SLOVENSKI STANDARD

SIST EN 60444-3:2002

01-september-2002

Measurement of quartz crystal unit parameters by zero phase technique in a pi-network - Part 3: Basic method for the measurement of two-terminal parameters of quartz crystal units up to 200 MHz by phase technique in a pi-network with compensation of the parallel capacitance C< (Index)o> (IEC 60444-3:1986)

Measurement of quartz crystal unit parameters by zero phase technique in a pi-network -- Part 3: Basic method for the measurement of two-terminal parameters of quartz crystal units up to 200 MHz by phase technique in a pi-network with compensation of the parallel capacitance C0

Messung von Schwingquarz-Parametern nach dem Null-Phasenverfahren in einem Pi-Netzwerk -- Teil 3: Verfahren zur Messung der Zwei-Pol-Parameter von Schwingquarzen bis 200 MHz nach dem Phasenverfahren in einem Pi-Netzwerk mit Kompensation der Parallelkapazität C0

Mesure des paramètres des quartz piézoélectriques par la technique de phase nulle dans le circuit en pi -- Partie 3: Méthode fondamentale pour la mesure des paramètres à deux pôles des résonateurs à quartz à la fréquence jusqu'à 200 MHz par la technique de phase dans le circuit en pi avec compensation de la capacité parallèle C0

Ta slovenski standard je istoveten z: **EN 60444-3:1997**

ICS:

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EUROPEAN STANDARD

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EN 60444-3

April 1997

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Descriptors: Quartz crystal units, measurement of parameters, zero phase technique in a pi-network, basic method, two-terminal parameters, compensation of the parallel capacitance, test circuit

English version

Measurement of quartz crystal unit parameters by zero phase technique in a pi-network
Part 3: Basic method for the measurement of two-terminal parameters of quartz crystal units up to 200 MHz by phase technique in a pi-network with compensation of the parallel capacitance C_0

(IEC 444-3:1986)

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(IEC 444-3:1986)

This European Standard was approved by CENELEC on 1997-03-11. CENELEC members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the Central Secretariat or to any CENELEC member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CENELEC member into its own language and notified to the Central Secretariat has the same status as the official versions.

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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

Ref. No. EN 60444-3:1997 E

Foreword

The text of the International Standard IEC 444-3:1986, 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 60444-3 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 444-3:1986 was approved by CENELEC as a European Standard without any modification.

COMMISSION ÉLECTROTECHNIQUE INTERNATIONALE

RAPPORT DE LA CEI

INTERNATIONAL ELECTROTECHNICAL COMMISSION

IEC REPORT

Publication 444-3

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

Troisième partie: Méthode fondamentale pour la mesure des paramètres à deux pôles des résonateurs à quartz à la fréquence jusqu'à 200 MHz par la technique de phase dans le circuit en π avec compensation de la capacité parallèle C_0

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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

It forms Part 3 of the series of IEC publications on phase measuring methods, and contains the 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.

Part 1, containing a basic method for the measurement of resonance frequency and resonance resistance of quartz crystal units by zero phase technique in a π-network, is issued as IEC Publication 444-1 (second edition, 1986).

Part 2, containing a phase offset method for the measurement of motional capacitance of quartz crystal units, is issued as IEC Publication 444-2 (first edition, 1980).

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 report is based on the following documents:

Six Months' Rule	Report on Voting
49(CO)154	49(CO)172

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 3: 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

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1. Scope

This report specifies a method for the measurement of the parameters of quartz crystal units using an inductance to compensate for the effects of C_0 at the frequency of the crystal unit with accuracy depending on the type of crystals for:

a) frequency with a fractional accuracy ranging between 10^{-6} and 10^{-8};

b) resistance with a fractional accuracy ranging between 2% and 5%;

c) motional capacitance and motional inductance with a fractional accuracy ranging between 3% and 7%.

This report is based on the π-network described in IEC Publication 444-1: 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.

Essentially new is the compensation of parallel capacitance C_0 of the crystal unit by an inductance at the frequency of the crystal unit.

In the report, two possible circuits for compensation of C_0 are discussed in detail. The compensation circuits can also be constructed in different ways; for example: with discrete inductance and capacitance or with a resonant line with a moving shorting link. The requirements for the compensation circuit and the measurement method are the same.

2. C_0 compensation circuit

2.1 *Electrical specifications*

Close to its resonance frequency a crystal unit can be treated as the circuit of Figure 1, page 9, where the effect of C_0 is eliminated by a variable inductor L_p. This inductor can be realized by a parallel resonant circuit which may be electronically tuned.

