ACT5 EIT System

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Abstract: This paper introduces ACT5, a new multiple-source EIT system for medical applications. ACT5 is able to deploy variable number of electrodes, where each source has an operation frequency range of 30 kHz to 1 MHz, achieving a voltage measurement SNR of 96 dB.

1 Introduction

Adaptive Current Tomograph 5 (ACT5) is a multiple-source applied current EIT system that is designed in a modular fashion that allows it to utilize arbitrary number of electrodes up to a maximum of 48. The target application of ACT5 is thorax imaging where it can take 30 frames of images per second under the 32-electrode configuration. ACT5 utilizes a novel shunt impedance measurement technique that continuously monitors the parallel impedance values so that its adaptive current sources can accurately compensate for the current shunted to ground.

2 Methods

ACT5 hardware consists of a controller board, a calibration board, and multiple current source boards. The controller board is connected to a PC through a serial communication link, where it receives the necessary information from the PC and transmits back the collected data. The controller board is connected to the other boards through a VME backplane where it transfers data back and forth via links using the serial peripherial interface (SPI) protocol.

Each current source board consists of 4 adaptive current sources [1, 2] with 5 cable connectors where 4 of the connectors are used to connect to electrodes via 2 meter double-shielded cables and the fifth connector connects the analog side of the sources to the calibration system. The current sources, paired with voltmeters, can operate in the frequency range of 30 kHz to 1 MHz, applying maximum current of 1 mA peak-to-peak and reading voltages of up to 1 V peak-to-peak. Using Xilinx Artix 7 FPGA as a DDS combined with a 16-bit DAC, an 18-bit ADC, and 0.1% precision resistors, these sources achieve a signal-to-noise ratio of 96 dB under their maximum swing.

The current sources can adaptively adjust their output current based on their voltage measurements so that they negate the effects of the shunt impedance on the electrodes. The adaptive sources need the values of the shunt impedance to work correctly and ACT5 deploys a novel impedance measurement technique [3] that can update the shunt impedance values while collecting image data. This operation requires the use of one additional orthogonal current pattern supplementing those required for imaging. Alternately, ACT5 can measure the shunt impedance by applying a small current to an open-circuit configuration.

The ACT5 sources and voltmeters do not need any analog adjustments. Current source boards can be plugged into the backplane and then calibrated with reference to the calibration board and they can be used immediately after the calibration process. The hardware of ACT5 is shown in fig. 1. Boards are plugged into the backplane which is assembled on a subrack. The subrack in addition to the power supply are enclosed in a box with temperature-sensitive fans. The final piece is the computer that provides the interface for the users to interact with the ACT5 system.

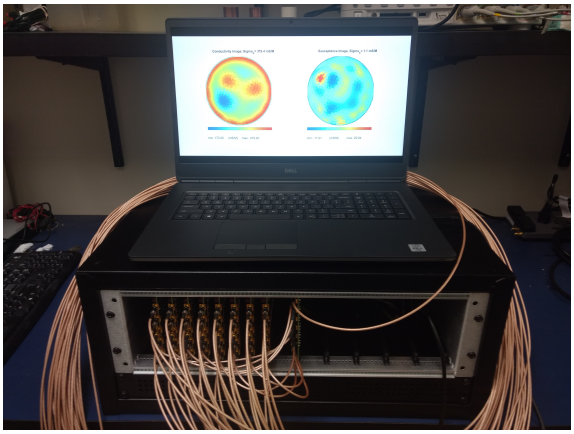

Figure 1: ACT5 Hardware

Other planned features of ACT5 include extraction of ECG signal off the existing electrodes, monitoring the electrode contact impedance, and adaptive change of current patterns that enables using optimal patterns for best quality of images. ACT5 also has safety features implemented both in the hardware and the software, including monitoring of voltages on electrodes to detect shorts and electrode disconnects, and monitoring the current on the extra ground electrode on a broad range of frequencies to detect faults in the system. Depending on the severity of the fault, ACT5 can alert the users, shut down the sources, or completely disconnect the power supply.

3 Conclusions

The ACT5 system, a multiple-source EIT device, is introduced and its features are explained broadly. ACT5 uses multiple novel ideas to accurately apply desired current from all sources and has flexible design that makes it suitable to be used under various configurations.

4 Acknowledgements

Research reported in this paper was supported by the National Institute of Biomedical Imaging and Bioengineering of the National Institutes of Health under award number 1R01EB026710-01A1. The content is solely the responsibility of the authors and does not necessarily represent the official views of the National Institutes of Health.

References

[1] G J Saulnier, A Abdelwahab, F Maysha *Conf 20th EIT*, p.46, London, UK, Jul 2019

[2] G J Saulnier, A Abdelwahab, O Rajabi Shishvan *Physiol. Meas*, **41** 064002, 2020

[3] O Rajabi Shishvan, A Abdelwahab, G J Saulnier *Conf 42nd EMBC*, p.1452-1456, Montreal, Canada, Jul 2020