# Reduced Echo Time Dualband Spatial-Spectral Pulse Sequence for Brain MRSI at 3T

P. Balchandani[1], D. Spielman[1]

[1]Radiology, Stanford University, Stanford, CA, United States

**Introduction**: [1]H Magnetic resonance spectroscopic imaging (1H MRSI) is a useful technique for measuring metabolite levels in the brain. Some of the main metabolites of interest are Choline (Cho), N-Acetyl-Aspartate (NAA) and Creatine (Cr). Inadequate water or lipid suppression, spectral shifts due to $B_0$ inhomogeneity, and low SNR of metabolite signals are some of the main problems faced when using MRSI. Dualband spatial-spectral (SPSP) pulses may be used to fully excite metabolites and partially excite water while suppressing lipids. Partial water excitation enables the use of water as a frequency reference in the presence of spectral shifts due to $B_0$ inhomogeneity. Dualband SPSP pulses may be designed for MRSI on 3T systems, which offers higher SNR and increased frequency separation when compared to MRSI at 1.5T. Dualband SPSP pulses have been used in PRESS sequences for brain MRSI at 1.5T [1] and prostate MRSI at 3T [2]. However, in these sequences, the 180º SPSP pulses must have nonlinear phase (along the spectral direction) in order to stay below RF peak power limits and consequently both 180º pulses in the PRESS excitation have to be spatial-spectral in order to refocus the nonlinear phase. This limits TE to a minimum of 90 ms for the brain. In this study, the use of a PRESS sequence with only one dualband spatial-spectral linear phase 90º pulse and two standard spatial 180º pulses is proposed for brain MRSI. This sequence provides spectral selectivity while allowing significantly shorter echo times than existing SPSP PRESS sequences for the brain. At 3T, shorter echo times will result in higher SNR [3]. Based on previous 3T in vivo single voxel measurements on a normal volunteer, reducing TE from 130ms to 65ms resulted in increased brain metabolite SNRs of 30%, 70% and 34% for NAA, Cr, and Cho respectively.

**Method**: A linear phase 90º dualband SPSP pulse was designed using twenty one linear phase subpulses that could excite a slice as thin as 5 mm. The passband for the pulse encompassed choline at 3.2 ppm to NAA at 2.0 ppm while suppressing the lipids at 1.3 ppm and below. The partial water band was designed to excite 2% of the water signal at 4.7 ppm. The final pulse duration was 24 ms resulting in TE=60 ms. However, the pulse could be shortened further to achieve TEs as low as 50 ms. The dualband SPSP 90º pulse had very low ripple in the metabolite passband but considerable ripple in the partial water passband. However, since we are only using water as a frequency reference and not concerned with its magnitude, this ripple is tolerable. Ripple could be reduced by increasing transition band width; however the close proximity of the NAA peak to the lipid peak sets a limit on this width. Figure 1 shows A) the final linear phase 90º pulse, B) The spectral profile (centered at choline) for the 90º pulse, C) the spatial profile for the 90º pulse and D) the gradient and RF waveforms for the excitation portion of the final PRESS sequence.

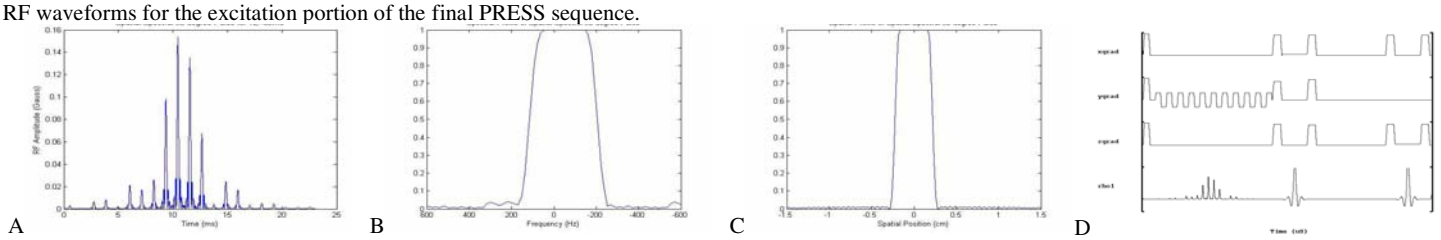


*Figure 1: Simulations for 3T linear phase 90º pulse: (A) RF waveform, (B) spectral profile, (C) spatial profile and (D) gradient and RF waveforms for excitation pulses*

