

Finding the Finer Things With Fabry-Pérot

Engineering Honors College: Capstone Project

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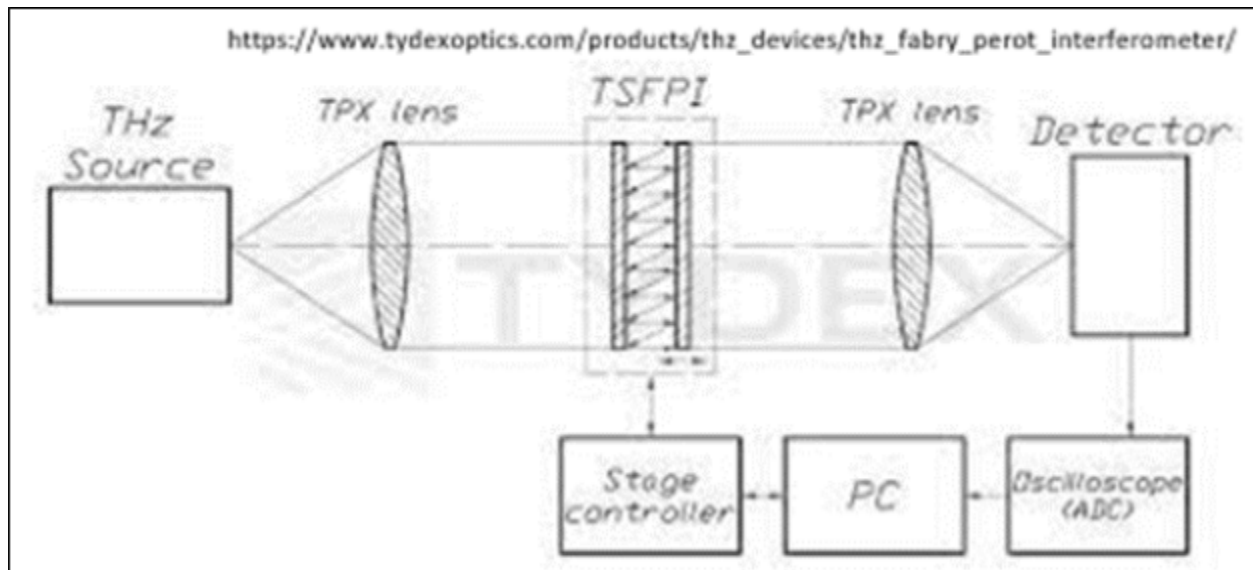


Figure: Basic Schematic of How a Fabry-Pérot Interferometer Works

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Abstract

In many modern optical experiments, it is necessary to be able to measure the wavelength components of a light source to a high degree of precision. Most commercial spectrometers, devices used to measure the wavelength components, are not able to resolve to a high degree the precise wavelength components in a light source. There is inherently some loss of accuracy in these measurements. Fabry-Pérot Interferometers (FPI), on the other hand, operate on the principle of the interference nature of light in order to measure the wavelengths present in a light source, and they are able to resolve the wavelength components to a much higher degree of accuracy. My capstone has been to take a commercially available FPI and write a program, using a software known as LabView, to interface with this FPI and generate the high-precision spectrum which is produced from the FPI.

Project Introduction and Motivation

As mentioned in the abstract, Fabry-Pérot Interferometers (FPI) are devices which can be used to generate the spectrum of a light source to a high degree of precision, in general higher than that of most commonly used spectrometers. In many modern optical or quantum experiments, it is necessary to be able to get one of these high resolution spectra of a light source, as the wavelength components present may be too close together to be detected by commonly used spectrometers. My project specifically has been to use one of these commercially available FPI devices, and write a program, using a software known as LabView, to talk with the FPI and other hardware devices in the lab, and then take the given data and generate one of these high-resolution spectra of a light source. Having a program in LabView will make it easy for someone running an experiment in the future to be able to position their FPI in front of a light source, run the code, and get a high-resolution spectrum as an output.

Background

The main device used in this project, a Fabry-Pérot Interferometer, is an optical device which operates on the principle of light interference to generate the necessary spectrum of a light source. Below is a schematic detailing the working principles behind the device.

