



Passive Components: Capacitors & Resistors

**Passive
Components
account for:**

**80% of BOM Count
60% of PCB Area
20% of BOM Cost**



Embedded System Design 8-2003

Topics:

General

Thru-Hole & SMT Assembly ...pages 3 ~ 6

Products

Capacitors ...pages 7 ~ 36

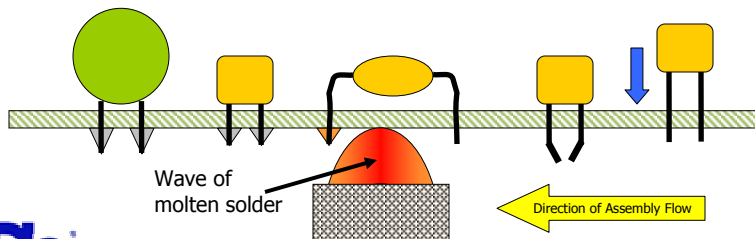
Resistors ...pages 37 ~ 47

- Types – Markets – Characteristics
- Substitution Guidelines
- Appearance – Sizes – Marking



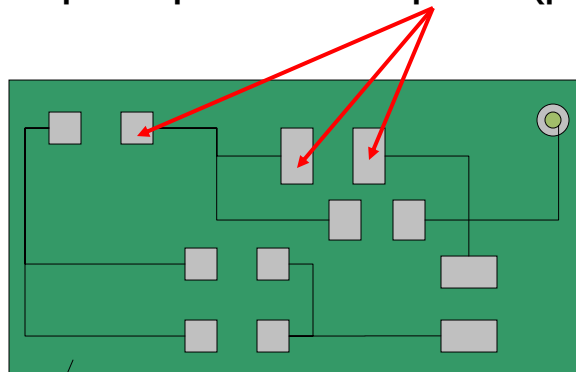
Thru-Hole Assembly

1. Leaded parts are inserted into holes in circuit board
2. Leads are clinched and cut.
3. Molten wave of solder connects leads to board.



