INTERNATIONAL STANDARD

IEC 61828

First edition
2001-05

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

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

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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

FOREWORD

1) The IEC (International Electrotechnical Commission) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of the IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, the IEC publishes International Standards. Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. The IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
2) The formal decisions or agreements of the IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested National Committees.
3) The documents produced have the form of recommendations for international use and are published in the form of standards, technical specifications, technical reports or guides and they are accepted by the National Committees in that sense.
4) In order to promote international unification, IEC National Committees undertake to apply IEC International Standards transparently to the maximum extent possible in their national and regional standards. Any divergence between the IEC Standard and the corresponding national or regional standard shall be clearly indicated in the latter.
5) The IEC provides no marking procedure to indicate its approval and cannot be rendered responsible for any equipment declared to be in conformity with one of its standards.
6) Attention is drawn to the possibility that some of the elements of this International Standard may be the subject of patent rights. The IEC shall not be held responsible for identifying any or all such patent rights.

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

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.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 3.

Annexes A, B and C are for information only.

The committee has decided that the contents of this publication will remain unchanged until 2005. 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 normative documents contain provisions which, through reference in this text, constitute provisions of this International Standard. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.

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*

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[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.