IEC 60679-6

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INTERNATIONAL STANDARD

NORME INTERNATIONALE

colour inside

Quartz crystal controlled oscillators of assessed quality –
Part 6: Phase jitter measurement method for quartz crystal oscillators and SAW oscillators – Application guidelines

Oscillateurs pilotés par quartz sous assurance de la qualité –
Partie 6: Méthode de mesure de la gigue de phase pour les oscillateurs à quartz et les oscillateurs SAW – Lignes directrices pour l'application

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International Standard IEC 60679-6 has been prepared by IEC technical committee 49: Piezoelectric, dielectric and electrostatic devices and associated materials for frequency control, selection and detection.

This standard cancels and replaces IEC/PAS 60679-6 published in 2008. This first edition constitutes a technical revision.

The text of this standard is based on the following documents:

FDIS	Report on voting
49/935/FDIS	49/944/RVD

Full information on the voting for the approval of this standard can be found in the report on voting indicated in the above table.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

A list of all parts of the IEC 60679 series, published under the general title *Quartz crystal controlled oscillators of assessed quality*, can be found on the IEC website.

The committee has decided that the contents of this publication will remain unchanged until the stability date indicated on the IEC web site under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

- reconfirmed,
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- replaced by a revised edition, or
- amended.

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INTRODUCTION

The study of phase jitter measurement methods was conducted in accordance with the agreement during the IEC TC 49 Berlin international meeting in 2001. At this meeting, the decision was made that Japan should assume the responsibilities of this study. Then, the technical committee of the Quartz Crystal Industry Association of Japan (QIAJ) proceeded with this study. This study was substantially conducted during the years 2002 to 2005 and can be referred to as the first stage of the study. The second stage is being continued at present.

Phase jitter has become one of the essential measurement items by digitization of electronic devices. However, theoretically, some ambiguity is still left in the phase jitter. Since no standard measurement method is proposed, suppliers and customers may be mutually exposed to a risk which could cause enormous economic losses.

To avoid this risk, this document provides a standard, based on the study results during the first stage, for each company of QIAJ members to avoid anxiety as to the measurement of the phase jitter and for the purpose of giving guidance without any mistakes.

In this standard, a recommendation to make r.m.s. jitter a measurement object is presented. The reason why this recommendation is submitted is because the oscillators resulting in ultra-low amount of jitter are targeted as the object to be measured.

Oscillators are analogue-type electronic devices. Their sine wave output signals are more favourable than the signals obtained by electronic systems. Moreover, the output is utilized as the reference clock of the measurement equipment, leading to a situation in which the amount of phase jitter is shown to be smaller than the amount of phase jitter of the measurement equipment. Accordingly, this may give the impression that the measured amount of phase jitter is not from the oscillators but rather the amount of phase jitter generated by the measurement equipment, or the measurement system. Therefore, when adopting the amount of other phase jitters as the measurement items, a recommendation is presented to select measurement equipment and a measurement system capable of being verified and confirmed sufficiently, contractually determined between suppliers and customers. Moreover, when the phase noise method is used, the random jitter values need to be discussed after defining the jitter frequency bands from start to end of integrating the phase noise.

In case of doubts related to the measurement values, refer to the application of Allan Variance [1][1].

Frequency stability was compiled into a single work by IEEE in 1966 [2]. Then, the definition was applied to atomic oscillators, crystal oscillators, as well as electronic systems for telecommunication, information, audio-visual, and the like.

Conventional crystal oscillators and electronic systems have analogue systems and their signal waveforms are sine waves. Therefore, the short-term frequency stability as one field of the frequency stability is measured as the phase noise or Allan Variance. Recently, digitization of electronic systems is progressing. Under such circumstance, the short-term frequency stability has been measured as the phase jitter.

On the other hand, the oscillators are analogue-type electronic devices. For the oscillators, the signals having square waves or waveforms similar thereto are demanded by users to be easily fit into the electronic systems. Naturally, for the short-term frequency stability, the measurement as the phase jitter is frequently demanded by users.

