SLOVENSKI STANDARD
SIST EN 60444-1:2002

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Measurement of quartz crystal unit parameters by zero phase technique in a pi-network - Part 1: Basic method for the measurement of resonance frequency and resonance resistance of quartz crystal units by zero phase technique in pi-network (IEC 60444-1:1986)

Measurement of quartz crystal unit parameters by zero phase technique in a pi-network -- Part 1: Basic method for the measurement of resonance frequency and resonance resistance of quartz crystal units by zero phase technique in a pi-network

Messung von Schwingquarz-Parametern nach dem Null-Phasenverfahren in einem Pi-Netzwerk -- Teil 1: Verfahren zur Messung der Resonanzfrequenz und des Resonanzwiderstandes von Schwingquarzen nach dem Null-Phasenverfahren in einem Pi-Netzwerk

Mesure des paramètres des quartz piézoélectriques par la technique de phase nulle dans le circuit en pi -- Partie 1: Méthode fondamentale pour la mesure de la fréquence de résonance et de la résistance de résonance des quartz piézoélectriques par la technique de phase nulle dans le circuit en pi

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English version

Measurement of quartz crystal unit parameters by zero phase technique in a pi-network
Part 1: Basic method for the measurement of resonance frequency and resonance resistance of quartz crystal units by zero phase technique in a pi-network
(IEC 444-1:1986)

Mesure des paramètres des quartz piézoélectriques par la technique de phase nulle dans le circuit en pi
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Teil 1: Verfahren zur Messung der Resonanzfrequenz und des Resonanzwiderstandes von Schwingquarzen nach dem Null-Phasenverfahren in einem Pi-Netzwerk
(IEC 444-1:1986)

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CENELEC

European Committee for Electrotechnical Standardization
Comité Européen de Normalisation Electrotechnique
Europäisches Komitee für Elektrotechnische Normung

Central Secretariat: rue de Stassart 35, B - 1050 Brussels

Foreword

The text of the International Standard IEC 444-1:1986, prepared by IEC TC 49, Piezoelectric and dielectric devices for frequency control and selection, was submitted to the formal vote and was approved by CENELEC as EN 60444-1 on 1997-03-11 without any modification.

The following dates were fixed:

- latest date by which the EN has to be implemented at national level by publication of an identical national standard or by endorsement (dop) 1997-12-01
- latest date by which the national standards conflicting with the EN have to be withdrawn (dow) 1997-12-01

Endorsement notice

The text of the International Standard IEC 444-1:1986 was approved by CENELEC as a European Standard without any modification.

NORME INTERNATIONALE

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Deuxième édition
Second edition
1986

Mesure des paramètres des quartz piézoélectriques par la technique de phase nulle dans le circuit en π

Première partie:
Méthode fondamentale pour la mesure de la fréquence de résonance et de la résistance de résonance des quartz piézoélectriques par la technique de phase nulle dans le circuit en π

Measurement of quartz crystal unit parameters by zero phase technique in a π-network

Part 1:
Basic method for the measurement of resonance frequency and resonance resistance of quartz crystal units by zero phase technique in a π-network

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

MEASUREMENT OF QUARTZ CRYSTAL UNIT PARAMETERS BY ZERO PHASE TECHNIQUE IN A Π-NETWORK

Part 1: Basic method for the measurement of resonance frequency and resonance resistance of quartz crystal units by zero phase technique in a π-network

FOREWORD

1) The formal decisions or agreements of the IEC on technical matters, prepared by Technical Committees on which all the National Committees having a special interest therein are represented, express, as nearly as possible, an international consensus of opinion on the subjects dealt with.

2) They have the form of recommendations for international use and they are accepted by the National Committees in that sense.

3) In order to promote international unification, the IEC expresses the wish that all National Committees should adopt the text of the IEC recommendation for their national rules in so far as national conditions will permit. Any divergence between the IEC recommendation and the corresponding national rules should, as far as possible, be clearly indicated in the latter.

PREFACE

This standard has been prepared by IEC Technical Committee No. 49: Piezoelectric Devices for Frequency Control and Selection.

This second edition replaces the first edition of IEC Publication 444 (1973).

This standard forms Part 1 of a series of publications dealing with the measurement of quartz crystal unit parameters by zero phase technique in a π-network.

Part 2: Phase Offset Method for Measurement of Motional Capacitance of Quartz Crystal Units, issued as IEC Publication 444-2 (1980).

Part 3, containing a basic method for the measurement of two-terminal parameters of quartz crystal units up to 200 MHz by phase technique in a π-network with compensation of the parallel capacitance C_0, will be issued as IEC Publication 444-3.

