HL2011: Exercise Set 1
RF excitation of the bulk magnetization

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1 Preparations

If you haven't done it already, download the package `seemri.zip` from Canvas and unzip it to a suitable directory. Start Matlab and add the path to seemri using the matlab command `addpath` <*path to seemri*>. In matlab, type `help seemri` and make sure you get the help page. You are now ready to start.

Define some useful constants:

```
gammabar = 42.58e6;
gamma = 2*pi*gammabar;
```

2 Getting started with SeeMRI

SeeMRI is an object-oriented simulator written for Matlab. That means objects in the real world are represented by software objects in Matlab.

2.1 Creating a magnetization vector

For example, to create an imaging volume with a single magnetization vector at position $(x, y) = (0, 0)$ with relaxation parameters T1 and T2 both set to 1e9 s type

```
iv = ImagingVolume(0, 0, 1e9, 1e9)
```

You can plot the vector by `plot(iv)`.

For more information see `help ImagingVolume`.

2.2 Creating an RF pulse

To create a rectangular RF pulse with amplitude $B_1 = 5.9\ \mu$T, frequency $f_{rf} = 42.58$ Mhz, phase $\phi_{rf} = \pi/2$, and pulse width $\tau_p = 1$ ms, type

```
rf = RectPulse(5.9e-6, 42.58e6, pi/2, 1e-3)
```

The command `plot(rf)` plots the envelope function of the pulse. You can also plot the envelope power spectrum using `powspec(rf)`.

Note: The simulator uses $\gamma\!\!\!^{-} = 42.58$ MHz/T which have to be taken into account when designing RF pulse for resonance.

For more information see `help RFPulse` and `help RectPulse`.

2.3 Running the simulation

Now, to apply the RF pulse to the imaging volume with the main magnetic field set to $B_0 = 1.0$ T type

```
seemri(iv, 1.0, rf);
```

The imaging volume maintains the state it had at the end of the simulation. To set it back to thermal equilibrium run `iv.toEquilibrium();`.

3 RF excitation

In this part you will investigate the effect of the pulse amplitude and pulse phase on the RF excitation.

You can start with the system defined in Section 2. Try varying the amplitude B_1 of the RF pulse.

Note: When doing repeated excitations on the same imaging volume, remember to set it back to thermal equilibrium between each run using the command `iv.toEquilibrium()`.

Q1: How does the amplitude of the pulse affect the flip angle of the RF excitation?

Now try varying the phase ϕ_{rf}.

Q2: How does the phase of the pulse affect the RF excitation?

Write a table for the phase (0°, 90°, 180°, and 270°), direction of B_1 in the rotating frame of reference and the direction of $\vec{M}$ after a 90° pulse. What is the relation between the B_1 direction and the direction of M after the pulse (in the rotating frame of referecce).

3.1 Pen and paper problem

Consider a bulk magnetization vector $\vec{M} = M_z^0 \hat{z}$ in a magnetic field of strength $B_0 = 1.0$ T. Design an RF pulse, by answering Q3 and Q4, such that the magnetization after the pulse is

$$\vec{M}(0+) = \frac{1}{\sqrt{2}}(-M_z^0 \hat{x}' + M_z^0 \hat{z}') \tag{1}$$

You can have a rectangular envelope function and let the pulse duration be 1 μs.

Q3: What is the mathematical expression for an RF pulse in the stationary frame (in the general case)? Use quadrature form.

Q4: What should the frequency, phase and amplitude of the pulse be (in this case)?

You can try your RF pulse in the simulator (by, for example, letting $M_z^0 = 1$), to see if you get the desired result. Type `iv.M` to access the magnetization vector.

4 Report

Write down your solutions and answers to questions Q1-Q4. Provide relevant plots as figures and make sure your report is self-contained. Submit your report *and* source code on Canvas, deadline Tuesday April 2, 23:59.