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## TECHNICAL TERMS

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The following technical terms are generally used for crystal oscillators:

**Nominal frequency:** Nominal output frequency of a crystal oscillator

**Frequency tolerance:** Deviation from the nominal frequency expressed in terms of ppm

**Operating temperature range:** Temperature range within which output frequencies and other output signal characteristics meet the specifications

**Operable temperature range:** Temperature range within which crystal oscillators are still operable despite the failure to meet the specifications

**Temperature characteristics (Frequency Stability):** Rate of output frequency change at normal temperature ( $+25\pm 2^\circ\text{C}$ ) given when only temperature is changed, with the other conditions kept constant.

**Frequency vs power source variation characteristics:**

Rate of output frequency change given when only power source voltage is changed, with the other conditions unchanged.

**Short-term frequency stability:** Average of irregular output frequency fluctuations. There are several measurement methods which provide different points of view regarding irregularity. For crystal oscillators, either the definition in the frequency domain or the definition in the time domain shall be selected.

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## CRYSTAL OSCILLATORS

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Crystal oscillators are classified into the following four types.

### ■ Simple packaged crystal oscillator (SPXO)

The characteristic between frequency and temperature is the sum of temperature characteristic of crystal oscillator in use (3-dimensional-curves because AT-cut vibrators are used in most cases) and temperature characteristic of oscillating circuit (characteristic that can be regarded nearly as linear), showing 3-dimensional curves, as a result. To improve overall characteristic between frequency and temperature, temperature compensating capacitors are used in some case for the purpose of compensating inclined temperature characteristic of the circuit as shown in Figure 1.

As said above, simple packaged type crystal oscillators cover various wide temperature ranges from  $\pm 5 \times 10^{-6}$  to  $\pm 1000 \times 10^{-6}$ .

These oscillators are mainly used as the reference oscillators for micro-communication devices, broadcasting devices and measuring instruments.

### ■ Temperature compensated crystal oscillator (TCXO)

The temperature characteristic of crystal oscillators mostly depends on that of quartz resonators, generally indicating 3-dimensional curves (AT-cut). To secure a satisfactory temperature characteristic, it is necessary to maintain the ambient temperature of crystal units constant by limiting the range of working temperature or using a constant temperature oven.

Temperature compensated crystal oscillators are designed to secure satisfactory temperature characteristic covering a wide range by incorporating temperature compensating circuits, the above said conditions being taken into consideration.

There are two types of temperature compensated crystal oscillators. One is the type combined with resistances or capacitors, using thermistors as thermo-sensitive devices, and the other is the type forming temperature compensated circuits using the elements contained in LSI circuits as thermo-sensitive devices. As far as large-scale temperature compensated circuits are concerned, the whole oscillating circuits are integrated in one chip. Although depending on the combination of compensated circuits and specified temperature range, the temperature characteristic shows 3-dimensional to 5-dimensional curves. (See Figure 2.)

These crystal oscillators consuming less electric power with satisfy a short time. These crystal oscillators are used for various types of communication devices (mobile telephones, global position systems, land mobile radios, microwave communications equipment and satellite communication system), and also used as the reference oscillators for measuring instruments including frequency counters, synthesizers, etc..

### ■ Voltage-controlled crystal oscillator (VCXO)

Voltage-controlled crystal oscillators vary diode capacity using the voltage impressed from the outside by inserting variable capacity diodes in series to crystal units to obtain variable frequencies meeting the load capacity characteristic of crystal between the voltage impressed to variable capacity diodes, and the combinations between crystal units capacity characteristic and oscillation frequencies are taken into consideration. Consequently, a wide range of frequency variation and satisfactory frequency linearity are obtainable. The frequency band also covers a wide range from 0.6 to 670MHz.

The temperature characteristic of these crystal oscillators is same as that of simple packaged crystal oscillators (SPXOs), the sum of the temperature characteristic of crystal units and the temperature characteristic of oscillating circuits, forming 3-dimensional curves.

These crystal oscillators are mainly used for transmitters, exchangers, PLLs, FM modulators, sweep generators, etc.

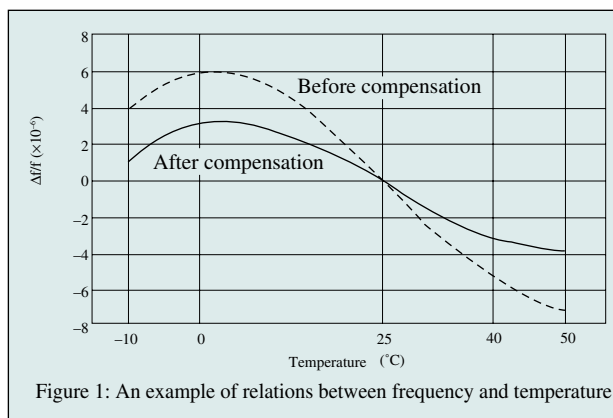


Figure 1: An example of relations between frequency and temperature

### ■ Oven-controlled crystal oscillator (OCXO)

Oven-controlled crystal oscillators maintain the ambient temperature of crystal units constant by constant temperature ovens, provided with better temperature characteristic compared to other crystal oscillators.

The temperature characteristic of these crystal oscillators (AT-cut) is the temperature inside the ovens set at the zero temperature coefficient point high-temperature side of 3-dimensional curves), and this temperature is almost determined by the position of crystal oscillators contained inside the ovens, and the temperature characteristic of constant temperature ovens.

In addition, the lower limit of operating temperature range is determined by the maximum value of electric power consumption, and the upper limit is determined by the setup temperature of constant temperature ovens and the thermal contribution rate of electric power consumed in the circuits.

The oven-controlled crystal oscillators introduced in this leaflet are generally called highly stabilized crystal oscillators.

To obtain high frequency stability, crystal units with a frequency range of 4-70MHz are used. Highly stabilized crystal oscillators with a frequency range up to 200MHz are produced on a commercial basis by continuous multiplication.

The quartz resonators used for these oscillators are the products developed and manufactured using high technologies in an excellent environment. Use of these excellent crystal units enables manufacturing crystal oscillators with various characteristics including frequency aging characteristic, short-term stability, frequency reproducibility, phase noise and temperature characteristic. These oven-controlled crystal oscillators are optimum for various communication devices used in mobile bases and for various electronic measuring instruments including frequency counters, spectrum analyzers, etc.

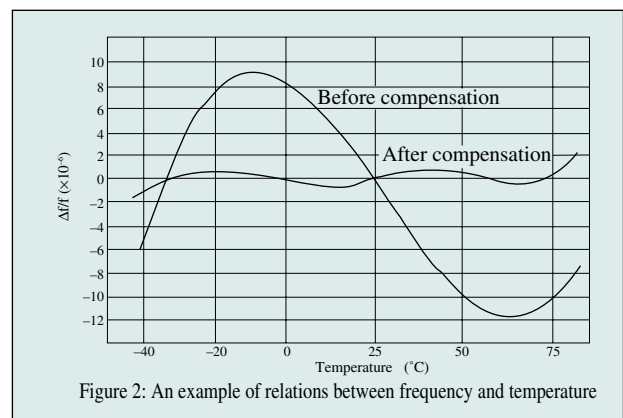


Figure 2: An example of relations between frequency and temperature