Grad Students

Music Transmitter Via Laser Diode and Photocell

ECE 543 Optical Fiber Communications

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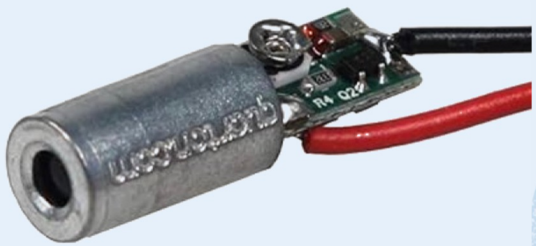

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Objectives

- Typically music is transmitted over bluetooth or cables. We wanted to explore other options with optics.
- Demonstrate it is possible we can transmit music over a laser source into a photocell and play music on speakers.
- Learn to use a pin laser diode to carry data.

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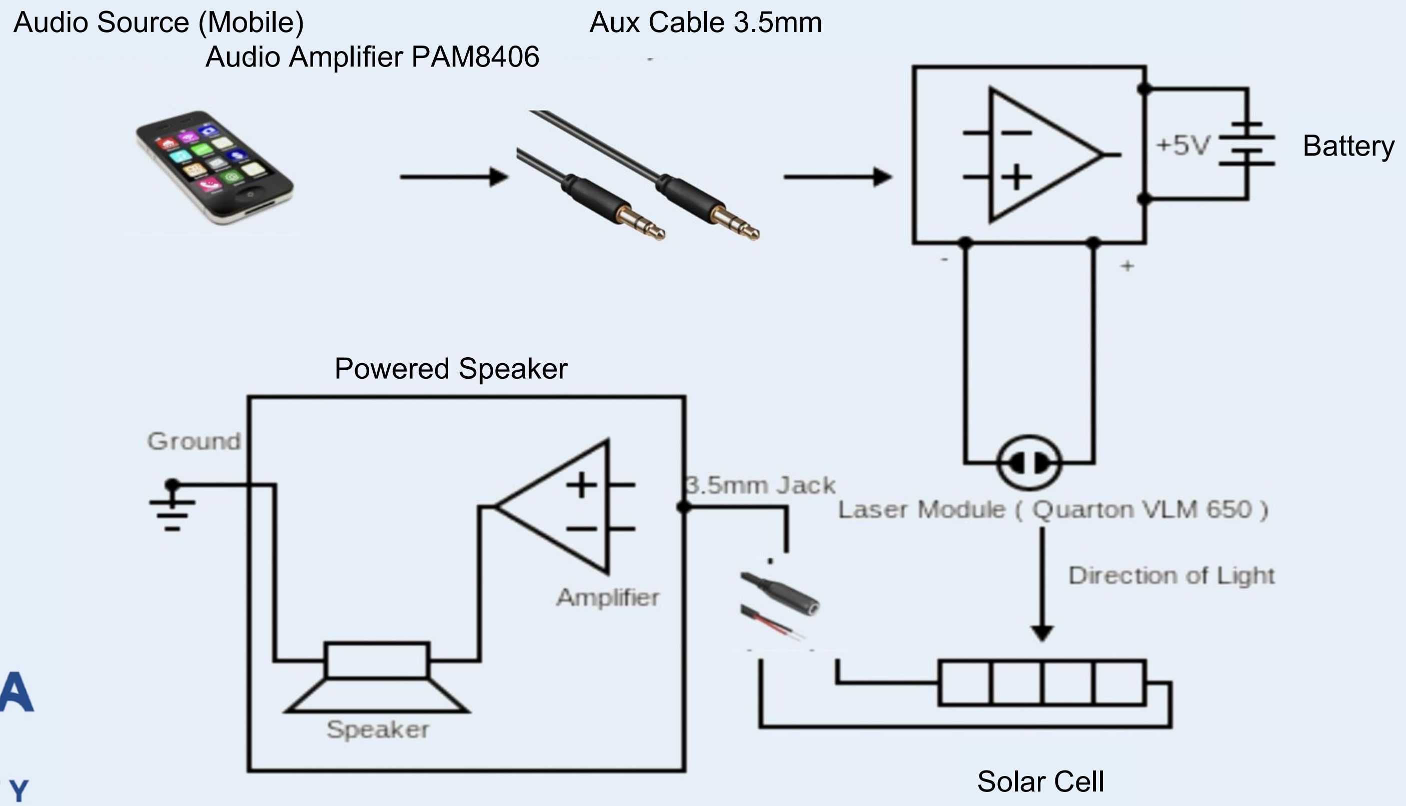
Circuit Diagram



