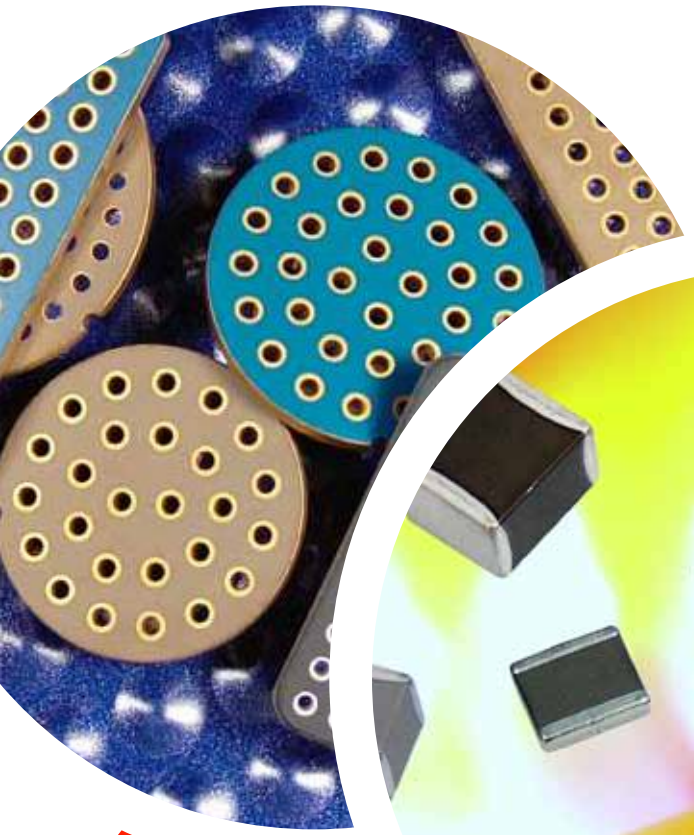
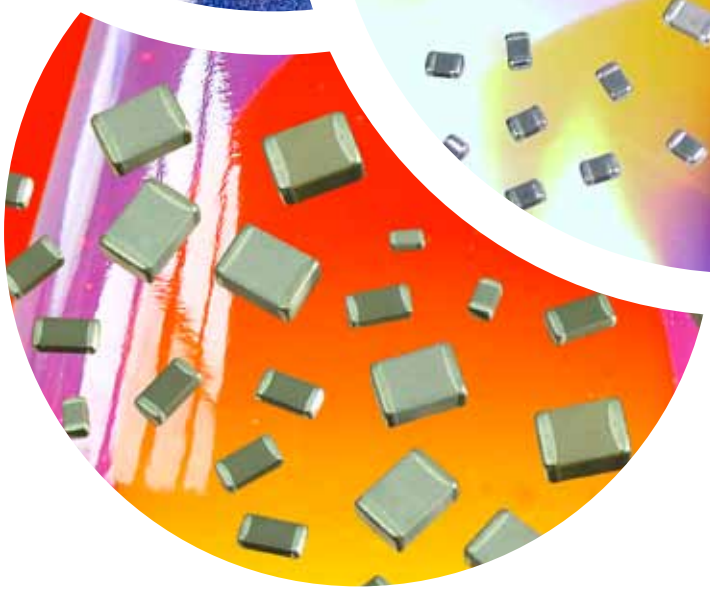
High Reliability Products





knowles®

DLI•Novacap•Syfer•Voltronics

Introduction

Knowles manufactures quality multilayer ceramic components supplied to a worldwide customer base.

Customers utilise Knowles' components in all types of applications including telecoms, industrial, automotive, military, aerospace, space and medical.

Different applications require corresponding reliability grade components. The purpose of this document is to provide a guide to the different reliability grades of multilayer ceramic components offered by Knowles.

Knowles' state-of-the-art manufacturing and test equipment in the Suzhou facility is supported by an integrated management system approved by BSI to ISO 9001.

Customers are encouraged to visit Knowles and review / audit our facilities and systems.

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www.knowlescapacitors.com

Contents

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 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
Recommended for Solder Attachment				●	●		●	●	●	●	●	●	●	●	●	●
Recommended for Conductive Epoxy Attachment		●	●			●										
Termination ordering code:	**DLI**	-	-	Z	U	S	-	-	-	-	-	-	-	-	-	-
	Novacap	P	PR	N	Y	NG	C	D	-	-	-	B	-	E	S	K
	Syfer	-	F	J	A	-	Y	H	3	-	5	2	-	4	-	-
Dielectric	**Code**															
C0G - Hi Q/Low ESR	DLI - UL			●	●	●										
	Syfer - Q, U			●	●											
C0G - Hi Q/Low ESR BME	Syfer - H			●												
C0G/NP0	Novacap - N/RN	●	●	●	●	●	●	●							●	●
	Syfer - **A**			●			●									
	Syfer - C, **F**		●	●	●		●	●								
C0G/NP0 - BME	Syfer - G, **K**			●												
C0G/NP0 - Non-Mag	Novacap - M	●	●									●		●		●
	Syfer - C, Q								●		●	●		●		
	Voltronics - Q		●							●		●	●			
X5R	Syfer - P		●	●	●		●	●								
	Novacap - BW			●	●	●										
X7R	Novacap - B/RB	●	●	●	●	●	●	●							●	●
	Syfer - **E**						●									
	Syfer - X, **D**		●	●	●		●	●								
X7R - BME	Novacap - BB			●	●	●										
	Syfer - J			●			●									
	Syfer - **S**						●									
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 - **T**						●									
C0G/NP0 (160°C)	Novacap - F	●	●	●	●		●	●							●	●
C0G/NP0 (200°C)	Novacap - D														●	●
C0G/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.

FlexiCap™ overview

FlexiCap™ termination

MLCCs are widely used in electronic circuit design for a multitude of applications. Their small package size, technical performance and suitability for automated assembly makes them the component of choice for the specifier.

However, despite the technical benefits, ceramic components are brittle and need careful handling on the production floor. In some circumstances they may be prone to mechanical stress damage if not used in an appropriate manner. Board flexing, depanelisation, mounting through hole components, poor storage and automatic testing may all result in cracking.

Careful process control is important at all stages of circuit board assembly and transportation - from component placement to test and packaging. Any significant board flexing may result in stress fractures in ceramic devices that may not always be evident during the board assembly process. Sometimes it may be the end customer who finds out - when equipment fails!

Knowles has the solution - FlexiCap™

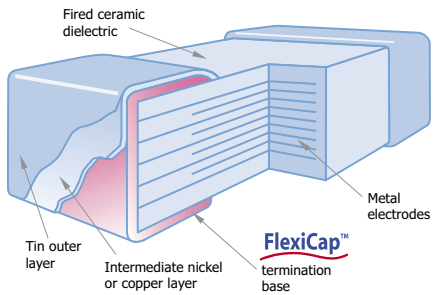
FlexiCap™ has been developed as a result of listening to customers' experiences of stress damage to MLCCs from many manufacturers, often caused by variations in production processes.

Our answer is a proprietary flexible epoxy polymer termination material, that is applied to the device under the usual nickel barrier finish. FlexiCap™ will accommodate a greater degree of board bending than conventional capacitors.

Knowles FlexiCap™ termination

Ranges are available with FlexiCap™ termination material offering increased reliability and superior mechanical performance (board flex and temperature cycling) when compared with standard termination materials. Refer to Knowles application note reference AN0001. FlexiCap™ capacitors enable the board to be bent almost twice as much before mechanical cracking occurs. Refer to application note AN0002.

FlexiCap™ is also suitable for Space applications having passed thermal vacuum outgassing tests. Refer to Syfer application note reference AN0026.



FlexiCap™ MLCC cross section

FlexiCap™ benefits

With traditional termination materials and assembly, the chain of materials from bare PCB to soldered termination, provides no flexibility. In circumstances where excessive stress is applied - the weakest link fails. This means the ceramic itself, which may fail short circuit.

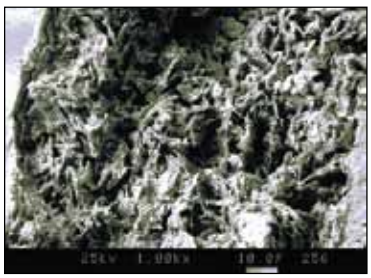
The benefit to the user is to facilitate a wider process window - giving a greater safety margin and substantially reducing the typical root causes of mechanical stress cracking.

FlexiCap™ may be soldered using your traditional wave or reflow solder techniques including lead free and needs no adjustment to equipment or current processes.

Knowles has delivered millions of FlexiCap™ components and during that time has collected substantial test and reliability data, working in partnership with customers world wide, to eliminate mechanical cracking.

An additional benefit of FlexiCap™ is that MLCCs can withstand temperature cycling -55ºC to 125ºC in excess of 1,000 times without cracking.

FlexiCap™ termination has no adverse effect on any electrical parameters, nor affects the operation of the MLCC in any way.



- Picture taken at 1,000x magnification using a SEM to demonstrate the fibrous nature of the FlexiCap™ termination that absorbs increased levels of mechanical stress.

Available on the following ranges:

- All High Reliability ranges
- Standard and High Voltage Capacitors
- Open Mode and Tandem Capacitors
- Safety Certified Capacitors
- Non-magnetic Capacitors
- 3 terminal EMI chips
- X2Y Integrated Passive Components
- X8R High Temperature capacitors

Summary of PCB bend test results

The bend tests conducted on X7R have proven that the FlexiCap™ termination withstands a greater level of mechanical stress before mechanical cracking occurs.

The AEC-Q200 test for X7R requires a bend level of 2mm minimum and a cap change of less than 10%.

Product X7R	Typical bend performance under AEC-Q200 test conditions
Standard termination	2mm to 3mm
FlexiCap™	Typically 8mm to 10mm

Application notes

FlexiCap™ may be handled, stored and transported in the same manner as standard terminated capacitors. The requirements for mounting and soldering FlexiCap™ are the same as for standard SMD capacitors.

For customers currently using standard terminated capacitors there should be no requirement to change the assembly process when converting to FlexiCap™.

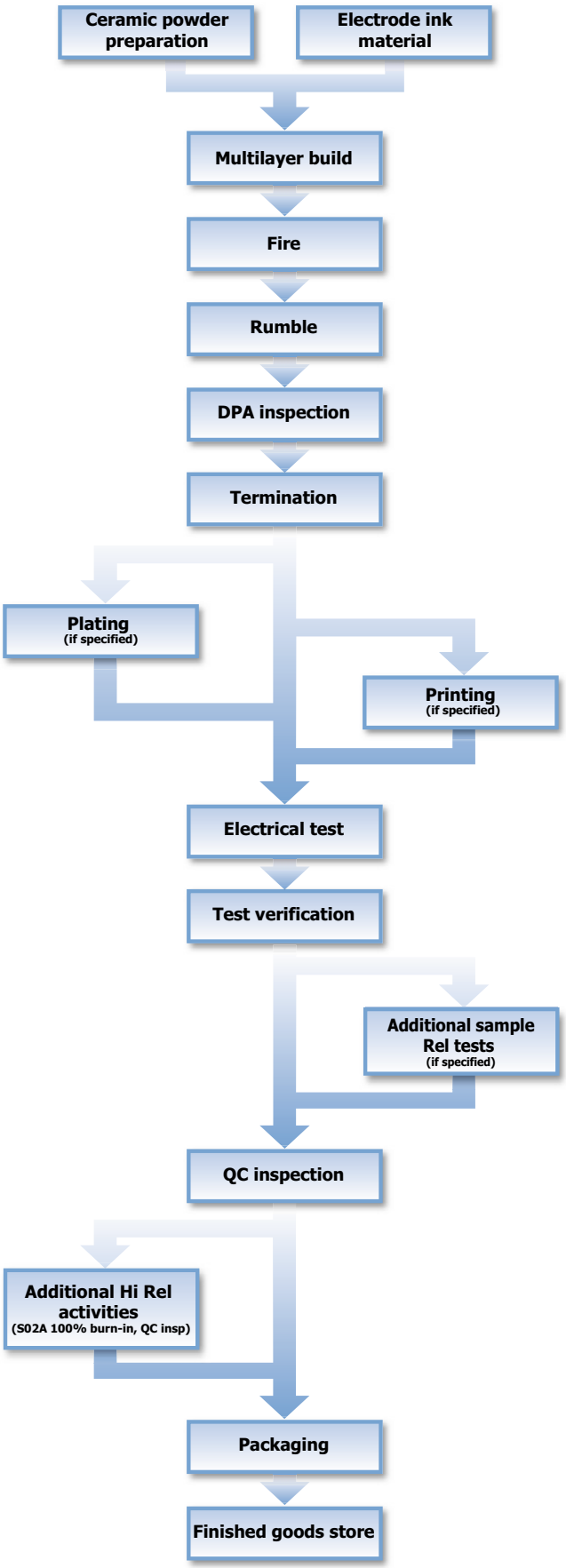
Based upon board bend tests in accordance with IEC 60384-1 the amount of board bending required to mechanically crack a FlexiCap™ terminated capacitor is significantly increased compared with standard terminated capacitors.

It must be stressed however, that capacitor users must not assume that the use of FlexiCap™ terminated capacitors will totally eliminate mechanical cracking. Good process controls are still required for this objective to be achieved.

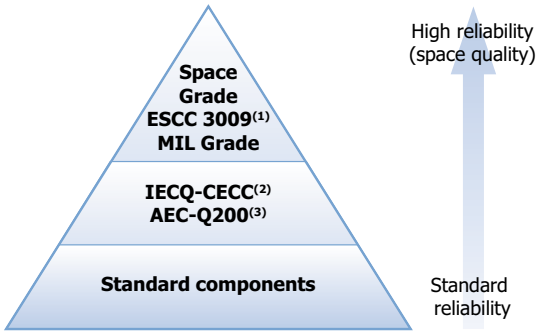
FlexiCap™

Manufacturing processes

Production process flowchart



Knowles reliability grades

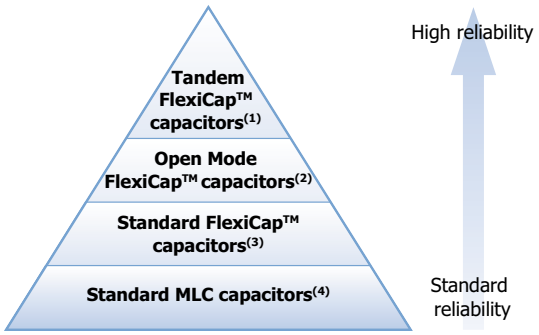


Notes:

1) Space grade tested in accordance with ESCC3009 (refer to Knowles Spec S02A 0100) or MIL Grade (in accordance with MIL-PRF-123, MIL-PRF-55681).
2) IECQ-CECC. The International Electrotechnical Commission (IEC) Quality Assessment System for Electronic Components. This is an internationally recognised product quality certification which provides customers with assurance that the product supplied meets high quality standards.

   View Knowles IECQ-CECC approvals at http://www.iecq.org or at www.knowlescapacitors.com
3) AEC-Q200. Automotive Electronics Council Stress Test Qualification For Passive Components. Refer to Knowles application note reference AN0009.

Knowles reliability surface mount product groups



Notes:

1) "Tandem" construction capacitors, ie internally having the equivalent of 2 series capacitors. If one of these should fail short-circuit, there is still capacitance end to end and the chip will still function as a capacitor, although capacitance maybe affected. Refer to application note AN0021. Also available qualified to AEC-Q200.
2) "Open Mode" capacitors with FlexiCap™ termination also reduce the possibility of a short circuit by utilising inset electrode margins. Refer to application note AN0022. Also available qualified to AEC-Q200.
3) Multilayer capacitors with Knowles FlexiCap™ termination. By using FlexiCap™ termination, there is a reduced possibility of the mechanical cracking occurring.
4) "Standard" capacitors includes MLCCs with tin finish over nickel but no FlexiCap™.

Testing

Tests conducted during batch manufacture

	Knowles reliability SM product group			
	Standard SM capacitors	IECQ-CECC / MIL grade	AEC-Q200	S (Space grade) High Rel S02A ESCC 3009 MIL-PRF-123
Solderability	●	●	●	●
Resistance to soldering heat	●	●	●	●
Plating thickness verification (if plated)	●	●	●	●
DPA (Destructive Physical Analysis)	●	●	●	●
Voltage proof test (DWV / Flash)	●	●	●	●
Insulation resistance	●	●	●	●
Capacitance test	●	●	●	●
Dissipation factor test	●	●	●	●
100% visual inspection	❍	❍	●	●
100% burn-in. (2xRV @125ºC for 168 hours)	❍	❍	❍	●
Load sample test @ 125ºC	❍	❍	●	LAT1 & LAT2 (1000 hours)
Humidity sample test. 85ºC/85%RH	❍	❍	●	240 hours
Hot IR sample test	❍	❍	❍	❍
Axial pull sample test (MIL-STD-123)	❍	❍	❍	❍
Breakdown voltage sample test	❍	❍	❍	❍
Deflection (bend) sample test	❍	❍	❍	❍
SAM (Scanning Acoustic Microscopy)	❍	❍	❍	❍
LAT1 (4 x adhesion, 8 x rapid temp change + LAT2 and LAT3)	-	-	-	❍
LAT2 (20 x 1000 hour life test + LAT3)	-	-	-	❍
LAT3 (6 x TC and 4 x solderability)	-	-	-	❍

● Test conducted as standard.
❍ Optional test. Please discuss with the Sales Office.

High Reliability Testing

Our High Rel products are designed for optimum reliability and are burned in at elevated voltage and temperature levels. They are 100% electrically inspected to ascertain conformance to a strict performance criteria.

Applications for High Reliability products include medical implanted devices, aerospace, airborne, various military applications, and consumer uses requiring safety margins not attainable with conventional product.

We have the ability to test surface mount and leaded capacitors to High Reliability standards as detailed below, or to customer SCD.

Military performance specifications are designed and written for the voltage/capacitance ratings of the individual product slash numbers associated with the specification.

Some of the requirements of the military document may not apply to the High Reliability product. The following details the intent of the individual military specifications available for test and the deviations that may apply.

Product voltage ratings outside of the intended military specification will follow the voltage test potential outlined.

Contact the Sales Office with any requirements or deviations that are not covered here.

Environmental Testing

We also have the capability to perform all the Environmental Group B, Group C and Qualification testing to the referenced military specifications.

Testing abilities include the following:

- Nondestructive internal examination
- Destructive physical analysis
- Radiographic inspection
- Terminal strength
- Resistance to soldering heat
- Voltage-temperature limits
- Temperature coefficient
- Moisture resistance
- Humidity, steady state, low voltage
- Vibration
- Resistance to solvents
- Life
- Thermal shock and immersion
- Low temperature storage
- Barometric pressure
- Shock, specified pulse
- Mechanical shock
- Constant acceleration
- Wire bond evaluation
- Partial discharge (corona)
- 200°C Voltage Conditioning

Military Performance Specifications

MIL-PRF-55681 (GROUP A)

General purpose military high reliability specification for surface mount sizes 0805 through 2225 in 50V and 100V.

- VOLTAGE CONDITIONING
- 100 HRS, 2X VDCW, 125°C
- DWV, IR, 125°C IR, CAP, DF TEST
- VISUAL & MECH. INSPECTION (AQL SAMPLE PLAN)
- SOLDERABILITY, SAMPLE 13(0)
- 8% PDA MAXIMUM

MIL-PRF-123 (GROUP A)

The specification affords an increased reliability level over MIL-PRF-55681 for space, missile and other high reliability applications such as medical implantable or life support equipment. The specification covers surface mount sizes 0805 through 2225 in 50V rating and various radial / axial leaded products in 50V, 100V and 200V ratings.

- THERMAL SHOCK, 20 CYCLES
- VOLTAGE CONDITIONING 168/264 HRS, 2X VDCW, 125°C
- DWV, IR, 125°C IR, CAP, DF TEST
- VISUAL & MECH. INSPECTION SAMPLE 20(0)
- DPA(1)
- PDA, 3% (0.1%), 5% (0.2%) MAX(2)

MIL-PRF-39014 (GROUP A)

The specification covers general military purpose radial / axial leaded and encapsulated product in 50V, 100V, and 200V ratings.

- THERMAL SHOCK, 5 CYCLES
- VOLTAGE CONDITIONING 96 HRS, 2X VDCW, 125°C
- DWV, IR, 125°C IR, CAP, DF TEST
- VISUAL & MECH. INSPECTION (AQL SAMPLE PLAN)
- SOLDERABILITY, SAMPLE 13(0)
- 8% PDA MAXIMUM

MIL-PRF-49467 (GROUP A)

General purpose military high reliability specification for radial leaded epoxy coated. The specification covers sizes 1515 through 13060 with 600V, 1kV, 2kV, 3kV, 4kV and 5kV ratings.

- THERMAL SHOCK, 5 CYCLES
- VOLTAGE CONDITIONING 96 HRS, RATED VDCW, 125°C
- PARTIAL DISCHARGE (OPTION) (3)
- DWV, IR, 125°C IR, CAP, DF TEST
- VISUAL & MECH. INSPECTION SAMPLE 13(0)
- SOLDERABILITY, SAMPLE 5(0)
- 10% PDA MAXIMUM

MIL-PRF-49470 (DSCC 87106) (GROUP A)

General purpose military high reliability specification for stacked and leaded capacitors for switch mode power supplies. The specification covers sizes 2225 through 120200 in 50V, 100V, 200V and 500V ratings.

- THERMAL SHOCK, 5 CYCLES
- VOLTAGE CONDITIONING 96 HRS, 2X VDCW(4), 125°C
- DWV, IR, 125°C IR, CAP, DF TEST
- VISUAL & MECH. INSPECTION SAMPLE 13(0)
- SOLDERABILITY, SAMPLE 5(0)
- 10% PDA MAXIMUM

MIL-PRF-38534

Specification for Hybrid Microcircuits with a section for Element Evaluation on passive components.

There are two classification levels of reliability. Class H is for a standard military quality level. Class K is for the highest reliability level intended for space application.

Knowles will perform a 100-hour burn-in on all Class K products and assumes Class K Subgroup 3 samples will be unmounted and Subgroup 4 (wirebond) shall not apply unless otherwise stated.

TEST VOLTAGE (VDC)

This test potential shall be used on all High Reliability Testing unless otherwise specified.

WVDC	DWV	V/C*
<200	2.5X Rated	2.0X Rated
250	500V	400V
300	500V	400V
400	600V	500V
500	750V	600V
600	750V	600V
>700	1.2X Rated	1.0X Rated

*V/C Is Voltage Conditioning.

Notes:

1. MIL-PRF-123 DPA shall be per TABLE XIV AQL requirements unless otherwise specified.
2. MIL-PRF-123 allowable PDA shall be 3% overall and 0.1% in the last 48 hours for capacitance/voltage values listed in MIL-PRF-123, and be 5% overall and 0.2% in the last 48 hours for capacitance/voltage values beyond MIL-PRF-123.
3. MIL-PRF-49467 standard Group A is without Partial Discharge. Partial Discharge test is optional and must be specified.
4. MIL-PRF-49470 (DSCC 87106) 500V rated product has Voltage Conditioning at 1.2X VDCW.

Regulations and Compliance

Release documentation

	Knowles reliability SM product group			
	Standard SM capacitors	IECQ-CECC	AEC-Q200 MIL grade	S (Space grade) High Rel S02A
Certificate of conformance	●	-	●	●
IECQ-CECC Release certificate of conformity	-	●	-	-
Batch electrical test report	❍	❍	❍	Included in data pack
S (space grade) data documentation package	-	-	-	●

● Release documentation supplied as standard.
❍ Original documentation.

Periodic tests conducted and reliability data availability

Standard Surface Mount capacitors

Components are randomly selected on a sample basis and the following routine tests are conducted:

- Load Test. 1,000 hours @125ºC (150ºC for X8R). Applied voltage depends on components tested.
- Humidity Test. 168 hours @ 85ºC/85%RH.
- Board Deflection (bend test).

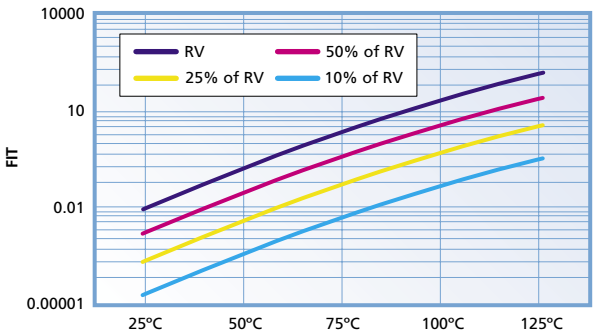
Test results are available on request.

Conversion factors

From	To	Operation
FITS	MTBF (hours)	$10^9 \div$ FITS
FITS	MTBF (years)	$10^9 \div$ (FITS x 8760)

FITS = Failures in 10^9 hours.
MTBF = Mean time between failures.

Example of FIT (Failure In Time) data available:



Component type: 0805 (C0G/NP0 and X7R).
Testing location: Knowles reliability test department.
Results based on: 16,622,000 component test hours.

REACH (Registration, Evaluation, Authorisation and restriction of Chemicals) statement

The main purpose of REACH is to improve the protection of human health and the environment from the risks arising from the use of chemicals.

Knowles maintains both ISO14001, Environmental Management System and OHSAS 18001 Health and Safety Management System approvals that require and ensure compliance with corresponding legislation such as REACH.

For further information, please contact the Knowles Capacitors Sales Office at www.knowlescapacitors.com

RoHS compliance

Knowles routinely monitors world wide material restrictions (e.g. EU/China and Korea RoHS mandates) and is actively involved in shaping future legislation.

All standard C0G/NP0, X7R, X5R and High Q Knowles MLCC products are compliant with the EU RoHS directive (see below for special exceptions) and those with plated terminations are suitable for soldering using common lead free solder alloys (refer to 'Soldering Information' for more details on soldering limitations). Compliance with the EU RoHS directive automatically signifies compliance with some other legislation (e.g. China and Korea RoHS). Please refer to the Knowles Capacitors Sales Office for details of compliance with other materials legislation.

Breakdown of material content, SGS analysis reports and tin whisker test results are available on request.

Most Knowles MLCC components are available with non RoHS compliant tin lead (SnPb) solderable termination finish for exempt applications and where pure tin is not acceptable. Other tin free termination finishes may also be available – please refer to the Knowles Capacitors Sales Office for further details.

Radial components have tin plated leads as standard but tin/lead is available as a special option. Please refer to the radial section of the catalogue for further details.

X8R ranges <250Vdc are not RoHS 2011/65/EU compliant. Check the website, www.knowlescapacitors.com for latest RoHS update.

Export controls and dual-use regulations

Certain Knowles catalogue components are defined as 'dual-use' items under international export controls - those that can be used for civil or military purposes which meet certain specified technical standards.

The defining criteria for a dual use component with respect to Knowles Capacitor products is one with a voltage rating of >750Vdc and a capacitance value of >250nF when measured at 750Vdc and a series inductance <10nH. Components defined as dual-use under the above criteria may require a licence for export across international borders. Please contact the Sales Office for further information on specific part numbers.

Explanation of Ageing of MLC

Ageing

Capacitor ageing is a term used to describe the negative, logarithmic capacitance change which takes place in ceramic capacitors with time. The crystalline structure for barium titanate based ceramics changes on passing through its Curie temperature (known as the Curie Point) at about 125°C. This domain structure relaxes with time and in doing so, the dielectric constant reduces logarithmically; this is known as the ageing mechanism of the dielectric constant. The more stable dielectrics have the lowest ageing rates.

The ageing process is reversible and repeatable. Whenever the capacitor is heated to a temperature above the Curie Point the ageing process starts again from zero.

The ageing constant, or ageing rate, is defined as the percentage loss of capacitance due to the ageing process of the dielectric which occurs during a decade of time (a tenfold increase in age) and is expressed as percent per logarithmic decade of hours. As the law of decrease of capacitance is logarithmic, this means that in a capacitor with an ageing rate of 1% per decade of time, the capacitance will decrease at a rate of:

a) 1% between 1 and 10 hours

b) An additional 1% between the following 10 and 100 hours

c) An additional 1% between the following 100 and 1000 hours

d) An additional 1% between the following 1000 and 10000 hours etc

e) The ageing rate continues in this manner throughout the capacitor's life.

Typical values of the ageing constant for our Multilayer Ceramic Capacitors are:

Dielectric class	Typical values
Ultra Stable C0G/NP0	Negligible capacitance loss through ageing
Stable X7R	<2% per decade of time

Capacitance measurements

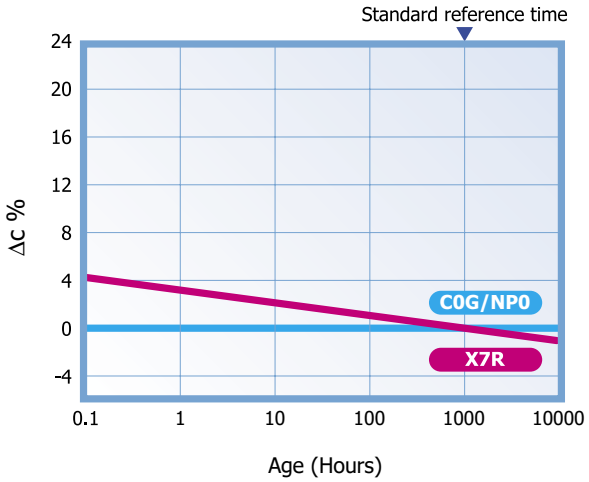
Because of ageing it is necessary to specify an age for reference measurements at which the capacitance shall be within the prescribed tolerance. This is fixed at 1000 hours, since for practical purposes there is not much further loss of capacitance after this time.

All capacitors shipped are within their specified tolerance at the standard reference age of 1000 hours after having cooled through their Curie temperature.

The ageing curve for any ceramic dielectric is a straight line when plotted on semi-log paper.

Capacitance vs time

(Ageing X7R @ <2% per decade)



Tight tolerance

One of the advantages of Knowles' unique 'wet process' of manufacture is the ability to offer capacitors with exceptionally tight capacitance tolerances.

The accuracy of the printing screens used in the fully automated, computer controlled manufacturing process allows for tolerance as close as +/-1% on C0G/NP0 parts greater than or equal to 10pF. For capacitance values below <4.7pF, tolerances can be as tight as +/-0.05pF.

Mounting, Soldering, Storage & Mechanical Precautions

Detailed application notes intended to guide and assist our customers in using multilayer ceramic capacitors in surface mount technology are available on the Knowles website www.knowlescapacitors.com

The information concentrates on the handling, mounting, connection, cleaning, test and re-work requirements particular to MLC's for SMD technology, to ensure a suitable match between component capability and user expectation. Some extracts are given below.

Mechanical considerations for mounted ceramic chip capacitors

Due to their brittle nature, ceramic chip capacitors are more prone to excesses of mechanical stress than other components used in surface mounting.

One of the most common causes of failure is directly attributable to bending the printed circuit board after solder attachment. The excessive or sudden movement of the flexible circuit board stresses the inflexible ceramic block causing a crack to appear at the weakest point, usually the ceramic/termination interface. The crack may initially be quite small and not penetrate into the inner electrodes; however, subsequent handling and rapid changes in temperature may cause the crack to enlarge.

This mode of failure is often invisible to normal inspection techniques as the resultant cracks usually lie under the capacitor terminations but if left, can lead to catastrophic failure. More importantly, mechanical cracks, unless they are severe may not be detected by normal electrical testing of the completed circuit, failure only occurring at some later stage after moisture ingression.

The degree of mechanical stress generated on the printed circuit board is dependent upon several factors including the board material and thickness; the amount of solder and land pattern. The amount of solder applied is important, as an excessive amount reduces the chip's resistance to cracking.

It is Knowles's experience that more than 90% are due to board depanelisation, a process where two or more circuit boards are separated after soldering is complete. Other manufacturing stages that should be reviewed include:

1) Attaching rigid components such as connectors, relays, display panels, heat sinks etc.
2) Fitting conventional leaded components. Special care must be exercised when rigid terminals, as found on large can electrolytic capacitors, are inserted.
3) Storage of boards in such a manner which allows warping.
4) Automatic test equipment, particularly the type employing "bed of nails" and support pillars.
5) Positioning the circuit board in its enclosure especially where this is a "snap-fit".

