

DATA SHEET

Class 1, NP0 50/100/200/500 V Noble Metal Electrode Surface mount ceramic multilayer capacitors

Product specification
Supersedes data of 24th May 2000
File under Discrete Ceramics, ACM2

2000 Sep 11

Surface mount ceramic multilayer capacitors

Class 1, NP0 50/100/200/500 V Noble Metal Electrode

FEATURES

- Seven standard sizes
- High capacitance per unit volume
- Supplied in tape on reel or in bulk case (case sizes 0402, 0603 and 0805 only)
- For high frequency applications
- NiSn terminations (AgPd on request).

APPLICATIONS

- Consumer electronics
- Telecommunications
- Automotive
- Data processing.

DESCRIPTION

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

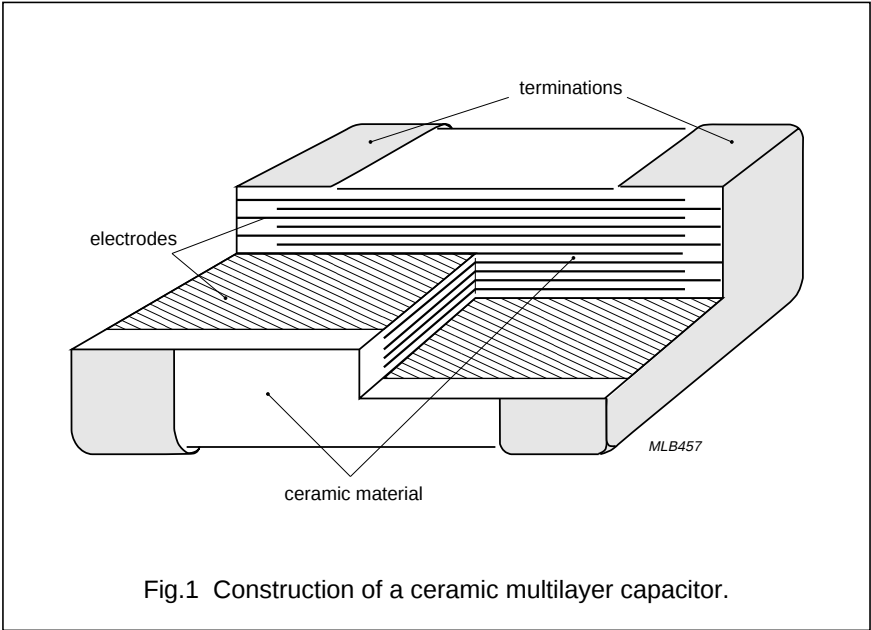
The inner electrodes are connected to the two terminations, either by silver palladium (AgPd) alloy in the ratio 65 : 35, or silver dipped with a barrier layer of plated nickel and finally covered with a layer of plated tin (NiSn). A cross section of the structure is shown in Fig.1.

QUICK REFERENCE DATA

DESCRIPTION	VALUE
Rated voltage U_R (DC)	50 V, 100 V, 200 V and 500 V (IEC)
Capacitance range (E12 series); note 1: 50 V; note 2 100 V 200 V 500 V	0.47 pF to 47 000 pF 10 pF to 22 nF 10 pF to 5600 pF 10 pF to 3300 pF
Tolerance on capacitance: $C \geq 10$ pF $C < 10$ pF	$\pm 5\%$; $\pm 2\%$ ± 0.5 pF; ± 0.25 pF
Test voltage (DC) for 1 minute: 50 V and 100 V 200 V 500 V	$2.5 \times U_R$ $3 \times U_R$ $2 \times U_R$
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

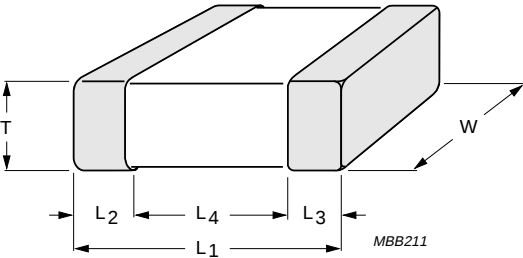
1. Other values below 10 pF and non E12 series are available on request.
2. Also applicable for applications up to 63 V.



