A Case Study of the 60 T Long Pulse Magnet: Sample Heating

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Introduction

Recently a pulsed echo experiment on HfV$_2$ was carried out in the 60 Tesla long pulse magnet using the “Optics Pulse” profile at a peak field of 55 Tesla. Analysis of the HfV$_2$ sound velocity data indicated that the sample experienced varying degrees of heating during the course of the pulse. We have correlated this heating with changes in the high frequency components of the power supply waveforms.

Experimental

To measure sound velocities for this experiment, an ultrasonic transducer is affixed to a sample. The transducer is excited by a short rf pulse which launches an acoustic pulse into the sample. The acoustic pulse is reflected from the opposing end of the sample and excites the transducer, producing a rf pulse of the same shape and frequency of the initiating pulse but with reduced amplitude. The sound velocity of the acoustic pulse in the sample can be determined from the elapse time between the transmitted pulse and the received echo.

Results and Discussion

The rf pulse delay data is shown in the following figure. This figure has the magnetic pickup coil data (red trace), the integrated Bdot which is the actual magnetic field profile (blue trace), and the echo delay time shift of the acoustic pulse (black curve). If you follow the black curve, you will see a substantial change in time delay (sound velocity) even before any significant magnetic field is applied to the sample. There is, however, a significant increase in the power supply chopping signal. This is due to the scr switching leakage supplying very small amounts of current to the magnet, but at a high frequency. A careful look at the data shows that every time there is a change in the SCR switching wave form there is a change in the slope of the sound velocity measurement. We assert that this scr switching component of the dB/dt signal is a source of sample heating.

Conclusions

In order to utilize the sensitivity of the pulse echo method in the 60 Tesla long pulse magnet we will need to considerably reduce the high frequency ripple. A damper tube inserted into the bore of the magnet will serve this function. This tube has been designed and is now being constructed. Calculations indicate that the tube will all but eliminate the heating problem at the sensitivity level of the ultrasound measurements.

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