Sydney Kaplan BIOMEDE 599

Homework 1

Question 1

Question 1a

The amplitude of the slice-select gradient is 15.66 mT/m and the total duration including both rise times and flat-top time is 1.17ms. See attached code for computation details.

Question 1b

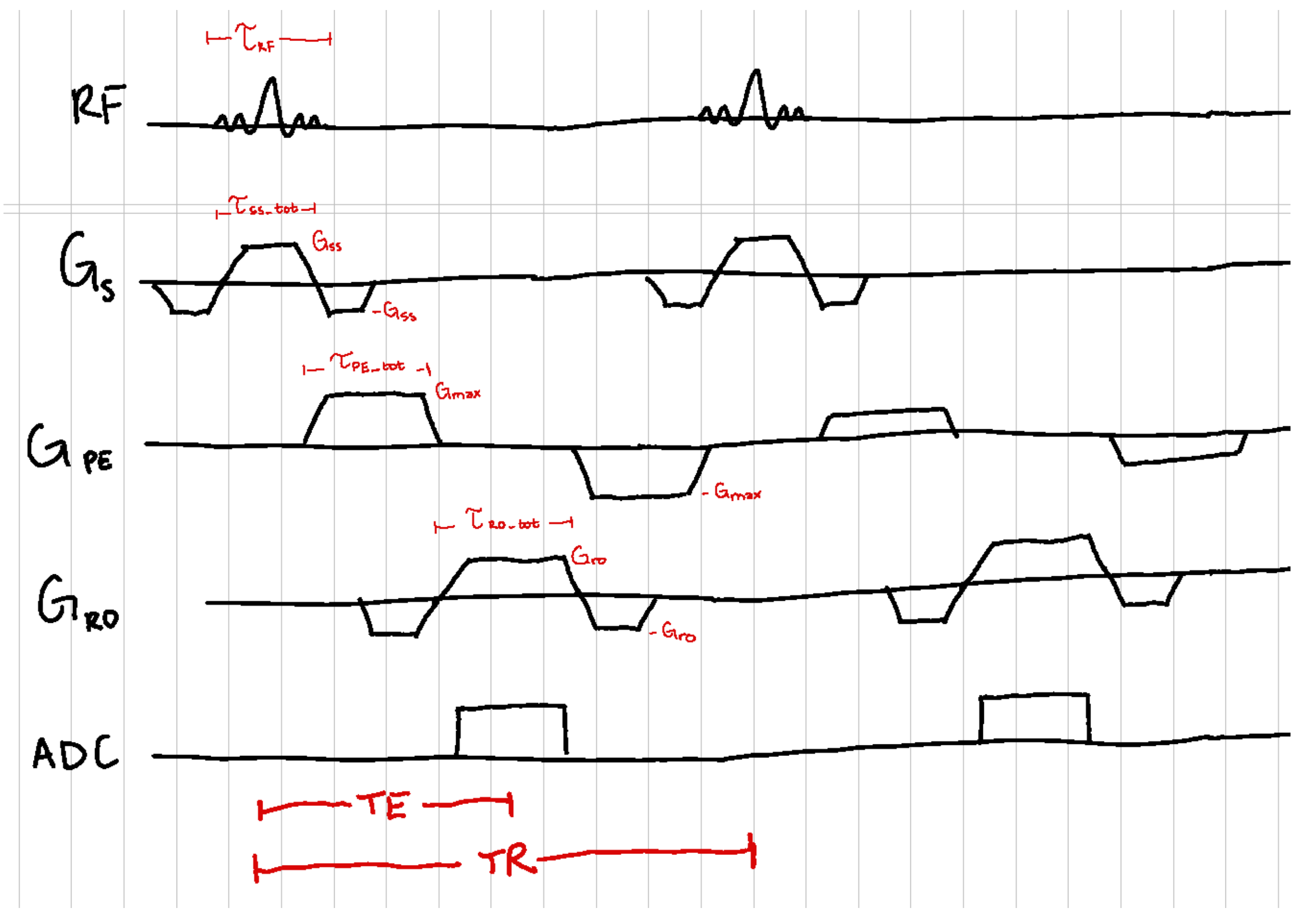
The minimum duration of the phase encoding gradient including both rise times and flat-top time is 0.67ms. See attached code for computation details.

