Independent dual-band spectral-spatial RF pulses: implementation for bilateral breast MRI

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INTRODUCTION Currently, there is a tradeoff between high resolution unilateral breast imaging [1] and lower resolution bilateral breast imaging [2]. High resolution breast imaging provides detailed morphology. Bilateral imaging allows for contralateral comparison and bilateral diagnosis in one acquisition. Our goal is to develop a high resolution bilateral protocol. Fat suppression is important, but is made difficult by the large volume (both breasts) over which magnetic-field shims must be applied. To solve this problem, Pauly et al [3] described a method for designing dual-band spectral-spatial RF (SSRF) pulses that excite two slabs simultaneously, each with independently controlled shims and center frequency. In this abstract, we present the design and implementation of such a pulse, with a demonstration of its functionality on a state-of-the art MRI scanner.

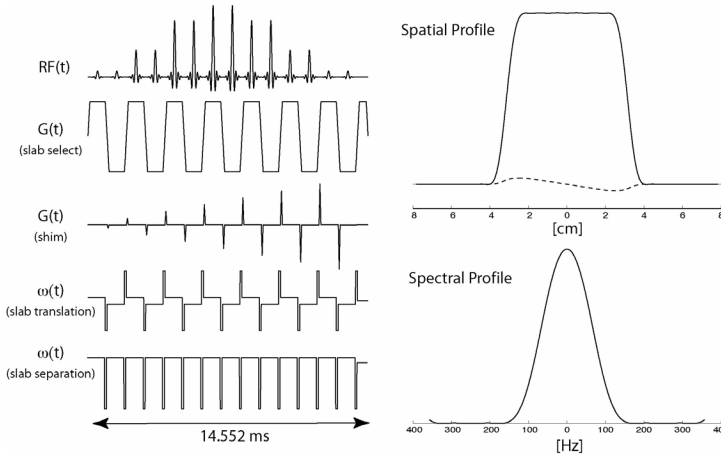

Figure 1: (left) RF, gradient, and frequency waveforms are shown. The spatial profile of the pulse (right, upper) is sharp, with 18% transitions, limiting the number of unusable points in the through-slab phase encode direction. The spectral profile (right, lower) shows robust lipid suppression, with greater than 56 dB attenuation over +/- 1.37 ppm (+/- 88 Hz). The passband is 143 Hz (FWHM), giving tolerance to main field inhomogeneity.

METHODS An independent dual-band (IDB) SSRF pulse was designed for lipid suppression and slab excitation at 1.5 T, using 150 mT/m/ms gradients (see Fig. 1). The shim waveform was designed to enable a shim gradient of 13.4 uT/m. This waveform also doubles as a waveform for center-frequency control when transmitted on the frequency channel of the scanner.

For control over the slab positions, additional waveforms were designed for the frequency channel (Fig. 1, left). With this approach, parameters such as slab separation correspond directly to the amplitude of one of the waveforms. Simultaneous manipulation of the slab positions and center frequencies is then just a matter of summing waveforms, which can easily be accomplished in the pulse-sequence code running on the host computer.

The pulse was implemented in a 2DFT gradient echo pulse sequence on a GE Signa 1.5 T scanner (GE Healthcare Technologies, Waukeshaw WI). The independent control of the slabs was demonstrated with images acquired in a slab phantom and a bottle phantom containing tap water and peanut oil.

RESULTS The performance of the pulse, shown in Fig. 1 (right), is well-suited to the contrast-enhanced breast exam. The sharp transitions of the spatial profile will enable efficient phase encoding in the through slab direction. The lipid suppression is robust, and is further aided by the ability to shim each slab optimally. This approach allows twice the temporal resolution in comparison to the alternative method to achieve independent shims, which is interleaving the acquisitions from each breast from TR to TR.

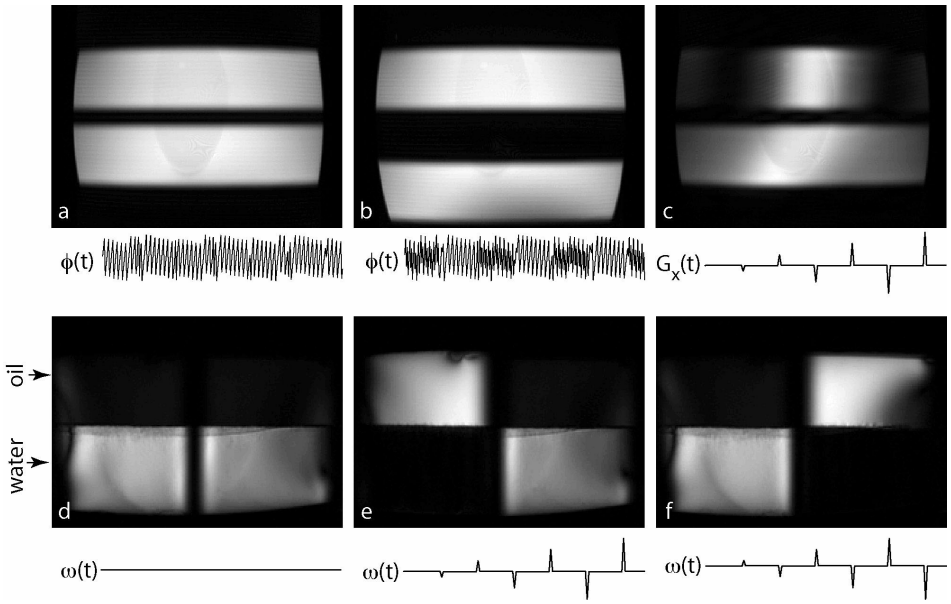

Figure 2: Demonstration of the functionality of the pulse. The first 6.5 ms of the relevant waveform is shown below each panel. (a) Two separate slabs are excited using a repeating phase waveform. Independent slab positioning is demonstrated in (b). The ability to apply different shims to the two slabs is seen in (c), with the light to dark transition in the upper slab reflecting the spectral profile seen in Fig. 1(b). The suppression of lipids is shown in (d), with excitation only of the water in the oil/water phantom. By using a replica of the gradient-shim waveform on the frequency channel, the center frequencies of the two slabs are swapped between water and fat in (e) and (f).

CONCLUSIONS An independent dual-band spectral-spatial RF pulse has been designed and demonstrated. This configuration is currently being implemented in a fast pulse sequence for bilateral breast MRI, where it is anticipated to provide improved fat suppression and the high temporal resolution achieved with simultaneous signal reception from both breasts with separate receiver coils.

REFERENCES

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[3] Pauly et al. Proceedings of the ISMRM, 2003