Improving Robustness for Voxel Based Transmit Gain Calibration using Bloch-Siegert Shift Method for MR Spectroscopy at 7T

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Target audience

Scientists and clinicians interested in magnetic resonance spectroscopy (MRS)

Purpose

With the high B_1 field inhomogeneity at ultra-high field the adjustment of the transmit gain (TG) on a slice might lead to miscalibration of TG in smaller target volumes. This can result in poor excitation slice profile and out-of-voxel signal suppression in single-voxel MRS.

The phase based Bloch-Siegert (BS) shift method has already been successfully used for TG calibration [1] and can be included in various types of imaging and spectroscopy sequences. BS-PRESS [2] determines the optimal TG in the same volume that is excited for the spectroscopy experiment from the average of the BS phase shift of the first high SNR data points of the FID. Even though this technique has already been successfully implemented at 7T [3] in several cases the BS phase shift shows a high standard deviation. This can be caused by a larger TG miscalibration in some brain regions that leads to signal from outside the volume of interest.

This study will present an implementation of the Bloch-Siegert phase shift method within a standard spectroscopy STEAM-based localization sequence that shows a high robustness to determine TG for the same volume that is excited for the spectroscopy experiment in-vivo at 7T.

Methods

BS shift method was implemented by modifying a standard STEAM sequence (BS-STEAM). One off-resonant BS pulse (fermi, 6 ms, ± 4 kHz relative to water) applied after the last excitation pulse was included. Center frequency of STEAM excitation pulses was set to water resonance frequency.

Experiments were performed both in a MRS phantom (MRS HD Sphere, GE Healthcare, diameter = 18 cm) and in-vivo on 8 healthy volunteers in a whole body MR950 7T scanner (GE Healthcare) with standard head coil (Nova Medical, 2-channel Tx, 2 or 32 channel Rx).

Data processing was implemented in MATLAB (MathWorks) as an automatic process on the scanner after scan execution. $TG_{predicted}$ was calculated from the mean of the Bloch-Siegert phase shift [3] using data up to the point of the FID where magnitude signal dropped to 50% of the initial signal.

$TG_{starting}$ was first set by the standard slice-based multi-echo sequence in the automated prescan (APS) process [4]. In order to test the robustness of the technique, $TG_{predicted}$ was calculated with $TG_{starting}$ set manually over a larger range around optimal TG. Short TE STEAM (TE/TM/TR = 7ms/8.8ms/2s, 32 avg) and image of voxel were acquired with $TG_{predicted}$.

Results

The average of the standard deviation (SD) of $TG_{predicted}$ was 0.5 for phantom and 1.1 for the in-vivo measurements. SD of $TG_{predicted}$ for a large range of $TG_{starting}$ in various locations of the phantom was 1.2 (figure 1) and 1.8 in-vivo (figure 2) with ΔTG of 10 equals 1dB. This is also true in the in-vivo cases where BS-PRESS gives a non-constant phase shift with large SD (figure 2). Even in these cases the BS-STEAM approach results in good voxel selection and spectrum (figure 3).

Discussion and Conclusion

It has been demonstrated that the proposed voxel-based TG calibration using the Bloch-Siegert shift method with STEAM excitation allows to set TG over a large range of starting values in one step and therefore effectively selects a uniform and sharp voxel. This technique shows a higher robustness compared to the previously implemented PRESS-based approach resulting in a faster and more reliable calibration procedure.

References

1. Sacolick et al, Magn Reson Med 2010; 63: 1315-1322 **2.** Noeske et al, Proceedings of ISMRM 2012; 1733 **3.** Toncelli et al, Proceedings of ISMRM Workshop on UHF MRI 2013; 34 **4.** King et al, Proceedings of ISMRM 1995; 699

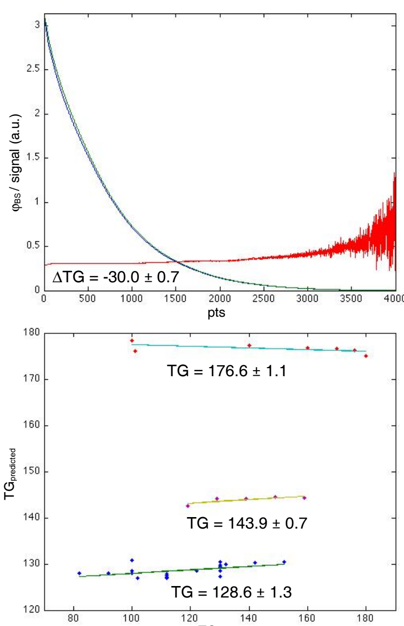

Figure 1: (top) Bloch-Siegert phase shift φ_{BS} (red) calculated from phase difference of two FIDs acquired with +4kHz (blue) and -4kHz (green) off-resonant BS pulse up to the point of the FID where magnitude signal dropped to 50% of the initial signal. (bottom) $TG_{predicted}$ vs. $TG_{starting}$ acquired at different voxel positions within a phantom

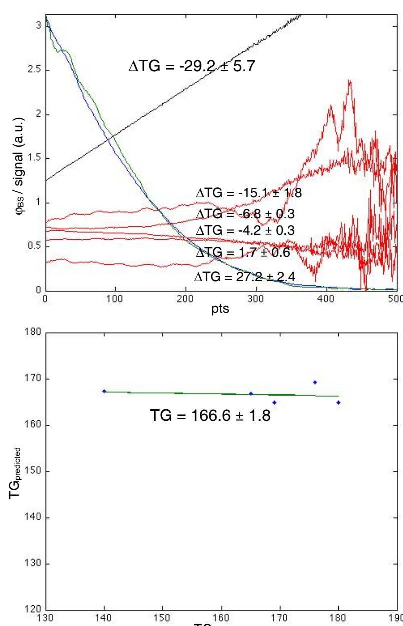

Figure 2: (top) Bloch-Siegert phase shift φ_{BS} acquired with BS-PRESS (black) and BS-STEAM (red) in occipital cortex (figure 3). For BS-STEAM the BS phase acquired with 5 different $TG_{starting}$ is shown. (bottom) $TG_{predicted}$ vs. $TG_{starting}$

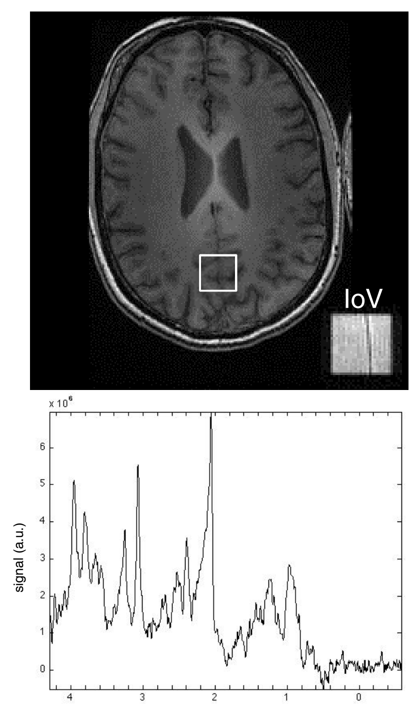

Figure 3: (top) Voxel position in occipital cortex with image of voxel (IoV) inlayed (bottom) STEAM spectrum (TE/TM/TR = 7ms/8.8ms/2s, 32 avg)