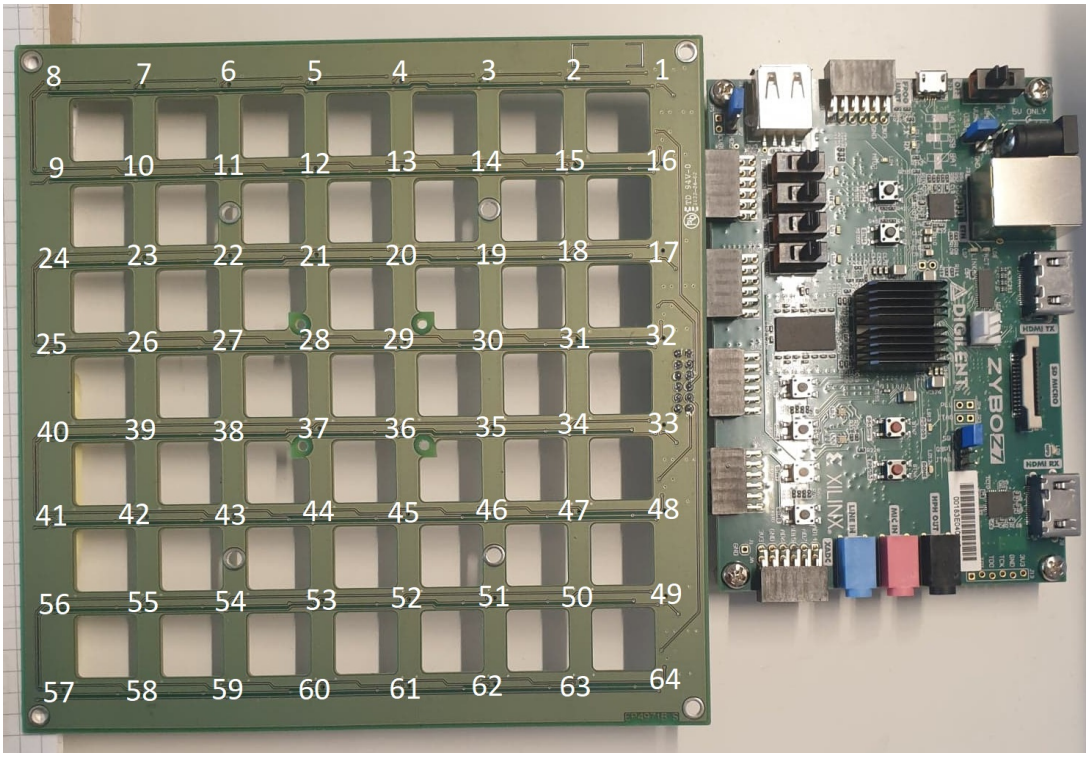
Testing the arrays - Version 2



Recommended tone generator: szynalski

Version of FPGA-sampling used during the tests: Github release

Download the release above or clone the Test_Manual_version branch

Use the following BOOT.bin version BOOT.bin version 1.1

Checklist:

- Make sure the mini SD-card is inserted onto the FPGA, and that it is the right BOOT.bin.
- The JP5 pins on the fpga-board is set to SD.
- Make sure you have changed to the correct IP address on your PC. IPv4: 192.168.1.2 mask: 255.255.255.0.
- Also make sure you are using an open port on the PC.
- Turn on the power switch on the FPGA and after a few seconds the lights underneath the ethernet port should blink rapidly.

If you should need help with the installation or help to get the code running, please see the user manual under the project wiki. User-Manual

Test 3: Does the microphones sample data simultaneously, standing array

This is the same test as in *Testing the arrays version 1*, but this time the array is standing.