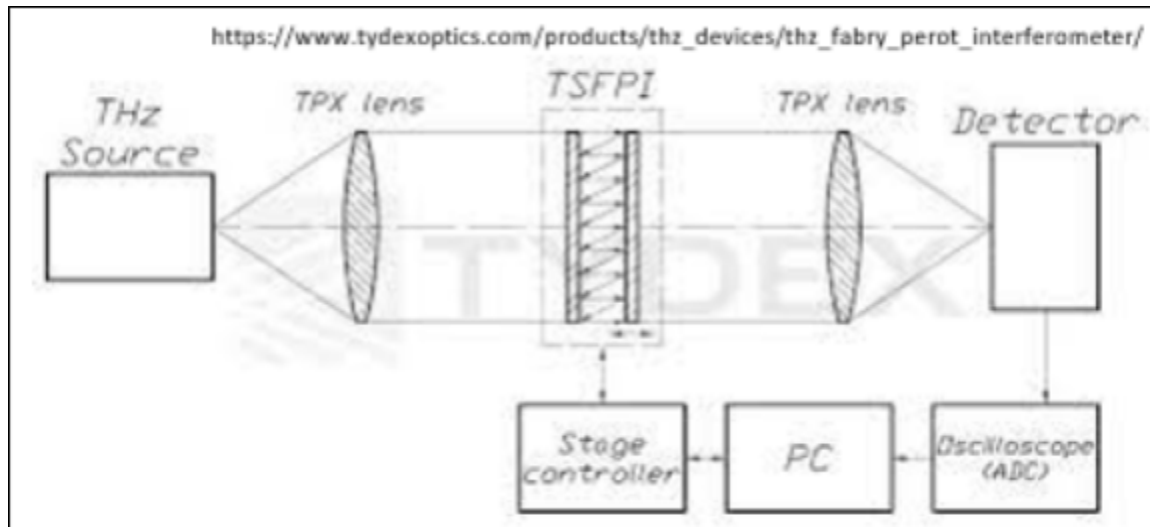


Figure 1: Schematic of a FPI, to demonstrate the working principle of the device

The way that the device works is that a light source enters the device from the left end, and then gets trained into a cavity with two mirror surfaces on either end of the cavity, labeled TSFPI in the above figure, and then the light bounces back and forth many times, and due to the wave nature of light, will interfere with itself, and only light of a single wavelength will be passed through to the output. The wavelength that is transmitted is determined by the separation of the mirror surfaces, and in an FPI, this separation is purposefully controlled in a way such that we can scan the light source across several wavelengths in order to get the intensity of every single wavelength component in a light source. The separation is controlled by a stage controller, which is controlled directly by applying different values of a DC voltage to the device. On the right end of the device is a photodetector, which takes in the light that has been sent through the FPI cavity, and sends out an analog voltage value which can be measured and data sent to the LabView program for processing. In the next section I will discuss how my specific setup works to interact with all the various components needed in my setup.

Project Setup

Experimental Bench Setup

The below figure shows the hardware components needed for my capstone project.

