MULTI-CHANNEL DIGITAL LOCK-IN FOR DC AND PULSED MAGNETS

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Introduction

The ability to measure multiple physical channels of data in parallel provides many-fold increase in throughput and efficiency of a typical experiment. It is particularly useful when a large number of independent measurements have to be conducted within a limited time frame, i.e. while accessing high magnetic field facilities. One example of the experiment that necessitates simultaneous measurements of multiple channels of data is combinatorial investigation of the complex materials (COMBI) via high-sensitivity transport measurements, where a single sample can contain up to 64 independent resistivity bridges. While conventional lock-in technique can provide desirable sensitivity, procuring and operating 64 commercially available lock-ins is prohibitive because of cost and complexity.

Results and Discussion

We have designed and implemented multi-channel lock-in instrumentation based on a desktop PC outfitted with off-the-shelf multi-channel data acquisition (DAQ) boards. The DAQ boards provide parallel analog-to-digital conversion (ADC) and buffering of the sample signals, while the actual lock-in algorithm is implemented in software (NHMFL Digital Lock-In). The actual number of available parallel channels depends on the type and the number of the DAQ boards installed and can be anywhere from 1 to over a hundred, with typical cost of hardware in the range of several hundred dollars per channel. The data acquisition is configured in the synchronous digitization mode, where ADC clock rate is an integer multiple of the excitation sine wave frequency, enabling settling time as short as a half-period of the excitation sine wave. The sine wave excitation voltage and ADC clock is provided by either a pair of commercially available signal generators or by single NHMFL dual synthesizer, which was developed within previous IHRP project. To improve the multi-channel lock-in sensitivity we have also designed and built low-noise multi-channel preamplifiers with a typical front-end noise figure of just 0.9 nV(Hz)$^{1/2}$, which can be used in conjunction with the DAQ boards.

Acknowledgements

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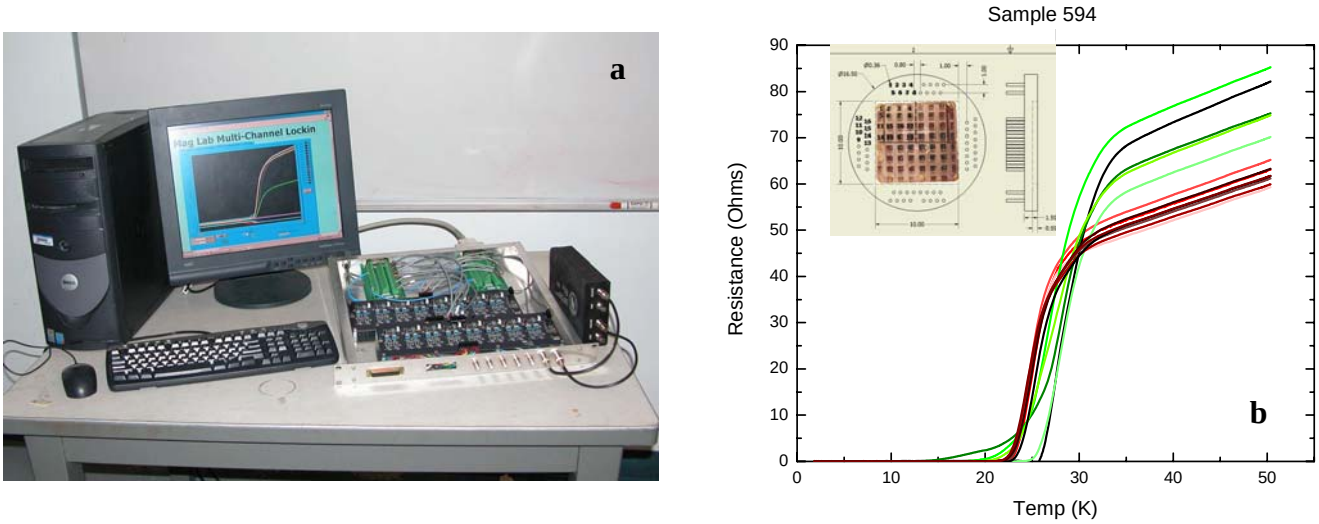

Figure 1. (a) PC-based digital lock-in (left) with the multi-channel preamplifier (middle) and NHMFL dual synthesizer (right) in a 16-channel configuration. **(b)** Typical $La_{2-x}Sr_xCuO_4$ COMBI sample data. (inset) The 64-channel COMBI sample.