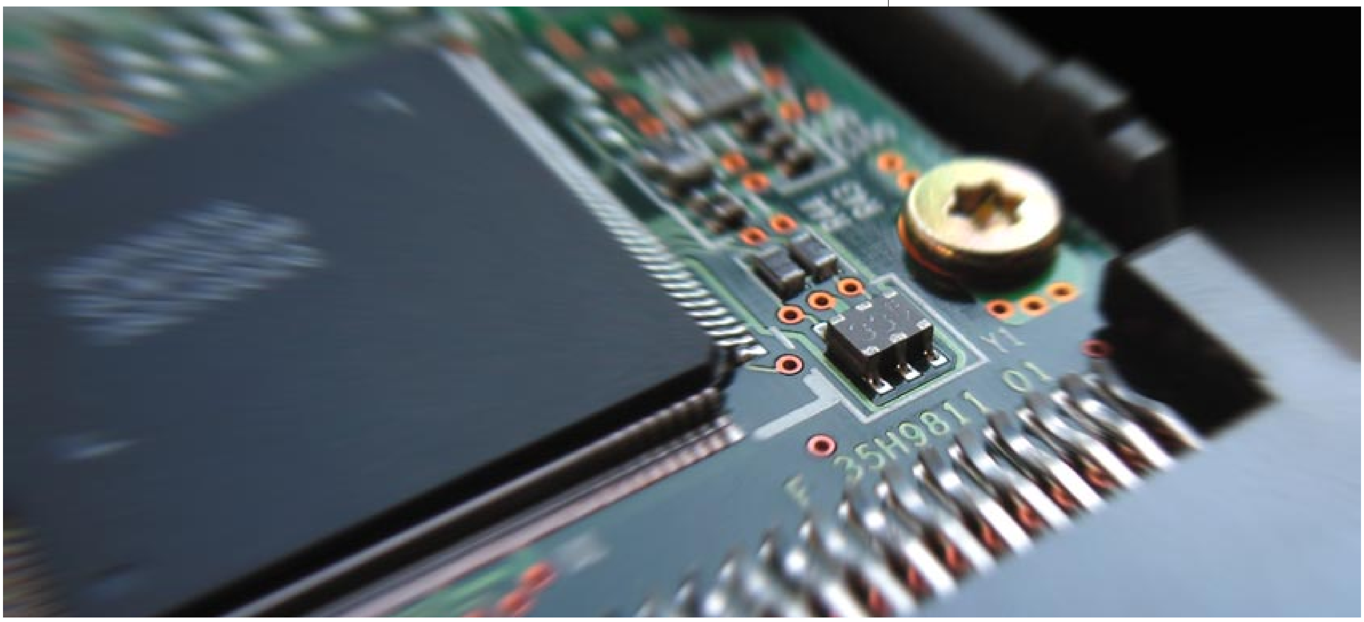
# Fundamental Mode (4.0 to 11.0MHz) / 3rd Harmonic Mode (16.0 to 50.0MHz) Ceramic Chip Resonators

# CCR Series

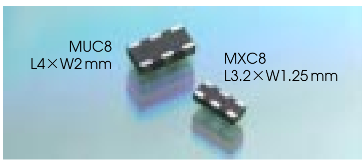
**Conforming to RoHS Directive**
Conformity to RoHS Directive: This means that, in conformity with EU Directive 2002/95/EC, lead, cadmium, mercury, hexavalent chromium, and specific bromine-based flame retardants, PBB and PBDE, have not been used, except for exempted applications.



## Development Background / Product Features

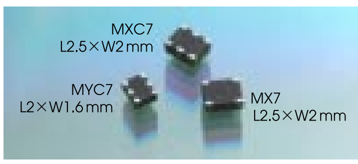
A ceramic chip resonator is a piezoceramic applied product. Its demand is increasing for use as an oscillator to generate necessary clock signals in digital machines.
Oscillators are expected the function to maintain a stable oscillation with temperature and voltage variations, i.e. the oscillation frequency stability.
To achieve the superior stability in the world's smallest chip size, TDK provides an enriched lineup including fundamental-mode products oscillating at 4.0 to 11.0MHz and 3rd harmonic-mode products oscillating at 16.0 to 50.0MHz.

**4.0MHz to 11.0MHz Products**




With the data processing of digital machines evolving rapidly to high-speed and large-capacity, the system clock frequency is also going high-frequency, and there are more demands on oscillator frequency in clock generators to be 15MHz or higher.
However, to realize a ceramic chip resonator with frequency over 11.0MHz, the maintenance limits of physical strength and dimensional accuracy exist as the piezo-ceramic element gets thinner. With practical element thickness, it is difficult to use the fundamental mode; instead it could be excited at 3rd harmonic mode. However, to use the 3rd harmonic mode, it is necessary to technically suppress the coupled fundamental oscillation, and this has become the bottleneck in practical use.

