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A UNIPLANAR MANIPULATOR FOR PRECISION ACOUSTIC STUDIES

T. KAMISIŃSKI, A. FLACH

AGH University of Science and Technology
Faculty of Mechanical Engineering and Robotics
Al. Mickiewicza 30, 30-059 Kraków, Poland
e-mail: kamisins@agh.edu.pl

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Directional studies of acoustic systems and acoustic transducers require considerable precision of orientation combined with co-ordination of control and measurement processes. The paper describes a manipulator designed and built by the authors. The manipulator is so designed that it allows a studied sample to be precisely rotated with a remote control of the rotation angle. It makes it also possible to measure angle-dependent radiation and reception patterns of loudspeakers, microphones, antennas, noisy mechanisms etc. The method of control and data collection from the manipulator via an RS-232 port should also be noted. It is also possible to communicate with the plain table through LAN.

Key words: turntable, microphone boom, rotation angle, digital remote control.

1. Introduction

Current research papers and engineering projects of various disciplines indicate the need of high resolution of measurement data. The cognitive process demands increasingly high accuracy to identify the studied phenomena. In acoustics, similarly, modern research procedures employed in the study of acoustic systems and directional acoustic transducers call for considerable precision in positioning. Automation of control and measurement processes is also needed along with a system of data transmission and storage allowing prolonged maintenance-free measurements. The common turntable or the "uniplanar manipulator" becomes thus the subject of the science of mechatronics. There are several designs of turntables available on the market. Among renowned manufactures, noteworthy is the Norsonic Company, which currently manufactures a very good turntable NOR-265 (Fig. 1) employing digital technology – a successor to model NOR-252. The Bruel&Kjaer Company manufactures the BK 9640 turntable (Fig. 2) with an analogue drive connected to a system working with a personal computer. Both tables differ in their designs and technical specifications but have a similar range of applications. The authors of this paper have designed and built a prototype of a new device, intended to combine the benefits of both designs and extend the control and measurement functions.

Fig. 1. Norsonic NOR265 turntable.
Max load: vertical – 50 kg,
Resolution: 0.01°
Rotation speed: from 22.7 to 720 s/rev.
Turntable plate dimensions: 300 mm
Weight: 6 kg
Drive: stepper motor.

Fig. 2. Brüel&Kjær type 9640 turntable.
Max load: vertical – 100 kg, horizontal – 30 kg
Resolution: 1°
Rotation speed: from 22.7 to 720 s/rev.
Turntable plate dimensions: 354 mm
Weight: 12 kg
Drive: DC motor.

2. The concept and practical implementation of the uniplanar manipulator

In undertaking the design of the measurement stand, the following assumptions were made:

- Full control of the turntable will be provided by a computer, notwithstanding the basic functions available at the turntable's control panel.
- Two-way communication between the table and the computer will ensure control and measurement functions:
  - setting, readout and following the turntable plate rotation,
  - possibility of modelling the movement pattern (speed, acceleration, direction, cyclic operation, etc.),
  - possibility of mounting additional sensors.
- Positioning resolution and reproducibility: 0.1°.
- Permissible load along the drive shaft: 70 kg.
- Compact design allowing versatile range of applications.

To attain the resolution and reproducibility of the turntable disc positioning, a stepper motor was used, as in the Norsonic Nor265 model. This design allows precise control of both speed, acceleration and the direction of rotation. Mechanical power is transmitted from the motor via a 486 mm long toothed band with a 1 mm module. The 10 mm thick gear wheel is made of aluminium and has 126 teeth. The wheel is set on a hollow shaft mounted on a 6204N bearing. The rectangular enclosure is made of 5 mm aluminium sheet metal, allowing mounting multifunction holders. Elements of the drive system and a complete prototype of the uniplanar manipulator in two basic outfit versions are shown in the pictures below.

The turntable is controlled by an ATmega8 microcontroller. Transmission of control characters between the personal computer and the turntable employs the RS232 serial port technology. A character sent by the software is received and interpreted by the At-

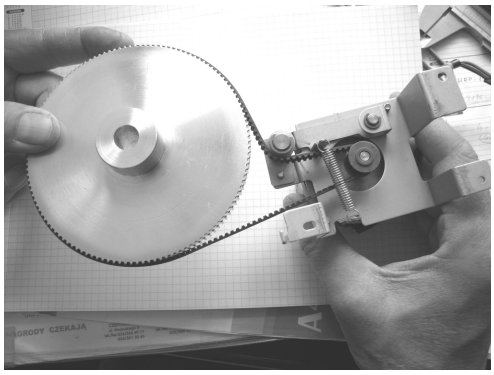


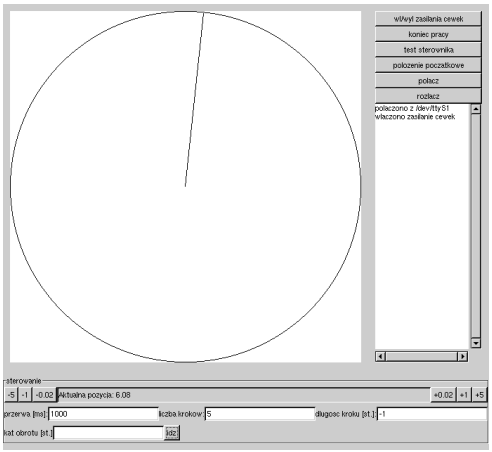
Fig. 3. Power transmission.

Fig. 4. Prototype manipulator.

Fig. 5. Rotating arm version.

Fig. 6. Turntable version.

mega8 microcontroller which in response sends control information to stepper motor controllers and to an LCD model WC1602A. The microcontroller acknowledges the receipt of information to the control software. The TEST function is used to check the software and establish the correct communication with the turntable and the starting position. Work is currently going on to attach the EVBedu.net module of the Propox Company, to make possible communication with the turntable using the TCP/IP protocol and make it available via a www website. It will also enable simple control of numerous sensors measuring e.g., temperature, pressure and humidity. The turntable is fed by an impulse 250 W power supply, to provide for possible extension of internal equipment. The turntable is controlled by software operating under the Linux system. Figure 7 shows a screen of a version of the control software, which makes it possible to follow the rotation angle (in the graphical and digital form), and to make settings and read information about the course of the task. The software can be modified in terms of its functionality and adaptation to specific measurement needs.



Turntable characteristics:

Static load	70 kg
Resolution	0.025°
Max turntable plate rotation	10 s/rotation
Dimensions:	
- width	300 mm
- height	222 mm
- length	316 mm
Total weight	6 kg
Max torque loading	2.6 Nm
Power supply	230 V, 50 Hz, 25 W

Fig. 7. Control software screen.

3. Conclusions

Experimental verification of the turntable prototype proved the usefulness of the device as a tool for laboratory operations in acoustic measurements. The high resolution ensures precise setting of the rotation angle and its reproducibility. The main role in the automation of measurements is played by the control software, which undergoes continuous improvement. Due to the noisy operation of the drive system, the model is rather predisposed to fixed-point acoustic measurements. Further work will focus on extending the application range.

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