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Edition 2.0 2016-12

INTERNATIONAL STANDARD

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Measurement of quartz crystal unit parameters –
Part 8: Test fixture for surface mounted quartz crystal units

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MEASUREMENT OF QUARTZ CRYSTAL UNIT PARAMETERS –

Part 8: Test fixture for surface mounted quartz crystal units

FOREWORD

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International Standard IEC 60444-8 has been prepared by IEC technical committee 49: Piezoelectric, dielectric and electrostatic devices and associated materials for frequency control, selection and detection.

This second edition cancels and replaces the first edition published in 2003. This edition constitutes a technical revision.

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

a) modification of Clause 1;
b) modification of 5.2;
c) modification of 5.3;
d) modification of 5.4;

e) 6.3 Calibration of the reflection measurement system.

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

CDV	Report on voting
49/1126/CDV	49/1175/RVC

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- withdrawn,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

A bilingual version of this publication may be issued at a later date.

IMPORTANT – The 'colour inside' logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

INTRODUCTION

This document focuses on test fixtures applied to leadless surface mounted quartz crystal units. The document is the specification for fixtures [1][2][1] that allow the measurement of (series) resonance frequency, (series) resonance resistance, and equivalent electrical circuit parameters of leadless surface mounted quartz crystal units. The measurement method using an automatic network analyzer with error correction is described in IEC 60444-5, which also contains proposals for test fixtures for quartz crystal units in through-hole packages.

The measuring frequency range is from 1 MHz to 1 200 MHz, and is limited to 1 MHz to 30 MHz, if a physical load capacitance is used. The use of the test fixtures in connection with error correction measurement techniques yields measurement accuracy of about 10^{-6} over of the frequency range, and the accuracy of the resonance resistance is ±2 Ω or ±10 %.

This document forms Part 8 of a series of publications dealing with measurements of quartz crystal unit parameters.

The IEC 60444 series consists of the following parts under the general title *Measurement of quartz crystal unit parameters:*

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

Part 2: Phase offset method for measurement of motional capacitance of quartz crystal units

Part 4: Method for the measurement of the load resonance frequency f_L, load resonance resistance R_L and the calculation of other derived values of quartz crystal units, up to 30 MHz

Part 5: Methods for the determination of equivalent electrical parameters using automatic network analyzer techniques and error correction

Part 6: Measurement of drive level dependence (DLD)

Part 7: Measurement of activity and frequency dips of quartz crystal units

Part 8 Text fixture for surface mounted quartz crystal units

Part 11 Standard method for the determination of the load resonance frequency f_L and the effective load capacitance C_{Leff} using automatic network analyzer techniques and error correction.

[1] Numbers in square brackets refer to the Bibliography.

MEASUREMENT OF QUARTZ CRYSTAL UNIT PARAMETERS –

Part 8: Test fixture for surface mounted quartz crystal units

1 Scope

This part of IEC 60444 describes test fixtures suitable for leadless surface mounted quartz crystal units in enclosures as defined in IEC 61837 (all parts). These fixtures allow the measurement of (series) resonance frequency, (series) resonance resistance, and equivalent electrical circuit parameters L_1, C_1 and C_0 using the measurement techniques specified in IEC 60444-5 and for the determination of load resonance frequency and load resonance resistance according to IEC TR 60444-4 and IEC 60444-11.

Two test fixtures are described in this document:

1) A fixture using the π-network circuit with electrical values as described in IEC 60444-1 for measurements in transmission mode up to 500 MHz. This fixture includes optional means to add physical load capacitors for the measurement of load resonance parameters up to 30 MHz in accordance with IEC 60444-4. The range of load capacitance is 10 pF or more. Calibration of the measurement system and C_L adapter board is explained hereinafter.
2) A fixture based on the reflection method, suitable for a frequency range up to 1 200 MHz. No provisions for adding a physical load capacitance are anticipated. Load resonance parameters can be measured by using the method of IEC 60444-11.

