Direct Probe Mounted High-Performance Amplifiers for Pulsed Measurement

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Introduction

High electrical noise and short time scales of pulsed magnets create significant challenges for electrical measurements, particularly in the sub-MHz frequency window, where bulk of the transport measurements is routinely conducted. The proper design of the first stage of signal conditioning and amplification is the critical step in increasing sensitivity of the measurements in such a harsh environment. We developed a custom instrumentation amplifier to implement a number of noise-reducing features for pulsed field measurements. The amplifier utilizes single-chip design based on recently released AD8421 [1].

Experimental

The AD8421 is chosen for high common mode rejection, high accuracy, large frequency range of up to 10MHz, and low input noise of 3 nV/Hz$^{1/2}$. Among the key improvement that we achieved over commercial amplifiers are high gain stability, immunity to background fields of NHMFL 100T and 60T magnets, small footprint in single channel and 8-channel designs, long-term battery operation, and low procurement cost of complete boards through outside contractor. The amplifiers can attach directly to the sample probe, thus minimizing low-voltage cable runs, expanding useful bandwidth and enabling continuous Faraday shield around most sensitive part of the measurements. Fig. 1. shows single channel and 8-channel amplifier boards. Fig. 2 shows the single channel preamp directly attached to the top of the probe.

Results and Discussion

The amplifiers were employed in a transport measurement of High-T_c superconductors, heavy Fermion compounds, topological insulators, which were conducted in NHMFL 100T and 65T pulsed magnets. Significant signal improvement was seen during the measurements, with noise levels as low 5nV/Hz$^{1/2}$ even at the peak of the 100T magnet pulse.

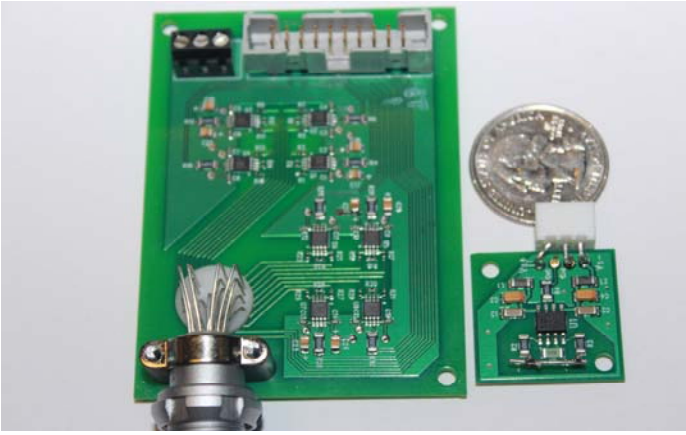

Figure 1. 8-channel and single channel amplifier boards

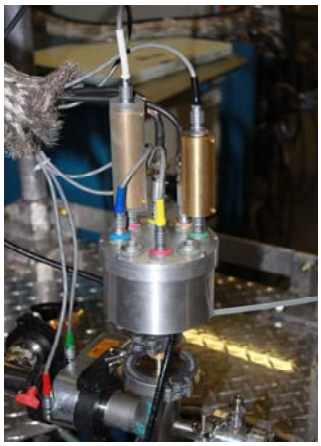

Figure 2. Single channel preamps plugged into probe top. Cylindrical brass can surrounds amplifier, providing Faraday shielding and is grounded to the probe body

Conclusions

The preamp design has proven to be successful and is now being implemented on a variety of probes. The design is continuously being revised and updated as better preamp chips become available.

Acknowledgements

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References

[1] http://www.analog.com/en/specialty-amplifiers/instrumentation-amplifiers/ad8421/products/product.html