



# ACOUSTIC BEAMFORMING

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Supervisor

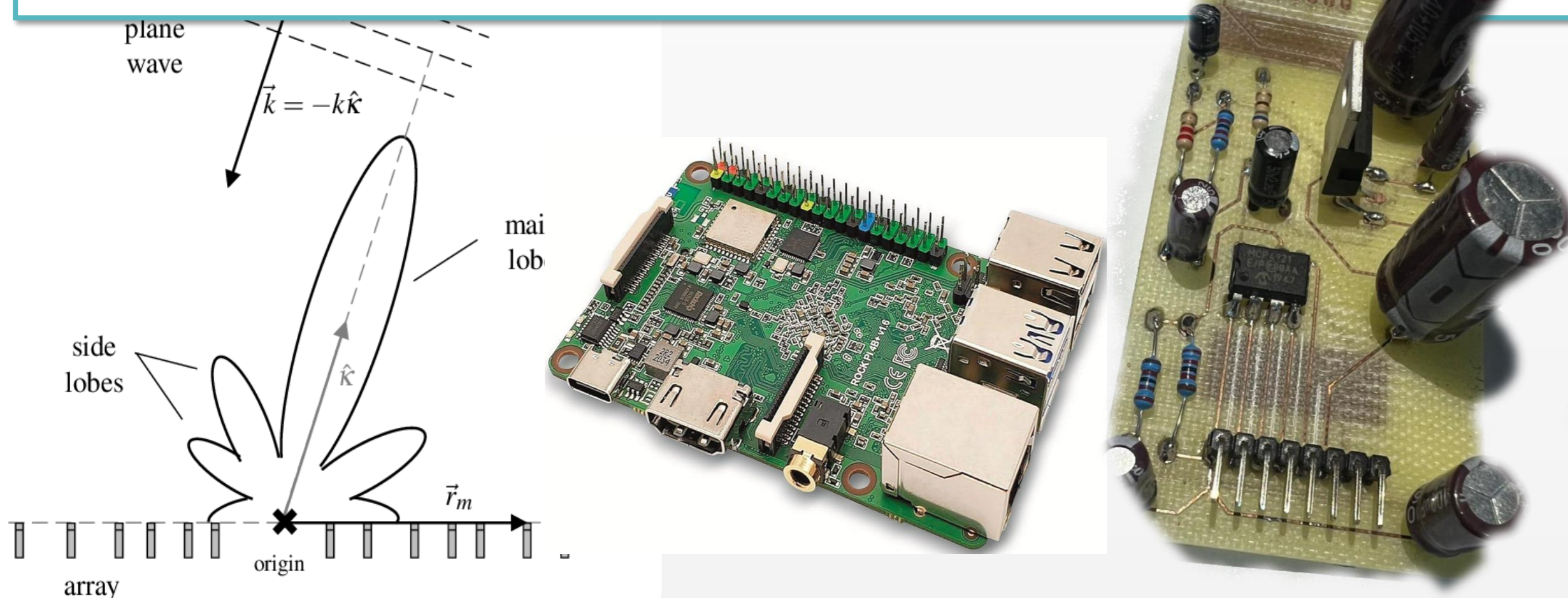
