Comparison of Flux Regulation and Follow-B Approach for Enabling Magnetic Resonance (MR) Imaging in Powered Magnets

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Abstract

Clinical magnetic resonance (MR) imaging systems typically operate at 1.5 Tesla using low-temperature superconducting (LTS) magnets that provide a spatially uniform and temporally constant magnetic field. The downside of LTS magnets include high initial cost, large physical size, and the expense of replenishing cryogens. Development of compact and cryogen-free magnet systems could lead to the widespread use of MR systems in physician's offices. Replacing LTS magnets with powered or permanent magnets presents an engineering challenge as the resulting magnetic fields are not temporally constant. This research compares flux regulation and follow-B approach to enable MR imaging in powered magnets using the scalar performance metric of structural similarity (SSIM).

MRI Experiments

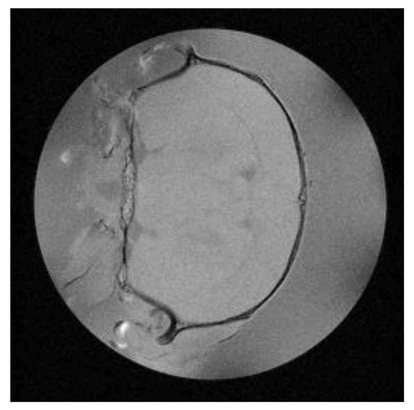

Figure 1. Mouse brain image in LTS magnet

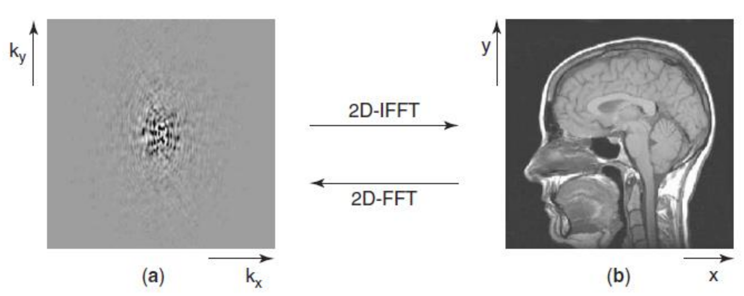

Figure 2. Image generation in MRI

Figure 3. Corrupted MR image

Conclusion

- Flux regulation provides a means for improving the quality of MR images acquired with magnets that do not possess the field stability of LTS magnets. In addition to high field magnets, such as the 36 Tesla series connected hybrid magnet under development at the National High Magnetic Field Laboratory, flux regulation facilitates the use of low-cost, low-field powered and permanent magnets for MRI. Although, flux regulation requires additional 40 dB of attenuation to enable MR imaging for gradient echo (GE) image.
- Follow-B method is efficient only for sinusoidal field fluctuations of very low frequency of the order of 10^{-2}

