TEXAS A&M UNIVERSITY Engineering

Ultra Low Size, Weight, and Power DAQ

EPS Booth: 354

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Sponsor: Dr. Matthew McDonough

Sandia National Laboratories

ELECTRICAL & COMPUTER ENGINEERING

Sponsor Overview

Our sponsor is Sandia National Laboratories where their motto is "National security is our business. We apply Science to help detect, repel, defeat, or mitigate threats." (Sandia). They have operated for over 70 years and contracted themselves to the United States on several occasion. Sandia works with government agencies in programs such as Nuclear Weapons, National Security, Energy, and Global Security.

The Problem

New sensors are being produced and tested every day, but the current technology for data collection is not standardized across multiple sensors leading to increased complexity, power consumption, and ineffective use of payload. Collectively, more rocket test flights are required leading to harmful emissions, higher costs, and longer testing periods.

The Solution

Our product is a compact, energy efficient, and standardized device for collecting data across many different sensors to reduce the payload on rocket flights and overall power consumption.

Methodology

The product our team developed is divided into three main subsystems described below.

Power – *Robert Brown*

- Developed a set of power efficient rails to translate a varying high voltage input into an adequate supply of power for each of the other subsystems' components

Processor and Interface – *John McWhirter*

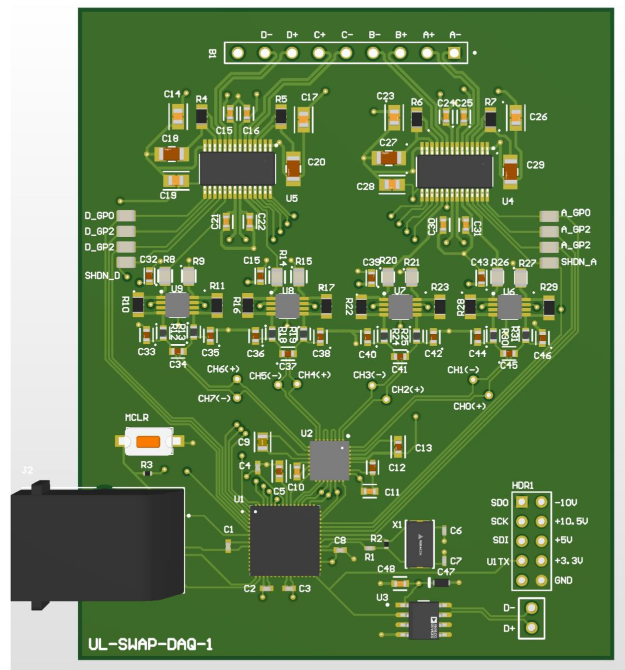
- Developed a high speed, low noise method for sampling voltage signals and transmitting the data efficiently over a Low Voltage Differential Signal

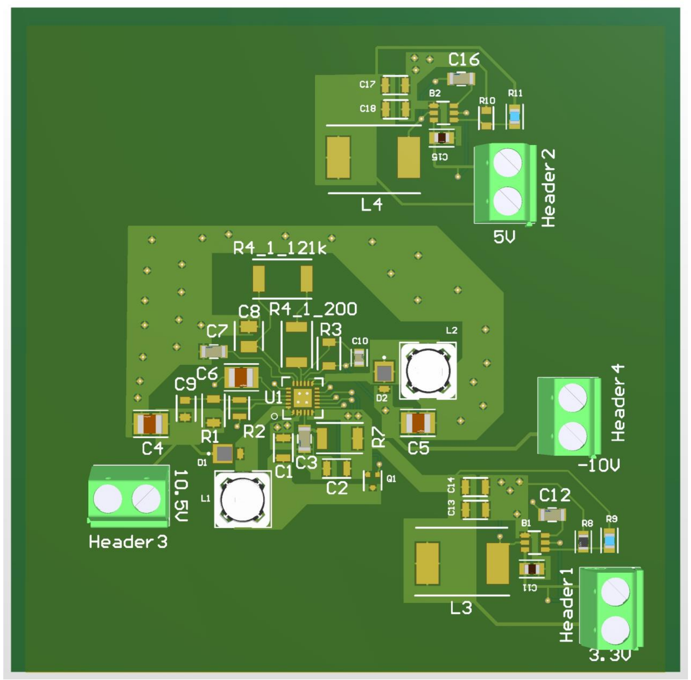
Signal Conditioning – *Andrew Bainbridge*

- Developed a unique system for variable selectable gain to amplify or attenuate a sensor's differential signal and allowed for various sensor hardware specifications

First Iteration

- Modular Design
- Test-oriented
- ~48 cubic inches





Second Iteration

- Integrated Design
- Production Oriented
- ~25.3 cubic inches

Item	Theory	Target	Stretch	Measured
Sampling Frequency	1 Msps	10 kHz	100 kHz	154-170 kHz
Data Output Error	±3%	3%	1%	~1.0254%

