USE OF HIGHLY SENSITIVE HALL SENSORS IN MAGNETOMETERS

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Introduction

Magnetometer is a device for measuring characteristics of a magnetic field and magnetic properties of physical objects. Magnetometers are classified into two groups. The first group includes devices for measuring characteristics of a magnetic field: intensity, induction, magnetic flux. The second group includes devices for measuring magnetic properties of physical objects and rocks. Magnetometers are used in different fields:

- geology;
- archeology;
- military intelligence to detect submarines;
- biology and medicine;
- scientific experiments.

Magnetometers can be used as metal detectors. This is possible due to the fact that different objects with ferromagnetic properties including metals, such as iron, can distort the Earth's magnetic field. Such objects are detected by means of detecting deviations from the original magnetic field. The magnetometer traces some magnetic inhomogeneity that is usually caused by metal objects.

Magnetometers cover a larger range of detection of metals, unlike other metal detectors that apply different detection methods. However, it has several drawbacks:

- magnetometers cannot detect non-ferrous metals;
- magnetometers can react to natural magnetic anomalies (mineral deposits).

On the other hand, if you search under water (search for sunken tanks and ships), such devices are out of competition. [1]

The goal of this work is to design a simple and highly sensitive magnetometer. This device will be used to determine a direction of the constant magnetic field. Typically, flux-gate sensors are used as sensitive elements in such devices, because they have good performance and high accuracy. However, the design of such devices is difficult because the flux-gate sensors are powered by AC and produce an AC signal, which should be processed. Hall sensors are not as accurate as flux-gate sensors, but they provide a DC output analog signal, so it is easier to work with them. In this project, it is planned to use modern Hall sensors. Their characteristics are similar or accede characteristics of fluxgate sensors. Therefore, the use of modern Hall sensors simplifies the design of the device and reduces the cost of a final product.

Development of the block diagram

A block diagram is shown in Fig 1.

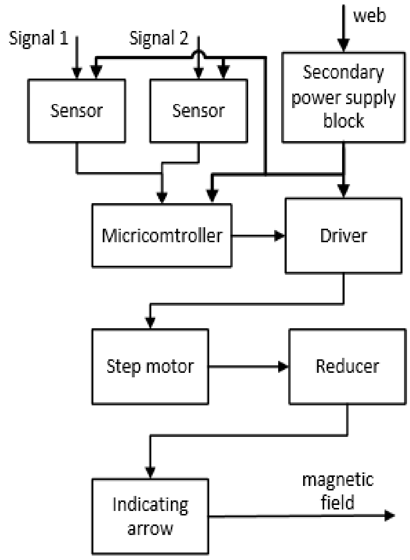

Fig. 1. Block diagram of the magnetometer

Sensor blocks are instruments for measuring characteristics of a magnetic field and magnetic properties of materials.

A microcontroller block includes a one-chip microprocessor. It consists of a microprocessor core, operational and long-term memory, input/output ports and standard interfaces. In our device, the microcontroller will process signals from sensors and calculate the direction of the magnetic field source to issue a control signal to a motor driver.

A driver block is a high-capacity power circuit, which feeds windings of a stepper motor. The type of the circuit impacts motor control and the power received at a shaft [3].

A secondary power supply block is a device that converts AC or DC voltage obtained from the primary power supply to AC or DC voltage that fits the system parameters.

A stepper motor block is a brushless synchronous motor with several windings, wherein the current injected into one of the stator windings causes locking of rotor. In the designed system, it is necessary that the rotor could be still in certain positions and could rotate with a small step. The sequential activation of the motor windings provides discrete angular movements (steps) of the rotor.

A reducer block is a mechanism consisting of a toothed gear. It converts and transmits the torque of the motor shaft. In this system, the reducer decreases the angular speed of rotation and increases the torque, being demultiplicator.

An indicator block is an arrow pointing in the direction of the magnetic field source.

Development of functional circuits

Let us consider each functional block in more details.

In the scheme below two blocks called *sensors* are shown. Each block includes two Hall sensors arranged perpendicular to each other. As a result each pair of sensors scan the XY plane for the presence of a constant magnetic field. Using this data, we can determine location of the magnetic field. The principle of sensor arrangement is shown in Fig 2.

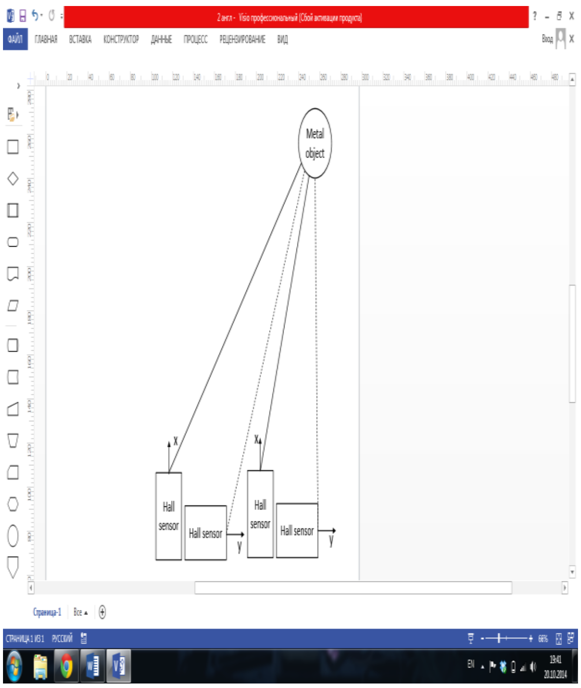

Fig. 2. Arrangement of sensors

Currently, there is a big variety of microcontrollers. In the designed system, the controller is used to calculate the position of a magnetic field source and convert this data into a control signal by a special algorithm. For convenience, we will use an embedded programmable controller with a closed architecture, which operates at a voltage of not more than 12 V. We chose a microcontroller that has from 16 to 100 input/outputs, because it fits our tasks and consumes little power.

The driver will be selected according to the type of the selected motor.

The Secondary power supply must convert commercial AC voltage of 220 V to a constant voltage of 5 V. A stepper motor should be used as a driver, because it is necessary that the rotor can be locked in different positions and can have a small rotation step. The task of the motor is to propel the arrow that points the position of the magnetic field by transmitting rotary motion through a reducer. The main desired characteristics of the motor are:

- step size of not more than 2 degrees;
- error in the angular step less than 0.2 degrees;
- operating voltage of 5 V because of the secondary power supply voltage;
- the smallest possible size and weight.

Radial and axial load on the motor is low, so it is neglected.

A toothed gear with a total decreasing coefficient 4–6 is used as a reducer. The first gearwheel is located on the rotor shaft of the motor. The last gearwheel with the indication arrow is located on the same shaft. Selection of the number of gearwheels, their sizes and other parameters will depend on the design of the device. The indication arrow will be made of aluminum, because in this case it will be easy to produce and sufficiently resistant to deformation.

Conclusion

During 2015, it is planned to design and investigate a high-sensetivity magnetometer with Hall sensors. To do this calculations will be performed, software will be developed, a prototype will be manufactured and tested. In future, a deep-water magnetometer will be developed based on the described device to search for magnetic fields in water columns.

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