Analyzing the Tin-Can Walkie-Talkie

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I. Introduction and Motivation

The "tin-can walkie-talkie" is a staple of childhood tinkering and moms' "creative things to do with your kids" websites. I remember when I was little and made a tin-can walkie-talkie with my brothers. We were mystified by our creation and its ability to transmit our voices from room to room over a cotton string. My classmates apparently were too. When I was first talking about my idea, the general response was "those things work?" To be completely honest, I never really got over just how odd this common creation is. I wanted to figure out how it worked and if there could be an easy way to improve its simple design with different materials through my time in Phys 406.

In the interest of time for the course of the semester, I chose to focus on the transmission cans and string. I built six different walkie-talkies, tested their ability to transmit sound, and analyzed the results.

Image 1) An example of the types of images I encountered while planning my walkie-talkies

II. Method

First, I had to create my test walkie-talkies. After browsing websites for pictures (image 1) and details on creating the most effective walkie-talkies, I assembled a list of six designs I would assemble (table 1). I decided that the most classic design was that of two aluminum cans connected by cotton twine. To replace the cotton twine, I chose nylon and steel. To replace the aluminum cans, I chose plastic and paper cups. I also did a test with the length of cotton twine in the "classic" set doubled. In order to create the devices, I drilled holes into the center of each transmitter end and either tied or soldered the transmission line inside. I chose to make the line 3 meters long because a few of the websites I viewed suggested 10 feet of length.

Transmitters	Transmission Line	Reason for interest
Aluminum Cans	3m Cotton Twine	This appeared to be the most "classic" design for the walkie-talkie and would serve as my "control"
Aluminum Cans	3m Nylon Cord	Nylon cord has a tighter weave and is more substantial than cotton
Aluminum Cans	3m Steel Cable	Steel cable is very solid and more what one would think of when considering a transmission line
Aluminum Cans	6m Cotton Twine	I was interested to see if doubling the transmission length would significantly affect the transmission capability
Paper Cups	3m Cotton Twine	One website told me that paper was a better option. Additionally, I thought maybe the paper would serve as a better diaphragm for exciting the transmission line than aluminum.
Plastic Cups	3m Cotton Twine	Similar to paper, but a different material.

Table 1) Walkie-talkies created and rationale for their creation

To test the devices, we clamped the transmitters 3 meters apart from each other and placed a small speaker at one end (image 2,3). The speaker played white noise. A microphone was placed first at the speaker end of the device in order to control for imperfect white noise from the speaker in data analysis (image 3). Next, a microphone was placed at the opposite end to record the transmitted signal. The data was recorded and then processed for each of the six walkie-talkies to achieve a power spectrum analysis.

