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Handling Notes

CITIZEN FINEDEVICE CO., LTD.

1. Handling notes for Crystal Units

I. When dropped by mistake: < All products >

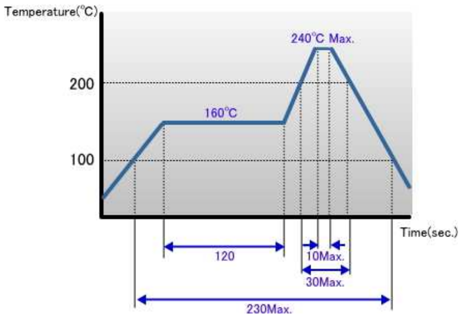
Crystal units are designed and manufactured to resist physical shocks. However, in the event crystal units are subjected to excessive impact such as being dropped onto the floor or subjected to shock during mounting, you will need to make sure its satisfactory performance before using it.

II. Soldering:< Through hole type >

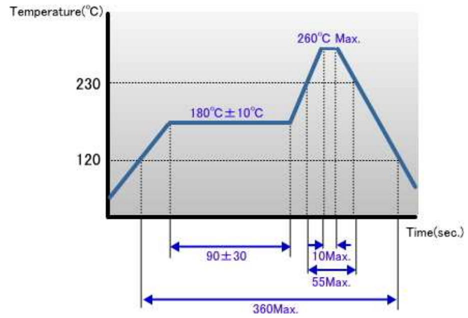
1. Lead wires should be soldered within 3 seconds, with the soldering iron heated to a temperature no higher than 380ºC.
2. For solder-dip mounting, it should be within 10 seconds with a temperature no higher than 260ºC. And take care not to heat the whole crystal units in the dip mounting process. Mounting upright is recommended (preventing heat conduction directly to the body of the crystal units).
3. Heating the whole crystal units, for example, in a reflow oven may impair their performance. This is because the holder is quite small and it is sealed by press sealing with solder material, so the reflow process is not permissible.

< SMD type products >

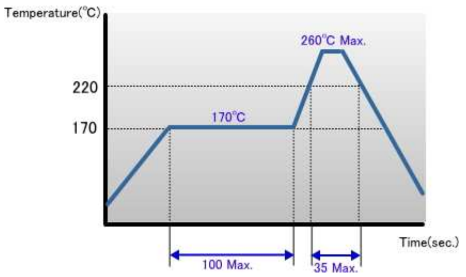
1. Pd solder



2. Pb free solder (excepting CM309E)



3. Pb free solder (CM309E)

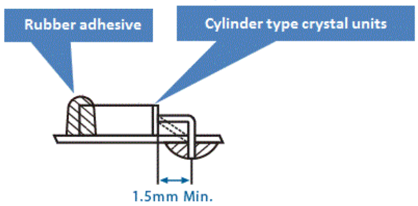


III. Bending Lead: < Cylinder type products >

1. When the lead of a cylinder type crystal units needs to be bent, leave more than 1.5 mm (3.0 mm is recommended) of lead from the case in order to prevent any cracks of the hermetic seal glass at the root of the lead, and use a jig for bending if possible. Please avoid bending it directly from the lead wire root.
2. When bending the lead of cylinder type crystal units, do not scrape off the solder plating from the lead surface.

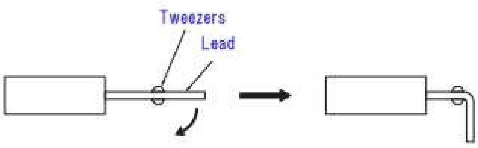
IV. Mounting: < Cylinder type products >

1. Soldering on the body of cylinder type crystal units must be strictly avoided due to deteriorate the characteristics or damage the product. Rubber adhesive is recommended.



2. When bending the lead of cylinder type crystal units, do not scrape off the solder plating from the lead surface.

- Hold the body of cylinder type crystal units by hand.
- Grip the part that you intend to bend with tweezers. The part where you bend should be more than 1.5 mm from the body case, but we on the part of the hermetic seal glass.
- Press and bend the lead 90° with the tweezers without pulling the lead strongly. Please be sure that pulling the lead strongly may crack the hermetic seal glass at the root of the lead and may cause the airtightness and the characteristics to deteriorate.



