LabVIEW based Automatic Data acquisition system for Electrical Impedance Tomography

Vidya Sarode¹, Hema Patil², Alice N. Cheeran³

¹Research Scholar, Xavier Institute of Engineering, Mumbai, India.
²³Electrical Department, VJTI, Mumbai, India.

Abstract— Electrical Impedance Tomography (EIT) is developing and promising imaging modality for early detection of breast cancer. An EIT system uses an array of surface electrode to apply current to an imaging object & measures the resulting voltages on the periphery. The measurement results are then input to a reconstruction algorithm to produce an image of impedance distribution of the object. In this study a LabVIEW based automatic data acquisition system is designed. In this Data Acquisition system input current injection and voltage measurement are carried out using switching. An Electrode Switching Network (ESN) consist of four 16:1 analog multiplexers that are used for switching. The electrode switching network is controlled by Virtual Instrument (VI) developed in LabVIEW. The NI myDAQ DAQ card is used to interface PC with other hardware.

Keywords— Analog multiplexer, Electrical Impedance Tomography, Electrode switching network, LabVIEW, Phantom, State machine, Surface electrode, Virtual Instrument

I. INTRODUCTION

EIT is developing as a biomedical imaging technique. The objective of the EIT is to obtain the spatial distribution of the conductivity and/or permittivity inside the human body and interpret it as an image. The technique is applied for early detection of breast cancer since the conductivity of many malignant tumors greatly differs from that of healthy breast tissues [1]. EIT has the advantages of being a radiation-free imaging technique, inexpensive, and portable [2], [3].

Figure 1 shows the basic EIT system which consists of two parts data acquisition hardware and image acquisition software. Block diagram consist of following parts-[4]

1) A signal generator and voltage to current converter, which applies alternate constant current to pair of electrodes at constant frequency.
2) Array of sixteen electrodes arranged on inner surface of phantom with normal saline as a phantom solution.
3) Multimeter is required for voltage measurement between consecutive pair of electrodes.
4) An image reconstruction algorithm for reconstruction of image based on voltage datasets.

Phantom is developed with circular plastic container of14 cm diameter and 7cm height. An array of 16 electrodes is equally spaced on the inner surface of plastic container.Electrodes are of size 2.5 X 0.5 cm and length dipped in solution is 1.5 cm. They are made up of silver and coated with gold to avoid corrosion effect. Wires used are of equal in length to connect phantom to circuitry. Solution used in phantom is normal saline with 0.9% of sodium chloride. The volume of normal saline used is 360 ml to ensure all electrodes immersed in solution. Electrical conductivity of normal saline is 300ms/m. Phantom with array of electrodes is shown in figure 2.
The remainder of this work is organized as follows. In Section 2, we reviewed adjacent current injection protocol used for electrode selection. Section 3 presents the basic system design and the theory of operation of system for the measurement technique described in Section 2. Measured results are shown in Section 4. This work is brought to an end by concluding remarks in Section 5.

II. MEASUREMENT TECHNIQUE

The constant current injection protocol is used for the selection of pair of electrodes used for current injection and voltage measurement. Figure 3 shows a measurement technique for adjacent current injection protocol. In this protocol initially constant current source is applied between pair of adjacent electrode and then resulting boundary potential is measured between other pairs of adjacent electrode which are non-current electrode [4], [9].

For projection 1 current source is applied between electrode 1 and 2 and boundary potentials are measured between electrode pair 3-4, 4-5 till 15-16. In this way total 13 readings are taken in each projection. Then current source is switched between next adjacent pair of electrodes i.e. electrode 2 & 3. In this way total 16 x 13 = 208 voltage readings are taken which forms voltage database for a single measurement.

The time required for obtaining this voltage dataset manually is large. Figure 4 shows a flow chart for measurement.

