

Frequency Based Optical Detection of Plasmonic Absorbance for Label Free DNA Detection



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Abstract

Specifically detecting small amounts of DNA has many applications in biological research as well as medical diagnosis. Gold nanorods are able to be functionalized with segments of DNA that are able to interact with other targeted segments of DNA in solution. These interactions cause the absorbance curve of the GNRs to shift, resulting in a colour change that is not only measurable but can often be seen by the naked eye. Here a system is presented that is able to detect changes in the absorbance of GNRs. The system uses a 650 nm beam passing through a sample contained in a glass tube that is read by a photodiode. The signal is then amplified and filtered by a low cost (around 50\$) lock in amplifier. This system demonstrates high immunity to noise and high consistency between separate implementations.

Introduction

- Gold nanorods (GNRs) display high absorption as a result of their surface plasmon resonance (SPR). The absorption curve can be shifted if aggregation of the nanoparticles is induced.
- A lock in amplifier takes an input and reference signal, then extracts the signal from the input that is the same frequency and in the same phase as the reference signal
 - A lock in amplifier typically costs several thousand dollars

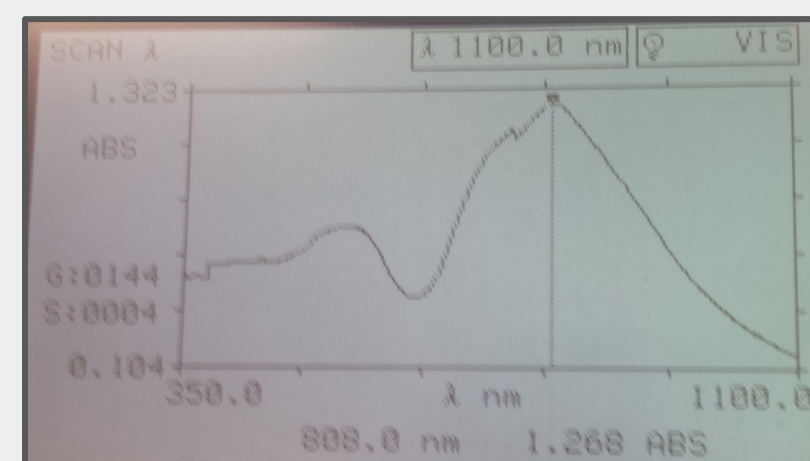


Fig. 1: Absorbance spectrum of GNRs synthesized

Results and Discussion

- A procedure for the synthesis of nanorods of the appropriate absorbance was developed and used to produce nanorods
- Circuits to accomplish the various tasks were designed and tested
 - Laser pulsing at 490 Hz
 - Reading optical signal with photodiode
 - Amplifying and filtering signal with lock in amplifier