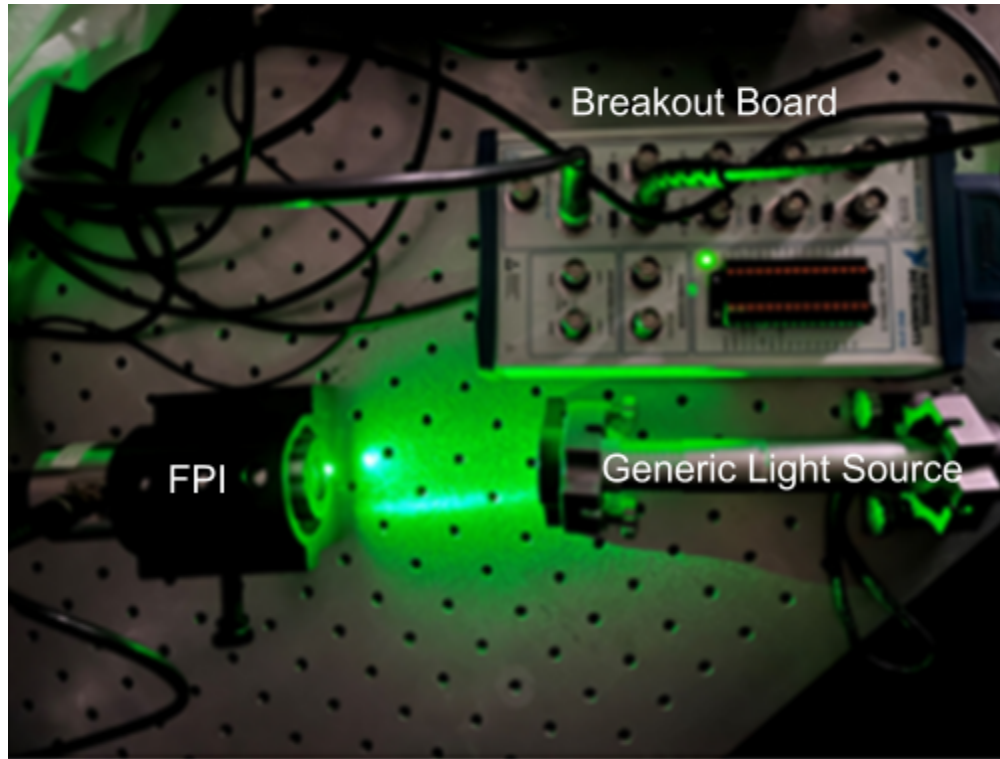


Figure 2: Lab Setup for Running my Program

On the left side of the figure is the Fabry-Pérot device itself, which takes in the light (a generic laser light source in this case) and sends an analog voltage signal from the photodetector. The heart of the setup is the breakout board, which connects all of the components together. The breakout board connects to the computer's Data Acquisition System, or DAQ, which takes the data and converts it into digital values for the computer to interpret and store. The breakout board deals with analog voltage signals, and for this project, it sends out a voltage signal to a high voltage device, which controls the FPI, and it also reads in the voltage value from the photodetector. Another component used, which is not pictured in the above figure, is a high voltage source, capable of producing between 0-500 V, which is controlled by the breakout board in the above figure. The last component, also not pictured, is a computer that has a DAQ port available, which will do the job of running the code and collecting the data to be processed later in order to generate the spectrum.

Software Side Setup

In addition to figuring out how to put together the actual hardware setup required for my project to work properly, I have also been in charge of writing the LabView code which will actually talk to everything and collect the necessary data from the FPI device. LabView is a software often used in research labs which is a way to write programs that interface a computer with the hardware devices used in a lab. As mentioned above, my program has the role of generating a voltage signal to control the spacing of the FPI, and thus determine what wavelength to measure, as well as read the output value from the photodetector, to determine the intensity of a certain wavelength present in the light source that I am trying to measure. Below is a block diagram of the control flow of how my program will be talking to all the devices.

