

Arbitrary Shape Excitation Using a 2D SPOKE Pulse at 7T

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Introduction

Excitation of arbitrarily shaped volumes in an object has a variety of potential applications in MRI. By restricting the excitation to specific shapes of interest, the information obtained can be isolated to particular anatomical or functional regions. FOV reduction also has the benefit of allowing faster acquisitions for high resolutions as a result of collecting fewer data points. To accomplish this, multi-pulse composites can be applied at various points in excitation k-space [1,2]. Simulations can be used to determine the necessary RF and gradient waveforms for a specific desired excitation pattern. The effects of B1 inhomogeneities, prevalent at ultra-high field strengths such as 7T, can also be accounted for in the calculation. Here we demonstrate the performance of a SPOKE based arbitrary shape excitation at 7T in phantoms.

Methods

Simulation: The necessary input parameters to establish the desired target field of excitation (FOX) were determined using an iterative difference minimization algorithm coded in Matlab. Along with the target FOX, additional inputs included the number of pulses, pulse and gradient duration constraints, maximum allowable B1 and gradient amplitudes, and the gradient slew rate limit to prevent peripheral nerve stimulation. The final output consisted of the amplitudes and phases for each individual RF pulse, and the x and y gradient waveforms.

Pulse Sequence: Using the simulated parameters, a multi-pulse composite was generated prior to a standard gradient echo sequence, with x and y gradients interleaved between pairs of gaussian shaped RF pulses (figure 1). Refocusing gradients along x and y were performed following the pulse chain, with the GE slice selection RF pulse angle set to 180° with matched spoiler gradients on either side.

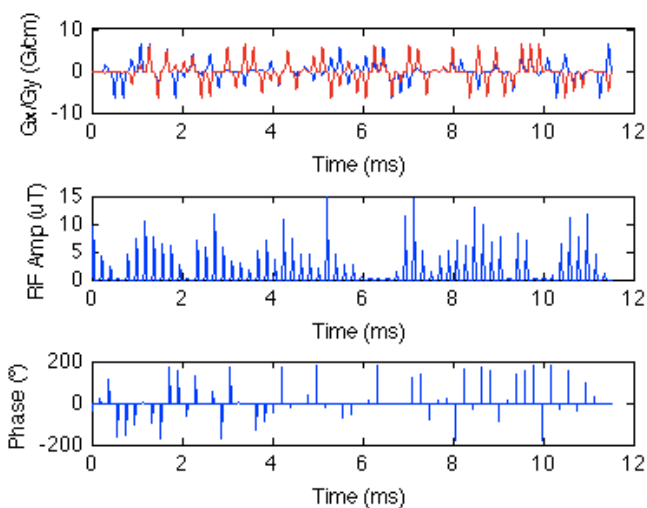


Figure 1 – Gradient profiles for x and y, RF amplitudes and phases for a 60 pulse composite to generate a square shape.

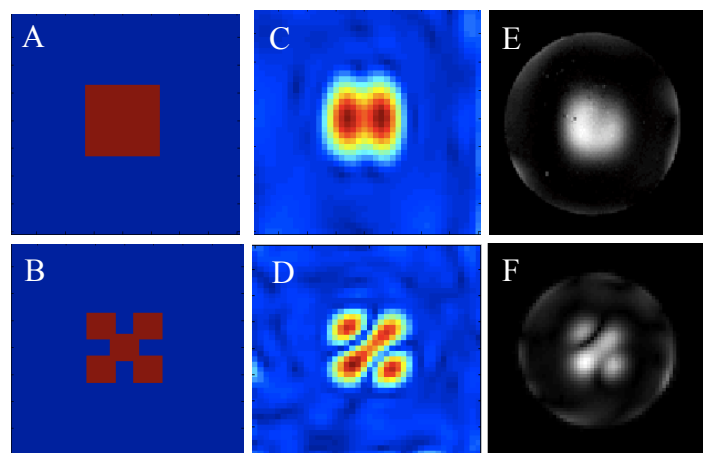


Figure 2 – A, B.) Inputted excitation shape, C, D.) expected based on simulation, and E, F.) result from imaging.

Imaging Tests: All experiments were performed on a 7T Philips Achieva system using a 16 channel SENSE head array and a spherical FBIRN agar phantom. Pulse sequence parameters were prepared for a 42x42 cm square and a 3x3 checkerboard pattern using 60 and 80 pulses, respectively. The imaging parameters were as follows: TR/TE = 250/16 ms, 64x64 points, 240x240x3 mm, one acquisition. The overall duration for the excitation composite was 12 ms with 60 pulses and 16 ms for 80.

Results and Discussion

Simulated excitations matched well with the target (figure 2). Likewise, the imaging was consistent with the simulation for both patterns. Pulse durations for the composite were short with low SAR (<50%). Future work will focus on obtaining sharper pattern boundaries, shimming optimization to correct for B0 inhomogeneities and incorporation of B1 maps for more uniform excitation.

References [1] Hardy HJ, et al, J Magn Reson, 82: 647-654 (1989) [2] Sersa, SM, J Magn Reson B, 111: 186-188 (1989)