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 units parameters – Part 5: Methods for the determination of equivalent electrical parameters using automatic network analyzer techniques and error correction*

3 Specifications

The test fixture and the method for measuring the (series) resonance frequency, (series) resonance resistance, and equivalent electrical circuit parameters shall be specified in the contract between the crystal unit supplier and the user. The crystal unit requires special consideration as it has no lead wires, in particular if load resonance parameters are to be determined [3].

4 Leadless surface mounted quartz crystal units

4.1 Enclosure

No particular specification shall be made regarding the enclosure type. However, it is recommended that enclosures such as those shown in IEC 61837, be used.

4.2 Overtone and frequency range

No particular specification shall be made regarding the overtone. The frequency range is from 1 MHz to 500 MHz for the described transmission fixture when the physical load capacitance is not used, and from 1 MHz to 30 MHz when the physical load capacitance is used. The frequency range for the reflection fixture is up to 1 200 MHz.

5 Specifications of measurement method, test fixture

5.1 Specifications of measurement method

The basic measurement method is IEC 60444-5. The model of equivalent circuit of the quartz crystal unit is shown in IEC 60122-1. It could be necessary to use a more advanced model for the housed crystal in the high frequency range above several hundred MHz. Depending on the construction of the SMD enclosure, different results may occur between grounded and ungrounded measurements, namely for the measurement of load resonance parameters [3], [4].

If the crystal is grounded in the application, the working frequency may depend on the orientation of the crystal in the circuit. It is therefore recommended to make use of the orientation mark on the crystal (for example pad 1) when correlating the working frequency in the oscillator with the load resonance measurement according to IEC 60444-5.

5.2 Specifications of transmission test fixture

The equivalent circuit of the π-network test fixture and its electric values are based on IEC 60444-1. To match the leadless crystal packages, the size and the structure are different in this document from those of IEC 60444-1 and IEC 60444-5. The test fixture configuration is similar to that in IEC 60444-1. Figure 1 and Figure 2 show the test fixture, but stray capacitances between measurement terminals such as C_{t1} and C_{t2} in IEC 60444-1:1986, Figure 2, are not specified. Figure 3 and Figure 4 show a 3-D view and the mechanical design of the test fixture.

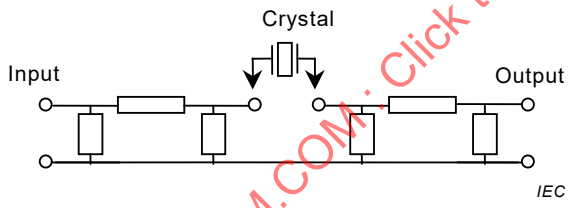


Figure 1 – Transmission π-network test fixture: Simplified equivalent circuit diagram, frequency range from 1 MHz to 500 MHz

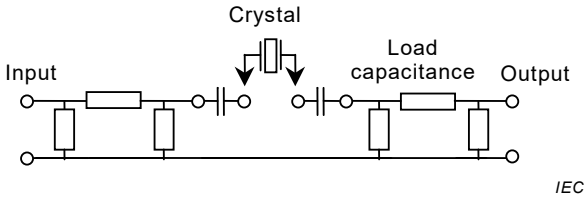


Figure 2 – Transmission π-network test Fixture with physical load capacitors: simplified equivalent circuit, frequency range from 1 MHz to 30 MHz

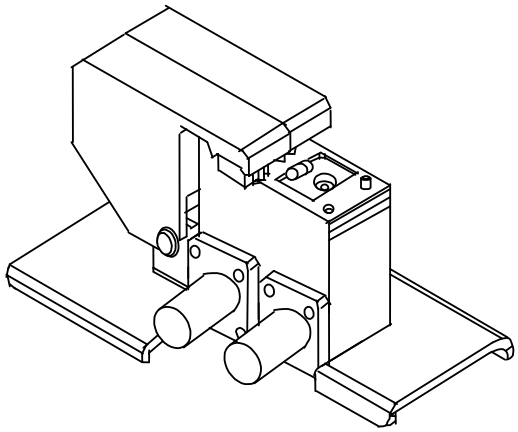


Figure 3 – Transmission π-network test fixture: Three-dimensional projection for the test fixture

