# SYSTEM FOR MEASUREMENT OF MAGNETIC INDUCTION OF LOW FREQUENCY MAGNETIC FIELD

Vladimir Nikolov

Faculty of Telecommunication, TU-Sofia
Author Affiliation: Bulgarian
Postal address: Bulgaria, Sofia, Post Code 1000, boulevard "Kliment Ohridski" 8
T. +359 965 2278; F. +359 965 2278; E. v_nikolov@tu-sofia.bg.

***Abstract***

*In this article is considered the construction of an apparatus for measuring the low-frequency magnetic fields in the range 0,1 Hz to 100 Hz. The construction of an apparatus for measuring the low-frequency magnetic fields in the range 0,1 Hz to 100 Hz is considered in this article. This instrument is capable of measuring low frequency magnetic fields used in many procedures in physiotherapy.*

## 1. INTRODUCTION

During the past few decades, the advances in the theory and technology of modern electronics have led to improvements in medical diagnostic and therapeutic methods. As a result, bioelectric and biomagnetic phenomena have become increasingly important. Today it is not possible to imagine a hospital without electrocardiography and electroencephalography. The development of microelectronics has made the respective equipment portable and has increased its diagnostic power. Implantable cardiac pacemakers have made it possible for millions of people to return to normal life. The development of superconducting technology has provided the means to detect the weak biomagnetic fields induced by bioelectric currents. The latest advances in the measurement of electric currents flowing through a single ion channel of the cell membrane with the patch clamp have opened up completely new applications for bioelectromagnetism. With the patch clamp, bioelectromagnetism can also be applied to molecular biology, e.g. in developing new pharmaceuticals. These examples illustrate that bioelectromagnetism is a vital part of our everyday life. Modern bio-medical diagnostic technique involves two main groups of measuring instruments: ones for measuring bioelectric, biomagnetic, etc. signals and imaging systems. Registration systems are non-invasive bio-signals - with sensors and electrodes attached to the surface of the body in the form of implants, needle electrodes or chemical sensors.

The effect has been discovered in 1879 by Edwin Hall. There is a voltage between two sides of the plate (semiconductor) when it is placed in a magnetic field. Voltage Uhall depends linearly on the magnetic induction field B (unit tesla T or gauss G, by 1G = 0,1mT). This relationship is one of the great advantages of the Hall sensors, as it allows accurate measurements over a wide range of constant magnetic field through $U_{hall}$. The magnitude of $U_{hall}$ is the sensitivity of the Hall element. Moreover, the expression of voltage $U_{hall}$ is in force perpendicular to the magnetic field sensor and its value decreases when the field is at an perpendicular angle.

The output voltage of the Hall element is too small (amended by tens mV change in the magnetic field of 1mT), which is why their use alone is rare. An additional amplifier should be putted in the semiconductor in the case of measurement magnetic induction with small value. The positive supply voltage VCC has stabilized since REG, to reduce the impact of changes on its output voltage of the sensor. The transistor, which is NMOS in some ICs, is not mandatory. It is placed to provide enough current output. Due to the single power supply voltage output voltage is equal to 0,5 VCC where the semiconductor is out of magnetic field. This part is always one of the great sides of the hull of IC that is appropriately marked. The exact location of the sensor and the active thickness representing the distance between him and the marked side is given in the catalogs. The linear dependence of the magnetic induction B of Vout is valid only in a given part of its range, which. It corresponds to the minimum and maximum output voltage, which is shown in Fig. 1

| Сензор | Производител | $V_{CC}$, V | $I_{CC}$, mA | S, mV/mT | BW, kHz | $V_{off}$, µV | $R_{out}$, Ω | $T_A$ ($T_J$), °C | Размери, mm |
|---|---|---|---|---|---|---|---|---|---|
| A1301K | Allegro MicroSystems | 4,5 - 6 | 11max | 25 | 20 | 150 | 2 | -40 ÷ +125 | 4,09x3,02x1,52 |
| AH350 | Diodes (Anachip) | 4,5 - 6 | 5 | 18 | 23 | 90 | 50 | -20 ÷ +85 | 4,17x3,1x1,57 |
| EQ-411L | AKM Semic. | 3 - 5,5 | 9 | 65 | 50 | - | - | -30 ÷ +100 | 3,6x3x1,2 |
| OHS3150U | TT Electronics | 4,5 - 6 | 5,5 | 25 | - | - | - | -40 ÷ +150 | 4,57x4,56x1,52 |
| A1395 | Allegro MicroSystems | 2,5-3,5 | 3,2 | 100 | 10 | 80000 | 20 | -20 ÷ +85 | 3x3x0,75 |
| MLX90215L | Melexis | 4,5-5,5 | 4 | 4,1-140 | 1,3max | 25000 | 6 | -40 ÷ +150 | 5,33x3,79x1,2 |
| HAL 1820 | Micronas | 4,5-5,5 | - | 0,6x8 am ±(20÷160)mT | 1 | - | - | (-40 ÷ +170) | SOT89B |

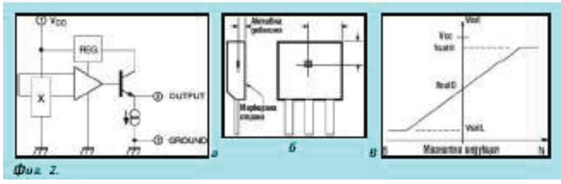


Fig. 1

These voltages are usually given as parameters for the IC. The most important parameter is the sensitivity. It allows us to calculate the maximum value of magnetic induction B B - to the graph of Fig. 2 for this south pole is BS = (VoutO - VsatL)/S and north pole BS = (VsatH - VoutO)/S, and usually both are equal and one is referred to as positive and the other as negative. For many applications it is essential that VoutO depends on temperature, which introduces an error in the measurement of C. Therefore, in most of the catalogs there is a graphics VoutO (t°). A note must be made that the voltage often increases in one direction of the magnetic field and decreases in the other. The temperature should be taken in account in the process of measurement of magnetic induction.

