Galvanomagnetic Device for Angular Displacement Measurement

Nikola D. Draganov[1], Totka A. Draganova[2]

Abstract – **Galvanomagnetic devices are found a very wide application for linear and angular measurement in spheres of instrumentation, automatics, motor industry, building machinery, geology, shipping. They are based on galvanomagnetic sensor for angular displacement and unit for information processing and visualizing. Block diagram and principled electrical scheme, operation algorithm and conversion characteristics of galvanomagnetic device for angular displacement measurement have been presented in this article.**

Keywords – **Galvanomagnetic sensors, Hall elements, Displacement measuring, Angular and Linear measuring.**

I. INTRODUCTION

Angular displacement measurement is pressing problem which is solved by creating of new more modern sensory mechanisms and modules for information collection and processing. Hall elements are most spreaded galvanomagnetic elements which enable on their basis to create sensors for angular displacement. They have high sensitivity, linear conversion characteristics and high operational reliability.

The problem connected with collection, treatment and indication of the information obtained by the sensors is very pressing for engineering practice. Using modern element base is possible to achieve good results in magnetic quantities measurement.

The purpose of the present elaboration is to create and investigate a galvanomagnetic device on a basis of experimental galvanomagnetic transducer for angular displacement with Hall elements and established analog-to-digital converter (ADC). The device is designed on a basis of a possible small number of electronic elements and enables easy measurement of angular displacement in one plane.

This elaboration can be a base of later investigations and implementations.

II. PRESENTATION

Hall elements application for measurement of magnetic field, electrical and unelectrical quantities are wide discussed in [5].

[1]Nikola D. Draganov is with the Technical University of Gabrovo, Hadgi Dimitar, str.4, 5300 Gabrovo, Bulgaria,
E-mail: niko_draganov@mail.bg
[2]Totka A. Draganova is with the Technical University of Gabrovo, Hadgi Dimitar, str.4, 5300 Gabrovo, Bulgaria,
E-mail: totka_koeva@mail.bg

Block diagram of a synthesized device is depicted in Fig 1.

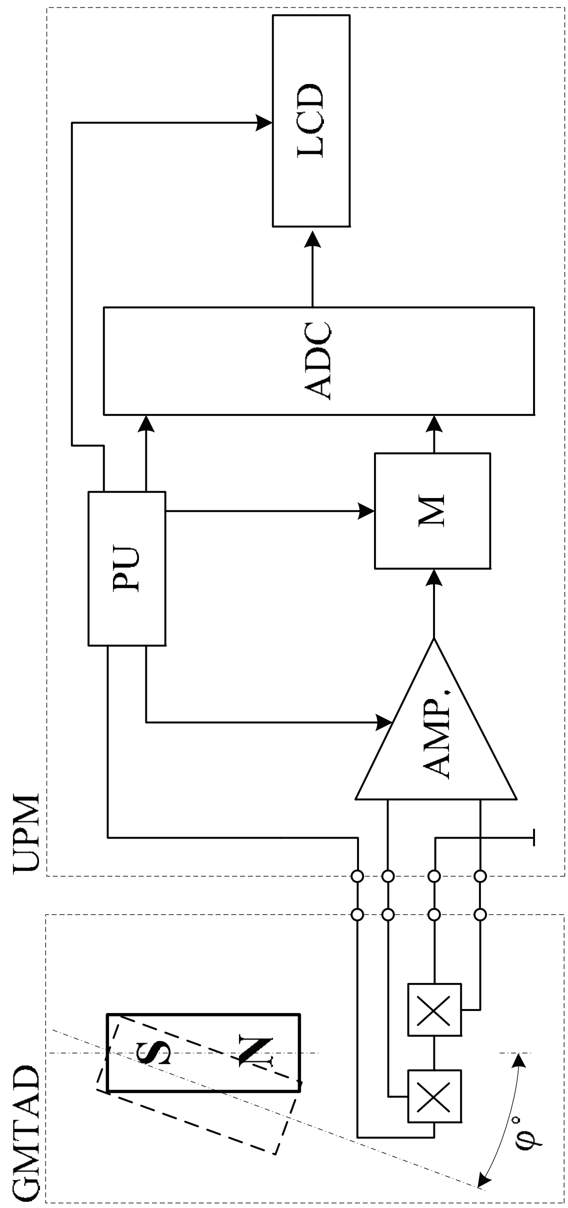

Fig.1. Block diagram of galvanomagnetic device for angular displacement.

It is composed of two modules – galvanomagnetic transducer for angular displacement (GMTAD) and unit for processing and measuring (UPM).

Module GMTAD consists of two uniform Hall elements, of the type VHE101, and a permanent magnet. Hall elements are immovably installed at a distance a=1mm in relation to a permanent magnet which depending on purpose and operating way can turn if it is fixed in a center or can incline if it is fixed in upper edge. Detailed description of offered constructed variant of galvanomagnetic sensor for angular displacement is made in [1, 2].

GMTAD operation is based on double energy transformation. Angular displacement alternations is transformed into magnetic inductance alteration which by means of Hall elements is converted into electrical signal and magnetic field influence angle is changed [2]. Therefore the appeared angular displacement is detected by GMTAD and the obtained output signal is proportional to angular displacement.