**16.0MHz to 50.0MHz Products**




TDK, with its new piezoceramic material development and the unique multilayer structure design which can almost completely suppress the fundamental-mode oscillation, was able to quickly establish the mass production techniques for 16.0 to 50.0MHz ceramic chip resonators working in the 3rd harmonic mode. Besides the 4.0 to 11.0MHz products using fundamental mode, TDK will also provide you with the 16.0 to 50.0MHz products to satisfy your ad-

## Development Background / Product Features

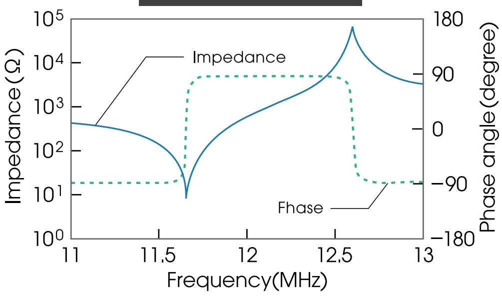
vanced needs. Below, we focus on the 3rd harmonic-mode products where the fundamental mode will not oscillate at all, and explain our unique techniques integrated in the products.

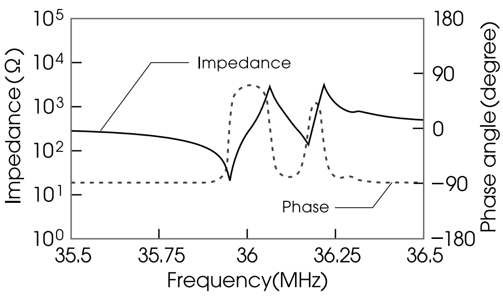
**The limit of the traditional technology and TDK's development**

Ceramic resonators used as clock oscillators are often made using PZT material - Titanic acid lead zirconate: $Pb(Zr,Ti)O_3$ - which has a superior electromechanical coupling factor. Such resonators are used in “energy enclosing / thickness expansion / fundamental mode”, which can resonate in the 10MHz band.
Due to the principle in which resonance occurs at odd multiples of half-wavelengths, the thickness of a laminated element at low frequencies is 1 half-wave-length, namely with fundamental mode, and in the over 15MHz range, where element lamination becomes very difficult due to limits in strength, it is thought that tripling the thickness (3 half-wavelengths) enables support of 3rd harmonic mode.
However, the general PZT material, from its material characteristic, is supposed to be suitable for fundamental-mode oscillation; as shown in the following data, even though using 3rd harmonic-mode operation it exists a strong fundamental-mode response in the low frequency, and operates in the fundamental mode.

**The oscillation mode of $Pb(Zr,Ti)O_3$ ceramics**
(conventional material)

Thickness expansion
Fundamental mode

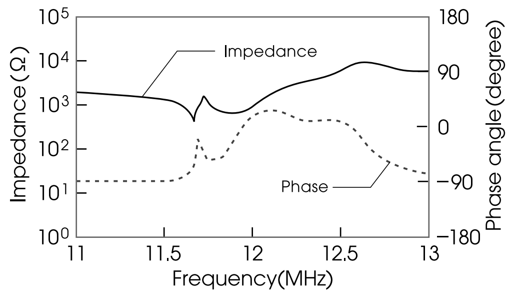


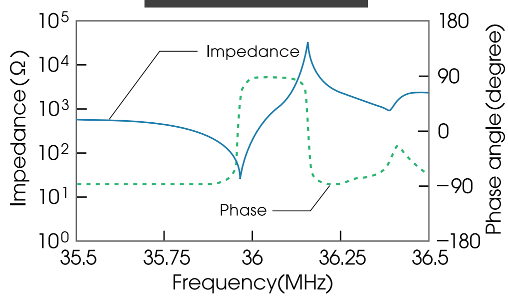

Because of this, PT material - $PbTiO_3$ (lead titanate) has been receiving much attention, because it does not easily resonate in fundamental mode and it produces significant response in 3rd harmonic mode. However, pure $PbTiO_3$ has a Curie point near 500℃. When the material passes this temperature during the cooling process after high-temperature sintering, a significant variance occurs between the spontaneous-polarization crystal axis and its right-angled crystal axis . When it cools to room temperature, this difference grows even larger. Massive internal stress is produced after cooling, and the material becomes so fragile that it shatters into pieces from the slightest amount of shock.
In contrast with $PbTiO_3$ which can't even sinter with pure composition, TDK developed the unique composition control techniques combined with elemental substitution and additive control to encourage the conversion of crystal structure. Moreover, by controlling the powder particle size distribution and improving the sintering process control, TDK established the mass production techniques for thin $PbTiO_3$ piezo substrate to enable the high-frequency oscillation.

**The oscillation mode of $PbTiO_3$ ceramics**

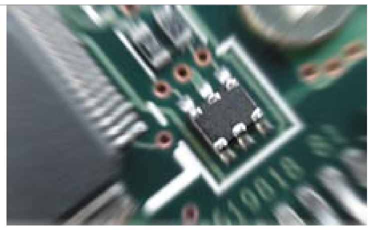
Thickness expansion / Fundamental mode




Thickness expansion
3rd harmonic mode

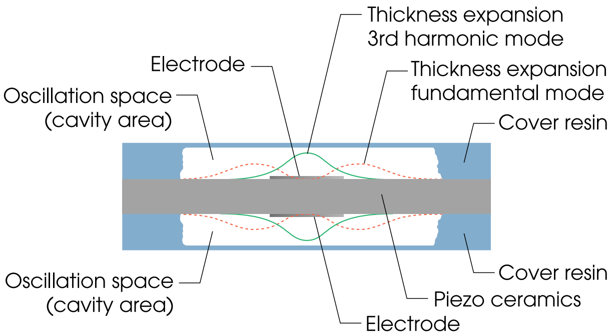



Even though the PT material is more difficult to oscillate when compared with $Pb(Zr,Ti)O_3$, the PT material still has the danger of operating in the fundamental mode, as shown in the above data. Therefore, it



requires actions to work on oscillation circuits, and this is not a practical method.

