Innovative Service Around the Globe YAGEO

DATA SHEET

SURFACE-MOUNT CERAMIC MULTILAYER CAPACITORS

Microwave: Class 1 NP0

50 V

NME

Phycomp

Product Specification – Jul 21, 2003 V.4

Surface-mount ceramic multilayer capacitors

Microwave: Class 1, NP0, NME 50 V

FEATURES

- Low insertion loss/ESR up to 3 GHz:
  - First parallel resonance above 2 GHz
  - Second parallel resonance above 3 GHz
- Small dimensions; sizes 0603, 0805 and 1206 available
- High reliability
- Standard tolerance on capacitance: ±10%, ±5%, ±2% and ±1%
- Suitable for reflow and wave soldering
- s-parameter data available on floppy disk
- NiSn terminations (AgPd on request).

APPLICATIONS

- Mobile telephones
- Satellite television
- Instrumentation.

DESCRIPTION

The capacitor consists of a rectangular block of ceramic dielectric in which a number of interleaved metal electrodes are contained. This structure gives rise to a high capacitance per unit volume.

The inner electrodes are connected to the two terminations, either by silver palladium (AgPd) alloy in the ratio 65 : 35, or silver dipped with a barrier layer of plated nickel and finally covered with a layer of plated tin (NiSn). A cross section of the structure is shown in Fig.1.

QUICK REFERENCE DATA

DESCRIPTION	VALUE
Rated voltage U_R (DC)	50 V (IEC); note 1
Capacitance range (E12 series), NP0 dielectric; note 2:	
case size 0603	0.47 pF to 47 pF
case size 0805	0.47 pF to 82 pF
case size 1206	0.47 pF to 120 pF
Tolerance on capacitance:	
$C \geq 10$ pF	±10%, ±5%, ±2% and ±1%
5 pF $\leq C < 10$ pF	±0.5 pF, ±0.25 pF and ±0.1 pF
$C < 5$ pF	±0.25 pF and ±0.1 pF
Test voltage (DC) for 1 minute	$2.5 \times U_R$
Insulation resistance after 60 s at U_R (DC)	>100 GΩ
Sectional specifications	IEC 60384-10, second edition 1989-04; also based on CECC 32 100
Detailed specification	based on CECC 32 101-801
Climatic category (IEC 60068)	55/125/56

Notes

1. Also applicable for applications up to 63 V.
2. Non E12 values are available on request.

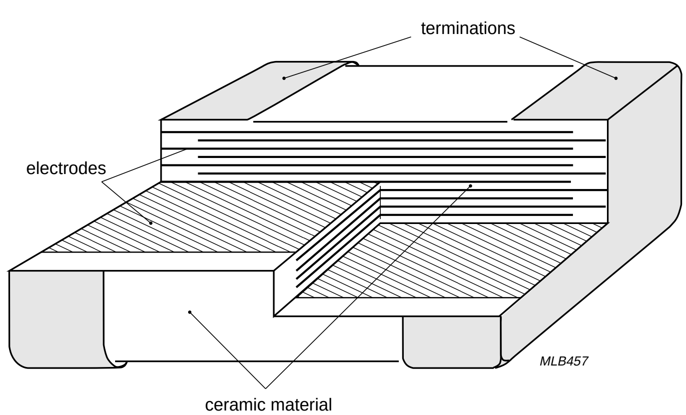
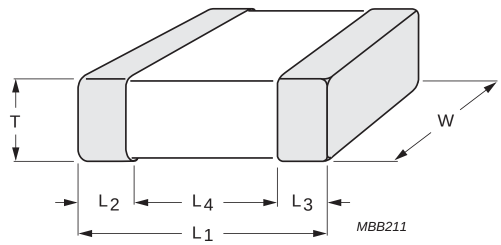


Fig.1 Construction of a ceramic multilayer capacitor.

Surface-mount ceramic multilayer capacitors

Microwave: Class 1, NP0, NME 50 V

MECHANICAL DATA



For dimensions see Table 1.

Fig.2. Component outline.