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Bill of Materials (BOM)

Music Transmitter Via Laser Diode and Photocell				
Part	Description	Qty	Price ($)	Link
VLM-650-04 LPA	Laser Diode	1	13.37	Link_laser_diode
PAM 8406	Audio Amplifier	1	13.50	Link_audio_amp
1/8" 3.5mm Plug	Aux Audio Cable	1	2.99	Link_Aux_Cable
1/8" 3.5mm Jack	Female Audio Jack	1	9.00	Link_Female_Jack
2V 40mA 36mm	Solar Cell	1	6.50	Link_Solar_cell
Total Spent			45.36	

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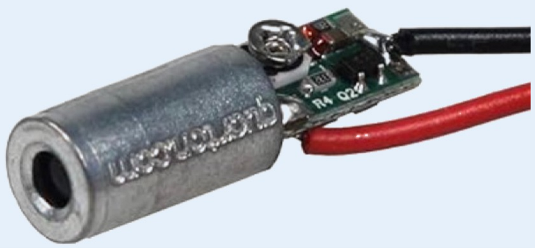
Laser Diode Specs



Model Number	VLM-650-04
Dimensions	∅6.55 x 21.1mm
Operating Voltage	2.6 – 6 VDC
Operating Current	< 50 mA
Laser Power Output	< 2.5 mW
Laser Class	IIIa
Wavelength	645 – 665 nm
Collimating lens	Plastic lens
Output aperture	3mm
Beam shape	Ellipse
Spot size	6±1 mm at 5 meters
Divergence (Half Angle)	0.6 mRad
Beam Alignment	Less than 3°
Operating Temp	+15°C – +30°C
Potential of Housing	VDD(+)
Mean time to failure	5000 hrs
Application	Economic Type
Suggestion	10 meters / 3 – 40 feet

[Laser Class Safety Link]

Laser Class IIIa = 3R

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Tests

1. How far can be the distance between the transmitter and the receiver

1. What happens if we place a piece of transparent plastic between the TX and RX?
2. Can you use a mirror to reflect the light and still receive the data?

1. What is the wavelength of your laser ?

1. What is the lower power level that the detector can receive? How can it be improved

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How far can be the distance between the transmitter and the receiver

- Since the photocell was small it was hard to accurately point the laser diode. We were not able to go farther than 5 meters.

- Overall it seems like distance from the solar cell does not affect how loud the sound was played.

- The following slide demonstrates power received from solar cell versus distance.

