A.2 Parallel Transmit GUI

A parallel transmit GUI was developed and used for the work reported in various chapters of the thesis. Figure A.3 shows the workflow of a parallel transmission experiment with the numbers in the parentheses indicating corresponding locations in the GUI that can be found in Figure A.4.

B_1^+ distributions of individual transmit channels can be visualized inside the GUI after including them from either MR images obtained with turbo FLASH based flip angle mapping technique as described in section 1.3.6 or .mat files which contain flip angle information from any imaging method or simulations. Parallel transmission requires desired excitation profile to be defined. Three different ROI selection mechanisms are implemented as shown in the *Desired Profile Selection* panel (Figure A.4-**2**). The desired excitation profile can be selected interactively from an image obtained with sum of squares (SoS) combination of the B_1^+ profiles. Additionally, the desired excitation profile can be defined as the whole sample or incorporated from a saved .mat file. After choosing the desired excitation profile, the user must specify the coils to be used in parallel transmission RF pulse calculation. Initially all eight coils are pre-selected. As for RF shimming, the user can choose any subset of transmit coils by using check boxes and for convenience odd and even coils can be selected easily by pressing the corresponding button from the *Select channels* panel (Figure A.4-**4**). Main magnetic field inhomogeneities can be included in RF pulse design using the *B0 Map* panel in Figure 1.1-**3** by including a predefined .mat file or by first choosing names of

two GRE images with different TEs from a pop-up menu and then pushing the *Calculate B0 Map* button.

Within the *pTx Pulse Info* panel, the *k-space Trajectory* panel enables users to choose the type of excitation *k*-space trajectory for RF pulse design. Three different *k*-space trajectories are implemented:

1. Constant Density Spiral

2. Variable Density Spiral

3. EPI like (Echo Planar)

Constant density spirals were used in Chapters 1 & 3 and variable density spirals were used in Chapter 1. EPI-like trajectories were not incorporated in RF pulse design in the thesis, but were implemented in the GUI since they provide a useful educational perspective for accelerated excitations. Changing parameters in the GUI, such as excitation resolution, excitation field of view and acceleration, enables automatic calculation and display of the selected type of *k*-space trajectory. *k*-space trajectory calculation aims for the shortest possible RF pulse length while obeying gradient specifications defined in the GUI. Additionally, the RF pulse length for the calculated *k*-space trajectory is displayed in the *k-space Trajectory* panel.

Three different RF pulse calculation algorithms are implemented and shown in the *Pulse Design Type* panel (Figure A.4-**6**). Depending on the type of solution, they are classified as regularized and not regularized. Regularization based RF pulse designs are implemented in STA and LTA regime. On the other hand, strict constraint

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RF pulse design (not regularized) is implemented only in the STA regime. Regularized RF pulse design methods and strict constraint RF pulse design methods were used in Chapter 1 and 3, respectively. For constrained RF pulse design, the user must choose a constraint type from the *Constraints* panel. All options include peak and average forward and reflected power constraints and global SAR constraints as defined in the *Power Constraints* panel. The power correlation matrix must be imported, using the *Include PHI* button, for accurate power prediction which is essential in constrained RF pulse design. Additional parameters for RF pulse design e.g. flip angle, smoothing profile, and regularization parameter, can be included from Figure A.4-**7**. After all the parameters are selected the RF pulse will be designed and displayed in Figure A.4-**8** after pushing the *Calculate RF Pulse* button. Relevant information such as NRMSE and number of iterations (e.g. conjugate gradient iterations) used in pulse design is displayed under the amplitude of the designed RF pulse. Calculated RF pulse can be exported to different formats which can be used in the MR scanner. *Write In Float* button generates .float files of individual channel RF pulses and gradients, then puts them in an ".Output/RFPulses" directory with separate folder names for each individual transmit channel (TX1-TX8). The *WriteIn_pTXRFPulse* button generates the 'pTXRFPulse0.ini' file under the directory ".Output/RFPulses". All variables inside the GUI can be saved for future reference using the *Save Variables* button.

