Low Cost Desktop Design Evaluation System

ELECOMP Capstone Design Project 2019-2020

Sponsoring Company:

Vicor Corporation
1 Albion Rd
Lincoln, RI 02865
http://www.vicorpower.com

Company Overview:

Vicor Corporation designs, develops, manufactures and markets modular power components and complete power systems based upon a portfolio of patented technologies. Headquartered in Andover, Massachusetts, Vicor sells its products to the power systems market, including enterprise and high-performance computing, industrial equipment and automation, telecommunications and network infrastructure, vehicles and transportation, aerospace and defense.

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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.

The mixed signal parts themselves can have multiple communication interfaces, all which need verification and testing. Having a uniform, self-contained way to select and specify known interface protocols and have them simply 'run' from a GUI would be very handy for debugging an array of serial ports – VR, SVI2, I2C, PMBus, AVS – for example.

Finally, sometimes we need to evaluate parts using equipment that is not available locally. It is typically impossible to ship an entire lab set up out to a vendor for product evaluation. For FA evaluation, this situation can create problems for customers and hurt business relationships.

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... This is where our collaboration with the URI Capstone team will be crucial in helping to maximize all variables and meet our utility target.

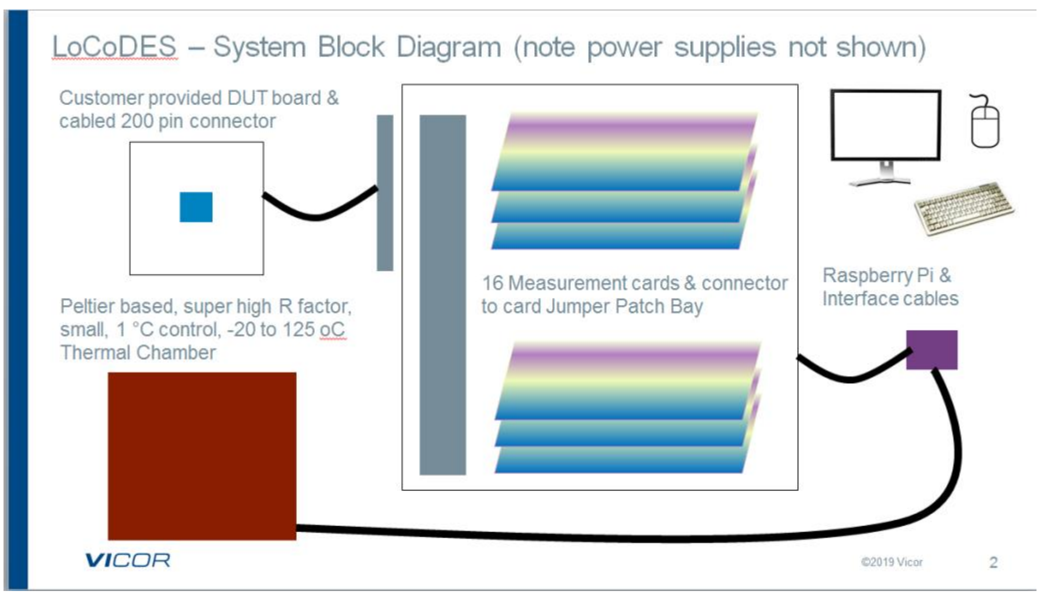
Anticipated Best Outcome:

The Anticipated Best Outcome would be a BOM and 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.

Project Details:

Please see attached Power Point Slides:

The overall system concept is the development of a very low-cost Mixed Signal IC tester that can complete full pin level over-temperature characterization on a designer's desktop. Typically, this activity is managed using an expensive production level tester. Or it is completed with older lab equipment, cobbled together with some sort of National Instruments suite. Much like when Eagle Systems noticed an inflection point in the test space 25 years ago with PC based testing, it is now time to see the inflection point with Arduino and Raspberry PI based systems and knock the test cost down another factor of 50. Now, there are some companies attempting lab-based systems using low cost tools (see "Labjack" on the web). But the accuracy, portability and professional approach to IC characterization is not present. Again, this situation is not unlike the paradigm Eagle Systems faced 25 years ago.