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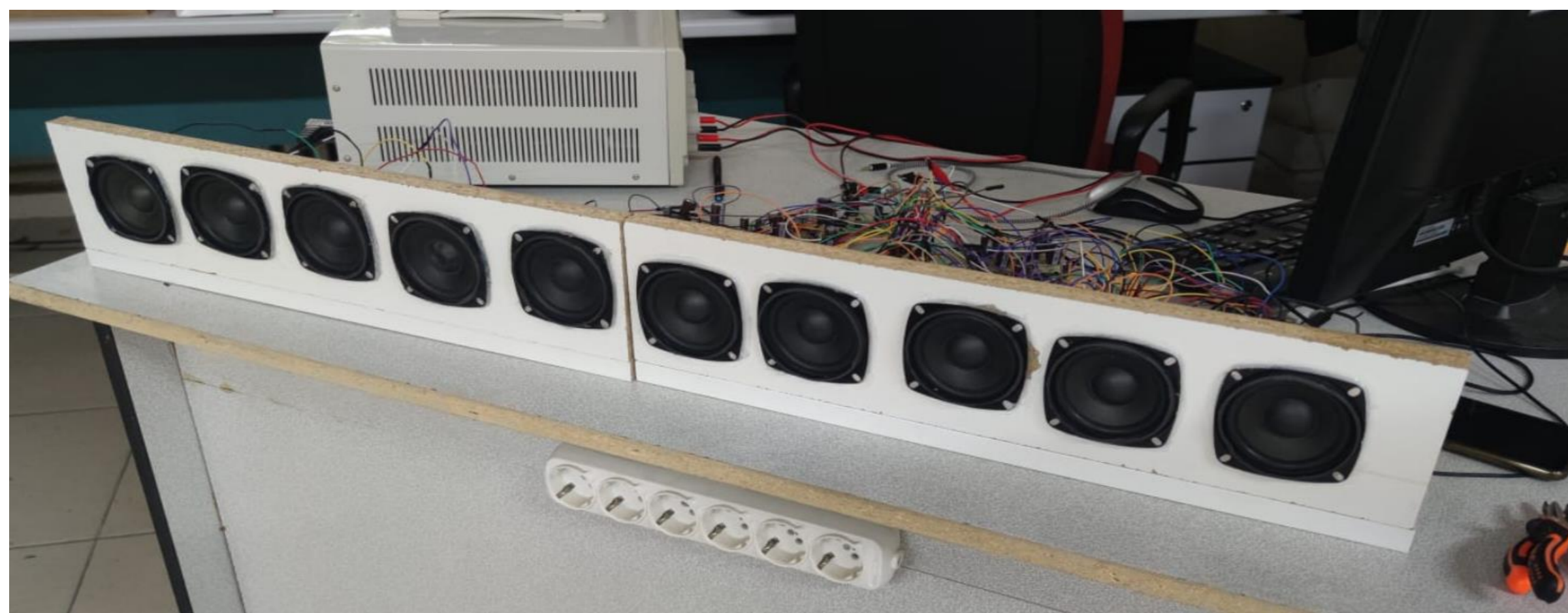
## Introduction

