High Voltage Conformal Coated Leaded Capacitors

TCF Series

FEATURES

- Multilayer chip ceramic capacitors
- NPO, C4xx and X7R dielectrics
- Capacitance range: 10 pF to 39 μF
- Voltage range: 200 V_{DC} to 10,000 V_{DC}

PHYSICAL CHARACTERISTICS

CONSTRUCTION

Epoxy conformal coated radial leaded capacitors suited to through-hole circuits.

MARKING

Series, capacitance value, tolerance, rated voltage, date code.

ELECTRICAL SPECIFICATIONS

According to

DIELECTRIC	NPO	C4xx	X7R
Dielectric code	**1**	**4**	**2**
Maximum $\Delta C/°C$ over temperature range without voltage	NA	NA	±15%
Temperature coefficient	(0±30) ppm/°C	(−2,200±500) ppm/°C	NA
Aging	None	None	≤2.5% per decade hour
Operating temperature	−55°C to +125°C		
Rated voltage (U_{RC})	200 V_{DC} to 10,000 V_{DC}	200 V_{DC} to 5,000 V_{DC}	200 V_{DC} to 10,000 V_{DC}
Dielectric withstanding voltage	2.5 U_{RC} for $U_{RC} \leq 500$ V_{DC} 1.6 U_{RC} for $U_{RC} \geq 1{,}000$ V_{DC} **Extended range:** 2 U_{RC} for $U_{RC} \leq 500$ V_{DC} 1.3 U_{RC} for $U_{RC} \geq 1{,}000$ V_{DC}	2.5 U_{RC} for $U_{RC} = 200$ V_{DC} 2 U_{RC} for $U_{RC} = 500$ V_{DC} 1.5 U_{RC} for $U_{RC} = 1{,}000$ V_{DC} 1.4 U_{RC} for $U_{RC} > 1{,}000$ V_{DC} **Extended range:** 1.5 U_{RC} for $U_{RC} \leq 500$ V_{DC} 1.2 U_{RC} for $U_{RC} \geq 1{,}000$ V_{DC}	2.5 U_{RC} for $U_{RC} = 200$ V_{DC} 2 U_{RC} for $U_{RC} = 500$ V_{DC} 1.5 U_{RC} for $U_{RC} = 1{,}000$ V_{DC} 1.2 U_{RC} for $U_{RC} > 1{,}000$ V_{DC} **Extended range:** 1.5 U_{RC} for $U_{RC} \leq 500$ V_{DC} 1.2 U_{RC} for $U_{RC} \geq 1{,}000$ V_{DC}
Capacitance	@ 1 MHz for C ≤ 1,000 pF @ 1 kHz for C > 1,000 pF	@ 1 kHz	@ 1 kHz
Dissipation factor	≤0.015 (150/C + 7)% @ 1 MHz for C ≤ 50 pF ≤0.15% @ 1 MHz for 50 pF < C ≤ 1,000 pF ≤0.15% @ 1 kHz for C > 1,000 pF	≤0.10% @ 1 kHz	≤2.5% @ 1 kHz
Insulation resistance @ 25°C **under U_{RC} for $U_{RC} \leq 500$ V** **under 500 V_{DC} for $U_{RC} > 500$ V**	≥100,000 MΩ for C ≤ 10 nF ≥1,000 MΩ.μF for C > 10 nF	≥20,000 MΩ for C ≤ 25 nF ≥500 MΩ.μF for C > 25 nF	
Voltage proof body insulation	under U_{RC} for $U_{RC} \leq 1{,}250$ V_{DC} under 1,300 V_{DC} for $U_{RC} > 1{,}250$ V_{DC}		

HIGH VOLTAGE

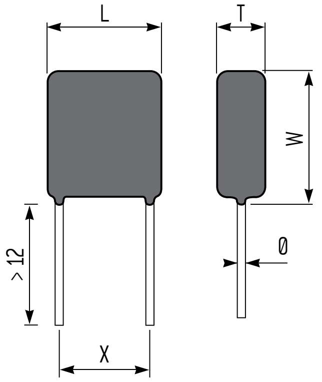
HOW TO ORDER

TCF	1	82	W	F	680pF	10%	4,000 V	B
Series	Dielectric code	Exxelia size code	RoHS compliant	Quality level	Capacitance	Tolerance	Rated voltage	Reliability level
TCF = Conformal coated radial leaded capacitor	**1** = NPO **2** = X7R **4** = C4xx	**79** **90** **80** **91** **81** **82** **83** **84** **89** **85** **87** **88**	**-** = No RoHS **W** = RoHS compliant	**-** = standard quality level **F** = Hi-Rel quality: screening in accordance with Exxelia specification	Capacitance value in clear	NPO dielectric: **±1%** **±2%** **±5%** **±10%** **±20%** C4xx dielectric: **±2%** **±5%** **±10%** **±20%** X7R dielectric: **±10%** **±20%**	**200 V** **500 V** **1,000 V** **1,500 V** **2,000 V** **3,000 V** **4,000 V** **5,000 V** **7,500 V** **10,000 V** Intermediary and higher voltages available: contact your sales representative.	For F parts only. Acc. to Exxelia spec. **-** **T5** **T6** See page XX

TCF Series

High Voltage Conformal Coated Leaded Capacitors

DIMENSIONS in inches (mm)



STANDARD RATINGS

	Exxelia size code	78		79			90			80			91			81			82		
Dimensions inches (mm)	L max.	0.249 (6.3)		0.256 (6.5)			0.256 (6.5)			0.315 (8)			0.319 (8.1)			0.394 (10)			0.414 (10.5)		
	W max.	0.229 (5.8)		0.237 (6)			0.355 (9)			0.355 (9)			0.355 (9)			0.355 (9)			0.453 (11.5)		
	T max.*	0.205 (5.2)		0.197 (5)			0.197 (5)			0.197 (5)			0.2kV up to 3kV: 0.237 (6) 4kV-5kV: 0.276 (7)			0.2kV up to 3kV: 0.237 (6) 4kV: 0.276 (7) 5kV: 0.315 (8)			0.2kV up to 3kV: 0.237 (6) 4kV: 0.276 (7) 5kV: 0.315 (8)		
	Ø ± 10%	0.024 (0.6)		0.024 (0.6)			0.024 (0.6)			0.024 (0.6)			0.024 (0.6)			0.031 (0.8)			0.031 (0.8)		
	X	0.2 ± 0.02 (5.08 ± 0.5)		0.2 ± 0.012 (5.08 ± 0.3)			0.2 ± 0.012 (5.08 ± 0.3)			0.2 ± 0.012 (5.08 ± 0.3)			0.2 ± 0.012 (5.08 ± 0.3)			0.3 ± 0.012 (7.62 ± 0.3)			0.4 ± 0.012 (10.16 ± 0.3)		
Dielectric		**NPO**	**X7R**	**NPO**	**C4xx**	**X7R**	**NPO**	**C4xx**	**X7R**	**NPO**	**C4xx**	**X7R**	**NPO**	**C4xx**	**X7R**	**NPO**	**C4xx**	**X7R**	**NPO**	**C4xx**	**X7R**
Exxelia ceramic code		1	2	1	4	2	1	4	2	1	4	2	1	4	2	1	4	2	1	4	2
Min. Capacitance value		12pF	120pF	10pF	27pF	100pF	10pF	33pF	150pF	10pF	33pF	150pF	15pF	47pF	150pF	18pF	56pF	150pF	33pF	82pF	330pF
Rated voltage (U_{RC}) 0.2kV	Standard	-	-	5.6nF	120nF	220nF	12nF	220nF	470nF	12nF	220nF	390nF	15nF	330nF	560nF	18nF	390nF	820nF	33nF	680nF	1.5µF
	Extended	-	-	18nF	-	470nF	27nF	-	-	22nF	-	1µF	39nF	-	-	56nF	-	1.8µF	100nF	-	2.7µF
0.5kV	Standard	-	-	3.3nF	22nF	47nF	6.8nF	47nF	100nF	5.6nF	47nF	100nF	6.8nF	68nF	150nF	8.2nF	82nF	220nF	22nF	120nF	390nF
	Extended	-	-	10nF	39nF	150nF	18nF	68nF	-	18nF	68nF	270nF	22nF	100nF	-	27nF	120nF	560nF	68nF	220nF	1µF
1kV	Standard	-	-	1.8nF	6.8nF	15nF	2.7nF	12nF	24nF	2.2nF	12nF	22nF	3.3nF	18nF	33nF	3.9nF	22nF	47nF	10nF	39nF	68nF
	Extended	820pF	12nF	5.6nF	10nF	27nF	8.2nF	15nF	-	6.8nF	15nF	56nF	10nF	22nF	-	12nF	27nF	120nF	33nF	56nF	220nF
1.5kV	Standard	-	-	820pF	2.7nF	5.6nF	1.2nF	5.6nF	10nF	1.5nF	5.6nF	10nF	2.2nF	8.2nF	15nF	2.7nF	10nF	18nF	4.7nF	18nF	33nF
	Extended	-	-	1.5nF	3.9nF	12nF	2.2nF	8.2nF	-	2.2nF	6.8nF	22nF	3.3nF	12nF	-	4.7nF	15nF	47nF	8.2nF	27nF	82nF
2kV	Standard	-	-	390pF	1.5nF	3.3nF	680pF	2.7nF	5.6nF	470pF	2.7nF	5.6nF	820pF	4.7nF	6.8nF	1.2nF	5.6nF	10nF	3.3nF	10nF	18nF
	Extended	470pF	2.7nF	820pF	2.2nF	5.6nF	1.2nF	3.9nF	-	1nF	3.9nF	12nF	1.8nF	6.8nF	-	2.7nF	8.2nF	27nF	6.8nF	15nF	47nF
3kV	Standard	-	-	180pF	680pF	1.2nF	180pF	1.2nF	2.2nF	220pF	1.2nF	2.2nF	330pF	1.8nF	3.3nF	470pF	2.2nF	3.9nF	820pF	3.9nF	6.8nF
	Extended	220pF	1nF	390pF	1nF	2.7nF	680pF	1.8nF	-	470pF	1.8nF	4.7nF	820pF	2.7nF	-	1nF	3.3nF	12nF	1.8nF	5.6nF	22nF
4kV	Standard	-	-	100pF	330pF	680pF	120pF	680pF	1nF	150pF	820pF	1.2nF	220pF	1.2nF	1.8nF	390pF	1.5nF	2.7nF	680pF	3.3nF	4.7nF
	Extended	150pF	470pF	220pF	560pF	-	330pF	1nF	-	330pF	1.2nF	2.2nF	680pF	1.8nF	-	820pF	2.2nF	4.7nF	1.5nF	4.7nF	10nF
5kV	Standard	-	-	-	-	-	-	-	-	100pF	560pF	820pF	150pF	820pF	1nF	270pF	1nF	1.8nF	470pF	2.2nF	3.3nF
	Extended	-	-	-	-	-	-	-	-	220pF	820pF	1.5nF	320pF	1.2nF	-	560pF	1.5nF	3.3nF	1nF	2.7nF	6.8nF