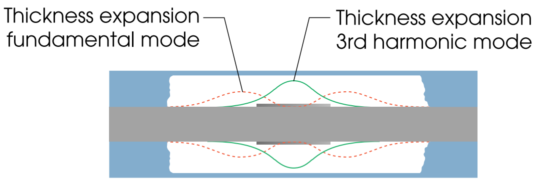
**Fundamental mode and 3rd harmonic mode**



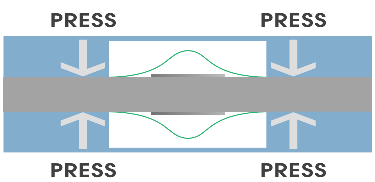

Unwanted oscillation (fundamental mode occurs as a result of improper cavity formation)

As shown in the above model, the oscillating elements of the 3rd harmonic mode concentrate on the center of oscillating electrode, and those of the fundamental mode also exist as if surrounding around the electrode. Here, if we mechanically fix the electrode edges by structural members, the oscillation near the electrode, i.e. the fundamental-mode elements could be suppressed. In this case, to keep the 3rd harmonic mode from being suppressed, the sophisticated structural design and the elaborative techniques are essential.

**Fundamental-mode oscillation control model**



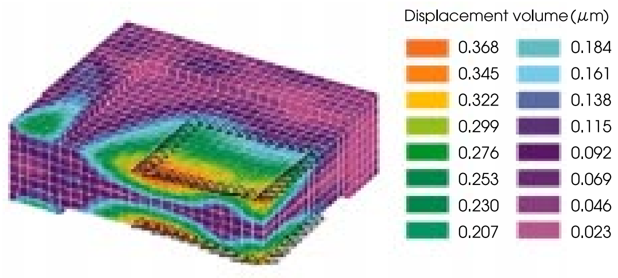

High-precision formation of cavity area
(Optimization of cavity area)



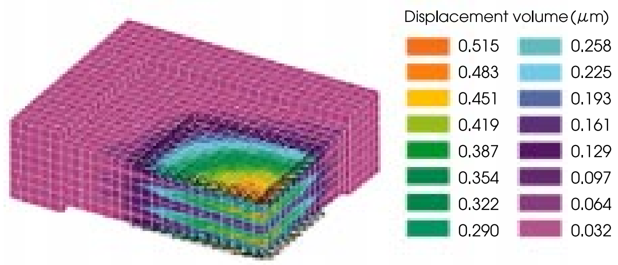

To thoroughly clear the problem, TDK pursues the ideal cavity formation inside the element, and has completed the structural design which can almost completely suppress the fundamental mode, as well as the high-precision process control techniques to mass-produce the structure. Below shows one example of the fundamental oscillating mode suppression model, oscillating status simulation model used in the optimized cavity design, and the multilayer structural model of high-precision, high-tolerance products which cover 16.0 to 50.0MHz.

**Oscillation form simulation model (1/4 cut model)**

Distribution of displacement (state of oscillation) when unwanted oscillation (basic wave) occurs as a result of improper cavity formation




Distribution of main oscillation (third harmonic) displacement (state of oscillation)
Unwanted oscillation is almost completely constrained by optimizing cavity formation (mainly depth and area)



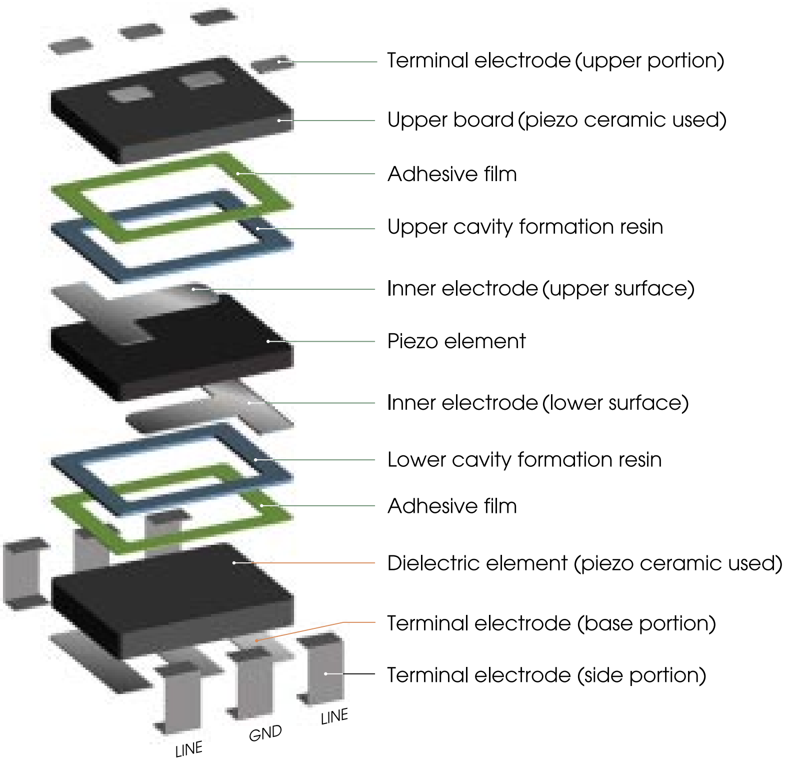

## Future efforts

With the prevalence of frequency synthesis techniques and the need for EMC design (radiation noise suppression), the once-popular trend of clock signals going high frequency has settled down for the time being. However, on the other hand, it is predicted that data transmission is going rapidly to higher-speed and larger-capacity, and the demand for oscillation frequency of system clock is going low-tolerance (high-precision). Needless to say, a great need remains for miniaturization and low-cost design.
In order to meet the high-precision needs, it requires unprecedented efforts to work on not only the oscillation frequency tolerance that is assured by the specifications, but also temperature characteristics (stability) and the aging change. The oscillation frequency tolerance on specifications mainly depends on the dimensional accuracy of element structure, so it is necessary to refine the control accuracy in the mass production process and continually work