Obtain B_1^+ distribution and add to GUI from (1)	
an MR experiment (1a)	a simulation (1b)

Select the desired excitation profile (2) from		
an image obtained with SoS combination of B_1^+	a saved .mat file	the whole sample

Include the B_0 map (3) from	
two GRE MR images	precalculated .mat file

Select channels to be used in pTx experiment (5)

Select type of the excitation *k*-space to be used (4)		
Constant Density Spiral	Variable Density Spiral	EPI

Select type of RF pulse design method (6)	
Using regularization (Chapter 1) • STA • LCLTA	Without using regularization (STA, Chapter 3) • Unconstrained • Only global SAR constrained • Constrained

Define additional parameters for RF pulse design (7)

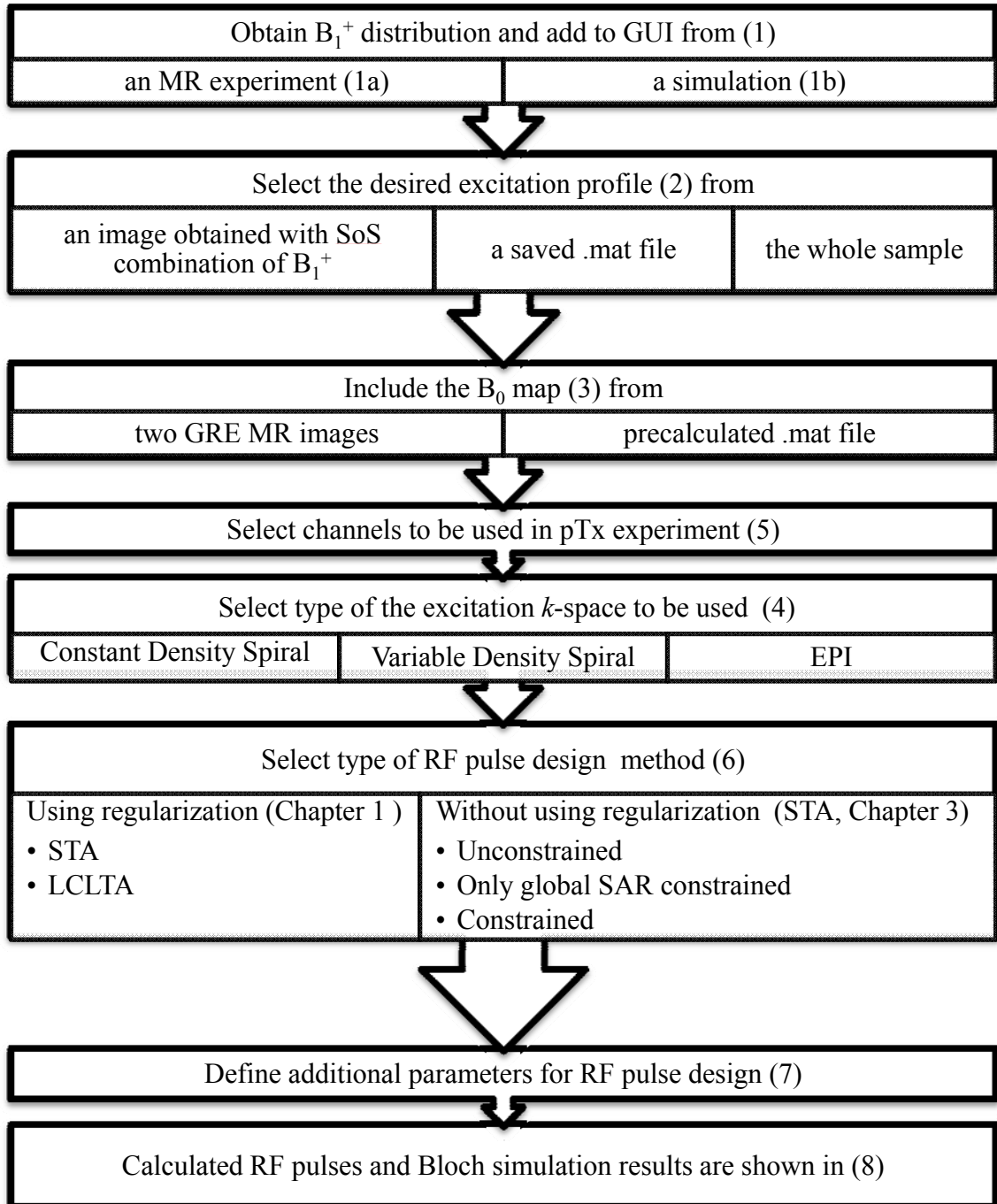| Calculated RF pulses and Bloch simulation results are shown in (8) |
|---|