Surface mount ceramic
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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.
			MIN.	MAX.	MIN.	MAX.	
Dimensions in millimetres							
0402	1.0 ±0.05	0.5 ±0.05	0.45	0.55	0.20	0.30	0.40
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
1210	3.2 ±0.20	2.5 ±0.20	0.50	1.80	0.25	0.75	1.40
1812	4.5 ±0.20	3.2 ±0.20	0.50	1.80	0.25	0.75	2.20
2220	5.7 ±0.20	5.0 ±0.20	0.50	1.80	0.25	0.75	2.90
Dimensions in inches							
0402	0.040 ±0.002	0.020 ±0.002	0.018	0.022	0.008	0.012	0.016
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
1210	0.126 ±0.008	0.098 ±0.008	0.020	0.072	0.010	0.030	0.056
1812	0.177 ±0.008	0.126 ±0.008	0.020	0.072	0.010	0.030	0.088
2220	0.224 ±0.008	0.197 ±0.008	0.020	0.072	0.010	0.030	0.114

Surface mount ceramic multilayer capacitors

Class 1, NP0 50 V Noble Metal Electrode

SELECTION CHART FOR 50 V

C (pF)	LAST THREE DIGITS OF 12NC	50 V						
		0402	0603	0805	1206	1210	1812	2220
0.47	477							
0.56	567							
0.68	687							
0.82	827							
1.0	108							
1.2	128							
1.5	158							
1.8	188							
2.2	228							
2.7	278							
3.3	338							
3.9	398							
4.7	478							
5.6	568							
6.8	688							
8.2	828							
10	109	0.5 ±0.05						
12	129							
15	159							
18	189		0.8 ±0.07					
22	229							
27	279							
33	339			0.6 ±0.1				
39	399							
47	479							
56	569				0.6 ±0.1			
68	689							
82	829							
100	101							
120	121							
150	151							
180	181							
220	221							
270	271							
330	331							
390	391							
470	471						S	
560	561							
680	681							
820	821					0.5 to 1.0		
1000	102							
1200	122							
1500	152			0.85 ±0.1				
1800	182							
2200	222			1.25 ±0.1			0.5 to 1.0	
2700	272							
3300	332							
3900	392				0.85 ±0.1			
4700	472							
5600	562				1.15 ±0.1			
6800	682							
8200	822	Values in shaded cells indicate thickness classification.						
10000	103							0.5 to 1.0
12000	123							

Surface mount ceramic multilayer capacitors

Class 1, NP0 50 V Noble Metal Electrode

C (pF)	LAST THREE DIGITS OF 12NC	50 V						
		0402	0603	0805	1206	1210	1812	2220
15000	153						0.5 to 1.0	
18000	183						0.9 to 1.3	
22000	223							0.5 to 1.0
27000	273							
33000	333							
39000	393							
47000	473							0.9 to 1.3

Thickness classification and packaging quantities

THICKNESS CLASSIFICATION (mm)	8 mm TAPE WIDTH AMOUNT PER REEL				12 mm TAPE WIDTH AMOUNT PER REEL		AMOUNT PER BULK CASE		
	Ø180 mm; 7"		Ø330 mm; 13"		Ø180 mm; 7" BLISTER				
	PAPER	BLISTER	PAPER	BLISTER	1812	2220	0402	0603	0805
0.5 ±0.05	10000	—	50000	—	—	—	50000	—	—
0.6 ±0.1	4000	—	20000	—	—	—	—	—	10000
0.85 ±0.1	4000	—	15000	—	—	—	—	—	8000
0.5 to 1.0	—	4000	—	10000	2000	1500	—	—	—
0.8 ±0.07	4000	—	15000	—	—	—	—	15000	—
0.9 to 1.3	—	3000	—	10000	1500	—	—	—	—
1.15 ±0.1	—	3000	—	10000	—	—	—	—	—
1.25 ±0.1	—	3000	—	10000	—	—	—	—	5000

Surface mount ceramic
multilayer capacitors

Class 1, NP0 50 V
Noble Metal Electrode

ORDERING INFORMATION FOR 50 V

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

Clear text code

EXAMPLE: 0805CG102J9B200

SIZE CODE	TEMP. CHAR.	CAPACITANCE	TOL.	VOLTAGE	TERMINATION	PACKAGING	MARKING	SERIES
0402	CG = NP0	102 = 1000 pF;	C = ±0.25 pF	9 = 50 V	B = NiSn A = AgPd (2220 only)	2 = 180 mm; 7" paper	0 = no marking 2 = 2-character marking in North America only	0 = conv. ceramic
0603		the third digit signifies the multiplying factor:	D = ±0.5 pF			3 = 330 mm; 13" paper		
0805		8 = × 0.01	G = ±2%			B = 180 mm; 7" blister		
1206		9 = × 0.1	J = ±5%			F = 330 mm; 13" blister		
1210		0 = × 1				P = bulk case		
1812		1 = × 10						
2220 (AgPd only)		2 = × 100 3 = × 1000						