Figure 1: The side of the array is facing the audio source

The main purpose of this test is to ensure that the microphones sample data at the same time. To investigate this the script calculates the phase difference for each microphone relative to the previous microphone. The array is built so that the microphones in a line are spaced 2 cm apart. Therefore the audio source needs to be placed in the same vertical plane as the array to make sure that the distance between each microphone maintains 2 cm.
Perform this test with multiple distances and frequencies of the audio source. Do several recordings before you move the audio source. Simply close the graph and a new recording is started immediately with the same settings entered at the start of the script. Repeat for other lines.

If the array and audio source are placed in the same vertical plane it makes it possible to estimate the phase difference of the microphones relative to the previous microphone. For example, if the frequency of the audio source is 880 Hz the phase difference for each microphone should be around 18.6 degrees, as can be seen in the equation below.

$$\phi = \frac{\Delta s}{v} \cdot 360^\circ \cdot f = \frac{0.02 \text{ m}}{340 \text{ m/s}} \cdot 360^\circ \cdot 880 \text{ Hz} \approx 18.6^\circ \tag{1}$$

Results of test 3 (Standing array, PCBA1) with horizontal lines at 2 cm and 880 Hz audio source:

$$\phi = \frac{\Delta s}{v} \cdot 360^\circ \cdot f = \frac{0.02 \text{ m}}{340 \text{ m/s}} \cdot 360^\circ \cdot 880 \text{ Hz} \approx 18.6^\circ \tag{2}$$

Test 3 standing. horizontal lines: 880hz audio source at 2 cm								
Line	Ref	$\Delta\phi$	$\Delta\phi$	$\Delta\phi$	$\Delta\phi$	$\Delta\phi$	$\Delta\phi$	$\Delta\phi$
L1 →	MK8: ref	MK7: 16.33°	MK6: 16.56°	MK5: 17.83°	MK4: 19.33°	MK3: 28.27°	MK2: 37.2°	MK1: 38.7°
L2 →	MK9: ref	MK10: 18.19°	MK11: 16.96°	MK12: 17.56°	MK13: 20.47°	MK14: 26.39°	MK15: 32.83°	MK16: 31.28°
L3 →	MK24: ref	MK23: 18.54°	MK22: 17.8°	MK21: 18.39°	MK20: 21.16°	MK19: 25.29°	MK18: 29.96°	MK17: 27.06
L4 →	MK25: ref	MK26: 20.23°	MK27: 22.54°	MK28: 24.61°	MK29: 24.41°	MK30: 21.66°	MK31: 18.99°	MK32: 18.21°

Table 1

Results of test 3 (Standing array, PCBA1) with horizontal lines at 1 meter and 880 Hz audio source:

$$\phi = \frac{\Delta s}{v} \cdot 360^\circ \cdot f = \frac{0.02 \text{ m}}{340 \text{ m/s}} \cdot 360^\circ \cdot 880 \text{ Hz} \approx 18.6^\circ \tag{3}$$

Test 3 standing. horizontal lines: 880hz audio source at 1 m								
Line	Ref	$\Delta\phi$	$\Delta\phi$	$\Delta\phi$	$\Delta\phi$	$\Delta\phi$	$\Delta\phi$	$\Delta\phi$
L1 →	MK8: ref	MK7: 9.76°	MK6: 10.37°	MK5: 12.34°	MK4: 12.64°	MK3: 16.4°	MK2: 15.24°	MK1: 14.12°
L2 →	MK9: ref	MK10: 17.18°	MK11: 21.9°	MK12: 47.24°	MK13: 58.98°	MK14: 23.35°	MK15: 10.19°	MK16: 4.26°
L3 →	MK24: ref	MK23: 12.15°	MK22: 13.64°	MK21: 21.44°	MK20: 41.45°	MK19: 46.32°	MK18: 25.53°	MK17: 11.1
L4 →	MK25: ref	MK26: 10.65°	MK27: 11.36°	MK28: 16.74°	MK29: 226.44°	MK30: 33.11°	MK31: 29.5°	MK32: 19.84°

Table 2

Test 4: With a standing array and dedicated speaker, source at 3 meters

Figure 2: The side of the array is facing the audio source

Place the speaker lined up with the lines of the array, just like in test 3 but with increased distance.

