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DEVELOPMENT OF PROGRAM FOR MEASURING THE MOTOR ROTATION SPEED WITH THE HALL SENSOR

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The objective of this work is the development of laboratory training set-up for measuring the rotation speed of motor using a Hall sensor. The developed set–up was assembled of an electric motor, digital Hall sensors, motor and sensor power supply, and MyRIO set-up. The program for calculation the angular speed was designed in LabVIEW graphical environment and NI MyRIO. The result of this work istheautomated facilitydevelopment for studying the Hall sensor in measuring ofthe angular velocity. This facility can be used in such disciplines as «Fundamentals of Measurement in Physical Science», «Information and Measurement Systems» and «Measurement Automation» when studying the LabVIEW environment.

Key words
magnetic field sensors,the Hall sensor,angular velocity, angular speed measurement

Introduction

Magnetic field measurement is a critical priority in the area of space exploration, navigation, magnetic tomography, mineral exploration and non-destructive testing. The high current magnetic field sensors are used in mobile phones, notebooks, microsatellites and microrobotics. There are different types of magnetic field sensors: Reed sensors, GMR, Hall effect sensors, Wiegand effect sensors, magnetoresistive and induction sensors, squids.

The Hall sensors gained the most widespread acceptance. They are used for measurements of current, power, speed, and distance. The Hall electromotive force is used even in the CD-drive in any personal computer. But the most common application of the Hall generator was provided in the motor-vehicle industry for measuring the camshaft and crankshaft positions, as well as for motor control applications, as the electronic ignition.

This paper presents the development of a training set-up based on the National Instruments MyRIO-1900 designed for measuring the angular speed with the Hall sensors.

NI MyRIO-1900 includes dual-core ARM® Cortex™, Xilinx field programmable gate array (FPGA) used for designing real-time applications. NI MyRIO has the programmable Zynq-7010 installed, which allows designers to use the LabVIEW environment in full scale to develop a laboratory training set-up. The FPGA facilities and imbedded Wi-Fi provide the remote control over the set-up. NI MyRIO includes 40 digital I/O, ten analog inputs and six analog outputs to add a great number of sensors.

Hall sensor principle

The Hall sensor is a magnetic field sensor based on the phenomenon of the Hall effect. The Hall effect is the transverse voltage by placing the conductor with direct current in a magnetic field. This effect was discovered by Edwin Hall in 1879, in thin gold plates.

So, the current from an external source goes across a semiconductor plate.

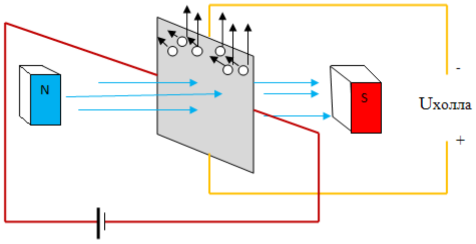

Fig.1. The Hall Effect

The plate is placed in the magnetic field, the magnetic field vector is perpendicular to current direction. As a result, the Lorenz force holds electrons deviating from straight-line motion. under the action of the Lorentz force electrons to deviate from a straight forward. This strength moves electrons in the direction perpendicular to the magnetic field and the current (Figure 1).

In this case, the number of electrons at the upper edge of the plate is greater than at the lower edge, therefore, there is a potential difference. This potential difference causes the appearance of the Hall voltage. The Hall voltage is proportional to the current and the magnetic field induction. At constant value of the current through the plate, it is determined only by the value of the magnetic field induction (Figure 2).

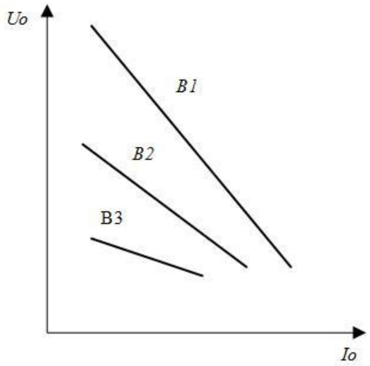

Fig.2. Dependence of output voltage from current

Sensitive elements are made of thin semiconductor films. These elements are grown on substrates and supplied with outputs for external connections.