Question 1c

The amplitude of the slice-select gradient is 14.68 mT/m and the total duration including both rise times and flat-top time is 1.50ms. See attached code for computation details.

Question 1d

The minimum TE is 2.08ms and the minimum TR is 4.17ms. See attached code for computation details.



Question 1e

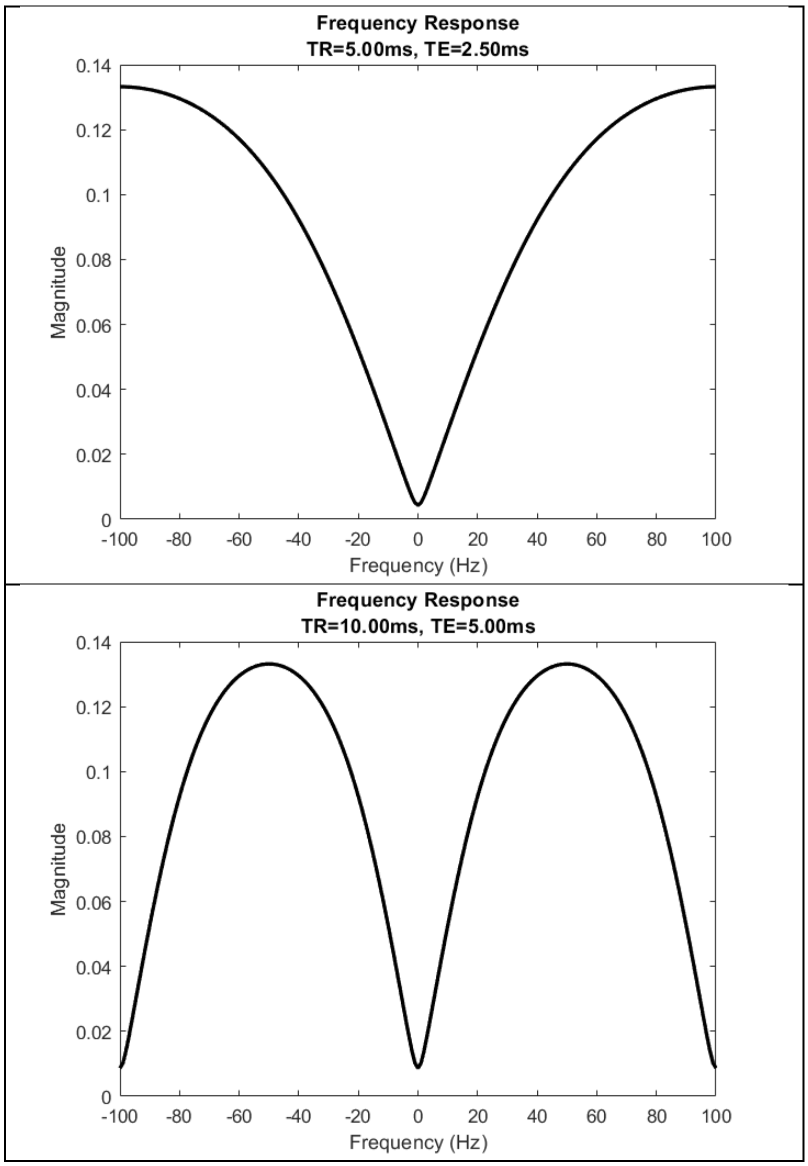
Three ways to reduce TE/TR without changing spatial resolution:

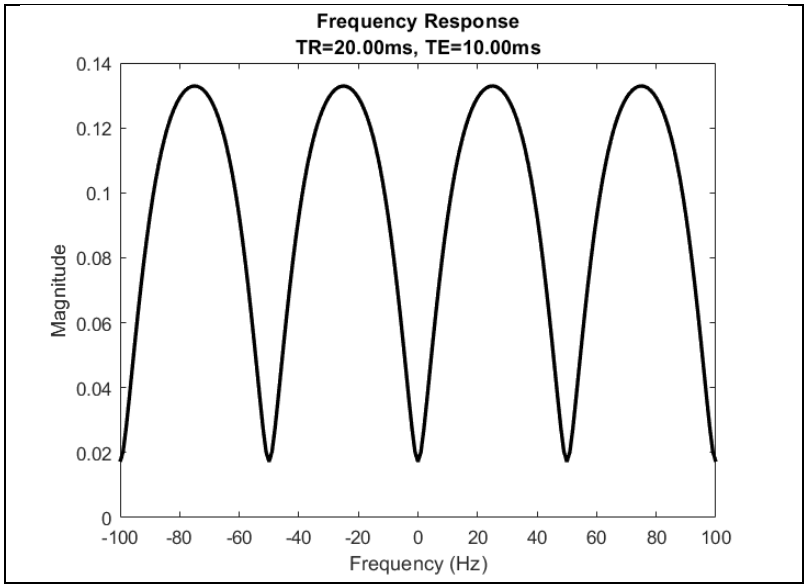
1. Increase rBW
2. Decrease TBW
3. Decrease RF pulse duration