Acknowledgements

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Flux Regulator

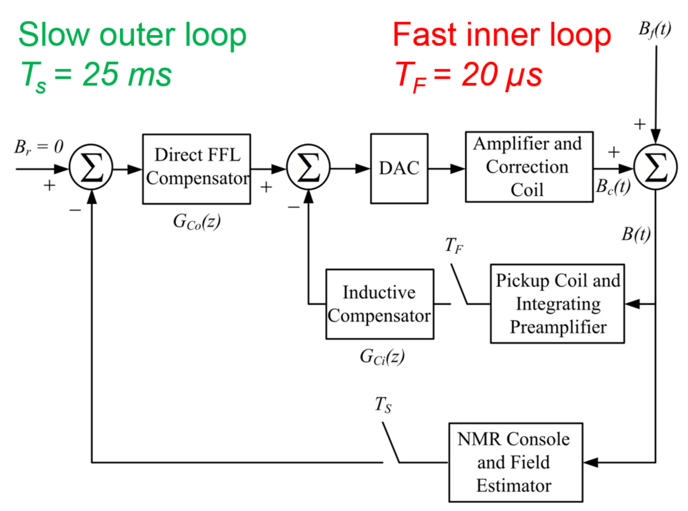

Figure 4. Flux regulator

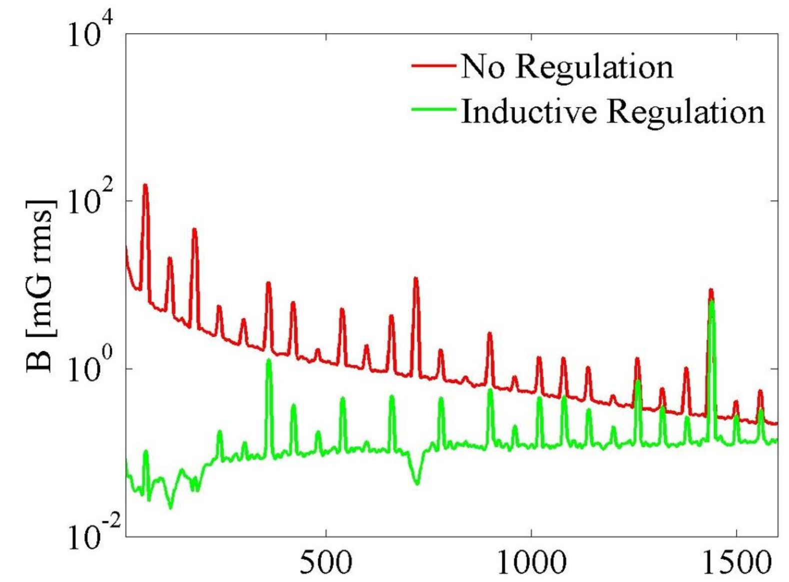

Figure 5. Field Spectra

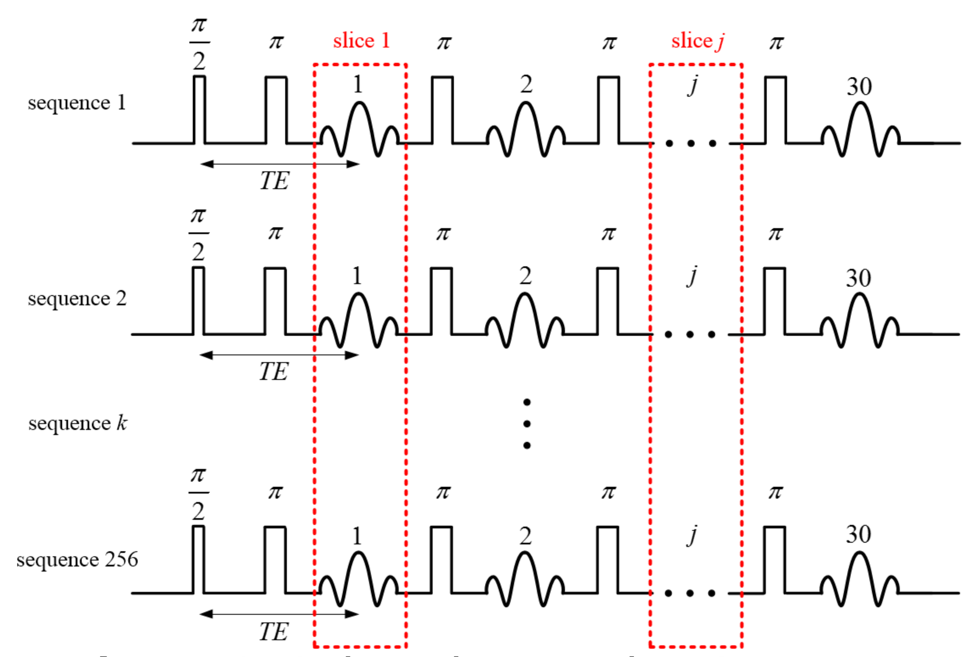

Figure 6. Spin Echo Imaging Sequence

Follow-B