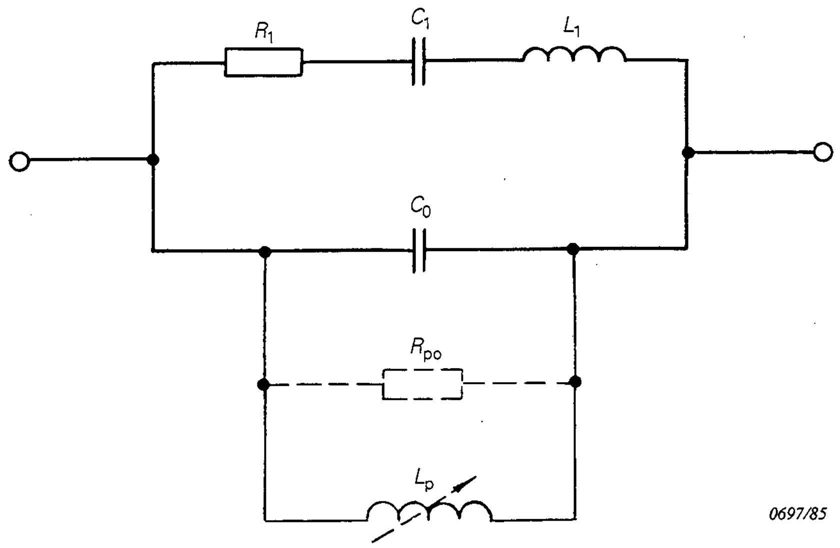
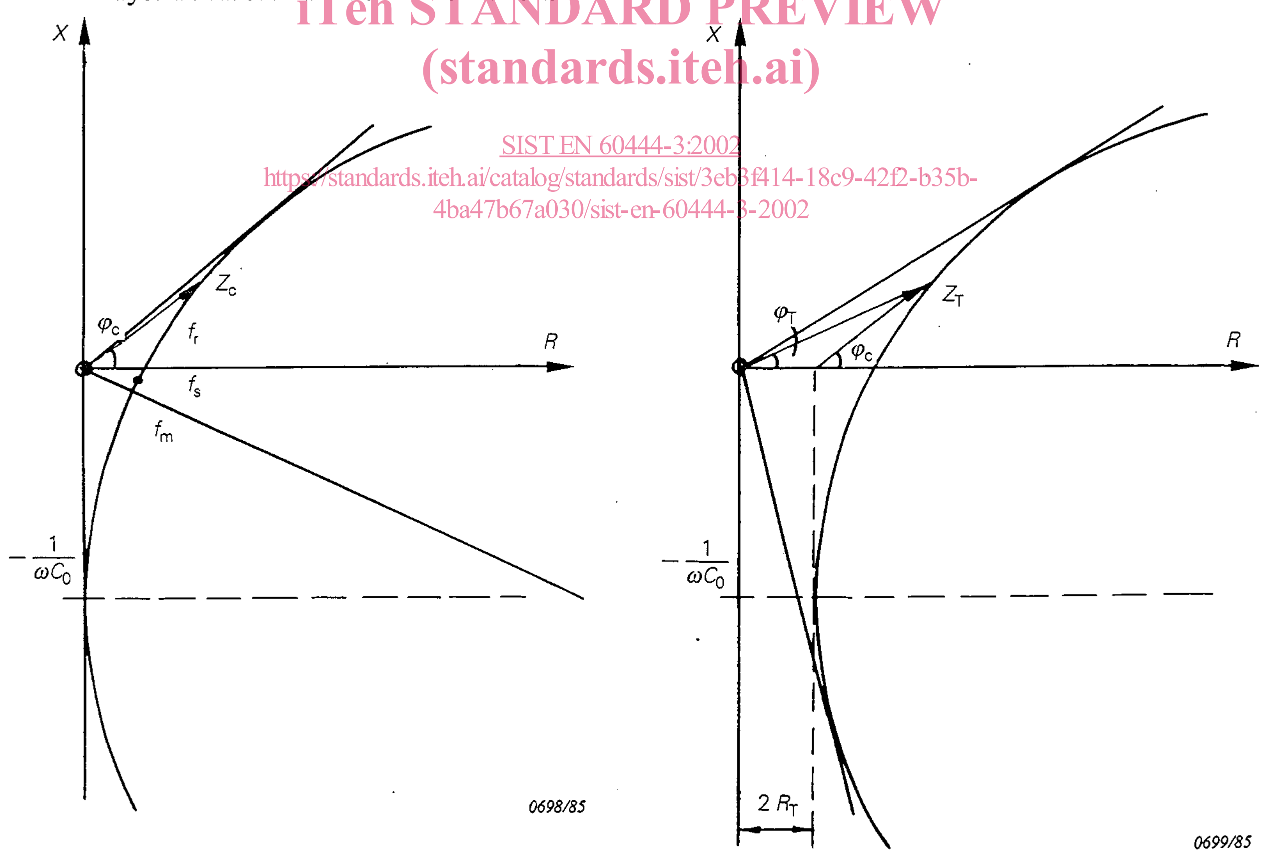


FIG. 1. — Equivalent circuit of a crystal unit with compensation of C_0.

