Asymmetric Pushing Pulse for Acoustic Radiation Force Based Ultrasound Imaging

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Background, Motivation and Objective

One limitation of acoustic radiation force (ARF) based imaging techniques is generating sufficient displacement magnitude, which acts as the signal in these imaging modes. The induced displacement is directly related to the applied force, and thus the local acoustic intensity, which is often limited by the Mechanical Index (MI). The MI, defined as $MI = \frac{P_{max}^{-}}{\sqrt{f_c}}$, where P_{max}^{-} is the peak rarefactional pressure and f_c is the center frequency, is restricted to a maximum value of 1.9 by the FDA[1]

Statement of Contribution/Methods

For the MI limit, peak negative voltage applied to the transducer is the limiting factor. Therefore, one method to increase the intensity in these situations is to utilize an asymmetric transmit pulse that has higher absolute positive voltage/pressure than negative voltage/pressure.

One example of such a pulse is to combine a sinusoid with a phase-shifted sinusoid of twice the frequency. As long as the transducer bandwidth contains both transmit frequencies the output pulse can be appropriately generated, which is viable for typical ARF pulses in most modern ultrasound transducers.

Results, Discussion and Conclusions

A simulation was performed in PZFlex (Weidlinger Associates, New York City, NY) using a model of a linear array transducer with a bandwidth that contains both 5 MHz and 10 MHz in its -6 dB bandwidth. As demonstrated in figure 1, the asymmetric waveform is appropriately transmitted by the transducer. In this case, the peak negative pressure would be very slightly higher than the conventional transmits, but the acoustic intensity, defined as the integral of the pressure squared, doubles. The pushing radiation force therefore is significantly increased with no appreciable change in MI.

Future work includes implementation of this pulse on a clinical ultrasound system with relevant hydrophone and phantom experiments to evaluate the impacts of transmit focusing and non-linear propagation on the MI and displacement magnitude.

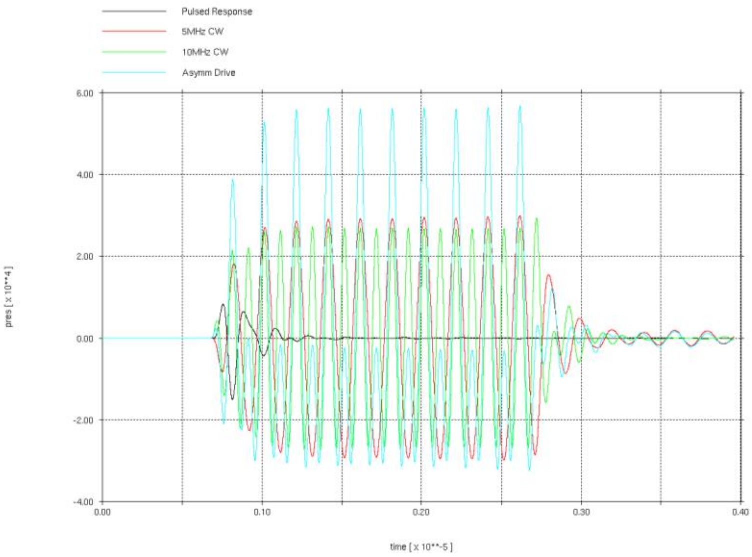

Figure 1: Conventional 5 MHz and 10 MHz transmits as well as the asymmetric drive pulse

[1] Szabo, Thomas L. *Diagnostic ultrasound imaging: inside out*. 2004.