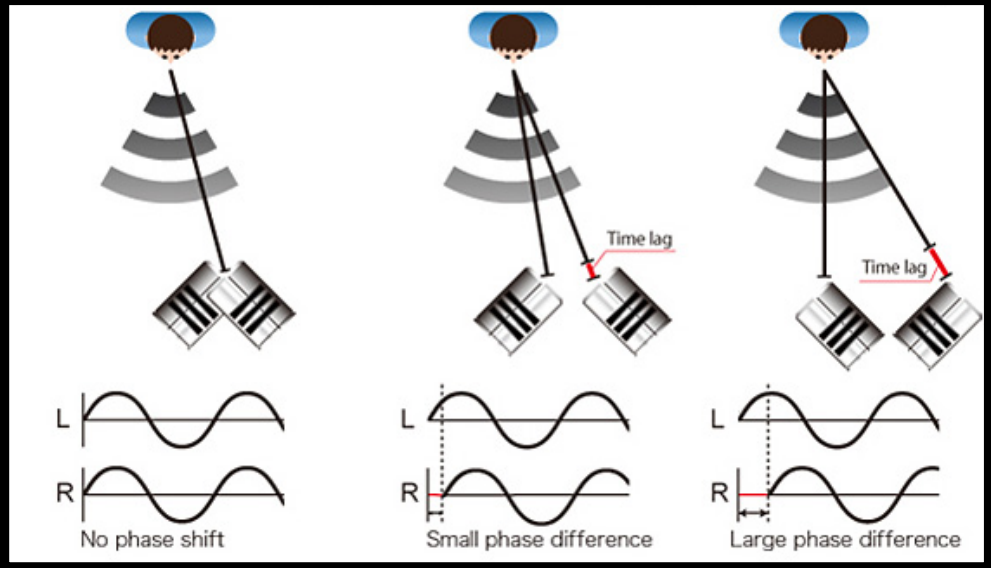
MICROPHONE PHASE DETECTOR AND INDICATOR

Parker Foresman

PHASE IN CONTEXT

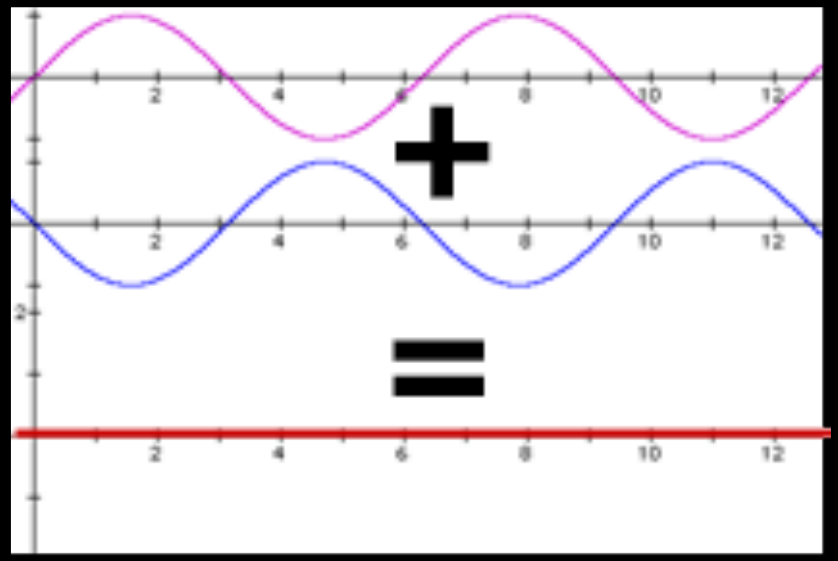
- Defined as the **time delay** of a given signal from a reference signal
- Microphones at varying distances from a common source result in differences in signal phase
  - Due to slight time lag



THE PROBLEM

- When recording using multiple microphones, "out of phase" signals can cause phase cancellations
  - Positive and negative portions of the waveform cancel each other out
  - e.g. 400Hz sinusoid recorded by microphones about 1.5' apart

- Phase cancelations between microphones can cause dull sounding recordings



GOALS

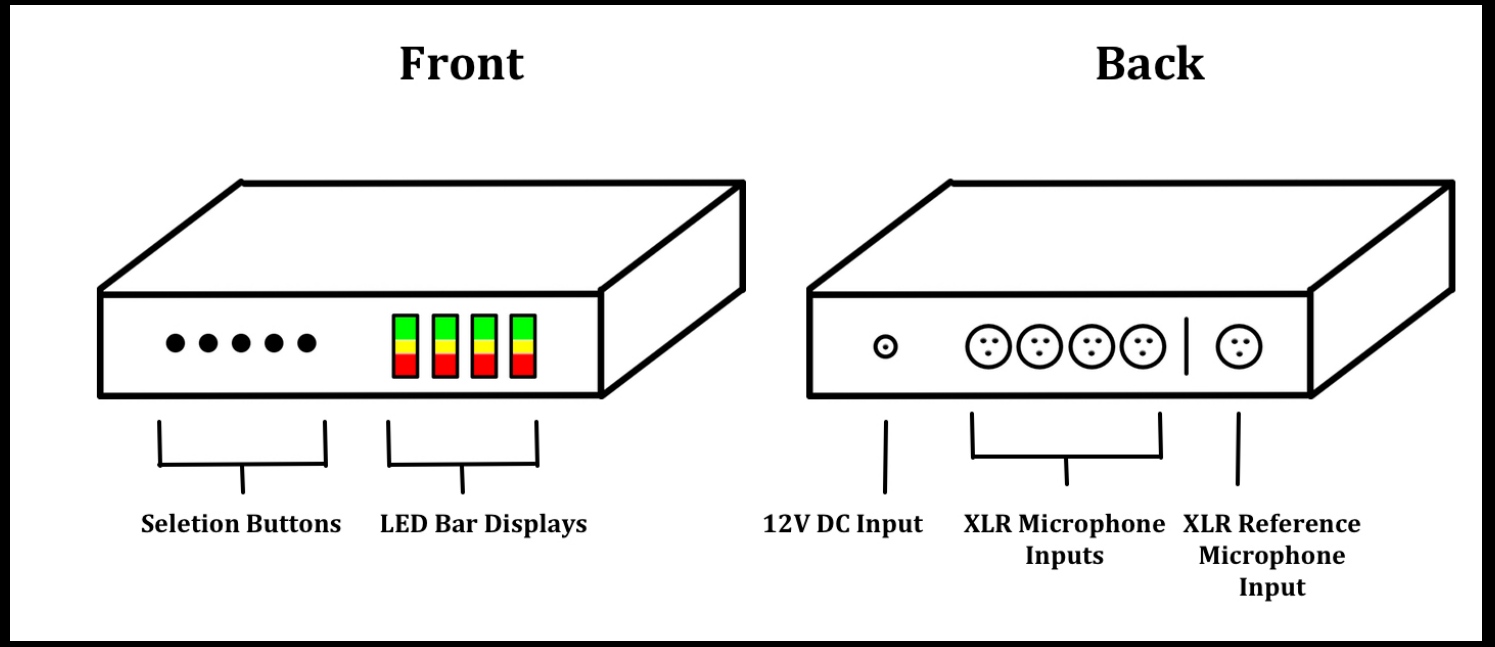
- Accurately detect the phase of multiple microphone signals relative to a reference microphone
- Indicate any “out of phase” signals to the user
- Would allow for an optimized multi-microphone setup
  - Minimum phase cancellation between microphones
  - Better quality recordings or live mix
- Would be used by amateur or professional audio engineers to help achieve full sounding recordings

PERFORMANCE CRITERIA

- Detect phase difference with less than 5% error
- Indicate the magnitude of phase difference between inputs
- Indicate all phase differences with a turnaround time of less than 20 seconds
- At least 5 XLR inputs
- Powered by line voltage w/transformer
  - 12V DC
- Less than $300
  - To allow for amateur use
- Around 8”W x 6”D x 2”H
  - Small enough to easily transport

