

## A CONCEPT OF AN ACTUATOR FOR THE POSITIONING MEASUREMENT SYSTEM IN AN ANECHOIC ROOM

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Automation of acoustic measurements constitutes a considerable challenge to designers. On one hand, the special character of acoustic measurements in an anechoic room requires designs that minimize disturbances to the acoustic field; on the other hand, automation always involves the introduction of additional mechanical elements, which disturb this field. The authors of this paper attempt to reconcile these conflicting demands by designing a mechatronic measurement system. On the basis of known solutions and current measurement needs, a number of concepts has been proposed, and a design has been identified that can be implemented in the room under study.

**Keywords:** acoustic measurements, anechoic room, mechatronics system, microphone boom.

### 1. Introduction

Automation of acoustic measurements in an anechoic room is a real challenge to designers. The special character of the measurements needs solutions that minimize the disturbance to the acoustic field, whereas automation systems always introduce additional mechanical elements which disturb the free acoustic field in an anechoic room. The anechoic room in question is a reinforced concrete cubic shell resting on spring vibroinsulators. All the internal surfaces are covered with sound absorbing systems in the form of 1.2 m long wedges. The working floor has the form of a steel rope net suspended at a height of 0.3 m above the wedge apexes. On the room ceiling there is a room housing, a hoist and a ventilation system (Fig. 2). The room outside dimensions are 10.4 m [H] × 10.2 m × 9.7 m, the inside dimensions are 6.9 m [H] × 7.2 m × 6.8 m,

and the volume is  $821.5 \text{ m}^3$  (Fig. 1). The chamber weighs about  $6 \cdot 10^8$  [kg] and with the vibroinsulation in place the room natural frequency is about 5 Hz.

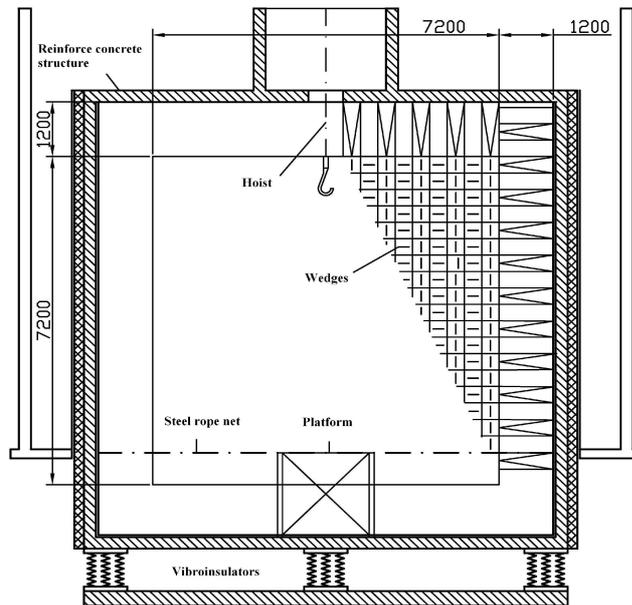


Fig. 1. Vertical cross-section of the anechoic chamber in AGH University of Science and Technology.



Fig. 2. The hoist positioned over the chamber ceiling.

The main goal of the manipulator under construction is to ensure greater precision, and versatility, to facilitate the research work and teaching, and to conform to the procedures specified in relevant standards. Analyses and studies have shown so far that these procedures require proper positioning of the microphone – mainly on the hemisphere surface.

## 2. Conceptual design of the manipulator for acoustic measurements

Practically most geometric and dynamic requirements allowing for automation of measurements are typical of the measurement procedures identified below:

- determination of the sound power level of noise sources (PN-EN ISO 3745:2005),
- determination of directional characteristics of sound diffusion for electroacoustic transducers (PN-EN 60268-5:2005),
- determination of sound distribution pattern on a pre-set measurement grid,
- multipoint studies of structures and sound sources using the impulse response method.