## Development Background / Product Features

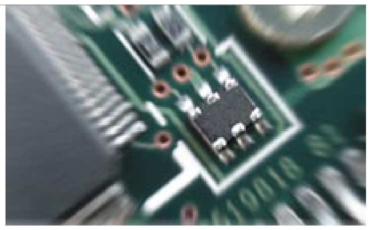
on its improvement. Moreover, on temperature characteristics and aging change, it is important to optimize the temperature characteristics of capacitor material (substrate) as well as to improve the piezoceramic material, and the finely-tuned process is done on every product.
As shown in the product specifications, the current research achievement has reduced the oscillation frequency drift from ±0.2% to ±0.1% on temperature characteristics (−40 to +80℃), and the oscillation frequency drift (10 years) has been suppressed from the previous ±0.1% to ±0.05% (CCR**MYC7 series). Furthermore, the total frequency tolerance can meet the request of "below ±0.25%".
On miniaturization, besides the smallest chip series of 4020 size on 4 to 7.99MHz frequency and 3213 size on 8 to 11MHz frequency band, we line up the standard 2520 size for 16 to 50MHz and 2016 size for 24 to 50MHz. Miniaturization also means the response to lower price needs, and we will keep working on it, including the material and structure improvement.

**Exclusive high-durability multilayer construction that provides high-precision cavity formation and industry-leading heat shock resistance properties**




Resonator
By optimizing the cavity formation resin, and through the application of a highly accurate printing process, we have established a mass production process that accurately creates cavity dimensions and thickness, while almost completely controlling unwanted fundamental-mode oscillation and achieving superior impedance characteristics.

Capacitor
Piezo ceramic material with a linear expansion coefficient aligned to the resonator for the upper board and the dielectric element is used. This allows for the realization of industry-leading heat shock resistance properties.
Moreover, on temperature characteristics, the capacitor material improves the compensation relationship with piezo element and increases the stability of oscillation frequency in terms of temperature change.



# Product Lineup (Common Specification)

- The "thickness shear/ fundamental mode" and the "thickness expansion/3rd harmonic mode" thin chip type provide the wide frequency range of 4.0 to 11.0MHz and 16.0 to 50.0MHz.
- For the piezo element is mounted in dielectric base substrate which forms the load capacitors, the external capacitors won't be needing and the simplification of the circuit and the lower assembly cost can be achieved.
- By optimizing the temperature characteristics of piezo element and dielectric material, the deviation of oscillation frequency is suppressed.
- This product can be used with reflow solder and lead-free solder (260°C, within 10 seconds). The package form is embossed tape.
- We also support your needs of setting oscillating frequencies according to special-purpose ICs and customized ICs, as well as the latest IC models, and needs of matching frequencies.

**Performance (reliability test categories and ratings)**

| | |
|---|---|
| Low temperature storage test | Left in a constant temperature chamber at −40±3°C for 1000h |
| High temperature storage test | Left in a constant temperature chamber at 85±2°C for 1000h |
| Humidity durability test | Left in a constant temperature and humidity chamber at 60±2°C with humidity of 90 to 95%RH for 1000h |
| Heat shock durability test | 30 mins in a constant temperature chamber at −40°C, 100 cycles with 1 cycle being 30 mins in a constant temperature chamber at 85°C |
| Solder heat durability test | 260°C peak, 10 seconds reflow through furnace |
| Freefall test | 3 freefalls from 1m height onto concrete |
| Vibration test | In case of sweeping, 10→55→10Hz/min, 1.5mm amplitude, 2h for X, Y, Z in each direction |
| Board bending test | Solder to glass epoxy board*, put pressure at a speed of 1mm/s until board displacement volume reaches 1mm. Hold for 5 seconds. |

* L100×W40mm thickness : 1.6mm

All products in the CCR series meet all of the following ratings in all of the reliability tests listed below.

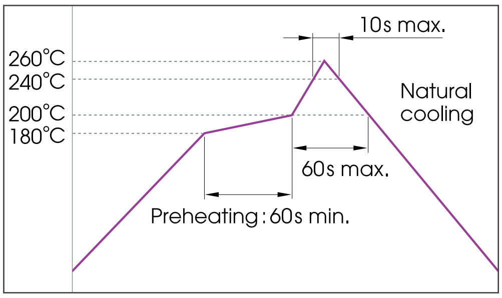
1. Oscillation frequency change less than ±0.25%.
2. Resonant resistance change less than ±10Ω.
3. No noticeable changes or abnormalities in external appearance.