Surface Mount (SMT) Assembly

1. Solder paste is printed onto land patterns (pads).

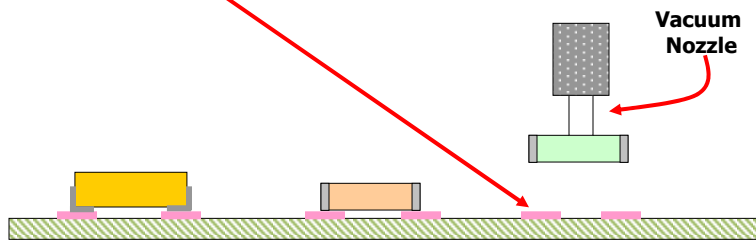




Surface Mount (SMT) Assembly

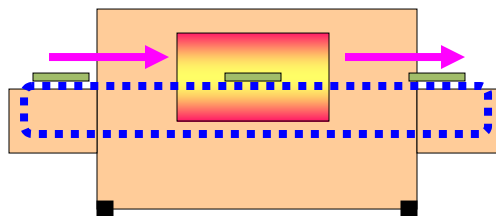


2. SMT parts are placed (by automatic pick and place equipment) onto solder paste covered land patterns.

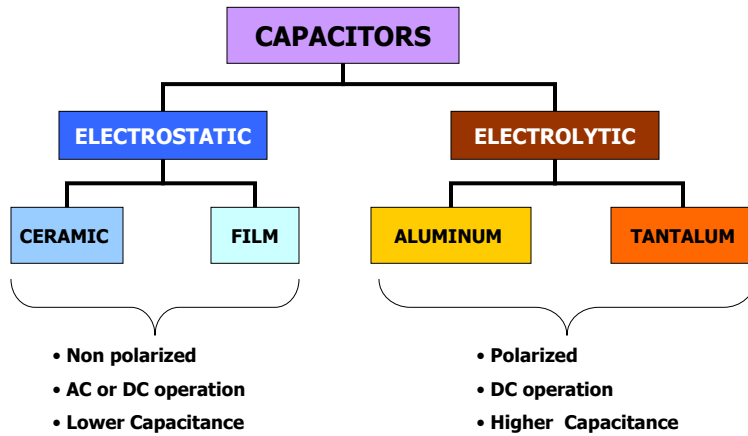


Surface Mount (SMT) Assembly

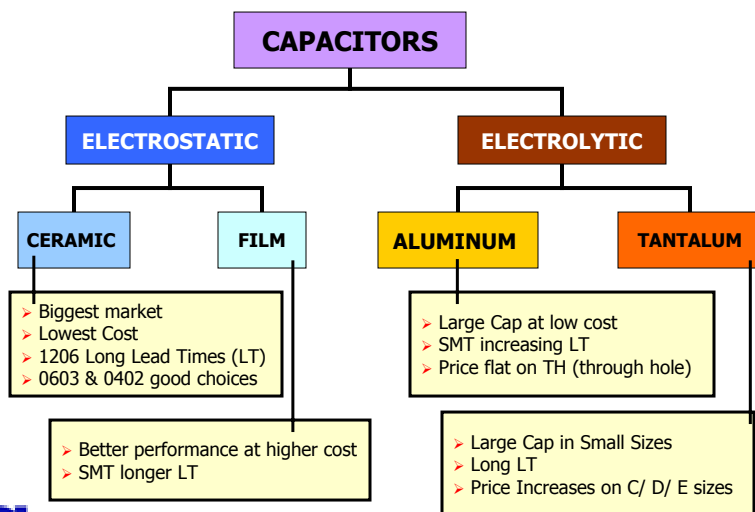
3. Circuit board is run through a reflow soldering oven. Where the solder paste liquefies, and electrically connects the SMT component terminations to the circuit board land patterns. As the circuit board moves out of heating zone the liquid solder solidifies mechanically fixing the SMT components to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



Capacitor Family Tree

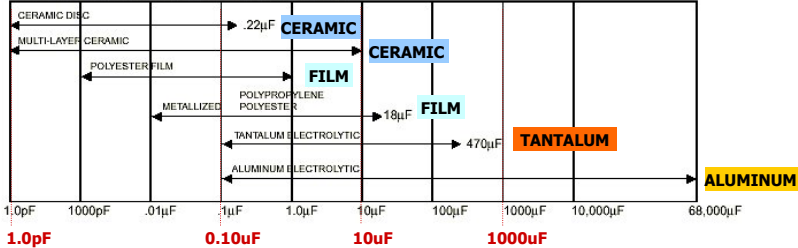


Markets



Capacitance Values

EFFECTIVE CAPACITANCE RANGE BY DIELECTRIC*



ALUMINUM } $\mu\text{F} = \text{micro-Farad} = 1 \times 10^{-6} \text{ F} = 1 \text{ millionth of a Farad}$

$\text{nF} = \text{Nano-Farad} = 1 \times 10^{-9} \text{ F} = 1 \text{ billionth of a Farad}$

TANTALUM
CERAMIC
FILM } $\text{pF} = \text{Pico-Farad} = 1 \times 10^{-12} \text{ F} = 1 \text{ trillionth of a Farad}$



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Capacitance Values – EIA Codes

3 digit code
(pF)

TANTALUM
CERAMIC
FILM

EIA Code	Pico-Farad (pF)	Nano-Farad (nF)	Micro-Farad (µF)
1 R 5	1.5	0.0015	
2 R 2	2.2	0.0022	
3 R 3	3.3	0.0033	
4 R 7	4.7	0.0047	
6 R 8	6.8	0.0068	
1 0 0	10	0.01	
1 5 0	15	0.015	
2 2 0	22	0.022	
2 5 0	25	0.025	
3 3 0	33	0.033	
3 9 0	39	0.039	
4 7 0	47	0.047	
5 6 0	56	0.056	
6 8 0	68	0.068	
7 5 0	75	0.075	
8 2 0	82	0.082	
1 0 1	100	0.1	0.0001
1 2 1	120	0.12	0.00012
1 5 1	150	0.15	0.00015
1 8 1	180	0.18	0.00018
2 0 1	200	0.2	0.0002
2 2 1	220	0.22	0.00022
2 7 1	270	0.27	0.00027
3 0 1	300	0.3	0.0003
3 3 1	330	0.33	0.00033
3 9 1	390	0.39	0.00039
4 7 1	470	0.47	0.00047
5 1 1	510	0.51	0.00051
5 6 1	560	0.56	0.00056
6 8 1	680	0.68	0.00068
7 5 1	750	0.75	0.00075
8 2 1	820	0.82	0.00082
1 0 2	1 000	1	0.001

3 digit code
"R" represents decimal point
4R7 = 4.7pF

3 digit code
First 2 digits are significant.
Third digit is number of zeros.
101 = 100pF



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Capacitance Values – EIA Codes

