The Laser Microphone

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Abstract

The sound waves people generate while talking cause vibrations in the objects around them, thus exposing information about their conversation through mechanical vibrations. We plan to build a laser-snooping device to take advantage of these vibrations, particularly in windows. We plan to bounce a laser off a vibrating window and capture the signal with a light sensitive receiver. The window's vibration will cause the laser's reflected path to change slightly, which the receiver will capture, filter, amplify, and output as an audio signal. A human listening to this audio signal will be able to interpret the conversation.

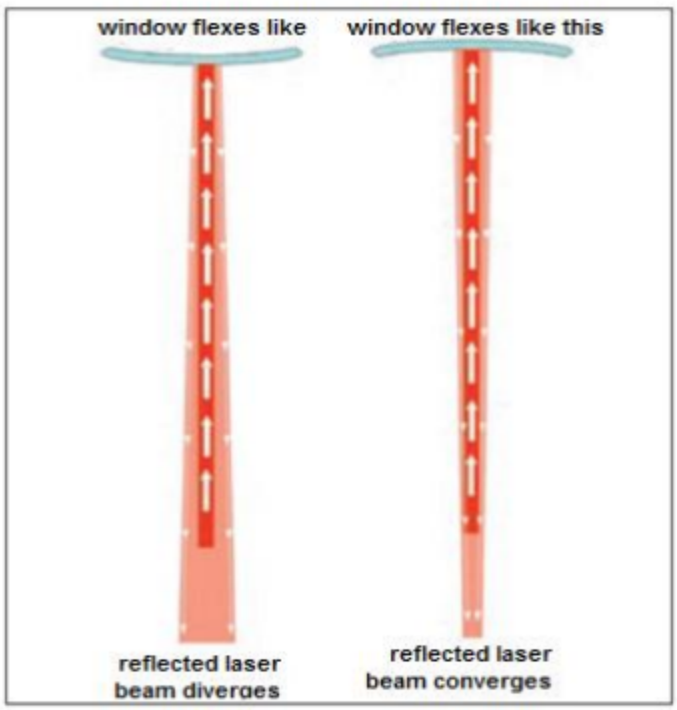
This project could be extended in a number of ways, ranging from implementing modulation in the laser to allow for the output to be less noise sensitive, to designing a controls system to optimize the initial position and angle of the receiver. Another extension would be to encode information in the laser's modulation such that two people could communicate by shooting the laser directly at the receiver.

Project Overview

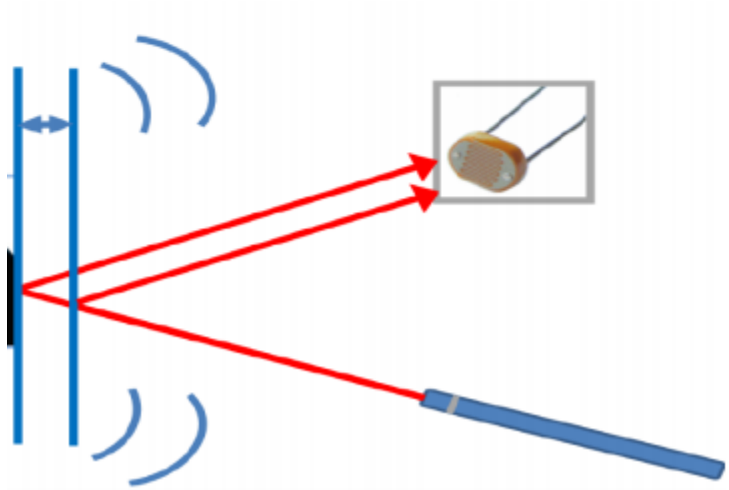
Sound waves generated by human conversation causes the objects around them to vibrate. In our case, we're interested in the vibrations of windows. In order to obtain our basic functionality, we will need to capture these vibrations. It's unknown the amplitude of windows' oscillations, but it's certainly enough to be able to detect.

Our first goal is to attain a basic functionality of the laser snooper; to be able to shoot a laser at a window and output the audio from the room that window is attached to in such a manner that a human can interpret the audio. We will accomplish this by bouncing a laser off the window and placing a receiver to catch the laser reflection. On the transmitting end of the device, we could use any type of laser for this. We plan to use a red laser such that the laser will be visible to allow ease of testing, yet it will still be safe. If we later want to eliminate some of the noise interference that would come from ambient red light, we could eventually use an infra-red laser.

As for the receiving end of the laser, we will use some type of photo-transistor in order to capture the reflected laser. This phototransistor will generate a current of varying intensity as the laser the phototransistor receives changes. There are two key considerations in the intensity of laser the receiver will experience: Firstly, the window's oscillation will cause the beam's reflection to move slightly. Secondly, though we will shoot a cylinder of laser at the window, the laser will scatter somewhat and the reflection will come back as a cone with the intensity of laser decreasing with radial distance from the center of the cone. The result will be that the receiver experiences a moving cone of varying intensity of laser being reflected off the window. This variable intensity can be converted into a current by the phototransistor. This current can then be passed through a transimpedance amplifier to convert the current into a voltage, which can then be filtered and amplified before being put through a speaker. The audio output of the speaker will be human interpretable.