< SMD type products >

When using an automatic loading mounter, test and confirm that no damage has been caused to the characteristics of crystal units before mounting. Bending a circuit board in the process of cleaving boards after mounting and soldering crystal units may cause peeling off the soldering or package cracks by mechanical stress. Please be sure that the layout of the crystal unit position is on the less stressed and the cleaving process is under less stressed for the crystal units.

V. <Cleaning:All products>

1. Crystal units may be affected and, at worst, destroyed by ultrasonic cleaning. Please be sure to check if your cleaning process causes any damages to crystal units prior to use.
2. Some cleaning fluids may cause damage to crystal units. Please be sure to check the suitability of the cleaning fluid in advance.

2. Mounting:< Cylinder type products >

I. When dropped by mistake:

Please refer to 1. Handling notes for Crystal Units.

II. Soldering:

Should be soldered within 10 seconds at no higher than 260ºC or 3 seconds at no higher than 380ºC. Please refer to <SMD type products> in “1. Handling notes for Crystal Units” regarding the reflow profile.

III. Cleaning:

1. 1.Crystal oscillators may be affected and, at worst, destroyed by ultrasonic cleaning. Please be sure to check if your cleaning process causes any damages to crystal oscillators prior to use.
2. 2.Some cleaning fluids may cause damage to crystal oscillators. Please be sure to check the suitability of the cleaning fluid in advance.

IV. Mounting:

Mounting crystal oscillators reversed may cause malfunctions or damage, so please check the orientation before mounting. When using an automatic loading mounter, please select a machine with low impact and check for damages on the products. Thermal shock:

V. Thermal shock

Repetitive rapid temperature changes with a large amplitude may cause deterioration of the crystal oscillators and break the wires inside the package. Such conditions must be avoided.

VI. Static electricity:

Excessive levels of electricity may cause damage to the IC inside crystal oscillators even if an anti-static electricity protection circuit is provided in the circuit board. Please be sure to use conductive packing materials and transport containers, use a soldering iron and measuring circuit free from high-voltage leakage, and provide a grounding connection while using crystal oscillators.

VII.Noise:

Applying excessive levels of extraneous noise to the power supply or input pin may cause latch-up or spurious phenomena, which results in malfunction and breakdown. Do not permit any object that emits a high level of noise in the vicinity of crystal oscillators.

VIII.Power supply lines:

Line impedance of the power supply should be as low as possible. To maintain stable operation, power supplies to crystal oscillators should have by-pass capacitor (0.01µF ~ 0.1µF). Place the capacitor as close as possible to crystal oscillators supply pins (the VDD pin and the GND pin). The supply lines (the VDD and the GND) should be as thick and short as possible.

IX.Output line:

To reduce the line impedance of the output line and reduce the electromagnetic radiation, the output load should be installed as close as possible to the crystal oscillators.

X. Input line:

The input pin (OE) is pulled up with an internal resister, it should be used at low impedance for noise suppression, but if it is not used, connect it to VDD.

3. Handling notes common to All Products

I. Storage:

Storage of crystal products under higher temperature or high humidity may affect frequency stability or solderability. Please store crystal products under normal temperature and humidity without exposing to direct sunlight or dew condensation, and avoid storing crystal products over the long term: mount them as soon as possible after unpacking.

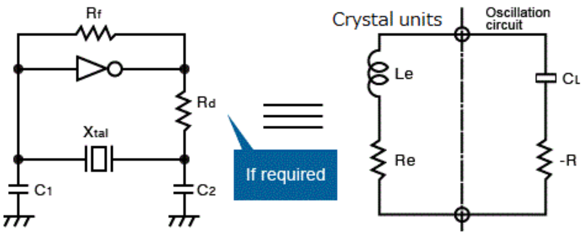
Handling Notes

Handling notes in Oscillation Circuit Design

To fully utilize the characteristics of crystal units, it is necessary to design an oscillation circuit constant with optimal conditions.

