
D = +/-50pF
F = +/-1%
G = +/-2%
J = +/-5%
K = +/-10%
M = +/-20%
Z = +80%/-20%

Example shown
P/N: NCD102K1KVY5PTR

Cap Value
103 = 0.01uF

Dielectric
Y5P

Cap Tolerance
C = +/-25pF
D = +/-50pF
F = +/-1%
G = +/-2%
J = +/-5%
K = +/-10%
M = +/-20%
Z = +80%/-20%

Example shown
P/N: NCD103K1KVY5PTR

Cap Value
102 = 1000pF

Voltage
1KV = 1000VDC

Example shown
P/N: NCD102K1KVY5F

Cap Value
103 = 0.01uF

Voltage
1KV = 1000VDC

Example shown
P/N: NCD103K1KVY5PTR
Part Numbering System

NIC NCD Series - Ceramic Disc Capacitor

NCD 102 M 1KV Z5U D TR

Tape and Reel
Optional Lead Forming:
No Code = Straight Leads
C, D, E, J, K = Crimped Leads

Temperature Coefficient: 15 TCs Available
Voltage Rating (VDC): 12V ~ 15KV

Capacitance Value Tolerance:  F = ±1%, G = ±2%,  J = ±5%, K = ±10%, M = ±20% and Z = +80%/-20%

Capacitance Value in pF: 0.5pF ~ 0.22uF
(3 digit code) First 2 digits are significant. Third digit is number of zeros.
100 = 10pF, 101 = 100pF, 332 = 3300pF, 103 = 10,000pF = 0.01uF
Values less than 10pF R = decimal 1R0 = 1.0pF, 4R7 = 4.7pF
## Capacitance Range per TC

**NIC NCD Series - Ceramic Disc Capacitor**

**Temperature Coefficients:**

<table>
<thead>
<tr>
<th>TC</th>
<th>Capacitance Range</th>
<th>Capacitance Value Code</th>
<th>Voltage Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>NPO</td>
<td>0.5pF ~ 470pF</td>
<td>0R5 ~ 471</td>
<td>50VDC ~ 15KVDC</td>
</tr>
<tr>
<td>SL</td>
<td>3pF ~ 1000pF</td>
<td>3R0 ~ 102</td>
<td>50VDC ~ 15KVDC</td>
</tr>
<tr>
<td>N150 &amp; N470</td>
<td>3pF ~ 150pF</td>
<td>3R0 ~ 151</td>
<td></td>
</tr>
<tr>
<td>N750</td>
<td>22pF ~ 470pF</td>
<td>220 ~ 471</td>
<td>50VDC ~ 1KVDC</td>
</tr>
<tr>
<td>N1500</td>
<td>22pF ~ 1000pF</td>
<td>220 ~ 102</td>
<td></td>
</tr>
<tr>
<td>N3300</td>
<td>47pF ~ 1000pF</td>
<td>470 ~ 102</td>
<td></td>
</tr>
<tr>
<td>Y5F</td>
<td>100pF ~ 4700pF</td>
<td>101 ~ 472</td>
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</tr>
<tr>
<td>Y5P</td>
<td>100pF ~ 0.015uF</td>
<td>101 ~ 153</td>
<td>50VDC ~ 15KVDC</td>
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</table>
## Capacitance Range per TC

**NIC NCD Series - Ceramic Disc Capacitor**

**Temperature Coefficients:**

<table>
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<tr>
<th>TC</th>
<th>Capacitance Range</th>
<th>Capacitance Value Code</th>
<th>Voltage Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Y5R / Y5S / Y5T</td>
<td>0.01uF ~ 0.1uF</td>
<td>103 ~ 104</td>
<td>12VDC ~ 50VDC</td>
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<tr>
<td>Y5V</td>
<td>0.01uF ~ 0.22uF</td>
<td>103 ~ 224</td>
<td>12VDC ~ 50VDC</td>
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<tr>
<td>Z5U</td>
<td>1000pF ~ 0.1uF</td>
<td>102 ~ 104</td>
<td>50VDC ~ 15KVDC</td>
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<tr>
<td>Z5V</td>
<td>1000pF ~ 0.1uF</td>
<td>102 ~ 104</td>
<td>50VDC ~ 5KVDC</td>
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</tbody>
</table>
Capacitance Range per TC

