DLI • Novacap • Syfer • Voltronics

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FlexiCap™ Termination

"An alternative termination material specifically designed to absorb greater levels of mechanical stress thereby reducing capacitor failures associated with mechanical cracking"

FlexiCap™ Introduction

Syfer Technology Ltd introduced FlexiCap™ in 1999 and became the first multilayer capacitor manufacturer to offer a flexible termination to customers. This type of termination has proven to be very successful as customers realize the benefits and also as demonstrated by other capacitor manufacturers subsequently introducing flexible terminations, some with very similar names to FlexiCap™.

FlexiCap™ refers to the termination material that is applied over the electrodes. This material is a silver loaded epoxy polymer that is applied using conventional termination techniques and then cured at 180ºC. Following the curing process, components are processed through the same manufacturing, test and inspection stages when compared with the more traditional sintered terminated products.

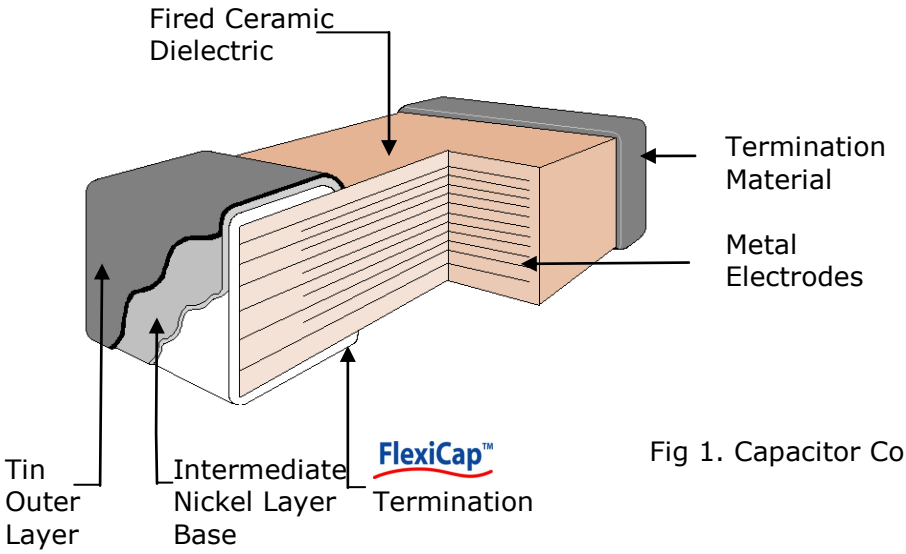
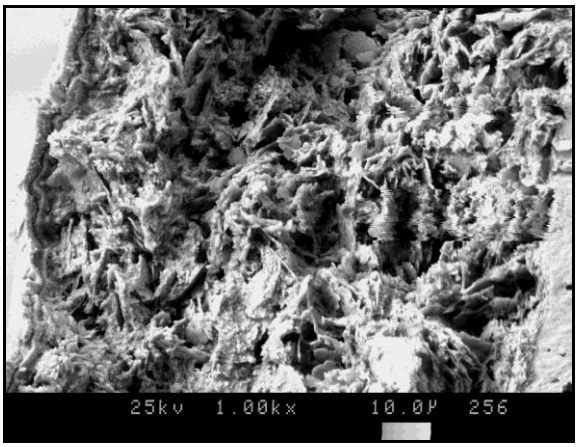


Fig 1. Capacitor Construction



Picture taken at 1000x magnification using a SEM showing a fracture section through a capacitor termination.

The picture demonstrates the fibrous nature of the FlexiCap™ termination that absorbs greater levels of mechanical stress when compared with standard sintered silver termination.

Queens Award for Innovation

The Queen's Awards for Enterprise are the UK's most prestigious awards for business performance. The Awards are presented in three categories: International Trade, Innovation and Sustainable Development

The Awards are made each year by The Queen, on the advice of the Prime Minister, who is assisted by an Advisory Committee that includes representatives of UK Government, industry and commerce, and the trade unions.

The Queens Award for Innovation recognizes companies that have demonstrated commercial success through innovative products or services.

Her Majesty The Queen conferred the Queens Award for Innovation upon Syfer Technology Ltd in 2008 for recognition of outstanding achievements in Innovation with respect to FlexiCap™.

Benefits of Using FlexiCap™

Sintered termination materials are fired onto the ceramic body of the component at approximately 800ºC. The result is a very hard material that provides minimal protection to the ceramic body of the component with respect to mechanical strain when the component is situated on an assembly.