Knowles were the first MLCC manufacturer to launch a flexible termination to significantly reduce the instances of mechanical cracking. FlexiCap™ termination introduces a certain amount of give into the termination layer absorbing damaging stress. Unlike similar systems, FlexiCap™ does not tear under tension, but absorbs the stress, so maintaining the characteristics of the MLCC.

SM Pad Design

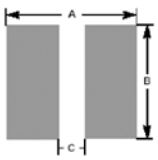
Knowles conventional 2-terminal chip capacitors can generally be mounted using pad designs in accordance with IPC-7351, Generic Requirements for Surface Mount Design and Land Pattern Standards, but there are some other factors that have been shown to reduce mechanical stress, such as reducing the pad width to less than the chip width. In addition, the position of the chip on the board should also be considered.

3-Terminal components are not specifically covered by IPC-7351, but recommended pad dimensions are included in the Knowles catalogue / website for these components.

Alternative Printed Wire Board Land Patterns

Printed Wire Board land pattern design for chip components is critical to ensure a reliable solder fillet, and to reduce nuisance type manufacturing problems such as component swimming and tombstoning. The land pattern suggested can be used for reflow and wave solder operations as noted. Land patterns constructed with these dimensions will yield optimized solder fillet formation and thus reduce the possibility of early failure.[1]

A = (Max Length) + 0.030" (.762mm)*
B = (Max Width) + 0.010" (.254mm)**
C = (Min Length) – 2 (Nominal Band)***



* Add 0.030" for Wave Solder operations.
** Replace "Max Width" with "Max Thickness" for vertical mounting.
*** "C" to be no less than 0.02", change "A" to (Max Length) + 0.020".

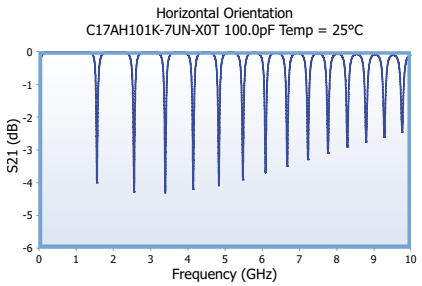
For C04 "C" to be no less than 0.01".

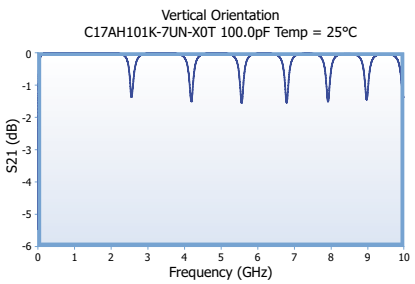
1. Frances Classon, James Root, Martin Marietta Orlando Aerospace, "Electronics Packaging and Interconnection Handbook".

MLC Orientation - Horizontal and Vertical Mounting

The orientation of the MLC relative to the ground plane affects the devices' impedance. When the internal electrodes are parallel to the ground plane (Horizontal mounting) the impedance of the MLC resembles a folded transmission line driven from one end.

The graphs below show the modeled insertion loss and parallel resonances of Knowles product C17AH101K-7UN-X0T with horizontal mounting (modeling can be done in CapCad). When the internal electrodes are perpendicular to the ground plane (Vertical mounting, bottom graph) the MLC impedance resembles a folded transmission line driven from the center reducing resonance effects.





Mounting, Soldering, Storage & Mechanical Precautions

Knowles MLCCs are compatible with all recognised soldering / mounting methods for chip capacitors.

Specific application notes on mounting and soldering Knowles components are included on the website for each brand.

- For DLI brand components please see DLI application note "Recommended Solder Attachment Techniques for MLC Chip and Pre-Tinned Capacitors" located at: **http://www.knowlescapacitors.com/dilabs/en/gn/resources/application-notes**
- For Syfer brand components, please see Syfer application note AN0028 "Soldering / Mounting Chip Capacitors, Radial Leaded Capacitors and EMI Filters" located at: **http://www.knowlescapacitors.com/syfer/en/gn/technical-info/application-notes**
- For Novacap brand products please refer to the appropriate application note located at: **http://www.knowlescapacitors.com/novacap/en/gn/technical-info/application-notes**

The volume of solder applied to the chip capacitor can influence the reliability of the device. Excessive solder can create thermal and tensile stresses on the component which can lead to fracturing of the chip or the solder joint itself. Insufficient or uneven solder application can result in weak bonds, rotation of the device off line or lifting of one terminal off the pad (tombstoning). The volume of solder is process and board pad size dependent.

Soldering methods commonly used in industry are Reflow Soldering, Wave Soldering and, to a lesser extent, Vapour Phase Soldering. All these methods involve thermal cycling of the components and therefore the rate of heating and cooling must be controlled to preclude thermal shocking of the devices.

Without mechanical restriction, thermally induced stresses are released once the capacitor attains a steady state condition. Capacitors bonded to substrates, however, will retain some stress, due primarily to the mismatch of expansion of the component to the substrate; the residual stress on the chip is also influenced by the ductility and hence the ability of the bonding medium to relieve the stress. Unfortunately, the thermal expansion of chip capacitors differ significantly from those of most substrate materials.

Large chips are more prone to thermal shock as their greater bulk will result in sharper thermal gradients within the device during thermal cycling. Large units experience excessive stress if processed through the fast cycles typical of solder wave or vapour phase operations.

Reflow soldering Surface Mount Chip Capacitors

Knowles recommend reflow soldering as the preferred method for mounting MLCCs. Knowles MLCCs can be reflow soldered using a reflow profile generally as defined in IPC / JEDEC J-STD-020. Sn plated termination chip capacitors are compatible with both conventional and lead free soldering, with peak temperatures of 260ºC to 270ºC acceptable.

The heating ramp rate should be such that components see a temperature rise of 1.5ºC to 4ºC per seconds to maintain temperature uniformity through the MLCC. The time for which the solder is molten should be maintained at a minimum, so as to prevent solder leaching. Extended times above 230ºC can cause problems with oxidation of Sn plating. Use of inert atmosphere can help if this problem is encountered. PdAg terminations can be particularly susceptible to leaching with lead free, tin rich solders and trials are recommended for this combination. Cooling to ambient temperature should be allowed to occur naturally, particularly if larger chip sizes are being soldered. Natural cooling allows a gradual relaxation of thermal mismatch stresses in the solder joints. Forced cooling should be avoided as this can induce thermal breakage.

Wave soldering Surface Mount Chip Capacitors

Wave soldering is generally acceptable, but the thermal stresses caused by the wave have been shown to lead to potential problems with larger or thicker chips. Particular care should be taken when soldering SM chips larger than size 1210 and with a thickness greater than 1.0mm for this reason. 0402 size components are not suitable for wave soldering. 0402 size components can also be susceptible to termination leaching and reflow soldering is recommended for this size MLCC.

Wave soldering exposes the devices to a large solder volume, hence the pad size area must be restricted to accept an amount of solder which is not detrimental to the chip size utilized. Typically the pad width is 66% of the component width, and the length is .030" (.760 mm) longer than the termination band on the chip. An 0805 chip which is .050" wide and has a .020" termination band therefore requires a pad .033" wide by .050" in length. Opposing pads should be identical in size to preclude uneven solder fillets and mismatched surface tension forces which can misalign the device. It is preferred that the pad layout results in alignment of the long axis of the chips at right angles to the solder wave, to promote even wetting of all terminals. Orientation of components in line with the board travel direction may require dual waves with solder turbulence to preclude cold solder joints on the trailing terminals of the devices, as these are blocked from full exposure to the solder by the body of the capacitor.

The pre-heat ramp should be such that the components see a temperature rise of 1.5ºC to 4ºC per second as for reflow soldering. This is to maintain temperature uniformity through the MLCC and prevent the formation of thermal gradients within the ceramic. The preheat temperature should be within 120ºC maximum (100ºC preferred) of the maximum solder temperature to minimise thermal shock. Maximum permissible wave temperature is 270ºC for SM chips. Total immersion exposure time for Sn/Ni terminations is 30s at a wave temperature of 260ºC. Note that for multiple soldering operations, including the rework, the soldering time is cumulative.

The total immersion time in the solder should be kept to a minimum. It is strongly recommended that plated terminations are specified for wave soldering applications. PdAg termination is particularly susceptible to leaching when subjected to lead free wave soldering and is not generally recommended for this application.

Cooling to ambient temperature should be allowed to occur naturally, particularly if larger chip sizes are being soldered. Natural cooling allows a gradual relaxation of thermal mismatch stresses in the solder joints. Forced cooling should be avoided as this can induce thermal breakage.

Vapour phase soldering Chip Capacitors

Vapour phase soldering can expose capacitors to similar thermal shock and stresses as wave soldering and the advice is generally the same. Particular care should be taken in soldering large capacitors to avoid thermal cracks being induced and natural cooling should be use to allow a gradual relaxation of stresses.

Hand soldering and rework of Chip Capacitors

Attachment using a soldering iron requires extra care and is accepted to have a risk of cracking of the chip. Precautions include preheating of the assembly to within 100°C of the solder flow temperature and the use of a fine tip iron which does not exceed 30 watts. In no circumstances should the tip of the iron be allowed to contact the chip directly.

Knowles recommend hot air/gas as the preferred method for applying heat for rework. Apply even heat surrounding the component to minimise internal thermal gradients.

Minimise the rework heat duration and allow components to cool naturally after soldering.

Mounting, Soldering, Storage & Mechanical Precautions

Wave soldering Radial Leaded Chip Capacitors

Radial leaded capacitors are suitable for wave soldering when mounted on the opposite side of the board to the wave. The body of radial components should not be exposed directly to the wave. Maximum permissible wave temperature is 260ºC for Radial Leaded capacitors.

Hand soldering Radial Leaded capacitors

Radial capacitors can be hand soldered into boards using soldering irons, provided care is taken not to touch the body of the capacitor with the iron tip. Soldering should be carried out from the opposite side of the board to the radial to minimise the risk of damage to the capacitor body. Where possible, a heat sink should be used between the solder joint and the body, especially if longer dwell times are required.

Solder leaching

Leaching is the term for the dissolution of silver into the solder causing a failure of the termination system which causes increased ESR, tan δ and open circuit faults, including ultimately the possibility of the chip becoming detached. Leaching occurs more readily with higher temperature solders and solders with a high tin content. Pb free solders can be very prone to leaching certain termination systems. To prevent leaching, exercise care when choosing solder alloys and minimize both maximum temperature and dwell time with the solder molten.

Plated terminations with nickel or copper anti leaching barrier layers are available in a range of top coat finishes to prevent leaching occurring. These finishes also include Syfer FlexiCap™ for improved stress resistance post soldering.

Bonding

Hybrid assembly using conductive epoxy or wire bonding requires the use of silver palladium or gold terminations. Nickel barrier termination is not practical in these applications, as intermetallics will form between the dissimilar metals. The ESR will increase over time and may eventually break contact when exposed to temperature cycling.

Cleaning

Chip capacitors can withstand common agents such as water, alcohol and degreaser solvents used for cleaning boards. Ascertain that no flux residues are left on the chip surfaces as these diminish electrical performance.

Handling

Ceramics are dense, hard, brittle and abrasive materials. They are liable to suffer mechanical damage, in the form of chips or cracks, if improperly handled.

Terminations may be abraded onto chip surfaces if loose chips are tumbled in bulk. Metallic tracks may be left on the chip surfaces which might pose a reliability hazard.

Components should never be handled with fingers; perspiration and skin oils can inhibit solderability and will aggravate cleaning.

Chip capacitors should never be handled with metallic instruments. Metal tweezers should never be used as these can chip the product and may leave abraded metal tracks on the product surface. Plastic or plastic coated metal types are readily available and recommended - these should be used with an absolute minimum of applied pressure.

Counting or visual inspection of chip capacitors is best performed on a clean glass or hard plastic surface.

If chips are dropped or subjected to rough handling, they should be visually inspected before use. Electrical inspection may also reveal gross damage via a change in capacitance, an increase in dissipation factor or a decrease either in insulation resistance or electrical strength.

Transportation

Where possible, any transportation should be carried out with the product in its unopened original packaging. If already opened, any environmental control agents supplied should be returned to packaging and the packaging re-sealed.

Avoid paper and card as a primary means of handling, packing, transportation and storage of loose components. Many grades have a sulphur content which will adversely affect termination solderability.

Loose chips should always be packed with sulphur-free wadding to prevent impact or abrasion damage during transportation.

Storage

Incorrect storage of components can lead to problems for the user. Rapid tarnishing of the terminations, with an associated degradation of solderability, will occur if the product comes into contact with industrial gases such as sulphur dioxide and chlorine. Storage in free air, particularly moist or polluted air, can result in termination oxidation.

Packaging should not be opened until the MLCs are required for use. If opened, the pack should be re-sealed as soon as is practicable. Alternatively, the contents could be kept in a sealed container with an environmental control agent.

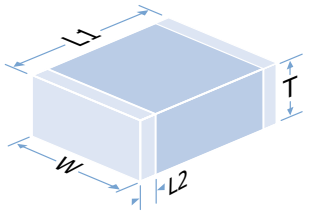
Long term storage conditions, ideally, should be temperature controlled between -5 and +40°C and humidity controlled between 40 and 60% R.H.

Taped product should be stored out of direct sunlight, which might promote deterioration in tape or adhesive performance.

Product, stored under the conditions recommended above, in its "as received" packaging, has a minimum shelf life of 2 years.

Chip dimensions

1. For FlexiCap™ terminations, length increase by maximum 0.004" (0.1mm).
2. For special ranges, inc. High Q and Ultra-low ESR, dimensions may vary. See individual catalogue page.
3. High Q and Ultra-low ESR ranges dimensions may vary for optimum performance.
4. Non-standard thicknesses are available – consult local Knowles Capacitors Sales Office.



Size	Length (L1)	Width (W)	Max. Thickness (T)	Termination Band (L2)	
	mm ~ inches	mm ~ inches	mm ~ inches	min (mm ~ inches)	max (mm ~ inches)
0402	1.0 ± 0.10 ~ 0.04 ± 0.004	0.50 ± 0.10 ~ 0.02 ± 0.004	0.60 ~ 0.024	0.10 ~ 0.004	0.40 ~ 0.016
C04	1.057 ± 0.188 ~ 0.042 ± 0.008	0.515 ± 0.153 ~ 0.02 ± 0.006	0.64 ~ 0.025	0.097 ~ 0.004	0.427 ~ 0.017
0504	1.27 ± 0.152 ~ 0.050 ± 0.006	1.02 ± 0.152 ~ 0.04 ± 0.006	1.12 ~ 0.044	0.20 ~ 0.008	0.50 ~ 0.02
0505	1.4 +0.35 -0.25 ~ 0.055 +0.014 -0.01	1.4 ± 0.25 ~ 0.055 ± 0.01	1.27 ~ 0.05	0.13 ~ 0.005	0.5 ~ 0.02
RF0505	1.4 ± 0.13 ~ 0.055 ± 0.005	1.4 ± 0.381 ~ 0.055 ± 0.015	1.45 ~ 0.057	0.20 ~ 0.008	0.50 ~ 0.02
C11	1.477 ± 0.391 ~ 0.059 ± 0.016	1.416 ± 0.451 ~ 0.056 ± 0.018	1.334 ~ 0.053	0.193 ~ 0.008	0.733 ~ 0.029
0603	1.6 ± 0.15 ~ 0.063 ± 0.006	0.8 ± 0.15 ~ 0.032 ± 0.006	0.90 ~ 0.036	0.20 ~ 0.004	0.40 ~ 0.016
C06	1.532 ± 0.229 ~ 0.06 ± 0.009	0.77 ± 0.191 ~ 0.031 ± 0.008	0.8 ~ 0.032	0.169 ~ 0.007	0.680 ~ 0.027
C07	1.797 ± 0.470 ~ 0.071 ± 0.019	2.813 ± 0.521 ~ 0.111 ± 0.021	2.667 ~ 0.105	0.193 ~ 0.008	1.20 ~ 0.047
0805	2.0 ± 0.20 ~ 0.079 ± 0.008	1.25 ± 0.20 ~ 0.049 ± 0.008	1.37 ~ 0.054	0.25 ~ 0.010	0.75 ~ 0.030
C08	2.048 ± 0.407 ~ 0.081 ± 0.016	1.28 ± 0.267 ~ 0.051 ± 0.011	1.360 ~ 0.054	0.362 ~ 0.014	1.04 ~ 0.041
0907	2.29 ± 0.203 ~ 0.090 ± 0.008	1.78 ± 0.203 ~ 0.070 ± 0.008	1.52 ~ 0.06	0.25 ~ 0.010	0.75 ~ 0.030
1005	2.54 ± 0.203 ~ 0.100 ± 0.008	1.27 ± 0.203 ~ 0.050 ± 0.008	1.37 ~ 0.054	0.25 ~ 0.010	0.75 ~ 0.030
1111	2.79 +0.51 -0.25 ~ 0.11 +0.02 -0.01	2.79 ± 0.38 ~ 0.113 ± 0.015	1.78 ~ 0.07	0.13 ~ 0.005	0.63 ~ 0.025
RF1111	2.79 ± 0.39 ~ 0.110 ± 0.005	2.79 ± 0.381 ~ 0.110 ± 0.015	2.59 ~ 0.102	0.25 ~ 0.010	0.75 ~ 0.030
C17	2.94 ± 0.527 ~ 0.116 ± 0.021	2.813 ± 0.521 ~ 0.111 ± 0.021	2.667 ~ 0.105	0.193 ~ 0.008	1.2 ~ 0.047
C18	3.14 ± 0.727 ~ 0.124 ± 0.029	2.946 ± 0.654 ~ 0.116 ± 0.026	2.667 ~ 0.105	0.193 ~ 0.008	1.2 ~ 0.047
1206	3.2 ± 0.20 ~ 0.126 ± 0.008	1.6 ± 0.20 ~ 0.063 ± 0.008	1.70 ~ 0.068	0.25 ~ 0.010	0.75 ~ 0.030
1210	3.2 ± 0.20 ~ 0.126 ± 0.008	2.5 ± 0.20 ~ 0.098 ± 0.008	2.0 ~ 0.08	0.25 ~ 0.010	0.75 ~ 0.030
1515	3.81 ± 0.381 ~ 0.150 ± 0.015	3.81 ± 0.381 ~ 0.150 ± 0.015	3.3 ~ 0.13	0.381 ~ 0.015	1.143 ~ 0.045
1808	4.5 ± 0.35 ~ 0.180 ± 0.014	2.0 ± 0.30 ~ 0.08 ± 0.012	2.0 ~ 0.08	0.25 ~ 0.01	1.0 ~ 0.04
1812	4.5 ± 0.30 ~ 0.180 ± 0.012	3.2 ± 0.20 ~ 0.126 ± 0.008	3.2 ~ 0.125	0.25 ~ 0.010	1.143 ~ 0.045
1825	4.5 ± 0.30 ~ 0.180 ± 0.012	6.40 ± 0.40 ~ 0.252 ± 0.016	4.2 ~ 0.16	0.25 ~ 0.010	1.0 ~ 0.04
2020	5.0 ± 0.40 ~ 0.197 ± 0.016	5.0 ± 0.40 ~ 0.197 ± 0.016	4.5 ~ 0.18	0.25 ~ 0.01	1.0 ~ 0.04
2220	5.7 ± 0.40 ~ 0.225 ± 0.016	5.0 ± 0.40 ~ 0.197 ± 0.016	4.2 ~ 0.165	0.25 ~ 0.01	1.0 ~ 0.04
2211	5.7 ± 0.40 ~ 0.225 ± 0.016	2.79 ± 0.30 ~ 0.11 ± 0.012	2.5 ~ 0.1	0.25 ~ 0.01	0.8 ~ 0.03
2215	5.7 ± 0.40 ~ 0.225 ± 0.016	3.81 ± 0.35 ~ 0.35 ± 0.02	2.5 ~ 0.1	0.25 ~ 0.01	0.8 ~ 0.03
2221	5.59 ± 0.381 ~ 0.220 ± 0.015	5.33 ± 0.381 ~ 0.210 ± 0.015	2.03 ~ 0.08	0.381 ~ 0.015	1.143 ~ 0.045
2225	5.7 ± 0.40 ~ 0.225 ± 0.016	6.30 ± 0.40 ~ 0.252 ± 0.016	4.2 ~ 0.165	0.381 ~ 0.01	1.143 ~ 0.045
C22	5.734 ± 0.667 ~ 0.226 ± 0.026	6.37 ± 0.699 ~ 0.251 ± 0.028	3.467 ~ 0.137	N/A	N/A
2520	6.35 ± 0.40 ~ 0.250 ± 0.016	5.08 ± 0.40 ~ 0.200 ± 0.016	4.57 ~ 0.18	0.381 ~ 0.015	1.143 ~ 0.045
RF2525	5.84 ± 0.21 ~ 0.230 ± 0.008	6.35 ± 0.381 ~ 0.250 ± 0.015	4.19 ~ 0.165	0.381 ~ 0.015	1.143 ~ 0.045
3333	8.38 ± 0.432 ~ 0.330 ± 0.017	8.38 ± 0.432 ~ 0.330 ± 0.017	6.35 ~ 0.25	0.381 ~ 0.015	1.143 ~ 0.045
3530	8.89 ± 0.457 ~ 0.350 ± 0.018	7.62 ± 0.381 ~ 0.300 ± 0.015	6.35 ~ 0.25	0.381 ~ 0.015	1.143 ~ 0.045
3640	9.2 ± 0.50 ~ 0.36 ± 0.02	10.16 ± 0.50 ~ 0.40 ± 0.02	4.5 ~ 0.18	0.50 ~ 0.02	1.50 ~ 0.06
C40	9.732 ± 0.804 ~ 0.384 ± 0.032	8.665 ± 1.737 ~ 0.381 ± 0.029	3.467 ~ 0.137	N/A	N/A
4040	10.2 ± 0.508 ~ 0.400 ± 0.020	10.2 ± 0.508 ~ 0.400 ± 0.020	7.62 ~ 0.30	0.50 ~ 0.02	1.50 ~ 0.06
4540	11.4 ± 0.584 ~ 0.450 ± 0.023	10.2 ± 0.508 ~ 0.400 ± 0.020	7.62 ~ 0.30	0.50 ~ 0.02	1.50 ~ 0.06
5440	13.7 ± 0.686 ~ 0.540 ± 0.027	10.2 ± 0.508 ~ 0.400 ± 0.020	7.62 ~ 0.30	0.50 ~ 0.02	1.50 ~ 0.06
5550	14.0 ± 0.711 ~ 0.550 ± 0.028	12.7 ± 0.635 ~ 0.500 ± 0.025	7.62 ~ 0.30	0.50 ~ 0.02	1.50 ~ 0.06
6560	16.5 ± 0.838 ~ 0.650 ± 0.033	15.2 ± 0.762 ~ 0.600 ± 0.030	7.62 ~ 0.30	0.50 ~ 0.02	1.50 ~ 0.06
7565	19.1 ± 0.965 ~ 0.750 ± 0.038	16.5 ± 0.838 ~ 0.650 ± 0.033	7.62 ~ 0.30	0.50 ~ 0.02	1.50 ~ 0.06
8060	20.3 ± 0.5 ~ 0.80 ± 0.02	15.24 ± 0.50 ~ 0.60 ± 0.02	4.2 ~ 0.165	0.50 ~ 0.02	1.50 ~ 0.06

Chip Marking System

If required, we can mark capacitors with the EIA 198 two digit code to show the capacitance value of the part. On chips larger than 3333, or for leaded encapsulated devices, ink marking is available. However, for chip sizes 0805 through to 3333 identification marking is accomplished by using either laser or ink jet printer. This system does not degrade the ceramic surface, or induce microcracks in the part.

Marking for other sizes may be available upon special request to determine if applicable; please contact the sales office.

Marking is an option on Novacap and Syfer branded products and needs to be specified when ordering.

Two position alpha numeric marking is available on chip sizes 0805 through 3333.
The marking denotes retma value and significant figures of capacitance (see table) eg: A5 = 100,000pF.

Three position alpha numeric marking is available on chip sizes 1206 and larger.
The making denotes Novacap as vendor (N), followed by the standard two digit alpha numeric identification.

Marking Code - value in picofarads for alpha-numeric code

Number		0	1	2	3	4	5	6	7
Letter	A	1.0	10	100	1,000	10,000	100,000	1,000,000	10,000,000
	B	1.1	11	110	1,100	11,000	110,000	1,100,000	11,000,000
	C	1.2	12	120	1,200	12,000	120,000	1,200,000	12,000,000
	D	1.3	13	130	1,300	13,000	130,000	1,300,000	13,000,000
	E	1.5	15	150	1,500	15,000	150,000	1,500,000	15,000,000
	F	1.6	16	160	1,600	16,000	160,000	1,600,000	16,000,000
	G	1.8	18	180	1,800	18,000	180,000	1,800,000	18,000,000
	H	2.0	20	200	2,000	20,000	200,000	2,000,000	20,000,000
	J	2.2	22	220	2,200	22,000	220,000	2,200,000	22,000,000
	K	2.4	24	240	2,400	24,000	240,000	2,400,000	24,000,000
	L	2.7	27	270	2,700	27,000	270,000	2,700,000	27,000,000
	M	3.0	30	300	3,000	30,000	300,000	3,000,000	30,000,000
	N	3.3	33	330	3,300	33,000	330,000	3,000,000	33,000,000
	P	3.6	36	360	3,600	36,000	360,000	3,600,000	36,000,000
	Q	3.9	39	390	3,900	39,000	390,000	3,900,000	39,000,000
	R	4.3	43	430	4,300	43,000	430,000	4,300,000	43,000,000
	S	4.7	47	470	4,700	47,000	470,000	4,700,000	47,000,000
	T	5.1	51	510	5,100	51,000	510,000	5,100,000	51,000,000
	U	5.6	56	560	5,600	56,000	560,000	5,600,000	56,000,000
	V	6.2	62	620	6,200	62,000	620,000	6,200,000	62,000,000
	W	6.8	68	680	6,800	68,000	680,000	6,800,000	68,000,000
	X	7.5	75	750	7,500	75,000	750,000	7,500,000	75,000,000
	Y	8.2	82	820	8,200	82,000	820,000	8,200,000	82,000,000
	Z	9.1	91	910	9,100	91,000	920,000	9,200,000	92,000,000
	a	2.5	25	250	2,500	25,000	250,000	2,500,000	25,000,000
	b	3.5	35	350	3,500	35,000	350,000	3,500,000	35,000,000
	d	4.0	40	400	4,000	40,000	400,000	4,000,000	40,000,000
	e	4.5	45	450	4,500	45,000	450,000	4,500,000	45,000,000
	f	5.0	50	500	5,000	50,000	500,000	5,000,000	50,000,000
	m	6.0	60	600	6,000	60,000	600,000	6,000,000	60,000,000
	n	7.0	70	700	7,000	70,000	700,000	7,000,000	70,000,000
	t	8.0	80	800	8,000	80,000	800,000	8,000,000	80,000,000
	y	9.0	90	900	9,000	90,000	900,000	9,000,000	90,000,000

MIL-PRF-123 Periodic Lot Testing

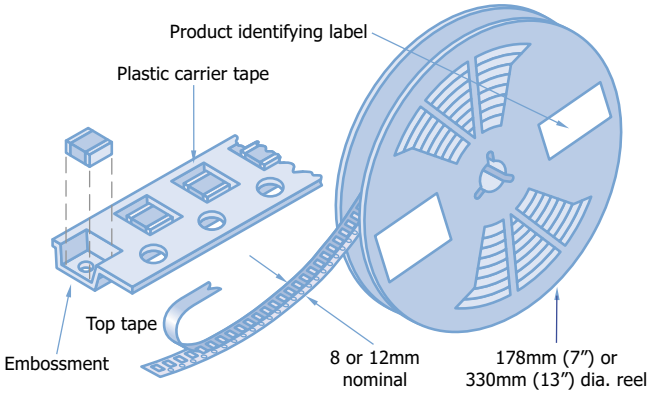
Periodic Lot tests conducted for MIL-PRF-123

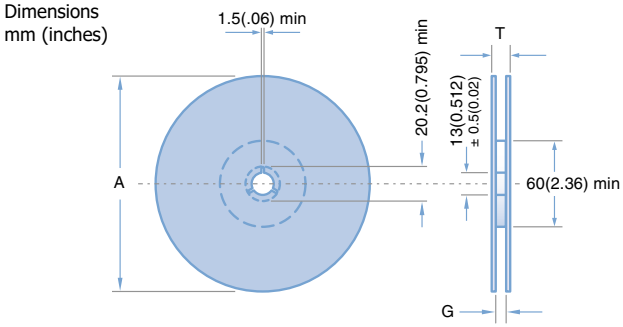
Test Name	Test Method	Details	Sample Size	Rejects Allowed
Electrical Characteristics				
Capacitance/Dissipation Factor	MIL-STD-202 M305	1Vrms, 1kHz	325	0
Insulation Resistance	MIL-STD-202 M302	Rated Voltage 1000 MΩ - µF min	325	0
Dielectric Withstanding Voltage	MIL-STD-202 M301	2.5x Rated Vdc min	325	0
Group A - Subgroup 1				
Thermal Shock	MIL-PRF-123 4.6.6.1 MIL-STD-202 M107	20 cycles -55ºC to +125ºC	325	5% PDA (16 pcs) and < 0.2% (0 pcs) in last 48 hrs
Voltage Conditioning	MIL-PRF-123 4.6.6.2	2x Rated Vdc, 125ºC, 168-264 Hours		
Group A - Subgroup 2				
"Visual and mechanical inspection; material, physical dimensions, design, construction, marking and workmanship."	MIL-PRF-123 4.6.3	Parts must pass criteria	20	0
Group A - Subgroup 3				
Destructive Physical Analysis	MIL-PRF-123 4.6.11	Parts must pass criteria	10	0
Group B - Subgroup 1				
Thermal Shock	MIL-PRF-123 4.6.6.1 MIL-STD-202 M107	100 cycles -55ºC to +125ºC	200	Report
Life Test	MIL-PRF-123 4.6.19 MIL-STD-202 M108	2xVdc, 125ºC, 1000 Hours		
Group B - Subgroup 2				
Humidity, Steady State Low Voltage	MIL-PRF-123 4.6.16.1 MIL-STD-202 M103	85% RH, 85ºC, 240 Hrs, 1.3V	12	0
Group B - Subgroup 3				
Voltage - Temperature Limits	MIL-PRF-123 4.6.15	-55ºC -25ºC -125ºC 1Vrms ±15%(X7R), ±30ppm (C0G)	12	1
Moisture Resistance	MIL-PRF-123 4.6.16.2 MIL-STD-202 M106	20 cycles 25V 1st 10 cycles		
Group C - Subgroup 2 Chip Devices				
Terminal Strength	MIL-PRF-123 4.6.12.2 MIL-STD-202 M211	Pull test, nail leads, x-x kg	6	1
Solderability	MIL-PRF-123 4.6.13.2 MIL-STD-202 M208 J-STD 002C	8 Hr Steam Age, SAC305 at 255ºC, 5 seconds, 95% coverage	6	
Resistance To Soldering Heat	MIL-PRF-123 4.6.14.2 MIL-STD-202 M210	60/40 Tin/Lead at 230ºC, 2 five second dips	6	

C0G/NP0 and X7R test packages available on request.

Ceramic Chip Capacitors - Packaging information

Tape and reel packing of surface mounting chip capacitors for automatic placement are in accordance with IEC60286-3.





Symbol	Description	178mm reel	330mm reel
A	Diameter	178 (7)	330 (13)
G	Inside width	8.4 (0.33)	12.4 (0.49)
T	Outside width	14.4 (0.56) max	18.4 (0.72) max

Peel force

The peel force of the top sealing tape is between 0.2 and 1.0 Newton at 180°. The breaking force of the carrier and sealing tape in the direction of unreeling is greater than 10 Newtons.

