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Design and Development of an Inexpensive Embedded System to Measure the Magnetic Field for Low Frequency NMR Applications

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Abstract: *Nuclear Magnetic Resonance is widely used in most of the applications such as Solution structure, Molecular dynamics, Protein folding, Ionization state, Weak intermolecular interactions, Protein hydration, Hydrogen bonding, Drug screening and design, Native membrane protein, Metabolite analysis. ButMagnetic field measurement is essential in Nuclear Magnetic Resonance (NMR).For every NMR, magnetic field should be uniform to calculate various parameters as structure determination, motional properties, residual structures of unfolded proteins and the structures of folding intermediates, ionization states.In the matter of magnetic field there is an effect occurred which is called Hall Effect. Magnetic field measurement for NMR applications can be done in many ways. In the present studythe magnetic field is measured by using hall probe.The measurement of large magnetic fields in the order of a Tesla is often done by making use of the Hall Effect. A thin film Hall probe is placed in the magnetic field and the transverse voltage (on the order of microvolts) is measured.*
Keywords*: Hall Effect, Molecular, Protein, Metabolite, NMR, Magnetic Field.*

I. Introduction

Magnetic field strength is measured using a variety of different technologies. Each technique has uniqueproperties that make it more suitable for particular applications. These applications can range fromsimply sensing the presence or change in the field to the precise measurements of a magnetic field's scalarand vector properties.

The Hall Effectis a conduction phenomenon which is different for different charge carriers. In most common electrical applications, the conventional current is used partly because it makes no difference whether you consider positive or negative charge to be moving. But the Hall voltage has a different polarity for positive and negative charge carriers, and it has been used to study the details of conduction in semiconductors and other materials which show a combination of negative and positive charge carriers.

The Hall Effect can be used to measure the average drift velocity of the charge carriers by mechanically moving the Hall probe at different speeds until the Hall voltage disappears. Other types of investigations of carrier behavior are studied in the quantum Hall effect.

In present study we used WSH49Esensor as aHall Effect sensor. It is a liner, wide operating range from 3.0 to 6.5V, temperature range is as -20°C to 100°C, Flat Response to 23kHz, Low noise output, wide sensible magnetic field range on different supplied voltage, ±900 Guass on 5V supplied voltage and Small package styles TO-92S available.

II. Theory

Nuclear magnetic resonance, or NMR, is a phenomenon which occurs when the nuclei of certain atoms are immersed in a static magnetic field and exposed to a second oscillating magnetic field. Some nuclei experience this phenomenon, and others do not, dependent upon whether they possess a property called spin.

In NMR, EM radiation is used to "flip" the alignment of nuclear spins from the low energy spin aligned state to the higher energy spin opposed state. The energy required for this transition depends on the strength of the applied magnetic field. With no applied field, there is no energy difference between the spin states, but as the field increases so does the separation of energies of the spin states and therefore so does the frequency required to cause the spin-flip, referred to as resonance.

Imagine a nucleus of spin 1/2 in a magnetic field. This nucleus is in the lower energy level (i.e. its magnetic moment does not oppose the applied field). The nucleus is spinning on its axis. In the presence of a magnetic field, this axis of rotation will precess around the magnetic field. The frequency of precession is termed the Larmor frequency, which is identical to the transition frequency.

III. Magnetic Force

The magnetic field B is defined from the Lorentz Force Law, and specifically from the magnetic force on a moving charge as shown in figure 1.

$$\vec{F} = q\vec{v}\, X\, \vec{B}$$

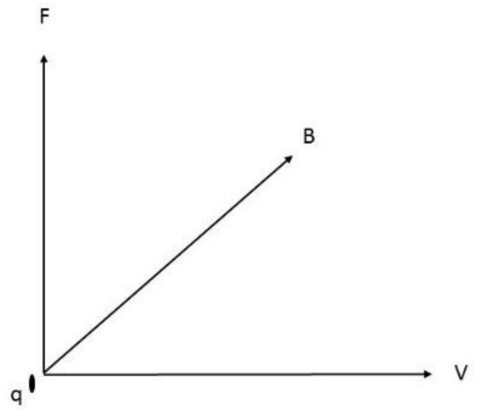


Figure1: Magnetic Force

1. The force is perpendicular to both the velocity v of the charge q and the magnetic field B.
2. The magnitude of the force is F = qvBsinθ where θ is the angle < 180 degrees between the velocity and the magnetic field. This implies that the magnetic force on a stationary charge or a charge moving parallel to the magnetic field is zero.
3. The direction of the force is given by the right hand rule. The force relationship above is in the form of a vector product.