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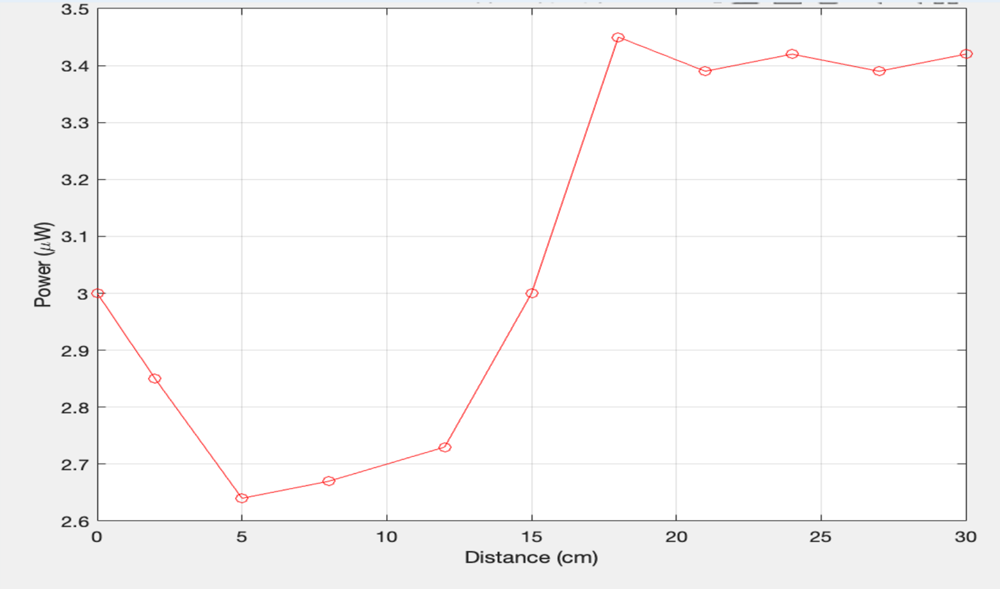
Power Vs Distance

No	Distance(cm)	Voltage(v)	Current (Micro Amp)	Power (micro watt)
1	0	1	3	3
2	2	0.95	3	2.85
3	5	0.88	3	2.64
4	8	0.89	3	2.67
5	12	0.91	3	2.73
6	15	1	3	3
7	18	1.15	3	3.45
8	21	1.13	3	3.39
9	24	1.14	3	3.42
10	27	1.13	3	3.39
11	30	1.14	3	3.42



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The power output varies as the laser light hits different spots on the photocell.

What happens if we place a piece of transparent plastic between the TX and RX?

- Placing a piece of transparent plastic between the laser and the photocell caused made no difference in sound quality but looking at it through the oscilloscope, we noticed the overall voltage was 50mv lower.

- I believe the plastic caused the light to scatter more and reduce the intensity of light received at the photocell.

Can you use a mirror to reflect the light and still receive the data?

- It was very difficult to align the laser diode and the photocell using the mirror. The photocell is not much larger than a quarter.

- We tried using the mirror to transmit data but we were having a hard time performing the test since we did not have a hand held mirror.

- There was some kind of noise coming out from the speaker and it was hardly audible.

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What is the wavelength of your laser ?

- Bought this laser light from Quarton. The company is located in Taiwan and deals mainly with laser technology.
- The Laser model number is VLM-650-04.
- According to the manufacturer this model's wavelength spreads from 645 nm to 665nm.
- The wavelength falls in the range of red light.

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What is the lowest power level that the detector can receive? How can it be improved?

According to the datasheet the output power of the diode laser is less than 2.5mW. The operating voltage is 2.6 to 5V.

We ran our laser at different voltages ranging from 3V to 5V.

We noticed the sound coming out from the speaker was lower in volume for lower operating voltage, but still worked.

The solar cells was rated for 2V at 40mA. I noticed that if we shine a light on the solar cell at the same time as the laser, the volume went up.

