TECHNICAL PAPER

Properties and Characteristics of Crystal Units

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Abstract

Numerous devices in people's lives today are becoming more sophisticated. As a result, the number of crystal devices installed is increasing. For example, with the evolution of autonomous driving, we are using crystal devices for many functions such as sensor systems to detect distance, camera systems to capture images, image processing systems to process captured images and communication systems to communicate many of those digital data in and out of the vehicle at high speed.

PROPERTIES AND CHARACTERISTICS OF CRYSTAL UNITS

INTRODUCTION

Numerous devices in people's lives today are becoming more sophisticated. As a result, the number of crystal devices installed is increasing. For example, with the evolution of autonomous driving, we are using crystal devices for many functions such as sensor systems to detect distance, camera systems to capture images, image processing systems to process captured images and communication systems to communicate many of those digital data in and out of the vehicle at high speed.

In addition, in the network market, the number of crystal devices is increasing along with the further increase in the speed of communication devices, as well as the increase in the frequency and precision. This paper describes KYOCERA AVX's technology for Crystal Units, one of its crystal device products.

WHAT ARE CRYSTAL UNITS?

From here we will explain about Crystal Units. Crystal Unit is a piezoelectric element which produces electricity on the surface when mechanical pressure is applied, and when electricity is applied it vibrates in a certain manner. A Crystal Unit is a product that utilizes this piezoelectric effect. Figure 1 shows the overall image, and Figure 2 shows the vibration mode.

Frequency is dependent on Crystal thickness, the thinner it gets the higher the frequency. Our technology development is targeted for thinner and smaller products. Due to our own unique technology which are CVM technology and photolithography, we have realized the world's smallest Crystal Unit in 1008 size shown in Figure 3.

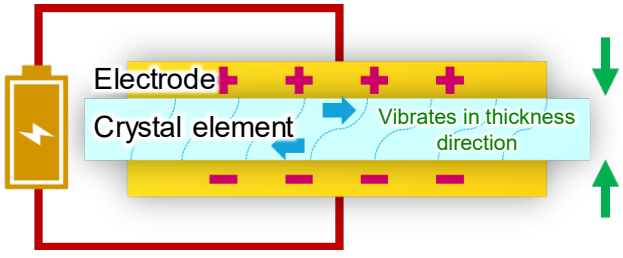


Figure 1: Crystal Unit Image

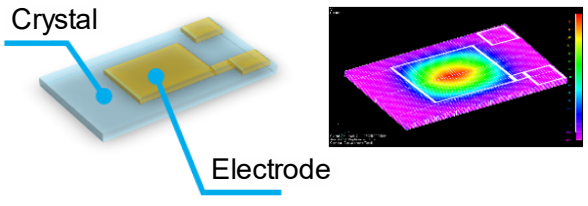


Figure 2: Vibration image

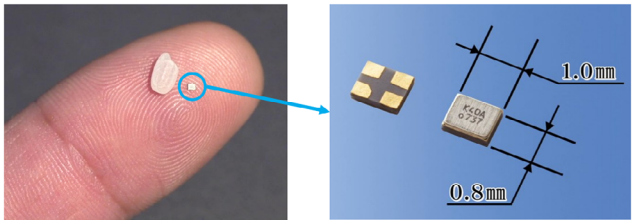


Figure 3: World's smallest Crystal Unit CX1008SB series

From here we will explain regarding increased reliability in the junction. Due to the difference in thermal expansion coefficient between the ceramic package and customer's board, when the component is mounted on a board residual stress remains in the junction, which may lead to solder cracks as shown in Figure 4 below.

CX3225SB 3.2×2.5mm size Crystal Unit
-40~ + 125°C, After 3,000 cycles

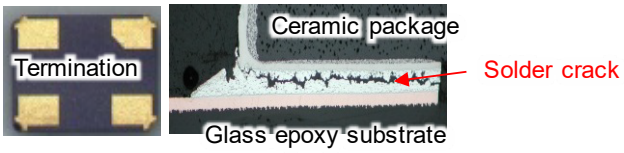


Figure 4: Crack for conventional product

In order to improve the above, the pitch between the terminations have been shortened and termination area has been enlarged as shown in Figure 5. Ceramic package and the glass epoxy board are electrically connected with solder. The improved junction reliability is one of the main features of this product.

