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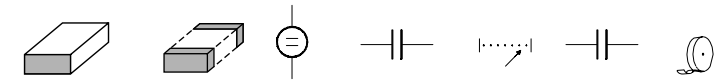
# Multilayer ceramic capacitors

## Chip capacitors, HQF

Date: October 2006

## Ordering code system



**B37923 K 5 100 J 0 60**

**Packaging**

60 ≙ cardboard tape, 180-mm reel
70 ≙ cardboard tape, 330-mm reel

**Decimal place** for cap. values <10 pF, otherwise not used

**Capacitance tolerance**

$C_R$ < 10 pF: **B ≙ ±0.1 pF (standard for capacitance values ≤3.9 pF)**
**C ≙ ±0.25 pF (standard for capacitance values ≤8.2 pF)**
D ≙ ±0.5 pF

$C_R$ ≥ 10 pF: F ≙ ± 1%
G ≙ ± 2%
**J ≙ ± 5% (standard)**
K ≙ ±10%

**Capacitance**, coded (example) 100 ≙ 10 · $10^0$ pF = 10 pF

**Rated voltage**

| Rated voltage [VDC] | 50 |
|---|---|
| Code | 5 |

**Termination** Standard: K ≙ nickel barrier for all case sizes

| **Type and size** | |
|---|---|
| Chip size (**inch** / mm) | Temperature characteristic HQF |
| **0402** / 1005<br>**0603** / 1608 | B37923<br>B37933 |

SMD

## Features

- Ultra-low ESR and high Q factor
- Tight capacitance tolerances
- High stability with respect to time, temperature ($T_{CC}$: 0 ± 60 ppm/°C), frequency and voltage
- Class 1 characteristic with copper inner electrodes
- Excellent attenuation
- High self-resonant frequency
- Lower power dissipation / Less energy absorption
- To AEC-Q200

## Applications

- High-frequency applications
- Matching circuits
- Cellular communication, Bluetooth, DECT
- Cable TV, satellite TV (LNB), GPS, satellite radio
- Filters, RF amplifiers, VCOs

## Termination

- For soldering: Nickel barrier terminations (Ni)

## Options

- Alternative capacitance tolerances available on request

## Delivery mode

- Cardboard tape, 180-mm and 330-mm reel available

## Electrical data

| | | | |
|---|---|---|---|
| Temperature characteristic | | C0H | |
| Climatic category (IEC 60068-1) | | 55/125/56 | |
| Standard | | EIA | |
| Dielectric | | Class 1 | |
| Rated voltage | $V_R$ | 50 | VDC |
| Test voltage | $V_{test}$ | $2.5 \cdot V_R$/5 s | VDC |
| Capacitance range | $C_R$ | 0.3 pF … 82 pF | |
| Temperature coefficient | | $0 \pm 60 \cdot 10^{-6}$/K | |
| Dissipation factor (limit value) | tan δ | $<1.0 \cdot 10^{-3}$ | |
| Insulation resistance[1)] at + 25 °C | $R_{ins}$ | $>10^5$ | MΩ |
| Insulation resistance[1)] at +125 °C | $R_{ins}$ | $>10^4$ | MΩ |
| Time constant[1)] at + 25 °C | τ | >1000 | s |
| Time constant[1)] at +125 °C | τ | >100 | s |
| Operating temperature range | $T_{op}$ | –55 … +125 | °C |
| Ageing | | none | |

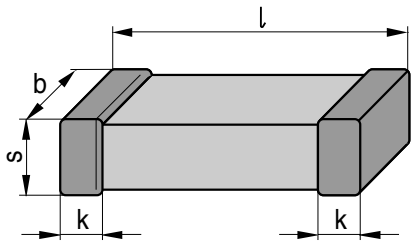
1) For $C_R$ >10 nF the time constant $\tau = C \cdot R_{ins}$ is given.

## Capacitance tolerances

| $C_R$ | $C_R \leq 3.9$ pF | | 4.7 pF $\leq C_R \leq$ 8.2 pF | | |
|---|---|---|---|---|---|
| Code letter | B (standard) | C | B | C (standard) | D |
| Tolerance | ±0.1 pF | ±0.25 pF | ±0.1 pF | ±0.25 pF | ±0.5 pF |

| $C_R$ | $C_R \geq 10$ pF | | | |
|---|---|---|---|---|
| Code letter | F | G | J (standard) | K |
| Tolerance | ±1% | ±2% | ±5% | ±10% |

## Dimensional drawing



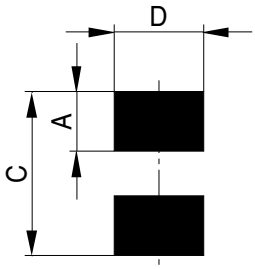

KKE0329-N

## Dimensions (mm)

| Case size (inch) (mm) | 0402 1005 | 0603 1608 |
|---|---|---|
| l | 1.0 ±0.10 | 1.6 ±0.15 |
| b | 0.5 ±0.05 | 0.8 ±0.10 |
| s | 0.5 ±0.05 | 0.8 ±0.10 |
| k | 0.1 –0.40 | 0.1 –0.40 |

