



JAPANESE
INDUSTRIAL
STANDARD

Translated and Published by
Japanese Standards Association

JIS C 6710 : 2007

(IEC 60679-1 : 1997, Amd.1 : 2002, Amd.2 : 2003)
(QIAJ/JSA)

Generic specification of crystal controlled oscillators

ICS 31.140

Reference number : JIS C 6710 : 2007 (E)

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Foreword

This translation has been made based on the original Japanese Industrial Standard revised by the Minister of Economy, Trade and Industry through deliberations at the Japanese Industrial Standards Committee as the result of proposal for revision of Japanese Industrial Standard submitted by Quartz Crystal Industry Association of Japan (QIAJ)/Japanese Standards Association (JSA) with the draft being attached, based on the provision of Article 12 Clause 1 of the Industrial Standardization Law applicable to the case of revision by the provision of Article 14.

Consequently **JIS C 6710:1999** is replaced with this Standard.

This revision has been made based on **IEC 60679-1:1997** *Quartz crystal controlled oscillators of assessed quality—Part 1: Generic specification*, Amendment 1 (2002) and Amendment 2 (2003), for the purpose of making it easier to compare this Standard with International Standard; to prepare Japanese Industrial Standard conforming with International Standard; and to propose a draft of an International Standard which is based on Japanese Industrial Standard.

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Date of Establishment: 1990-06-01

Date of Revision: 2007-08-20

Date of Public Notice in Official Gazette: 2007-08-20

Investigated by: Japanese Industrial Standards Committee

Standards Board

Technical Committee on Electronics Technology

JIS C 6710:2007, First English edition published in 2008-03

Translated and published by: Japanese Standards Association
4-1-24, Akasaka, Minato-ku, Tokyo, 107-8440 JAPAN

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the original JIS is to be the final authority.

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Printed in Japan

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Generic specification of crystal controlled oscillators

Introduction This Japanese Industrial Standard has been prepared based on the second edition of **IEC 60679-1** *Quartz crystal controlled oscillators of assessed quality—Part 1: Generic specification* published in 1997, and Amendment 1 (2002, Latch-up test/ Electrostatic discharge sensitivity classification) and Amendment 2 (2003, Phase jitter) without modifying the technical contents. However, the amendments has been edited and combined.

1 General

1.1 Scope This Standard specifies the methods of test and general requirements for quartz crystal controlled oscillators of assessed quality using either capability approval or qualification approval procedures based on **IEC** electronic components quality assessment system (IECQ).

NOTE : The International Standard corresponding to this Standard is as follows.

In addition, symbols which denote the degree of correspondence in the contents between the relevant International Standard and **JIS** are **IDT** (identical), **MOD** (modified), and **NEQ** (not equivalent) according to **ISO/IEC Guide 21**.

IEC 60679-1 : 1997 *Quartz crystal controlled oscillators of assessed quality—Part 1: Generic specification* (Amendment 1, 2) (**IDT**)

1.2 Normative references The following standards contain provisions which, through reference in this text, constitute provisions of this Standard. If the indication of the year of coming into effect/publication is given to these referred standards, only the edition of indicated year constitutes the provision of this Standard but the revision and amendment made thereafter do not apply. The normative references without the indication of the year of coming into effect/publication apply only to the most recent editions (including amendments).

JIS C 0025 *Basic environmental testing procedures Part 2: Tests Test N: Change of temperature*

NOTE : IEC 60068-2-14 : 1984 *Environmental testing—Part 2: Tests. Test N: Change of temperature* is identical with the said standard.

JIS C 0617-2 *Graphical symbols for diagrams—Part 2: Symbol elements, qualifying symbols and other symbols having general application*

NOTE : IEC 60617-2 : 1996 *Graphical symbols for diagrams—Part 2: Symbol elements, qualifying symbols and other symbols having general application* is identical with the said standard.

JIS C 0617-3 *Graphical symbols for diagrams—Part 3: Conductors and connecting devices*

NOTE : IEC 60617-3:1996 *Graphical symbols for diagrams—Part 3: Conductors and connecting devices* is identical with the said standard.

JIS C 60617-4 *Graphical symbols for diagrams—Part 4: Passive components*

NOTE : IEC 60617-4:1996 *Graphical symbols for diagrams—Part 4: Passive components* is identical with the said standard.

JIS C 60068-1 *Environmental testing Part 1: General and guidance*

NOTE : IEC 60068-1:1988 *Environmental testing—Part 1: General and guidance* and Amendment 1:1992 are identical with the said standard.

JIS C 60068-2-1 *Environmental testing procedures Part 2: Tests, Test A: Cold*

NOTE : IEC 60068-2-1:1990 *Environmental testing—Part 2: Tests—Test A: Cold*, Amendment 1:1993 and Amendment 2:1994 are identical with the said standard.

JIS C 60068-2-2 *Basic environmental testing procedures Part 2: Tests, Test B: Dry heat*

NOTE : IEC 60068-2-2:1974 *Environmental testing—Part 2: Tests—Test B: Dry heat*, Amendment 1:1993 and Amendment 2:1994 are identical with the said standard.

JIS C 60068-2-3 *Basic environmental testing procedures Part 2: Tests, Test Ca: Damp heat, steady state*

NOTE : IEC 60068-2-3:1969 *Environmental testing—Part 2: Tests—Test Ca: Damp heat, steady state* is identical with the said standard.

JIS C 60068-2-6 *Environmental testing Part 2: Tests—Test Fc: Vibration (sinusoidal)*

NOTE : IEC 60068-2-6:1995 *Environmental testing—Part 2: Tests—Test Fc: Vibration (sinusoidal)* is identical with the said standard.

JIS C 60068-2-7 *Basic environmental testing procedures Part 2: Tests—Test Ga and guidance: Acceleration, steady state*

NOTE : IEC 60068-2-7:1983 *Environmental testing—Part 2: Tests—Test Ga: Acceleration, steady state* and Amendment 1:1986 are identical with the said standard.

JIS C 60068-2-13 *Basic environmental testing procedures Part 2: Tests, Test M: Low air pressure*

NOTE : IEC 60068-2-13:1983 *Environmental testing—Part 2: Tests—Test M: Low air pressure* is identical with the said standard.

JIS C 60068-2-17 *Basic environmental testing procedures—Part 2: Tests—Test Q: Sealing*

NOTE : IEC 60068-2-17:1994 *Basic environmental testing procedures—Part 2: Tests—Test Q: Sealing* is identical with the said standard.

JIS C 60068-2-20 *Basic environmental testing procedures Part 2: Tests, Test T: Soldering*

NOTE : IEC 60068-2-20:1979 *Environmental testing—Part 2: Tests—Test T: Soldering* and Amendment 2:1987 are identical with the said standard.

JIS C 60068-2-21 *Environmental testing—Part 2-21: Tests—Test U: Robustness of termination and integral mounting devices*

NOTE : IEC 60068-2-21:1983 *Environmental testing—Part 2: Tests—Test U: Robustness of terminations and integral mounting devices* is identical with the said standard.

