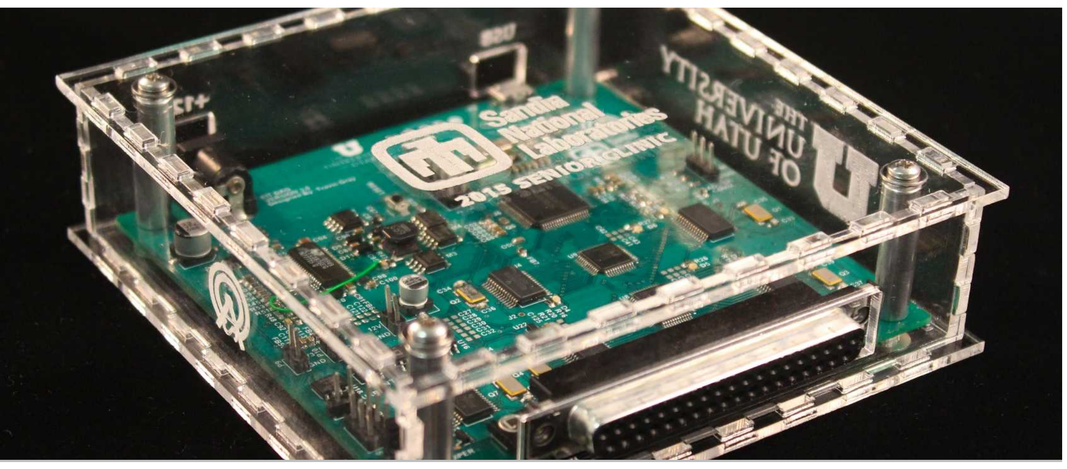
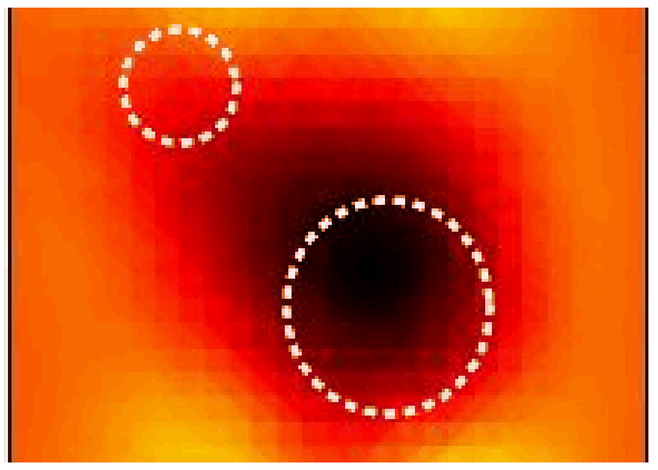
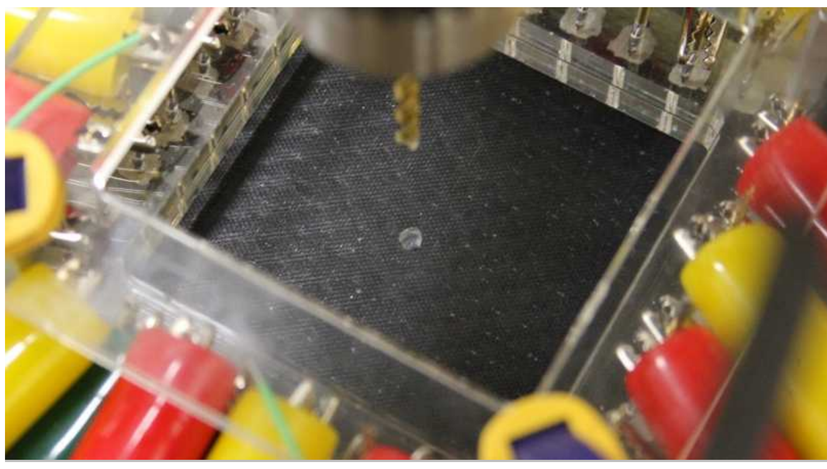
SAND2015-5930D

Exceptional service in the national interest

Sandia National Laboratories







Electrical Impedance Tomography Data Acquisition Unit for Structural Health Monitoring

Steven M. Brown[1,2], Michael Empey[1,2], Bryan Loyola[1]

[1]Sandia National Laboratories, Livermore, CA, 94550

[2]University of Utah, Salt Lake City, UT, 84112

To implement electrical impedance tomography (EIT) as a method for structural health monitoring (SHM), a modular data acquisition (DAQ) unit is created to test 6 in. x 6 in. conductive substrates surrounded by 32 nodes connected to analog-to-digital converters (ADC). A custom GUI controls the current injection method required to perform EIT measurements. Data collection is achieved at 11,200 nodal measurements per second.

Motivation

Lightweight composite materials are becoming increasingly prevalent in the aerospace, automotive and military industries. While composite materials provide a high strength-to-weight ratio, they are susceptible to damage modes that are internal to their structures that are difficult to detect. Modern SHM methods for composites are extremely costly and time consuming to implement. By utilizing a sprayable multiwall carbon nanotube (MWCNT) latex thin film paint, both existing and new structures can benefit from the application of a conductive surface to enable EIT as an alternative solution with potential real-time monitoring benefits.

