# SLOVENSKI STANDARD
# SIST EN 60444-1:2002/A1:2002

**01-september-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 a pi-network - Amendment A1 (IEC 60444-1:1986/A1:1999)**

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

**Ta slovenski standard je istoveten z: EN 60444-1:1997/A1:1999**

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**ICS:**

| | | |
|---|---|---|
| 31.140 | Piezoelektriļ ne in dielektriļ ne naprave | Piezoelectric and dielectric devices |

**SIST EN 60444-1:2002/A1:2002 en**

EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

# EN 60444-1/A1

October 1999

ICS 31.140

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 60444-1:1986/A1:1999)

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
(CEI 60444-1:1986/A1:1999)

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
(IEC 60444-1:1986/A1:1999)



This amendment A1 modifies the European Standard EN 60444-1:1997; it was approved by CENELEC on 1999-10-01. CENELEC members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this amendment 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 amendment 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.

CENELEC members are the national electrotechnical committees of Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and United Kingdom.

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 60444-1:1997/A1:1999 E

## Foreword

The text of document 49/442/FDIS, future amendment 1 to IEC 60444-1, prepared by IEC TC 49, Piezoelectric and dielectric devices for frequency control and selection, was submitted to the IEC-CENELEC parallel vote and was approved by CENELEC as amendment A1 to EN 60444-1:1997 on 1999-10-01.

The following dates were fixed:

| | | |
|---|---|---|
| – latest date by which the amendment has to be implemented at national level by publication of an identical national standard or by endorsement | (dop) | 2000-07-01 |
| – latest date by which the national standards conflicting with the amendment have to be withdrawn | (dow) | 2002-10-01 |

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## Endorsement notice

The text of amendment 1:1999 to the International Standard IEC 60444-1:1986 was approved by CENELEC as an amendment to the European Standard without any modification.

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# NORME INTERNATIONALE

# INTERNATIONAL STANDARD

**CEI**
**IEC**

**60444-1**

1986

AMENDEMENT 1
AMENDMENT 1
1999-08

Amendement 1

**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**



Amendment 1

**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**



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International Electrotechnical Commission
Международная Электротехническая Комиссия

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## FOREWORD

This amendment has been prepared by IEC technical committee 49: Piezoelectric and dielectric devices for frequency control and selection.

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

| FDIS | Report on voting |
|---|---|
| 49/442/FDIS | 49/445/RVD |

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

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*Add the title of annex B as follows:*





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*Add, after appendix A, the new annex B as follows:*

## Annex B
(normative)

## Updating of some formulae of appendix A

### B.1 Purposes

In this annex some formulae of the appendix A are updated, taking into account the modified calibration procedure of the π-network with a reference resistor $R_n$ = 25 Ω instead of a short.

The formula relating $R_r$ to the measured voltages is derived for arbitrary values of the reference resistor $R_n$. The error of $R_n$ is taken into account in the error analysis for $R_r$.

The formula for current and drive level of the crystal in the π-network is given. The phase slope of the crystal inserted in the π-network is derived and the formula for $Q_{eff}$ is corrected.

## B.2 The π-network terminated by $Z$ = 50 Ω (with power splitter according to figure 5a)

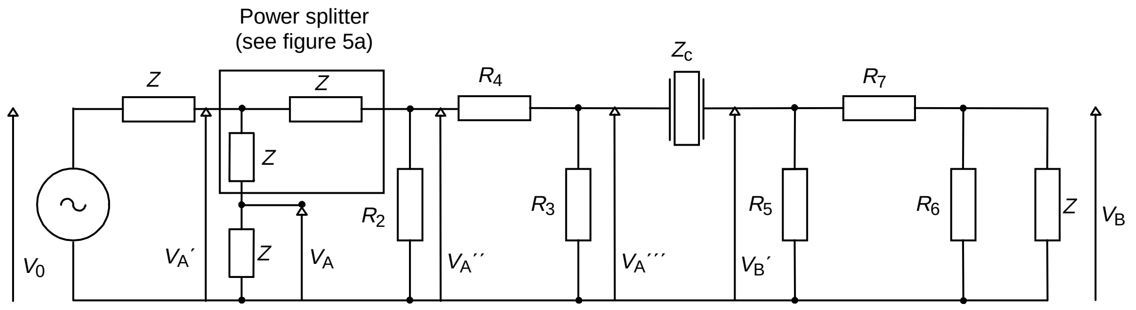


**Figure B.1 – Terminated π-network**

## B.3 Voltage transfer factor of the terminated π-network

In the following an elementary derivation of the voltage transfer factor is presented to provide a more comprehensive formula.