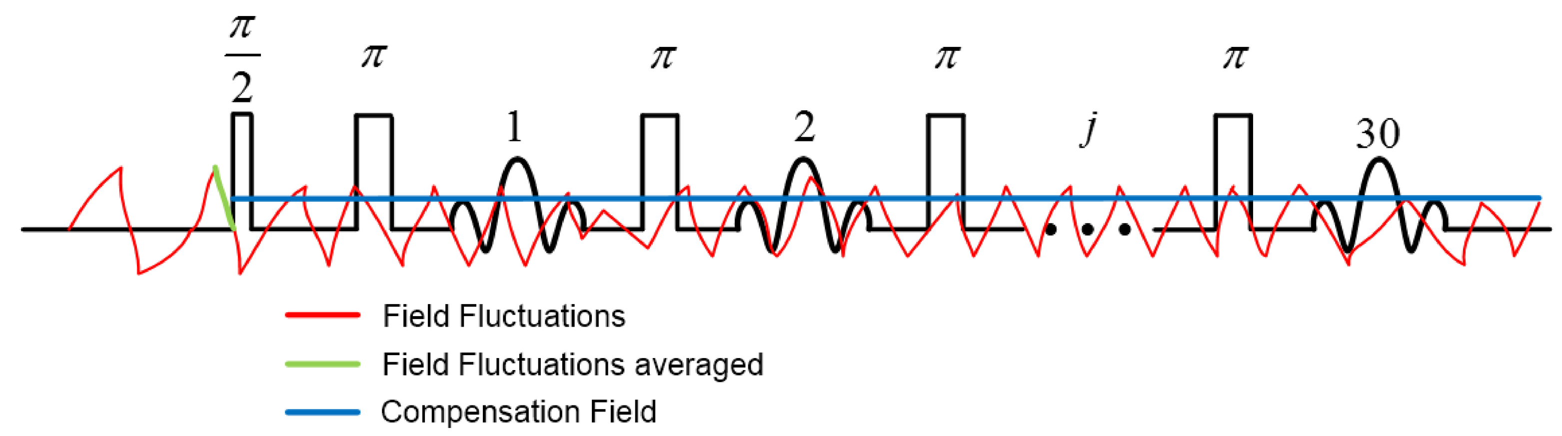

Figure 5. Spin-Echo sequence for Follow-B

Results

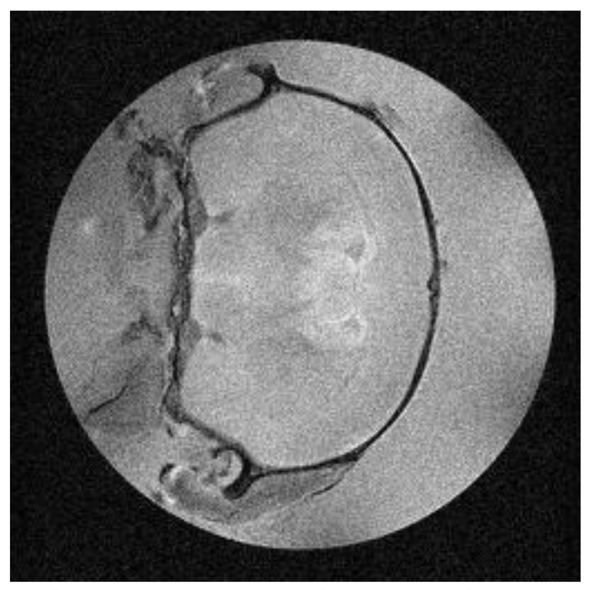

Figure 8. GE image in LTS magnet, SSIM = 1

Figure 9. Corrupted image with field fluctuations, SSIM = 0.170

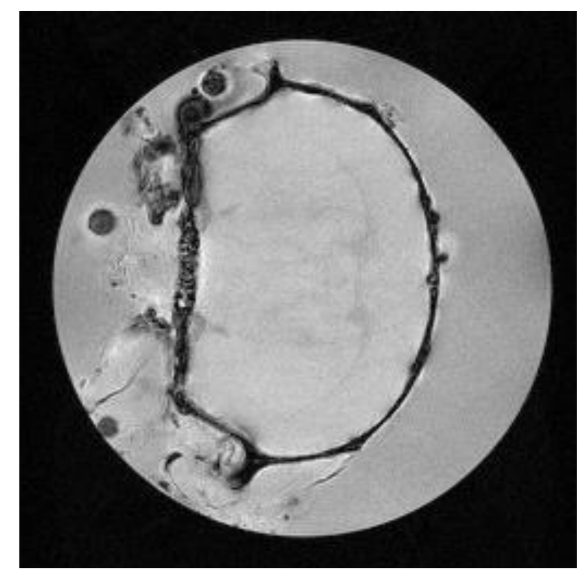

Figure 10. Flux regulated image with 40dB attenuation, SSIM = 0.824