Ordering code 12NC

2 2 X X 8 6 X X X X X

Carrier type

22 blister

38 paper

54 bulk

Size

9 0402

7 0603

1 0805

3 1206

2 1210

5 1812

6 2220 (AgPd only)

Packaging⁽²⁾

1 reel: Ø180 mm; 7"

7 reel: Ø330 mm; 13"

4 bulk case

Capacitance value⁽¹⁾

Tolerance

NiSn terminations

4 ±0.25 pF for C = 5.6 to 8.2 pF

±2% for C ≥ 10 pF

5 ±0.25 pF for C = 0.47 to 4.7 pF

±0.5 pF for C = 5.6 to 8.2 pF

±5% for C ≥ 10 pF

AgPd terminations

1 ±2% for C ≥ 10 pF

2 ±5% for C ≥ 10 pF

CCA622

(1) Refer to chapter "Selection chart for 50 V".

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

Surface mount ceramic
multilayer capacitors

Class 1, NP0 100 V
Noble Metal Electrode

SELECTION CHART FOR 100 V

C (pF)	LAST TWO DIGITS OF 12NC	100 V				
		0603	0805	1206	1210	1812
10	23					
12	24					
15	25					
18	26					
22	27					
27	28					
33	29					
39	31					
47	32					
56	33					
68	34					
82	35	0.8 ±0.07				
100	36					
120	37		0.6 ±0.1			
150	38					
180	39					
220	41			0.6 ±0.1		
270	42					
330	43					
390	44					
470	45					
560	46					
680	47					
820	48					
1000	49					
1200	51					
1500	52		0.85 ±0.1			
1800	53					
2200	54		1.25 ±0.1			
2700	55					
3300	56					
3900	57			0.85 ±0.1		
4700	58					
5600	59			1.15 ±0.1		
6800	61					
8200	62	Values in shaded cells indicate thickness classification.			0.5 to 1.0	
10000	63					
12000	64					0.5 to 1.0
15000	65					
18000	66					0.9 to 1.3
22000	67					
27000	68					
33000	69					
39000	71					
47000	72					

Surface mount ceramic
multilayer capacitors

Class 1, NP0 100 V
Noble Metal Electrode

Thickness classification and packaging quantities

THICKNESS CLASSIFICATION (mm)	8 mm TAPE WIDTH AMOUNT PER REEL				12 mm TAPE WIDTH AMOUNT PER REEL	AMOUNT PER BULK CASE	
	Ø180 mm; 7"		Ø330 mm; 13"		Ø180 mm; 7" BLISTER		
	PAPER	BLISTER	PAPER	BLISTER	1812	0603	0805
0.6 ±0.1	4000	—	20000	—	—	—	10000
0.85 ±0.1	4000	—	15000	—	—	—	8000
0.5 to 1.0	—	4000	—	10000	2000	—	—
0.8 ±0.07	4000	—	15000	—	—	15000	—
0.9 to 1.3	—	3000	—	10000	1500	—	—
1.15 ±0.1	—	3000	—	10000	—	—	—
1.25 ±0.1	—	3000	—	10000	—	—	5000

ORDERING INFORMATION FOR 100 V

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

Clear text code

EXAMPLE: 0805CG102G0B200

SIZE CODE	TEMP. CHAR.	CAPACITANCE	TOL.	VOLTAGE	TERMINATION	PACKAGING	MARKING	SERIES
0603 0805 1206 1210 1812	CG = NP0	102 = 1000 pF; the third digit signifies the multiplying factor: 0 = × 1 1 = × 10 2 = × 100 3 = × 1000	G = ±2% J = ±5%	0 = 100 V	B = NiSn	2 = 180 mm; 7" paper 3 = 330 mm; 13" paper B = 180 mm; 7" blister F = 330 mm; 13" blister P = bulk case	0 = no marking 2 = 2-character marking in North America only	0 = conv. ceramic

Ordering code 12NC

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

Carrier type
22 blister
38 paper
54 bulk

Rated voltage - Termination
60 100 V; NiSn

Size
6 0603
0 0805
1 1206
2 1210
4 1812

Capacitance value⁽¹⁾

Tolerance
4 ±2% for C ≥ 10 pF
5 ±5% for C ≥ 10 pF

Packaging⁽²⁾
1 reel: Ø180 mm; 7"
5 reel: Ø330 mm; 13"
4 bulk case

CCA623

(1) Refer to chapter "Selection chart for 100 V".