The measurement of sound power (PN-EN ISO 3745:2005), typical of the most frequent and most labour-consuming studies that require positioning of the measurement points on the hemisphere, was taken as a starting point for developing the idea of manipulator motions. Practically all the procedures mentioned above require positioning the microphone on the hemisphere surface and identifying directional characteristics of the source-object-microphone system. An exception is the determination of the sound intensity distribution on a plane measurement grid or on a grid matching the special shape of the machine studied. The latter option calls for special equipment and can be implemented in the future.



Fig. 3. The housing with springs located in the central point of support.

The structure of the chamber was analysed in terms of the possibility of installing a manipulator for measurements, with special regard to acoustic disturbance that can be caused by its drive system. Three possible concepts of positioning the manipulator were considered: on the chamber ceiling, under the floor slab and inside the room. The first two concepts were found difficult to implement: the first one, due to the increased length of the driving energy transmission path from the manipulator motors to the actuator units. This concept does not require breaking through the room's reinforced concrete owing to the presence of existing technological openings. The difficulty

with the second concept is that it requires breaking through the room's reinforced concrete structure. Also, it turned out that the floor slab is supported in its central point (Fig. 3) which prevents positioning the axle of any drive in the centre. The concept of installing the manipulator drives inside the room proved most convenient for imple-

