Characterizing the Frequency Response of a Voltage Controlled Oscillator For use in a Phase Locking System

Grant Richmond, Brian Arnold, and Harold Metcalf

Stony Brook Department of Physics, Metcalf Research Group,
Supported by ONR and Dept. of Education GAANN

ABSTRACT

The ultimate goal of this project is to measure optical forces acting upon atoms as a function of velocity. To do this, a system needed to be developed where velocities could be simulated on the atoms over a wide range. This was achieved by creating a phase locking system that locks the phase of a slave laser so that the phase of the beat frequency (produced by the slave and the master), matches the phase of a local oscillator. This will make the frequency of the slave differ from the master by the local oscillator frequency.

The frequency difference between the two lasers simulates velocity through the Doppler effect. In a two laser system, having one laser detuned below atomic resonance counter-propagating the other, detuned above atomic resonance, we can simulate a Doppler shift for an atom in its rest frame.

The desired varied frequency difference can be achieved by using a voltage controlled oscillator (VCO) as the local oscillator, within the phase locking system. Using the VCO, we can vary the oscillator frequency as a function of voltage. This allows us to control the difference in frequency between the slave and the master and, as a result, the magnitude of the Doppler shift. For this scheme to work, the voltage-frequency relationship of the VCO had to be determined. A test circuit was designed to measure this and the results are shown here.

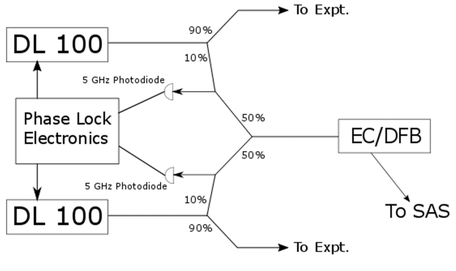
BACKGROUND

A moving atom with light shining on it that is off of resonance by a small amount (δ) can be Doppler shifted to atomic resonance. This causes the atom to undergo stimulated emission and a force results.

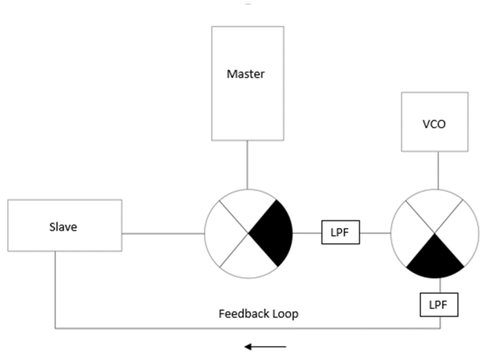
By varying this Doppler shift we can find the velocity dependence of this force.

Since the shift is set by the frequency of a local oscillator, a VCO can then be used to vary this shift.

SYSTEM DIAGRAM



THE PHASE LOCK

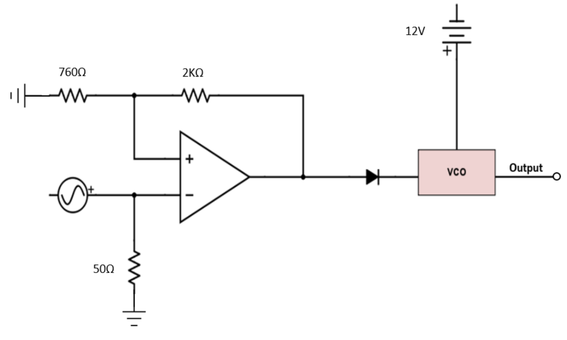


Schematic Diagram of the phase lock system:

Slave laser and master laser are co-propogated to give a beat signal. The beat is then mixed with the VCO output to create a feedback signal for the slave laser

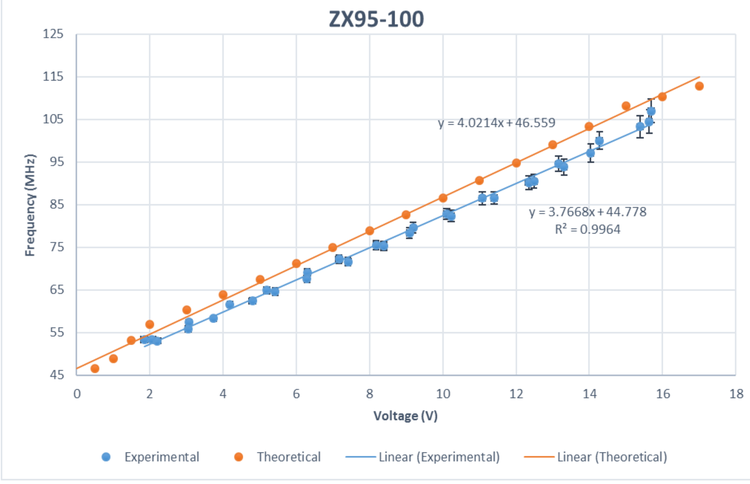
The feedback then varies the frequency of the slave laser such that the beat note between the master and slave lasers has constant phase and frequency.

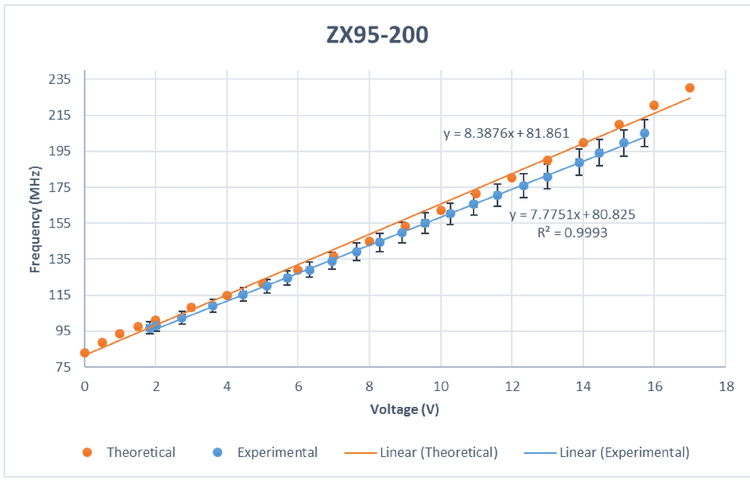
TEST CIRCUIT



- Test Circuit diagram: the amplifier delivers voltage across the operational range of the VCO, the diode acts as a protector against possible negative voltages across the VCO
- This circuit also is used in the lock scheme to give the variable local oscillator frequency by changing the variable voltage source

RESULTS





CONCLUSIONS

The VCO's tested have a very linear voltage-frequency relationship that is somewhat different than their manufactured standards within this circuit. This difference shows the importance of characterizing the VCO, as this would cause a large amount of errors within the larger experiment

This characterization now allows for us to create a calibrated and linear control over the velocity being seen by the atoms.