Results of test 4 with array PCBA1 with horizontal L3 at 3 m and 880 Hz with dedicated speaker source:

$$\phi = \frac{\Delta s}{v} \cdot 360^\circ \cdot f = \frac{0.02 \text{ m}}{340 \text{ m/s}} \cdot 360^\circ \cdot 880 \text{ Hz} \approx 18.6^\circ \tag{4}$$

Test 4 standing. horizontal lines: 880hz speaker source at 3 m								
Line	Ref	$\Delta\phi$	$\Delta\phi$	$\Delta\phi$	$\Delta\phi$	$\Delta\phi$	$\Delta\phi$	$\Delta\phi$
L4 →	MK24: ref	MK23: 14.56°	MK22: 8.48°	MK21: 6.27°	MK20: 6.4°	MK19: 9.91°	MK18: 95.55°	MK17: 62.54°

Table 3

1 Test 5: Comparing microphone pairs with the audio source facing the array

This test is an improvement of the *Bonus Test* from the first version. Place the audio source in the same vertical plane as the microphones to be compared. Make sure to have a good distance from the array and that the speaker is placed in the middle of the two microphones horizontally.

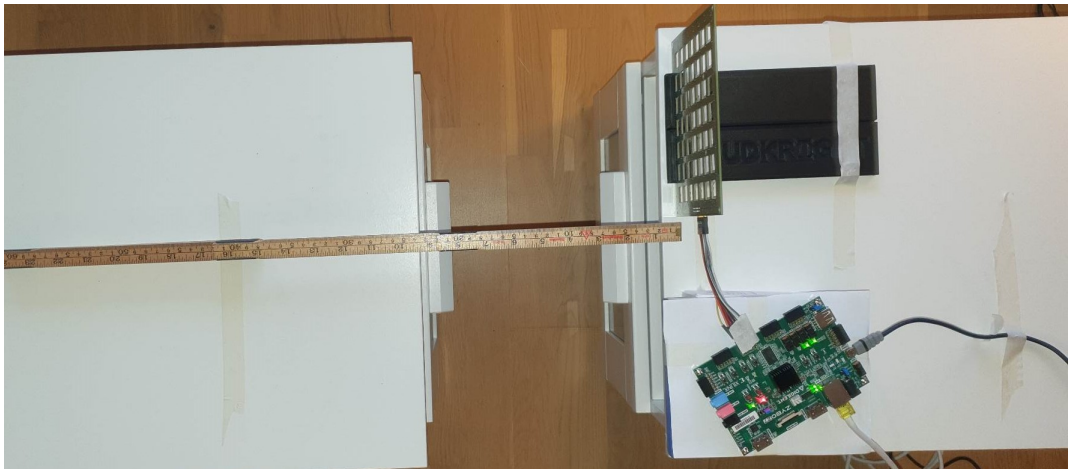


Figure 3: The front of the array is facing the audio source

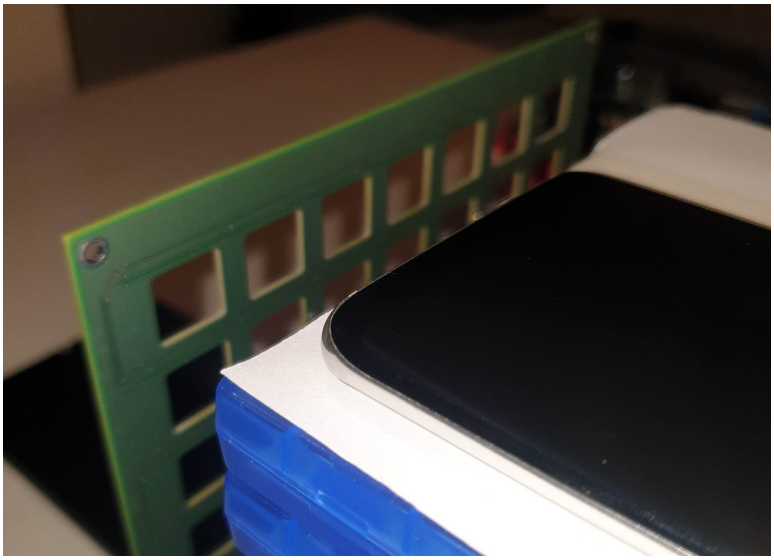


Figure 4: Place the source between two microphones

A longer distance is needed than what is shown in the picture, this short distance is just to clarify how the audio source should be placed

Results of test 5 with array PCBA1 with horizontal lines at 30 cm and 880 Hz audio source:

$$\phi = \frac{\Delta s}{v} \cdot 360^\circ \cdot f = \frac{0 \text{ m}}{340 \text{ m/s}} \cdot 360^\circ \cdot 880 \text{ Hz} \approx 0^\circ \tag{5}$$

Test 5. horizontal lines: 880hz audio source at 30 cm		
Line	Ref	$\Delta\phi$
L1 →	MK8: ref	MK7: 0.39°
L1 →	MK7: ref	MK6: 0.07°
L1 →	MK6: ref	MK5: 0.31°
L1 →	MK5: ref	MK4: 0.45°
L1 →	MK4: ref	MK3: 1.36°
L1 →	MK3: ref	MK2: 0.34°
L1 →	MK2: ref	MK1: 0.96°

Table 4

Test 6: Compare phase difference from the front

Similar to what was done in Task 5 but will now compare all the microphones in the array.

Place the audio source facing the array and centered in both vertical and horizontal orientation. In other words try to place the audio source at a point between mic 28,29,37,36. see picture below.

