Building a Radio Frequency Acousto-optic Modulator Driver

Andrew Ballin

Professor David Weld
Doctor Vyacheslav Lebedev, Zach Geiger

Department of Physics
University of California, Santa Barbara

Motivation

Our lab is building experiments to study the dynamics of quantum systems through the use of ultracold, optically trapped atoms. In these experiments, laser beams serve to cool our atoms to microkelvin temperatures and spatially trap them in a lattice configuration. The atoms are very sensitive to these procedures; therefore, we use a device called an acousto-optic modulator (AOM) to quickly and precisely control the frequency, intensity, and direction of multiple laser beams. In order for an AOM to manipulate these three properties of an incident beam, the AOM must receive a radio frequency (RF) electrical signal input; the specific frequency and power level of the RF signal input affects how the AOM manipulates the beam. An AOM driver is a piece of electrical equipment that is used to generate this RF signal because it contains an interface that allows the frequency and power level of the signal to be adjusted. AOM drivers are an existing technology and are already sold on the market, but they are generally expensive and are not easily customized. Since our experiments call for multiple AOMs, each of which requiring a dedicated driver, our lab deemed it necessary to develop our own AOM driver architecture.

Methods

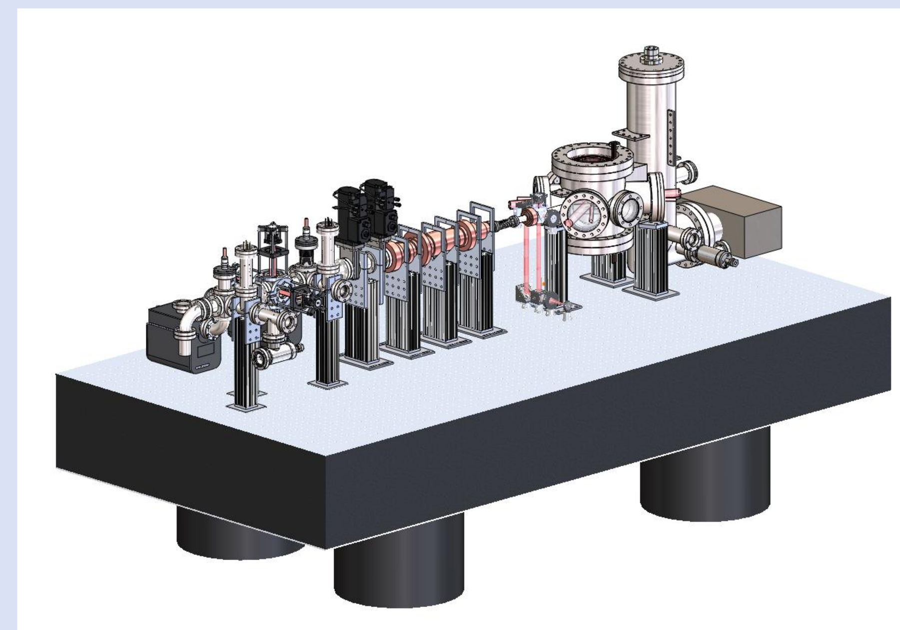
As with any design project, there was a lot of research and planning that needed to be done before any physical work could begin. In order to create an AOM driver with the same specifications that I was trying to match, I needed to search around online for the proper components. I judged whether a component would be sufficient by reading through it's data sheet. For example, when I was searching around for a power supply, I looked at its capabilities to check that it would be able to supply enough power for all of the components. While generating this parts list, I was simultaneously considering different arrangements of the internal components that would allow for easy maintenance and bulk reduction.

Once all of the parts arrived, I assembled the driver by installing the components in the chassis, hooking up internal cables, and soldering together circuits and electrical connections, as per my design layout. The circuit I built is designed to power the LED indicators on the instrument panel. The chip design process involved making calculations to determine the types of resistors I needed, figuring out an efficient circuit board layout, and, after soldering the connections, testing and debugging the circuit with a multimeter.

I am currently mid-build with this driver, so after it is fully constructed, I will characterize the device and see how well it matches the performance of the manufactured AOM drivers. I will use a frequency counter and a power meter to plot how the output power varies as a function of the frequency the driver is set to output. Additionally, I will be using an oscilloscope to judge the quality of the output signal.

Achievements

1. **Reduce cost:** Commercially available drivers cost about $1,000-1,500 each. Currently, the drivers I have developed cost about $800 each; about a 35% savings.
2. **Decrease spatial footprint:** Commercially available drivers are rather bulky. The design I created allows the driver to be placed in a location that is not obstructive to other equipment.
3. **Develop framework for future AOM driver construction:** I am developing a Wiki page for the lab so that they can quickly build a driver whenever they need without having to spend a large amount of time by starting from scratch; they will not need to perform the preliminary research/design before construction. The page documents the design and construction process of the driver and contains important information regarding the discoveries I made along the way.