Part 4 containing a method for the measurement of load resonance frequency f_L, load resonance resistance R_L, load resonance frequency offset Δf_L, frequency pulling range $\Delta f_{L1, L2}$ and pulling sensitivity S, will be issued as IEC Publication 444-4.

The text of this standard is based on IEC Publication 444 (first edition 1973) with the amendments contained in the following documents:

Six Months' Rule	Report on Voting
49(CO)141	49(CO)152

Further information can be found in the Report on Voting indicated in the table above.

MEASUREMENT OF QUARTZ CRYSTAL UNIT PARAMETERS BY ZERO PHASE TECHNIQUE IN A Π-NETWORK

Part 1: Basic method for the measurement of resonance frequency and resonance resistance of quartz crystal units by zero phase technique in a π-network

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1. Scope

This standard specifies a simple method of measurement of resonance frequency and resonance resistance of quartz crystal units and describes a suitable measuring network.

The measuring method and the network are suitable for use over the frequency range 1 MHz to 200 MHz with a fractional frequency accuracy of the order of 10^{-6} with a reproducibility of 10^{-6} to 10^{-8} depending on the type of crystal unit being measured, and an accuracy of the measurement of resonance resistance of ±2% to ±5% depending on the accuracy of the voltage measurement.

However, above approximately 100 MHz the use of this measuring method is limited by the effects of the shunt capacitance C_0 of the crystal unit under test. To enable the measuring method to be used under these conditions, the use of some method of C_0 compensation is advisable.

A method of C_0 compensation will be issued in IEC Publication 444-3 as an IEC report.

Note. — The modifications to the measuring system and network contained in this standard have been introduced to ensure that the claims contained within it are achievable. They do not, however, invalidate the network produced according to the first edition. These networks are still acceptable as an international standard method of measurement of resonance frequency f_r and resonance resistance R_r.
If the reference resistors described in the standard are slightly modified to allow insertion into networks manufactured according to the first edition of Publication 444 then the problem of obtaining satisfactory reference resistors is solved.

2. Definition of resonance frequency

The crystal unit is a 3-terminal network with a complex transfer admittance $Y_{12} = G_{12} + jB_{12}$, as defined in Sub-clause A1.1 of Appendix A.

The enclosure is considered as the common terminal.

For glass enclosures, the third terminal is defined in Clause 3.

The resonance frequency is defined as the lower of the two frequencies of the crystal unit alone under specified conditions at which B_{12} is zero.

At this frequency, the resonance resistance is $1/G_{12} = R_r$.

3. Reference plane and shielding box

Because of lead inductance of the crystal unit it is necessary to specify a reference plane at which the measurements are to be made. This plane is located at a distance of 2 mm from the place where the pins or leads emerge from the crystal unit, unless otherwise specified. The third terminal for glass enclosures is a metal shielding box with internal dimensions 27 mm in height and the base plane of 40 mm × 40 mm (base plane = reference plane) and closed at the top. The crystal unit is to be located at the centre of the base plane of the shielding box.

4. Principle of measurement

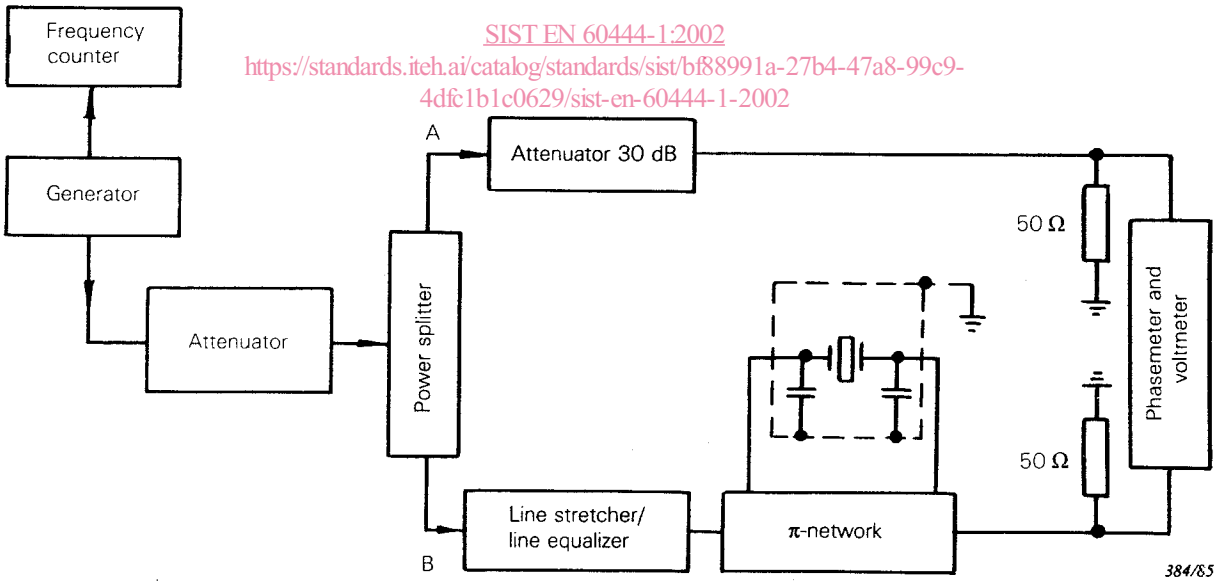
The measurement is reduced to a 2-terminal impedance measurement by inserting the crystal unit in a π-network (see Figure 1).