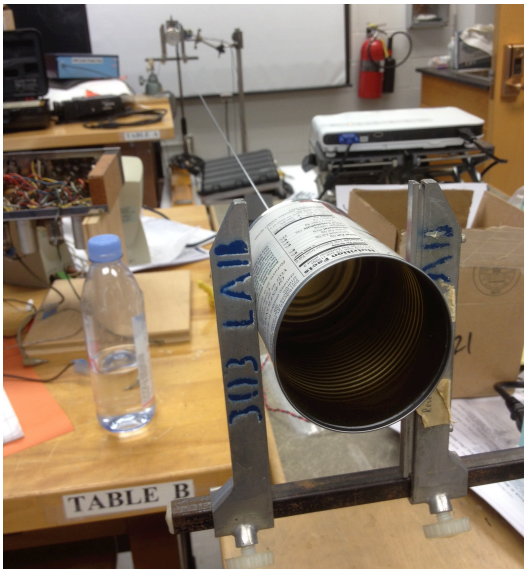


Image 3) Walkie-talkie ends clamped 3m apart

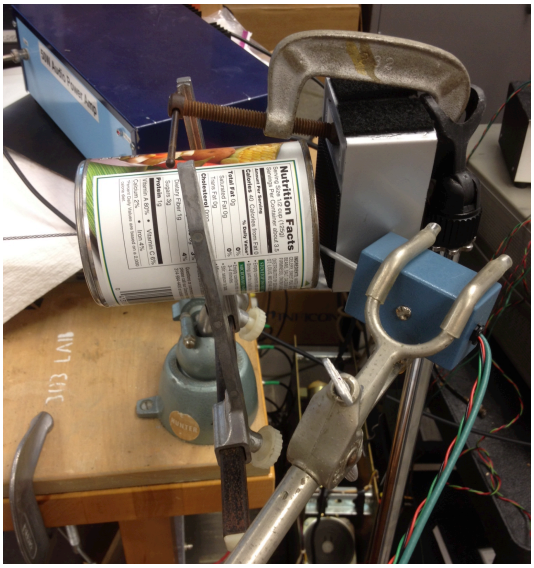
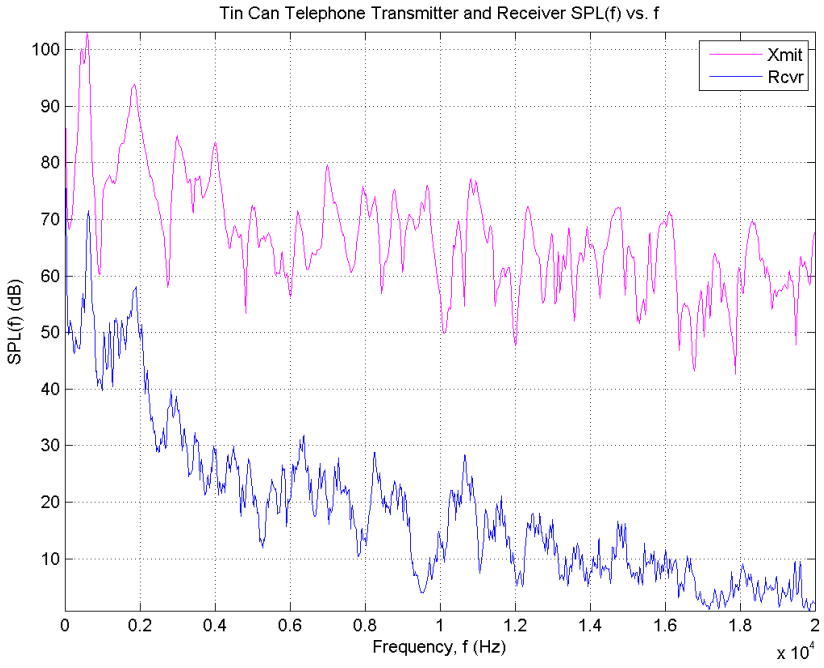