JIS C 60068-2-27 *Basic environmental testing procedures—Part 2: Tests—Test Ea and guidance: Shock*

NOTE : IEC 60068-2-27:1987 *Environmental testing. Part 2: Tests. Test Ea and guidance: Shock* is identical with the said standard.

JIS C 60068-2-29 *Basic environmental testing procedures Part 2: Tests Test Eb and guidance: Bump*

NOTE : IEC 60068-2-29:1987 *Environmental testing—Part 2: Tests—Test Eb and guidance: Bump* is identical with the said standard.

JIS C 60068-2-30 *Basic environmental testing procedures Part 2: Tests Test Db: Damp heat, cyclic (12 + 12-Hour cycle)*

NOTE : IEC 60068-2-30:1980 *Environmental testing—Part 2: Tests—Test Db and guidance: Damp heat, cyclic (12 h + 12 h cycle)* and Amendment 1:1985 are identical with the said standard.

JIS C 60068-2-32 *Environmental testing Part 2: Tests. Test Ed: Free fall*

NOTE : IEC 60068-2-32:1975 *Environmental testing—Part 2: Tests—Test Ed: Free fall* and Amendment 2:1990 are identical with the said standard.

JIS C 60068-2-45 *Environmental testing procedures of electronic and electrical resistance to solvents (immersion in cleaning solvents)*

NOTE : IEC 60068-2-45:1980 *Environmental testing—Part 2: Tests—Test XA and guidance: Immersion in cleaning solvents* and Amendment 1:1993 are identical with the said standard.

JIS C 60068-2-52 *Environmental testing—Part 2: Tests—Test Kb: Salt mist, cyclic (sodium, chloride solution)*

NOTE : IEC 60068-2-52:1996 *Environmental testing—Part 2: Tests—Test Kb: Salt mist, cyclic (sodium, chloride solution)* is identical with the said standard.

JIS C 60068-2-58 *Environmental testing—Part 2: Tests—Test Td: Test methods for solderability, resistance to dissolution of metallization and to soldering heat of surface mounting devices (SMD)*

NOTE : IEC 60068-2-58:2004 *Environmental testing—Part 2: Tests—Test Td: Solderability, resistance to dissolution of metallization and to soldering heat of surface mounting devices (SMD)* is identical with the said standard.

JIS Z 8202-3 *Quantities and units—Part 3: Mechanics*

NOTE : ISO 31-3:1992 *Quantities and units—Part 3: Mechanics* is identical with the said standard.

JIS Z 8203 *SI units and recommendations for the use of their multiples and of certain other units*

NOTE : ISO 1000:1992 *SI units and recommendations for the use of their multiples and of certain other units* is identical with the said standard.

IEC 60027 *Letter symbols to be used in electrical technology*

IEC 60050-561:1991 *International Electrotechnical Vocabulary (IEV)—Chapter 561: Piezoelectric devices for frequency control and selection*

IEC 60068-2-10:1988 *Environmental testing—Part 2: Tests—Test J and guidance: Mould growth*

IEC 60068-2-36:1973 *Environmental testing—Part 2: Tests—Test Fdb: Random vibration wide band Reproducibility Medium and Amendment 1 (1983)*

IEC 60469-1:1987 *Pulse techniques and apparatus—Part 1: Pulse terms and definitions*

IEC 60679-4:1997 *Quartz crystal controlled oscillators of assessed quality—Part 4: Sectional Specification—Capability approval*

IEC 60679-5:1998 *Quartz crystal controlled oscillators of assessed quality—Part 5: Sectional specification—Qualification approval*

IEC 60748-2:1997 *Semiconductor devices—Integrated circuits—Part 2: Digital integrated circuits*

IEC 60801-2:1991 *Electromagnetic compatibility for industrial-process measurement and control equipment—Part 2: Electrostatic discharge requirements*

IEC/PAS 62179:2000 *Electrostatic discharge (ESD) sensitivity testing human body model (HBM)*

IEC/PAS 62180:2000 *Electrostatic discharge (ESD) sensitivity testing machine model (MM)*

IEC QC 001001:1986 *Basic rules of IEC Quality Assessment System for Electronic Components (IECQ), Amendment 2 (1994) and Amendment 3 (1995)*

IEC QC 001002:1986 *Rules of the procedure of the IEC Quality Assessment System for Electronic Components (IECQ) and Amendment 2 (1994)*

IEC QC 001005:1996 *Register of firms, Products and Services approved under the IECQ System, including ISO 9000*

ITU-T G.810 *Definitions and terminology for synchronization networks*

ITU-T G.811 *Timing characteristics of primary reference clocks*

ITU-T G.812 *Timing requirements of slave clocks suitable for use as node clocks in synchronization networks*

ITU-T G.813 *Timing characteristics of SDH equipment slave clocks (SEC)*

ITU-T G.825 *The control of jitter and wander within digital networks which are based on the synchronous digital hierarchy (SDH)*

ITU-O.172 *Jitter and wander measuring equipment for digital systems which are based on the synchronous digital hierarchy (SDH)*

ANSI T1.101 *Synchronization Interface Standard*

ANSI T1.105.03 *Synchronous Optical Network (SONET)—Jitter and Wander at Network and Equipment Interfaces*

ETSI EN 300462 *Transmission and Multiplexing™; Generic requirements for synchronization networks*

1.3 Order of precedence Where any discrepancies occur for any reason, documents shall rank in the following order of precedence:

- detail specification;
- sectional specification (**IEC 60679-4**);
- generic specification (this Standard);
- any other international standards (for example of the **IEC**) to which reference is made.

2 Terminology and general requirements

2.1 General Units, graphical symbols, letter symbols and terminology shall, wherever possible, be taken from the following standards:

JIS C 0617-2

JIS C 0617-3

JIS C 0617-4

JIS Z 8203

IEC 60027

IEC 60050-561

IEC 60469-1

2.2 Definitions For the purpose of this Standard, the following definitions are applicable:

2.2.1 simple packaged crystal oscillator (SPXO) a crystal controlled oscillator having no means of temperature control or compensation, exhibiting a frequency/temperature characteristic determined substantially by the piezoelectric resonator employed [IEV 561-04-01]

2.2.2 overtone quartz crystal controlled oscillator an oscillator designed to operate with the controlling piezoelectric resonator functioning in a specified mechanical overtone order of vibration [IEV 561-04-02]

2.2.3 crystal cut the orientation of the crystal element with respect to the crystallographic axes of the crystal

NOTE : This definition is included as it may be desirable to specify the cut (and hence the general form of the frequency/temperature performance) of a crystal unit used in an oscillator application. The choice of the crystal cut will imply certain attributes of the oscillator which may not otherwise appear in the detail specification.

2.2.4 voltage controlled crystal oscillator (VCXO) a crystal controlled oscillator, the frequency of which can be deviated or modulated according to a specified relation, by application of a control voltage [IEV 561-04-03]

2.2.5 temperature compensated crystal oscillator (TCXO) a crystal controlled oscillator whose frequency deviation due to temperature is reduced by means of a compensation system, incorporated in the device [IEV 561-04-04]

2.2.6 oven controlled crystal oscillator (OCXO) a crystal controlled oscillator in which at least the piezoelectric resonator is temperature controlled [IEV 561-04-05]

NOTE : This mode of operation ensures that the oscillator frequency will remain sensibly constant over the operating temperature range of the OCXO, therefore independent of the frequency/temperature characteristic of the crystal unit.

