Quartz Crystal Units

■ Precautions for Use

Please read the following precautions regarding correct use of NDK' s crystal units and to ensure optimum performance over a long time.

1. To ensure good electrical performance

1-1 Crystal Oscillation Circuit

Crystal units are passive products like resistors and condensers. Therefore, in order to ensure a rapid start-up of oscillation and to obtain the required stable precise oscillation frequency, it is essential that the optimum oscillation circuit conditions are taken into consideration.

Please refer to typical oscillation circuits listed on pages 28 to 30.

The oscillation frequency of a crystal unit is determined by load capacitance (CL) and the crystal unit' s own equivalent constants. Although the values are fixed by the circuit, with regard to the circuit constants given in the examples, due to differences in the type of IC or transistor used, or different wiring patterns, the characteristics may be different.

Load capacitance for a basic oscillation circuit shown in Fig. 11 can be roughly found by using the following formula.

$C_L = \{C1\ C2 / (C1 + C2)\} + C_S + C_{IC}$

CS: Stay capacitance, CIC: IC's input/output capacitance

CL: Load capacitance, C1 = C2 = Capacitor which is connected

For example, when CS = 2 pF, CIC = 4 pF, C1 = C2 = 20 pF, calculated load capacitance (CL) gives CL = 16 pF. In such a case, it is essential to use a crystal unit with a center frequency designed to oscillate with CL = 16 pF.

1-2 Oscillation circuit, oscillation margin and check method

Fig. 9 (p. 27) shows a crystal unit and oscillation circuit when oscillation has started and reached a stable condition. This indicates a series circuit with negative resistance –R and load capacitance CL. The crystal unit side becomes equivalent to a series circuit with the effective inductance, X = ωLe, and the effective resistance Re (corresponding to R1 in p. 6). In this case, it is necessary to satisfy the following conditions simultaneously for oscillation.

(1) Phase condition: $\omega Le = 1 / \omega C_L = 0$

(2) Amplitude condition: Re ≤ l –R l (–R is negative resistance)

(1) Phase condition fixes the oscillation frequency, and this is determined by load capacitance CL as mentioned above.

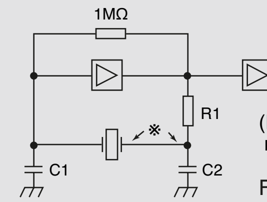
(2) The correct amplitude condition is essential to obtain a stable oscillation frequency for start-up and to ensure continuous oscillation.

It is necessary to design the circuit so that the absolute value of the negative resistance (–R) of the circuit is sufficiently higher than the effective resistance (Re) at the time of start-up. The higher the negative resistance, the higher the performance, i.e. the greater the oscillation margin of the oscillation circuit.

(Oscillation margin) = l –R l – (Re)

Although the required oscillation margin value is significantly affected by the choice of product application, environmental conditions, frequency or crystal' s model name and characteristics, common minimum values are 300 to 3000 Ω.

Check and ensure the oscillation margin, if not the crystal unit will not function as a crystal unit in the oscillation circuit.



(For circuit constants, refer to p. 7 of the material.)

Fig. 11 Example of Crystal Oscillation Circuit

– A simple test to check an oscillation circuit –

Insert a fixed resistor corresponding to the desired oscillation margin to a crystal unit in series. (See the position with the * mark in Fig. 11) Then, switch on & off several times. Make sure that oscillation starts each time without any delay. (In this case, because of the series connection, oscillation frequency is not the same as nominal frequency.) In this test, if oscillation does not start, there is a delay or oscillation is unstable, it can be assumed that the amplitude condition mentioned before is not sufficiently satisfied, and the composition of the oscillation circuit is wrong and requires improvement. If oscillation starts easily and is stable, then, remove the inserted fixed resistance and use the circuit.

1-3 Drive level of a crystal unit

Table 1 in p. 25 shows the mechanical oscillation modes of a crystal unit. However, without some limitation on the mechanical vibrations of a crystal unit, continuity of frequency may be lost at specific temperatures, or the effective resistance of the crystal unit may increase; therefore, use the crystal unit at an appropriate drive level.

When high frequency stability is required for such applications as mobile communications, it is recommended for use in the range between 10 μW and 100 μW.