The phase of the crystal transfer admittance is indicated on a phasemeter connected across the π-network. The frequency giving zero phase reading is measured.

Zero phase is calibrated by inserting a reference resistor in the π-network. The value of the resonance resistance can be calculated from the voltage readings on channels A and B.

5. Measuring circuit

The measuring circuit consists basically of a π-network connected with coaxial cables to the associated equipment (see Figure 1).



Notes 1. — The 30 dB attenuator in channel A may be desirable with certain phasemeters and voltmeters.

2. — The line stretcher of constant impedance in channel B may be desirable for ease of equalizing the electrical length of the connecting cables. (A "line stretcher" with variable length is a phase equalizing device of constant impedance.)

3. — When using some generators it may be advisable to use a filter to reduce the harmonic distortion to the level specified in Sub-clause 5.3.1.1.

FIGURE 1

The fact is emphasized that the construction of the π-network determines the accuracy of the set-up, whereas the associated equipment can be extended, if necessary, to produce a very sophisticated set-up. For this reason, only the essential elements of the associated equipment are specified (see Sub-clause 5.3).

5.1 *The π-network*

5.1.1 *Electrical specification*

5.1.1.1 *Circuit diagram*

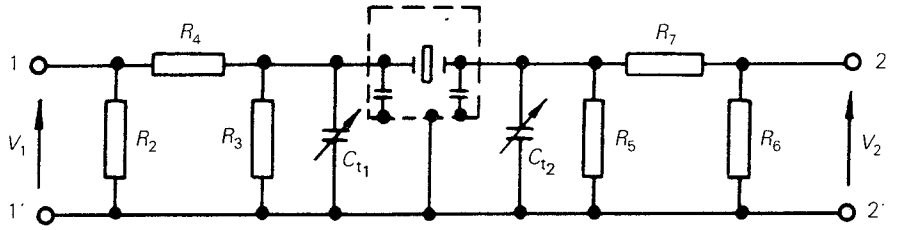


FIGURE 2

$R_2 = R_6 = 159\ \Omega$ (disk type)
$R_3 = R_5 = 14.2\ \Omega$ (disk type)
$R_4 = R_7 = 66.2\ \Omega$ (rod type)
Tolerance ±1%
$C_{t_1} = C_{t_2} = 0.5$ pF to 5 pF (air trimmer)

Note. — The function of the input and output pads is twofold:
a) to match the crystal impedance to the associated equipment;
b) to attenuate reflections from the associated equipment.

5.1.1.2 The frequency range shall be 1 MHz to 200 MHz.

5.1.1.3 The logarithmic ratio of the respective voltages at the B-channel with and without the shorting blank inserted in the π-network is termed the "cross-talk attenuation" of the π-network test set-up. The cross-talk attenuation a_c (in decibels) is given by the expression:

$$a_c = 20 \log \frac{V_{Bs}}{V_{Bo}},$$

where V_{Bs} is the voltage at the B-channel with the shorting blank inserted into the π-network and V_{Bo} is the voltage at the B-channel with the shorting blank removed from the π-network. Measured at a frequency of 100 MHz in the measuring circuit according to Figure 1, page 9, the cross-talk attenuation shall be ⩾60 dB.

5.1.1.4 At all frequencies between 1 MHz and 200 MHz the phase measured at 75 Ω shall not deviate by more than ±0.2° from the phase measured at 25 Ω in the measuring circuit according to Figure 1 (see Sub-clause 6.1).

At a frequency of 200 MHz, the phase over the resistance range 15 Ω to 100 Ω shall not deviate by more than ±0.5° from the phase measured at 25 Ω in the measuring circuit according to Figure 1 (see Figure 3, page 13, and Sub-clause 6.1).