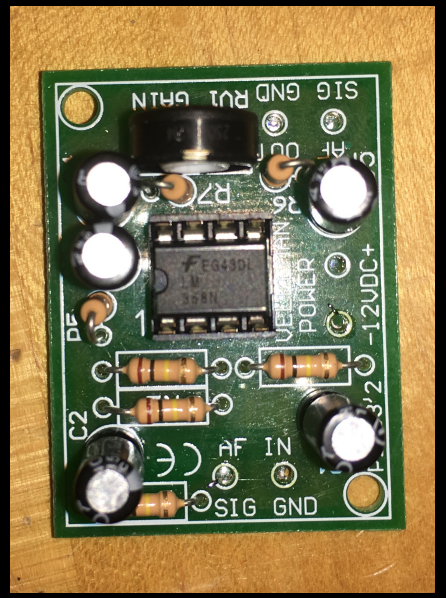
IMPLEMENTATION

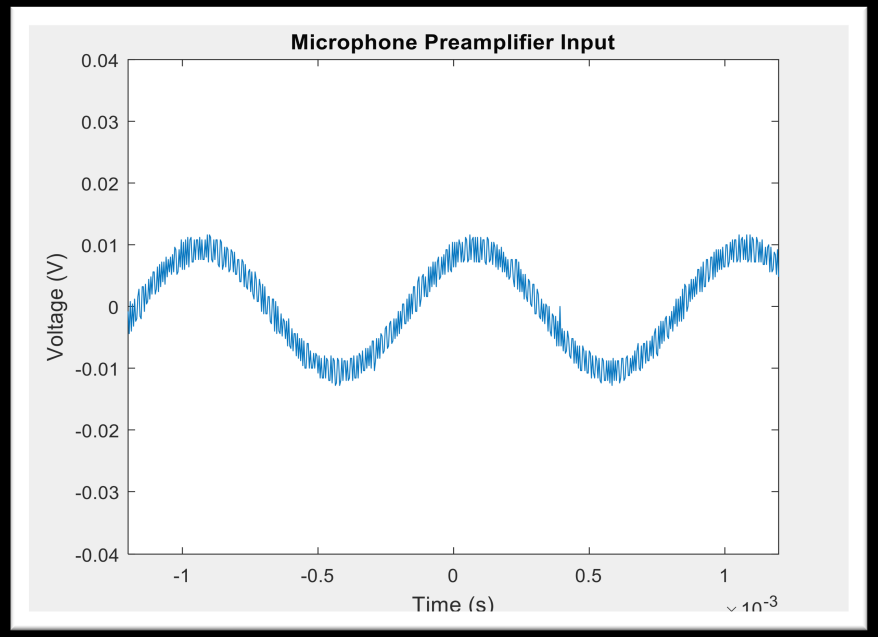
- 5 XLR inputs and 5 microphone preamplifiers
  - One reference input
- 4 phase correlation circuits
- 4 LED bar display indicators
- ON and selection Buttons

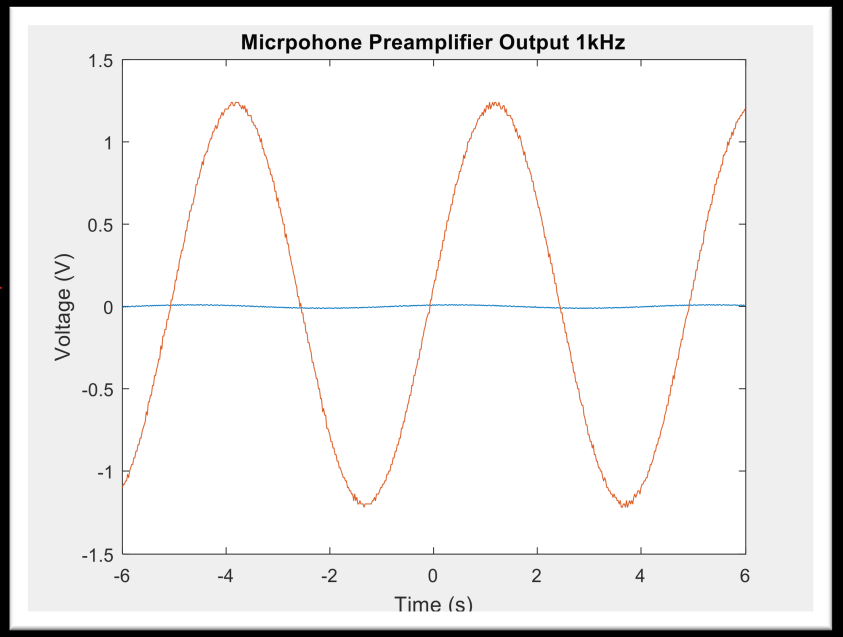


PREAMPLIFICATION

- To raise small microphone voltage level for proper reading
- Velleman K1803 Preamplifier Kit

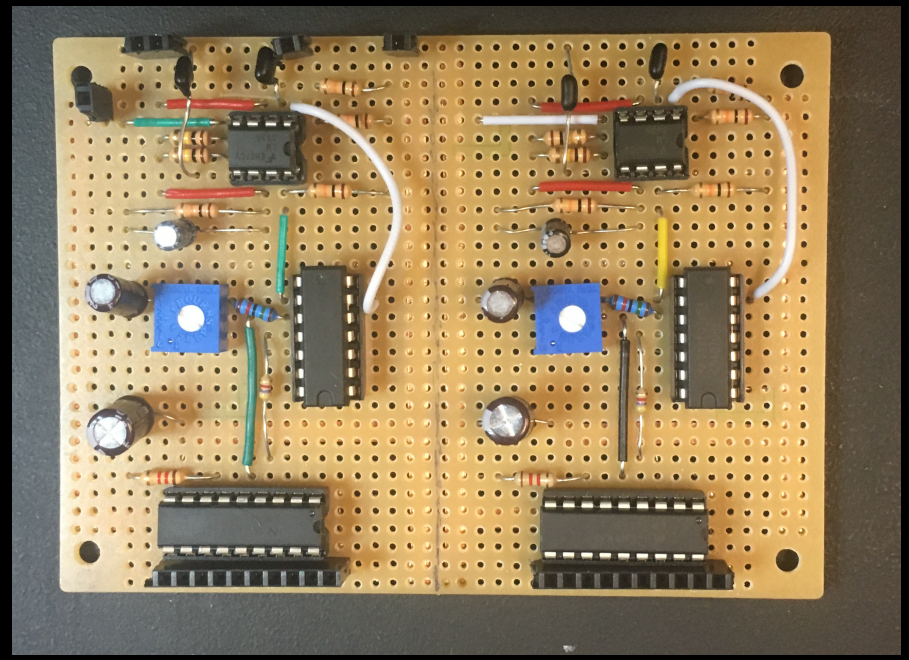




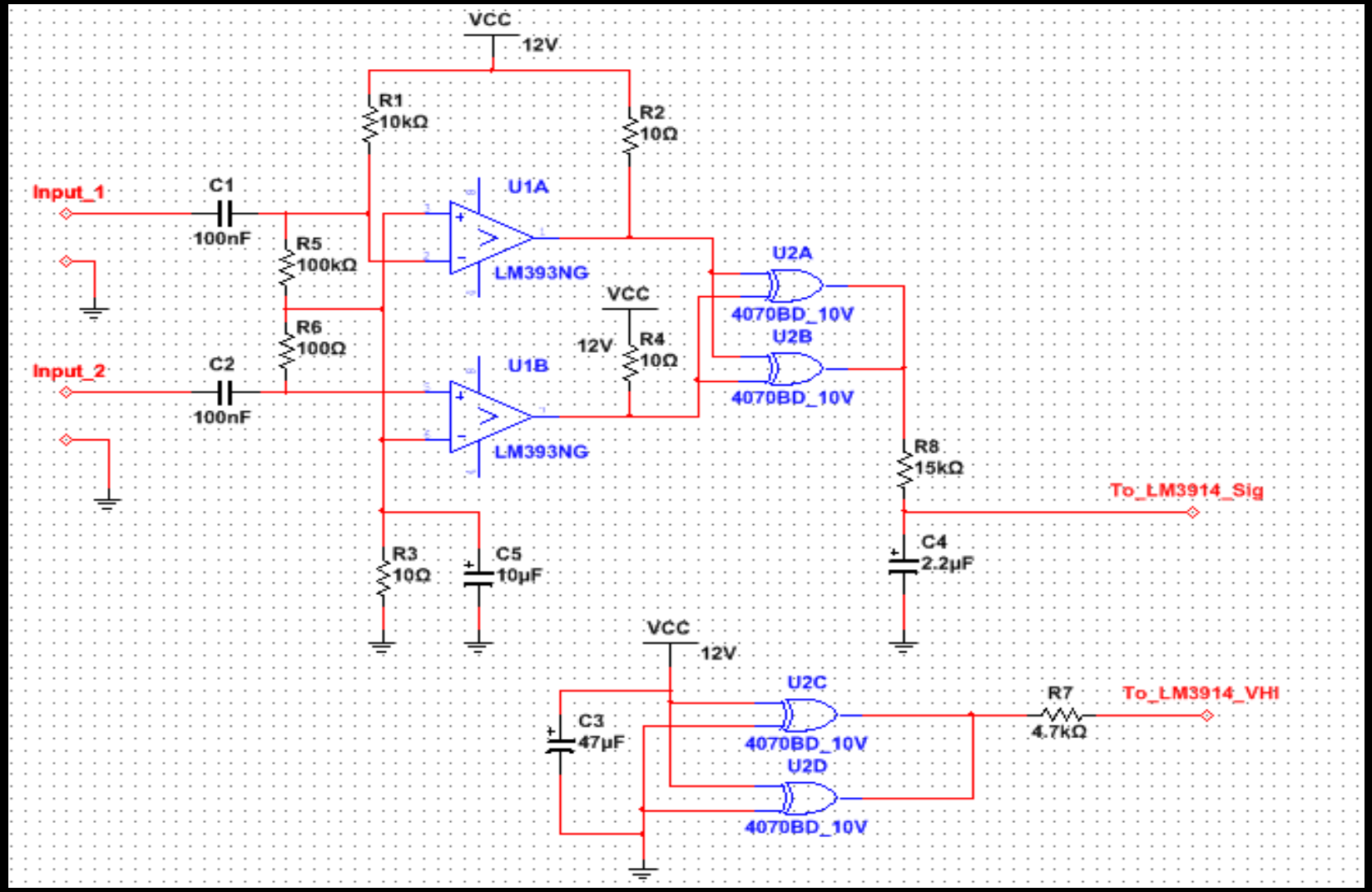


PHASE CORRELATION CIRCUIT

- Adjusts output voltage relative to phase difference between input signals
- Uses high gain clipping amplifiers, XOR gates, and a low pass filter
- Output voltage is sent to an LED controller