Based on the experience we have accumulated over the years, Citizen Finedevice offers services such as checking the oscillation circuit designed by a customer with regard to points mentioned below to ensure optimal matching between the crystal units and the oscillation circuit. The purpose of this investigation is that we make our products to ensure more safety and ease of use for the customers.

I. MOS crystal oscillation circuit



MOS Fundamental Crystal Oscillation Circuit

Correlation between crystal units and oscillation circuits

CMOS crystal oscillation circuit

CL	Load capacitance
-R	Negative resistance
Le	Effective Inductance
Re	Effective resistance

II. Load capacitance (CL)

The load capacitance (CL) refers to the effective external series capacitance in an oscillation circuit assumed to be viewed from the crystal units side. The resonance frequency will be determined based on the load capacitance and the crystal unit. For this reason, differences in the load capacitance of the oscillation circuit may cause frequency deviations (result in a different resonance frequency from the one required).

Equation of Load capacitance in an Oscillation Circuit

$$C_L = \frac{C_1 \cdot C_2}{C_1 + C_2} + C_{IC} + \Delta C$$

External capacitance | Intenal capacitance of IC | Stray capacitance of PCB

III. Negative resistance (-R)

The negative resistance reflects the allowance and margin for oscillation motility. An insufficient negative resistance may cause unexpected trouble such as No-Oscillation or slow start-up time.

IV.Drive current (i)

The drive current refers to the current flows through crystal units. An excessive drive current being applied to crystal units may cause the following trouble/phenomena.

1. Increase in the electromagnetic wave noise
2. Crystal unit element of T/F breaking off
3. Abnormalities occur in the frequency tolerance over operating temperature range.
4. Changes in the characteristics of crystal units
(Changes in the frequency, changes in the motional resistance, etc.)

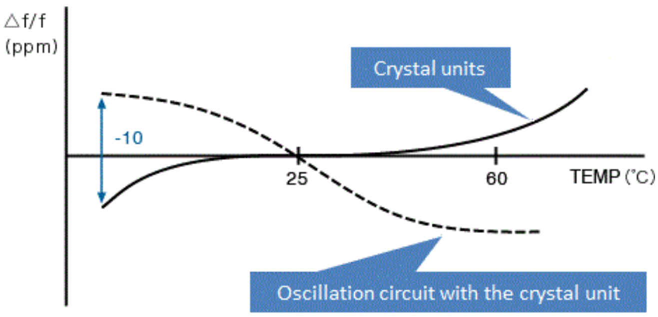
V. Frequency-voltage coefficient

Represents the rate of frequency change against variations in the supply voltage. The cause of frequency changes due to power supply variation can be attributed more to factors on the oscillation circuit side (especially the IC) than crystal unit s side. It is normally desirable to keep within ±5 ppm in the rate of frequency change against a ±10% variation in the supply voltage.

VI.Frequency -Frequency tolerance over operating temperature range

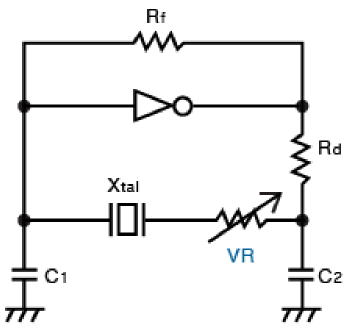
Represents the rate of frequency change against variations in operating temperature. There may be a large difference between the oscillation circuit and the crystal unit in terms of frequency tolerance over operating temperature range.

(Example)Frequency -Frequency tolerance over operating temperature range



VII. How to check the margin for oscillation motility

1. To determine the margin for oscillation motility, you should check the negative resistance (-R) of the oscillation circuit.
2. Connect a variable resistor (VR) to the oscillation circuit in series with crystal units. Adjust the resistance value of VR from the "no oscillation" status to oscillation startup. The value shall be a negative resistance (-R) when oscillation starts up.
3. Adjust values of C1, C2 and Rd such that the negative resistance is at least 5 times larger than the effective resistance in order to secure enough margins for oscillation motility. Please note that it is recommended that -R should be at least 10 times the effective resistance for equipment required to show high quality and reliability, such as automotive components.