Question 2

Question 2a

Frequency response for bSSFP sequence at various TE/TR combinations. See attached code for simulation details.





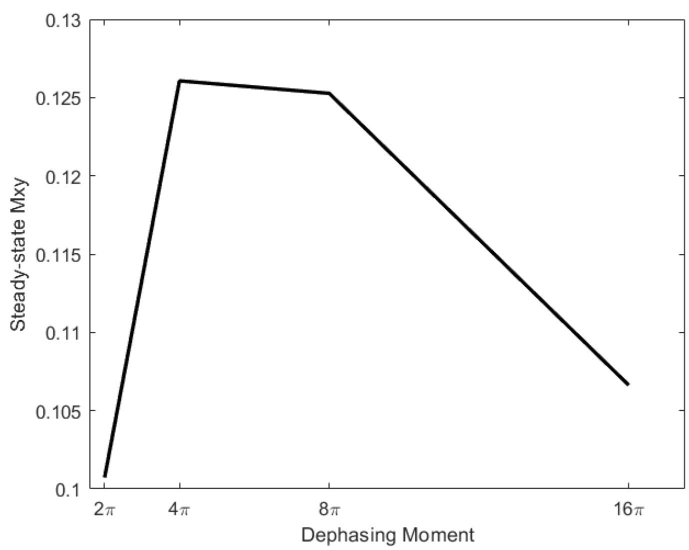
Question 2bi

See attached code for simulation details. The steady state-signal for a "perfect" spoiler was determined to be:

$$M = \begin{bmatrix} 0.07 \\ 0 \\ 0.4 \end{bmatrix}, \; M_{xy} = 0.07$$

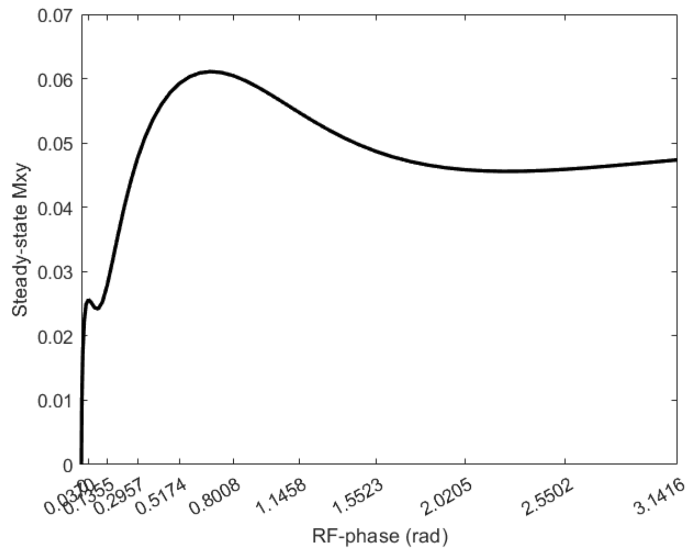
Question 2bii

Gradient spoiled sequence with imperfect spoiling using 200 isochromats. See attached code for simulation details.



Question 2biii

RF and gradient spoiled sequence with imperfect spoiling achieving 2π dephasing. The RF phase that best eliminates the transverse magnetization occurs at 0.68 radians (i.e. the max Mxy).