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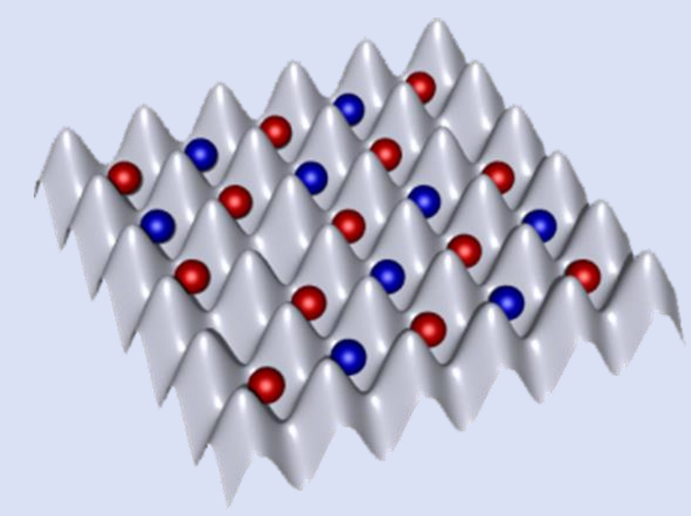

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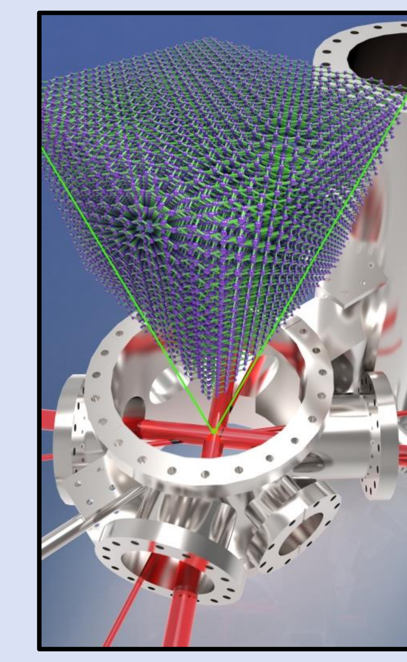

