1.

a. $\because$ $TBW = \tau_{RF} \times BW = 2$, $\tau_{RF} = 1ms$

$\therefore$ $BW = 2\times10^3 Hz$

$\therefore$ $\Delta f = BW = \gamma \cdot G_z \cdot \Delta z$

$\therefore$ $G_z = \dfrac{BW}{\gamma \cdot \Delta z} = \dfrac{2000\,Hz}{42.58\times10^6 \cdot 3\times10^{-3} m} = 15.7\ mT/m$

$\because$ $k_{sr} = 180\,T/m/s$

$\therefore$ $\tau_{ss}^{rise} = \dfrac{G_z - 0}{k_{sr}} = \dfrac{15.7\times10^{-3} T/m}{180\,T/m/s} = 0.0872\times10^{-3} s = 0.0872\ ms$

$\therefore$ $\tau_{tt} = \tau_{ss}^{rise} \times 2 + \tau_{ss} = 0.0872\times2 + 1 = 1.1744\ ms.$

b. $\because$ $k_y = \gamma \cdot [\ G_y \cdot \tau_y + 2\times\frac{1}{2}(G_y - 0)\cdot \tau_{yrise}\ ] = \dfrac{1}{2\Delta y}$

$\because$ $G_y - 0 = 180 \times \tau_{yrise}$

$\therefore$ $\tau_{yrise} = \dfrac{25\times10^{-3} T/m}{180\,T/m/s} = 0.1389\ ms$

$\therefore$ $\gamma\,[\,25\times10^{-3} T/m \cdot \tau_y + 25\times10^{-3} T/m \cdot 0.1389\times10^{-3} s\,] = \dfrac{1}{2\times1.2\times10^{-3}}$

$\therefore$ $\tau_y = 0.2525\ ms$

$\therefore$ $\tau_{ytotal} = \tau_y + 2\tau_{yrise} = 0.2525 + 0.2778 = 0.5303\ ms.$

c. $\because$ $\Delta f = \gamma \cdot FOV_x \cdot G_x = rBW = rBW_{pixel} \cdot N = 750 Hz/pixel \cdot 256 = 192000\ Hz$

$\because$ $FOV_x = N \cdot \Delta x = 256 \times 1.2\times10^{-3} = 307.2\times10^{-3}\ m$

$\therefore$ $G_x = \dfrac{rBW}{\gamma \cdot FOV_x} = \dfrac{192000\,Hz}{42.58\times10^6 Hz/T \times 307.2\times10^{-3} m} = 14.7\ mT/m$

$\therefore$ $\tau_{xrise} = \dfrac{G_x}{k_{sr}} = \dfrac{14.7\times10^{-3} T/m}{180\,T/m/s} = 81.7\ \mu s$

$\tau_{ADC} = \dfrac{1}{rBW} = 1.33\,ms$

(Sorry I didn't noticed the Hint :))

d. overlap 1: Gy and Gz

$$\because \begin{cases} G_{nz} \cdot T_{nz} + \frac{1}{2} G_{nz} \cdot T_{rise} = \frac{1}{2} G_z \cdot T_{ss} \\ T_{nz} + 3T_{rise} = T_{ytotal} \end{cases}$$

(where $T_{rise} = 0.0872$ ms , $G_z = 15.7$ mT/m , $T_{ytotal} = 0.5303$ ms , $T_{ss} = 1$ ms)

$$\therefore \begin{cases} T_{nz} = 0.2687 \text{ ms} \\ G_{nz} = 25.07 \text{ mT/m} > 25 \text{ mT/m} \end{cases}$$

$\therefore$ max $G_{nz} = 25$ mT/m

$\because G_{nz} \cdot T_{nz} + \frac{1}{2} G_{nz} \cdot T_{rise} = \frac{1}{2} G_z \cdot T_{ss} = \frac{1}{2} \cdot 15.7$ mT/m

$\therefore T_{nz} = 0.2696$

$\therefore T_{nztotal} = T_{nz} + 3T_{rise} = 0.5312$

Overlap 2 Gz and Gx

$$\because \begin{cases} G_{nx} \cdot T_{nx} + \frac{1}{2} G_{nx} \cdot T_{xrise} = \frac{1}{2} G_x \cdot T_{ADC} \\ T_{nx} + 3T_{xrise} = T_{nztotal} \end{cases}$$