2.2.7 nominal frequency the frequency used to identify the crystal controlled oscillator [IEV 561-04-06]

2.2.8 frequency tolerance the maximum permissible deviation of the oscillator frequency from a specified nominal value when operating under specified conditions [IEV 561-04-07]

NOTE : Frequency tolerances are often assigned separately to specified ambient effects, namely electrical, mechanical and environmental. When this approach is used, it is necessary to define the values of other operating parameters as well as the range of the specified variable, that is:

- deviation from the frequency at the specified reference temperature due to operation over the specified temperature range, other conditions remaining constant;
- deviation from the frequency at the specified supply voltage due to supply voltage changes over the specified range, other conditions remaining constant;
- deviation from the initial frequency due to ageing, other conditions remaining constant;
- deviation from the frequency with specified load conditions due to changes in load impedance over the specified range, other conditions remaining constant.

In some cases, an overall frequency tolerance may be specified, due to any/all combinations of operating parameters, during a specified lifetime.

2.2.9 frequency offset the frequency difference, positive or negative, which should be added to the specified nominal frequency of the oscillator, when adjusting the oscillator frequency under a particular set of operating conditions in order to minimize its deviation from nominal frequency over the specified range of operating conditions [IEV 561-04-08]

Example : In order to minimize the frequency deviation from nominal over the entire temperature range, a frequency offset may be specified for adjustment at the reference temperature (see figure 1).

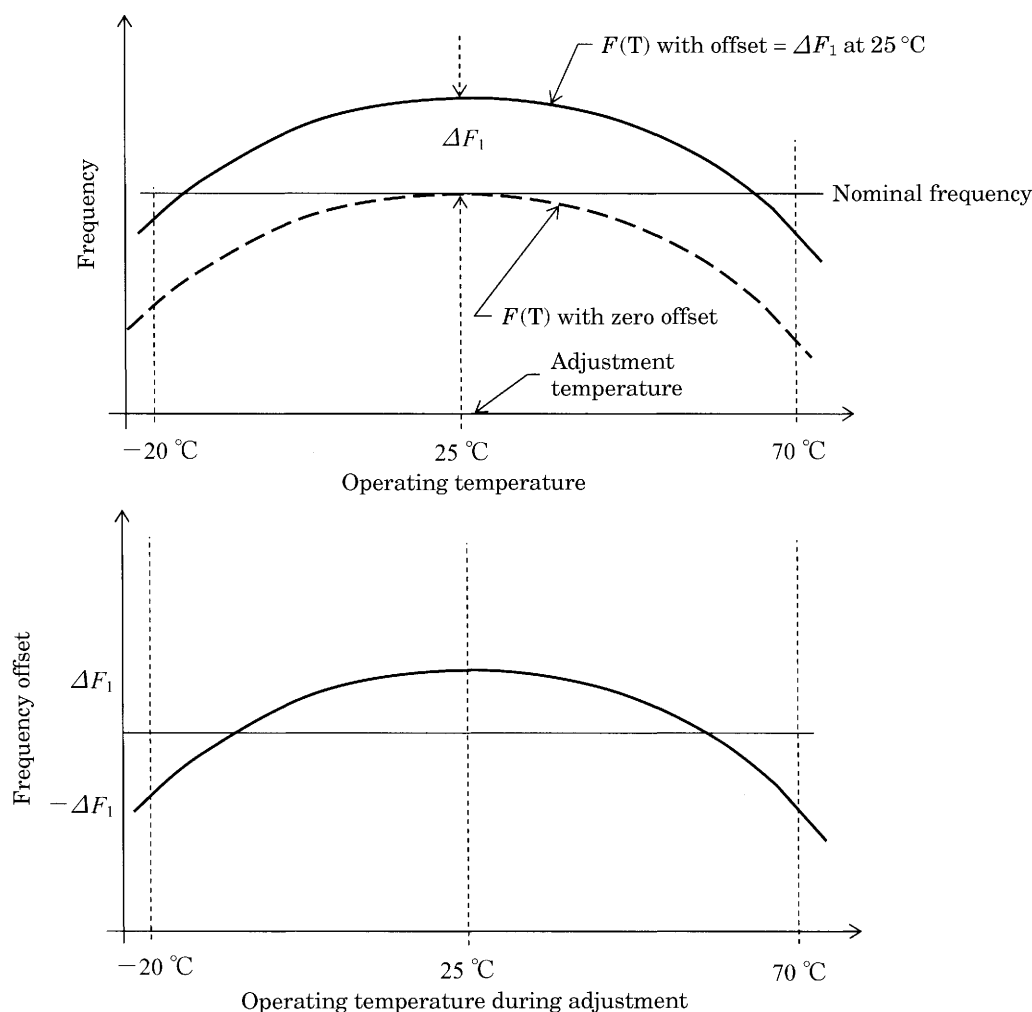


Figure 1 Example of the use of frequency offset

2.2.10 adjustment frequency the frequency to which an oscillator must be adjusted, under a particular combination of operating conditions, in order to meet the frequency tolerance specification over the specified range of operating conditions, i.e. adjustment frequency = nominal frequency + frequency offset [IEV 561-04-09]

2.2.11 frequency adjustment range the range over which the oscillator frequency may be varied by means of some variable element, for the purpose of:

- a) setting the frequency to a particular value, or

- b) to correct the oscillator frequency to a prescribed value after deviation due to ageing, or other changed conditions. [IEV 561-04-10]

2.2.12 storage temperature range the minimum and maximum temperatures as measured on the enclosure at which the crystal controlled oscillator may be stored without deterioration or damage to its performance

2.2.13 operating temperature range the range of temperature over which the oscillator will function, maintaining frequency and other output signal characteristics within specified tolerances [IEV 561-04-11]

2.2.14 operable temperature range the range of temperature over which the oscillator will continue to provide an output signal, though not necessarily within the specified tolerances of frequency, level, waveform, etc. [IEV 561-04-12]

2.2.15 reference temperature the temperature at which certain oscillator performance parameters are measured, normally $25\text{ °C} \pm 2\text{ °C}$

2.2.16 reference point temperature the temperature measured at a specific reference point relative to the oscillator

2.2.17 thermal transient frequency stability the oscillator frequency time response when ambient temperature is changed from one specific temperature to another with a specific rate

2.2.18 stabilization time the time, measured from the initial application of power, required for a crystal controlled oscillator to stabilize its operation within specified limits [IEV 561-04-13]

2.2.19 frequency/voltage coefficient the fractional change in output frequency resulting from an incremental change in supply voltage, other parameters remaining unchanged [IEV 561-04-14]

NOTE 1 In the case of OCXOs, a considerable time may elapse before the full effect of a supply voltage change is observed, as the temperature of the oven may drift gradually to a new value following the voltage perturbation.

NOTE 2 In the case of crystal controlled oscillator, the frequency/voltage coefficient may be called “supply voltage coefficient”.

