# Transmit SENSE with Measured and Simulated B1+ Fields

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**Introduction**: Transmit SENSE method [1] has been introduced in recent MRI methods. Such technique is capable of alleviating the inhomogeneity of B1+ fields especially at higher fields. The method relies on the sensitivity map of each transmit channel, which can be difficult to measure. Here we explore the Tx SENSE method using sensitivity maps fully calculated from simulations. The benefit of such method includes i) the exclusion of B1+ measurements, ii) accurate prediction of the local SAR for each RF pulse design. To demonstrate the proposed method, we present the comparison results of Transmit SENSE experiments using B1+ profiles calculated from simulations and measured from experiments obtained with a 7 tesla system equipped with an 8-channel Tx-array. The experiments are done using a 17.5cm (diameter) spherical water phantom filled with saline with electromagnetic properties similar to the brain.

**Method: *Transmit Array:*** We used an unconventional (for Tx SENSE) EPI-friendly coil described in [2] for the following experiment. Instead of having 2x2 distributed elements at the top of the coil structure, we used 3x3 distributed elements. The 4 excitation channels are connected to the middle elements of each side. The shield of the coil is slotted to avoid eddy current for fast imaging. ***Simulations:*** We use an in-house finite-difference time-domain method [3] to calculate the B1+ profiles. The resolution of the model is 0.16cm to guarantee all the fine structure of the coil is captured for accurate modeling. All four channels of the coil are connected to 50Ω transmission line. The S-parameters of the coil is calculated and later verified with the measurement from the network analyzer. ***Sensitivity map:*** The extraction of the B1+ profile of the coil from experiment uses flash sequence with multiple flip angles. *RF pulse design*: The designed pattern is a rectangular box in the center of the water phantom. A segmented spiral trajectory is numerical designed with maximum gradient amplitude 24mT/m, slew rate 18mT/m/ms, FOV 200mm, and matrix size 32. To achieve certain acceleration factor (AF), the segment is set to be the AF. Pulse design was accelerated using the Conjugate Gradient (CG) algorithm. The Tx-array was utilized to produce the 4 pulses simultaneously on the 7T scanner. The excitation was followed by 3D gradient echo (GRE) readout with the following parameters: TR=60ms, TE=1.16ms, slick thickness=2.0mm, FoV=200mm and Resolution=64x64.

Fig. 1 The designed excitation Pattern is a 4.5cmx9cm rectangular box within center of the water phantom.

**Results and Discussion:** Both the measurement and simulation show that coupling of the coil is high with the maximum coupling is -4dB. The designed pattern is given in Fig. 1 with a rectangular box within the center of the phantom. The designed RF pulses are shown in Fig. 2. Fig. 3 shows the comparison of the two methods with different AF. Other than AF=4, where the two methods both excited a distorted rectangular box, the two methods both perform very well in exciting the desired pattern. In addition, we also examined designed RF pulses based on wrong B1 maps. Fig. 4 shows the edge of the rectangular is now blurred when using artificially rotated (10deg) B1+ maps. Fig. 5 shows the excitation based on the swapping the B1+ maps of different channel. The rectangular box is no longer recognizable.

**Conclusion:** The presented results validate the accuracy of our simulated B1 maps for highly coupled T/Rx arrays. It also shows that accurate B1 maps are needed in order to produce relatively acceptable (compared to the designed) excitation patterns. In addition, these results also demonstrate that highly-coupled coils can be used for transmit SENSE without significant difficulties.

**Reference:** 1. Katscher, U. et al., MRM, 2003. 2. Ibrahim, T. et al. ISMRM 2008, P 438. 3. Yee, K. S. IEEE AP, 1966.

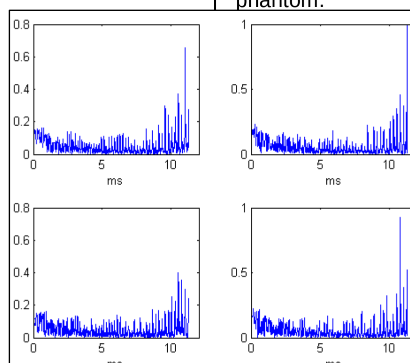


Fig. 2. Without acceleration factor (AF) the designed pulse length is about 12ms. Fig shows the RF pulses for the four channels without AF. For AF=2,3,4, the pulse length is equal to 5.6, 3.8 and 2.8ms, respectively.

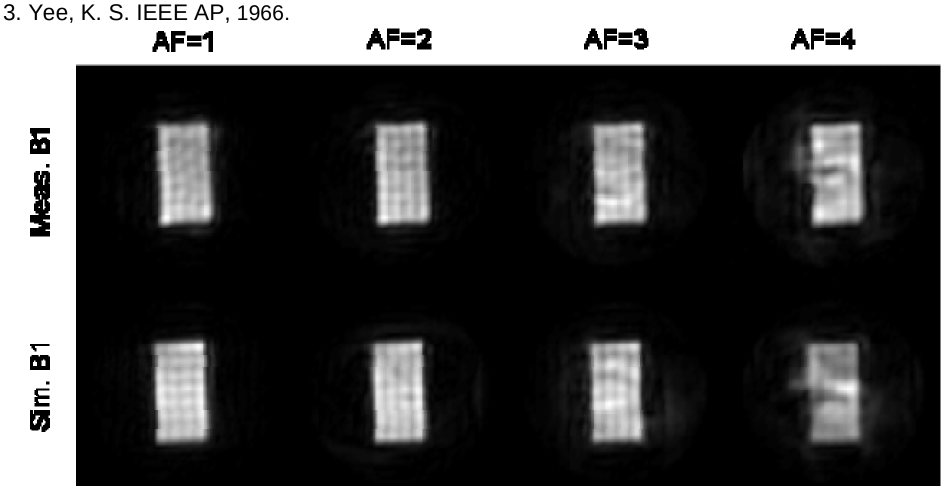


Fig. 3: The comparison between the excitation pattern using measured B1 field and using simulated B1 field with acceleration factor (AF)=1, 2, 3 and 4. For AF =1,2,3, the excited rectangular box is still very much similar to the designed pattern with slightly tilted angle. For AF=4, the pattern is similarly distorted for both cases.

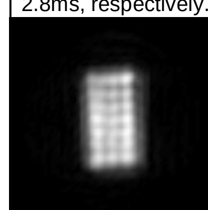

Fig. 4 Excitation using B1+ maps that are rotated 10 deg. The edge of the rectangular box is blurred.

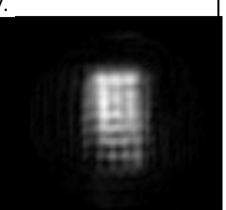

Fig. 5 Excitation using the wrong B1+ map. The rectangular box is no longer recognizable.