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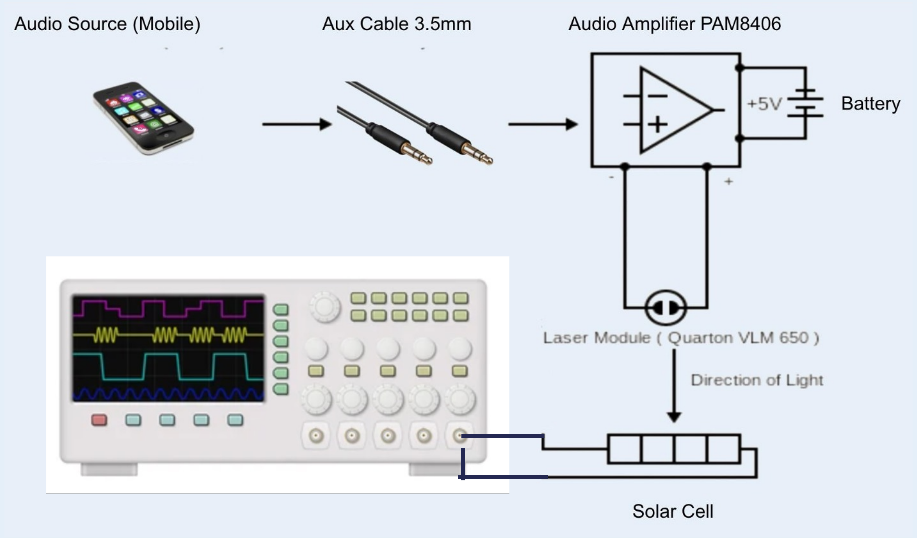
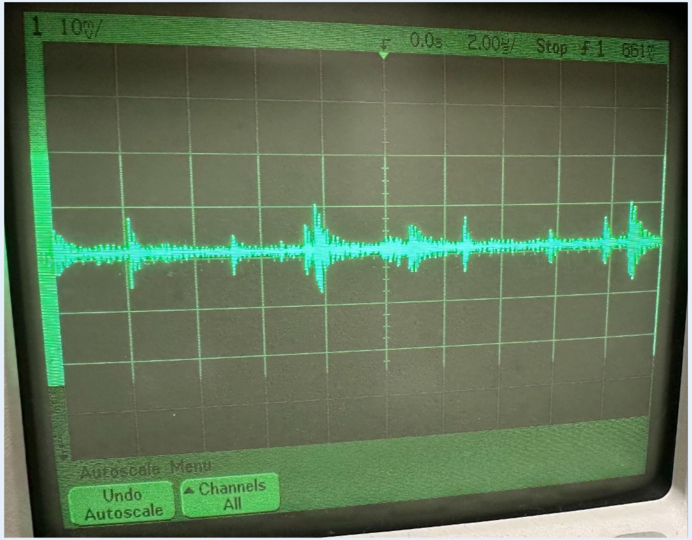
Data Received on Oscilloscope





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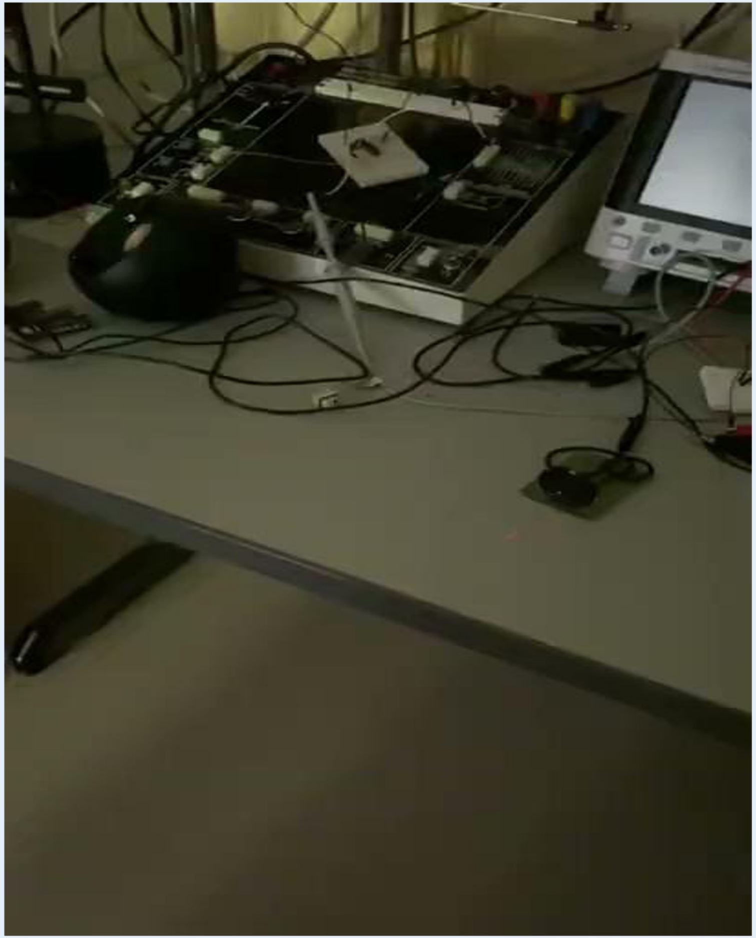
Video Demo

Issac can be seen pointing the laser diode at the photocell. The laser is carrying the music signal and passing it on to the photocell. Where the powered speakers pick up the audio from the aux jack.

