

# INTERNATIONAL STANDARD

## NORME INTERNATIONALE

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**Measurement of quartz crystal unit parameters –  
Part 6: Measurement of drive level dependence (DLD)**

**Mesure des paramètres des résonateurs à quartz –  
Partie 6: Mesure de la dépendance du niveau d'excitation (DNE)**



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## INTERNATIONAL ELECTROTECHNICAL COMMISSION

**MEASUREMENT OF QUARTZ CRYSTAL UNIT PARAMETERS –****Part 6: Measurement of drive level dependence (DLD)**

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IEC 60444-6 has been prepared by IEC technical committee 49: Piezoelectric, dielectric and electrostatic devices and associated materials for frequency control, selection and detection. It is an International Standard.

This third edition cancels and replaces the second edition published in 2013. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

- a) some equations have been removed and corrected;
- b) it has been specified in the note of the Scope that the measurement methods specified in this document are not only applicable to AT-cut but also to other crystal cuts and vibration modes.

The text of this International Standard is based on the following documents:

FDIS	Report on voting
49/1374/FDIS	49/1377/RVD

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

The language used for the development of this International Standard is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at [www.iec.ch/members\\_experts/refdocs](http://www.iec.ch/members_experts/refdocs). The main document types developed by IEC are described in greater detail at [www.iec.ch/standardsdev/publications](http://www.iec.ch/standardsdev/publications).

A list of all parts in the IEC 60444 series, published under the general title *Measurement of quartz crystal unit parameters*, can be found on the IEC website.

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

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- amended.

## INTRODUCTION

The drive level (expressed as power/voltage across or current through the crystal unit) forces the resonator to produce mechanical oscillations by way of piezoelectric effect. In this process, the acceleration work is converted to kinetic and elastic energy and the power loss to heat. The latter conversion is due to the inner and outer friction of the quartz resonator.

The frictional losses depend on the velocity of the vibrating masses and increase when the oscillation is no longer linear or when critical velocities, elongations or strains, excursions or accelerations are attained in the quartz resonator or at its surfaces and mounting points (see Annex A). This causes changes in resistance and frequency, as well as further changes due to the temperature dependence of these parameters.

At “high” drive levels (e.g. above 1 mW or 1 mA for AT-cut crystal units) changes are observed by all crystal units and these also can result in irreversible amplitude and frequency changes. Any further increase of the drive level may could destroy the resonator.

Apart from this effect, changes in frequency and resistance are observed at “low” drive levels in some crystal units (e.g. below 1  $\mu$ W or 50  $\mu$ A for AT-cut crystal units). In this case, if the loop gain is not sufficient, the start-up of the oscillation is difficult. In crystal filters, the transducer attenuation and ripple will change.

Furthermore, the coupling between a specified mode of vibration and other modes (e.g. of the resonator itself, the mounting and the back-fill gas) also depends on the level of drive.

Due to the differing temperature response of these modes, these couplings give rise to changes of frequency and resistance of the specified mode within narrow temperature ranges. These changes increase with increasing drive level. However, this effect will not be considered further in this part of IEC 60444.

In this new edition, the concept of DLD in IEC 60444-6:2013 is maintained. However, the more suitable contents for the user’s severe requirements have been introduced.

# MEASUREMENT OF QUARTZ CRYSTAL UNIT PARAMETERS –

## Part 6: Measurement of drive level dependence (DLD)

### 1 Scope

This part of IEC 60444 applies to the measurements of drive level dependence (DLD) of quartz crystal units. Two test methods (A and C) and one referential method (B) are described. “Method A”, based on the  $\pi$ -network according to IEC 60444-5, can be used in the complete frequency range covered by this part of IEC 60444. “Reference Method B”, based on the  $\pi$ -network or reflection method according to IEC 60444-5 or IEC 60444-8 can be used in the complete frequency range covered by this part of IEC 60444. “Method C”, an oscillator method, is suitable for measurements of fundamental mode crystal units in larger quantities with fixed conditions.

NOTE The measurement methods specified in this document are not only applicable to AT-cut, but also to other crystal cuts and vibration modes, such as doubly rotated cuts (IT,SC) and to tuning fork crystal units (by using a high impedance test fixture).

### 2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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 60444-5, *Measurement of quartz crystal unit parameters – Part 5: Methods for the determination of equivalent electrical parameters using automatic network analyzer techniques and error correction*

IEC 60444-8, *Measurement of quartz crystal unit parameters – Part 8: Test fixture for surface mounted quartz crystal units*

### 3 Terms and definitions

No terms and definitions are listed in this document.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at <http://www.electropedia.org/>
- ISO Online browsing platform: available at <http://www.iso.org/obp>

### 4 DLD effects

#### 4.1 Reversible changes in frequency and resistance

Reversible changes are changes in frequency and resistance occurring under the same drive levels after repeated measurements made alternatively at low and high levels, or after continuous or quasi-continuous measurements from the lowest to the highest level and back, if these changes remain within the limits of the measurement accuracy.