Design of Forward Problem for Early Detection of Breast Cancer using Electrical Impedance Tomography (EIT) Technique

MAJOR PROJECT REPORT

Submitted in Partial Fulfillment of the Requirements of the Degree of

Bachelor of Technology in Electronics and Telecommunication

Engineering

By

PRATHAMESH AWATE	**(Roll No.B-32)**
BHAVESH PATEL	**(Roll No.B-50)**
YASH SALUNKHE	**(Roll No.B-58)**

Under the Guidance of

Dr. PRIYA HANKARE

Department of Electronics and Telecommunication Engineering

K. J. Somaiya Institute of Technology,

An Autonomous Institute permanently affiliated to University of Mumbai

Ayurvihar, Sion (E.), Mumbai 400022.

University of Mumbai
(2023-2024)

CERTIFICATE

*This is to certify that the project entitled "**Design of Forward Problem for Early Detection of Breast Cancer using Electrical Impedance Tomography (EIT) Technique**" is a bonafide work of students Prathamesh Awate, Bhavesh Patel, and Yash Salunkhe submitted to the University of Mumbai in partial fulfillment of the requirement for the award of the degree of Bachelor of Technology in Electronics and Telecommunication Engineering.*

____

Dr. Priya Hankare
(Project Guide)
Department of Electronics and Telecommunication Engineering

____

Dr. Jayashree Khanapuri
(Head of Department)

____

Dr. Vivek Sunnapwar
(Principal)

Place: Sion, Mumbai-400022

Date:

Seal of the College

MAJOR PROJECT APPROVAL

For

Bachelor of Technology in Electronics and Telecommunication Engineering

This Project report entitled

“**DESIGN OF FORWARD PROBLEM FOR EARLY DETECTION OF BREAST CANCER USING ELECTRICAL IMPEDANCE TOMOGRAPHY (EIT) TECHNIQUE**”

By

PRATHAMESH AWATE (Roll No. B-32)

BHAVESH PATEL (Roll No. B-50)

YASH SALUNKHE (Roll No. B-58)

is approved for the degree of **Bachelor of Technology in Electronics and Telecommunication Engineering.**

Examiners:

1. ____________________________

2. ____________________________

3. ____________________________

4. ____________________________

Date:

Place: Sion, Mumbai-400022

DECLARATION

We declare that this written submission represents our ideas in our own words and where others' ideas or words have been included, we have adequately cited and referenced the original sources. We also declare that we have adhered to all principles of academic honesty and integrity and have not misrepresented or fabricated or falsified any idea/data/fact/source in our submission. We understand that any violation of the above will be cause for disciplinary action by the Institute and can also evoke penal action from the sources which have thus not been properly cited or from whom proper permission has not been taken when needed.

Prathamesh Awate __________

Bhavesh Patel ______________

Yash Salunkhe _____________

Date:

ACKNOWLEDGEMENT

A successful work of dissertation is the result of inspiration, support, guidance, motivation and co-operation of facilities during study. It gives a great pleasure to acknowledge our deep sense of gratitude to present our project titled; "Design of Forward Problem for Early Detection of Breast Cancer using Electrical Impedance Tomography (EIT) Technique".

We would like to give sincere thanks to our Principal Dr. Vivek Sunnapwar and H.O.D. Dr. Jayashree Khanapuri for giving me opportunity to present this seminar. I am also thankful to my respected guide Dr. Priya Hankare for this whole hearted support and affectionate encouragement. Her dynamism, vision, sincerity have deeply inspired us. She has taught us the methodology to present the research work as clearly as possible.

Prathamesh Awate (Roll No. B-32)

Bhavesh Patel (Roll No. B-50)

Yash Salunkhe (Roll No. B-58)

TABLE OF CONTENT

List of Figures

ABSTRACT

This research presents design and development of a forward problem solver for early detection of breast cancer using Electrical Impedance Tomography (EIT) technique. The forward problem, which involves predicting the electrical measurements based on theinternal conductivity distribution, is a fundamental aspect of EIT. This study focuses on the formulation and implementation of the forward problem, considering the complexities of breast tissue and electrode arrangements.

Electrical Impedance Tomography (EIT) is a new imaging technique that has the ability to image human body without prolonged exposure to radiations. Early detection of breast cancer is crucial for improving patient outcomes and reducing mortality rates. Electrical Impedance Tomography (EIT) is a non-invasive imaging technique that has shown promise in detecting breast abnormalities. In this study, we focus on the design and implementation of a forward problem solver for EIT to aid in the early detection of breast cancer. Developing countries like India suffers from the availability of imaging devices due to its high cost and its danger to health due to the use of ionizing radiation.

This problem can be solved by designing a simple and low cost radiation free medical imaging system. We will design an Arduino-based EIT system for radiation free medical imaging. This system consists of AC current generator, Voltage Controlled Current Source, 16 electrodes and an automatic electrode switching module. Control of the system isachieved by Arduino which decreases the overall cost of the system while adding simplicityto the design. The system results in voltage measurements which are processed in MATLAB interfaced with EIDORS (Electrical Impedance and Diffuse Optical Tomography Reconstruction Software) to reconstruct the image

CHAPTER 1

INTRODUCTION

The introduction for a research paper on "Design of Forward Problem for Early Detection of Breast Cancer using Electrical Impedance Tomography (EIT) Technique" can set the stage for the study and provide background information. Here's a sample introduction:

Breast cancer is a significant global health concern, with early detection playing a pivotal role in improving patient outcomes and reducing mortality rates. While various imaging modalities such as mammography and magnetic resonance imaging (MRI) have been established as effective tools for breast cancer screening and diagnosis, there is a persistent need for non-invasive and cost-effective alternatives. Electrical Impedance Tomography (EIT) has emerged as a promising technique in this regard, offering the potential for early detection of breast abnormalities without the use of ionizing radiation or invasive procedures. [1]

EIT technique apply a current - As human cell acts like capacitor the behavior of the tissue impedance depend on the frequency of the applied current- to human tissue and according to the conductivity distribution of the tissue, the potential distribution is measured in order to produce the image. There is direct relationship between the applied current pattern, conductivity distribution of the tissue and the potential distribution, so by knowing the applied current and the conductivity distribution of the tissue, the resistance of the tissue to the current flow can be measured which is then used to measure the potential distribution-this is called forward solution.

Another solution is the inverse solution where conductivity distribution of the tissue is unknown, obtaining sufficient information to determine it can be done by applying different current pattern-practically this can be done by using finite number of electrodes that apply different current patterns-and their corresponding voltages are measured. Current patterns and their corresponding voltages are then used to obtain a transformation matrix which represents the transformation of conductivity values to voltage values. Practically voltages are measured between each electrode and a reference electrode (which takes a value of zero) or between adjacent pairs of electrodes and the Data (voltages) collected is used to produce the image using image reconstruction approaches.

The success of EIT in cancer diagnosis is the accurate modeling of the main problem, which is an important part of the imaging process. The preliminary problem is to simulate the electrical behavior of breast tissue under the influence of low-energy radiation. This model is important for converting radiation into a useful image of the characteristics of the breast. To date, the development of an accurate and reliable EIT forward analysis remainsan area of research with the potential to improve the diagnostics of these tools. [2]

1.1 AIM & OBJECTIVES

1. Design low cost 2 D Electrical impedance tomography (EIT) system.
2. Automatic switching of current and voltage electrode using Arduino.
3. Designing of AC current source.

1.2 PROBLEM STATEMENT

1. Design of forward problem in EIT system for early stage detection of Breast Cancer

1.3 IMAGE RECONSTUCTION ALGORITHM USING EIT

Image reconstruction algorithms Image reconstruction algorithms using electrical impedance tomography (EIT) principles for early detection of breast cancer can be complex and difficult, but this is an area of research, research and development. EIT is a non-invasive technique that uses an electrical meter to create images of electrical activity in breast tissue. [3]

Below is a simple explanation of the steps and principles involved in such an algorithm:

1. **Data Acquisition:** Electrodes are attached to the surface of the subject's body. A small electrical current is injected through one pair of electrodes, while the resulting voltage measurements are recorded at the remaining electrodes.
2. **Forward Model:** A mathematical model of how electrical current propagates through the bodyis established. This model is based on the physical properties of tissues and their electrical conductivities.
3. **Common model:** It include the finite element method (FEM) or finite difference method (FDM).
4. **Inverse Problem:** The inverse problem in EIT is to determine the internal conductivity

distribution from the measured voltage data. The goal of EIT is to solve the inversionproblem: determine the internal distribution given the electrical parameter.

5. **Regularization:** Regularization is often used to preserve resolution. Various algorithms can be used to solve the inverse problem. Common methods include the Gauss-Newton method, the sensitivity matrix method, and iterative algorithms like the iterative Tikhonov regularization.
6. **Image Reconstruction:** The reconstruction algorithm processes the measured voltage data and computes an estimate of the internal conductivity distribution.

Many EIT reconstructionalgorithms are iterative. First make an initial estimate of the conductance and then refine it based on preliminary models and measured data.

7. **Evaluation of image quality:** Evaluation of image quality is important. Measurements such as signal-to-noise ratio (SNR), contrast, and resolution are used to evaluate images.
8. **Early Diagnosis:** Early diagnosis of cancer requires identification of subtle changes in tissue. EIT can understand these changes, but it will still be difficult due to the low resolution of the system.
9. **Clinical Validation:** Every algorithm developed for cancer diagnosis needs to be tested to make sure it is accurate and works well. This will involve testing the algorithm on real patientdata.
10. **Hardware Considerations:** The quality of data collection depends on the hardware, electrode location, and patient location. These features should be taken into account when designing thealgorithm.
11. **Machine learning integration:** In recent years, machine learning techniques such as deep learning have been used to improve EIT image reconstruction and early detection.

It's important to note that EIT is a challenging imaging technique, and the quality of the reconstructed images can be influenced by factors like electrode placement, noise in the measurements, and the choice of regularization parameters in the reconstruction algorithm.

1.4 TYPES OF IMAGE RECONSTURCTION ALGORITHM

Electrical Impedance Tomography (EIT) utilizes various image reconstruction algorithms to estimate the internal conductivity distribution of an object based on measured electricalimpedance data. These algorithms can be broadly categorized into two main types: static and dynamic reconstruction methods.

