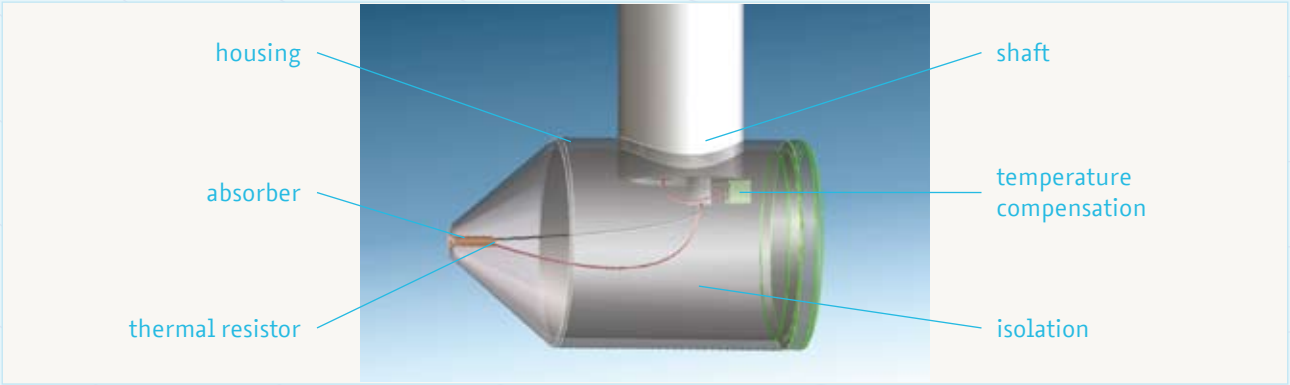
Thermo-acoustic ultrasound sensor

Introduction

In general, the measurement of the emitted sound power of ultrasound equipment and sensors is carried out by means of ultrasound hydrophones. Such measurements form the basis for the assessment of patient safety and the quality assurance of medical ultrasound equipment are essential for the development and production of high-performance ultrasound probes. Especially the maximum sound intensities of diagnostic ultrasound equipment have to be measured and declared by the manufacturers in accordance with the standard IEC61157. Due to the often extremely sensitive measuring methods using hydrophones, however, ultrasound intensity measurements are very cost-intensive and time-consuming.
An easy-to-use and above all cost-effective alternative are the thermo-acoustic sensors of the company GAMPT. Here, the measurement of the sound intensity is based on the conversion of the sound energy into heat inside a very small acoustic absorber. Its temperature change is measured with high resolution. As a number of different absorbers can be selected, it is possible to adjust the sensor to the respective measurement range.

Description

The thermo-acoustic sensors consist of a robust stainless steel housing with a very small acoustic absorber in its inside. The absorber is thermally isolated from the housing. A small sound entry surface with a diameter of 0.5 mm is at its front. Thus, a high spatial resolution of the sensor is achieved. On the rear of the absorber, there is a thermosensor by means of which the heating of the absorber during the sound exposure is measured.
In order to minimise the influence of the ambient temperature, a temperature compensation has been integrated into the head of the probe. With the aid of the measurement amplifier, the temperature change in the sensor is converted into a simple voltage value that is either recorded directly with the PC via USB or can be recorded using a multimeter.



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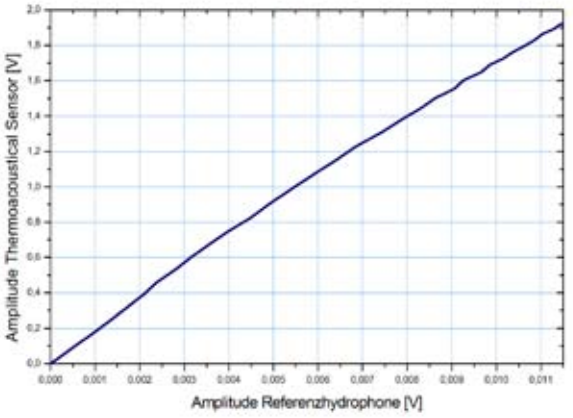
Advantages of thermoacoustic sensors