Available capacitance values:
NPO, C4xx dielectrics: E6, E12, E24 in standard (see page xx). Specific values upon request.
X7R dielectric: E6, E12 (see page xx). Specific values upon request.

The above table defines the standard products, other components may be built upon request.

STANDARD RATINGS

	Exxelia size code	83			84			89			85			87			88		
Dimensions inches (mm)	L max.	0.552 (14)			0.689 (17.5)			0.701 (17.8)			0.788 (20)			1.221 (31)			1.772 (45)		
	W max.	0.571 (14.5)			0.571 (14.5)			0.689 (17.5)			0.749 (19)			0.945 (24)			0.906 (23)		
	T max.*	0.2kV up to 3kV: 0.237 (6) 4kV: 0.276 (7) 5kV up to 10kV: 0.315 (8)			0.2kV up to 3kV: 0.237 (6) 4kV: 0.276 (7) 5kV up to 10kV: 0.315 (8)			0.2kV up to 3kV: 0.237 (6) 4kV: 0.276 (7) 5kV up to 10kV: 0.315 (8)			0.2kV up to 3kV: 0.237 (6) 4kV: 0.276 (7) 5kV up to 10kV: 0.315 (8)			0.2kV up to 3kV: 0.237 (6) 4kV: 0.276 (7) 5kV: 0.315 (8) 7.5kV up to 10kV: 0.335 (8.5)			0.2kV up to 3kV: 0.237 (6) 4kV: 0.276 (7) 5kV: 0.315 (8) 7.5kV up to 10kV: 0.335 (8.5)		
	Ø ± 10%	0.031 (0.8)			0.031 (0.8)			0.031 (0.8)			0.031 (0.8)			0.039 (1)			0.039 (1)		
	X	0.5 ± 0.012 (12.7 ± 0.3)			0.6 ± 0.012 (15.24 ± 0.3)			0.6 ± 0.012 (15.24 ± 0.3)			0.7 ± 0.012 (17.8 ± 0.3)			1.1 ± 0.012 (27.94 ± 0.3)			1.6 ± 0.012 (40.64 ± 0.3)		
Dielectric		NPO	C4xx	X7R	NPO	C4xx	X7R	NPO	C4xx	X7R	NPO	C4xx	X7R	NPO	C4xx	X7R	NPO	C4xx	X7R
Exxelia ceramic code		1	4	2	1	4	2	1	4	2	1	4	2	1	4	2	1	4	2
Min. Capacitance value		10pF	180pF	270pF	22pF	270pF	390pF	27pF	390pF	560pF	47pF	470pF	1nF	120pF	1nF	2.2nF	150pF	1.8nF	2.7nF
Rated voltage (U_{RC}) 0.2kV	Standard	56nF	1.2µF	2.7µF	82nF	1.5µF	3.9µF	100nF	1.8µF	4.7µF	180nF	2.7µF	6.8µF	330nF	6.8µF	12µF	390nF	8.2µF	15µF
	Extended	180nF	-	5.6µF	270nF	-	6.8µF	220nF	-	8.2µF	560nF	-	12µF	1µF	-	33µF	1.2µF	-	39µF
0.5kV	Standard	33nF	270nF	680nF	47nF	330nF	1µF	56nF	390nF	1.2µF	82nF	680nF	1.8µF	150nF	1.5µF	3.9µF	270nF	1.8µF	4.7µF
	Extended	100nF	390nF	1.5µF	150nF	560nF	2.2µF	150nF	680nF	2.7µF	270nF	1µF	3.9µF	470nF	2.2µF	10µF	820nF	2.7µF	12µF
1kV	Standard	15nF	82nF	150nF	22nF	82nF	220nF	33nF	120nF	270nF	39nF	220nF	390nF	82nF	560nF	1µF	150nF	680nF	1.2µF
	Extended	47nF	120nF	390nF	68nF	120nF	560nF	82nF	220nF	560nF	120nF	330nF	1µF	270nF	680nF	2.7µF	470nF	1µF	3.3µF
1.5kV	Standard	8.2nF	39nF	82nF	12nF	39nF	100nF	15nF	68nF	150nF	22nF	100nF	180nF	47nF	220nF	470nF	68nF	330nF	560nF
	Extended	18nF	56nF	180nF	22nF	56nF	220nF	33nF	100nF	330nF	47nF	150nF	470nF	100nF	330nF	1.2µF	150nF	470nF	1.5µF
2kV	Standard	4.7nF	18nF	33nF	6.8nF	22nF	68nF	8.2nF	39nF	68nF	12nF	56nF	100nF	27nF	120nF	220nF	39nF	180nF	330nF
	Extended	10nF	27nF	100nF	15nF	33nF	150nF	18nF	56nF	150nF	27nF	82nF	220nF	56nF	180nF	560nF	82nF	270nF	820nF
3kV	Standard	1.5nF	8.2nF	15nF	2.7nF	10nF	27nF	3.3nF	18nF	27nF	4.7nF	27nF	39nF	12nF	56nF	100nF	15nF	68nF	120nF
	Extended	3.3nF	12nF	39nF	5.6nF	15nF	56nF	10nF	22nF	68nF	10nF	39nF	100nF	27nF	82nF	270nF	33nF	100nF	330nF
4kV	Standard	1.2nF	6.8nF	10nF	2.2nF	6.8nF	15nF	2.7nF	12nF	18nF	3.9nF	18nF	27nF	10nF	39nF	68nF	12nF	47nF	100nF
	Extended	2.7nF	10nF	18nF	4.7nF	10nF	27nF	6.8nF	18nF	39nF	8.2nF	27nF	47nF	22nF	56nF	120nF	27nF	82nF	150nF
5kV	Standard	1nF	4.7nF	5.6nF	1.8nF	4.7nF	10nF	1.8nF	8.2nF	12nF	3.3nF	12nF	18nF	8.2nF	27nF	56nF	10nF	33nF	68nF
	Extended	2.2nF	6.8nF	15nF	3.9nF	6.8nF	22nF	4.7nF	12nF	27nF	6.8nF	18nF	39nF	15nF	39nF	82nF	18nF	47nF	100nF
7.5kV	Standard	150pF	-	1.5nF	270pF	-	2.7nF	470pF	-	3.3nF	560pF	-	6.8nF	1.5nF	-	18nF	2.2nF	-	27nF
	Extended	330pF	-	3.3nF	560pF	-	5.6nF	1.2nF	-	6.8nF	1.2nF	-	12nF	3.3nF	-	33nF	4.7nF	-	47nF
10kV	Standard	100pF	-	680pF	180pF	-	1.2nF	270pF	-	1.5nF	390pF	-	3.3nF	1nF	-	8.2nF	1.5nF	-	12nF
	Extended	220pF	-	1.8nF	390pF	-	3.3nF	680pF	-	3.9nF	820pF	-	6.8nF	2.2nF	-	15nF	3.3nF	-	27nF

Available capacitance values:
NPO, C4xx dielectrics: E6, E12, E24 in standard (see page xx). Specific values upon request.
X7R dielectric: E6, E12 (see page xx). Specific values upon request.