NIC **NCD** Series - Ceramic Disc Capacitor
# Cross Reference

## Ceramic Disc Capacitor Cross Reference

<table>
<thead>
<tr>
<th>NIC</th>
<th>Illinois Capacitor</th>
<th>Mallory</th>
<th>Murata</th>
<th>Panasonic</th>
<th>Phillips</th>
<th>Tecate</th>
<th>Xicon</th>
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<tr>
<td>NCD</td>
<td>BCR</td>
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<td>DD</td>
<td>ECC</td>
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</table>
Multilayer Ceramic Capacitors (MLC)

- Single Layer Ceramic Dielectric Sheet
- Silver Electrode Printed
- Multilayer Ceramic Sheets Stacked
Multilayer Ceramic Capacitors (MLC)

MULTILAYER CERAMIC SHEETS PRESSED, FIRED AND CHIP ELEMENT TERMINATED

MULTIPLE LAYERS CONSTRUCTION RESULTS IN MULTIPLE INCREASE IN CAPACITANCE SURFACE AREA = INCREASED CAPACTANCE VALUE

Example above shows five times increase in capacitance as compared to single layer
Multilayer Ceramic Capacitors (Leaded)

**NCM Series**
- Radial Leaded Multilayer Ceramic Capacitor
  - Epoxy Resin Coating
  - Lead Wire

**NCMA Series**
- Axial Leaded Multilayer Ceramic Capacitor
  - Epoxy Resin Coating
  - Lead Wire

LEAD WIRE
SOLDER
MLC Ceramic Capacitor (Radial)

<table>
<thead>
<tr>
<th>SIZE CODE</th>
<th>WIDTH</th>
<th>HEIGHT</th>
<th>THICKNESS</th>
<th>LEAD SPACING</th>
<th>LEAD DIAMETER</th>
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<tr>
<td>15</td>
<td>3.81</td>
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<td>5.08</td>
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<td>0.63</td>
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<td>3.81</td>
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<tr>
<td>50</td>
<td>12.70</td>
<td>12.70</td>
<td>5.08</td>
<td>10.16</td>
<td>0.63</td>
</tr>
</tbody>
</table>

Body Width
3.8mm ~ 12.7mm
(0.15” ~ 0.50”)

Lead Diameter
0.5mm = 0.020”
0.63mm = 0.025”

Body Height
3.8mm ~ 12.7mm
(0.15” ~ 0.50”)

Lead Spacing
2.54mm = 0.1”
5.1mm = 0.2”
10.2mm = 0.4”

Body Thickness
2.54mm ~ 5.1mm (0.1” ~ 0.2”)

NCM Series
Multilayer Ceramic
Nippon
MLC Ceramic Capacitor (Radial)

NIC NCM Series - Radial Leaded Multilayer Ceramic Capacitor

Part Marking

Cap Value
100 = 10pF

Dielectric
A = NPO
C = X7R
E = Z5U

Voltage
1 = 100VDC
2 = 200VDC
5 = 50VDC

Cap Tol.
C = +/- .25pF
D = +/- .5pF
F = +/- 1%
G = +/- 2%
J = +/- 5%

K = +/- 10%
M = +/- 20%
Z = +80%/-20%

Date Code
YWW
8 = 1998
06 = 6th week

Example shown P/N: NCM15NPO100J200
**Part Numbering System**

NIC NCM Series - Radial Leaded Multilayer Ceramic Capacitor

**NCM 21 X7R 104 K 50 TR**

- **Tape and Reel**
- **Voltage Rating (VDC):** 50V, 100V & 200V
- **Capacitance Value Tolerance:**
  - F = ±1%, G = ±2%, J = ±5%, K = ±10%, M = ±20% and Z = +80%/-20%
- **Capacitance Value in pF:** 1.0pF ~ 2.2uF
  (3 digit code) First 2 digits are significant. Third digit is number of zeros. 100 = 10pF, 101 = 100pF, 332 = 3300pF, 103 = 10,000pF = 0.01uF. Values less than 10pF R = decimal 1R0 = 1.0pF, 4R7 = 4.7pF

