SLOVENSKI STANDARD
SIST EN 61828:2002

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Ultrasonics - Focusing transducers - Definitions and measurement methods for the transmitted fields (IEC 61828:2001)

Ultrasonics - Focusing transducers - Definitions and measurement methods for the transmitted fields

Ultraschall - Fokusierende Wandler - Definitionen und Messverfahren für die erzeugten Felder

Ultrasons - Transducteurs focaliseurs - Définitions et méthodes de mesure des champs transmis

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English version

Ultrasonics - Focusing transducers - Definitions and measurement methods for the transmitted fields
(IEC 61828:2001)

Ultrasons - Transducteurs focaliseurs - Définitions et méthodes de mesure des champs transmis (CEI 61828:2001)

Ultraschall - Fokusierende Wandler - Definitionen und Messverfahren für die erzeugten Felder (IEC 61828:2001)

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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

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Foreword

The text of document 87/196/FDIS, future edition 1 of IEC 61828, prepared by IEC TC 87, Ultrasonics, was submitted to the IEC-CENELEC parallel vote and was approved by CENELEC as EN 61828 on 2001-09-01.

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)	2002-06-01
– latest date by which the national standards conflicting with the EN have to be withdrawn	(dow)	2004-09-01

Annexes designated "normative" are part of the body of the standard.
Annexes designated "informative" are given for information only.
In this standard, annex ZA is normative and annexes A, B and C are informative.
Annex ZA has been added by CENELEC.

Endorsement notice

The text of the International Standard IEC 61828:2001 was approved by CENELEC as a European Standard without any modification.

In the official version, for Bibliography, the following notes have to be added for the standards indicated:

IEC 61161:1992 NOTE: Harmonized as EN 61161:1994 (not modified).

IEC 62092:2001 NOTE: Harmonized as EN 62092:2001 (not modified).

Annex ZA
(normative)

Normative references to international publications with their corresponding European publications

This European Standard incorporates, by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this European Standard only when incorporated in it by amendment or revision. For undated references, the latest edition of the publication referred to applies (including amendments).

NOTE When an international publication has been modified by common modifications, indicated by (mod), the relevant EN/HD applies.

Publication	Year	Title	EN/HD	Year
IEC 60050-801	1994	International Electrotechnical Vocabulary (IEV) - Chapter 801: Acoustics and electroacoustics	-	-
IEC 61102	1991	Measurement and characterisation of ultrasonic fields using hydrophones in the frequency range 0,5 MHz to 15 MHz	EN 61102	1993
IEC 61157	1992	Requirements for the declaration of the acoustic output of medical diagnostic ultrasonic equipment	EN 61157	1994
IEC 61689	1996	Ultrasonics - Physiotherapy systems - Performance requirements and methods of measurement in the frequency range 0,5 MHz to 5 MHz	EN 61689	1996

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Ultrasonics – Focusing transducers – Definitions and measurement methods for the transmitted fields

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

ULTRASONICS – FOCUSING TRANSDUCERS – DEFINITIONS AND MEASUREMENT METHODS FOR THE TRANSMITTED FIELDS

FOREWORD

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International Standard IEC 61828 has been prepared by IEC technical committee 87: Ultrasonics.

This bilingual version (2006-07) replaces the English version.

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

FDIS	Report on voting
87/196/FDIS	87/204/RVD

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

The French version of this standard has not been voted upon.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

The committee has decided that the contents of this publication will remain unchanged until the maintenance result 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.

INTRODUCTION

Focusing transducers are essential in medical applications for obtaining high-resolution images, Doppler and flow data and for concentrating ultrasonic energy at desired sites for therapy. Present terminology for focusing transducers is inadequate for communicating precisely the characteristics of the focused fields of the wide variety of transducers and transducer array types and focusing means in common usage.