(where $T_{ADC} = 1.33$ ms , $G_x = 14.7$ mT/m , $T_{nztotal} = 0.5312$ ms , $T_{xrise} = 0.0817$ ms)

$$\therefore \begin{cases} T_{nx} = 0.2861 \text{ ms} \\ G_{nx} = 29.9 \text{ mT/m} > 25 \text{ mT/m} \end{cases}$$

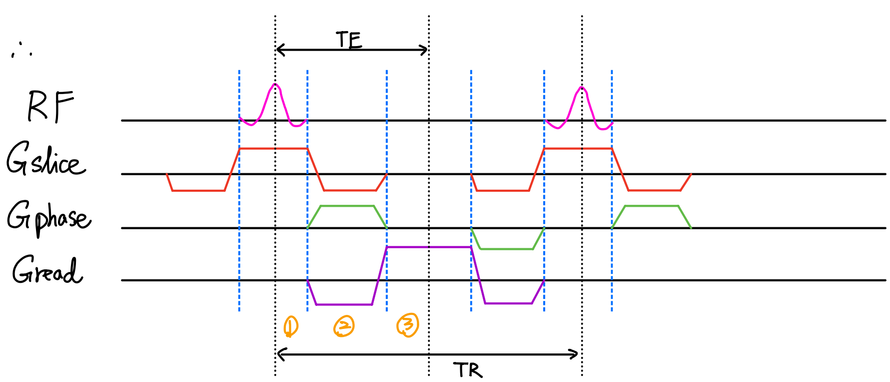
$\therefore$ max $G_{nx} = 25$ mT/m

$\because G_{nx} \cdot T_{nx} + \frac{1}{2} G_{nx} \cdot T_{xrise} = \frac{1}{2} G_x \cdot T_{ADC}$

$\therefore T_{nx} = 0.35$ ms

$\therefore T_{nxtotal} = 0.35 + 3 \times 0.0817$ ms $= 0.595$ ms

$\therefore$



$\therefore$ TE = ① + ② + ③ $= \frac{1}{2} \times 1$ ms $+ 0.595$ ms $+ \frac{1}{2} \times 1.33$ ms $= 1.76$ ms

TR = $2 \times$ TE $= 3.52$ ms

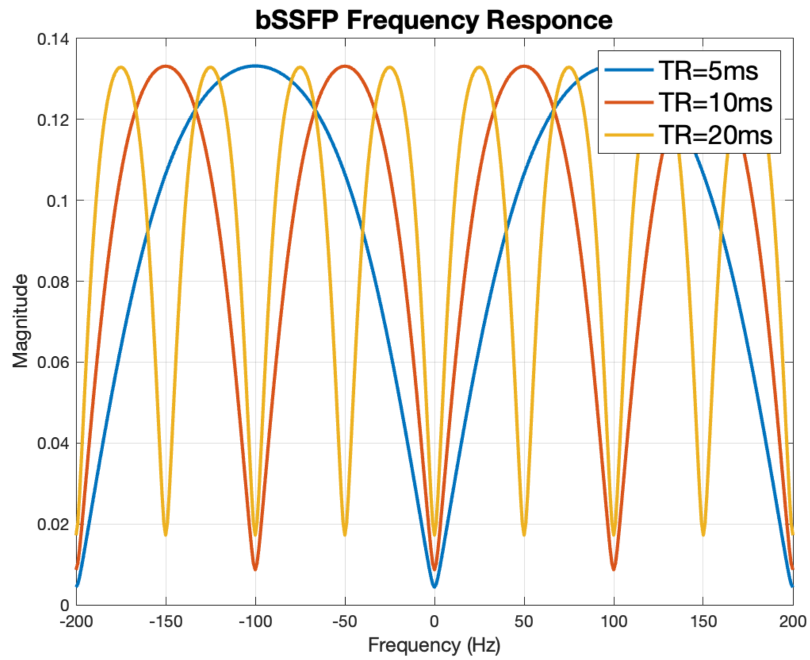
e. (i) increase receiver bandwidth

(ii) increase the maximum slew rate

(iii) decrease the duration time of the RF pulse.