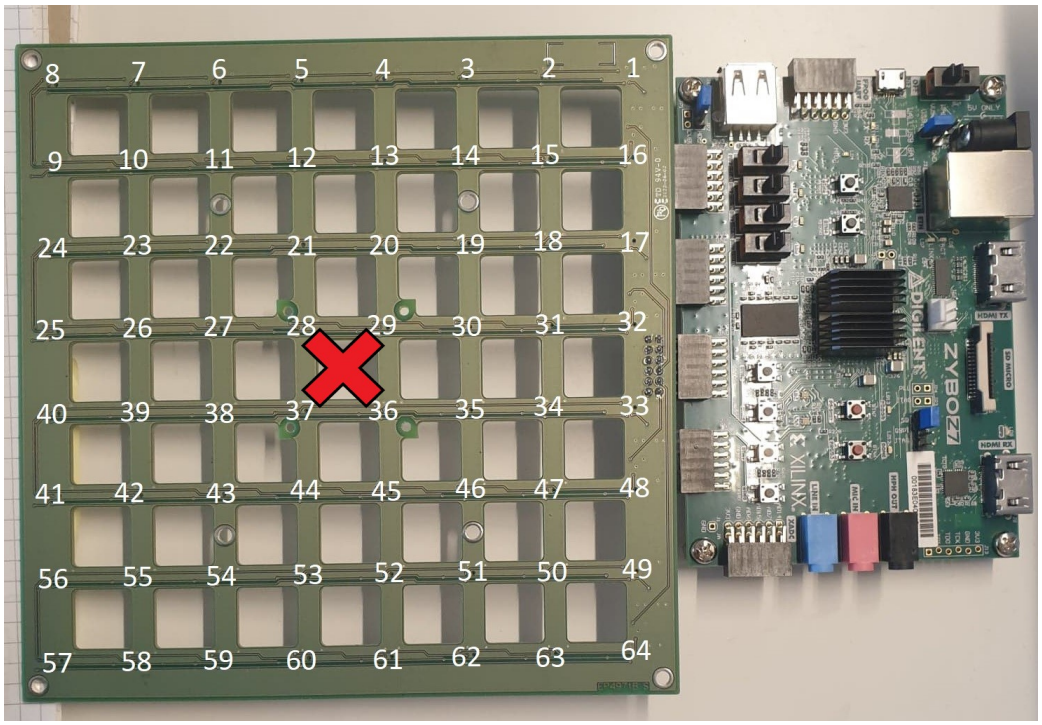


Figure 5: aim the audio source at the center of the array

Result of Test 6: 880 Hz audio source, 1 meter distance and mic 28 as reference

Test 6. 880hz audio source at 1 m. mic 28 ref.									
Line	$\Delta\phi$	$\Delta\phi$	$\Delta\phi$	$\Delta\phi$	$\Delta\phi$	$\Delta\phi$	$\Delta\phi$	$\Delta\phi$	ref
L1 →	MK8: 25.97°	MK7: 26.850°	MK6: 27.54°	MK5: 28.91°	MK4: 28.82°	MK3: 30.76°	MK2: 30.27°	MK1: 28.24°	MK28 ref
L2 →	MK9: 18.42°	MK10: 19.33°	MK11: 18.22°	MK12: 16.34°	MK13: 13.57°	MK14: 9.69°	MK15: 2.91°	MK16: −13.91°	MK28 ref
L3 →	MK24: 14.17°	MK23: 12.16°	MK22: 9.5°	MK21: 6.32°	MK20: 2.75°	MK19: −2.51°	MK18: −9.46°	MK17: −26.12°	MK28 ref
L4 →	MK25: 15.79°	MK26: 10.53°	MK27: 5.01°	MK28: 0.0°	MK29: −4.93°	MK30: −13.08°	MK31: −24.22°	MK32: −43.98°	MK28 ref
L5 →	MK40: 18.49°	MK39: 10.65°	MK38: 4.25°	MK37: −1.63°	MK36: −8.12°	MK35: −15.32°	MK34: −25.78°	MK33: −44.02°	MK28 ref
L6 →	MK41: 24.26°	MK42: 13.95°	MK43: 6.35°	MK44: −0.09°	MK45: −6.71°	MK46: −12.95°	MK47: −22.26°	MK48: −40.36°	MK28 ref
L7 →	MK56: 29.8°	MK55: 18.66°	MK54: 9.97°	MK53: 4.45°	MK52: −0.64°	MK51: −6.52°	MK50: −13.52°	MK49: −28.79°	MK28 ref
L8 →	MK57: 49.99°	MK58: 33.19°	MK59: 22.78°	MK60: 16.62°	MK61: 11.64°	MK62: 8.45°	MK63: 7.88°	MK64: 8.43°	MK28 ref