Physical dimensions

Table 1 Capacitor dimensions

CASE SIZE	L_1	W	T		L_2 and L_3		L_4
			MIN.	MAX.	MIN.	MAX.	MIN.
Dimensions in millimetres							
0603	1.6 ±0.10	0.8±0.07	0.73	0.87	0.25	0.65	0.40
0805	2.0 ±0.10	1.25 ±0.10	0.50	1.35	0.25	0.75	0.55
1206	3.2 ±0.15	1.6 ±0.15	0.50	1.75	0.25	0.75	1.40
Dimensions in inches							
0603	0.063 ±0.004	0.032 ±0.003	0.029	0.035	0.010	0.026	0.016
0805	0.079 ±0.004	0.049 ±0.004	0.020	0.053	0.010	0.030	0.022
1206	0.126 ±0.006	0.063 ±0.006	0.020	0.069	0.010	0.030	0.056

SELECTION CHART

C (pF)	LAST TWO DIGITS OF 12NC	50 V		
		0603	0805	1206
0.47	05			
0.56	06			
0.68	07			
0.82	08			
1.0	09			
1.2	11			
1.5	12			
1.8	13			
2.2	14			
2.7	15			
3.3	16			
3.9	17			
4.7	18	0.8 ±0.07		
5.6	19			
6.8	21		0.6 ±0.1	
8.2	22			
10	23			0.6 ±0.1
12	24			
15	25			
18	26			
22	27			
27	28			
33	29			
39	31			
47	32			
56	33			
68	34			
82	35			
100	36			
120	37			

Note

1. Values in shaded cells indicate thickness class.

Thickness classification and packing quantities

THICKNESS CLASSIFICATION (mm)	8 mm TAPE WIDTH QUANTITY PER REEL		QUANTITY PER BULK CASE	
	∅180 mm; 7"	∅330 mm; 13"		
	PAPER	PAPER	0603	0805
0.6 ±0.1	4000	20000	–	10000
0.8 ±0.07	4000	15000	15000	–

ORDERING INFORMATION FOR 50 V

Components may be ordered by using either a Phycomp's unique 12NC or simple 15-digit clear text code.

Ordering code 12NC (preferred)

2 2 X X X X X X 1 X X X

Carrier type
- 38 paper
- 54 bulk

Size - Termination
- 578 0603 Ni-barrier
- 574 0805 Ni-barrier
- 576 1206 Ni-barrier

Packaging(2)
- 1 reel: ∅180 mm; 7"
- 5 reel: ∅330 mm; 13"
- 4 bulk case

Capacitance value(1)

Tolerance
- 0 ±0.1 pF for C < 10 pF
- 1 ±0.25 pF for C < 10 pF
- 2 ±0.5 pF for 5 pF C < 10 pF
- 3 ±1% for C 10 pF
- 4 ±2% for C 10 pF
- 5 ±5% for C 10 pF
- 6 ±10% for C 10 pF

CCA616

(1) Refer to chapter "Selection chart".

(2) Quantity on reel depends on thickness classification, see section "Thickness classification and packing quantities".

Clear text code

Example: 0805CG100G9B20M

Size Code	Temp. Char.	Capacitance	Tol.	Vol.	Termination	Packing	Marking	Series
0603 0805 1206	CG = NP0	100 = 10 pF; the third digit signifies the multiplying factor: 8 = × 0.01 9 = × 0.1 0 = × 1	B = ±0.1 pF C = ±0.25 pF D = ±0.5 pF F = ±1 % G = ±2 % J = ±5 % K = ±10 %	9 = 50 V	B = NiSn	2 = 180 mm; 7" paper 3 = 330 mm; 13" paper P = bulk case	0 = no marking	M = micro-wave

ELECTRICAL CHARACTERISTICS

Class 1 capacitors; NP0 dielectric; NiSn terminations

Unless otherwise stated all electrical values apply at an ambient temperature of 20 ±1 °C, an atmospheric pressure of 86 to 106 kPa, and a relative humidity of 63 to 67%.