3 digit code
(pF)
TANTALUM
CERAMIC
FILM

EIA Code	Pico-Farad (pF)	Nano-Farad (nF)	Micro-Farad (uF)
1 2 2	1 200	1.2	0.0012
1 5 2	1 500	1.5	0.0015
2 0 2	2 000	2	0.002
2 2 2	2 200	2.2	0.0022
2 7 2	2 700	2.7	0.0027
3 0 2	3 000	3	0.003
3 3 2	3 300	3.3	0.0033
3 9 2	3 900	3.9	0.0039
4 7 2	4 700	4.7	0.0047
5 6 2	5 600	5.6	0.0056
6 8 2	6 800	6.8	0.0068
8 2 2	8 200	8.2	0.0082
1 0 3	10 000	10	0.01
1 2 3	12 000	12	0.012
1 5 3	15 000	15	0.015
1 8 3	18 000	18	0.018
2 2 3	22 000	22	0.022
3 3 3	33 000	33	0.033
4 7 3	47 000	47	0.047
5 6 3	56 000	56	0.056
6 8 3	68 000	68	0.068
8 2 3	82 000	82	0.082
1 0 4	100 000	100	0.10
1 2 4	120 000	120	0.12
1 5 4	150 000	150	0.15
2 2 4	220 000	220	0.22
3 3 4	330 000	330	0.33
4 7 4	470 000	470	0.47
5 6 4	560 000	560	0.56
1 0 5	1 000 000	1000	1.0
2 2 5	2 200 000	2200	2.2
3 3 5	3 300 000	3300	3.3
4 7 5	4 700 000	4700	4.7
6 8 5	6 800 000	6800	6.8
1 0 6	10 000 000	10 000	10
2 2 6	22 000 000	22 000	22

103 = 10,000pF
103 = 10nF
103 = 0.01uF
104 = 100,000pF
104 = 100nF
104 = 0.1uF
106 = 10,000,000pF
106 = 10,000nF
106 = 10uF



Capacitance Values – EIA Codes

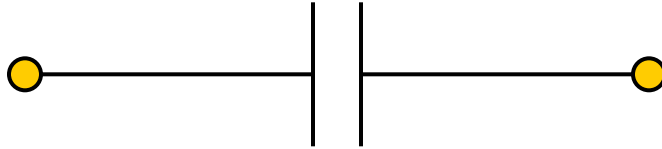
3 digit code
(uF)
ALUMINUM

EIA Code	Pico-Farad (pF)	Nano-Farad (nF)	Micro-Farad (uF)
R10	100,000	100	0.1
R22	220,000	220	0.22
R33	330,000	330	0.33
R47	470,000	470	0.47
1R0	1,000,000	1 000	1
2R2	2,200,000	2 200	2.2
3R3	3,300,000	3 300	3.3
4R7	4,700,000	4 700	4.7
100	10,000,000	10 000	10
220	22,000,000	22 000	22
330	33,000,000	33,000	33
470	47,000,000	47,000	47
101	100,000,000	100,000	100
221			220
331			330
471			470
102			1000
222			2200
332			3300
472			4700
103			10,000
223			22,000
333			33,000
473			47,000

3 digit code
"R" represents decimal point
R33 = 0.33uF
3 digit code
First 2 digits are significant.
Third digit is number of zeros
471 = 470uF



Capacitance Values



Standard Capacitance Values:

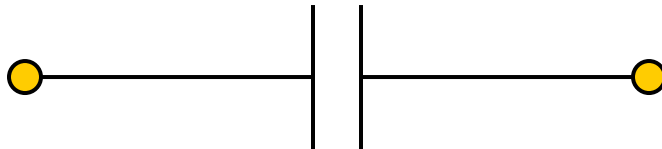
Electrolytic Capacitors: Aluminum & Tantalum

10 22 33 47

Examples:

**0.1, 0.22, 0.33, 0.47... 1.0, 2.2, 3.3, 4.7. 10, 22, 33, 47...
100, 220, 330 ...**

Capacitance Values



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

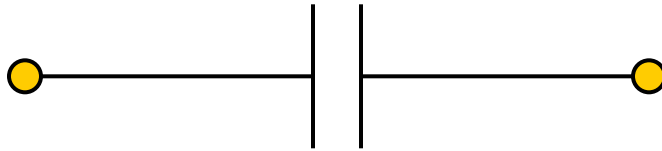
Electrostatics: Ceramic & Film

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,... 560K, 680K, 820K,... 1uF, 2.2uF, 4.7uF,...**

Capacitance Values

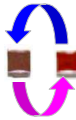


Standard Capacitance Values: (PER EIA-575 & RS 460)

Electrostatics: Ceramic & Film

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



Component Characteristics Substitution Guide: **Capacitors**

» **Capacitance Value Substitution**

In many cases increasing to higher capacitance value is acceptable

i.e... 2200uF part can be considered for use in place of 1500uF part

i.e... 3.3uF part can be considered for use in place of 2.2uF part

i.e... 0.22uF part can be considered for use in place of 0.1uF part

Tolerance

Capacitance Tolerance :

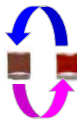
The allowable window - limits that the capacitors' +25°C (room temperature) capacitance value will be within.