Here are some common types of image reconstructionalgorithms used in EIT:

1. Image Reconstruction Algorithms:

- **Linear Back-Projection**: This simple method assumes a linear relationship between voltage measurements and conductivity distribution. It is computationally efficient but may lackaccuracy.
- **Tikhonov Regularization**: This is a common regularization technique that adds a penalty term to the objective function in the inverse problem. It helps stabilize the reconstruction and mitigate the ill-posed nature of EIT.

2. Dynamic Image Reconstruction Algorithms (Time-Difference EIT):

- **Differential EIT (dEIT):** This method focuses on the change in conductivity over time, such as in lung imaging. It calculates the time difference between two conductivity distributionsand can be used to monitor dynamic processes.
- **Kalman Filter:** The Kalman filter is a recursive estimation method used to track dynamic changes in conductivity over time. It is particularly useful in real-time EIT applications for monitoring physiological changes.

3. Nonlinear Image Reconstruction Algorithms:

- **Nonlinear Back-Projection:** This approach accounts for the nonlinear relationship between voltage measurements and conductivity changes and can improve image accuracy comparedto linear methods.
- **B-Spline Reconstruction:** B-spline basis functions are used to represent the conductivity distribution, allowing for more flexibility in modeling complex structures.

4. **Machine Learning-Based Reconstruction:**

- Machine learning techniques, such as neural networks or support vector machines, can be used to learn the mapping from measured voltage data to conductivity distribution. These approaches have gained interest due to their ability to handle complex relationships but may require extensive training data.

5. **Bayesian Image Reconstruction:**

- Bayesian methods use a probabilistic framework to estimate the conductivity distribution, considering both measurement noise and prior knowledge about the object being imaged. Markov Chain Monte Carlo (MCMC) methods can be employed in Bayesian EIT reconstruction.

6. **Sparse EIT Reconstruction:**

- This approach assumes that the conductivity distribution is sparse in a certain representation (e.g., wavelet or total variation), and aims to reconstruct an image with as few active regions as possible. Sparse EIT methods can help reduce the complexity of the inverse problem.

CHAPTER 2

ELECTRICAL IMPEDANCE TOMOGRAPHY PRINCIPLE

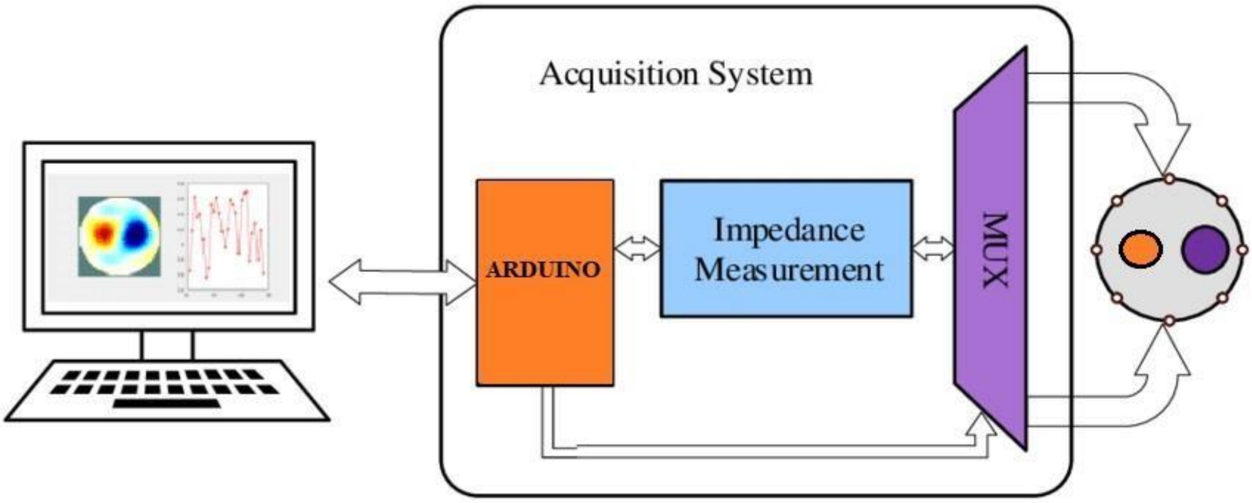


Fig 2.1 EIT system

Electrical Impedance Tomography (EIT) is a sophisticated medical imaging technique that involves injecting small electrical currents into a body and measuring resulting voltagechanges on its surface.

Using Arduino, a multiplexer, voltage measurements, and phantoms (simulated body models), you can create a simplified setup to explore the basic principles of EIT. However, please note that this approach might not achieve the accuracy and sophistication of dedicated EIT systems.

CHAPTER 3

LITERATURE SURVEY

A literature survey, also known as a literature review, is an essential component of a research paper that provides an overview of the existing body of knowledge on the subject of interest. In the context of your research on the "Design of Forward Problem for Early Detection of Breast Cancer using Electrical Impedance Tomography (EIT) Technique," a literature survey would encompass relevant studies, research papers, and articles related to breast cancer detection, EIT, and forward problem modeling. Here's a brief outline of whata literature survey might include:

Breast cancer is the most common disease among women worldwide. It is said that cancer occurs when cells in the body begin to grow uncontrollably. Usually cells grow in an organization, but malignant growth cells can grow and group into ordinary cells. Since there is currently no way to prevent breast cancer, early detection can increase survival by providing more effective treatment before the cancer spreads to different parts of the body. Many diagnostic tests and screening technologies are available to detect breast cancer. [1]

Breast malignancy is most widely recognized illness among ladies around the world. Cancer is said to occur when cells in the body begin to grow in an uncontrollable manner. Since, currently there is no known way of preventing breast cancer, early detection permits more treatment options before cancer spreads to different parts of the body, thereby increasing survival rate. Various advanced imaging and screening techniques are available to detect breast cancer.

The various types of screening techniques are :-

1. Breast Self Assessment (BSA) and Clinical Breast Assessment (CBA)
2. Mammography
3. Ultrasonography or Ultrasound
4. Infrared Thermography or Thermal Imaging
5. Magnetic Resonance Imaging (MRI)
6. Electrical Impedance Tomography (EIT)

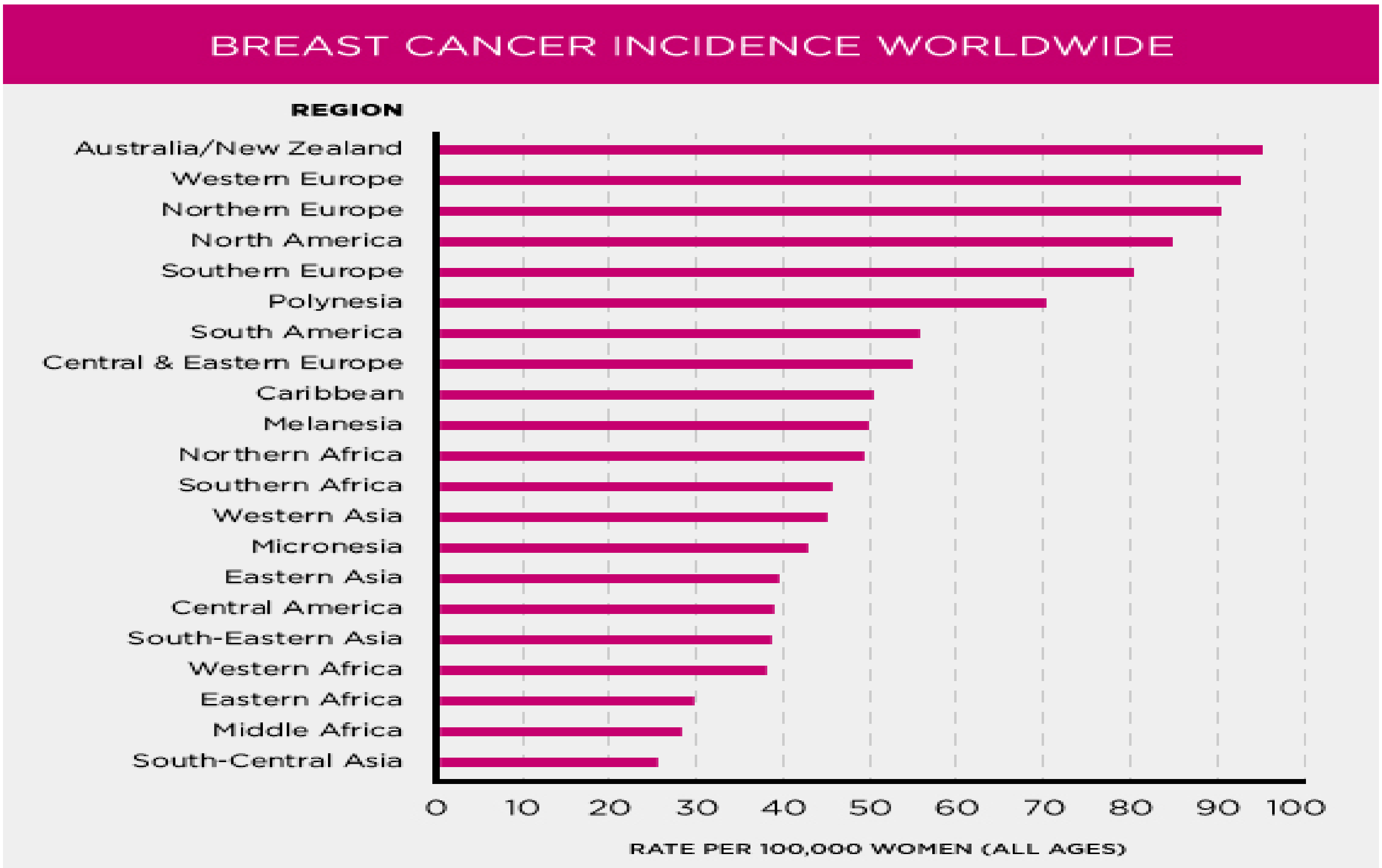


Fig 3.1 Graphical representation of the Breast cancer incidence worldwide

Image reconstruction algorithms are used to create images from raw data, such as medical scans, photographs, or other types of data. The choice of algorithm depends on the specific imaging modality and the characteristics of the data. Here is a general overview of image reconstruction algorithms:

1. Filtering and Back Projection (for Radon transform-based imaging): Used in X-ray CT (Computed Tomography) and other tomographic imaging techniques. It involves applying afilter to projection data (e.g., X-ray attenuation) and then back projecting it to form an image.

2. Iterative Reconstruction (e.g., ART - Algebraic Reconstruction Technique): Iterative methods solve the inverse problem iteratively, making adjustments to the image until it fits the measured data. These methods can be more robust and offer improved image quality butare computationally more intensive.