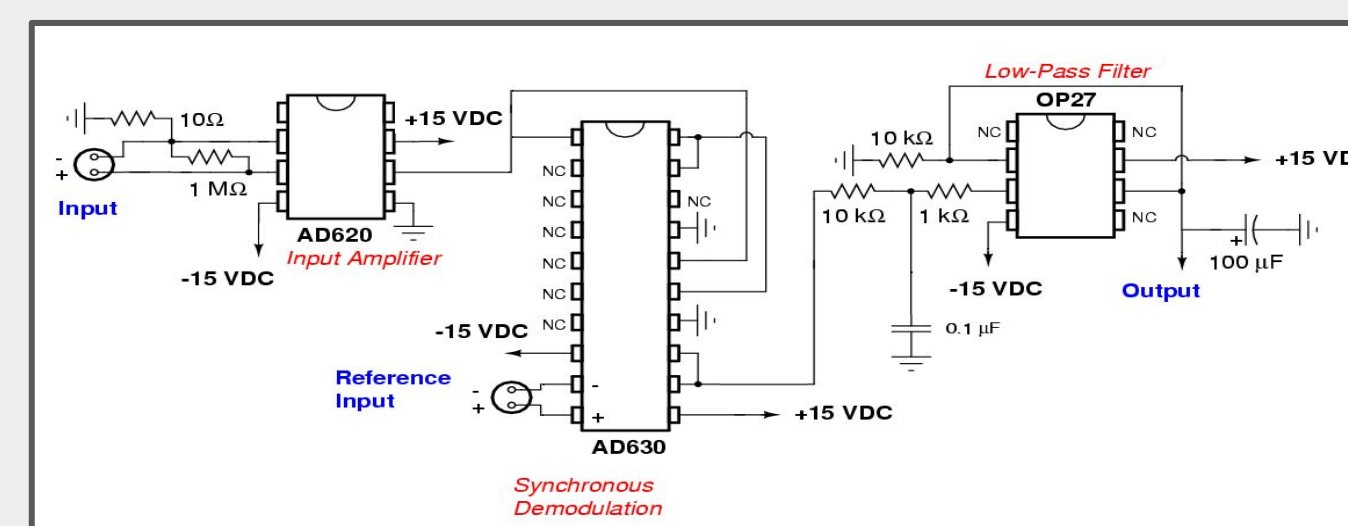


Fig. 2: Circuit diagram of low cost lock in amplifier

- An Arduino is used to control the pulsing of the laser as well as read the analog output of the lock in amplifier
- The consistency of different implementations of the lock in amplifiers was verified and the effectiveness of the lock in amplifiers with varying types and frequencies of noise was examined

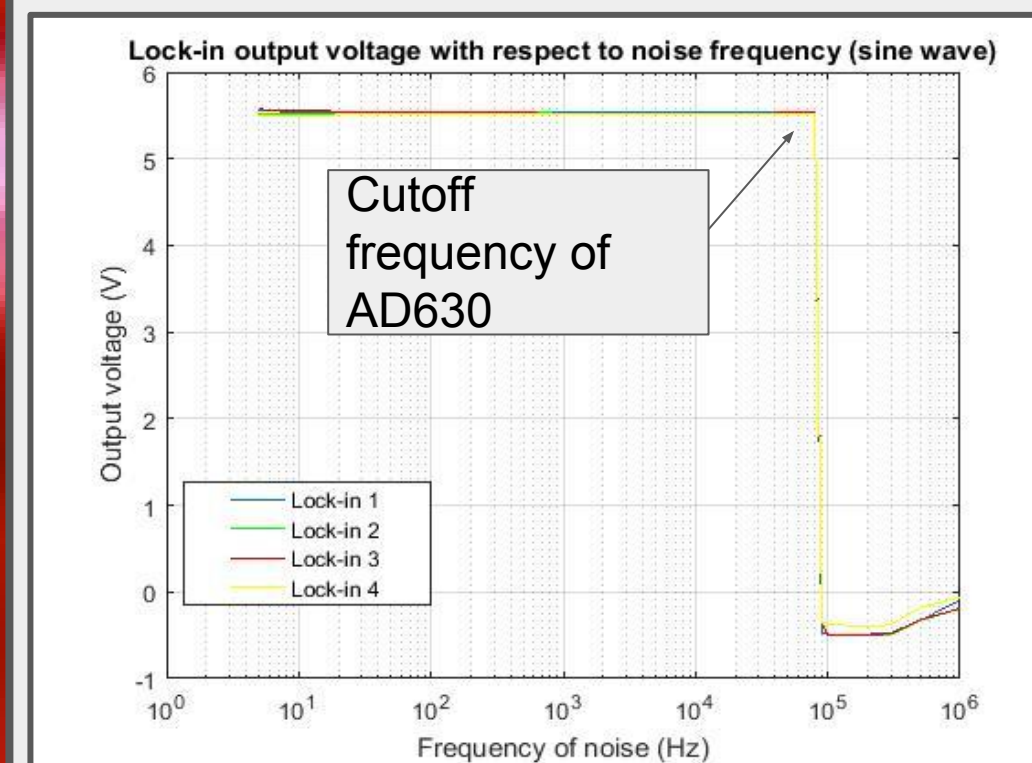


Fig. 3: DC output of lock in amplifiers with an input composed of a constant signal and noise (-2V to 2V sine wave) of increasing frequency