Measurement of motor rotational speed

One of the basic examples of the Hall sensor application is measuring the rotation speed of motor shaft. Unlike mechanical and optical sensors, Hall sensors have an important advantage – they are hardly sensitive to mechanical impact and changing of environment and minimize the cost of complete solutions therewith. In order to measure the speed of rotation, the Hall sensor is fastened on stationary parts and then, magnets are fastened on moving parts.

Figure 3 shows a block diagram of the lab set-up for measuring the rotation speed of the disc. A permanent magnet disk (2) divided into 5 Northern and Southern poles was fastened on the motor shaft (1). The Hall sensor (3) output was connected to the analog-to-digital converter (ADC) NI MyRIO (6). When rotating magnetic disk (2), the output Hall sensor signaloccured in the form of rectangular pulses (figure 4) with the frequency directly proportional to the disk rotation speed.

The motor rotation speed is calculated with the ADC digitized data according to formulas (1-3).

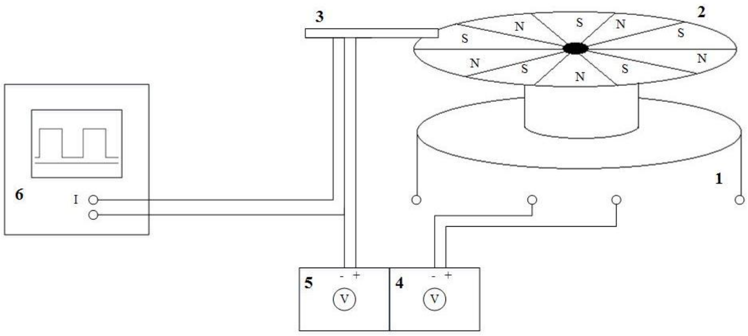

Fig.3. Block–diagram of lab set-up for measuring the disk rotational speed.
1 – electric motor; 2 – magnetic disk; 3 – digital Hall sensor; 4 –motor power supply; 5 – Hall sensor power supply; 6 – MyRIO set-up.

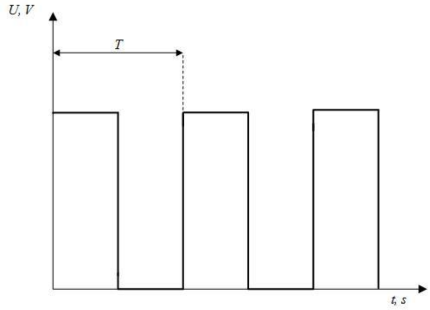

Fig.4. Signal obtained as the outcome of experiment

Signal processing sensor probes

$$T = \frac{1}{f} \quad (1)$$

T-period of rotation, s; *f*- rotation frequency, Hz.
Angular velocity is often defined in rotations per minute. One turn is 2π radians or 360°:

$$w = \frac{\pi \cdot V}{30} \quad (2)$$

thus,

$$V = 60 \cdot f \quad (3)$$

where*w* is circular frequency, rad/s;
V is angular speed, rpm.

Program to measure angular speed

Algorithm for measuring the angular speed is shown in Figure 5.

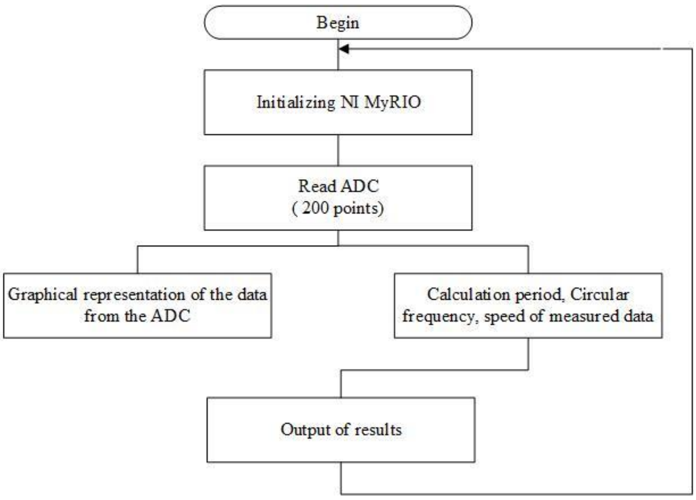

Fig.5. Program for measurement of angular speed

The algorithm was realized as a program written in LabVIEW. Block diagram of the program is presented in Figure 6.

