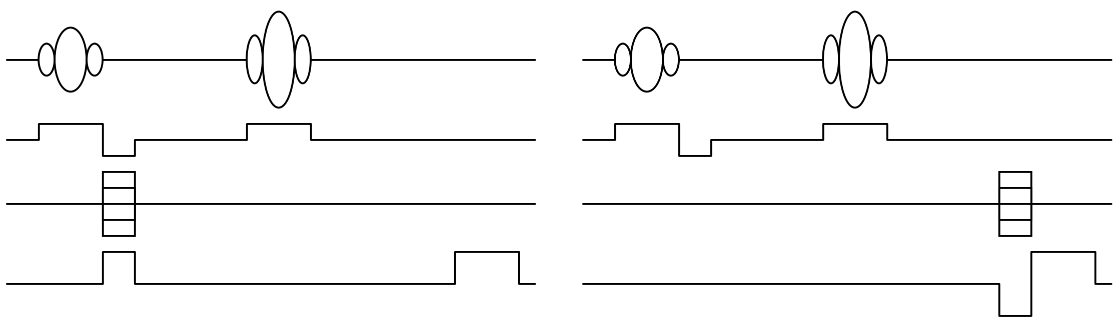
BIOEN 6330 Principles of Magnetic Resonance Imaging
Homework #5
Due Tuesday, March 30, 2010

1. (a) Sometimes it is possible to improve the image SNR without extending the scan time by employing a combination of higher NEX (i.e., signal averaging) and proportionally shortened TR. Suppose spin-echo (90°-180°) imaging is done on a tissue with T1 of 1.5 sec. Using the case of NEX = 1 and TR = 6.0 sec as reference, what combination(s) of NEX and TR will yield improved SNR? Which combination will give the best SNR, and what is the SNR improvement factor?

   (b) Suppose the excitation flip angle is no longer constrained to be 90°. What is the additional SNR improvement factor achievable for the optimal NEX-TR combination? (Hint: a closely separated α-and-180° pulse pair can be treated as a single 180°– α pulse.)

2. For the following implementations of the idealized spin echo sequence (*note: not drawn to scale*), suppose the phase-encoding and read-dephase pulses are placed either immediately after the excitation RF pulse or before the readout pulse. Moreover, suppose all gradient pulses are 2.0-ms long, except for the readout pulse, which is 4.0 ms, and that ± 2.0 G/cm is used for the readout and read-dephase pulses. Lastly, assume a TE of 25 ms is used.



   (a) Determine the velocity sensitivity (i.e., $d\phi/dV$) of the frequency-encoding gradient for each of the two implementations.
   (b) Similarly, determine the diffusion-induced signal attenuation in a tissue with diffusivity of 1.0×10^{-3} mm^2/s caused by the frequency-encoding gradient for each of the two implementations.

3. Suppose three (3) consecutive gradient pulses are to be used in a phase-contrast sequence to encode velocity in a manner that is compensated (i.e., has *zero* sensitivity) for acceleration.
   (a) If the gradient pulses are to have the same pulse width, determine amplitudes of the gradient pulses required (suffice to express them in terms of the amplitude of the first pulse).
   (b) Likewise, determine pulse widths of the gradient pulses required if instead the gradient pulses are to have the same absolute amplitude.

4. (a) Suppose two 10 cm-radius circular loops of are to be used to construct a Helmholtz RF coil. What directions must the currents run, and what is the optimal distance to separate the loops to ensure maximal B_1 homogeneity at the center?

   (b) What modifications in the current direction, separation distance and coil orientation in the magnet need to be made to convert the RF coil into a Maxwell gradient coil?

5. (a) Following the example of the saddle RF coil, design a parallel-conductor gradient coil by determining the appropriate conductor placements and current directions. Sketch the gradient coil and note how it should be oriented with respect to the static field.

   (b) Determine the current needed to generate 2.0 G/cm gradient amplitude at the center of the coil. In practice, the current is achieved by increasing the number of wires in each location.