For advance application in electronic information and communication technology: (e.g.: advanced satellite communications, control circuits for electric vehicle (EV) and etc.), necessity arises for the measurement method for common guidelines of phase jitter. In these

1 Numbers in square brackets refer to the Bibliography.

days, measurement method of phase jitter also becomes more important from the electromagnetic influence (EMI) point of view.

In that sense, international standardization as IEC 60679-6 of phase jitter measurement method is significant and timely. The measurement method of phase jitter described in this document is the newest method by which quantitative measurement was made possible from the breakthrough of the measurement system technology, in the hope to get attention from not only a device engineer but also a system engineer and expected to be widely used.

QUARTZ CRYSTAL CONTROLLED OSCILLATORS OF ASSESSED QUALITY –

Part 6: Phase jitter measurement method for quartz crystal oscillators and SAW oscillators – Application guidelines

1 Scope

This part of the IEC 60679 series applies to the phase jitter measurement of quartz crystal oscillators and SAW oscillators used for electronic devices and gives guidance for phase jitter that allows the accurate measurement of r.m.s. jitter.

In the measurement method, phase noise measurement equipment or a phase noise measurement system is used.

The measuring frequency range is from 10 MHz to1 000 MHz.

This standard applies to quartz crystal oscillators and SAW oscillators used in electronic devices and modules that have the multiplication or division functions based on these oscillators. The type of phase jitter applied to these oscillators is the r.m.s. jitter. In the following text, these oscillators and modules will be referred to as "oscillator(s)" for simplicity.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60679-1:2007, *Quartz crystal controlled oscillators of assessed quality – Part 1: Generic specification*

3 Terms, definitions and general concepts

3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60679-1:2007 apply.

Units, drawings, codes, and characters are also based on IEC 60679-1.

3.2 General concepts

3.2.1 Phase jitter

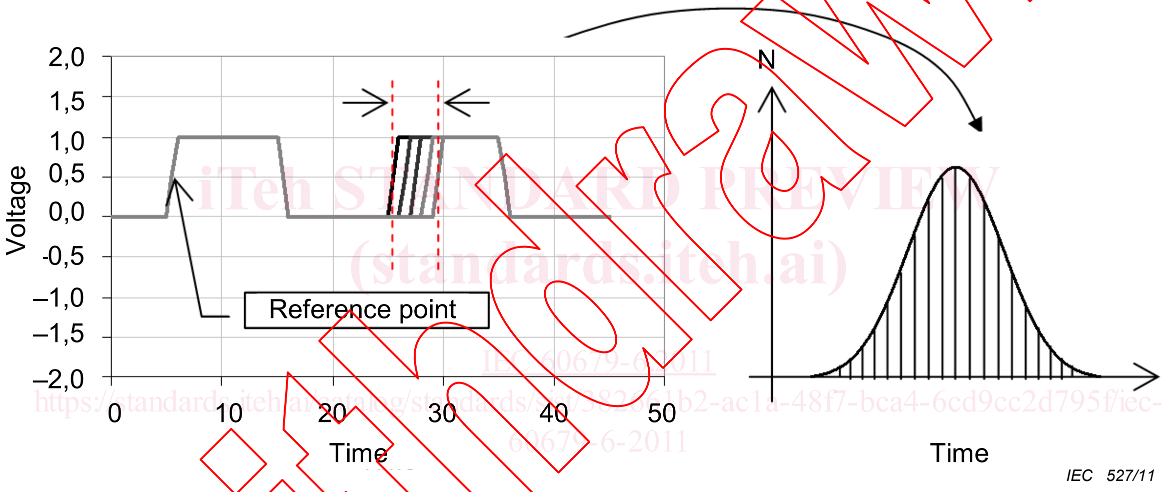
The phase jitter of oscillators means an electronic noise of signal waveforms in terms of time. On the other hand, the phase jitter is described as a jitter in which the frequency of signal deflection exceeds 10 Hz and as a wander in which the frequency is 10 Hz or less.

It is difficult to observe the wander of oscillators. The wander is a phenomenon which is confirmed in electronic parts such as optical cables susceptible to expansion and contraction even by a small amount of temperature changes. Therefore, the wander is generally not discussed in the oscillators. In this document also, phase jitter is targeted only to the jitter.