Tolerances to CECC 32101-801

## Recommended solder pad



KKE0308-1

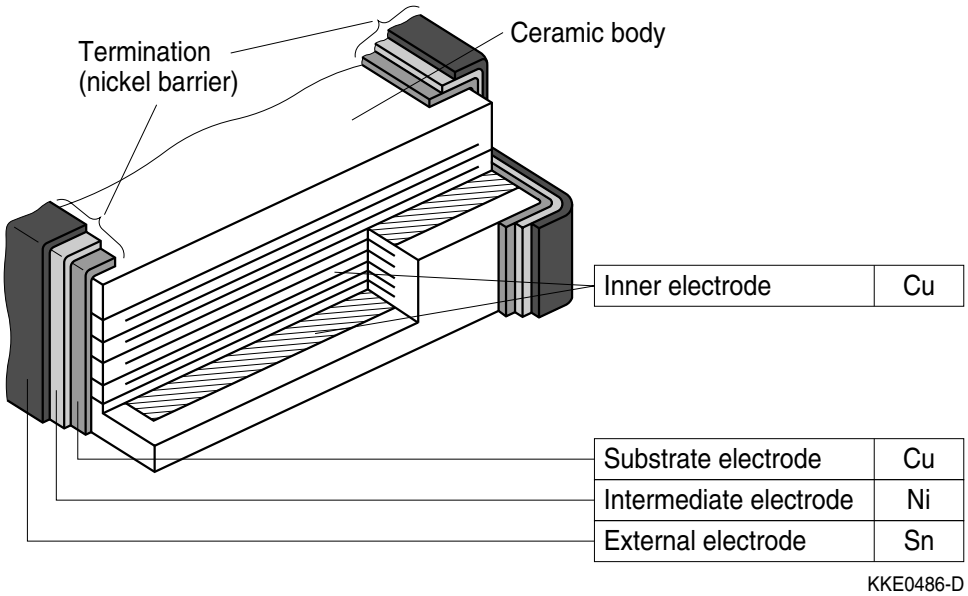
## Recommended dimensions (mm) for reflow soldering

| Case size | (inch/mm) | Type | A | C | D |
|---|---|---|---|---|---|
| | 0402/1005 | single chip | 0.35 … 0.45 | 1.0 … 1.4 | 0.4 … 0.6 |
| | 0603/1608 | single chip | 0.60 … 0.70 | 1.8 … 2.2 | 0.6 … 0.8 |

## Recommended dimensions (mm) for wave soldering

| Case size | (inch/mm) | Type | A | C | D |
|---|---|---|---|---|---|
| | 0603/1608 | single chip | 0.8 … 0.9 | 2.2 … 2.8 | 0.6 … 0.8 |

## Termination



KKE0486-D

## Product range for HQF chip capacitors

| Size[1)] **inch** mm | **0402** 1005 | | **0603** 1608 | |
|---|---|---|---|---|
| Type | B37923 | | B37933 | |
| $V_R$ (VDC) / $C_R$ | 50 | | 50 | |
| 0.3 pF | ■ | | | |
| 0.4 pF | ■ | | ■ | |
| 0.5 pF | ■ | | ■ | |
| 0.6 pF | ■ | | ■ | |
| 0.7 pF | ■ | | ■ | |
| 0.8 pF | ■ | | ■ | |
| 0.9 pF | ■ | | ■ | |
| 1.0 pF | ■ | | ■ | |
| 1.2 pF | ■ | | ■ | |
| 1.5 pF | ■ | | ■ | |
| 1.8 pF | ■ | | ■ | |
| 2.2 pF | ■ | | ■ | |
| 2.7 pF | ■ | | ■ | |
| 3.3 pF | ■ | | ■ | |
| 3.9 pF | ■ | | ■ | |
| 4.7 pF | ■ | | ■ | |
| 5.6 pF | ■ | | ■ | |
| 6.8 pF | ■ | | ■ | |
| 8.2 pF | ■ | | ■ | |
| 10 pF | ■ | | ■ | |
| 12 pF | ■ | | ■ | |
| 15 pF | ■ | | ■ | |
| 18 pF | ■ | | ■ | |
| 22 pF | ■ | | ■ | |
| 27 pF | | | ■ | |
| 82 pF | | | ■ | |

1) l × b (inch) / l × b (mm)