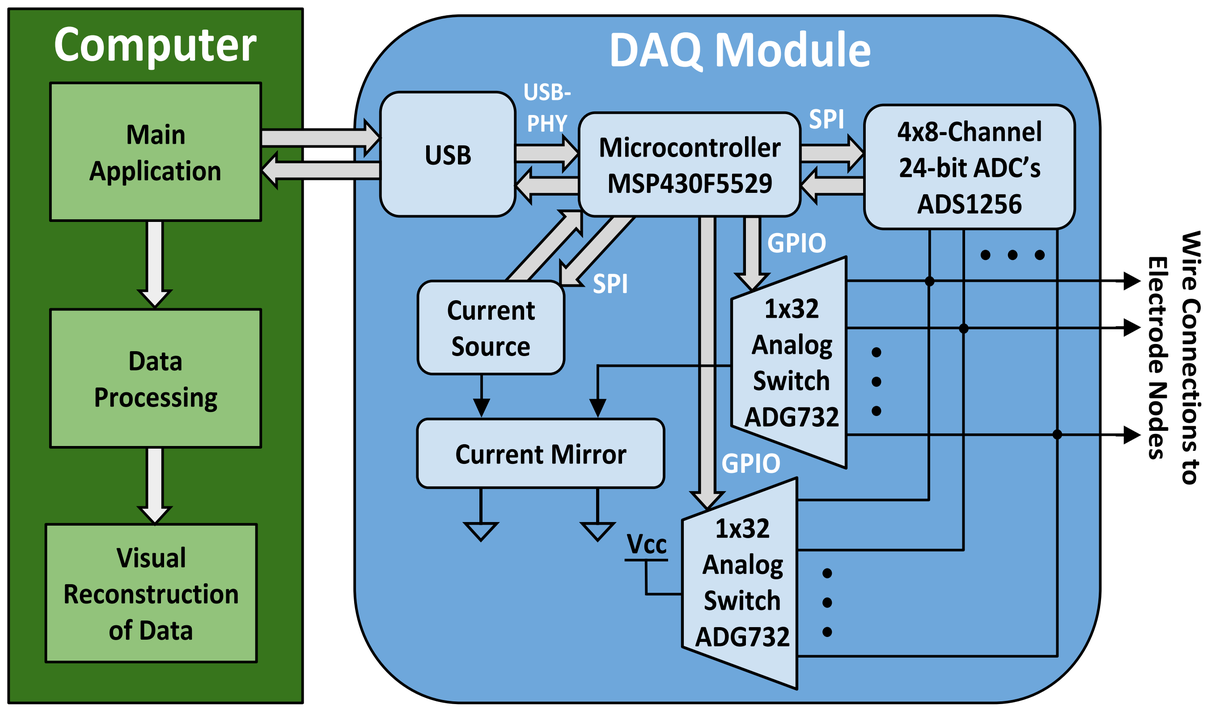
Project Goals

- EIT Measurement Rate: 100Hz (i.e., 512k nodal meas./sec)
- Adjustable current source: 1uA – 100mA
- GUI to control data collection
- Modular
- Unit cost < $1,000

Results

- EIT Measurement Rate: 37mHz (i.e., 11.2k nodal meas./sec)
- Adjustable current source: 10uA – 10mA
- Custom C# GUI
- Modular via USB
- Unit cost: $422

System Architecture



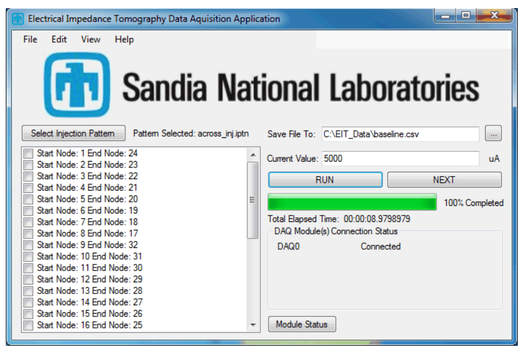
Hardware Design

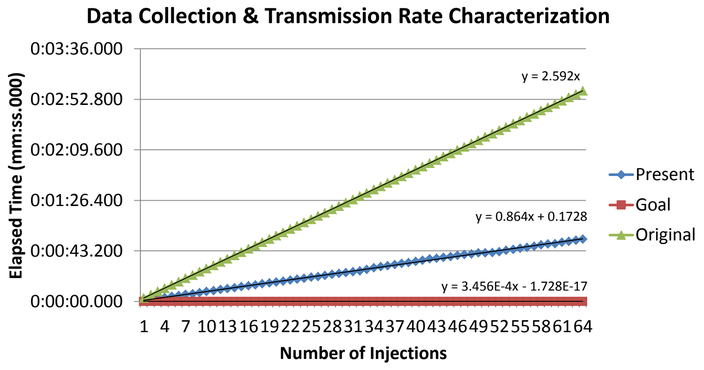
MSP430F5529: An ultra low-power microcontroller with four serial communication modules and integrated USB.

ADS1256: High resolution (24-bit), 30ksps, 8-channel sigma-delta ADC with SPI protocol.

ADG732: 32-Channel Analog Multiplexer with 4 Ohm on resistance.

LM334: Constant current source with 1uA – 10mA range. Adjustable with 3 digitally-controlled potentiometers.





Future Work

- Use single ADC with faster sampling rate (1Msps) to improve both data accuracy and data collection rate
- Improve current source range by adding an additional constant current source in parallel
- Refine power supply design to mitigate noise
- Fabricate additional DAQ units to test modularity
- Validate data reconstruction

U.S. DEPARTMENT OF ENERGY

National Nuclear Security Administration

Sandia National Laboratories is a multi-program laboratory managed and operated by Sandia Corporation, a wholly owned subsidiary of Lockheed Martin Corporation, for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000.
SAND No. 2011-XXXXP