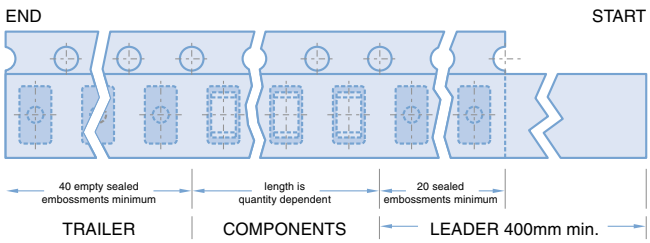
Identification

Each reel is labelled with the following information: manufacturer, chip size, capacitance, tolerance, rated voltage, dielectric type, batch number, date code and quantity of components.

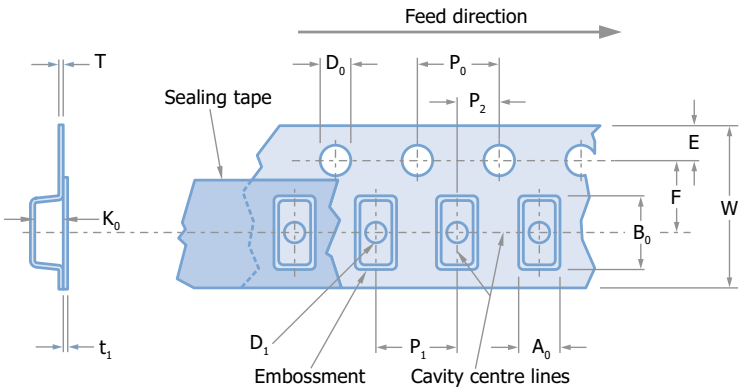
Missing components

Maximum number of missing components shall be 1 per reel or 0.025% whichever is greater. There shall not be consecutive components missing from any reel for any reason.

Leader and Trailer



Tape dimensions



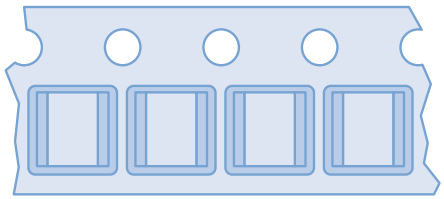
		Dimensions mm (inches)	
Symbol	Description	8mm tape	12mm tape
A_0 B_0 K_0	Width of cavity Length of cavity Depth of cavity	Dependent on chip size to minimize rotation	
W	Width of tape	8.0 (0.315)	12.0 (0.472)
F	Distance between drive hole centres and cavity centres	3.5 (0.138)	5.5 (0.213)
E	Distance between drive hole centres and tape edge	1.75 (0.069)	
P_1	Distance between cavity centres	4.0 (0.156)	8.0 (0.315)
P_2	Axial distance between drive hole centres and cavity centres	2.0 (0.079)	
P_0	Axial distance between drive hole centres	4.0 (0.156)	
D_0	Drive hole diameter	1.5 (0.059)	
D_1	Diameter of cavity piercing	1.0 (0.039)	1.5 (0.059)
T	Carrier tape thickness	0.3 (0.012) ±0.1 (0.004)	0.4 (0.016) ±0.1 (0.004)
t_1	Top tape thickness	0.1 (0.004) max	

Component orientation

Tape and reeling is in accordance with IEC 60286 part 3, which defines the packaging specifications of lead less components on continuous tapes.

Notes: 1) IEC60286-3 states Ao ≤ Bo
(see tape dimensions on page 19).

2) Regarding the orientation of 1825 and 2225 components, the termination bands are right to left, NOT front to back. Please see diagram.

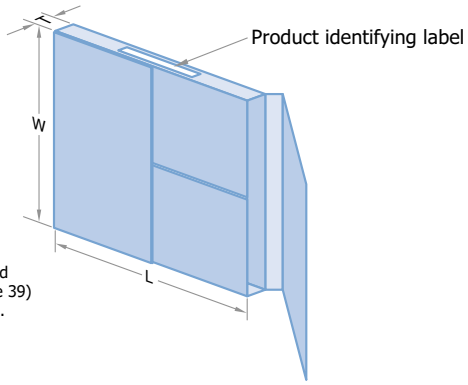


Orientation of 1825 & 2225 components

Outer Packaging

Outer carton dimensions mm (inches) max.

Reel Size	No. of reels	L	W	T
178 (7.0)	1	185 (7.28)	185 (7.28)	25 (0.98)
178 (7.0)	4	190 (7.48)	195 (7.76)	75 (2.95)
330 (13.0)	1	335 (13.19)	335 (13.19)	25 (0.98)



Note: Labelling of box and reel with bar codes (Code 39) available by arrangement.

Reel quantities - Novacap, Syfer and Voltronics products

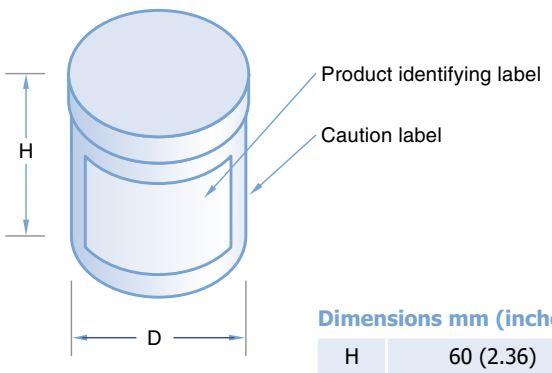
Chip size	0402	0505	0603	0805	1111	1206	1210	1410	1515	1808	1812	1825	2211	2215	2220	2221	2225	2520	3333	3530	3640	4540	5550	6560	7565
Max. chip thickness																									
mm	0.61	1.3	0.89	1.37	1.8	1.63	2.0	2.0	3.3	2.0	3.2	4.2	2.5	2.5	4.2	2.0	4.2	4.57	6.35	6.35	4.2	7.62	7.62	7.62	7.62
inches	0.02"	0.05"	0.03"	0.05"	0.07"	0.06"	0.08"	0.08"	0.13"	0.08"	0.13"	0.165"	0.1"	0.1"	0.165"	0.08"	0.165"	0.18"	0.25"	0.25"	0.165"	0.3"	0.3"	0.3"	0.3"
Reel quantities																									
178mm (7")	10k	2500	4000	3000	1000	2500	2000	2000	500	1500	500	500	750	500	500	1000	500	1000	-	-	-	-		-	-
330mm (13")	15k	10k	16k	12k	5000	10k	8000	8000	-	6000	2000	2000	4000	4000	2000	-	2000	1000	1000	500	500	500	500	500	200

Packaging configurations - DLI products

Chip size		7" Reel, 8mm Tape		7" Reel, 16mm Tape	13" Reel, 16mm Tape	2" x 2" Waffle Pack
Style	L x W	Horizontal Orientation	Vertical Orientation	Horizontal Orientation		
C04	0.040" x 0.020"	4000	-	-	-	-
C06	0.060" x 0.030"	4000	-	-	-	108
C07	0.110" x 0.070"	2000	-	-	-	-
C08	0.080" x 0.050"	5000	3100	-	-	108
C11	0.055" x 0.055"	3500	3100	-	-	108
C17	0.110" x 0.110"	2350	750	-	-	49
C18	0.110" x 0.110"	2350	750	-	-	49
C22	0.220" x 0.245"	500	-	-	-	-
C40	0.380" x 0.380"	250	-	250	1300	-

Bulk packaging, tubs

Chips can be supplied in rigid re-sealable plastic tubs together with impact cushioning wadding. Tubs are labelled with the details: chip size, capacitance, tolerance, rated voltage, dielectric type, batch number, date code and quantity of components.

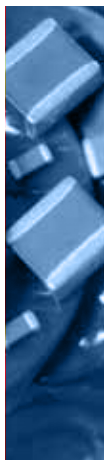


Dimensions mm (inches)

H	60 (2.36)
D	50 (1.97)

Chip ordering information - Novacap parts

XX	1206	N	472	J	101	N	X050	H	T	M	HB
Prefix	Case Size	Dielectric	Capacitance Codes	Capacitance Tolerance	Voltage	Termination	Special Thickness	High Reliability Testing	Packaging	Marking	High Reliability Test Criteria



Prefix Definitions

None	Standard chip	
RF	Improved ESR Capacitor	p. 39
ST	Stacked Capacitor Assembly	p. 76 - 81
SM	Stacked Hi-Rel Capacitor Assembly	p. 76 - 81
CR	Cap Rack Arrays	p. 82

Dielectric Codes

N	C0G/NP0	Ultra Stable
K	R3L	Ultra Stable
B	X7R	Stable
W	X5R	Stable
X	BX	MIL
BB	X7R	Stable BME
BW	X5R	Stable BME
M	C0G/NP0	Non Magnetic
C	X7R	Non Magnetic
F	C0G/NP0	High Temp. (up to 160ºC)
D, RD	C0G/NP0	High Temp. (up to 200ºC)
S	X8R	High Temp. (up to 150ºC)
E, RE	Class II	High Temp. (up to 200ºC)
G	Class II	High Temp. (up to 160ºC)
RN	C0G/NP0	Lead free
RB	X7R	Lead free

Capacitance Codes

1st two digits are significant figures of capacitance, 3rd digit denotes number of zeros, R = decimal point Examples:	1R0	1.0pF
	120	12pF
	471	470pF
	102	1,000pF
	273	0.027µF
	474	0.47µF
	105	1.0µF

Voltage Code

1st two digits are significant, third digit denotes number of zeros. For example:	
160	16 Volts
101	100 Volts
501	500 Volts
102	1,000 Volts
502	5,000 Volts
103	10,000 Volts

Special Thickness

None	Standard thickness as per Novacap catalog specifications
X	Denotes a special thickness other than standard. Specify in inches if required. (As shown above X = 0.050")

Marking

None	Unmarked
M	Marked *Marking not available on sizes ≤ 0603

Note: Refer to page 17.

Packaging

None	Bulk
T	Tape and Reel
W	Waffle Pack

High Reliability Testing

None	Standard product
H	High Reliability Testing
H	High Temp Screening

High Reliability Testing Criteria

HB	MIL-PRF-55681 Group A
HV	MIL-PRF-49467 Group A
HS	MIL-PRF-123 Group A
HK	MIL-PRF-38534 Class K

Termination Codes

P	Palladium Silver	
PR	Palladium Silver*	
K	Solderable Palladium Silver*	
N	Nickel Barrier*	100% tin
Y	Nickel Barrier	90% tin, 10% lead
NG	Nickel Barrier Gold Flash*	
C	FlexiCap™/Nickel Barrier*	100% tin
D	FlexiCap™/Nickel Barrier	90% tin, 10% lead
B	Copper Barrier*	100% tin
E	Copper Barrier	90% tin, 10% lead
S	Silver*	

*Indicates RoHS terminations

Capacitance Tolerance Codes

Code	Tolerance * Not RF series		C0G/NP0 N	C0G/NP0 M	C0G/NP0 F/D, RD	R3L K	X7R B	X7R C, RE	BX X	X8R S	Class II E/G	X5R W
B	±0.10pF	Cap. Value < 10pF	•	•								
C	±0.25pF		•	•		•						
D	±0.50pF		•	•		•						
F	±1%		•	•	•							
G	±2%		•	•	•	•						
J	±5%		•	•	•	•	•*	•	•*	•	•	
K	±10%		•	•	•	•	•	•	•	•	•	•
M	±20%		•		•	•	•	•	•	•	•	•

Chip ordering information - Syfer parts

1210	Y	100	0103	K	X	T	_ _ _
Chip Size	Termination	Voltage	Capacitance in picofarads (pF)	Capacitance Tolerance	Dielectric	Packaging	Suffix code

Case Code

0402
0603
0805
1206
1210
1808
1812
1825
2220
2225
3640
5550
8060

Capacitance Tolerance Codes

Code	Tolerance	
H	±0.05pF	< 4.7pF
H	±0.05pF	Cap. Value < 10pF
B	±0.10pF	
C	±0.25pF	
D	±0.50pF	
F	±1%	Cap. Value ≥ 10pF
G	±2%	
J	±5%	
K	±10%	
M	±20%	

Packaging

Code	
T	178mm (7") reel
R	330mm (13") reel
B	Bulk pack - tubs or trays

Suffix Definitions

Used for specific customer requirements	
PXX	Palladium electrodes
LS*	Chip marking *(consult sales office)

Termination Codes

A	Nickel barrier	90/10% tin/lead
F	Palladium Silver*	
H	FlexiCap™/Nickel Barrier	90/10% tin/lead
J	Nickel Barrier*	100% tin
Y	FlexiCap™/Nickel Barrier*	100% tin
2	Copper Barrier* (Non Mag)	100% tin
3	FlexiCap™/Copper Barrier* (Non Mag)	100% tin
4	Copper Barrier (Non Mag)	90/10% tin/lead
5	FlexiCap™/Copper Barrier (Non Mag)	90/10% tin/lead

*Indicates RoHS terminations

Dielectric Codes

Code	Dielectric	Features
C	C0G/NP0 (1B)	Ultra Stable
H	X8G	Ultra Stable
P	X5R	Stable
X	X7R (2R1)	Stable
J	X7R (BME)	Stable
N	X8R	Stable
Q	C0G/NP0	High Q version
U	C0G/NP0	Ultra-low ESR version
A	C0G/NP0 (1B/NP0)	AEC -Q200 approved
S	X7R (BME)	AEC -Q200 approved
E	X7R (2R1)	AEC -Q200 approved
T	X8R	AEC -Q200 approved
X	X7R	AEC -Q200 approved
F	C0G/NP0 (1B/NP0)	IECQ-CECC release
D	X7R (2R1)	IECQ-CECC release
R	BZ (2C1)	IECQ-CECC release
B	BX (2X1)	IECQ-CECC release
G	C0G/NP0 (BME)	High Temp (up to 200ºC)

Voltage Code

Code	Value	Code	Value	Code	Value
010	10Vdc	**1K0**	1kVdc	**A25**	250Vac
016	16Vdc	**1K2**	1.2kVdc		
025	25Vdc	**1K5**	1.5kVdc		
050	50Vdc	**2K0**	2kVdc		
063	63Vdc	**2K5**	2.5kVdc		
100	100Vdc	**3K0**	3kVdc		
200	200Vdc	**4K0**	4kVdc		
250	250Vdc	**5K0**	5kVdc		
500	500Vdc	**6K0**	6kVdc		
630	630Vdc	**8K0**	8kVdc		
		10K	10kVdc		
		12K	12kVdc		

Capacitance Code

Calculation	Example	Capacaitance value
<1.0pF Insert a P for the decimal point as the 1st character.	**P300**	0.3pF (values in 0.1pF steps)
≥1.0pF & <10pF Insert a P for the decimal point as the 2nd character.	**8P20**	8.2pF (values are E24 series)
≥10pF 1st digit is 0. 2nd and 3rd digits are significant figures of capacitance value. 4th digit is number of zeros.	**0101**	100pF (values are E24 series)

Automotive Grade Capacitors - AEC-Q200 range

We offer a range of high quality automotive grade components. With AEC-Q200 approved ranges up to a voltage rating of 1kV we provide for the requirements of modern automotive applications including EV and HEV.

Ranges include :-

1. Standard MLCCs
2. StackiCap™ - large capacitance/small case size MLCCs
3. Open Mode and Tandem capacitors
4. 3 terminal EMI components
5. X2Y Integrated Passive Component
6. X8R high temperature MLCCs
7. Safety Certified MLCCs

All fully tested / approved and available with a range of suitable termination options, including tin/lead plating and Knowles FlexiCap™.

AEC-Q200 MLCC range - maximum capacitance values

		0603	0805	1206	1210	1808	1812	1812 StackiCap™ 3.2mm max thickness	1825	2220	2220 StackiCap™ 4.5mm max thickness	2225	3640	3640 StackiCap™ 4.5mm max thickness
50/ 63V	C0G/NP0	470pF	2.7nF	10nF	18nF	8.2nF	39nF	-	68nF	68nF	-	100nF	220nF	-
	X7R	33nF	150nF	470nF	1µF	-	1.5µF	-	1.8µF	3.3µF	-	3.3µF	4.7µF	-
	X8R	-	33nF	120nF	220nF	270nF	470nF	-	-	680nF	-	1.0µF	-	-
100V	C0G/NP0	330pF	1.8nF	6.8nF	12nF	8.2nF	27nF	-	47nF	47nF	-	68nF	180nF	-
	X7R	10nF	47nF	150nF	470nF	-	1µF	-	1.2µF	1.5µF	-	1.5µF	3.3µF	-
	X8R	-	15nF	56nF	120nF	150nF	220nF	-	-	470nF	-	560nF	-	-
200/ 250V	C0G/NP0	100pF	1nF	3.3nF	6.8nF	6.8nF	15nF	-	22nF	33nF	-	27nF	82nF	-
	X7R	5.6nF	27nF	100nF	220nF	-	470nF	1.0µF	1.0µF	1.0µF	-	1.0µF	1.5µF	-
	X8R	-	10nF	33nF	68nF	82nF	120nF	-	-	220nF	-	330nF	-	-
500V	C0G/NP0	-	680pF	2.7nF	6.8nF	5.6nF	15nF	-	15nF	22nF	-	22nF	56nF	-
	X7R	-	15nF	68nF	100nF	-	270nF	470nF	560nF	560nF	-	680nF	1.0µF	-
	X8R	-	3.9nF	18nF	39nF	47nF	100nF	-	-	180nF	-	270nF	-	-
630V	C0G/NP0	-	560pF	2.7nF	6.8nF	5.6nF	15nF	-	8.2nF	15nF	-	15nF	39nF	-
	X7R	-	10nF	47nF	68nF	-	150nF	330nF	180nF	330nF	1.0µF	390nF	680nF	-
	X8R	-	1.8nF	3.9nF	10nF	12nF	33nF	-	-	150nF	-	180nF	-	-
1kV	C0G/NP0	-	150pF	1.5nF	2.2nF	2.2nF	3.3nF	-	4.7nF	10nF	-	10nF	22nF	-
	X7R	-	3.3nF	10nF	22nF	-	68nF	180nF	120nF	120nF	470nF	150nF	180nF	1.0µF
	X8R	-	1nF	2.2nF	4.7nF	5.6nF	18nF	-	-	39nF	-	56nF	-	-
1.2kV	C0G/NP0	-	68pF	390pF	680pF	680pF	3.3nF	-	3.9nF	4.7nF	-	6.8nF	18nF	-
	X7R	-	-	3.3nF	10nF	-	33nF	100nF	68nF	82nF	-	100nF	150nF	-
	X8R	-	-	1.8nF	3.9nF	4.7nF	12nF	-	-	33nF	-	39nF	-	-
1.5kV	C0G/NP0	-	68pF	390pF	680pF	680pF	2.2nF	-	2.7nF	4.7nF	-	4.7nF	12nF	-
	X7R	-	-	2.7nF	6.8nF	-	22nF	-	47nF	47nF	-	68nF	100nF	-
	X8R	-	-	1.2nF	2.2nF	2.7nF	8.2nF	-	-	22nF	-	27nF	-	-
2kV	C0G/NP0	-	47pF	220pF	470pF	470pF	1.5nF	-	1.2nF	2.2nF	-	2.2nF	5.6nF	-
	X7R	-	-	2.2nF	4.7n	-	10nF	-	10nF	27nF	-	33nF	47nF	-
	X8R	-	-	470pF	1.2nF	1.8nF	4.7nF	-	-	12nF	-	18nF	-	-
2.5kV	C0G/NP0	-	-	100pF	180pF	270pF	680pF	-	-	1.5nF	-	-	-	-
	X8R	-	-	-	-	1.0nF	2.7nF	-	-	6.8nF	-	10nF	-	-
3kV	C0G/NP0	-	-	68pF	150pF	220pF	470pF	-	-	1nF	-	-	-	-
	X8R	-	-	-	-	680pF	2.2nF	-	-	4.7nF	-	5.6nF	-	-

Safety Certified Capacitors

Dielectric	Approval Body	X1 PY2		X2 SP	Y2/X1 SP		Y2/X1 B16	X2 B17
		1808	1812	1808	2211	2215	2220	2220
C0G/NP0	TÜV, UL	4.7pF - 390pF	4.7pF - 390pF	4.7pF - 1.5nF	4.7pF - 1.5nF	820pF - 1.0nF	-	-
X7R	TÜV, UL	150pF - 1nF	150pF - 2.2nF	150pF - 4.7nF	100pF - 3.9nF	2.7nF - 3.9nF	150pF - 5.6nF	150pF - 22nF (TÜV approval only)

Automotive Grade Capacitors - AEC-Q200 range

AEC-Q200 range - Open Mode - max capacitance values

	0603	0805	1206	1210	1808	1812	2220	2225
	X7R	X7R	X7R	X7R	X7R	X7R	X7R	X7R
16/25V	-	56nF	220nF	470nF	-	-	-	-
50/63V	22nF	100nF	220nF	470nF	470nF	1.0µF	1.5µF	2.7µF
100V	6.8nF	27nF	100nF	220nF	220nF	680nF	1.0µF	1.5µF
200/250V	2.7nF	15nF	68nF	100nF	100nF	330nF	680nF	1.0µF
500V	-	5.6nF	39nF	68nF	68nF	180nF	330nF	390nF
630V	-	-	22nF	33nF	27nF	100nF	180nF	220nF
1kV	-	-	6.8nF	15nF	15nF	47nF	82nF	100nF

AEC-Q200 range - Tandem - max capacitance values

	0603	0805	1206	1210	1812
	X7R	X7R	X7R	X7R	X7R
50/63V	6.8nF	33nF	100nF	180nF	390nF
100V	2.2nF	10nF	47nF	82nF	220nF
200/250V	1.0nF	4.7nF	22nF	47nF	100nF

AEC-Q200 range - 3 Terminal EMI Components (E01 & E07) - max capacitance values

		E01			E07		
		0805	1206	1806	0805	1206	1806
50V	C0G/NP0	820pF	1.0nF	2.2nF	220pF	1nF	1.5nF
	X7R	47nF	100nF	200nF	47nF	100nF	200nF
100V	C0G/NP0	560pF	1.0nF	2.2nF	120pF	560pF	680pF
	X7R	15nF	15nF	68nF	15nF	15nF	68nF

Note: For some lower capacitance parts, higher voltage rated parts may be supplied. See page 54 for full details of the product range.

AEC-Q200 range - X2Y Integrated Passive Components (E03) - capacitance values

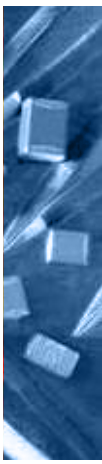
		0805	1206	1410	1812
50V	C0G/NP0	390pF - 470pF	1.2nF - 1.5nF	4.7nF - 5.6nF	8.2nF - 10nF
	X7R	18nF - 33nF	56nF - 150nF	180nF - 330nF	390nF - 560nF
100V	C0G/NP0	10pF - 330pF	22pF - 1.0nF	100pF - 3.9nF	820pF - 6.8nF
	X7R	470pF - 15nF	1.5nF - 47nF	4.7nF - 150nF	8.2nF - 330nF

Note: For some lower capacitance parts, higher voltage rated parts may be supplied. See page 56 for full details of the product range.

Ordering information - AEC-Q200 ranges

1210	Y	100	0103	K	S	T	_ _ _
Chip size	Termination	Voltage	Capacitance in picofarads (pF)	Capacitance tolerance	Dielectric Release codes	Packaging	Suffix code
0603 **0805** **1206** **1210** **1808** **1812** **1825** **2220** **2225** **3640**	**Y** = FlexiCap™ termination base with Ni barrier (100% matte tin plating). RoHS compliant. **H** = FlexiCap™ termination base with Ni barrier (Tin/lead plating with min. 10% lead). Not RoHS compliant. **J** = Nickel barrier (100% matte tin plating). RoHS compliant. Lead free. **A** = Nickel barrier (Tin/lead plating with min. 10% lead). Not RoHS compliant.	**050** = 50V **063** = 63V **100** = 100V **200** = 200V **250** = 250V **500** = 500V **630** = 630V **1K0** = 1kV **1K2** = 1.2kV **1K5** = 1.5kV **2K0** = 2kV **2K5** = 2.5kV **3K0** = 3kV	First digit is 0. Second and third digits are significant figures of capacitance code. The fourth digit is number of zeros following Example: **0103** = 10nF	**F** = ±1% **G** = ±2% **J** = ±5% **K** = ±10% **M** = ±20%	**S** = X7R (BME) AEC-Q200 **E** = X7R (2R1) AEC-Q200 **A** = C0G/NP0 (1B/NP0) AEC-Q200 **T** = X8R with AEC-Q200 release Note: AEC-Q200 X7R is only available in Y or H termination.	**T** = 178mm (7") reel **R** = 330mm (13") reel **B** = Bulk pack - tubs or trays	**WS2** = StackiCap™ **M01** = Open Mode **T01** = Tandem **E01 & E07**= 3 terminal EMI component **E03** = X2Y product

Periodic tests conducted for IECQ-CECC and AEC-Q200



Test ref	Test	Termination type	Additional requirements	Sample acceptance			Reference
				P	N	C	
P1	High temperature exposure (storage)	All types	Un-powered. 1,000 hours @ T=150ºC. Measurement at 24 ± 2 hours after test conclusion	12	77	0	MIL-STD-202 Method 108
P2	Temperature cycling	C0G/NP0: All types X7R: Y and H only	1,000 cycles -55ºC to +125ºC Measurement at 24 ± 2 hours after test conclusion	12	77	0	JESD22 Method JA-104
P3	Moisture resistance	All types	T = 24 hours/cycle. Note: Steps 7a and 7b not required. Un-powered. Measurement at 24 ± 2 hours after test conclusion	12	77	0	MIL-STD-202 Method 106
P4	Biased humidity	All types	1,000 hours 85ºC/85%RH. Rated voltage or 50V whichever is the least and 1.5V. Measurement at 24 ± 2 hours after test conclusion	12	77	0	MIL-STD-202 Method 103
P5	Operational life	All types	Condition D steady state TA=125ºC at full rated. Measurement at 24 ± 2 hours after test conclusion	12	77	0	MIL-STD-202 Method 108
P6	Resistance to solvents	All types	Note: Add aqueous wash chemical. Do not use banned solvents	12	5	0	MIL-STD-202 Method 215
P7	Mechanical shock	C0G/NP0: All types X7R: Y and H only	Figure 1 of Method 213. Condition F	12	30	0	MIL-STD-202 Method 213
P8	Vibration	C0G/NP0: All types X7R: Y and H only	5*g's* for 20 minutes, 12 cycles each of 3 orientations. Note: Use 8" x 5" PCB 0.031" thick 7 secure points on one long side and 2 secure points at corners of opposite sides. Parts mounted within 2" from any secure point. Test from 10-2,000Hz	12	30	0	MIL-STD-202 Method 204
P9	Resistance to soldering heat	All types	Condition B, no pre-heat of samples: Single wave solder - Procedure 2	3	12	0	MIL-STD-202 Method 210
P10	Thermal shock	C0G/NP0: All types X7R: Y and H only	-55ºC/+125ºC. Number of cycles 300. Maximum transfer time - 20 seconds, dwell time - 15 minutes. Air-Air	12	30	0	MIL-STD-202 Method 107
P11	Adhesion, rapid temp change and climatic sequence	X7R: A, F and J only	5N force applied for 10s, -55ºC/ +125ºC for 5 cycles, damp heat cycles	12	27	0	BS EN132100 Clause 4.8, 4.12 and 4.13
P12	Board flex	C0G/NP0: All types X7R: Y and H only	3mm deflection Class I 2mm deflection Class II	12	30	0	AEC-Q200-005
P13	Board flex	X7R: A, F and J only	1mm deflection.	12	12	0	BS EN132100 Clause 4.9
P14	Terminal strength	All types	Force of 1.8kg for 60 seconds	12	30	0	AEC-Q200-006
P15	Beam load test	All types	-	12	30	0	AEC-Q200-003
P16	Damp heat steady state	All types	56 days, 40ºC / 93% RH 15x no volts, 15x 5Vdc, 15x rated voltage or 50V whichever is the least.	12	45	0	BS EN132100 Clause 4.14

Test results are available on request.
P = Period in months.
N = Sample size.
C = Acceptance criteria.

IECQ-CECC range - Specialty High Rel. and approved parts

A range of specialist, high reliability, multilayer ceramic capacitors for use in critical or high reliability environments. All fully tested / approved and available with a range of suitable termination options, including tin/lead plating and Knowles FlexiCap™.

Ranges include:

1. Range tested and approved in accordance with IECQ-CECC QC32100.
2. Range qualified to the requirements of Knowles detail specification S02A-0100 (based on ESCC 3009).

IECQ-CECC - maximum capacitance values

		0603	0805	1206	1210	1808	1812	2220	2225
16V	C0G/NP0	1.5nF	6.8nF	22nF	33nF	33nF	100nF	150nF	220nF
	X7R	100nF	330nF	1.0µF	1.5µF	1.5µF	3.3µF	5.6µF	6.8µF
25V	C0G/NP0	1.0nF	4.7nF	15nF	22nF	27nF	68nF	100nF	150nF
	X7R	56nF	220nF	820nF	1.2µF	1.2µF	2.2µF	4.7µF	5.6µF
50/63V	C0G/NP0	470pF	2.7nF	10nF	18nF	18nF	33nF	68nF	100nF
	X7R	47nF	220nF	470nF	1.0µF	680nF	1.5µF	2.2µF	3.3µF
100V	C0G/NP0	330pF	1.8nF	6.8nF	12nF	12nF	27nF	47nF	68nF
	X7R	10nF	47nF	150nF	470nF	330nF	1.0µF	1.5µF	1.5µF
200/ 250V	C0G/NP0	100pF	680pF	2.2nF	4.7nF	4.7nF	12nF	22nF	27nF
	X7R	5.6nF	27nF	100nF	220nF	180nF	470nF	1.0µF	1.0µF
500V	C0G/NP0	n/a	330pF	1.5nF	3.3nF	3.3nF	10nF	15nF	22nF
	X7R	n/a	8.2nF	33nF	100nF	100nF	270nF	560nF	820nF
1kV	C0G/NP0	n/a	n/a	470pF	1.0nF	1.2nF	3.3nF	8.2nF	10nF
	X7R	n/a	n/a	4.7nF	15nF	18nF	56nF	120nF	150nF

Ordering information - IECQ-CECC range

1210	Y	100	0103	J	D	T	_ _ _
Chip size	Termination	Voltage	Capacitance in picofarads (pF)	Capacitance tolerance	Dielectric Release codes	Packaging	Suffix code
0603 **0805** **1206** **1210** **1808** **1812** **2220** **2225**	**Y** = FlexiCap™ termination base with Ni barrier (100% matte tin plating). RoHS compliant. **H** = FlexiCap™ termination base with Ni barrier (Tin/lead plating with min. 10% lead). Not RoHS compliant. **F** = Silver Palladium. RoHS compliant. **J** = Nickel barrier (100% matte tin plating). RoHS compliant. **A** = Nickel barrier (Tin/lead plating with min. 10% lead). Not RoHS compliant.	**016** = 16V **025** = 25V **050** = 50V **063** = 63V **100** = 100V **200** = 200V **250** = 250V **500** = 500V **630** = 630V **1K0** = 1kV	First digit is 0. Second and third digits are significant figures of capacitance code. The fourth digit is number of zeros following Example: **0103** = 10nF	**F** = ±1% **G** = ±2% **J** = ±5% **K** = ±10% **M** = ±20%	**D** = X7R (2R1) with IECQ-CECC release **F** = C0G/NP0 (1B/NP0) with IECQ-CECC release **B** = 2X1/BX released in accordance with IECQ-CECC **R** = 2C1/BZ released in accordance with IECQ-CECC For **B** and **R** codes please refer to TCC/ VCC range for full capacitance values	**T** = 178mm (7") reel **R** = 330mm (13") reel **B** = Bulk pack - tubs or trays	Used for specific customer require-ments

High Reliability Chip - C0G/NP0 - 16Vdc to 10kVdc

A range of MLC chip capacitors in Ultra stable EIA Class I C0G/NP0, dielectric with special testing for long term reliability. They are designed for optimum reliability; burned in at elevated voltage and temperature, and 100% physically and electrically inspected to ascertain conformance to strict performance criteria. Units may be tested in accordance with MIL-PRF-55681, MIL-PRF-123, MIL-PRF-49467 or customer SCD.