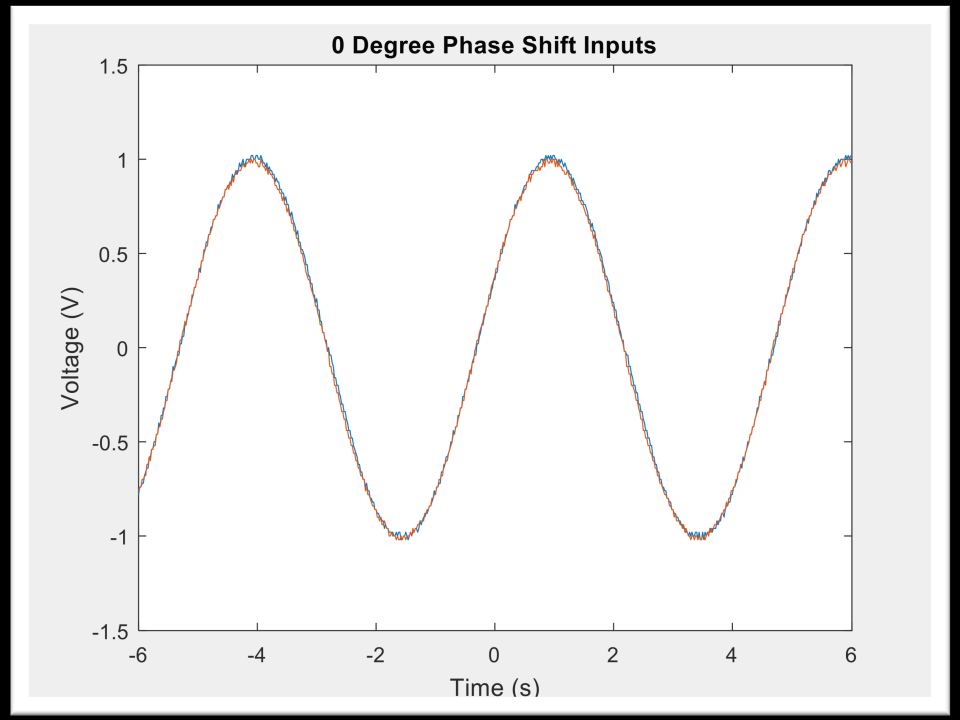


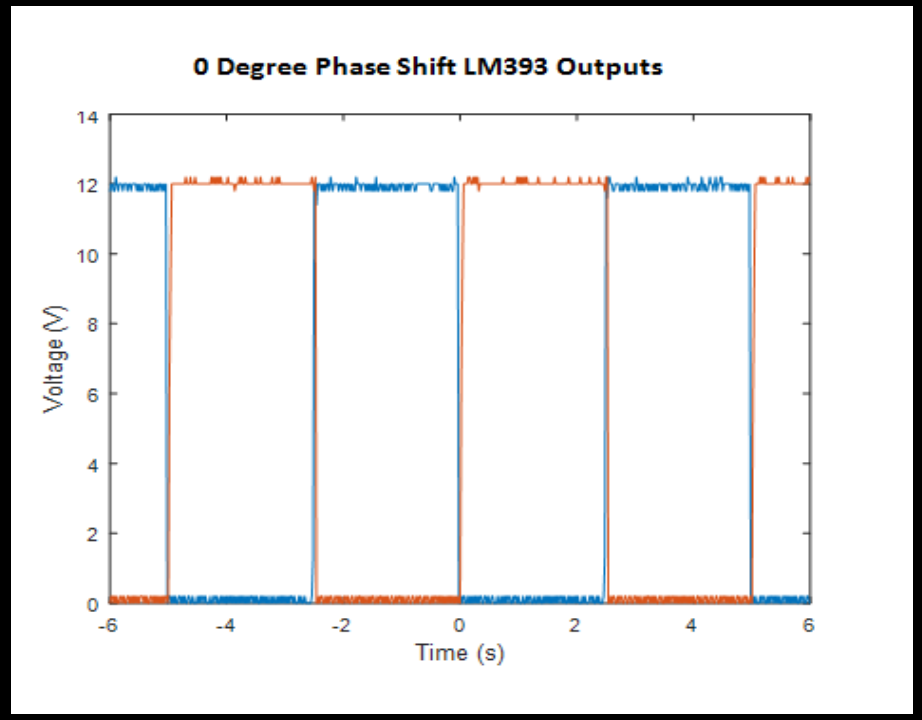
Schematic

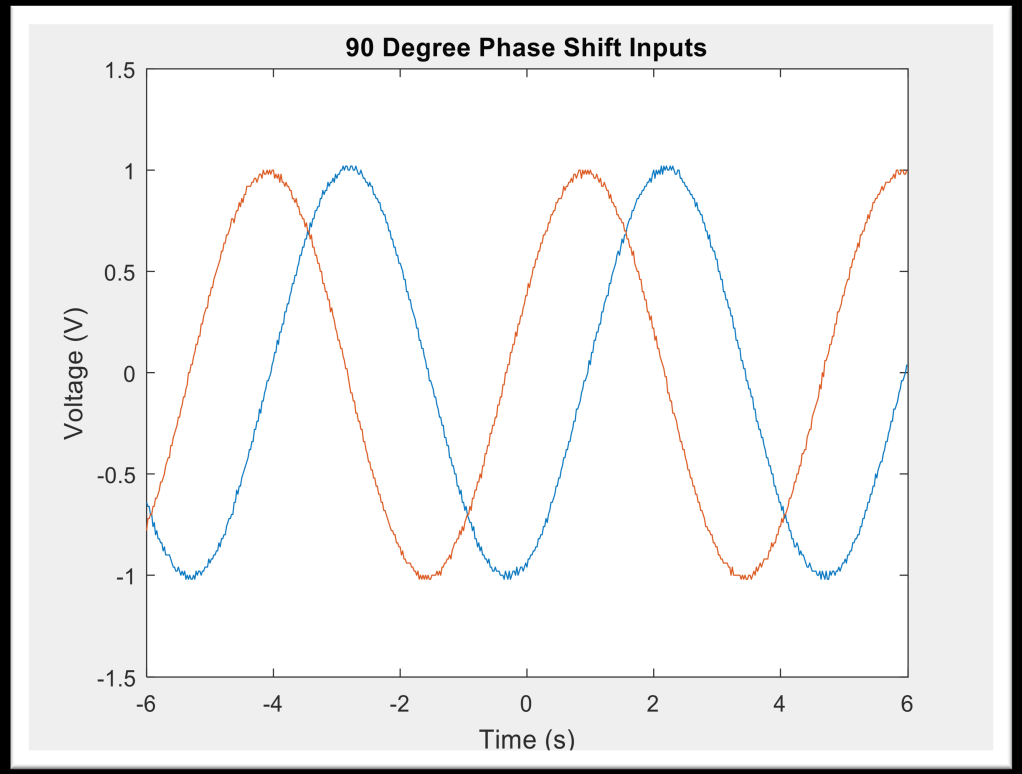

VCC
12V
R1
10kΩ
R2
10Ω
Input_1
C1
100nF
U1A
LM393NG
R5
100kΩ
R6
100Ω
Input_2
C2
100nF
U1B
LM393NG
VCC
12V
R4
10Ω
U2A
4070BD_10V
U2B
4070BD_10V
R8
15kΩ
To_LM3914_Sig
C4
2.2µF
R3
10Ω
C5
10µF
VCC
12V
U2C
4070BD_10V
U2D
4070BD_10V
C3
47µF
R7
4.7kΩ
To_LM3914_VHI

