Reduction of Temporal Field Fluctuations in Powered Magnets using Feedback Control

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Introduction

This work will enable NMR on powered magnets, in particular, the 36 T series-connected-hybrid (SCH) magnet, by attenuating temporal field fluctuations introduced by the magnet power supply and cooling system. We previously demonstrated a feedback system that uses inductive measurements to attenuate the 60 Hz field fluctuation by more than 60 dB[1]. This approach is less effective for attenuating low frequency fluctuations due to 1/f measurement noise. We overcome this limitation by combining inductive and NMR measurements, and now report on a feedback control system that attenuates both low- and high-frequency temporal fluctuations.

Experimental

We assess the ability of the feedback system to reduce low-frequency temporal field fluctuations in the Keck powered magnet operating at 25 T by estimating the magnetic field from the proton Larmor frequency.

Results and Discussion

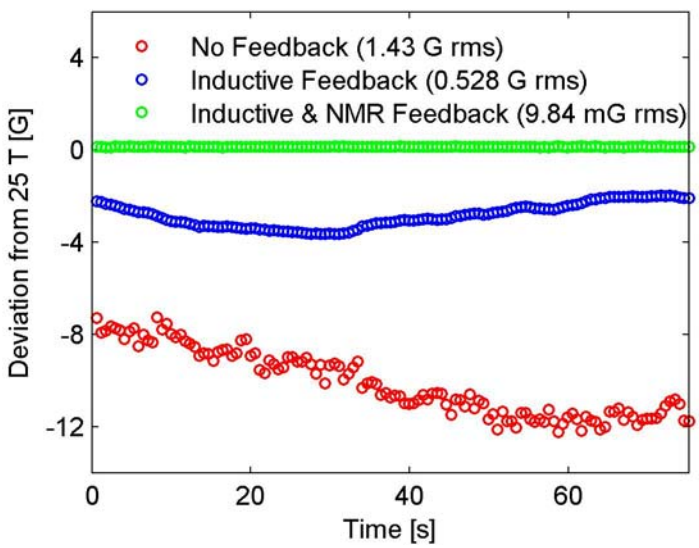

Figure **1** shows the deviation from the 25 T field as a function of time without feedback (red), feedback using inductive measurements (blue), and feedback using inductive and NMR measurements (green). Over a period of one minute, the uncompensated field drift is 1.43 G rms (5.72 ppm rms). Combining inductive and NMR measurements reduces the drift by more than two-orders of magnitude to 9.84 mG rms (0.0394 ppm rms).

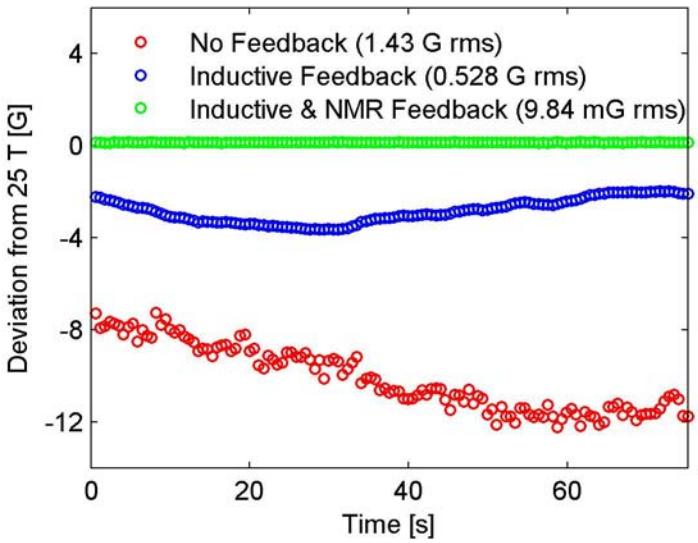

Figure 1. Field fluctuations in the Keck powered magnet

Conclusions

We demonstrate a two-order of magnitude reduction in the low-frequency temporal fluctuations of a powered magnet using a feedback system that combines inductive and NMR measurements. We expect further improvements through refinements of instrumentation and control algorithms. This work supports the development of the 36 T series-connected hybrid magnet scheduled for completion in 2015.

Acknowledgements

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References

[1] Li, M., *et al.*, Reduction of magnetic field fluctuations in powered magnets for NMR using inductive measurements and sampled-data feedback control, Journal of Magnetic Resonance. **212**, 254-264 (2011).