2.2.20 frequency/load coefficient the fractional change in output frequency resulting from an incremental change in electrical load impedance, other parameters remaining unchanged [IEV 561-04-15]

NOTE : In the case of crystal controlled oscillator, the frequency/load coefficient may be called “load coefficient”.

2.2.21 long-term frequency stability (frequency ageing) the relationship between oscillator frequency and time

This long-term frequency drift is caused by secular changes in the crystal unit and/or other elements of the oscillator circuit, and should be expressed as fractional change in mean frequency per specified time interval.

2.2.22 short-term frequency stability the random fluctuations of the frequency of an oscillator over short periods of time [IEV 561-04-16]

2.2.23 Allan variance of fractional frequency fluctuation An unbiased estimate of the preferred definition in the time domain of the short-term stability characteristic of the oscillator output frequency:

$$\sigma_y^2(\tau) \cong \frac{1}{M-1} \sum_{k=1}^{M-1} \frac{(Y_{k+1} - Y_k)^2}{2}$$

where

Y_k : the average fractional frequency fluctuations obtained sequentially, with no systematic dead time between measurements;

τ : the sample time over which measurement is averaged;

M : the number of measurements.

The confidence on the estimate improves as M increases.

2.2.24 RMS fractional frequency fluctuation a measure in the time domain of the short-term frequency stability of an oscillator, based on the statistical properties of a number of frequency measurements, each representing an average of the frequency over the specified sampling interval τ

The preferred measure of fractional frequency fluctuation is:

$$\frac{\Delta F}{F_0}(\tau)_{rms} = \left[\frac{1}{2(M-1)} \sum_{k=1}^{M-1} (Y_{k+1} - Y_k)^2 \right]^{1/2} = \left[\sigma_y^2(\tau) \right]^{1/2}$$

2.2.25 phase noise the frequency-domain measure of the short-term frequency stability of an oscillator, normally expressed as the power spectral density of the phase fluctuations, $S_\varphi(f)$, where the phase fluctuation function is $\varphi(t) = 2\pi Ft - 2\pi F_0 t$

The spectral density of phase fluctuation can be directly related to the spectral density of frequency fluctuation by:

$$S_\varphi(f) = \left(\frac{F_0}{f} \right)^2 S_y(f) \quad \text{radian}^2 \text{ per hertz}$$

where

F : the oscillator frequency;

F_0 : the average oscillator frequency;

f : the Fourier frequency.

2.2.26 spectral purity the measure of frequency stability in the frequency domain usually represented as the signal side noise power spectrum expressed in decibels relative to total signal power, per hertz bandwidth

It includes non-deterministic noise power, harmonic distortion components and spurious signal frequency interferences.

2.2.27 incidental frequency modulation the optional measure of frequency stability in the frequency domain

Incidental frequency modulation is best described in terms of the spectrum of the resultant base-band signal obtained by applying the oscillator signal to an ideal discriminator circuit of specified characteristics. If the detection bandwidth is adequately specified, the incidental frequency modulation may be expressed as a fractional proportion of the output frequency (for example 2×10^{-8} r.m.s. in a 10 kHz band).

NOTE : In the case of crystal controlled oscillator, the term “residual FM” may be used for “incidental frequency modulation”.

2.2.28 amplitude modulation distortion the non-linear distortion in which the relative magnitudes of the spectral components of the modulating signal waveform are modified

It is also commonly known as frequency distortion, amplitude distortion and amplitude/frequency distortion.

2.2.29 linearity of frequency modulation deviation measure of the transfer characteristic of a modulation system as compared to an ideal (straight line) function, usually expressed as an allowable non-linearity in per cent of the specified full range deviation. Modulation linearity can also be expressed in terms of the permissible distortion of base-band signals produced by the modulation device (for example, intermodulation and harmonic distortion products not to exceed -40 dB relative to the total modulating signal power).

Example : Figure 2 is a plot of the output frequency of a typical modulated oscillator specified to have a modulation characteristic of 133.3 Hz/V over a range of ± 3 V, with an allowed non-linearity of $\pm 5\%$. Curve D is the actual characteristic compared with the ideal (curve A) and the limits (curves B and C).

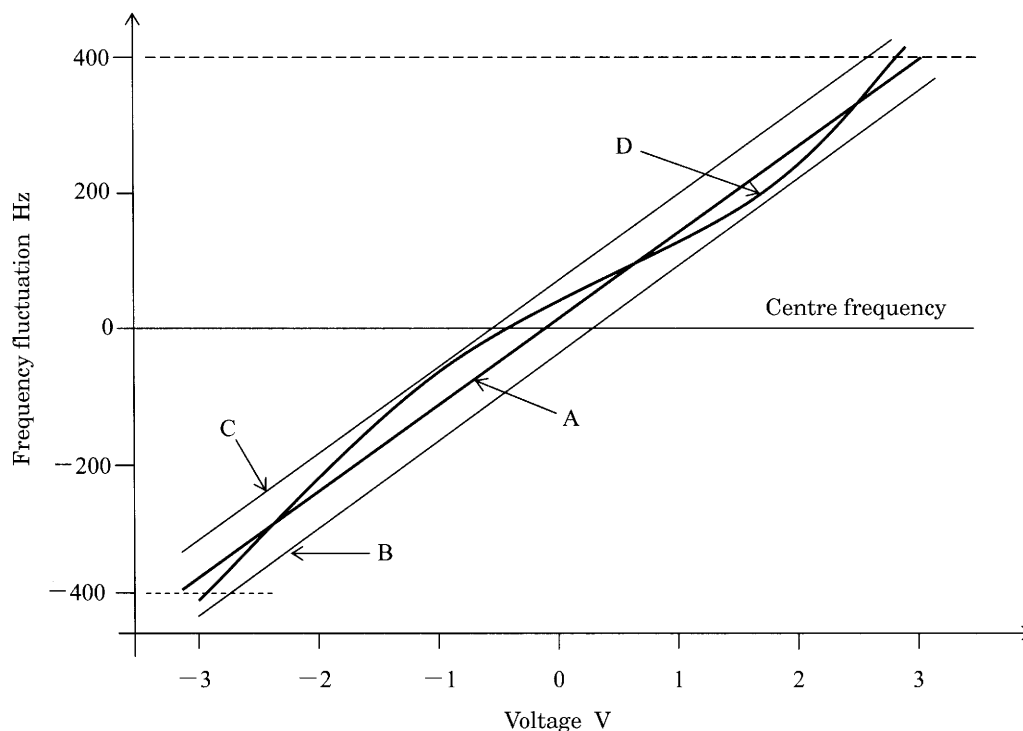


Figure 2 Typical frequency fluctuation characteristics

2.2.30 harmonic distortion the non-linear distortion characterized by the generation of undesired spectral components harmonically related to the desired signal frequency

Each harmonic component is usually expressed as a power ratio (in decibels) relative to the output power of the desired signal.

2.2.31 spurious oscillations the discrete frequency spectral components, non-harmonically related to the desired output frequency, appearing at the output terminal of an oscillator

These components may appear as symmetrical sidebands or as signal spectral components, depending upon the mode of generation. Spurious components in the output spectrum are usually expressed as a power ratio (in decibels) with respect to the output signal power.