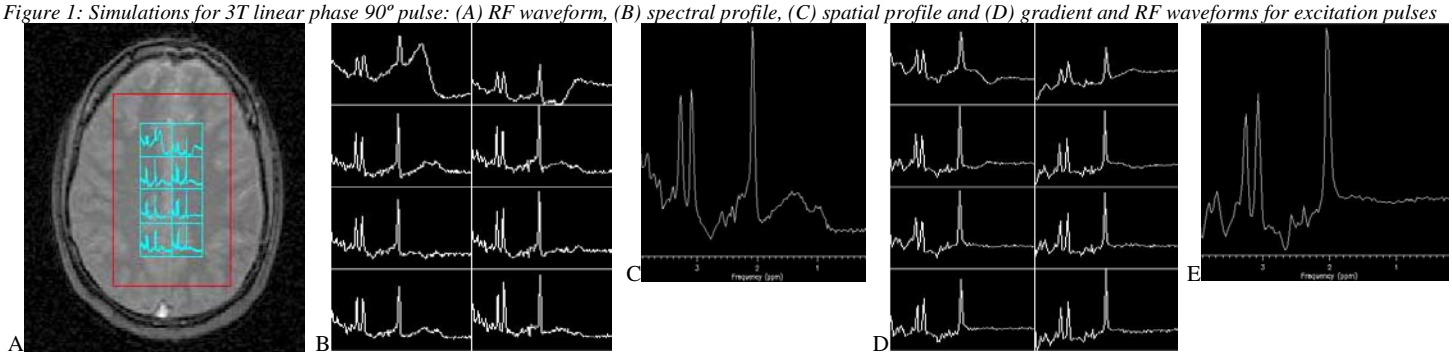


*Figure 2: In vivo data from normal volunteer: (A) ROI and PRESS box (B) spectral grid using standard GE PRESS, (C) averaged spectrum using standard GE PRESS (D) spectral grid using dualband SPSP 90º pulse, (E) averaged spectrum using dualband SPSP 90º pulse*

**Results**: Refer to Figure 2 for in vivo spectra from the brain of a normal volunteer scanned at 3T (GE Echospeed Whole Body Magnet). Figure 2 A shows the ROI with 8 cc voxels within the selected PRESS box. For this experiment, the PRESS box is large with corners that are close to the edge of the brain resulting in significant lipid contamination. This broad lipid peak can be seen at approx 1.4 ppm in the metabolite map (Figure 2 B) and averaged spectrum (Figure 2 C) obtained using the standard GE PRESS sequence (TE/TR = 60/1500 ms). When the same region is excited with a PRESS sequence using the dualband SPSP linear phase 90º pulse (TE/TR= 60/1500 ms), the metabolite map and averaged spectrum in Figure 2 D and E are obtained. It is evident that fat has been significantly suppressed while not degrading the NAA signal (at 2 ppm). Not seen in the spectra is the water peak that was successfully suppressed to approximately 2% of the full value.

**Discussion**: It can be seen from in vivo data that the linear phase dualband SPSP 90º pulse successfully suppresses fat when compared to the standard GE PRESS sequence at the same echo time. Similar fat suppression may be achieved by current 3T PRESS sequences that utilize SPSP 180's, however; these sequences are unable to achieve echo times as short as the ones possible for the sequence in this study. A major advantage of using this sequence is that, unlike standard PRESS and PRESS using SPSP 180's, only 2% of the water is excited in the final echo. This allows for the integration of an additional pulse in the same series that excites just the remaining water signal. By interleaving a water excitation pulse in this manner, water density information, which is useful as a reference for absolute quantification, may be directly incorporated into the spectroscopy acquisition rather than as a separate series. Implementation of this water interleaved sequence is currently underway.

**References**: [1] Star-Lack JM, et al. *Magn Reson Med* 2000; 43:325-330. [2] Cunningham CH, et al. *Magn Reson Med.* 2005 May; 53(5):1033-9. [3] Barker PB, et al. *Magn Reson Med.* 2001 May;45(5):765-9.

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