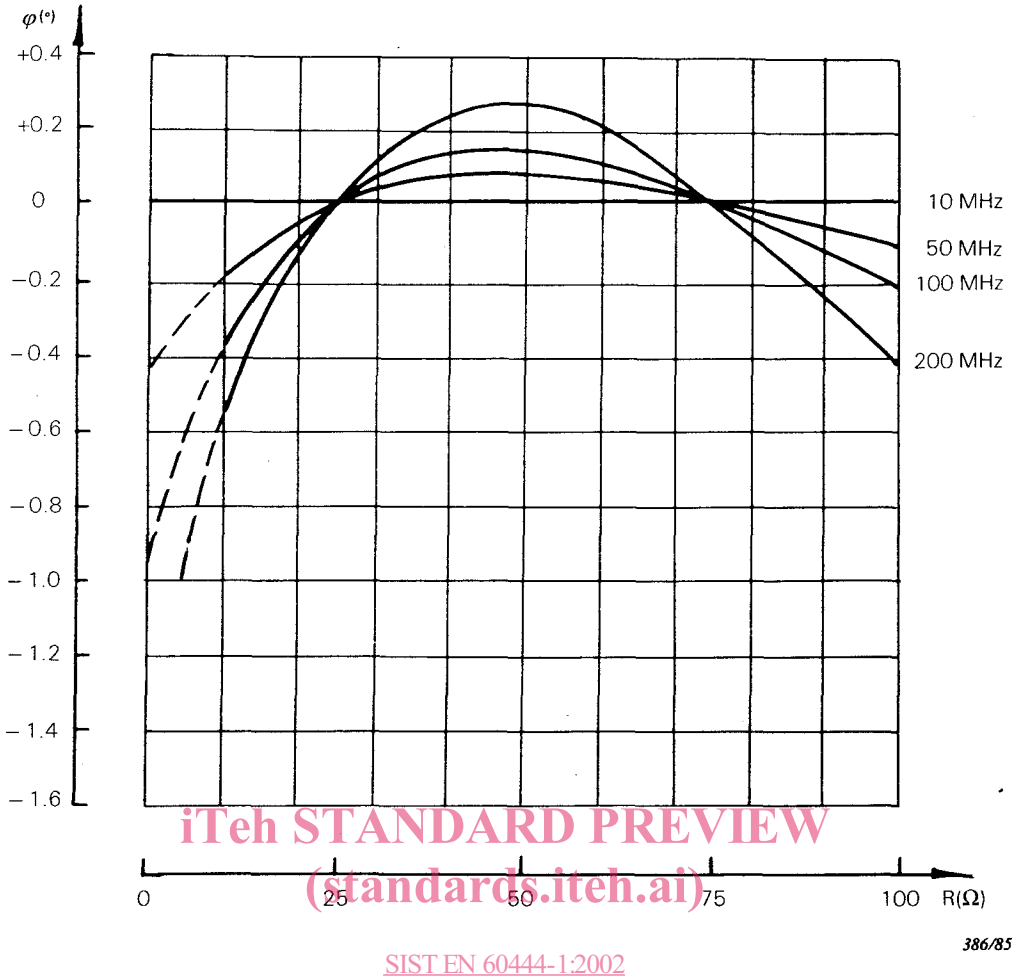


FIG. 3. – Plot showing the phase change from the value at 25 Ω versus reference resistor values from 0 to 100 Ω at 10 MHz, 50 MHz, 100 MHz and 200 MHz. Measuring circuit according to Figure 1, page 9.

5.1.1.5 At all levels of drive between 5 μW and 5 mW the phase measured at 25 Ω shall not deviate by more than ±0.5° over the frequency range 1 MHz to 200 MHz from the phase measured at 0.5 mW in the measuring circuit according to Figure 1.

5.1.1.6 At all frequencies between 1 MHz and 200 MHz the resistance of the 25 Ω reference resistor shall not deviate by more than 2% from the value measured at 1 MHz in the measuring circuit according to Figure 1.

5.1.1.7 At a frequency of 200 MHz, the reflection coefficient measured with the shorting blank having the dimensions of Sub-clause 5.2.2 shall be less than 5% within the reference temperature range −55 °C to +105 °C. The output and input shall be terminated within 50 Ω.

5.1.1.8 Measured with the shorting metal blank of Sub-clause 5.2.2 in the π-network, the insertion attenuation over the specified frequency range shall be 29.6 ± 0.3 dB.

5.1.1.9 The stray capacitance between contact plates shall be smaller than 0.05 pF.