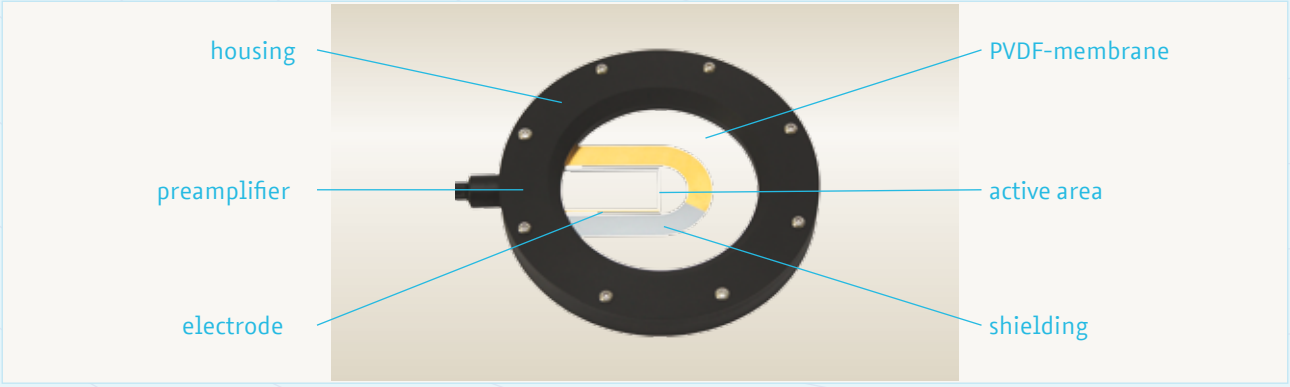
Membrane hydrophone

Introduction

Ultrasound membrane hydrophones are used for all applications where emitted sound intensities of ultrasound equipment or sensors have to be measured. Such measurements are not only of tremendous importance for the quality assurance of medical ultrasound equipment, but also for the development and verification of ultrasound sensors for industrial and test engineering. Especially for the compliance with safety relevant limit values in the ultrasound exposimetry for medical equipment that is increasingly demanded by international legislation, membrane hydrophones with an extremely large bandwidth and slight fluctuations in the transfer function are required.
Moreover, membrane hydrophones are able to measure the sound pressure of a sound field with high spatial resolution. By scanning along lines or surfaces, the spatial distribution of the high-frequency sound pressure is recorded. From this data, a range of other important parameters of a sound field, such as location and dimensions of a focus, width of the sound beam or local changes in intensity, can be derived.

Description

In collaboration with the working group “Ultrasound” of the Physikalisch-Technische Bundesanstalt (PTB) in Braunschweig, one of the leading institutes in the field of the development and calibration of highly sensitive measuring equipment (www.ptb.de), a membrane hydrophone with excellent properties was developed and made ready for the market by the company GAMPT. Thanks to its exceptionally large bandwidth of up to 90 MHz, its extremely flat transfer function up to 40 MHz and its very small active surface of not more than 200 µm, this hydrophone is not only suitable for the spatial resolution characterisation of sound fields, but is also used as reference hydrophone for the calibration of ultrasound sources. The membrane hydrophone consists of a round plastic housing with an embedded membrane and vapour deposited gold electrodes.



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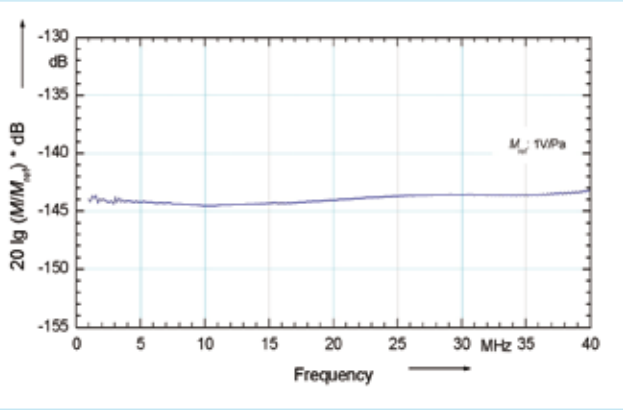
As the preamplifier has already been integrated into the housing, the hydrophone can be directly connected to an oscilloscope or to the Ultrasound Hydrophone Controller (UHC-80) from GAMPT. In connection with the 3D sound field scanner (SFS-3), the scan controller (SFD-4) and the sound field measurement tank, a complete and easy-to-use measuring system for the complete characterisation of sound sources is available.

