

ВИМІРЮВАЛЬНІ ПЕРЕТВОРЮВАЧІ ТА СЕНСОРИ

LABORATORY OF ROBOT'S SENSORS

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Gdańsk University of Technology, Gdańsk, Poland

dswis@ely.pg.gda.pl

1. Introduction. Metrology is one of the numerous lectures carried out for students from the majors of Electrical Engineering or Control Engineering and Robotics (Metrology is recommended in the standards prepared by the Ministry). Classes on other subjects connected with measurements, for example Measurement Systems or Digital Signal Processing, are often carried out as well. Among the main subjects there are also specialized subjects, which are directly related to the field of studies. Robot's Sensors studied at the Faculty of Electrical and Control Engineering in Gdansk University of Technology is one of them.

Sensors used in robots allow to obtain information on the current location and parameters of the movement of its elements as well as on the surroundings of the robot [1]. Careful acquaintance with such systems on the grounds of a basic laboratory of metrology is insufficient and that is why on the outset of 2007 a new laboratory was prepared.

Robot's Sensors in the major of Controls Engineering and Robotics, Gdansk University of Technology is an obligatory subject for students with specialisation in Robotics and Mechatronic Systems and an optional one for those specializing in Control Engineering and in Technical Informatics.

The number of sensors produced in the fields where robotics is applied, is considerably lower than in e.g. motorization or in domestic appliances [2]. However, due to higher quality requirements they have to satisfy, their price is higher. Sensors used in robotics are sensors of the sensing systems: of location and displacement, speed, touch, sight, presence and rapprochement.

2. Laboratory stands. In the laboratory of Robot's Sensors, laboratory stands were prepared, which enable research on the following systems:

1. Photoelectric sensors

- distance sensors (BOD66M LA04-S92 and BOD66M RA01-S92 from BALLUFF and WTA24-P5501 from SICK),

- retro reflective (BOS 6K-PU-1QC-C-02 from BALLUFF),

- diffuse (BOS 6K-PU-1OC-C-02 and BOS 6K-PU-1HA-C-02 with background suppression, from BALLUFF),

- as a standard – micropulse transducer BTL.

2. Ultrasonic sensors

- with programmable switching outputs (UM 30-11112 from SICK),

- with voltage output signal (UM 30-11113 from SICK),

- as a standard a digital electronic caliper.

3. Inductive sensors (from BALLUFF):

- with voltage output signal (BAW G06EE UAE20B-EP03K and BAW-M18MI2 UAC50B-BP05-00),

- with switching outputs (BES 515-360-BO-C-PU-03, BES 516-3044-G-E4-C-PU-02, BES 516-3048-G-E4-C-PU-02, BES M08MI-NSC20B-S49G, BES M12ML-PSC30A-S04G-W, BES R01ZC-PAC70B-BP03),

- with self diagnosis (BES 113-356-SA6-PU-03),

- as a standard a digital micrometer.

4. Capacitive sensors

- with switching outputs (CM18-12NPP-KC1 and CQ35-25NPP-KC1 from SICK),

- as a standard a digital micrometer.

5. Magnetic field sensors

- with switching outputs (BMF 307K-PS-C-2-PU-05 and BMF 307K-R-AS-L-3-03 from BALLUFF),

- as a standard a digital micrometer.

6. Limit switches

- a number different limit switches (eg. BNS 519-FD-60-101 from BALLUFF),

- as a standard digital indicator.

7. Rotary encoders

- incremental encoder (BDG 6360-0-10-30-1000-65 from BALLUFF),

- absolute encoder (BRGD 0 WAD 256-00-P-R-K-02 from BALLUFF).

8. Intelligent Camera Sensors

- ICS002-B1111 from SICK.

9. Mobile robot with four sensors

- touch sensor,
- sound sensor,
- light sensor,
- ultrasonic sensor.

3. Course of the classes. 30 hours per semester are stipulated to classes in the laboratory of Robot's Sensors. This time is divided into 10 3-hour meetings (first class is introductory, next classes are conducted on the stands described in chapter 2). Individual stands were designed and made in modular form, thanks to which various sensors of the same kind can be studied on a given stand. Students select the sensors, connect them to the system by themselves and perform measurements stipulated by the exercise. Students have documentation of the sensors enclosed by the producers at their disposal and they have to look the necessary information up in them on their own (ways of connecting them, ranges, characteristics).

As an example, on the stand for studying optical sensors, one of many sensors can be fastened (different ranges and different functioning rule – infrared light or laser). Measurement with linear BLT micropulse transducer is assumed to be the model indication. Slider of this transducer is linked to a handle, in which you can place the element, from whose surface the optical sensor beam of light is reflected. This surface can have various colors and textures (shiny or mat). You can also use a special mirror here. Figure 1 presents students examining optoelectronic sensors.