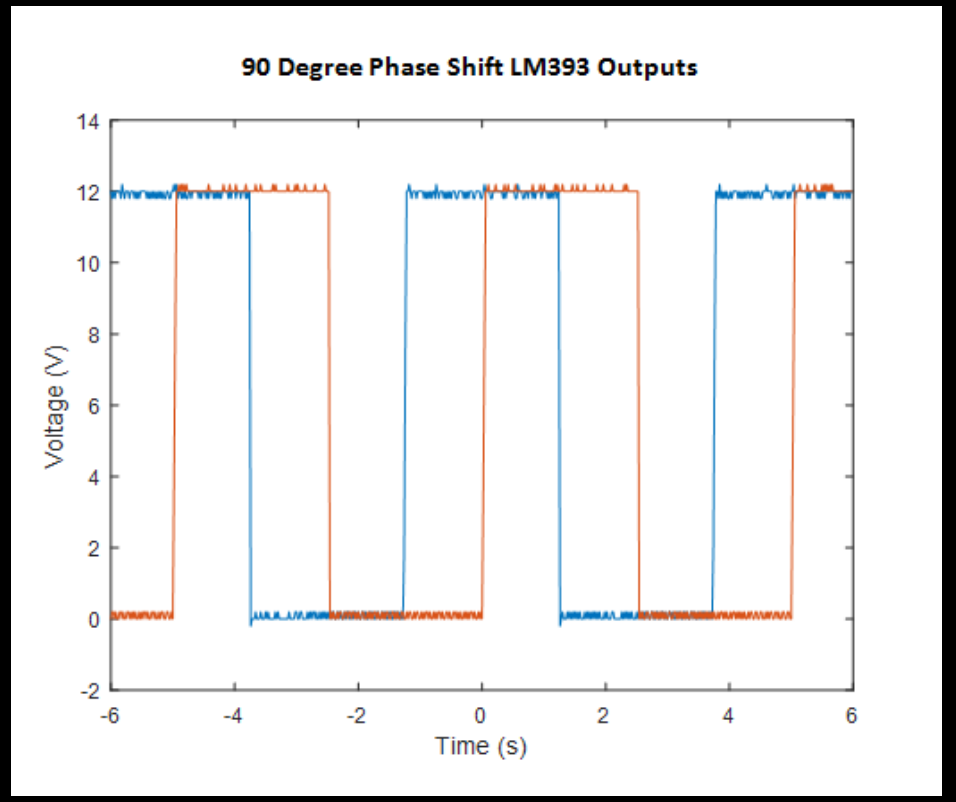
HIGH GAIN CLIPPING AMPLIFIER

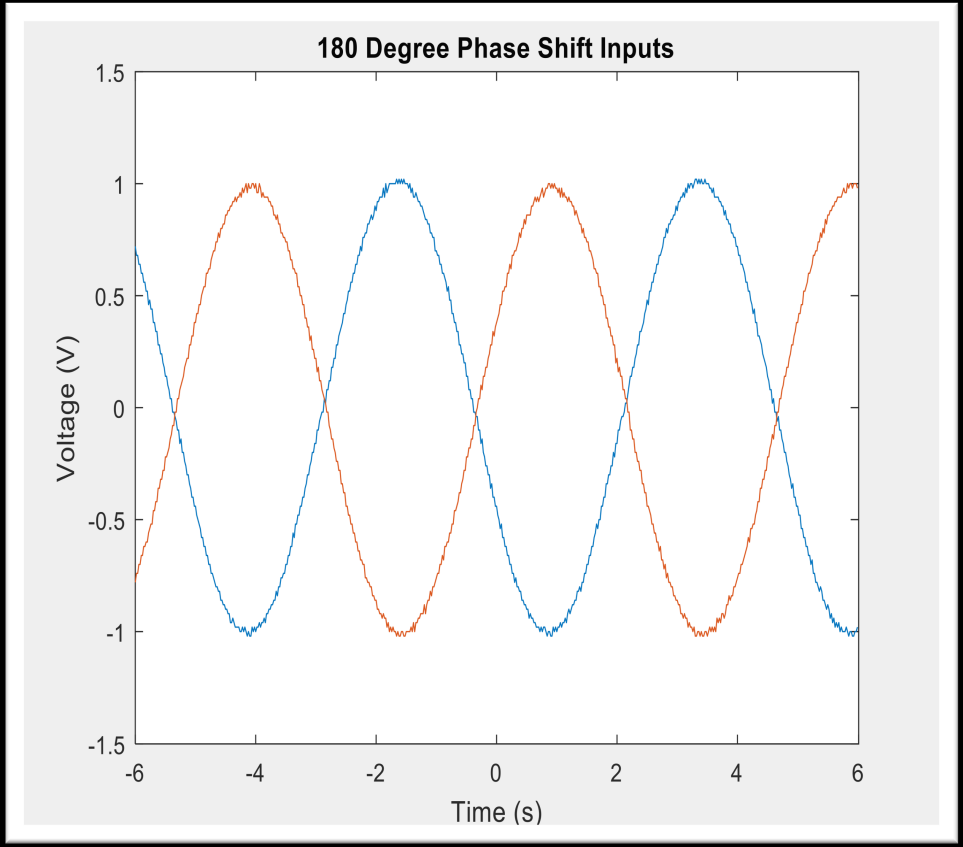
- Turns input signals into square waves of equal amplitude
  - Note: one amplifier is inverted