Designed for surface mount application with nickel barrier terminations making them suitable for solder wave and reflow solder board attachment as well as vapor phase attachment for part sizes 2225 or smaller. Silver-palladium terminations are also available for hybrid use with conductive epoxy.

C0G/NP0 chips are used in precision circuitry requiring Class I stability and exhibit linear temperature coefficient, low loss and stable electrical properties with time, voltage and frequency.

They find application for High Reliability use such as medical implanted devices, aerospace, airborne and military use as well as consumer uses requiring safety margins not attainable with commercial products.

Standard EIA case sizes and available C/V values are listed below - special sizes, thicknesses and other voltage ratings are available; please contact the Sales Office for information.

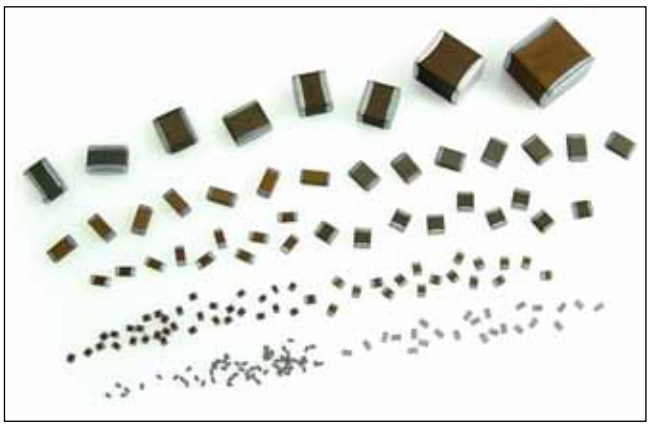
Capacitance and voltage selection for popular chip sizes

Size	0402	0504	0603	0805	1206	1206	1210	1515	1808		1812		1825	
Min cap.	0R3	0R5	0R3	0R5	0R5	3R0	5R0	3R0	5R0	5R0	100	100	150	150
Tmax inches:	0.024	0.044	0.035	0.054	0.054	0.064	0.065	0.130	0.065	0.080*	0.065	0.100*	0.080	0.140*
mm:	0.61	1.12	0.89	1.37	1.37	1.63	1.63	3.02	1.63	2.03	1.63	2.54	2.03	3.56
16V	81	152	102	392	562	103	223	393	223	273	473	473	104	104
25V	181	152	102	392	562	123	223	393	223	273	473	473	104	104
50V	181	152	102	392	562	123	223	333	183	223	393	393	104	104
100V	101	821	561	222	332	682	123	273	123	183	273	273	683	823
200V	101	561	331	152	222	392	822	223	822	103	153	273	473	683
250V	390	391	271	102	152	272	562	183	562	682	123	183	273	473
300V	•	•	•	681	681	182	392	123	392	472	822	123	223	273
400V	•	•	•	681	561	152	392	822	392	472	822	103	183	183
500V	•	•	•	681	561	152	392	682	392	392	822	103	183	183
600V	•	•	•	•	•	122	392	682	392	392	822	103	183	183
800V†	•	•	•	•	•	102	222	472	222	222	472	682	123	153
1kV†	•	•	•	•	•	681	152	392	152	152	332	562	822	123
1.5kV†	•	•	•	•	•	271	681	222	681	102	152	222	392	682
2kV†	•	•	•	•	•	151	391	122	391	391	821	122	222	392
3kV†	•	•	•	•	•	•	•	561	181	181	391	561	102	182
4kV†	•	•	•	•	•	•	•	•	•	•	•	•	391	681
5kV†	•	•	•	•	•	•	•	•	•	•	•	•	221	471
6kV†	•	•	•	•	•	•	•	•	•	•	•	•	•	•
7kV†	•	•	•	•	•	•	•	•	•	•	•	•	•	•
8kV†	•	•	•	•	•	•	•	•	•	•	•	•	•	•
9kV†	•	•	•	•	•	•	•	•	•	•	•	•	•	•
10kV†	•	•	•	•	•	•	•	•	•	•	•	•	•	•

Note: † Units rated above 800V may require conformal coating to preclude arcing over chip surface. Maximum voltage for MIL-PRF-123 tested parts is 1kV.

High Reliability Chip - C0G/NP0 - 16Vdc to 10kVdc

- For dielectric characteristics see pages 4 & 5.
- For dimensions see page 16.
- For termination options see pages 6.
- For capacitance tolerances available see page 21.
- For ordering information see page 21.



Note: Maximum capacitance values are shown below as 3 digit code: 2 significant figures followed by the no. of zeros e.g. 183 = 18,000pF.

Capacitance and voltage selection for popular chip sizes

2020	2221	2225		2520	3333	3530	4040	4540	5440	5550	6560	7565	Size
270	270	270	270	390	390	390	390	390	390	390	560	101	**Min cap.**
0.180 4.57	0.080 2.03	0.080 2.03	0.150* 3.81	0.180 4.57	0.250 6.35	0.250 6.35	0.300 7.62	0.300 7.62	0.300 7.62	0.300 7.62	0.300 7.62	0.300 7.62	inches: **Tmax** mm:
683	104	124	124	104	184	184	334	334	334	394	684	824	**16V**
683	104	124	124	104	184	184	334	334	334	394	684	824	**25V**
683	104	124	124	104	154	184	274	334	274	394	564	824	**50V**
563	683	823	104	823	124	154	224	274	224	274	474	564	**100V**
473	393	473	823	683	104	104	184	184	184	224	394	474	**200V**
393	223	273	563	563	823	104	154	184	184	224	394	474	**250V**
333	183	273	473	473	823	823	154	154	154	184	334	394	**300V**
223	183	273	273	333	563	563	124	124	124	154	274	334	**400V**
153	183	273	273	183	473	473	823	104	104	124	224	274	**500V**
153	183	273	273	183	393	393	683	823	823	124	184	274	**600V**
103	103	153	223	123	333	333	563	683	683	104	154	184	**800V†**
103	822	123	183	123	273	273	473	563	563	823	124	184	**1kV†**
682	392	562	103	822	183	183	333	393	393	563	823	124	**1.5kV†**
392	182	272	562	472	153	153	223	273	333	473	683	823	**2kV†**
182	821	122	272	222	682	682	153	183	183	273	393	473	**3kV†**
681	331	471	102	102	272	272	562	682	822	103	153	223	**4kV†**
391	221	331	681	561	182	182	392	472	472	682	103	123	**5kV†**
•	•	•	•	•	152	152	272	332	332	472	822	822	**6kV†**
•	•	•	•	•	•	821	152	182	182	272	392	472	**7kV†**
•	•	•	•	•	•	•	102	122	122	182	272	392	**8kV†**
•	•	•	•	•	•	•	•	821	102	122	222	272	**9kV†**
•	•	•	•	•	•	•	•	681	821	122	182	222	**10kV†**

Note: † Units rated above 800V may require conformal coating to preclude arcing over chip surface
Maximum voltage for MIL-PRF-123 tested parts is 1kV

High Reliability Chip - X7R - 16Vdc to 10kVdc

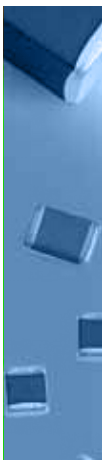
A range of MLC chip capacitors in Stable EIA Class II dielectric with special testing for long term reliability. They are designed for optimum reliability; burned in at elevated voltage and temperature, and 100% physically and electrically inspected to ascertain conformance to strict performance criteria. Units may be tested in accordance with MIL-PRF-55681, MIL-PRF-123, MIL-PRF-49467 or customer SCD.

Designed for surface mount application with nickel barrier terminations making them suitable for solder wave and reflow solder board attachment as well as vapor phase attachment for part sizes 2225 or smaller. Silver-palladium terminations are also available for hybrid use with conductive epoxy.

Class II X7R chips are used as decoupling, by-pass, filtering and transient voltage suppression elements and exhibit +/-15% temperature coefficient and predictable variation of electrical properties with time, temperature and voltage.

They find application for High Reliability use such as medical implanted devices, aerospace, airborne and military use as well as consumer uses requiring safety margins not attainable with commercial products.

Standard EIA case sizes and available C/V values are listed below - special sizes, thicknesses and other voltage ratings are available; please contact the Sales Office for information.



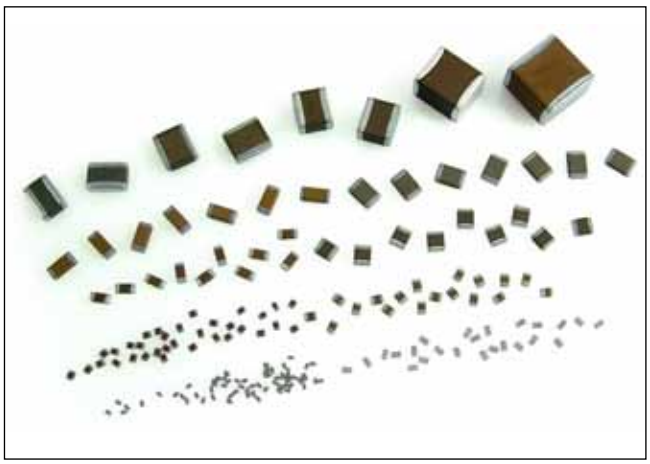
Capacitance and voltage selection for popular chip sizes

Size	0402	0504	0603	0805	1005	1206	1210	1515	1808		1812		1825	
Min cap.	121	121	121	121	121	121	121	151	151	151	151	151	471	471
Tmax inches: mm:	0.024 0.61	0.044 1.12	0.035 0.89	0.054 1.37	0.054 1.37	0.064 1.63	0.065 1.63	0.130 3.02	0.065 1.63	0.080* 2.03	0.065 1.63	0.100* 2.54	0.080 2.03	0.140* 3.56
16V	472	333	223	104	124	274	474	105	394	684	824	824	155	225
25V	472	333	223	104	124	274	474	824	394	564	824	824	155	225
50V	472	333	223	823	104	224	394	824	334	474	684	684	125	185
100V	392	273	183	563	683	154	274	684	224	334	474	474	105	185
200V	182	123	822	223	333	823	124	394	124	154	224	394	564	105
250V	102	822	562	183	273	393	823	224	683	104	124	124	394	684
300V	•	•	•	103	123	273	563	184	563	683	104	154	274	474
400V	•	•	•	682	682	183	333	104	333	393	563	124	184	334
500V	•	•	•	472	472	123	273	823	273	333	473	683	124	274
600V	•	•	•	332	272	682	153	563	183	223	273	473	823	184
800V†	•	•	•	222	182	472	103	333	103	123	183	273	563	104
1kV†	•	•	•	122	821	222	562	183	562	822	103	183	333	563
1.5kV†	•	•	•	•	•	102	222	822	272	332	392	822	123	273
2kV†	•	•	•	•	•	471	102	392	122	152	182	332	682	123
3kV†	•	•	•	•	•	•	•	102	391	471	821	152	152	332
4kV†	•	•	•	•	•	•	•	•	181	271	391	681	821	182
5kV†	•	•	•	•	•	•	•	•	•	•	•	•	561	102
6kV†	•	•	•	•	•	•	•	•	•	•	•	•	•	•
7kV†	•	•	•	•	•	•	•	•	•	•	•	•	•	•
8kV†	•	•	•	•	•	•	•	•	•	•	•	•	•	•
9kV†	•	•	•	•	•	•	•	•	•	•	•	•	•	
10kV†	•	•	•	•	•	•	•	•	•	•	•	•	•	•

Note: † Units rated above 800V may require conformal coating to preclude arcing over chip surface.
Maximum voltage for MIL-PRF-123 tested parts is 1kV.

High Reliability Chip - X7R - 16Vdc to 10kVdc

- For dielectric characteristics see pages 4 & 5.
- For dimensions see page 16.
- For termination options see pages 6.
- For capacitance tolerances available see page 21.
- For ordering information see page 21.



Note: Maximum capacitance values are shown below as 3 digit code: 2 significant figures followed by the no. of zeros e.g. 183 = 18,000pF.

Capacitance and voltage selection for popular chip sizes

2020	2221	2225		2520	3333	3530	4040	4540	5440	5550	6560	7565	Size
102	471	471	471	102	102	102	102	102	102	102	222	222	Min cap.
0.180 4.57	0.080 2.03	0.080 2.03	0.150* 3.81	0.180 4.57	0.250 6.35	0.250 6.35	0.300 7.62	0.300 7.62	0.300 7.62	0.300 7.62	0.300 7.62	0.300 7.62	inches: **Tmax** mm:
185	125	185	275	225	475	475	825	825	106	126	186	226	**16V**
155	125	185	225	225	475	475	685	825	106	126	186	206	**25V**
155	125	155	225	155	395	395	685	685	825	106	156	186	**50V**
125	824	125	185	125	335	335	565	685	685	825	106	156	**100V**
105	474	564	125	125	275	275	475	475	565	685	825	106	**200V**
684	394	394	684	804	225	225	475	475	565	685	825	106	**250V**
564	224	334	684	684	185	185	335	335	395	475	685	825	**300V**
334	154	184	394	394	105	105	185	225	225	275	335	565	**400V**
224	154	154	334	274	684	684	125	155	155	185	275	395	**500V**
154	823	104	224	184	474	474	824	824	105	155	225	275	**600V**
104	563	683	124	124	334	334	564	684	824	125	185	225	**800V†**
563	273	393	823	683	184	184	394	474	474	684	105	125	**1kV†**
123	123	153	333	333	823	823	184	184	224	274	474	564	**1.5kV†**
123	562	822	153	153	473	473	104	104	124	184	224	334	**2kV†**
272	182	222	392	562	223	223	333	473	473	683	104	154	**3kV†**
182	821	102	222	272	123	123	183	223	273	393	563	823	**4kV†**
102	561	561	122	182	682	822	103	153	183	273	393	473	**5kV†**
•	•	•	•	•	472	562	682	103	123	183	273	333	**6kV†**
•	•	•	•	•	•	392	472	682	822	123	183	273	**7kV†**
•	•	•	•	•	•	272	392	562	682	103	153	183	**8kV†**
•	•	•	•	•	•	222	272	392	472	682	123	153	**9kV†**
•	•	•	•	•	•	152	222	332	392	562	822	123	**10kV†**

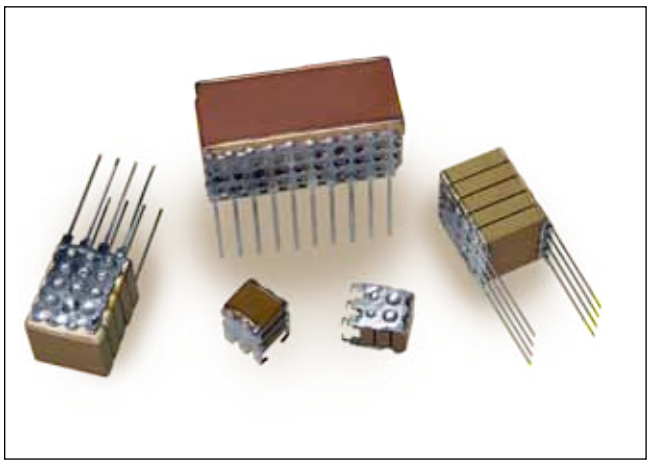
Note: † Units rated above 800V may require conformal coating to preclude arcing over chip surface.
Maximum voltage for MIL-PRF-123 tested parts is 1kV.

DSCC Approved Capacitor Assemblies

A range of switch mode leaded capacitor assemblies in three approved DSCC 87106 case codes sizes.

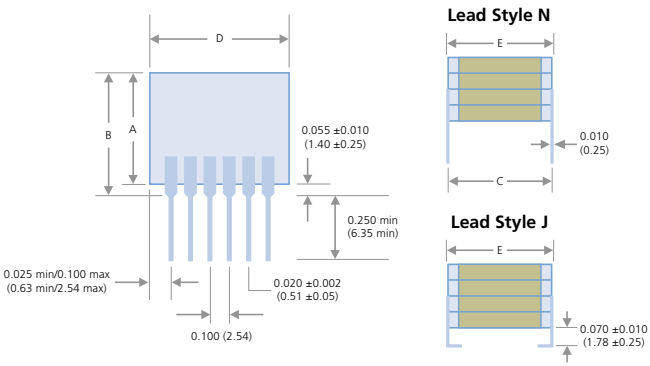
The below referenced DSCC (Defense Supply Center Columbus) dash numbers show our approved range.

Novacap Vendor CAGE code is 65238.



Dimensions - inches/mm

Case code		5	4	3
C	±0.025 inches: ±0.635 mm:	0.250 6.35	0.400 10.16	0.450 11.43
Dmin	inches: mm:	0.224 5.69	0.350 8.89	0.950 24.13
Dmax	inches: mm:	0.275 6.99	0.425 10.80	1.075 27.30
Emax	inches: mm:	0.300 7.62	0.440 11.18	0.500 12.70
Leads per side		3	4	10
For dimensions A and B please refer to DSCC 87106				



Lead style N - DSCC 87106 Dash Numbers

Voltage	Case code	5	4	3
50V	Dash#	001-020	021-028	029-040
	Cap value	105-565	825-156	186-476
	Dash#	•	222-223	•
	Cap value	•	685	•
100V	Dash#	055-072	073-082	083-092
	Cap value	684-335	395-825	126-276
	Dash#	•	•	229-230
	Cap value	•	•	106
200V	Dash#	113-126	127-136	137-148
	Cap value	474-155	185-395	475-126
500V	Dash#	173-190	191-198	199-208
	Cap value	154-684	105-185	275-565
	Dash#	•	231-232	233-234
	Cap value	•	824	225

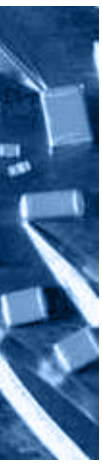
Lead style J - DSCC 87106 Dash Numbers

Voltage	Case code	5	4	3
50V	Dash#	241-260	261-270	271-282
	Cap value	105-565	685-156	186-476
100V	Dash#	301-318	319-328	329-340
	Cap value	684-335	395-825	106-276
200V	Dash#	361-374	375-384	385-396
	Cap value	474-155	185-395	475-126
500V	Dash#	421-438	439-448	449-460
	Cap value	154-684	824-185	225-565

How to Order - The purchase order or contract must specify the following:

1	2	3
The Complete DSCC part number - Drawing Number and Dash Number Example: 87106-222	Whether you want Novacap to perform the Group B Test, or provide a certification of compliance for Group B requirement.	Specify requirements for packaging.

S02A Space ranges - C0G/NP0 & X7R



S02A Space ranges
Maximum capacitance values

		0603	0805	1206	1210	1812	2220	2225
16V	C0G/NP0	390pF - 1.5nF	1pF - 6.8nF	1pF - 22nF	10pF - 33nF	220pF - 100nF	470pF - 150nF	560pF - 220nF
	X7R	330pF - 100nF	100pF - 330nF	680pF - 1.0µF	1.0nF - 1.5µF	3.9nF - 3.3µF	10nF - 5.6µF	18nF - 6.8µF
25V	C0G/NP0	390pF - 1.0nF	1pF - 4.7nF	1pF - 15nF	10pF - 22nF	220pF - 68nF	470pF - 100nF	560pF - 150nF
	X7R	330pF - 56nF	100pF - 220nF	680pF - 820nF	1.0nF - 1.2µF	3.9nF - 2.2µF	10nF - 4.7µF	18nF - 5.6µF
50/63V	C0G/NP0	0.5pF - 470pF	1pF - 2.7nF	1pF - 10nF	10pF - 18nF	220pF - 39nF	470pF - 68nF	560pF - 100nF
	X7R	330pF - 47nF	100pF - 220nF	680pF - 470nF	1.0nF - 1.0µF	3.9nF - 2.2µF	10nF - 3.3µF	18nF - 3.3µF
100V	C0G/NP0	1pF - 330pF	1pF - 1.8nF	1pF - 6.8nF	10pF - 12nF	220pF - 27nF	470pF - 47nF	560pF - 68nF
	X7R	100pF - 10nF	100pF - 47nF	100pF - 150nF	1.0nF - 470nF	3.9nF - 1.0µF	10nF - 1.5µF	18nF - 1.5µF
200V	C0G/NP0	1pF - 100pF	1pF - 680pF	1pF - 2.2nF	10pF - 4.7nF	220pF - 12nF	470pF - 22nF	560pF - 27nF
	X7R	100pF - 5.6nF	100pF - 27nF	100pF - 100nF	1.0nF - 220nF	3.9nF - 470nF	10nF - 1.0µF	18nF - 1.0µF
500V	C0G/NP0	-	1pF - 270pF	1pF - 1.2nF	10pF - 2.7nF	180pF - 6.8nF	390pF - 15nF	4.7nF - 18nF
	X7R	-	10pF - 8.2nF	180pF - 33nF	390pF - 100nF	390pF - 270nF	1nF - 560nF	15nF - 820nF

Note: In accordance with ESCC 3009.

Ordering information - S02A Space grade ranges product code construction

1210	A	100	0103	J	X	T	_ _ _
Chip size	Termination(1)	Voltage	Capacitance in picofarads (pF)	Capacitance tolerance	Dielectric Rel Release codes	Packaging	Suffix code
0603 0805 1206 1210 1812 2220 2225	**A** = Silver base with nickel barrier (Tin/lead plating with min. 10% lead). **F** = Silver Palladium. RoHS compliant. **H** = FlexiCap™ termination base with Ni barrier (Tin/lead plating with min. 10% lead).	016 = 16V 025 = 25V 050 = 50V 063 = 63V 100 = 100V 200 = 200V 500 = 500V	First digit is 0. Second and third digits are significant figures of capacitance code. The fourth digit is number of zeros following Example: 0103 = 10nF	<10pF B = ±0.1pF C = ±0.25pF D = ±0.5pF ≥ 10pF F = ±1% G = ±2% J = ±5% K = ±10% M = ±20%	**C** = C0G/NP0 (1B) **X** = X7R (2R1)	**T** = 178mm (7") reel **R** = 330mm (13") reel **B** = Bulk pack - tubs **Q** = Waffle pack	Used for specific customer requirements **S02A** = S (Space Grade) High Rel

Notes:
(1) Termination **A, H** & **F** available for Space applications. If another termination type is required then contact Syfer Sales.
(2) Please include Lot Acceptance Test requirement (LAT1, LAT2 or LAT3) on purchase order against each line item.
Tests conducted after 100% Burn-In (2xRV @125ºC for 168 hours):
LAT1: 4 x adhesion, 8 x rapid temp change + LAT2 and LAT3.
LAT2: 20 x 1000 hour life test + LAT3.
LAT3: 6 x TC and 4 x solderability.

High Capacitance Chip - X7R, X5R

A range of High Capacitance value BME MLC chip capacitors, in stable Class II dielectrics X7R and X5R, with a spread of capacitance values offered up to 100µF.

Comparable circuit designs can be achieved at typically a third to a fifth of the capacitance values because of the low ESR characteristics these parts exhibit. As a consequence they are also ideal to replace Tantalum and Low ESR Electrolytic Capacitors without polarity concerns. They find application as power supply bypass capacitors, smoothing capacitors, input/output filters in DC-DC Converters and in digital circuits and LCD modules.

Parts are RoHS Compliant and suitable for reflow soldering process.

- Nickel Barrier terminations with tin, tin/lead or gold flash
- Capacitance tolerances available: ±10%, ±20%
- Available with high reliability screening. Contact the Knowles Capacitors Sales Office for details

Capacitance values - High Capacitance Chip

Size	0402		0603		0805		1206		1210				1812	
Tmax inches: mm:	0.024 0.61		0.035 0.89		0.054 1.37		0.072* 1.83		0.085* 2.16		0.110* 2.79		0.110* 2.79	
Dielectric	X7R	X5R	X7R	X5R	X7R	X5R	X7R	X5R	X7R	X5R	X7R	X5R	X7R	X5R
4V				22µF†				100µF†						-
6.3V	470nF	1µF 2.2µF† 4.7µF†		4.7µF 10µF†		22µF†		47µF†		47µF†	47µF†	100µF†		-
10V		1µF	2.2µF	4.7µF 10µF†	10µF†	10µF	22µF†	22µF†		22µF†		47µF†		-
16V	15nF 22nF 33nF 47nF 100nF 220nF	220nF 470nF 100nF 220nF 470nF	100nF 1µF	2.2µF 4.7µF	470nF 1.0µF 2.2µF 4.7µF†	4.7µF 10µF	10µF	10µF 22µF†	4.7µF† 10µF†			22µF†		-
25V	6.8nF 10nF 47nF 100nF	10nF 220nF	470nF 1.0µF	220nF 470nF 1.0µF 2.2µF	1.0µF 2.2µF 4.7µF	2.2µF 4.7µF	2.2µF 4.7µF 10µF	4.7µF 10µF	3.3µF† 4.7µF†	4.7µF† 10µF†	22µF†			-
35V										2.2µF† 4.7µF†		10µF		-
50V	10nF	100nF	220nF 470nF	100nF 470nF 1.0µF	220nF 470nF 1.0µF	220nF 470nF 1.0µF 2.2µF	470nF 1.0µF 2.2µF 4.7µF	4.7µF	1.0µF		4.7µF†	4.7µF† 10µF†		-
100V			100nF		220nF		1.0µF		1.0µF 2.2µF				1.0µF 2.2µF	-

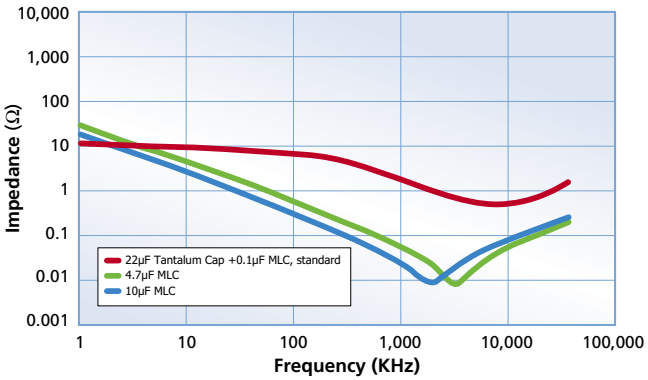
* Denotes non standard chip thickness. Order code needs to have an 'X' inserted together with the dimension in inches -e.g. X072 where dimension is 0.072".

† Denotes only available in ±20% capacitance tolerance

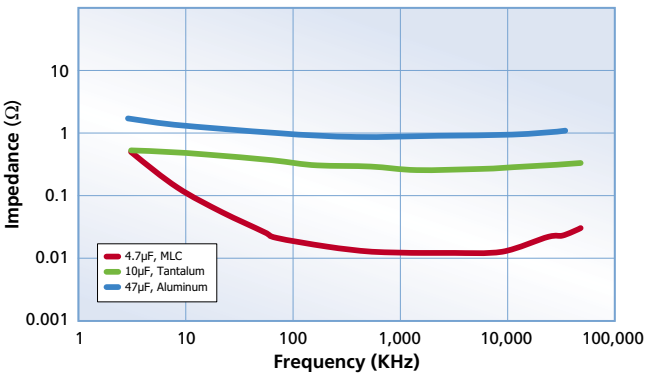
High Capacitance Chip - X7R, X5R

Comparison with other dielectric capacitors

Impedance Curves



ESR Characteristics



Dielectric characteristics

	X7R (BB) Stable	X5R (BW) Stable
Operating temperature range:	-55°C to 125°C	-55°C to 85°C
Temperature coefficient:	±15% ΔC Max.	±15% ΔC Max.
Dissipation factor:	3.5% max except: 0402 ≥ 0.1µF = 5%, 0603 ≥ 0.22µF = 10%, 0805 ≥ 1.0µF = 5%, 0805 ≥ 2.2µF = 10%, 1206 ≥ 2.2µF = 10%, 1210 ≥ 4.7µF = 5%, 1210 ≥ 22µF = 10%	5% max except: 0402 ≥ 1.0µF = 10%, 0603 ≥ 1.0µF = 10%, 0805 ≥ 4.7µF = 10%, 1206 ≥ 4.7µF = 10%, 1210 ≥ 10µF = 10%
Insulation resistance @25°C:	>10GΩ or >100ΩF whichever is less	>10GΩ or >100ΩF whichever is less
Dielectric withstanding voltage:	250%	250%
Ageing Rate:	X7R 3.5% typical	X5R 5% typical
Test parameters @ 25°C:	1KHz, 1.0 ±0.2 VRMS	1KHz, 1.0 ±0.2 VRMS 120Hz, 0.5 ±0.1 VRMS for 22µF, 47µF & 100µF

Ordering information - High Capacitance Chip Capacitors

1206	W	476	K	6R3	N	X080	T
Chip sizes	Dielectric	Capacitance	Tolerance	Voltage-VDCW	Termination	Thickness option	Packing
0402 **0603** **0805** **1206** **1210** **1812**	BB* = X7R BW*= X5R *Formerly B & W codes	Value in Picofarads. Two significant figures, followed by number of zeros: **476** = 47µF (47,000,000pF)	**K** = ± 10% **M** = ± 20%	Two significant figures, followed by number of zeros. R denotes decimal point: **6R3** = 6.3V **501** = 500V	**N** = Nickel Barrier (100% tin) **Y** = Nickel Barrier (90% tin/10% lead) **NG** = Nickel Barrier Gold Flash	Blank = Standard thickness **X** = special thickness, specified in inches: **X085** = 0.085"	No suffix = Bulk **T** = Tape & Reel

Note: BME parts available with added high reliability test. Consult the factory.

Lot Testing

	Standard Commercial Capacitors	HH MIL-PRF-38534 Class H	HB MIL-PRF-55681	HK MIL-PRF-38534 Class K	HS MIL-PRF-123
Destructive Physical Analysis (DPA)	S	S	S	S	S
CSAM (C-Mode Scanning Acoustic Microscopy)	O	O	O	O	O
Plating Thickness Verification	S	S	S	S	S
Solderability*	S	S	S	S	S
Electrical Characteristics (DWV, IR, Cap, DF)	S	S	S	S	S
Sample Visual Inspection	S	S	S	S	S
100% Visual Inspection	O	O	O	S	S
Thermal Shock -55°C to +125°C	O	O	O	O	S
100% Burn-In**	O	O	S	S	S
100% Hot IR	O	O	O	O	S
Hot IR Sample Test (at rated voltage)	O	O	S	S	S
10 Piece Sample Temp Cycling, Constant Acceleration, Burn-In	O	O	O	S	O
Life Sample Test	O	O	O	O	O
Humidity Sample Test	O	O	O	O	O
Resistance to Soldering Heat Sample Test	O	O	O	O	O
Terminal Strength Sample Test	O	O	O	O	O
Group B Testing	N/A	N/A	N/A	N/A	O
Group C Testing	N/A	N/A	O	O	O

S = Test conducted as standard.

O = Optional test. Please discuss with Novacap Sales.

* Solderability and plating thickness verification does not apply to palladium/silver terminations.