**Temperature Range**

| | |
|---|---|
| In operation / In Storage | −40 to +85°C |

**Recommended soldering conditions**

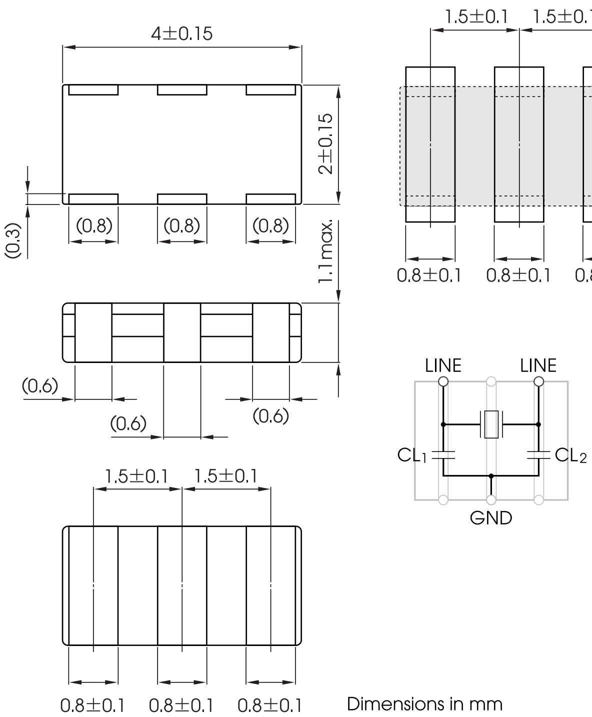
Lead free solder/High-temperature reflow process



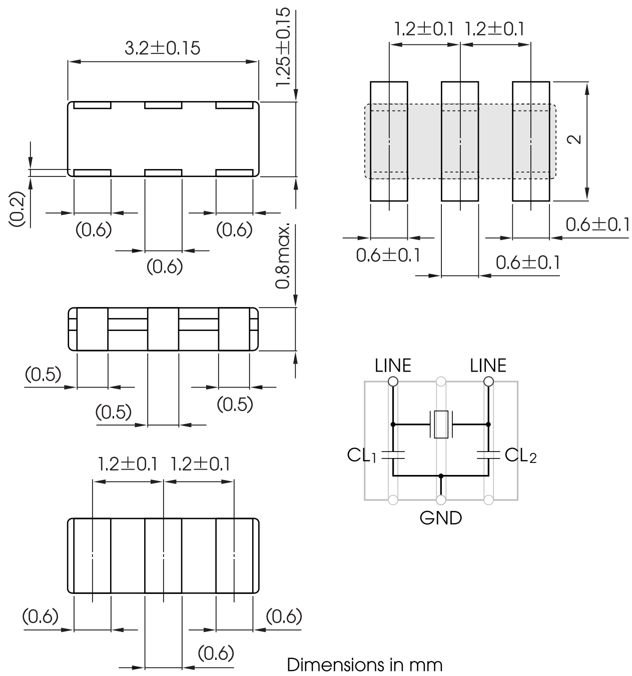
# Product Lineup

**Dimensions / Terminal connection / Electrical characteristics**

MUC8 type
Fundamental Mode : 4.0 to 7.99MHz
Internal Load Capacitance




MXC8 type
Fundamental Mode : 8.0 to 11.0MHz
Internal Load Capacitance




MUC8 type

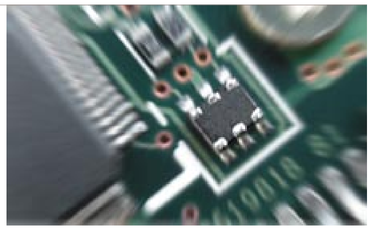
| Part No. | Oscillation frequency Fosc (MHz) | Resonance Impedance $Z_0$ (Ω) max. | Initial Oscillation Frequency Tolerance* (%) max. | Internal load capacitance (pF) $CL_1$ | $CL_2$ | T (mm) |
|---|---|---|---|---|---|---|
| CCR4.0MUC8T | 4.000 | 40 | ±0.5/0.3 | 27 | 27 | 1.1 max. |
| CCR4.19MUC8T | 4.194 | 40 | ±0.5/0.3 | 27 | 27 | 1.1 max. |
| CCR4.91MUC8T | 4.915 | 40 | ±0.5/0.3 | 27 | 27 | 1.1 max. |
| CCR5.0MUC8T | 5.000 | 40 | ±0.5/0.3 | 27 | 27 | 1.1 max. |
| CCR6.0MUC8T | 6.000 | 40 | ±0.5/0.3 | 27 | 27 | 1.1 max. |

● The data shown is a representative characteristic example.
Other oscillating frequencies and internal load capacities can also be supported.
* The allowable tolerance of the standard products is plus and minus 0.5%.
Of course, we can deal with requests for products with smaller allowable tolerance shown in the table.