FlexiCap™ termination material is a silver loaded epoxy polymer that is flexible and absorbs some of the mechanical strain between the PCB and the ceramic component. Components terminated with FlexiCap™ withstand greater levels of mechanical strain when compared with sintered terminated components

Types of mechanical strain where FlexiCap™ terminated capacitors offer enhanced protection include mechanical cracking (which is the largest cause for ceramic component failure) and also in applications where rapid temperature changes can occur.

Mechanical Cracking

Due to its brittle nature, multilayer ceramic capacitors are more prone to excesses of mechanical stress than other components used in surface mounting. One of the most common causes of capacitor failures is directly attributable to bending of the printed circuit board (PCB) after solder attachment. Excessive bending will create mechanical crack(s) within the ceramic capacitor. Mechanical cracks, depending upon severity, may not cause capacitor failure during the final assembly test. Over time moisture penetration into the crack can cause a reduction in insulation resistance and eventual dielectric breakdown leading to capacitor failure in service.

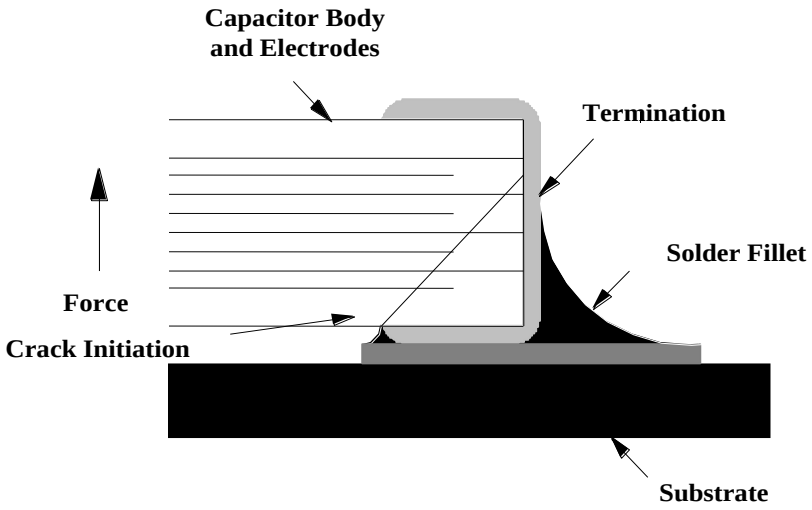
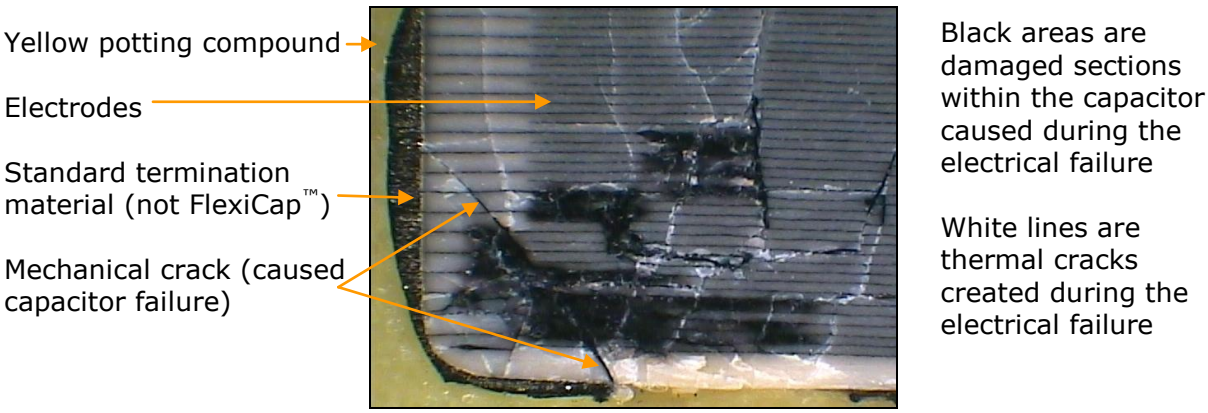


Fig 1. Mechanical Crack

Example of a capacitor issued by a customer to Syfer for failure investigation:



Temperature Cycling

Rapid temperature changes when components are mounted on a PCB can induce stress as a result of different material CTE (Coefficient of Thermal Expansion) rates. For example, a sintered terminated component will typically fail a temperature cycle test consisting of 1000 cycles (-55ºC to 125ºC). The difference in material (PCB, ceramic, solder) expansion rates can induce cracks within components that cause components to electrically fail.