## Ordering codes and packing for HQF capacitors, 50 VDC, nickel barrier terminations

### Case size 0402, 50 VDC

| $C_R$ | Ordering code[1)] | Chip thickness mm | Cardboard tape, ∅ 180-mm reel ** ≙ 60 pcs/reel | Cardboard tape, ∅ 330-mm reel ** ≙ 70 pcs/reel |
|---|---|---|---|---|
| 0.3 pF | B37923K5000B3** | 0.5 ±0.05 | 10000 | 50000 |
| 0.4 pF | B37923K5000B4** | 0.5 ±0.05 | 10000 | 50000 |
| 0.5 pF | B37923K5000B5** | 0.5 ±0.05 | 10000 | 50000 |
| 0.6 pF | B37923K5000B6** | 0.5 ±0.05 | 10000 | 50000 |
| 0.7 pF | B37923K5000B7** | 0.5 ±0.05 | 10000 | 50000 |
| 0.8 pF | B37923K5000B8** | 0.5 ±0.05 | 10000 | 50000 |
| 0.9 pF | B37923K5000B9** | 0.5 ±0.05 | 10000 | 50000 |
| 1.0 pF | B37923K5010B0** | 0.5 ±0.05 | 10000 | 50000 |
| 1.2 pF | B37923K5010B2** | 0.5 ±0.05 | 10000 | 50000 |
| 1.5 pF | B37923K5010B5** | 0.5 ±0.05 | 10000 | 50000 |
| 1.8 pF | B37923K5010B8** | 0.5 ±0.05 | 10000 | 50000 |
| 2.2 pF | B37923K5020B2** | 0.5 ±0.05 | 10000 | 50000 |
| 2.7 pF | B37923K5020B7** | 0.5 ±0.05 | 10000 | 50000 |
| 3.3 pF | B37923K5030B3** | 0.5 ±0.05 | 10000 | 50000 |
| 3.9 pF | B37923K5030B9** | 0.5 ±0.05 | 10000 | 50000 |
| 4.7 pF | B37923K5040C7** | 0.5 ±0.05 | 10000 | 50000 |
| 5.6 pF | B37923K5050C6** | 0.5 ±0.05 | 10000 | 50000 |
| 6.8 pF | B37923K5060C8** | 0.5 ±0.05 | 10000 | 50000 |
| 8.2 pF | B37923K5080C2** | 0.5 ±0.05 | 10000 | 50000 |
| 10 pF | B37923K5100J0** | 0.5 ±0.05 | 10000 | 50000 |
| 12 pF | B37923K5120J0** | 0.5 ±0.05 | 10000 | 50000 |
| 15 pF | B37923K5150J0** | 0.5 ±0.05 | 10000 | 50000 |
| 18 pF | B37923K5180J0** | 0.5 ±0.05 | 10000 | 50000 |
| 22 pF | B37923K5220J0** | 0.5 ±0.05 | 10000 | 50000 |

1) The table contains the ordering codes for the standard capacitance tolerance.
For other available capacitance tolerances see page 154.

## Ordering codes and packing for HQF capacitors, 50 VDC, nickel barrier terminations

### Case size 0603, 50 VDC

| $C_R$ | Ordering code[1)] | Chip thickness mm | Cardboard tape, ∅ 180-mm reel ** ≙ 60 pcs/reel | Cardboard tape, ∅ 330-mm reel ** ≙ 70 pcs/reel |
|---|---|---|---|---|
| 0.4 pF | B37933K5000B4** | 0.8 ±0.1 | 4000 | 16000 |
| 0.5 pF | B37933K5000B5** | 0.8 ±0.1 | 4000 | 16000 |
| 0.6 pF | B37933K5000B6** | 0.8 ±0.1 | 4000 | 16000 |
| 0.7 pF | B37933K5000B7** | 0.8 ±0.1 | 4000 | 16000 |
| 0.8 pF | B37933K5000B8** | 0.8 ±0.1 | 4000 | 16000 |
| 0.9 pF | B37933K5000B9** | 0.8 ±0.1 | 4000 | 16000 |
| 1.0 pF | B37933K5010B0** | 0.8 ±0.1 | 4000 | 16000 |
| 1.2 pF | B37933K5010B2** | 0.8 ±0.1 | 4000 | 16000 |
| 1.5 pF | B37933K5010B5** | 0.8 ±0.1 | 4000 | 16000 |
| 1.8 pF | B37933K5010B8** | 0.8 ±0.1 | 4000 | 16000 |
| 2.2 pF | B37933K5020B2** | 0.8 ±0.1 | 4000 | 16000 |
| 2.7 pF | B37933K5020B7** | 0.8 ±0.1 | 4000 | 16000 |
| 3.3 pF | B37933K5030B3** | 0.8 ±0.1 | 4000 | 16000 |
| 3.9 pF | B37933K5030B9** | 0.8 ±0.1 | 4000 | 16000 |
| 4.7 pF | B37933K5040C7** | 0.8 ±0.1 | 4000 | 16000 |
| 5.6 pF | B37933K5050C6** | 0.8 ±0.1 | 4000 | 16000 |
| 6.8 pF | B37933K5060C8** | 0.8 ±0.1 | 4000 | 16000 |
| 8.2 pF | B37933K5080C2** | 0.8 ±0.1 | 4000 | 16000 |
| 10 pF | B37933K5100J0** | 0.8 ±0.1 | 4000 | 16000 |
| 12 pF | B37933K5120J0** | 0.8 ±0.1 | 4000 | 16000 |
| 15 pF | B37933K5150J0** | 0.8 ±0.1 | 4000 | 16000 |
| 18 pF | B37933K5180J0** | 0.8 ±0.1 | 4000 | 16000 |
| 22 pF | B37933K5220J0** | 0.8 ±0.1 | 4000 | 16000 |
| 27 pF | B37933K5270J0** | 0.8 ±0.1 | 4000 | 16000 |
| 82 pF | B37933K5820J0** | 0.8 ±0.1 | 4000 | 16000 |

1) The table contains the ordering codes for the standard capacitance tolerance.
For other available capacitance tolerances see page 154.