DESCRIPTION	VALUE
Capacitance range (E12 series), NP0 dielectric; note 1:	
case size 0603	0.47 pF to 47 pF
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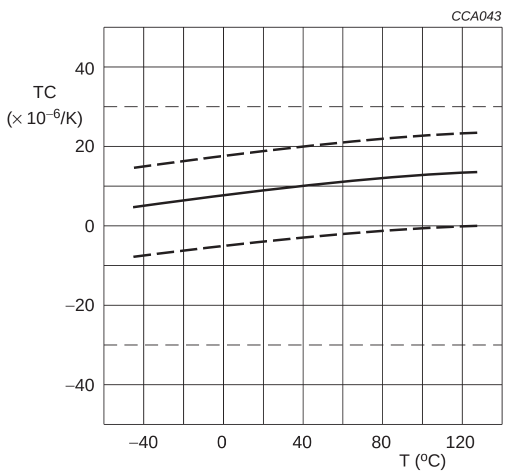
Tolerance on capacitance	
C ≥ 10 pF	±10%, ±5%, ±2% and ±1%
5 pF ≤ C < 10 pF	±0.5 pF, ±0.25 pF and ±0.1 pF
C < 5 pF	±0.25 pF and 0.1 pF
Tan δ; note 1:	
C < 10 pF	$\leq 10\left(\frac{3}{C} + 0.7\right) \times 10^{-4}$ or 30×10^{-4}, whichever is the smallest
C ≥ 10 pF	$\leq 10 \times 10^{-4}$
Temperature coefficient; note 2:	
0.47 pF ≤ C < 5 pF	$(0 \pm 150) \times 10^{-6}$/K
5 pF ∂ ≤ C < 10 pF	$(0 \pm 150) \times 10^{-6}$/K
C ≥ 10 pF	$(0 \pm 30) \times 10^{-6}$/K
High frequency properties	for ESR values see Figs 7, 8 and 9. The first parallel resonance frequency in the s_{21} and s_{12} scattering parameters lies above 2 GHz and the second resonance frequency above 3 GHz.

Notes

1. Measured at 1 V, 1 MHz, using a four-gauge method.
2. For size 0603 all capacitance values from 0.47 pF to 47 pF have a temperature coefficient $(0 \pm 30) \times 10^{-6}$/K.



Sample limits (broken lines).
Requirement levels (dotted lines).

Fig.3 Typical temperature coefficient as a function of temperature.

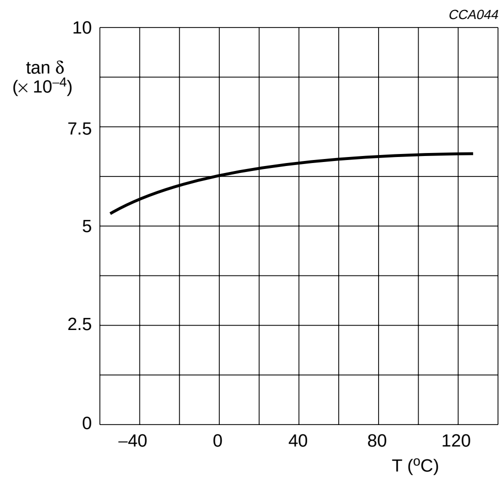


Fig.4 Typical tan δ as a function of temperature.

