Two-way Characterization of High Frequency Ultrasonic Transducers

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In most ultrasonic applications, pulse-echo measurements are performed. This means that the transducer both for emission and for detection is being used. For proper tissue characterization, it is necessary to calibrate the transducer first and subsequently correct for its acoustic behavior. Therefore it is necessary to determine both the temporal and the spatial properties of the ultrasonic transducer. For low frequency transducers it is common to measure these acoustic properties of the transducer in emission using a small detector, producing in a one-way pressure registration as function of time and place, known as the grid point function. A good approximation of a point detector is a needle hydrophone with a diameter less than half the wavelength. For high frequency ultrasonic transducers, i.e. 30 MHZ, needle hydrophones with a diameter less than 25 m are not available. The measurement with a large hydrophone can be seen as spatial averaging of the acoustic pressure over the hydrophone surface. New high resolution methods such as laser interferometry can only be used for the transducer properties in emission and not in detection. In our study we characterize the two-way transducer properties with pulse-echo measurements using two different targets, a rotatable plane reflector and a spherical reflector. The spherical reflector either can be convex or concave. Measurements on a plane reflector perpendicular to the acoustic beam at different depth positions make it possible to define the position of the focal zone and to characterize the temporal characteristics of the transducer. Reflection measurements with the rotatable plane reflector at different angles make it possible to characterize the overall beam properties. The overall beam is the product of the beam in emission and the beam in detection. With the pulse-echo measurements the spatial properties in the tau-p domain can be obtained. Inverse Radon transformation and arrival time correction retains the spatial properties of the transducer. A spherical reflector can be seen as a virtual diffractor situated in the center of the sphere. The reflector surface can be made very accurately. If the ratio focal length - diameter of the sphere is less than the ratio of the transducer, the size of the virtual diffractor is sufficiently small for good characterization of the spatial properties of the transducer. After time-correction of the pulse-echo measurements with the spherical reflector a two-way grid point function is acquired. The main advantage of two-way characterization is twofold, no calibrated hydrophone is needed and the method shows a better analogy with the backscatter measurements.