- **Temperature Coefficient:** NPO, X7R and Z5U

- **Size:** 15, 20, 21, 30, 40 and 50

**Series**

<table>
<thead>
<tr>
<th>SIZE CODE</th>
<th>WIDTH</th>
<th>HEIGHT</th>
<th>THICKNESS</th>
<th>LEAD SPACING</th>
<th>LEAD DIAMETER</th>
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<tr>
<td>15</td>
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</tbody>
</table>
Capacitance Range per TC

NIC **NCM** Series - Radial Leaded Multilayer Ceramic Capacitor

**Temperature Coefficients:**

<table>
<thead>
<tr>
<th>TC</th>
<th>Capacitance Range</th>
<th>Capacitance Value Code</th>
<th>Voltage Range</th>
<th>Standard Tolerance</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>NPO</strong></td>
<td>1.0pF ~ 0.1uF</td>
<td>1R0 ~ 104</td>
<td>50VDC ~ 200VDC</td>
<td>(J) +/-5%</td>
</tr>
<tr>
<td><strong>X7R</strong></td>
<td>470pF ~ 4.7uF</td>
<td>470 ~ 475</td>
<td>50VDC ~ 200VDC</td>
<td>(K) +/-10%</td>
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<tr>
<td><strong>Z5U</strong></td>
<td>1000pF ~ 4.7uF</td>
<td>102 ~ 475</td>
<td>50VDC ~ 200VDC</td>
<td>(M) +/-20%</td>
</tr>
</tbody>
</table>

**Diagram:**

- NPO
- X7R
- Z5U

**Code:**

- 1R0
- 100
- 101
- 102
- 103
- 104
- 105
- 106
MLC Ceramic Capacitor (Axial)

**Body Diameter**
2.54mm ~ 3.81mm (0.1” ~ 0.15”)

**Lead Diameter**
0.5mm (0.020”)

**Body Length**
4.32mm ~ 10.2mm (0.17” ~ 0.4”)

<table>
<thead>
<tr>
<th>SIZE CODE</th>
<th>DIAMETER</th>
<th>LENGTH</th>
<th>LEAD DIAMETER</th>
</tr>
</thead>
<tbody>
<tr>
<td>NCMA 10</td>
<td>2.54</td>
<td>4.32</td>
<td>0.5</td>
</tr>
<tr>
<td>NCMA 11</td>
<td>3.5</td>
<td>6.6</td>
<td></td>
</tr>
<tr>
<td>NCMA 20</td>
<td>2.54</td>
<td>7.37</td>
<td></td>
</tr>
<tr>
<td>NCMA 30</td>
<td>3.81</td>
<td>10.16</td>
<td></td>
</tr>
<tr>
<td>NCMA 40</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
MLC Ceramic Capacitor (Axial)

NIC NCMA Series - Axial Leaded Multilayer Ceramic Capacitor
Part Marking

Cap Value
330 = 33pF

Voltage
1 = 100VDC
2 = 200VDC
5 = 50VDC

Dielectric
A = NPO
C = X7R
E = Z5U

Cap Tol.
C = +/-0.25pF
D = +/-0.5pF
F = +/-1%
G = +/-2%
J = +/-5%
K = +/-10%
M = +/-20%
Z = +/-80%/-20%