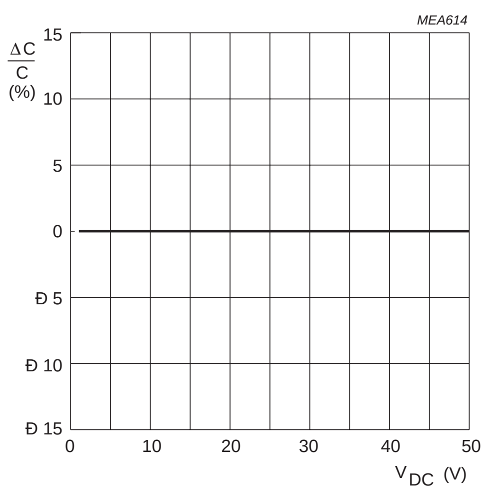
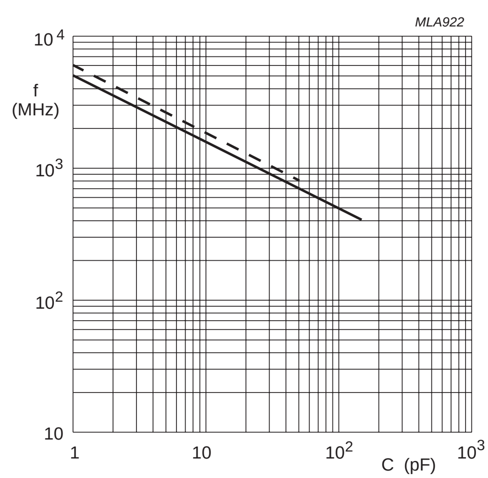
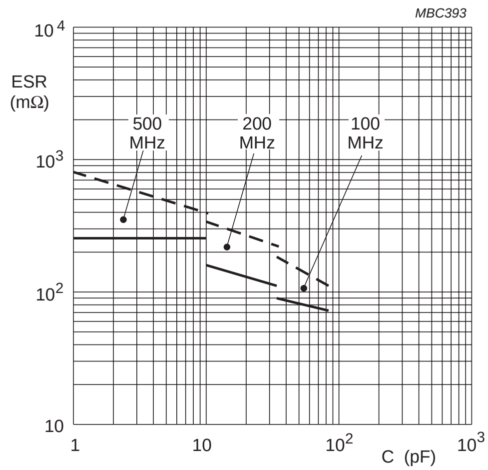


Fig.5 Typical capacitance change with respect to the capacitance at 1 V as a function of DC voltage.



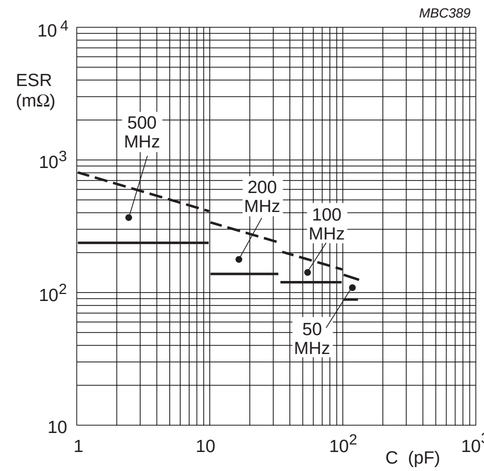
Case sizes **0805** and **1206** (solid line).
Case size **0603** (broken line).

Fig.6 Series resonance frequency as a function of capacitance.



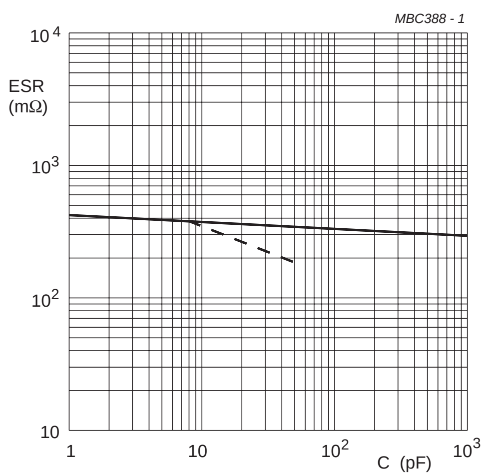
Case sizes **0603** and **0805**.
Typical values (solid lines).
Maximum values (broken lines).
Measuring equipment HP4191A.

Fig.7 Equivalent series resistance (ESR) as a function of capacitance.



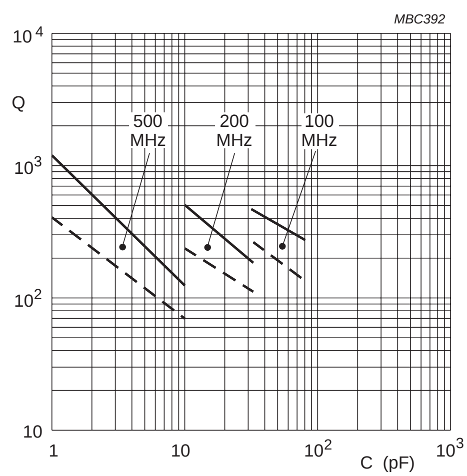
Case size **1206**.
Typical values (solid lines).
Maximum values (broken lines).
Measuring equipment HP4191A.