** Burn-In for MIL-PRF-55681 and MIL-PRF-38534 Class K is 100 hours. Burn-In for MIL-PRF-123 is 168 to 264 hours.

Lot Test Details

DPA	Destructive Physical Analysis, Device is mounted in an epoxy plug and cross sectioned, with a fine grit sand paper while examining the internal construction of the device per relevant sections of EIA 469 and NOVACAP's internal design criteria.
CSAM	C-Mode Scanning Acoustic Microscopy; A method of non-destructive analysis is of the internal construction of a device per MIL-PRF-123. The optional test is to assure the highest quality of internal microstructure.
Plating Thickness Verification	X-Ray fluorescent [XRF) equipment/instrument is utilized to verily the plating thickness of a device according to NOVACAP's criteria.
Solderability	Determines the ability for solder to wet/adhere to the termination by dipping the component into molten solder according to MIL-STD-202 Method 208.
Electrical Characteristics (DWV, IR, Cap, DF)	DWV: Dielectric Withstanding Voltage, Determines the ability of the dielectric to withstand accelerated voltage without breaking down. IR: Insulation Resistance; The insulation resistance is a measure of the capability of a material to withstand leakage of current under a VDC potential gradient.
Sample Visual Inspection	Is an AQL level inspection, which is based on lot size and consists of a bulk scan under microscope between 7-10X magnification.
100% Visual Inspection	Each side of every part in a lot is subjected to inspection under microscope between 7-10X magnification in accordance with MIL-PRF-123 Appendix B.
Thermal Shock -55°C to +125°C	Devices are subjected to sudden temperature extremes (hot and cold) to determine the physical integrity of the components. All parts receive 20 cycles in accordance with MIL-PRF-123.
100% Burn-In	A method of screening infantile failures by testing at accelerated conditions. Product groups HB and HK follow the guidelines of MIL-PRF-55681. The parts receive a 100% Burn-in at 125°C and a voltage specified in page 27 for 100 hours. Product group HS follows the guidelines of MIL-PRF-123. The parts receive a 100% Bum-in at 125°C and a voltage specified in page 27 for a minimum of 168 and a maximum of 264 hours. The Burn-In may be terminated at any time between the hours of 168 and 264 when failures are less than 0.1% or 1 pieces during the last 48 hours of the test.
100% Hot IR	Tested for IR at rated voltage and elevated temperatures.
Hot IR Sample Test	A sample that is tested for IR at rated voltage and elevated temperatures.
10 Piece Sample Temp Cycling, Constant Acceleration, Burn-In	The 10 piece sample is tested in accordance with MIL-PRF-38534 TABLE C-lll Subgroup 3. The tests include Temperature Cycling per MIL-STD-883 Method 1010 Condition C, Constant Acceleration per MIL-STD-883 Method 2001 with 3,000g's in Y1 direction, Burn-in according to MIL-PRF-55681, and Visual inspection.
Life Sample Test	A test that determines the long-term reliability of a device that is performed at accelerated electrical and environ mental conditions. Life test for product groups HH,HB, and HK shall be in accordance with MIL PRF-55681. Life test for product group HS shall be in accordance with MIL-PRF-123.
Humidity Sample Test	Humidity, steady state, low voltage test in accordance with MIL-PRF-202 method 103 condition A with the capacitor requirements of MIL-PRF-55681/MIL-PRF-123. A twelve piece sample is tested with accept on zero failures.
Resistance to Soldering Heat Sample Test	The ability of a device to withstand soldering temperatures. Capacitors shall be tested in accordance with MIL-STD-202 Method 210 with applicable detail of MIL-PRF-55681/MIL-PRF-123.
Terminal Strength Sample Test	It is the strength of the adhesion of the termination to the ceramic body. Capacitors shall be tested in accordance with MIL-STD-202 Method 211 Test Condition A with applicable details of MIL-PRF-123. A six piece sample is tested with accept on zero failures.
Group B Testing	Group B environmental testing for product group HS shall consist of the tests specified in table XII of MIL-PRF-123 and shall be performed on sample units from lots that have been subjected to and have passed group A inspection. Copies of Group B data shall be forwarded to purchaser with parts. Parts may not be shipped until the conclusion of life test.
Group C Testing	Group C environmental testing shall consist of the tests specified in table XI of MIL-PRF-55681 for product groups HB and HK. Testing shall consist of the tests specified in table XIII of MIL-PRF-123 for product group HS. Tests shall be performed on sample units from lots that have been subjected to and have passed group A inspection. Copies of Group C data shall be forwarded to purchaser with parts. Parts may not be shipped until the conclusion of life test.

High Temperature Caps - up to 150°C X8R, Commercial, AEC-Q200

The X8R dielectric will operate from -55°C to +150°C, with a maximum capacitance change ±15% (without applied voltage).

The devices are available in sizes 0805 to 2225, with voltage ranges from 25V to 3kV and capacitance values from 100pF to 1.8µF.

The capacitors have been developed by Knowles to meet demand from various applications in the automotive and industrial markets and in other electronic equipment exposed to high temperatures. The increased use of electronics in automotive "under the hood" applications has created demand for this product range.

The X8R range incorporates a specially formulated termination with a nickel barrier finish that has been designed to enhance the mechanical performance of these SMD chip capacitors in harsh environments typically present in automotive applications.

For information, X8R dielectric contains lead within the ceramic and parts rated less than 250Vdc are not compliant with the EU 2011/65/EU RoHS directive.

Capacitance Range
100pF to 1.8µF (0805 to 2225)

Temperature Coefficient of Capacitance (TCC)
±15% from -55°C to +150°C

Dissipation Factor (DF)
≤ 0.025

Termination
Nickel Barrier Tin Plated

Insulation Resistance (IR)
100G Ω or 1000secs (whichever is the less).

Dielectric Withstand Voltage (DWV)
2.5 x rated voltage for 5±1 seconds,
50mA charging current maximum.

Ageing Rate
1% per decade (typical)

X8R High Temperature Capacitors - minimum/maximum cap. values according to the rated d.c. voltage

	0805	1206	1210	1808	1812	2220	2225	4540*	7565*
Min cap	100pF	100pF	100pF	100pF	150pF	220pF	330pF	1nF	2.2nF
25V	56nF	180nF	330nF	470nF	680nF	1.5µF	1.8µF	5.6µF	15µF
50V	33nF	120nF	220nF	270nF	470nF	680nF	1µF	4.7µF	12µF
100V	15nF	56nF	120nF	150nF	220nF	470nF	560nF	3.9µF	10µF
200/250V	10nF	33nF	68nF	82nF	120nF	220nF	330nF	2.7µF	6.9µF
500V	3.9nF	18nF	39nF	47nF	100nF	180nF	270nF	1.2µF	3.2µF
630V	1.8nF	3.9nF	10nF	12nF	33nF	150nF	180nF	-	-
1kV	1nF	2.2nF	4.7nF	5.6nF	18nF	39nF	56nF	-	-
1.2kV	-	1.8nF	3.9nF	4.7nF	12nF	33nF	39nF	-	-
1.5kV	-	1.2nF	2.2nF	2.7nF	8.2nF	22nF	27nF	-	-
2kV	-	470pF	1.2nF	1.8nF	4.7nF	12nF	18nF	-	-
2.5kV	-	-	-	1nF	2.7nF	6.8nF	10nF	-	-
3kV	-	-	-	680pF	2.2nF	4.7nF	5.6nF	-	-

Notes: = X8R ranges in yellow available as qualified AEC-Q200. *Only available as Novacap parts.

Ordering information - Syfer X8R High Temperature Capacitors

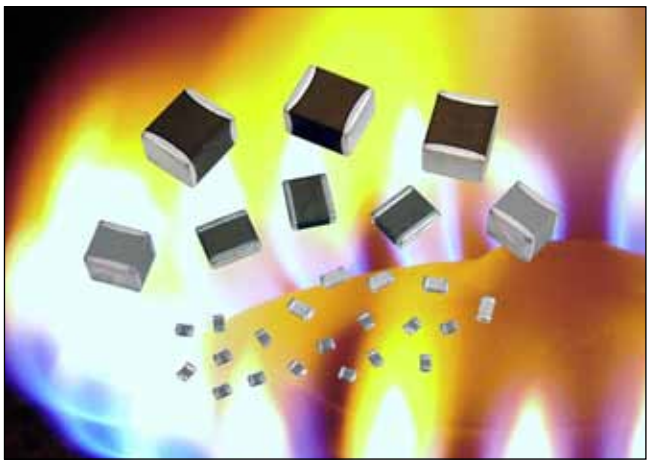
1206	Y	100	0473	K	N	T
Chip size	Termination	Voltage d.c.	Capacitance in picofarads (pF)	Capacitance tolerance	Dielectric codes	Packaging
0805 **1206** **1210** **1808** **1812** **2220** **2225**	**Y** = FlexiCap™ termination base with nickel barrier (100% matte tin plating).	**025** = 25V **050** = 50V **100** = 100V **200** = 200V **250** = 250V **500** = 500V **630** = 630V **1K0** = 1kV **1K2** = 1.2kV **1K5** = 1.5kV **2K0** = 2kV **2K5** = 2.5kV **3K0** = 3kV	First digit is 0. Second and third digits are significant figures of capacitance code. The fourth digit is number of zeros following. Example: **0473** = 47000pF = 47nF	**J** = ±5% **K** = ±10% **M** = ±20%	**N** = X8R **T** = X8R AEC-Q200	**T** = 178mm (7") reel **R** = 330mm (13") reel **B** = Bulk pack - tubs or trays

Ordering information - Novacap High Temperature Capacitors

4540	S	125	K	501	N	T	M
Chip size	Dielectric codes	Capacitance in picofarads (pF)	Capacitance tolerance code	Voltage code	Termination codes	Packaging	Marking
0805 **1206** **1210** **1812** **1825** **2225** **4540** **7565**	**S** = X8R High Temp. (up to 150ºC)	Value in Picofarads. Two significant figures, followed by number of zeros: **125** = 1.2nF	**J** = ±5% (X8R) **K** = ±10% (Class II) **M** = ±20% (Class II)	Two significant figures, followed by number of zeros: **250** = 25 Volts **500** = 50 Volts **101** = 100 Volts **251** = 250 Volts **501** = 500 Volts	**P** = Palladium Silver **PR** = Palladium Silver* **K** = Solderable Palladium Silver* **N** = Nickel Barrier* 100% tin **Y** = Nickel Barrier* 90% tin, 10% lead **C** = FlexiCap™/Nickel Barrier* 100% tin **D** = FlexiCap™/Nickel Barrier* 90% tin, 10% lead **S** = Solderable Silver* *Indicates RoHS terminations	**None** = Bulk **T** = Tape & Reel **W** = Waffle Pack	**None** = Unmarked **M** = Marked

High Temperature Caps - 160°C, 200°C

A range of chip capacitors, available in sizes 0805 to 7565, designed to operate from -55°C to 160°C, (Class II Dielectric) and from -55ºC to 200ºC (C0G/NP0 and Class II Dielectrics). Voltage ratings of 25V to 4kV.



Maximum capacitance values - 160ºC C0G (F)/Class II (G) and 200ºC C0G/NP0 (D)/Class II (E) Dielectrics

Size	0805	1206	1210	1515	1808	1812	1825	2225	3530	4540	6560	7565
Tmax	0.054 1.37	0.064 1.63	0.065 1.65	0.130 3.30	0.065 1.65	0.065 1.65	0.080 2.03	0.080 2.03	0.250 6.35	0.300 7.62	0.300 7.62	0.300 7.62

Maximum capacitance values - C0G/NP0 - 160ºC (F) and 200ºC (D)

Min cap.	0R5	1R0	5R0	5R0	120	220	330	470	221	390	560	101
25V	2.7nF	5.6nF	12nF	22nF	12nF	22nF	56nF	56nF	100nF	180nF	330nF	390nF
50V	1.8nF	3.9nF	8.2nF	18nF	8.2nF	15nF	39nF	47nF	82nF	150nF	270nF	330nF
100V	680pF	1.8nF	3.3nF	10nF	3.3nF	8.2nF	15nF	18nF	56nF	100nF	220nF	270nF
250V	180pF	1.0nF	2.2nF	3.9nF	2.2nF	5.6nF	12nF	18nF	33nF	56nF	120nF	150nF
500V	100pF	390pF	820pF	2.7nF	1.0nF	2.2nF	3.9nF	5.6nF	12nF	27nF	56nF	68nF
1kV	47pF	100pF	220pF	820pF	220pF	560pF	820pF	1.0nF	5.6nF	15nF	33nF	39nF
2kV	•	27pF	56pF	180pF	56pF	120pF	180pF	270pF	1.5nF	3.3nF	8.2nF	10nF
3kV	•	•	•	82pF	22pF	56pF	82pF	100pF	560pF	1.5nF	3.3nF	3.9nF
4kV	•	•	•	47pF	12pF	27pF	33pF	47pF	330pF	820pF	1.8nF	2.2nF

Maximum capacitance values - Class II - 160ºC (G) and 200ºC (E)

Min cap.	121	121	121	151	151	151	471	471	102	102	222	222
25V	82nF	220nF	390nF	820nF	330nF	680nF	1.5µF	1.8µF	3.9µF	5.6µF	15µF	18µF
50V	47nF	120nF	220nF	680nF	270nF	470nF	1.0µF	1.2µF	2.7µF	4.7µF	12µF	15µF
100V	18nF	47nF	100nF	270nF	82nF	150nF	470nF	470nF	2.2µF	3.3µF	8.2µF	12µF
250V	4.7nF	10nF	27nF	68nF	22nF	47nF	120nF	150nF	560nF	1.2µF	2.7µF	3.9µF
500V	1.0nF	2.2nF	5.6nF	18nF	5.6nF	10nF	27nF	33nF	120nF	330nF	680nF	820nF
1kV	180pF	390pF	820pF	2.7nF	820pF	1.5nF	4.7nF	5.6nF	27nF	68nF	150nF	220nF
2kV	•	•	150pF	560pF	•	220pF	560pF	680pF	6.8nF	18nF	39nF	47nF
3kV	•	•	•	•	•	•	•	•	2.7nF	6.8nF	15nF	18nF
4kV	•	•	•	•	•	•	•	•	1.2nF	2.7nF	5.6nF	8.2nF

Ordering information - High Temperature Capacitors

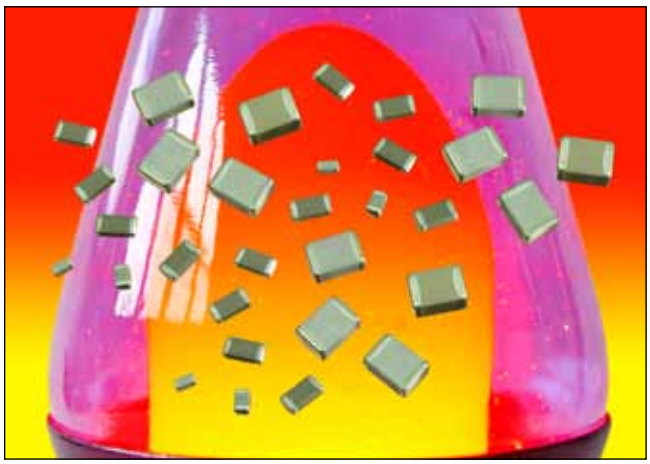
1206	G	224	K	250	N	X050	H	T	M
Chip size	Dielectric codes	Capacitance in picofarads (pF)	Capacitance tolerance code	Voltage code	Termination codes	Thickness options	High Reliability Testing	Packaging	Marking
0805 **1206** **1210** **1515** **1808** **1812** **1825** **2225** **3530** **4540** **6560** **7565**	**F** = C0G/NP0 High Temp. (up to 160ºC) **D** = C0G/NP0 High Temp. (up to 200ºC) **E** = Class II High Temp. (up to 200ºC) **G** = Class II High Temp. (up to 160ºC)	Value in Picofarads. Two significant figures, followed by number of zeros: **224** = 220nF (220,000pF)	**F** = ±1% (C0G/NP0) **G** = ±2% (C0G/NP0) **J** = ±5% (X8R) **K** = ±10% (Class II) **M** = ±20% (Class II)	Two significant figures, followed by number of zeros: **250** = 25 Volts	**P** = Palladium Silver **PR** = Palladium Silver* **K** = Solderable Palladium Silver* **N** = Nickel Barrier* 100% tin **Y** = Nickel Barrier* 90% tin, 10% lead **C** = FlexiCap™/Nickel Barrier* 100% tin **D** = FlexiCap™/Nickel Barrier* 90% tin, 10% lead **S** = Solderable Silver* *Indicates RoHS terminations Note: Nickel barrier not available in 200ºC dielectric	**Blank** = Standard thickness **"X"** = Special thickness, specified in inches: **X050** = 0.050"	High Temperature Screening	**None** = Bulk **T** = Tape & Reel **W** = Waffle Pack	**None** = Unmarked **M** = Marked *Marking not available on sizes <0603

High Temperature HiT range - 200°C - C0G/NP0 & X7R

The HiT range of multilayer ceramic capacitors is suitable for a variety of high temperature applications including: oil exploration, geothermal, military, automotive under-hood and avionics.

This range is manufactured to exacting standards using our unique screen printing process. This provides a high quality component suitable for demanding applications.

- 200ºC operating temperature
- 0805 to 2220 chip sizes
- C0G/NP0 and X7R dielectric options
- Capacitance range C0G/NP0 from 4.7pF up to 22nF
- Capacitance range X7R from 100pF up to 3.3µF
- Voltage ratings from 16V to 630V
- RoHS compliant / Pb Free
- Sn over Ni termination
- Sample kits available



Insulation Resistance (IR)
25ºC >100GΩ or 1000secs (whichever is the less).
200ºC >1GΩ or 10secs (whichever is the less).

Temperature Coefficient of Capacitance (TCC)
C0G/NP0 30ppm/ºC to +125°C. **X7R** ±15% to +125°C

Ageing Rate
C0G/NP0 Zero. **X7R** X7R typically less than 2% per time decade.

Maximum capacitance values - High Temperature HiT range - 200ºC C0G/NP0 & X7R

Rated Voltage	Chip Size											
	0805		1206		1210		1808		1812		2220	
	C0G/NP0	X7R	C0G/NP0	X7R	C0G/NP0	X7R	C0G/NP0	X7R	C0G/NP0	X7R	C0G/NP0	X7R
Min Cap	4.7pF	100pF	10pF	100pF	22pF	100pF	22pF	100pF	47pF	150pF	68pF	220pF
16V	-	220nF	-	470nF	-	1.0µF	-	680nF	-	2.2µF	-	3.3µF
25V	-	47nF	-	150nF	-	470nF	-	330nF	-	1.0µF	-	1.5µF
50V	1nF	15nF	2.2nF	47nF	4.7nF	100nF	4.7nF	100nF	10nF	330nF	22nF	560nF
100V	560pF	6.8nF	1.5nF	18nF	3.9nF	39nF	3.9nF	39nF	6.8nF	100nF	15nF	180nF
200V	150pF	1nF	330pF	4.7nF	1.0nF	10nF	1.0nF	10nF	2.7nF	22nF	4.7nF	47nF
500V	39pF	470pF	150pF	1.0nF	390pF	2.2nF	390pF	2.2nF	1.0nF	5.6nF	2.2nF	15nF
630V	18pF	270pF	100pF	560pF	220pF	1.2nF	220pF	1.2nF	680pF	3.3nF	1.2nF	6.8nF

Note: Other capacitance values may become available, please contact the Sales Office if you need values other than those shown in the above table. For dimensions and soldering information, please go to our website www.knowlescapacitors.com or see our MLC Catalogue.

Ordering information - Novacap Brand - High Temperature HiT range

1206	RE	331	J		501	N	H	T
Case size	Dielectric	Capacitance in picofarads (pF)	Capacitance tolerance		Voltage	Termination	Screening	Packaging
0805 **1206** **1210** **1808** **1812** **2220**	**RD** = C0G/NP0 (200ºC) **RE** = X7R (200ºC)	First and Second digits are significant figures of capacitance code. The fourth digit is number of 0's following. Example : **103** = 10000pF R = decimal	**C0G/NP0** **F** = ±1% **G** = ±2% **J** = ±5% **K** = ±10%	**X7R** **J** = ±5% **K** = ±10% **M** = ±20%	**160** = 16V **250** = 25V **500** = 50V **101** = 100V **201** = 200V **501** = 500V **631** = 630V	**N =** Nickel barrier with 100% matte tin plating. RoHS compliant. Lead free.	**H =** High Temp Screening - if required	**T** = 178mm (7") reel 330mm (13") reel **None** = Bulk pack - tubs

Ordering information - Syfer Brand - High Temperature HiT range

1206	J	1K0	0103	M		X	T	H20
Chip size	Termination	Voltage	Capacitance in picofarads (pF)	Capacitance tolerance		Dielectric	Packaging	Suffix Code
0805 **1206** **1210** **1808** **1812** **2220**	**J** = Nickel barrier with 100% matte tin plating. RoHS compliant. Lead free.	**016** = 16V **025** = 25V **050** = 50V **063** = 63V **100** = 100V **200** = 200V **250** = 250V **500** = 500V **630** = 630V	≥1.0pF & <10pF Insert a P for the decimal point as the second character. e.g., 8P20 = 8.2pF ≥10pF First digit is 0. Second and third digits are significant figures of capacitance code. The fourth digit is the number of zeros following. e.g., **0101** = 100pF	**C0G/NP0** **F** = ±1% **G** = ±2% **J** = ±5% **K** = ±10%	**X7R** **J** = ±5% **K** = ±10% **M** = ±20%	**G** = C0G/ NP0 (BME) **X** = X7R	**T** = 178mm (7") reel **R** = 330mm (13") reel **B** = Bulk pack - tubs	**H20** HiT range

UL Series: Ultra Low ESR Ceramic Capacitors

Description

- Ceramic Capacitors • SMD Compatibility • Stable TC NP0
- Low ESR, High Q • Capacitance range 0.2 - 2200 pF
- Operating Range -55° to +125°C • High Voltage
- Low Noise • EIA 0603 & 0805 Case Size

Functional Applications

- DC Blocking • Bypass • Coupling • Tuning & Feedback
- Amplifier Matching Networks • VCO Frequency Stabilization
- Filtering, Diplexers & Antenna Matching
- High RF Power Circuits • Oscillators • Timing Circuits
- Filters • Broadcast Power Amps
- RF Power Amplifiers & Delay Lines

Dielectric Characteristics

Dielectric Material Code		UL
Temperature Coefficient (ppm/°C)		0 ± 30
Dissipation Factor (% @ 1MHz Maximum)		0.05
Dielectric Withstanding Voltage	Voltage Rating (Volts)	Refer to table
	DWV (Volts)	250% of rated
Insulation Resistance (MΩ minimum)		
High Frequency Capacitors (C11, C17 & C18)		
@ +25°C: 10^6 MΩ (0.1pF to 470pF) / 10^5 MΩ (510pF to 1000pF)		
@ +125°C: 10^5 MΩ (0.1pF to 470pF) / 10^4 MΩ (510pF to 1000pF)		
All other Case sizes (C04, C06, C07, C08, C18, C22 & C40)		
@ +25°C: 10^5 MΩ		
@ +125°C: 10^4 MΩ		
Aging		None
Piezoelectric Effects		None
Dielectric Absorption		None

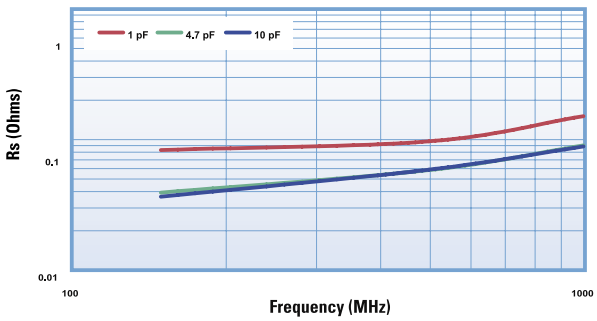
Capacitance and Voltage Table

Cap Code	Cap (PF)	C04 0402	C06 0603	C07 0711	C08 0805	C11 0505	C17 1111
		Case Size					
0R1	0.1	200V Code 6	250V Code 9	250V Code 9	150V Code 8	200V Code 6	50V Code 5
0R2	0.2			500V Code 4	250V Code 9	1KV Code 7	100V Code 1
0R3	0.3						200V Code 6
0R4	0.4						500V Code 4
0R5	0.5						1KV Code 7
0R6	0.6						
0R7	0.7						
0R8	0.8						
0R9	0.9						
1R0	1.0						
1R1	1.1						
1R3	1.3						
1R4	1.4						
1R5	1.5						
1R6	1.6						
1R7	1.7						
1R8	1.8						
1R9	1.9						
2R0	2.0						
2R1	2.1						
2R2	2.2						
2R4	2.4						
2R7	2.7						
3R0	3.0						
3R3	3.3						
3R6	3.6						
3R9	3.9						
4R3	4.3						
4R7	4.7						
5R1	5.1						
5R6	5.6						
6R2	6.2						
6R8	6.8						
7R5	7.5						
8R2	8.2						
9R1	9.1						
100	10						
110	11						
120	12						
130	13						
150	15						
160	16						
180	18						
200	20						
220	22						
240	24						
270	27						
300	30						
330	33						
360	36						
390	39						
430	43						
470	47						
510	51						
560	56						
620	62						
680	68						
750	75						
820	82						
910	91						
101	100						
111	110						
121	120						
151	150						
181	180						
221	220						
271	270						
331	330						
391	390						
471	470						
511	510						
561	560						
621	620						
681	680						
821	820						
911	910						
102	1000						
Reel QTY Horizontal		5000	4000	2350	5000	3500	2350

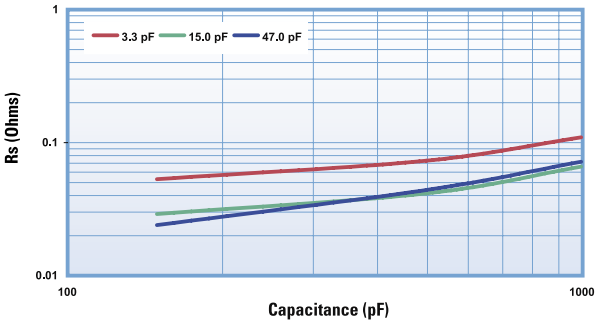
Special capacitance values available upon request.

UL Series: Ultra Low ESR Ceramic Capacitors

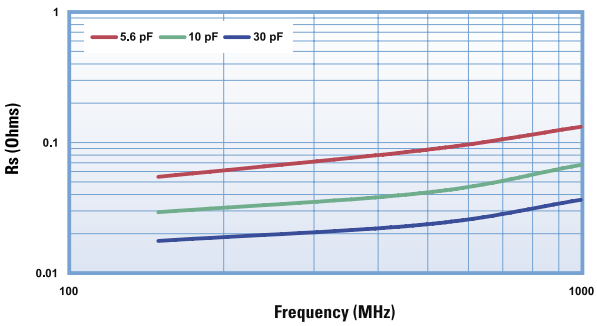
ESR vs Frequency DLI C04 UL Series



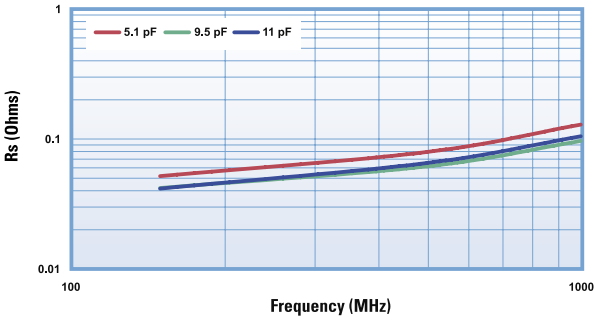
ESR vs Frequency DLI C06 UL Series



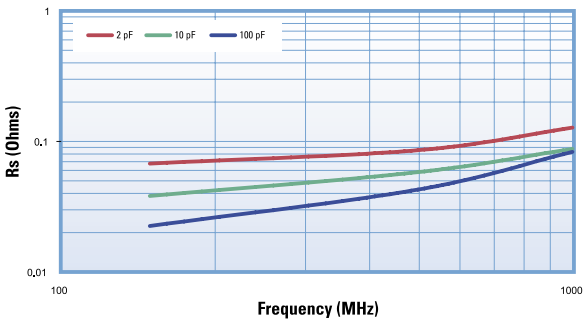
ESR vs Frequency DLI C07 UL Series



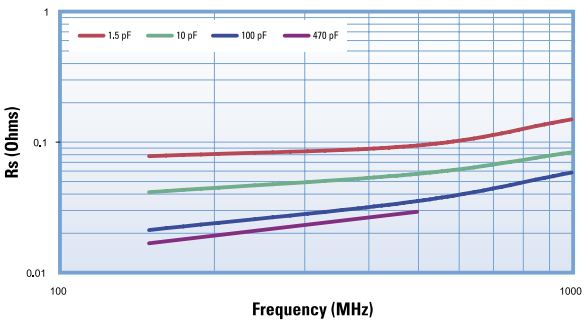
ESR vs Frequency DLI C08 UL Series



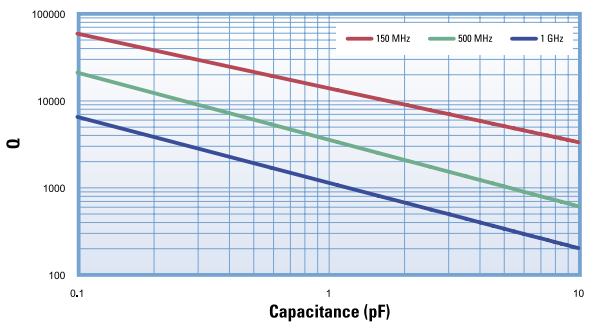
ESR vs Frequency DLI C11 UL Series



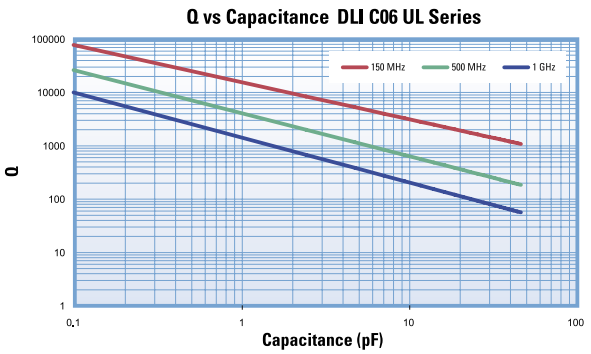
ESR vs Frequency DLI C17 UL Series



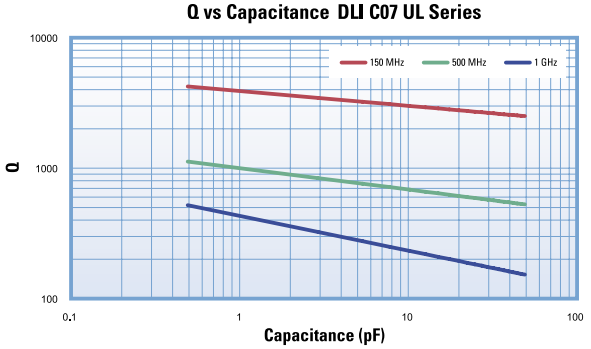
Q vs Capacitance DLI C04 UL Series



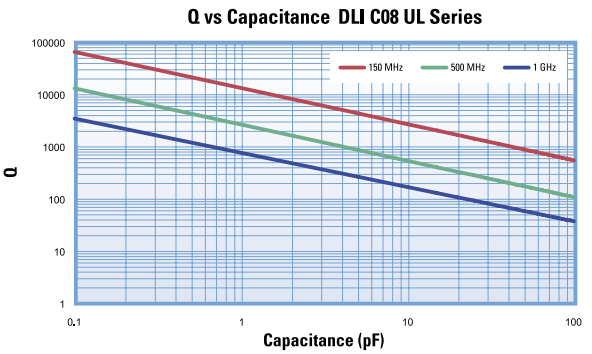
Q vs Capacitance DLI C06 UL Series



Q vs Capacitance DLI C07 UL Series



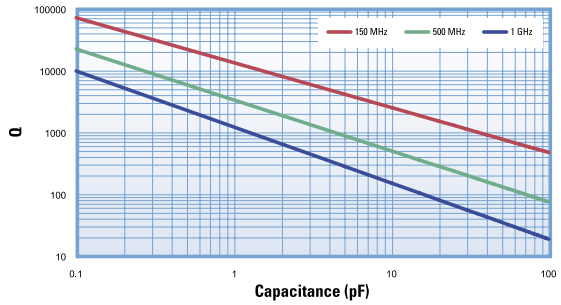
Q vs Capacitance DLI C08 UL Series



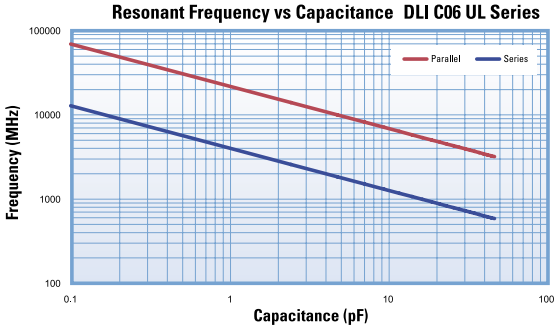
The information above represents typical device performance.