Image 4) Clamped speaker and microphone

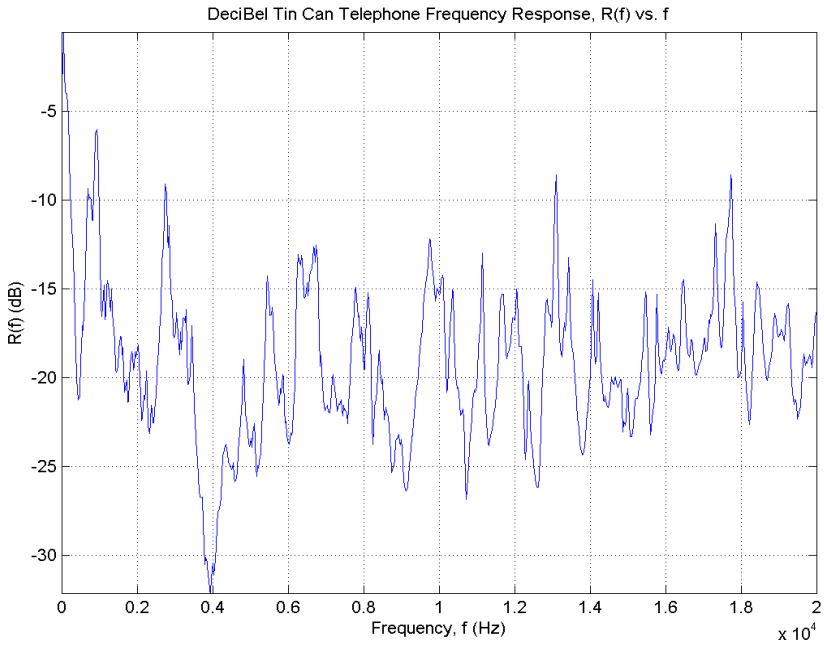
III. Results

From each of the six tests, transmitter and receiver sound data was recorded and analyzed. An example of a graph of transmitter vs receiver frequency response can be viewed in graph 1 below. The data of the two responses was compared to show difference in in power and decibel response (graphs 2,3). Perhaps the most useful and interesting data comes from the percentage decibel response, which

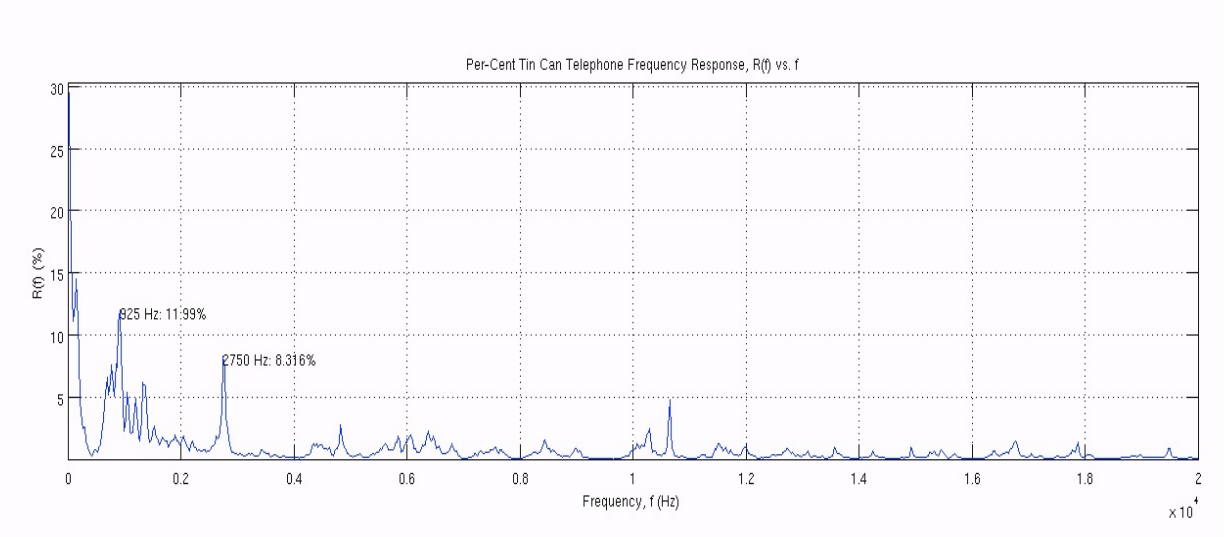
displays the percentage of sound, transmitted by each walkie-talkie (graph 4). The graphs from each of the six tests can be compared to show which were most effective for transmitting at different frequencies.



Graph 1) Transmission comparison of transmitter vs. receiver signal for "classic" case