2.2.32 pulse duration the duration between pulse start time and pulse stop time (see figure 3) [IEC 60469-1]

2.2.33 rise time the time interval required for the leading edge of a waveform to change between two defined levels

These levels may be two logic levels V_{OL} and V_{OH} or 10 % to 90 % of its maximum amplitude ($V_{HI} - V_{LO}$), or any other ratio defined in the detail specification (see figure 3).

where

V_{OL} : the low level output voltage;

V_{OH} : the high level output voltage;

V_{HI} : the upper flat voltage of the pulse waveform;

V_{LO} : the low flat voltage of the pulse waveform.

2.2.34 decay (or fall) time the time interval required for the trailing edge of a waveform to change between two defined levels

These levels may be two logic levels V_{OH} and V_{OL} or 90 % to 10 % of its maximum amplitude ($V_{HI} - V_{LO}$), or any other ratio as defined in the detail specification (see figure 3).

2.2.35 tri-state output an output stage which may be enabled or disabled by the application of an input control signal

In the disable mode the output impedance of the gate is set to a high level permitting the application of test signals to following stages.

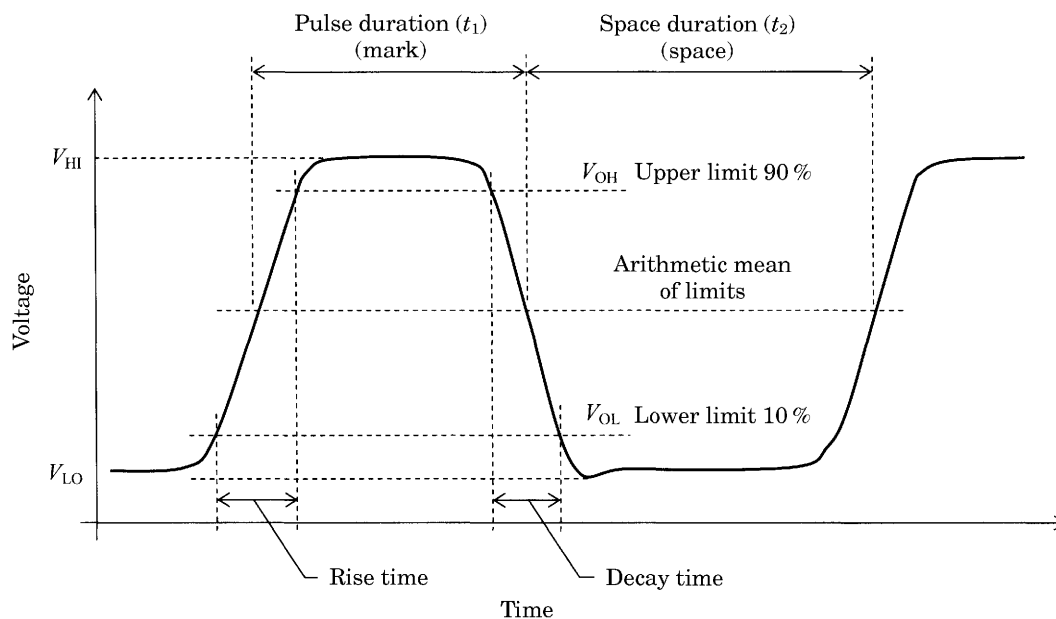


Figure 3 Characteristics of an output waveform

2.2.36 symmetry (mark/space ratio or duty cycle) the ratio between the time (t_1), in which the output voltage is above a specified level, and the time (t_2), in which the output voltage is below the specified level, in percent of the duration of the full signal period

The specified level may be the arithmetic mean between levels V_{OL} and V_{OH} , or 50 % of the peak-to-peak amplitude (see figure 3).

The ratio is expressed as:

$$\frac{100t_1}{t_1 + t_2} \cdot \frac{100t_2}{t_1 + t_2}$$

2.2.37 retrace characteristics the ability of an oscillator to return, after a specified time period, to a previously stabilised frequency, following a period in the energised condition

2.2.38 start-up time the time difference t_{SU} between the application of the supply voltage to the oscillator and the time when the r.f. output signal of desired frequency controlled by the quartz resonator fulfils specific conditions which are given below

- Quasi-sinusoidal waveforms** The signal envelope is 90 % of the steady-state peak-to-peak amplitude (see figure 20).
- Pulse waveforms** The output pulse sequence is periodical near the steady-state frequency while its low level V_{LO} remains below V_{OL} and its high level V_{HI} exceeds V_{OH} permanently, where V_{OH} and V_{OL} are defined by the applicable logic family.

NOTE : The output signal may show spurious oscillations prior to the appearance of the steady-state signal.

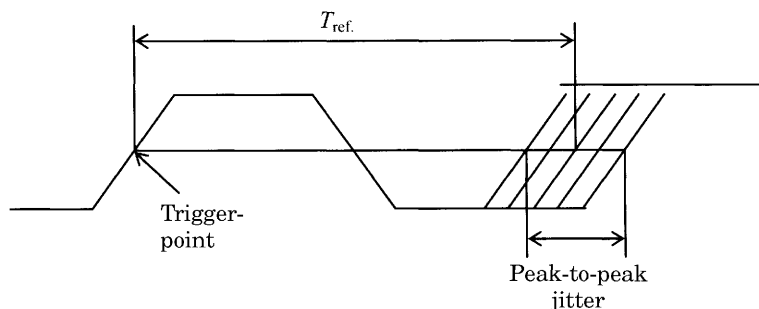
2.2.39 phase jitter phase jitter is the short-term variation of the zero crossings of the oscillator output signal from their ideal position in time (see figure 4)

Phase jitter is defined as phase variation $\Delta\varphi$ with frequency components greater than or equal to 10 Hz. Variations slower than 10 Hz are called “wander”. Excessive jitter can increase the bit error rate (BER) of a communication signal by incorrectly transmitting a data-stream and can cause synchronisation problems.

The corresponding variation of the period length

$$\Delta T = \Delta\varphi / (2\pi f_C)$$

is called “period jitter” (f_C is the clock frequency).



NOTE : T_{ref} is the period of an ideal reference signal.

Figure 4 Clock signal with phase jitter

The jitter amplitude is usually referred to the Unit Interval (UI) of one data bit-width (e.g. UI = 6.43 ns for 155.52 Mbit/s for STM-1/OC-3) or defined as absolute time variation (in nanoseconds, picoseconds or femtoseconds). It is quantified either as the peak-to-peak value, or as the r.m.s. value thereof (see figure 5).