UL Series: Ultra Low ESR Ceramic Capacitors

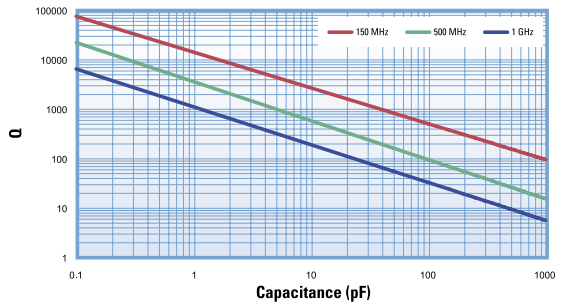
Q vs Capacitance DLI C11 UL Series



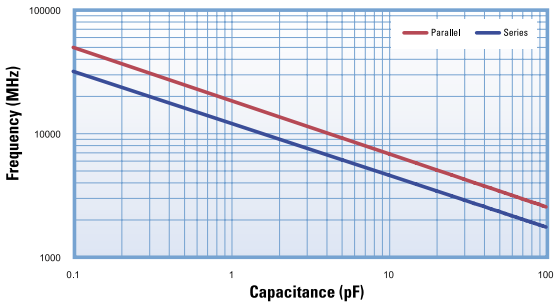
Resonant Frequency vs Capacitance DLI C06 UL Series



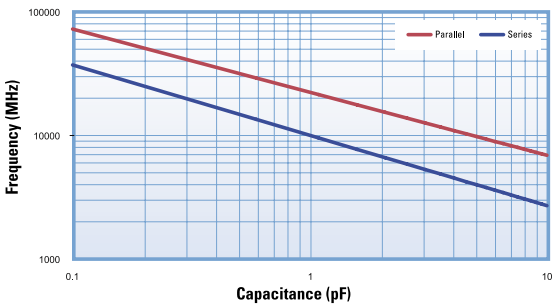
Q vs Capacitance DLI C17 UL Series



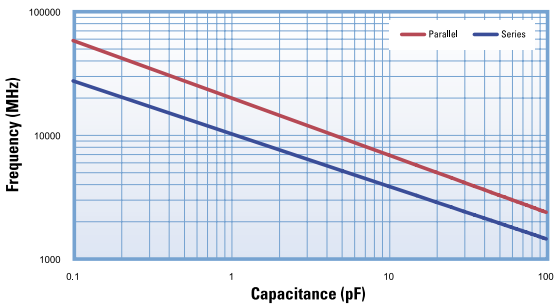
Resonant Frequency vs Capacitance DLI C08 UL Series



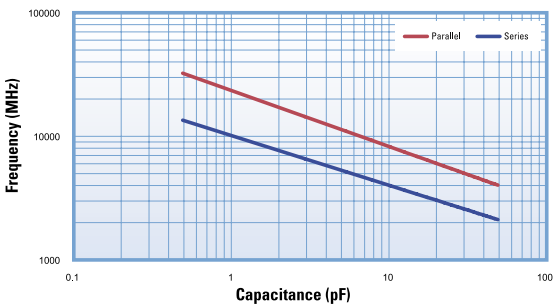
Resonant Frequency vs Capacitance DLI C04 UL Series



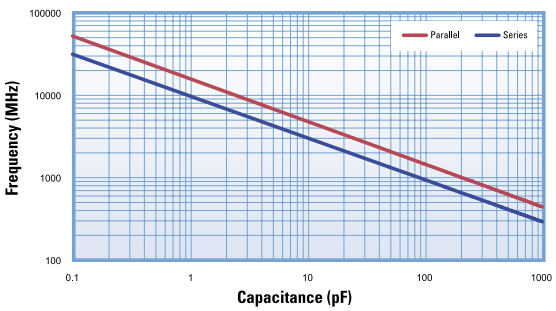
Resonant Frequency vs Capacitance DLI C11 UL Series



Resonant Frequency vs Capacitance DLI C07 UL Series



Resonant Frequency vs Capacitance DLI C17 UL Series



The information above represents typical device performance.

Part Number

C	17	CF	620	J	-	7	U	N	-	X	0	T
MLC Capacitor	Case Size	Dielectric	Capacitance Codes	Capacitance Tolerance		Rated voltage	Termination	Lead Type		Test Level	Marking	Packaging

Terminations

C04	S
C06	U, S, Z,
C07	S, Z,
C08/11/17	U, S, Z,

Lead Types

C04/6/7/8	N
C11	A, B, D
C17	A, B, C, D, E, F

*Special leading requirements available.

Test Level - All Case Sizes

X	Standard
Y	Reduced Visual
A	MIL-PRF-55681 Group A
C	MIL-PRF-55681 Group C
D	Customer Specified

Laser Marking

C04	0
C06	0, 1, 2
C07	0, 1
C08/11/17	0, 1, 2

Packaging

C04/6	T, W, B, P, S
C07	W, B, P, S
C08/11/17	T, V, W, B, P, S

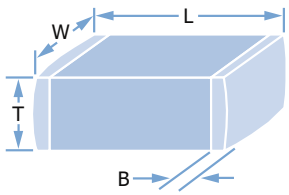
Broadband Blocks - C04/C06/C08

Description

- Resonance free DC Blocking / Decoupling
- Less than 0.25 db loss @ 4 GHz (typical)
- Surface mountable

Functional Applications

- Fiber Optic Links • High Isolation Decoupling
- LAN's, VCO Frequency Stabilization • Diplexers
- RF/Microwave Modules • Instruments • Test Equipments



Mechanical Specification

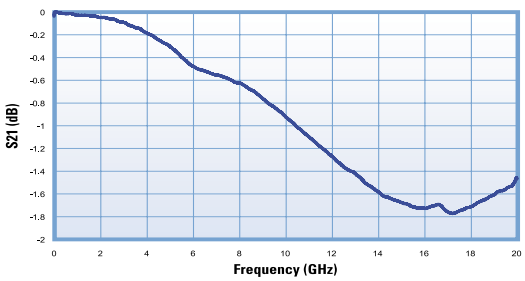
Product Code	Body Dimensions			Band Dimensions (B)	
	Length (L)	Width (W)	Thickness (T)	Min	Max
C04BL	0.040" ± 0.008"	0.020" ± 0.006"	0.028" Max	0.003"	0.019"
C06 BL	0.060" ± 0.012"	0.031" ± 0.009"	0.036" Max	0.006"	0.03"
C08 BL	0.081" ± 0.020"	0.051" ± 0.013"	0.061" Max	0.012"	0.0468"
C18BL	0.1200" ± 0.925"	0.1100" ± 0.010"	0.100" Max	0.008"	0.045"

Part Characteristics

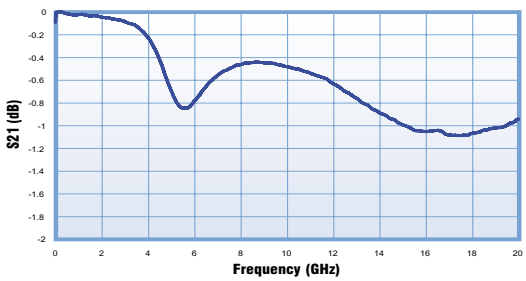
Part Number	Capacitance Guaranteed Minimum Value	Voltage Rating	Temperature Coefficient -55°C to 125°C	Maximum Dissipation Factor	Insulation Resistance (MΩ Minimum)	Aging Rate	Frequency Range	Termination
C04BL121X-5UN-X0T	120pF @ 1KHz,.2Vrms	50 Vdc	± 15%	3.0%@ 1KHz, .2Vrms	10^4	<=1.5%/ decade hours	10MHz – 40GHz	"U" & "S"
C06BL851X-1UN-X0T	850pF @ 1KHz,.2Vrms	100 Vdc 50 Vdc					2MHz – 30GHz	"U", "S" & "Z"
C08BL242X-5UN-X0T	2400pF @ 1KHz,.2Vrms	50 Vdc					1MHz – 20GHz	"U", "S" & "Z"
C08BL102X-1UN-X0T	1000pF @ 1KHz,.2Vrms	100 Vdc					1MHz – 20GHz	"U", "S" & "Z"
C18BL103X-4GN-XOT	10,000pF @ 1KHz,.2Vrms	500 Vdc					1MHz – 6GHz	"U", "S" & "Z"

Performance

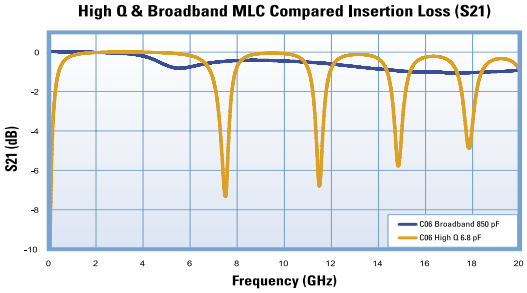
C08BL242X-5UN-X0T Insertion Loss (S21)



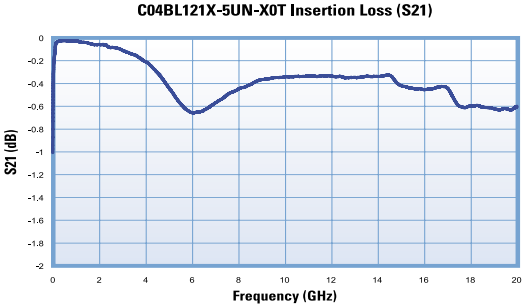
C06BL851X-1UN-X0T Insertion Loss (S21)



High Q & Broadband MLC Compared Insertion Loss (S21)



C04BL121X-5UN-X0T Insertion Loss (S21)

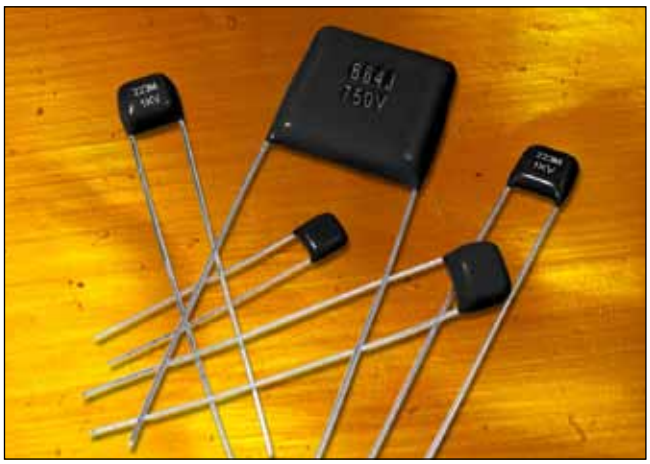


The information above represents typical device performance.

High Temperature Radial Leaded Caps - Epoxy Coated

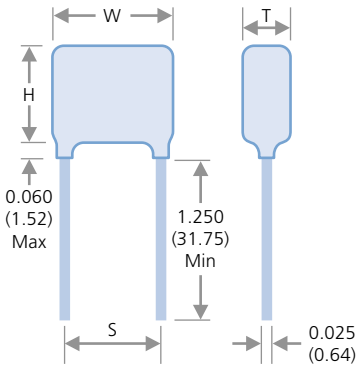
A range of Radial Leaded capacitors available in sizes 1515 to 7565 designed to operate from -55ºC to 200ºC in C0G/NP0 and Class II dielectrics with voltage ratings of 25V to 4kV. These capacitors find typical application in harsh environments such as Oil Exploration and Automotive/Avionics engine compartment circuitry. The epoxy coating ensures environmental protection and a rugged configuration for optimum performance. They are also offered without the conformal coating for less harsh environmental applications.

- Capacitance tolerances: ±1%*, ±2%*, ±5%, ±10%, ±20% (*C0G/NP0 only)



Dimensions - inches/mm

Lead Style		LG with black epoxy coating - LO without						
Size		1515	1812	2520	3530	4540	6560	7565
W	inches:	0.250	0.300	0.370	0.470	0.570	0.770	0.870
	mm:	6.35	7.62	9.40	11.90	14.50	19.60	22.10
H	inches:	0.250	0.200	0.300	0.400	0.500	0.720	0.770
	mm:	6.35	5.08	7.62	10.20	12.70	18.30	19.60
T	inches:	0.190	0.160	0.240	0.310	0.360	0.360	0.360
	mm:	4.83	4.06	6.10	7.87	9.14	9.14	9.14
S	inches ±0.02:	0.170	0.200	0.280	0.380	0.480	0.680	0.780
	mm ±0.508:	4.32	5.08	7.10	9.65	12.20	17.30	19.80



Maximum capacitance values - 200ºC C0G/NP0 (D)/Class II (E) dielectrics

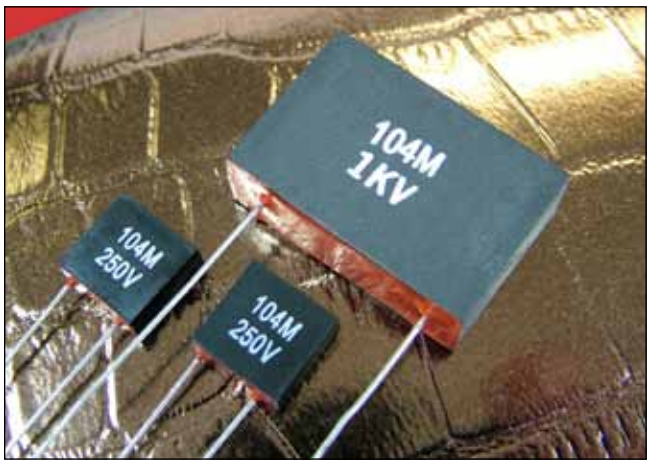
Size	1515		1812		2520		3530		4540		6560		7565	
Min cap.	5R0	151	220	151	390	102	390	102	390	102	560	222	101	222
Dielectric	C0G	Class II	C0G	Class II	C0G	Class II	C0G	Class II	C0G	Class II	C0G	Class II	C0G	Class II
25V	22nF	820nF	27nF	1.0µF	56nF	2.2µF	100nF	3.9µF	180nF	5.6µF	330nF	15µF	390nF	18µF
50V	18nF	680nF	22nF	650nF	56nF	1.8µF	82nF	2.7µF	150nF	4.7µF	270nF	12µF	330nF	15µF
100V	10nF	270nF	10nF	270nF	33nF	1.2µF	56nF	2.2µF	100nF	3.3µF	220nF	8.2µF	270nF	12µF
250V	3.9nF	82nF	6.8nF	100nF	15nF	270nF	33nF	560nF	56nF	1.2µF	120nF	2.7µF	150nF	3.9µF
500V	2.7nF	18nF	3.3nF	22nF	5.6nF	56nF	12nF	120nF	27nF	330nF	56nF	680nF	68nF	820nF
1kV	820pF	2.7nF	1.0nF	3.3nF	1.8nF	12nF	5.6nF	27nF	15nF	68nF	33nF	150nF	39nF	220nF
2kV	180pF	560pF	220pF	680pF	390pF	2.2nF	1.5nF	6.8nF	3.3nF	18nF	8.2nF	39nF	10nF	47nF
3kV	8.2pF	220pF	100pF	220pF	180pF	820pF	560pF	2.7nF	1.5nF	6.8nF	3.3nF	15nF	3.9nF	18nF
4kV	4.7pF	•	•	•	100pF	220pF	330pF	1.2nF	820pF	2.7nF	1.8nF	5.6nF	2.2nF	8.2nF

Note: Maximum capacitance values are shown above as 3 digit code: 2 significant figures followed by the no. of zeros e.g. 183 = 18,000pF.
R denotes decimal e.g. 2R7 = 2.7pF.

High Temperature Radial Leaded Caps - Encapsulated

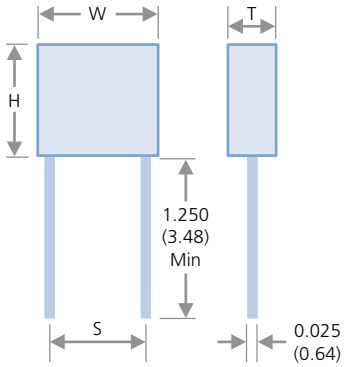
A range of Radial Leaded capacitors available in sizes 1515 to 7565 designed to operate from -55ºC to 200ºC in C0G/NP0 and Class II dielectrics. Voltage ratings of 25V to 500V. These capacitors find typical application in very harsh environments where isolation and protection of the device is required for optimum reliability. They are also offered without the molded case for less harsh environmental applications. Consult the Sales Office if your specific requirements exceed our catalogue maximums (size, cap. value and voltage).

- Capacitance tolerances: ±1%*, ±2%*, ±5%, ±10%, ±20% (*C0G/NP0 only)



Dimensions - inches/mm

Lead Style	LC with encapsulation - LO without						
Size	1515	2520	3530	4540	5550	6560	7565
W inches ±0.015:	0.300	0.400	0.500	0.725	0.795	0.925	1.125
mm ±0.381:	7.62	10.20	12.70	18.40	20.20	23.50	28.60
H inches ±0.015:	0.300	0.400	0.500	0.500	0.745	0.750	0.750
mm ±0.51:	7.62	10.20	12.70	12.70	18.90	19.00	19.00
T inches ±0.015:	0.150	0.200	0.265	0.325	0.370	0.350	0.375
mm ±0.51:	3.81	5.08	6.73	8.26	9.40	8.89	9.52
S inches ±0.02:	0.170	0.280	0.380	0.480	0.580	0.680	0.780
mm ±0.508:	4.32	7.10	9.65	12.20	14.70	17.30	19.80



Maximum capacitance values - 200ºC C0G/NP0 (D)/Class II (E) dielectrics

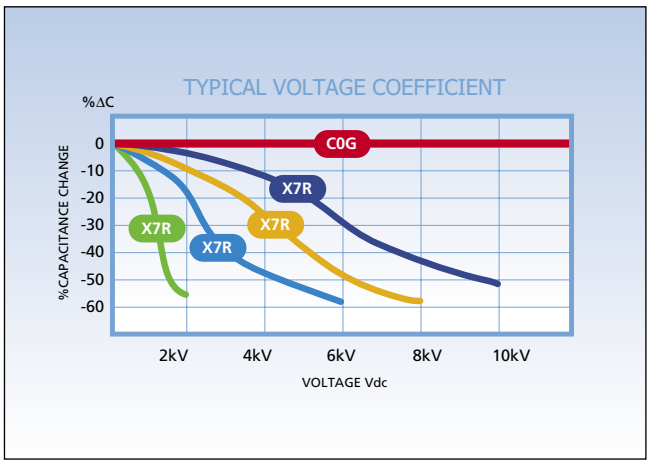
Size	1515		2520		3530		4540		5550		6560		7565	
Min cap.	3R0	221	390	102	390	102	390	102	390	102	560	222	101	222
Dielectric	C0G	Class II	C0G	Class II	C0G	Class II	C0G	Class II	C0G	Class II	C0G	Class II	C0G	Class II
25V	18nF	560nF	56nF	2.2µF	100nF	3.9µF	180nF	5.6µF	220nF	10µF	330nF	15µF	390nF	18µF
50V	15nF	390nF	56nF	1.5µF	82nF	2.7µF	150nF	4.7µF	180nF	6.8µF	270nF	12µF	330nF	15µF
100V	5.6nF	120nF	27nF	820nF	56nF	1.8µF	100nF	3.3µF	150nF	5.6µF	220nF	8.2µF	270nF	10µF
250V	3.9nF	39nF	12nF	180nF	273	560nF	56nF	1.2µF	82nF	2.2µF	120nF	2.7µF	150nF	3.9µF
500V	1.5nF	8.2nF	5.6nF	39nF	12nF	82nF	27nF	220nF	39nF	330nF	56nF	470nF	82nF	680nF

Note: Maximum capacitance values are shown above as 3 digit code: 2 significant figures followed by the no. of zeros e.g. 183 = 18,000pF.
R denotes decimal e.g. 2R7 = 2.7pF.

High Reliability Radial Lead - 500V to 10kV

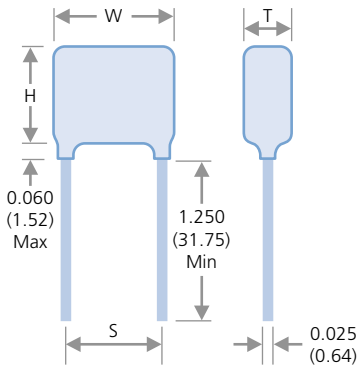
Radial Leaded Capacitors available in C0G/NP0 and X7R characteristics with special testing for long term reliability. The conformal coating and lead mounting style provide a rugged configuration for optimum performance. Units may be tested to MIL-PRF-49467 and/or MIL-PRF-39014 and find application for High Reliability use such as power supplies, voltage multiplier circuits, aerospace, airborne and military use for radar. They are also offered without the conformal coating for less harsh environmental applications and as RoHS compliant parts upon request.

- For dielectric characteristics see pages 4 & 5.
- For capacitance tolerances available see page 21.
- For ordering information see page 21.



Dimensions - inches/mm

Lead Style	LE with conformal coating - LO without coating						
Size	1515	2520	3530	4540	5550	6560	7565
Wmax inches:	0.250	0.400	0.500	0.600	0.700	0.800	0.900
mm:	6.35	10.20	12.70	15.20	17.80	20.30	22.80
Hmax inches:	0.250	0.350	0.450	0.550	0.650	0.750	0.850
mm:	6.35	8.89	11.40	14.00	16.50	19.00	21.60
Tmax inches:	0.200	0.250	0.350	0.400	0.400	0.400	0.400
mm:	5.08	6.35	8.89	10.20	10.20	10.20	10.20
S inches ±0.02:	0.170	0.280	0.380	0.480	0.580	0.680	0.780
mm ±0.51:	4.32	7.10	9.65	12.20	14.70	17.30	19.80



Capacitance and Voltage Selection

Size	1515		2520		3530		4540		5550		6560		7565	
Min cap.	3R0	151	390	102	390	102	390	102	390	102	560	222	101	222
Dielectric	C0G	X7R	C0G	X7R	C0G	X7R	C0G	X7R	C0G	X7R	C0G	X7R	C0G	X7R
500V	682	823	183	274	473	684	823	155	124	185	224	275	274	395
600V	682	563	183	184	393	474	823	824	124	155	184	225	274	275
800V	472	333	123	124	333	334	683	684	104	125	154	185	184	225
1kV	392	183	123	683	273	184	563	474	823	684	124	105	184	125
2kV	122	392	472	153	153	473	273	104	473	184	683	224	823	334
3kV	561	152	222	562	682	223	183	472	273	683	393	104	473	154
4kV	•	•	102	272	272	123	682	223	103	393	153	563	223	823
5kV	•	•	561	182	182	822	472	153	682	273	103	393	123	473
6kV	•	•	•	•	152	562	332	103	472	183	822	273	822	333
7kV	•	•	•	•	821	392	182	682	272	123	392	183	472	273
8kV	•	•	•	•	•	272	122	562	182	103	272	153	392	183
9kV	•	•	•	•	•	•	821	392	122	682	222	123	272	153
10kV	•	•	•	•	•	•	681	332	122	562	182	822	222	123

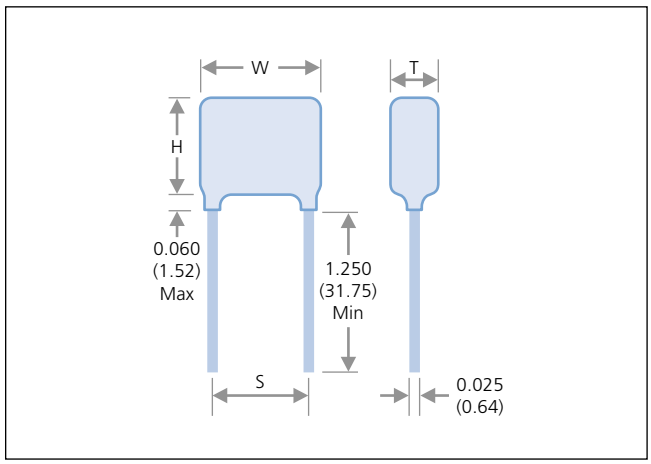
Note: Maximum capacitance values are shown above as 3 digit code: 2 significant figures followed by the no. of zeros
e.g. 183 = 18,000pF. R denotes decimal e.g. 2R7 = 2.7pF.

DSCC Approved Radial Lead Capacitors - 1kV to 10kV

A range of High Voltage leaded capacitors available in ten DSCC approved specifications.

The below referenced DSCC (Defense Supply Center Columbus) drawing numbers cover the C0G/NP0 and X7R dielectrics with a voltage rating from 1kV to 10kVdc.

Novacap Vendor CAGE code is 65238.



Dimensions - inches/mm

Lead Style	LE with conformal coating											
Size	**1515**	**2020**	**2520**	**3015**	**3530**	**4020**	**4540**	**5550**	**6560**	**9040**	**11050**	**13060**
Wmax inches:	0.250	0.320	0.370	0.450	0.470	0.550	0.570	0.670	0.770	1.050	1.250	1.450
mm:	6.35	8.13	9.40	11.43	11.94	13.97	14.48	17.02	19.56	26.67	31.75	36.83
Hmax inches:	0.220	0.280	0.300	0.220	0.400	0.280	0.500	0.600	0.720	0.500	0.600	0.720
mm:	5.59	7.11	7.62	5.59	10.16	7.11	12.70	15.24	18.29	12.7	15.24	18.29
Tmax inches:	0.200	0.250	0.250	0.270*	0.270	0.250	0.270	0.270	0.270	0.270	0.270	0.270
mm:	5.08	6.35	6.35	6.86	6.86	6.35	6.86	6.86	6.86	6.86	6.86	6.86
S ±0.03 inches:	0.170	0.220	0.275	0.300	0.375	0.400	0.475	0.575	0.675	0.900	1.100	1.300
±0.76 mm:	4.32	5.59	6.98	7.62	9.53	10.16	12.07	14.61	17.15	22.86	27.94	33.02

Note: *Maximum thickness for 87076 is 0.200/5.08.

Dash Numbers

DSCC#	Rated Voltage	1515	2020	2520	3015	3530	4020	4540	5550	6560	9040	11050	13060
87043	1kV	01-50	51-58	59-60	•	61-70	•	71-78	79-84	85-90	•	•	•
87046	1kV	01-50	51-56	57-58	•	59-66	•	67-74	75-80	81-84	•	•	•
87040	2kV	04-40	41-46	47-50	•	51-60	•	61-66	67-70	71-74	•	75-78	79-82
87047	3kV	•	01-38	39-42	•	43-54	•	55-62	63-64	65-68	•	69-70	71-75
87114	3kV	•	01-44	45-46	•	47-54	•	55-64	65-68	69-72	•	•	•
87076	4kV	•	•	•	01-24	25-50	•	51-58	59-62	63-64	•	•	65-70
89044	4kV	•	•	•	01-24	25-46	•	47-50	51-54	55-60	•	61-62	63-68
87070	5kV	•	•	•	•	•	01-24	25-46	47-50	51-54	55-58	59-60	61-62
87077	5kV	•	•	•	•	•	01-40	•	41-58	59-60	•	•	61-68
87081	10kV	•	•	•	•	•	•	•	•	•	01-22	23-26	27-34

How to Order - The purchase order or contract must specify the following:

1	2	3
The Complete DSCC part number - Drawing Number and Dash Number Example: 87043-47	Whether you want Novacap to perform the Group B Test, or provide a certification of compliance for Group B requirement.	Specify requirements for packaging.

Filters for High-Rel Applications

Introduction

Knowles is experienced at providing products for the most demanding applications:

- Space - ESA and NASA projects
- Automotive - AEC-Q200 qualified
- Military and Civil aviation
- Motorsports - F1 and World Rally
- Oil/Downhole/Industrial
- Rail
- Medical

Knowles product qualifications include AEC-Q200, ESA vendor approval and space grade planar arrays and filters.

Special finishes (eg. Sn/Pb) are available for exempt applications such as military and space. Please contact our Sales Office for further details.

Surface Mount Filters

The surface mount C filter (E01, E07), Pi filter (SBSPP) and X2Y Integrated Passive Components (E03) are all available with Knowles FlexiCap™ (standard solderable proprietary flexible epoxy polymer termination material).

FlexiCap® advantages

- Solves cracking problems caused by excessive mechanical stress
- The polymer allows greater degrees of Pcb deflection during de-panelisation, typically twice that of standard capacitors
- Permits more stress to be placed on components when using large through hole parts, eg. transformers, connectors, heatsinks
- More resistant to cracking due to temperature cycling
- No degradation in electrical performance
- Capacitors with tin-lead termination are also available with Knowles FlexiCap™ technology

The following are qualified to AEC-Q200:

- Surface Mount 'C' Filter (E01 and E07 ranges)
- X2Y Integrated Passive Component (E03 range)

Resin Sealed Ceramic based Panel Mount Filters

Designed and manufactured to meet or exceed the requirements of MIL C 15733 and MIL C 28861. The test methods are in accordance with MIL STD 220 and MIL STD 202:

- Insertion loss
- Solderability
- Bump and vibration
- Temperature cycling
- Humidity
- Temperature rise under dc load

Special test requirements can be accommodated e.g. 100% burn-in.

Discoidals and Planar Arrays

Knowles were instrumental in delivering the standard for space approved planar arrays which includes Scanning Acoustic Microscopy (SAM) testing.

Discoidal and Planar Arrays - C0G/NP0 & X7R

The multilayer planar array is an application specific multi capacitor array designed for use in multiway EMI filter circuits. Derived from discoidal capacitor theory, it provides capacitance between the outside perimeter and the internal through holes.

The most common use of planar arrays is as the capacitor element in filter connectors, although they are also suitable in many other applications.

Knowles' core wet manufacturing process and ceramic handling expertise allows components to be produced with mechanical precision and electrical accuracy, enabling a filter assembly to withstand the most rigorous of electrical specifications. This has resulted in Knowles' position as the manufacturer of choice for the filter connector industry. To date, Knowles have delivered in excess of 4,000 different designs of planar array.

Mechanical

With many years experience, Knowles have developed a comprehensive range of designs, including planform designs for the following connectors:

- Circular (MIL-C-38999, MIL-C-26482 and similar)
- Arinc 404 and 600
- 'D' sub
- High Density 'D' sub
- µD (MIL-C-83513)

Special custom shapes and layouts can also be accommodated. Complex shapes including internal and external radii, multiple hole diameters and alignment guides can be considered.

As a guide, Knowles can manufacture planars to a maximum of 3.18mm (0.125") thick and to a maximum of 100mm (4.0") diameter or square.

Standard termination finish is gold plate over nickel for maximum electrical and mechanical performance.

Solderless assembly/compliant spring clip

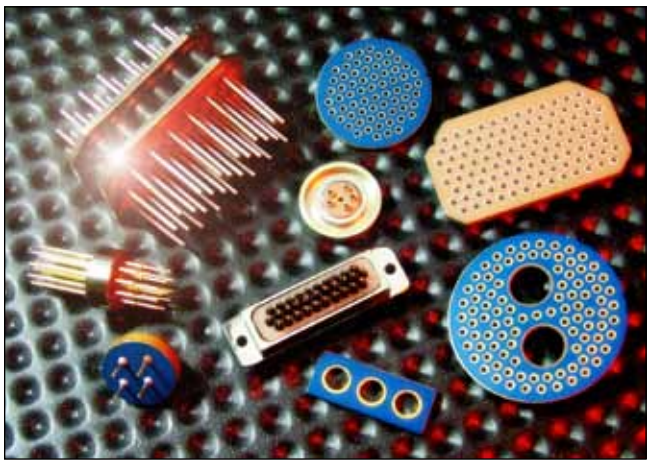
Solderless assembly of planars can be accommodated by the inclusion of compliant spring clips into the holes, allowing the array to be push fitted to through contact pins.

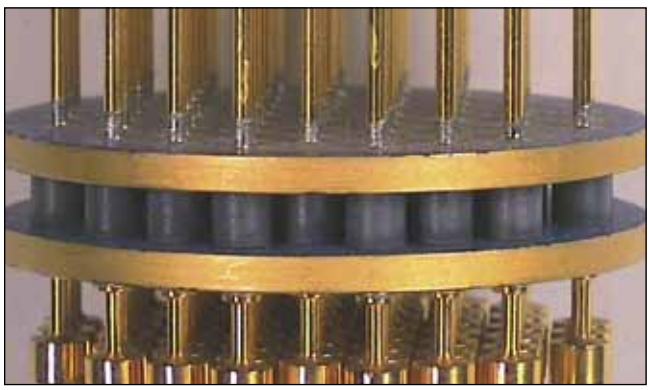
Knowles can supply a standard range of solder-in spring clips, or fit customer supplied compliant clips before shipping the finished array assembly.