(The losses of L_p are represented by R_{po})

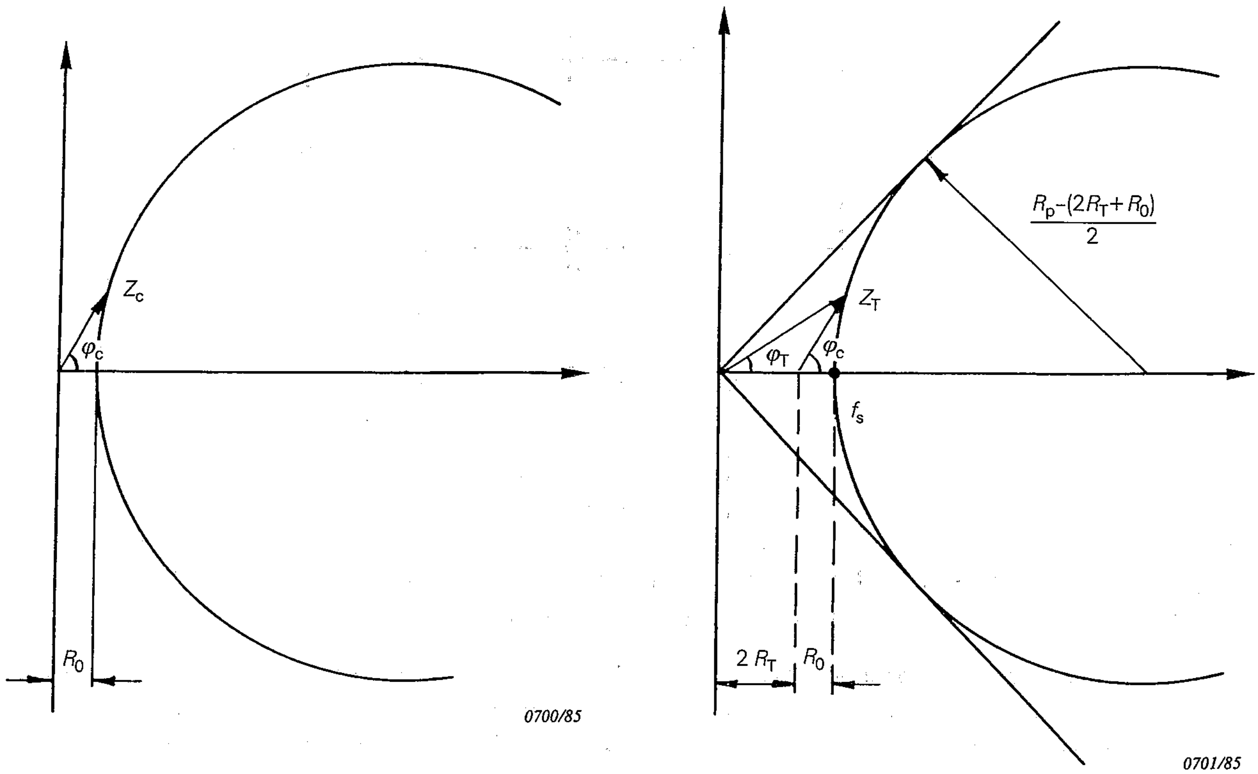
The complex impedance $Z = R + jX$ of the uncompensated crystal unit is given in Figure 2. Figure 2*a)* shows the impedance of the crystal unit alone, while Figure 2*b)* is for the crystal unit connected in the π-network. Figure 3 (page 11) shows the impedance of the compensated crystal unit under the same conditions.



2*a)* Crystal unit alone.

2*b)* Crystal unit connected in a π-network.

FIG. 2. — Impedance diagram of a crystal unit without compensation of parallel capacitance C_0.



3*a)* Crystal unit with C_0 compensation. 3*b)* Same when connected in a π-network.

FIG. 3. — Impedance diagram of a crystal unit when C_0 is compensated with a properly tuned compensation network according to Figure 1.