Module UPM is designed from input differential amplifier (AMP), former (M), analog-to-digital converter (ADC), liquid crystal indicator (LSD) and power supply (PU). By means of this module is fulfilled sensory signal processing, transformation and measurement.

A schematic circuit diagram is depicted in Fig. 2.

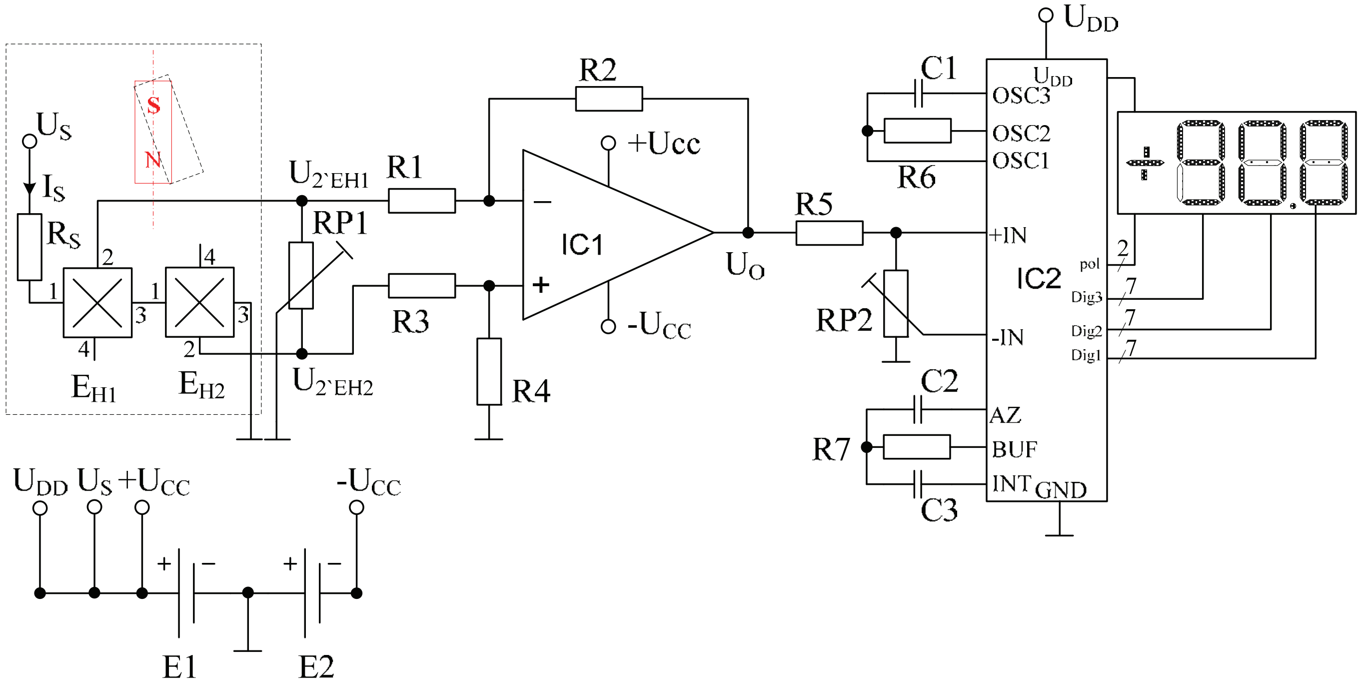

Fig. 2. A schematic circuit diagram.

Galvanomagnetic transducer for angular displacement is consisted of Hall elements E_{H1} and E_{H2}, of the type VHE101. They are supplied from accomplished by the high-resistance resistor R_S generator. The operating point of both connected in series galvanomagnetic elements depends on value and power of this resistor which is choice with parameters R_S =1kΩ and P_{RS}=0,5W. In this case Hall elements are supplied with rated control current I_S=5mA at which they have maximal magneto-sensitivity and more linear conversion characteristics.

A sensory signal (Hall voltage) received direct from both homonymous electrodes of Hall elements (pin 2 of $E_{H1}$and pin 2 of E_{H2}) is delivered to differential amplifier inputs. It is constructed on the basis of operational amplifier LM358. The inverting input of the operational amplifier (IC1) is enveloped in negative feed-back by resistor R1 and R2. Resistors R3 and R4 deliver symmetry on no inverting input.

At direct current I_S=5mA and without a slope (φ°=0) by means of potentiometer RP1 a voltage asymmetry between both homonymous electrodes of Hall elements (pin 2 of E_{H1} and pin 2 of E_{H2}) is eliminated (U_H=0). Amplified sensory signal is given to input of 10 Bit ADC realized by special integrated circuit ICL7106. It has high input resistance, good conversion characteristics, simple setting and possibility to indicate results on liquid crystal display without additional driver. By means of voltage divider consisting of resistors R5 and PR2 device setting and calibrating is provided. Clock frequency of ADC is set up by group R6 and C1. Capacitors C2, C3 and resistor R7 set up in ADC processing results refreshing time. Two dry batteries E1 and E2 (9V) are used to supply a circuit.