Link to the video:

https://drive.google.com/file/d/1o7OEbPcEZ6BGfe1LJ2fFo7huBAnxUWIK/view?usp=share_link



Objective 1

- Previously we replaced a transformer with an amplifier to the source in order to increase the signal current which in turn increased the laser diodes intensity. This allowed us to increase the volume and properly hear data transmitted.
- Now we will be adding an amplifier to the receiver end. Our aim is to increase sound quality and signal strength by having amplification on receiver and transmitted ends

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Objective 2

- The solar cell is too small. It is just slightly larger than a coin. When we increase the distance of the laser source, it becomes hard to focus the laser on the solar cell. In order to overcome this problem, we will use some equipment from the lab to focus the laser on the solar cell and observe what is the maximum distance a sound can be transmitted and heard clearly.
- In order to accomplish this, we would have to set up an ideal case. This objective may or may not be possible to complete for large distances.

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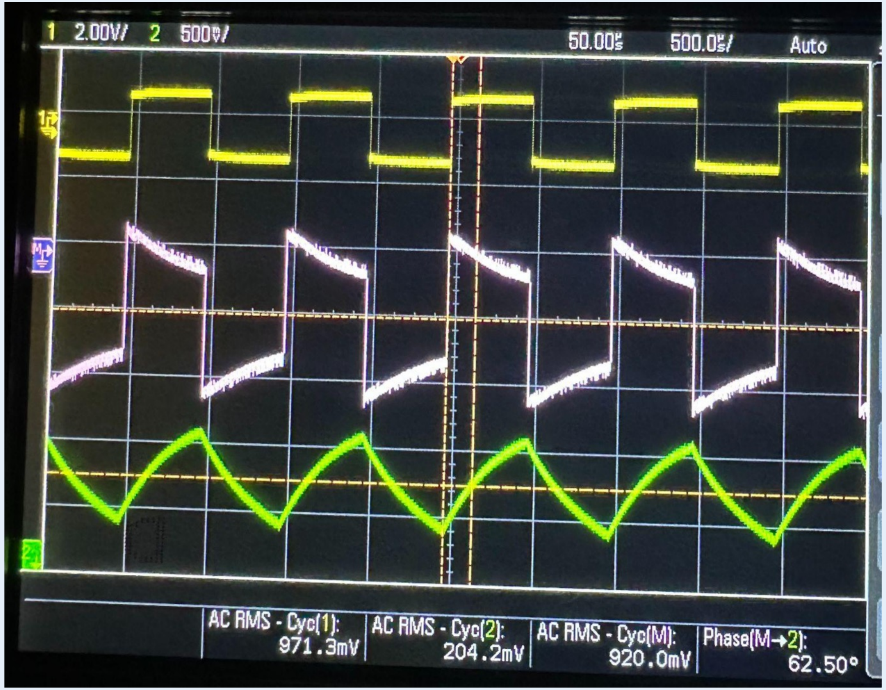
Test 1 & Test 2

Sweep amplifier input voltage and measure signal changes at receiver.

Our measurement setup focused on the input (yellow). The receiver output (green) and the difference between the signals (purple).

This way we were able to systematically measure the output signal voltage, phase change and difference between the input.



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Data

Taken at 1 KHz 10 inches away from receiver.