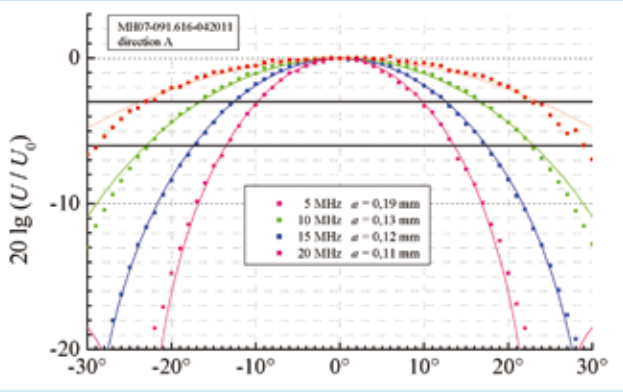
Transfer function of the membrane hydrophone

In addition to the bandwidth and spatial resolution, one of the most important quality features of a membrane hydrophone is a sensitivity that is as constant as possible across a wide frequency range. In the frequency ranges between 0.5 and 40 MHz, our membrane hydrophones demonstrate an average sensitivity fluctuation of not more than 5 %. The resonance frequency of the hydrophones is well above 100 MHz. Thus, a usable frequency range of up to 90 MHz is possible. Furthermore, due to the integrated preamplifier, the hydrophones have a very good signal-to-noise ratio. In addition to this, the applied shielding electrodes prevent unwanted interfering signals from coupling. Thanks to the special arrangement of the shielding electrodes, interference with signals can be avoided to the greatest possible extent.



Directionality and effective radius of the hydrophone

The membrane hydrophones are characterised by their extremely small effective spots (size of the active sensor surface) of not more than 200 µm at 5 MHz. Thus, high-resolution sound field measurements where small local inhomogeneities in the sound pressure amplitude can also be recorded are possible. Due to the good directionality, especially focussed ultrasound fields can also be measured accurately.

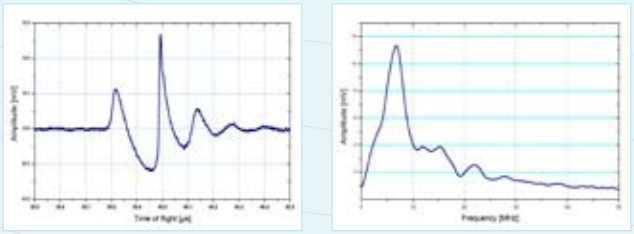


Calibration

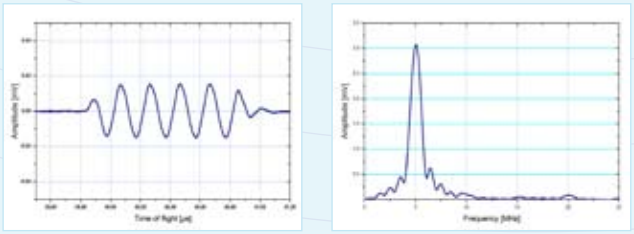
Depending on the customer's requirements, the membrane hydrophones can be offered with different calibrations. The spectrum ranges from simple amplitude calibrations in the frequency ranges of 0.5 – 20 MHz up to complete characterisations of the amplitude, phase, directionality and effective diameter up to 40 MHz.
In the Physikalisch-Technische Bundesanstalt in Braunschweig, the calibration of the hydrophones is carried out with utmost precision. Thus, the consistent high level of quality of the hydrophones is ensured.
Since our membrane hydrophones have excellent stability properties, they are used in measuring and calibration laboratories as reference hydrophones for secondary calibration.