Dimensions in millimetres

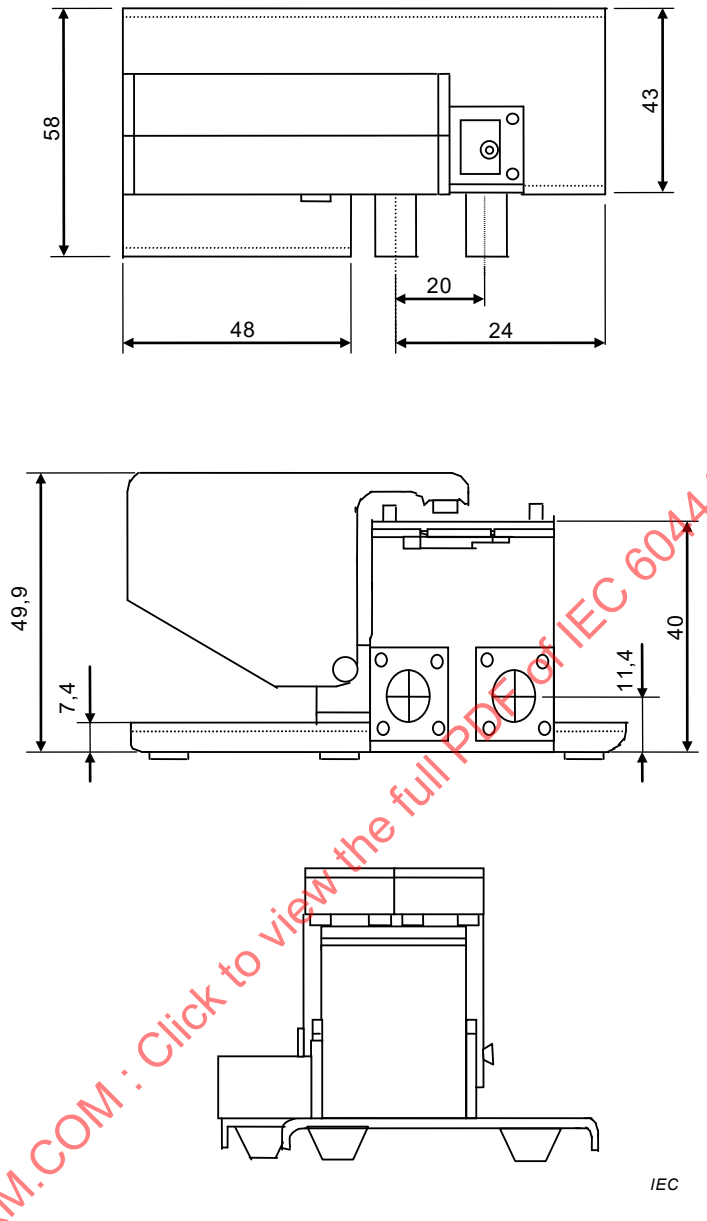


Figure 4 – Transmission π-network test fixture: Mechanical design of the test fixture

No specifications need to be made as to the detail structures of the test fixture to be used, except that it shall secure a reliable mechanical contact of the electrodes performing the same function as the lead wire of a through-hole quartz crystal unit and the measurement terminals of the test fixture. The reference plane of the measurement is the plane of the SMD pads. The necessary mechanical force to assure a reliable contact is 2 N.

Figure 5 shows the structure of the π-network test fixture with physical load capacitors.