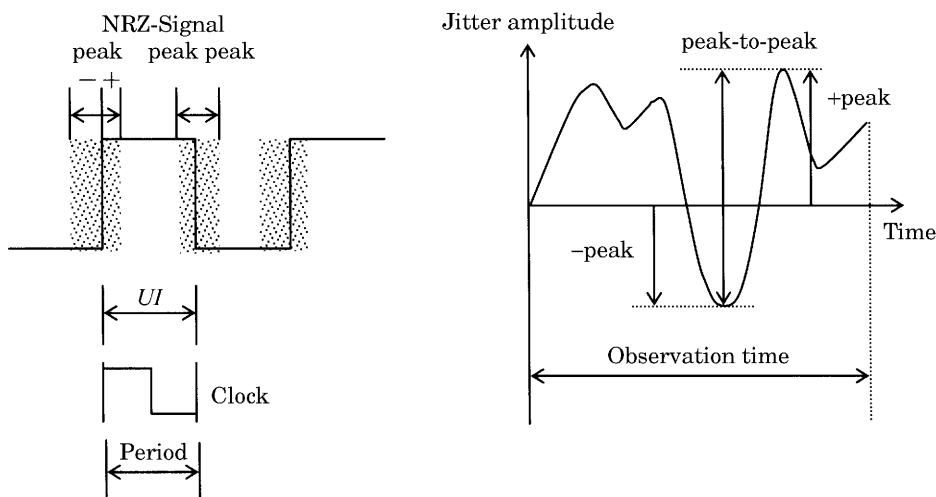


Figure 5 Phase jitter measures

For random type jitter the r.m.s. value is defined as the standard deviation σ (sigma) of the underlying Gaussian distribution. The peak-to-peak jitter is then the range covered by 7σ (i.e. $\pm 3.5\sigma$), according to a confidence level of 99.953 48 % (i.e. 465×10^{-6} tail) (see figure 6).

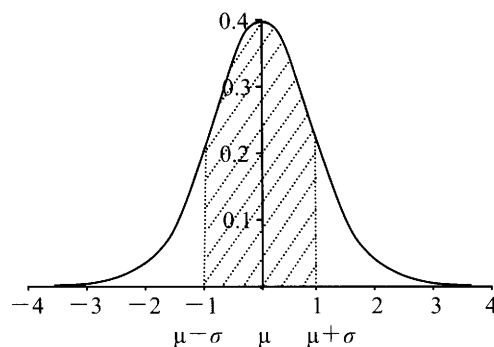


Figure 6 Gaussian distribution of jitter

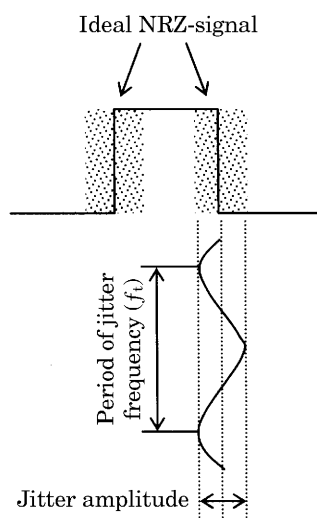


Figure 7 Jitter amplitude and period of jitter frequency

In the case of subharmonics involved in the signal generation, phase jitter may contain non-random spectral components due to periodical change of the duty cycle. This causes a non-Gaussian distribution, i.e. the 7σ -rule for peak-to-peak values no longer applies. In such cases only peak-to-peak values are meaningful. However, the determination of peak-to-peak values is sensitive to incidents. The recommended observation time for peak-to-peak jitter is 1 min.

For the characterisation of jitter it is important to define the considered Fourier frequency range, i.e. the frequency components of the jitter itself (see figure 7). This is defined by the application (see standards **ITU-T G.825**, **ANSI T1.105.03** and **ETSI EN 300462**) (see figure 8).

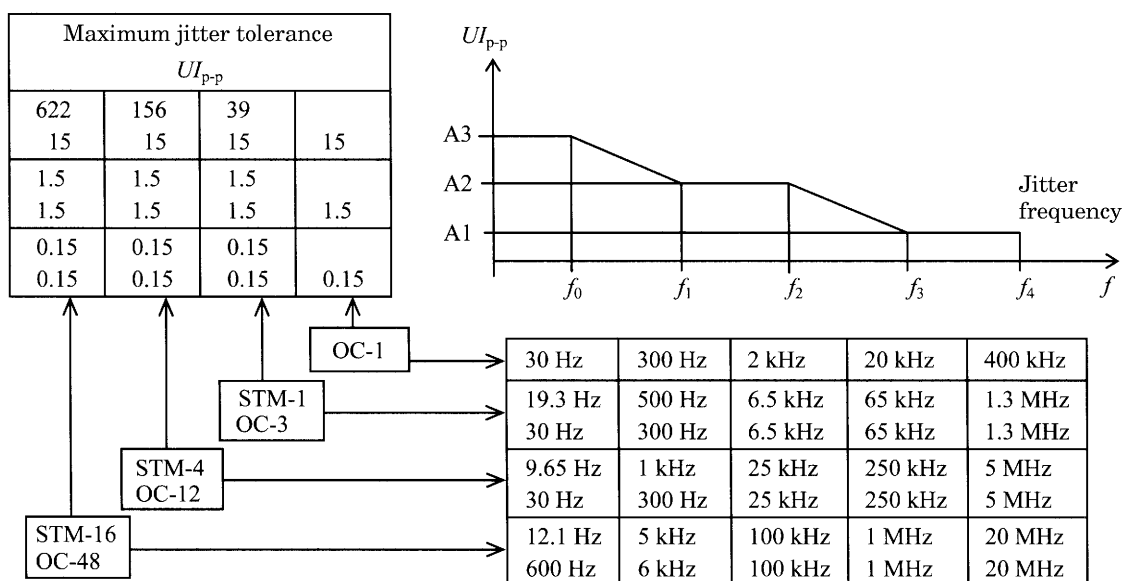


Figure 8 Jitter tolerance according to ITU-T G.825, ANSI T1.105.03, and ETSI EN 300462

In connection with jitter and wander, the following three parameters are also used for clock characterisation:

- TIE Time Interval Error (in nanoseconds or picoseconds);
- MTIE Maximum Time Interval Error (peak-to-peak TIE);
- TDEV Time deviation (r.m.s. value).

TIE is defined as the time deviation between the signal being measured and the reference clock, typically measured in nanoseconds.

MTIE is a measure that characterises frequency offsets. $MTIE(\tau)$ is defined as the largest peak-to-peak TIE in any observation interval of length τ (in seconds).

TDEV characterises the spectral content. $TDEV(\tau)$ is defined as the r.m.s. of filtered TIE, where the bandpass filter is centred on a frequency of $0.42/\tau$. It is calculated from the TIE samples for each point τ_i by the standard deviation $\sigma(\tau_i)$ (see NOTE).

NOTE : For more details, refer to standards **ITU-T G.810 to G.813**, or **ANSI T1.101 and T1.105.03** and **ETSI EN 300462**.

2.3 Preferred values for ratings and characteristics Values should be preferably chosen from the following paragraphs, unless otherwise stated in the detail specification.

2.3.1 Climatic category For 56 days at the temperature $-40\text{ }^{\circ}\text{C}$ and $+85\text{ }^{\circ}\text{C}$. For requirements where the operating temperature range of the quartz crystal controlled oscillator is greater than $-40\text{ }^{\circ}\text{C}$ to $+85\text{ }^{\circ}\text{C}$, a climatic category consistent with the operating temperature range shall be specified.

2.3.2 Bump severity $(4\,000 \pm 10)$ bumps at 400 m/s^2 peak acceleration in each direction along three mutually perpendicular axes (see **4.6.6**). Pulse duration: 6 ms.