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Technical Guide

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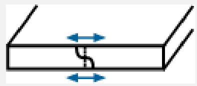
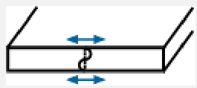
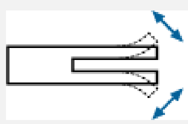
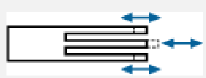
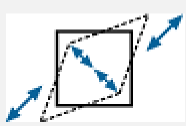
Types of crystal cut

Relation among crystal cut, mode of vibration and frequency range

Crystal Cut	Mode of vibration		Frequency range (kHz)	Capacitance ratio (C0/C1)
AT	Thickness shear Fundamental		800~5,000 2,000~80,000	450~300 220
	3rd overtone		20,000~90,000	n2 x 250 n: Overtone order
	5rd overtone		40,000~150,000	
	7rd overtone		70,000~210,000	
BT	Thickness shear Fundamental		3,000~30,000	650
XY	Flexural (Tuning fork)		16~150	425~800
	Extensional		600~3,000	400
DT	Face shear		100~500	400
CT			150~850	350
SL			180~700	400

Crystal unit equivalent circuit

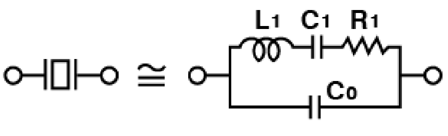
A crystal unit in the main resonance frequency may be expressed as an electrical equivalent circuit: a circuit ordinarily composed of a series circuit consisting of an inductance, capacitance and resistance, and a capacitance connected in parallel to the series circuit as shown in the drawing.

Here, C0, which is commonly known as the shunt capacitance, comprises an inter-electrode static capacitance to which the inter-terminal stray capacitance is added.

L1 and C1 are the equivalent constants of the crystal unit viewed as an electrical and mechanical oscillation system. Since both constants are determined by such factors as the type of cut, cutting angle, dimensions of the crystal blank, and construction of the electrodes, and are thus reproducible, crystal units can be manufactured with high precision.

R1, which denotes oscillation loss, is governed by conditions such as processing, storage, and dimensions of the crystal unit.

L1 is referred to as motional inductance, C1 is referred as motional capacitance, and R1 is referred as motional (series) resistance.



L1	Motional inductance
C1	Motional capacitance
R1	Motional(series)resistance
C0	Shunt capacitance

The electrical equivalent circuit, composed of L1, C1, R1 and C0, all of which are correlated, may be expressed by the following equation.

$$f_r = \frac{1}{2\pi\sqrt{L_1 C_1}}$$

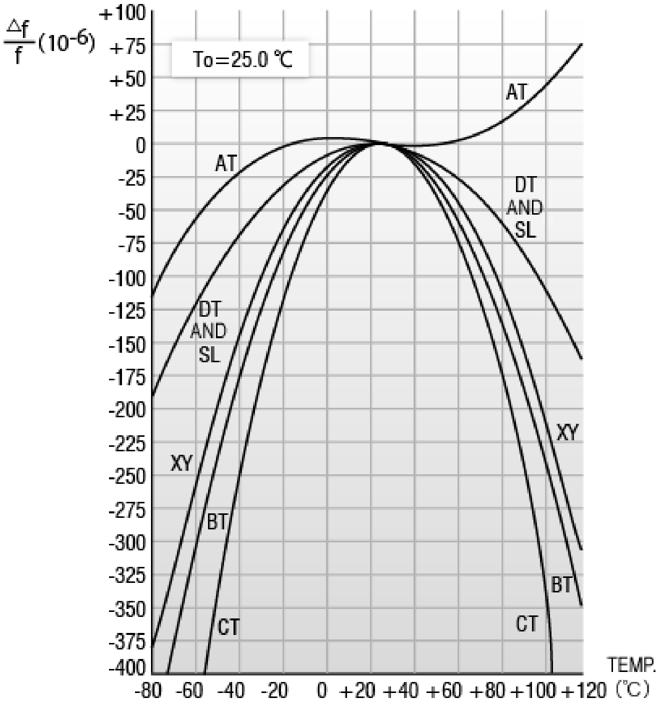
Shown below are some equations by which the performances of crystal units are expressed