1-4 Frequency / temperature characteristics

Frequency / temperature characteristics of a crystal unit used alone are different from those of a unit installed as an oscillator. If the standards for frequency / temperature characteristics of oscillation circuits are narrowed, some circuits may not meet the standards. This is because not only crystal units but also oscillation circuits have temperature / frequency characteristics. In such cases, it will be necessary to carefully check the frequency / temperature characteristics of the oscillation circuit to be used, and then place an order for a crystal unit with frequency / temperature characteristics capable of correcting the difference (see Fig. 12).

If more strict specifications are required, we recommend that you use a temperature-compensated crystal oscillator. Refer to our technical data sheet on crystal oscillators.

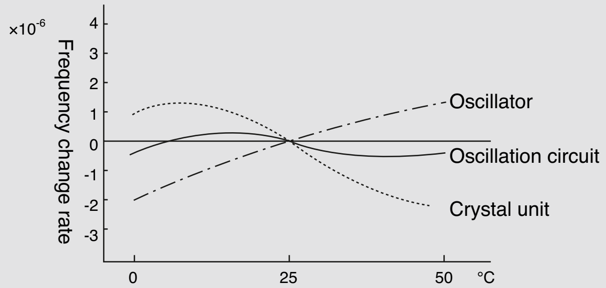


Fig. 12 Influence Exerted on Frequency / Temperature Characteristics by a Circuit

■ Precautions for Use

2. To satisfy functional performance requirements

According to the particular internal structure, the inside of the holder of a crystal unit is evacuated or filled with inert gas to maintain its characteristics.

2-1 Mounting of surface-mount type crystal unit

(1) Severe temperature change
Under prolonged and repeated severe temperature changes solder may crack; this is caused by expansion due to the different temperature coefficients of the print wire board material and surface-mount type crystal unit ceramic package.
If such conditions are anticipated and to avoid such problems, please contact us beforehand for temperature conditions, etc.

(2) Shock from automatic mounting
Please take note, during automatic mounting, such processes as adsorption, chucking, or mounting to the circuit board, may administer too great a mechanical shock to the crystal unit, and the electrical characteristics may change or deteriorate.

(3) Stress caused by bending the PC board
If after a crystal unit is soldered to the PC board, the board is bent, the mechanical stress may cause the soldered part to peel away or the crystal unit package to crack.

(4) Grounding terminal
If the crystal unit is provided with a grounding terminal, be sure to solder it to GND or to the power supply terminal. If it is not grounded, the correct frequency may not be obtained.

2-2 Soldering and ultrasonic cleaning

The soldering temperature conditions of a crystal unit are designed so as to allow the simultaneous processing of other electronic components, but depending upon the product type the conditions may be subject to restrictions. Confirm the conditions prior to use. Basically, the ultrasonic cleaning of flux is allowed, but in some cases, the resonance with the oscillation frequency of the ultrasonic wave cleaner might cause the characteristics of the crystal unit to deteriorate. Please check all conditions before cleaning.

2-3 Effect of corrosive materials

When a crystal unit contacts salt or corrosive materials or is exposed for long periods to certain substances in the atmosphere such as chloride or sulfide-based gases, this may cause a serious flaw such as the package losing its airtight seal due to corrosion.
Exercise great care when selecting an adhesive or potting agent to be used at the perimeter of a crystal unit.

2-4 Mounting a lead-mount type crystal unit

(1)Mount a crystal unit on the PC board so that the height of the unit is lower than those of other parts; this will prevent the holder-base glass from breakage caused by shocks given from the upper side. Breakage of the glass may affect the airtight seal causing a deterioration of performance.

(2) When mounting a lead-mount type crystal unit in contact with a PC board, the distance between the holes on the PC board should equal the distance between the terminals of the crystal unit to be mounted.
The slightest error in pitch may cause cracks in the glass section of the crystal unit holder.

(3) When mounting a lead-mount type crystal unit, we recommend that the unit should make contact with the PC board and be soldered in such a way as to prevent fatigue and breakage of the leads due to mechanical resonance (see Fig. 13).