Figure 1: Processor & Interface – Validation

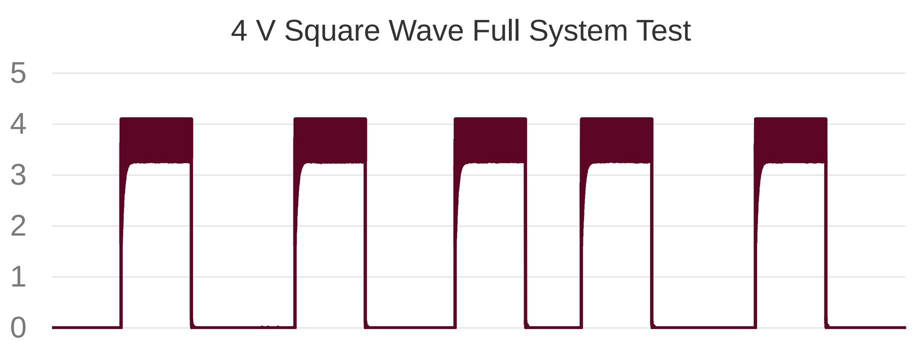
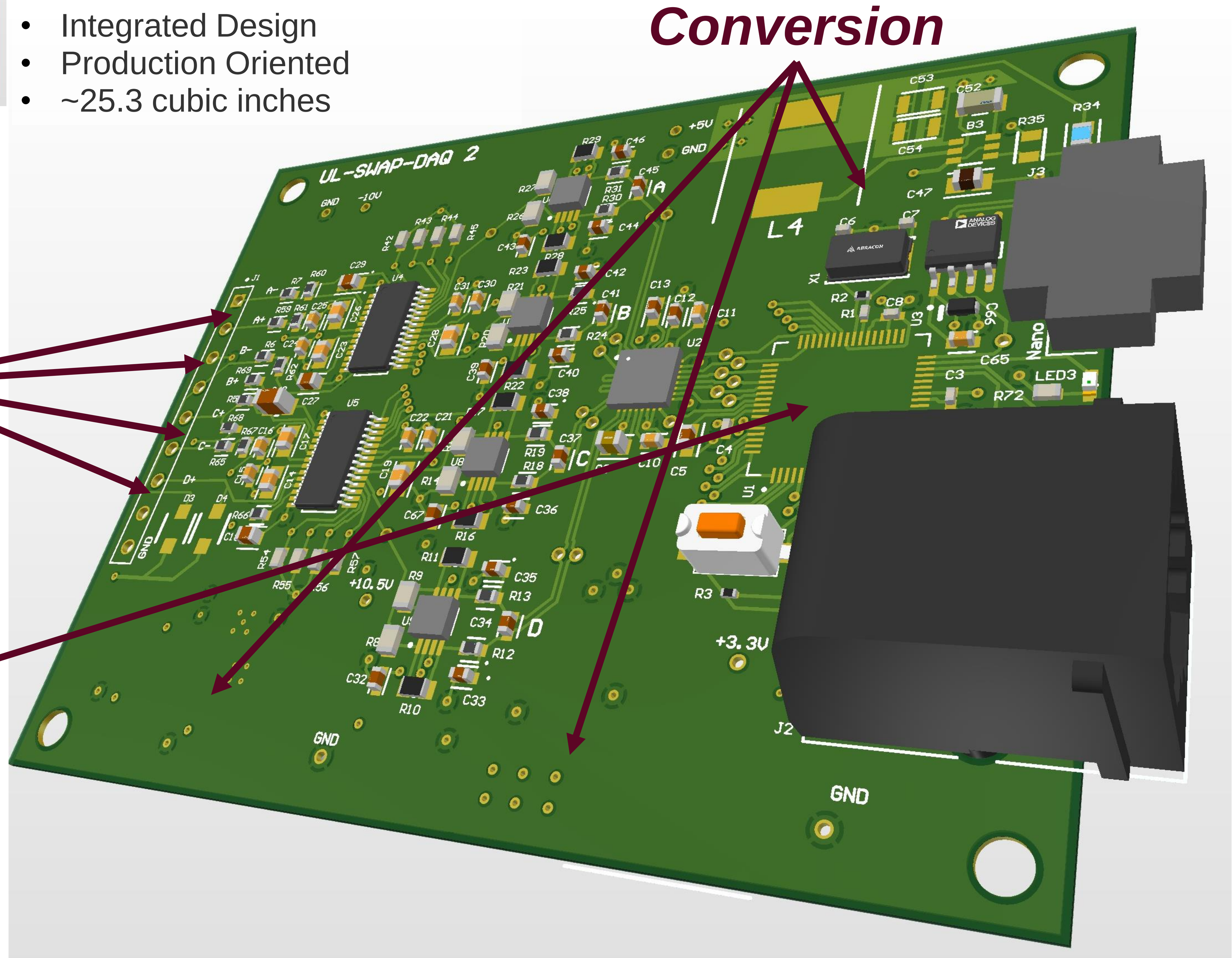