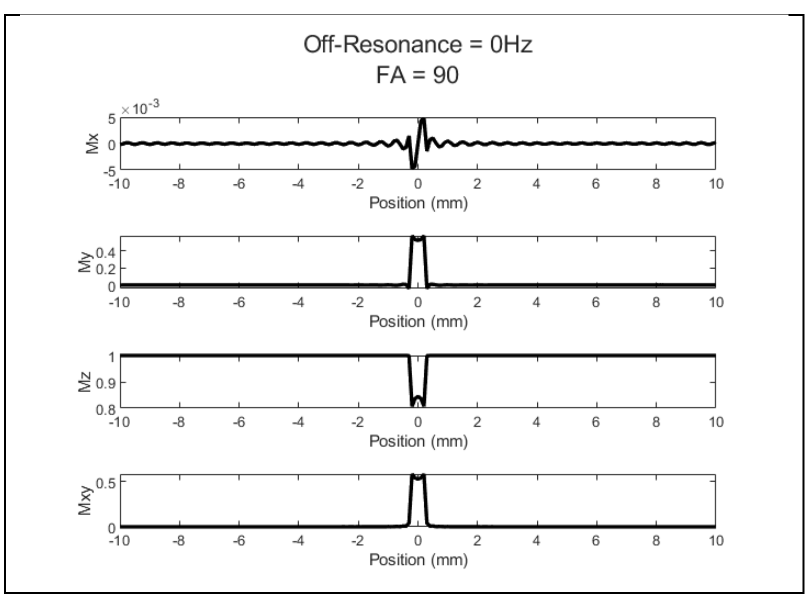
Question 3

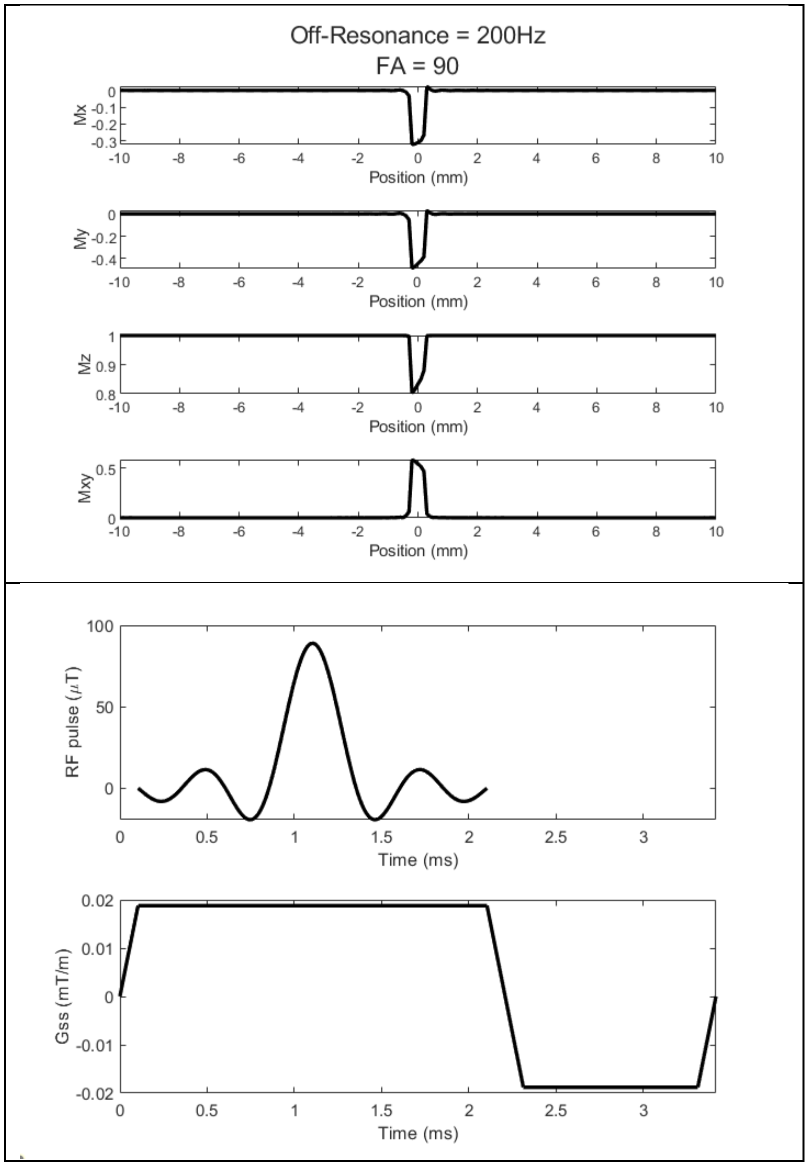
Question 3.1

The amplitude of the slice-select gradient is 18.79 mT/m and the total duration including both rise times and flat-top time is 2.21ms. The RF pulse will follow the equation sinc(4t) and is truncated symmetrically around 0 for a total of 1ms. See attached code for computation details.