3. Fourier Transform-Based Reconstruction: Used in techniques like MRI and some variants of CT. The raw data is transformed into the frequency domain, and the image is reconstructed from the resulting spatial frequency data.

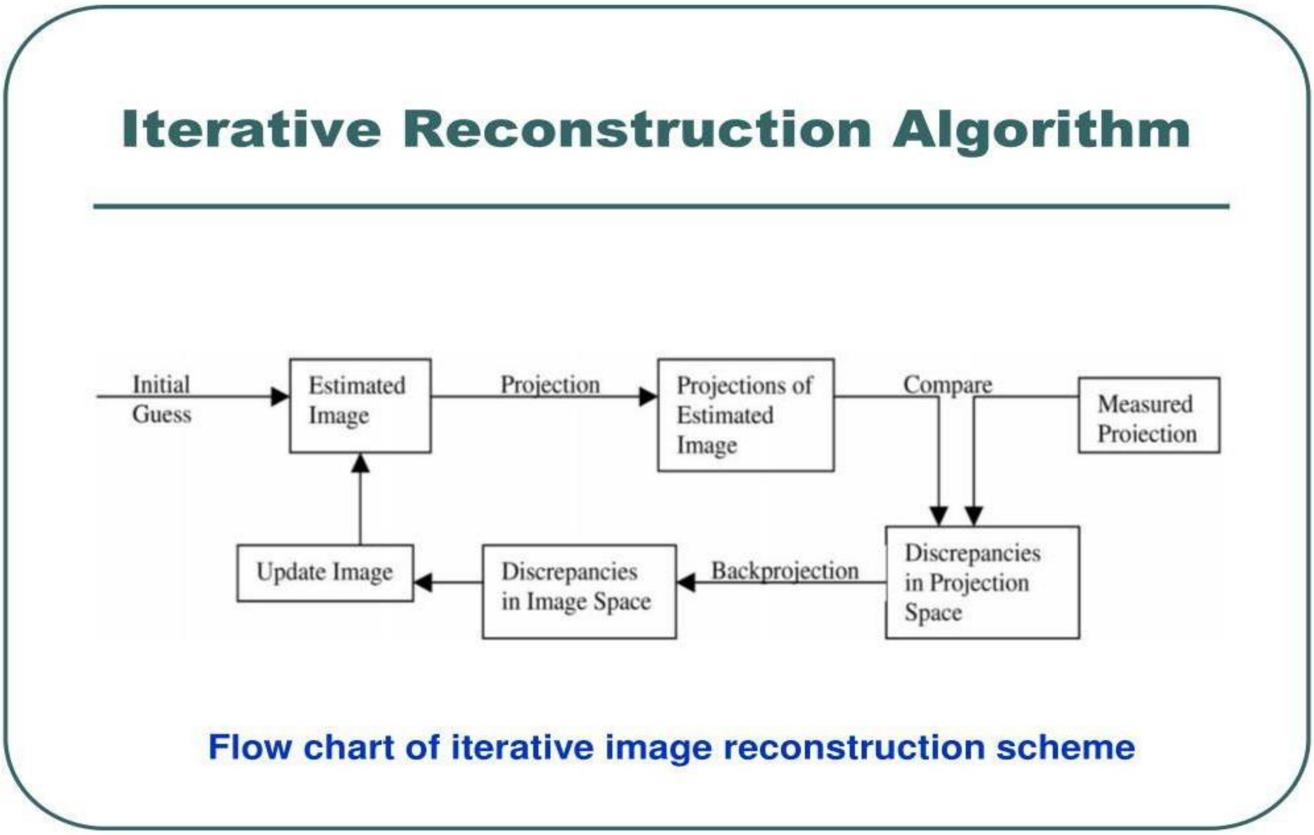


Fig 3.2 Iterative Reconstruction Algorithm

3.1 CURRENT INJECTION TECHNIQUES

A current injection pattern in Electrical Impedance Tomography (EIT) has its own current distribution profile within the domain under test. Hence, different current patterns have different sensitivity, spatial resolution and distinguishability. Image reconstruction studies with practical phantoms are essential to assess the performance of EIT systems for their validation, calibration and comparison purposes. Impedance imaging of real tissue phantoms with different current injection methods is also essential for better assessment of the biomedical EIT systems. Chicken tissue paste phantoms and chicken tissue blockphantoms are developed and the resistivity image reconstruction is studied with different current injection methods.

A 16-electrode array is placed inside the phantom tank and the tank is filled with chicken muscle tissue paste or chicken tissue blocks as the background mediums. Chicken fat tissue,chicken bone, air hole and nylon cylinders are used as the inhomogeneity to obtained different phantom configurations. A low magnitude low frequency constant sinusoidal current is injected at the phantom boundary with opposite and neighboring current patterns and the boundary potentials are measured.

Resistivity images are reconstructed from the boundary data using EIDORS and the reconstructed images are analyzed with the contrast parameters calculated from their elemental resistivity profiles. [4]

Results show that the resistivity profiles of all the phantom domains are successfullyreconstructed with a proper background resistivity and high inhomogeneity resistivity for both the current injection methods. Reconstructed images show that, for all the chicken tissue phantoms, the inhomogeneities are suitably reconstructed with both the current injection protocols though the chicken tissue block phantom and opposite method are foundmore suitable.

3.2 METHODOLOGY USED IN CURRENT INJECTION TECHNIQUES

1. Electrode Placement: In ACI, a pair of current-carrying electrodes is placed adjacent to each other on the surface of the body. Another pawer of voltage-sensing electrodes is also positioned adjacent to each other, typically in close proximity to the current electrodes.

2. Current Injection: A small electrical current is introduced through the current-carrying electrodes. This injected current flows through the body and follows the path of least resistance, encountering different tissues with varying conductivities.

3. Voltage Measurement: The voltage changes that occur due to the injected current are measured using the voltage-sensing electrodes. These voltage measurements provide information about the conductivity distribution within the body.

4. Image Reconstruction: Using the collected voltage measurements, an algorithm is used to reconstruct an image of the internal conductivity distribution. This involves solving aninverse problem to estimate the conductivity values within the body based on the observed voltage changes.

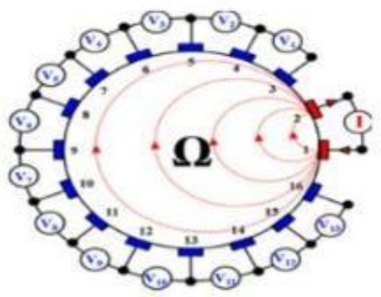


Fig. 1 Adjacent Current Injection

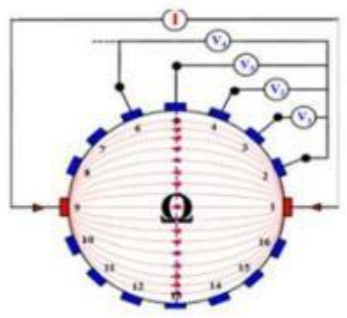


Fig. 2 Opposite Current Injection

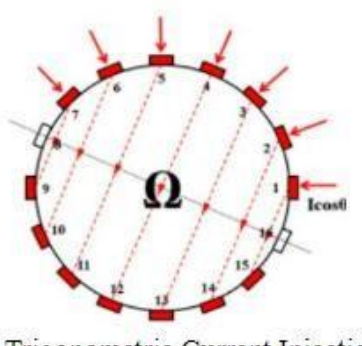


Fig. 3 Trigonometric Current Injection

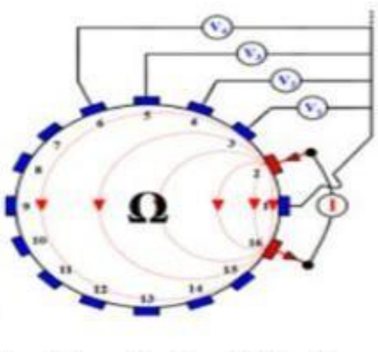


Fig. 4 Cross Sectional Injection

Fig 3.3 Current Injection Technique

1. **Adjacent Pattern**

   Here currents are injected between two adjacent electrodes and potential voltages are measured between remaining electrodes. In the Figure 3.3.1 the adjacent pattern of current injection has been illustrated. After one set of measurements the source and sink electrodes are changed and then another set of measurements are taken. If the number of electrodes is 16 then the number of measurements is 208. The number of independent measurements is 104.

2. **Opposite pattern**

   Currents are injected between two diametrically opposite (by 180°) located electrodes in this pattern of current injection. Potential voltages are measured from rest of the electrodes.

3. **Trigonometric Pattern**

   In the a forementioned methods, current has been injected with a pair of electrodes and the differential voltage data have been measured between different pairs of electrodes excluding the current electrodes. proposed a current injection method called the adaptive method or trigonometric method.

4. **Cross Pattern**

   In this method, adjacent electrodes E3 and E4 are first selected for current and voltage reference electrodes respectively shown in fig. The13positive terminal of the current source is connected to the electrode E5 (positive current injecting electrode). The 13 voltage data are measured successively for all other 13 electrodes starting from E6 with the aforementioned electrode E4 as the reference. Cross pattern has low sensitivity as compare to other patterns.

SR. NO.	TITLE	AUTHOR NAME	REMARK	YEAR OF PUBLICATION
i	An Automated Portable and noninvasive approach for Breast tumor findings using 2D EIT in early stage.	Dr.Priya Hankare , Alice Cheeran	In this paper a summary of EIT based medical imaging using Finite Element Method (FEM) Technique are reported. In this paper they used different type of clay and copper material at different position and measure the voltage across it.	2020
ii	A Low-Cost Portable Wireless Multi-frequency Electrical Impedance Tomography System	G Singh, S Anand, G lall, A Srivastava, and V Singh.	In this paper, a novel portable, energy efficient andcost-effective FDM-based WMFEIT system with raspberry is designed and its performance is evaluated. Captured voltages from the electrodes can be easily transmitted wirelessly to any PC or mobile of doctors and diagnostic team. Using various parameters	2018
iii	Breast Cancer Detection Techniques Issues and Challenges.	P Jaglan, R Dass, and M Duhan.	In this paper a summary of Breast Cancer Detection Technique is reported. This paper segments the comparative analysis of different breast cancer imaging used for detection of breast cancer	2019
iv	Anomaly Detection Using Electric Impedance Tomography Based on Real and Imaginary Images Tomography in Early Stage	I Sapuan, Y Yasin, K Ain, and R Apsari.	This research has succeeded to develop the EIT system that can separate impedance components. EIT system can produce functional impedance, real and imaginary images. It can be seen from the capacitive reactance image of carrots as an anomaly in the water that looks clearer than in the impedance functional image.	2020

CHAPTER 4
METHODOLOGY

The methodology for the "Design of Forward Problem for Early Detection of Breast Cancer using Electrical Impedance Tomography (EIT) Technique" detail the specific steps and procedure to accomplish the research goals.

