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:-

a) Time does not significantly affect capacitance and dissipation factor (Tan δ) – no ageing.
b) Capacitance and dissipation factor are not affected by voltage.
c) Linear temperature coefficient.

		Class I Dielectrics						
		C0G/NP0 (Porcelain)	P90 (Porcelain)	C0G/NP0		X8G	Class I High Temperature	
Dielectric classifications		Ultra stable	Ultra stable	Ultra stable		Ultra stable	Ultra stable	
	IECQ-CECC	-	-	1B/CG		-	-	-
	EIA	C0G/NP0	P90	C0G/NP0		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		-55ºC to +125ºC	-55ºC to +125ºC	-55ºC to +125ºC	-55ºC to +125ºC	-55ºC to +150ºC	-55ºC to +160ºC	-55ºC to +200ºC
Maximum capacitance change over temperature range	No DC voltage applied	0 ± 15 ppm/ºC	± 20 ppm/ºC	0 ± 30 ppm/ºC	± 30 ppm/ºC	0 ± 30 ppm/ºC	0 ± 30 ppm/ºC	0 ± 30 ppm/ºC
	Rated DC voltage applied	-						
Tangent of loss angle (tan δ)		≤0.05		≤0.0005 @1MHz	>50pF ≤0.0015 ≤50pF 0.0015 $(\frac{15}{Cr} + 0.7)$		≤0.001	
Insulation resistance (Ri)	Time constant (Ri x Cr)	@25ºC = 10^6 MΩ min @125ºC = 10^5 MΩ min		100GΩ or 1000s (whichever is the least)			@25ºC = 100GΩ or 1000ΩF @160ºC & 200ºC = 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	
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 ±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:-

a) Time (Ageing)
b) Voltage (AC or DC)
c) Frequency

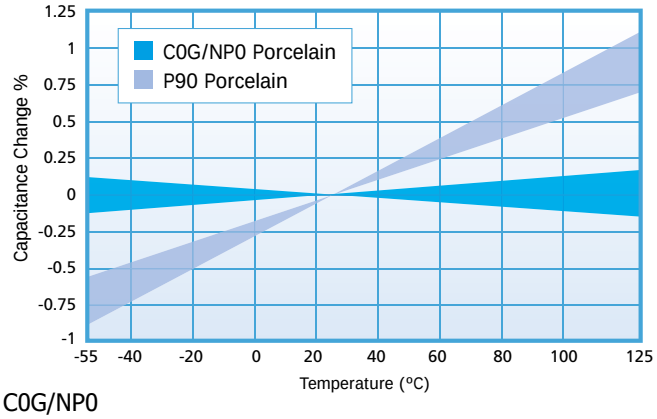
Class II Dielectrics								
X5R	X7R			X8R	Class II High Temperature			
Stable	Stable			Stable	Stable			Dielectric classifications
-	2C1	2R1	2X1	-	-	-	IECQ-CECC	
X5R	-	X7R	-	X8R	-	-	EIA	
-	BZ	-	BX	-	-	-	MIL	
-	-	-	-	-	-	-	DLI	Ordering code
BW	-	B	X	S	G	E, RE	Novacap	
P	R	X	B	N	-	X	Syfer	
-	-	X	-	-	-	-	Voltronics	
-55ºC to +85ºC	-55ºC to +125ºC			-55ºC to +150ºC	-55ºC to +160ºC	-55ºC to +200ºC		Rated temperature range
±15%	±15%	±15%	±15%	±15%	+15 -40%	+15 -65%	No DC voltage applied	Maximum capacitance change over temperature range
-	+15 -45%	-	+15 -25%	-	-	-	Rated DC voltage applied	
≤ 0.025 Typical*	>25V ≤0.025 ≤25V ≤0.035			≤0.025	≤0.025			Tangent of loss angle (tan δ)
100GΩ or 1000s (whichever is the least)							Time constant (Ri x Cr)	Insulation resistance (Ri)
±5%, ±10%, ±20%								Capacitance Tolerance
2.5 times	2.5 times			2.5 times	2.5 times		≤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		≥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 61 for details of Dissipation Factor.