FlexiCap™ termination absorbs some of the strain created during repeated rapid temperature changes and components terminated with FlexiCap™ pass temperature cycle tests such as 1000 cycles (-55ºC to 125ºC).

Customer Assembly Process Requirements

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

FlexiCap™ components are compatible with lead solder applications and lead-free solder applications with a maximum recommended reflow temperature of 270ºC.

FlexiCap™ Moisture Sensitivity Level (MSL) = 1.

FlexiCap™ Test Summary

FlexiCap™ has been rigorously tested and approved/ qualified to the following test requirements:

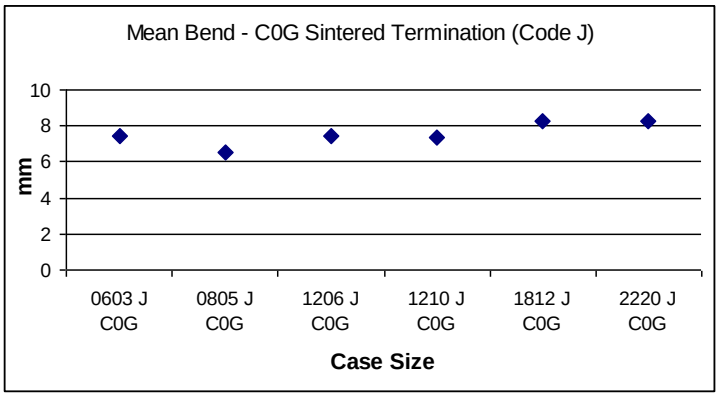
- Syfer qualification and ongoing routine tests.
- IECQ-CECC QC32100 approval.
- TUV Safety Capacitor approvals.
- UL Safety Capacitor approvals.
- AEC-Q200 qualification.

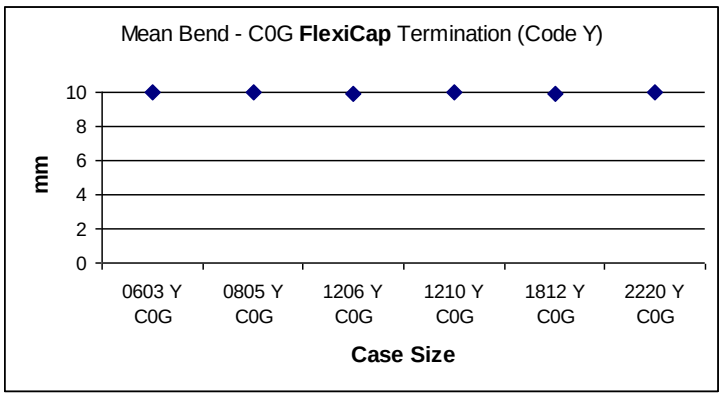
The key tests with respect to FlexiCap™ performance are as follows.

- Bend Test (Board Flex).

  Method: Capacitor samples mounted onto a 100mm FR4 Test PCB and subjected to bend testing in accordance with IEC 60068-2-21. Environmental testing: Test U: Robustness of terminations and integral mounting devices or AEC-Q200-005.