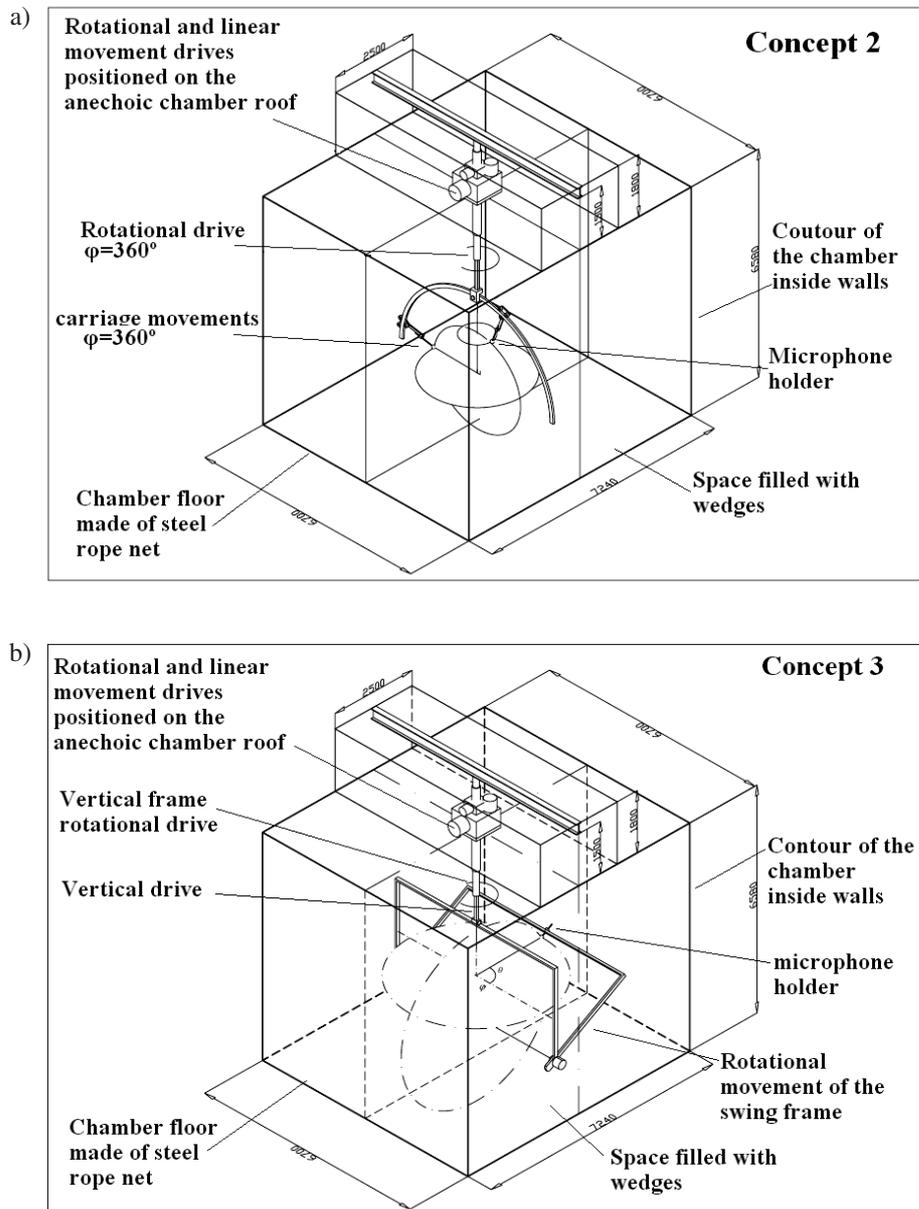


Fig. 4. A concept of the manipulator with the drive positioned above the chamber.

mentation in terms of construction. Figures 4 and 5 show the selected variants of the manipulator concepts considered, and Fig. 6 shows the variant selected for implementation.