MXC8 type

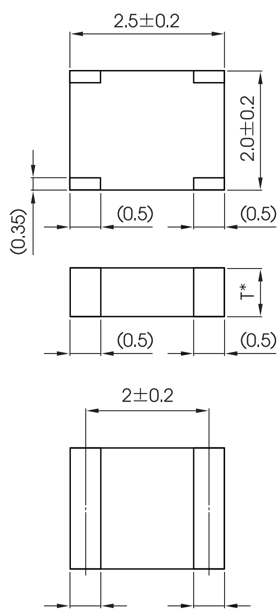
| Part No. | Oscillation frequency Fosc (MHz) | Resonance Impedance $Z_0$ (Ω) max. | Initial Oscillation Frequency Tolerance* (%) max. | Internal load capacitance (pF) $CL_1$ | $CL_2$ | T (mm) |
|---|---|---|---|---|---|---|
| CCR8.0MXC8T | 8.000 | 40 | ±0.5/0.3 | 18 | 18 | 0.8 max. |
| CCR8.38MXC8T | 8.380 | 40 | ±0.5/0.3 | 18 | 18 | 0.8 max. |
| CCR10.0MXC8T | 10.000 | 40 | ±0.5/0.3 | 18 | 18 | 0.8 max. |
| CCR11.0MXC8T | 11.000 | 40 | ±0.5/0.3 | 18 | 18 | 0.8 max. |

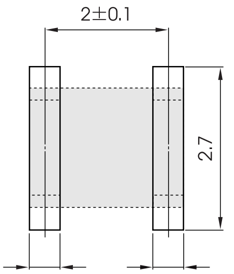
● The data shown is a representative characteristic example.
Other oscillating frequencies and internal load capacities can also be supported.
* The allowable tolerance of the standard products is plus and minus 0.5%.
Of course, we can deal with requests for products with smaller allowable tolerance shown in the table.



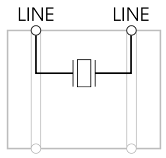
### Dimensions / Terminal connection / Electrical characteristics

MX7 type
3rd Harmonic Mode : 16.0 to 50.0MHz
External Load Capacitance




*The value of T is stated in the table of electrical characteristics.




Dimensions in mm

MX7 type

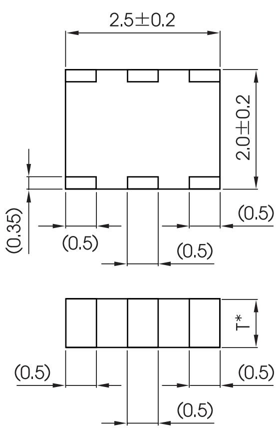
| Part No. | Oscillation frequency Fosc (MHz) | Resonance Impedance $Z_0$ (Ω) max. | Initial Oscillation Frequency Tolerance* (%) max. | Internal load capacitance (pF) $CL_1$ | $CL_2$ | T (mm) |
|---|---|---|---|---|---|---|
| CCR16.0MX7T | 16.000 | 70 | ±0.5/0.3/0.15 | — | — | 1.1±0.2 |
| CCR16.93MX7T | 16.934 | 70 | ±0.5/0.3/0.15 | — | — | 1.1±0.2 |
| CCR18.0MX7T | 18.000 | 70 | ±0.5/0.3/0.15 | — | — | 1±0.2 |
| CCR20.0MX7T | 20.000 | 40 | ±0.5/0.3/0.15 | — | — | 1±0.2 |
| CCR22.58MX7T | 22.580 | 40 | ±0.5/0.3/0.15 | — | — | 1±0.2 |
| CCR24.0MX7T | 24.000 | 40 | ±0.5/0.3/0.15 | — | — | 1±0.2 |
| CCR25.0MX7T | 25.000 | 40 | ±0.5/0.3/0.15 | — | — | 0.9±0.2 |
| CCR30.0MX7T | 30.000 | 40 | ±0.5/0.3/0.15 | — | — | 0.9±0.2 |
| CCR32.0MX7T | 32.000 | 40 | ±0.5/0.3/0.15 | — | — | 0.8±0.2 |
| CCR33.33MX7T | 33.333 | 40 | ±0.5/0.3/0.15 | — | — | 0.8±0.2 |
| CCR33.86MX7T | 33.868 | 40 | ±0.5/0.3/0.15 | — | — | 0.8±0.2 |
| CCR34.57MX7T | 34.570 | 40 | ±0.5/0.3/0.15 | — | — | 0.8±0.2 |
| CCR40.0MX7T | 40.000 | 40 | ±0.5/0.3/0.15 | — | — | 0.8±0.2 |
| CCR48.0MX7T | 48.000 | 40 | ±0.5/0.3/0.15 | — | — | 0.8±0.2 |
| CCR50.0MX7T | 50.000 | 40 | ±0.5/0.3/0.15 | — | — | 0.8±0.2 |

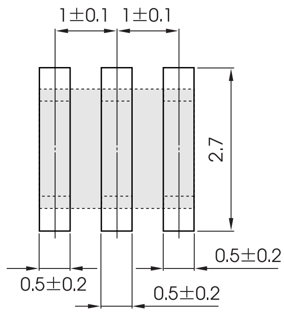
● The data shown is a representative characteristic example.
Other oscillating frequencies and internal load capacities can also be supported.
* The allowable tolerance of the standard products is plus and minus 0.5%.
Of course, we can deal with requests for products with smaller allowable tolerance shown in the table.