## Typical RF performance for HQF capacitors, case size 0402, 50 VDC

| Capacitance pF | $f_{res}$ [1] MHz | ESR @ 1 GHz [2] mΩ | Q @ 1 GHz [2] | ESR @ $f_{res}$ [2] mΩ |
|---|---|---|---|---|
| 0.3 | 23400 | 560 | 920 | 710 |
| 0.4 | 20350 | 490 | 805 | 605 |
| 0.5 | 19700 | 440 | 720 | 535 |
| 0.6 | 17400 | 405 | 650 | 485 |
| 0.7 | 15100 | 375 | 600 | 445 |
| 0.8 | 14450 | 355 | 560 | 415 |
| 0.9 | 12600 | 335 | 520 | 385 |
| 1.0 | 12000 | 320 | 490 | 365 |
| 1.2 | 10600 | 295 | 440 | 330 |
| 1.5 | 8900 | 265 | 390 | 290 |
| 1.8 | 7100 | 245 | 350 | 265 |
| 2.2 | 6400 | 225 | 310 | 235 |
| 2.7 | 6000 | 205 | 275 | 210 |
| 3.3 | 5500 | 185 | 245 | 190 |
| 3.9 | 5350 | 170 | 225 | 175 |
| 4.7 | 4650 | 155 | 200 | 155 |
| 5.6 | 3950 | 145 | 175 | 140 |
| 6.8 | 4100 | 130 | 155 | 125 |
| 8.2 | 3650 | 120 | 140 | 115 |
| 10 | 3350 | 110 | 120 | 105 |
| 12 | 3350 | 102 | 104 | 94 |
| 15 | 2600 | 92 | 88 | 82 |
| 18 | 2300 | 84 | 70 | 74 |
| 22 | 2200 | 78 | 56 | 66 |

1) Measured with impedance analyser E 4991A, parts not soldered.
2) Measured with network analyser HP 8753D, parts soldered.

## Typical RF performance for HQF capacitors, case size 0603, 50 VDC

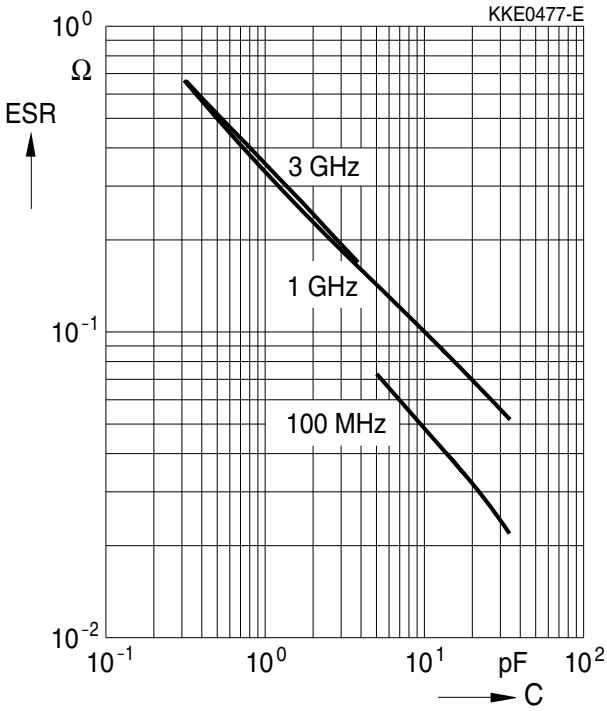
| Capacitance pF | $f_{res}$ [1] MHz | ESR @ 1 GHz [2] mΩ | Q @ 1 GHz [2] | ESR @ $f_{res}$ [2] mΩ |
|---|---|---|---|---|
| 0.4 | 17800 | 445 | 860 | 595 |
| 0.5 | 17100 | 400 | 805 | 540 |
| 0.6 | 13600 | 385 | 755 | 510 |
| 0.7 | 12200 | 345 | 635 | 440 |
| 0.8 | 11400 | 325 | 595 | 410 |
| 0.9 | 10600 | 315 | 560 | 390 |
| 1.0 | 9600 | 300 | 525 | 365 |
| 1.2 | 8800 | 275 | 455 | 335 |
| 1.5 | 7900 | 250 | 395 | 300 |
| 1.8 | 6900 | 240 | 360 | 285 |
| 2.2 | 5750 | 215 | 305 | 250 |
| 2.7 | 5100 | 200 | 270 | 235 |
| 3.3 | 4700 | 185 | 235 | 210 |
| 3.9 | 4150 | 175 | 210 | 200 |
| 4.7 | 3550 | 165 | 185 | 185 |
| 5.6 | 3130 | 150 | 160 | 170 |
| 6.8 | 2850 | 140 | 135 | 155 |
| 8.2 | 2730 | 130 | 115 | 140 |
| 10 | 2580 | 120 | 96 | 130 |
| 12 | 2400 | 110 | 76 | 118 |
| 15 | 2150 | 102 | 62 | 108 |
| 18 | 2050 | 96 | 50 | 100 |
| 22 | 1870 | 88 | 34 | 90 |
| 27 | 1780 | 80 | 26 | 82 |

| Capacitance pF | $f_{res}$ [1] MHz | ESR @ 300 MHz [2] mΩ | Q @ 300 MHz [2] | ESR @ $f_{res}$ [2] mΩ |
|---|---|---|---|---|
| 82 | 930 | 52 | 105 | 52 |