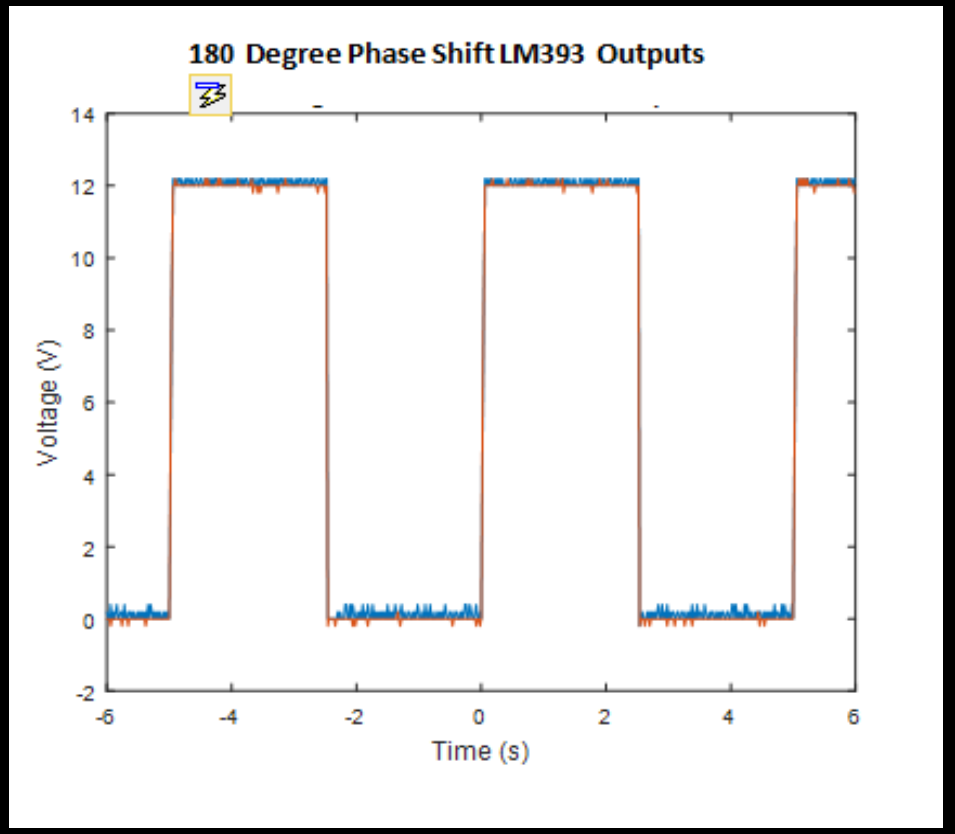





90 Degree Phase Shift Inputs
Voltage (V)
Time (s)
1.5
1
0.5
0
-0.5
-1
-1.5
-6
-4
-2
0
2
4
6

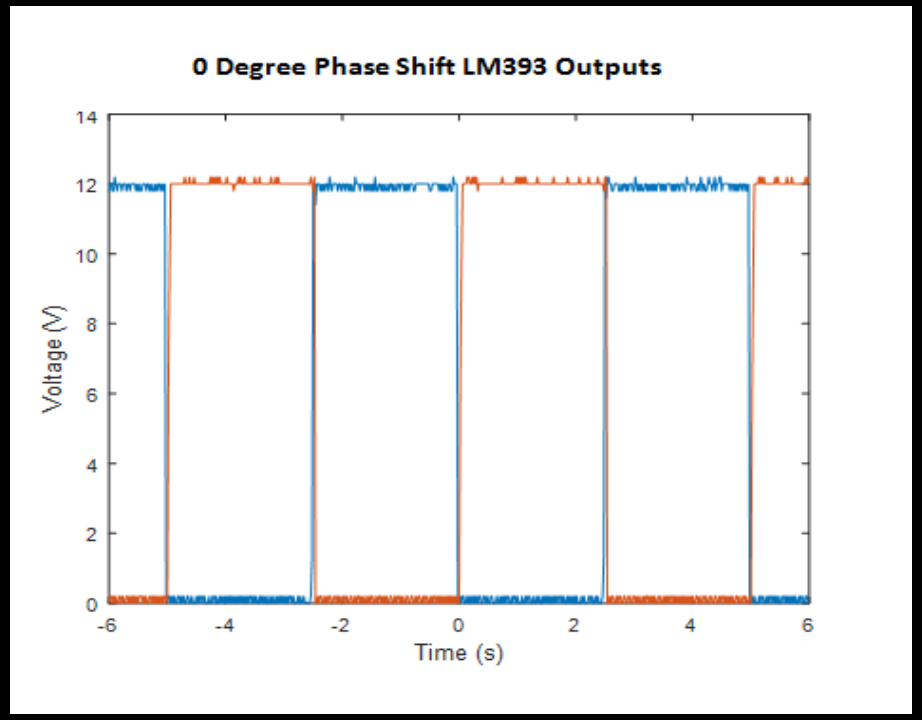

90 Degree Phase Shift LM393 Outputs
Voltage (V)
Time (s)
14
12
10
8
6
4
2
0
-2
-6
-4
-2
0
2
4
6

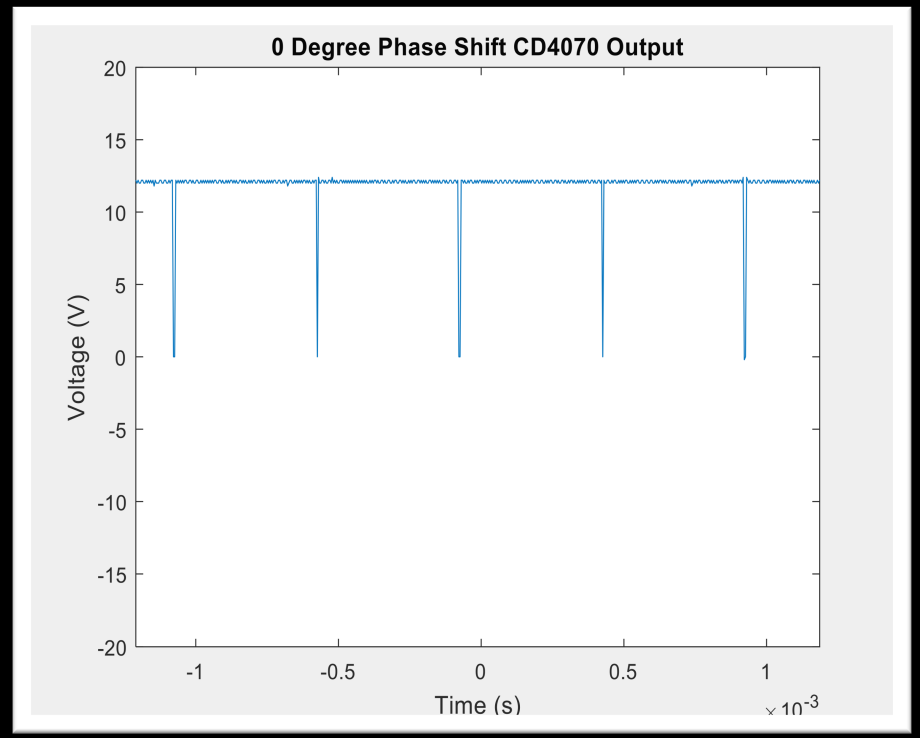

180 Degree Phase Shift Inputs
Voltage (V)
Time (s)
1.5
1
0.5
0
-0.5
-1
-1.5
-6
-4
-2
0
2
4
6

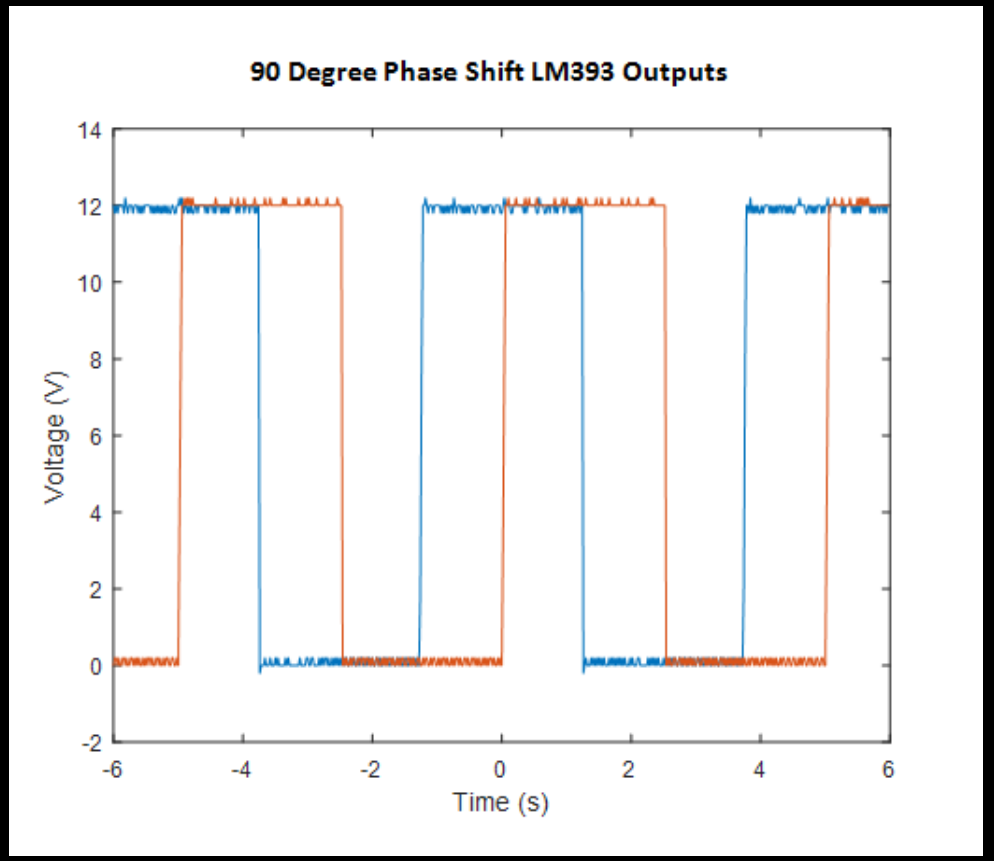

180 Degree Phase Shift LM393 Outputs
Voltage (V)
Time (s)
14
12
10
8
6
4
2
0
-2
-6
-4
-2
0
2
4
6

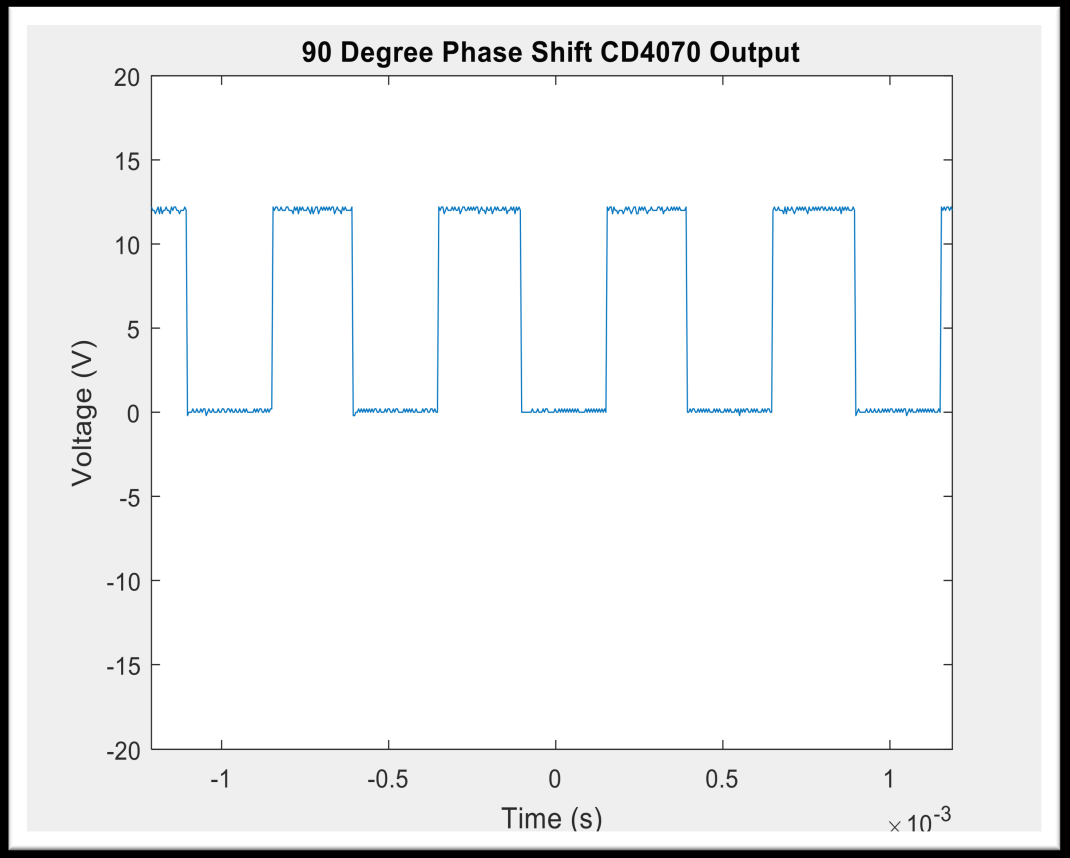
XOR GATE

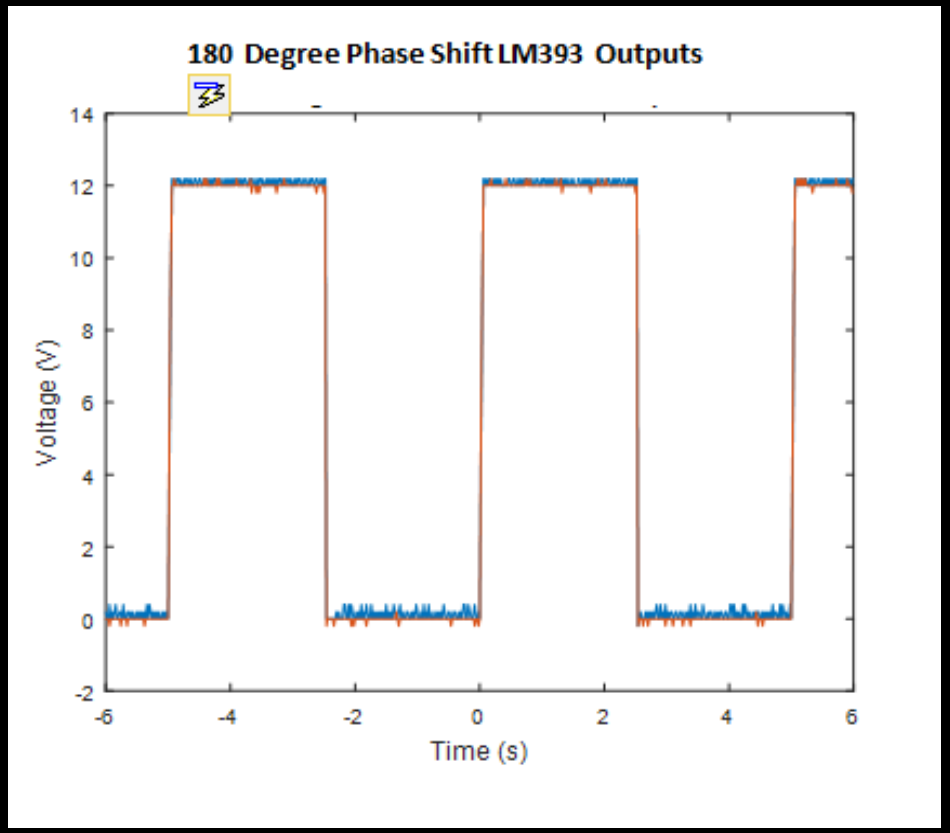
- Takes the XOR of both signals and outputs a single voltage

