ELECOMP CAPSTONE
VIRTUAL SUMMIT
FRIDAY, MAY 8, 2020

THE UNIVERSITY OF RHODE ISLAND

Low-Cost Desktop Design Evaluation System

Team Members: Brady Peacock (CPE), James Gannon (ELE), Nathan Shake (ELE)

VICOR

Technical Directors: Chris J. Sanzo, Andreas Ladas, Al Binder

Project Motivation

Engineering Lab Bench Equipment is expensive, bulky, and poorly suited to rapid evaluation of new mixed signal silicon. Because of these qualities, equipment is often shared and/or takes up valuable lab real estate. If multiple development programs are urgently needed, equipment must be taken from one setup to another; creating opportunities for error.

Furthermore, digital communication on traditional lab bench equipment requires knowledge of communication language and instruction set for each piece. Often, even a simple meter or bench supply is not interchangeable. And the protocol for communicating can be very slow – making datalogging very time consuming.

Our project goal is to make low-cost, small, portable, self-contained systems that only require a keyboard and monitor to complete a full product characterization over temperature. Clearly, such a system will have limitations for number of resources, current capacity, voltage rating, accuracy, etc.

Key Accomplishments

Component Selection: Researched and selected various IC's and switching regulators to be integrated into the first desktop FSU system prototype that were compliant with predefined design specifications. Various tests were performed on selected components to prove their usability and functionality.

Communication Protocols: Having had no prior experience with any sort of communication protocols, over the course of this project we had to learn and master three. We first had to learn I2C in order to control the DUT board. Next, we learned the Serial communication protocol in order to establish a connection between the Arduino Due and Raspberry Pi. Finally, the DAC and ADC were controlled by SPI.

Embedded Systems: With a heavy use of both the Raspberry Pi and Arduino Due in this project, there was a lot to learn about embedded systems in general. We learned how powerful these devices can be, as well as where their limitations may lie. With no prior experience, we had to master our control and expertise of these devices.

Design Tool Proficiencies: The final product cannot be produced or understood without first building a model or simulating the design in the virtual world. While building core knowledge in the structure of the project's circuit topology, competencies were developed in LTSpice, PCB design with Altium tools using CircuitMaker, and initially building and verifying ideas with equations.

Schematic Design: The schematics of both the Final FSU PCB as well as the MUX card (for future system integration) were made and improved upon, following a hierarchical design approach.

PCB Design: With guidance from the team's Technical Directors, a Dual (two-channel) FSU PCB was designed. The design process consisted of cross-referencing LTSpice simulations with board schematics, and .pcb files in CircuitMaker, board layout, making improvements during design reviews, producing a BOM and ordering the board. Many key design skills were learned in the areas of copper parasitics, kelvin sensing principles, circuit protection and analog circuit fundamentals.

Final FSU Prototype: The FSU system is capable of forcing and sensing current and voltage at precision across a Device Under Test (DUT), for up to 48-pin IC's. The custom 2-channel FSU PCBs were designed from scratch in CircuitMaker, while the 2-channel FSU prototype board is a one-plug system that utilizes few off the shelf components with circuit protection. The concept behind the prototype is that it will greatly reduce the cost and time factors involved in the IC testing process.

Software and Hardware Documentation: A software library for all files used to control the system is documented and available on a project GitHub repository, while the hardware documentation is still being produced.

API: Our system comes with a fully-fletched and well-documented API, to make the user experience smoother and more efficient. This API performs all the basic functions of our system, allowing the user to use the API functions as building blocks to create any test they desire in an easy manner. This API also takes care of error handling, prohibiting one to access an out of range voltage or current, for example.

Measurement Scripts: The product will be delivered with two sample measurement scripts. These scripts perform the following tests on the DUT: measure a comparator threshold voltage going either up or down, and measuring a pulldown voltage/resistor. The user may modify these scripts in any way, or ideally use them as an example to go off of when creating their own scripts and/or tests.

MUX Card Design: A MUX card design has been created in CircuitMaker for future integration into the FSU system. Implementation of this MUX card design will allow for scalable force/sense system capabilities and overall project expandability. Its reconfigurable design allows for utility in integrating either 4 FSUs, or 2 FSUs and 2 sense modules.

Anticipated Best Outcome

The Anticipated Best Outcome would be a BOM and a demonstrated prototype for a sub-$5000, portable evaluation unit that meets or exceeds all specifications. It would also have clear documentation, a well-maintained firmware/software library and a high level of robustness for shipping either with or without the thermal chamber. Ideally, the desktop evaluation unit should offer a sustainable and scalable design as to accommodate the integration of additional modular hardware and measurement cards with clean pin hookups.