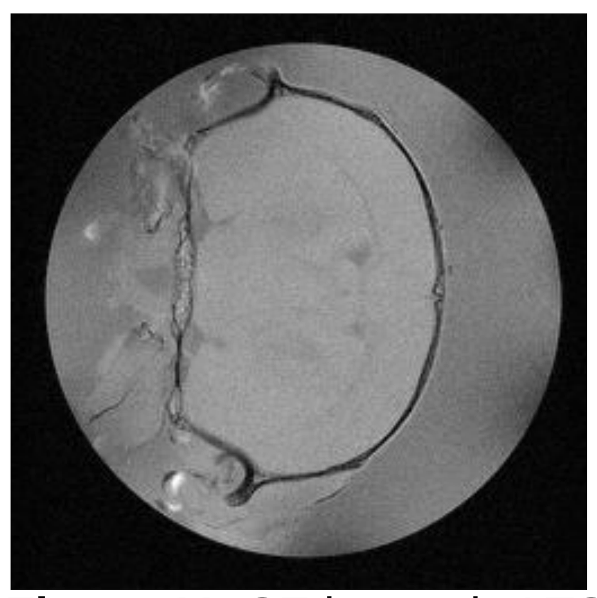

Figure 11. SE image in LTS magnet, SSIM = 1

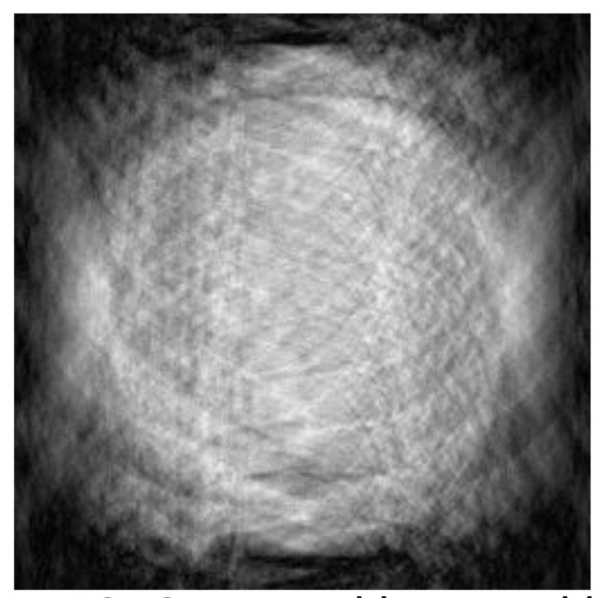

Figure 12. Corrupted image with 0.03Hz sinusoids, SSIM = 0.214

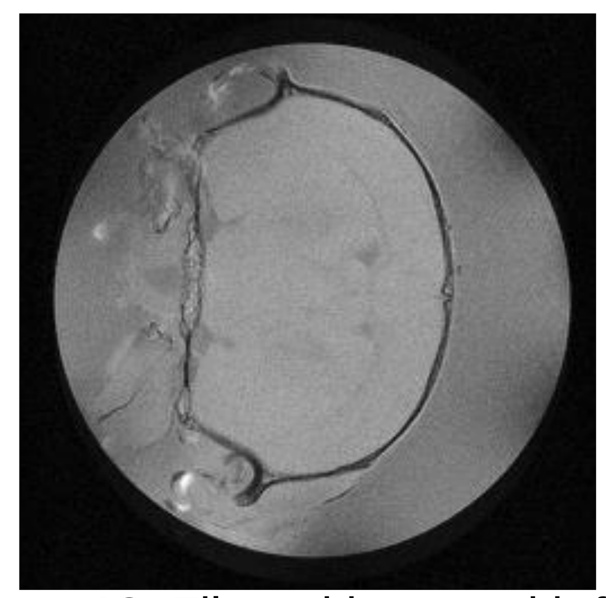

Figure 13. Filtered image with follow-B method, SSIM = 0.981