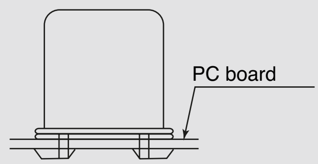


Fig. 13 Crystal Unit Mounting Method

(4) After installation of a crystal unit on a PC board, moving the unit as shown in Fig. 14 causes the holder-base glass to crack resulting in the deterioration of characteristics. Do not move the crystal unit in this way.

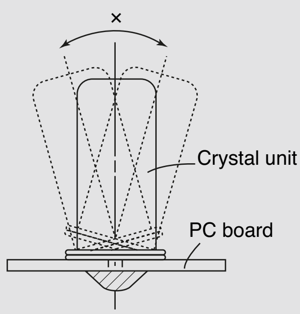


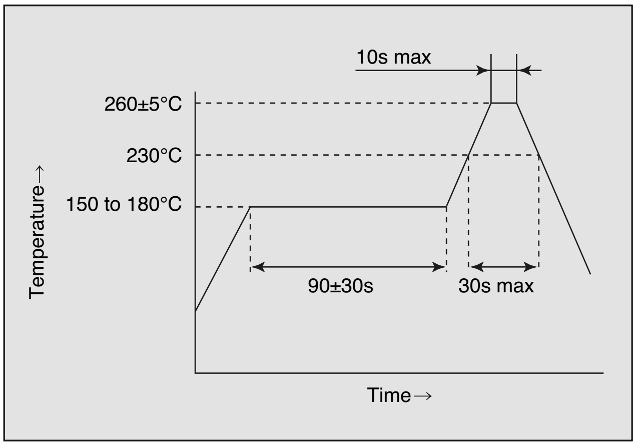
Fig. 14 Care to be Taken After Mounting a Crystal Unit

■ Precautions for Use

3. Reflow Soldering

The figure below shows the standards for reflow soldering temperature profiles of surface-mount type crystal units.

• Examples of soldering conditions



●Soldering conditions
Peak-temperature: 260±5 °C   Max. 10 seconds
Heating conditions: Min 230 °C Max. 30 seconds
Warm-up rate: Max. 3 °C/second
Cool-down rate: Max. 6 °C/second
Preheating conditions: 150 to 180 °C 90 ±30 seconds

Precautions

Never use these products under any conditions that exceed the following limits; such use may cause the product’ s characteristics to deteriorate or the product may break.

Heat Resistance of SMD Crystal Products
[Reflow Soldering Heat Resistance]
Peak-temperature: 265 °C, 10 sec.
Heating conditions: Min. 230 °C, 40 sec.
Warm-up rate: 3 °C/second
Cool-down rate: 6 °C/second
Preheating conditions: 150 to 180 °C, 120 seconds
Number of reflow passes: 2

[Manual Soldering Heat Resistance]
Use condition: Apply 400 °C soldering iron to product terminal electrode for 4 seconds.
Number of applications: 2

(1) Glass-sealed product
When using a soldering iron for soldering glass-sealed products, apply the iron tip below the sealed part to prevent the iron touching the sealed glass part
(if the iron tip touches the glass part, the glass may melt and the inner airtight seal may be destroyed).

(2) Au/Sn-sealed product
Do not touch the tip of a soldering iron to the sealed part of an Au/Sn-sealed product.
(The iron tip may melt the sealant and break the airtight seal.)
In addition, if possible, it is recommended that this product it to be mounted with reflow without using a soldering iron or an air-heater.
In purpose of reworking crystal unit, during removing from the board or module, or removing module from board, any excessive heat may melt the Au/Sn sealant, resulting in the deterioration of characteristics or the breaking of the airtight seal. Therefore, please handle this product with particular care to the above precautions. However, in case an air-heater is need to be used, do not exceed below heating conditions.
Air-heater temperature: 280 °C, time: 10 seconds

Heat Resistance of Crystal Products other than SMD
[Reflow Soldering Heat Resistance]
Soldering temperature: 265 °C, 10 sec.
Number of flow applications: 2
[Manual Soldering Heat Resistance]
Use conditions: Apply 400 °C soldering iron to product terminal electrode for 4 seconds.
Number of applications: 2

4. PC boards

When mounting SMD crystal devices on glass epoxy boards, FR-4 (JIS:GE) is recommended; it is hard to crack during soldering.