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

Surface mount ceramic multilayer capacitors

Class 1, NP0 200 V and 500 V Noble Metal Electrode

SELECTION CHART FOR 200 V AND 500 V

C (pF)	LAST TWO DIGITS OF 12NC	200 V				500 V		
		0805	1206	1210	1812	1206	1210	1812
10	23							
12	24							
15	25							
18	26							
22	27							
27	28							
33	29							
39	31					0.6 ±0.1		
47	32	0.6 ±0.1						
56	33							
68	34		0.6 ±0.1					
82	35							
100	36							
120	37							
150	38							
180	39							
220	41						0.8 to 1.0	
270	42							
330	43	0.85 ±0.1						
390	44							
470	45							
560	46	1.25 ±0.1				0.85 ±0.1		
680	47							
820	48					1.15 ±0.1		
1000	49		0.85 ±0.1					
1200	51						0.9 to 1.3	
1500	52		1.15 ±0.1					
1800	53			0.8 to 1.0			1.2 to 1.75	
2200	54							
2700	55			0.9 to 1.3				0.9 to 1.3
3300	56							
3900	57				0.8 to 1.0			
4700	58				0.9 to 1.3			
5600	59							
6800	61	Values in shaded cells indicate thickness classification.						
8200	62							
10000	63							

Thickness classification and packaging quantities

THICKNESS CLASSIFICATION (mm)	8 mm TAPE WIDTH AMOUNT PER REEL				12 mm TAPE WIDTH AMOUNT PER REEL	AMOUNT PER BULK CASE
	Ø180 mm; 7"		Ø330 mm; 13"		Ø180 mm; 7" BLISTER	
	PAPER	BLISTER	PAPER	BLISTER	1812	
0.6 ±0.1	4000	—	20000	—	—	10000
0.85 ±0.1	4000	—	15000	—	—	8000
0.8 to 1.0	—	4000	—	10000	2000	—
0.9 to 1.3	—	3000	—	10000	1500	—
1.15 ±0.1	—	3000	—	10000	—	—
1.25 ±0.1	—	3000	—	10000	—	5000
1.2 to 1.75	—	2500	—	7000	1200	—

Surface mount ceramic
multilayer capacitors

Class 1, NP0 200 V and 500 V
Noble Metal Electrode

ORDERING INFORMATION FOR 200 V AND 500 V

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

Clear text code

EXAMPLE: 1206CG102GGB200

SIZE CODE	TEMP. CHAR.	CAPACITANCE	TOL.	VOLTAGE	TERMINATION	PACKAGING	MARKING	SERIES
0805 1206 1210 1812	CG = NP0	102 = 1000 pF; the third digit signifies the multiplying factor: 0 = × 1 1 = × 10 2 = × 100 3 = × 1000	G = ±2% J = ±5%	B = 200 V D = 500 V	B = NiSn	2 = 180 mm; 7" paper 3 = 330 mm; 13" paper B = 180 mm; 7" blister F = 330 mm; 13" blister P = bulk case	0 = no marking 2 = 2-character marking in North America only	0 = conv. ceramic

Ordering code 12NC

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

Carrier type

22 blister
38 paper
54 bulk

Rated voltage - Termination

93 200 V; NiSn
97 500 V; NiSn

Size

0 0805
1 1206
2 1210
4 1812

Capacitance value⁽¹⁾

Tolerance

4 ±2%
5 ±5%

Packaging⁽²⁾

1 reel: Ø180 mm; 7"
5 reel: Ø330 mm; 13"
4 bulk case

CCA624

(1) Refer to chapter "Selection chart for 200 V and 500 V".

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

Surface mount ceramic multilayer capacitors

Class 1, NP0 50/100/200/500 V Noble Metal Electrode

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%.