The above table defines the standard products, other components may be built upon request.

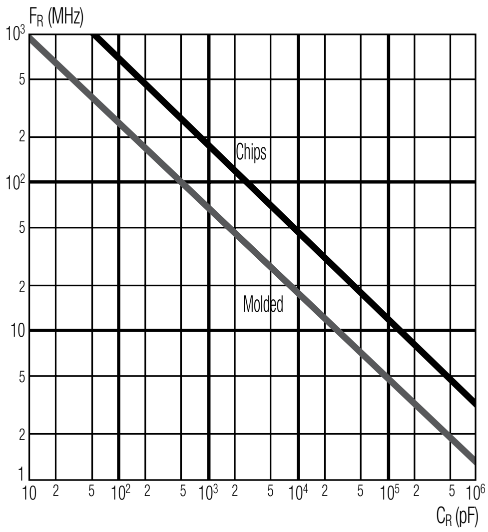
General Information

High voltage multilayer ceramic capacitors designed by EXXELIA are adapted to applications in electronics such as high voltage power supplies and high voltage multiplier circuits. Their multilayer construction offers significant size and space saving advantage. They are available in class 1 (NPO), class 2 (X7R) and C4xx (−2,200 ppm/°C) dielectrics versions complying with the main requirements of applicable standards. They are suited for use in commercial, industrial and High-Rel military and space circuits.

As standard products can't meet all the specificities of all applications, special applications may require specific features (higher voltage, burn-in, dimensions, coating, leading, marking…) not described in this catalogue. Based on the «state of the Art», and our knowledge of the technology, our Engineers may study at your request all special components to meet your application.

Please, consult us for more information.

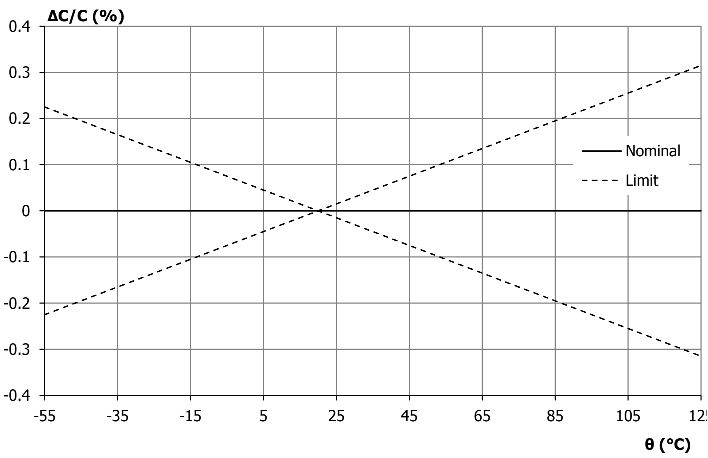
NPO, X7R, C4xx: SELF-RESONANCE FREQUENCE VS CAPACITANCE



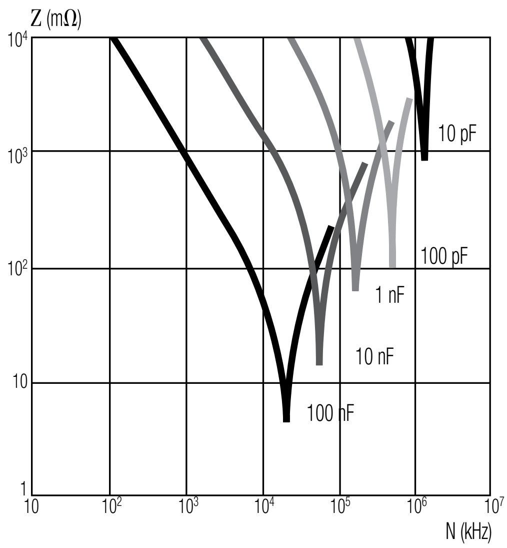
NPO/COG DIELECTRICS (CLASS 1)

Made of titanium oxide and other various selected oxides, they feature unique stability of all parameters under such constraints as operating time, temperature, voltage applied. For example, the quality factor remains very high over an extremely wide frequency range. As example, loss angle tangent value at 1 MHz is typically in the order of 3.10^{-4}. These characteristics make them compatible with steep-edge impulse mode without noticeable temperature rise. The different parameters and related variations are illustrated in figures below:

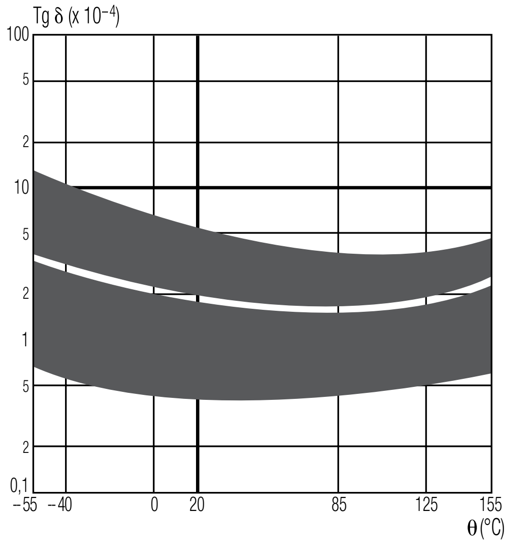
NPO: RELATIVE CAPACITANCE CHANGE VS TEMPERATURE



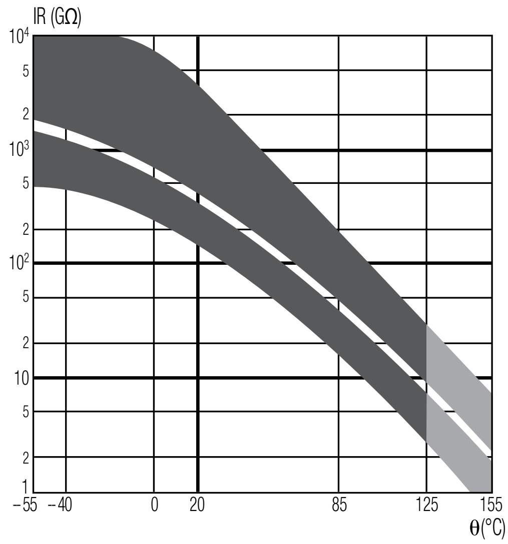
NPO: IMPEDANCE VS FREQUENCY



NPO: LOSS TANGENT VS TEMPERATURE



NPO: INSULATION RESISTANCE VS TEMPERATURE



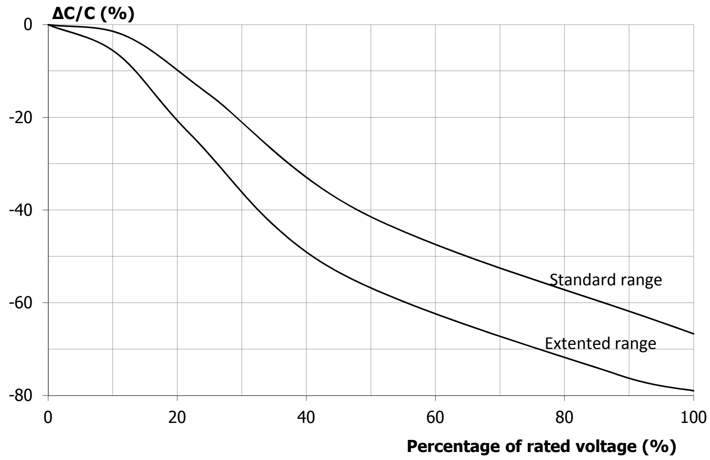
X7R DIELECTRICS (CLASS 2)

They are mainly made of barium titanate modified by various oxides to achieve the electrical properties required. A specific ceramic dielectric is used to achieve an excellent dielectric strength. High dielectric constant enables to achieve high capacitance values.

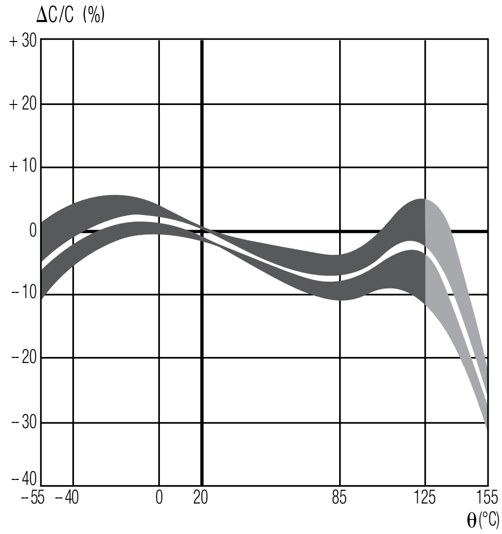
For optimum use, the specific properties of barium titanate in function of the different parameters must be taken into account.