Question 3.2

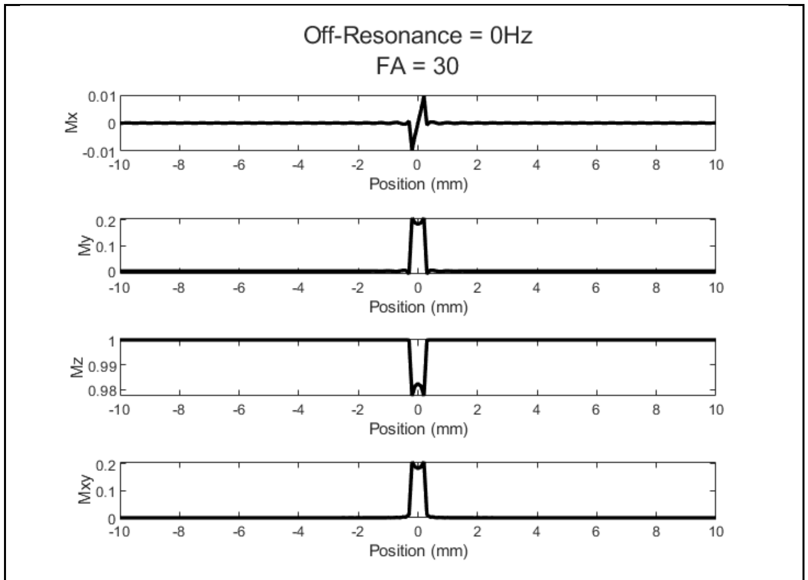
The slice profile at both 0 and 200 Hz off resonance for a 90° flip as well as the RF and gradient waveforms. See attached code for computation details.

