REDUCTION OF TEMPORAL MAGNETIC FIELD VARIATIONS IN RESISTIVE MAGNETS USING DIGITAL FEEDBACK CONTROL

M. Li, J. Samra, J.L. Schiano (Penn State University); Kiran Shetty, W.W. Brey (NHMFL/FSU)

As temporal magnetic field variations in resistive magnets are undesirable, a research effort is underway to reduce these variations using feedback control. A useful metric for gauging temporal magnetic field variations is the standard deviation of the NMR signal phase at the center of a spin echo generated by a 90°-TE/2-180°-TE/2-acquire pulse sequence. For a TE value of 1 ms, the phase deviation is about two degrees for a self-persistent superconducting magnet, and about 50 degrees for the Keck resistive magnet.

During the last several months, implementation of a digital feedback control system reduced the standard deviation of the spin echo phase by a factor of two compared to the best results obtained a year ago. Figure 1 shows the standard deviation, σ, of the echo phase as a function of TE for spin echo data acquired with the Keck magnet. The blue squares show reductions in σ afforded by an analog proportional controller, while the black diamonds show data obtained in 2005 using a digital phase-lead-lag control system. The red stars show the most recent results, obtained with a digital phase-lead-lag controller that incorporates a disturbance rejection system for specifically eliminating fluctuations due to harmonics of the Keck supply current ripple. The three curves document the continual improvement in system performance afforded by the development of feedback algorithms for reducing the affects of temporal magnetic field fluctuations.

Our recent efforts also included an investigation aimed at identifying mechanisms limiting the performance of the digital control system. This study indicates the need for improving the noise figure of the inductive measurement system and implementing a second feedback loop to attenuate disturbances below the low frequency limit of the inductive sensor.

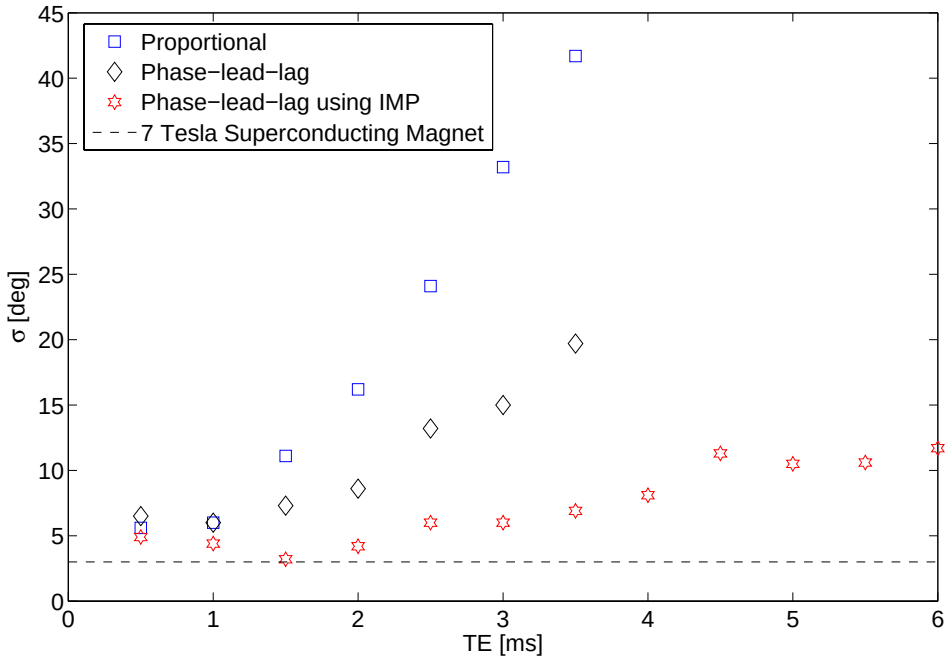

Figure 1: Incremental improvements in feedback control designs have resulted in notable reductions in the standard deviation of spin echo phase.