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Milestone 3 Report

Integrated Design Project (Audio Direction Finding)

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Objective

The objective for this milestone is to generate an equation for the angle between the microphones and the speaker. Another goal for this week was to implement this equation into code and incorporate the code into the hardware part of our project.

Results and Analysis

Figure 1

This figure shows the system of the two microphones and the speaker. Even though Mic 1 (M1) is closer to the speaker the signals obtained by both microphones should have an equal amplitude but should have a delay in time. The time difference between these two microphones will be represented by T. Therefore, the signal captured by M1 is S(t) and M2 is S(t-T).

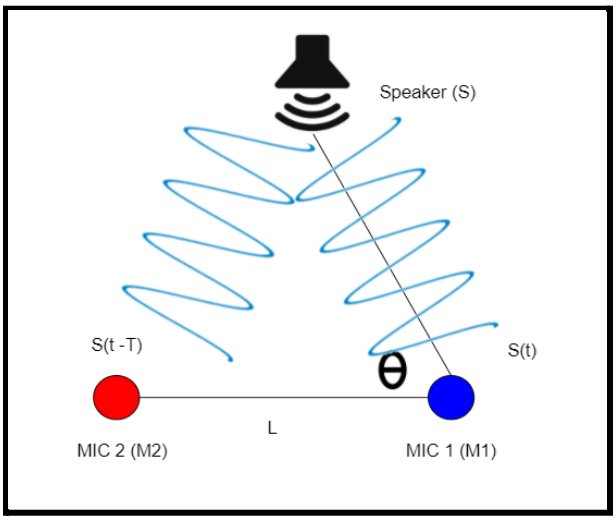
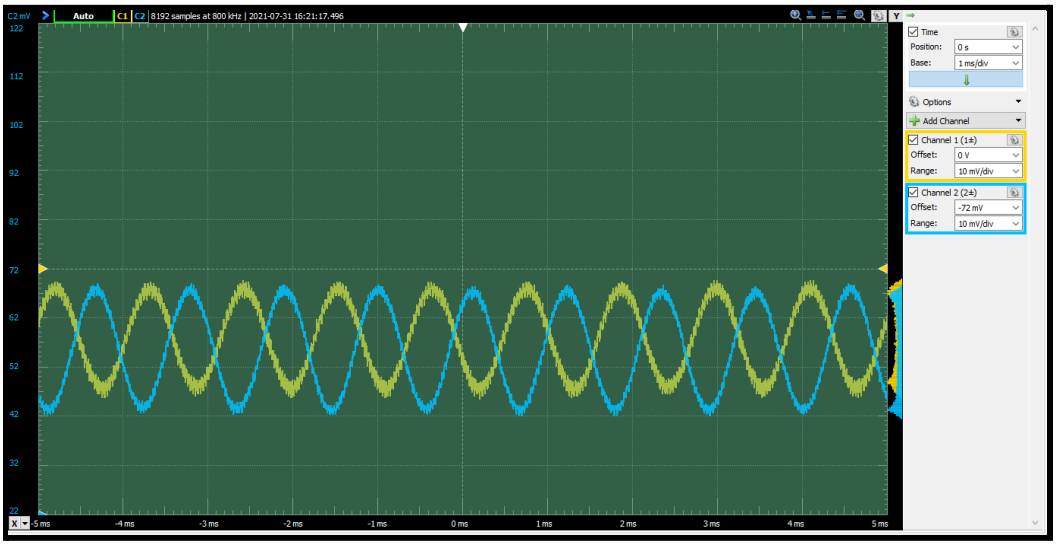


Figure 2



From the two microphones, figure 2 shows the phase and time difference between the two signals when the speaker is playing a 900 Hz tone.