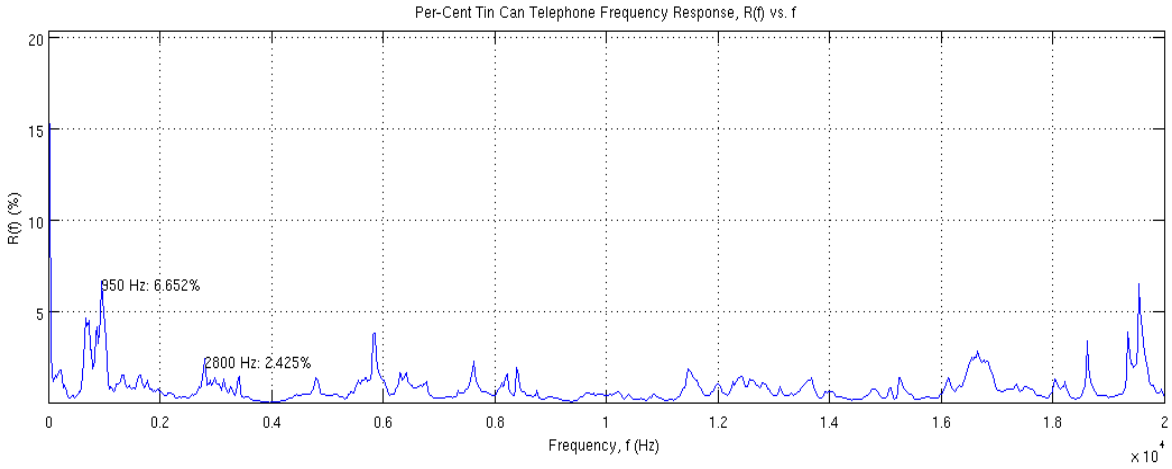


Graph 2) Transmission loss (in decibels) at receiver end



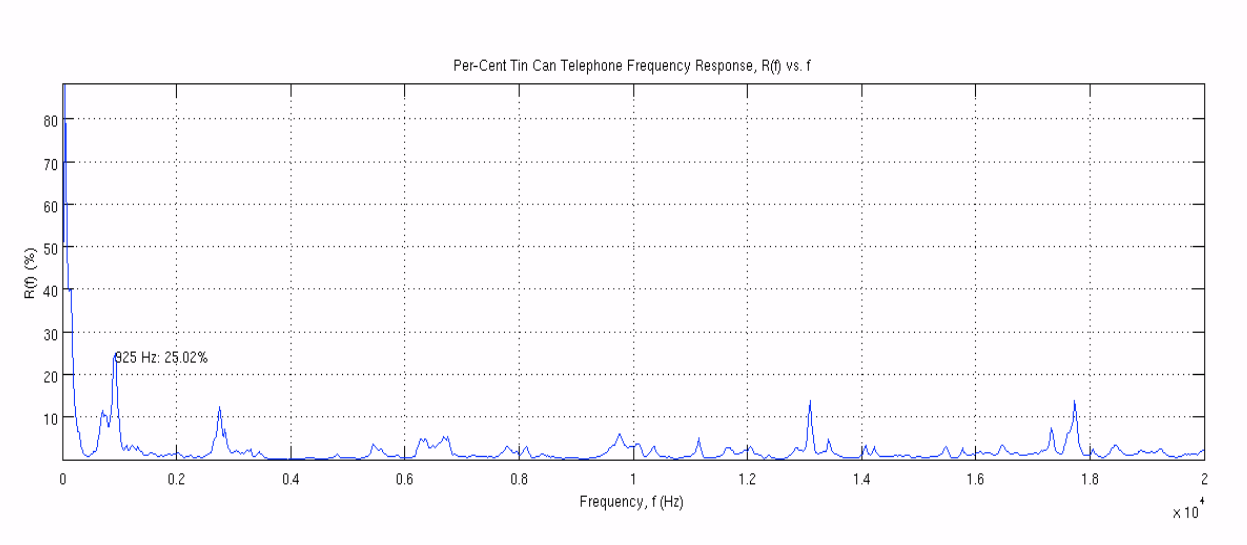
Graph 3) Percent transmission for aluminum cans with 3 meter cotton twine

The response for the "classic" walkie-talkie (aluminum and cotton) displays distinct peaks at 825 Hz and 2750 Hz with 11.99% and 8.316% response respectively, both within the vocal range