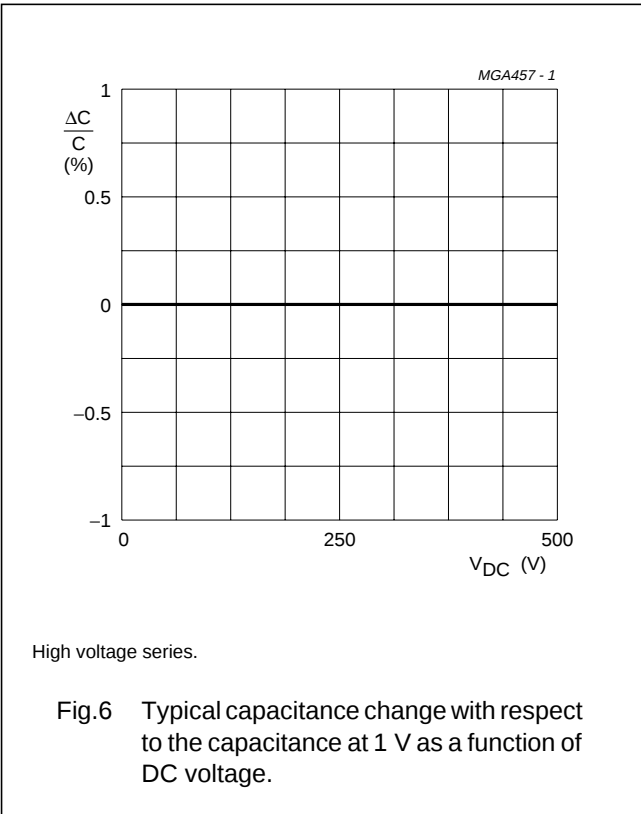
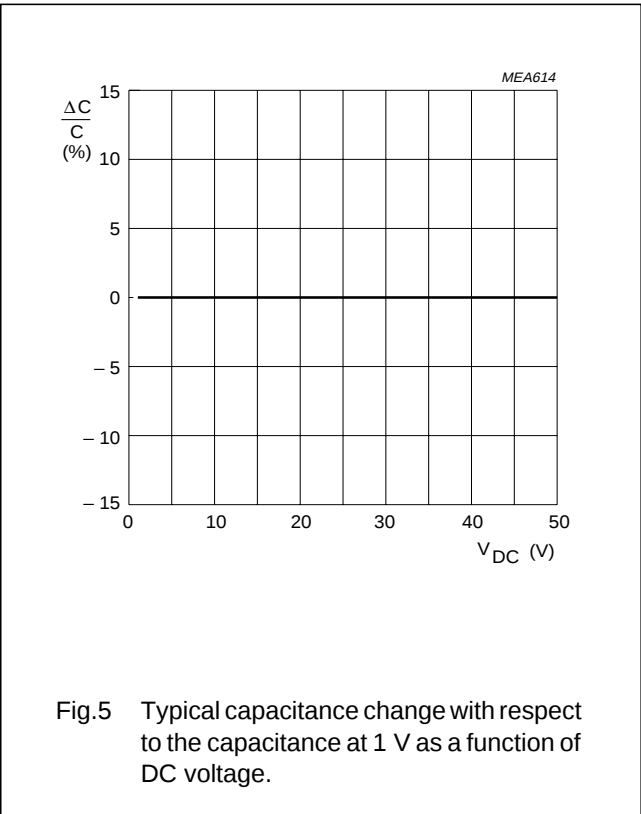
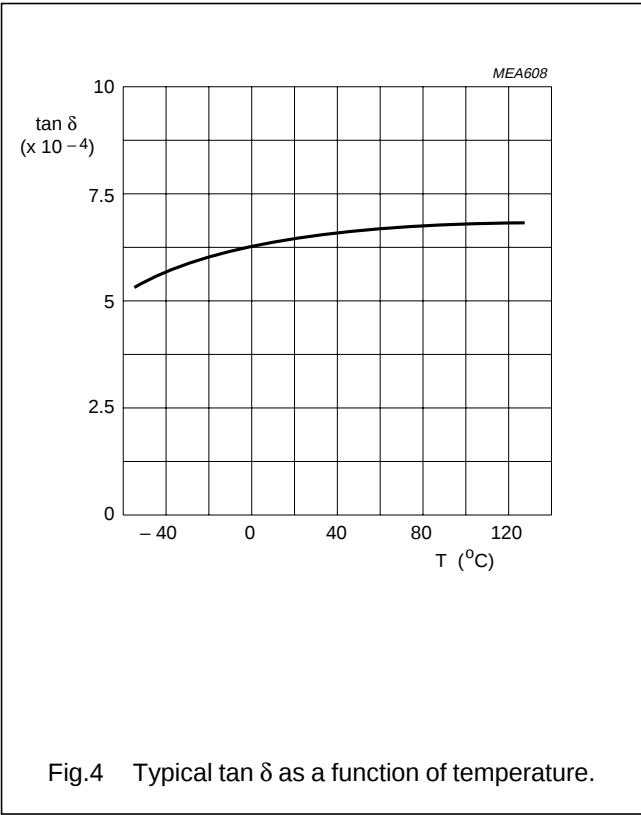
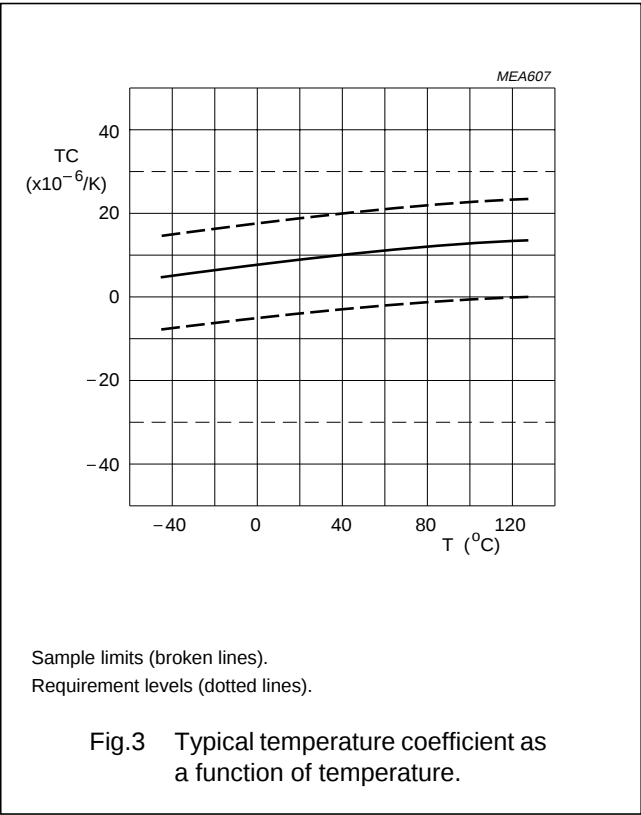
DESCRIPTION	VALUE
Capacitance range (E12 series); note 1: 50 V 100 V 200 V 500 V	0.47 pF to 47 000 pF 10 pF to 22 nF 10 pF to 5 600 pF 10 pF to 3 300 pF
Tolerance on capacitance after 1000 hours: $C \geq 10$ pF $5 \text{ pF} \leq C < 10$ pF $C < 5$ pF	$\pm 5\%$; $\pm 2\%$ ± 0.5 pF, ± 0.25 pF ± 0.25 pF
Tan δ ; note 1: $C < 10$ pF $C \geq 10$ pF	$\leq 10 \left(\frac{3}{C} + 0.7 \right) \times 10^{-4}$ or 30×10^{-4} , whichever is smallest $\leq 10 \times 10^{-4}$
Insulation resistance after 1 minute at U_R (DC)	$R_{ins} > 100 \text{ G}\Omega$
Temperature coefficient: $C < 10$ pF $C \geq 10$ pF	$(0 \pm 150) \times 10^{-6}/\text{K}$; note 2 $(0 \pm 30) \times 10^{-6}/\text{K}$; note 2
Ageing	not applicable