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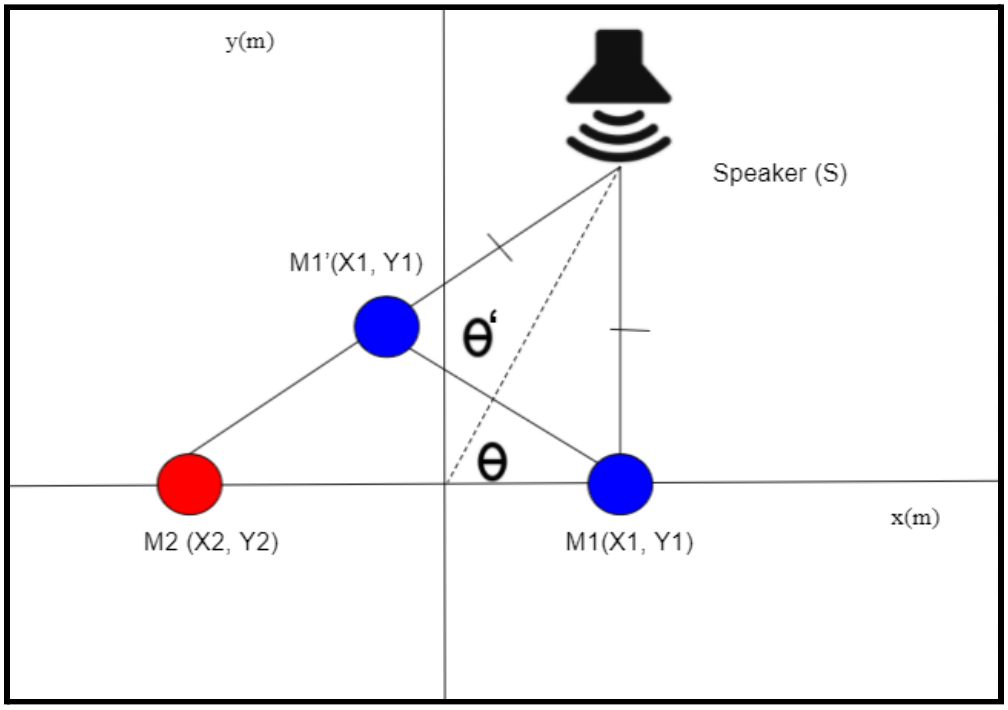
Figure 3



We will use figure 3 to calculate the y coordinate of the speaker.

$\overline{M2M1'} = \overline{M2S} - \overline{M1'S}$

$y_2 = y_1 = 0$
$x_1 = x_2$

$\overline{M1S} = \overline{M1'S}$

$\overline{M2M1'} = \overline{M2S} - \overline{M1S}$

$\overline{M1S} = \sqrt{(x_1 - x)^2 + (y_1 - y)^2}$

$\overline{M2S} = \sqrt{(x_2 - x)^2 + (y_2 - y)^2}$

$(\overline{M2M1'})^2 = (\overline{M2S} - \overline{M1S})^2$

$= \overline{M2S}^2 - 2(\overline{M2S})(\overline{M1S}) + \overline{M1S}^2$

$\overline{M2S}^2 = (x_1 - x)^2 + (y^2)$

$\overline{M1S} = (x_2 - x)^2 + (-y^2)$

$\overline{M2S}\,\overline{M1S} = \frac{T \cdot S}{f_s}$

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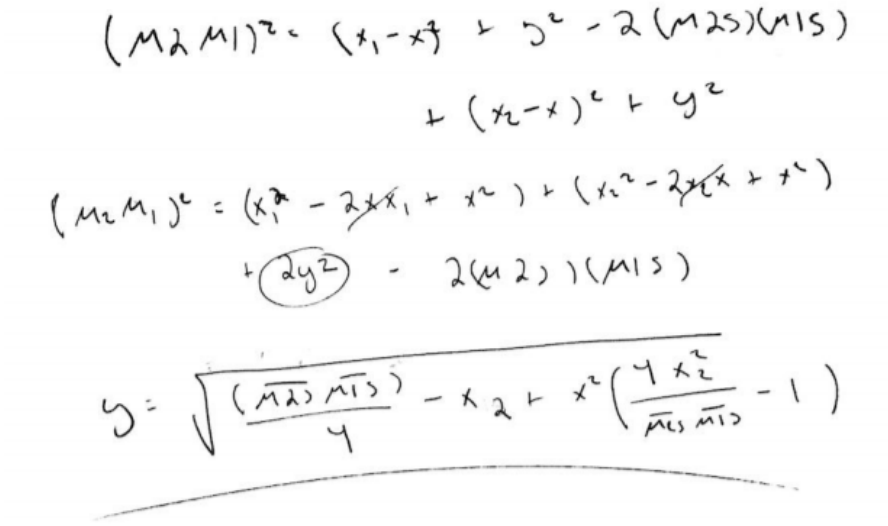
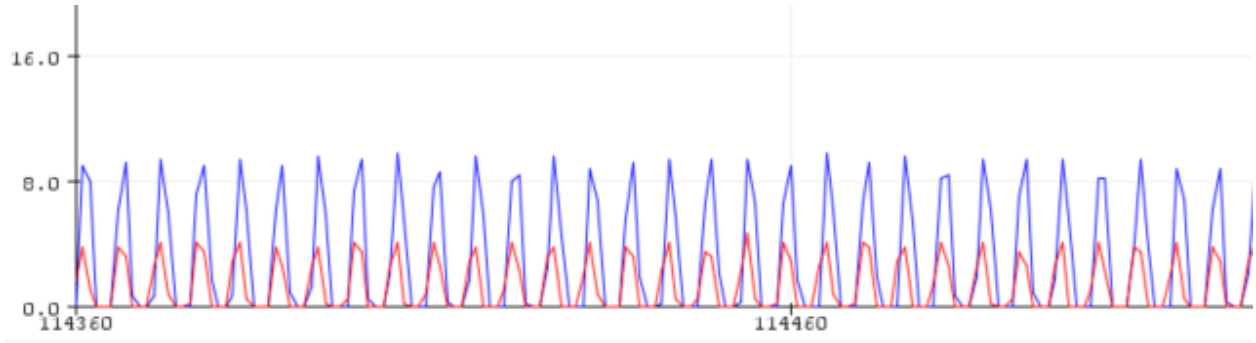


