Optimization of Audio System Wireless Transmitter using Green Laser

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Abstract: Nowadays, many activities are done digitally using wireless technology. Wireless technology is the mainstay of communication, but along with the development of the times, there is a wireless technology that utilizes LASER. There has been quite a lot of research on audio systems with wireless transmitters, but none have analyzed the potential of green lasers to obtain the optimal wavelength for communication. This study aims to design a voice transmission system using a laser, determine the relationship between input voltage and laser light intensity, and compare the output frequency with the input frequency. There are three types of measurements: light intensity and distance, laser diode voltage and intensity, and output frequency compared to input frequency. The audio input signal from the source is modulated and transmitted through a laser light medium. The laser beam is then fired into a receiver circuit that can demodulate the signal which is then sent to the output device in the form of a speaker. The study found that the output frequency had the highest error percentage of 38.70% at 125 Hz and the lowest error percentage of 0.07% at 500 Hz when compared to the input frequency. The biggest mistake comes from the volume dropping at a low frequency. The oscilloscope reading is not accurate due to the smaller volume, which leads to a high deviation value and affects the system performance negatively.

Keywords: Green LASER; Frequency; Modulation; Demodulation

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http://dx.doi.org/10.12962/j24604682.v20i3.21861
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I. INTRODUCTION

Technology advancements are making it easier for people to create a more comfortable living environment. This includes having access to various wireless devices and equipment. Nowadays, many new electronic devices are using wireless systems instead of cables. Wireless technology is used in products like microphones, wireless printer adapters, wireless mouse and keyboards, and more [1]. Wireless transmission has a lot of benefits compared to using cables. Wireless energy transmission can make it cheaper to install cables, improve the look of the environment, and make the ecosystem more comfortable [2, 3].

Basically, a wireless audio connection is a system for sending audio signal data via air media that uses a certain frequency that is transmitted by a device in the form of a transmitter and then this signal is forwarded to the receiver, where the audio data is then translated into analog so that it can be received by our sense of hearing [4]. A study on wireless transmission was done in 2014 by the Beijing Institute of Technology. They showed a laser power transmission system that worked over a 100 m distance using an improved photovoltaic converter. The system produced 9.7 watts of power with an efficiency of 11.6% [5]. Supriyatno conducted research on modeling a Wireless Audio Transmitter System using a Laser with a 635 nm wavelength. The research results included parameters such as the signal received by the photodiode, the position of the radiation to the photodiode, the position of the receiver, and the optimal distance between the transmitter and receiver to produce the best sound quality [4]. Supriyanto and others have not analyzed how using laser light of various wavelengths can enhance wireless audio transmission in their research and other studies [1, 6-10]. This research looked at how a green laser with a wavelength of 532 nm affects wireless audio transmission.

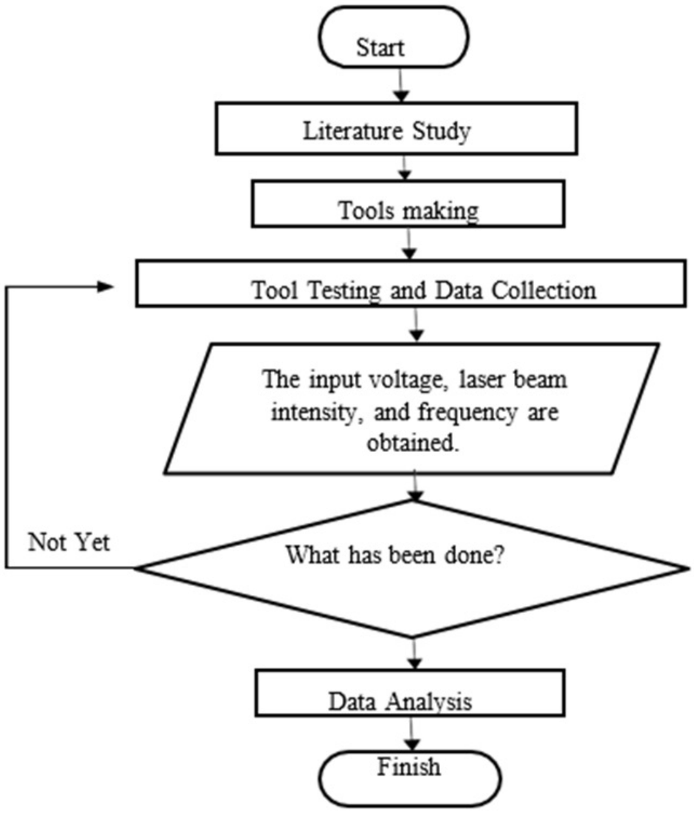
II. METHODOLOGY

The equipment used in this study were 532 nm laser pointers, speakers, lux meters, multimeters, resistors, capacitors, potentiometers, cables, IC CD 4046, LM317, LM386, photodiodes, 9 volt batteries, DSO 138 Digital oscilloscopes, and smartphones to generate audio signals. The flow diagram of this research is shown in Fig. 1.