# Product Lineup

### Dimensions / Terminal connection / Electrical characteristics

MXC7 type
3rd Harmonic Mode : 16.0 to 50.0MHz
Internal Load Capacitance

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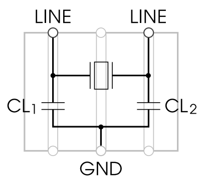


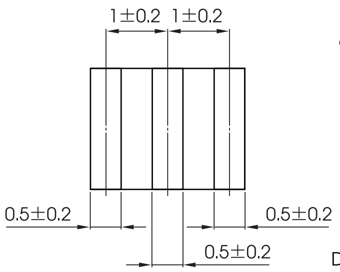


Dimensions in mm

MXC7 type

| Part No. | Oscillation frequency Fosc (MHz) | Resonance Impedance $Z_0$ (Ω) max. | Initial Oscillation Frequency Tolerance* (%) max. | Internal load capacitance (pF) $CL_1$ | $CL_2$ | T (mm) |
|---|---|---|---|---|---|---|
| CCR16.0MXC7T | 16.000 | 70 | ±0.5/0.3/0.15 | 10.0 | 10.0 | 1.1±0.2 |
| CCR16.93MXC7T | 16.934 | 70 | ±0.5/0.3/0.15 | 9.0 | 9.0 | 1.1±0.2 |
| CCR18.0MXC7T | 18.000 | 70 | ±0.5/0.3/0.15 | 9.0 | 9.0 | 1±0.2 |
| CCR20.0MXC7T | 20.000 | 40 | ±0.5/0.3/0.15 | 9.0 | 9.0 | 1±0.2 |
| CCR22.58MXC7T | 22.580 | 40 | ±0.5/0.3/0.15 | 9.0 | 9.0 | 1±0.2 |
| CCR24.0MXC7T | 24.000 | 40 | ±0.5/0.3/0.15 | 9.0 | 9.0 | 1±0.2 |
| CCR25.0MXC7T | 25.000 | 40 | ±0.5/0.3/0.15 | 8.0 | 8.0 | 0.9±0.2 |
| CCR30.0MXC7T | 30.000 | 40 | ±0.5/0.3/0.15 | 8.0 | 8.0 | 0.9±0.2 |
| CCR32.0MXC7T | 32.000 | 40 | ±0.5/0.3/0.15 | 8.0 | 8.0 | 0.8±0.2 |
| CCR33.33MXC7T | 33.333 | 40 | ±0.5/0.3/0.15 | 8.0 | 8.0 | 0.8±0.2 |
| CCR33.86MXC7T | 33.868 | 40 | ±0.5/0.3/0.15 | 8.0 | 8.0 | 0.8±0.2 |
| CCR34.57MXC7T | 34.570 | 40 | ±0.5/0.3/0.15 | 8.0 | 8.0 | 0.8±0.2 |
| CCR40.0MXC7T | 40.000 | 40 | ±0.5/0.3/0.15 | 8.0 | 8.0 | 0.8±0.2 |
| CCR48.0MXC7T | 48.000 | 40 | ±0.5/0.3/0.15 | 8.0 | 8.0 | 0.8±0.2 |
| CCR50.0MXC7T | 50.000 | 40 | ±0.5/0.3/0.15 | 8.0 | 8.0 | 0.8±0.2 |

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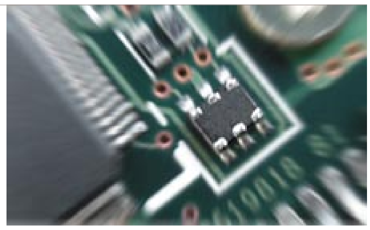
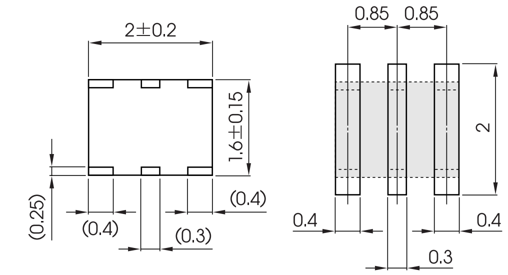
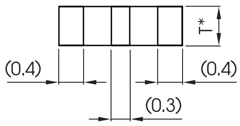


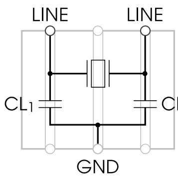
## Dimensions / Terminal connection / Electrical characteristics

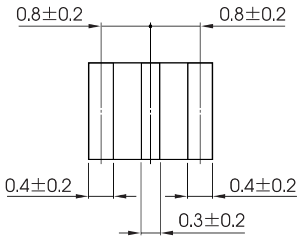
MYC7 type
3rd Harmonic Mode : 24.0 to 50.0MHz
Internal Load Capacitance




*The value of T is stated in the table of electrical characteristics.




Dimensions in mm

MYC7 type

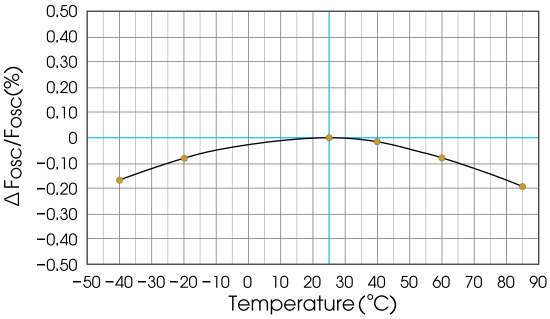
| Part No. | Oscillation frequency Fosc (MHz) | Resonance Impedance Z0 (Ω) max. | Initial Oscillation Frequency Tolerance* (%) max. | Internal load capacitance (pF) CL1 | CL2 | T (mm) |
|---|---|---|---|---|---|---|
| CCR24.0MYC7T1 | 24.000 | 40 | ±0.5/0.3/0.15 | 7.0 | 7.0 | 0.9±0.1 |
| CCR25.0MYC7T1 | 25.000 | 40 | ±0.5/0.3/0.15 | 7.0 | 7.0 | 0.9±0.1 |
| CCR27.12MYC7T1 | 27.120 | 40 | ±0.5/0.3/0.15 | 7.0 | 7.0 | 0.85±0.1 |
| CCR30.0MYC7T1 | 30.000 | 40 | ±0.5/0.3/0.15 | 7.0 | 7.0 | 0.85±0.1 |
| CCR33.33MYC7T1 | 33.333 | 40 | ±0.5/0.3/0.15 | 7.0 | 7.0 | 0.85±0.1 |
| CCR33.86MYC7T1 | 33.868 | 40 | ±0.5/0.3/0.15 | 7.0 | 7.0 | 0.85±0.1 |
| CCR40.0MYC7T1 | 40.000 | 40 | ±0.5/0.3/0.15 | 7.0 | 7.0 | 0.8±0.1 |
| CCR48.0MYC7T1 | 48.000 | 40 | ±0.5/0.3/0.15 | 7.0 | 7.0 | 0.8±0.1 |