The compact and robust design of the sensor, the easy and quick handling and the different sensitivity levels predestine the thermo-acoustic sensor particularly for the use in the field of quality assurance and constancy testing of ultrasound equipment in medical diagnostics and therapy to the application for measurements of HITU (High Intensity Therapeutic Ultrasound) equipment.
In most cases, modern ultrasound equipment, as deployed, for instance, in imaging diagnostics, use very complex pulse sequences to control the ultrasound sensors. Therefore, the synchronisation of the intensity measurement is often a difficult, and from time to time, even insoluble technical problem. For the thermo-acoustic sensor, however, a synchronisation is not required, since the time-related averaging over all sound events is already carried out in the sensor. Thus, the sensor always provides the local, time-averaged sound intensity of the respective measuring point.
Due to the variation of the acoustic absorbers inside the sensors, the sensitivity of the sensor can be adjusted to the respective measuring tasks.
At the moment, three different sensitivity levels are available. The most sensitive sensors (0.01-0.1 W/cm²) are suitable for ultrasound equipment with very low sound intensities as applied, for example, in medical diagnostics or for non-destructive testing (NDT). The mean sensitivity level (0.1-1 W/cm²) was developed for use in ultrasound therapy equipment. The lowest sensitivity level reaches far into the measurement range of the HITU sensors (<10 W/cm²) and its upper limit is rather defined by the occurrence of cavitations and the mechanical stability of the sensor brackets. The thermoacoustic sensor is always ready for immediate use. The use of deionised water as measurement medium is not required. Hence, constancy tests of ultrasound equipment, in particular can be performed on site and within a short period of time.

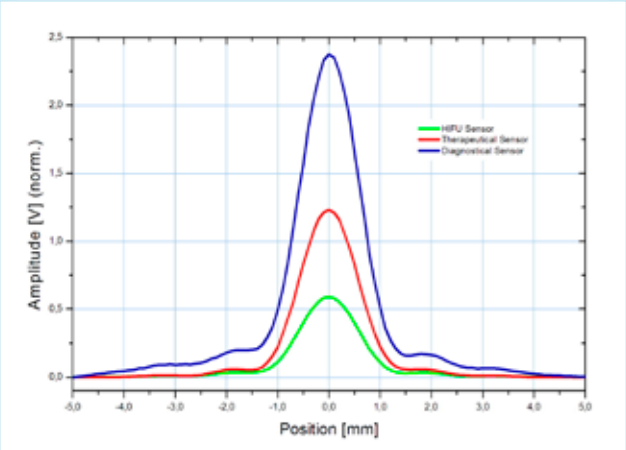
Calibration

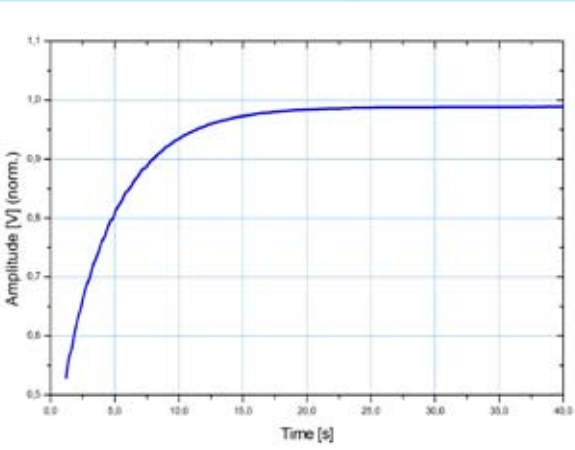
For selected frequencies, the thermo-acoustic sensors are calibrated by means of a reference membrane hydrophone of the company GAMPT. The reference hydrophones have the same effective diameter than the thermoacoustic sensors and thus allow direct comparisons to be made between the measured values. They are calibrated over a wide frequency range in the Physikalisch-Technische Bundesanstalt (PTB) in Braunschweig and can subsequently be used as reference measuring system for secondary calibrations.



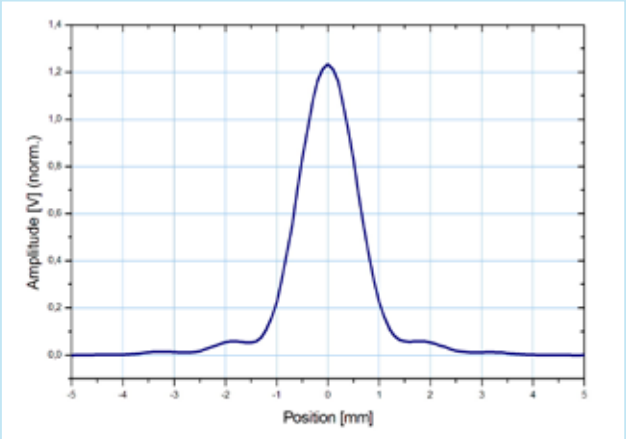
Measurements

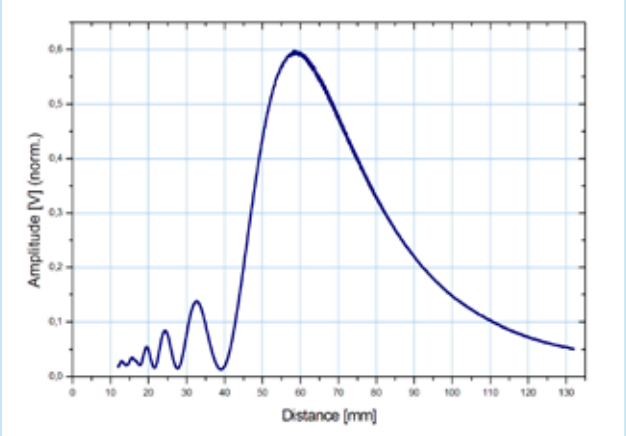
The thermo-acoustic sensors are used in addition to the measurements using membrane or pointed hydrophones. Thus, the local intensities of a sound source can be determined as individual values, line scans or field distributions.
As thermosensors have a certain response time, the user must wait until the equilibrium value is reached at each measuring point. The thermo-acoustic sensors of the company GAMPT are characterised by their very short response times of less than 15 s. Even for larger data fields, the measurements remain at quite an acceptable level.