Fig.8 Equivalent series resistance (ESR) as a function of capacitance.



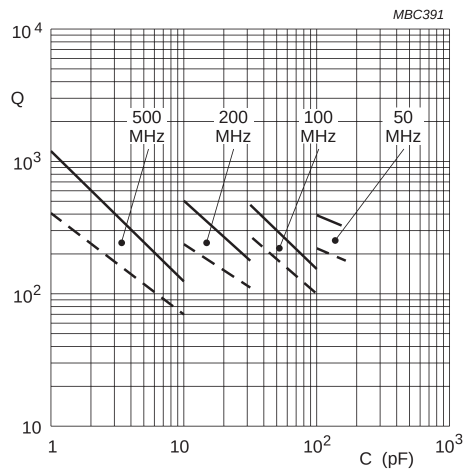
Case sizes **0805** and **1206** (solid line).
Case size **0603** (broken line).
Measuring equipment HP4191A.

Fig.9 Typical ESR values at 1 GHz as a function of the capacitance value



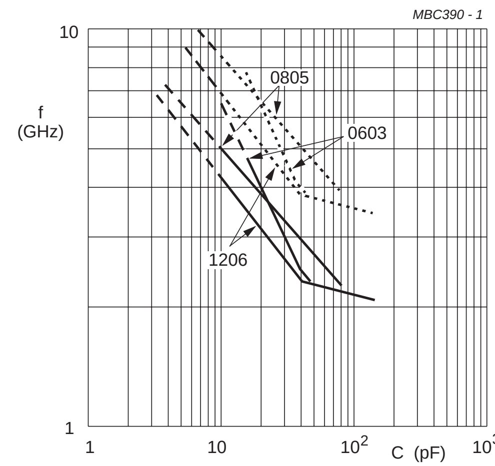
Case sizes **0603** and **0805**.
Typical values (solid lines).
Maximum values (broken lines).
Measuring equipment HP4191A.

Fig.10 Quality factor (Q) as a function of the capacitance.



Case sizes **1206**.
Typical values (solid lines).
Maximum values (broken line).
Measuring equipment HP4191A.

Fig.11 Quality factor (Q) as a function of the capacitance.



Case sizes **0603**, **0805** and **1206**.
First resonant frequency (solid lines).
Second resonant frequency (dotted lines).

Fig.12 Typical first and second parallel resonance as a function of capacitance.

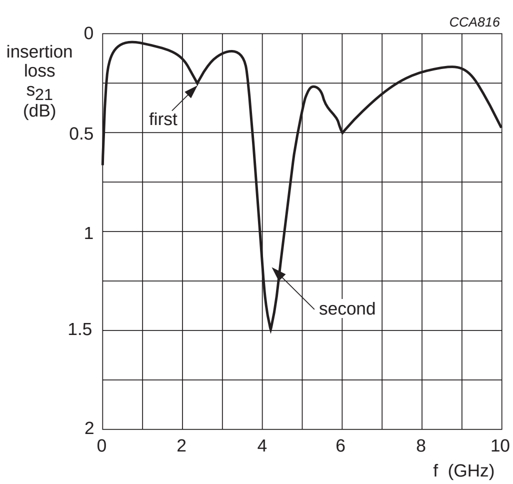


Fig.13 Example of the insertion loss as a function of frequency showing the parallel resonances.

MICROWAVE BEHAVIOUR OF MULTILAYER CHIP CAPACITORS

Multilayer chip capacitors (MLCCs) from the microwave series are suitable for use at high frequencies. At frequencies below the series resonance frequency, the MLCC can be represented by an equivalent circuit as shown in Fig.14.

In general, the quantities C, ESR and L are frequency dependent. For most applications, C and L can be regarded as frequency independent below 1 GHz.

The equivalent series self-inductance L is:

- Independent of the dielectric material
- Dependent on the size of the capacitor and is approximately:
  - 0.6 nH for case size 0603
  - 1 nH for case sizes 0805 and 1206 (these figures are accurate to within ±20%).

