Project Proposal: Lock-In Amps

Lock-In Amplifiers under LabVIEW Control

General Goal

The goal for this project is to understand the operation and application of the Lock-In Amplifier and LabVIEW and its applications in scientific research. This project will help develop new labs or tweak existing labs that can be used in the Advanced Lab course offered at University of Redlands. LabVIEW's instrumentation control features will be used to run the lock-in amp and perform the experiments.

Motivation

The Lock-In Amplifiers is powerful and popular measuring tool whose operation should be familiar to undergraduate physics majors, especially those planning to pursue graduate studies in experimental physics. Similarly, LabVIEW is a powerful and predominant tool in experimental physics. If we are able to get a proper understanding of the Lock-In Amp along with LabVIEW, we will be able to develop new Labs that will educate future physics undergrads. Experiments under instrumentation control via LabVIEW have not been conducted in the Advanced Lab section before. This research will help achieve a greater understanding of the LabView interface, which will lead to other experimental possibilities beyond the Lock-In Amp. Also, this project will showcase my developed skills in physics, mathematics, and computer science, and provide an insight to the engineering aspect of the instrument.

Context

Background for instrument

A Lock-In Amplifier, otherwise known as a phase-sensitive detector, is an electronic instrument designed to extract wanted signals that are usually accompanied by unwanted noise, disturbances, or background interference. This instrument reduces the unwanted interference in order to increase the clarity of the desired signal to enhance the overall signal-to-noise ratio of the electric signal being measured. This means that if the signal of interest oscillates at a known frequency, the Lock-In Amp can amplify only at that frequency and average out any random noise. Recovering signals at low signal-to-noise ratios requires a strong, clean reference signal the same frequency as the received signal. This is not the case in many experiments, so the instrument can recover signals buried in the noise only in a limited set of circumstances. An image of a Lock-in Amp is shown below.


Figure 1: Lock-In Amplifier front view (http://www.nano.org.tr/lock-in_amplifier.html)

Background for LabVIEW

LabView is a graphical programming language that provides an intuitive interface and is used to control scientific lab instruments and collect data. This software is popular with most scientist and undergrads because it has any easy to use visual interface and does not directly depend on a

computer programming language.   It also has the ability to process signals and analyze

waveforms.   These waveform analysis tools can be used in conjunction with the lock in

amplifier because with LabView it is possible to directly ''code'' the correlation integral

that underlies Lock-In signal processing into a virtual instrument. The band pass properties of

the LabView Lock-In are explored by varying the reference frequency and recording the outputs.

An image of the LabView interface is shown in Figure 2.
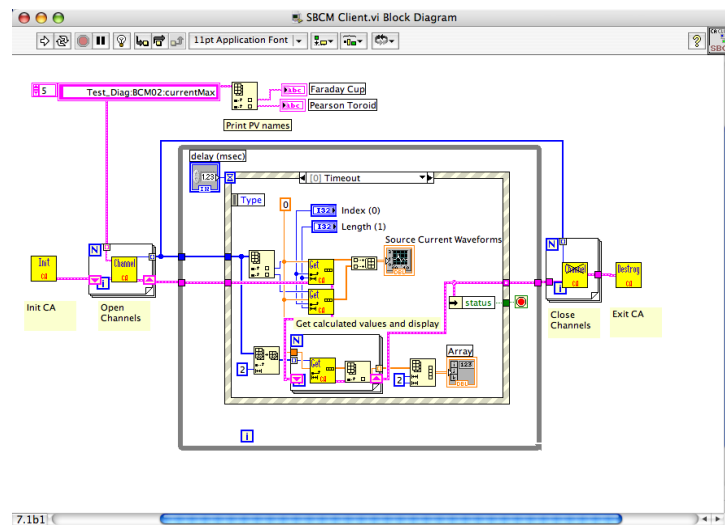
Figure 2: Lab View Interface

(http://neutrons.ornl.gov/diagnostics/documents/epics/LabVIEW/SNS_LabVIEWEPICS.html)

Some similar work in the field of Lock-In Amps includes using the amp to measure the

Faraday rotation of semiconductors, measuring light, detecting magnetic resonance, and wave

converters. One prominent experiment was the work on the Faraday rotation. The Faraday

rotation causes a linearly polarized light's plane of polarization to rotate by an angle which is

linearly proportional to the component of the magnetic field in the direction of the light's

propagation. The strategy for measuring this rotation is to sinusoidally vary the solenoids

magnetic field, and then sinusoidally vary the intensity of light transmitted through the second

polarizer. This experiment can show off the capabilities of the Lock-In Amplifier because, in the presence of a magnetic field reasonably obtained with a laboratory power supply and a solenoid, there is only a small rotation of the plane of polarization and thus a small variation in transmitted intensity. And this small variation can be extracted by the Lock-In Amp, while other measuring devices would not be able to.

Procedure/Timeline

Overall, the main goal of the project is to combine the Lock-In Amp hardware and LabVIEW software to develop new lab techniques and experiments that can be used in upcoming sections of Advanced Lab. As for the timeline, my research will begin in June of summer 2012 with the help from my advisors Dr. Deweerd and Dr. Hill, along with my colleague Francis Acquaye. The first couple weeks of research will be dedicated to learning the basics of the LabVIEW software as well as Lock-In theory. This will include reading the LabView manual and performing basic experiments with the Lock-In Amplifier. Next, we will be learning about advanced Lock-In theory and exploring experiment options by reading literature on various experiments. One or two of these experiments will be selected, tested, and reviewed in order to determine whether they will be compatible with the LabVIEW code. From here, we will develop LabVIEW code that is appropriate for the experiments. Our final step will be to optimize this experiment under LabVIEW control and develop appropriate Advanced Lab instructions and readings to accompany the experiment. Looking towards the future, I will be giving a poster presentation in September 2012 of the research and work conducted over the summer. Then I will start developing my drafts for my senior thesis and Power Point presentation, which will take place in March of 2013.

References

Advisors: Dr. Hill, Dr. Deweerd
pg. 2-4 C:\Users\Michael\Downloads\Lock-In-Intro.pdf
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