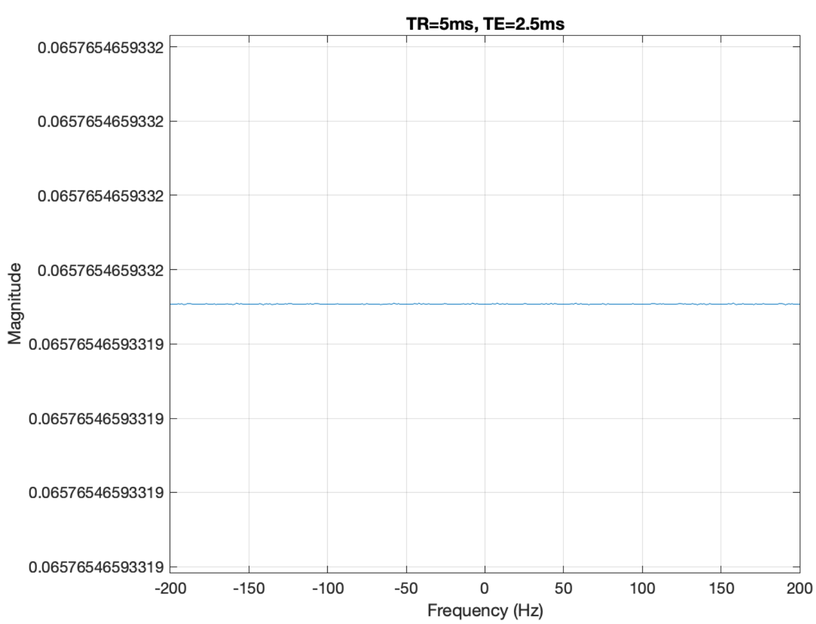
2.

a.

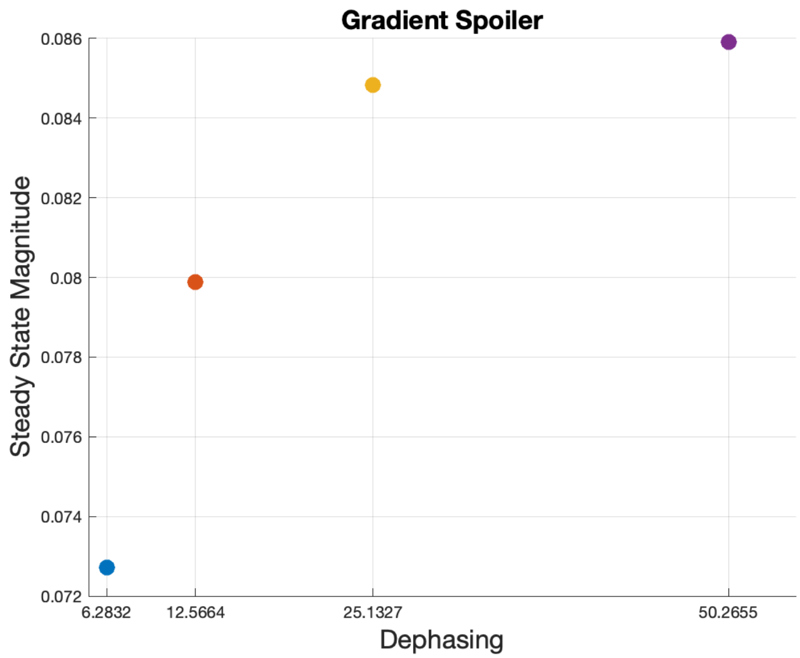


b

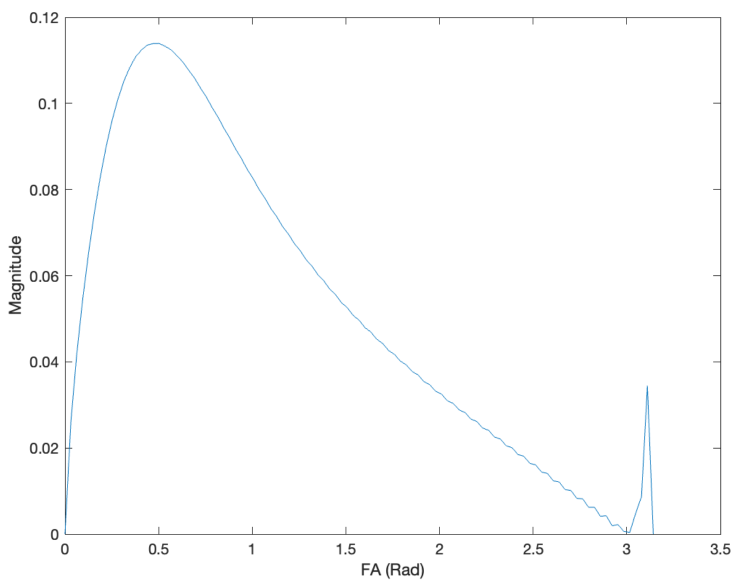
i,



ii



iii



When RF phase ≈ 3 Rad, elimate the transverse magnetization.