See the variations illustrated in figures below:

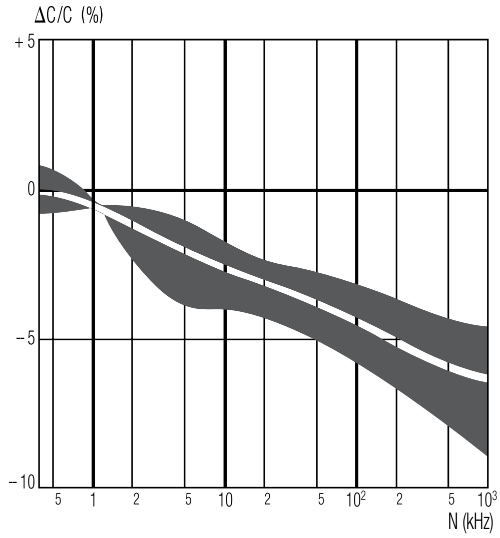
CHANGE VS PERCENTAGE OF RATED VOLTAGE APPLIED



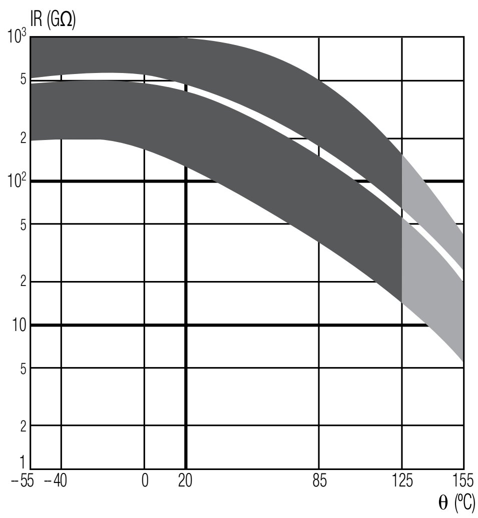
X7R: CAPACITANCE CHANGE VS TEMPERATURE



X7R: CAPACITANCE CHANGE VS FREQUENCY



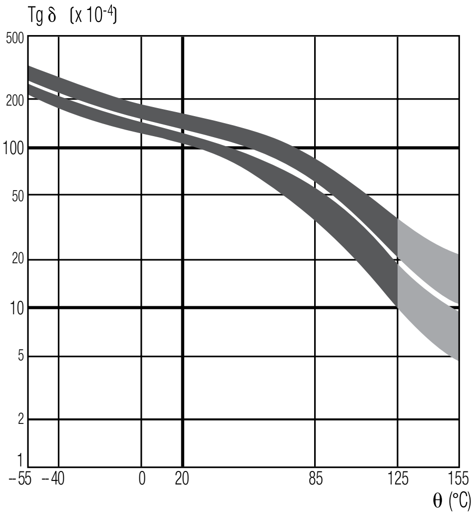
X7R: INSULATION RESISTANCE VS TEMPERATURE



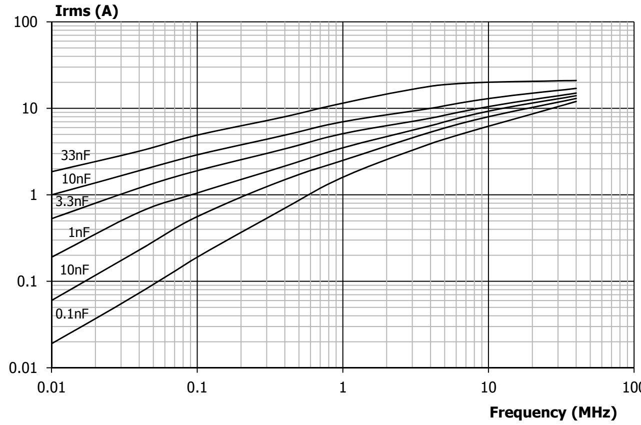
HIGH VOLTAGE

General Information

X7R: LOSS TANGENT CHANGE VS TEMPERATURE



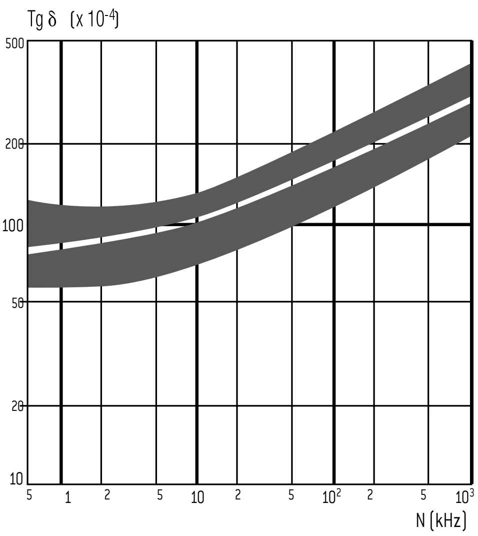
X7R: MAXIMUM ADMISSIBLE CURRENT VS FREQUENCY



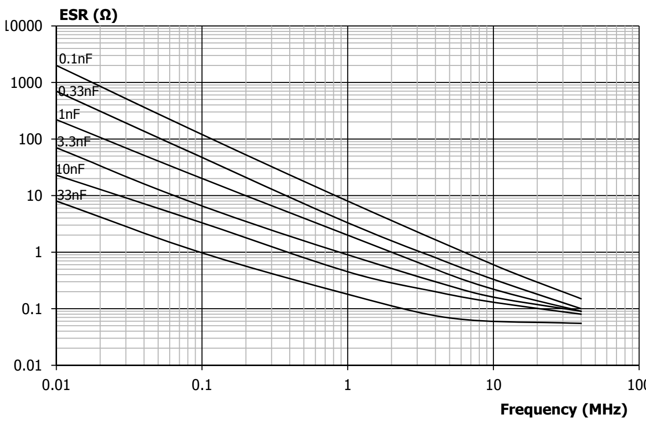
These typical curves are examples of admissible currents for one family of chip capacitors (size 3333). For other curves and products or for further information, please contact us.

Note: for the calculations, we have considered that the terminations are directly connected to an infinite heat sink. In other words, the thermal resistance of the circuit itself which depends on its type and design has not been taken into account. Moreover, the ambient temperature taken is 25°C.

X7R: LOSS TANGENT CHANGE VS FREQUENCY



X7R: ESR VS FREQUENCY

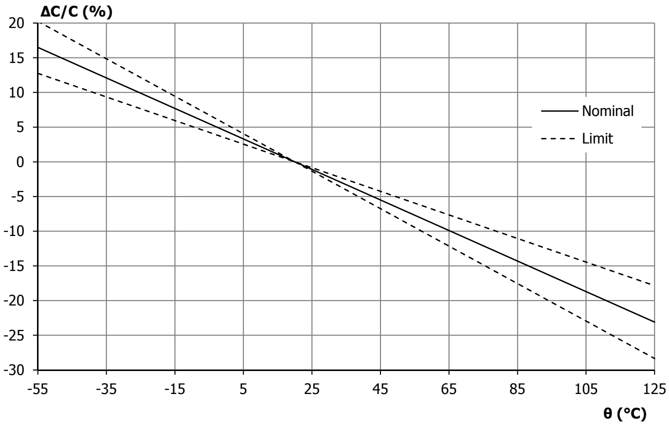


The ESR (Equivalent Serial Resistance) typical curves are given, here for SMD (chip) capacitors. Regarding the curves for the leaded capacitors, they are rather the same. Indeed, due to the resistivity of the raw material used and the wire diameters, the resistance of the wires is much lower than the ESR of the chips. So, in a first approach, their influence can be considered as negligible.

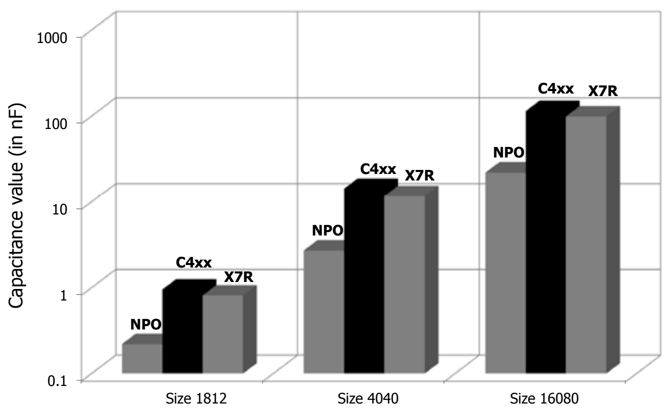
C4xx DIELECTRIC

This ceramic is a negative temperature coefficient dielectric (–2,200 ppm/°C). Its advantage is that it combines the high dielectric constant of an X7R dielectric with the stability of an NPO dielectric. As the C4xx ceramic exhibits low dissipation factor it is recommended for AC line filtering from 110 Vrms to 230 Vrms, 20 to 400 Hz, for high power RF at high voltage up to 5,000 V and for pulse applications.