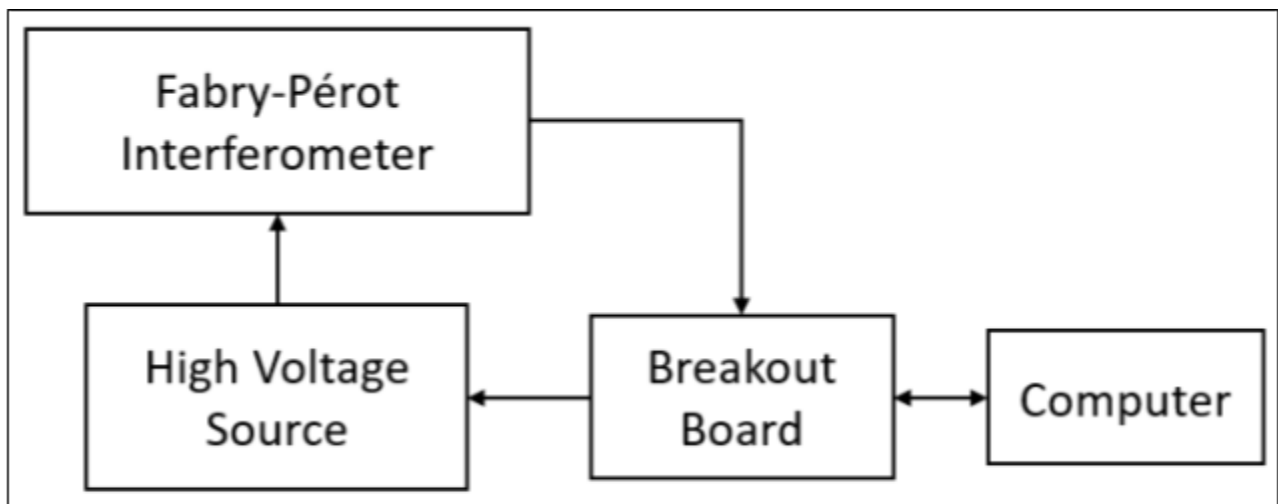


Figure 3: Block diagram outlining the flow of signals in my setup, to give an overview of what is happening in my program

Once I understood the basic flow of how everything would be talking to each other, I put this diagram into actual LabView code, which is used to actually interface everything together with each other. Below is a diagram of the LabView code that I have written.

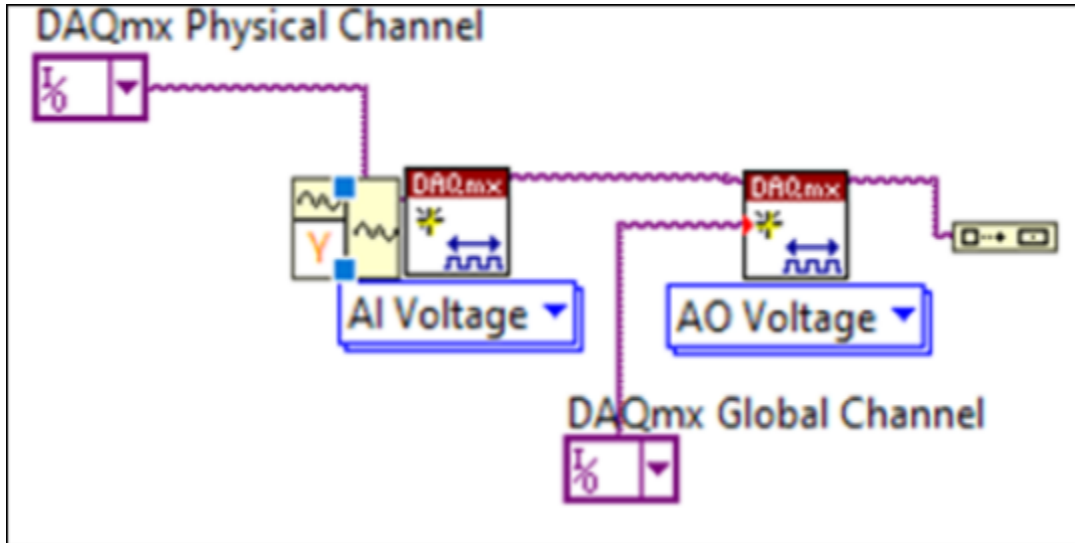


Figure 3: LabView code block diagram for my setup

The code above attempts to carry out the role of generating a voltage signal (AI Voltage), and then measuring a received voltage signal (AO Voltage) and storing it in a file that can be processed later by another program, most likely MATLAB. The I/O blocks in the above figure are designed to tell the LabView code what channel to be communicating with when producing the input voltage signal, or trying to read the voltage output from the FPI device.

Discussion/Next Steps

Up to this point in my project, I understand how the physical setup works and have written a LabView program that should work well to communicate with all the devices in my setup. However, the challenges that I am still facing are mainly to do with the LabView program struggling to establish a connection with all the devices that I am working with. My next steps for this project moving forward are to work on debugging on the LabView side of things, in order to get the LabView software to properly detect the devices that I am trying to connect to and from there, I will test the code to ensure that I am capturing proper data from the photodetector of the FPI. Once I have this working, I can gather data from a known test light source, and then plot the spectrum from the data I collect and match it up to a correct spectrum to ensure that my program is working properly to acquire the data.