1 digit code

CAPACITANCE TOLERANCE CODES			
Code	Tol.	Code	Tol.
A	± 0.05pF	M	± 20%
B	± 0.1pF	N	± 30%
C	± 0.25pF	P	-0~+100%
D	± 0.5pF	Q	-10~+30%
E	± 0.5%	S	± 22%
F	± 1.0%	T	-10~+50%
G	± 2.0%	U	-10~+75%
H	± 2.5%	W	-10~+100%
J	± 5.0%	Y	-20~+5%
K	± 10%	Z	-20~+80%
L	± 15%		

CERAMIC (points to A, B, C, D, E, F, G, H, J, K, L)
 CERAMIC FILM (points to F, G, H, J, K, L)
 TANTALUM (points to J, K, L)
 CERAMIC FILM (points to F, G, H, J, K, L)
 ALUMINUM (points to M, N, P, Q, S, T, U, W, Y, Z)
 CERAMIC (points to M, N, P, Q, S, T, U, W, Y, Z)

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Component Characteristics Substitution Guide: Capacitors

» 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

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Voltage Rating

Voltage Rating

The maximum VDC that can be applied to the capacitor

Range of Voltage Ratings: 2.0VDC ~ 15,000VDC

2 digit code

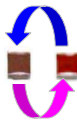
CODE	VDC
0G	4.0
0J	6.3
1A	10
1C	16
1E	25
1V	35
1H	50
1J	63
2A	100
2D	200
2E	250
2V	350
2G	400
2W	450

Component Derating/Safety Factor

Components should not be operated at their maximum ratings. Components should be derated in designs, such that component maximum ratings are not approached or exceeded. The amount of derating to apply depends on the circuit and operating environment. As a general rule of thumb, derate components by 50%. For example, a decoupling capacitor used on a 5V bus should have a voltage rating of at least 10V.



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Component Characteristics Substitution Guide: **Capacitors**

» Capacitance 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.



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TC Characteristic

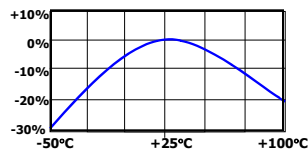
Each Capacitor will have a temperature coefficient (TC). TC is a measure of how the capacitance value behaves over temperature.

All parts are supplied to be within tolerance at room temperature (+25°C = +77°F)

Aluminum Electrolytic styles have TC of $\pm 20\%$ over -40°C to +105°C

Tantalum Electrolytic styles have TC of $\pm 5\%$ over -55°C to +85°C

Film styles have TC of $\pm 7\%$ over -40°C to +105°C



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 (*Electronic 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

TC Characteristic



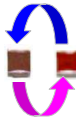
Standard Temperature Coefficients (TC) of ceramic capacitors:

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

X7R = ±15% ΔC over -55°C ~ + 125°C



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Component Characteristics Substitution Guide: Capacitors

» Temperature Coefficient Substitution

“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.

NPO... X7R... X5F... X5P... X5R... XRS... X5T... Y5U... Y5V... Z5U... Z5V...

MOST STABLE

LEAST STABLE



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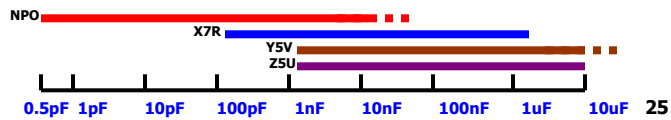
Capacitance Range per TC



Multilayer Ceramic Chip Capacitor

Temperature Coefficients:

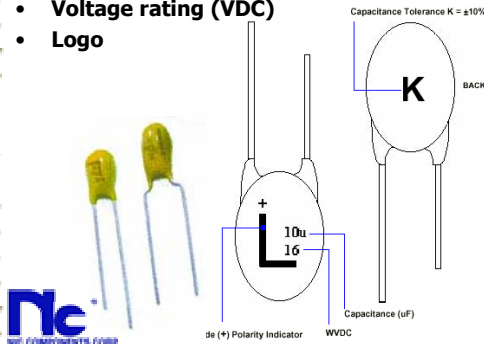
TC	Capacitance Range	Capacitance Value Code	Voltage Range	Standard Tolerance
NPO	0.5pF ~ 0.056uF	0R5 ~ 563	25VDC ~ 1KVDC	(J) +/-5%
X7R	100pF ~ 2.2uF	101~ 225	16VDC ~ 1000VDC	(K) +/-10%
Y5V	1000pF ~ 10uF	102 ~ 106	16VDC ~ 50VDC	(Z) -20%/+80%
Z5U	1000pF ~ 10uF	102 ~ 106	16VDC ~ 50VDC	(M) +/-20%



Appearance

Radial Leaded Electrolytic Capacitors

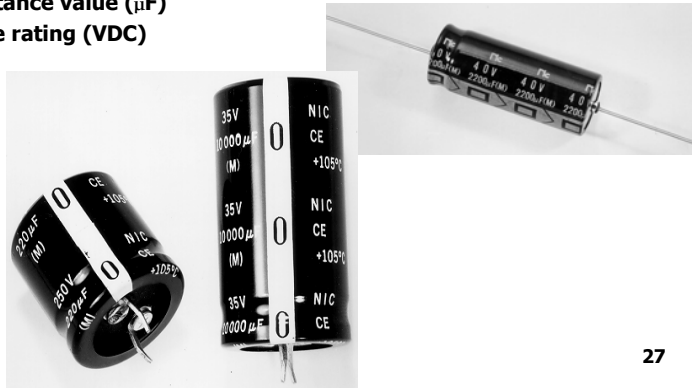
- Cathode lead (-) shorter than anode (+)
- Cathode polarity band or anode strip
- Date code (YYWW) "9614" = 14th week of 1996
- Temperature rating
- Capacitance value (μ F)
- Voltage rating (VDC)
- Logo