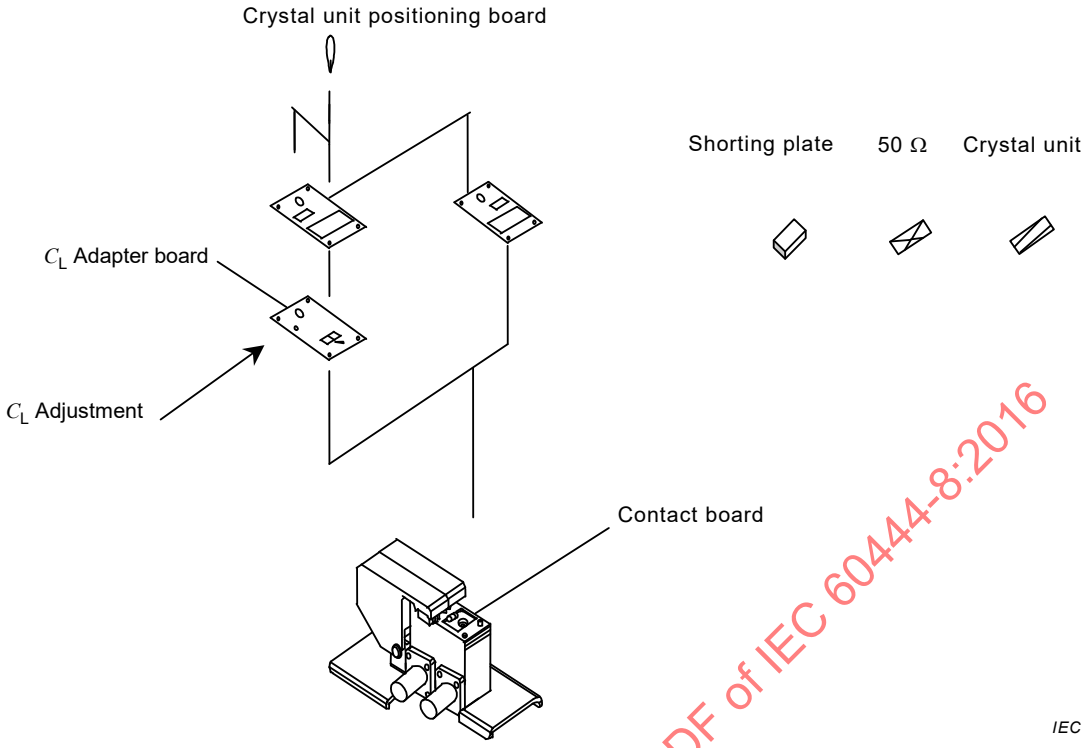
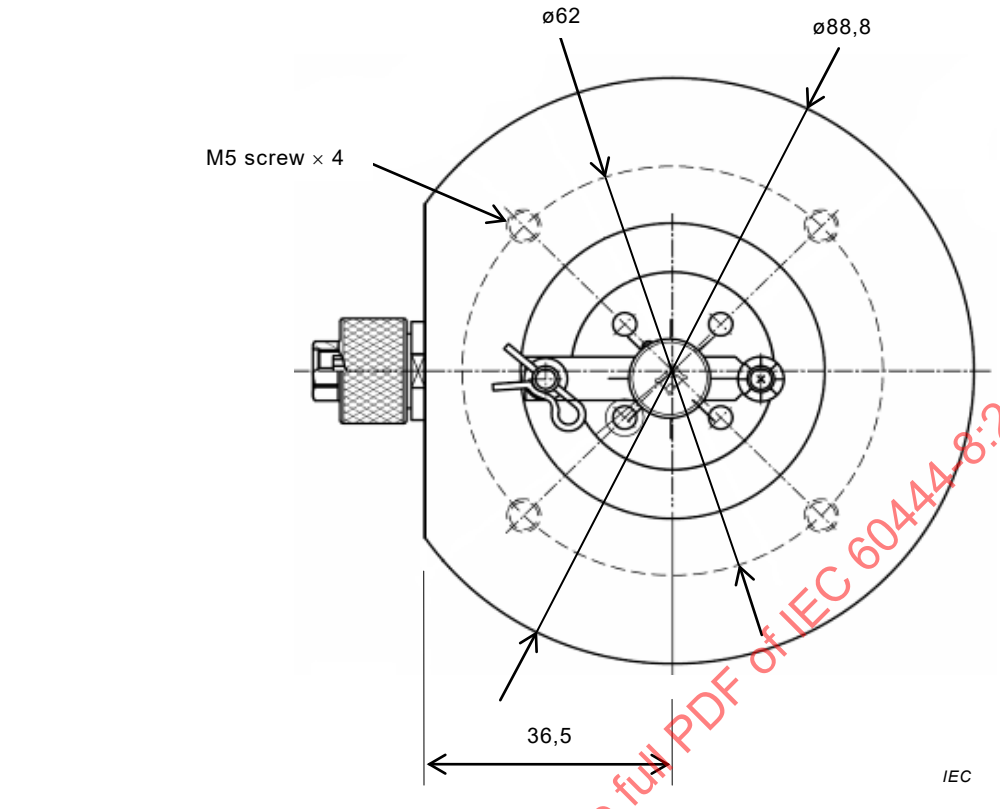