As for signals, an ideal cycle (t) is inversely proportional to a frequency (f). More specifically, the relation is expressed by Equation (1).

$$t = \frac{1}{f} \qquad (1)$$

Actually, the cycle is varied by receiving various influences. This phenomenon is the phase jitter and can be confirmed by thickening of edges of waveforms when using oscilloscopes or the like. Regarding the method for measuring and evaluating such phase jitter, statistical measurement techniques are utilized as shown is shown in Figure 1. The numerical values in Figure 1 are treated as a symbol. The position of 0,5 of signal waveform is defined as a reference point in the vertical axis, and the edges of the reference point are defined to be not varied. When attention is paid to the edges after one cycle, every time when the signals repeatedly move on the screen of CRT in the lateral direction, the edges after one cycle are not reproduced. Then, plurality edges have become to exist. This phenomenon is induced when repeatedly measuring the signals, and referred to as the phase jitter.



a) Output waveform **b) Histogram of the all jitters**

Figure 1 – Voltage versus time

This phase jitter is treated as a normal distribution. Then, when analysed, the phase jitter can be divided into several types of properties. More specifically, the phase jitter is classified in several types. In this document, the phase jitter is classified in the seven types as described below. In the following, these properties and the cause systems are made clear.

3.2.2 r.m.s jitter

The r.m.s. jitter is the phase jitter which comes to have the normal distribution shown in Figure 2. The r.m.s. jitter is a standard deviation obtained on the basis of statistical treatments and defined as a 1 σ portion

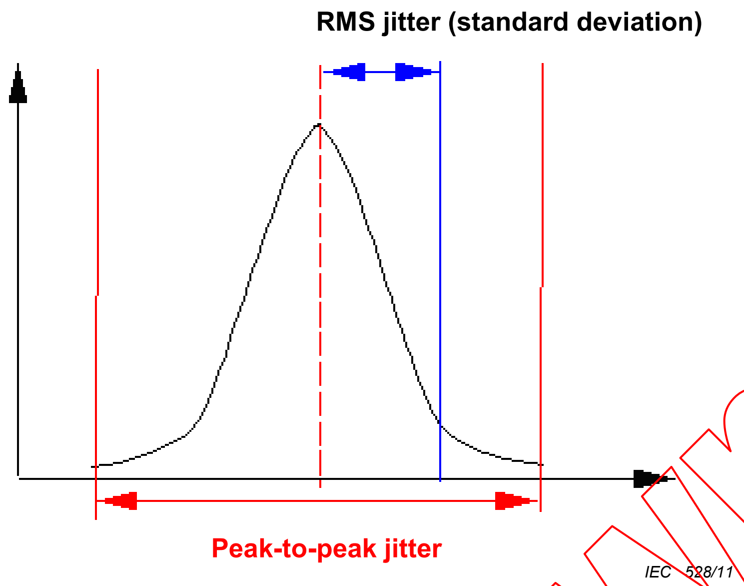


Figure 2 – Explanatory diagram of the amount of jitter applied to r.m.s. jitter

From statistics, any measurement data is meant to exist in 1 σ at a probability of 68,26 %. Therefore, when the measurement times are 10 000, approximately 6 826 pieces of the measurement data are considered to be contained. On the contrary, 31,74 % (3 174 pieces) of the measurement data is indicated to be outside the plus and minus sides of 1 σ. If the data outside the definition is considered to be errors, 31,74 % can be considered to be the error rate.

3.2.3 Peak-to-peak jitter

The peak-to-peak jitter is the phase jitter which comes to have the normal distribution shown in Figure 2. The amount of phase jitter of one cycle is totalized and statistically treated on the base point of the reference point of phase jitter shown in Figure 1. In this case, the amount of phase jitter is assumed to provide the normal distribution.

The difference between the maximum value and the minimum value (namely, change width) is referred to as the peak-to-peak jitter. Since the jitter values become larger as the measurement times are increased, the jitter also becomes the total jitter as described later. This term comes on when negotiating specifications between customers and oscillator makers.

