Senior Project – Electrical Engineering–Class of 2018

Microphone Phase Detector and Indicator

Parker Foresman

Advisor – Prof. Catravas

Abstract

When recording music using multiple microphones, the sound quality may be limited due to phase cancellations between microphones. These cancellations occur due to differences in microphone distance from a common sound source. When the positive and negative portions of a sound signal are added together, cancellations at certain frequencies can occur, resulting in a dull sounding recording. Using phase correlation hardware, this project aims to give audio engineers an indication of any phase cancellation problems that may be present in a recording setting prior to recording an instrument. By doing so, the device will assist the user in obtaining quality sounding recordings.

Goals

- Accurately detect the phase of multiple microphone signals relative to a reference microphone
- Indicate any "out of phase" signals to the user
- Provide easily readable results for both simple and complicated signals
- Allow for easy portability

Design and Implementation

In order to increase the miniscule signals generated from the microphones, simple microphone preamplifiers were implemented. These amplifiers raised voltage levels from ~10mVpp to ~1.3Vpp to allow for proper phase correlation reading.

For the phase correlation circuits, three stages of signal processing were utilized. The first stage contained high gain clipping amplifiers that essentially converted both input signals into square waves of equal amplitude (±12V). By converting these signals to square waves, the exact zero crossings of the waveforms relative to one another could be seen. The second stage contained an integrated circuit that took the XOR of the two new signals, outputting a single 0-12V square wave. The third stage was a low pass filter that acted as a moving averager, taking the output of the XOR stage and converting it into a constant voltage level based on the PWM of the square wave. This DC voltage acted as the input to an LED controller and determined the height of an LED bar display. Figures 1 and 2 below show the implemented circuitry and the completed device, respectively. The implemented circuitry contains 5 preamplifiers (one for a reference microphone) and 4 phase correlation circuits.

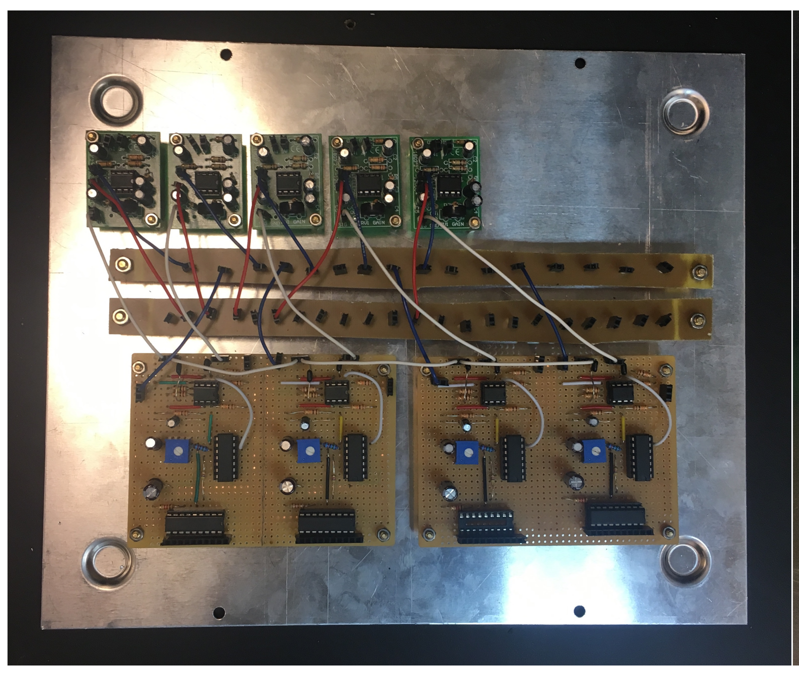

Figure 1: Implemented circuitry

Figure 2: Completed Device

Results

The device was able to accurately detect the phase difference between microphone signals and the LED bar displays properly indicated the magnitude of phase cancellation with ease of interpretation. Testing of each circuit stage took place for sinusoidal signals with varying phase shifts and for complicated signals captured by microphones.

Figures 3, 4, 5, and 6 show an example of the signal flow through the correlation circuit (from left to right) for a pair of 1kHz sine waves with a phase shift of 90 degrees apart. It can be seen that the resulting output voltage is a constant 6V signal. This resulting voltage lies halfway between the bottom end (0V) and top end (12V) potential outputs, indicating a phase shift halfway, or 90 degrees, out of phase.