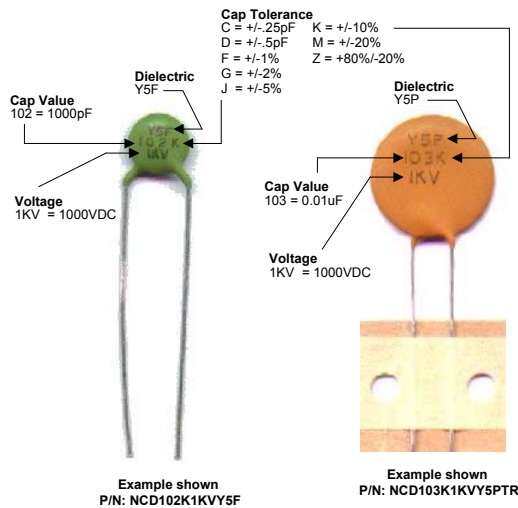
Appearance

Axial & Snap-In Leaded Electrolytic Capacitors

- Cathode polarity band
- Date code (YYWW) "9614" = 14th week of 1996
- Temperature rating
- Capacitance value (μF)
- Voltage rating (VDC)
- Logo

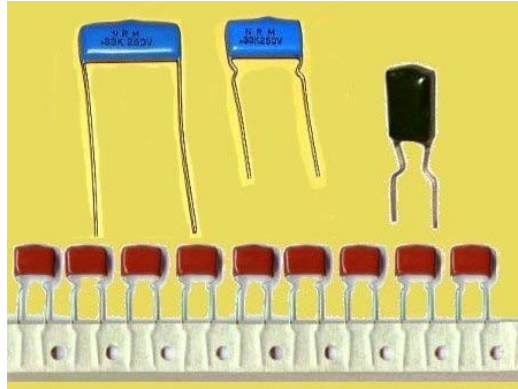


Ceramic Disc Capacitor (Radial)



Film Capacitor (Radial Leaded)

- Capacitance value (pF) & Tolerance Code
- Voltage rating (VDC)



Appearance

SMT Electrolytic Capacitors

- Cathode (-) & Anode (+) markers
- Capacitance value (μF)
- Voltage rating (VDC)
- Date Code

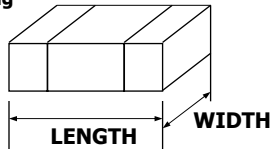


Dimensions (Surface Mount)



English	Metric	Length	Width
0201	0603	0.6mm (0.02")	0.3mm (0.01")
0402	1005	1.0mm (0.04")	0.5mm (0.02")
0603	1608	1.6mm (0.06")	0.8mm (0.03")
0805	2012	2.0mm (0.08")	1.2mm (0.05")
1206	3216	3.2mm (0.12")	1.6mm (0.06")
1210	3225	3.2mm (0.12")	2.5mm (0.10")
1812	4532	4.5mm (0.18")	3.2mm (0.12")
2225	5764	5.7mm (0.22")	6.4mm (0.25")

No Component Marking

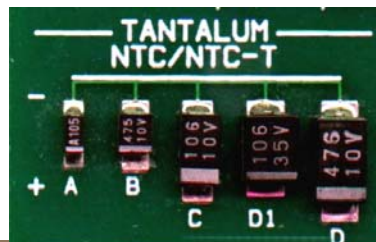


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Surface Mount Tantalum Electrolytic Capacitors

Case Code	Metric	English	Length	Width
P	2012	0805	2.0mm (0.08")	1.2mm (0.05")
A, A2	3216	1206	3.2mm (0.12")	1.6mm (0.06")
B, B2	3528	1411	3.5mm (0.14")	2.8mm (0.11")
C	6032	2412	6.0mm (0.24")	3.2mm(0.12")
D1*	5846	2318	5.8mm (0.23")	4.6mm(0.18")
D, E	7343	2917	7.3mm (0.29")	4.3mm (0.17")

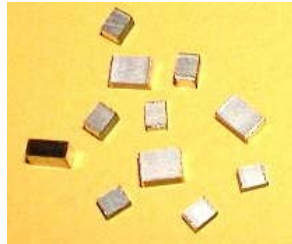
* - D1 is Japanese size



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Surface Mount Film Chip Capacitors