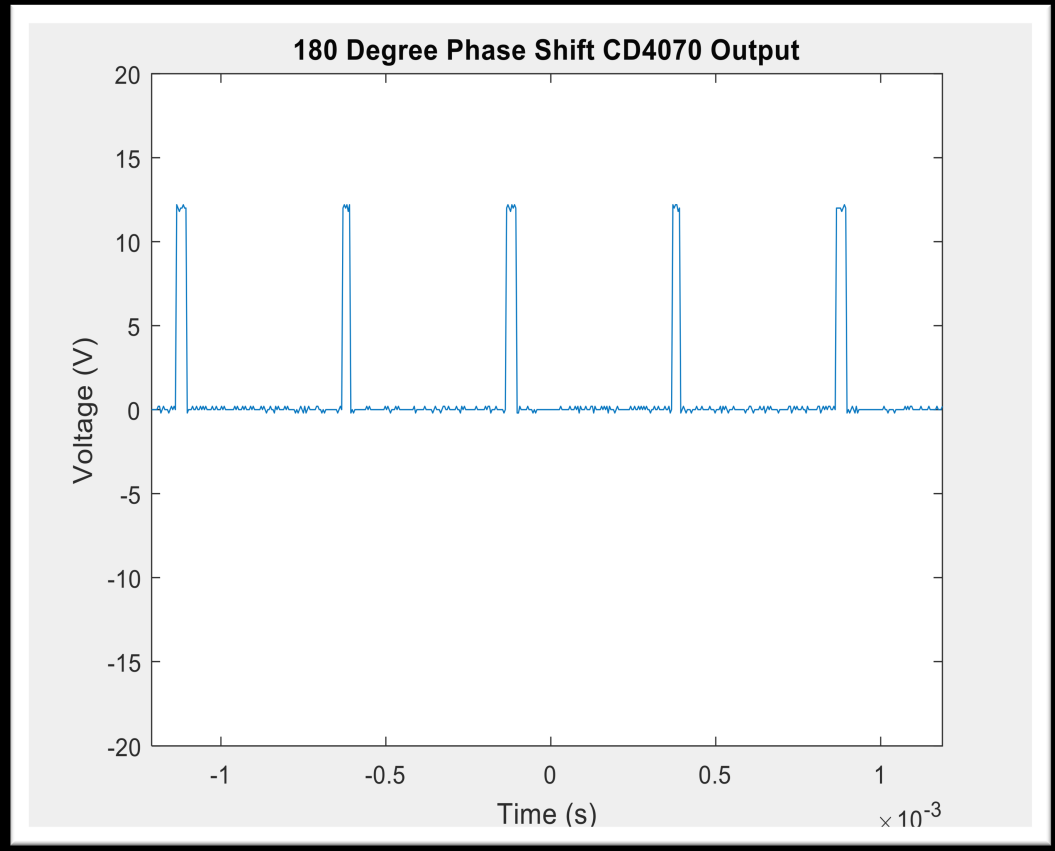





90 Degree Phase Shift LM393 Outputs
Voltage (V)
Time (s)
14
12
10
8
6
4
2
0
-2
-6
-4
-2
0
2
4
6

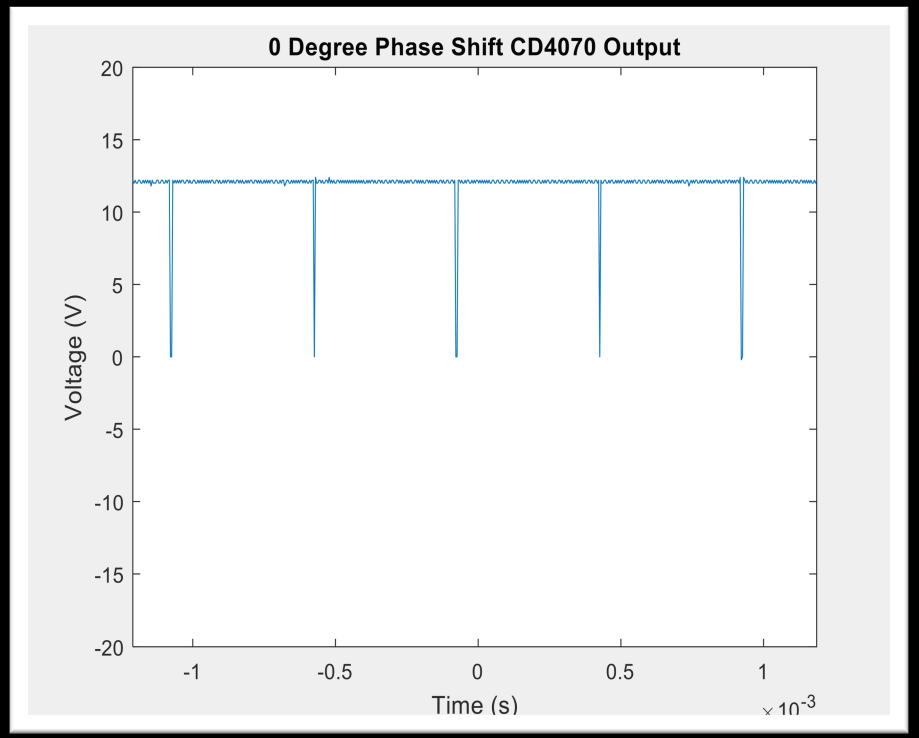

90 Degree Phase Shift CD4070 Output
Voltage (V)
Time (s)
20
15
10
5
0
-5
-10
-15
-20
-1
-0.5
0
0.5
1
× 10^-3

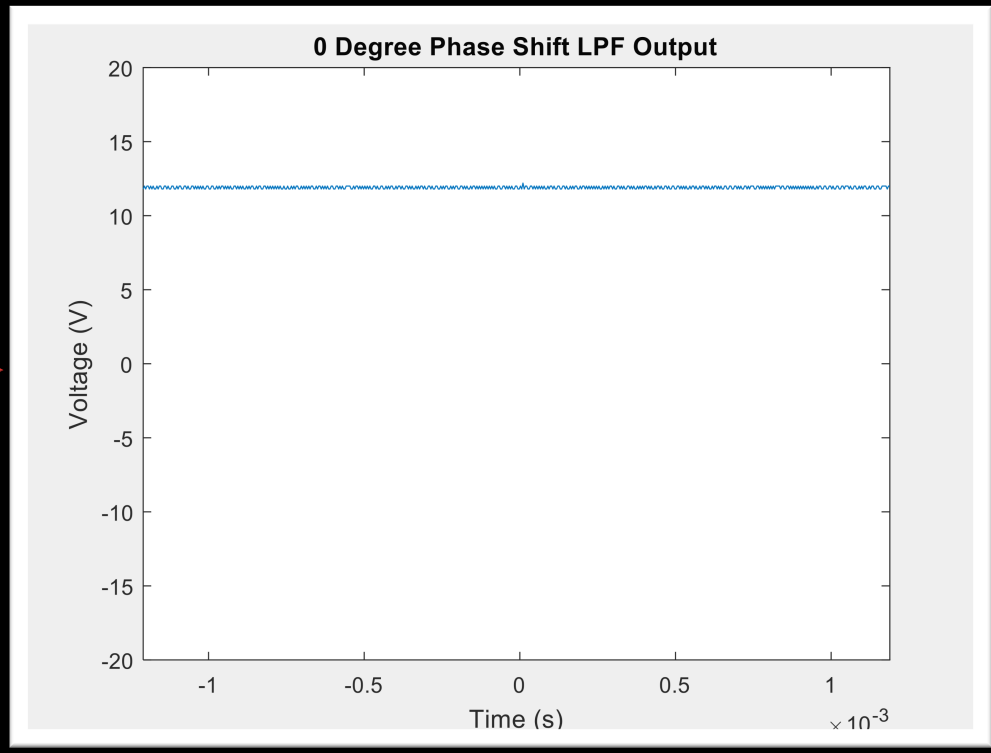

180 Degree Phase Shift LM393 Outputs
