Electroacoustic Project
IMDEA Master 2

B. Gazengel & M. Melon

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When using sound reinforcement systems, **directivity** is an important parameter that allows radiating high sound levels where they are expected (on the audience area) while keeping lower levels on the stage or in the neighborhood. To that purpose, directive subwoofer systems are now commonly used both for outdoor or indoor events.
Different solutions are available from the loudspeaker system manufacturers:

- Cardioid subwoofers
- Line array subwoofers
- End fire arrays: the terms "end-fire arrays" or "forward-steered arrays" refer to loudspeaker arrays whose direction of maximum radiation is along the axis of the array. They are mainly used for low frequency reinforcement systems. An example is given on Fig. 1. You can find additional information in Refs. 1 and 2.

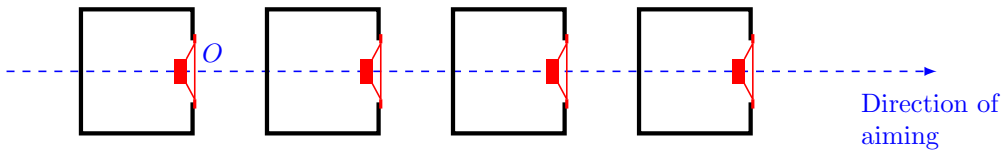

Figure 1: Linear end-fire array with four subwoofers

1 Work to do

Your work is to design and build a **scale model** (1 : 10) of a **directive subwoofer system** for the concert venue depicted in Fig. 2. The expected

full scale frequency bandwidth is 20 – 120 Hz yielding a 200 – 1200 Hz bandwidth for the mock-up.

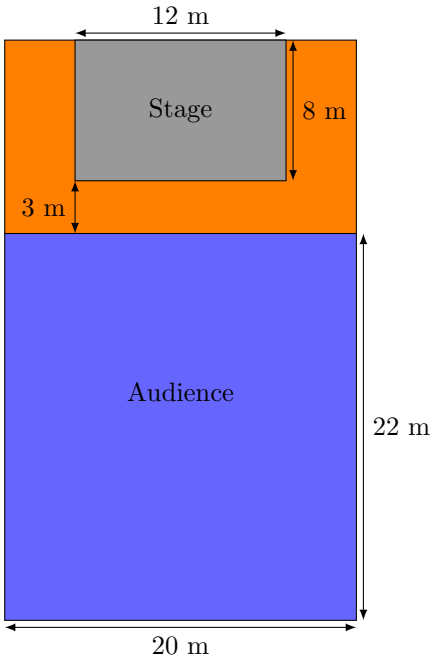

Figure 2: Geometry of the outdoor concert venue (real dimensions)

Mandatory specifications:

- The system must use 4 identical closed box subwoofers (so 4 small closed box loudspeakers for the mock-up).
- The whole system is driven by a mono signal but each single subwoofer can be amplified, filtered or delayed separately.
- To save space on the stage, sources must be placed in the orange area of Fig. 2.
- The sources are put on the floor and cannot be hung.

Free specifications:

- You can use any combination of these 4 subwoofers (loudspeaker spacing can be irregular).

Expected characteristics: You are asked to design a system that

- Has the more constant frequency response in the 200 – 1200 Hz frequency bandwidth (for the mock-up);
- Provides a nearly even coverage of the audience area (low level fluctuations);
- That radiates significantly less energy on the stage than on the audience or in the neighborhood.

2 Available equipment

- 4 small closed box systems
- A 8 channel USB sound card.
- A digital loudspeaker processor (with equalization and delay management)
- A 4 channel amplifier
- A computer with Matlab and various audio software
- Cables

3 Suggested schedule

In your timetable, you have 12 time slots of 3 hours dedicated to this work for which you can have access to the project room.Practical work and measurements must be performed within these slots. If required, you can also perform simulations or writing work in the free time of your schedule.

1. Bibliographic study
2. Simulation of the chosen geometry with monopoles
3. Measurement of individual closed box system responses.
4. Simulation of the system with individual closed box responses.
5. Building and Measurement of the system in the semi-anechoic room. (directivity and coverage)
6. Comparison with theory

7. Poster design

At the beginning, you can start by simulating the subwoofer behavior by using a monopole formulation:

$$p = \frac{jk\rho cQ}{4\pi}\frac{-e^{jkR}}{R} \tag{1}$$

In Equation 1, the time dependence $e^{j\omega t}$ has been omitted. The volume velocity of the source is denoted Q.

4 Presentation of your work

You are asked to design a scientific poster design (A0 size). You will be evaluated both on the poster (scientific work quality, pertinence, conciseness and clarity of the material printed) and on the oral defense of the material presented on the poster (15 minutes).

The poster should be printed for the 28$^{\text{th}}$ of November. The oral defense is scheduled on the 1$^{\text{st}}$ of December at 2pm.

Tips for poster design http://www.cns.cornell.edu/documents/ScientificPosters.pdf

Latex templates http://www.latextemplates.com/cat/conference-posters, http://www.brian-amberg.de/uni/poster/, http://www-i6.informatik.rwth-aachen.de/~dreuw/latexbeamerposter.php

Powerpoint templates http://www.posterpresentations.com/html/free_poster_templates.html,www.wakehealth.edu/Creative/Resources/Tip-Sheets/Creating-Large-Format-Posters-Using-PowerPoint.htm

References

1. M. Boone, W. Cho & J. Ih, "Design of a highly directional endf i re loudspeaker array", J. Audio Eng. Soc., 309-25, 382-92 (2009).

2. "Forward Steered Arrays in Precision Directivity Speaker Systems", JBL Technical note vol. 1, Number 28 (2001).

3. A. Hill, M. Hawkford, A Rosenthal & G Gand, "Subwoofer positioning, orientation and calibration for large-scale sound reinforcement", 128th AES convention, London, May 2010.