3.

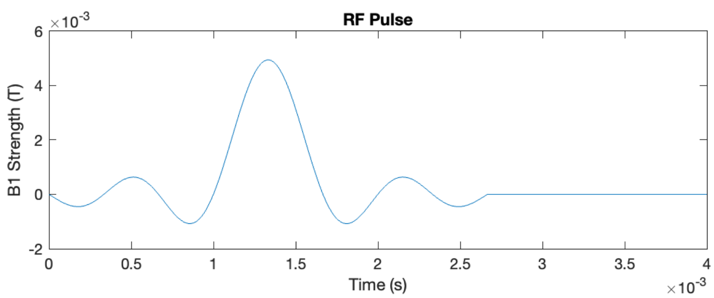
a. $\because\ TBW = BW \times \tau_{RF} = 8, \quad \tau_{RF} = 2ms$

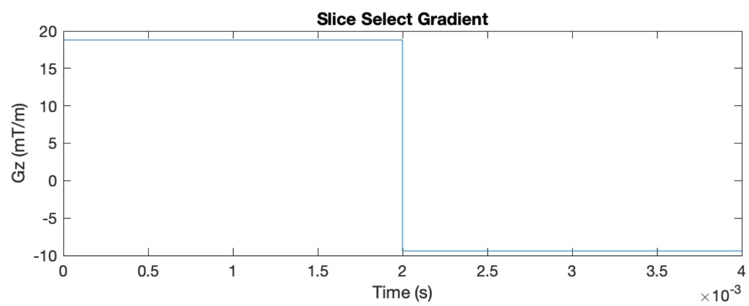
$$\therefore\ BW = \frac{TBW}{\tau_{RF}} = \frac{8}{2ms} = 4000\ Hz$$

$$\because\ \Delta f = \bar{\gamma} \cdot G_z \cdot \Delta z = BW$$

$$\therefore\ G_z = \frac{BW}{\bar{\gamma} \cdot \Delta z} = \frac{4000\ Hz}{42.58 \times 10^6 Hz/T \cdot 5 \times 10^{-3} m} = 18.8\ mT/m$$

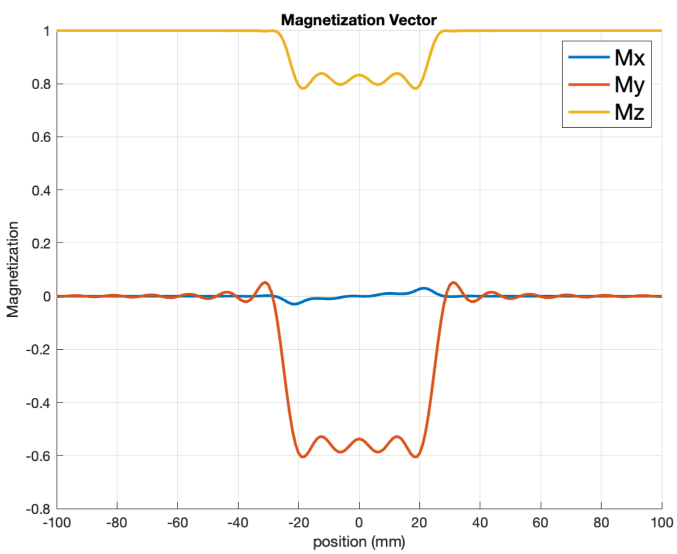
$$\therefore\ T_{rise} = \frac{G_z - 0}{ksr} = \frac{18.8\ mT/m}{180\ mT/(m \cdot ms)} = 0.104\ ms$$