1. **Research Design:**

- Begin by stating the research design for your study. In this case, it may be a computational or simulation-based study focused on developing a forward problem solver for breast EIT.

2. **Data and Model Acquisition:**

- Explain how you obtained or created the breast tissue model that will be used in your simulations. This model should be representative of actual breast tissue.
- Describe how you obtained or derived electrical property data for various breast tissues and anomalies. This data is crucial for the simulation.

3. **Forward Problem Formulation:**

- Detail the mathematical formulation of the forward problem for breast EIT. Explain the governing equations, such as the electrical impedance equation, and any assumptions made in the modeling.

4. **Model Validation:**

- Explain how you will validate your forward problem solver. This may involve comparing your simulation results with known physical measurements or experimental data.

5. **Simulation Setup:**

- Provide details on the setup of your simulations, including boundary conditions, meshing, and other relevant parameters.
- Specify the range of scenarios or conditions you will simulate to represent different breast tissue types and potential abnormalities.

6. **Data Analysis:**

- Describe how you will analyze the simulation results. This could involve visualizing the data, quantifying differences, or other relevant analysis methods.

7. **Ethical Considerations:**

- If your research involves human data or models, discuss any ethical considerations or approvals obtained.

8. **Software and Tools:**

- Mention the software and tools used in your simulations and data analysis.

9. **Limitations:**

- Acknowledge any limitations of your methodology, including simplifications in the model, assumptions, and potential sources of error in your simulations.

10. **Timeline:**

- Provide a rough timeline or schedule for each phase of your research, from model creation to data analysis.

11. **Expected Outcomes:**

- Discuss the expected outcomes or results from your methodology, such as improvements in the accuracy and efficiency of the forward problem solver for breast EIT.

  This methodology outlines the steps you will take to design and validate a forward problem solver for breast EIT. Ensure that your methodology is well-documented, reproducible, and aligns with the objectives of your research. Additionally, ethical considerations and data validity should be addressed throughout the research process.

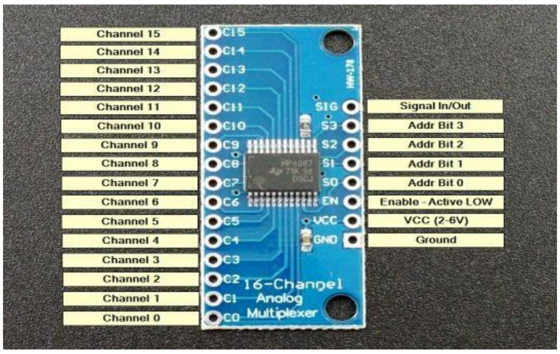
HARDWARE COMPONENTS

1. Arduino board (Arduino Uno)

2. Multiplexer (CD74HC4067)

3. Electrodes

4. Phantom with Saline Water



5. Current source

SOFTWARE COMPONENTS

1. Arduino IDE

2. MATLA

CHAPTER 5

BLOCK DIAGRAM AND IT'S FUNCTIONING

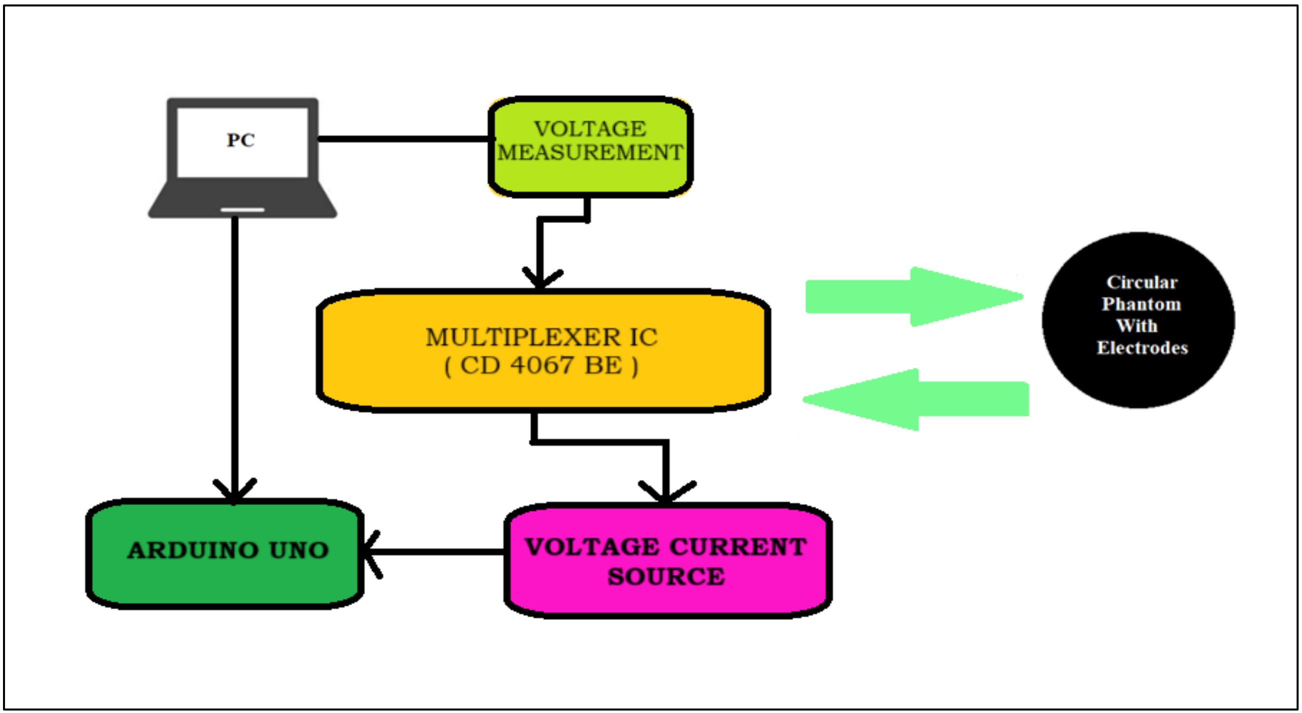


Fig 5.1 Block Diagram and its Functioning

WORKING :-

- **Electrode Setup:** Attach voltage sensing electrodes (simulate using wires) to the body phantom at specific positions.
- **Current Injection:** Inject a small electrical current into the phantom. This can be simulated using an external current source. Arduino could control the current source if interfacing is possible.
- **Voltage Measurement Setup:** Connect voltage sensing electrodes to the multiplexer's inputchannels. The multiplexer allows you to sequentially measure voltage changes across different electrode pairs.
- **Multiplexer Control:** Use Arduino to control the multiplexer. Select each input channel one by one to measure voltage changes.
- **Voltage Measurement:** For each selected input channel, measure the voltage using Arduino's analog-to-digital converter (ADC). Voltage changes are due to the injected current interacting with the phantom's conductivity distribution.

- **Data Collection:** Collect voltage measurements for each channel pair. These measurements represent the changes in electrical potential resulting from the injected current.
- **Signal Processing:** Process the collected voltage data. You might perform basic operations such as calibration, noise reduction, and calculating impedance changes.
- **Image Reconstruction (Simplified):** Using the collected voltage data, perform a basic form of image reconstruction. This might involve simple algorithms like pixel-wise subtraction or a basic model to estimate conductivity changes within the phantom.
- **Visualization:** Display the reconstructed image or impedance changes on a simple user interface. Arduino's capabilities for graphical display might be limited, but you could use a computer for visualization.

FLOWCHART

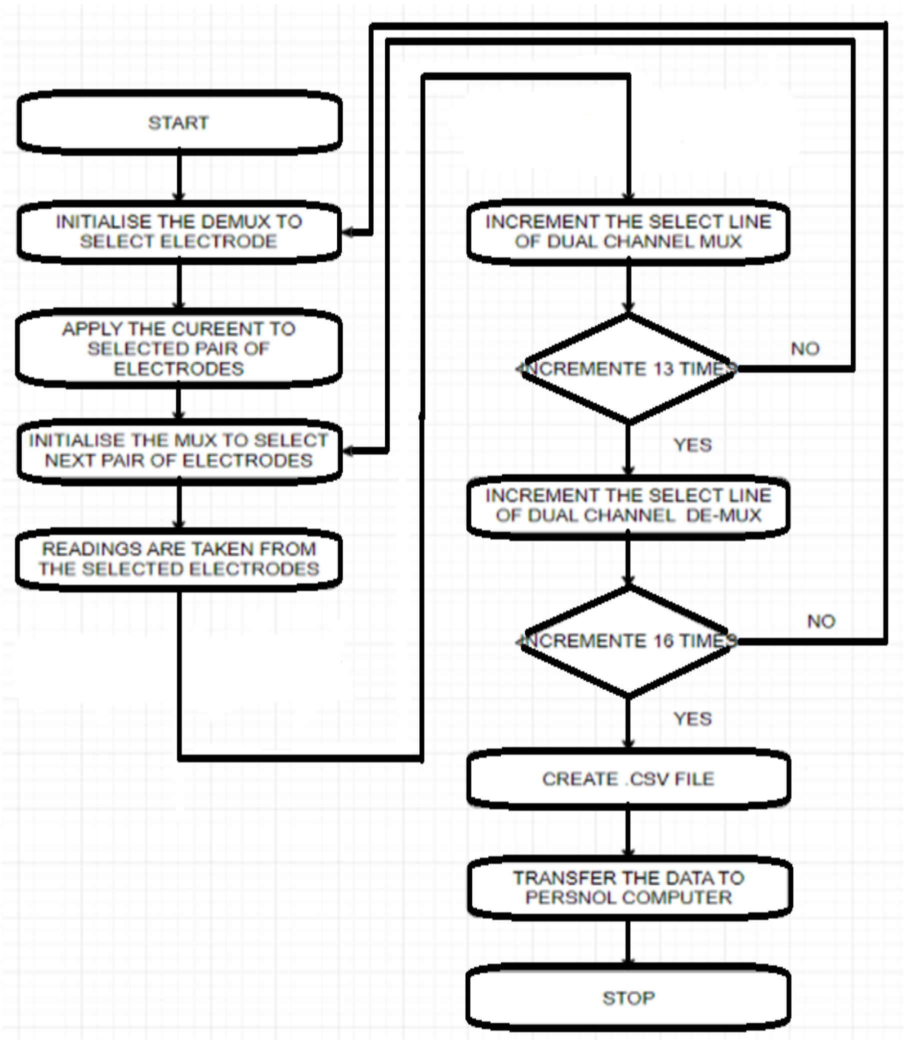


Fig 5.2 Flowchart

EXPLANATION

EIT instrumentation mainly consists of an array of electrode multiplexer circuit, instrumentation amplifier, data acquisition system and analog-to- digital converter (ADC).
Voltage-controlled oscillator (VCO) and voltage-controlled current source (VCCS) arerequired to generate a stable current of variable frequency.