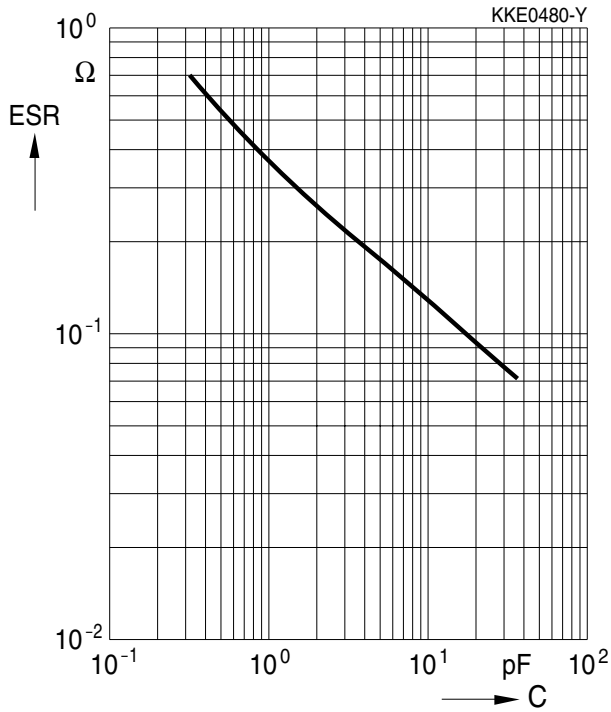
1) Measured with impedance analyser E 4991A, parts not soldered.
2) Measured with network analyser HP 8753D, parts soldered.

## Typical characteristics for case size 0402 [1)]

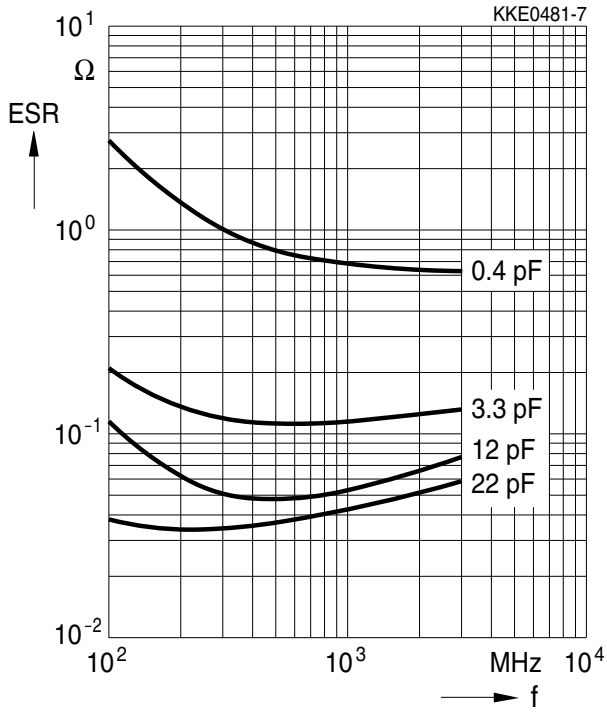
ESR versus capacitance C
(for not soldered parts)



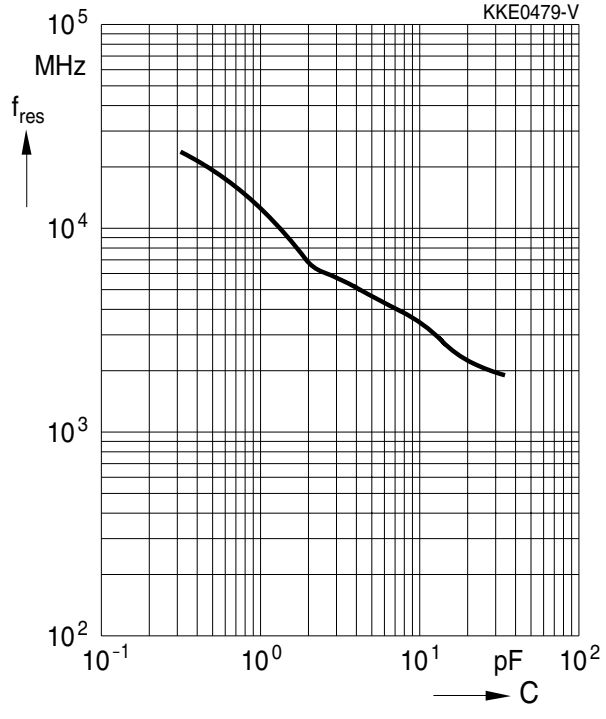

ESR versus capacitance C
at self-resonant frequency (for soldered parts)