Project Outcome

The Anticipated Best Outcome was achieved during this project. We were tasked with building an objective set of hardware and performing measurement tests to achieve results within project specifications. We were able to build a 2-channel force/sense unit that interfaces with a 48-to-1 MUX in order to individually select each pin on the DUT, and we were able to perform a comparator threshold test and a pulldown resistance test with desirable results, however we were not able to put the two together in order to achieve said results using said hardware due to some unforeseen hardware issues and time constraints. After discussing with the Technical Directors, we still consider this outcome to be a success, and ultimately consider the ABO to have been achieved under these circumstances.

Figures

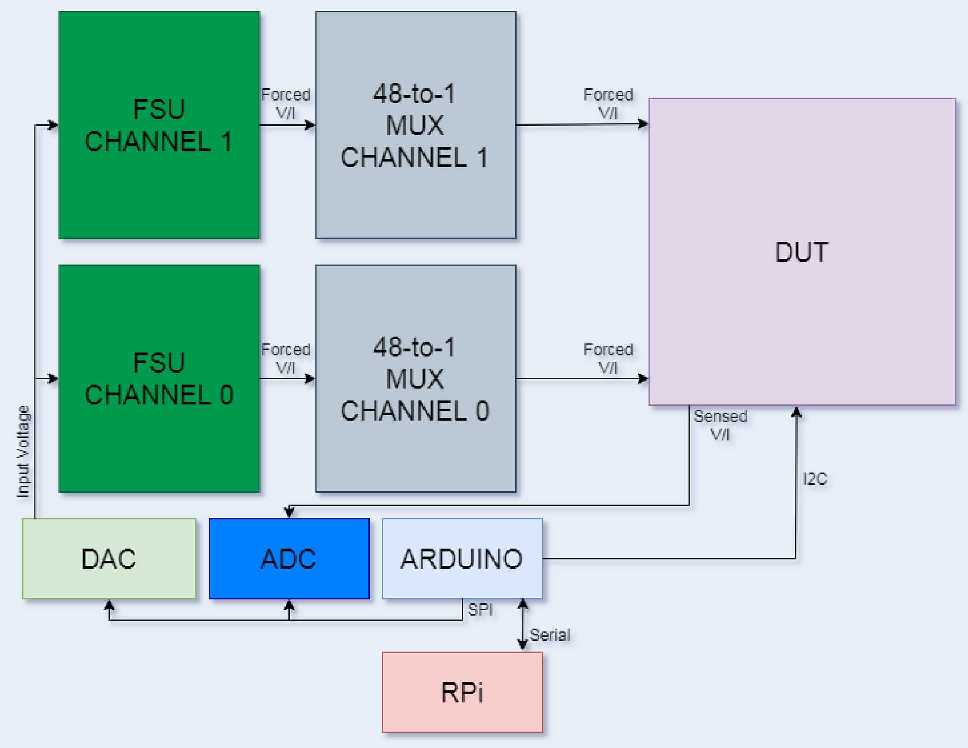

Figure 1: Block diagram of FSU system interfaced with external DUT and Raspberry Pi