Table 5

Result of Test 6: 880 Hz audio source, 3 meter distance and mic 28 as reference

Test 6. 880hz audio source at 3 m. mic 28 ref.									
Line	$\Delta\phi$	$\Delta\phi$	$\Delta\phi$	$\Delta\phi$	$\Delta\phi$	$\Delta\phi$	$\Delta\phi$	$\Delta\phi$	ref
L1 →	MK8: 24.78°	MK7: 17.36°	MK6: 9.94°	MK5: 3.41°	MK4: −4.65°	MK3: −10.51°	MK2: −18.6°	MK1: −27.4°	MK28 ref
L2 →	MK9: 21.92°	MK10: 14.32°	MK11: 6.11°	MK12: −1.69°	MK13: −8.89°	MK14: −15.22°	MK15: −20.66°	MK16: −25.37°	MK28 ref
L3 →	MK24: 22.82°	MK23: 15.09°	MK22: 8.12°	MK21: 1.87°	MK20: −3.19°	MK19: −7.85°	MK18: −10.47°	MK17: −13.44°	MK28 ref
L4 →	MK25: 21.93°	MK26: 13.86°	MK27: 6.2°	MK28: 0.0°	MK29: −4.59°	MK30: −10.08°	MK31: −14.43°	MK32: −16.46°	MK28 ref
L5 →	MK40: 19.33°	MK39: 9.67°	MK38: 2.43°	MK37: −3.01°	MK36: −7.55°	MK35: −10.64°	MK34: −13.22°	MK33: −13.83°	MK28 ref
L6 →	MK41: 16.22°	MK42: 5.23°	MK43: −1.84°	MK44: −6.68°	MK45: −10.4°	MK46: −11.91°	MK47: −13.06°	MK48: −13.95°	MK28 ref
L7 →	MK56: 3.79°	MK55: −3.64°	MK54: −9.12°	MK53: −11.49°	MK52: −13.04°	MK51: −14.39°	MK50: −14.23°	MK49: −14.13°	MK28 ref
L8 →	MK57: −20.06°	MK58: −21.37°	MK59: −19.86°	MK60: −19.52°	MK61: −18.9°	MK62: −17.52°	MK63: −16.7°	MK64: −15.68°	MK28 ref