No	Applied Voltage/(voltage)	Applied current (Amp)	Tone RMS Input Signal (mv)	AC RMS Output Signal (mv)	Phase difference (angle)	Signal Difference /Noise (mv)
1	3	0.009	971	54	77	963
2	3.5	0.012	977	110	70	954
3	4	0.015	971	191	61	924
4	4.5	0.018	977	311	51	880
5	5	0.021	977	405	85	830
6	5.5	0.024	976	475	115	787

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Data

Taken at 2.75 KHz 10 inches away from receiver.

	Amplifier Input Voltage/(voltage)	Amplifier Input current (amp)	Tone RMS Input Signal (mv)	AC RMS Output Signal (mv)	Phase difference (angle)	Signal Difference /Noise (mv)
1	3	0.009	953	23.5	90	952
2	3.5	0.012	953	47	83	951
3	4	0.015	953	83	82	948
4	4.5	0.018	953	135	75	939
5	5	0.021	953	185	68	924
6	5.5	0.024	953	218	62	907

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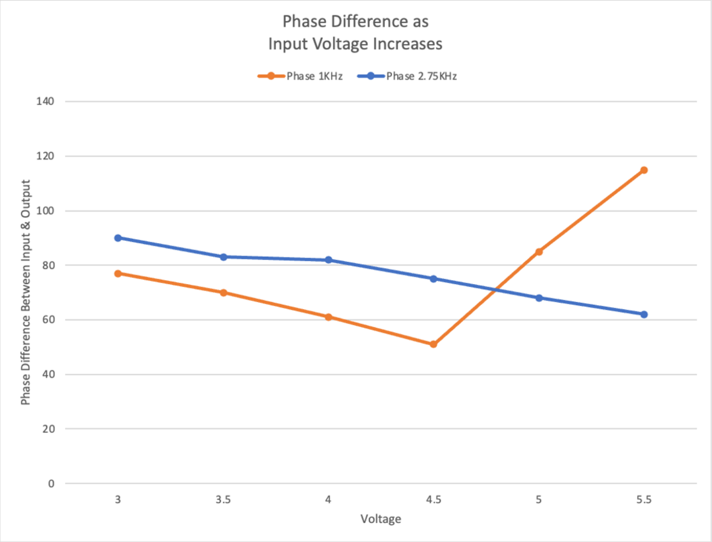
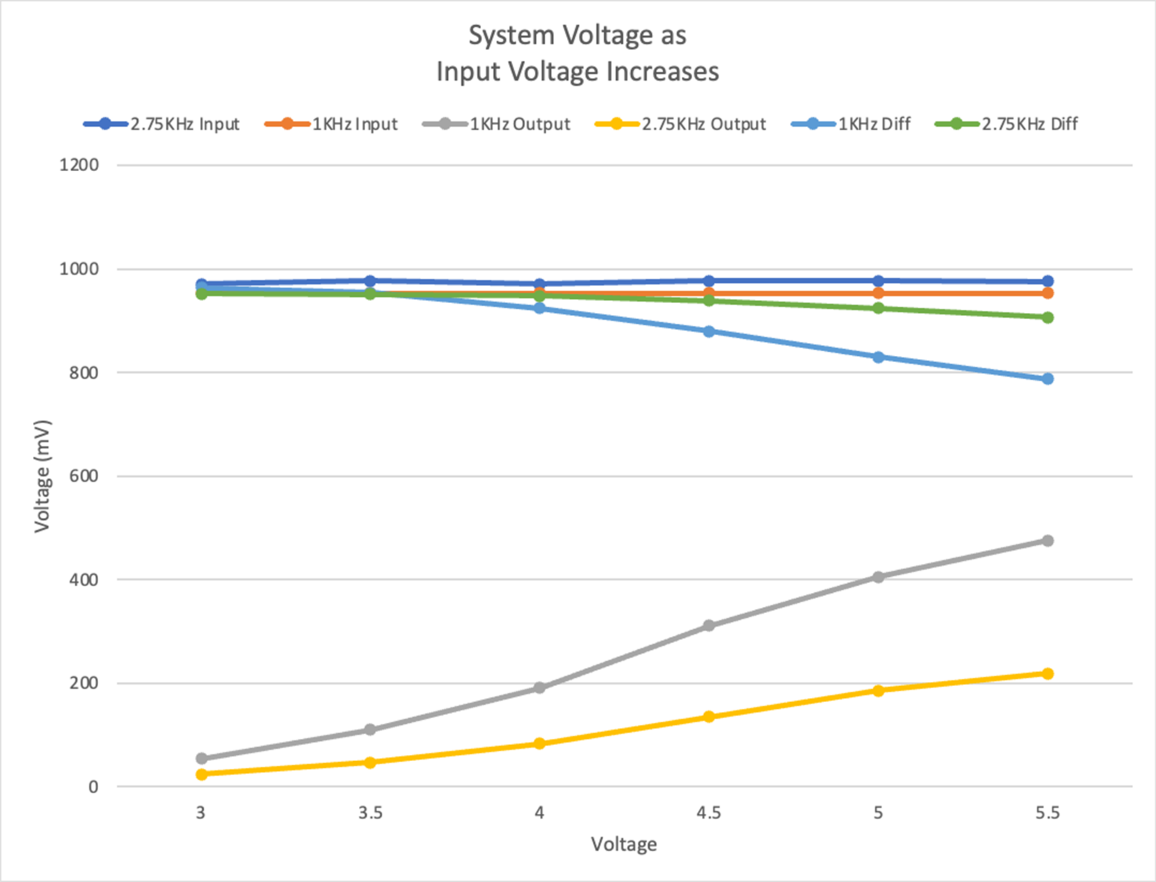
Measurements