PROPERTIES AND CHARACTERISTICS OF CRYSTAL UNITS

WHAT ARE CRYSTAL UNITS?

Solder Crack Test
-40~ + 125°C, After 3,000 cycles

CX3225SA 3.2×2.5mm size | CX3225GA 3.2×2.5mm size | CX2016GR 2.0×1.6mm size

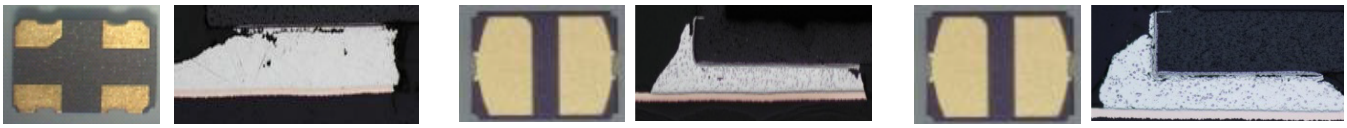
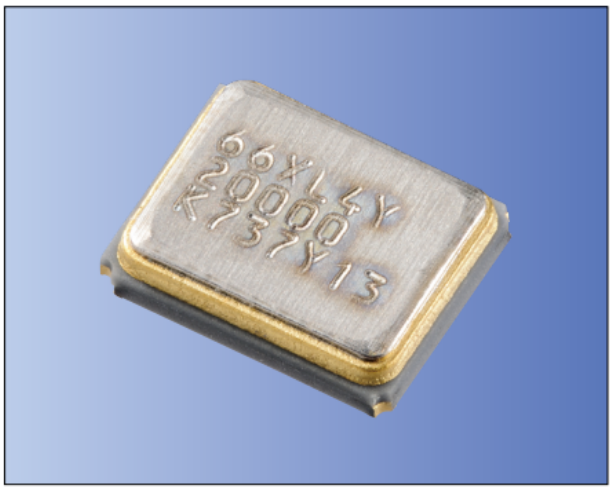


Figure 5: No solder crack confirmed regarding improved product series

CX2016SA SERIES

CX2016SA

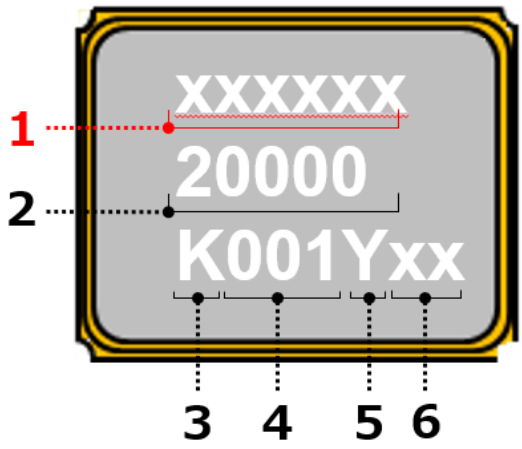


AEC-Q200 RoHS Compliant

Features

- Supports a wide range of applications.
- Ceramic package for increased reliability.
- Reflow compatible.

Item	Symbol	Specification			Unit
Frequency Range	f_{nom}	16, 20, 24, 25, 26, 27, 30, 32, 37.4, 38.4, 40, 48, 50			MHz
Overtone Order	OT	Fundamental			—
Load Capacitance	CL	8			pF
Frequency Tolerance	f_{tol}	±15			$\times 10^{-6}$
Motional Series Resistance	R1	Table 1			ohm
Drive Level	DL	10μW(200μW max.)			μW
Operating Temp. Range	T_{use}	−40 to +125	−40 to +150	−30 to +85	°C
Storage Temp. Range	T_{stg}	−40 to +150			°C
Frequency Temp. Characteristics	f_{tem}	±50	±200	±20	$\times 10^{-6}$



Features

- Traceability
  The upper marking(1) is a 6-digit serial number printed on parts that passed inspection. Therefore, this serial number and characteristic data (RT Frequency, RT ESR, etc) can be traced to the component level. ※Most other manufacturers can only trace up to week level.