$$Q = \frac{1}{2\pi f_r C_1 R_1} = \frac{2\pi f_r L_1}{R_1}$$

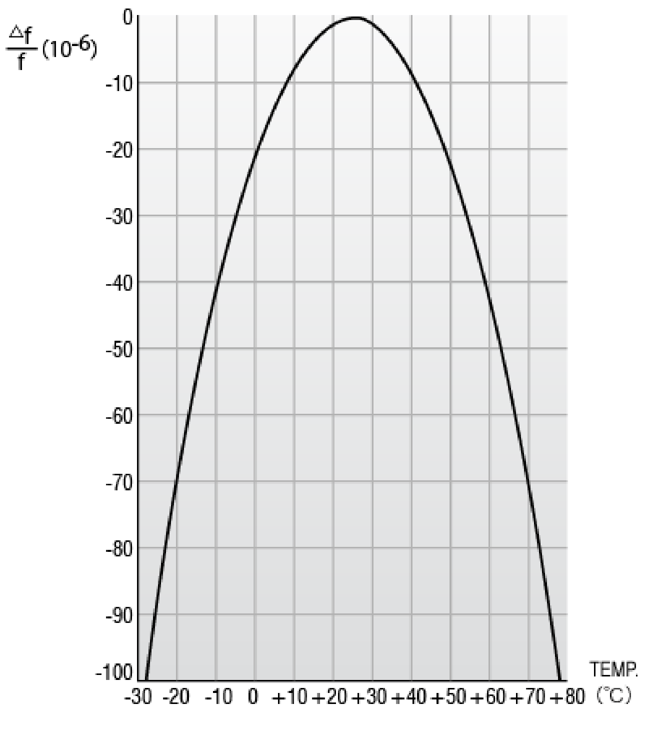
$$\gamma = \frac{C_0}{C_1}$$ (Capacitance ratio)

Frequency-temperature characteristics

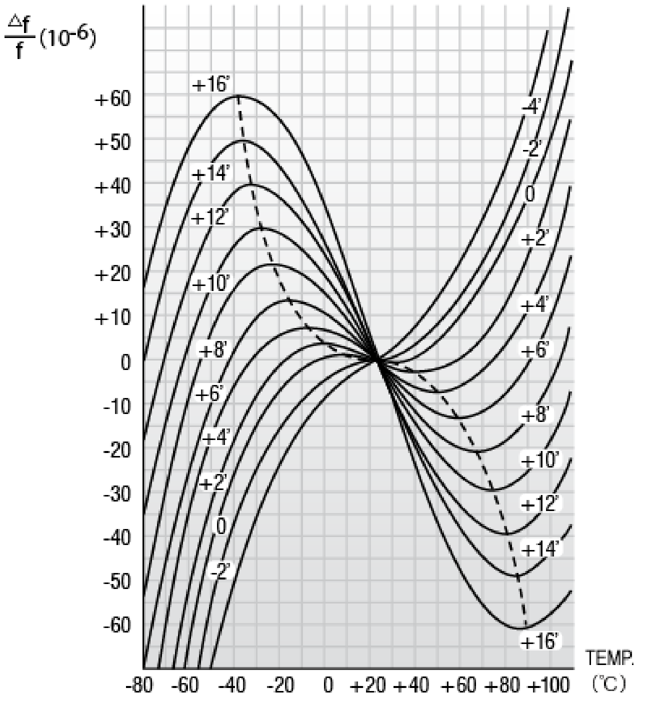
Correlation between Crystal cutting angle and Frequency-temperature characteristics



Frequency-temperature characteristics of Tuning Fork Crystal Unit

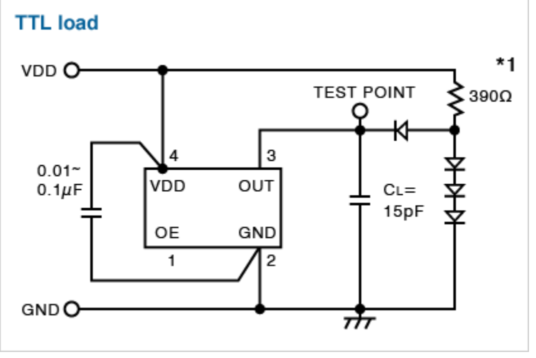


Correlation between Crystal cutting angle and Frequency-temperature characteristics of AT-cut Crystal Unit