III. SYSTEM DESIGN

A. System Overview

In EIT system Surface electrodes are placed around the object to be imaged. A sinusoidal current source of constant magnitude and frequency in the range 1 KHz to 100 KHz is injected through a pair of electrodes called Current electrode. These surface electrodes are selected in a particular order depending on kind of current injection protocol used. Selection of surface electrode for injection of constant current and voltage database measurement is achieved through Electrode Switching Network (ESN). This module is developed with four analog multiplexer/De-multiplexer ICs CD4067. IC CD4067 can be used as an analog multiplexer or de-multiplexer depending on the requirement. The whole system is designed to operate under the control of the NI myDAQ DAQ card and Virtual Instrument developed in LabVIEW 8.6. Figure 5 shows an automatic data acquisition system for modern 16 electrode EIT system. Using this DAQ system variable frequency sinusoidal constant current is injected to object and resultant boundary potentials are collected for different impurities using adjacent current injection protocol.
The details of constant magnitude and variable frequency current source are given in next section.

B. Constant Current Source

Constant current injector consists of signal generator, a voltage to current converter using IC AD 711 (1mA at 5 KHz). Figure 6 shows a voltage to current converter in which load resistor $R_L$ is floating (not connected to ground).

$$i_L = i_in = \frac{v_{in}}{R}$$

From the above equation, it can be seen that the output current is independent of the value of load resistance. Thus the input voltage is converted into the current. The source is capable of supplying this load current.

Figure 8 shows the designed PCBs for the electrode switching network (ESN). It consist of three parts, part (a) is current source switching, part (b) is voltage measurement switching circuit and part (c) is connector plane used for connection of the ESN module to the phantom.
The 8-bit parallel digital data \(D_{11}D_{10}D_{9}D_{8}D_{7}D_{6}D_{5}D_{4}\) is generated in LabVIEW. LabVIEW program sequentially generates sixteen sets of 4-bit parallel digital data varying from 0000 to 1111 these 4-bit parallel digital data is directly fed to MUX-I1. Then for each set of \(D_{3}D_{2}D_{1}D_{0}\) binary adder circuit generates another set of 4-bit parallel digital data \(D_{7}D_{6}D_{5}D_{4}\) by adding 0001 to \(D_{3}D_{2}D_{1}D_{0}\). Then \(D_{7}D_{6}D_{5}D_{4}\) are fed to MUX-I2. In this way current electrode switching is obtained for adjacent current injection protocol. Similarly LabVIEW program generates another 16 sets of 4-bit parallel digital data \(D_{11}D_{10}D_{9}D_{8}\) which is directly fed to MUX-V1 and for each set of \(D_{11}D_{10}D_{9}D_{8}\) binary adder circuit generates another set of 4-bit parallel digital data \(D_{15}D_{14}D_{13}D_{12}\) by adding 0001 to \(D_{11}D_{10}D_{9}D_{8}\), then these \(D_{15}D_{14}D_{13}D_{12}\) bits are fed to MUX-V2.

State machine in LabVIEW is implemented using While loop, Case structure and Shift register. The flow of the state diagram is implemented by the loop, while the individual states are replaced by cases in the case structure. A shift register on the while loop keeps track of the current state, which is fed into the case structure input. Figure 10 shows state machine architecture in LabVIEW 8.6 [10], [11].

![State machine architecture in LabVIEW](image)

**Fig 10: State machine architecture in LabVIEW**

### IV. RESULTS

A non-conducting impurity of size 2.4x2x1.5 cm is selected and is placed near electrode 1 in the phantom as shown in figure 11.

![Container with non-conducting wooden impurity near the phantom](image)

**Fig 11: Container with non-conducting wooden impurity near the phantom**

The voltage data base is obtained using our LabVIEW based DAQ system. Then this voltage database is fed to Total variation Algorithm for image reconstruction. The reconstruction results give the exact location of impurity present in the phantom as shown in figure 12.

![Graph for noncon wooden float near 1 in saline at 5 kHz](image)

**Graph for noncon wooden float near 1 in saline at 5 kHz**

**Fig 12: voltage density plot**

### V. CONCLUSION

In this study, LabVIEW based automatic data acquisition system for electrical Impedance tomography is designed, in which adjacent current injection protocol is used for measurement. USB based data acquisition system greatly reduces data acquisition time of the EIT system. Also the frequency of the input signal can be varied from 1 KHz to 50 KHz and sampling frequency of DAQ card can also be programmatically changed to upper limit of 200 KHz through the GUI. Then measured database of boundary potential is transferred to EDIORS for image reconstruction.

### REFERENCES


Impedance Tomography (EIT)