Voltage (V)
Time (s)
14
12
10
8
6
4
2
0
-2
-6
-4
-2
0
2
4
6

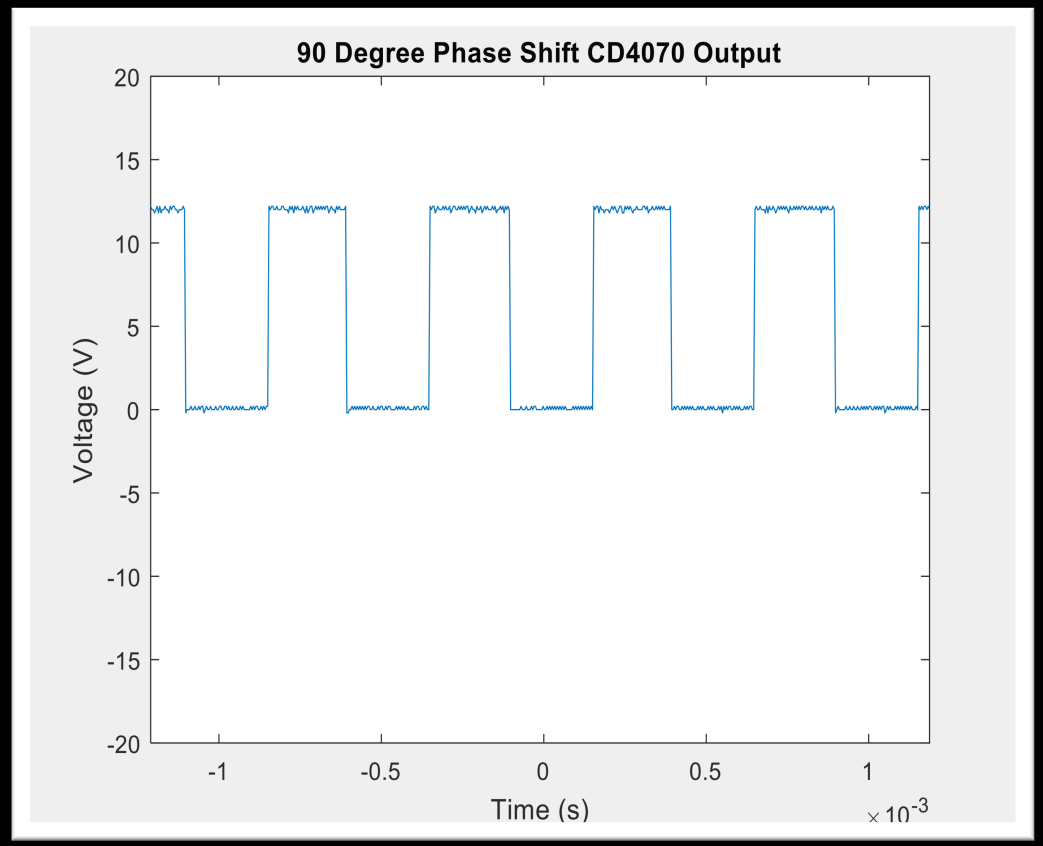

180 Degree Phase Shift CD4070 Output
Voltage (V)
Time (s)
20
15
10
5
0
-5
-10
-15
-20
-1
-0.5
0
0.5
1
×10-3

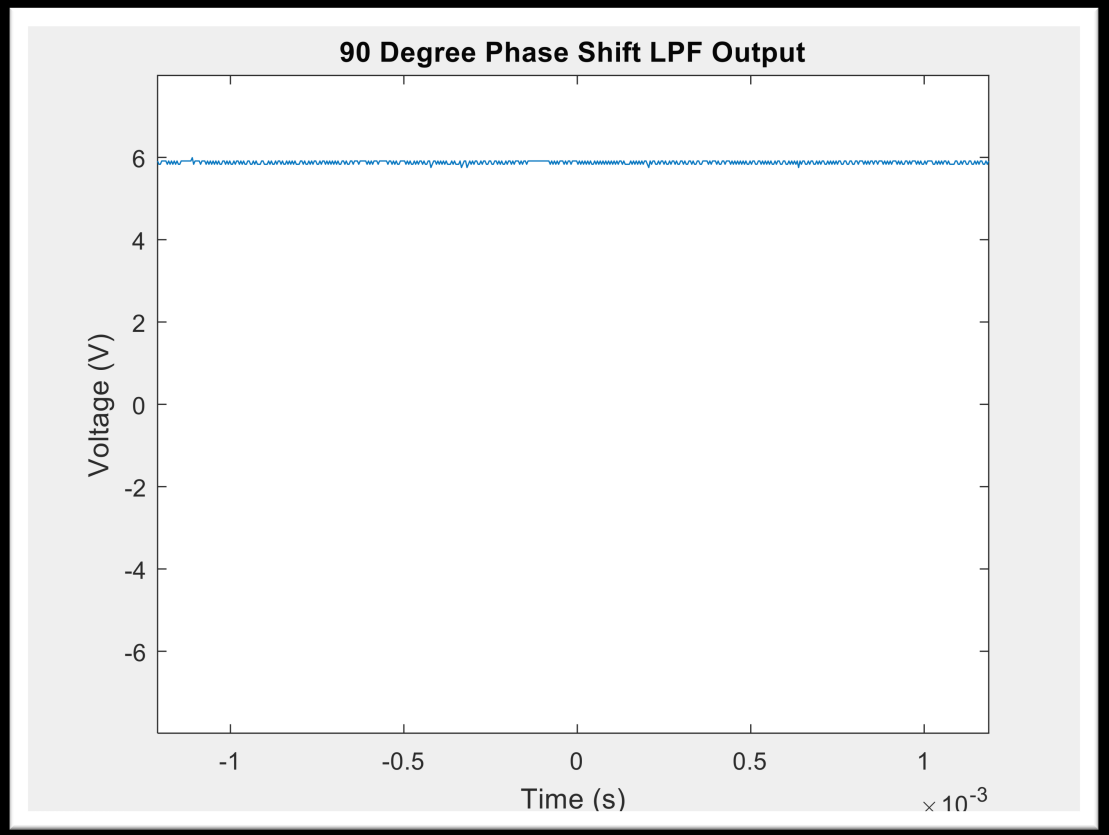
LOW PASS FILTER

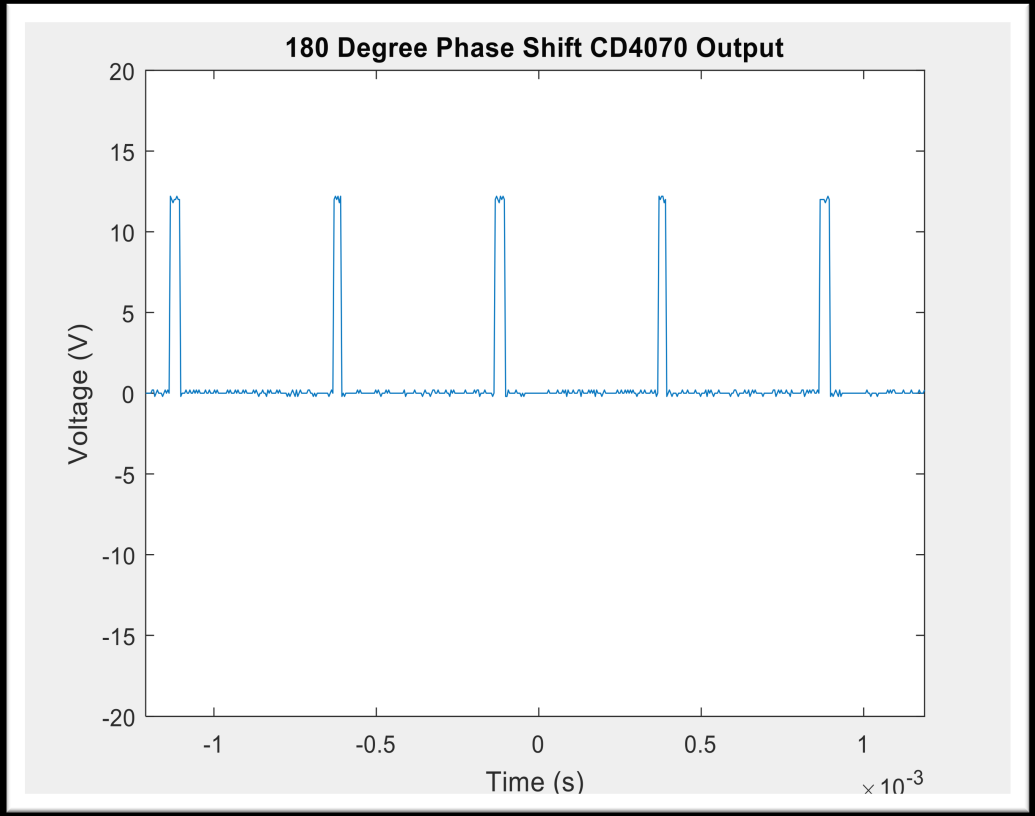
- Reduces high frequency components and acts as a moving averager