English	Metric	Length	Width
0805	2012	2.0mm (0.08")	1.2mm (0.05")
1206	3216	3.2mm (0.12")	1.6mm (0.06")
1210	3225	3.2mm (0.12")	2.5mm (0.10")
1913	4833	4.8mm (0.19")	3.3mm (0.13")
2416	6041	6.0mm (0.24")	4.1mm (0.16")



No Component Marking

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Reel Labeling

Part Number, Product Lot Number and Date Code identified on product reel labels provides trace-ability to production

CERAMIC CHIP CAPACITORS	
CODE NO.	
P. NO.	NMC0603NF010J100TRP
DESC.	100P +/-5% 100J
SIZE.	0603
QTY.	4000 D/C 0214
LOT NO.	0002F01596

NIC COMPONENTS CORP. Taiwan

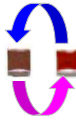
FILM CAPACITORS	
P/N:	N5PC6R23501001
DESC:	6000PF 50 V +/-5%
QTY:	3,000
PART NO:	500013029
LOT NO:	092L 072 9

Nippon Industries Co., Ltd. **Nic**

0805	±1%	1.50KΩ
(P) SUPPLIER PROD ID: NRC10F1501TR		
1501 F		
(Q) QUANTITY: 5000		
(D) DATE CODE: 0008		
0008712		

Nippon Industries Co., Ltd. **Nic**

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Component Characteristics Substitution Guide: Capacitors

» Component Size: (Radial Leaded Styles)



Substitution Rule: In many cases a smaller size component may be acceptable... if lead spacing is same (see page 1) and electrical specifications differences are acceptable (see this page)

i.e... a smaller diameter size **taped** part could be considered to replace a larger diameter size **taped** part
i.e... 5mm, 7mm or 9mm height size could be considered to replace a larger 7, 9 or 11mm height size
i.e... 10mm diameter size could be considered to replace a 12mm diameter size (same LS = 5.0mm)

» Temperature Rating : (Electrolytic Capacitors)



Substitution Rule: A component with a **higher (better) temperature rating** can replace a **lower temperature rated component**.

i.e...an +125°C rated part can replace a +105°C or +85°C part (NACT replaces NACEW / NACZ / NACE)
i.e...an +105°C rated part can replace a +85°C (NRWA or NRSZ replaces NRSA / NRSS NACEW / NACZ replaces NACE)



Component Characteristics Substitution Guide: Capacitors

» Dissipation Factor (DF) :



Substitution Rule: A component with a **lower DF (%)** can replace a **higher DF (%)** component.

i.e... NPO part can replace X7R or Z5U / Y5V part
i.e... X7R part can replace Z5U / Y5V part
i.e... NACZ series can replace NACE
i.e... NRSA series can replace NRSS

» Equivalent Series Resistance (ESR) & Impedance (Z):



Substitution Rule: A component with a **lower ESR or Z (ohm)** can replace a **higher ESR or Z (ohm)** component.

i.e... NTP series part can replace NTC series part
i.e... NACZ & NACZF series can replace NACEW or NACE
i.e... NRSX series can replace NRSZ or NRSY

» Ripple Current Rating:



Substitution Rule: A component with a **higher ripple current rating (mArms)** can replace a **lower ripple current rated component**.

i.e... NTP series part can replace NTC series part
i.e... NACZ & NACZF series can replace NACEW or NACE
i.e... NRSX series can replace NRSZ or NRSY

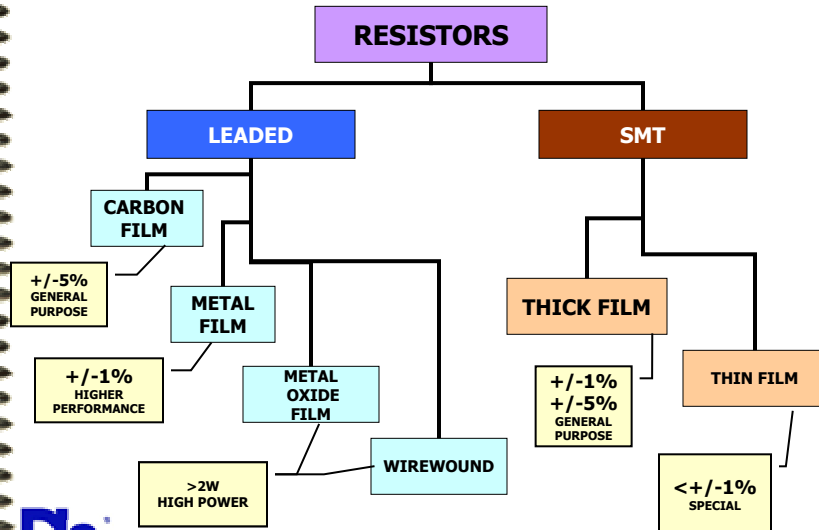
» Leakage Current Rating: (Electrolytic Capacitors)