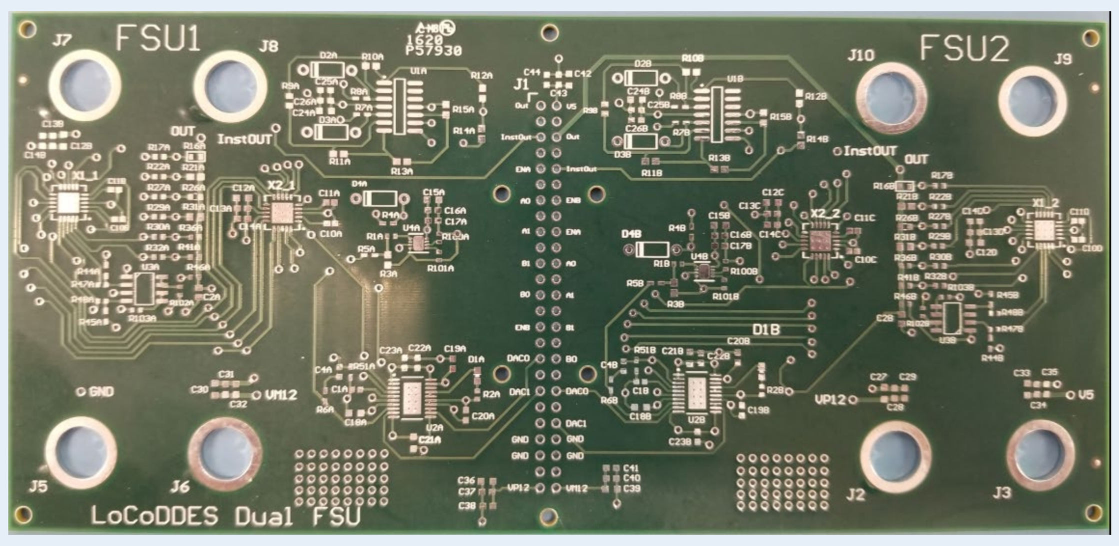

Figure 2: Fabricated PCB for 2-Channel FSU board

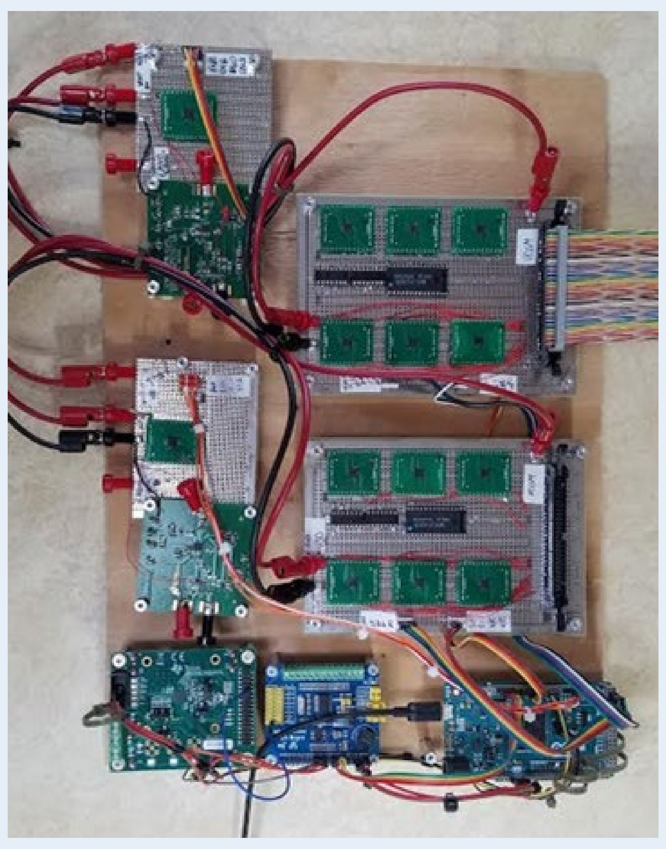

Figure 3: Physical version of the block diagram in **Figure 1.**
Not in picture: RPi, DUT

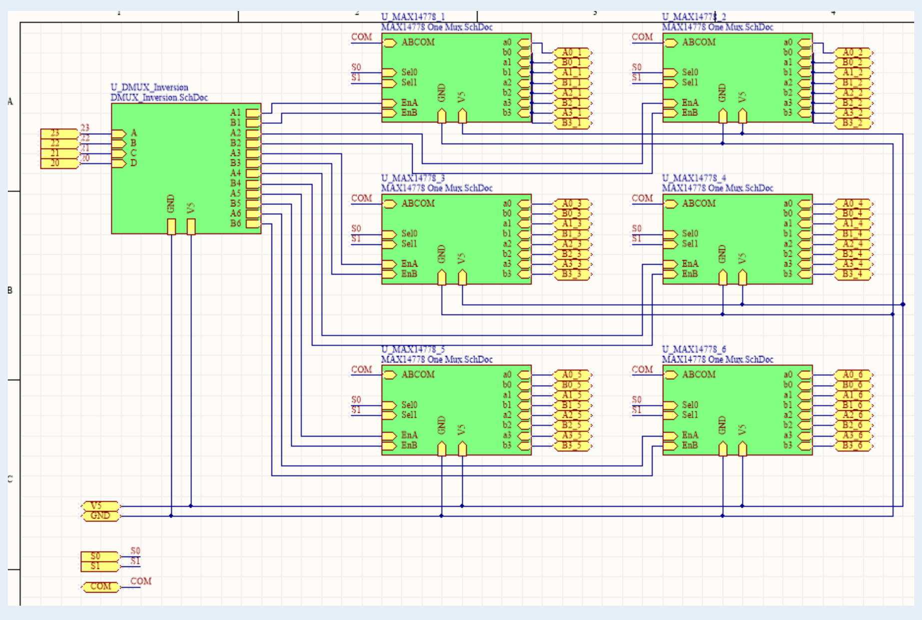

Figure 4: MUX card schematic layer design showcasing the ability to select and communicate with all 48 pins on the DUT with only a 4-signal input DEMUX. Each of the 6 Maxim Integrated MUX ICs to the right of the DEMUX can handle 8 selective outputs (6 x 8 = 48 pins)

ELECOMP Capstone Program Director: Professor Harish R D Sunak

email: sunak@ele.uri.edu telephone: 401-874-5859 ELECOMP Website: https://uri.edu/elecomp-capstone