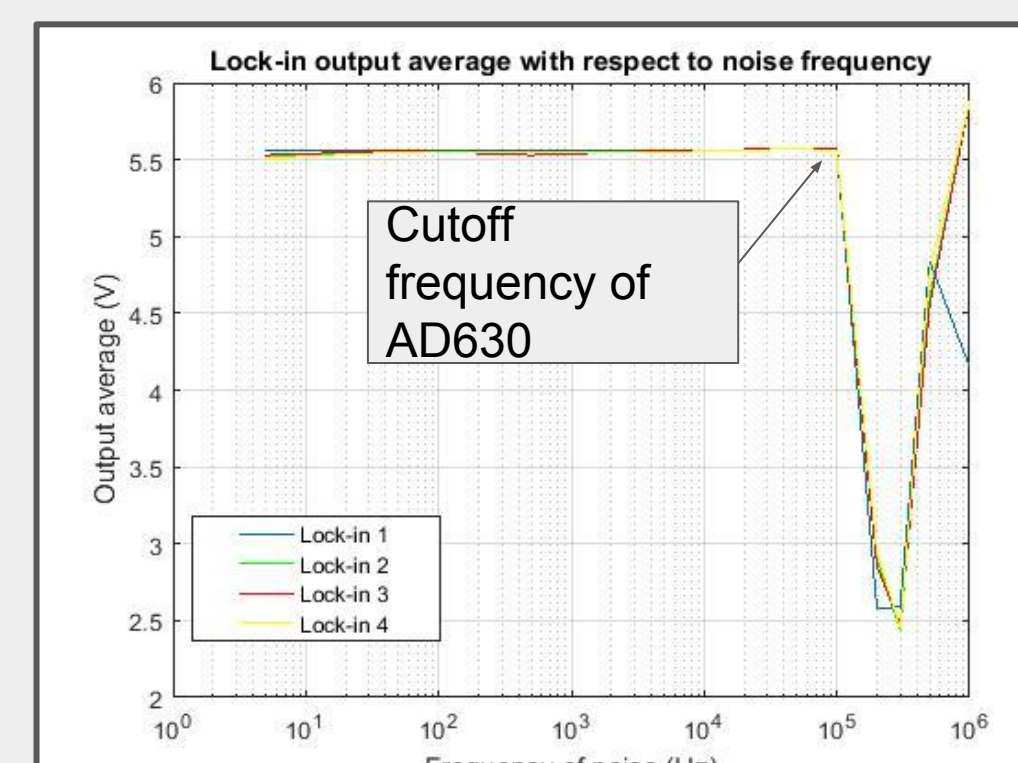


Fig. 4: DC output of lock in amplifiers with an input composed of a constant signal and noise (0V to 6V square wave) of increasing frequency