From the force relationship above it can be deduced that the units of magnetic field are Newton seconds / (Coulomb meter) or Newtons per Ampere meter. This unit is named the Tesla. It is a large unit, and the smaller unit Gauss is used for small fields like the Earth's magnetic field. A Tesla is 10,000 Gauss. The Earth's magnetic field is on the order of half a Gauss.

Field Measurement System

The block diagram of magnetic field measurement system is shown in figure 2. In the present study the magnetic field of a magnet is determined by using a Hall Effect sensor WSH49E. The WSH49E integrates Hall sensing element, linear amplifier, sensitivity controller and emitter follower output stage. It accurately tracks extremely small change in magnetic flux density –generally too small to operate Hall Effect switch.

WSH49E can be applied as current sensor, tooth sensor, proximity detectors and motion detectors. As sensitive monitor of magnetic flux, it can effectively measure a system's performance with negligible system loading while providing isolation from contaminated and electrically noisy environments.This measurement system is mainly consist Hall probe, Amplifier, Analog to Digital converter, Microcontroller and a PC.

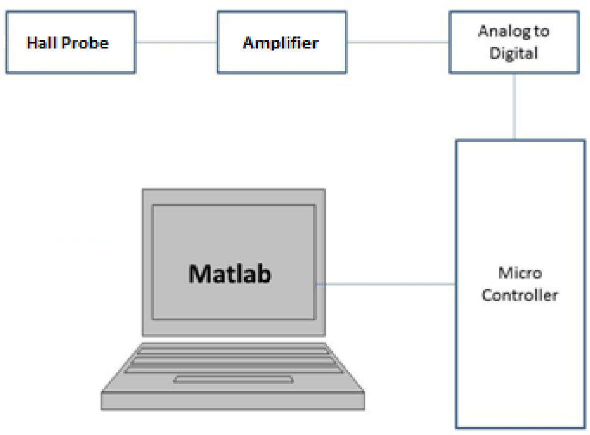


Figure2: Magnetic Field Measurement System Block Diagram

The magnetic field measurement circuit diagram is shown in figure 3. From the circuit Hall Effect sensor interfaced to the microcontroller using instrumentation amplifier INA121 as non – inverting configuration. The amplified signal will be connected to analog input of controller and then converted in to digital and the field will be measured.

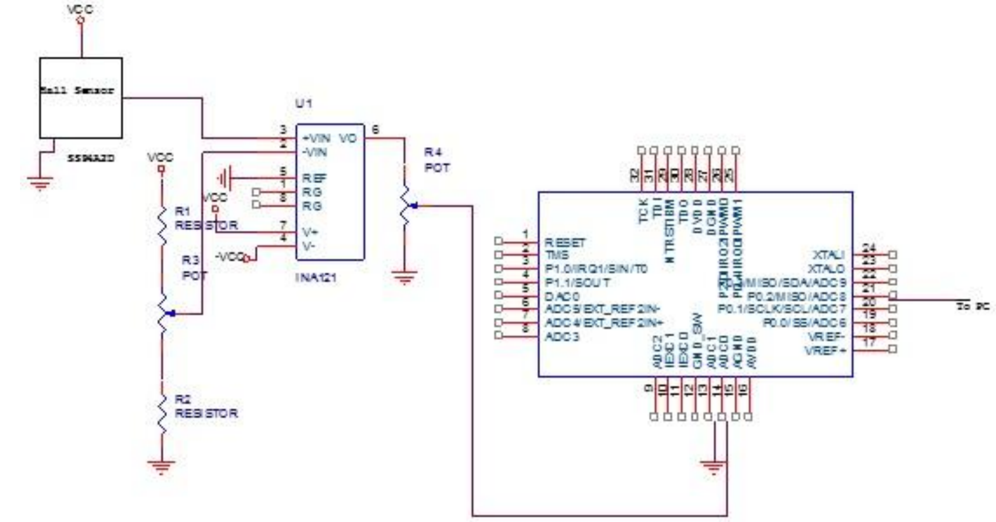
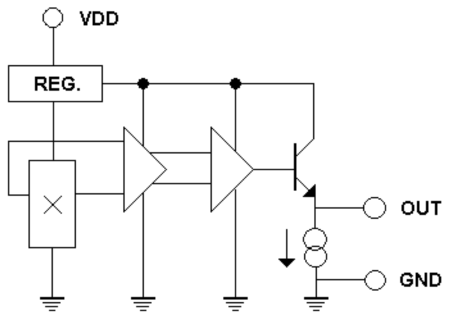


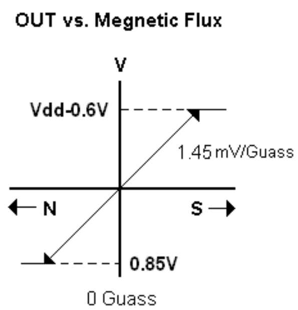
Figure 3: Circuit diagram of Magnetic field measurement

IV. Calibration Procedure

The calibration of the sensor is done as follows.