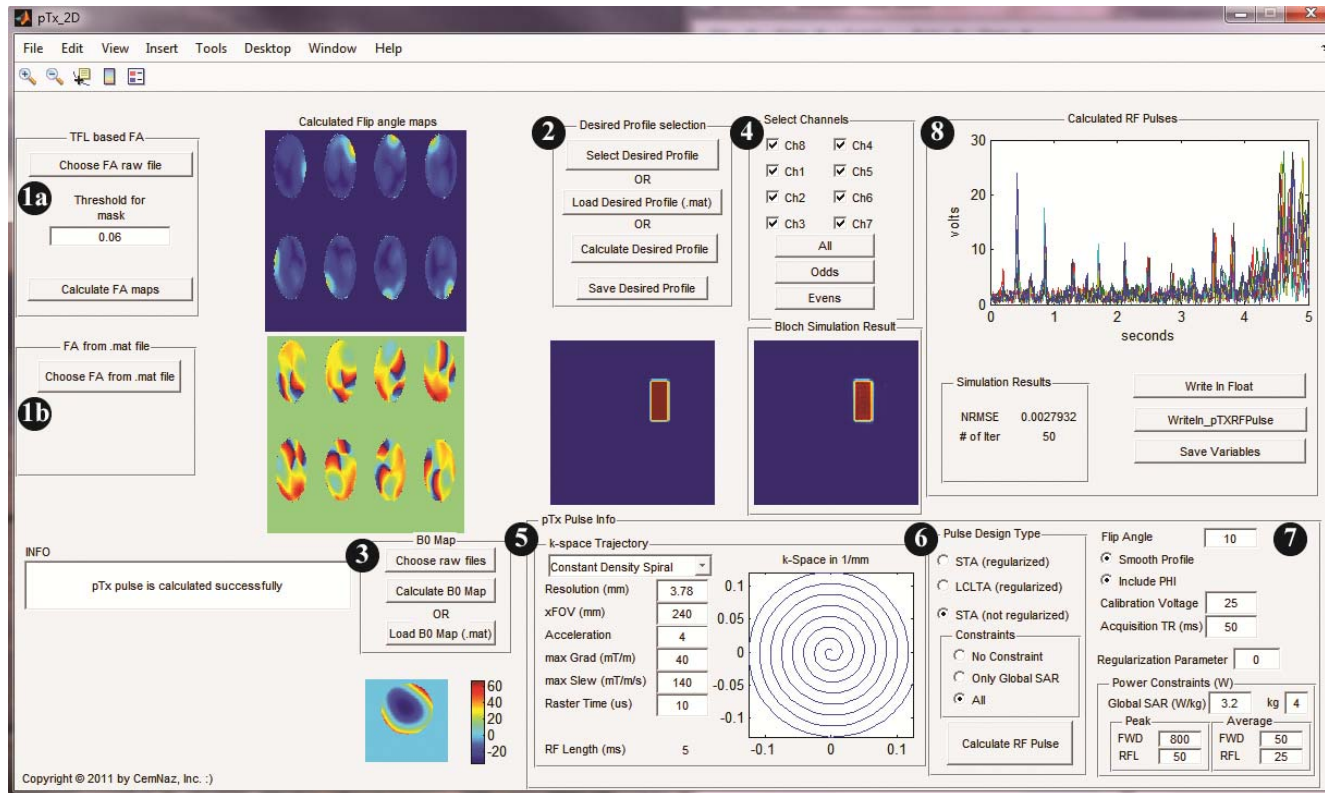Figure A.3 Workflow of a parallel transmission experiment. Relations to the parallel transmission GUI are given by the numbers in parentheses.

Figure A.4 Screenshot of Parallel Transmit GUI