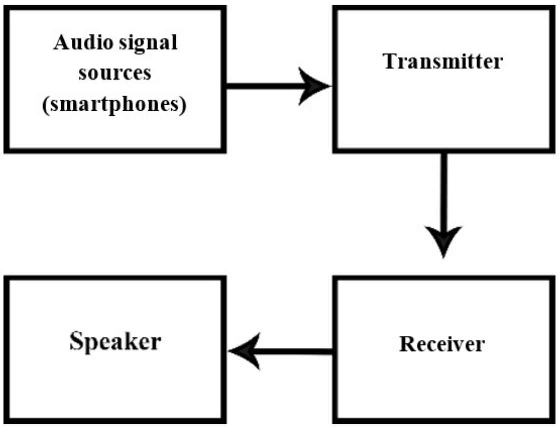
The experiment is divided into 3, namely measuring the current against intensity, measurement of intensity against distance, and measurement output frequency and waveform.

A. Measurement Intensity to Distance

Two instruments are utilized in this measurement: a Luxmeter and a laser diode. A luxmeter is a device used to measure the intensity of light. Placing the lux meter at a specific distance from the laser diode allows one to measure the



(a)



(b)

FIG. 1: (a) Research flow chart. (b) Block diagram of the sound transmission process using a laser.

laser beam's intensity. Meters are used to measure the distance. The relationship between the laser beam's intensity and distance will be derived from the measurement's findings. Fig. 2 displays the intensity measurement scheme against distance..

It is used to measure distance in relation to laser beam intensity. Eq. (1) which explains the relationship between distance and intensity rays, which is

$$I_L = \frac{1}{tan^2\theta}\frac{P}{\pi L^2} \quad (1)$$

$$\theta = \frac{\lambda}{\pi w_\circ} \quad (2)$$

where is I_L is the laser intensity (W/m^2), P is the laser power (Watt), L is distance (meters), θ is divergence angle, λ is wavelength of laser light (meters), and $w_\circ$ is the radius of the

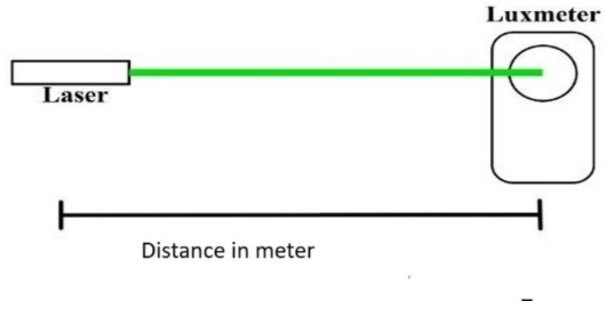


FIG. 2: Measurement Scheme Intensity to distance.

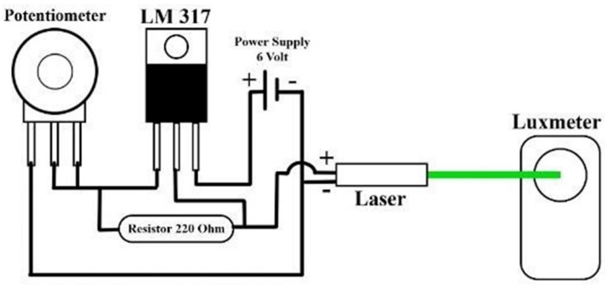


FIG. 3: Measurement Scheme Voltage to Intensity.

light beam on point narrowest from ray from equality range Rayleigh in theory Gaussian beam.

B. Measurement Voltage to Intensity

Using a multimeter, the input voltage required for the laser diode to function is measured. The relationship between voltage and intensity produced by the ray laser is then determined by measuring the intensity produced by the laser using a luxmeter. The voltage-to-intensity measuring scheme is displayed in Fig. 3. A potentiometer and an LM317 are utilized components for measuring voltage to intensity. LM317 acts as a current regulator, and the potentiometer controls the desired current input.