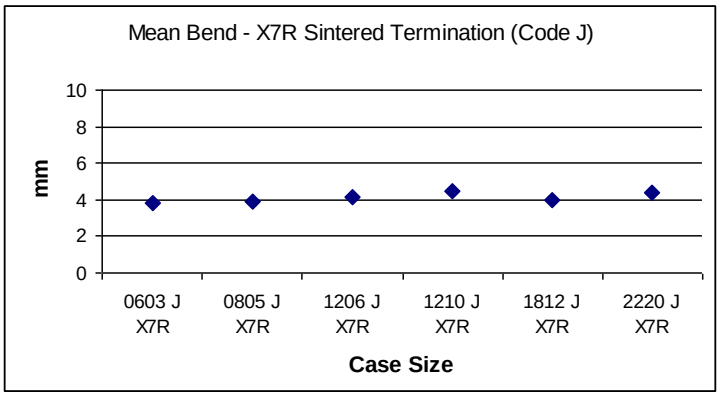
C0G (NP0) Performance

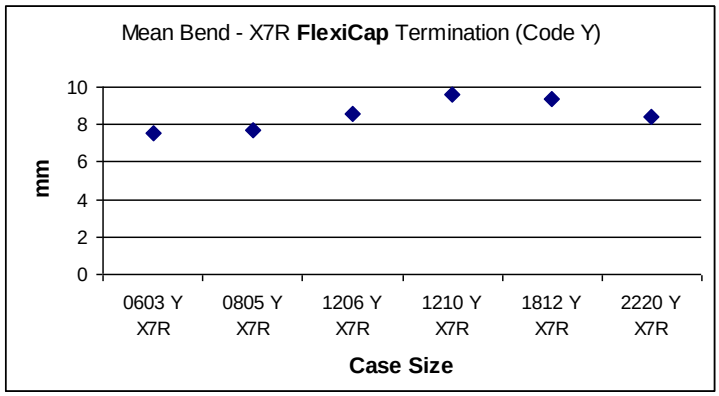




(10mm maximum bend test equipment capability)

X7R Performance





The bend test summary provides a comparison between component case sizes in the following groups:

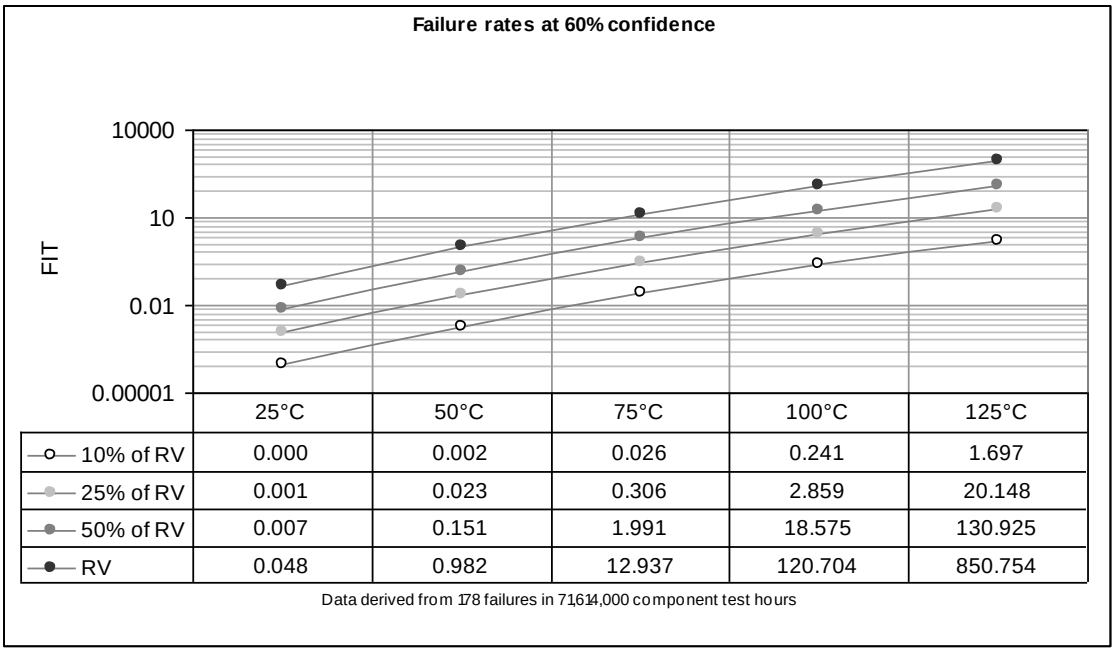
- C0G (NP0) dielectric material with sintered termination material.
- C0G (NP0) dielectric material with FlexiCap™ termination material.
- X7R dielectric material with sintered termination material.
- X7R dielectric material with FlexiCap™ termination material.

The bend tests conducted confirm that the FlexiCap™ termination withstands greater mechanical strain when compared with sintered termination materials.

- Load (Life) Tests

Product type: FlexiCap™ X7R components
Time period analyzed: 11th June 2001 to 11th June 2009.
Test laboratory: Syfer Technology Reliability Test Department.
Number of components tested: 71,614
Endurance test conditions: 1000 hours with 1.5x(1) rated voltage applied at 125°C.
Results: 178 failures in 71,614,000 component test hours.

Notes:
1). 1.5x rated voltage used during Syfer routine reliability tests. AEC-Q200 and IECQ-CECC require 1.0x rated voltage. Product specific reliability data available on request.



