Monitoring of Temperature and Analysis of Image Degradation in EFMRI System

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Abstract: In MRI scanning system the in homogeneity of the magnetic field is one of the most critical parameter, a variation in the temperature causes a change in the frequency of resonance, phase, causes field drift (inhomogeneous magnetic field).Due to this in homogeneous magnetic field signal loss and line-broadening in MR spectroscopy is observed .Because of this quality of the image is degraded. The objective of this project is thus to overcome these affects i.e. To reduce the signal loss and get better quality images. Field in homogeneity affects the signal-to-noise ratio (SNR) and resolution in MR spectroscopy.

***Keywords:** T1, T2, D, inhomogenity, SNR correction, temperature monitoring*

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I. INTRODUCTION

Magnetic resonance imaging (MRI) is primarily used in medical imaging to visualize the structure and function of the body. MRI scanner consists of magnet, RF coils, gradient coils at the hardware side and at the firmware we have a pulse programmer which is considered as the heart of the MRI scanner.

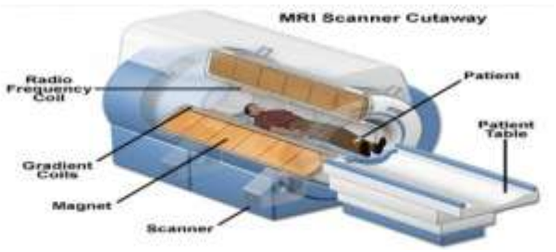

Figure1: overview of an MRI scanner

The Terranova-MRI Earth's Field Nuclear Magnetic Resonance (EFNMR) apparatus provides a low cost alternative to high field instruments for the demonstration of pulsed NMR/MRI techniques or for the determination of NMR properties of samples outside of the laboratory [1].

Figure2. A view of EFNMR system

The EFNMRI system consists of three coils. Outermost, or polarizing (Bp), coil is used to provide an initial polarizing field via the application of a large current - establishing a nuclear magnetization in a sample placed inside the apparatus. The middle, or gradient coils are used to provide linear magnetic field gradients across the sample. The inner most, or *B*1, coil is used to excite and detect the precessing magnetization.

In homogeneity is the degree of lack of homogeneity, for example the fractional deviation of the local magnetic field from the average value of the field. In homogeneities of the static magnetic field, produced by the scanner as well as by object susceptibility, is unavoidable in MRI. Because of variations in field, field drift accurse so there are various methods for corrections of in homogeneity [2].

Imperfections in the magnetic gradient fields for image encoding can severely deteriorate the quality of magnetic resonance imaging (MRI), especially in the case of advanced imaging applications such as fast-acquisition, phase-contrast based flow quantification, and diffusion-tensor imaging. Gradient field imperfections are caused by eddy currents induced in the conductive structures of the MRI scanner, gradient amplifier nonlinearities, and anisotropic gradient delays, as well as system instabilities and parameter drifts caused by heating [5].

II. METHLODOGY AND DESIGN

A. Proposed method for real-time time temperature monitoring of EFNMR system

We are making use sensor for measure the temperature of the system as time goes on increases then

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temperature of the system also increases, the block diagram for the proposed method is shown in figure 4.

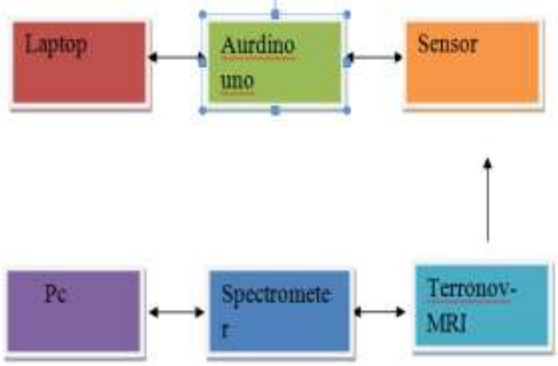

Fig 4: Block diagram of temperature monitoring system.

DHT11 sensor is temperature and humidity sensor it is connected to the AURDINO UNO board it has ATMEG328 microcontroller it is connected to the personal computer, we have to run the prospa software in another system to turn on the TERRANOVA-MRI. In another pc we have to run the code for monitoring the temperature of the system so we can observe temperature rise value in serial monitor

III. Dependence of several MRI parameters such as T1, T2, D, signal amplitude on temperature

A. Relaxation:

Nuclear magnetic resonance Spectroscopy and magnetic resonance imaging (MRI) the term relaxation describes how signals change with time.

B. T1 AND T2

T1 relaxation is the process by which the net magnetization (M) grows/returns to its initial maximum value (Mo) parallel to Bo.

T2 relaxation is the process by which the transverse components of magnetization (Mxy) decay or dephase.

C. BPP Theory

IN1948, Nicolaas Bloembergen, Edward Mills Purcell, and Robert Pound proposed the so-called Bloembergen-Purcell-Pound theory (BPP theory) to explain the relaxation constant of a pure substance in correspondence with its state, taking into account the effect of tumbling motion of molecules on the local magnetic field disturbance.