Table 6

Result of Test 6: (Again) 880 Hz audio source, 3 meter distance and mic 28 as reference.

Same test as in table 6 but the audio source is moved slightly.

Test 6. 880hz audio source at 3 m. mic 28 ref.									
Line	$\Delta\phi$	$\Delta\phi$	$\Delta\phi$	$\Delta\phi$	$\Delta\phi$	$\Delta\phi$	$\Delta\phi$	$\Delta\phi$	ref
L1 →	MK8: 19.04°	MK7: 10.22°	MK6: 2.81°	MK5: −2.62°	MK4: −8.84°	MK3: −12.52°	MK2: −18.45°	MK1: −25.87°	MK28 ref
L2 →	MK9: 11.74°	MK10: 8.55°	MK11: 3.99°	MK12: −0.43°	MK13: −4.72°	MK14: −8.8°	MK15: −13.06°	MK16: −19.5°	MK28 ref
L3 →	MK24: 9.77°	MK23: 6.9°	MK22: 3.32°	MK21: −0.29°	MK20: −3.36°	MK19: −6.81°	MK18: −9.34°	MK17: −14.79°	MK28 ref
L4 →	MK25: 7.65°	MK26: 5.74°	MK27: 2.62°	MK28: 0.0°	MK29: −1.89°	MK30: −5.39°	MK31: −9.07°	MK32: −13.8°	MK28 ref
L5 →	MK40: 6.67°	MK39: 5.06°	MK38: 3.07°	MK37: 0.94°	MK36: −1.62°	MK35: −3.58°	MK34: −6.02°	MK33: −9.19°	MK28 ref
L6 →	MK41: 5.53°	MK42: 4.45°	MK43: 2.95°	MK44: 1.22°	MK45: −0.854°	MK46: −1.76°	MK47: −3.14°	MK48: −6.29°	MK28 ref
L7 →	MK56: 3.81°	MK55: 4.24°	MK54: 2.5°	MK53: 1.62°	MK52: 0.33°	MK51: −1.38°	MK50: −2.06°	MK49: −4.56°	MK28 ref
L8 →	MK57: 4.25°	MK58: −0.22°	MK59: −1.2°	MK60: −2.53°	MK61: −3.73°	MK62: −4.28°	MK63: −4.97°	MK64: −5.11°	MK28 ref