The phase angle $\varphi = \varphi_T$ between input and output of a π-network with a termination for the crystal unit of resistance $2R_T = 25\ \Omega$ is given by:

$$\tan \varphi_T = \frac{X}{R} = \frac{X}{R_1 + 2R_T} \quad (1)$$

To a first approximation for small values of φ_T it can be expressed by:

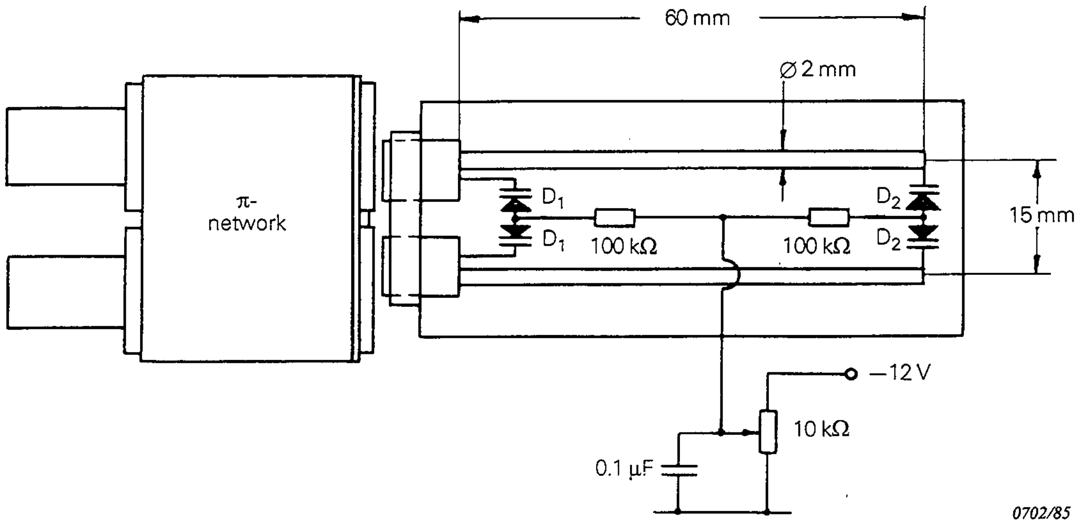
$$\tan \varphi_T = \frac{2\Delta\,\omega L_1}{R_1 + 2R_T} = \frac{\Delta f}{f} \times 2Q_{eff} \quad (2)$$

$$\text{with } Q_{eff} = \frac{\omega_0 L_1}{R_1 + 2R_T}$$

As can be seen from Figures 2 and 3 in both cases, there exists a maximum and a minimum phase angle; both are equal in value only for the compensated parallel capacitance C_0. Furthermore the impedance is now symmetric with respect to the series resonance frequency f_s.

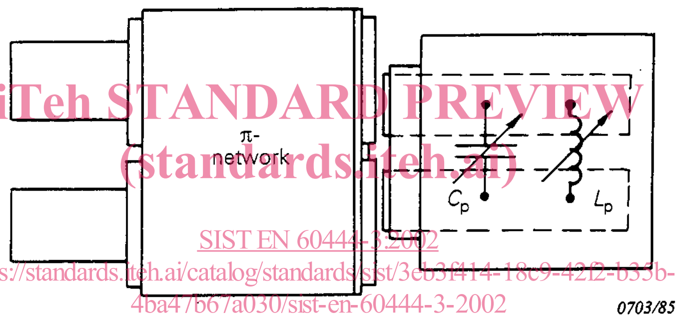
2.2 *Mechanical specification*

Two possible modifications of the π-network which meet the requirements of Sub-clause 2.1 are given in Figures 4*a)* and 4*b)*, page 13.



Note. — Additional information on circuit components is given in Appendix C.

FIG. 4*a*). — Simplified diagram of the π-network with electrical adjustment of C_0 compensation.



Note. — Additional information on circuit components is given in Appendix C.

FIG. 4*b*). — Simplified diagram of the π-network with mechanical adjustment of C_0 compensation.

3. Crystal unit parameters with and without C_0 compensation

3.1 *Series resonance frequency f_s and resonance frequency f_r*

The compensation of C_0 permits the direct measurement at zero phase of the frequency of the series branch

$$f_s = \frac{1}{2\pi \sqrt{L_1 C_1}} \tag{3}$$

whereas IEC Publication 444-1 specifies the direct measurement of the resonance frequency by zero phase technique

$$f_r = f_s \left(1 + \frac{C_0}{2 C_1 Q^2}\right)$$

to a first approximation.