Eq. (3) provides the formula for determining the voltage value when measuring the voltage to intensity ray laser, which is

$$V = \sqrt{I_L tan^2 \theta \pi R L^2} \tag{3}$$

where R is the resistance (Ohm) and V is the diode laser's voltage (volt). In order for the laser to generate the desired beam intensity at its best, the results of measuring the laser diode voltage against the intensity ray laser used as a reference voltage.

C. Measurement Output Frequency to Input Frequency

The transmitter and receiver are the two components of the tool scheme under study in this measurement. This measurement's circuit diagram makes use of a circuit architecture that Siswanto employed in 2016. General Audio System Modeling Wireless Transmitters Using Laser Pointers is the title of his study. Fig. 4 depicts the transmitter scheme, whereas Fig. 5 [4] shows the receiving apparatus.

The circuit receives a sound signal input from the smartphone and transmits it. The transmitter's primary component is the CD4046, which modulates audio signals from smartphones before being converted into electromagnetic waves by a diode laser. The photodiode on the receiver, which is light-sensitive, absorbs the signal-carrying laser beam and transforms it into electrical energy. The signal received by the photodiode will then be demodulated by the CD4046 on the series receiver. After being demodulated, the signal is sent to the LM386 to serve as a low-voltage power amplifier. The signal is received by the speaker as an output device after it has passed through the LM386. A DSO 138 oscilloscope is then used to measure and examine the output signal. A distance of one meter between the transmitter circuit and the receiver was used for the measurements.

III. RESULTS AND DISCUSSION

A. Results

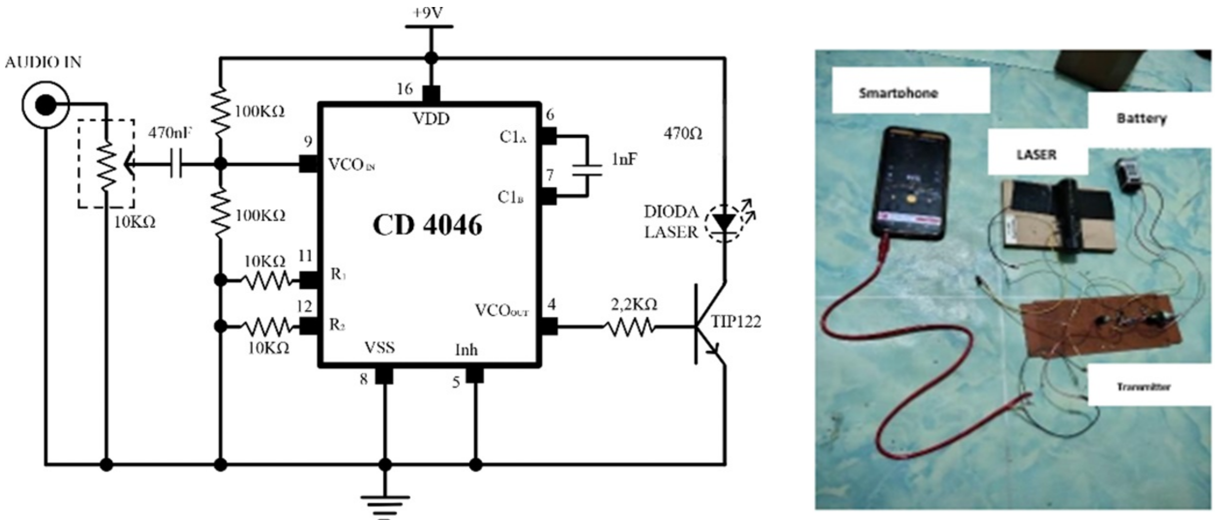
Three measurement techniques are used to categorize the features of the created audio transmission device: distance measurement data on laser beam intensity, current measurement data on laser beam intensity, and data measuring the relationship between input and output frequencies. The graphs in Fig. 6, Fig. 7, and Fig.8 illustrate the link between laser beam intensity and distance, as well as the relationship between laser diode voltage and laser intensity, based on the research data.

- Laser beam intensity distance measurement data (Connection Distance to Intensity Ray Laser)
  Based on an experiment, Fig. 6 illustrates the relationship between laser beam intensity and distance. As the distance between the luxmeter and laser pointer increases, the laser beam's strength drops. The intensity of the ray laser that can be read at a distance of one meter is 10900 Lux. On distance 50 meters intensity ray laser Which readable is 6428 Lux. Fig. 7 shows the relation between Distance and Light Intensity Laser Based on Eq. (1).