Figure 5 – Transmission π-network test fixture with physical load capacitors: Structure of the test fixture

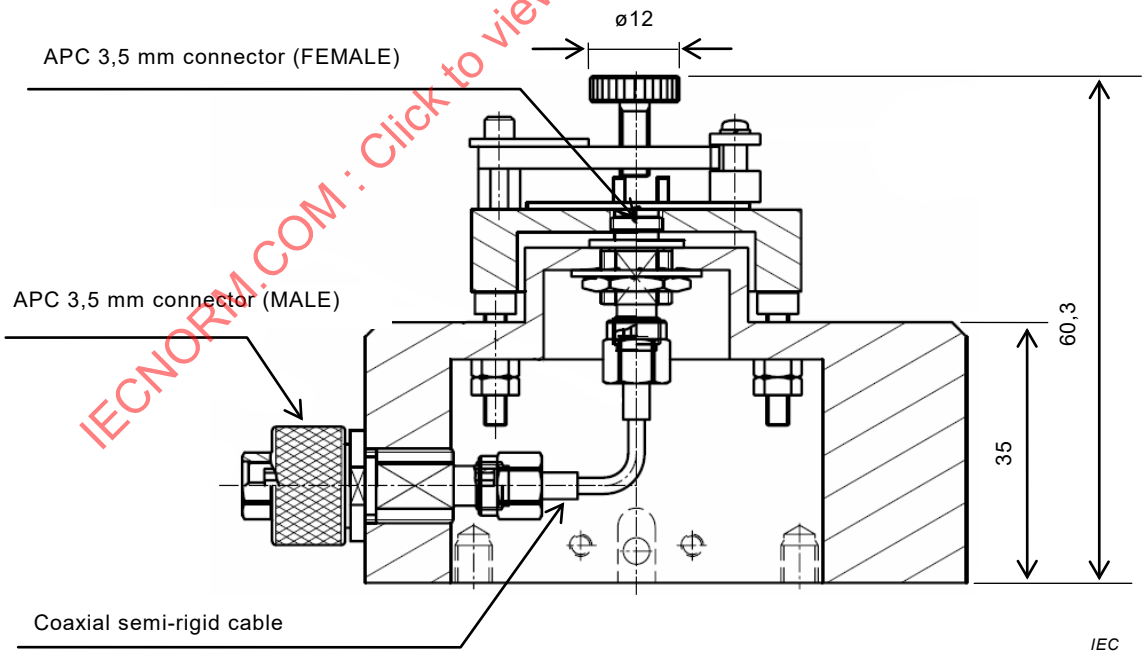
5.3 Specifications of reflection test fixture

The mechanical design of the reflection test fixture is shown in Figures 6, and its usable frequency range is from 1 MHz to 1 200 MHz [2]. It is the SMD version of the one-port reflection test fixture shown in IEC 60444-5.