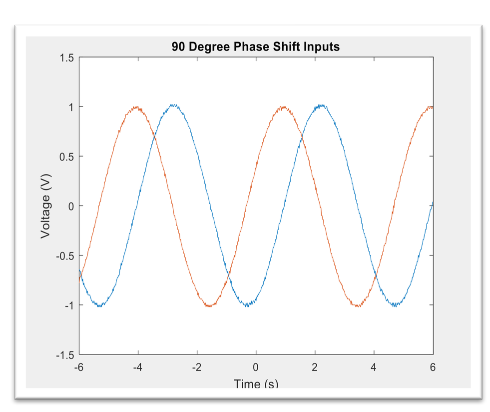

Figure 3: Input Waveforms

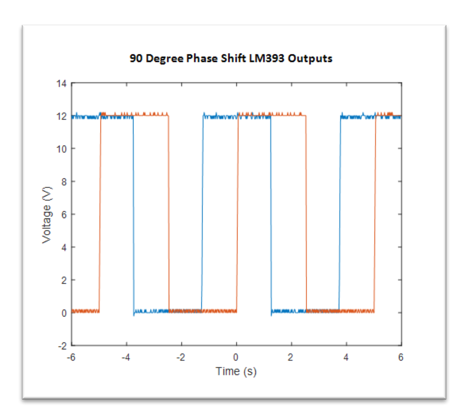

Figure 4: Waveforms after high gain clipping amplifiers

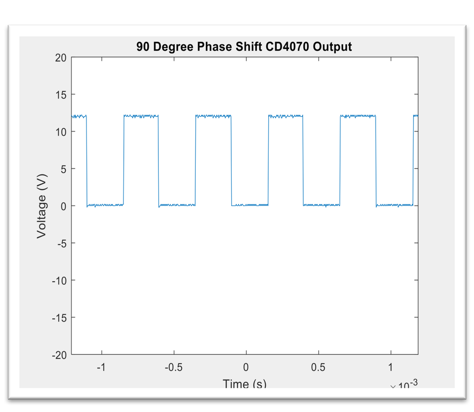

Figure 5: XOR resulting waveform

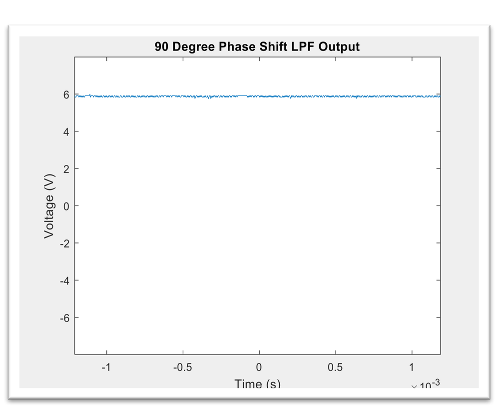

Figure 6: Circuit output

Figures 7, 8, 9, and 10 show the signal flow of a much more complicated waveform monitored with two microphones which varied by 6 inches away from a common sound source. Although this data is much harder to interpret, the device successfully outputted a single DC voltage that varied with differences in phase. In this case, the output voltage can be seen as 9.33V, indicating a generally in-phase signal.

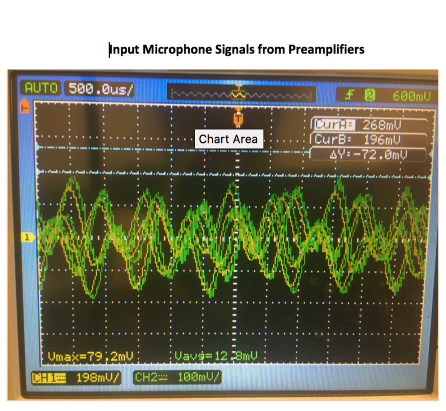

Figure 7: Input Waveforms

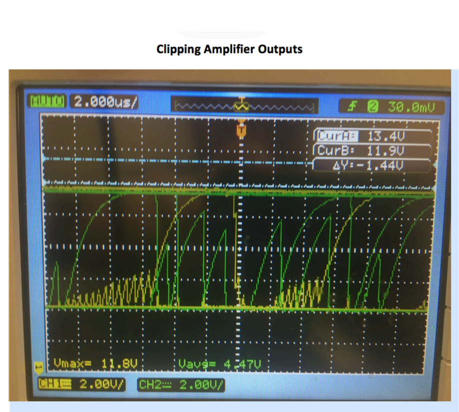

Figure 8: Waveforms after high gain clipping amplifiers

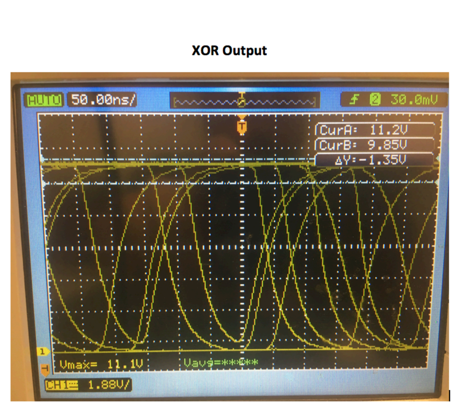

Figure 9: XOR resulting waveform

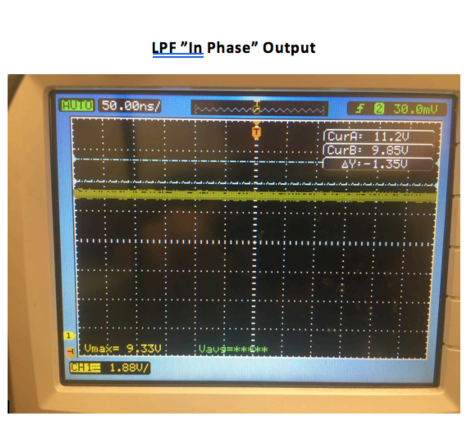

Figure 10: Circuit output

Future Work

Future work will include more in depth testing with live instruments as well as testing with all five input microphones. Testing the full functionality of the device with different instruments in multiple different acoustic settings is imperative to fulfilling the initial goals of the project. Other future work may include implementing this technology into an audio interface to allow for phase indication directly before or even during recording.