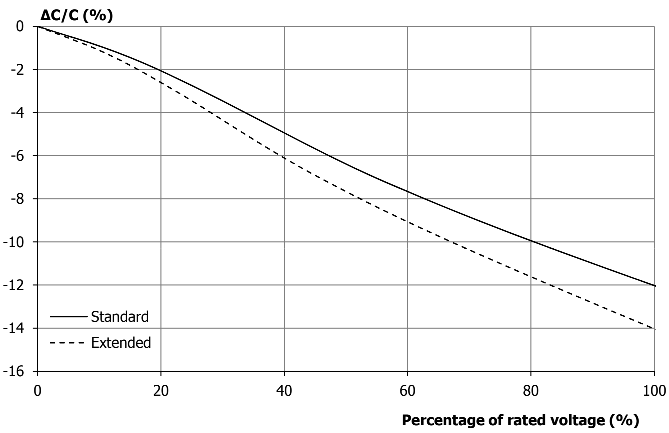
C4xx: TEMPERATURE COEFFICIENT



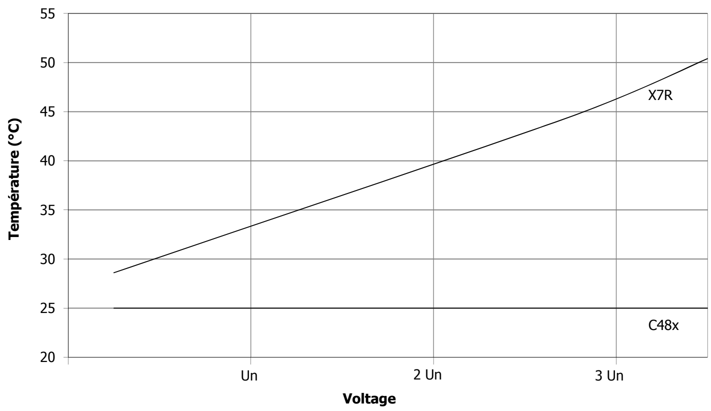
COMPARISON OF CAPACITANCE VALUE UNDER RATED VOLTAGE AT 125°C



C4xx: VOLTAGE COEFFICIENT

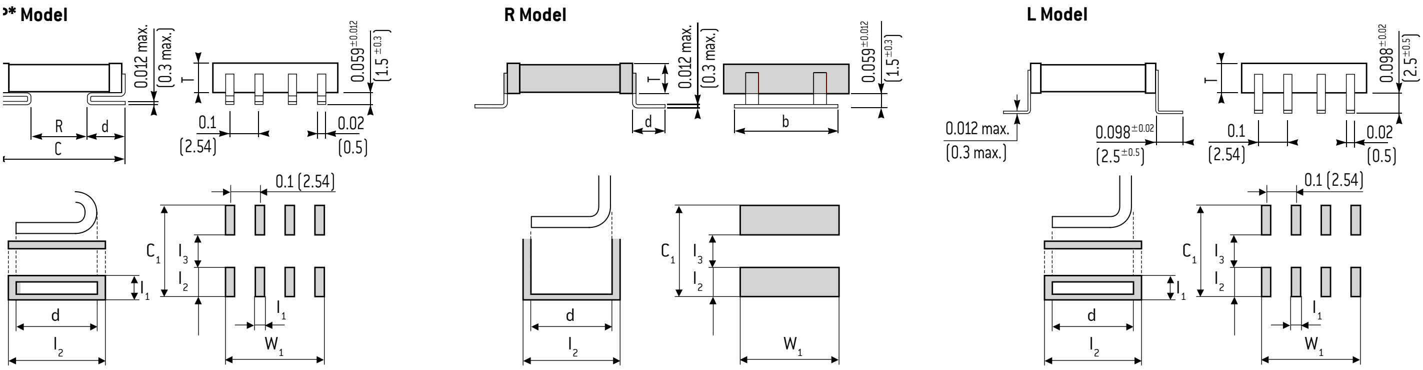


COMPARISON OF SELF-HEATING AT 400 Hz BETWEEN C4xx AND X7R DIELECTRICS



General Information

RECOMMENDED FOOTPRINTS



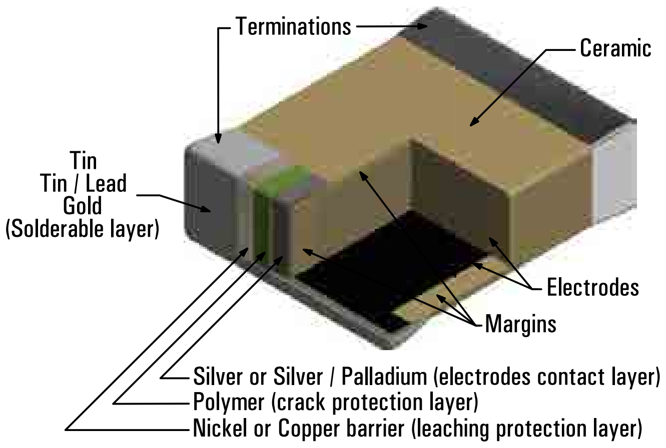
DIMENSIONS in inches (mm)

Exxelia size code	Lead shape	C max inches (mm)	Leads per side	d inches (mm)	b inches (mm)	C_1 inches (mm)	W_1 inches (mm)	l_1 inches (mm)	l_2 inches (mm)	l_3 inches (mm)
90	P*	0.228 (5.8)	2	0.06 ± 0.012 (1.5 ± 0.3)	- -	0.268 (6.8)	0.147 (3.74)	0.047 (1.2)	0.108 (2.75)	0.098 (2.5)
	L	0.394 (10)	2	0.098 ± 0.02 (2.5 ± 0.5)	- -	0.433 (11)	0.147 (3.74)	0.047 (1.2)	0.152 (3.85)	0.130 (3.3)
	R	0.386 (9.8)	1	0.087 ± 0.008 (2.2 ± 0.2)	0.197 ± 0.02 (5 ± 0.5)	0.425 (10.8)	0.244 (6.2)	- -	0.148 (3.75)	0.130 (3.3)
80	P*	0.276 (7)	2	0.06 ± 0.012 (1.5 ± 0.3)	- -	0.315 (8)	0.147 (3.74)	0.047 (1.2)	0.108 (2.75)	0.098 (2.5)
	L	0.480 (12.2)	2	0.098 ± 0.02 (2.5 ± 0.5)	- -	0.520 (13.2)	0.147 (3.74)	0.047 (1.2)	0.171 (4.35)	0.177 (4.5)
	R	0.433 (11)	1	0.087 ± 0.008 (2.2 ± 0.2)	0.197 ± 0.02 (5 ± 0.5)	0.472 (12)	0.244 (6.2)	- -	0.148 (3.75)	0.177 (4.5)
91	P*	0.276 (7)	2	0.06 ± 0.012 (1.5 ± 0.3)	- -	0.315 (8)	0.147 (3.74)	0.047 (1.2)	0.108 (2.75)	0.098 (2.5)
	L	0.480 (12.2)	2	0.098 ± 0.02 (2.5 ± 0.5)	- -	0.520 (13.2)	0.147 (3.74)	0.047 (1.2)	0.171 (4.35)	0.177 (4.5)
	R	0.433 (11)	1	0.087 ± 0.008 (2.2 ± 0.2)	0.197 ± 0.02 (5 ± 0.5)	0.472 (12)	0.244 (6.2)	- -	0.148 (3.75)	0.177 (4.5)
81	P*	0.315 (8)	2	0.087 ± 0.012 (2.2 ± 0.3)	- -	0.354 (9)	0.147 (3.74)	0.047 (1.2)	0.108 (2.75)	0.138 (3.5)
	L	0.531 (13.5)	2	0.098 ± 0.02 (2.5 ± 0.5)	- -	0.571 (14.5)	0.147 (3.74)	0.047 (1.2)	0.171 (4.35)	0.228 (5.8)
	R	0.484 (12.3)	1	0.087 ± 0.008 (2.2 ± 0.2)	0.197 ± 0.02 (5 ± 0.5)	0.524 (13.3)	0.244 (6.2)	- -	0.148 (3.75)	0.228 (5.8)
82	P*	0.354 (9)	3	0.087 ± 0.012 (2.2 ± 0.3)	- -	0.394 (10)	0.247 (6.28)	0.047 (1.2)	0.108 (2.75)	0.177 (4.5)
	L	0.587 (14.9)	3	0.098 ± 0.02 (2.5 ± 0.5)	- -	0.626 (15.9)	0.247 (6.28)	0.047 (1.2)	0.171 (4.35)	0.283 (7.2)
	R	0.642 (16.3)	1	0.138 ± 0.008 (3.5 ± 0.2)	0.315 ± 0.02 (8 ± 0.5)	0.681 (17.3)	0.362 (9.2)	- -	0.199 (5.05)	0.283 (7.2)
83	P*	0.472 (12)	4	0.087 ± 0.012 (2.2 ± 0.3)	- -	0.512 (13)	0.347 (8.82)	0.047 (1.2)	0.118 (3)	0.276 (7)
	L	0.676 (17.16)	4	0.098 ± 0.02 (2.5 ± 0.5)	- -	0.715 (18.16)	0.347 (8.82)	0.047 (1.2)	0.191 (4.85)	0.333 (8.46)
	R	0.731 (18.56)	1	0.138 ± 0.008 (3.5 ± 0.2)	0.315 ± 0.02 (8 ± 0.5)	0.770 (19.56)	0.362 (9.2)	- -	0.219 (5.55)	0.333 (8.46)
84	P*	0.610 (15.5)	4	0.087 ± 0.012 (2.2 ± 0.3)	- -	0.650 (16.5)	0.347 (8.82)	0.047 (1.2)	0.128 (3.25)	0.394 (10)
	L	0.815 (20.7)	4	0.098 ± 0.02 (2.5 ± 0.5)	- -	0.854 (21.7)	0.347 (8.82)	0.047 (1.2)	0.191 (4.85)	0.472 (12)
	R	0.870 (22.1)	1	0.138 ± 0.008 (3.5 ± 0.2)	0.315 ± 0.02 (8 ± 0.5)	0.909 (23.1)	0.362 (9.2)	- -	0.219 (5.55)	0.472 (12)
89	P*	0.630 (16)	5	0.087 ± 0.012 (2.2 ± 0.3)	- -	0.669 (17)	0.347 (8.82)	0.047 (1.2)	0.128 (3.25)	0.413 (10.5)
	L	0.827 (21)	5	0.098 ± 0.02 (2.5 ± 0.5)	- -	0.866 (22)	0.347 (8.82)	0.047 (1.2)	0.191 (4.85)	0.484 (12.3)
	R	0.882 (22.4)	1	0.138 ± 0.008 (3.5 ± 0.2)	0.315 ± 0.02 (8 ± 0.5)	0.921 (23.4)	0.362 (9.2)	- -	0.219 (5.55)	0.484 (12.3)
85	P*	0.728 (18.5)	6	0.087 ± 0.012 (2.2 ± 0.3)	- -	0.768 (19.5)	0.547 (13.9)	0.047 (1.2)	0.128 (3.25)	0.512 (13)
	L	0.925 (23.5)	6	0.098 ± 0.02 (2.5 ± 0.5)	- -	0.965 (24.5)	0.547 (13.9)	0.047 (1.2)	0.191 (4.85)	0.583 (14.8)
	R	0.980 (24.9)	1	0.138 ± 0.008 (3.5 ± 0.2)	0.591 ± 0.02 (15 ± 0.5)	1.020 (25.9)	0.638 (16.2)	- -	0.219 (5.55)	0.583 (14.8)
87	P*	1.260 (32)	6	0.087 ± 0.012 (2.2 ± 0.3)	- -	1.299 (33)	0.547 (13.9)	0.047 (1.2)	0.128 (3.25)	0.945 (24)
	L	1.398 (35.5)	6	0.098 ± 0.02 (2.5 ± 0.5)	- -	1.437 (36.5)	0.547 (13.9)	0.047 (1.2)	0.191 (4.85)	1.055 (26.8)
	R	1.453 (36.9)	1	0.138 ± 0.008 (3.5 ± 0.2)	0.591 ± 0.02 (15 ± 0.5)	1.492 (37.9)	0.638 (16.2)	- -	0.219 (5.55)	1.055 (26.8)
88	P*	1.654 (42)	6	0.087 ± 0.012 (2.2 ± 0.3)	- -	1.693 (43)	0.547 (13.9)	0.047 (1.2)	0.128 (3.25)	1.378 (35)
	L	1.831 (46.5)	6	0.098 ± 0.02 (2.5 ± 0.5)	- -	1.870 (47.5)	0.547 (13.9)	0.047 (1.2)	0.191 (4.85)	1.488 (37.8)
	R	1.886 (47.9)	1	0.138 ± 0.008 (3.5 ± 0.2)	0.591 ± 0.02 (15 ± 0.5)	1.925 (48.9)	0.638 (16.2)	- -	0.219 (5.55)	1.488 (37.8)

