

LABVIEW BASED INTERFACING OF SERIAL AND ETHERNET PROTOCOL IN GRADIENT SYSTEM IN MRI SYSTEM

Dr.K.M.Gaikwad

Associate Professor Sinhgad Academy of Engineering, Kondhwa Savitribai Phule Pune University, Pune, India.

Miss. Shriya Rajendra Siraskar*

Department of Electronics and Telecommunication Engineering Sinhgad Academy of Engineering, Kondhwa Savitribai Phule Pune University, Pune, India. *Corresponding Author

Dr.D.K.Kamat

Department of Electronics and Telecommunication Engineering Sinhgad Academy of Engineering, Kondhwa Savitribai Phule Pune University, Pune, India.

ABSTRACT

Technology has been developing to a greater extent day by day. MR technology systems use three sets of gradient coils, x, y & z gradients. The main objective of this description is to provide details regarding few specifications of gradient amplifier, interfacing, tuning of the coils and its implementation of command transfer in LabVIEW. Gradient amplifier NG 500 is connected to the MR systems through any available protocol for operating the gradient functionality. This communication helps in individual tuning of the three coils, offset compensation of the axes. It also provides the profile generation tool to input dummy waveforms to the amplifier and observe the generated current and voltage waveforms in oscilloscope. We have used a RS 232 to RS 422 converter to implement the serial command transfer on LabVIEW platform.

KEYWORDS : Gradient Amplifier, MR System, LabVIEW

I. INTRODUCTION

When the MRI system is in a resting state and not actually producing an image, the magnetic field is quite uniform or homogeneous over the region of the patient's body. However, during the imaging process the field must be distorted with gradients. A gradient is just a change in field strength from one point to another in the patient's body. Gradients are simply loops of wire or thin conductive sheets on a cylindrical shell that lies just inside the bore of an MRI Scanner. When an electrical current passes through these coils, the result is a secondary magnetic field. This gradient field distorts the main magnetic field in a slight but predictable pattern. This causes the resonance frequency of protons to vary in a function of position. The main function of gradients is to allow spatial encoding of the MRI signal, but is also critical for a wide range of physiologic techniques. Examples includes MR angiography, diffusion and perfusion imaging.

II. LITERATURE SURVEY

The process to produce an MR image includes nuclear alignment, RF excitation, spatial encoding, and image formation. In simple terms, an magnetic resonance imaging (MRI) system consists of five major components: a magnet, gradient systems, an RF coil system, a receiver, and a computer system. To form an image, it is necessary to perform spatial localization of the MR signals, which is achieved using gradient coils. In modern MRI, gradient coils able to generate high gradient strengths and slew rates are required to produce high imaging speeds and improved image quality. MRI also requires the use of gradient coils that generate magnetic fields, which vary linearly with position over the imaging volume. Gradient coils for MRI must therefore have high current efficiency (defined as the ratio of gradient generated to current drawn), short switching time (i.e., low inductance), gradient linearity over a large volume, low power consumption, and minimal interaction with any other equipment, which would otherwise result in eddy currents.

III. METHODOLOGY

In this system, we have been provided with the NGToolSuite software for connecting the system. We create a DHCP server, IP address is assigned to the system and it is connected in the network. We can get a overlook of the internal blocks of the system, the tuning of each coil is done. After tuning and offset

compensation, we generate sample current profile to give input to the gradient amplifier for testing purpose. Through serial to RS422 converter, we establish the connection in LabVIEW and we try sending echo command through serial port.

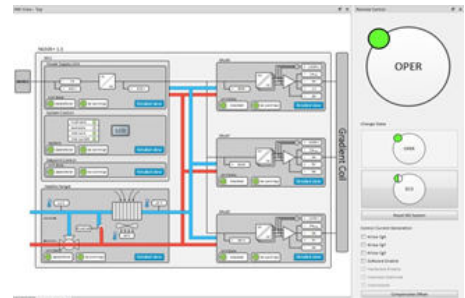


Fig 1. Block diagram

IV. HARDWARE REQUIREMENT

1) Gradient Amplifier NG 500 :-

The Gradient Amplifier is a three axes system, which can be used in a MRI system to control the X, Y and Z Gradient Coils. It has RS422-based interface intended for control and diagnostics of MRI system host. This communication interface uses the RS-422 electrical standard with UART protocol to transfer characters between the Gradient amplifier and National Instrument compact RIO (NI-cRIO) controller.



Fig2. NG 500 model

2) Rs232 To Rs422 converter :

Scitex XLJet Converter RS232 TO RS422 - 620B00020 This Converter RS232 to RS422 is suitable for HP Scitex XL1200 / Scitex XL1500 printers. It has a supply voltage range of 10-30V and a 16-bit resolution.



Fig3.RS232 to RS422 converter

3) CN_CONTROL connector:

There is a provision of CN_control for provision of enable and interlock inputs as well as for command transfer.