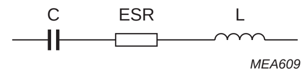
Because of the inductance L, associated with the MLCC, there will be a frequency at which the inductive reactance will be equal to the reactance of the capacitor.

This is known as the series resonance frequency (SRF) and is given by:

$$SRF = \frac{1}{2\pi\sqrt{LC}}$$

At the SRF, the MLCC will appear as a small resistor. The transmission loss through the MLCC at this series resonance frequency will be low.

Using the values of C, L (= 1 nH) and the ESR at a specific frequency (f), two often used quantities can be derived.



C = capacitance.
ESR = equivalent series resistance which is determined by the energy dissipation mechanisms (in the dielectric material as well as in the electrodes).
L = equivalent series self-inductance.

Fig.14 Equivalent series representation of an MLCC.

The impedance (Z) is given by: $Z = \frac{1-(2\pi f)^2 LC}{2j\pi fC} + ESR$

The quality factor (Q) is given by: $Q = \frac{\left|1-(2\pi f)^2 LC\right|}{2\pi f ESRC}$

The frequency region above the SRF is difficult to model using lumped elements and should be described in terms of a network of transmission lines. The behaviour of the MLCC in this frequency region can be best described in terms of scattering or ‘s’ parameters. Knowing these parameters, one can predict the response of a network accurately. There are four scattering parameters for a two-port network: s_{11}, s_{12}, s_{21} and s_{22}:

s_{11} is the reflection coefficient at the input port with the output port terminated in a 50 Ω load.

s_{12} is the reverse transmission coefficient in a 50 Ω system.

s_{21} is the forward transmission coefficient in a 50 Ω system.

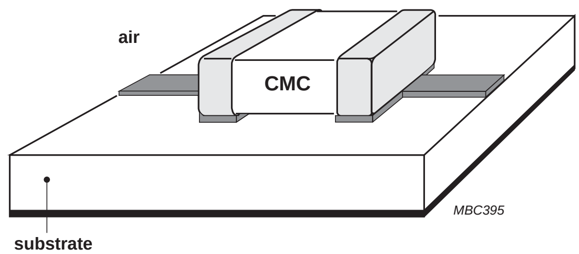
s_{22} is the reflection coefficient at the output port with the input port terminated into a 50 Ω load.

When comparing the insertion loss (i.e. s_{21}) of an MLCC at high frequencies with that of an ideal capacitor, parallel resonances above the SRF are observed. In series or shunt connections parallel resonances are usually detrimental to the operation of the circuit. They may be the cause of unacceptable insertion loss or parasitic oscillations of amplifiers. For the microwave series, we specify that the first parallel resonance frequency lies above 2 GHz and the second above 3 GHz. It is found that the typical insertion loss at the first resonance frequency is more than a factor 5 smaller than at the second resonance frequency.

The high frequency behaviour of our CMCs is measured in a strip line configuration as shown in Fig.15 using a test fixture with the following features:

- Microstrip structure (dielectric: Al2O3; thickness: 0.635 mm)
- Suitable for the TRL calibration method
- De-embedding for the low-frequency range (up to 3 GHz).

The measurements are carried out using the HP 8510B network analyser.



Substrate permittivity: ε_r = 9.8.
Substrate thickness = 0.635 mm.

Fig.15 Microwave behaviour measured using a microstrip.

Data sheet status	
Objective specification	This data sheet contains target or goal specifications for product development.
Preliminary specification	This data sheet contains preliminary data; supplementary data may be published later.
Product specification	This data sheet contains final product specifications.
Application information	
Where application information is given, it is advisory and does not form part of the specification.	

LIFE SUPPORT APPLICATIONS

These products are not designed for use in life support appliances, devices, or systems where malfunction of these products can reasonably be expected to result in personal injury. Phycomp customers using or selling these products for use in such applications do so at their own risk and agree to fully indemnify Phycomp for any damages resulting from such improper use or sale.

REVISION HISTORY

Revision	Date	Change Notification	Description
Rev.3	2001 May 30	-	- Converted to Phycomp brand
Rev.4	2003 Jul 21	-	- Updated company logo