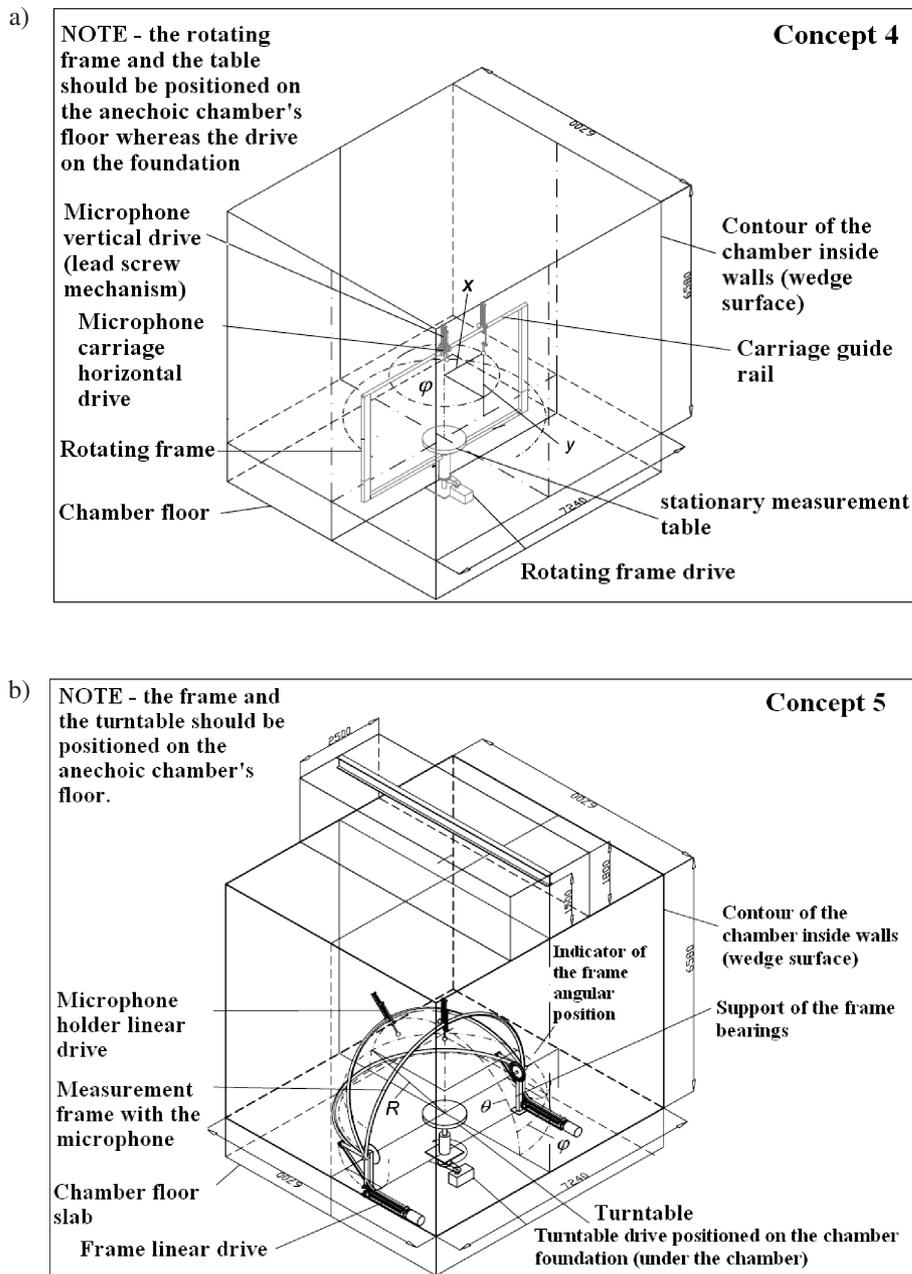


Fig. 5. A concept of the manipulator with the drive positioned under the chamber

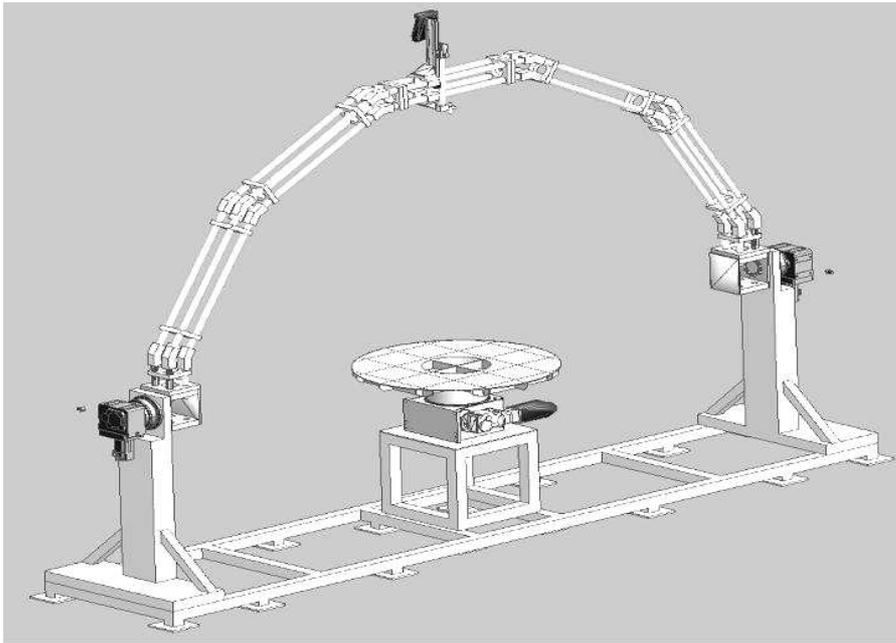


Fig. 6. The concept of the manipulator selected for implementation.

### 3. Conclusions

During the design work, several concepts of the manipulator design were analysed. The key problems in developing the concept were in ensuring the required rigidity of the supporting system structure under the assumed working space and the number of the device's degrees of freedom.

Finally it was decided that the device will have three degrees of freedom and the working space will be a hemisphere. One degree of freedom will be ensured by the rotation of the measurement turntable positioned in the centre of the room; the second degree of freedom will be ensured by a rotating frame supported by bearings positioned on the horizontal axis of the table plane thereby making it possible to change the angular position of the measurement system relative to the object studied. The third degree of freedom allowing the hemisphere radius to be changed will be ensured by installing a linear motion module on the rotating frame.

A concept was developed for fixing the measurement elements (microphones) and cables onto the frame. Also, a concept was developed for positioning the frame; mechanical drives were identified to be used in the model solution. On the basis of the analysis results, a rotating system with an actuator was proposed. The work resulted in a conceptual design of the manipulator for acoustic measurements that meets all the planned technical requirements. The model of the manipulator selected for construction is shown in Fig. 6.

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