Dimensions in millimetres



a) Top view



b) Cross section view

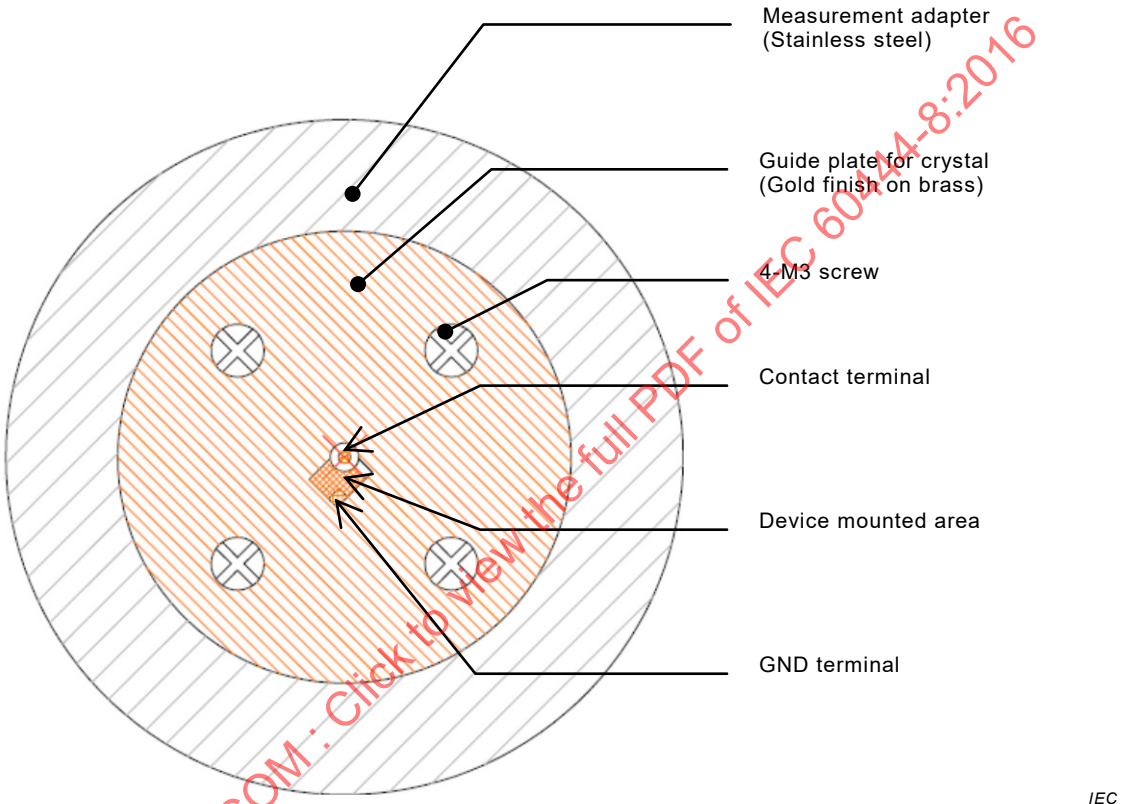
Figure 6 – Design of the reflection test fixture

The test fixture is to be connected with the s_{11} port of the network analyser through a high quality coaxial cable with an APC 3,5 precision coaxial connector at the test fixture side. For higher frequencies, the use of semi-rigid or rigid coaxial cable is recommended.