- Reliability
  Products shipped for Consumer applications are also compliant to AEC-Q200 reliability.

PROPERTIES AND CHARACTERISTICS OF CRYSTAL UNITS

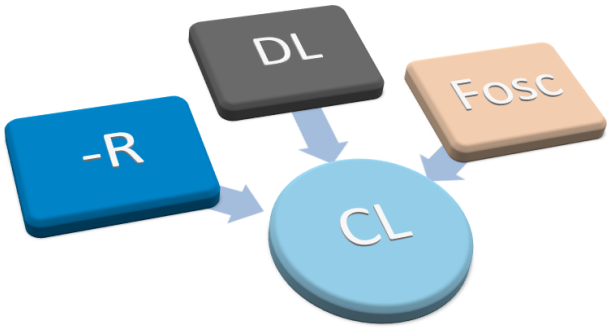
CX2016SA SERIES

Kyocera Vietnam Company Limited

Kyocera will be launching our new Vietnam factory to invest in additional capacity for mainly 2016 size crystals to cope with the increase in demand for automotive applications.

Mass production schedule: FY25

BOARD CHARACTERIZATION



Optimizing CL is the first step to design the oscillation circuit.

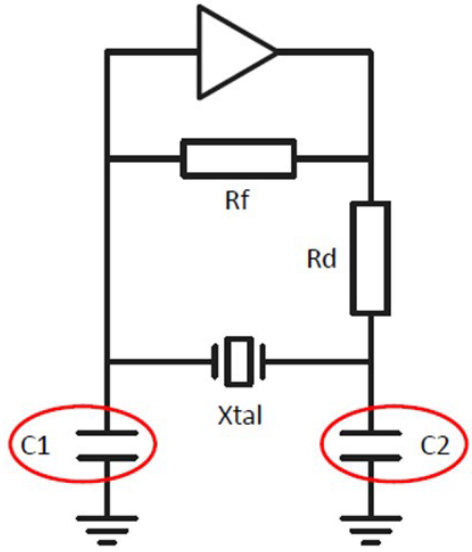
- The lower the CL, the lower Drive Level.
- The lower the CL, the better Negative resistance.
- The lower the CL, the higher Oscillation frequency.
- The lower CL, the more sensitive Fosc against load change.

Merits of Board Characterization

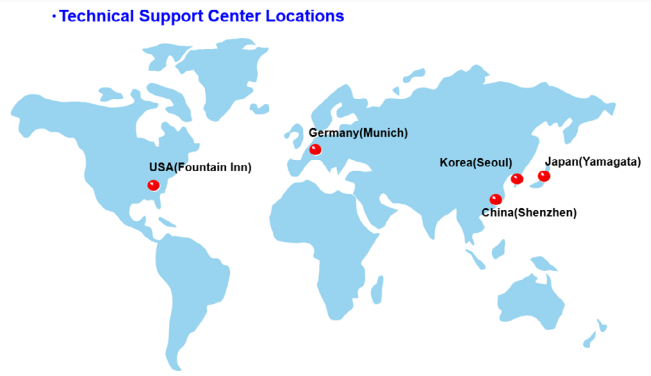
- Secures enough oscillation margin to avoid malfunction on board.
- Optimizes oscillation circuit design.
- Quick response and direct communication.
- Free of charge.

Technical Support Center Locations

- Fountain Inn, SC (USA)
- Yamagata (Japan)
- Munich (Germany)
- Shenzhen (China)
- Seoul (Korea)