2.3.3 Vibration severity

Sinusoidal	10 Hz to 55 Hz 0.75 mm displacement amplitude (peak value) 55 Hz to 500 Hz or 55 Hz to 2 000 Hz 100 m/s ² acceleration amplitude (peak value)	10 Hz to 55 Hz 1.5 mm displacement amplitude (peak value) 55 Hz to 2 000 Hz 200 m/s ² acceleration amplitude (peak value)	30 min in each of three mutually perpendicular axes at 1 octave/min (see 4.6.7)
Random	(19.2 m/s ²) ² /Hz between 20 Hz and 2 000 Hz 196 m/s ² acceleration	or (48 m/s ²) ² /Hz between 20 Hz and 2 000 Hz 314 m/s ² acceleration	30 min in each of three mutually perpendicular axes at 1 octave/min (see 4.6.7)

2.3.4 Shock severity 1 000 m/s² peak acceleration for 6 ms duration; three shocks in each direction along three mutually perpendicular axes (see 4.6.8), half-sine pulse, unless otherwise stated in the detail specification.

2.3.5 Leak rate (if applicable)

10⁻¹ Pa·cm³/s (10⁻⁶ bar·cm³/s)

10⁻³ Pa·cm³/s (10⁻⁸ bar·cm³/s)

2.3.6 Type of destructive test Two methods are available for destructive test of CMOS integrated circuit used in crystal controlled oscillator. They are latch-up test and electrostatic breakdown test, and their methods are shown in Annex B and Annex C.

2.4 Marking

2.4.1 The quartz crystal controlled oscillator shall be clearly and durably marked (see 4.6.21) with items **a)** to **g)** below, and with as many of the remaining items **h)** to **j)** as considered necessary:

- a) type designation as defined in the detail specification;
- b) nominal frequency in kilohertz (kHz) or megahertz (MHz);
- c) year and week of manufacture;
- d) mark of conformity (unless a certificate of conformity is used);
- e) factory identification code;
- f) manufacturer's name or trade mark;
- g) terminal identification;
- h) designation of electrical connections;
- j) power supply voltage and polarity (if applicable);
- k) serial number (if applicable).

Where the available surface area of miniature quartz crystal controlled oscillators imposes practical limits in the amount of marking, instructions on the marking to be applied shall be given in the detail specification.

2.4.2 The primary packaging containing the quartz crystal controlled oscillator(s) shall be clearly marked with the information listed in **2.4.1** except item **g)** and electrostatic sensitive device (ESD) identification, where necessary.

3 Quality assessment procedures Two methods are available for the approval of quartz crystal controlled oscillators of assessed quality. They are qualification approval and capability approval.

3.1 Primary stage of manufacture The primary stage of manufacture for a quartz crystal controlled oscillator in accordance with **11.1.1** of **IEC QC 001002** shall be as follows:

- a) for oscillators incorporating a sealed crystal unit:
 - the assembly of the quartz crystal controlled oscillator;
- b) for oscillators incorporating an unencapsulated crystal unit:
 - the final surface finishing of the crystal element in addition to the assembly of the oscillator.

NOTE : The final surface finishing of the crystal element could be any of the following operations: lapping; polishing; etching; cleaning, in the case of polished plates.

3.2 Structurally similar components The grouping of structurally similar crystal controlled oscillators for the purpose of qualification approval, capability approval and quality conformance inspection shall be prescribed in the relevant sectional specification.

3.3 Subcontracting These procedures shall be in accordance with **11.1.2** of **IEC QC 001002**.

There shall be no subcontracting after the assembly of the crystal to the electronic circuit, except in the case of sealed crystal units, where the sealing of the final enclosure of the oscillator may be permitted.

3.4 Incorporated components Where the final component contains components of a kind covered by a generic specification in the **JIS** series, these shall be produced using the normal **JIS** release procedures.

Where the contained components are not produced to a **JIS** detail specification, the approved manufacturer's chief inspector shall verify their quality by the use of

- a procurement specification covering all aspects necessary to ensure their satisfactory performance as part of the final product,
- an adequate approval test programme maintaining a record of results,
- sufficient goods inward inspection procedures to ensure continued satisfactory performance of the final product.

3.5 Manufacturer's approval To obtain manufacturer's approval the manufacturer shall meet the requirements of **10.2** of **IEC QC 001002**.

3.6 Approval procedures

3.6.1 General To qualify a quartz crystal controlled oscillator, either capability approval or qualification approval procedures may be used. These procedures conform to those stated in **IEC QC 001001** and **IEC QC 001002**.

3.6.2 Capability approval Capability approval is appropriate when structurally similar quartz crystal controlled oscillators based on common design rules, are fabricated by a group of common processes.

Under capability approval, detail specifications fall into the following three categories.

- a) **Capability qualifying components (CQCs)** A detail specification shall be prepared for each CQC as agreed with the National Supervising Inspectorate (NSI). It shall identify the purpose of the CQC and include all relevant stress levels and test limits.
- b) **Standard catalogue items** When a component covered by the capability approval procedure is intended to be offered as a standard catalogue item, a detail specification complying with the blank detail specification shall be written. Such specifications shall be registered by the IECQ and the component may be listed in **IEC QC 001005**.
- c) **Custom built quartz controlled oscillators** The contents of the detail specification shall be by agreement between the manufacturer and the customer in accordance with **11.7.4.2** of **IEC QC 001002**.

Further information on detail specifications is contained in the sectional specification **IEC 60679-4**.

The product and capability qualifying components (CQCs) are tested in combination and approval given to a manufacturing facility on the basis of validated design rules, processes and quality control procedures. Further information is given in **3.7** and in the sectional specification **IEC 60679-4**.

3.6.3 Qualification approval Qualification approval is appropriate for components manufactured to a standard design and established production process and conforming to a published detail specification.

The programme of tests defined in the detail specification for the appropriate assessment and severity level applies directly to the quartz crystal controlled oscillator to be qualified, as prescribed in **3.8** and the sectional specification **IEC 60679-5**.

3.7 Procedures for capability approval

3.7.1 General The procedures for capability approval shall be in accordance with **IEC QC 001002**.

3.7.2 Eligibility for capability approval The manufacturer shall comply with the requirements of **11.1** of **IEC QC 001002** and the primary stage of manufacture as defined in **3.1** of this generic specification.

3.7.3 Application for capability approval In order to obtain capability approval the manufacturer shall apply the rules of procedure given in **11.7** of **IEC QC 001002**.

3.7.4 Granting of capability approval Capability approval shall be granted when the procedures in accordance with **11.7** of **IEC QC 001002** have been successfully completed.

3.7.5 Capability manual The contents of the capability manual shall be in accordance with the requirements of the sectional specification.

The NSI shall treat the capability manual as a confidential document. The manufacturer may, if he so wishes, disclose part or all of it to a third party.

3.8 Procedures for qualification approval

3.8.1 General The procedures for qualification approval shall be in accordance with **IEC QC 001002**.

3.8.2 Eligibility for qualification approval The manufacturer shall comply with the requirements of **11.1** of **IEC QC 001002** and the primary stage of manufacture as defined in **3.1** of this generic specification.