Test Circuit

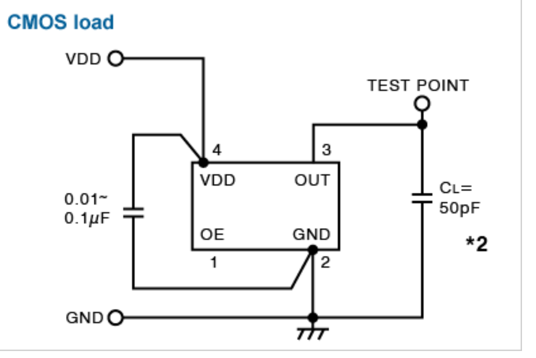
CSX-750F/SSX-750P SERIES



*1

390Ω	CSX-750(FC)
820Ω	SSX-750(PT, PK)

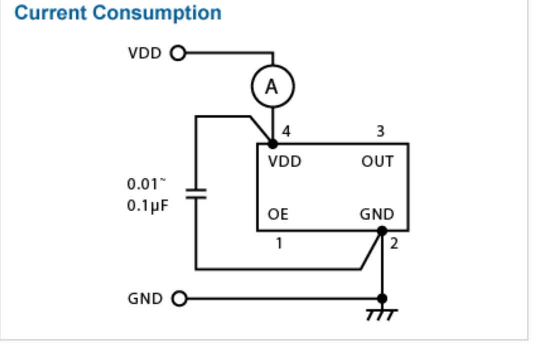
CMOS load



*2

50pF	CSX-750(FC)
30pF	CSX-750(FB, FJ)
25pF	SSX-750(PC, PD)
15pF	SSX-750(PB, PJ), CSX-252F

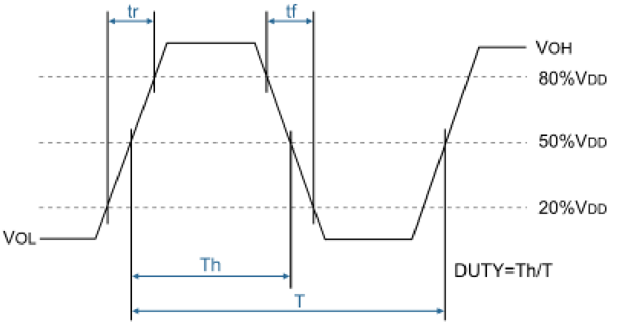
Current Consumption



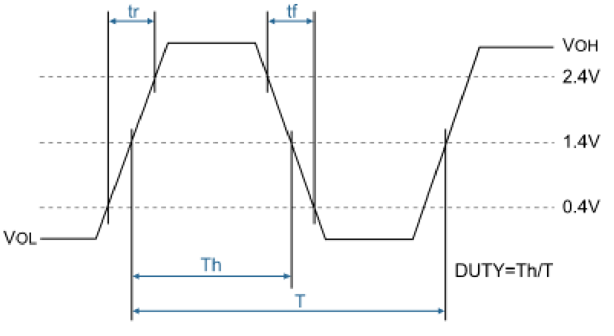
Output wave-form

Oscillators output wave-form

CMOS load



TTL load



Measurement conditions

1. Oscilloscope
   - Input impedance: No less than 1 MΩ
   - Input capacitance: No more than 15 pF
   - Band width: No less than 500 MHz
   - Make the grounding lead of the probe as short as possible
2. The CL includes the probe capacitance.
3. Grounding should be single-point grounding.
4. Supply voltage impedance should be as low as possible. Rise time from 0V to 0.9Vdd is to be more than 150 µs.
5. Use an ammeter with small internal impedance.

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Glossary

Equivalent circuit of quartz crystal

The electrical circuit which has the same impedance as the unit in the immediate neighborhood of resonance.