Date Code
YWW
9 = 1999
12 = 12th week

Production Lot Code
2A 330 J HV 9 12
Part Numbering System

NIC NCMA Series - Axial Leaded Multilayer Ceramic Capacitor

NCMA 10 Z5U 104 M 50 TR

Series

Tape and Reel

Voltage Rating (VDC): 50V, 100V & 200V

Capacitance Value Tolerance:
F = ±1%, G = ±2%, J = ±5%, K = ±10%, M = ±20% and Z = +80%/-20%

Capacitance Value in pF: 1.0pF ~ 1.0uF
(3 digit code) First 2 digits are significant. Third digit is number of zeros.
100 = 10pF, 101 = 100pF, 332 = 3300pF, 103 = 10,000pF = 0.01uF
Values less than 10pF R = decimal 1R0 = 1.0pF, 4R7 = 4.7pF

Temperature Coefficient: NPO, X7R and Z5U

Size: 10, 11, 20, 30, and 40

<table>
<thead>
<tr>
<th>SIZE CODE</th>
<th>DIAMETER</th>
<th>LENGTH</th>
<th>LEAD DIAMETER</th>
</tr>
</thead>
<tbody>
<tr>
<td>NCMA 10</td>
<td>2.54</td>
<td>4.32</td>
<td></td>
</tr>
<tr>
<td>NCMA 11</td>
<td>3.5</td>
<td>4.32</td>
<td>0.5</td>
</tr>
<tr>
<td>NCMA 20</td>
<td>2.54</td>
<td>6.6</td>
<td></td>
</tr>
<tr>
<td>NCMA 30</td>
<td>3.81</td>
<td>7.37</td>
<td></td>
</tr>
<tr>
<td>NCMA 40</td>
<td>3.81</td>
<td>10.16</td>
<td></td>
</tr>
</tbody>
</table>
### Capacitance Range per TC

**NIC NCMA Series** - Axial Leaded Multilayer Ceramic Capacitor

Temperature Coefficients:

<table>
<thead>
<tr>
<th>TC</th>
<th>Capacitance Range</th>
<th>Capacitance Value Code</th>
<th>Voltage Range</th>
<th>Standard Tolerance</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>NPO</strong></td>
<td>1.0pF ~ 0.01uF</td>
<td>1R0 ~ 103</td>
<td>50VDC ~ 200VDC</td>
<td>(J) +/-5%</td>
</tr>
<tr>
<td><strong>X7R</strong></td>
<td>220pF ~ 0.47uF</td>
<td>221~ 474</td>
<td>50VDC ~ 200VDC</td>
<td>(K) +/-10%</td>
</tr>
<tr>
<td><strong>Z5U</strong></td>
<td>0.01uF ~ 1.0uF</td>
<td>103 ~ 105</td>
<td>50VDC ~ 200VDC</td>
<td>(M) +/-20%</td>
</tr>
</tbody>
</table>

![Diagram showing capacitance range and value codes](image-url)
## Cross Reference

**Leaded Multilayer Ceramic Capacitor Cross Reference:**

<table>
<thead>
<tr>
<th>NIC</th>
<th>AVX</th>
<th>KEMET</th>
<th>Mallory</th>
<th>Panasonic</th>
<th>Philips</th>
<th>XICON</th>
</tr>
</thead>
<tbody>
<tr>
<td>NCM Series</td>
<td>SR</td>
<td>C315 ~ C350</td>
<td>M</td>
<td>ECU-S</td>
<td>K</td>
<td>EDM</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>CN</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>CW</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>CZ</td>
<td></td>
</tr>
<tr>
<td>NCMA Series</td>
<td>SA</td>
<td>C410 ~ C440</td>
<td>P</td>
<td>n/a</td>
<td>A</td>
<td>CA</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>A40</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>A41</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>A43</td>
<td></td>
</tr>
</tbody>
</table>
Styles - Appearance (Surface Mount)

SMT Ceramic Chip

Monolithic Multi-layer Ceramic Chip (MLC)