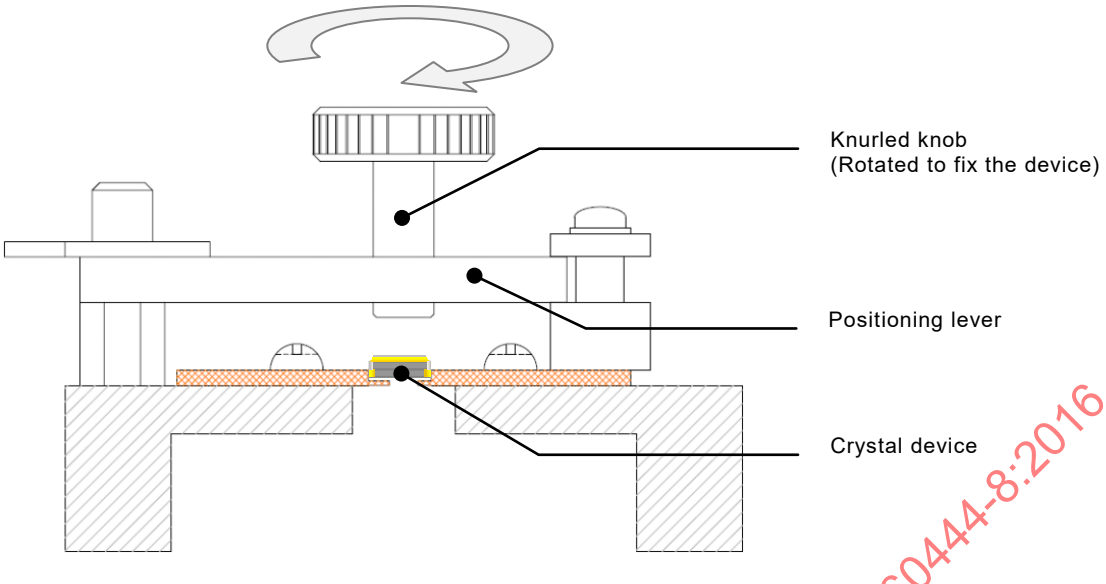
The device under test (DUT) is fixed to the measurement adapter as shown in Figure 7. A guide plate to fix the DUT shall be designed in accordance with IN-OUT terminals of the DUT.

A contact pin is inserted into the central conductor of the coaxial connector at the DUT side. Care shall be taken during the insertion to avoid deformation due to excessive force.

A holding clamp is screwed and fixed to the base unit. The depth of the screw motion shall be adjusted in accordance with the mechanical conditions. If the clamp is screwed too tightly, the coaxial connector or DUT may be damaged. Adjust the length of the M5 screw such that it will not penetrate too deeply into the measurement unit.



a) Top view



b) Cross section view

Figure 7 – Mechanical details of the reflection test fixture

5.4 Measuring equipment

The vector network analyzer shall provide an error-correction-feature using internal mathematical processing of the measurement values, and shall be able to effectively eliminate the causes of errors via the connection of the S-parameter equipment with the test fixture.

6 Calibration

6.1 Calibration of the transmission test system

The calibration is done in accordance with IEC 60444-5 by the use of three reliable standard impedance elements for calibration. These are: a short element, an open element and a load element of 25 Ω or 50 Ω.

The specification of the load element of 25 Ω or 50 Ω has to be prescribed in the range from 1 MHz to 500 MHz. For low frequencies < 150 MHz, it is sufficient if the resistance value is 50 Ω ± 5 % and the phase is 0,2° maximum. For higher frequencies, the calibration elements shall be described by the elements for their equivalent electric circuit (see IEC 60444-5 for details).

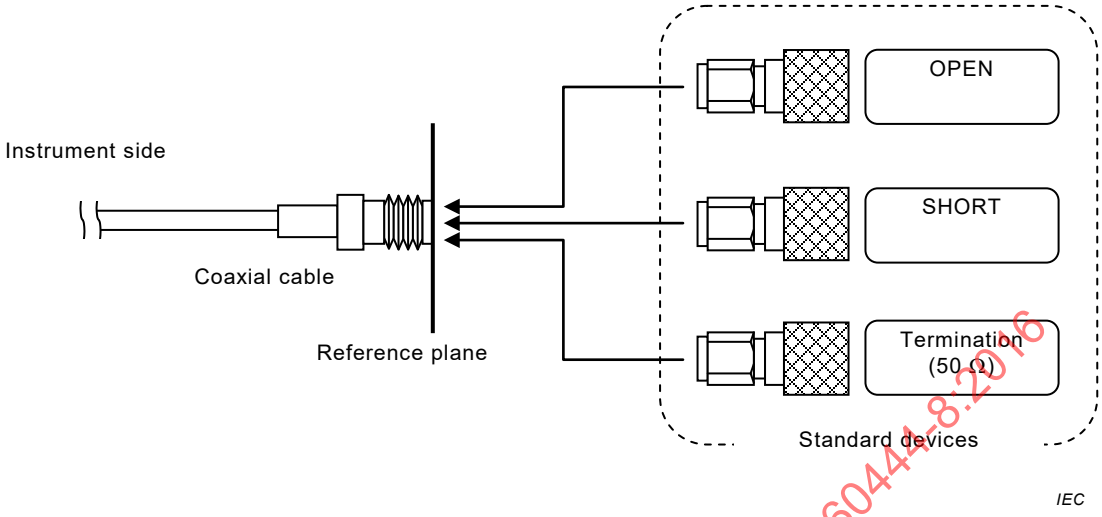
6.2 Additional calibration of the transmission test system with C_L adapter board