Load capacitance (CL)

The effective external capacitance associated with the crystal unit which determines the load resonance frequency (fL).

Nominal frequency (f0)

The frequency assigned by the specification of the crystal unit.

Resonance frequency (fr)

The lower of the two frequencies of the crystal unit alone, under specified conditions, at which the electrical impedance of the crystal unit is resistive.

Load resonance frequency (fL)

One of the two frequencies of a crystal unit in association with a series or with a parallel load capacitance, under specified conditions, at which the electrical impedance of the combination is resistive. The frequency is the lower of the two frequencies when the load capacitance is in series.

Resonance resistance (Rr,R1)

The resistance of the crystal unit alone at the resonance frequency.

Load resonance resistance (RL)

The resistance of the crystal unit in series with a stated external capacitance at the load resonance frequency.

Motional inductance (L1)

The inductance in the motional (series) arm of the equivalent circuit.

Motional capacitance (C1)

The capacitance of the motional (series) arm of the equivalent circuit.

Shunt capacitance (C0)

The static capacitance between the electrodes, together with stray capacitances of the mounting system.

Capacitance ratio (C0/C1)

The ratio of the shunt capacitance to the motional capacitance.

Overtone order

The numbers allotted to the successive overtones of a given mode of vibration from the integral numbers commencing with the fundamental as unity.

Unwanted response

Frequency responses other than the main, or desired response, which the crystal elements have.

Frequency tolerance (Δf/f0)

The permissible deviation from the nominal frequency at the reference temperature (usually 25<C).

Storage temperature range

The temperature range over which the standard characteristics of the crystal unit can be maintained when the crystal unit is not in operation.

Drive level, (Level of drive)

The level of power or current in the crystal unit when in the operating state.

Insulation resistance

Resistance between leads, or between lead and case.

Q value

In a resonace circuit composed of an L, C and R, a quantity that represents the sharpness of a resonance curve-a curve that shows the relationship between the circuit current and power frequency.

Frequency stability

Within operating temperature, operating voltage and output load range, deviation in actual frequency from nominal frequency.

Supply current

The electric current to supply (VDD) pin with no output load when output is enabled.

Duty

The 1/2 cycle to 1 cycle ratio (as expressed in percentages) of an output waveform at the specified voltage level.

Output load

The load that can be connected to the oscillator.

Rise time(tr)

The time interval required for the leading edge of a pulse wave form to change from specified L voltage level to specified H voltage level.

Fall time(tf)

The time interval required for the trailing edge of a pulse wave form to decay from specified H voltage level to specified L voltage level.

Start up time

The time interval between power on and supply voltage becomes the specified voltage until the output waveform becomes stable.

Output enable function

The function to change the output signal.

When pins OE are at H level or open : Specified frequency is output. (Enable)

When pins OE are at L level : Output has high impedance. (Disable).

Frequency adjustment range

Frequency adjustment (pulling) range of a crystal oscillator which enable to change the frequency with a variable component.

Phase noise

Unit of measurement of frequency sphere in short-term frequency stability of a crystal oscillator.

Harmonic distortion

Non-linear distortion by occurrence of the needless spectral element in a higher harmonic wave of the requisite signal frequency.

Each harmonic element is generally expressed in power ratio (dB) to output power of a requiring signal.

Allan variance fractional frequency fluctuation

Objective evaluation is defined by timedomain in short-term frequency stability of a crystal oscillator.

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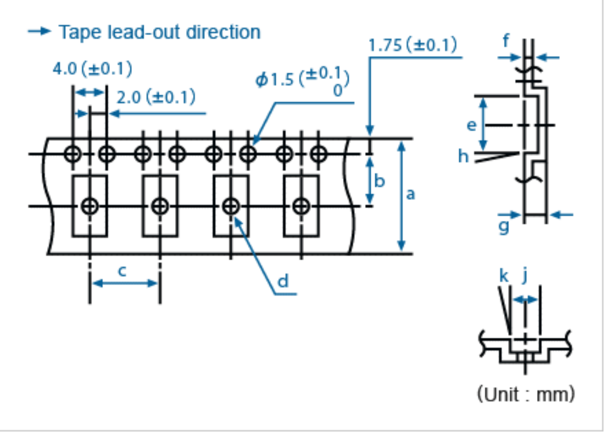
Packing specification

1. Taping & reel form is conforming to JIS C 0806 and EIAJ RC-1009B and a unit in quantity per reel shall be 1,000pcs, 2,000pcs or 3,000pcs.
2. A "Label" on which necessary information is clearly written is on the surface of the packing box and the reel.
3. Goods will be ship out after packing some taping reels into the shipping box.