- Laser Diode Voltage and Beam Intensity Laser Relationship

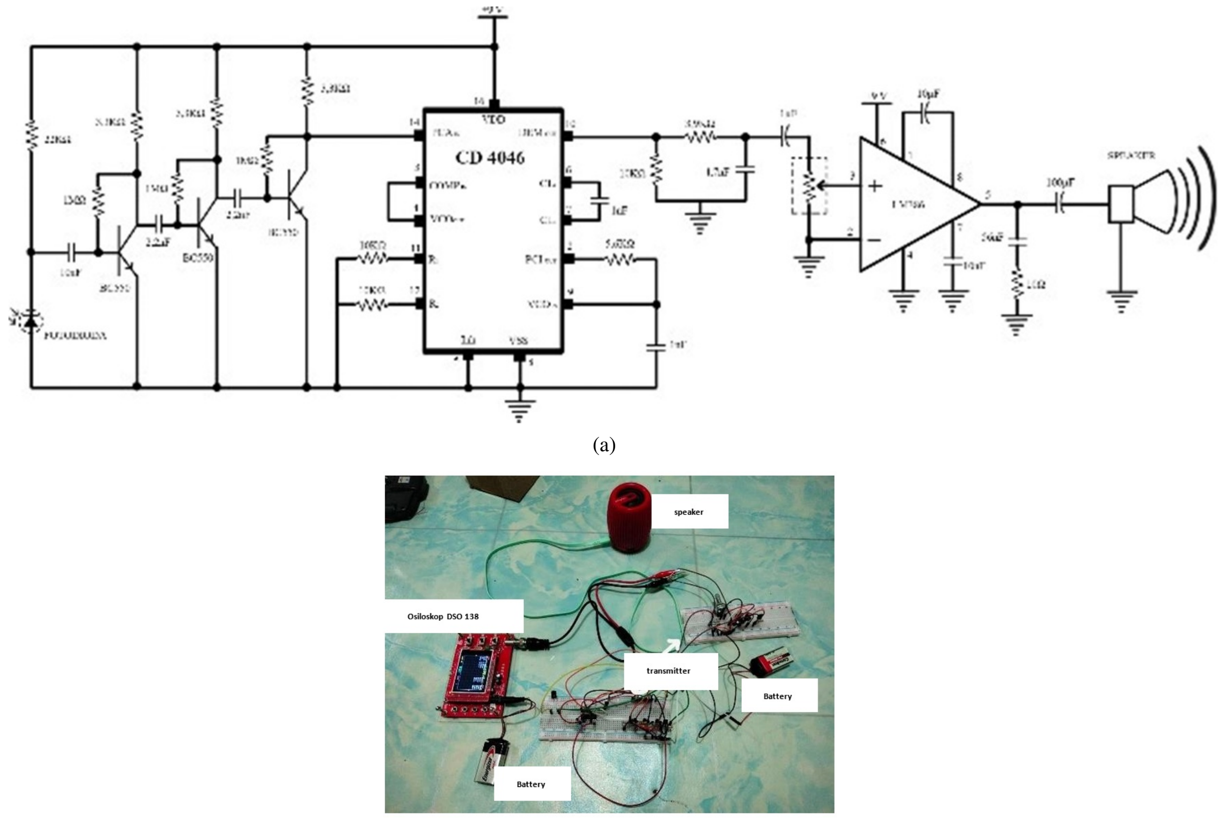
  Fig. 8 illustrates how the laser's intensity increases in tandem with the laser diode's voltage. As the voltage rises from 1.938 to 2.352 volts, the laser beam's strength significantly increases.

- Output Frequency Measurements in relation to Frequency Input



(a) (b)

FIG. 4: Transmitter Circuit.



(a)

(b)

FIG. 5: Receiver Circuit.

Results measurement frequency output to frequency input shown by Table I. Table I show that frequency output which readable on oscilloscope after through process modulation and demodulation approaching the input frequency value. The results of measuring the input signal before being modulated and emitted by the laser is shown by Table II.

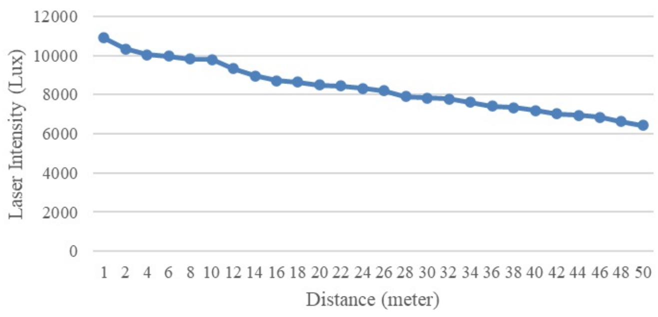


FIG. 6: The relationship between distance and laser beam intensity based on experiment.