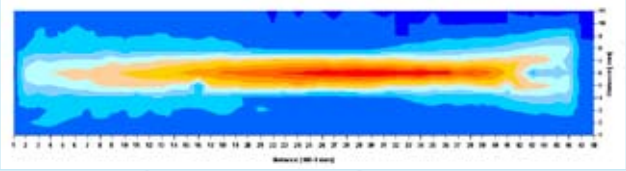


For spatial resolution measurements, the sound entry surface with a diameter of 0.5 mm is sufficiently small to characterise the intensity distribution of ultrasound probes.
Measurements carried out horizontally and vertically to the sound propagation direction indicate the main sound beam with its secondary maxima and the modulations of the intensity along the propagation axis to the end of the near-field length of the sound converter.
With respect to the measurements, especially the small dimensions of the sensor are an advantage, as large-dimensioned water basins are not required.





For scanning a complete sound field, we recommend using our SFS-3 ultrasound field scanner. Using this scanner, the different dimensions of the scanning area, the spatial resolution and die specific parameters for the use of the thermo-acoustic sensor, such as the rise time, can be realised very easily.

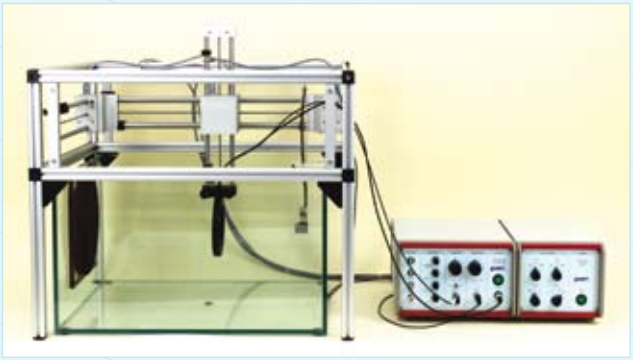


Application

The thermo-acoustic sensors are mainly used for measurements where the sound pressure amplitudes do not have to be analysed. Especially if the triggering on the measuring signal is not possible for technical reasons or if the sound emission is to be measured as average intensities, the thermo-acoustic sensors provide excellent results. Furthermore, the application of sensors is extremely quick, easy and cost-effective. So measurements in the field of quality assurance and constancy testing of ultrasound sources can also be carried out in facilities that do not have the technical equipment of ultrasound testing laboratories, such as hospitals and clinics, physiotherapy practices or engineering firms for non-destructive testing.

Accessories

The thermo-acoustic sensors can be delivered as individual ultrasound sensors to be connected to a reference voltage source and a digital voltmeter or with the measurement amplifier to be directly connected to the PC. For the determination of intensity distributions of an ultrasound source, the sound field scanner of the company GAMPT with a control unit including the corresponding software, a suitable measurement tank and, if required, an absorber mat is available.



Technical data

Acoustic frequency range:	100 kHz to 20 MHz
Optional calibrated frequency range:	0,1 MHz to 20 MHz
Measurement range:	0.01-0.1 W/cm² 0.1-10 W/cm² <10 W/cm²
Max. ultrasonic pressure:	> 100 MPa
Aktive area	~ 0,2 mm²
Spatial resolution:	500 µm
Output impedance	10 kOhm
Reference voltage	+5V DC
Connector:	5 pole diode connector output / reference voltage / GND
Housing dimension:	8 mm diameter
	16 mm length
Measurement amplifier	80 x 107 x 140 mm
Signal outputs:	+/- 10V DC USB AFC for PC audio line in
Power input:	100-240 V AC / 50-60Hz
Power consumtion:	< 20 W

Literature

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GAMPT

Gesellschaft für Angewandte Medizinische Physik und Technik

(Company for Applied Medical Physics and Technique)

Founded in 1998 by employees of the Institut für Medizinische Physik und Biophysik of Martin Luther University Halle-Wittenberg, the name **GAMPT** now stands for comprehensive expertise in the field of ultrasonic measuring technology. We design our own projects and work together with partners from business and research to find solutions. A growing network of customers and partners in Germany, Europe, Asia and the USA is a reflection of many successful collaborations.

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