Let $R_6' = R_6 \,||\, Z = \left( \dfrac{1}{R_6} + \dfrac{1}{Z} \right)^{-1}$

Then $\dfrac{V_B}{V_B'} = \dfrac{R_6'}{R_6' + R_7} = k_\pi = 0{,}3649$ (B.1)

Define $R_5' = R_5 \,||\, \left( R_6' + R_7 \right) = \left( \dfrac{1}{R_5} + \dfrac{1}{R_6' + R_7} \right)^{-1} = R_{T2} = 12{,}5\ \Omega$

where $R_{T2}$ is the termination resistance at the output of the π-network as seen by the crystal.

Then $\dfrac{V_B'}{V_A'''} = \dfrac{R_5'}{R_5' + Z_c}$ (B.2)

Define $R_3' = R_3 \,||\, \left( R_5' + Z_c \right) = \left( \dfrac{1}{R_3} + \dfrac{1}{R_5' + Z_c} \right)^{-1}$

Then $\dfrac{V_A'''}{V_A''} = \dfrac{R_3'}{R_3' + R_4}$ (B.3)

Define $R_2' = R_2 \,||\, \left(R_3' + R_4\right) = \left(\dfrac{1}{R_2} + \dfrac{1}{R_3' + R_4}\right)^{-1}$

Then, for a power splitter according to figure 5a and disregarding the cables:

$$\frac{V_A''}{V_A'} = \frac{R_2'}{R_2' + Z} \tag{B.4}$$

and $$\frac{V_A'}{V_A} = \frac{2Z}{Z} = 2 \tag{B.5}$$

The voltage transfer factor $V_B$ / $V_A$ is obtained by multiplying formulae (B.1) × (B.2) × (B.3) × (B.4) × (B.5):

$$\frac{V_B}{V_A} = \frac{V_B}{V_B'} \times \frac{V_B'}{V_A'''} \times \frac{V_A'''}{V_A''} \times \frac{V_A''}{V_A'} \times \frac{V_A'}{V_A}$$

After some substitutions and rearrangements it can be shown that



$$\frac{V_B}{V_A} = \frac{R_2 R_{T1}\, 2\, Z\, R_{T2} R_6}{\left(Z(R_2 + R_4) + R_2 R_4\right) \times \left(Z(R_6 + R_7) + R_6 R_7\right)} \times \frac{1}{Z_c + R_{T1} + R_{T2}} \tag{B.6}$$



where

$$R_{T1} = \left(\frac{1}{R_3} + \frac{1}{R_4 + \left(\dfrac{1}{R_2} + \dfrac{1}{Z}\right)^{-1}}\right)^{-1} = 12{,}5\ \Omega$$

and

$$R_{T2} = \left(\frac{1}{R_5} + \frac{1}{R_7 + \left(\dfrac{1}{R_6} + \dfrac{1}{Z}\right)^{-1}}\right)^{-1} = 12{,}5\ \Omega$$

$V_B/V_A$ is symmetric with respect to the input and the output of the $\pi$-network and splits into a factor which depends only on $Z$ and the resistance values of the $\pi$-network and a factor which depends on the crystal impedance $Z_c$ loaded by the termination impedances of the $\pi$-network.

$$\frac{V_B}{V_A} = K\left(R_2....R_7, Z\right) \times \frac{1}{Z_c + R_T}$$

where $R_T = R_{T1} + R_{T2} = 25\ \Omega$.

Thus far, no approximations have been made. Equation (B.6) holds even if the resistors are assumed to have complex impedance.

The value of $V_B/V_A$ for $Z_c = 0\ \Omega$ is

$$K/R_T = 0{,}0333$$

corresponding to an attenuation of 29,6 dB.

## B.4 Calibration with reference resistor $R_n$ = 25 Ω

As $K$ does not depend on $Z_c$, application of formula (B.6) yields:

for a reference resistor $R_n$ inserted in the $\pi$-network



$$\frac{V_{Bn}}{V_{An}} = \frac{K}{R_n + R_T} \qquad \text{(B.7)}$$



for a crystal with impedance $Z_c$ inserted in the $\pi$-network

$$\frac{V_{Bc}}{V_{Ac}} = \frac{K}{Z_c + R_T} \qquad \text{(B.8)}$$

By dividing (B.7) by (B.8) and solving the equation for $Z_c$ one obtains

$$Z_c = \frac{V_{Bn}}{V_{An}} \times \frac{V_{Ac}}{V_{Bc}}\left(R_n + R_T\right) - R_T \qquad \text{(B.9)}$$

At the resonance frequency $f_r$ the crystal impedance $Z_c$ is equal to the resonance resistance $R_r$, which gives

$$R_r = \left[\frac{V_{Bn}}{V_{An}} \times \frac{V_{Ac}}{V_{Bc}}\left(\frac{R_n}{R_T} + 1\right) - 1\right] R_T \qquad \text{(B.10)}$$

For $R_n = R_T = 25\ \Omega$ the above equation results in the formula used in 6.2.2.7.