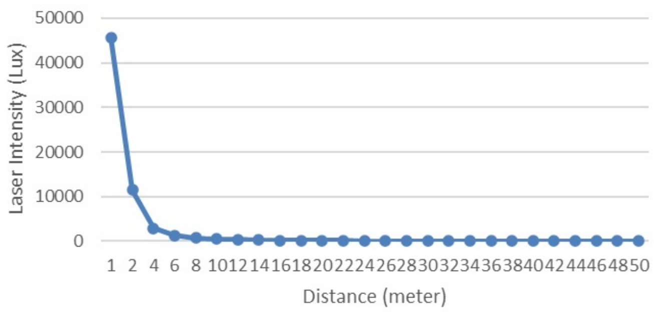


FIG. 7: The relationship between distance and laser beam intensity based on equation.

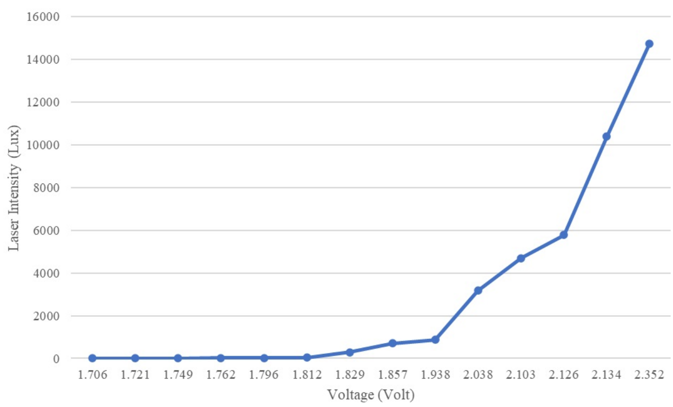


FIG. 8: The Relationship between Laser Diode Voltage and Intensity Ray Laser.

TABLE I: Results of Input Frequency Measurements and Output Frequency.

Input Frequency (Hz)	Output Frequency (Hz)	Error (%)
125	173.37	38.70
250	250.50	0.20
500	500.34	0.07
750	745.82	0.56
1000	1,014.00	1.4
2000	2,012.00	0.6
4000	3,996.00	0.1

TABLE II: Results Measurement Frequency Input Signal.

Input Frequency from application (Hz)	Input Frequency from Osiloskop (Hz)	Error (%)
125	125.156	0.125
250	250.250	0.100
500	499.001	0.200
750	749.250	0.100
1000	1,001.000	0.100
2000	2,002.000	0.100
4000	4,001.000	0.025

B. Discussion

This study investigated the ability of signal transmission across laser light media at various wavelengths using a 532 nm laser diode. Using a laser pointer positioned 45 cm above the ground, the connection between distance and laser light intensity was measured. After that, the laser beam was directed at a specific distance in the direction of the luxmeter. One meter, two meters, and multiples of that were the distances used. To get regular data, this was used. It is known from the findings of measuring the relationship between distance and laser light intensity in Fig. 7 that the laser light intensity obtained decreases with increasing distance between the luxmeter and the laser pointer. This happens because, according to equation 1, the laser's intensity or irradiance is inversely proportional to the square of the distance between the luxmeter and the laser pointer. When the laser beam propagates through the atmosphere, there are parameters that also affect the intensity of the laser beam, namely the efficiency of laser transmission in the atmosphere. Atmospheric gases can absorb energy from laser light at certain wavelengths. This certainly has an impact on its transmission efficiency [11, 12].

The further the laser beam travels in the atmosphere, the more energy will be absorbed because the interaction between the laser beam and the gas in the atmosphere will be greater so that the laser intensity read by the luxmeter will be smaller. The intensity of a laser beam decreases as it travels through the atmosphere. This happens because, over longer distances, more of the laser's energy is absorbed by gases in the air. As the beam interacts with these gas molecules, it loses energy, reducing its intensity. Thus, the greater the distance the laser travels in the atmosphere, the weaker its measured intensity will be. This shows that the distance a laser beam travels in the atmosphere directly impacts its intensity. So, it can be said that the distance traveled by the laser beam in its propagation in the atmosphere affects its intensity.