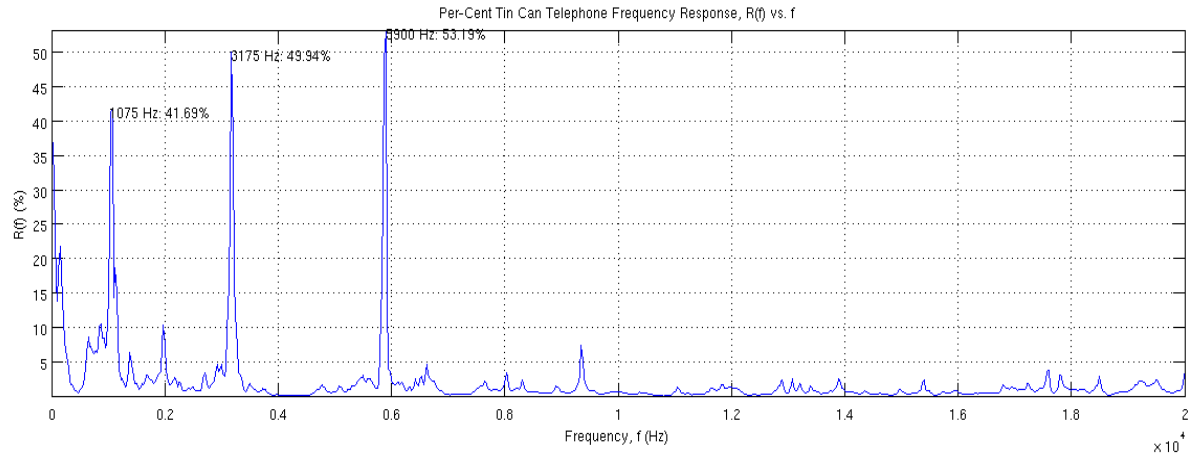
Graph 4) Percent transmission for aluminum cans with 6 meter cotton twine

The test for the 6 meter walkie-talkie was performed at twice the intensity of the 3 meter tests. The data displays peaks at roughly the same places as the 3 meter "classic" test, but with decreased percentages at 6.652% and 2.425%.



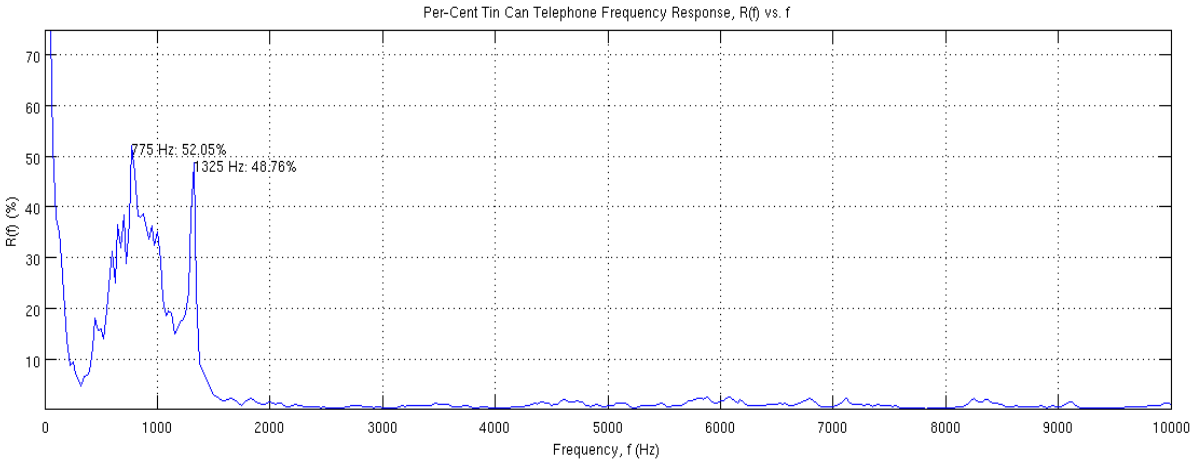
Graph 5) Percent transmission for aluminum cans with nylon cord

The nylon shows peaks at the same frequencies as above (825 and 2750 Hz), but is better able the 825 Hz peak with 25.02% response.