Below equations shows howT1, T2, D, signal amplitude dependence on temperature.

$$\frac{1}{T_1} = K\left[\frac{\tau_c}{1+\omega_0^2\tau_c^2} + \frac{4\tau_c}{1+4\omega_0^2\tau_c^2}\right] \quad \ldots (1)$$

$$\frac{1}{T_2} = \frac{K}{2}\left[3\tau_c + \frac{5\tau_c}{1+\omega_0^2\tau_c^2} + \frac{2\tau_c}{1+4\omega_0^2\tau_c^2}\right] \quad \ldots\ldots (2)$$

D. Larmor frequency

For a particular magnetic field strength, the (resonant) frequency of precession can be calculated via the Larmor equation. The Larmor equation is

$$\omega_0 = \gamma B_0 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots(3)$$

E. Stokes–Einstein relation

Stokes-Einstein equation, showing that the diffusion coefficient (*D*) is directly proportional to the absolute temperature (*T*) and Boltzmann constant (*k*),but inversely proportional to the radii of the particles (*r*) and the viscosity of the medium (*η*).

Stokes–Einstein equation, for diffusion of spherical particles is given by

$$D = \frac{k_B T}{6\pi\eta r} \quad \ldots\ldots\ldots\ldots\ldots\ldots (4)$$

F. Signal intensity equation:

$$S = \frac{So(1-e^{-TR/T1})\sin\alpha * e^{-TE/T2} * e^{-bD}}{(1-e^{-TR/T1})\cos\alpha} \quad ..(5)$$

Where

$$So = \frac{Ns*\gamma 2*h2*Bp}{4KBT} \ldots\ldots\ldots\ldots\ldots\ldots (6)$$

So by making use of above equations we wrote a matlab code to show variations inT1, T2, D, signal amplitude with respect to temperature results shown in figure 6.

IV. SNR:

Peak signal to noise ratio, often abbreviated PSNR is a ratio between the maximum possible power of a signal and the power of corrupting noise that affects the fidelity of its representation. The PSNR (in dB) is defined as:

$$PSNR = 20 \cdot \log_{10}(MAX_I) - 10 \cdot \log_{10}(MSE) \quad . (7)$$

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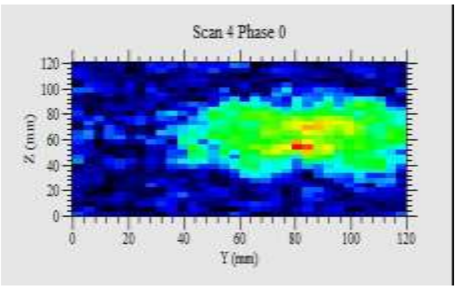
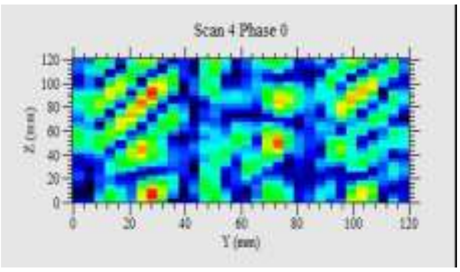




Comparing 1st and 2nd image so we can observe

Quality of image is degraded and PSNR values for different images are shown in below table.

PSNR values of 1st &2nd image	PSNR values of 1st 3rd image	PSNR values of 1st 4th image
15.7784	12.5219	10.5219

V. Cooling system for the earth field MRI system

In MRI system temperature is the parameter it is continuously raising so control the temperature and keep the system cool so that we can get good quality images by cooling the system. We are going to control DC fan speed according to the system temperature and show these parameter changes on a 16x2 LCD display

A. Block diagram

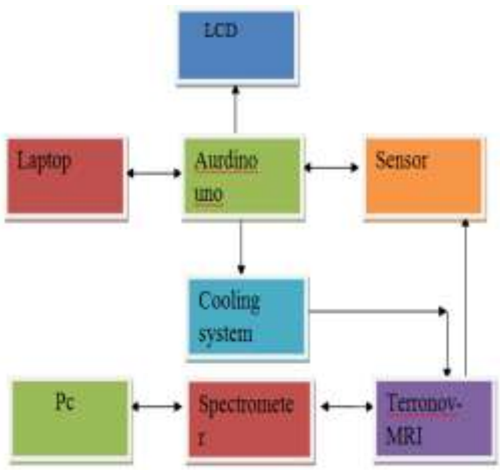
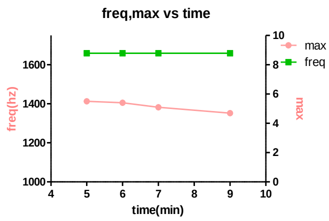


Fig 5: Block diagram for cooling system

We have created PWM at pwm pin of arduino and applied it at base terminal of transistor. Then transistor creates a voltage according to the pwm input.