7" AND 10" REELS

Packaged on tape for auto insertion
Multilayer Ceramic Capacitors

- Single Layer Ceramic Dielectric Sheet
- Silver Electrode Printed
- Multilayer Ceramic Sheets Stacked
Multilayer Ceramic Capacitors (MLC)

MULTILAYER CERAMIC SHEETS PRESSED, FIRED AND CHIP ELEMENT TERMINATED

MULTIPLE LAYERS CONSTRUCTION RESULTS IN MULTIPLE INCREASE IN CAPACITANCE SURFACE AREA = INCREASED CAPACITANCE VALUE

Example above shows *five times* increase in capacitance as compared to *single layer*
Multilayer Ceramic Capacitors

NMC Series

CERAMIC DIELECTRIC

TIN PLATE FINISH

NICKEL BARRIER LAYER

SILVER BASE

Nippon

Multilayer ceramic

Chip
<table>
<thead>
<tr>
<th>English</th>
<th>Metric</th>
<th>Length</th>
<th>Width</th>
</tr>
</thead>
<tbody>
<tr>
<td>0402</td>
<td>1005</td>
<td>1.0mm (0.04&quot;)</td>
<td>0.5mm (0.02&quot;)</td>
</tr>
<tr>
<td>0603</td>
<td>1608</td>
<td>1.6mm (0.06&quot;)</td>
<td>0.8mm (0.03&quot;)</td>
</tr>
<tr>
<td>0805</td>
<td>2012</td>
<td>2.0mm (0.08&quot;)</td>
<td>1.2mm (0.05&quot;)</td>
</tr>
<tr>
<td>1206</td>
<td>3216</td>
<td>3.2mm (0.12&quot;)</td>
<td>1.6mm (0.06&quot;)</td>
</tr>
<tr>
<td>1210</td>
<td>3225</td>
<td>3.2mm (0.12&quot;)</td>
<td>2.5mm (0.10&quot;)</td>
</tr>
<tr>
<td>1812</td>
<td>4532</td>
<td>4.5mm (0.18&quot;)</td>
<td>3.2mm (0.12&quot;)</td>
</tr>
<tr>
<td>2225</td>
<td>5764</td>
<td>5.7mm (0.22&quot;)</td>
<td>6.4mm (0.25&quot;)</td>
</tr>
</tbody>
</table>
Reel Labeling System

The NIC part number, lot number, date code, reel quantity, customer part number, purchase order number, etc. is printed (and bar coded if requested) on the reel label(s) for each reel of product.
Part Numbering System

NIC **NMC** Series - Multilayer Ceramic Chip Capacitor

**NMC 0603** X7R 104 K 16 TRP

- **Tape and Reel**
- **Voltage Rating (VDC):** 16V, 25V, 50V, 100V, 200V, 500V and 1KV
- **Capacitance Value Tolerance:**
  - F = ±1%, G = ±2%, J = ±5%, K = ±10%, M = ±20% and Z = +80%/-20%
- **Capacitance Value in pF:** 0.5pF ~ 22uF
  - (3 digit code) First 2 digits are significant. Third digit is number of zeros. 100 = 10pF, 101 = 100pF, 332 = 3300pF, 103 = 10,000pF = 0.01uF Values less than 10pF R = decimal 1R0 = 1.0pF, 4R7 = 4.7pF
- **Temperature Coefficient:** NPO, X7R, Y5V and Z5U

**Size:** 0402, 0603, 0805, 1206, 1210, 1812 and 2225

Series **NMC (Standard)**, **NMC-E** (Low Profile), **NMC-H** (High Voltage) and **NMC-Q** (High Q NPO)
## Capacitance Range per TC

**NIC NMC Series - Multilayer Ceramic Chip Capacitor**

Temperature Coefficients:

<table>
<thead>
<tr>
<th>TC</th>
<th>Capacitance Range</th>
<th>Capacitance Value Code</th>
<th>Voltage Range</th>
<th>Standard Tolerance</th>
</tr>
</thead>
<tbody>
<tr>
<td>NPO</td>
<td>0.5pF ~ 0.056uF</td>
<td>0R5 ~ 563</td>
<td>25VDC ~ 1KVDC</td>
<td>(J) +/-5%</td>
</tr>
<tr>
<td>X7R</td>
<td>100pF ~ 2.2uF</td>
<td>101~ 225</td>
<td>16VDC ~ 1000VDC</td>
<td>(K) +/-10%</td>
</tr>
<tr>
<td>Y5V</td>
<td>1000pF ~ 10uF</td>
<td>102 ~ 106</td>
<td>16VDC ~ 50VDC</td>
<td>(Z) -20%/+80%</td>
</tr>
<tr>
<td>Z5U</td>
<td>1000pF ~ 10uF</td>
<td>102 ~ 106</td>
<td>16VDC ~ 50VDC</td>
<td>(M) +/-20%</td>
</tr>
</tbody>
</table>
## Cross Reference

**Multilayer Ceramic Chip Capacitor Cross Reference:**

<table>
<thead>
<tr>
<th>NIC</th>
<th>AVX</th>
<th>KEMET</th>
<th>JDI</th>
<th>Murata</th>
<th>Panasonic</th>
</tr>
</thead>
<tbody>
<tr>
<td>NMC0402</td>
<td>0402</td>
<td>C0402</td>
<td>R07</td>
<td>GRM36</td>
<td>ECU(Q)</td>
</tr>
<tr>
<td>NMC0603</td>
<td>0603</td>
<td>C0603</td>
<td>R11</td>
<td>GRM39</td>
<td>ECU(V)</td>
</tr>
<tr>
<td>NMC0805</td>
<td>0805</td>
<td>C0805</td>
<td>R15</td>
<td>GRM40</td>
<td>ECV(N)</td>
</tr>
<tr>
<td>NMC1206</td>
<td>1206</td>
<td>C1206</td>
<td>R18</td>
<td>GRM42-6</td>
<td>ECU(M)</td>
</tr>
<tr>
<td>NMC1210</td>
<td>1210</td>
<td>C1210</td>
<td>S41</td>
<td>GRM42-2</td>
<td>ECU(P)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>NIC</th>
<th>Phillips</th>
<th>TDK</th>
<th>Vitramon</th>
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</thead>
<tbody>
<tr>
<td>NMC0402</td>
<td>Cxxxx0402</td>
<td>CC0402</td>
<td>VJ0402</td>
</tr>
<tr>
<td>NMC0603</td>
<td>Cxxxx0603</td>
<td>CC0603</td>
<td>VJ0603</td>
</tr>
<tr>
<td>NMC0805</td>
<td>Cxxxx0805</td>
<td>CC0805</td>
<td>VJ0805</td>
</tr>
<tr>
<td>NMC1206</td>
<td>Cxxxx1206</td>
<td>CC1206</td>
<td>VJ1206</td>
</tr>
<tr>
<td>NMC1210</td>
<td>Cxxxx1210</td>
<td>CC1210</td>
<td>VJ1210</td>
</tr>
</tbody>
</table>
Multilayer Ceramic Capacitors

Packaged on tape for auto insertion

TR

PAPER TAPE

TRPL

PLASTIC TAPE

7 INCH REEL QUANTITIES*

<table>
<thead>
<tr>
<th>Size</th>
<th>0402</th>
<th>0603</th>
<th>0805</th>
<th>1206</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tape Size</td>
<td>8 mm</td>
<td>8 mm</td>
<td>8 mm</td>
<td>8 mm</td>
</tr>
<tr>
<td>Min Qty Per Reel</td>
<td>10,000</td>
<td>10,000</td>
<td>4000</td>
<td>4000</td>
</tr>
<tr>
<td>Max Qty Per Reel</td>
<td>5000</td>
<td>5000</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Qty Dependent on Chip Thickness

Notes:
1. Specifications are in compliance with EIA RS481.1-A
2. "Taping of Surface Mount Components for Automatic Placement"
### Dimensions (Surface Mount)

