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Mateusz SUMERA, Mariusz Piotr HETMAŃCZYK[1]

[1]Institute of Engineering Processes Automation and Integrated Manufacturing Systems, Faculty of Mechanical Engineering, The Silesian University of Technology, Gliwice, Poland
*mariusz.hetmanczyk@polsl.pl

SIMPLE ANGLE TRANSDUCER WITH ENHANCED RESOLUTION

Abstract: The article presents concept of simple angle transducer implemented for measurement of physical pendulum angular position. An introduction to the most commonly used transducers of angle of rotation was also described. The structure and the basic functional characteristics of developed transmitter were discussed. Another significant element is mounting in the laboratory stand used for optimization of swing values of the physical pendulum.

1. Introduction

Implementation of tasks associated with industrial drives positioning requires the use of complicated angle sensors. These sensors shall be characterized by a sufficiently large resolution (in order to obtain accurate information about the angular position of the machine), interference immunity (required for the measurement in harsh environment e.g. pollution, which in the case of sensors with optical systems may adversely affect the measured value). Angle transducers are used to [1,2]: a measurement of a speed (linear or rotational), obtaining information about the current position of movable elements, execution of reference movement, ensure a proper operation of drives using vector control algorithms.
In terms of action mode transducers can be divided into the following groups:

- incremental encoders - systems consisting of a shield and scanning elements (which may be optocouplers),
- absolute encoders - transmitters with memory of current position, even after turning off the power supply and fast change of position,
- resolvers - the most commonly used transducers in case of synchronous servo motors.

In case of a incremental encoder a disc transducer has on the perimeter two rows of holes with a determined spacing. Number of drill holes of the channel indicates encoder resolution, or accuracy of the measurement position. The measuring system is responsible for counting the number of pulses in order to obtain information about the current position.

An absolute encoder generates a coded signal corresponding to the position. An example is the absolute encoder with Gray coding, in which two successive code words differ only in the state of one bit. These transmitters can be divided into single-turn (which distinguish the

position of only one turn) and multi-turn (producing an output signal with information about the angular position and the number of revolutions).

Resolvers are constructed with stator and rotor windings. Rotor winding generates an alternating magnetic field that causes induction of the voltage in the two coils of stator (which are offset by 90). The voltage of one of the coils allows to determine the value of the cosine, while the second coil allows to determine the value of the sine of the angle of rotation. The ratio of voltages which are induced in individual windings depends on the rotor angular position [1,3].

2. Design of the angle transducer with enhanced resolution

In order to simulate a process of damping (in terms of different control algorithms realized by electric motors operated via frequency inverters) the model used to study a swing position of the physical pendulum was constructed. Described laboratory enables testing of advanced algorithms for damping of oscillations [6].

To meet requirements connected with obtaining information about the current position of the oscillator and implementation of damping algorithms the value of current angle of rotation is required. Outputs of described transducer are connected to a PLC controller. Due to the high cost of finished products the authors improve their own concept of incremental encoder. The two-channel transducer delivers pulses at different phase (Fig. 1), in order to determine the direction and angle of rotation of the physical pendulum.

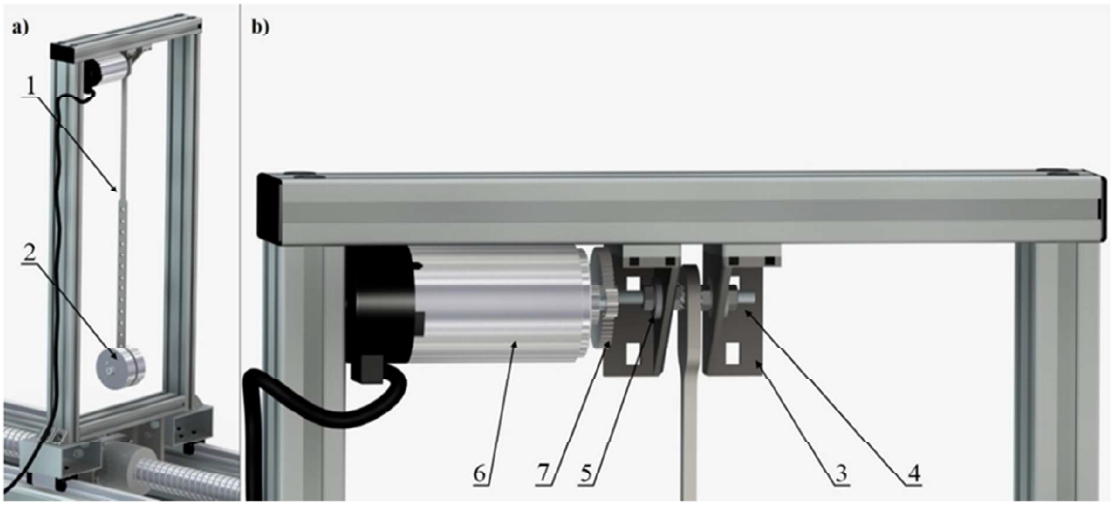

Fig. 1. View of the physical pendulum model: a) the frame, b) the clamping unit, where: 1 - the frame of the pendulum, 2 - test masses, 3 - mounting brackets, 4 - rotary axis, 5 - ball bearings, 6 - an encoder, 7 - a gear

Element used for generating pulses is a mechanical rotary winding pulser (Fig. 2). The system has three channels labelled A, B, C. Channel C is an input signal, which is based on the angle of rotation calculated on the basis of set at the inputs A and B. One turn generates 24 rising edges on the each of defined channel [7].