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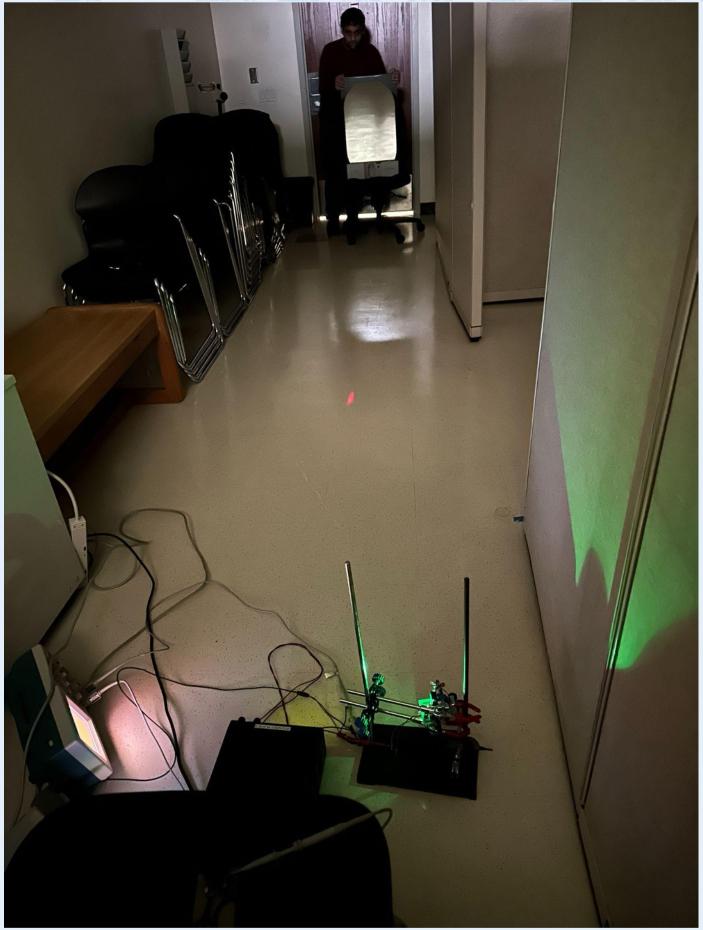
Test 3

The purpose of this test is to investigate how much distance we can put between the source and receiver and read any phase shift. This test was determined to be unrealizable. Umar can be seen holding a mirror trying to reflect the laser back to the receiver. It is very difficult to aim and we consider this test impossible without a large solar cell and stronger laser.