- ❖ The project explores advanced acoustic beamforming techniques using a ten-speaker array controlled by a Raspberry Pi. Our goal is to precisely direct sound waves to specific locations, enabling targeted audio delivery without the need for physical movement of the speakers.
- ❖ The project serves as an academic tool demonstrating complex audio engineering and signal processing concepts.
- ❖ Develops technologies to improve precision in home audio systems, enhancing user experience through dynamic audio manipulation.



## Specifications and Design Requirements

- Control Unit:** Raspberry Pi for audio output control.
- Audio Circuit:** Custom PCB with integrated DACs with speaker array.
- Noise Mitigation:** Redesigned grounding system between audio output and DACs to improve sound clarity.
- Power Adjustments:** Increased DAC power to 6.5 volts and amplifier power to 23 volts to minimize noise.
- System Testing:** Iterative testing and integration for optimal performance and sound fidelity.
- Directionality Control:** Effective steering of sound waves to targeted areas.
- Sound Quality:** High fidelity with minimal distortion.
- System Stability:** Consistent performance under various conditions.



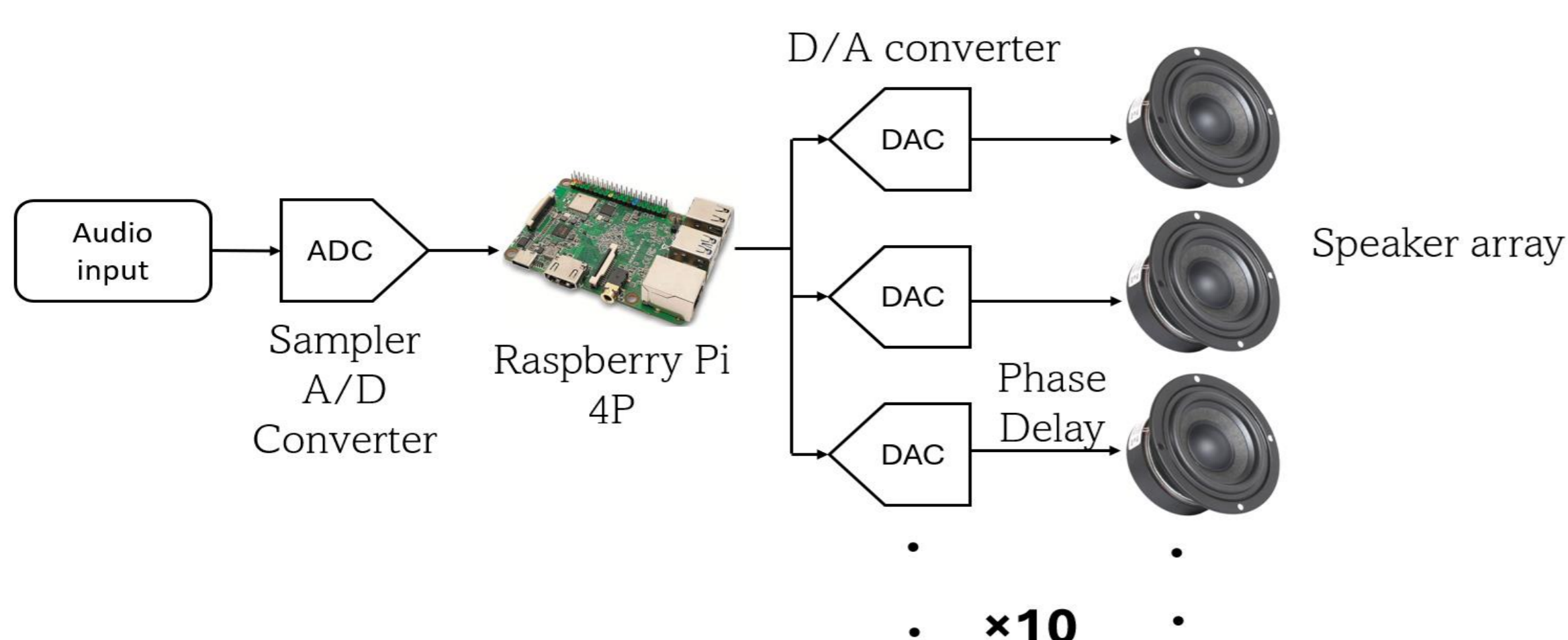
## Solution Methodology

- ❖ The formula used for the array system:

$$d < \frac{\lambda}{1 + \sin \theta_{max}} \Rightarrow d < \frac{\lambda}{2} \text{ when } \theta_{max} = \frac{\pi}{2}$$

- ❖ The formula used for the phase delay:

$$\varphi = \frac{2\pi}{\lambda} d \sin \alpha, \text{ for } \alpha \in \left[-\frac{\pi}{2}; \frac{\pi}{2}\right]$$