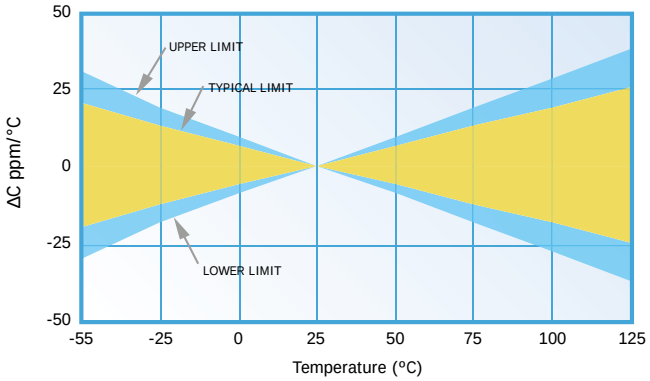
Dielectric characteristics

Typical dielectric temperature characteristics

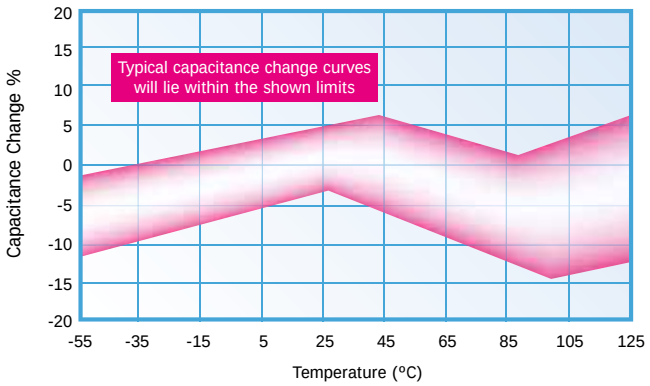
Porcelain C0G/NP0 & P90



C0G/NP0

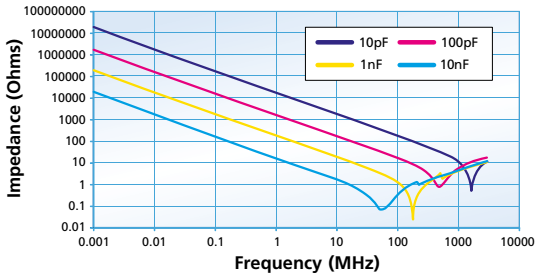


X7R

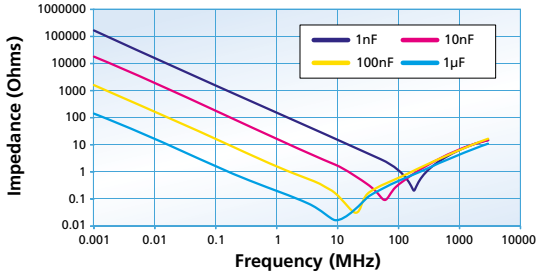


Impedance vs Frequency

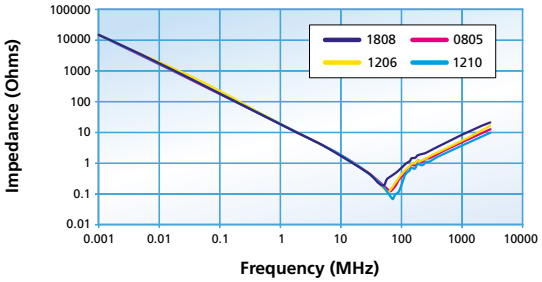
Ultra Stable C0G/NP0 dielectric



Stable X7R dielectric

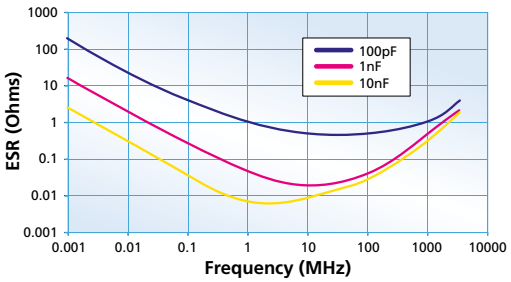


Stable X7R dielectric - 10nF

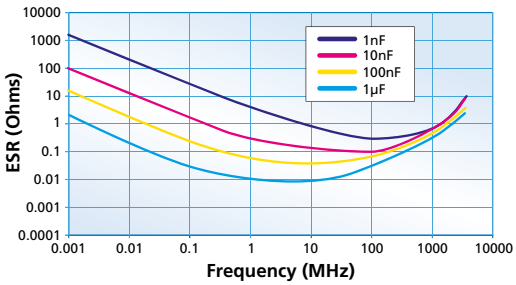


ESR vs Frequency - chips

Ultra Stable C0G/NP0 dielectric



Stable X7R dielectric



Dielectric characteristics

Typical ESR and Series Resonance characteristics

Porcelain C0G/NP0 and P90

Dielectric	DLI Series	Cap (pF)	Typical ESR 150 MHz	Typical ESR 500 MHz	Typical ESR 1 GHz	Series Resonance (MHz)
CF TCC (ppm/°C) (-55° to +125°C) Porcelain (C0G/NP0) 0 ±15	C06CF 0603	1	0.182	0.276	0.428	10300
		10	0.095	0.159	0.243	3200
		47	0.081	0.127	0.173	1400
	C11CF 0505	1	0.073	0.089	0.146	9900
		10	0.049	0.075	0.107	3100
		100	0.040	0.073	0.111	970
	C17CF 1111	1	0.073	0.082	0.124	9060
		10	0.065	0.098	0.136	3100
		100	0.041	0.070	0.102	1300
		1000	0.034	0.073	–	400
	C18CF 1111	1	0.068	0.086	0.158	9060
		10	0.058	0.087	0.118	3100
		1000	0.041	0.068	–	1000
	C22CF 2225	10	0.072	0.113	0.164	2480
		100	0.047	0.079	0.119	1000
		1000	0.036	0.067	–	320
		2700	0.035	–	–	214
			10MHz	30MHz	100MHz	
	C40CF 3838	10	0.121	0.054	0.037	2100
		100	0.044	0.038	0.045	680
		1000	0.032	0.036	0.038	210
		5100	0.011	0.016	0.040	95

Dielectric	DLI Series	Cap (pF)	Typical ESR 150 MHz	Typical ESR 500 MHz	Typical ESR 1 GHz	Series Resonance (MHz)
AH TCC (ppm/°C) (-55° to +125°C) Porcelain (P90) +90 ±20	C11AH 0505	1	0.067	0.08	0.136	9200
		10	0.044	0.071	0.104	3000
		100	0.032	0.055	0.086	1000
	C17AH 1111	1	0.059	0.063	0.114	9064
		10	0.039	0.06	0.085	3100
		1000	0.024	0.05	0.074	1290
	C18AH 1111	10	0.059	0.094	0.138	3100
		100	0.028	0.069	0.109	1290
		1000	0.023	0.063	–	400
	C22AH 2225	10	0.074	0.207	0.249	2480
		100	0.048	0.116	0.19	1000
		1000	0.028	0.14	–	320
		2700	0.027	–	–	214
			10MHz	30MHz	100MHz	
	C40AH 3838	15	0.066	0.033	0.027	2100
		100	0.018	0.026	0.052	680
		1000	0.009	0.017	0.033	210
		5100	0.008	0.016	0.033	95