Table 7

Result of Test 6: 880 Hz audio source, 1 meter distance and mic 1 as reference

Test 6. 880hz audio source at 1m. mic 1 ref.									
Line	$\Delta\phi$	$\Delta\phi$	$\Delta\phi$	$\Delta\phi$	$\Delta\phi$	$\Delta\phi$	$\Delta\phi$	$\Delta\phi$	ref
L1 →	MK8: −38.05°	MK7: −26.54°	MK6: −16.72°	MK5: −8.49°	MK4: −3.85°	MK3: 0.68°	MK2: 1.25°	MK1: 0°	MK1 ref
L2 →	MK9: −41.44°	MK10: −36.59°	MK11: −33.81°	MK12: −32.44°	MK13: −32.14°	MK14: −32.61°	MK15: −34.03°	MK16: −38.44°	MK1 ref
L3 →	MK24: −42.31°	MK23: −39.73°	MK22: −38.27°	MK21: −37.97°	MK20: −38.17°	MK19: −39.5°	MK18: −40.52°	MK17: −44.85°	MK1 ref
L4 →	MK25: −36.76°	MK26: −35.06°	MK27: −34.59°	MK28: −34.42°	MK29: −43.43°	MK30: −36.75°	MK31: −39.75°	MK32: −43.97°	MK1 ref
L5 →	MK40: −41.0°	MK39: −40.11°	MK38: −39.12°	MK37: −39.04°	MK36: −40.16°	MK35: −41.57°	MK34: −44.06°	MK33: −46.9°	MK1 ref
L6 →	MK41: −35.43°	MK42: −38.19°	MK43: −38.65°	MK44: −39.15°	MK45: −40.5°	MK46: −41.21°	MK47: −24.9°	MK48: −45.94°	MK1 ref
L7 →	MK56: −13.6°	MK55: −23.45°	MK54: −28.65°	MK53: −31.22°	MK52: −33.72°	MK51: −36.79°	MK50: −38.99°	MK49: —- 41.93°	MK1 ref
L8 →	MK57: 1.93°	MK58: −16.29°	MK59: −24.88°	MK60: −29.17°	MK61: −32.77°	MK62: −35.67°	MK63: −38.22°	MK64: −41.42°	MK1 ref

Table 8

Result of Test 6: 880 Hz audio source, 3 meter distance and mic 1 as reference

It is more difficult to line up the mobile correctly at longer distances.

Test 6. 880hz audio source at 3m. mic 1 ref.									
Line	$\Delta\phi$	$\Delta\phi$	$\Delta\phi$	$\Delta\phi$	$\Delta\phi$	$\Delta\phi$	$\Delta\phi$	$\Delta\phi$	ref
L1 →	MK8: 72.63°	MK7: 59.40°	MK6: 46.34°	MK5: 35.2°	MK4: 24.01°	MK3: 16.54°	MK2: 8.23°	MK1: 0°	MK1 ref
L2 →	MK9: 77.66°	MK10: 65.39°	MK11: 52.3°	MK12: 40.5°	MK13: 30.43°	MK14: 22.38°	MK15: 16.12°	MK16: 11.48°	MK1 ref
L3 →	MK24: 78.11°	MK23: 64.52°	MK22: 51.73°	MK21: 40.86°	MK20: 32.66°	MK19: 26.10°	MK18: 22.66°	MK17: 20.23°	MK1 ref
L4 →	MK25: 79.47°	MK26: 65.59°	MK27: 52.81°	MK28: 42.98°	MK29: 36.29°	MK30: 29.94°	MK31: 25.6°	MK32: 24.47°	MK1 ref
L5 →	MK40: 77.14°	MK39: 61.88°	MK38: 49.49°	MK37: 40.21°	MK36: 33.19°	MK35: 28.75°	MK34: 25.87°	MK33: 26.25°	MK1 ref
L6 →	MK41: 75.69°	MK42: 58.52°	MK43: 45.59°	MK44: 36.53°	MK45: 29.94°	MK46: 26.67°	MK47: 24.8°	MK48: 24.49°	MK1 ref
L7 →	MK56: 78.63°	MK55: 60.73°	MK54: 46.51°	MK53: 37.75°	MK52: 31.97°	MK51: 27.95°	MK50: 26.76°	MK49: 26.78°	MK1 ref
L8 →	MK57: 82.89°	MK58: 57.35°	MK59: 42.24°	MK60: 33.24°	MK61: 28.15°	MK62: 25.47°	MK63: 23.62°	MK64: 23.64°	MK1 ref

Table 9

Test 7: Improvisation of Test 6..