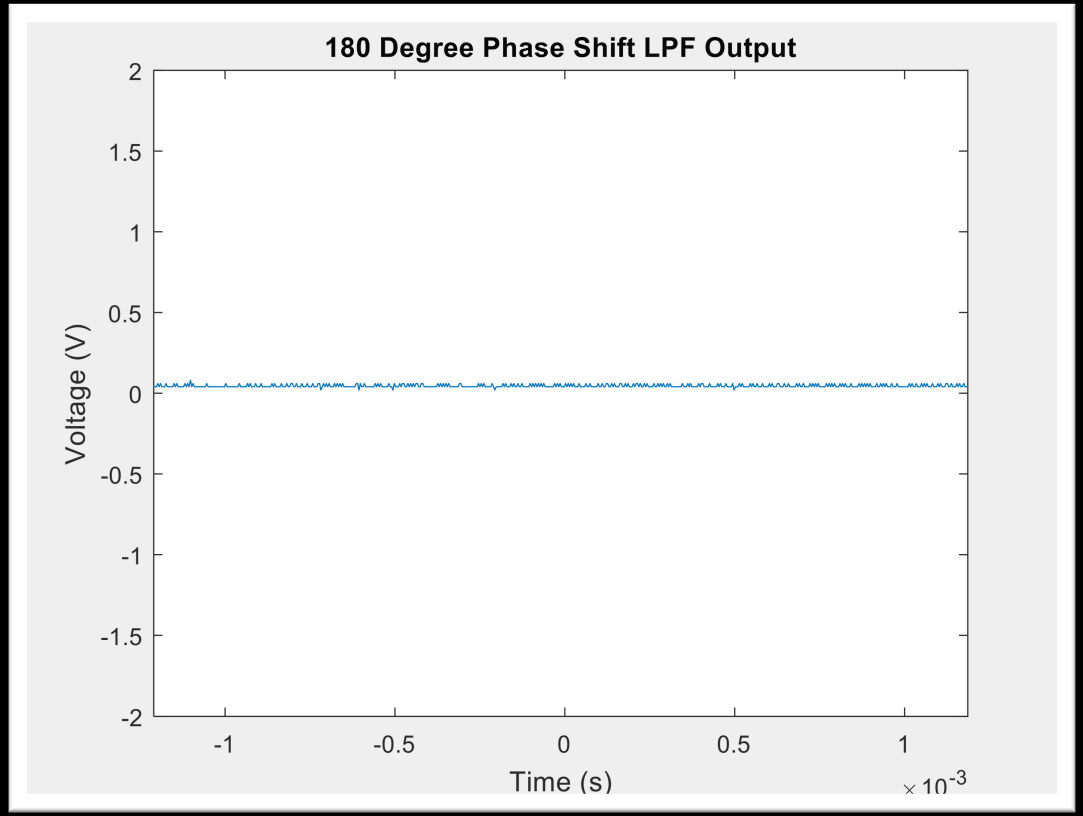





90 Degree Phase Shift CD4070 Output
Voltage (V)
20
15
10
5
0
-5
-10
-15
-20
-1
-0.5
0
0.5
1
Time (s)
× 10-3


90 Degree Phase Shift LPF Output
Voltage (V)
6
4
2
0
-2
-4
-6
-1
-0.5
0
0.5
1
Time (s)
× 10-3

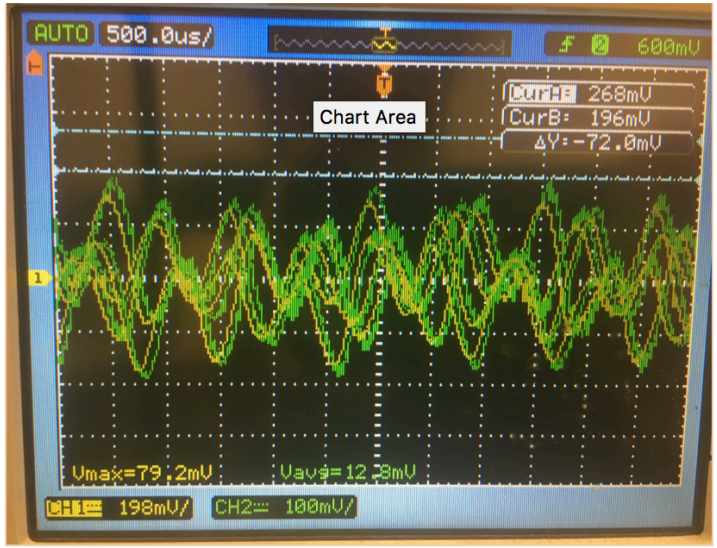

180 Degree Phase Shift CD4070 Output
Voltage (V)
20
15
10
5
0
-5
-10
-15
-20
-1
-0.5
0
0.5
1
Time (s)
× 10^-3


180 Degree Phase Shift LPF Output
Voltage (V)
2
1.5
1
0.5
0
-0.5
-1
-1.5
-2
-1
-0.5
0
0.5
1
Time (s)
× 10^-3

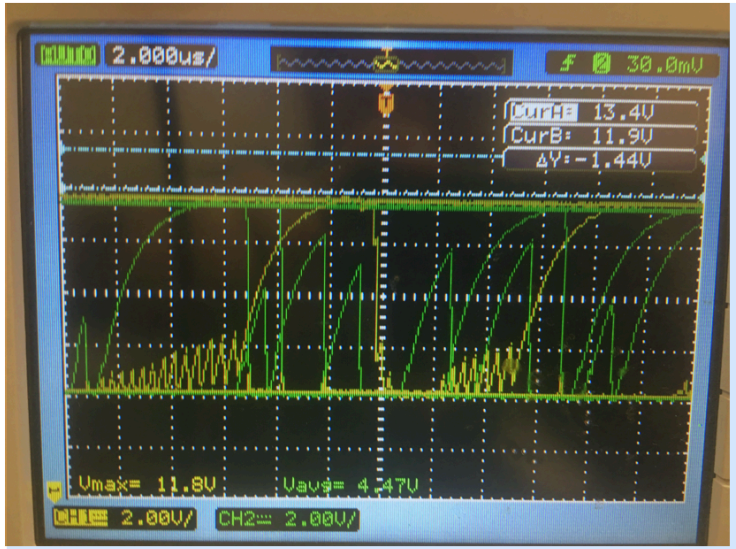
CORRELATION OF COMPLICATED SIGNALS

Does work but results are less definitive due to high range of frequencies

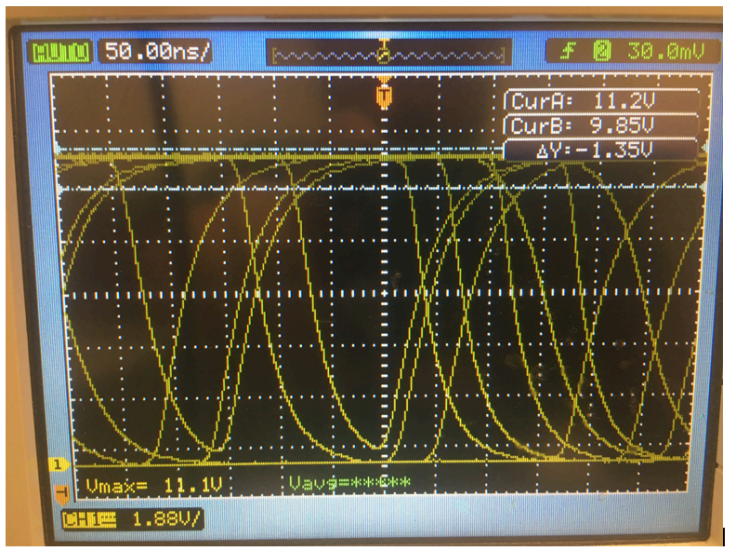
Input Microphone Signals from Preamplifiers



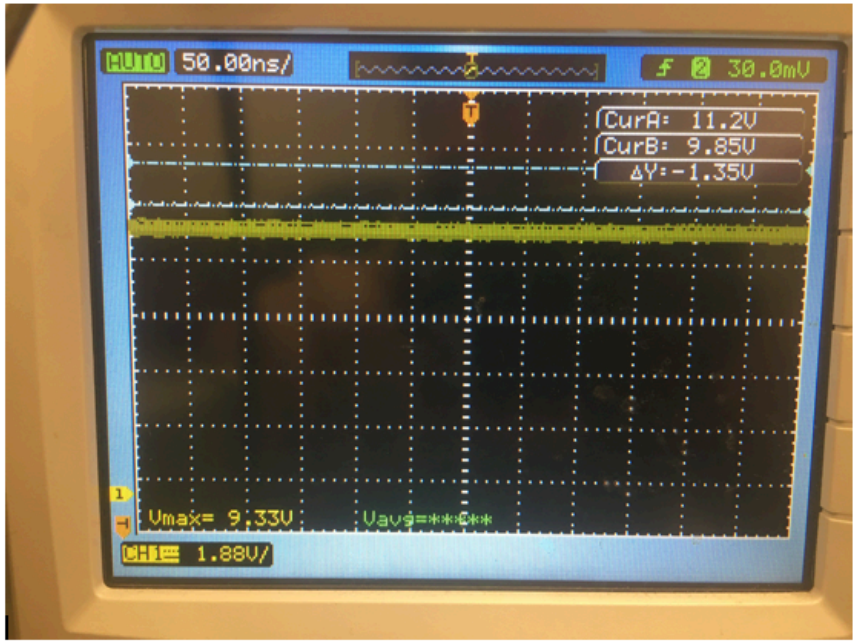
Clipping Amplifier Outputs



XOR Output



LPF "In Phase" Output



LPF "Out of Phase" Output

FUTURE WORK

- Test with live instruments for recording purposes
- Implement all four correlators and test with 3 or more microphones
- Add a phase shifting option to allow user to manually change the phase of a desired signal
  - This would also require audio outputs

QUESTIONS?