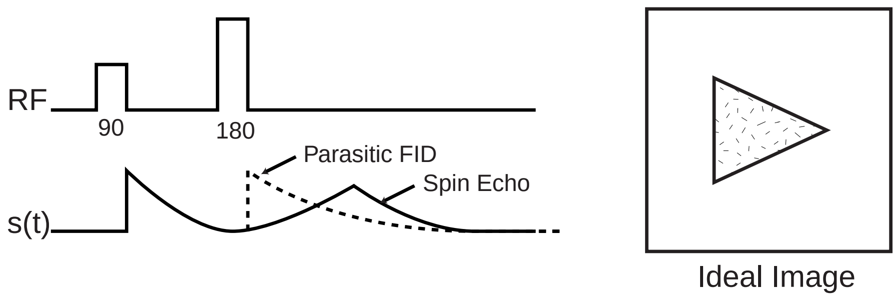
EE225E/BIOE265 Spring 2012 Miki Lustig
Principles of MRI

Assignment 9

Due April 8th, 2012

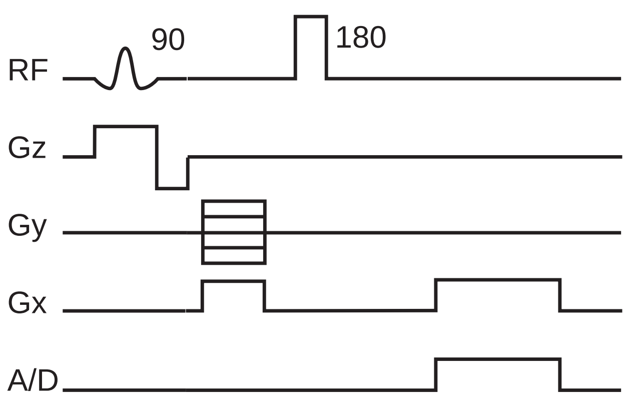
1. Nishimura 7.1

2. In a spin-echo pulse sequence the 180° pulse refocuses the magnetization produced by the 90° excitation. Since the 180° is never perfect, it will will also excite magnetization. This produces additional signals, as is shown on the left below:

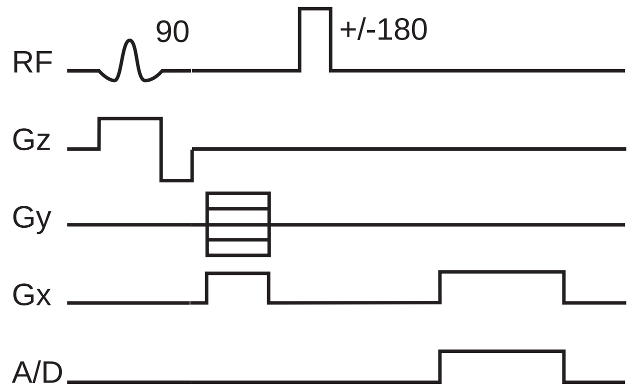


These signals, called “parasitic” FID’s, will produce image artifacts that depend on the acquisition method. In each of the examples below, draw (i) where the parasitic FID ends up in k-space, and (ii) the image artifact it produces. Assume that the ideal image is as shown above on the right, and that signal only comes from the excited slice.

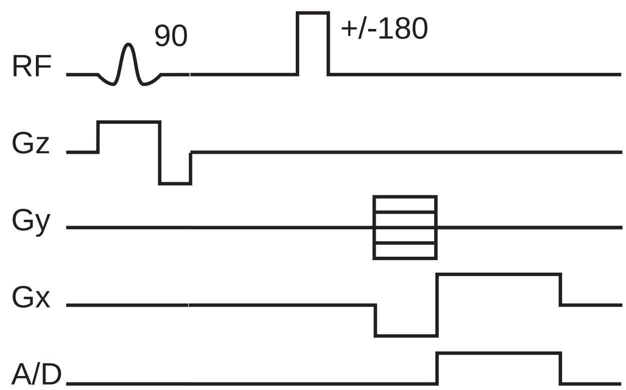
a) In this case the phase encode and the readout dephaser are before the 180.



b) The same pulse sequence as in (1), with the addition that the 180 is inverted every other phase encode step.



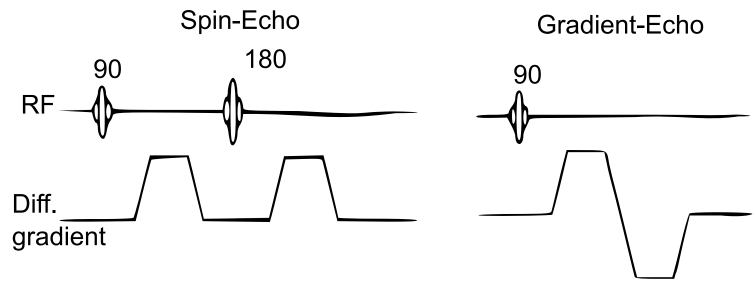
c) The same pulse sequence as in (2), with the phase encode and readout dephaser after the 180.



3. Diffusion simulation

The MR signal can be sensitized to diffusion. It is in fact the only way in which diffusion of water molecules can be observed *in-vivo*. Diffusion weighting is used clinically very often. for example, stroke often shows much earlier on diffusion weighted images than on T_1 or T_2-weighted images. Diffusion weighting also provides us information on micro-structures. For example, the diffusion of water molecules within axon in white matter fiber is restricted across the axon, and is free along the axon. This allows us to track white matter fibers in the brain non-invasively.

Diffusion weighting is achieved by applying a diffusion sensitizing gradient. The most common approach is to apply two gradient lobes with equal area. In spin echo sequences, the two lobes will have the same polarity and be placed at either side of the 180 spin-echo pulse. In gradient echo sequences the lobes will have opposite polarity and be often placed next to each other. The gradient amplitude for diffusion weighting is usually the maximum and their duration is usually much longer than imaging gradients.



A population of spins going through brownian motion will exhibit signal attenuation due to dephasing after the application of diffusion gradients. In this assignment we will simulate this effect.

a. Download the script diffSim.m from the class website. In order to run the script you will need the bloch simulator at the same directory. The script simulates the effect of diffusion in a gradient-echo sequence. Familiarize yourself with the script before continuing.

   There are three main parameters in the script. N is the number of spins in the simulation. M is the duration of the diffusion gradient (in samples of dt). D is the diffusion parameter and is the variance of the random motion that the spins exhibit. Run the script with D=0, D=2E-3 and D=3E-3. Submit the result of the simulation. Explain the results.

   In the presence of inhomogeneity, the observed signal decays with $T2^*$. In spin-echo-train sequences the signal exhibits T_2 relaxation at the times of the spin-echoes. In class, we briefly mentioned that the T_2 measurements can be a function of the refocusing interval. In this section we will simulate this effect.

b. Download the script T2Sim.m from the class website. The script simulates a population of spins in the presence of a gradient, spin-echo train and brownian motion. Here, there is an additional parameter SE which is the interval between spin-echo pulses (in samples). This example can represent a voxel of water molecules next to a vain.

   Run the script with D=0 (no brownian motion) N=500, M = 1000 and SE = 200. You should see 5 spin echoes exhibiting very mild T_2 relaxation.

   Now, run the script with D=3E-3 (N=500, M=1000, SE=200). What happened?

   Run it again with SE=100 and SE=20. Explain.