1. Connect thesensor to operation voltage of 5 V then it read its output as from 2.25 V to 2.27 V
2. From the data sheet of the sensor WSH49E 1.45mv/Gauss





3. So for 1v is 68.96 Gauss
4. Measured Gauss is = (output voltage)*(68.96)

Magnetic field measurement system screen shot is shown in figure 4.

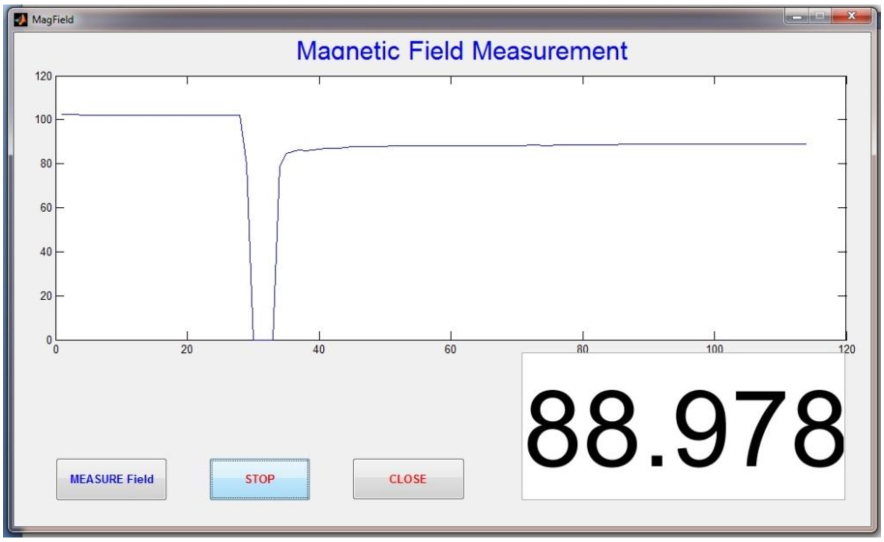


Figure 4: Screen shot of the Magnetic Fieldmeasurement system

V. Results

S.no	Output voltage(V)	Measured Magnetic Field(Guass)	Theoretical Magnetic Field (Guass)	Error
1	1.29	88.978	88.95	-0.028
2	2	137.96	137.92	-0.04
3	2.5	172.56	172.4	-0.1
4	3	205.67	206.88	1.21

VI. Conclusion

By using “An inexpensiveembedded system to measure the magnetic field for low frequency NMR applications was design and developed. The different magnetic fieldsmeasured successfully. This system is connected to Microcontroller, which has special feature of built in Analog to Digital converter.

References

[1]. PELNAŘ, J.: Measurement of the Distribution of B1 Field in thePresence of Linear Magnetic Field Gradient, Journal of Magnetic Resonance,70, (1986), pp. 456-460
[2]. WEIS, J. ¾ ERICSSON, A. ¾ HEMMINGSON, A.: Chemical ShiftArtifact-Free Microscopy: Spectroscopic Microimaging of the HumanSkin, Magnetic Resonance in Medicine, 41, (1999), pp. 904-908
[3]. WEIS, J. ¾ FROLLO, I. ¾ BUDINSKY, L.: Magnetic field distributionmeasurement by modified FLASH method, ZeitschriftfürNaturforschung44a, (1989), pp. 1151-54
[4]. Cho Z H, Nalcioglu 0, Park H W, Ra J B and Hilal S K 1985 Magn. Reson. Med. 2 253.
[5]. Cho Z H, Park H W, Ra J B, Lee S W and Hilal S K 1984 3rd Annual Meeting of Soc. Magn. Reson. InDixon W T 1984 Radiology 153 189
[6]. Feig E, Greenhleaf F and Perlin M 1986 Phys. Med. Biol. 31 1091
[7]. Hanley P 1981 Proc. Inr. Symp. on Nuclear Magnetic Resonance Imaging, Winston-Salem ed R L Witcofski,NKarstaedt and C L Partain (Winston-Salem, NC: Bowman Gray School of Medicine of Wake ForestUniversity) p 41
[8]. http://www.nve.com
[9]. http://www.stoner.leeds.ac.uk
[10]. http://www.sensormag.com
[11]. http://www.iemw.tuwien.ac.at
[12]. http://www.fzu.cz
[13]. http://mypage.bluewin.ch/hera/magnet
[14]. CERN Accelerator Schools on Magnetic Measurements:–March 16-20, 1992,Montreux(CERN 92-05, 15 Sep. 1992)–April 11-17, 1997,Anacapri(CERN 98-05, 4 Aug. 1998)