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| **Lab 04: Frequency Aliasing**  MAE 311L - Section 06 |
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# Abstract

This lab allowed the group to experiment with Data Acquisition systems and potential aliasing that they introduce. This is done in order to demonstrate potential issues regarding a poor choice in sampling rates. Overall the experiments showed that a frequency less than the Nyquist frequency, shown in Equation 1, introduces a high potential for aliasing, which makes the recorded data unreliable.

# Background

## Equations

(1)

Where *fNyq* is the calculated Nyquist frequency based on *fs*, the sample rate of the data acquisition system.

Where *f* is the frequency of the item being sampled and *fNyq* is the Nyquist frequency, a frequency greater than Nyquist causes aliasing.

(3)

Where *Δf* is the resolution of the FFT spectrum, *N* is the number of data points and *fs* is the sampling frequency.

(4)

Where f is the frequency of the signal, fa is the aliased frequency, fN is the Nyquist frequency and *n* is a positive integer that makes fa/fN between 0 and 1.

(5)

Where Vamp is voltage amplitude, dBV is log scale representing a conversion from volts.

## Information

This lab will allow for the visualization of an analog signal utilizing a DAQ, or Digital Acquisition system. This requires an understanding of some basic principles shown in the previous equations. The harmonic equation of several types of waves is required in order to understand the relation to the Fourier analysis of their respective functions. The Fourier transform allows for the visualization of the amplitude of the wave along a frequency domain, instead of the usual time.

In order to complete this transformation, the aformentioned DAQ is used. Why the DAQ is notable is due to the sampling frequency of the DAQ. When the DAQ is sampling at an adequate frequency the FFT, or Fast Fourier Transform, should be perfectly accurate, but if it is too low then there is a possibility of aliased data, which would lead to incorrect FFTs.

# **Data**, **Analysis and Results**

## Data and Analysis

For this experiment several different waves were produced and measured using the VirtualBench software. The oscilloscope was attached to the function generator and the software was used to define the characteristics of the waves. Initially a sine wave was setup and alongside it an FFT was displayed. Data available during this setup is available in section 4.1 as answers to questions posed in the lab manual. Information regarding the inital waves is also shown in Table 1.

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| Frequency (Step 3) | 200 kHz |
| Frequency (Step 4) | Not Shown (too little resolution) |
| Number of Data Points (Step 4) | 794 |

Table 1: Display Aliasing

After this was completed the data was collected for a series of sine, square and triangle waves at specified conditions. The data was stored in several csv files and due to its notable length is not included in this report, however the data collected is generally as expected, given the generated functions and sampling frequencies.

Following this, data was collected for several waveforms with a variation of .01 kHz between 250.02 and 249.98 kHz. Initially the same setup was tested at 250 kHz 5 times. This showed a variation in waveform voltage, which shows aliasing as a potential problem with this setup. The data collected for the waves is shown in Table 2. Overall this data makes sense, as it shows an expected aliasing issue with the collected data.

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| Frequency(kHz) | Peak Frequency(FFT, Hz) | Frequency (Hz) |
| 250 | 159.4 | 10 |
| 250.01 | 156.99 | 10 |
| 249.99 | 164.21 | 10 |
| 250.02 | 164.21 | 20 |
| 249.98 | 163.18 | 20 |

# **Questions**

## VirtualBench Setup Questions

1. *Move the red vertical cursor around. What does this do? Determine what are the time/division and the voltage/division?* 
   * The red cursor allows one to find values of the red graph, which follows the time domain. The Time/Div is 2 microseconds/ and the mV/Div is 500/.
2. *Move the purple vertical cursor around. What does this do? Determine what are the frequency/division and dBV/division?* 
   * The purple cursor operates like the red one, but along the frequency domain. freq/div is 500kHz and dBV/div is 20/.
3. *Click on the stretched out sine wave button under the “Time/Div” and note of what happens to the waveform and the FFT each time you reduce the time/division.* 
   * Clicking the stretched wave decreases the time/div, thus zooming in on the wave.
4. *What is the peak value of the FFT in dBV? What is the peak FFT frequency? What is the frequency listed in the “Waveform Measurements” area? (You may have to change the Time/Div to see the frequency and period values in the “Waveform Measurements” area.)* 
   * The peak dBV is -1.9 dBV at -200 Hz. The frequency is 200 kHz.
5. *Click on the compressed sine wave button and note of what happens to the waveform and the FFT each time you increase the time/division above “100 µs/”.* 
   * The waveform becomes more compressed, until eventually becoming a rectangle.

## Overall Questions

1. *In Procedure 3.2.4 you recorded the peak value of the FFT in dBV. What is this value in volts? What are some reasons that the calculated value in dBV is different from the known amplitude of the signal from the function generator? Explain any differences?*
   * Using equation 5 you can find the amplitude to be .804V. Potential reasons for the discrepency could include the offset and that it may be finding around half of the amplitude.
2. *In Procedure 3.3.4 you collected a waveform file. Calculate the aliased frequency and compare this to the approximate frequency you measured in Procedure 3.3.4.*
   * Using the maximum FFT value the frequency is 195.4 kHz. This is certainly within reason for the expected value of 200 kHz.
3. *In Procedure 3.4.5 you collected a waveform file. What was the zero frequency amplitude in dBV? What is this value in Volts? Is the FFT voltage consistent with the DC offset of the function generator? Explain any differences?*
   * -1.7967 dBV, .8131V. the FFT voltage is equivalent to the offset, with only a 1% difference.
4. *What aliased frequency would you expect to measure in Procedures 3.5.6 through 3.5.9? Is the “Waveform Measurements” frequency or the FFT frequency more accurate? Why is it more accurate?*
   * The expected value would be around .8 V. The FFT frequency would be more accurate as the one displayed in the program suffers from aliasing when displaying the frequency.

# Conclusion

Overall, throughout all of the experimentation exepcted values were generally found. The experiments conducted include several sine waves and their data being measured at both aliased and unaliased frequencies. This allowed for the visualization of potential problems associated with aliasing.

# References

1. Armentrout, D., “MAE 311L Lab 4: Frequency Aliasing,” Lab Manual, MAE Dept., Univ. Alabama in Huntsville, 2017.