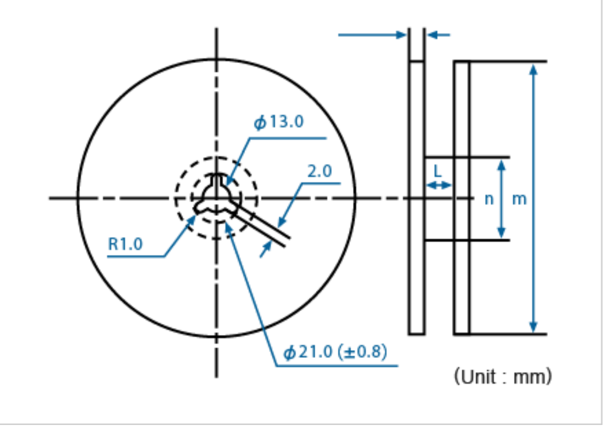
Taping dimensions

(Conforming to JIS C 0806 TB1208NEIAJ and RC-1009B TE1208N)



Reel dimensions

(Conforming to JIS C 0806 R12R and EIAJ RC-1009B R15)



Model	Region													
	Quantity pcs/reel	a	b	c	d (Φ)	e	f	g	h	j	k	l	m (Φ)	n (Φ)
CMR200T	2,000	16.0	7.5	8.0	-	9.4	0.3	2.15	-	5.0	-	17.5	330	100
CMJ206T	3,000	16.0	9.2	8.0	-	9.5	0.3	2.1	-	3.0	5°	17.5	330	100
CM200C	3,000	16.0	7.5	8.0	1.0	8.2	0.3	2.65	5°	4.0	5°	17.5	330	100
CM250C	3,000	16.0	7.5	8.0	1.0	8.2	0.3	2.65	5°	4.0	5°	17.5	330	100
CM130	3,000	16.0	7.5	4.0	1.0	7.2	0.3	1.4	5°	1.55	5°	17.0	180	50
CM519	3,000	12.0	5.5	4.0	1.0	5.3	0.3	1.1	5°	2.1	5°	13.0	180	60
CM415	3,000	12.0	5.5	4.0	1.0	4.5	0.3	1.0	5°	1.9	5°	13.0	180	60
CM315D	3,000	12.0	5.5	4.0	1.0	3.6	0.3	1.0	5°	1.9	5°	13.0	180	60
CM315DL	3,000	12.0	5.5	4.0	1.0	3.6	0.3	1.0	5°	1.9	5°	13.0	180	60
CM2012H	3,000	8.0	3.5	4.0	1.0	7.2	0.3	1.4	5°	1.55	5°	17.0	180	50
HCM49	1,000	24.0	11.5	12.0	2.0	16.1	0.4	4.3	5°	5.1	5°	25.5	330	100
CM309E	1,000	24.0	11.5	12.0	1.5	11.9	0.4	4.0	5°	4.9	5°	25.5	330	100
CS325S	3,000	8.0	3.5	4.0	1.1	3.5	0.25	0.75	5°	2.8	-	11.4	180	60
CSX-750F	2,000	16.0	7.5	8.0	1.5	7.4	0.3	1.9	5°	5.4	5°	17.5	254	100
SSX-750P	2,000	16.0	7.5	8.0	1.55	7.4	0.3	2.0	5°	5.4	5°	17.5	254	100
CSX-750V	2,000	16.0	7.5	8.0	1.5	7.4	0.3	1.9	5°	5.4	5°	17.5	254	100
CSX-252F	3,000	8.0	3.5	4.0	1.1	2.7	0.25	1.15	5°	2.25	5°	9.0	180	60

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