$$y = \sqrt{((M_2S)(M_1S)/4 - X_2 + X^2((4X_2^2)/(M_2S)(M_1S) - 1)}$$

At the end of the calculation, we get the formula above for the y-coordinate of the speaker.

Real Testing



We tested the circuit on the arduino and recorded the output of the circuit using the arduino serial plotter. We used a very high baud rate to make sure no data was lost. We can very clearly see that when the source is placed in line with the 2 mics, the phase angle looks to be 0 since the peaks are aligned.

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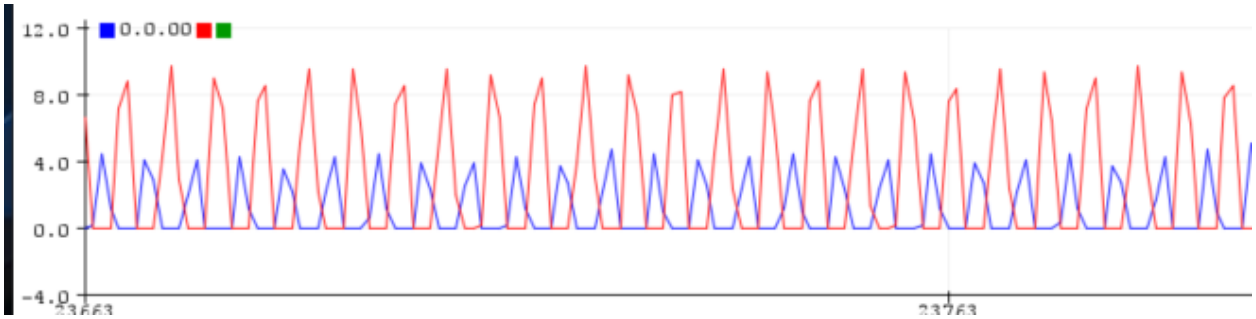
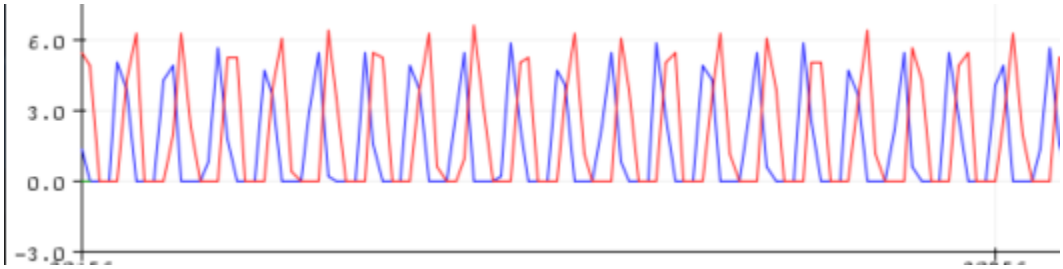


We then placed the source at the other end of the line and we saw that the peaks were opposite each other showing that they were 180 degrees apart which is exactly what we wanted.



Placing it at 90 degrees (in between the 2 mics) showed a 90 degree shift (the blue signal peaks when the red signal is about to rise, and the red peaks when the blue reaches 0). This means that we could find the angle of the source directly by finding the phase shift in the signal. This also means that for the particular setup we have, the distance between the 2 mics, and the speed of sound is entirely irrelevant.

We are not sure why this works, or if I am interpreting this data incorrectly, but right now it seems like its working better than expected. However, once more code is programmed, this might change since more code might change certain aspects of the speed of the program which could affect the phase of the plots.

Plans For Next Week

The plan for next week is figuring out how to sample and find the phase through the Arduino. We still need to code and finish the calculations.

Author Recognition
Jeff Kedda - Y coordinate calculation and phase difference between the two microphones
Saksham Goyal - Real circuit testing with arduino and plotting data from arduino output.