1. Introduction:

Rensselaer’s 4th generation Adaptive Current Tomograph (ACT 4) is being used to collect electrical impedance spectroscopy data in register with 3D x-ray tomosynthesis mammography data in a clinical setting. This poster presents details about the design and performance of the ACT 4 system and the radiolucent electrode arrays. The electrical characteristics of the electrode arrays are presented as well as approaches for accommodating their large capacitance and resistance.


- The ACT 4 system has the following properties:
  - Applies sinusoidal voltage or current excitation signals to all electrodes simultaneously
  - Supports up to 72 electrodes
  - Uses electrical excitation frequencies between 3.3 kHz and 1 MHz
  - Acquires data at one frequency at approximately 1.5 frames/second
  - Performs a frequency sweep (7 frequencies) in approximately 5 seconds
  - Uses Field-Programmable Gate Array (FPGA) and Digital Signal Processing (DSP) devices
  - Has a modular circuit design

3. Radiolucent Electrode Array:

ACT 4 is being used to collect patient data in register with x-ray 3D tomosynthesis mammograms. 6 x 6 radiolucent electrode arrays have been constructed by depositing thin layers of metal on kapton to produce the desired connections on a single layer and stacking the layers to produce the complete array [3].

4. Dummy Loads:

Electrical lumped-element dummy loads have been developed to test the performance of the ACT 4 system and electrode arrays. The loads are in the shape of a 1 cm by 1 cm by 1.5 cm brick which can be placed between the electrode arrays in the mammography unit and connected to ensure good contact. Printed circuit boards with pads arranged in the same geometry as that of the electrode array form the top and bottom sides of the brick. Pieces of compressible EMI gasket material, essentially a foam rubber strip encased in a conductive fabric with a conductive adhesive on one side are attached to the pads to improve the electrical contact. Potting epoxy is used to fill the space between the circuit boards once the electrical connections are made to make the brick incompressible. The present version has an electrical network between each electrode on the top surface and the electrode directly beneath it on the bottom surface. Connectivity between all adjacent pads is possible by populating additional component locations on the printed circuit boards.

5. Results

Due to the large surface area of the aluminum traces and the use of grounding leads, the electrode arrays present a relatively high capacitance to ground. This capacitance varies from electrode to electrode and array to array (250 pF – 600 pF) due to geometry differences. To obtain suitably high output impedance, current source components would have to be selected for each specific electrode. Instead, voltage sources are used and the current to ground through the electrode capacitance is compensated for through calibration. The resistance and capacitance of the electrode array and the 2 m cables connecting the array to ACT 4 are compensated for by using a series-parallel model for each, the components of which are determined by measuring open- and short circuit impedances.

6. Discussion:

The Cole-Cole plots for the pairs of electrodes show good agreement with each other and with the analytical solution. The spread of values increases somewhat as the frequency increases (right of the Cole-Cole plot), likely due to the greater dependence of the admittance on the capacitors which have a 5% tolerance compared to the resistors. Angle of the plot becomes slightly negative at 1 MHz, likely due to some residual cable inductance that has not be accounted for in the compensation process.

7. Acknowledgements:

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8. References


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