Measurements

For the measurement of short ultrasound pulses, a high bandwidth of the hydrophone is required in order to be able to also include the much higher harmonious signal components.



Ultrasound bursts with low sound intensity require a good signal-to-noise ratio of the hydrophone.



For the assessment of the width of the sound beam of focussed ultrasound fields, a high lateral resolution of the hydrophone is needed. This lateral resolution is, above all, determined by the effective diameter of the sensor surface. In connection with our sound field scanner, the spatial distribution of the sound pressure amplitude of a sound source can be measured in all three spatial dimensions. This is an important tool for the development and optimisation of ultrasound sensors for both medical imaging and the application in material testing equipment and sensors in industry and engineering.

Application

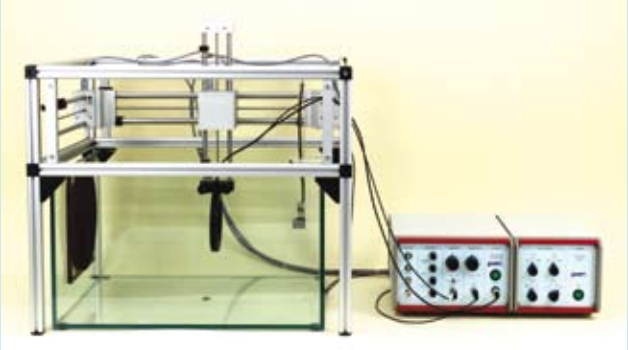
The fields of application of our membrane hydrophones cover many areas of science and engineering. For instance, the hydrophones are used at various universities and institutions of higher education to develop new methods and techniques in the field of ultrasound imaging and sensor technology. Manufacturers of ultrasound sensors for medical ultrasound diagnostics use our hydrophones to monitor quality features and develop their own ultrasound products further. Several national institutes for the measurement and calibration of physical values use the membrane hydrophones as reference for the secondary calibration of other measuring systems.
Due to the regulations for the declaration and limitation of the output of medical ultrasound equipment (IEC61157) increasingly demanded by legislators, the application of membrane hydrophones will also play in important role for the routine quality control and constancy tests in medical facilities.
Since the specific issues of our customers can often not be solved by providing one hydrophone in the standard version, particular specifications regarding design, cable lengths, connectors or environmental conditions can also be taken into account upon customer request. Even specific requirements for the sensitivity, spot size or frequency range can be realised upon consultation.

Accessories

The membrane hydrophone is delivered in a robust plastic case. Thus, damage to the sensitive membrane and the electrodes can be excluded.

In order to operate the hydrophone without using the UHC-80 hydrophone controller, a separate power supply unit is available. The measured values are recorded by means of a suitable oscilloscope. In order to connect the membrane hydrophone to an oscilloscope, a suitable broadband in-line network terminator (50 Ohm) is available.

In addition to this, the company GAMPT offers a wide range of high-quality measuring equipment for the ultrasound intensity measurement such as ultrasound scanners, hydrophone controllers, HIFU-hydrophones and thermo-acoustic sensors.



Technical data

Acoustic frequency range:	500 kHz to 90 MHz
Optional calibrated frequency range:	1 MHz to 40 MHz, 1 to 20 MHz, 0,5 to 5 MHz
Typical sensitivity:	~ 8,16 $*10^{-8}$ V/Pa @ 5 MHz
Max. ultrasonic pressure:	10 MPa
Frequency response:	+/- 3 dB signal tolerance over 1-40 MHz
Effective diameter:	< 250 µm
Polarity:	noninverted
Output impedance	50 Ohm
Membrane:	11 µm PVDF film
Housing dimension:	130 mm diameter
Membran area:	80 mm diameter
Distance membrane to housing:	front side: 6 mm
	back side: 9 mm (with screws)
Signal output:	RG174 cable (50 Ohm), BNC connector
Power input:	3 pole diode connector +8..15 V / Ground / -8..15 V
Input current:	+/- 20 mA

Literature

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GAMPT

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(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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