Fig. 7 shows the relationship between laser beam intensity and distance does not show a quadratic function graph, when compared to the graph in Fig. 8. which is a graph of the calculation results using Eq. (3). There is one factor that influences this, one of which is the specification factor of the laser diode used. In this study, a laser with a beam power of up to 5000 mW was used. The beam power value is quite large compared to laser diodes in general. The coherence level of the laser beam also has a major influence on the attenuation of the laser beam intensity. The laser used in this study has quite large power and coherence so that the attenuation that occurs is very small. As a result, the graph formed only looks like a linear function graph.

The relationship between the laser diode voltage and the intensity of the laser beam produced is shown in the graph in Fig. 9. In accordance with the working principle of the laser diode, at this voltage, optimal stimulated emission is possible so that the laser intensity produced increases significantly in the voltage range of 1.938 Volts to 2.352 Volts for the type of laser pointer used in this study. In this study, the test frequencies used were 125 Hz, 250 Hz, 500 Hz, 750 Hz, 1000 Hz, 2000 Hz, and 4000 Hz. The frequency is used based on the ISO 3382 acoustic parameter measurement procedure instructions which state that for engineering purposes and for more precise results, the frequency should be at least in the range of 124 Hz to 4000 Hz (*octave band*), or at 100 Hz to 5000 Hz (*one third of an octave band*). The highest error at a frequency of 125 Hz of 38.70% is caused by the volume decreasing with the small frequency. Measurement errors vary across frequencies due to how different frequencies affect the lasers transmission properties and the oscilloscope's ability to capture the signal accurately, that is:

1. Signal Amplitude and Frequency.
   At lower frequencies (e.g., 125 Hz), the transmitted audio signal has a lower amplitude (volume), which makes it more susceptible to loss and inaccuracies during transmission. The laser may not transmit these lower amplitudes as effectively, especially if the signal power is weak. This results in larger deviations from the expected output when measured, leading to higher error values

2. Oscilloscope Sensitivity and Frequency Response.
   The DSO 138 oscilloscope used here has limited specifications, which affects its ability to accurately measure signals at lower amplitudes and frequencies. This oscilloscope may have a frequency response that isnt optimized for accurately capturing low-frequency, low-amplitude signals, leading to higher deviations in readings. At higher frequencies (like 500 Hz), the signal amplitude tends to be more stable and within the oscilloscope's optimal range, resulting in more accurate measurements and lower error rates. The smaller volume causes the reading by the oscilloscope to be inaccurate because of its high deviation value. This is also influenced by the limited specifications of the DSO 138 Oscilloscope.

3. Laser Modulation Efficiency.
   In audio transmission via laser, the lasers modulation efficiency, the ability of the laser to vary its intensity in response to the audio signal may be more stable at certain frequencies. Lower frequencies may experience more noise or distortion, especially with inexpensive or lower-quality lasers, affecting the signals integrity and leading to higher errors at 125 Hz compared to 500 Hz [13, 14]. To overcome this problem, an oscilloscope with better specifications can be used with better sensitivity and frequency response would improve measurement accuracy, especially at lower frequencies where signal loss and deviations are more prominent.

The results of the output frequency measurements in Table 1 show results that are close to the input frequency. This means that the signal modulation and demodulation process occurs as expected from the audio transmission circuit system in this study. In the transmitter circuit, the sound signal from the smartphone enters the CD4046 IC which functions to modulate the signal into the carrier frequency. The modulated signal then rides and is transmitted through a green laser pointer with a wavelength of 532 nm. In this process, there is a change in sound energy into electricity, then into light energy. The laser beam carrying this signal is then captured and received by the receiver circuit through a photodiode.

IV. CONCLUSION

By comparing the output frequency from the speaker with the input frequency from the sound signal source, which is the smartphone, it is possible to transmit audio using a laser beam with a wavelength of 532 nm. These are the findings from this study. The intensity of the laser beam that strikes the target is significantly influenced by the distance between the target and the laser beam source. With a 532 nm wavelength laser pointer, the laser intensity decreases with increasing distance. The beam intensity in this study was 10900 lux at a distance of one meter and 6428 lux at a distance of fifty meters. Transmission of sound With the maximum error value of 38.70% at 125 Hz and the lowest error value of 0.07% at 500 Hz, employing a laser beam with a wavelength of 532 nm yields an output frequency that is near the input frequency.

Acknowledgments

The authors would like to thank the Physics Department Institute of Technology Sepuluh Nopember Surabaya and colleagues who have contributed to completing this research. Hopefully this research can provide progress in the fields of science and technology in the future.

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