Basic oscillation circuit by inverter

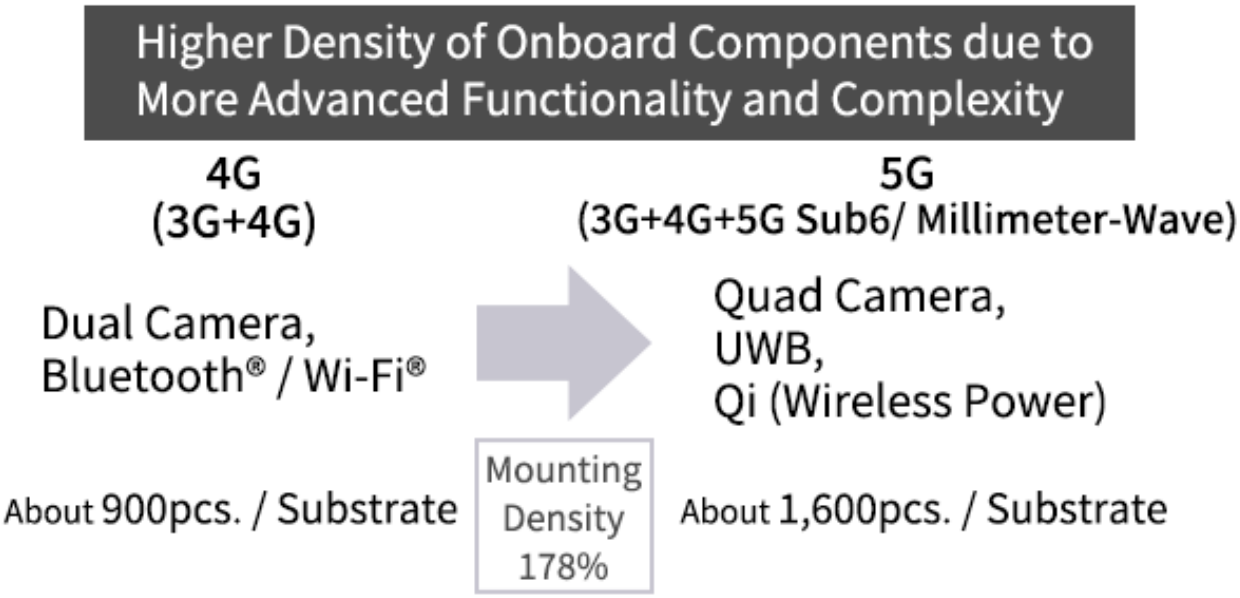


Results of board characterization and reference IC can be searched on the web.

http://prdct-search.kyocera.co.jp/crystal-ic/?p=en_search/

PROPERTIES AND CHARACTERISTICS OF CRYSTAL UNITS

MINIATURIZATION OF CRYSTAL UNITS



In recent years, the mounting density of electronic devices has increased due to the increasing number of functions of communication terminals for 5G communications, faster Wi-Fi®, and the electrification of onboard components. In addition, due to the limited space available in the mounting area, the size of mounted components is becoming smaller. Among them, Kyocera developed excellent photolithography and ultra-high precision machining technology jointly with Osaka University, and we have succeeded in mass-producing an ultra-small crystal unit, the CX1008SB Series.

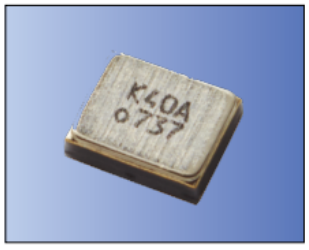
If the size is reduced from the conventional size of 1.2 x 1.0mm to 1.0 x 0.8mm, the series resistance value (CI value) will increase by about 30%. To avoid this, it was necessary to review the circuit design of the substrate on which the crystal is mounted.

Therefore, by optimizing the design of the crystal device using Kyocera's proprietary piezoelectric analysis technology, Kyocera achieved a size as small as 1.0 x 0.8mm while also achieving electrical characteristics equivalent to 1.2 x 1.0 mm*1. This made it possible to use the circuit on the board without making changes.