3.8.3 Application for qualification approval In order to obtain qualification approval the manufacturer shall apply the procedures given in **11.2** of **IEC QC 001002**.

3.8.4 Granting of qualification approval Qualification approval shall be granted when the procedures in accordance with **11.3** of **IEC QC 001002** have been successfully completed.

3.8.5 Quality conformance inspection The blank detail specification associated with the sectional specification shall prescribe the test schedule for quality conformance inspection.

3.9 Test procedures The test procedures to be used shall be selected from this generic specification. If any required test is not included, then it shall be defined in the detail specification.

3.10 Screening requirements Where screening is required by the customer for quartz crystal controlled oscillators, this shall be specified in the detail specification.

3.11 Rework and repair work

3.11.1 Rework Rework is the rectification of processing errors and shall not be carried out if prohibited by the sectional specification. The sectional specification shall state if there is a restriction on the number of occasions that rework may take place on a specific component.

All rework shall be carried out prior to the formation of the inspection lot offered for inspection to the requirements of the detail specification.

Such rework procedures shall be fully described in the relevant documentation produced by the manufacturer and shall be carried out under the direct control of the chief inspector. Subcontracting of rework is not permitted.

3.11.2 Repair work Repair work is the correction of defects in a component after release to the customer.

Components that have been repaired can no longer be considered as representative of the manufacturer's production and may not be released under the IECQ system.

3.12 Certified test records The requirements of clause 14 of IEC QC 001002 shall apply. When certified test records (CTR) are prescribed in the sectional specification for qualification approval and are requested by the customer, the results of the specified tests shall be summarized.

3.13 Validity of release Quartz crystal controlled oscillators held for a period exceeding two years following acceptance inspection shall be reinspected for the electrical tests detailed in 4.5.4 and 4.5.17 prior to release.

3.14 Release for delivery Quartz crystal controlled oscillators shall be released in accordance with 12.5 of IEC QC 001002.

3.15 Unchecked parameters Only those parameters of a component which have been specified in a detail specification and which were subject to testing, can be assumed to be within the specified limits. It should not be assumed that any parameter not specified will remain unchanged from one component to another. Should it be necessary for further parameters to be controlled, then a new, more extensive, detail specification should be used. The additional test method(s) shall be fully described and appropriate limits, AQLs and inspection levels specified.

4 Test and measurement procedures

4.1 General The test and measurement procedures shall be carried out in accordance with the relevant detail specification.

4.2 Test and measurement conditions

4.2.1 Standard conditions for testing Unless otherwise specified, all tests shall be carried out under the standard atmospheric conditions for testing as specified in 5.3 of JIS C 60068-1.

Temperature	15 °C to 35 °C
Relative humidity	25 % to 75 %
Air pressure	86 kPa to 106 kPa (860 mbar to 1 060 mbar)

In case of dispute, the referee conditions are the following:

Temperature	25 °C ± 2 °C
Relative humidity	48 % to 52 %
Air pressure	86 kPa to 106 kPa (860 mbar to 1 060 mbar)

Before measurements are made, the quartz crystal controlled oscillators shall be stored at the measuring temperature for a time sufficient to allow the quartz crystal controlled oscillator to reach thermal equilibrium. Controlled recovery conditions and standard conditions for assisted drying are given in **5.4** and **5.5** of **JIS C 60068-1**.

The ambient temperature during the measurements shall be recorded and stated in the test report.

4.2.2 Equilibrium conditions All electrical tests shall be conducted under equilibrium conditions, unless otherwise specified. When test conditions cause a significant change with time of the characteristic being measured, means of compensation for such effects shall be specified, for example the period of time that the oscillator shall be maintained at specified test conditions before making a measurement.

4.2.3 Air flow conditions for temperature tests When devices are to be measured at temperatures other than $25\text{ °C} \pm 2\text{ °C}$, they shall be subjected to adequate forced air circulation to ensure close temperature control.

If heat loss due to forced air circulation affects the performance of the oscillator, still air conditions shall be simulated by enclosing the oscillator in a draught shield consisting of a thermally conducting box, having internal dimensions such that a $20\text{ mm} \pm 5\text{ mm}$ clearance is maintained from all surfaces. The temperature at which measurements should be taken under these conditions is the reference point temperature on the surface of the draught shield.

If a draught shield is necessary, it shall be used for both high and low temperature tests.

4.2.4 Power supplies DC power sources used in the testing of crystal controlled oscillators shall not have a ripple content large enough to effect the desired accuracy of measurement; a.c. power sources shall be transient free. When the ripple and/or the transient content of the power sources are critical to the measurement being performed, their effects shall be fully defined in the detail specification.

4.2.5 Precision of measurement The limits given in the detail specification are true values. Measurement inaccuracies shall be taken into account when evaluating the results. Precautions should be taken to reduce measurement errors to a minimum.

4.2.6 Precautions

4.2.6.1 Measurements The measurement circuits shown for specified electrical tests are the preferred circuits. Due allowance shall be made for any loading effects in cases where the measuring apparatus modifies the characteristics being examined.

4.2.6.2 Electrostatic sensitive devices Where the component is identified as electrostatic sensitive, precautions shall be taken to prevent damage from electrostatic charge both before, during, and after test (see **IEC 60801-2**).

4.2.7 Alternative test methods Measurements shall preferably be carried out using the methods specified. Any other method giving equivalent results may be used, except in case of dispute.

NOTE : “Equivalent” means that the value of the characteristic established by such other methods falls within the specified limits when measured by the specified method.

4.3 Visual inspection Unless otherwise specified, external visual examination shall be performed under normal factory lighting and visual conditions.

4.3.1 Visual test A The quartz crystal controlled oscillator shall be visually examined to ensure that the condition, workmanship and finish are satisfactory. The marking shall be legible.

4.3.2 Visual test B The quartz crystal controlled oscillator shall be visually examined under $\times 10$ magnification. There shall be no cracks in the glass or damage to the terminations. Minute flaking around the further edge of a meniscus shall not be considered a crack.

4.3.3 Visual test C The quartz crystal controlled oscillator shall be visually examined. There shall be no corrosion or other deterioration likely to impair satisfactory operation. The marking shall be legible.

4.4 Dimensions and gauging procedures

4.4.1 Dimension—Test A The dimensions, spacing, and alignment of the terminations shall be checked and shall comply with the specified values.

4.4.2 Dimensions—Test B The dimensions shall be measured and shall comply with the specified values.

4.5 Electrical test procedures

4.5.1 Insulation resistance A maximum voltage of 20 V, unless otherwise stated in the detail specification, shall be applied to the specified test points using the test circuit shown in figure 9a. The resulting current shall be measured. It shall be less than the specified maximum value.

Alternatively, the resistance shall be directly measured with an ohmmeter (see figure 9b). It shall be greater than the minimum specified.

Precautions shall be taken to ensure that measurements are made across the specified points with an applied voltage of the correct polarity and not exceeding the specified value. Failure to observe any of these conditions may result in damage to the device under test.

After the test, measurements shall be made to ensure that the oscillator is still functional.