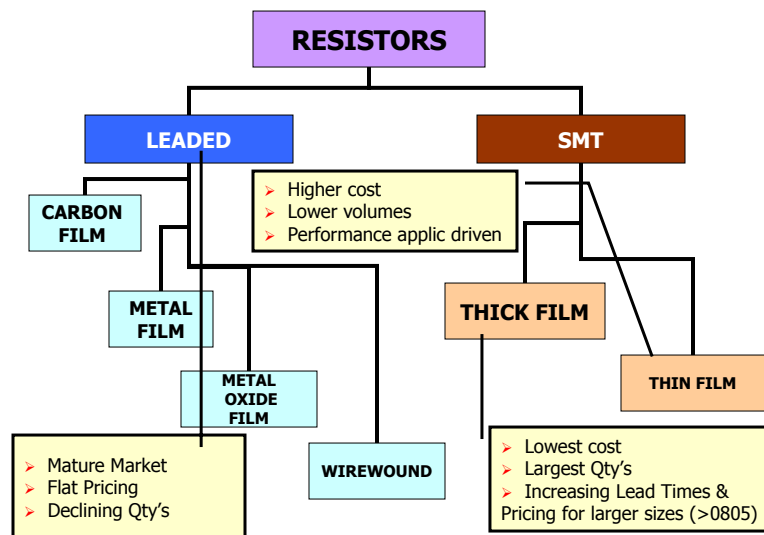
Substitution Rule: A component with a **lower leakage current rating (uA)** can replace a **higher leakage current rated component**.

i.e... NACL series part can replace NACE series part
i.e... NLE-L series can replace NRSA or NRSS

Resistor Family Tree



Resistor Family Tree



Resistor Characteristics

RESISTANCE VALUE

Resistance is expressed in *ohms* (Ω). Typical resistance values are industry standard (E24 & E96) values from 1.0 ohm to 10 Meg-ohms (10,000,000 ohm = 10MegOhm)

Ohm = Ω
1000 = K
1 Million = M
1ohm = 0.001 K
10 ohm = 0.01 K
100 ohm = 0.1K
1000 ohm = 1.0K
10,000 ohm = 10K
100,000 ohm = 100K = 0.1M
1,000,000 ohm = 1000K = 1M

Component Characteristics: "E24" Resistance Values

E24 Values
common to +/-5% tolerance

10	22	47
11	24	51
12	27	56
13	30	62
15	33	68
16	36	75
18	39	82
20	43	91

E96 Values
common to +/-1% tolerance

10.0	14.7	21.5	31.6	46.4	68.1
10.2	15.0	22.1	32.4	47.5	69.8
10.5	15.4	22.6	33.2	48.7	71.5
10.7	15.8	23.2	34.0	49.9	73.2
11.0	16.2	23.7	34.8	51.1	75.0
11.3	16.5	24.3	35.7	52.3	76.8
11.5	16.9	24.9	36.5	53.6	78.7
11.8	17.4	25.5	37.4	54.9	80.6
12.1	17.8	26.1	38.3	56.2	82.5
12.4	18.2	26.7	39.2	57.6	84.5
12.7	18.7	27.4	40.2	59.0	86.6
13.0	19.1	28.0	41.2	60.4	88.7
13.3	19.6	28.7	42.2	61.9	90.9
13.7	20.0	29.4	43.2	63.4	93.1
14.0	20.5	30.1	44.2	64.9	95.3
14.3	21.0	30.9	45.3	66.5	97.6

Component Characteristics Substitution Guide: **Resistors**

» Resistance Value: (ohm)

**Substitution Rule:**

- CASE 1: **Standard Values** [E24](#) & [E96](#): In most cases you cannot change to different resistance value
 CASE 2: **Non-Standard Values**: Offer closest standard [E24](#) & [E96](#) values

» Resistance Tolerance: (%)

**Substitution Rule:** A component with a tighter (better) tolerance can replace a looser tolerance component

- i.e... ±1%(F) tolerance part can replace ±2%(G), ±5%(J) or ±10% (K) tolerance part
 i.e... ±5%(J) tolerance part can replace ± 10%(K) tolerance part

» Power Rating: (Watt)

**Substitution Rule:** A component with a higher power rating can replace a lower power rated component

- i.e... 1/16W rating can replace 1/32W rating
 i.e... 1/8W rating can replace 1/16W & 1/32W ratings
 i.e... 1/4W rating can replace 1/8W, 1/16W & 1/32W ratings
 i.e... 1/2W rating can replace 1/4W, 1/8W, 1/16W & 1/32W ratings
 i.e... 1W rating can replace 1/2W, 1/4W, 1/8W, 1/16W & 1/32W ratings

Component Characteristics Substitution Guide: Resistors

» Temperature Coefficient of Resistance Value (TCR):