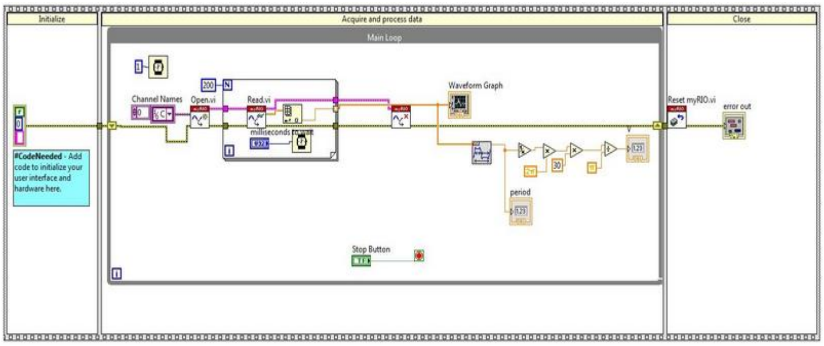

Fig. 6. Block-diagram of program for angular speed measurement

The user interface is presented in Figure 7. The ADC data are plotted as a waveform and used for calculating the signal period. Angular velocity is calculated according to formulas (1-3).

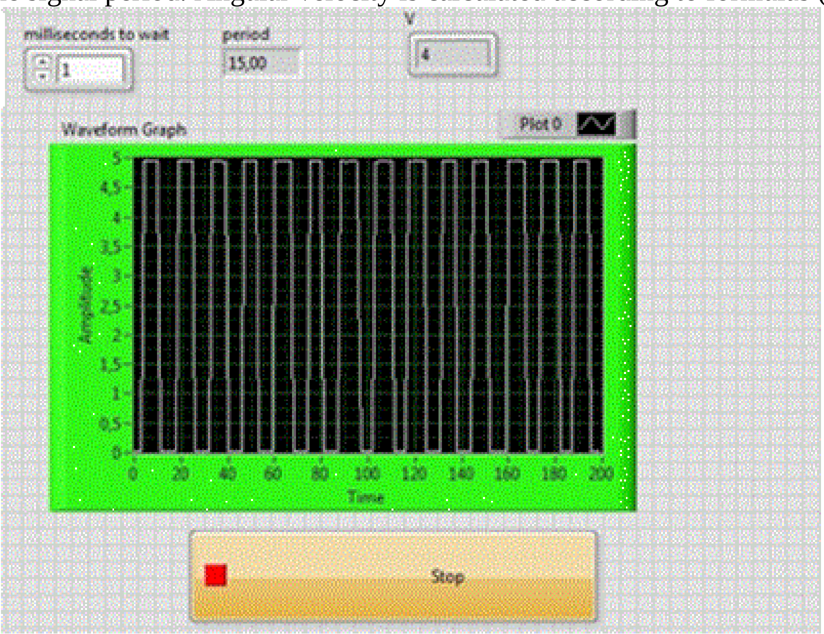

Fig.7. Front panel of program for angular speed measuring

Conclusion

An automated laboratory facility was developed for measuring the angular velocity with the magnetic Hall sensors. Both analog and digital Hall sensors can be studied by means of this laboratory set-up. The developed training set-up can be used in «Fundamentals of Measurement in Physical Science» when studying the Hall sensors, as well as in «Information and Measurement Systems» and «Measurement Automation» courses studying the LabVIEW environment.

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