* For PL and PLS, add 0.098 in (2.5 mm) to d and l2 and 0.197 in (5 mm) to C1.

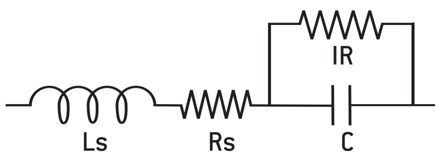
Ceramic Capacitors Technology

MLCC STRUCTURE



EQUIVALENT CIRCUIT

Capacitor is a complex component combining resistive, inductive and capacitive phenomena. A simplified schematic for the equivalent circuit is:



DIELECTRIC CHARACTERISTICS

Insulation Resistance (IR) is the resistance measured under DC voltage across the terminals of the capacitor and consists principally of the parallel resistance shown in the equivalent circuit. As capacitance values and hence the area of dielectric increases, the IR decreases and hence the product (C x IR) is often specified in Ω.F or MΩ.μF.

The Equivalent Series Resistance (ESR) is the sum of the resistive terms which generate heating when capacitor is used under AC voltage at a given frequency (f).

Dissipation factor (DF) is the ration of the apparent power input will turn to heat in the capacitor:

DF = $2\pi f C$ ESR

When a capacitor works under AC voltage, **heat power loss (P),** expressed in Watt, is equal to:

P = $2\pi f C Vrms^2$ DF

The series inductance (Ls) is due to the currents running through the electrodes. It can distort the operation of the capacitor at high frequency where the **impedance (Z)** is given as:

Z = Rs + j (Ls.ω - 1/(C.ω)) with $\omega = 2\pi f$

When frequency rises, the capacitive component of capacitors is gradually canceled up to the resonance frequency, where :

Z = Rs and LsC.ω^2 = 1

Above this frequency the capacitor behaves like an inductor.

	P100	NPO	N2200 (C4xx)	BX	2C1	X7R
Dielectric material	Porcelain	Magnesium titanate or Neodynium baryum titanate	Barium zirconate titanate	Baryum titanate ($BaTiO_3$)		
Dielectric constant	15 – 18	20 – 85	450	2,000 – 5,000		
Electrode technology	PME (Precious Metal Electrodes): Ag/Pd					
Capacitance variation between –55°C and +125/°C without DC voltage	(100±30)ppm/°C	(0±30)ppm/°C	(–2,200±500) ppm/°C	±15%	±20%	±15%
Capacitance variation between –55°C and +125/°C with DC rated voltage			0 -15%	15% –25%	20% –30%	Not applicable
Piezo-electric effect	None		None	Yes		
Dielectric absorption	None		Few %	Few %		
Thermal shock sensitive	+		+	++		

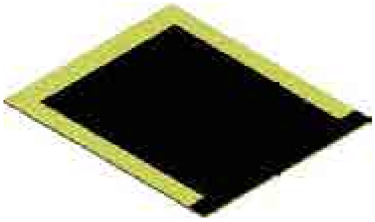
Ceramic Capacitors Technology

MANUFACTURING STEPS

SLIP CASTING

A slurry, a mix of ceramic powder, binder and solvents, is poured onto conveyor belt inside a drying oven, resulting in a dry ceramic sheet.

ELECTRODE SCREEN PRINTING

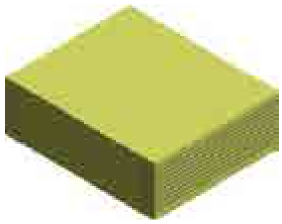


The electrode ink, made from a metal powder mixed with solvents, is printed onto the ceramic sheets using a screen printing process.

STACKING

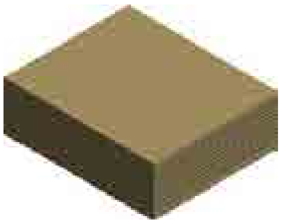
The sheets with electrode printed are stacked to create a multilayer structure.

PRESSING



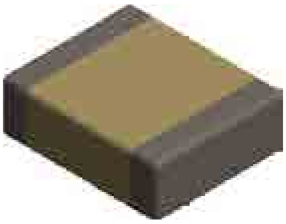
Pressure is applied to the stack to fuse all the separate layers, this created a monolithic structure.

SINTERING



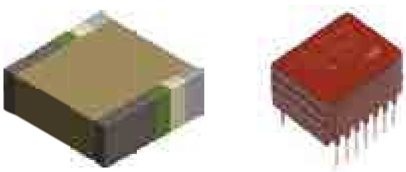
The parts are sintered in an oven with a precise temperature profile which is very important to the characteristics of the capacitors.

TERMINATIONS



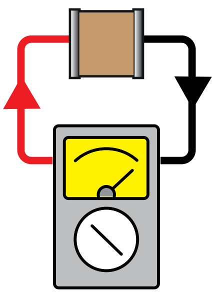
Each terminal of the capacitor is dipped in the termination ink, mix of metal powder, solvents and glass frit and the parts are fired in an oven.