When a supply power is connected without applied incline the permanent magnet magnetic field will act in the same degree on both magneto-sensitivity elements E_{H1} and E_{H2}. As a result a voltage difference applied to the differential amplifier inputs (U_{H22}) will be zero. An angular displacement causes an incline of GMTAD permanent magnet (Fig. 1) to one of both Hall elements in according to displacement direction. Magnetic field begins to act more on one Hall element and less on other (Fig. 2). A voltage difference appears between pin 2 of $E_{H1}$and pin 2 of E_{H2}– $U_{2`EH1}$<$U_{2`EH2}$. This difference is amplified by differential amplifier (IC1) and by means of resistor R5 and potentiometer RP2 a reading of GMTAD is set up in degrees. If GMTAD is tilted to another direction the circuit operation will be analogous but the display will show a sign of minus. When angular displacement is changed output voltage difference between pin 2 of E_{H1} and pin 2 of E_{H2} is now with opposite polarity, i.e. $U_{2`EH1}>U_{2`EH2}$ (Fig. 2).

GMTAD is investigated and conversion characteristics are obtained at the angle incline $\varphi°$ = (-90°÷+90°). The conversion characteristics families $U_O=f(\varphi°)$ obtained by experiment are depicted in Fig. 3 for three control current values I_S=1; 5; 10mA and a constant temperature (T_O=const).

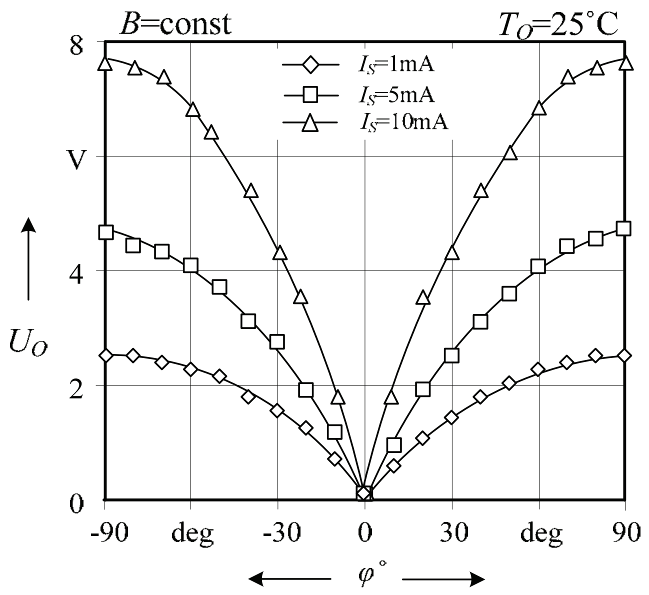

Fig. 3. Conversion characteristics $U_O = f(\varphi°)$.

The analysis shows that they are non-linear over the entire range of angle change and their symmetrical disposition in the first and second quadrants of coordinates. The biggest characteristic slope is obtained at initial angular displacement. For instance at $\varphi°$= (0 ÷ 60°) the slope is S_A= 0,03; 0,09; 0,065V/deg at I_S = 1; 5; 10mA respectively. At bigger angles displacement $\varphi°$= (60°÷ 90°) the slope is S_A= 0,01V/deg at I_S= 10mA, i.e. it is 6 time smaller than at small angular displacement.

III. Conclusion

A device for angular displacement measurement on the basis of galvanomagnetic transducer with Hall elements, differential amplifier and analog-to-digital converter has been synthesized and investigated.

Measuring block has been realized by means of conventional analog-to-digital converter (ICL7106) with accuracy (±5%) in view of there are not requirements to electronic elements limits and they do not influence on measurement accuracy.

The power supply can be realized external or by batteries which makes device portable.

Experimental conversion characteristics $U_O=f(\varphi°)$ of galvanomagnetic transducer for angular displacement are obtained at I_S=const and T_O=const. They show a wide change of measured parameter ($\varphi°$= -900 ÷+900).

The circuit design is characterized with accessible accomplishment, simple setting and calibration which opens up it to a wide group of specialists.Created galvanomagnetic device for angular displacement can find various application as electronic leveling appliance in construction, for incline measurement of moving means of transport, for determination of freight in a cargo ship and etc.

References

[1] Draganov, N. Experimental Galvanomagnetic Transducers of Linear and Angular Offset – Part II. Proceedings of papers – ICEST, Ohrid, Macedonia, 23-26 June, 2010.

[2] Draganov, N. Experimental Galvanomagnetic Transducers of Linear and Angular Offset – Part I. Proceedings of papers – ICEST, Ohrid, Macedonia, 23-26 June, 2010.

[3] Draganov, N., A.Aleksandrov. Galvanomagnetic Field Transducer with Analog Output. Proceedings of papers – ELECTONICS – 10,Sofia, Bulgaria, 28 May2010.

[4] Draganov, N. Research of Joint Operation of Hall Elements. Proceedings of papers – UNITEX-07, Gabrovo, Bulgaria, 23-24 November, 2007, Vol 1, p.210-214.

[5] Roumenin, C.S. Solid Etate Magnetic Sensors, Amsterdan.