● The data shown is a representative characteristic example.
Other oscillating frequencies and internal load capacitics can also be supported.
* The allowable tolerance of the standard products is plus and minus 0.5%.
Of course, we can deal with requests for products with smaller allowable tolerance shown in the table.

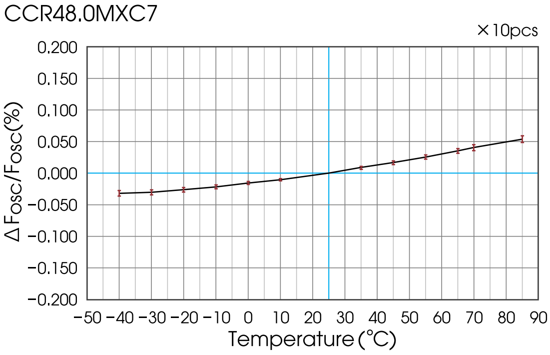
# Product Lineup

### Oscillation frequency vs. temperature characteristics example

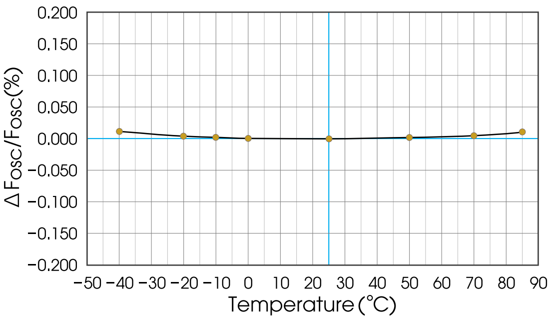
CCR8.0MXC8




CCR48.0MXC7

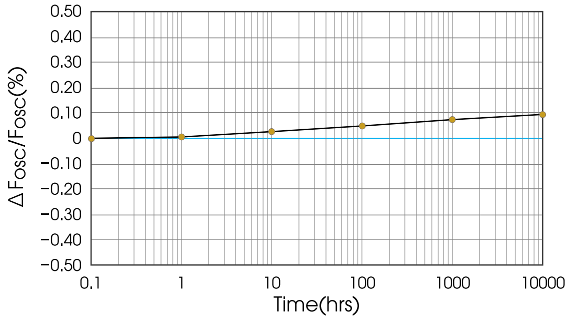



CCR48.0MYC7T1

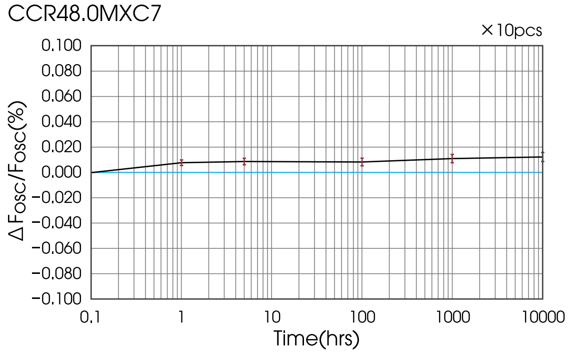



### Oscillation frequency time-lapse variation (long-term stability)

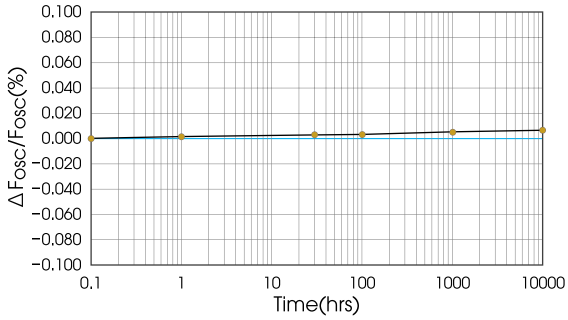
CCR8.0MXC8



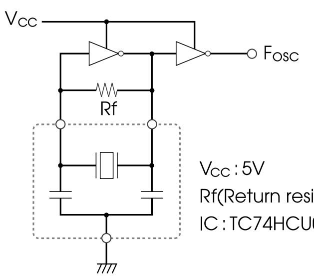

CCR48.0MXC7




CCR48.0MYC7T1




Measurement circuit of
Oscillation frequency vs.
temperature characteristics




$V_{CC}$ : 5V
Rf(Return resistance) : 1MΩ
IC : TC74HCU04 (TOSHIBA)