Notes

1. Measured at 1 V, 1 MHz for $C \leq 1000$ pF and 1 V, 1 kHz for $C > 1000$ pF, using a four-gauge method.
2. For sizes 0402 and 0603 all capacitance values from 0.47 pF to 150 pF have a temperature coefficient of $(0 \pm 30) \times 10^{-6}/\text{K}$.

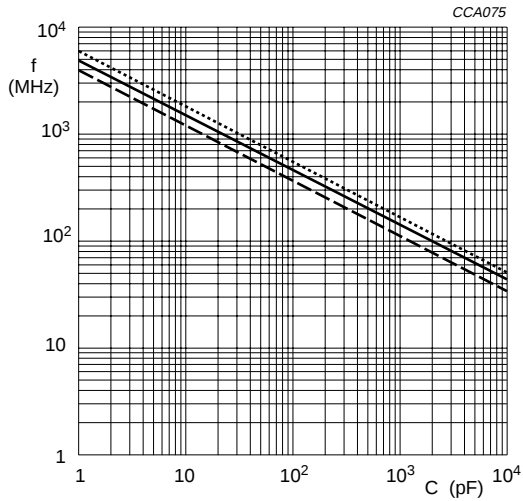
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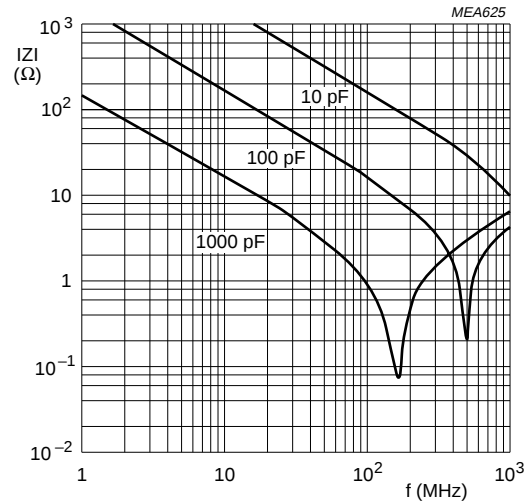
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Class 1, NP0 50/100/200/500 V Noble Metal Electrode