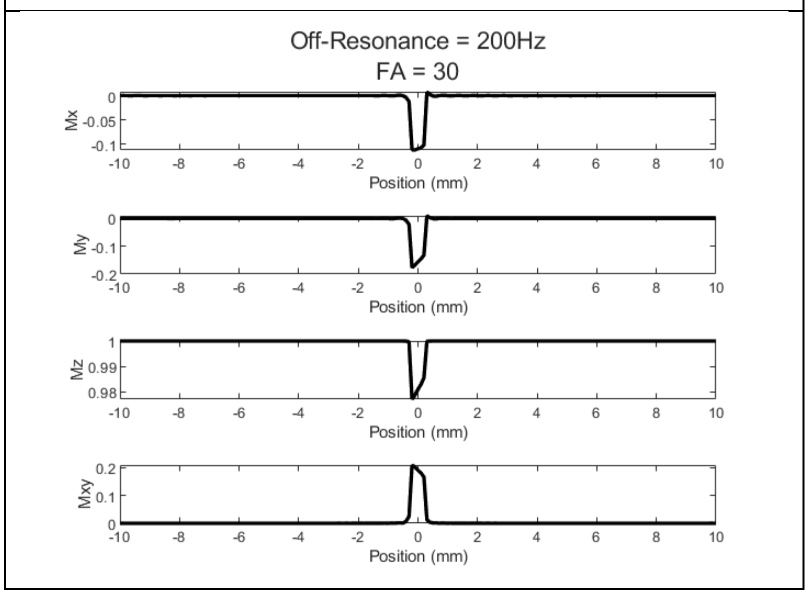


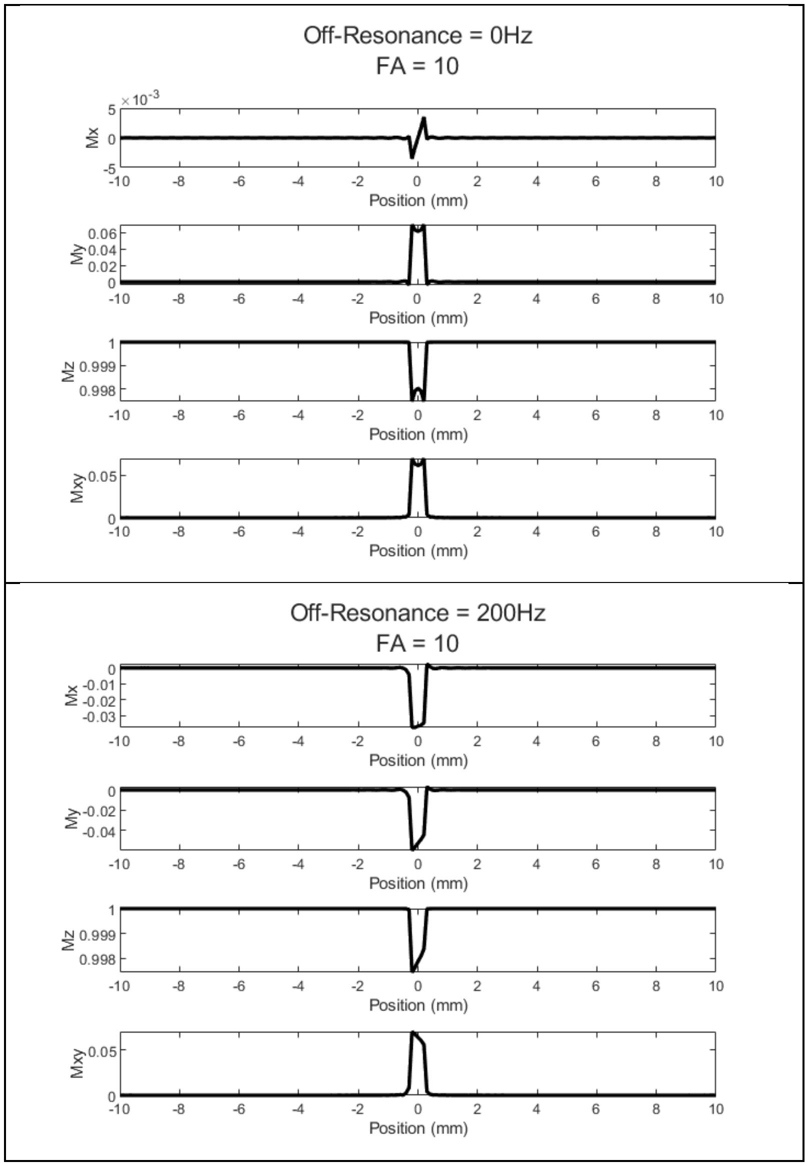


Question 3.3

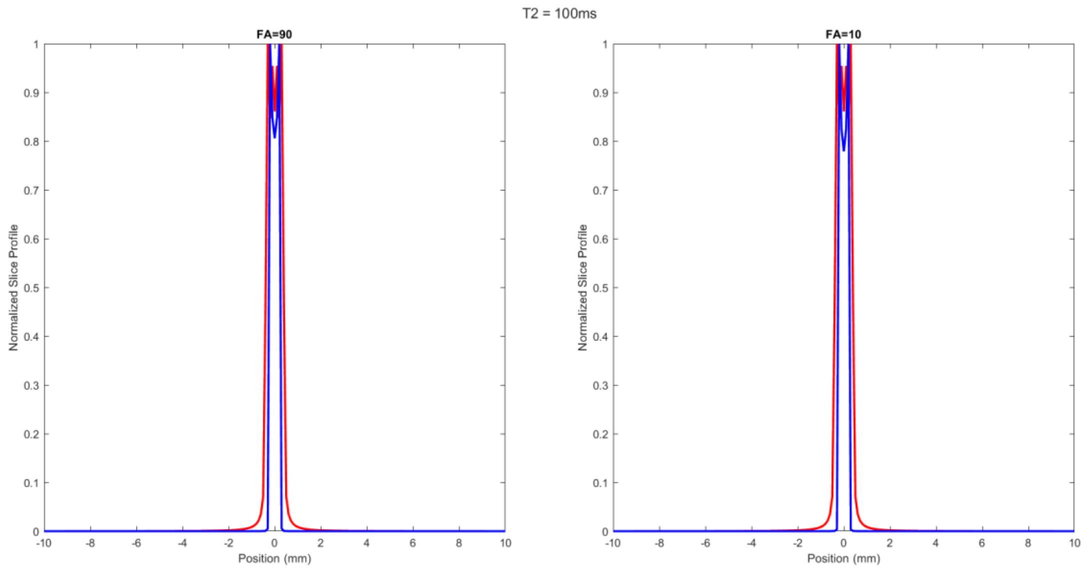
The slice profile at both 0 and 200 Hz off resonance for 30° and 10° flips. See attached code for computation details.