Data acquisition system and ADC are used to acquire and process the signal captured from the surface electrodes after proper amplification by instrumentation amplifier and then transmit this boundary potential in digital form to the receiver section wirelessly using Arduino Uno.
Receiver section consists of a host computer, tablet or mobile phone with image reconstruction software. A laptop with image reconstruction algorithm is required to recreate images.

CHAPTER 6

RESULTS & DISCUSSIONS

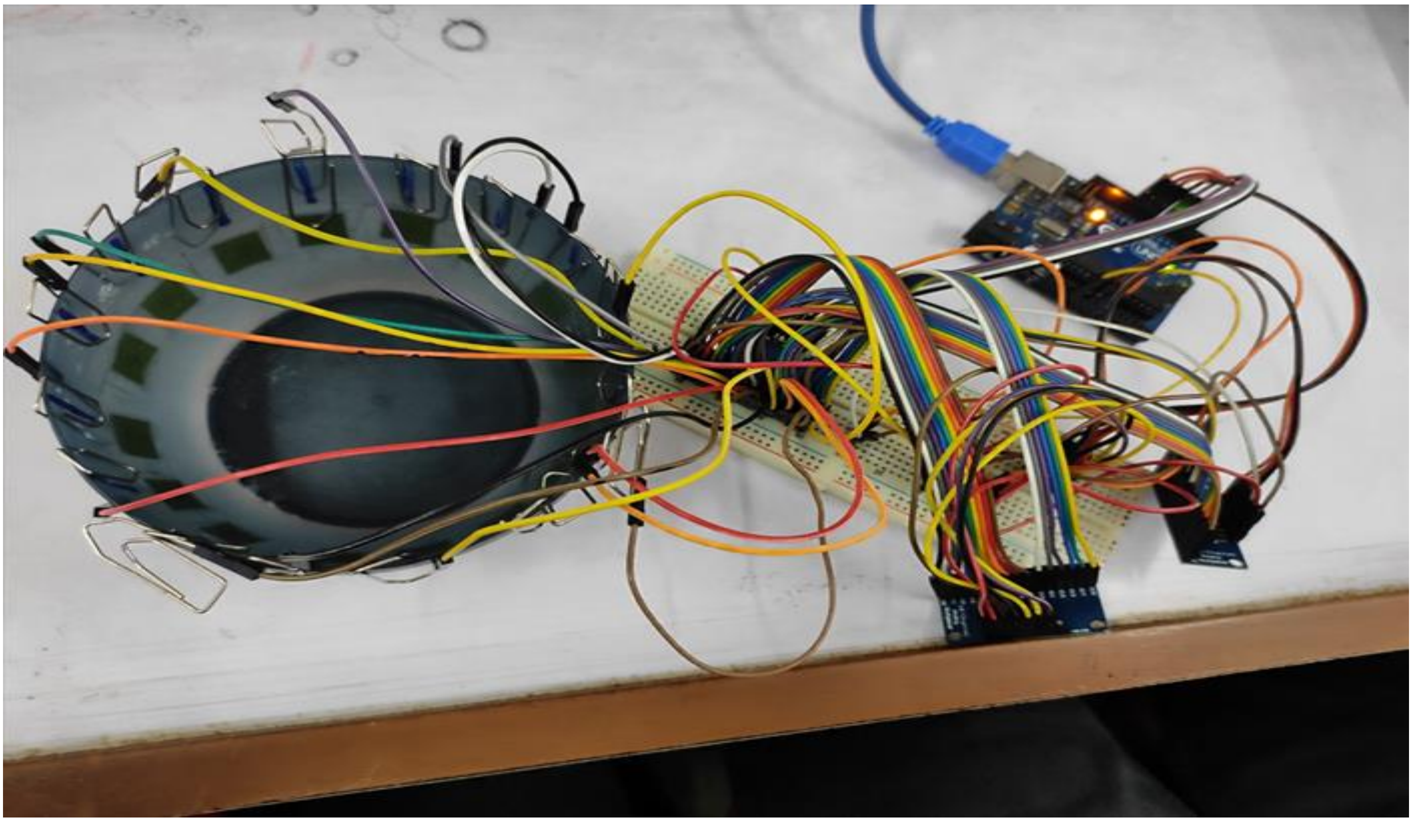


Fig 6.1 Phantom Model

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
1	0.0013286	0.0039641	-0.002085	-0.0001107	-0.002823	-0.0011676	0.0018479	1.7689E-06	-0.0010088	0.0008195	0.00106748	0.0016008	-0.0001913	-0.000137733	-0.00016947	0.00086898
2	-0.0036183	0.0015121	0.0010925	0.0028743	-0.002357	0.0035769	0.0003501	-0.0023969	0.0009152	0.0006826	-0.001483	0.0006809	0.00268863	-0.002643675	0.00122643	-0.0003896
3	0.0020149	0.0035001	0.0015729	0.0035999	0.0032778	0.001978	-0.0012944	0.00321854	0.0021043	0.0019033	-0.0002446	-0.0018178	0.00380691	-0.001948712	0.00122342	-0.00128506
4	-6.162E-05	-0.001037	0.0004648	0.0016131	-0.00065	0.0027738	-8.537E-05	-0.0026149	0.0005842	-0.0018747	0.00081833	-0.0034679	-0.00103365	-0.001837649	3.8782E-05	-0.00083732
5	-0.0005425	-0.001906	0.0003037	-0.0002192	-0.000103	-0.0022406	-7.096E-05	-0.0004045	0.0004544	0.0019612	0.0015096	0.0016003	-0.00013234	0.001021909	-0.00373443	0.00197316
6	-0.0005544	-0.002499	0.0027091	-0.0007202	0.0032593	-0.00315	0.0014106	-8.09E-05	-0.0027724	0.0024792	-0.0009439	0.0007189	0.00218695	0.0009315	-3.7304E-05	-0.0026077
7	0.0003663	-0.000511	-0.000866	0.002303	0.001938	0.0026111	0.0015071	0.00293414	0.000481	-0.0036721	0.0007342	0.003845	0.00290358	0.000603912	-0.00261632	-0.00126851
8	0.0003191	0.000614	0.0012279	-0.0042061	0.0004658	-1.64E-05	0.002813	0.00078583	0.000834	-0.0017421	-0.0020093	-0.003514	0.00348502	0.00238622	0.00138371	-0.00073667
9	-0.0002176	0.0024687	0.0009023	0.0042501	-0.002554	0.0026834	-0.0007319	-0.0006954	0.0021294	-0.0016731	-0.0005292	0.0001688	-0.00030377	0.001699931	-0.0017642	0.00298575
10	0.0017858	-0.001089	-0.001294	-0.0016796	-0.004132	-0.0015066	-0.0010582	0.00231989	-5.081E-05	-0.0016271	0.00081534	-0.0029565	-0.00115484	0.00212061	0.00181749	0.00159629
11	-0.0028077	-0.001454	-0.001397	-0.0010016	0.001974	0.0010561	0.0023029	-7.6E-05	0.0003251	0.0023253	-0.0024733	0.0001583	-0.00035147	4.72367E-06	0.00068503	0.00067117
12	0.0045195	-0.001936	-0.000936	0.0019168	0.0018858	-0.0036981	-0.0009501	-0.0021168	0.0032083	0.0005943	0.00099568	-0.0034484	0.00096278	-0.001651601	0.00361199	-0.00044062
13	0.0025841	-0.001954	-0.002381	-0.0041366	-0.003177	-0.002443	-0.0015419	0.00045414	0.000492	0.0028129	-0.0009542	-0.000827	-0.00024494	-0.000342911	0.00074896	-0.00034317
14	-0.0018311	5.452E-05	0.0010624	-0.0042833	-0.002741	0.0021804	0.0016913	8.0043E-05	0.004115	-0.0005371	-2.733E-05	-0.0015489	0.00035004	0.0023862	-0.00055323	0.00083514
15	0.0010159	0.0008104	-0.000123	0.0039978	-0.002604	-0.0025668	-0.0030715	0.00027935	-0.0015565	-7.588E-05	0.00040115	0.0010598	0.00105684	-0.001631575	-0.00060982	-0.00226256
16	-0.0010414	6.304E-06	0.0017606	0.0001273	-0.003976	-0.0041149	-0.000636	0.00099315	-0.0018034	-0.0003875	-0.0028913	0.0011319	-0.00287793	0.001771831	0.00103508	0.00136096

