# Dual-Band Adiabatic Selective Refocussing for Signal Suppression in High Field MR

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**Introduction**: Translation of many MRI and MRS sequences to B0 field strengths of 3T and higher is often hampered by problems related to power-deposition and B1 inhomogeneity. The RF power deposition, or Specific Absorption Rate (SAR), is intricately linked with the B1 field inhomogeneity problem (1). The most obvious solutions to B1 inhomogeneity problems are either using a larger coil, or the use of adiabatic pulses, both of which would increase SAR. Conversely, attempts to reduce SAR by using smaller excitation coils usually lead to loss of B1 field homogeneity. Here, a method is presented that can help reduce the SAR penalty associated with the introduction of adiabatic pulses in sequences where multiple frequency bands need to be inverted or saturated.

**Theory:** Multi-band adiabatic pulses can be created by summing adiabatic pulses that have been frequency shifted with a phase ramp (2,3). These pulses can deliver an adiabatic type response over a limited B1 range, enough to remedy B1 inhomogeneity related problems in many pulse sequences. In the MEGA (4) or BASING (5) sequences a pair of inversion pulses is inserted in a spin echo sequence and dephasing gradients are set up to eliminate the signals in the excitation bands of the pulses. A pair of sech pulses can be used to create spin echo (6) and MEGA or BASING pulses do not need to be linear phase(5). Thus, simple substitution of the selective pulses in the MEGA sequence should yield an adiabatic suppression of two frequency bands. We have tried this on a phantom using a pulse optimized for simultaneous water and fat suppression.

**Methods :** Phantom experiments were performed on a Siemens Avanto 1.5T MRI scanner using a phased array receive head coil and body coil excitation. A spin echo (SE) imaging sequence was modified by insertion of a pair of 31 ms dual band adiabatic selective refocusing pulses preceded and followed by matched crusher gradients (see Figure 1). The sequence was run with TR/TE=500/100ms with 5 mm slice thickness and 25 cm FOV. After shimming and optimization of the SE 90º and 180º pulses several images were recorded with the RF amplitude of the pair of selective refocusing pulses at varied between 0 and 9 µT. The pulse was designed to have a 400 Hz pass-band at 31ms pulse length. During the dual band adiabatic pulses a gradient was applied in the readout direction with amplitude adjusted to 20 mm/Hz to create a 2cm pass-band in the images.

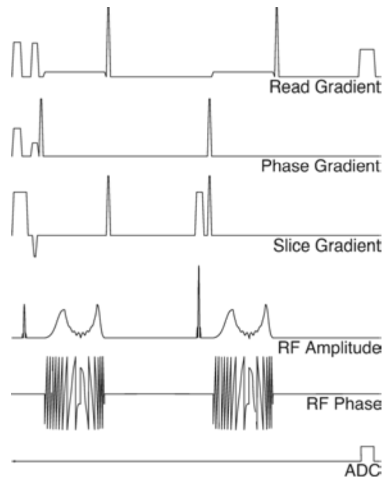


*Figure 1. Pulse sequence for measuring the suppression profile of a 30ms dual band adiabatic pulse.*

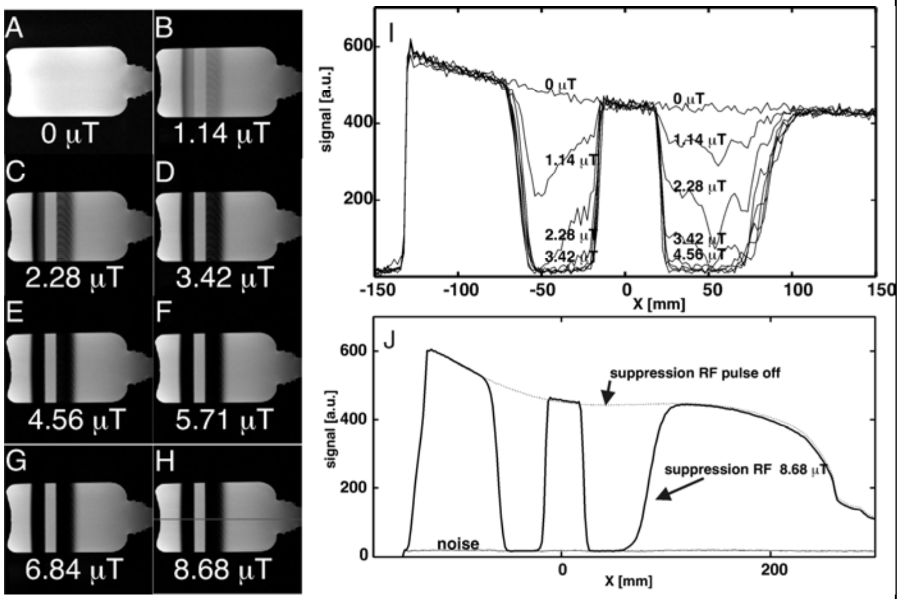


*Figure 2. A-H) SE images of a bottle with MEGA RF pulse amplitudes set to the values shown. I) Profiles through the mid line of the bottle (shown in H) labelled with the MEGA RF amplitudes. J) Averaged signals with and without suppression. Solid line: mean signal of 110 image lines over the width of the bottle of image H (MEGA RF = 8.68 µT). Thin dotted line: mean signal over the width of the bottle of image A (MEGA RF pulse off) and the thin solid line labelled noise indicates the mean noise level over the top 70 lines of the image outside the bottle*

**Results:** SE images of a bottle phantom with the suppression pulses at set at various RF amplitudes are shown in Figure 2 A-H. The profiles of these images through the mid line of the bottle are shown in Figure 2I. Clearly at RF amplitudes of 4.56 µT and beyond and excellent selective signal suppression is obtained. The signals with the suppression pulses at 8.68 µT and 0 µT were averaged over 110 lines spanning the width of the bottle and shown as function of lengthwise position compared with the average image noise level in 70 lines recorded outside the bottle. The result is shown in Figure 2J and shows a very sharp profile of the pass-band with excellent suppression of signals on either side.

**Conclusion:** Dual band adiabatic pulses can be used for signal suppression by selective dephasing and are ideal for simultaneous water and fat suppression or outer volume suppression in MR spectroscopy in systems with inhomogeneous B1 fields.

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**References**

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