INTRODUCTION

Most analytical models of pulse-echo imaging derive an integration on the product of propagating pulse and the reflectors or scatterers, over the location of the pulse at some point in time (Macovski, 1983; Szabo, 2004; Prince and Links, 2006). Under a number of approximations and simplifications about attenuation and diffraction, the integration can be reduced to a convolution model (Macovski, 1983).

The problems of poor resolution and speckle can be understood as a direct result of this convolution. The spatial resolution is set by the full spatial extent of the propagating pulse in 3D which is typically many multiples of a wavelength. However, in tissue, small scatterers at the cellular level and micro- structural level such as the arterioles and capillaries will have a dimensions zeroes of the pulse transform $P(z)$ become the poles of the inverse filter. Generally, for a casual, right-handed system to be stable the poles of the Z-transform must lie within the unit circle and the region of convergence

FIGURE 2. An asymmetric pulse formed by multiplying the Gaussian envelope with a geometric series is shown in (a). The zeroes of the Z-transform are retracted into the unit circle as shown in (b). This leads to a stable inverse filter.

Now all the zeroes of the transform lie within the unit circle, as seen in Figure 2b. Accordingly, the inverse filter will have poles within the unit circle and will have a bounded input/bounded output impulse response of limited duration.

In general, we have found that the formation of a stabilized pulse is not restricted to the use of e^{n} type function; rather this is illustrative of envelopes that have a sharp initial rise and a more gradual fall-off from the peak. We call these "asymmetric" envelopes or pulses, and these can be characterized by a number of different analytic functions. As an example, the function $p(x) = x^2 e^{-x^2/2\sigma^2}\,\mathrm{UnitStep}(x)$ is selected as a stable function for the transverse beampattern. The program Field II (Jensen, 2004) was used to simulate a focused beampattern. The approximate Fourier transform of $p(x)$ is used to set the apodization function. A 5 MHz transducer with 129 active elements is simulated with half-wavelength spacing. The transverse beampattern at the focus (60 mm depth) is shown in Figure 3. There is a good match between the beampattern and the design function $p(x)$.

FIGURE 3. An asymmetric function (heavy line) is used as a design for a focal transverse beampattern (squares) at 5 MHz. Vertical axis: magnitude of the focal transverse beampattern (arbitrary uni

DISCUSSION AND CONCLUSIONS

An inverse filter approach has been derived using

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