	25°C	50°C	75°C	100°C	125°C
10% of RV	0.000	0.002	0.026	0.241	1.697
25% of RV	0.001	0.023	0.306	2.859	20.148
50% of RV	0.007	0.151	1.991	18.575	130.925
RV	0.048	0.982	12.937	120.704	850.754

Data derived from 178 failures in 71,614,000 component test hours

The FIT (Failure In Time) rate graph provides an indication of component reliability in relation to a customer's application with respect to temperature and voltage being applied. For example, at 25ºC and 50%RV (Rated Voltage), the FIT rate graph indicates 0.007 FITs. As a comparison, an automotive customer specifies maximum of 0.1 FITs at 25ºC and 50%RV (Rated Voltage).

- Termination Bend Performance - Endurance Testing

A sample of FlexiCap™ terminated X7R capacitors has been subjected to 20,000 hours at 125°C. Tests conducted after 20,000 hours indicated no deterioration in the electrical or mechanical performance of the FlexiCap™ termination.

A sample of FlexiCap™ terminated X8R capacitors has been subjected to 5,000 hours at 150°C. Tests conducted after 5,000 hours indicated no deterioration in the electrical performance.

- Humidity Tests

From June 2001 to June 2009, a total of 27194 components (4,568,592 component test hours) have been tested at 85°C @ 85RH for either 168hours or 1000hours. There have been 3 failures that have not been attributed to FlexiCap™.

In addition to the Syfer routine and AEC-Q200 tests, samples have been tested by an external test laboratory for IECQ-CECC Damp Heat Steady State periodic test (56 days 40ºC/ 93%RH with applied voltages of 0Vdc, 5Vdc or 50Vdc). Samples pass this test requirement.

- Temperature Cycling

  Temperature Cycle Profile: 40-minute cycle consisting of 10 minute ramp and 10 minute dwell at temperature extremes.
  Temperature Extremes: -55°C to +125°C.
  Number of Cycles: 1000.
  Method: Samples of FlexiCap™ terminated capacitors were soldered onto FR4 test PCB's and subjected to temperature cycling. After 1000 cycles, the capacitors were sectioned mounted on the test PCBs for internal visual examination.
  Results: There were no cracks within the capacitors.

- Passive Flammability Test

  Method: A sample of FlexiCap™ terminated capacitors were subjected to a needle flame test in accordance with IEC 60384-1.
  Requirement: Burning droplets of glowing parts falling down shall not ignite the tissue paper (placed underneath the specimen being tested).
  Results: The sample passed the Passive Flammability Test.

- Thermal Vacuum Outgassing Test

  FlexiCap™ material successfully passed ECSS-Q-70-02A Thermal vacuum outgassing test for the screening of space materials. The test was conducted by an external test laboratory and results are available in Syfer application note AN0026.

- Customer Qualification

  Samples of FlexiCap™ terminated capacitors have been supplied to customers for qualification.

  The qualifications conducted by customers have been successful and customer reaction to FlexiCap™ termination has been extremely favorable. Demand for FlexiCap™ terminated capacitors continues to increase as customers realize the advantages provided.

  FlexiCap™ terminated capacitors are supplied to many blue chip companies, O.E.M's, E.M.S's and international component distributors. Applications include telecoms, military, aerospace, automotive, industrial and power supplies.

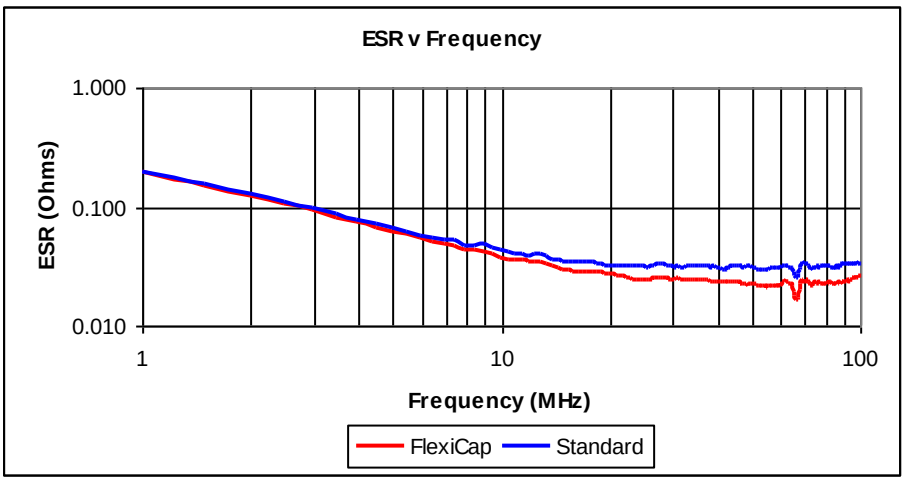
Key Electrical Characteristics

FlexiCap™ terminated capacitors have equivalent electrical characteristics when compared with sintered terminated capacitors.