TERMINATIONS PLATING



Stacking + leads soldering + encapsulation
(see pages 10-11)

FINAL TESTING



PACKAGING

User Guide

SMD TERMINATIONS

NON RoHS COMPLIANT	Code	RoHS COMPLIANT	Code	Magnetic	Recommended mounting process						Storage (months)*
					Epoxy bonding	Iron soldering	Wave soldering	Vapor phase soldering	Infrared soldering	Wire bonding	
Ag	**Q**	Ag	**QW / P**	No	•	•	•	•			18
Ag/Pd/Pt	**-**	Ag/Pd/Pt	**W / A**	No	•	•	•				24
Ag + Ni + dipped Sn/Pb 60/40	**T****	-	**-**	No		•	•	•	•		24
Ag/Pd/Pt + dipped Sn/Pb 60/40	**H**	Ag/Pd/Pt + dipped Sn	**HW**	No		•					24
Ag + Ni + electrolytic Sn/Pb 95/5	**C**	Ag + Ni + electrolytic Sn	**CW / S**	Yes		•	•	•	•		18
Ag + Ni + electrolytic Sn/Pb 60/40	**D**	-	**-**	Yes		•	•	•	•		18
-	**-**	Ag + Cu + electrolytic Sn	**C**	No		•	•	•	•		18
Ag + Ni + dipped Sn/Pb 60/40	**E**	Ag + Ni + electrolytic Sn	**EW**	Yes		•	•				24
Ag + Ni + Au	**G**	Ag + Ni + Au	**GW**	Yes	•	•	•	•	•	•	36
Ag + Polymer + Ni + Sn/Pb 95/5	**YC**	Ag + Polymer + Ni + Sn	**YCW**	Yes		•	•	•	•		18
Ag + Polymer + Ni + Sn/Pb 60/40	**YD**	-	**-**	Yes		•	•	•	•		18
Ag + Polymer + Ni + Au	**YG**	Ag + Polymer + Ni + Au	**YGW**	Yes	•	•	•	•	•	•	36

Nickel (Ni) or Copper (Cu) barriers amplify thermal shock and are not recommended for chip sizes larger than 3030.

* Storage must be in a dry environment at a temperature of 20° C with a relative humidity below 50%, or preferably in a package enclosing a desiccant.
** Maintenance only.

SMD ENVIRONMENTAL TESTS

Ceramic chip capacitors for SMD are designed to meet test requirements of **CECC 32100** and **NF C 93133** standards as specified below in compliance with NF C 20700 and IEC 68 standards:

- Solderability: **NF C 20758,** 260° C, bath 62/36/2.
- Adherence: 5N force.
- Vibration fatigue test: **NF C 20706,** 20 g, 10 Hz to 2,000 Hz, 12 cycles of 20 minutes each.
- Rapid temperature change: **NF C 20714,** – 55° C to + 125° C, 5 cycles.
- Combined climatic test: **IEC 68-2-38.**
- Damp heat: **NF C 20703,** 93 %, H.R., 40° C.
- Endurance test: 1,000 hours, 1.5 U_{RC}, 125° C.

STORAGE OF CHIP CAPACITORS

STORAGE IN INDUSTRIAL ENVIRONMENT:

- 2 years for tin dipped chip capacitors,
- 18 months for tin electroplated chip capacitors,
- 2 years for non tinned chip capacitors,
- 3 years for gold plated chip capacitors.

STORAGE IN CONTROLLED NEUTRAL NITROGEN ENVIRONMENT:

- 4 years for tin dipped or electroplated chip capacitors,
- 4 years for non tinned chip capacitors,
- 5 years for gold plated chip capacitors.

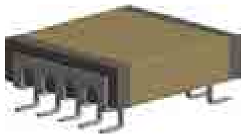
Storage duration should be considered from delivery date and not from batch manufacture date. The tests carried out at final acceptance stage (solderability, susceptibility to solder heat) enable to assess the compatibility to surface mounting of the chips.

LEAD STYLES

SURFACE MOUNTING

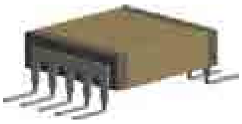
DIL LEADS

P style

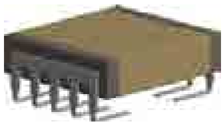


PL style

L style



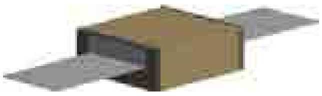
J style



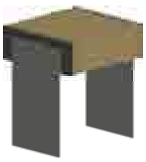
RIBBON LEADS

Micro-strip (type 1)
Short Micro-strip (type 1S)

Axial (Type 2)

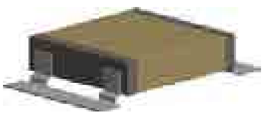


Radial (Type 3)



R style

RX style



RJ style

Please contact Exxelia sales for any lead configuration not shown.

TROUGH-HOLE MOUNTING

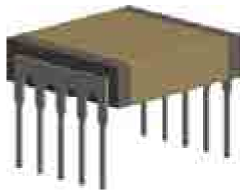
AXIAL AND RADIAL

Radial leads (Type 6)

Radial leads (4 leads)

Axial leads (Type 7)

DIL leads: N style

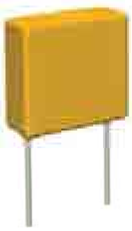


ENCAPSULATION STYLES

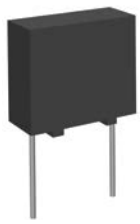
Ceramic encapsulation
(selfprotected)

Varnish

Conformal coating

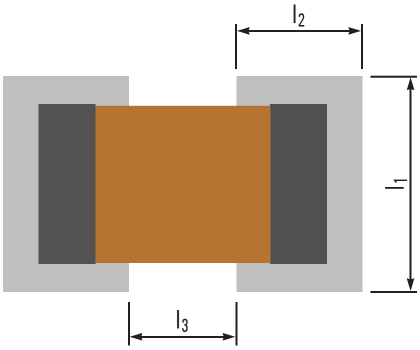


Molding



User Guide

SOLDERING ADVICES FOR REFLOW SOLDERING



Large chips above size 2225 are not recommended to be mounted on epoxy board due to thermal expansion coefficient mismatch between ceramic capacitor and epoxy. Where larger sizes are required, it is recommended to use components with ribbon or other adapted leads so as to absorb thermo-mechanical strains.

Dimensions in inches (in mm)	Reflow soldering						Wave soldering					
	l_1		l_2		l_3		l_1		l_2		l_3	
0402	0.043	(1.1)	0.035	(0.9)	0.012	(0.3)	0.043	(1.1)	0.047	(1.2)	0.012	(0.3)
0403	0.055	(1.4)	0.035	(0.9)	0.012	(0.3)	0.055	(1.4)	0.047	(1.2)	0.012	(0.3)
0504	0.063	(1.6)	0.051	(1.3)	0.016	(0.4)	0.063	(1.6)	0.063	(1.6)	0.016	(0.4)
0603	0.055	(1.4)	0.059	(1.5)	0.02	(0.5)	0.055	(1.4)	0.071	(1.8)	0.02	(0.5)
0805	0.073	(1.85)	0.065	(1.65)	0.024	(0.6)	0.073	(1.85)	0.077	(1.95)	0.024	(0.6)
0907	0.094	(2.4)	0.065	(1.65)	0.035	(0.9)	0.094	(2.4)	0.077	(1.95)	0.035	(0.9)
1005	0.073	(1.85)	0.067	(1.7)	0.039	(1)	0.073	(1.85)	0.079	(2)	0.039	(1)
1206	0.083	(2.1)	0.067	(1.7)	0.059	(1.5)	0.083	(2.1)	0.079	(2)	0.059	(1.5)
1210	0.118	(3)	0.069	(1.75)	0.059	(1.5)	0.118	(3)	0.081	(2.05)	0.059	(1.5)
1605	0.073	(1.85)	0.071	(1.8)	0.087	(2.2)	0.073	(1.85)	0.083	(2.1)	0.087	(2.2)
1806	0.087	(2.2)	0.073	(1.85)	0.102	(2.6)	0.087	(2.2)	0.085	(2.15)	0.102	(2.6)
1812	0.152	(3.85)	0.073	(1.85)	0.102	(2.6)	0.152	(3.85)	0.085	(2.15)	0.102	(2.6)
1825	0.281	(7.15)	0.073	(1.85)	0.102	(2.6)	0.281	(7.15)	0.085	(2.15)	0.102	(2.6)
2210	0.13	(3.3)	0.079	(2)	0.146	(3.7)	0.13	(3.3)	0.091	(2.3)	0.146	(3.7)
2220	0.228	(5.8)	0.079	(2)	0.146	(3.7)	0.228	(5.8)	0.091	(2.3)	0.146	(3.7)
2225	0.281	(7.15)	0.079	(2)	0.146	(3.7)	0.281	(7.15)	0.091	(2.3)	0.146	(3.7)

RECOMMENDED FOOTPRINT FOR SMD CAPACITORS

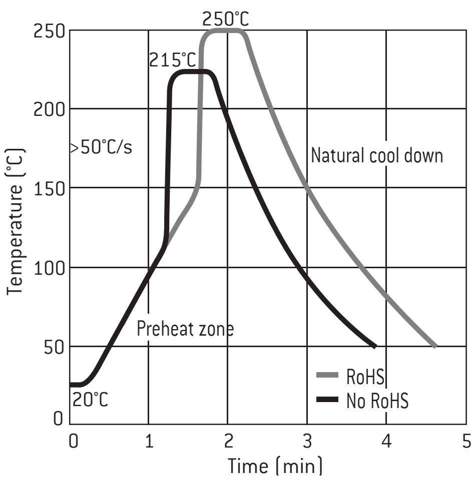
Ceramic is by nature a material which is sensitive both thermally and mechanically. Stresses caused by the physical and thermal properties of the capacitors, substrates and solders are attenuated by the leads.