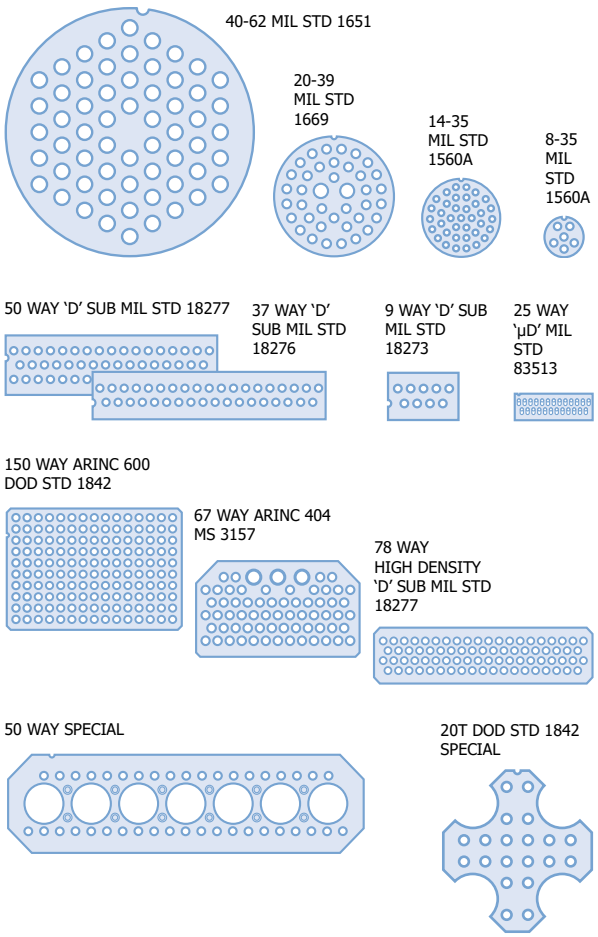
Contract assembly and technical back-up

Having an EMI filter assembly line alongside the ceramic manufacturing area allows Knowles to offer unprecedented technical back-up and advice to planar array and discoidal customers. This can include design and handling advice and forensic analysis assistance. Knowles personnel have many years experience in the use of planar arrays, having been involved directly in the development of the technology from its inception.

Knowles are also able to offer subcontract and prototype manufacturing services to planar customers and connector companies.



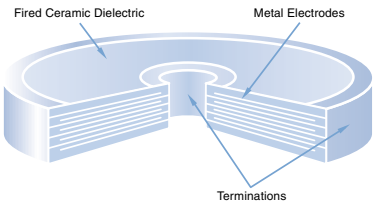




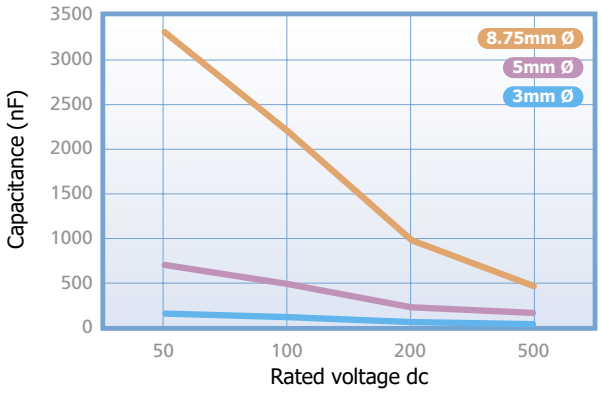
Discoidal capacitors - C0G/NP0 & X7R

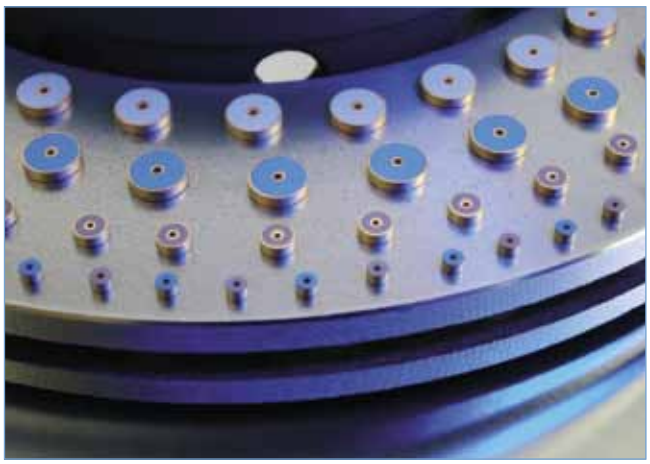
Discoidal capacitors are at the heart of many EMI filters. More robust and reliable than tubular capacitors, they offer higher capacitance options, with values up to several microfarads. In addition to standard configurations, Knowles is able to meet customers' specific drawings in terms of electrical performance and mechanical design.

Discoidal multilayer ceramic capacitors are of a configuration suitable for direct mounting into filters, onto bulkheads and hybrid circuits. Due to their geometry, they have excellent RF performance characteristics as well as very high self resonant frequencies. They are offered with a choice of C0G/NP0 or X7R ceramic.



Typical capacitance vs disc size vs voltage
Based on typical hole diameter of 0.8mm, and X7R dielectric.





General Specification

Dielectrics:
C0G/NP0, X7R

Mechanical:
Outer diameter 2.0mm minimum
Inner diameter 0.5mm minimum
Minimum wall thickness requirements apply. Refer to factory.

Capacitance range:
pF to µF

Capacitance tolerance:
±5%, ±10%, ±20%, -0%+100%

Voltage:
50V to 3kVdc or higher

Operating temperature range:
-55°C to +125°C

Termination:
Gold over nickel

To reflect the unique custom nature of discoidals and planar arrays, we do not list a standard range. Please contact the sales office to discuss your specific requirements.

Planar Arrays - C0G/NP0 & X7R

Electrical

- Only stable X7R and ultra stable C0G/NP0 dielectrics used
- Capacitance values from pF to µF
- High voltage capability - DWV (Dielectric Withstand Voltage) to 10kV
- Feedthrough low capacitance unterminated lines
- Grounded earth lines - maximum ground plane resistance specifications included
- Mix of capacitance values within planar – up to a ratio of 400:1 within individual planar possible
- Mixed capacitance lines/no cap feedthrough lines/grounded earth lines available within single planar

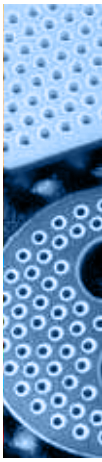
Quality

All planars are tested for the following:

- Capacitance
- Dissipation factor
- DWV (Dielectric Withstand Voltage)
- Insulation resistance
- Visual inspection
- Sample solderability and dimensional check

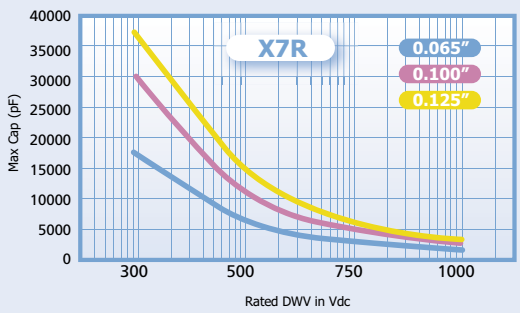
} 100%

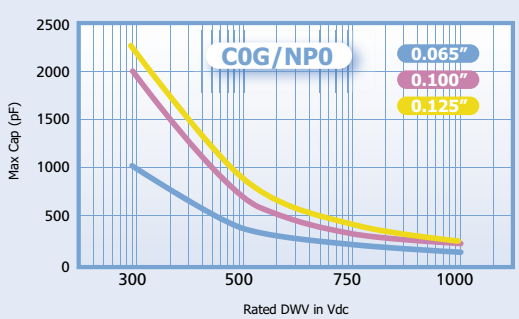
100% SAM (Scanning Acoustic Microscopy) testing is offered as an option on all planars intended for more critical applications.



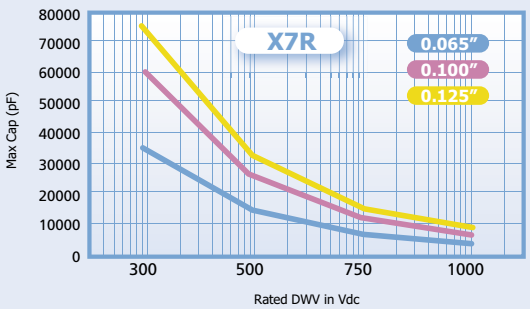
Graphs of typical maximum capacitance values against voltage for array thicknesses of 0.065" (1.65mm), 0.100" (2.54mm) and 0.125" (3.18mm).

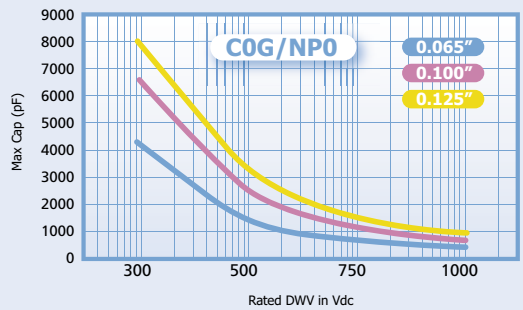
µD planforms



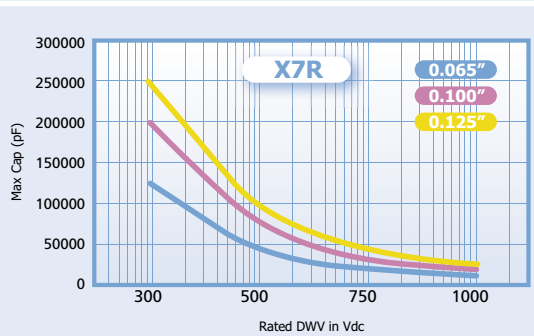


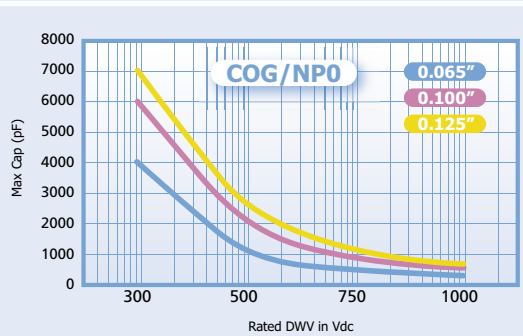
D-Sub planforms



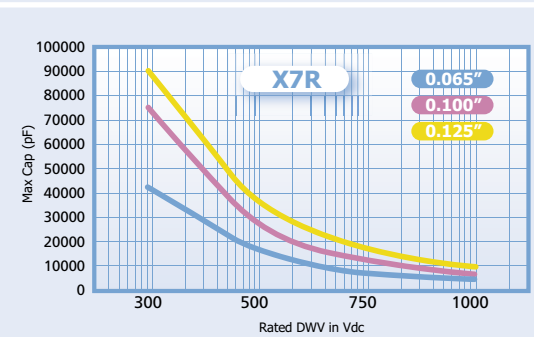


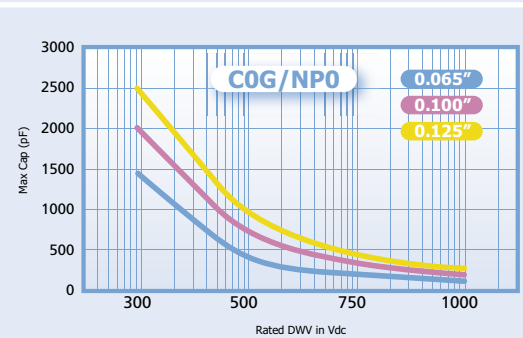
Low density circular planforms



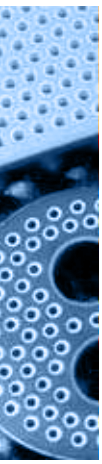


High density circular planforms





Special Filters and Assemblies



Manufacturing to customer designs or working together with the customer to develop a solution to a problem, Knowles offer the ability to modify standard filter designs or develop custom designs to suit your application.

Modifications to standard filters

Special mechanical outline

Typical examples:

- Lead lengths to suit
- Special thread options – e.g. M5 x 0.5 – 6g
- Special lead forms – e.g. headed pin/threaded contact
- Larger pin diameters
- Special body or pin finishes

Special electrical testing

Typical examples:

- Special test voltages – e.g. 500Vac 50Hz DWV test
- Special capacitance values
- 100% burn-in
- Higher current ratings possible

Multiway filter assemblies

From a simple panel fitted with our single line discrete filters to a complex custom designed Pi filter assembly, we offer a full design and manufacture service. Assemblies can be based around discoidal capacitors for maximum flexibility or planar arrays for optimum space utilisation.

As an extension to our planar array range, we can offer soldered-in spring retaining clips for easy assembly into difficult applications such as hermetic sealed connectors and our extensive experience with filter connectors allows us to offer subcontract manufacturing to this industry sector.

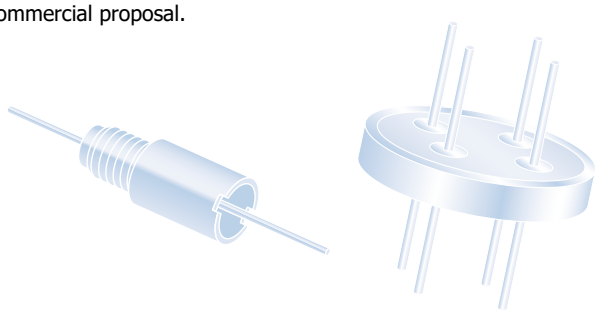
- **Example 1** -

  4 way 22nF C section planar based filter assembly. DWV 2500Vdc, 100% tested. Supplied to sensor manufacturer for installation into commercial aerospace application.

- **Example 2** -

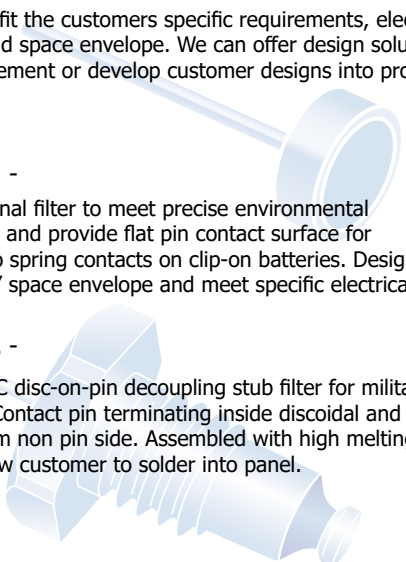
  85 way 1800pF L-C section planar based filter assembly, fitted into mounting plate for easy assembly. Designed to fit specific space envelope for military aerospace application.

Please contact our sales office to discuss your specific filtering requirement. We would be pleased to provide a technical and commercial proposal.



Special discrete filters to match your specific requirements

Manufactured to fit the customers specific requirements, electrical characteristics and space envelope. We can offer design solutions to meet your requirement or develop customer designs into production reality.



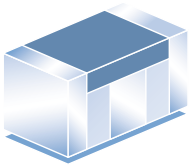
- **Example 1** -

  Battery terminal filter to meet precise environmental requirements and provide flat pin contact surface for connection to spring contacts on clip-on batteries. Designed to fit customers' space envelope and meet specific electrical parameters.

- **Example 2** -

  Special SFSSC disc-on-pin decoupling stub filter for military application. Contact pin terminating inside discoidal and insulated from non pin side. Assembled with high melting point solder to allow customer to solder into panel.

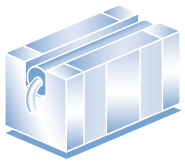
Filters for High Rel Applications - Ordering information



SBSP

SBS	P	P	100	0153	M	X	T
Type	Size	Configuration	Voltage	Capacitance in picofarads (pF)	Tolerance	Dielectric	Packaging
Surface mount board filter	P = 1206	P = Pi Section	025 = 25Vdc 050 = 50Vdc 100 = 100Vdc	First digit is 0. Second and third digits are significant figures of capacitance code. The fourth digit is number of zeros following Example: 0153=15nF.	M = ±20%	C=C0G/NP0 X=X7R	T=178mm (7") reel R=330mm (13") reel B = Bulk

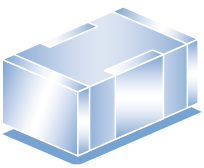
Reeled quantities	178mm (7") reel	1206	330mm (13") reel	1206
		1500		6000



SBSG

SBS	G	P	500	0473	M	X	T
Type	Size	Configuration	Voltage	Capacitance in picofarads (pF)	Tolerance	Dielectric	Packaging
Surface mount board filter	G = 1812	C = C Section P = Pi Section	050 = 50Vdc 100 = 100Vdc 200 = 200Vdc 500 = 500Vdc	First digit is 0. Second and third digits are significant figures of capacitance code. The fourth digit is number of zeros following Example: 0473=47nF.	M = ±20%	X=X7R	T=178mm (7") reel R=330mm (13") reel B = Bulk

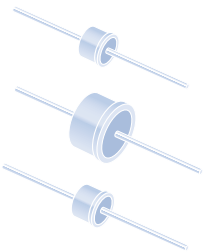
Reeled quantities	178mm (7") reel	1812	330mm (13") reel	1812
		500		2000



SBSM

SBS	M	P	050	0474	M	X	T
Type	Size	Configuration	Voltage	Capacitance in picofarads (pF)	Tolerance	Dielectric	Packaging
Surface mount board filter	M = 2220	C = C Section P = Pi Section	050 = 50Vdc 100 = 100Vdc 200 = 200Vdc 500 = 500Vdc	First digit is 0. Second and third digits are significant figures of capacitance code. The fourth digit is number of zeros following Example: 0474=470nF.	M = ±20%	X=X7R	T=178mm (7") reel R=330mm (13") reel B = Bulk

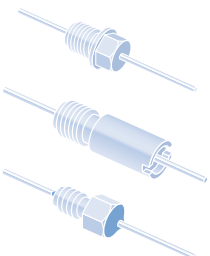
Reeled quantities	178mm (7") reel	2220	330mm (13") reel	2220
		500		2000



SFS

Solder-in types *Note: Ordering code can have up to 4 additional digits on the end to denote special requirements.*

SFS	T	C	500	0223	M	X	0
Type	Case dia.	Electrical configuration	Voltage	Capacitance in picofarads (pF)	Capacitance tolerance	Dielectric	Nuts & washers
Solder-in panel mount filter	S = Special (no case) Contact Sales Office for full part number R = 2.8mm T = 3.25mm U = 5.6mm	C = C section	050 = 50Vdc 100 = 100Vdc 200 = 200Vdc 300 = 300Vdc 500 = 500Vdc 1K0 = 1kVdc 2K0 = 2kVdc 3K0 = 3kVdc	First digit is 0. Second and third digits are significant figures of capacitance code. The fourth digit is number of zeros following Example: 0223=22nF	M = ±20% (Standard) P = -0 +100% S = -20%+50% Z = -20%+80%	C = C0G/NP0 X = X7R	0 = Without



SF

Threaded types *Note: Ordering code can have up to 4 additional digits on the end to denote special requirements.*

SF	J	E	L	050	0335	M	X	1
Type	Case style * = Low Profile	Thread	Electrical configuration	Voltage or varistor maximum continuous working voltage	Capacitance in picofarads (pF)	Capacitance tolerance	Dielectric	Nuts & washers
Screw mount filter	A = 4mm A/F B = 4.75mm A/F C = 6.35mm A/F D = 10mm A/F J = 9.8mm O.D. K = 4.4mm O.D. L = 6mm O.D. M = 6.35mm O.D. N = 3.5mm O.D. T = 6.35mm A/F * U = 6mm O.D. *	A = 4-40 UNC B = 6-32 UNC C = 8-32 UNC D = 12-32 UNEF E = 1/4-28 UNF G = 1/4-28 UNF I = 2BA J = M3 K = M3.5 L = M4 M = M5 N = M6 O = M2.5 P = M8	C = C section L = L-C section P = Pi section T = T section B = Balanced line filter V = Varistor EMI filter	050 = 50Vdc 100 = 100Vdc 200 = 200Vdc 300 = 300Vdc 500 = 500Vdc 1K0 = 1kVdc 2K0 = 2kVdc 3K0 = 3kVdc	First digit is 0. Second and third digits are significant figures of capacitance code. The fourth digit is number of zeros following Example: 0335=3.3µF 13N6=13.6nF	M = ±20% (Standard) P = -0 +100% S = -20%+50% Z = -20%+80%	C = C0G/NP0 X = X7R M = MOV (varistor material)	0 = Without 1 = With

Note: Other variants and fully custom parts are also available - please refer to main catalogue or www.knowlescapacitors.com
To discuss specific applications, please contact the Knowles sales office.

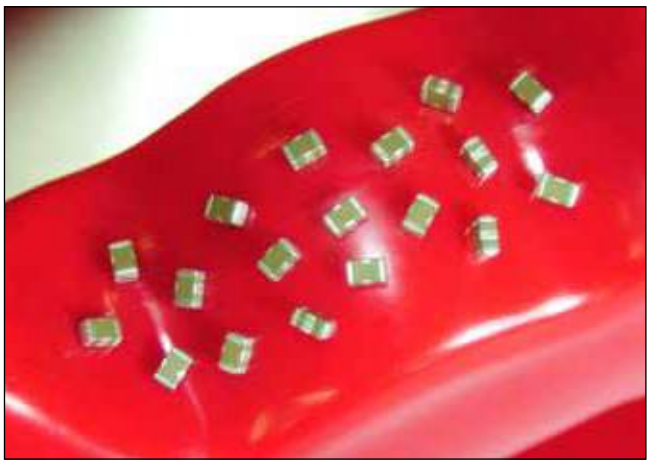
Surface Mount EMI Filters - E01 & E07 feedthrough capacitors

The Syfer E01 and E07 ranges of feedthrough MLCC chip 'C' filters are 3 terminal chip devices designed to offer reduced inductance compared to conventional MLCCs when used in signal line filtering.

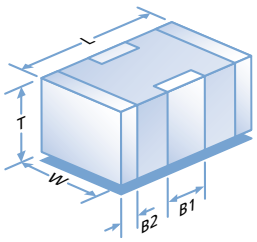
The filtered signal passes through the chip internal electrodes and the noise is filtered to the grounded side contacts, resulting in reduced length noise transmission paths.

Available in C0G/NP0 and X7R dielectrics, with current ratings of 300mA, 1A, 2A, 3A and voltage ratings of 25Vdc to 200Vdc. Also available with FlexiCap™ termination which is strongly recommended for new designs.

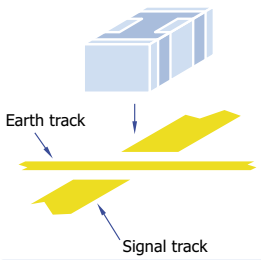
Commonly used in automotive applications, a range qualified to AECQ-200 is also available.



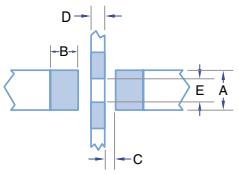
E01 300mA, E07 1A/2A/3A



E01/E07



Recommended solder lands



Dimensions

	0805	1206	1806	1812
L	2.0 ± 0.3 (0.079 ± 0.012)	3.2 ± 0.3 (0.126 ± 0.012)	4.5 ± 0.35 (0.177 ± 0.014)	4.5 ± 0.35 (0.177 ± 0.014)
W	1.25 ± 0.2 (0.049 ± 0.008)	1.6 ± 0.2 (0.063 ± 0.008)	1.6 ± 0.2 (0.063 ± 0.008)	3.2 ± 0.3 (0.126 ± 0.012)
T	1.0 ± 0.15 (0.039 ± 0.006)	1.1 ± 0.2 (0.043 ± 0.008)	1.1 ± 0.2 (0.043 ± 0.008)	2.0 ± 0.3 (0.079 ± 0.012)
B1	0.60 ± 0.2 (0.024 ± 0.008)	0.95 ± 0.3 (0.037 ± 0.012)	1.4 ± 0.3 (0.055 ± 0.012)	1.45 ± 0.35 (0.055 ± 0.012)
B2	0.3 ± 0.15 (0.012 ± 0.006)	0.5 ± 0.25 (0.02 ± 0.01)	0.5 ± 0.25 (0.02 ± 0.01)	0.75 ± 0.25 (0.02 ± 0.01)

	0805	1206	1806	1812
A	0.95 (0.037)	1.20 (0.047)	1.2 (0.047)	2.65 (0.104)
B	0.90 (0.035)	0.90 (0.035)	1.40 (0.055)	1.40 (0.055)
C	0.30 (0.012)	0.60 (0.024)	0.80 (0.031)	0.80 (0.031)
D	0.40 (0.016)	0.80 (0.031)	1.40 (0.055)	1.40 (0.055)
E	0.75 (0.030)	1.0 (0.039)	1.0 (0.039)	2.05 (0.080)

Notes: 1) All dimensions mm (inches).
2) Pad widths less than chip width gives improved mechanical performance.
3) The solder stencil should place 4 discrete solder pads. The unprinted distance between ground pads is shown as dim E.
4) Insulating the earth track underneath the filters is acceptable and can help avoid displacement of filter during soldering but can result in residue entrapment under the chip.

Standard Range - E01 & E07 Feedthrough Capacitors

Type		E01			E07			
Chip Size		0805	1206	1806	0805	1206	1806	1812
Max Current		300mA	300mA	300mA	1A	2A	2A	3A
Rated Voltage	Dielectric	Minimum and maximum capacitance values						
25Vdc	C0G/NP0	180pF-1.5nF	560pF-3.9nF	820pF-4.7nF	180pF-1.5nF	560pF-3.9nF	820pF-4.7nF	-
	X7R	470pF-100nF	5.6nF-330nF	3.9nF-560nF	820pF-100nF	10nF-330nF	22nF-560nF	560nF-1.8µF
50Vdc	C0G/NP0	22pF-820pF	22pF-3.3nF	22pF-3.9nF	10pF-220pF	22pF-1nF	100pF-1.5nF	-
	X7R	560pF-68nF	4.7nF-220nF	3.3nF-330nF	1nF-68nF	10nF-220nF	22nF-330nF	330nF-1.5µF
100Vdc	C0G/NP0	22pF-560pF	22pF-2.2nF	22pF-3.3nF	10pF-120pF	22pF-560pF	100pF-680pF	-
	X7R	560pF-27nF	1.8nF-100nF	3.3nF-180nF	1nF-27nF	10nF-100nF	22nF-180nF	180nF-820nF
200Vdc	C0G/NP0	-	560pF-1.2nF	56pF-1nF	-	15pF-180pF	56pF-470pF	-
	X7R	-	2.7nF-56nF	3.9nF-100nF	-	12nF-56nF	22nF-100nF	100nF-270nF

Note: E07 25Vdc C0G/NP0 1206 and 1806 ranges in green, have maximum current of 1A.

AEC-Q200 Qualified Range - E01 & E07 Feedthrough Capacitors - maximum capacitance values

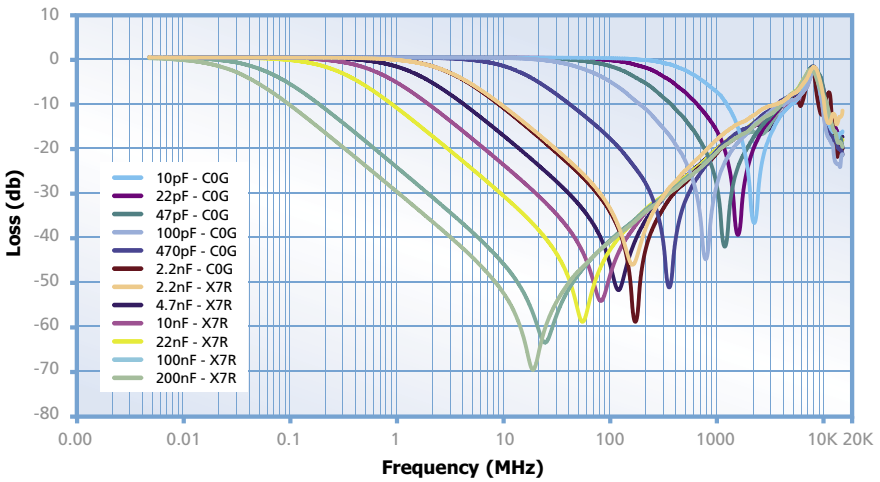
Type		E01			E07		
Chip Size		0805	1206	1806	0805	1206	1806
50V	C0G/NP0	820pF	1nF	2.2nF	220pF	1nF	1.5nF
	X7R	47nF	100nF	200nF	47nF	100nF	200nF
100V	C0G/NP0	560pF	1nF	2.2nF	120pF	560pF	680pF
	X7R	15nF	15nF	68nF	15nF	15nF	68nF

Note: For some lower capacitance parts, higher voltage rated parts may be supplied. Please refer to the table opposite.

Surface Mount EMI Filters - E01 & E07 feedthrough capacitors

Open board insertion loss performance in 50Ω system

Open Board Performance						
Capacitance	0.1MHz	1MHz	10MHz	100MHz	1GHz	Resonance Freq (MHz) approx.
10pF	0	0	0	0	7.5	2200
22pF	0	0	0	0	16	1600
33pF	0	0	0	1	22	1350
47pF	0	0	0	2	28	1150
68pF	0	0	0	3	41	900
100pF	0	0	0	5	28	800
150pF	0	0	0	8	24	700
220pF	0	0	0	12	20	600
330pF	0	0	1	15	20	500
470pF	0	0	2	18	20	425
560pF	0	0	3	20	20	350
680pF	0	0	4	22	20	300
820pF	0	0	5	24	20	260
1nF	0	0	7	27	20	220
1.5nF	0	0	9	31	20	200
2.2nF	0	0	12	34	20	170
3.3nF	0	1	14	39	20	135
4.7nF	0	2	18	46	20	110
6.8nF	0	3	21	50	20	90
10nF	0	5	24	48	20	80
15nF	0	8	27	45	20	65
22nF	0	12	31	43	20	56
33nF	1	14	34	40	20	40
47nF	2	17	38	40	20	34
68nF	4	20	41	40	20	30
100nF	6	24	45	40	20	28
150nF	8	26	48	40	20	24
220nF	10	30	52	40	20	17
330nF	13	33	55	40	20	15.5
470nF	16	36	60	40	20	14
560nF	18	39	65	40	20	12



Ordering Information - E01 & E07 feedthrough capacitors

1206	Y	100	0103	M	X	T	E07
Chip size	Termination	Voltage	Capacitance in picofarads (pF)	Tolerance	Dielectric	Packaging	Type
0805 **1206** **1806**	**J** = Nickel Barrier (Tin) *__Y__ = FlexiCap™ (Tin - X7R only) **A** = (Tin/Lead) Not RoHS compliant. *__H__ = FlexiCap™ (Tin/Lead) Not RoHS compliant.	**025** = 25V **050** = 50V **100** = 100V **200** = 200V	First digit is 0. Second and third digits are significant figures of capacitance code. The fourth digit is number of zeros following Example: **0103** = 10000pF.	**M** = ±20%	**A** = C0G/NP0 AEC-Q200 **C** = C0G/NP0 **E** = X7R AEC-Q200 **X** = X7R	**T** = 178mm (7″) reel **R** = 330mm (13″) reel **B** = Bulk	**E01** **E07**

Note: *FlexiCap™ termination only available in X7R material. Please contact our Sales Office for any special requirements.

Reeled quantities

178mm (7″) reel	0805	1206	1806
	3000	2500	2500

330mm (13″) reel	0805	1206	1806
	12000	10000	10000

Surface Mount EMI Filters - E03 X2Y Integrated Passive Components

The Syfer X2Y Integrated Passive Component is a 3 terminal EMI chip device.

When used in balanced line applications, the revolutionary design provides simultaneous line-to-line and line-to-ground filtering, using a single ceramic chip. In this way, differential and common mode filtering are provided in one device.

For unbalanced applications, it provides ultra low ESL (equivalent series inductance). Capable of replacing 2 or more conventional devices, it is ideal for balanced and unbalanced lines, twisted pairs and dc motors, in automotive, audio, sensor and other applications.

Available in sizes from 0805 to 1812, these filters can prove invaluable in meeting stringent EMC demands.

Manufactured by Knowles Capacitors under licence from X2Y Attenuators LLC.