For example (type 1812 100nF):

	Capacitance @ 1kHz	DF @ 1kHz	Resonant Frequency (RF)	Inductance @ RF
Sintered Termination	100.02nF	0.01167	14.468MHz	1.1965nH
FlexiCap™ Termination	101.14nF	0.01173	14.468MHz	1.2099nH

The ESR characterisation of an 18nF 1825 X7R capacitor was undertaken to a frequency of 100MHz. FlexiCap™ and sintered termination were tested in parallel to determine the relative ESR performance. From the graph below it can be seen that there is a reduction in ESR at high frequencies when capacitors are terminated using FlexiCap™ termination.



Additional Information

Syfer has generated a comprehensive range of application notes (available at www.knowlescapacitors.com/syfer) to provide additional information to customers.

Application notes that provide additional information with respect to FlexiCap™:

APPLICATION NOTE	CONTENTS
AN0002 Bend Testing	Test methods for Capacitor bend testing, and the shape of typical cracks
AN0005 Mechanical Cracking	Potential causes of mechanical cracking, corrective actions and depanelisation methods
AN0006 Dielectric Ageing	Capacitor dielectric ageing
AN0009 AEC-Q200 Stress Test Qualification	Provides information on tests performed by Syfer in accordance with the AEC-Q200 specification
AN0010 Lead-free soldering and bend test performance	The effects of Lead-free soldering on bend testing through solder choice
AN0019 Tin Whiskers	Tin Whiskers mitigation and surface mount chip capacitors
AN0021 Tandem Capacitors	Tandem capacitors terminated with FlexiCap™ provide an ultra robust and reliable component.
AN0022 Open Mode Capacitors	Open mode capacitors terminated with FlexiCap™ provide a robust component that fail in an open circuit mode.
AN0024 Moisture Sensitivity Level Classification for Syfer products	MSL classification IPC / JEDEC J-STD-020D for Syfer products.
AN0026 Outgassing test results for FlexiCap™ capacitors	Results for ECSS-Q-70-02A outgassing tests on FlexiCap™ capacitors.
AN0028 Soldering / Mounting Chip Capacitors, Radial Leaded Capacitors and EMI Filters	This gives guidance to engineers and board designers on mounting and soldering Syfer products.

Ordering Information – Standard MLCC Range

1210	Y	100	0103	J	X	T	□□□
Chip Size	**Termination**	**Voltage d.c. (marking code)**	**Capacitance in Pico farads (pF)**	**Capacitance Tolerance**	**Dielectric Codes**	**Packaging**	**Suffix Code**
0603 **0805** **1206** **1210** **1808** **1812** **1825** **2220** **2225** **3640** **5550** **8060**	**Y** = FlexiCap™ termination base with nickel barrier (100% matte tin plating). RoHS compliant. **H** = FlexiCap™ termination base with nickel barrier (tin/lead plating with min. 10% lead). Not RoHS compliant. **F** = Silver Palladium. RoHS compliant **J** = Silver base with nickel barrier (100% matte tin plating). RoHS compliant **A** = Silver base with nickel barrier (tin/lead plating with min. 10% lead). Not RoHS compliant	**010** = 10V **016** = 16V **025** = 25V **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 **4K0** =4kV **5K0** =5kV **6K0** =6kV **8K0** =8kV **10K** =10kV **12K** =12kV	<1.0pF Insert a P for the decimal point as the first character. e.g., **P300** = 0.3pF Values in 0.1pF steps ≥1.0pF & <10pF Insert a P for the decimal point as the second character. e.g., **8P20** = 8.2pF Values are E24 series ≥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** = 100 pF Values are E12 series	**H**: ± 0.05pF (only available for values <4.7pF) <10pF **B**: ± 0.10pF **C**: ± 0.25pF **D**: ± 0.5pF **F**: ± 1.0pF ≥10pF **F**: ± 1% **G**: ± 2% **J**: ± 5% **K**: ± 10% **M**: ± 20%	**C** = C0G/NP0 (1B) **X** = X7R (2R1) **P** = X5R	**T** = 178mm (7") reel **R** = 330mm (13") reel **B** = Bulk pack – tubs or trays	Used for specific customer requirements

For quotations please contact Syfer Sales Department sales@syfer.co.uk.