ESR versus frequency f



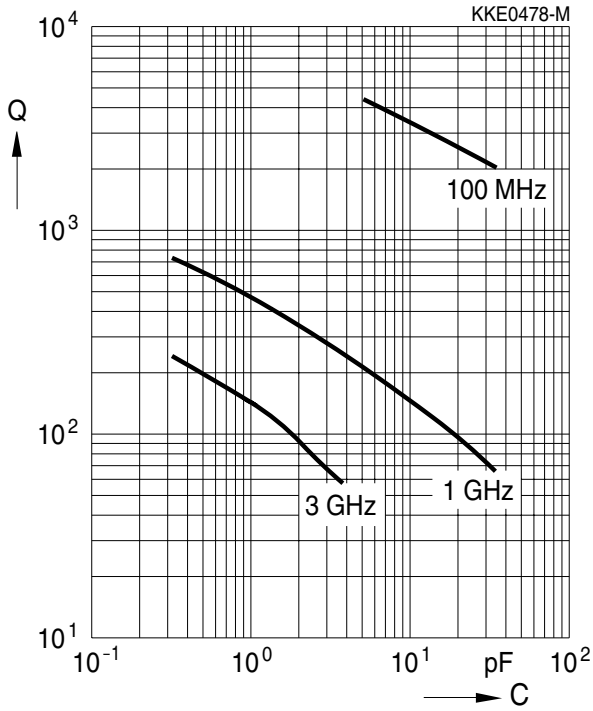

Self-resonant frequency $f_{res}$ versus
capacitance C



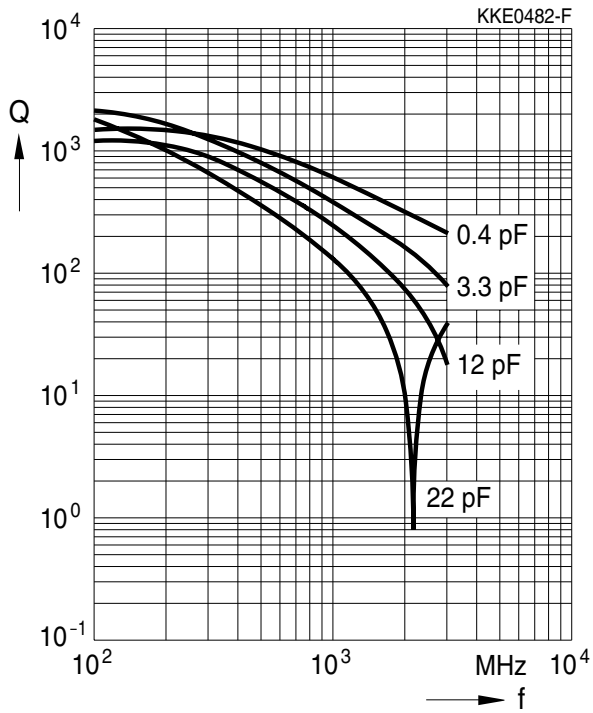

1) For more detailed information on frequency behavior and characteristics see www.epcos.com/mlcc_impedance.

**Typical characteristics for case size 0402** [1)]

Q factor versus
capacitance C



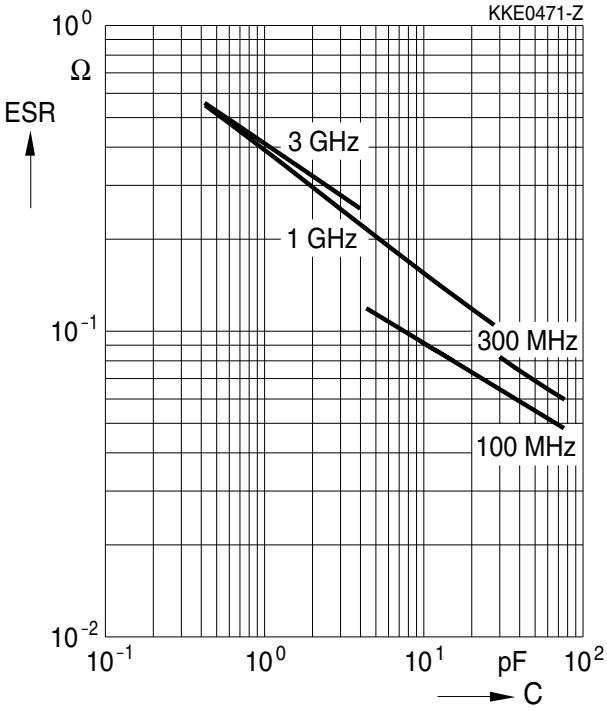

Q factor versus
frequency f



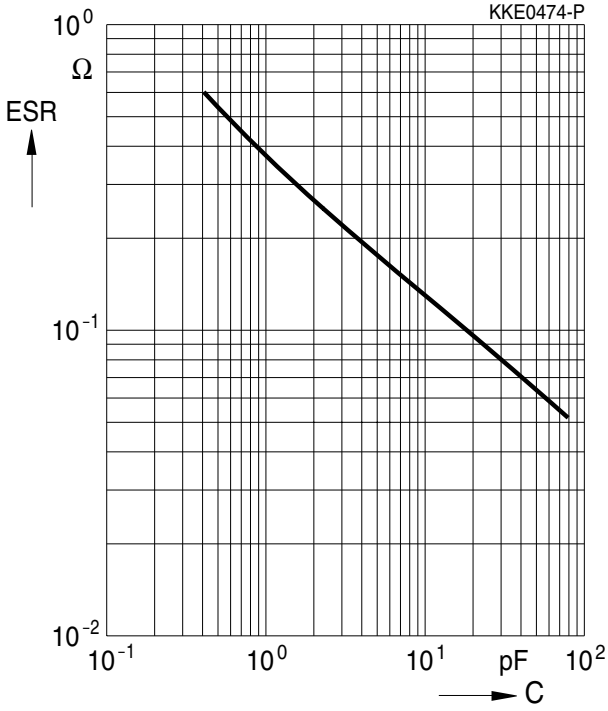

1) For more detailed information on frequency behavior and characteristics see www.epcos.com/mlcc_impedance.