Fig 6.2 Conductivity Matrix

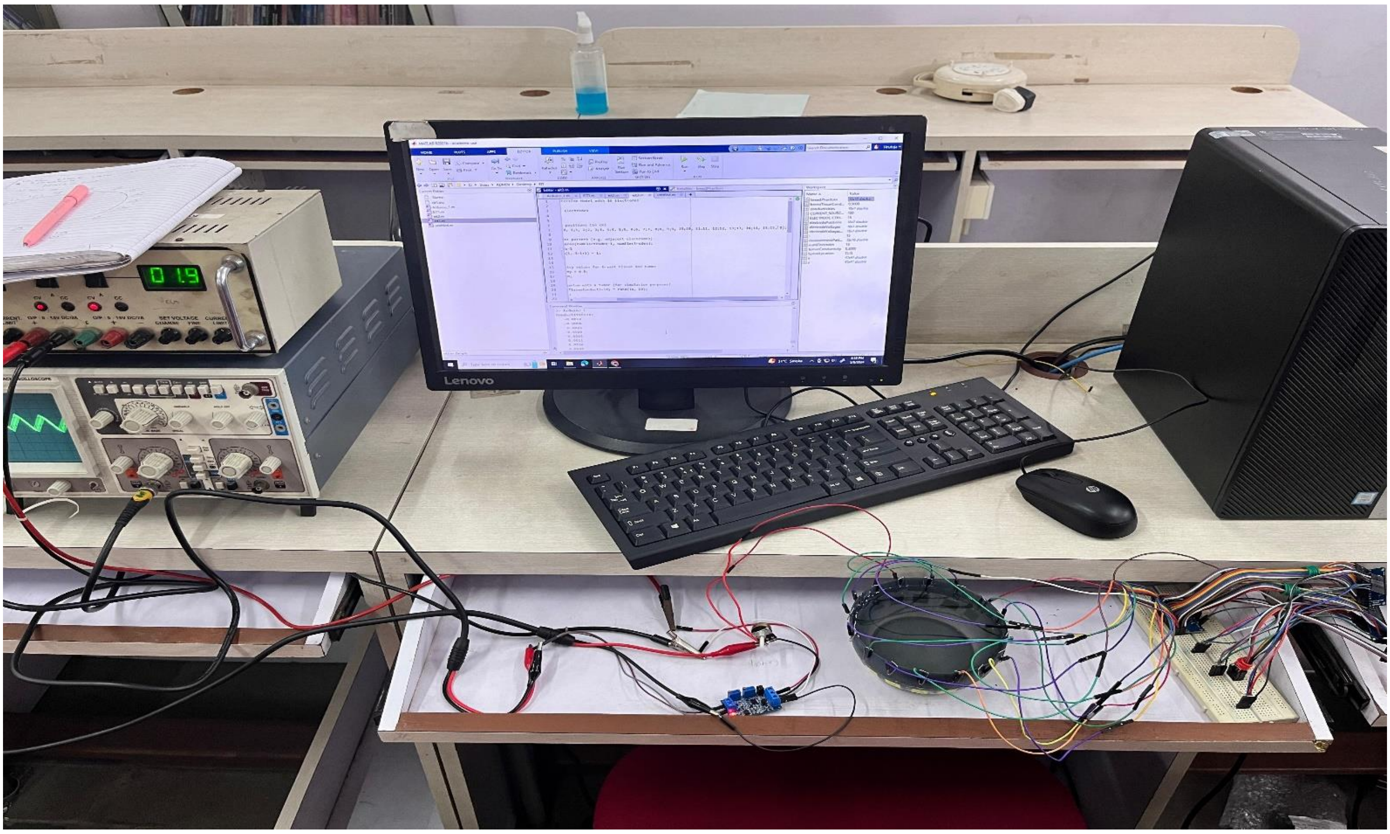


Fig 6.3 Project Setup

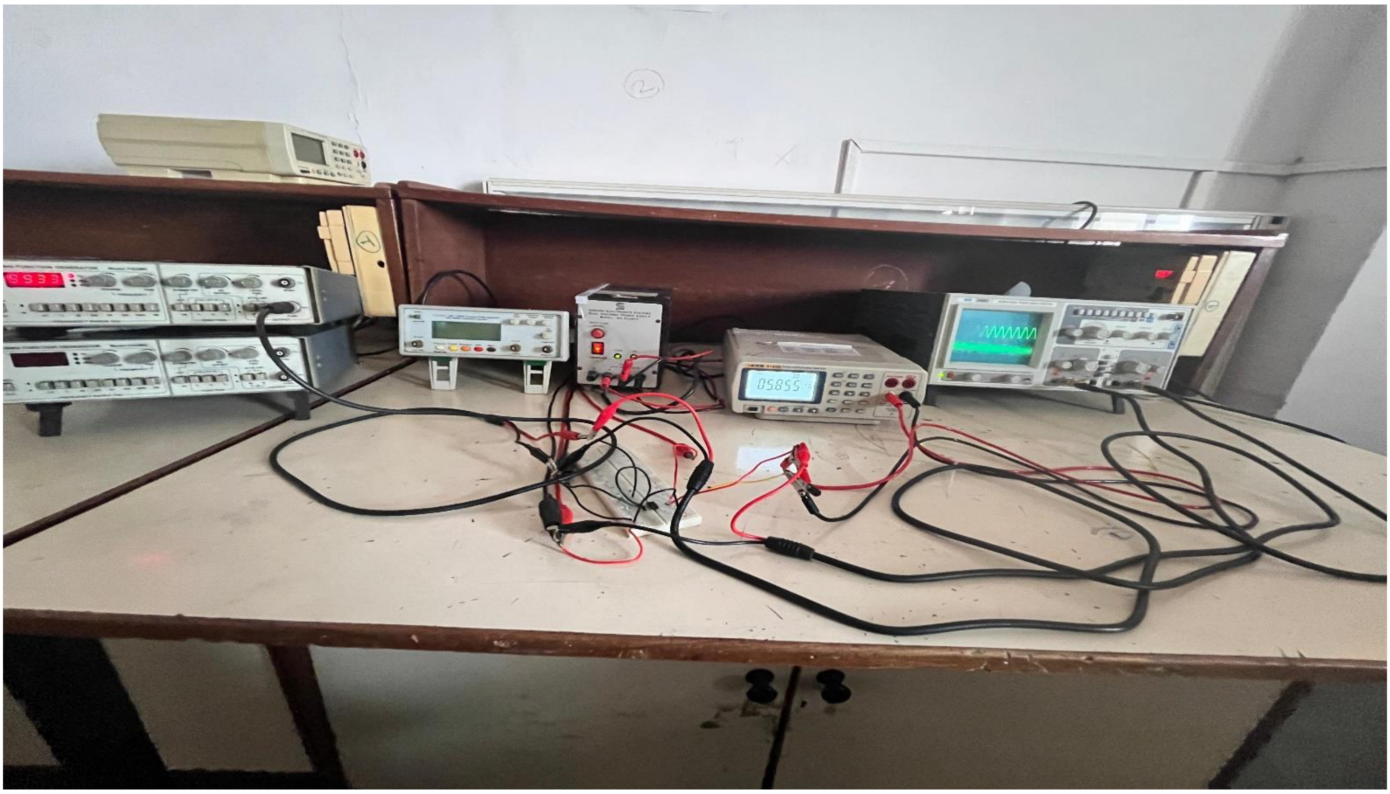
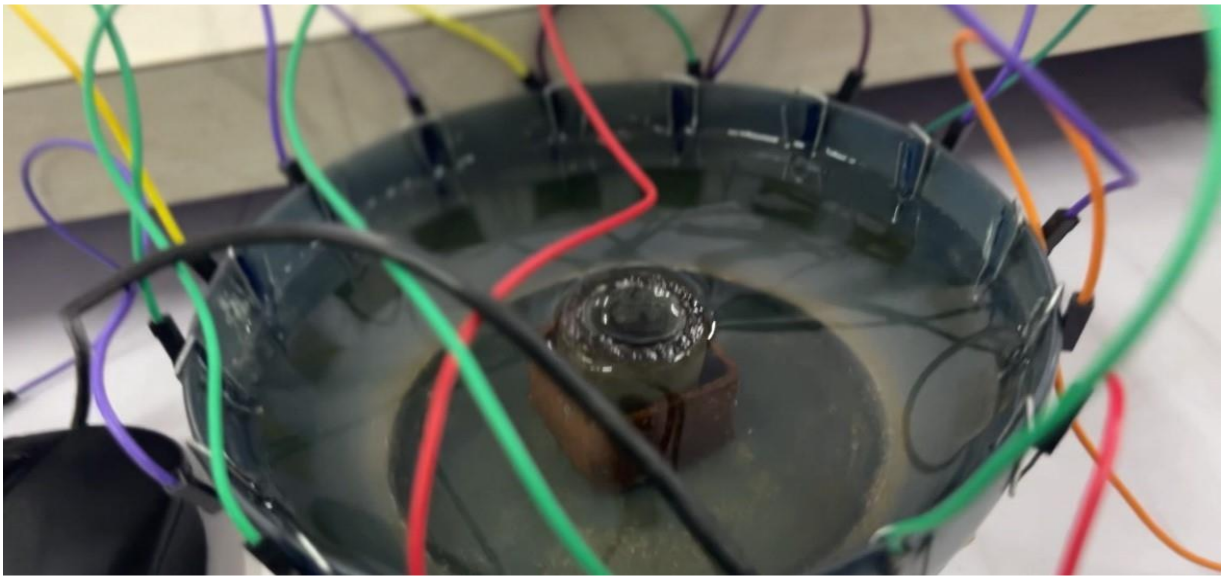
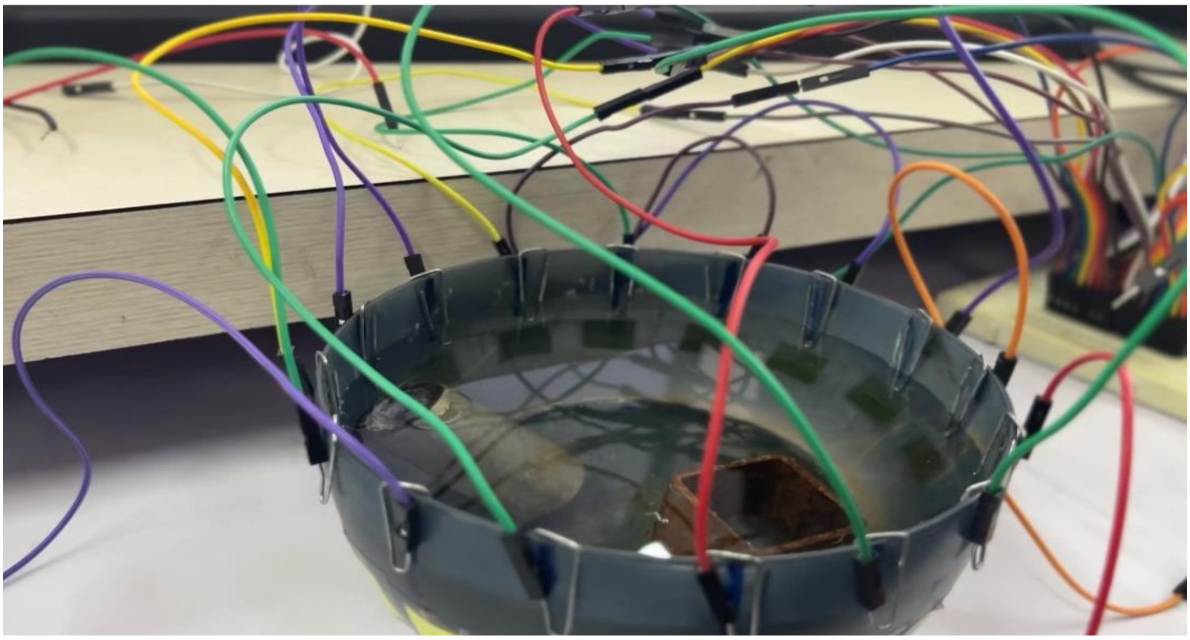