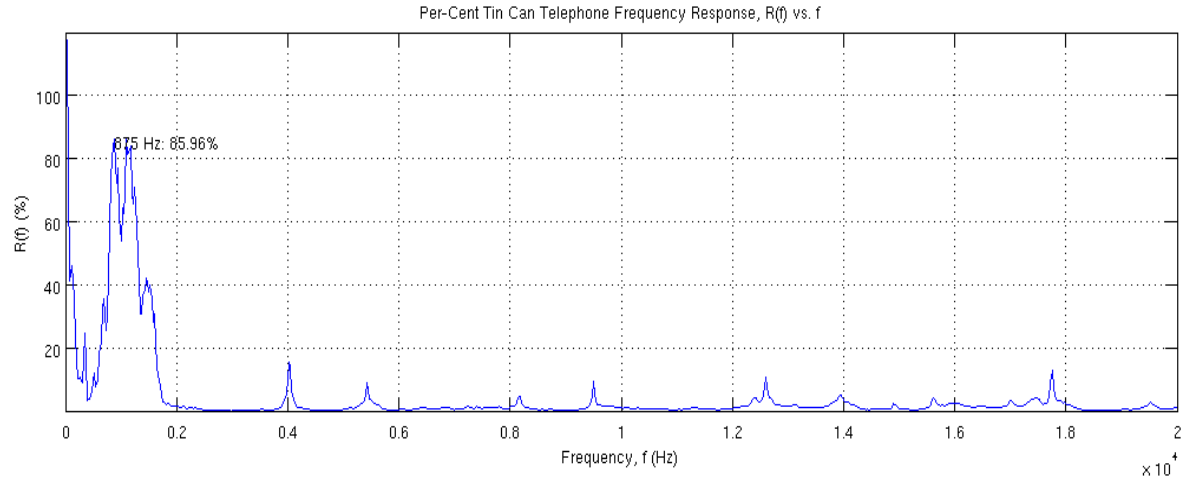
Graph 6) Percent transmission for aluminum cans with steel cable

The steel cable created extremely sharp peaks at 1075 Hz, 3175 Hz, and 5900 Hz with 41.69%, 49.94%, and 53.19% response at each respectively. The peak at 5900 Hz is well outside of the human vocal range.



Graph 7) Percent transmission of plastic cups with cotton twine

The plastic cups display noticeable transmission within the vocal range with notable peaks at 775 Hz and 1325 Hz at 52.05% and 48.76% transmission respectively.



Graph 8) Percent transmission of paper cups with cotton twine

The paper transmitters showed excellent response within the vocal range with a peak at 875 Hz with 85.96% transmission. They include a distinct mound of transmission between 400 and 1800 Hz.

IV. Conclusions

Prior to analytically testing my six walkie-talkie designs, I tested them qualitatively by using them for their designed purpose. In doing so, I noticed quite different effect from each of them: the "classic" case sounded very buzzy and the steel cable made speech sound very monotone and tinny, while the paper cups sounded like a muted voice.

In researching how to determine the "effectiveness" of each walkie-talkie, I found that the human vocal range generally falls between 300 and 3000 Hz and contains a wide breadth of frequencies whenever speaking. For this reason, I decided that an effective walkie-talkie is one that transmits well along a continuum of frequencies between 300 and 3000 Hz.

This explanation of effectiveness explains some of my observations listed above. The steel cable created a very tinny sound because it only translated very select notes within a person's vocal range. It is my assumption that this is because the steel only transmitted signals at select resonances. My initial thoughts about its rigidity being an advantage were disproved. The most effective walkie-talkies were those made from paper, as was suggested by one website I viewed. The paper works as a more effective diaphragm within the 300 to 3000 Hz range, specifically in its "mound" of transmission between 400 and 1800 Hz. It is able to better excite the cotton twine transmission line and create sound for the opposite listener to here.

Further investigation could certainly be performed into how the transmission and reception diaphragms along with the transmission line are excited by voice. A simulated model or more in depth analysis by future physics 406

students would likely be able to gather some pretty neat results into this very odd subject.

V. Acknowledgements

Special thanks to Professor Errede helping test and analyze during the walkie-talkie experiments. The power-spectrum analysis matlab scripts were extremely helpful in gathering meaningful data.