## Typical characteristics for case size 0603 [1)]

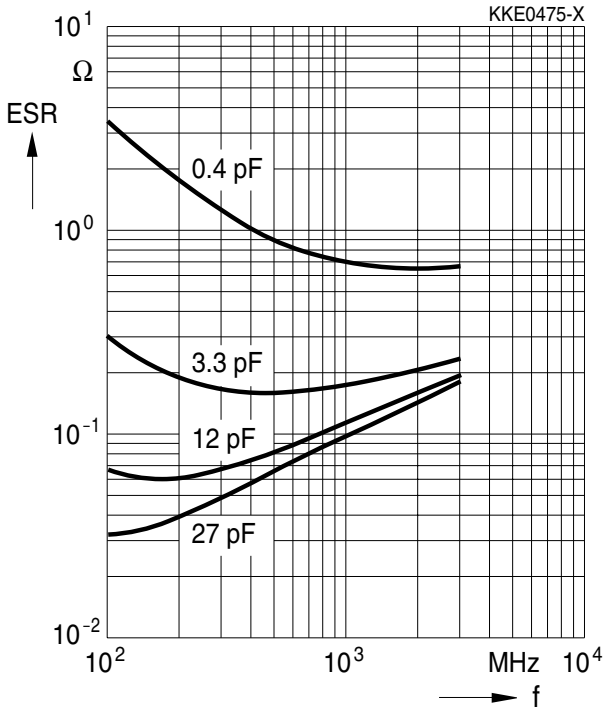
ESR versus capacitance C
(for not soldered parts)



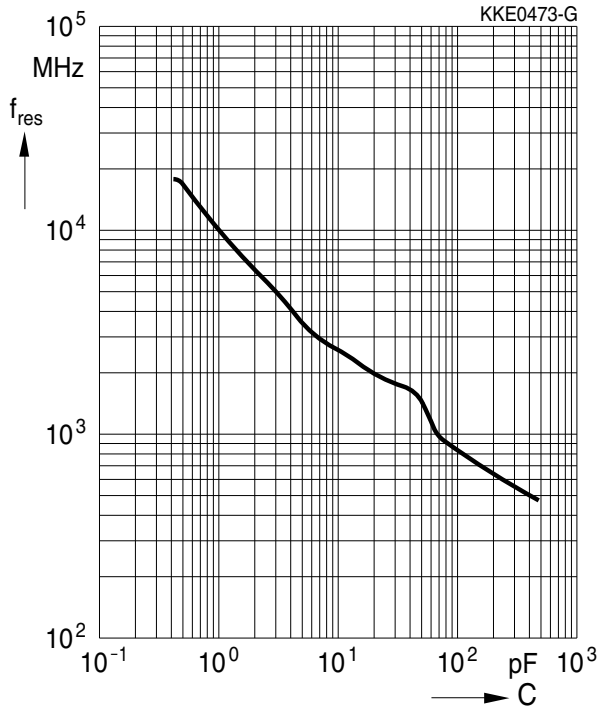

ESR versus capacitance C
at self-resonant frequency (for soldered parts)