**NIC NCA Series - Multilayer Ceramic Chip Capacitor Array**

<table>
<thead>
<tr>
<th>English</th>
<th>Metric</th>
<th>Length</th>
<th>Width</th>
</tr>
</thead>
<tbody>
<tr>
<td>1206</td>
<td>3216</td>
<td>3.2mm (0.12&quot;&quot;)</td>
<td>1.6mm (0.06&quot;&quot;)</td>
</tr>
</tbody>
</table>

**PART DIMENSIONS (mm)**

4 CERAMIC CAPACITOR ELEMENTS:
SAME VALUE, TOLERANCE, VOLTAGE RATING AND TC
Part Numbering System

NIC **NCA** Series - Multilayer Ceramic Chip Capacitor Array

**NCA 1206 X7R 104 K 16 TR**

- **Series NCA**
- **Size:** 1206
- **Capacitance Value in pF:** 10pF ~ 0.47μF
  - (3 digit code) First 2 digits are significant. Third digit is number of zeros. 100 = 10pF, 101 = 100pF, 332 = 3300pF, 103 = 10,000pF = 0.01μF
- **Capacitance Value Tolerance:**
  - J = ±5%, K = ±10% and Z = +80%/-20%
- **Voltage Rating (VDC):** 16V, 25V, 50V and 100V
- **Temperature Coefficient:** NPO, X7R and Y5V
- **Tape and Reel**
## Capacitance Range per TC

**NIC NCA Series - Multilayer Ceramic Chip Capacitor Array**

### Temperature Coefficients:

<table>
<thead>
<tr>
<th>TC</th>
<th>Capacitance Range</th>
<th>Capacitance Value Code</th>
<th>Voltage Range</th>
<th>Standard Tolerance</th>
</tr>
</thead>
<tbody>
<tr>
<td>NPO</td>
<td>10pF ~ 1000pF</td>
<td>100 ~ 102</td>
<td>16VDC ~ 100VDC</td>
<td>(J) +/-5%</td>
</tr>
<tr>
<td>X7R</td>
<td>470pF ~ 0.15uF</td>
<td>471~ 154</td>
<td>16VDC ~ 100VDC</td>
<td>(K) +/-10%</td>
</tr>
<tr>
<td>Y5V</td>
<td>0.01uF ~ 0.47uF</td>
<td>103 ~ 474</td>
<td>16VDC ~ 50VDC</td>
<td>(Z) -20%/+80%/-</td>
</tr>
</tbody>
</table>

![Graph showing capacitance range](image)
Cross Reference

**Multilayer** Ceramic Chip Capacitor Array Cross Reference:

- **NIC**: NCA1206
- **AVX**: W3A4
- **KEMET**: C1632
- **Murata**: GNM30-401
- **PHILIPS**: 0612
1. Solder paste is printed onto land patterns.
Assembly (Surface Mount)

2. SMT parts are placed (by automatic pick and place equipment) onto solder paste covered land patterns.
Assembly (Surface Mount)

3. Circuit board is run through a reflow soldering oven. Where the solder paste liquefies, and electrically connects the SMT component terminations to the circuit board land patterns. As the circuit board moves out of heating zone the liquid solder solidifies mechanically fixing the SMT components to the circuit board.
### 1998 CERAMIC CAPACITORS

<table>
<thead>
<tr>
<th>Type</th>
<th>Units (MILLIONS)</th>
<th>Value (USD)</th>
<th>ASP (USD)</th>
<th>Percent Units : Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>MLC</td>
<td>284,000</td>
<td>$2,855,000,000</td>
<td>$0.010</td>
<td>86% : 80%</td>
</tr>
<tr>
<td>SLC</td>
<td>44,000</td>
<td>$702,000,000</td>
<td>$0.016</td>
<td>14% : 20%</td>
</tr>
</tbody>
</table>

