# 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 ≤ | –R | (–R is negative resistance)

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

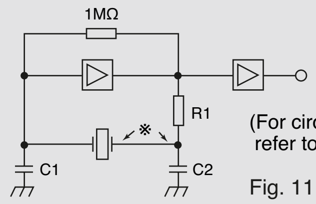
(2) The correct amplitude condition is essential to obtain a stable oscillation frequency for start-up and to ensure continuous oscillation.

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) = | –R | – (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 $\mu$W and 100 $\mu$W.

**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.

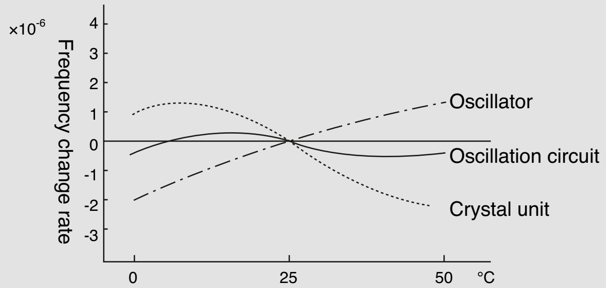



Fig. 12 Influence Exerted on Frequency / Temperature Characteristics by a Circuit