Dielectric
X7R or C0G/NP0

Electrical configuration
Multiple capacitance

Capacitance measurement
At 1000hr point

Typical capacitance matching
Better than 5%
(down to 1% available on request)

Temperature rating
-55°C to 125°C

Insulation resistance
100Gohms or 1000s (whichever is the less)

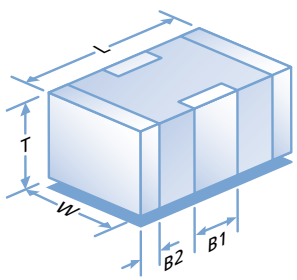
Dielectric withstand voltage
≤200V 2.5 times rated Volts for 5 secs 500V 1.5 times rated Volts for 5 secs Charging current limited to 50mA Max.

Type		E03			
Chip size		0805	1206	1410	1812
Rated voltage	Dielectric				
16Vdc	C0G/NP0	-	-	-	-
	X7R	-	-	-	-
25Vdc	C0G/NP0	560pF - 820pF	1.8nF - 3.3nF	6.8nF - 8.2nF	12nF - 15nF
	X7R	56nF - 68nF	-	470nF	820nF
50Vdc	C0G/NP0	390pF - 470pF	1.2nF - 1.5nF	4.7nF - 5.6nF	8.2nF - 10nF
	X7R	18nF - 47nF	56nF - 220nF	180nF - 400nF	390nF - 680nF
100Vdc	C0G/NP0	10pF - 330pF	22pF - 1.0nF	100pF - 3.9nF	820pF - 6.8nF
	X7R	470pF - 15nF	1.5nF - 47nF	4.7nF - 150nF	8.2nF - 330nF
200Vdc	C0G/NP0	-	22pF - 1.0nF	100pF - 3.3nF	820pF - 5.6nF
	X7R	-	820pF - 33nF	1.2nF - 120nF	2.7nF - 180nF
500Vdc	C0G/NP0	-	-	-	820pF - 3.9nF
	X7R	-	-	-	2.7nF - 100nF

Notes: 1) For some lower capacitance parts, higher voltage rated parts may be supplied.

AEC-Q200 range (E03) - capacitance values

Chip size		0805	1206	1410	1812
50Vdc	C0G/NP0	390pF - 470pF	1.2nF - 1.5nF	4.7nF - 5.6nF	8.2nF - 10nF
	X7R	18nF - 33nF	56nF - 150nF	180nF - 330nF	390nF - 560nF
100Vdc	C0G/NP0	10pF - 330pF	22pF - 1.0nF	100pF - 3.9nF	820pF - 6.8nF
	X7R	470pF - 15nF	1.5nF - 47nF	4.7nF - 150nF	8.2nF - 330nF

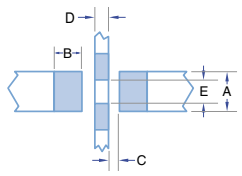


	0805	1206	1410	1812
L	2.0±0.3 (0.08±0.012)	3.2±0.3 (0.126±0.012)	3.6±0.3 (0.14±0.012)	4.5±0.35 (0.18±0.014)
W	1.25±0.2 (0.05±0.008)	1.60±0.2 (0.063±0.008)	2.5±0.3 (0.1±0.012)	3.2±0.3 (0.126±0.012)
T	1.0±0.15 (0.04±0.006)	1.1±0.2 (0.043±0.008)	2.0 max. (0.08 max.)	2.1 max. (0.08 max.)
B1	0.5±0.25 (0.02±0.01)	0.95±0.3 (0.037±0.012)	1.20±0.3 (0.047±0.012)	1.4±0.35 (0.06±0.014)
B2	0.3±0.15 (0.012±0.006)	0.5±0.25 (0.02±0.01)	0.5±0.25 (0.02±0.01)	0.75±0.25 (0.03±0.01)

Notes: 1) All dimensions mm (inches).
2) Pad widths less than chip width gives improved mechanical performance.
3) The solder stencil should place 4 discrete solder pads. The un-printed distance between ground pads is shown as dim E.
4) Insulating the earth track underneath the filters is acceptable and can help avoid displacement of filter during soldering but can result in residue entrapment under the chip.

Surface Mount EMI Filters - E03 X2Y Integrated Passive Components

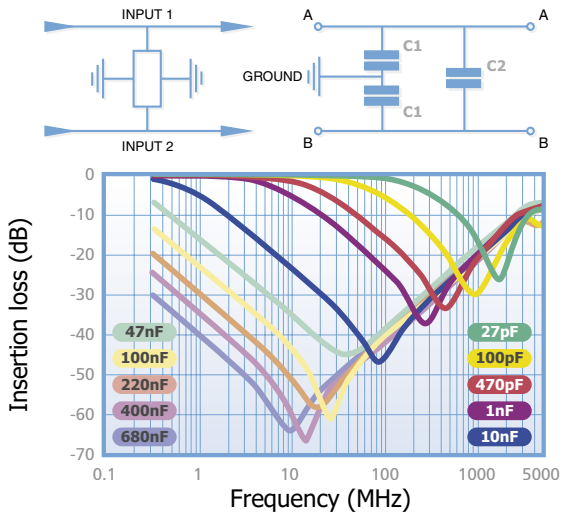
Recommended solder lands



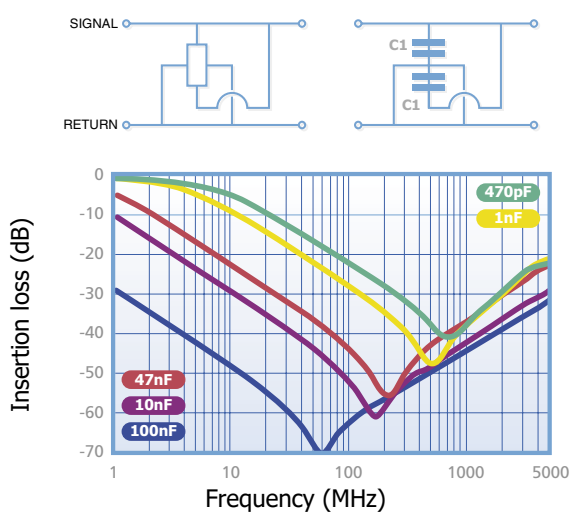
	0805	1206	1410	1812
A	0.95 (0.037)	1.2 (0.047)	2.05 (0.08)	2.65 (0.104)
B	0.9 (0.035)	0.9 (0.035)	1.0 (0.040)	1.4 (0.055)
C	0.3 (0.012)	0.6 (0.024)	0.7 (0.028)	0.8 (0.031)
D	0.4 (0.016)	0.8 (0.031)	0.9 (0.035)	1.4 (0.055)
E	0.75 (0.030)	1.0 (0.039)	1.85 (0.071)	2.05 (0.080)

Component	Advantages	Disadvantages	Applications
Chip capacitor	Industry standard	Requires 1 per line High inductance Capacitance matching problems	By-pass Low frequency
3 terminal feedthrough	Feedthrough Lower inductance	Current limited	Feedthrough Unbalanced lines High frequency
Syfer X2Y Integrated Passive Component	Very low inductance Replaces 2 (or 3) components Negates the effects of temperature, voltage and ageing Provides both common mode and differential mode attenuation Can be used on balanced & unbalanced lines	Care must be taken to optimise circuit design	By-pass Balanced lines High frequency dc electric motors Unbalanced lines Audio amplifiers CANBUS

Filtering application



Decoupling application



Ordering Information - X2Y IPC range

1812	Y	100	0334	M	X	T	E03
Chip Size	Termination	Voltage	Capacitance in picofarads (pF) C_1	Tolerance	Dielectric	Packaging	Type
0805 **1206** **1410** **1812**	**J** = Nickel Barrier (Tin) *__Y__ = FlexiCap™ (Tin - X7R only) **A** = (Tin/Lead) Not RoHS compliant. *__H__ = FlexiCap™ (Tin/Lead) Not RoHS compliant.	**016** = 16V **025** = 25V **050** = 50V **100** = 100V **200** = 200V **500** = 500V	First digit is 0. Second and third digits are significant figures of capacitance code. The fourth digit is number of zeros following Example: **0334**=330nF. Note: $C_1 = 2C_2$	**M** = ±20% (Tighter tolerances may be available on request).	**A** = C0G/NP0 AEC-Q200 **C** = C0G/NP0 **E** = X7R AEC-Q200 **X** = X7R	**T** = 178mm (7") reel **R** = 330mm (13") reel **B** = Bulk	Syfer X2Y Integrated Passive Component

Note: *FlexiCap™ termination only available in X7R material. Please contact the sales office for any special requirements.

Reeled quantities

178mm (7") reel	0805	1206	1410	1812
	3000	2500	2000	1000

330mm (13") reel	0805	1206	1410	1812
	12000	10000	8000	4000

Capacitor Assemblies - ST, SM - C0G/NP0, X7R

Our complete testing facility is available for any additional military testing requirements. Options available include thru-hole and surface mount lead styles, to make them suitable for mounting on ceramic substrates or epoxy PCBs.

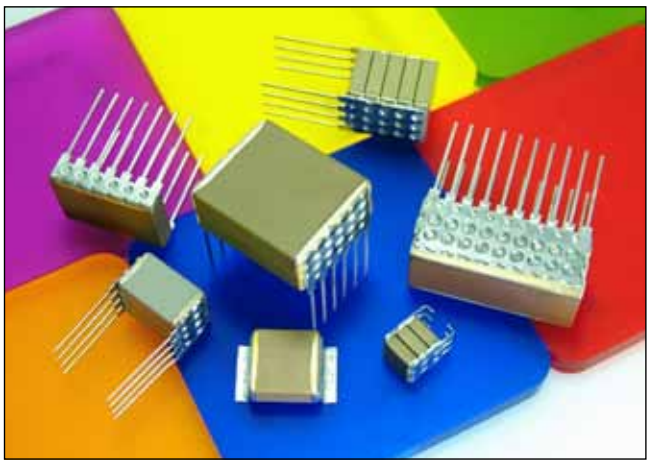
Consult the Sales Office if your specific requirements exceed our catalogue maximums (size, cap. value and voltage).

These ranges of both High Capacitance and High Voltage MLC assemblies are available in C0G/NP0 and X7R dielectrics.

Low ESR and Low ESL are inherent in the design giving the assemblies a high capability up to 1MHz and offer far superior performance than either Aluminium or Tantalum electrolytic capacitors.

They are designed for use in high power or high frequency applications such as switched mode power supplies, DC-DC converters, high capacitance discharge circuits and high temperature filtering/decoupling. They can be made with up to five same size chips with various lead configurations to safeguard against thermal and mechanical stresses.

The commercial 'ST' series provide the highest capacitance available and are 100% tested for Dielectric Withstanding Voltage, Insulation Resistance, Capacitance and Dissipation Factor.

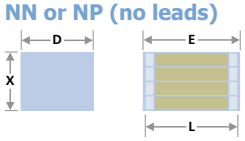


In contrast, the High Reliability 'SM' series is designed and tested for military and industrial applications and tested as per of MIL-PRF-49470 (DSCC 87106), Group A.

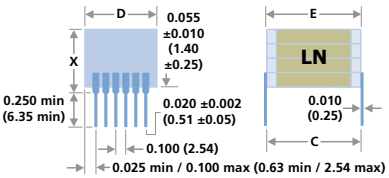
Maximum stack height, X dimension - inches/mm

No. of chips	Chip size	Style NN, NP	Style TJ & TL	Style LN, LJ & LL
1	1812	0.100/2.54	0.180/4.57	N/A
	1825	0.100/2.54	0.180/4.57	0.180/4.57
	2225	0.120/3.05	0.200/5.08	0.200/5.08
	>2225	N/A	0.200/5.08	0.200/5.08
2	1812	0.200/5.08	0.280/7.11	N/A
	1825	0.200/5.08	0.280/7.11	0.280/7.11
	2225	0.240/6.10	0.320/8.13	0.320/8.13
	>2225	N/A	0.320/8.13	0.320/8.13
3	812	0.300/7.62	0.380/9.65	N/A
	1825	0.300/7.62	0.380/9.65	0.380/9.65
	2225	0.360/9.14	0.440/11.2	0.440/11.20
	>2225	N/A	0.440/11.2	0.440/11.20
4	1812	0.400/10.20	0.480/12.2	N/A
	1825	0.400/10.20	0.480/12.2	0.480/12.20
	2225	0.480/12.20	0.560/14.2	0.560/14.20
	>2225	N/A	0.560/14.2	0.560/14.20
5	1812	0.520/13.20	0.600/15.2	N/A
	1825	0.520/13.20	0.600/15.2	0.600/15.2
	2225	0.635/16.10	0.715/18.2	0.715/18.2
	>2225	N/A	0.715/18.2	0.715/18.2

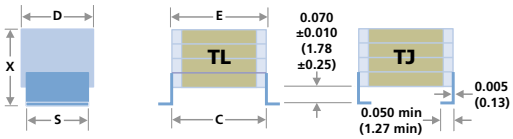
NN or NP (no leads)



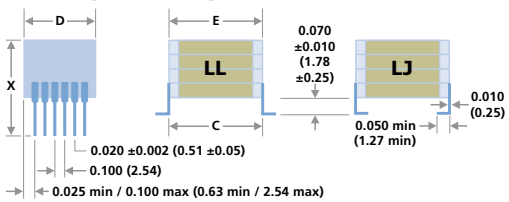
LN (straight leads)



TJ & TL (tab leads)



LJ & LL (bent leads)



Dimensions - inches/mm

Size	1812	1825	2225	3640	4540	5550	7565
C*	0.210/ 5.33	0.210/ 5.33	0.250/ 6.35	0.400/ 10.20	0.480/ 12.20	0.580/ 14.70	0.780/ 19.80
D*	0.125/ 3.18	0.250/ 6.35	0.250/ 6.35	0.400/ 10.20	0.400/ 10.20	0.500/ 12.70	0.650**/ 16.50
E max	0.260/ 6.60	0.260/ 6.60	0.300/ 7.62	0.430/ 10.90	0.530/ 13.50	0.630/ 16.00	0.830/ 21.10
L nom	0.180/ 4.57	0.180/ 4.57	0.220/ 5.59	0.360/ 9.14	0.450/ 11.40	0.550/ 14.00	0.750/ 19.10
Leads per side	N/A	3	3	4	4	5	6

Notes: 1) *C & D inches ±0.025:/mm ±0.64: 2) **±0.035/0.89

Ordering Information - ST & SM Capacitor Assemblies

ST	3640	B	474	M	101	LJ	X	W	-5	R
Style	Size	Dielectric	Capacitance	Tolerance	Voltage-VDCW	Lead style	Thickness option	Packing	No. Chips	RoHS
ST = Commercial **SM** = High Reliability	See Chart	**N** = C0G/NP0 **B** = X7R	Value in Picofarads. Two significant figures, followed by number of zeros: 825 = 8,200,000pF (8.2µF)	**F** = ±1%* **B** = ±2%* **H** = ±3%* **J** = ±5% **K** = ±10% **M** = ±20% **Z** = +80 -20% **P** = +100 -0% *C0G/NP0 only	Two significant figures, followed by number of zeros: **101** = 100V	**LN** = Straight* **LL** = L Lead* **LJ** = J Lead* **TL** = L Tab **TJ** = J tab **NN** = Nickel **NP** = Pd/Ag *Not 1812	Specify standoff dimension if less than max.	**W** = Waffle **T** = Tape & Reel* *Consult the sales office	1 to 5	≥250V RoHS

Capacitor Assemblies - 'Cap-Rack' Arrays

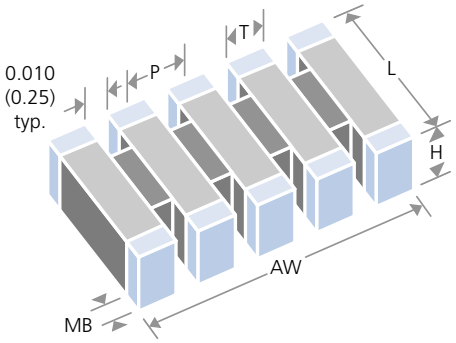
The 'Cap-Rack' (US Patent 6,058,004) is an assembly of individual chip capacitors, bonded with high temperature epoxy. A 'Cap-Rack' can be made up of a pair, to as many as eight same size chips - 0603, 0805, 1005, 1206, 1210, 1808, 1812, 1825, 2221 and 2225 - into one single component providing extended freedom for PCB space utilization. Footprint dimensions can also vary to further optimize board space usage. The patented design allows the chips to behave as individual components, not as a single large ceramic mass, and therefore reduces harmful thermal stress during assembly. Typical applications are in Multi-line designs, Mobile phones, Automotive, Computers, Network Devices and Medical products.

Electrical advantages include reduction in "cross talk", to insignificant levels, by elimination of capacitance coupling between adjacent capacitors; the ability to combine resistors and inductors within the 'Cap-Rack', as well as mixing and matching capacitance values and dielectrics.

Mechanical advantages include reduced board area; easier to handle; reduced placement cost; reduces component stress and decreased cycle time. 'Cap-Rack' can also be used with traditional pick and place equipment.

Consult the sales office for High Reliability versions and custom designs, particularly for high voltage applications.

- For dielectric characteristics see pages 4 and 5.
- For dimensions of individual chips see page 16.
- P and AW dimensions are dependant on the chips utilized in the array.
- Cap Arrays require drawings to specify length and width of array and chip size used. Please contact the Sales Office.



Dimensions - inches/mm

Size	0603	0805	1005	1206	1210	1808	1812	1825	2221	2225
Max number of Caps	6	6	6	6	6	6	8	8	8	8

Ordering information - 'Cap-Rack' Arrays

CR	1206	N	562	K	101	N	H	T	- 4
Style	Size	Dielectric	Capacitance in picofarads (pF)	Capacitance tolerance	Voltage d.c.	Termination	Hi-Rel Option	Packing	No. of chips
Cap-Rack	Size of individual chips that make up the array	**N** = C0G/NP0 **B** = X7R	Value in Picofarads. Two significant figures, followed by number of zeros: **562** = 5600pF	**B** = 0.10pF* **C** = 0.25pF* **D** = 0.50pF* **F** = ± 1.0%* **G** = ± 2.0%* **H** = ± 3.0%* **J** = ± 5% **K** = ± 10% **M** = ± 20% **Z** = +80% -20% **P** = +100% -0% *C0G/NP0 only	Two significant figures, followed by number of zeros: **101** = 100V	**N** = Nickel Barrier (100% tin) **P** = Palladium Silver **Y** = Nickel Barrier (90% tin/10% lead)	Ref: MIL-PRF-55681 & MIL-PRF-123	**T** = Tape & Reel **W** = Waffle Pack	

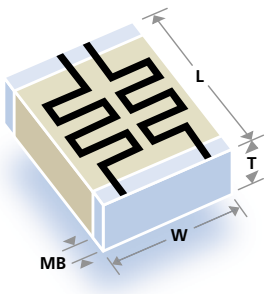
Specialty Products - Detonator and Pulse Energy

Designed for oil field exploration and perforation

These high temperature, high energy, capacitors are manufactured with a dielectric formulation designed for reliable operation under single or multiple pulse firing applications. Energy density exceeds that of conventional Class 1 materials and offers excellent short duration pulse delivery at temperatures to 200ºC. Discharge pulse width which is typically less than 100 nanoseconds will vary with load conditions which are influenced by inductive and resistive load components.

All parts are 100% tested to Novacap High Reliability Pulse Screening tests and are evaluated at temperature extremes up to 200ºC consistent with munitions and oil field exploration/seismic detonation conditions.

As an added safety feature, these pulse discharge capacitors can be supplied with integral bleed resistors at various resistance values. With exceptionally low ESR and low signal distortion, additional applications at high temperature include power supply filtering, energy storage and coupling/decoupling. When operated at temperatures less than 200ºC, higher capacitance values are available.



Dimensions - inches/mm

Size	1825	2225	3040	3640	4040	5550	6560	7565
Length L	0.180/4.57 ±0.012/0.305	0.220/5.59 ±0.015/0.381	0.300/7.62 ±0.015/0.381	0.360/9.15 ±0.018/0.457	0.400/10.2 ±0.020.508	0.550/14.0 ±0.028/0.711	0.650/16.5 ±0.033/0.838	0.750/19.1 ±0.038/0.965
Width W	0.250/6.35 ±0.015/0.381	0.250/6.35 ±0.015/0.381	0.400/10.2 ±0.020/0.508	0.400/10.2 ±0.020/0.508	0.400/10.2 ±0.020/0.508	0.500/12.7 ±0.025/0.635	0.600/15.2 ±0.030/0.762	0.650/16.5 ±0.033/0.838
End Band MB	0.024/0.610 ±0.0140.356	0.030/0.762 ±0.015/0.381	0.030/0.762 ±0.015/0.381	0.030/0.762 ±0.015/0.381	0.040/1.02 ±0.020/0.508	0.040/1.02 ±0.020/0.508	0.040/1.02 ±0.020/0.508	0.040/1.02 ±0.020/0.508

Pulse Energy - Capacitance and Voltage Selection

Size	1825	2225	3040	3640		4040	5550	6560	7565
Tmax inches: mm:	*0.140 3.56	*0.150 3.81	0.250 6.35	0.200 5.08	*0.250 6.35	0.300 7.62	0.300 7.62	0.300 7.62	0.300 7.62
1kV	463	633	204	204	224	254	394	614	724
1.1kV	393	543	184	184	214	244	354	564	674
1.2kV	353	483	174	174	204	224	334	524	624
1.3kV	283	393	164	174	194	204	314	474	574
1.4kV	263	373	154	164	194	204	294	454	544
1.5kV	233	333	144	154	184	194	274	414	514
1.6kV	193	273	124	124	154	174	254	394	464
1.7kV	153	203	963	963	124	154	224	354	414
1.8kV	123	173	793	793	104	134	204	324	374
1.9kV	103	133	653	653	853	104	174	254	294
2kV	842	113	563	563	723	913	144	224	254
2.5kV	472	682	313	313	403	503	833	134	154
3kV	162	202	113	113	143	173	283	433	513

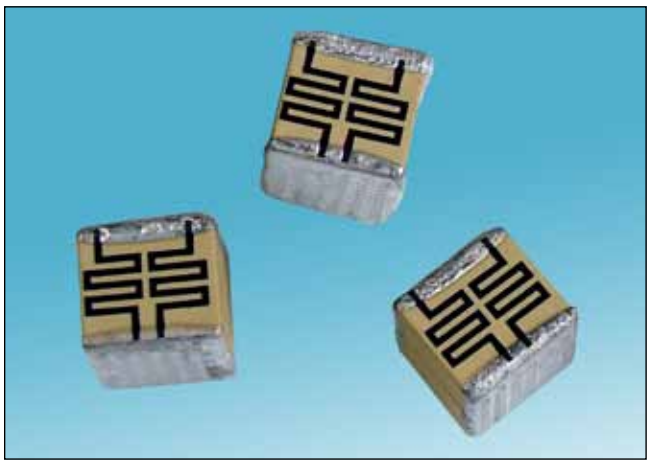
Notes: 1) Maximum capacitance values are shown above as 3 digit code: 2 significant figures followed by the no. of zeros e.g. 473 = 47,000pF
2) Capacitance values at 25ºC, 1vrms and 1kHz. Additional case sizes and voltages available. Listed capacitance values and performance characteristics are for reference only.
3) *X140, X150 or X250 needs to be in the part number for special thickness order.

Specialty Products - Detonator and Pulse Energy

Other sizes, voltages and capacitance ratings are available in single, series and series/parallel arrangement for custom applications.

500 Megohm safety bleed resistor are standard but other values are available.

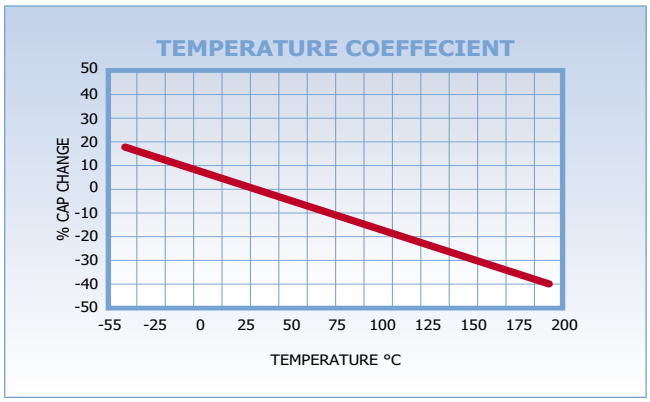
Please consult the Sales Office to best determine part size needed to meet your application requirements.



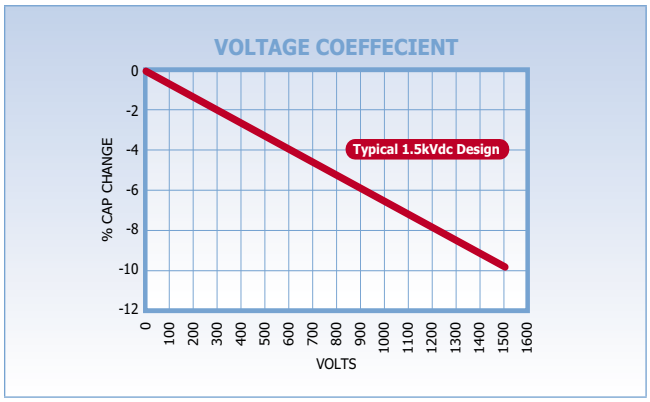
Dielectric Characteristics - Pulse Energy (R)

Operating temperature range:	-55°C to 200°C
Temperature coefficient:	-2200 ±500 ppm/°C
Dissipation factor @ 25°C:	0.1% Max.
Insulation resistance @25°C: @200°C:	>100GΩ or >1000ΩF whichever is less >1GΩ or >10ΩF whichever is less
Dielectric withstanding voltage:	120%
Ageing rate:	0% per decade
Test parameters:	1KHz, 1.0 ±0.2 VRMS, 25°C

Temperature-Capacitance Coefficient



Voltage-Capacitance Coefficient



How to Order - Detonator and Pulse Energy

RC	3640	R	124	K	102	P	X---	T
STYLE RC = Bleed Resistor (optional)	SIZE See chart	DIELECTRIC R = R2D	CAPACITANCE Value in Picofarads. Two significant figures, followed by number of zeros: 124 = 120,000pF	TOLERANCE J = ± 5.0% K = ± 10% M = ± 20% Z = +80-20% P = +100-0%	VOLTAGE VDCW Two significant figures, followed by number of zeros: 102 = 1000V	TERMINATION K = Palladium Silver for Lead Free Solder P = Palladium Silver	THICKNESS X140, X150 or X250 dependant on case size. See capacitance table.	PACKING T = Reeled

Specialty Products - Custom Designs

High Voltage Encapsulated Assemblies

Series-parallel assemblies encapsulated for harsh environments.

Specialty Feed Thru Capacitors

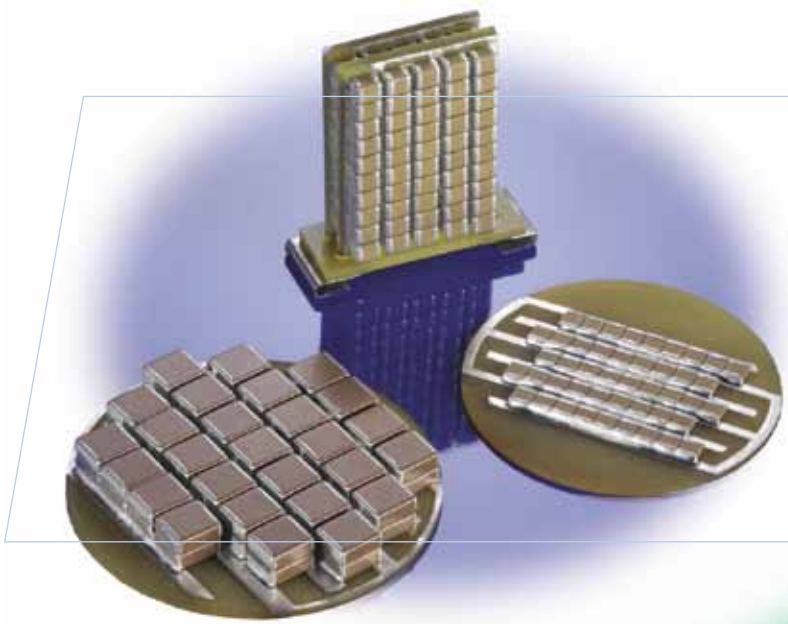
Feed Thru/High Current units for pacemaker/defibrillator applications. These units provide signal conduits through openings while suppressing EMI and RFI interference. Manufactured to customer SCD.

(Patent numbers 5,825,608 & 6,058,004)

Vertical Mount Capacitor

A vertical surface mount of a single large capacitor using specially designed and developed leads to allow for board space savings.

Specialty Products - Custom Designs

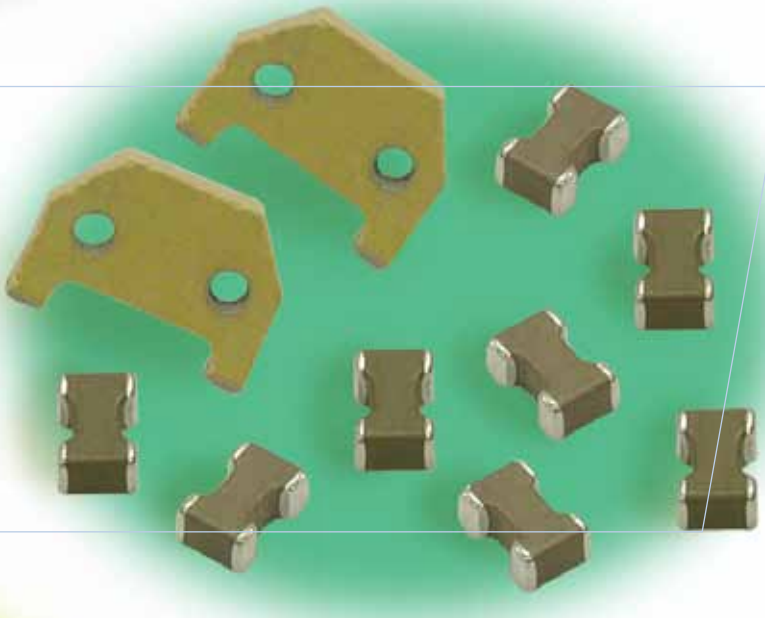


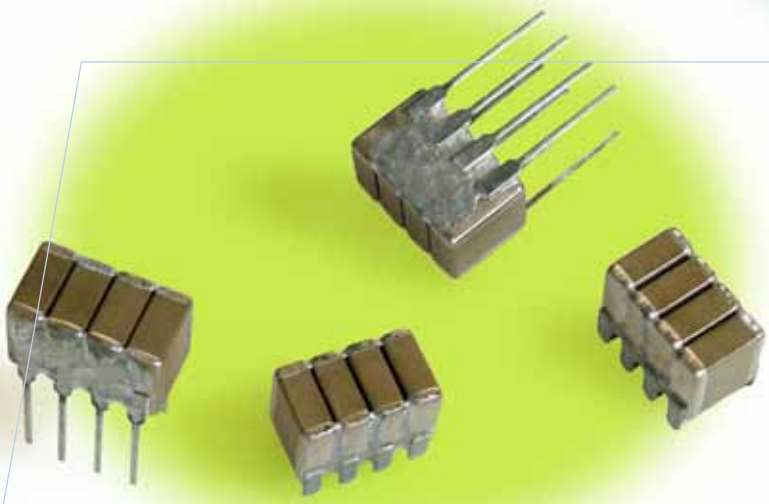
High Energy Modules

Specifically designed to offer high capacitance value in modular form for single component installation.

Free Form Capacitors

The Free Form capacitor allows any size geometry and shape for utilization in custom fit applications.





Vertical Capacitor Assemblies

Novacap is capable of stacking capacitors on the side for applications of limited height.

www.knowlescapacitors.com

knowles

DLI•Novacap•Syfer•Voltronics

Knowles Capacitors designs, manufactures and sells special electronic components. Our products are used in military, space, telecom infrastructure, medical and industrial applications where function and reliability are crucial.

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