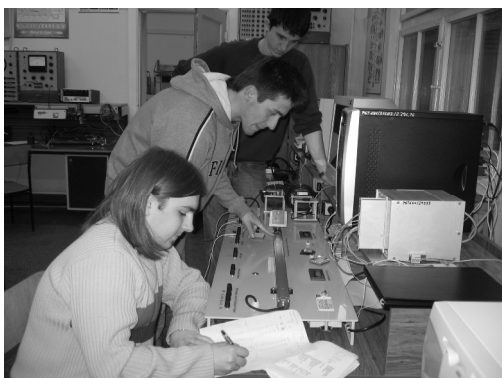


Fig. 1. Students examining optoelectronic sensors

During the process of test of inductive and capacitive sensors, students can use different material of object which is bring to the sensor, in test of ultrasonic sensors measurements are execute for different shapes of surface. Figure 2 presents laboratory stand for test of ultrasonic sensors.

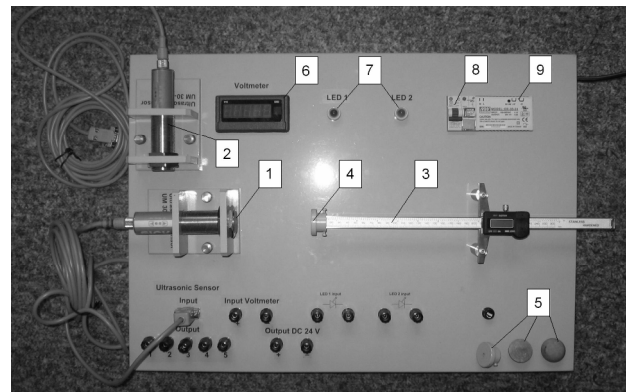


Fig. 2. Laboratory stand for test of ultrasonic sensors: 1 – sensor in test, 2 – second sensor, 3 – digital electronic caliper, 4 – flat tip, 5 – tips in other shape, 6 – meter for measurement voltage output signal, 7 – indicators for switching outputs, 8 – power switch, 9 – power supply

In the exercise with the rotating encoders, the incremental encoder is mechanically mounted to the absolute encoder. The outgoing signal of incremental encoder is brought to the counter input of the acquisition card [3], whereas the absolute encoder outputs to the binary inputs. Appropriate software allows to compare location of both encoders.

During the last exercise, students acquaint themselves with a simple mobile robot equipped with four sensors: of touch, sound, light and distance. The aim of this exercise is to study parameters of the used sensors. Next, a programme of the robot is prepared, in which robot's functioning is dependent upon signals from separate sensors. As an example, the robot moves on the black line painted on the floor (signal from the light sensor), changes the movement direction when it approaches an obstacle (signal from the ultrasonic sensor) or when it touches it (signal from the touch sensor), it moves on or stops after a sound signal (signal from the sound sensor).

4. Conclusion. The laboratory of Robot's Sensors at the Chair of Metrology and Information Systems of Gdansk University of Technology was launched only in

the outset of 2007 and that is why classes lasting only one semester were so far conducted there.

Laboratories consecrated to general robotics [4] do not allow acquaintance with robot sensors in such a great degree. That is why preparing specialist laboratories is advisable.

Classes that were so far carried out prove that the hereby subject is crucial for the future industrial robot specialists. Due to the variety of sensors (induction, capacitive, ultrasonic, optoelectronic) and hundreds of types included in one kind, experience in choosing sensors for certain applications is essential. Many factors have influence on it, e.g. place of fastening, type of the material used, color and texture of the surface, potential disruptions, contamination, pollination, lighting. The prepared laboratory allows to familiarize with properties of those sensors and consequently to make the right choice for the given application.

It is also a good idea to demand that students connect the measuring system on the basis of original documentation of the sensors. Not having ready systems at

their disposal, as it sometimes happens in other laboratories, students overcome problems which they may face during the engineering work. During the first classes, it may cause some problems but as the students gain experience, classes are conducted smoothly.

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ДОСЛІДЖЕННЯ ХАРАКТЕРИСТИК МАТЕРІАЛІВ ДЛЯ УЛЬТРАЗВУКОВОЇ ТЕРМОМЕТРІЇ

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Національний університет "Львівська політехніка", вул. С. Бандери, 12, Львів, Україна

ivt@polynet.lviv.ua

Наведено результати дослідження акустичних властивостей матеріалів для ультразвукової термометрії. Дослідження виконано на дослідному комплексі, в основі якого швидкісний аналого-цифровий перетворювач.

Приведены результаты исследований акустических свойств материалов для ультразвуковой термометрии. Исследования проводились на исследовательском комплексе, в основе которого лежит быстродействующий аналого-цифровой преобразователь.

There are shown the results of researches acoustic properties of materials for the sensible elements of ultrasonic materials. For researches acoustic properties an experimental complex based on fast-acting analog-digital transformer.

Вступ. Чутливий елемент ультразвукового імпульсного термометра – це ланка, яка забезпечує високі метрологічні характеристики засобу вимірювання. У ході досліджень експериментальних зразків ультразвукових термометрів було виявлено, що такі характеристики, як чутливість, діапазон вимірюваних температур, стабільність, ресурс тощо залежать

передовсім від властивостей матеріалу чутливого елемента термометра. Але відсутність достатньої інформації про температурні залежності пружних властивостей твердих матеріалів сьогодні обмежує вибір матеріалів для створення чутливого елемента ультразвукового термометра.