Wave soldering is unsuitable for sizes larger than 2220 and for the higher ends of capacitance ranges due to possible thermal shock (capacitance values given upon request).

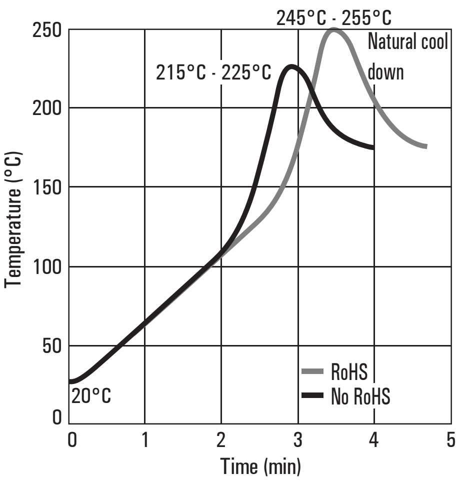
Infrared and vapor phase reflow, are preferred for high reliability applications as inherent thermo-mechanical strains are lower than those inherent to wave soldering.

Whatever the soldering process is, it is highly recommended to apply a thermal cycle, see hereafter our recommended soldering profile:

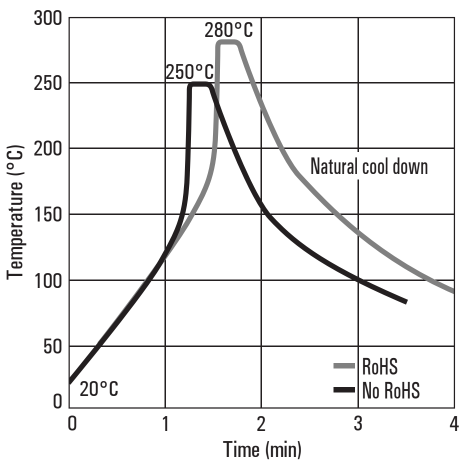
RECOMMENDED VAPOR PHASE REFLOW PROFILE



RECOMMENDED IR REFLOW PROFIL



RECOMMENDED WAVE SOLDERING PROFILE



SOLDERING ADVICES FOR IRON SOLDERING

Attachment with a soldering iron is discouraged due to ceramic brittleness and the process control limitations. In the event that a soldering iron must be used, the following precautions should be observed:

- Use a substrate with chip footprints big enough to allow putting side by side one end of the capacitor and the iron tip without any contact between this tip and the component,
- place the capacitor on this footprint,
- heat the substrate until the capacitor's temperature reaches 150° C minimum (preheating step, maximum 1°C per second),
- place the hot iron tip (a flat tip is preferred) on the footprint **without touching the capacitor.** Use a regulated iron with a 30 watts maximum power. The recommended temperature of the iron is 270 ± 10° C. The temperature gap between the capacitor and the iron tip must not exceed 120° C,
- leave the tip on the footprint for a few seconds in order to increase locally the footprint's temperature,
- use a cored wire solder and put it down on the iron tip. In a preferred way use Sn/Pb/Ag 62/36/2 alloy,
- wait until the solder fillet is formed on the capacitor's termination,
- take away iron and wire solder,
- wait a few minutes so that the substrate and capacitor come back down to the preheating temperature,
- solder the second termination using the same procedure as the first,
- let the soldered component cool down slowly to avoid any thermal shock.

PACKAGING

TAPE AND REEL

The films used on the reels correspond to standard IEC 60286-3. Films are delivered on reels in compliance with document IEC 286-3 dated 1991.

Minimum quantity is 250 chips.

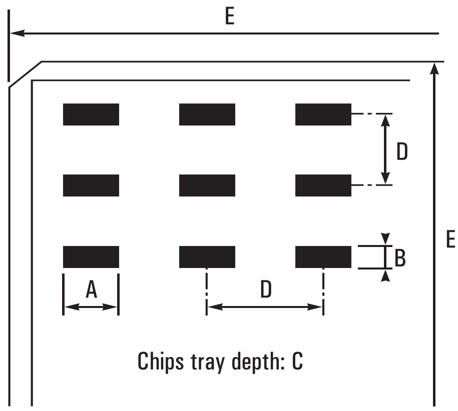
Maximum quantities per reel are as follows:

- Super 8 reel - Ø 180: 2,500 chips.
- Super 8 reel - Ø 330: 10,000 chips.
- Super 12 reel - Ø 180: 1,000 chips.

Reel marking complies with CECC 32100 standard:

- Model.
- Rated capacitance.
- Capacitance tolerance.
- Rated voltage.
- Batch number.

TRAY PACKAGES



DIMENSIONAL CHARACTERISTICS OF CHIPS TRAY PACKAGES

Sizes	Nr. of chips/ package	Oriented chips	Dimensions in inches (in mm)				
			A	B	C	D	E
0402	100	No	Ø 0.112 (Ø 3.02)		0.065 (1.65)	0.167 (4.24)	2 (50.8)
0403	100	No	Ø 0.112 (Ø 3.02)		0.065 (1.65)	0.167 (4.24)	2 (50.8)
0504	100	Yes	0.059 (1.5)	0.045 (1.14)	0.035 (0.89)	0.167 (4.24)	2 (50.8)
0603	340	Yes	0.1 (2.54)	0.06 (1.52)	0.045 (1.14)	0.167 (4.24)	2 (50.8)
0805	100	Yes	0.1 (2.54)	0.06 (1.52)	0.045 (1.14)	0.167 (4.24)	2 (50.8)
1206	100	No	0.14 (3.56)	0.14 (3.56)	0.06 (1.52)	0.167 (4.24)	2 (50.8)
1210	100	Yes	0.14 (3.56)	0.14 (3.56)	0.06 (1.52)	0.167 (4.24)	2 (50.8)
1812	100	No	0.25 (6.35)	0.25 (6.35)	0.13 (3.3)	0.345 (8.76)	4 (101.6)
	25	Yes	0.24 (6.1)	0.265 (6.73)	0.07 (1.78)	0.345 (8.76)	2 (50.8)
2220	100	Yes	0.25 (6.35)	0.25 (6.35)	0.13 (3.3)	0.345 (8.76)	4 (101.6)
	25	Yes	0.24 (6.1)	0.265 (6.73)	0.07 (1.78)	0.345 (8.76)	2 (50.8)

User Guide

EIA STANDARD CAPACITANCE VALUES

Following EIA standard, the values and multiples that are indicated in the chart below can be ordered. E48, E96 series and intermediary values are available upon request.

E6 (± 20%)	E12 (± 10%)	E24 (± 5%)
10	10	10
		11
	12	12
		13
15	15	15
		16
	18	18
		20
22	22	22
		24
	27	27
		30
33	33	33
		36
	39	39
		43
47	47	47
		51
	56	56
		62
68	68	68
		75
	82	82
		91

PART MARKING VOLTAGE CODES

Use the following voltage code chart for part markings:

Voltage (V)	Code	Letter code
25	250	A
40	400	B
50	500	C
63	630	D
100	101	E
200	201	G
250	251	H
400	401	K
500	501	L
1,000	102	M
2,000	202	P
3,000	302	R
4,000	402	S
5,000	502	T
7,500	752	U
10,000	103	W

EIA CAPACITANCE CODE

The capacitance is expressed in three digit codes and in units of pico Farads (pF). The first and second digits are significant figures of the capacitance value and the third digit identifies the multiplier.

For capacitance value < 10pF, R designates a decimal point.
See examples below:

EIA code	Capacitance value		
	in pF	in nF	in µF
2R2	2.2	0.0022	0.0000022
6R8	6.8	0.0068	0.0000068
220	22	0.022	0.000022
470	47	0.047	0.000047
181	180	0.18	0.00018
221	220	0.22	0.00022
102	1,000	1	0.001
272	2,700	2.7	0.0027
123	12,000	12	0.012
683	68,000	68	0.068
124	120,000	120	0.12
564	560,000	560	0.56
335	3,300,000	3,300	3.3
825	8,200,000	8,200	8.2
156	15,000,000	15,000	15
686	68,000,000	68,000	68
107	100,000,000	100,000	100
227	220,000,000	220,000	220

PART MARKING TOLERANCE CODES

Use the following tolerance code chart for part markings:

Tolerance	Letter code
±0.25pF	CU
±0.5pF	DU
±1pF	FU
±1%	F
±2%	G
±5%	J
±10%	K
±20%	M

RELIABILITY LEVELS

Exxelia proposes different reliability levels for the ceramic capacitors for both NPO and X7R ceramics.