ESR versus frequency f



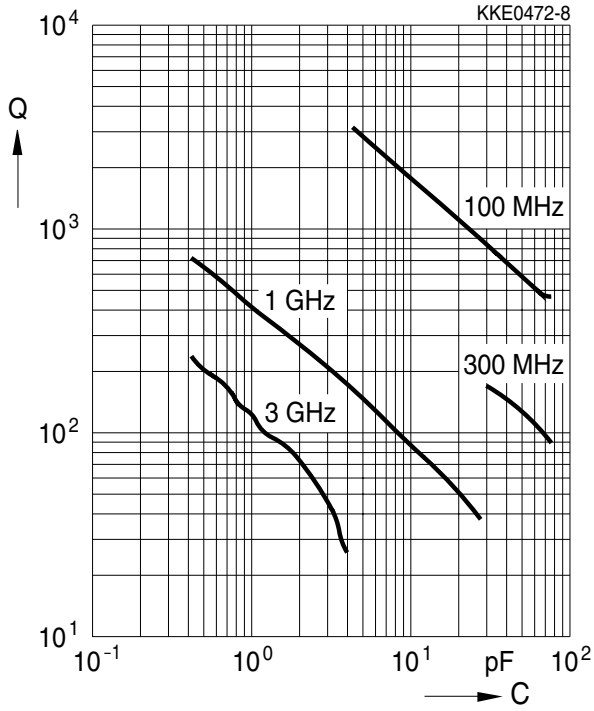

Self-resonant frequency $f_{res}$ versus
capacitance C



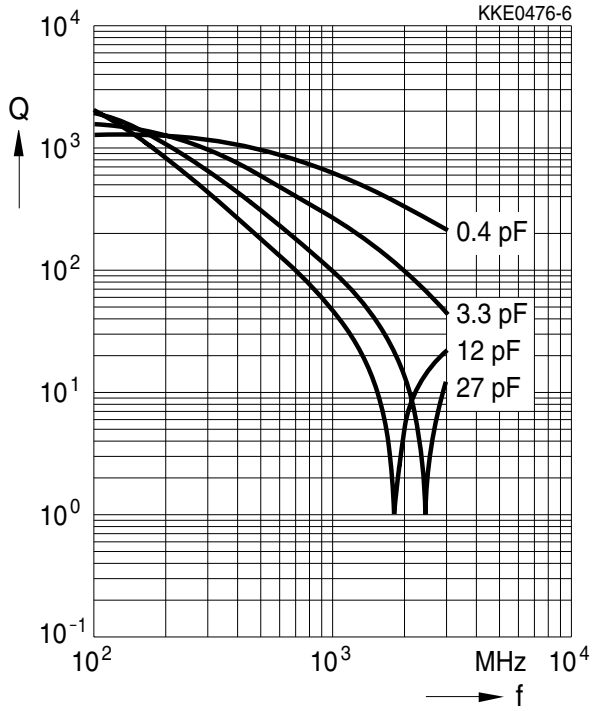

1) For more detailed information on frequency behavior and characteristics see www.epcos.com/mlcc_impedance.

## Typical characteristics for case size 0603 [1)]

Q factor versus
capacitance C




Q factor versus
frequency f




1) For more detailed information on frequency behavior and characteristics see www.epcos.com/mlcc_impedance.

### Notes on the selection of ceramic capacitors

In the selection of ceramic capacitors, the following criteria must be considered:

1. Depending on the application, ceramic capacitors used to meet high quality requirements should at least satisfy the specifications to AEC-Q200. They must meet quality requirements going beyond this level in terms of ruggedness (e.g. mechanical, thermal or electrical) in the case of critical circuit configurations and applications (e.g. in safety-relevant applications such as ABS and airbag equipment or durable industrial goods).
2. At the connection to the battery or power supply (e.g. clamp 15 or 30 in the automobile) and at positions with stranding potential, to reduce the probability of short circuits following a fracture, two ceramic capacitors must be connected in series and/or a ceramic capacitor with integrated series circuit should be used. The MLSC from EPCOS contains such a series circuit in a single component.
3. Ceramic capacitors with the temperature characteristics Z5U and Y5V do not satisfy the requirements to AEC-Q200 and are mechanically and electrically less rugged than C0G or X7R/X8R ceramic capacitors. In applications that must satisfy high quality requirements, therefore, these capacitors should not be used as discrete components (see the chapter “Effects on mechanical, thermal and electrical stress”, point 1.4).
4. For ESD protection, preference should be given to the use of multilayer varistors (MLV) (see the chapter “Effects on mechanical, thermal and electrical stress”, point 1.4).
5. An application-specific derating or continuous operating voltage must be considered in order to cushion (unexpected) additional stresses (see the chapter “Reliability”).

### The following should be considered in circuit board design

1. If technically feasible in the application, preference should be given to components having an optimal geometrical design.
2. At least FR4 circuit board material should be used.
3. Geometrically optimal circuit boards should be used, ideally those that cannot be deformed.
4. Ceramic capacitors must always be placed a sufficient minimum distance from the edge of the circuit board. High bending forces may be exerted there when the panels are separated and during further processing of the board (such as when incorporating it into a housing).
5. Ceramic capacitors should always be placed parallel to the possible bending axis of the circuit board.
6. No screw connections should be used to fix the board or to connect several boards. Components should not be placed near screw holes. If screw connections are unavoidable, they must be cushioned (for instance by rubber pads).

**The following should be considered in the placement process**

1. Ensure correct positioning of the ceramic capacitor on the solder pad.
2. Caution when using casting, injection-molded and molding compounds and cleaning agents, as these may damage the capacitor.
3. Support the circuit board and reduce the placement forces.
4. A board should not be straightened (manually) if it has been distorted by soldering.
5. Separate panels with a peripheral saw, or better with a milling head (no dicing or breaking).
6. Caution in the subsequent placement of heavy or leaded components (e.g. transformers or snap-in components): danger of bending and fracture.
7. When testing, transporting, packing or incorporating the board, avoid any deformation of the board not to damage the components.
8. Avoid the use of excessive force when plugging a connector into a device soldered onto the board.
9. Ceramic capacitors must be soldered only by the mode (reflow or wave soldering) permissible for them (see the chapter “Soldering directions”).
10. When soldering the most gentle solder profile feasible should be selected (heating time, peak temperature, cooling time) in order to avoid thermal stresses and damage.
11. Ensure the correct solder meniscus height and solder quantity.
12. Ensure correct dosing of the cement quantity.
13. Ceramic capacitors with an AgPd external termination are not suited for the lead-free solder process: they were developed only for conductive adhesion technology.

This listing does not claim to be complete, but merely reflects the experience of EPCOS AG.

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