For our case we will be unable to apply the elements of Hall, because of the magnetic field, which measures a variable rather than a constant.

## 2. DESIGN OF A MAGNETIC INDUCTION MEASUREMENT SYSTEM

A small coil can be used as semiconductor for measurement of magnetic induction of low frequency magnetic field. The coil is made of dielectric on which reel is wound a copper wire with a thickness of 0,2 mm The coil is placed in a special housing with dimensions 15 mm X 80 mm. It has a cylindrical shape and is easy to use by the physician. The coil is a small, because the magnetic field measured at fixed points in space. The measurement coil is connected to the electronic unit of the described system. The connection between the probe and the meter is through a coaxial cable. It necessarily requires the use of shielded cable because noises is quite possible. The cable length is chosen as a compromise. On one hand the cable has to be as short as possible to reduce the noises and on the other, the medic should work normally and comfortably.

### ADC

Analog-to-digital converter converts the digital signals. The resolution of the ADC is a 1024 levels. When this value of the quantization is achieved a high sensitivity of the system for measuring the magnetic field.

### Power

Power of the device is external constant power supply 5v and 12 v.

Power consumption is consistent with the scheme, and used items are consistent with the medical device requirements. The selected transformer meets the requirement for continuous insulation between the primary and secondary coil capable 4KV.

## 3. MICROPROCESSOR CONTROL

Since we have 16 piece Sensor, it has to be controlled by a microcontroller. The sensor's outputs are connected to ADC. The microprocessor provides management of connection of different sensor's output to the ADC. Resulting from the ADC digital signal is sent to the microprocessor.

A specially developed algorithm calculates the value of the magnetic induction in the 16 points where the sensors are located.

The principle of action described below diagram 2.

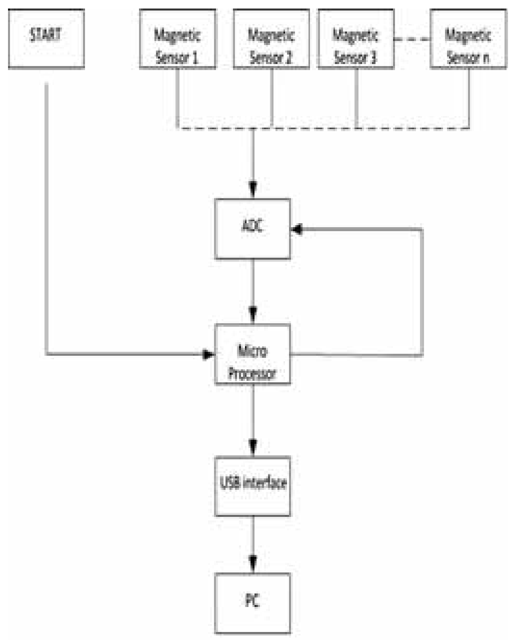


Fig. 2

The measured value of the magnetic field is supplied to the personal computer.

The PC processes the measured values of the magnetic induction and present them graphically.

## 4. ALGORITHM FOR GRADUATION OF SYSTEM FOR MEASUREMENT OF MAGNETIC INDUCTION

The adjustment of the measurement system can be provided using permanent magnetic field and low frequency magnetic field. The value of magnetic induction of permanent magnetic field should be the same as the amplitude of magnetic induction of low frequency magnetic field. The resulting value, which is measured, can be programmed in the memory of the microprocessor.

Table 1

| Voltage | small range, mT | wide range, mT |
|---|---|---|
| 1 | 0,5 | 10 |
| | 1 | 20 |
| 5 | 1,5 | 30 |

Based on this table is built and graduation curve (Fig.3) by the method of least squares

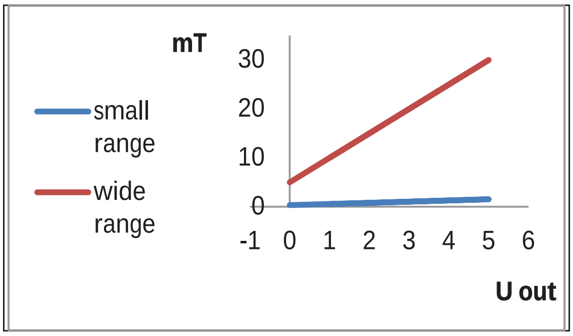


Fig. 3

## 5. CONCLUSION

The following processes are described in the paper. Inventions device for measuring low frequency magnetic field is consistent with the requirement for electrical safety. Power supply unit is used which has a power transformer, for galvanic separation of the device from grid

Using microprocessor allows for further upgrade of the system for measuring the low-frequency magnetic field.

The advantage of the invention device to Hall sensor that is able to measure low-frequency magnetic fields.

## Acknowledgment:

The research in this paper is supported by contract No.142ПД0002-7.

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