NOTE Since the peak-to-peak jitter or the r.m.s. jitter indicates the amount of phase jitter to the measurement times thereof, the jitter indicates operating conditions of measurement samples in a short period of time. Moreover, the jitter has values effective only to an ideal normal distribution (Gaussian distributions), and the effectiveness can be maintained to be low in cases of non-Gaussian distributions having distorted distributions such as binomial distributions and chi-square distributions. Accordingly, when applying the peak-to-peak jitter or the r.m.s. jitter, the measurement times are required to be clearly defined contractually between customers and supplier sides.

3.2.4 Random jitter

The random jitter is shown in Figure 3. The random jitter represents unpredictable phase jitter components.

The random jitter naturally and inductively occurs as influenced by the characteristics, thermal noise, etc., originally involved in the measurement equipment per se or oscillators. Furthermore, random jitter has the characteristics that the distribution width of measurement values becomes larger (namely, boundless characteristics) as the observation period of time becomes longer. Therefore, the distribution chart can be considered as an ideal normal distribution. Moreover, the random jitter is determined as a standard deviation based on the distribution chart obtained by the measurement of phase jitter. Accordingly, in the case of oscillators, the random jitter may become the amount of jitter equivalent to the r.m.s. jitter. Moreover, since the random jitter becomes the amount of jitter of the measurement equipment per second, the random jitter is one of the measures for judging applicability to measuring the phase jitter of oscillators.

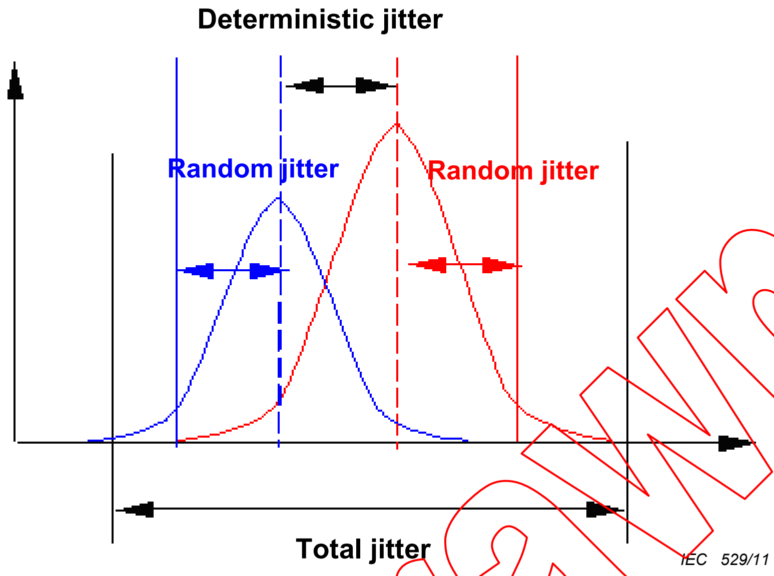


Figure 3 – Explanatory diagram of random jitter, deterministic jitter, and total jitter

3.2.5 Deterministic jitter

The deterministic jitter occurs by various factors of regularity (circuit designs, electromagnetic induction, or induced from external environment), and has characteristics inasmuch as the change width of distribution has a boundary and thus can be expressed by the parts sandwiched between right and left random jitters. On the other hand, the components forming the deterministic jitter include the period jitter or periodic jitter and the data-dependent jitter.

3.2.6 Period (periodic) jitter

The period jitter or periodic jitter shows variations of timings of multiple cycles consecutively provided such as two cycles and three cycles. The period jitter or periodic jitter can be determined by grasping the relationship with the r.m.s. jitter between the multiple cycles and each cycle, and thus grasping whether or not periodic irregularities appear. As for the periodic components of this jitter, such components are considered as an electronic noise caused by the power supply and cross-talk from electronic parts around oscillators to be measured, and further from cores in the vicinity in the case of IC.

If the Fast Fourier Transform (FFT) can be executed, the frequency as the cause clearly appears as a spectrum. Although this jitter is naturally required to be considered for the oscillators, it is difficult to detect the jitter by using measurement equipment in general.

3.2.7 Data-dependent jitter

The data-dependent jitter is considered to be the jitter components due to duty cycle distortion and inter symbol interference, and is negligible for oscillators.

3.2.8 Total jitter

The total jitter is defined as the jitter obtained by totalizing all of the jitters.