Off-Resonance = 0Hz
FA = 30
Mx
My
Mz
Mxy
Position (mm)

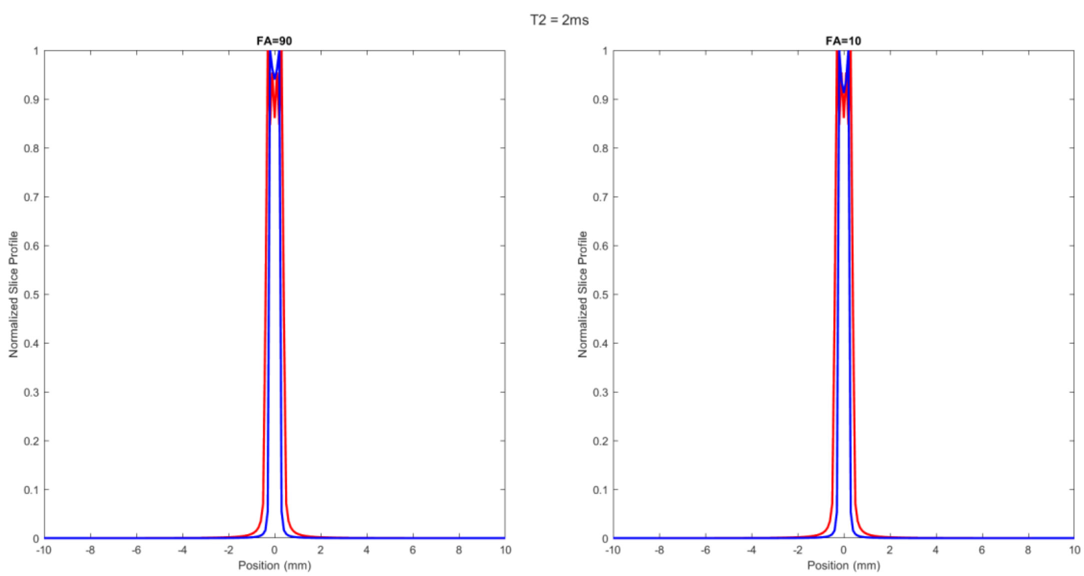

Off-Resonance = 200Hz
FA = 30
Mx
My
Mz
Mxy
Position (mm)



The slice profile of the 90° and 10° simulated using the Bloch equations compared to the fourier transform. The simulated profile has less rolloff around the edges of the slice and is skinnier than the fourier transform for both flip angles, at this T2 there isn't much difference between the large and small flip angles, but the large flip angle matches the top portion of the fourier transform better.

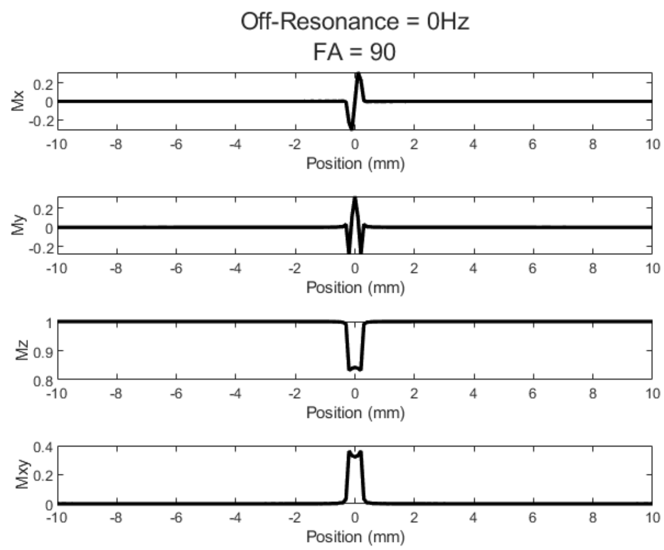


Now again reducing the T2 to 2ms. In this case, the slice profile is much closer to the fourier transform in terms of overall width and rolloff, where the smaller flip angle matches more closely at the flat top.



Question 3.4

The slice profile at 0 Hz off resonance for a 90° at the moment immediately prior to the rephasing gradient. See attached code for computation details. We can see that the overall signal magnitude is reduced due to the signal dephasing, the rephasing gradient re-aligns these spins resulting in an overall increase in signal magnitude.



Question 3.5
The RF signal can be adjusted by adding frequency components to the sinc pulse for each new slice. See attached code for computation details.