Pin	Mnemonic	Dir	Type	Remarks
1	RS422_TX_P	O	RS422	Positive NG500 communication interface Tx, MRI system host Rx.
2	RS422_RX_P	I	RS422	Positive NG500 communication interface Rx, MRI system host Tx.
3	GND	-	-	Ground.
4	ENABLE_IN_P	I	Table 3.5	Positive external hardware enable input.
5	INTERLOCK_IN_P	I	Table 3.6	Positive system interlock input.
6	INTERLOCK_OR_IN_P	I	Table 3.6	Positive system interlock override input.
7	FAULT_OUT_P	O	Table 3.7	Positive fault output.
8	IO_SUPPLY	O	PWR	Positive power supply output for control signals.
9	RS422_TX_N	O	RS422	Negative NG500 communication interface Tx, MRI system host Rx.
10	RS422_RX_N	I	RS422	Negative NG500 communication interface Rx, MRI system host Tx.
11	ENABLE_IN_N	I	Table 3.5	Negative external hardware enable input.
12	INTERLOCK_IN_N	I	Table 3.6	Negative system interlock input.
13	INTERLOCK_OR_IN_N	I	Table 3.6	Negative system interlock override input.
14	GND	-	-	Ground.
15	FAULT_OUT_N	O	Table 3.7	Negative fault output.
C	Chassis	-	-	Chassis is connected to housing.

Fig4. Control connector

4) Telegram Frame format:

A transaction is always started by the host transmitting a telegram frame (Tlg) and the Gradient amplifier replies with a reply telegram frame (TlgRpl).

It benefits read and write commands allow access to all memory mapped registers of the gradient amplifier, same or auto increment the address and the heartbeat protection is optional; only until after the first heartbeat is detected the heartbeat monitoring is started and missing heartbeat result is an error. For Ethernet connection, there should be provision of DHCP server.

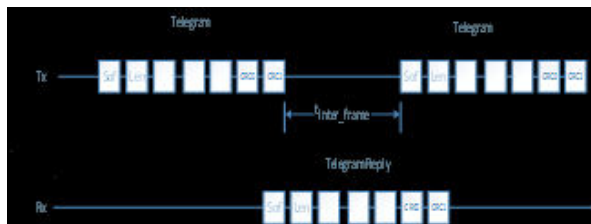


Fig4. Telegram frame format

IV. SOFTWARE REQUIREMENT

A. LabVIEW :-

LabVIEW is systems engineering software for applications that require test, measurement, and control with rapid access to hardware and data insights. LabVIEW offers a graphical programming approach that helps you visualize every aspect of your application, including hardware configuration, measurement data, and debugging. This visualization makes it simple to integrate measurement hardware from any vendor, represent complex logic on the diagram, develop data analysis algorithms, and design custom engineering user interfaces.

B. Tlthpd software :-

This is a very preliminary app that allows us to assign IP address to any system present in the network.



Fig6. Flow chart

V. RESULT AND DISCUSSION

Basically, we have seen overview of the system internals, how we it is connected via Ethernet for various purposes. The tuning was done for all the three individual axes. Adjustment in linearity corrections, tuning parameters, compensating few current generation parameters leads to changes in magnitude and phase graphs of frequency response of each axis. These graphs are monitored to ensure the minimization of eddy currents. The figure shows the current and voltage response to the input profile generated by profile generator tool. Similarly, through serial interface, the LabVIEW code implementation of command transfer i.e. Echo command, the sent command and reply command frame. Likewise, in further LabVIEW development, we could see transition of various states of amplifier during functionality of the system.

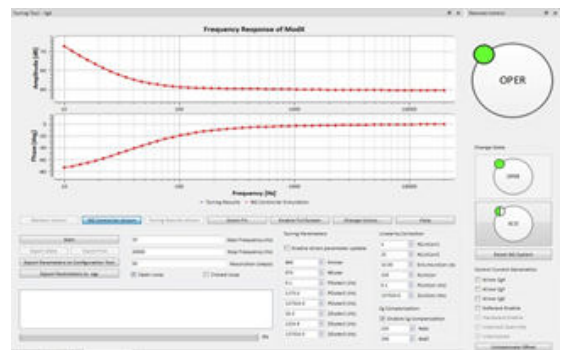


Fig7. Tuning process

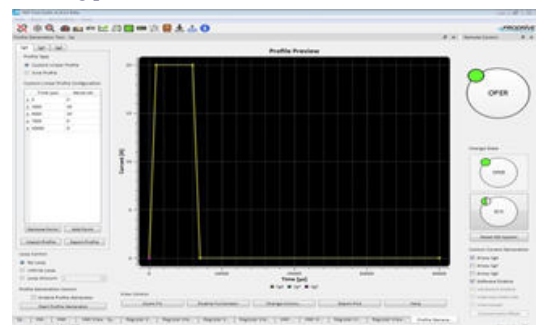


Fig8. Profile generation tool



Fig8. Oscilloscope tool



Fig9. LabVIEW command transfer

The current profile generator provides different options in simulation. The advantage of this generator is to ensure the less possibility of slope overload error.

VI. CONCLUSION

In this Paper, we have successfully implemented interfacing of the Gradient Amplifier NG 500 through serial as well Ethernet communication mode. The further work will include upgradation of LabVIEW code for full functionality of the system which will lead to independent operation of the system.

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