

# Dielectric characteristics

## Class I Dielectrics

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

Capacitors within this class have a dielectric constant range from 10 to 100. They are used in applications which require ultra stable

dielectric characteristics with negligible dependence of capacitance and dissipation factor with time, voltage and frequency. They exhibit the following characteristics:-

- Time does not significantly affect capacitance and dissipation factor (Tan  $\delta$ ) – no ageing.
- Capacitance and dissipation factor are not affected by voltage.
- Linear temperature coefficient.

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

# Dielectric characteristics

## Class II Dielectrics

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

Capacitance and dissipation factor are affected by:-

- Time (Ageing)
- Voltage (AC or DC)
- Frequency

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

\* Refer to page 34 for details of Dissipation Factor.

# Dielectric termination combinations



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

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