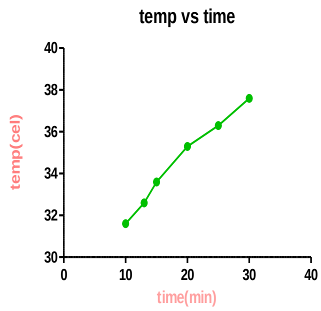
VI. Results

First pulse& collect sequence results



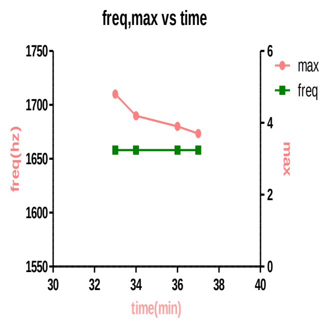
time(min)	max	freq
5	5.5	1659
6	5.4	1659
7	5.1	1659
9	4.7	1659

First spin echo imaging sequence results



time(min)	temp
10	31.6
13	32.6
15	33.6
20	35.3
25	36.3
30	37.6

Second pulse& collect sequence results



time(min)	max	freq
33	4.8	1658
34	4.2	1658
36	3.9	1658
37	3.7	1658

VII. Result of matlab code

By using the above equation we wrote a Matlab code to show variations in T1, T2, D, signal amplitude as function of temperature, so the results of the code is shown in the below graphs..

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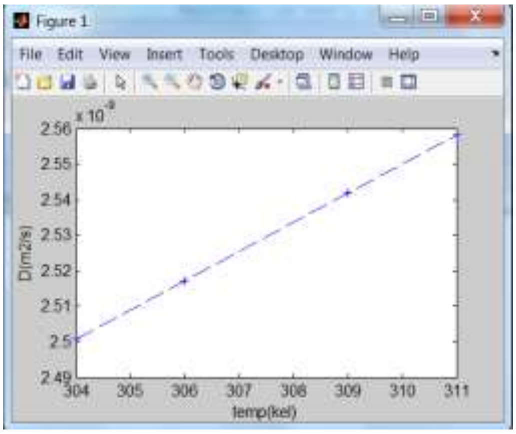

Fig 6: Diffusion vs temperature graph

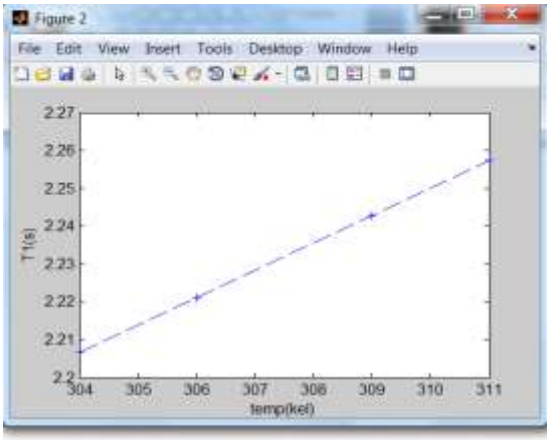

Fig 7: T1 vs temperature

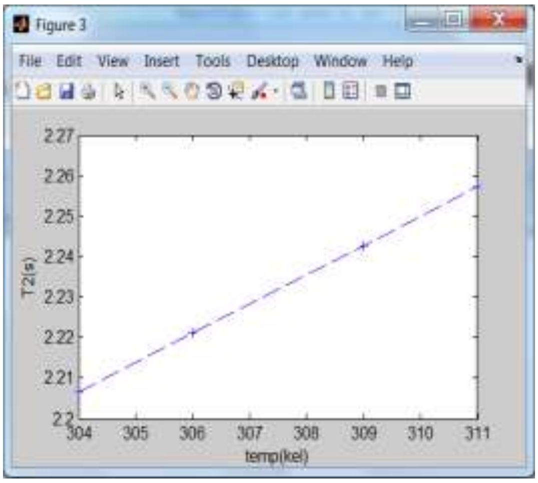

Fig 8: T2 vs temperature

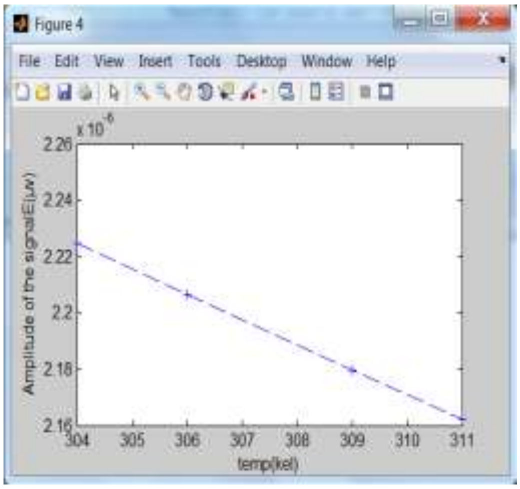

Fig 9: Amplitude of signal vs temperature

VIII. Conclusion

Temperature of the system is measured and we observed as time goes on increases temperature increases, and we also observe the effect of rise in temperature on T1, T2, D, signal amplitude and we plotted the graphs for that. We designed a cooling system in order to cool the system and to get the good quality images.

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