Figure 1: Sample Data Stream

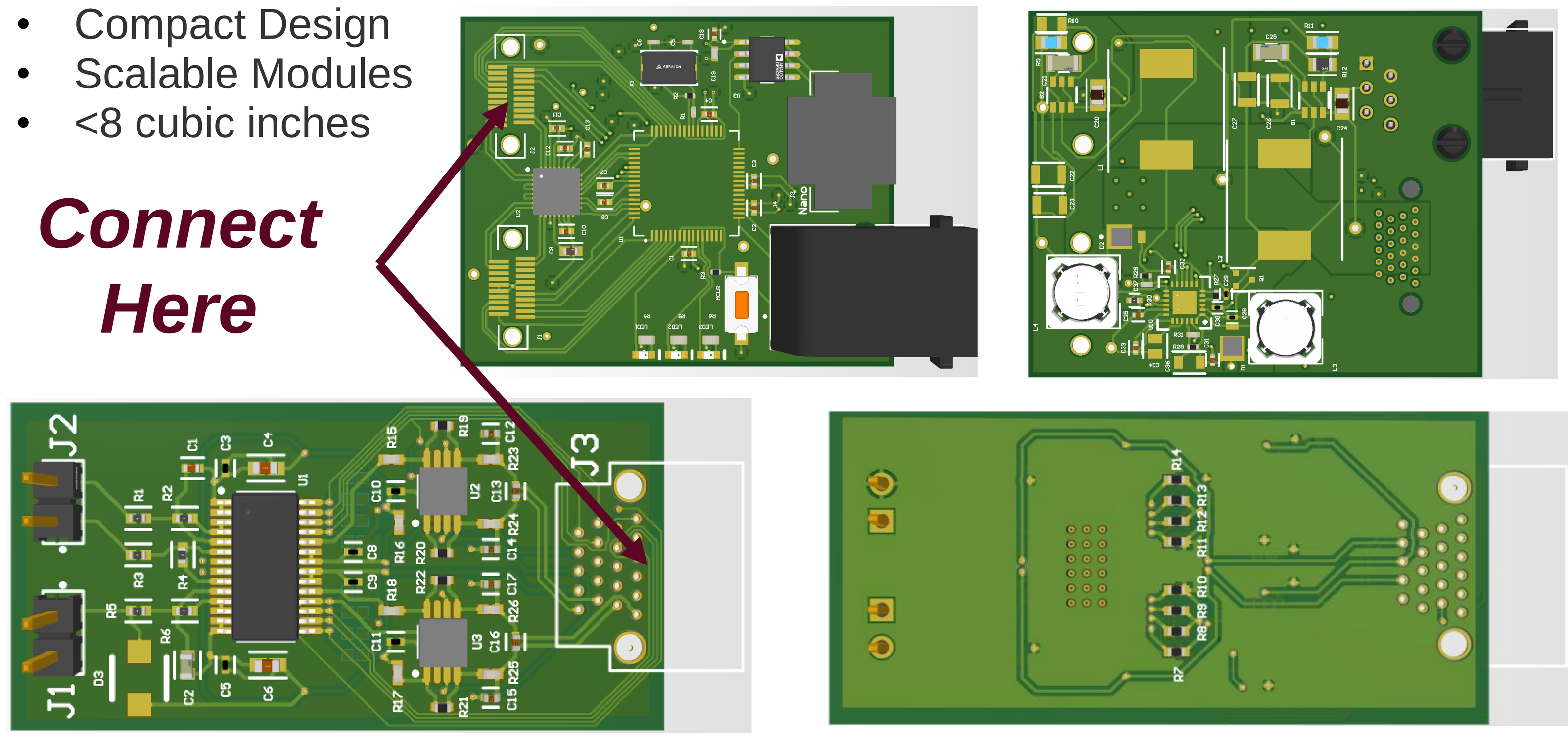


Input Voltage Sensor	Gain	Expected Output	Actual Output	% Error
1 V	0.16	0.16 V	0.155 V	3%
1 V	0.32	0.32 V	0.321 V	~0%
1 V	1.26	1.26 V	1.262 V	~0%
200 mV	10	2 V	2.01 V	~0.50%
Shock Accelerometer	0.08	43.98 mV	48 mV	20%
Shear Accelerometer	0.32	52.15 mV	50 mV	4%
Pressure	1.26	1.47	1.38	6%
RTD	5.01	0.548 V	1.62	19%
Voltage Output	10	1 V	0.99 V	1%

Figure 2: Signal Conditioning – Gain Error

Third Iteration Concept

- Compact Design
- Scalable Modules
- <8 cubic inches



Engineering Analysis

As the name of the project states, the goal was to create a highly compact and energy efficient data capture device. Our innovative design can accurately measure four differential signals and output a single LVDS signal.

