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Dual-frequency driving transducer for ultrasonic echography

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We propose a novel ultrasonic imaging technique by transmitting ultrasonic pulse of dual-frequency and receiving multi-frequency echoes from the biological tissues. When the ultrasonic pulse of two frequencies is transmitted from a transducer, the secondary waves are generated during the nonlinear propagation through the biological media. A choice of f_0 and $4f_0$ as the dual-frequency results in the generation of $2f_0$, $3f_0$ and $5f_0$ components as the secondary waves. Multi-frequency echoes are capable of improving the image quality by reducing the speckle noise. We have developed the following annular type transducer. The PZT disk of 7 mm in diameter is coaxially arranged in the PZT ring of 9 mm in inner diameter and 17 mm in outer diameter. The ring and circular transducers transmit the pulses of 2 and 8 MHz, respectively. It was confirmed that this transducer formed the ultrasonic beams of 4, 6 and 10 MHz as well as the beams of 2 and 8 MHz in degassed water. Then the experiments of imaging the agar-gel phantom and pork meat were carried out by mechanical scanning. As a result, we also confirmed the improvement of image quality by reducing the speckle noise.