- A cage system to house the detection system was designed and 3D printed

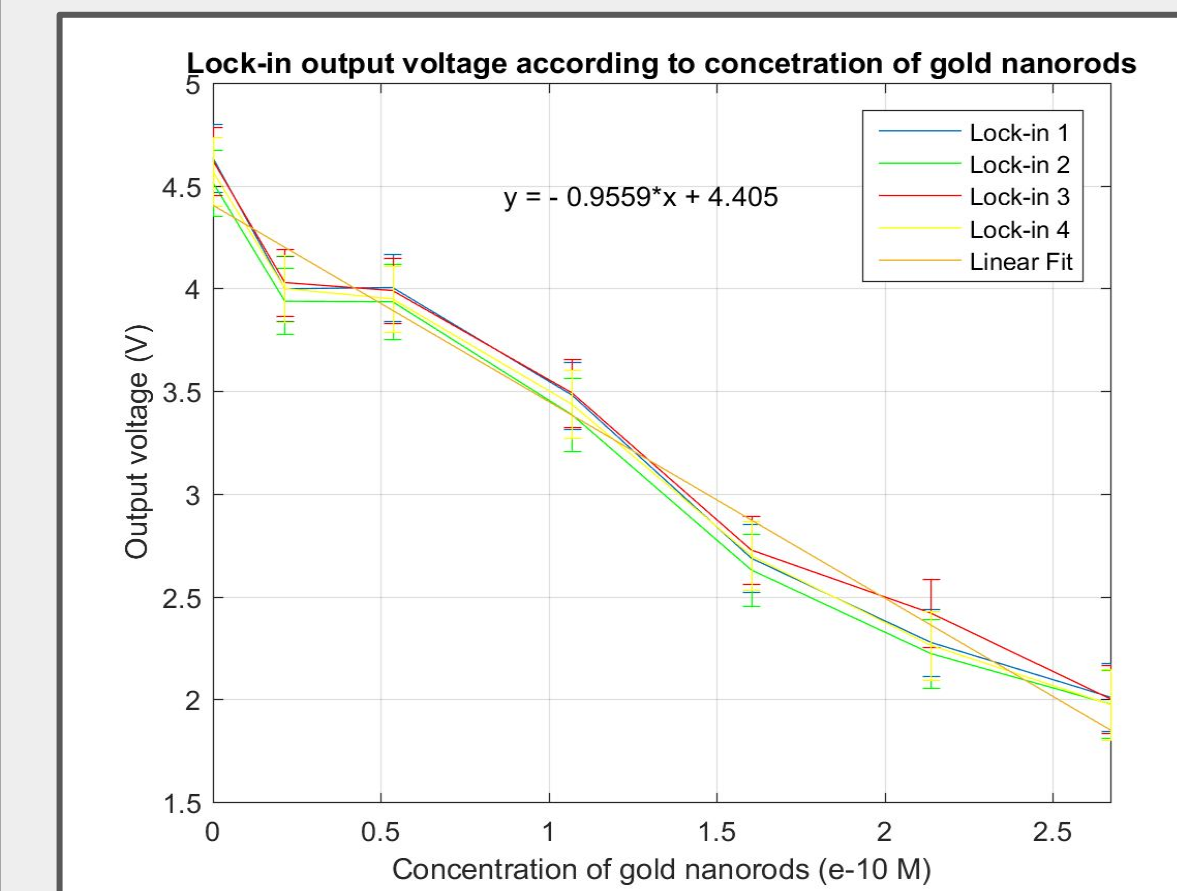


Fig. 5: The average voltage at the output of the lock in amplifiers as the concentration of GNRs in solution is increased. Error bars represent 3 standard deviations.

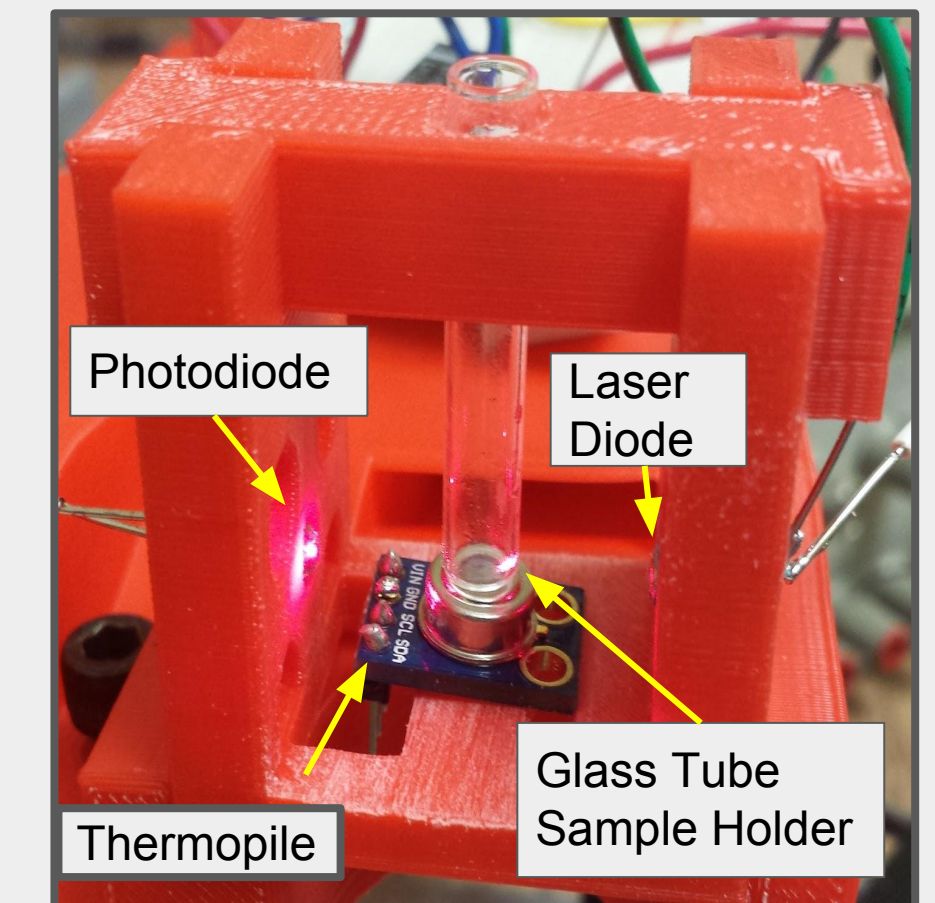


Fig. 6: 3D printed housing for the photodiode, laser diode and glass tube for holding the sample. Also pictured is a thermopile for reading the temperature of the sample.

- The lock ins used here are calibrated to output a value from 0-5V and demonstrate a detection limit of .33V (3 times average standard deviation of all points).

Conclusion

The lock in amplifiers are able to filter a signal with noise ranging from 5 Hz to nearly 100 kHz. They are quite consistent with another displaying an average standard deviation of less than .05V. This system has applications for quantifying amounts of DNA present by measuring absorption of prepared GNRs or conventional DNA dyeing agents such as SYBR Green. Future work will include:

- Preparing the GNRs with DNA primers that will trigger a shift in the absorbance spectrum the target DNA of the primers present
- Design a PCB of the 4 lock in system that will mount onto the arduino as a shield

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