*1 Kyocera's product CX1210 Series

CX1008 SERIES

CX1008



RoHS Compliant

Features

- Ultra-miniature and low profile
- Crystal unit fit for mobile applications
- Reflow compatible
- Ceramic package for high reliability

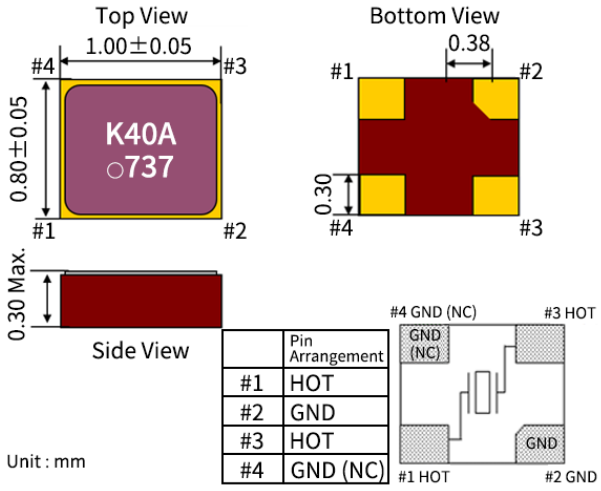
PROPERTIES AND CHARACTERISTICS OF CRYSTAL UNITS

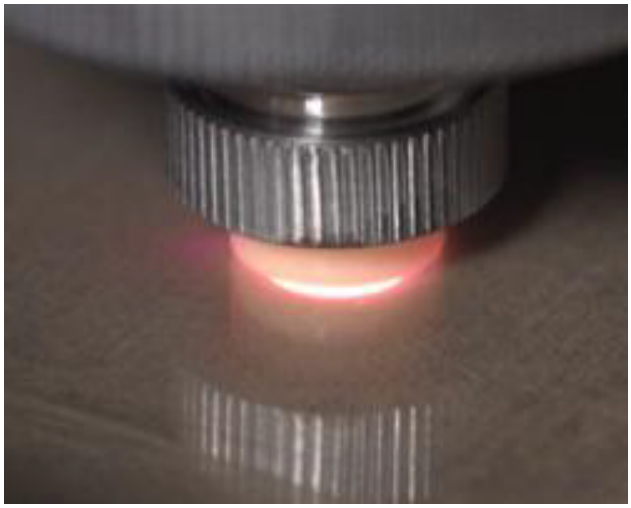
CX1008 SERIES

Size (mm)	L x W=1.0 x 0.8 T=0.30 Max.
Frequency Range (MHz)	In Mass Production 37.4, 40, 59.97 Under Development 38.4, 48, 76.8
Initial Frequency Deviation	+/- 10ppm (@+25℃)
Frequency Temperature Characteristics	+/- 12ppm (-30 to +85℃)

Series Resistance

37.4 MHz	38.4 MHz	40 MHz	48 MHz	59.97 MHz	76.8 MHz
60Ω Max.	60Ω Max.	60Ω Max.	60Ω Max.	50Ω Max.	35Ω Max.

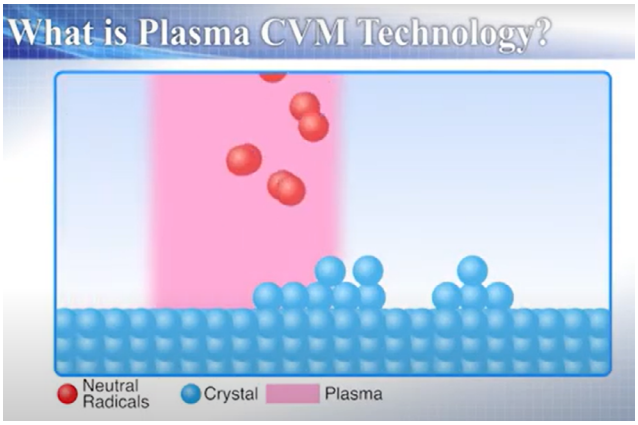




Plasma CVM Machining

With conventional machining accuracy, when a crystal device is miniaturized there is a problem that variations in electrical characteristics become large. Kyocera has resolved this problem with its ultra-high precision machining technology which Kyocera developed in collaboration with Osaka University.

This technology is a processing method that uses neutral radicals in plasma and chemical reactions on the surface of the workpiece, enabling precise control of crystal thickness and surface conditions. This has resulted in a successful reduction in frequency fluctuation.



Plasma is radiated to crystal wafers in atmospheric pressure, triggering a chemical reaction with neutral radicals to realize equal wafer thickness.

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