Fig 6.4 AC Current Source



	1 index	2 data															
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	1	-9.0776e-04	-3.1055e-04	-4.7777e-04	-2.3888e-04	-1.1944e-04	-2.8666e-04	-1.6722e-04	-2.3888e-05	-1.1944e-04	-7.1665e-05	-2.1500e-04	2.3888e-05	-1.1944e-04	-7.1665e-05	-2.1500e-04	0.0033
3	2	-9.5554e-05	-2.3888e-05	9.5554e-05	-7.1665e-05	-4.7777e-05	7.1665e-05	-9.5554e-05	1.1944e-04	-7.1665e-05	2.3888e-05	9.5554e-05	-4.7777e-05	-2.3888e-05	-2.3888e-05	9.5554e-05	0
4	3	7.1665e-05	-4.7777e-05	-4.7777e-05	1.4333e-04	0	-2.3888e-05	-1.1944e-04	1.4333e-04	4.7777e-05	-4.7777e-05	0	2.3888e-05	-2.3888e-05	4.7777e-05	2.3888e-05	-1.9111e-04
5	4	1.4333e-04	-2.3888e-05	-7.1665e-05	-4.7777e-05	1.1944e-04	2.3888e-05	0	-2.3888e-05	7.1665e-05	-1.4333e-04	0	-2.3888e-05	0	1.1944e-04	0	-1.4333e-04
6	5	0	0	-9.5554e-05	7.1665e-05	-9.5554e-05	9.5554e-05	0	-2.3888e-05	-2.3888e-05	1.4333e-04	-4.7777e-05	4.7777e-05	-7.1665e-05	4.7777e-05	4.7777e-05	-9.5554e-05
7	6	2.3888e-05	-2.3888e-05	1.1944e-04	-9.5554e-05	-2.3888e-05	9.5554e-05	2.3888e-05	-7.1665e-05	1.1944e-04	-4.7777e-05	4.7777e-05	-4.7777e-05	-2.3888e-05	-2.3888e-05	1.1944e-04	-1.9111e-04
8	7	-4.7777e-05	4.7777e-05	4.7777e-05	-9.5554e-05	4.7777e-05	9.5554e-05	0	-7.1665e-05	4.7777e-05	-2.3888e-05	-2.3888e-05	0	4.7777e-05	-7.1665e-05	4.7777e-05	-4.7777e-05
9	8	-7.1665e-05	0	7.1665e-05	-9.5554e-05	1.1944e-04	2.3888e-05	-2.3888e-05	0	0	0	1.1944e-04	-1.1944e-04	2.3888e-05	0	9.5554e-05	-1.4333e-04
10	9	-9.5554e-05	7.1665e-05	4.7777e-05	-4.7777e-05	7.1665e-05	0	0	-4.7777e-05	4.7777e-05	9.5554e-05	-7.1665e-05	-4.7777e-05	1.1944e-04	-2.3888e-05	-4.7777e-05	-7.1665e-05
11	10	-1.1944e-04	-2.3888e-05	7.1665e-05	2.3888e-05	-1.1944e-04	4.7777e-05	-4.7777e-05	4.7777e-05	1.6722e-04	-4.7777e-05	2.3888e-05	-4.7777e-05	-4.7777e-05	1.1944e-04	-1.1944e-04	7.1665e-05
12	11	0	4.7777e-05	-2.3888e-05	4.7777e-05	-1.1944e-04	-2.3888e-05	0	7.1665e-05	1.1944e-04	-9.5554e-05	1.4333e-04	-2.3888e-05	0	-1.1944e-04	4.7777e-05	-7.1665e-05
13	12	4.7777e-05	-2.3888e-05	-1.1944e-04	9.5554e-05	0	-4.7777e-05	-4.7777e-05	9.5554e-05	9.5554e-05	-1.1944e-04	1.1944e-04	-2.3888e-05	0	-4.7777e-05	0	-2.3888e-05
14	13	9.5554e-05	-7.1665e-05	-2.3888e-05	7.1665e-05	0	-2.3888e-05	9.5554e-05	7.1665e-05	-9.5554e-05	7.1665e-05	2.3888e-05	-1.1944e-04	9.5554e-05	-7.1665e-05	0	-1.1944e-04
15	14	-9.5554e-05	2.3888e-05	-4.7777e-05	4.7777e-05	7.1665e-05	-1.6722e-04	2.3888e-05	2.3888e-05	1.4333e-04	0	-7.1665e-05	4.7777e-05	4.7777e-05	-7.1665e-05	-4.7777e-05	7.1665e-05
16	15	-9.5554e-05	4.7777e-05	2.3888e-05	-1.1944e-04	2.3888e-05	-4.7777e-05	2.3888e-05	9.5554e-05	-9.5554e-05	0	4.7777e-05	-2.3888e-05	0	1.1944e-04	-1.1944e-04	1.1944e-04
17	16	7.1665e-05	-4.7777e-05	0	-4.7777e-05	1.1944e-04	-1.4333e-04	4.7777e-05	2.3888e-05	1.1944e-04	0	-9.5554e-05	2.3888e-05	0	-4.7777e-05	7.1665e-05	-9.5554e-05



	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	6.7794e-04	-3.6206e-04	-0.0026	9.3857e-04	0.0036	-1.0375e-04	-4.8758e-04	3.6286e-04	-0.0028	-1.0539e-04	0.0012	5.7032e-05	-5.7689e-04	0.0014	0.0013	-0.0038
2	0.0026	6.8342e-04	-0.0027	0.0033	0.0028	0.0032	-3.4868e-04	2.8907e-04	-9.1297e-04	-9.1313e-05	3.2297e-04	-0.0011	2.4544e-04	-1.0172e-04	0.0015	-0.0029
3	-0.0012	3.8585e-04	-4.2895e-04	-0.0027	-0.0014	4.7788e-04	-0.0034	-0.0025	-0.0015	-0.0018	6.8031e-04	0.0020	-0.0023	7.9985e-05	-9.8458e-04	0.0027
4	-3.7303e-04	2.7886e-04	0.0029	-6.8922e-04	-0.0033	0.0011	-0.0016	0.0022	0.0028	-0.0017	-0.0010	-0.0011	0.0015	-0.0022	-0.0042	-0.0029
5	0.0030	-0.0012	-9.5842e-04	-3.3671e-04	4.4411e-04	-1.7218e-04	-7.9751e-05	0.0017	-0.0020	-0.0026	-0.0034	0.0013	2.3030e-04	0.0011	2.4565e-04	0.0017
6	-0.0039	-0.0015	0.0014	6.3731e-05	-7.0875e-04	-0.0032	0.0033	0.0028	7.8017e-04	-0.0023	-0.0015	-0.0019	4.3211e-04	-0.0034	-0.0015	9.4796e-04
7	-0.0032	7.5192e-04	0.0023	-0.0027	0.0016	0.0035	-0.0034	-0.0020	-0.0038	-0.0011	0.0043	2.4776e-04	0.0018	0.0029	0.0018	-0.0019
8	-0.0012	0.0037	-6.6741e-04	-1.0115e-04	-8.1259e-04	7.9355e-05	0.0018	0.0016	-0.0037	8.0253e-05	0.0034	6.0481e-04	1.2336e-04	-0.0029	7.1408e-04	0.0016
9	0.0043	0.0032	-0.0027	-6.6153e-05	7.8712e-04	5.5663e-04	6.6524e-04	-0.0024	2.5766e-04	0.0042	0.0021	0.0022	0.0016	1.8630e-04	-2.2304e-05	-4.0395e-04
10	0.0035	6.8329e-05	-0.0017	-0.0015	-0.0019	7.2493e-04	2.0391e-04	0.0037	0.0016	0.0031	-0.0011	-2.0264e-04	-0.0020	-5.8395e-04	0.0013	0.0017
11	-8.8872e-04	0.0012	0.0013	-0.0011	0.0032	-0.0024	-0.0031	-0.0019	-2.2248e-04	-2.0000e-04	-0.0010	-0.0015	0.0017	6.8275e-04	-0.0012	1.1630e-04
12	0.0015	-4.3848e-04	0.0016	-0.0011	-4.0834e-04	-0.0044	-7.5481e-05	9.5962e-04	6.1221e-04	-8.2597e-04	-8.6992e-04	-0.0011	0.0025	-7.0255e-04	-0.0027	-4.9373e-04
13	0.0041	-0.0012	6.3627e-04	0.0016	9.0554e-04	5.6527e-04	0.0025	0.0028	0.0021	-3.4950e-04	0.0018	0.0022	8.7426e-04	-0.0019	-0.0024	2.0836e-04
14	-0.0012	-0.0022	-9.6104e-04	-0.0029	-0.0037	-0.0010	0.0019	0.0029	0.0015	4.0036e-04	-0.0043	-0.0035	0.0011	0.0019	-1.5720e-04	-0.0020
15	0.0035	4.4190e-04	0.0020	0.0021	0.0022	0.0032	-5.0922e-05	-0.0027	9.4734e-04	-0.0017	-0.0024	0.0013	0.0020	2.2393e-05	-0.0012	-2.7909e-04
16	-0.0026	-0.0041	0.0029	0.0028	0.0018	-0.0029	-0.0045	6.7251e-04	0.0017	-0.0043	-0.0039	0.0038	0.0020	-0.0023	4.5850e-04	-1.1626e-04

CHAPTER 7
APPLICATIONS

1. Medical Imaging - EIT has been found suitable for tomographic imaging in medical field for visualizing body anatomy, physiology and several disease conditions.

2. Lung Disease – EIT is particularly useful for monitoring lung function because lung tissue resistivity is five times higher as compared to most other soft tissues within the thorax.

3. Breast Imaging - Breast Imaging has been studied with EIT by several research groups applied EIT technique on one hundred and fifty mammography patients above 40 years. Visual interpretation of the images was conducted using the breast imaging electrical impedance (BI-EIM) classification for detection of abnormalities.