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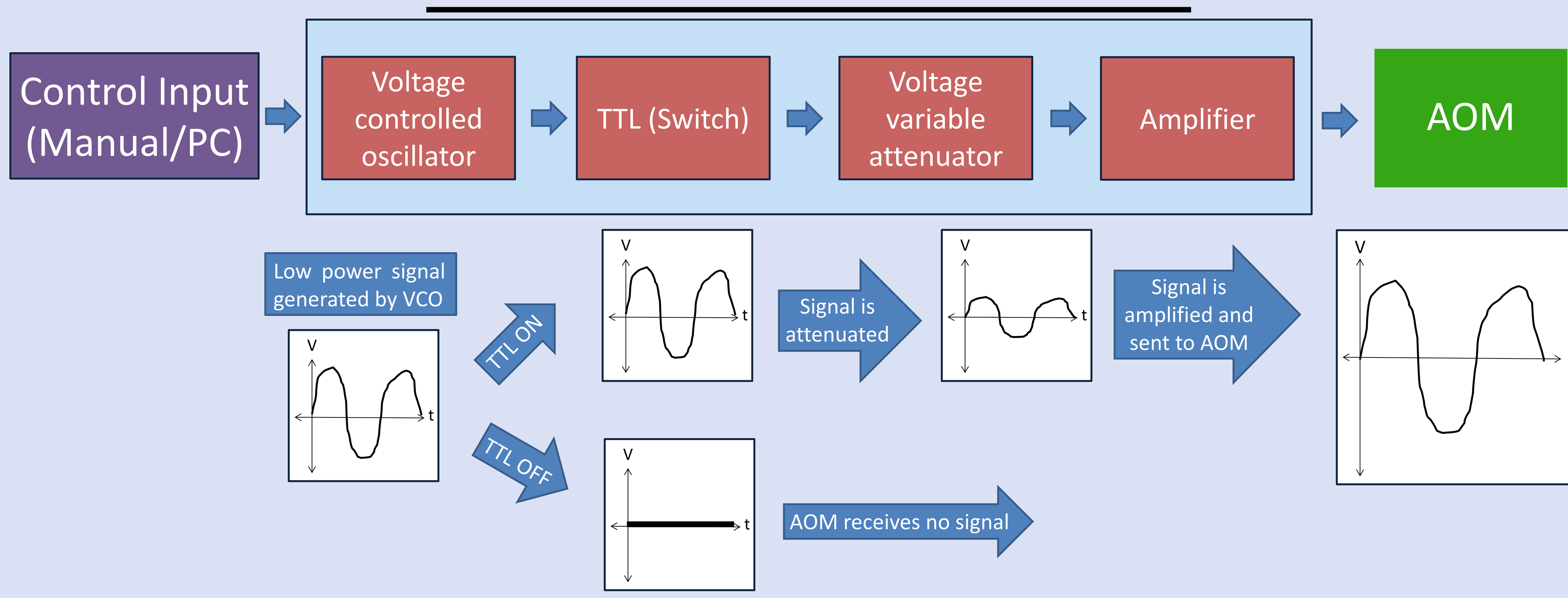
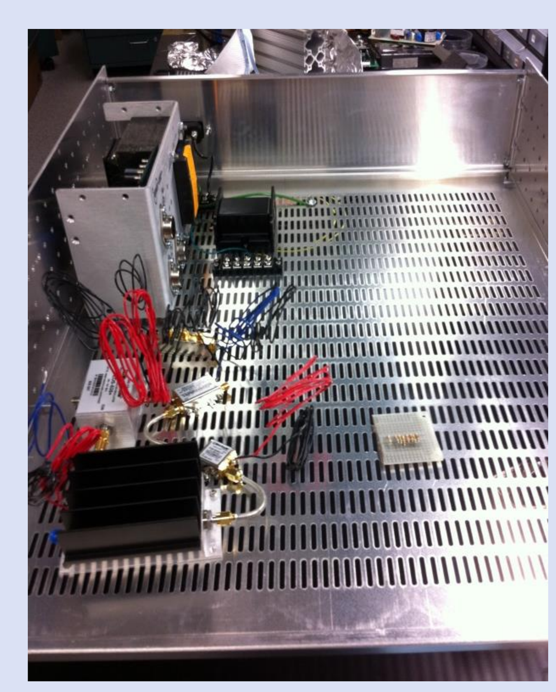
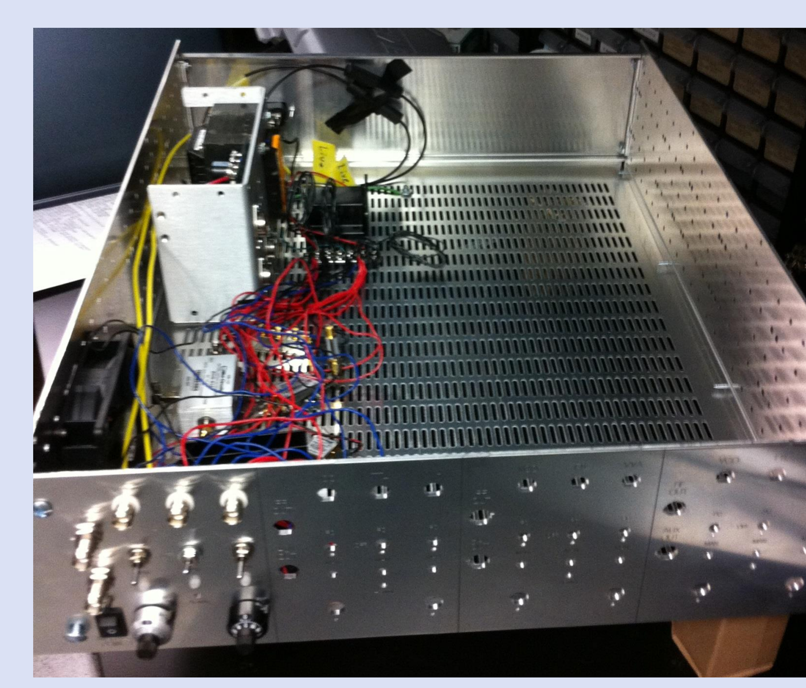
AOM Driver Schematic







	Required specifications	Our AOM driver performance (projected)	Interpretation
Frequency range	350 ± 80 MHz (270-430 MHz)	412 ± 112 MHz (300-525 MHz)	Larger spectrum coverage (the uncovered spectrum is not an issue for our experiments)
Maximum power output	1 Watt	1 Watt	Equally powerful
Cost	$1,500	$800	45% price reduction
Spatial footprint	425in^3 (7,000cm^3)	490in^3 (8,000cm^3)	15% increase in size (see 2. of Achievements section)

Future work

I plan to finish assembling the driver within the next week. Afterwards, I will test and characterize the device, solving any issues that may arise.

If this project is deemed successful, then I will build AOM drivers with a different frequency range and power output, adapting this current design.

Acknowledgements

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If you would like to discuss this research further, please contact me at andrewballin@umail.ucsb.edu, or go to our site website at http://web.physics.ucsb.edu/~weld/