A. The initial design utilized a hardware selectable gain through 0 ohm resistors; however, we improved this design and developed a **software selectable gain** with underutilized pins on the Microcontroller and Programmable Gain Amplifiers.

B. The sampling frequency desired was 10 kHz with a stretch goal of 100 kHz. Our team was able to achieve a consistent sampling frequency of approximately **160 kHz per channel**.

C. The power consumption of our device was desired to be under 3 Watts. Fortunately, our device consistently operates between **1.8 and 2.4 Watts**.

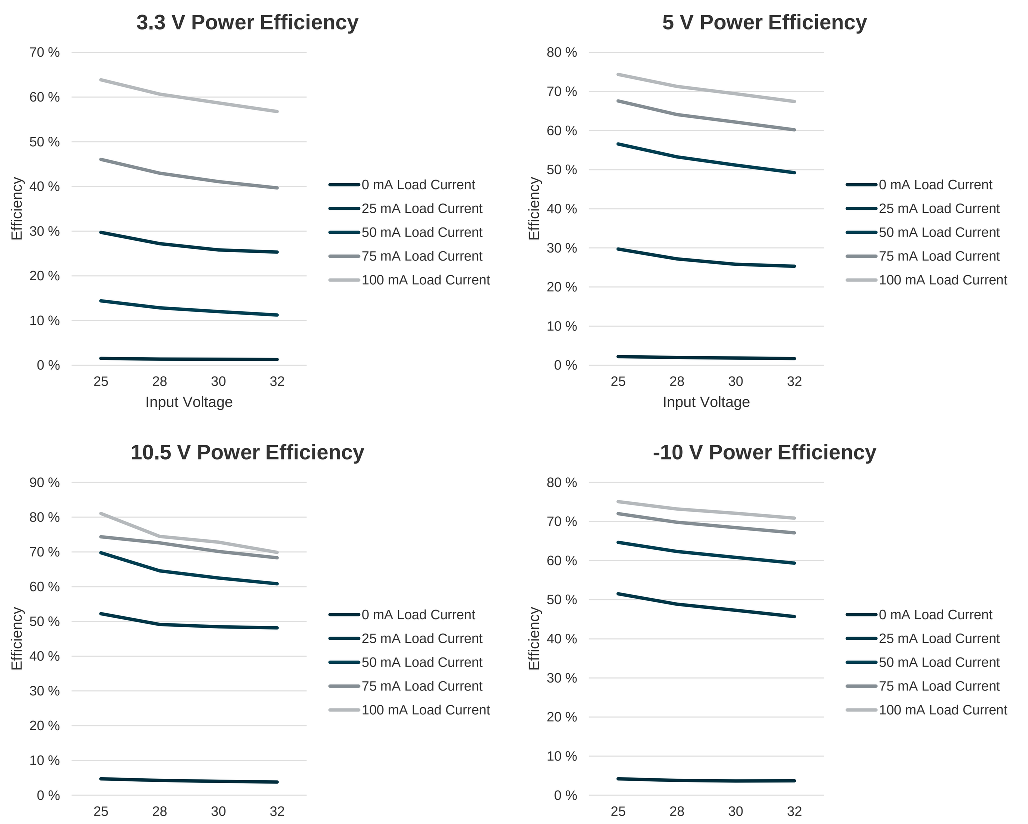


Figure 3: Power Efficiency Graphs

Outcomes

Our First iteration proved the concept we were hoping to achieve and provided insight into the problems of our initial design such as the LVDS Driver placement, -10 V rail part selection, and firmware for the MCU. However, in the 2nd Iteration, we made the necessary adjustments and achieved a complete and functioning power subsystem, an advanced software selectable gain, and a processed signal through the Signal Conditioners and digital system. The overall cost of our system is substantially less than other products and price per volume on rocket flights. Also, the uniqueness of our third design concept gives the industry a scalable, maintainable, and easily adjustable device for the future.

Impact

Our proposed solution will save Sandia's customers the labor required to design a personal Data Acquisition unit for their individual sensors. This will also save precious space on each flight, ultimately reducing the number of rocket test flights. The impact of our project will reduce carbon emissions and divert resources to production rather than testing, saving both time and overall spending.

References

1. "Sandia." *Sandia LLC*, https://www.sandia.gov/about/

2. "Microchip." *Microchip Technology Inc*, https://www.microchip.com/en-us/tools-resources/configure/mplab-harmony

3. "Texas Instruments." *Texas Instruments Inc.*, https://www.ti.com/design-resources/design-tools-simulation/webench-power-designer.html

Acknowledgements

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