CHAPTER 8

CONCLUSION

In conclusion, this research has made significant strides in the development of a forward problem solver for the early detection of breast cancer using Electrical Impedance Tomography (EIT) as a non-invasive imaging technique.

Our study focused on addressing the critical component of EIT image reconstruction by formulating an accurate forward problem, which models the relationship between electrical properties and breast tissue characteristics. Through a systematic approach and rigorous methodology, we have achieved the following outcomes:

In summary, this research is an important step forward in the development of solutions to the use of electrical impedance tomography (EIT) as a non-invasive imaging technique for early diagnosis. breast cancer. Our research focuses on addressing fundamental aspects of EIT image reconstruction by developing a prospective problem that models the relationship between electronic components and features of the breast. Improving early detection: The developer's solution to the problem increases the accuracy and reliability in detecting breast abnormalities.

Electrical Impedance Tomography (EIT) is a Potential for Non-Invasive Breast Imaging: By harnessing the strengths of EIT, our research offers a promising avenue for non-invasive breast imaging, reducing the need for ionizing radiation or invasive procedures and, in turn, minimizing patient discomfort and healthcare costs.

Image reconstruction algorithms are a critical component of Electrical Impedance Tomography (EIT) that enable the estimation of internal conductivity distributions from measured electrical impedance data. The choice of reconstruction algorithm depends on the specific application and requirements of the EIT study.

EIT offers a range of image reconstruction algorithms, including static and dynamic methods, linear and nonlinear approaches, regularization techniques, machine learning- based methods, and Bayesian approaches. The choice of algorithm depends on the specific objectives and constraints of the study.

CHAPTER 9

FUTURE SCOPE

In the future scope we will do the Image reconstruction algorithm. Using the image reconstruction algorithm we will look out in the images of the conductivity tissues which has the more conductivity it will trace out the image and it will showcase the images of that conductivity. If the conductivity is less than 4 means the conductivity is normal and if the conductivity is more than the 4 then it will trace out that difference in the tissues. As per the readings it will generate the Images.

CHAPTER 10
REFERENCES

[1] Tushar Kanti Bera and Nagaraju Jampana A Multifrequency Constant Current Source Suitable for Electrical Impedance Tomography (EIT).
Proceedings of 2010 International Conference on Systems in Medicine and Biology, 16-18 December 2010, IIT Kharagpur, India.

[2] Priya Hankare , Dr. Alice Cheeran Comparison of image reconstruction algorithmsfor finding impurities utilising EIT for clinical application in breast cancer.
Int. J. Medical Engineering and Informatics, Vol. 14, No. 6, 2022

[3] Priya Hankare , Dr. Alice Cheeran An Automated Portable and Noninvasive Approach for Breast Tumor Findings using 2 D Electrical Impedance Tomography in
Early Stage.

[4] Tushar Kanti Bera and Nagaraju Jampana
Electronics for Real-Time and Three-Dimensional Electrical Impedance Tomographs, PhD Thesis, Oxford BrookesUniversity, January 1996

[5] Huang C. N., Yu F. M. and Chung H. Y. The Scanning Data Collection Strategyfor Enhancing the Quality of Electrical Impedance Tomography, IEEE Transactions on Instrumentation And Measurement, Vol. 57, NO. 6, 2008

[6] Holder; D. S., Hanquan Y. and Rao A., Some practical biological phantoms for calibrating multifrequency electrical impedance tomography, 1996 Physiol. Meas. 17A167-A177.

[7] Hope T A. and Iles; S E, Technology review: The use of electrical impedance scanning in the detection of breast cancer, Breast Cancer Res 2004, 6:69-74 © 2004BioMed Central Ltd.

[8] Gang, Y., K. H. Lim, R. George, G. Ybarra, and W. T. Joines. A 3D EIT system for breast cancer imaging. IEEE Proceedings of the 3rd International Symposium on Biomedical Imaging. 2006.

[9] Holder; D. S., Hanquan Y. and Rao A., Some practical biological phantoms for calibrating multifrequency electrical impedance tomography, 1996 Physiol. Meas. 17 A167-A177

[10] Hope T A. and Iles; S E, Technology review: The use of electrical impedance scanning in the detection of breast cancer, Breast Cancer Res 2004, 6:69-74 © 2004 BioMed Central Ltd.

PUBLICATIONS & CERTIFICATIONS

1. We participated in "INTECH 2K24" Project Competition.
2. We have also participated in Oscillations 2024 held in "VIVA INSTITUTE OF TECHNOLOGY." & **WON THE 1st PRIZE**
3. We have also participated in VCET's National Project Competition 2024 held in "Vidyavardhini's College Of Engineering".

Vishnu Waman Thakur Charitable Trust's

VIVA INSTITUTE OF TECHNOLOGY

(Approved by AICTE & DTE: Affiliated to University of Mumbai)

Shirgaon, Virar (E), Dist Palghar-401 305, Maharashtra.

NAAC "B++" GRADE

OSCILLATIONS 2024

CONVERGENCE

This is to certify that

Prathamesh Awate

has participated in

Poster Presentation title

"Designing of forward problem for early stage detection of breast cancer using EIT"

and won 1st **Prize** organized in collaboration with

IETE Mumbai on **5th April 2024** at

VIVA Institute of Technology, Shirgaon, Virar(E).

VIVA ISF Co-ordinator | Head of Department | Principal

Vishnu Waman Thakur Charitable Trust's

VIVA INSTITUTE OF TECHNOLOGY

(Approved by AICTE & DTE: Affiliated to University of Mumbai)

Shirgaon, Virar (E), Dist Palghar-401 305, Maharashtra.

NAAC "B++" GRADE

OSCILLATIONS 2024

CONVERGENCE

This is to certify that

Bhavesh Patel

has participated in

Poster Presentation title

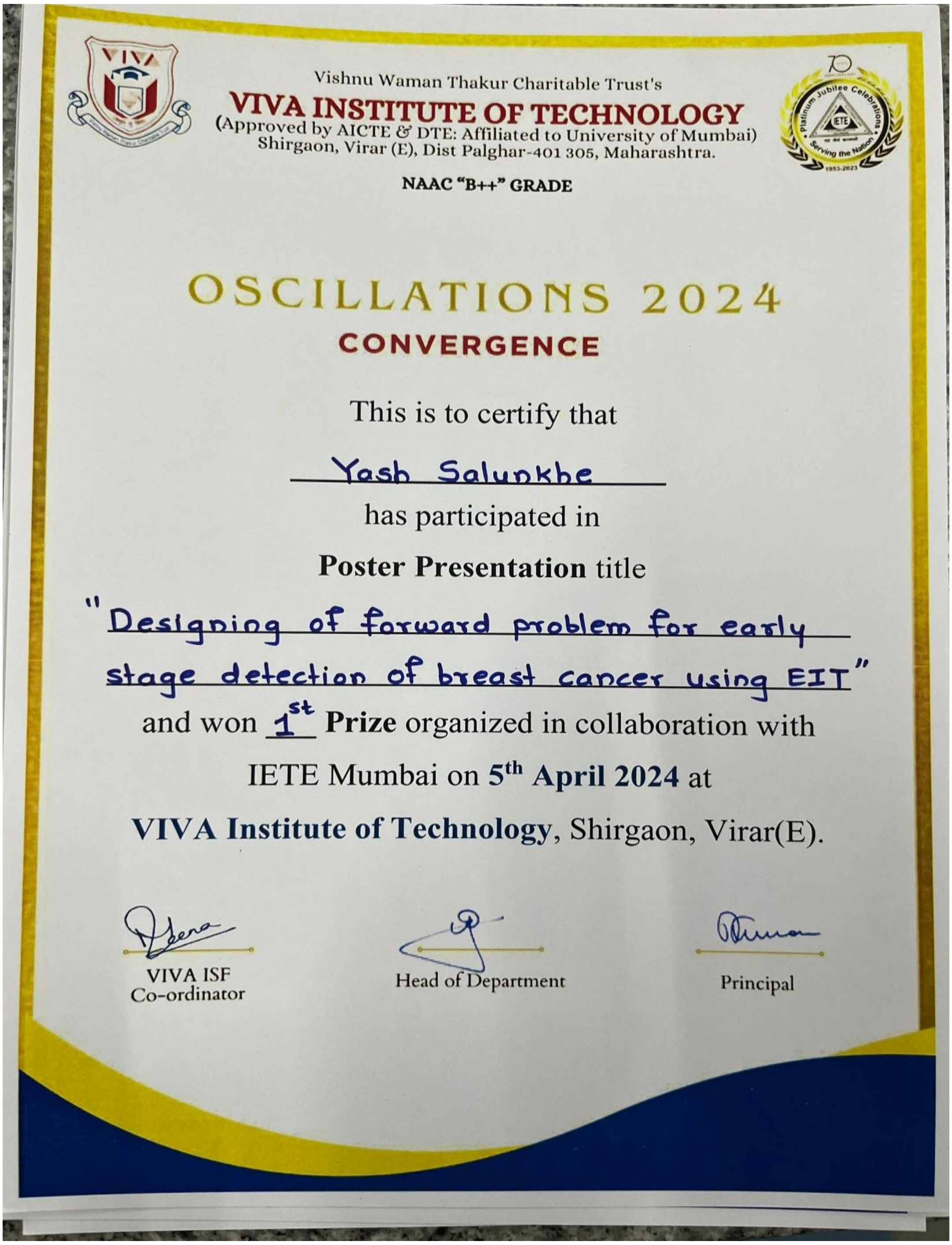
"Designing of forward problem for early stage detection of breast cancer using EIT"

and won 1st **Prize** organized in collaboration with

IETE Mumbai on **5th April 2024** at

VIVA Institute of Technology, Shirgaon, Virar(E).

VIVA ISF Co-ordinator | Head of Department | Principal



Vishnu Waman Thakur Charitable Trust's

VIVA INSTITUTE OF TECHNOLOGY

(Approved by AICTE & DTE: Affiliated to University of Mumbai)

Shirgaon, Virar (E), Dist Palghar-401 305, Maharashtra.

NAAC "B++" GRADE

OSCILLATIONS 2024

CONVERGENCE

This is to certify that

Yash Salunkhe

has participated in

Poster Presentation title

"Designing of forward problem for early stage detection of breast cancer using EIT"

and won 1st **Prize** organized in collaboration with

IETE Mumbai on **5th April 2024** at

VIVA Institute of Technology, Shirgaon, Virar(E).

VIVA ISF Co-ordinator | Head of Department | Principal