Substitution Rule: A component with **better (tighter) TCR** can replace component with **broader (wider) TCR**

- i.e... +/-50PPM TCR can replace +/-100PPM, +/-200PPM and +/-350PPM TCR
- i.e... +/-100PPM TCR can replace +/-200PPM and +/-350PPM TCR
- i.e... +/-200PPM TCR can replace +/-350PPM TCR

» Component Size (D x L): Axial Leded Styles



Substitution Rule: A **smaller** size component, with comparable ratings, **can replace a larger size component**

- i.e... NCF25R can replace NCF25
- i.e... NCF50R can replace NCF50
- i.e... NMO100S can replace NMO100
- i.e... NMO200S can replace NMO200
- i.e... NMO300S can replace NMO300



Leaded Types

Axial Leaded Styles



Carbon Film



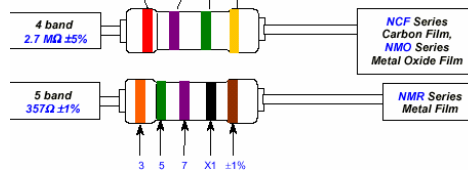
Metal Film



Metal Oxide

Resistor Color Coding Chart

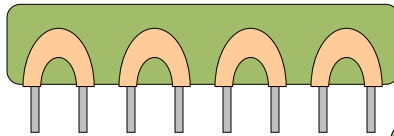
Color	Significant Figure			Multiplier	Tolerance
	1 st	2 nd	3 rd		
Black	0	0	0	1	-
Brown	1	1	1	10	F (±1%)
Red	2	2	2	100	G (±2%)
Orange	3	3	3	1,000	-
Yellow	4	4	4	10,000	-
Green	5	5	5	100,000	D (±0.5%)
Blue	6	6	6	1,000,000	C (±0.25%)
Violet	7	7	7	10,000,000	B (±0.1%)
Grey	8	8	8	-	-
White	9	9	9	-	-
Gold	-	-	-	0.1	J (±5%)
Silver	-	-	-	0.01	K (±10%)



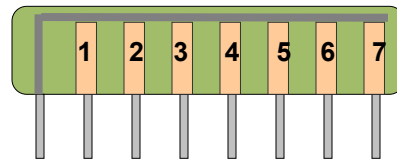
Leaded Types



Single In-Line Package ("SIP")
in 4 pin to 13 pin package



Isolated



Common / Bussed

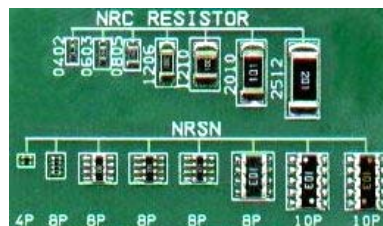
45



SMT Types

English	Metric	Length	Width
0201	0502	0.5mm (0.02")	0.25mm (0.01")
0402	1005	1.0mm (0.04")	0.5mm (0.02")
0603	1608	1.6mm (0.06")	0.8mm (0.03")
0805	2012	2.0mm (0.08")	1.2mm (0.05")
1206	3216	3.2mm (0.12")	1.6mm (0.06")
1210	3225	3.2mm (0.12")	2.5mm (0.10")
1812	4532	4.5mm (0.18")	3.2mm (0.12")
2225	5764	5.7mm (0.22")	6.4mm (0.25")

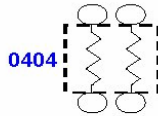
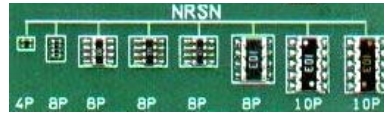
Thick Film Chips



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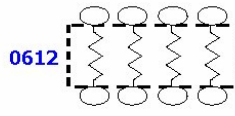
SMT Types

Thick Film Arrays



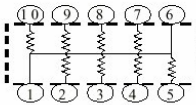
0404

Circuit Type "I"
Isolated



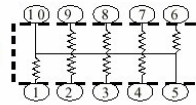
0612

Circuit Type "I"
Isolated



1225

Circuit Type "C"
Bussed/Common



Circuit Type "D"
Bussed/Common



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Summary & Recommendations

- NPO (a.k.a. C0G) capacitors are the most stable, and are often used for oscillator circuits.
- C0G, X7R, X5R, Y5V, and Z5U are the most common types.
- ESR and ESL can limit capacitor performance at high frequencies. Typically choose low ESR for critical decoupling.
- For prototyping on perf board, use leaded (through-hole) components. SMT can be used to a limited extent.
- If designing a PCB with SMT components and planning to assemble your PCB by hand, use larger SMT packages. 1206 and 0805 are relatively easy to handle. 0603 is manageable with practice. 0402 and 0201 are very difficult.
- An 0805 component can fit on 1206 pads.
- An 0603 component can fit on 0805 pads.
- Derate components to increase component life.

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