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Test 4

In this test we explore how different materials affect the output signal as we pass the laser light though the following materials.

Test conducted at 1KHz with 10 inch separation between laser and receiver.

No 1	materials	Input signals/mv	Output signal/mv	Phase degree/degrees	Rms difference/mv
1	Nothing	977	433	95	807
2	Glass Cup	977	390	75	835
3	Plastic	977	388	72	832
4	Water & Glass Cup	977	371	60	836
5	Alcohol & Glass Cup	977	405	77	820

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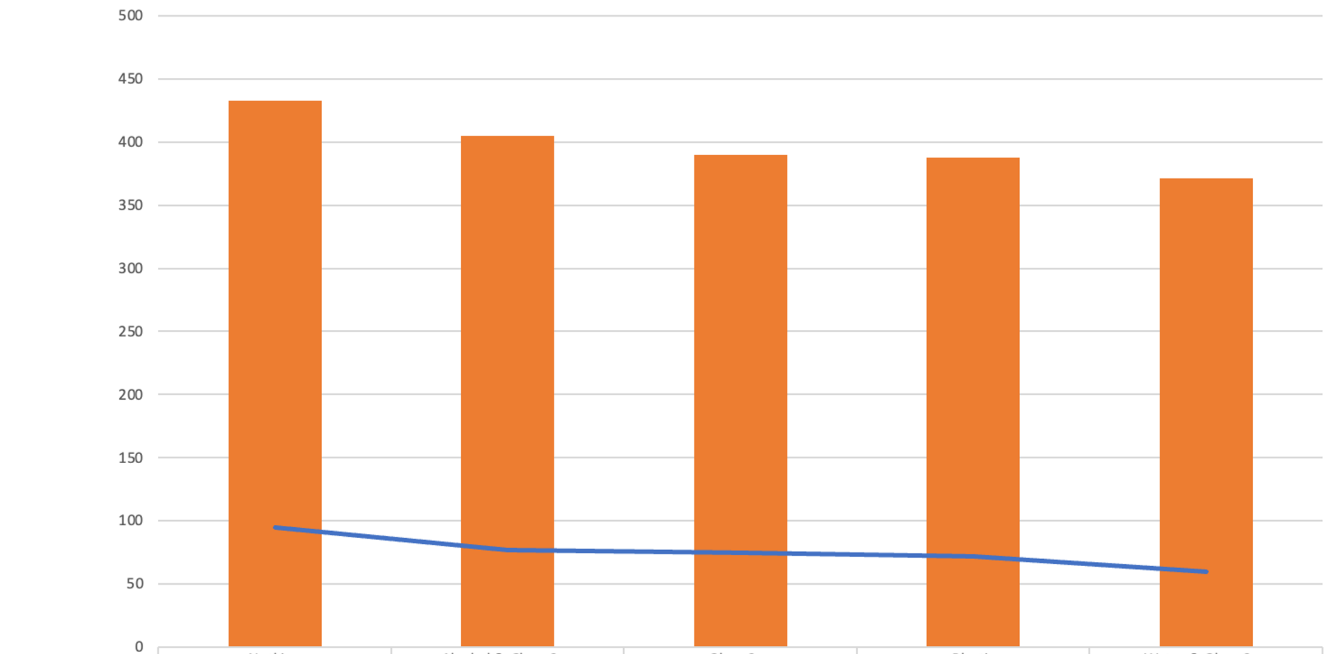
As Laser Passes Through These Materials, These are the Effects to the Receiver Voltage and Phase.



	Nothing	Alcohol & Glass Cup	Glass Cup	Plastic	Water & Glass Cup
Output Voltage	433	405	390	388	371
Phase	95	77	75	72	60

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Conclusion

- Overall this project was a success.
- The sound was transmitted through the laser diode and the transmitter received the signal.
- The volume was loud and clear.
- For the future it would be nice to use fiber optic cable instead of shine the laser on the photocell for a more reliable connection.

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