This International Standard provides specific definitions appropriate for describing the focused field from a theoretical viewpoint for transducers with known characteristics intended by design. Other specific definitions included in this standard, based on measurement methods, provide a means of determining focusing properties, if any, of a transducer of unknown field characteristics. The measurement method and definitions provide criteria for determining if the transducer is focusing, as well as a means of describing the focusing properties of the field. Beam axis alignment methods are given for focusing transducers.

ULTRASONICS – FOCUSING TRANSDUCERS – DEFINITIONS AND MEASUREMENT METHODS FOR THE TRANSMITTED FIELDS

1 Scope

This International Standard

– provides definitions for the transmitted field characteristics of focusing transducers for applications in medical ultrasound;

– relates these definitions to theoretical descriptions, design, and measurement of the transmitted fields of focusing transducers;

– gives measurement methods for obtaining defined characteristics of focusing transducers;

– specifies beam axis alignment methods appropriate for focusing transducers.

This International Standard relates to focusing ultrasonic transducers operating in the frequency range appropriate to medical ultrasound (0,5 MHz to 40 MHz) for both therapeutic and diagnostic applications. It shows how the characteristics of the transmitted field of transducers may be described from the point of view of design, as well as measured by someone with no prior knowledge of the construction details of a particular device. The radiated ultrasound field for a specified excitation is measured by a hydrophone in either a standard test medium (for example, water) or in a given medium. The standard applies only to media where the field behaviour is essentially like that in a fluid (i.e. where the influence of shear waves and elastic anisotropy is small), including soft tissues and tissue-mimicking gels. Any aspects of the field that affect their theoretical description or are important in design are also included. These definitions would have use in scientific communications, system design and description of the performance and safety of systems using these devices.

This standard incorporates definitions from other related standards[1] where possible, and supplies new, more specific terminology, both for defining focusing characteristics and for providing a basis for measurement of these characteristics.

2 Normative references

The following referenced documents are indispensable for the application 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 60050(801):1994, *International Electrotechnical Vocabulary (IEV) – Chapter 801: Acoustics and electroacoustics*

IEC 61102:1991, *Measurement and characterization of ultrasonic fields using hydrophones in the frequency range 0,5 MHz to 15 MHz*

[1] Specifically, IEC 61102 and IEC 61157 (see clause 2).

IEC 61157:1992, *Requirements for the declaration of the acoustic output of medical diagnostic ultrasonic equipment*

IEC 61689:1996, *Ultrasonics – Physiotherapy systems – Performance requirements and methods of measurement in the frequency range 0,5 MHz to 5 MHz*

3 General

The information contained in this clause is an introduction to the definitions given in clause 4 and the measurement methods given in clause 6.

3.1 Focusing transducers

The term "**focusing transducer**"[2] is commonly used for a device which has a smaller beamwidth in some regions of the field than a device which is "non-focusing". A "**non-focusing transducer**" can still have a **natural focus**, so it is necessary to distinguish a **focusing transducer** as having a greater concentration of pressure amplitude (for a given power output) than a **non-focusing transducer** at its **natural focus**. For example, a **non-focusing transducer** made of a simple disc of uniformly poled piezoelectric material has a beam whose intensity at its **natural focus** can be as much as four times the average intensity at the source, and whose –6 dB **beamwidth** can be approximately half of that at the source. A definition of a **focusing transducer** is given in 4.2.33 to make a quantitative distinction between **focusing** and **non-focusing transducers.**

3.1.1 Focusing methods

The simplest means of intentionally focusing an **ultrasonic transducer**, borrowed from analogous optical principles, is that of shaping the **ultrasonic transducer** into a concave form or adding to it a physical lens as illustrated in figure 1. In the top part of this figure, a transducer curved with a radius R is shown focusing to the centre of curvature, where R is positive by convention. By the geometrical-optics approximation, the focal length F is equal to R and hence is also positive. In the middle of figure 1 is shown a transducer with a plano-concave lens made of a material with longitudinal velocity, c_L, which is curved on one side with a radius, R_{LENS}, and radiates into a medium in which the velocity is c_W. In acoustics, c_W is typically less than c_L, i.e., the index of refraction n (equal to c_W/c_L) is less than 1. When this is true, the radius is considered to be negative and the focal length, given by the geometric-acoustics approximation as R_{LENS} divided by $(n – 1)$, is positive. At the bottom of the figure, for comparison, the typical situation for a convex lens in optics is shown: n is greater than 1 and the radius is considered to be positive, so the focal length is positive.