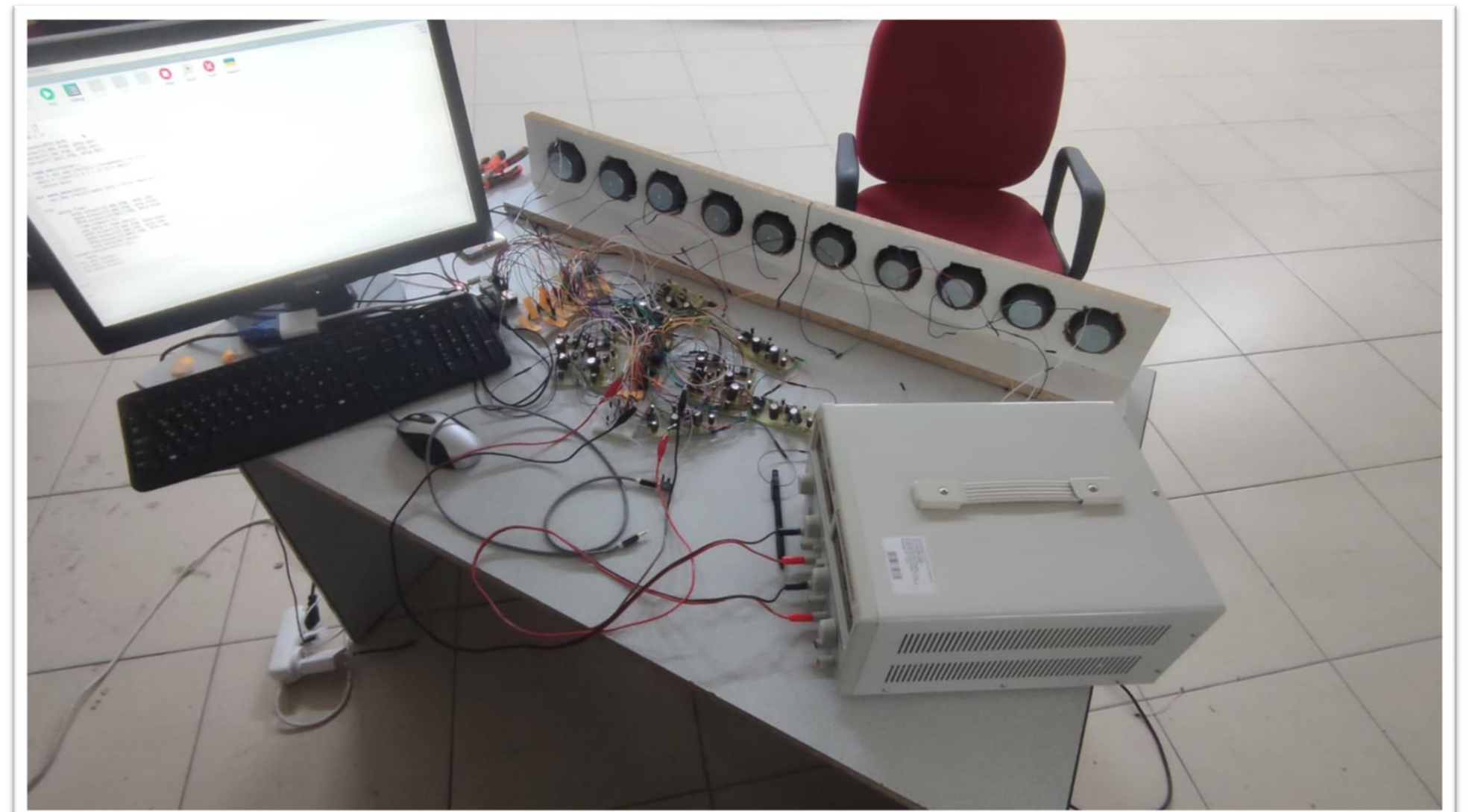


## Application Areas

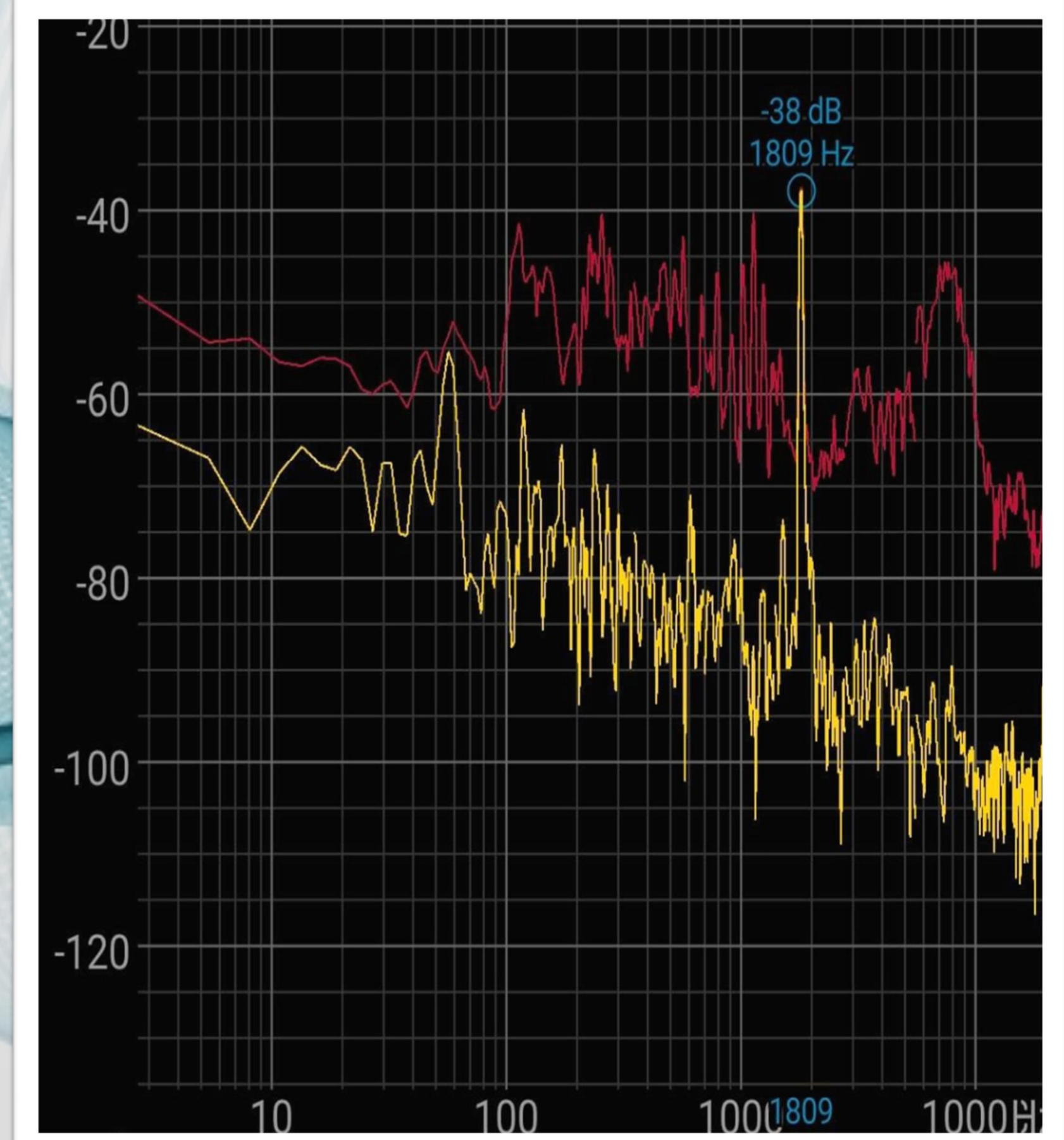
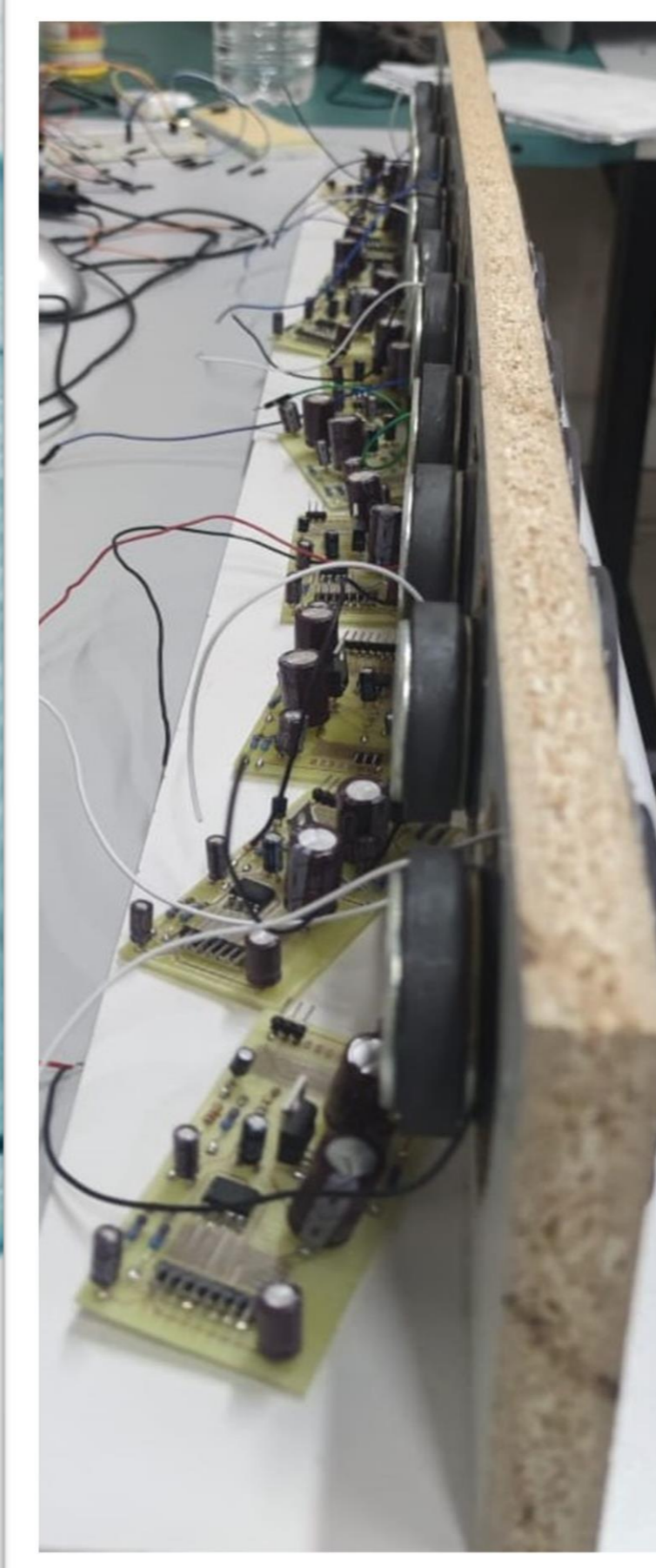
Our technology aims to transform audio delivery in public venues like cinemas and museums, allowing sounds to be directed precisely to specific areas. This ensures that audio can be heard only where intended, enhancing the experience without disturbing others.

## Results and Discussion

- ❖ Successfully minimized noise interference through optimized power supply adjustments and integration of noise reduction capacitors.
- ❖ Demonstrated precise directional control of sound using a Raspberry Pi-controlled ten-speaker array, meeting the project's beamforming objectives.
- ❖ Proved the system's utility in targeted audio applications, notably in cinemas and museums, enhancing auditory experiences without disrupting surrounding environments.



- ❖ Future work will focus on developing a microphone array designed to capture voice from the intended source only. This will complement the beamforming speaker array, creating a more integrated and efficient audio system.



## References

- Orfanidis, S. J. Electromagnetic Waves and Antennas. This book provided foundational theoretical insights for the phased array design in the project.
- B. Klaus and P. Horn, Robot Vision, Cambridge, MA: MIT Press, 1986.

## Acknowledgements

Special Thanks We extend our gratitude to **Ögeday Meriçler** for his invaluable assistance in the design and production of the PCBs. His expertise was crucial in realizing the technical aspects of our project.