Control of Rotator Angle for 1D String Rotator in Magnetic Field

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Introduction

We have been developing single-axis rotatable calorimeters capable of operation in the dilution refrigerator cryostats in tandem with the DC field facility's resistive and superconducting magnets [1]. Last year, we succeeded in carrying out measurements as a function of field angle for fixed temperature and magnetic field strength by replacing the stepper motor with an ac servo motor capable of sample rotations with a nominal resolution of 0.022° and continuous rotation at speeds as slow as 0.020°/second when used with the SCM1 string rotator. Three problems remain to be resolved: (1) RF heating from the rotator head and control box when using the rotator in combination with a calorimeter, particularly the sample thermometer, (2), improving the absolute accuracy of the rotator to better than the current limit of 0.1° (after correction for a backlash of 1.7 °), and (3) string length induced changes in rotator orientation (0.1°) upon transfer of LHe.

Experimental

For this experiment, a pair of Hall Effect sensors (Toshiba THS118) were mounted perpendicular to each other on the string rotator sample holder. A sketch of the rotator ball with mounted Hall sensors (in black) and cylindrical calorimeter (in blue) is shown in Fig. 1. The Hall sensor current leads were wired in series to reduce the number of needed wires to 6. The Hall sensors were driven at a current of 30 μA corresponding to a power dissipation of 1 μW.

Figure 1: sketch of string rotator sample holder with Hall sensors and calorimeter capsule

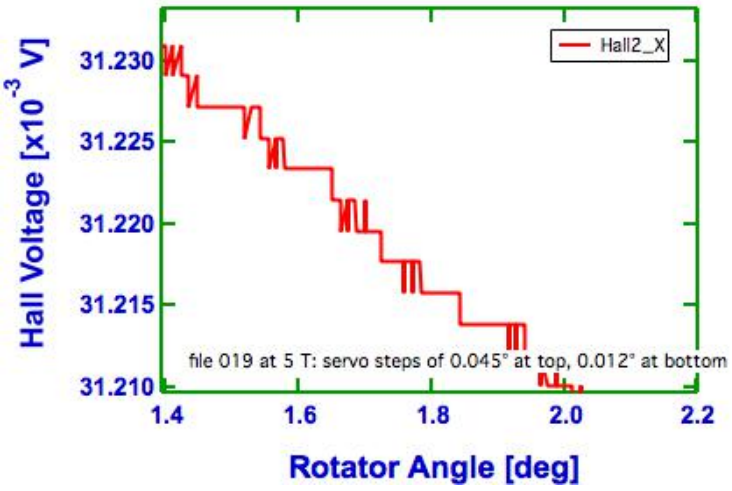

Figure 2: resolution of 20-step changes in ac servo position, corresponding to angle changes of 0.012°

Results and Discussion

The goals were (1) whether the sensors could be used to improve the absolute accuracy and control of the rotator orientation (for constant field and temperature) and (2) to measure how small a change in rotator angle could be resolved. In our preliminary results at 5 tesla, we were able to resolve a '20 step' change in the ac servo motor and hold a '40 step' change, corresponding to rotations of 0.012° and 0.024° respectively. We were therefore able to improve the absolute accuracy of the rotator positioning by a factor of 4 (to 0.024°) and the resolution. Further improvement requires a higher resolution controller and/or rotary to linear feedthrough capable of making (and holding) smaller size steps.

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