Constructed transmitter as an electronic system allows to work at a supply voltage of 5 Volts. On the other hand inputs signals of the most PLC controllers determine the value of the voltage according to the following ranges:

- 0÷5 [V] - logical zero,
- 6÷14 [V] - transient state,
- 15÷24 [V] - logical one.

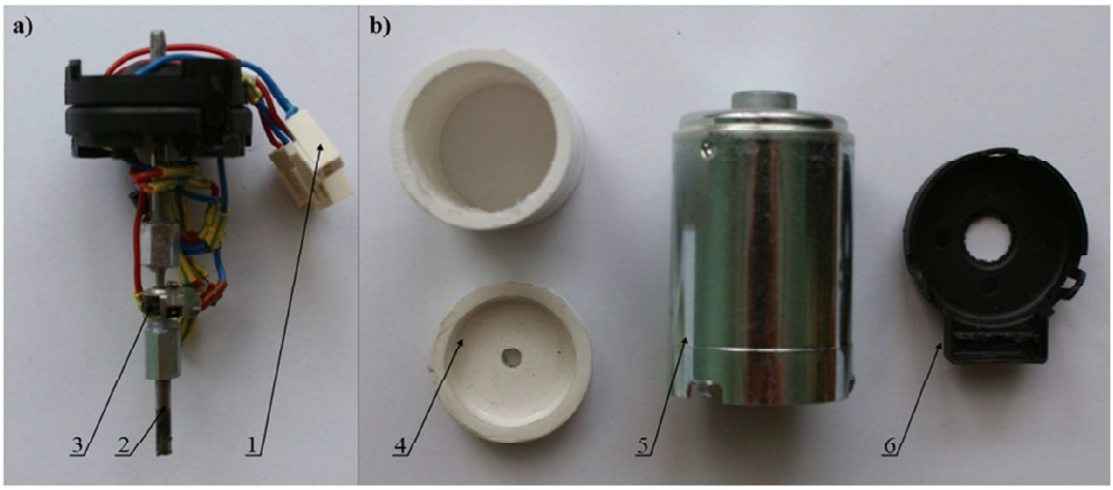

Fig. 2. View of encoder components: a) electronics, b) elements of the case, where: 1 - connection sockets, 2 - axis of the sensor, 3 - pulser, 4 - inner housing insulation, 5 - body, 6 - shielded wires

To ensure correct operation [5] of described encoder the authors used additional power source (changing of voltage to 24 Volts at the time of achieving a rising edge on any channel of encoder and sending the value to an input of a PLC controller). For this purpose, the technology of MOSFET N-type transistor (model BS170) was used, the operation of which is shown in Figure 3.

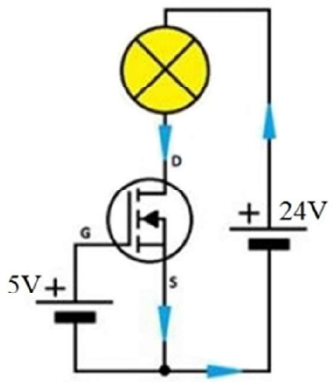

Fig. 3. Principle diagram of the MOSFET N transistor [4]

The transistors have three channels drain D, the goal G and the source S. The circuit compares the voltage found on a channel G and S at the moment the voltage from the encoder equals to 5 Volts. At the gate transistor facilitate a flow of voltage between the drain and the source, therefore it is possible to send required voltage to the PLC controller.

Control is made through voltage, therefore, the transmitter is equipped with the resistors to reduce the value of current intensities of described circuits (5 Volts - resistor 2.5 kΩ and 24 Volts- resistor 25 kΩ).

Due to the use of two-channel encoder, described relationship was performed twice. Created system has been assembled in a housing made of an insulating PVC (Fig. 2). As the body of a motor housing of DC was used. The housing is equipped with bushings in place of the support of the encoder axis.

Due to the low number of pulses generated between the axis of the physical pendulum and the encoder axis the author used a gear ratio of i=4 (Fig. 2). This results in 192 pulses per full revolution of the oscillator, i.e. generate a pulse occurs every 1,875°.

3. Summary

The article shows an implementation of the incremental encoder designed to determine the angle of rotation of physical pendulum. Control of the angular position belongs to difficult tasks due to the necessity of obtaining a high-resolution, self-acquired data and the reliability of measuring equipment.

Presented concept has been made due to lack of angle transducers characterized by required parameters and dimensions. The basic features of the described solutions are simplicity of implementation, a low cost and an acceptable accuracy. On the other hand, it is also essential resistance to external conditions (determined by the housing).

The described solution has been implemented and tested. In conjunction with the control system and advanced algorithms the authors obtained an opportunity to test the influence of inclination angles at positioning accuracy of transported masses on gantries, cranes and other handling equipment .

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