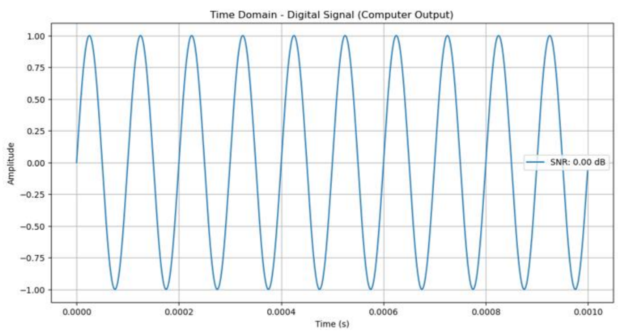
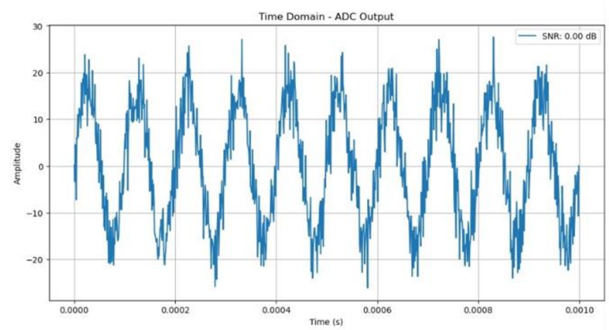
Lab Assignment 2

In this lab assignment, students will be working in groups of 2, with 1 student in the group working as the data transmitter and another student working as the data receiver. While the 2 students work together to collect the data and to write the code, students need to make **separate** submissions of the lab report on Brightspace. To complete some of the tasks below, you may find it helpful to start from codes we provided, however **you may need to change the existing Python or Arduino code or to add new code of your own**.

1. Consider 2 students, Ada and Bob, living in 2 towns 30 kilometers away from each other. One day, Ada decided to send a single bit b to Bob through optical fiber and Bob received the bit at time t. Ignore other possible system delays induced by ADC, DAC, etc., when do you think Ada sent the bit? Do you think there will be a problem if Ada decides to send 1000 more bits at a rate of 1k Hz and Bob always believes whatever bit he receives at time t is the bit that Ada sends at time t? (5pt)
2. After some communications, Ada realized that there were some unknown system delays induced by ADC, DAC, etc. between Bob and her. She believed the amount of delay can be calculated by recording the time t_1 (in global time, UTC) she sent the bit and the time t_2 (in global time) Bob received the bit. On the other hand, Bob believed that the delay can be circumvented by letting Ada send the bits prefixed by 'Hello' and use whenever he receives 'Hello' as the starting point of the transmission for recording. Experiment with both methods and share your discoveries. (10pt)
3. Slowly increase the supply voltage of the LED from 0V to 3.3V, plot the V_{led} vs. time. Report the step size that you increase the V_{led} and the timelapse between you change between each value of V_{led}. Record the measured current through the photodiode, I_{pd}. Report the sample rate that you record the current. Plot I_{pd} vs. time. The time in the 2 plots should be synchronized. (15pt)
4. Plot I_{pd} vs. V_{led} collected in step 3. Record the minimum V_{led} required to make I_{pd} larger than 0, and the maximum V_{led} that I_{pd} is not saturated. To make I_{pd} corresponding to each V_{led} distinguishable from each other, how should we choose the range of V_{led} and step size that we increase the V_{led} in value. (25pt)

5. Consider the case we talked about in class, shown below,





How should we control the supply voltage to the LED to make its brightness a sinusoidal function of time with an input signal frequency of 1Hz, such that $Brightness = \frac{A}{2}sin(2\pi t) + \frac{A}{2}$. Assume A is a constant that won't saturate I_{pd}. (15pt)

6. If the LED brightness is a sinusoidal function of time with an input signal frequency of 1Hz. Record the measured current through the photodiode, I_{pd1}, and plot I_{pd1} vs. time. Give a rough estimation of the signal to noise ratio (SNR). In addition, give a rough estimation for the output signal $\overline{I_{pd1}}$ (I_{pd1} subtracted by all the noises) in forms of $\overline{I_{pd1}} = \frac{B_1}{2}sin(2\pi t + \varphi_1) + \frac{B_1}{2}$. (15pt)

7. Change the input signal frequency to 200Hz, such that $Brightness = \frac{A}{2}sin(2\pi t \cdot 200) + \frac{A}{2}$. Repeat step 5 and 6. Discuss your observations. If the plot seems very noisy, discuss potential reasons. (15pt)

8. Experiment with different input signal frequencies f_i. Estimated $\overline{I_{pd_i}}$ in forms $\overline{I_{pd_i}} = \frac{B_i}{2}sin(2\pi t \cdot f_i + \varphi_i) + \frac{B_i}{2}$. Sketch the Bode plot for the system, i.e., sketch B_i vs. f_i and ϕ_i vs. f_i. An example of the Bode plot is shown below (which can be different from yours). Label your f_i on the plot. (BONUS +5pt; total score can't exceed 100pt)