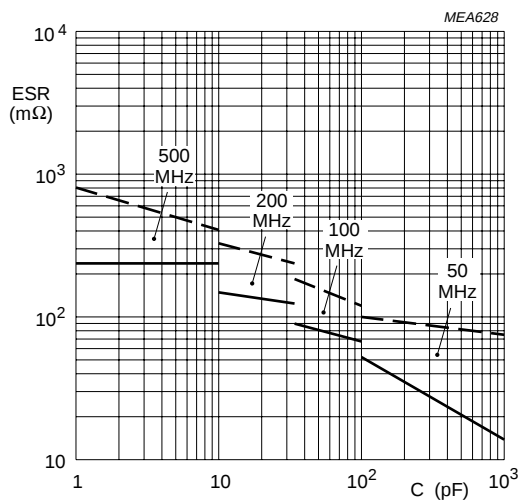
Case size **0603**: $L = 0.6$ nH (dotted line).
Case sizes **0805**, **1206** and **1210**: $L = 1$ nH (solid line).
Case sizes **1812** and **2220**: $L = 1.5$ nH (broken line).

Fig.7 Series resonance frequency as a function of capacitance.



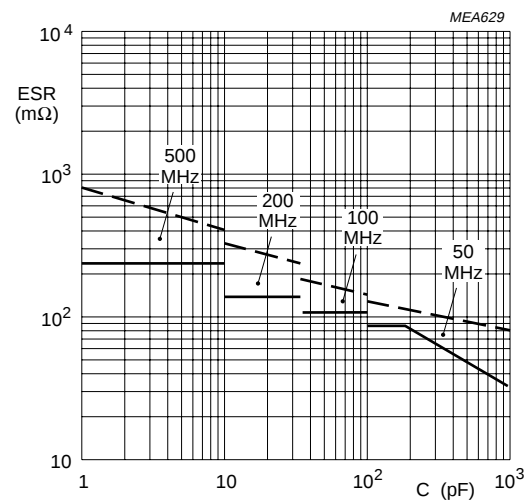
Case sizes **0603** to **1210**.

Fig.8 Typical impedance ($|Z|$) as a function of frequency.



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

Fig.9 Equivalent series resistance (ESR) as a function of capacitance.

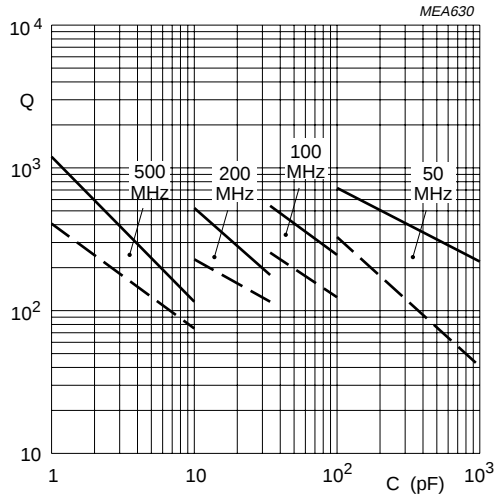


Case size **1206**.
Typical values (solid lines).
Maximum values (broken lines).
Measuring equipment HP4191A.
For $C > 1$ nF, maximum value of ESR = 80 mΩ measured at 50 MHz.

Fig.10 Equivalent series resistance (ESR) as a function of capacitance.

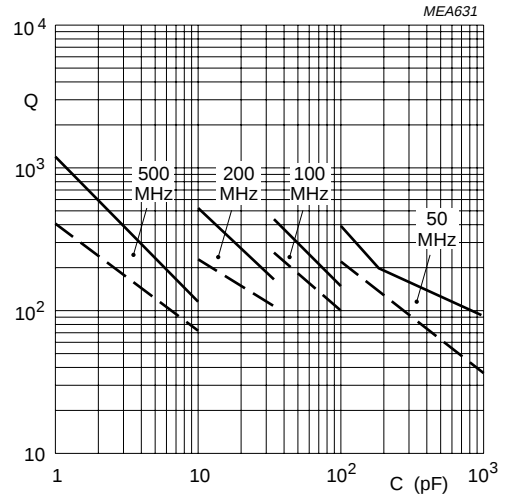
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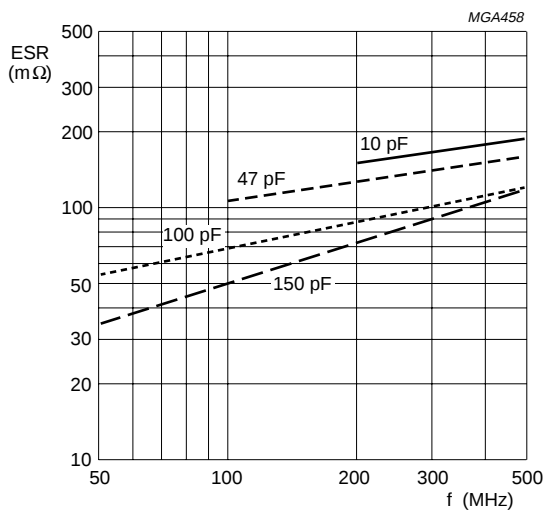
Case sizes **0603** and **0805**.
Typical values (solid lines).
Minimum values (broken lines).
Measuring equipment HP4191A.