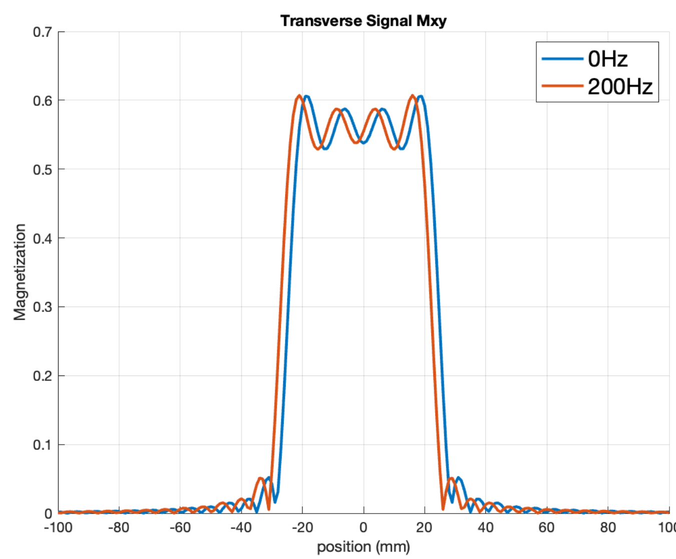




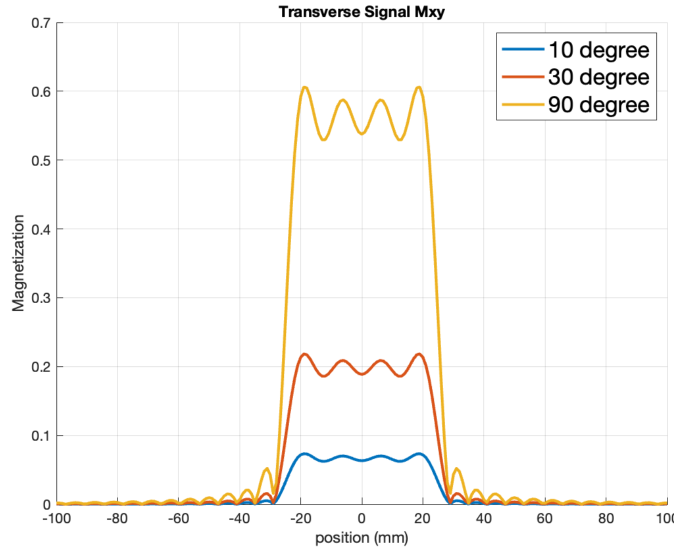
b.