3.1.2 Known and unknown focusing transducers

For **ultrasonic transducers** currently used in medical ultrasound applications, it is difficult to determine from physical observation if an **ultrasonic transducer** is focusing, because additionally many other focusing methods such as geometric shaping and arrangement, reflectors, arrays with electronic phasing and delay, Fresnel lenses, shading, etc. may be used singly or in combination. Because of inherent natural focusing and the potential complexity of additional focusing means used, any generally useful definition of a focusing transducer must be in terms of its field rather than its construction. If a focusing source were to be defined in terms of its pressure field, then this would be relatively easy to apply in practice, since the pressure can be measured directly with a hydrophone.

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2 Terms in bold print are defined in clause 4.

A distinction is also made between **ultrasonic transducers** whose construction is known and transducers about which very little information is available. For the first category of **ultrasonic transducers,** certain theoretical definitions, such as **geometric focal length**, are useful for describing and modelling focusing characteristics. **Ultrasonic transducers** falling in the second category function as an unknown "black box" and only the field may be accessible.

In the latter case, and in general, focusing parameters are determined from measurements, and the measurement procedures of clause 6 are appropriate. In clause 6, measurement methods are given for determining if a transducer system radiating into known propagation media under specified excitation conditions is "focusing". Because of the lack of knowledge of ultrasonic transducer construction and limited access to the **ultrasonic transducer** field, the focusing definitions shown in figure 2 are required. These definitions are given in clause 4 and their use is explained in 3.1.5.

3.1.3 Focusing and beamwidth

Previously, hydrophone measurements of beam characteristics were based on regions of axial peak pressure. For example, definitions for a **depth-of-field** were based on the fall-off in intensity on either the near side or the far side of an axial peak on the **beam axis**. For axially symmetric beams, this axial peak can be related to the **geometric focal length**. For typical rectangular arrays, azimuthal plane electronic focusing and elevational plane mechanical lens focusing can cause peaks of axial pressure at different locations along a **beam axis**. These individual peaks can be dealt with separately by **beamwidth** measurements made in the corresponding orthogonal planes: therefore, new definitions are based on **beamwidths** in a specified **longitudinal plane** (refer to figure 7). Focusing definitions must also distinguish between natural and intentional focusing.

3.1.4 New focusing parameter definitions

This document introduces new focusing parameters and provides more specific contexts for existing terminology. For example, the terms **"near field"** and **"far field"** are often misapplied to **focusing transducers**, though they have traditionally been defined for **non-focusing transducers** only. The definitions **near Fresnel zone**, **far Fresnel zone** and **focal Fraunhofer zone**, apply to **focusing transducers**. These definitions, explained in more detail in 3.3 and derived from annex A, are illustrated in figure 3b and are applied to a strongly focusing circular aperture in figure 4. Other concepts such as focusing in a particular plane are also necessary to reduce ambiguity in usage.

For the purposes of this document, the following definitions for a **focusing transducer** will be used.

For **ultrasonic transducers** of known construction (refer to figure 5 for transducer geometry and terms), a **focusing transducer** is an electro-acoustic device that produces, at any distance less than one-half of the **transition distance** from the **transducer aperture,** a –6 dB **beamwidth** in a **longitudinal plane** that is less than half the **transducer aperture width** in that plane. For measurement purposes and cases (see figure 2) where the geometry of the **ultrasonic transducer** is not known or where there is no direct access to the **ultrasonic transducer** (because of the device being used in some stand-off arrangement), a definition of focusing based on data is more appropriate. For this second case, a **focusing transducer** is an electro-acoustic device that produces, at any distance less than half of the **transition**