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# Project 99 Mini-Paper: Acoustic Frequency Analysis

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**Abstract**— *Project reports may not exceed two pages.* This report summarizes Project xx: whatever title it is. In this project, frequency content of acoustic signals were analyzed, addressing the main items required for this report: **all formulas listed below, all tables below, all figures missing below, all captions corrected, and a short description of all figures.**

## I. THEORY

The formula for the DFT of an N-point acoustic signal is

$$X[k] = \sum_{n=0}^{N-1} x[n] e^{-j\omega n} \quad (1)$$

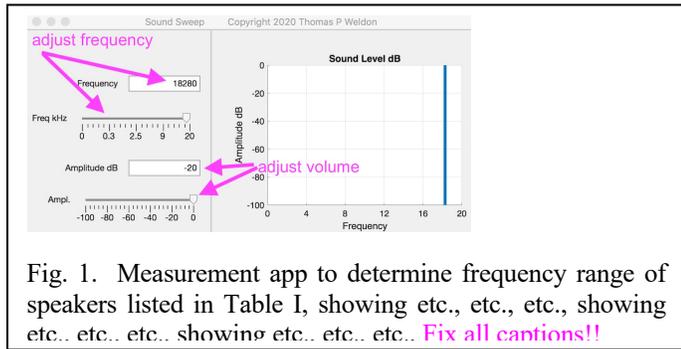
where  $X[k]$  is ???,  $x[n]$  is ??? and  $\omega$  is discrete time frequency in rad/sample. The relationship between continuous frequency and discrete-time frequency is

$$\Omega = 2\pi f \quad (1)$$

where  $\Omega$  is ???,  $x[n]$  is ??? and...

## II. EXPERIMENT 1

In the first experiment, the provided soundSweepApp software in Fig. 1 was used to manually sweep (using the frequency slider or typing into the frequency field) a pair of manufacturer/model speakers and a PC/laptop to determine the low end and high end of the frequency range. Use an earbud microphone or your pc microphone (whichever is best)



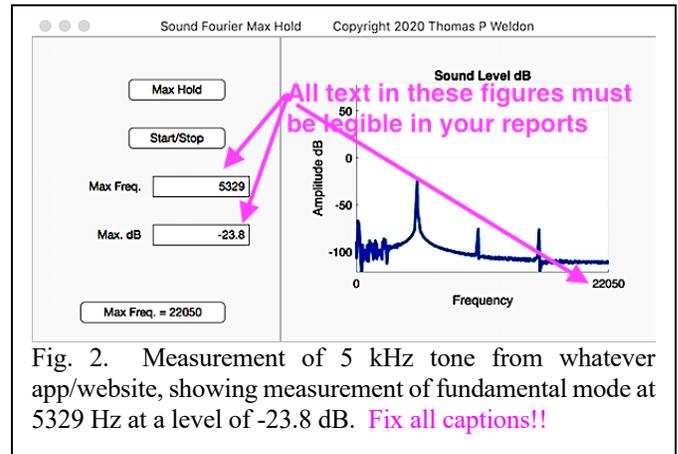
The measurements in Table 1 show the lower and upper limits of audible speaker output, although it is possible that the measurement might have been limited by the hearing limits of the listener.

TABLE I. MEASURED FREQUENCY LIMITS FOR SPEAKERS

Limits	S11 BT speaker	Lenovo x100 laptop
Lower frequency limit (Hz)	144	24
Upper frequency limit (Hz)	13,100	15,987

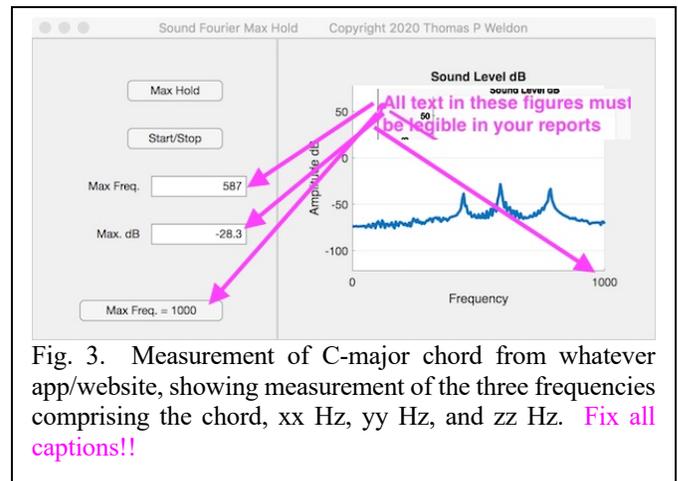
## III. EXPERIMENT 2

In the second experiment, the software in Fig. 2 was used to measure the frequency spectrum of a 5 kHz tone generated using whatever-app (choose a tool such as a cellphone app or online tone generator). As shown in Fig. 2, the tone frequency was measured as 5329 Hz at -23.8 dB level.