While playing around and moving the audio source a strange pattern was discovered. If aiming the audio source to the left of the array the result somehow had less difference in phase. See picture below.

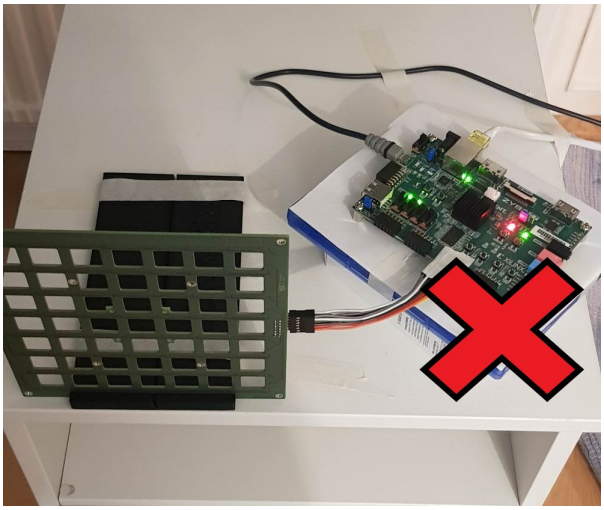


Figure 6: improvisation test while aiming 12 centimeters the right of the array

With the current audio source aligning the speaker 12 centimeter to the right seems to reduce the phase shift difference. This is probably related to the audio source itself and not that the array samples the data incorrectly.

Result of Test 7: 880 Hz audio source, 3 meter distance and aimed 12 cm to the left. Mic 1 as reference

Test 6. 880hz audio source at 3m. mic 1 ref.									
Line	$\Delta\phi$	$\Delta\phi$	$\Delta\phi$	$\Delta\phi$	$\Delta\phi$	$\Delta\phi$	$\Delta\phi$	$\Delta\phi$	ref
L1 →	MK8: 13.2°	MK7: 8.82°	MK6: 5.36°	MK5: 3.59°	MK4: 1.17°	MK3: 1.65°	MK2: 0.84°	MK1: 0°	MK1 ref
L2 →	MK9: 26.07°	MK10: 21.53°	MK11: 16.92°	MK12: 13.19°	MK13: 10.22°	MK14: 8.39°	MK15: 7.65°	MK16: 7.1°	MK1 ref
L3 →	MK24: 29.12°	MK23: 25.11°	MK22: 21.63°	MK21: 18.9°	MK20: 17.35°	MK19: 16.16°	MK18: 16.87°	MK17: 16.44°	MK1 ref
L4 →	MK25: 29.19°	MK26: 27.27°	MK27: 25.0°	MK28: 23.86°	MK29: 23.93°	MK30: 22.84°	MK31: 22.24°	MK32: 21.99°	MK1 ref
L5 →	MK40: 38.57°	MK39: 36.85°	MK38: 35.27°	MK37: 34.06°	MK36: 32.9°	MK35: 32.72°	MK34: 32.39°	MK33: 32.28°	MK1 ref
L6 →	MK41: 45.86°	MK42: 44.47°	MK43: 42.74°	MK44: 41.19°	MK45: 39.71°	MK46: 39.68°	MK47: 39.41°	MK48: 37.9°	MK1 ref
L7 →	MK56: 44.06°	MK55: 37.61°	MK54: 33.91°	MK53: 33.34°	MK52: 33.95°	MK51: 35.06°	MK50: 37.81°	MK49: 39.05°	MK1 ref
L8 →	MK57: 45.15°	MK58: 42.4°	MK59: 43.07°	MK60: 43.76°	MK61: 44.58°	MK62: 46.2°	MK63: 48.13°	MK64: 49.47°	MK1 ref

Table 10