### 1998 CERAMIC CAPACITORS (UNIT$)

- **MLC**
  - Units: 284,000
  - Value: $2,855,000,000
  - ASP: $0.010
  - Percent Units: 86%
  - Percent Value: 80%

- **SLC**
  - Units: 44,000
  - Value: $702,000,000
  - ASP: $0.016
  - Percent Units: 14%
  - Percent Value: 20%
 Buzz Words

- **“MLC”** = **Multi-Layer Ceramic** (NMC / NCM / NCMA Series are MLC) “MLCC” = **Multi-Layer Ceramic Chip** = NMC Series
- **“Mono”** = **“Monolithic”**: mono·lith·ic
  Formed from a single structure < relating to a monolithic multi-layer ceramic capacitor > (NMC / NCM / NCMA Series are Monolithic Type)
- **“SLC”** = **Single Layer Ceramic** (NCD Series - Ceramic Disc Capacitor is radial leaded SLC)
- **“SMT”** = **Surface Mount** referring to NMC Series - MLCC
- **“TC” (Temperature Coefficient)**: refers to the capacitor’s change in capacitance value over it’s operating temperature range. EIA TC codes (NPO… X7R… Z5U… etc…)
Buzz Words

- **“PPM”** *(Parts Per Million)*: when relating to TC (temperature coefficient) the amount of capacitance change in parts per million. 30PPM = 0.003% change in capacitance per degree Celsius. (At +125°C capacitance change will be +/-0.3% of +25 °C value)

- **“NPO”** *(also called COG)*: very stable, high Q, EIA class I ceramic dielectric. TC = 0 +/- 30PPM (-55C to +125C).

- **“X7R”**: Good performance, semi-stable, EIA class II ceramic dielectric. Capacitance change from +/-15% max. (-55C to +125C).

- **“Z5U”**: Fair performance, EIA class III ceramic dielectric. Capacitance change from +22% to -56% max. (+10C to +85C).

- **“Y5V”**: Fair performance, EIA class III ceramic dielectric. Capacitance changes from +22% to -82% max. (-30C to +85C).
Buzz Words

- **“DF”**: *(Dissipation Factor)* also referred to as “Loss Tangent” and “Power Factor”, the ratio of the ESR to the reactance (*Xc*) of the capacitor. Expressed in %. The lower the DF the better the part...

- **“ESR”**: *(Equivalent Series Resistance)* in ohms, all internal resistance of a capacitor. The lower the ESR the better the part...

- **“Q”** *(Quality Factor)*: figure of merit relating to material losses within the capacitor. *(Q = Xc/ESR)*. The higher the Q the better the part...

- **“IR”** *(Insulation Resistance)*: the insulating property of the dielectric material. Also called the standoff resistance. The higher the IR the better the part...
Technical Info

Customers may inquire into the following:

SMT Component Taping Specifications:
- All surface mount ceramic chip capacitors are supplied on tape and reel packaging
- Taping is in accordance with EIA-481-1-A guidelines
- Tape will be punched paper tape (“TR” part number suffix) or embossed plastic tape (“TRPLP” part number suffix). Industry trend is to move to paper tape.
- You can find the NMC series taping specifications at the end of the NMC series data sheets in our catalog or at web site page: http://www.niccomp.com/catalog/taping5.pdf
Technical Info

Customers may inquiry into the following:

**Leaded Component Taping Specifications:**

Leaded components are supplied either bulk (bags) or tape and reel/tape and box (ammo pack).

- Taping is in accordance with EIA-468-B (Radial) or EIA-296-E (Axial) guidelines.


For NCM Series specs please contact NIC’s TPMG
Technical Info

Customers may inquiry into the following:

**Soldering Land Patterns or Pads** (SMT styles, NMC series):

If the customer is looking for these, they are seeking the recommended land pattern dimensions.

These can be found on the application note section in the rear of our catalog or from web site location: [http://www.niccomp.com/pi/nmclnd.pdf](http://www.niccomp.com/pi/nmclnd.pdf)