## IV. EXPERIMENT 3

In the third experiment, the software in Fig. 3 was used to measure the frequency spectrum of C-major chord generated using a keyboard or whatever-app (perhaps a cellphone app, **it may be easiest to open 3 tone-generator browser windows to synthesize your own chords from 3 tones**). Since the frequencies were so low, the lower frequency range (Max freq" ) was used (**DO THIS so you can see all three frequencies!**)



## V. EXPERIMENT 4

In the fourth experiment, the spectrogram software in Fig. 4 was used to measure the frequency spectrum of whatever (choose something of interest, such as a house fan, truck, song, musical instrument). **Explain the experiment here!**

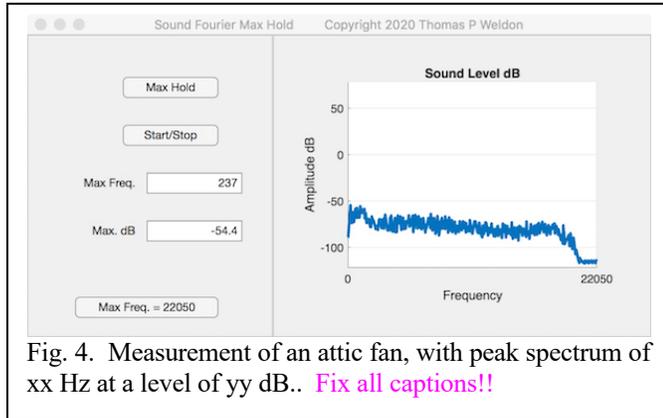


Fig. 4. Measurement of an attic fan, with peak spectrum of xx Hz at a level of yy dB.. **Fix all captions!!**

## VI. EXPERIMENT 5

In the final experiment, a quadratic 1 kHz to 10 kHz 2-second duration frequency chirp (**YOU MUST EDIT THE MATLAB CODE TO DO THIS**) was generated and played on audio. The 2D spectrogram of the frequency chirp is shown in Fig. 5, and a 3D spectrogram is shown in Fig. 6.

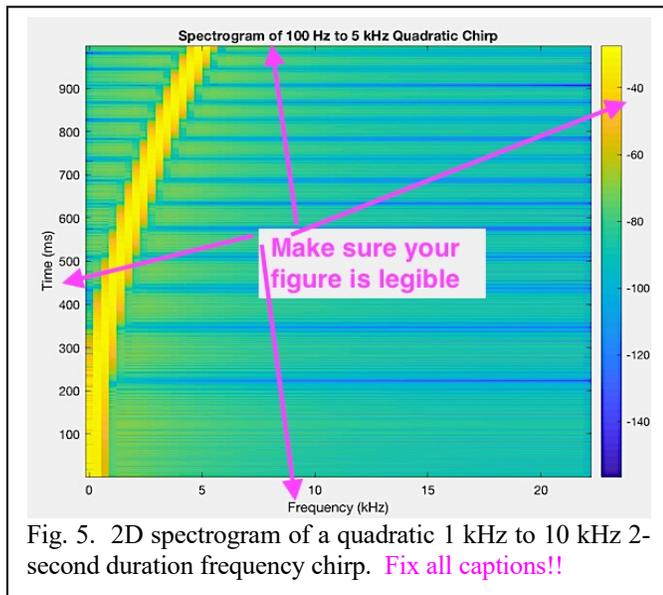


Fig. 5. 2D spectrogram of a quadratic 1 kHz to 10 kHz 2-second duration frequency chirp. **Fix all captions!!**

## VII. DISCUSSION

Discuss any particular issues, especially if you believe your experiment failed or measurements were more than 20% different than theory

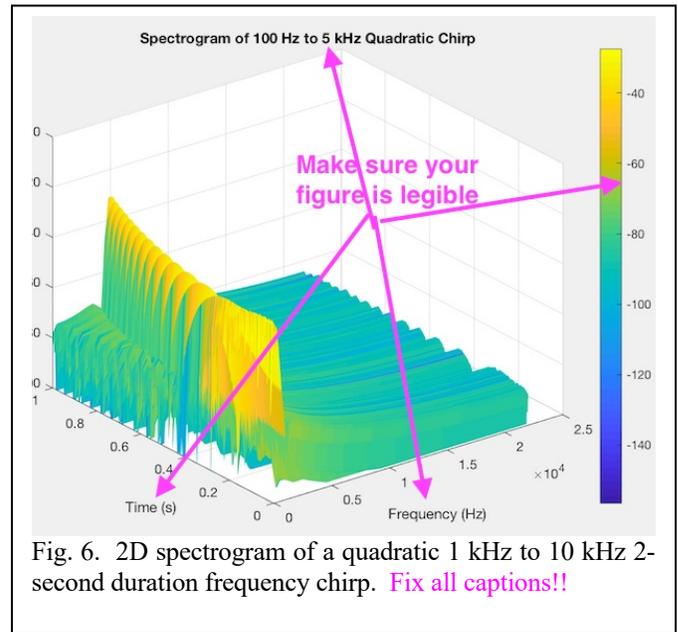


Fig. 6. 2D spectrogram of a quadratic 1 kHz to 10 kHz 2-second duration frequency chirp. **Fix all captions!!**

## REFERENCES

*Not required*

- [1] *FRDM-K64F Freedom Module User's Guide*. [Online]. Available: [http://cache.freescale.com/files/32bit/doc/user\\_guide/FRDMK64FUG.pdf](http://cache.freescale.com/files/32bit/doc/user_guide/FRDMK64FUG.pdf)
- [2] T.P. Weldon, J.M.C. Covington III, K.L. Smith, and R.S. Adams "Performance of Digital Discrete-Time Implementations of Non-Foster Circuit Elements," *2015 IEEE Int. Sym. on Circuits and Systems*, Lisbon, Portugal, May 24-27, 2015.
- [3] T.P. Weldon, J.M.C. Covington III, K.L. Smith, and R.S. Adams, "Stability Conditions for a Digital Discrete-Time Non-Foster Circuit Element," *2015 IEEE Int. Symposium on Antennas and Propagation*, Vancouver, BC, Canada, July 19-25, 2015.
- [4] Wikipedia contributors, "Waveguide," Wikipedia, The Free Encyclopedia, <https://en.wikipedia.org/wiki/Waveguide>, accessed 10 August 2018.