A precision capacitance meter is used for the calibration of the C_L adapter board. The measurement shall be done at 1 MHz. The permissible tolerance is ±0,02 pF.

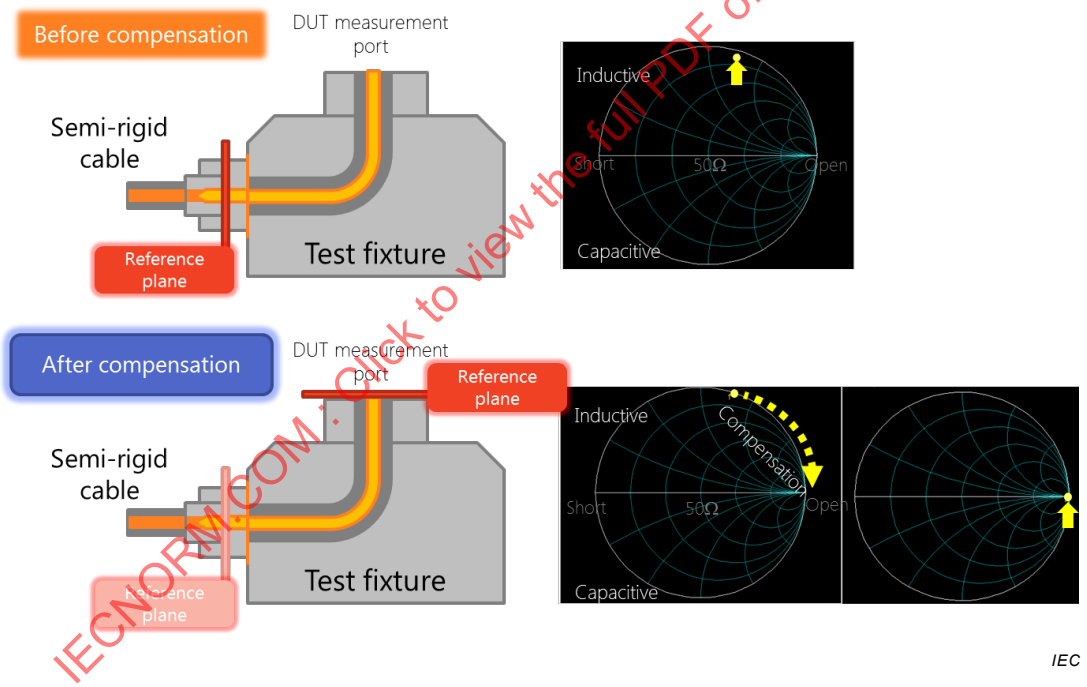
6.3 Calibration of the reflection measurement system

A 3-term calibration of the measurement system shall be performed before connecting the test fixture to the end of a coaxial cable. Precise APC 3,5 calibration devices (Open, Short, Termination) shall be used, which have a guaranteed characteristics in the measurement frequency band. After connecting the cable to the test fixture without a crystal unit inserted, the

measured phase will rotate in the Open condition. For compensation of the phase error, an electrical length shall be added. See Figure 8 for details.



a) Calibration method



b) Compensation for electrical length

Figure 8 – Calibration technique for the reflection test fixture