Mx, My, Mz with df = 0 Hz

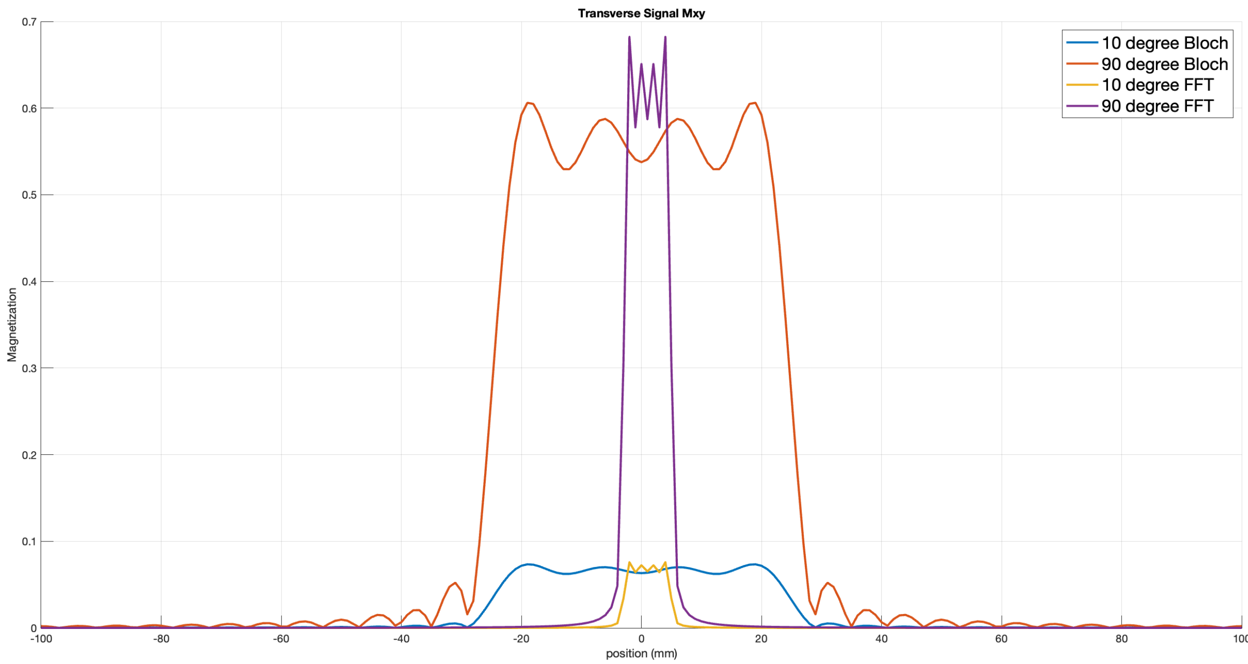




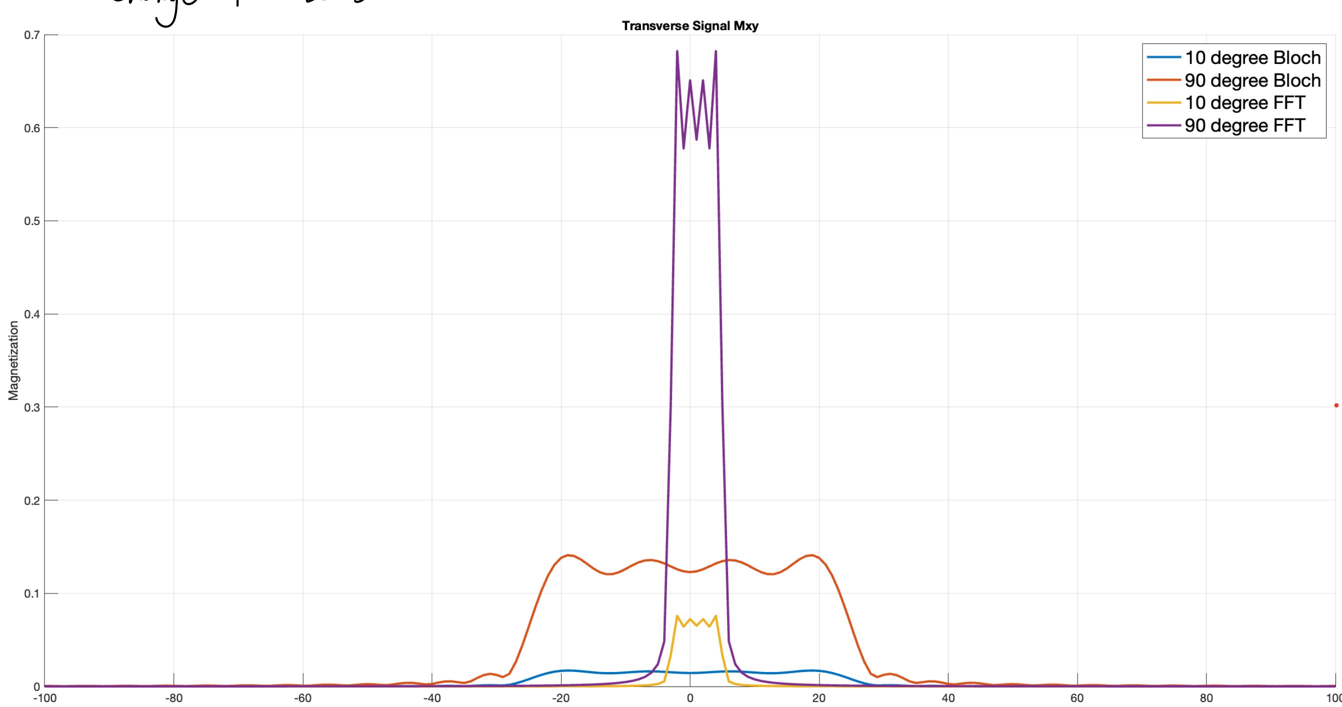
C.



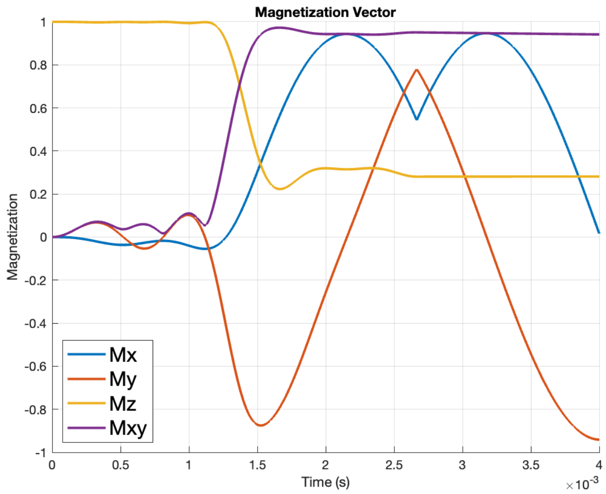
FA= 10°, 30°, 90°



Change T_2 = 2 ms



d.



Position $x = 5$ mm

The purpose of the rephasing gradients : Back to the center of the k-space.

e.