Beam divergence as window flexes



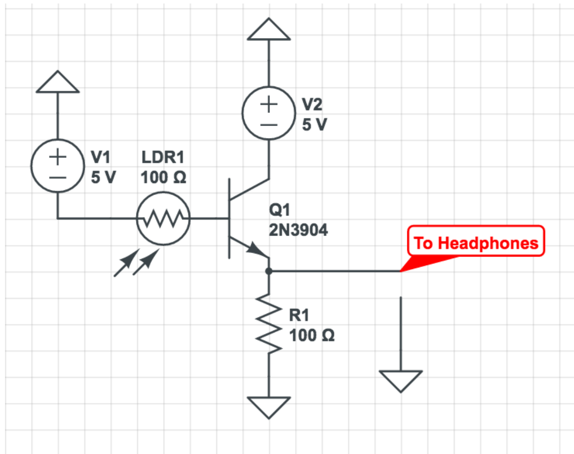
Center of beam shifting as the window vibrates

As a stepping stone to getting to our basic functionality, we will build our circuit and test it in a controlled environment. We will do this by attaching a small mirror to a speaker, playing music on the speaker, and then reflecting a laser off the speaker's mirror and into our receiver. This setup will allow us to test our basic circuit with a controlled input and few confounding variables.

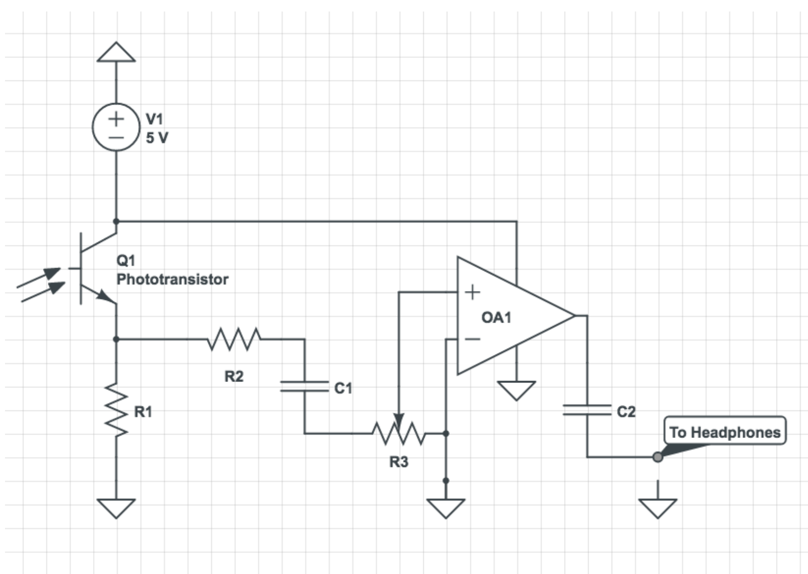
After we have obtained our basic functionality, we hope to be able to improve upon our project. One area in which we could improve is that the output audio will be quite noisy. One way we could reduce noise would be to add modulation to our laser when it's getting shot out, and then demodulate it on the receiving side. This would reduce pink noise from the phototransistor. We would likely implement amplitude modulation for this. We could also switch over to using an infra-red laser instead of a visible laser to minimize noise from ambient light. Another area in which we could improve would be to implement a controls system for a base in order to optimize the initial location and angle of the receiver. This would provide a cleaner signal. Lastly, we could improve upon our project by not only using our device to receive data, but also using it to transmit data. We would do this by encoding the data to transmit in the laser output and shooting the laser directly at the receiver.

Schematics & Block Diagram

1. A basic configuration that will be used to prove that it is possible to detect the small vibrations produced by audio waves against a mirror. Any change at the base of the transistor will amplify the current to the headphones. The changes detected should be directly related to the audio waves causing the vibrations (plus some noise that will need to be filtered out).



2. A slightly more detailed configuration, utilizing a phototransistor rather than a photoresistor, and an LM386 audio power amplifier IC (OA1). The potentiometer will be used for volume control of the output signal to the headphones. The signal is expected to be rather noisy, so noise reduction circuitry such as a 60Hz notch filter and vocal-range band-pass filters can be added to combat this.



Timeline and Risk Assessment Chart Below

https://docs.google.com/spreadsheets/d/1nYruNCNwQX-VUYcKvmtG-c44tkLYOq7BT1ZxelkZSRk/edit?usp=sharing

Flow Chart Below

https://drive.google.com/file/d/0BxliJZObDDULMUZpenl3dk5PVk0/view?usp=sharing

Uncommon Materials

Phototransistor
Laser
LM386 Audio Power Amplifier IC
Helping Hands/Mount
Small mirror
Speaker

References

https://www.academia.edu/13549827/Sound_Waves_Transmission_via_IR_Laser_The_Laser_Microphone_Device?auto=download