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



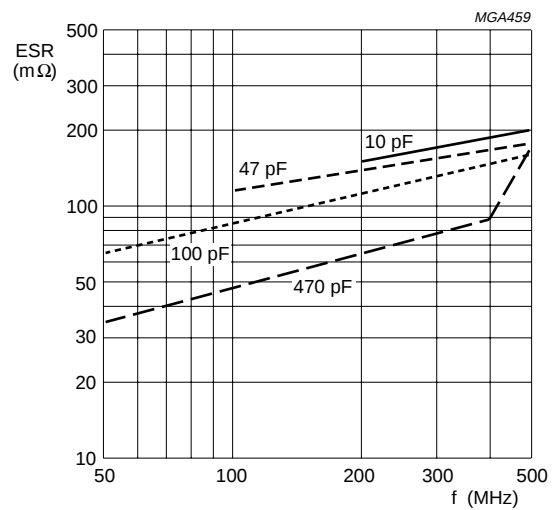
Case size **1206**.
Typical values (solid lines).
Minimum values (broken lines).
Measuring equipment HP4191A.
For $C > 1 \text{ nF}$, $Q_{\min} = 35$ measured at 50 MHz.

Fig.12 Quality factor (Q) as a function of the capacitance.



Case size **0805**.
High voltage 200 V.

Fig.13 Typical equivalent series resistance as a function of frequency.

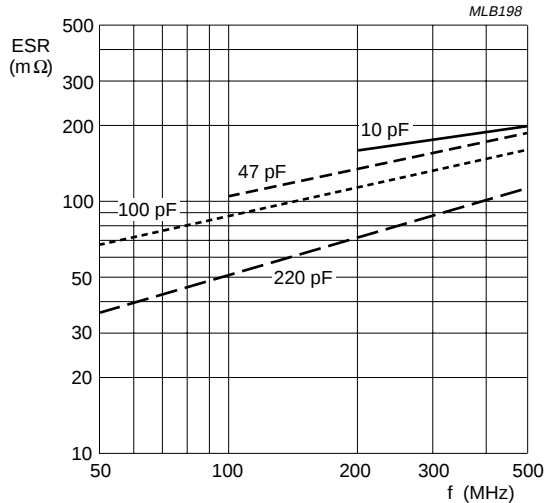


Case size **1206**.
High voltage 200 V.

Fig.14 Typical equivalent series resistance as a function of frequency.

Surface mount ceramic multilayer capacitors

Class 1, NP0 50/100/200/500 V Noble Metal Electrode



Case size 1206.
High voltage 500 V.

Fig.15 Typical equivalent series resistance as a function of frequency.



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.16 Equivalent series representation of a CMC.

HIGH FREQUENCY BEHAVIOUR OF CERAMIC MULTILAYER CAPACITORS

Ceramic multilayer capacitors (CMC) are suitable for use at high frequencies. At frequencies below the series resonance frequency, the CMC can be represented by an equivalent circuit as shown in Fig.16.

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, it increases with increasing length and decreases with increasing width or thickness of the product.
- The value of L is approximately:
 - 0.6 nH for case size 0603
 - 1 nH for case sizes 0805, 1206 and 1210
 - 1.5 nH for case sizes 1812 and 2220.

These figures are accurate to within 20%.

Because of the inductance L, associated with the CMC, 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 CMC will appear as a small resistor. The transmission loss through the CMC 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.

The impedance (Z) is given by:

$$Z = \frac{1 - (2\pi f)^2 LC}{2j\pi f C} + ESR$$

The quality factor (Q) is given by:

$$Q = \frac{|1 - (2\pi f)^2 LC|}{2\pi f ESR C}$$