CHAPTER IV

MATERIALS AND METHODS

The hybrid 3D tailored radiofrequency (TRF) pulse parameters

The hybrid spiral 3D TRF pulses were designed for 1.5 Tesla (T) MRI scanner with a 150 T/m/s gradient slew rate and a 40 mT/m maximum gradient to excite 4 different reduced excitation Field of Views (FOVs) including 24x24x10 cm^3 xyz, 18x18x10 cm^3 xyz, 12x12x10 cm^3 xyz, and 6x6x10 cm^3 xyz. The reduced excitation FOVs were determined by the passing band of the excitation pulse profiles. The pulse resolution was fixed at 1.5x1.5x1.25 cm^3. The minimum sampling points of the excitation pulse required for the full FOV of 24x24x20 cm^3 in xyz were 16x16x16.

The design of hybrid 3D TRF pulses

Along the z-direction: The key concept of half–pulse design along z-direction is self refocusing in each half pulse. The half-pulse selective excitation along z-direction consists of two excitation pulses using approximately half of sampling points along z-direction per shot. The first half-excitation played out in the presence of a preparation negative “blip” gradient prior to multiple positive “blip” along z-direction. The traversing of k_z began at the k_z-min an end at the center of k-space by refocusing negative “blip” gradient. For the second half-excitation, the opposite gradient was applied which prepared for positive “blip” and then followed by multiple negative “blip”. This implies a linearity of k-trajectory beginning at k_z-max and again ending at the center via refocusing “blip” gradient as shown in figure 4.1

Figure 4.1 (top row) is shown two shots of “blip” gradient along z-direction and k_z-traverse direction from k_z-min to the center of k-space in the first excitation (yellow) and k_z-max to the center of k-space in the second excitations(bottom row).

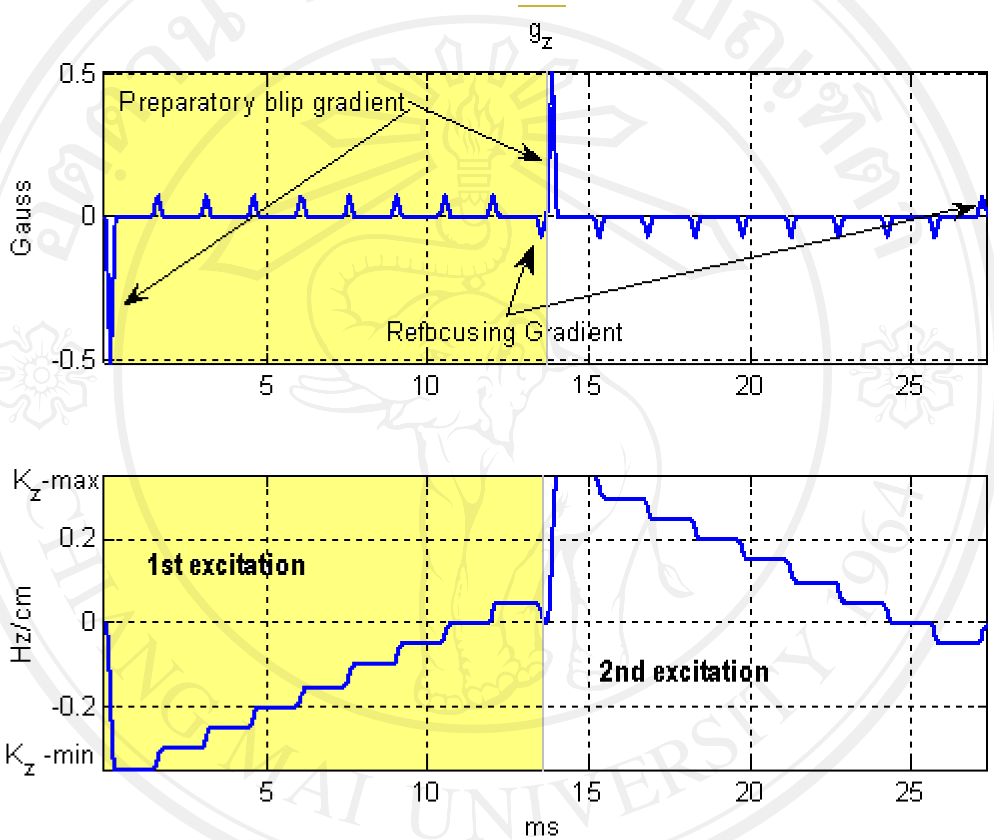

Figure 4.1 Shows two shots of “blip” gradient along z-direction (top row) and k_z-traverse direction from k_z-min to the center of k-space in the first excitation and k_z-max to the center of k-space in the second excitations(bottom row).

Part of MATLAB code for z-direction pulse design is shown in the appendix A:

Along the x-y: Reducing pulse width was done by applying a two-shot interleaves stack spiral k-space trajectory similar to that of Stenger *et al* (section 3.2.1). Each 2D trajectory spirally traverses starting from center to outside. Figure 4.2 shows one shot of 2D spiral trajectory.

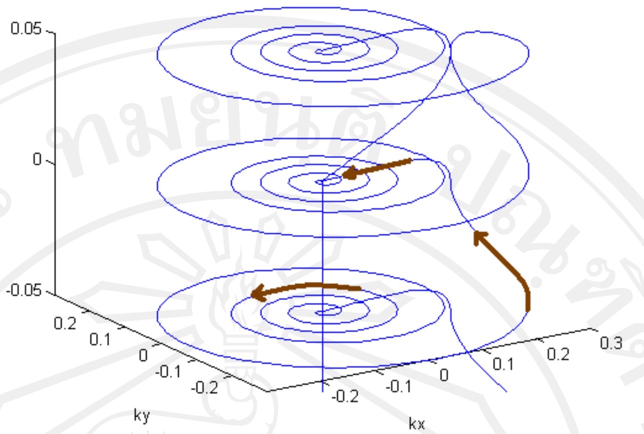

Figure 4.2 Shows one shot of 2D spiral trajectory and its traverse direction (arrow).

Exploiting the Fourier relationship which exists between the magnetization and weighting function, the pulse profile was built in the spatial domain. Construction of the pulse profile relied on several analytical functions, including a Fermi function along in plane coordinate and the rectangular window function along the through plane direction. Mathematical clarification is provided as Eq.4.1. The slice profile $W_0(r)$ is the rectangular window function along z and a Fermi function along xy plane.

$$W_0(r) = \frac{\mathrm{Re}\,ct(z/z_0)}{1+e^{(r-r_0)/width}} \tag{4.1}$$

This equation shows a cylinder profile, which z_0 is slab thickness along z direction, and r_0 is radius of the in-plane. The width is a parameter that control transition width. The pulses were generated offline using MATLAB (The Math-works, Inc., Natick MA) versions 7.1

Design weighting function: The equation 4.1, which Fourier transforms of the slice profile is the weighting function was used to design the RF as describe in chapter 3 (3.2.2).

The MATLAB code for weighting function is shown in the appendix B:

Pulse Optimization: The hybrid pulses were optimized by varying the sizes of the excitation FOVs from 24x24x10 to 12x12x10 cm. to obtain a set of calculated images from the Bloch equation simulation. The criteria to determine the optimum hybrid pulse design were minimum sampling points and minimum aliasing of the calculated images. The hybrid 3D TRF pulses were compared with the conventional 3D TRF pulses in terms of pulse width, sampling points and obtaining image profiles.