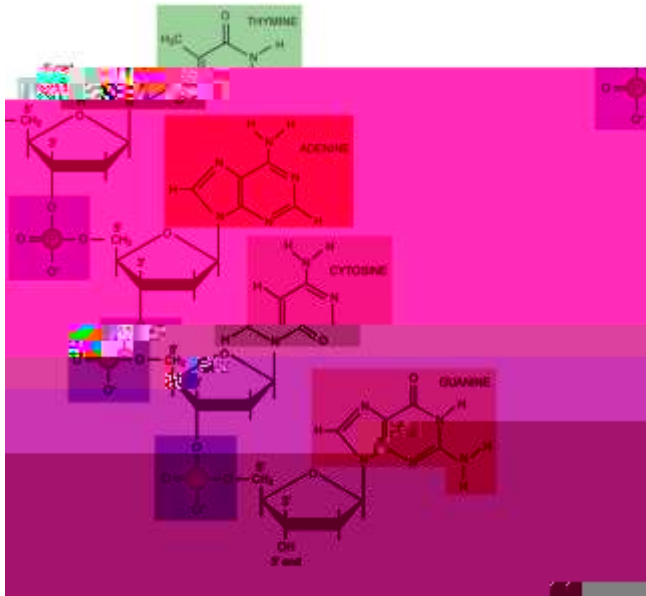tively charged free electrons in the phosphodiester bonds linking the phosphate backbone of DNA together would be electronically attracted to a positively charged surface, or a surface with a positive DC offset applied to the sensor. Re-

that the DNA became resonant at some AC frequency to indicate the presence of the DNA. The resonant frequencies of a particular strand were hypothesized to be unique to each strand, based upon the amount of nucleotides present and henceforth, the amount of electrons in each molecule. Each DNA solution was pipetted in samples of 10 μL onto the graphene substrate while it was in a circuit connected to an oscilloscope with a built in function generator (Agilent DSOX3014A). The experiment was designed with the intention of creating a mathematical model to predict the resonant frequency for any given amount of nucleotides. Three different lengths of dsDNA were tested, in addition to three different lengths of ssDNA, all of which were suspended in two different solutions (18 total combinations) to measure the voltage gain of the circuit in Figure 2. The resonant frequency of each of the strands was found when the voltage gain dropped substantially and rose again when
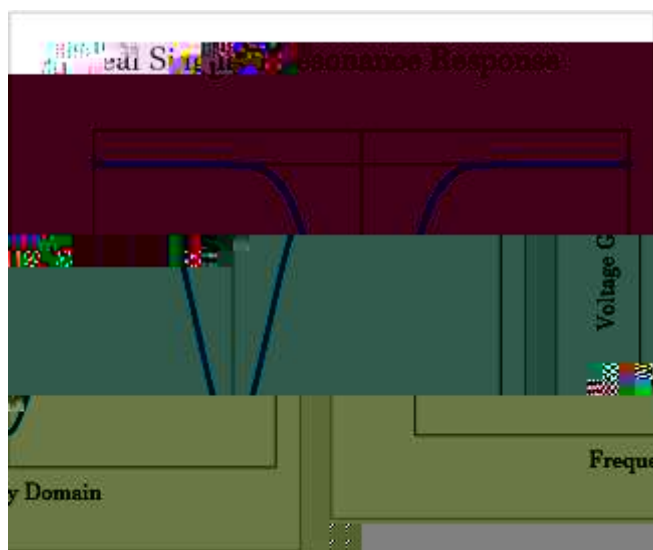
plotted against the frequency domain. Refer to Figure 3 to conceptualize the ideal measurement that was to be taken in the signal processing laboratory.

Figure 3: The idealized measurement for a circuit element resonating in the presence of an AC frequency creating a significant reduction in voltage gain as the element minimally impedes at resonance. The lowest point in this curve occurs at the resonant frequency as a drastic deviation from a standard response.

4. Results

This project resulted in five key findings, some of which are preliminary in nature for the purpose of further development of the sensor in the future when more time and funding is available. These findings were the product of careful considerations made when designing experiments. All findings were as expected and in line with common biological and physical theory.

4.1 Hyperchromicity

During experimentation in the biology laboratory, spectrophotometry was the main method of quantifying and organizing the solutions of nucleic acids. Hyperchromicity was tested by spectrally scanning two solutions of the same DNA sequence, one solution of deionized water and another of 10x PBS. The deionized water solution prohibits combined ssDNA from hybridizing at any temperature because of the lack of ions present in the solution. A high ionic content is necessary in a solution to force complementary single strands of DNA to hybridize at some temperature based on the GC base pair content of the sequence.

Using the spectrophotometer with this basic biological fact of DNA in mind, figures were created that show 30-40% increases in absorbance for complementary ssDNA pairs combined in deionized water. Figure 4 is an example of a plot that shows the hyperchromic effect for a sample of DNA with maximum absorbance occurring at 260 nm wavelength light.
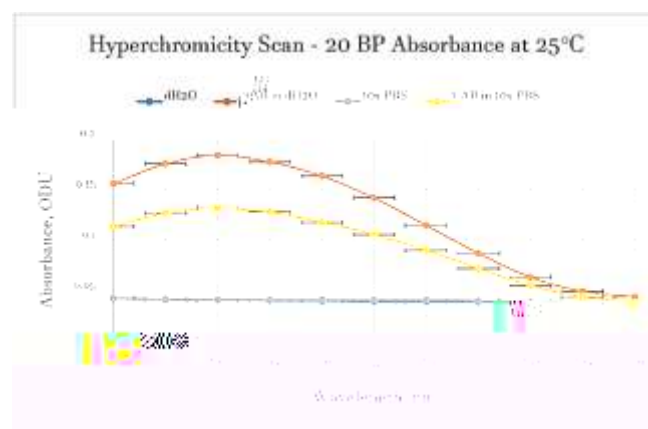

Figure 4: This plot shows a good example of the hyperchromic effect for a sample of DNA illuminated by light of 260 nm wavelength. Note the absorbance values at 260 nm for both the orange (ssDNA) and yellow (dsDNA) lines.

4.2 Hybridization Optimization

During the spectrophotometry experiments in the biology laboratory, it was paramount that the optimum conditions for hybridization be experimentally determined so that the conditions could be replicated when testing the DNA on the nanobiosensor to assure that hybridization is in fact occurring while being sensed with AC signals. It is known that DNA hybridizes at very specific temperatures, in specific solutions, and in a specific amount of time according to theory. The theory was experimentally confirmed in that the optimum hybridization temperature range exists between 20-65°C for the lengths and sequences of DNA used for our experiments. The optimum solution found for hybridization was 10x PBS as superior to 5x, 1x, 0.1x PBS and deionized water as a control. The optimum hybridization time as measured from the moment heating is applied at a fixed temperature was found to be in the range of 0-15 minutes.

4.3 Prototype Sensor Development

Two types of sensors were developed to control the cross contamination of the DNA samples during experiments in

measured data. The model must be refined and tested for accurate predictions in the future when more time and funding is available. Refer to Figure 8 to find the plot that was used to determine the predictive model. The importance of this model is that it would be the first of many intellectual challenges conceptualized and experimentally proven that would provide credence for a next-generation DNA sequencer.

5. Discussion

The applications of a DNA Hybridization sensor are far reaching. The ability to rapidly detect the presence of biological molecules in a cost effective and reusable method