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LoCoDES – Slightly more detail on Block Diagram….

- **200 Pin Cable**: Each pin of a 48 pin (maximum) IC will need force, force return, sense and sense return. 48 * 4 = 196. Or 200 for good measure (bias supply, spacing, whatever..). The cable pins are customized much like the Customer DUT to interface properly to the 16 Measurement Cards and the Patch Bay
- **The Jumper Patch Bay:** Used when pins need more functions than just Force/Measure. For example, a clock output pin may need a force/measure for DC capability and then a Timing Card for measuring frequency and edges. The jumper would connect just those pins to the Timing Card. Can be made from jumpers, relays or analog muxes. Resistance of jumpers/mux/relay must be consistent with voltage/current compliance – typically between 1 and 10 ohms.
- **Thermal Chamber:** A ridiculously small (8" by 8" by 3"), super high thermal resistance chamber capable of leveraging the cooling of a Peltier system – which is by nature wildly inefficient but easy. Will need external power supply – do not design.
- **Raspberry PI:** Portable Datalogger running GUI and Python for the entire system. Not real time control. Real time control is always handled on the cards via Arduino or some other real time device. Instructions are given from the PI to the Measurement Cards.
- **Measurement Cards:** Measurement cards take many forms but here are they typical examples:
  - Low Voltage/Current, Force/Measure – typically 5V, 50 mA pin compliance for IC.
  - High Voltage/Current, Force/Measure – typically 100V/2A pin compliance. Can be floating or ground referred
  - Timing Card – for measuring rise times, edge to edge times. Either for single pin or multiple pins.
  - Serial Card – a unique card that handles a specific protocol to a given specification and delivers results to Raspberry PI (PMBUS, AVS, I2C, SVI2, SVI3, VR13, VR14)
  - More on Measurement Cards on the next slide….

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LoCoDES – Measurement Cards

- **All measurement cards** must have built-in self test diagnostics (At a primitive level, the card must be able the Raspberry PI "I am good" or "I am bad".) Measurement cards should also be able to check for OV conditions to protect in case of improper voltage sense. All cards are serial bus configurable and have built in real time control – Raspberry PI simply commands, polls and collects data.
- **All measurement cards** will have disconnect and discharge/pre-charge features for all pins. If there are questions here, reviewing the concept of "Hot Swap" on the web will be a good tutorial.
- **Low Voltage Force/Measure (required card):** Can typically handle 8 IC pins. This set the card form factor of 72 pins (64 I/O, 4 pins for serial control, 4 pins for supply). A 48 pin part needs 6 such cards. 20 uV/10 nA measurement accuracy. 5.5V/200 mA maximum force. -1V/-200 mA maximum force.
- **High Voltage Force/Measure (stretch goal):** This card will requiring quadrupling of pins two handle voltage/current and possible floating. So one card can handle two pins. For 10 pins of HV, you will need 5 cards. Needed by Vicor, tough to build…
- **Serial Measurement (required card):** This is the other required card. The goal here is that the Raspberry PI sends a command and then this card converts to the correct protocol. If the card is NOT being used for bus compliance, then it is simply a translator whose voltage levels, clock speed, etc are programmed by the Raspberry PI. If it is being used as measurement, then it also works very much like a combination of Timing Card and LV F/M card except that it is checking to bus specifications, not necessarily leakage or compliance specifications. This card also handles 8 IC pins but they are specific pins (CLK, ADDR, DATA IN, DATA OUT, TELEMETRY OUT, ENABLE, FLAG1/2)
- **Timing Card (easy stretch goal):** The Timing Card should be a leftover from the Serial Measurement Card, except with more precision. That is, typical serial bus specifications are quite coarse and can be go/no go tests to a given specification. The Timing Card must be capable of resolving 20 ps. Also, it must be capable of dividing down high voltage signals by a maximum of 20 x and measuring those edges with 100 ps resolution. Typical edges are in the 1ns range so 100ps represents 10% error.

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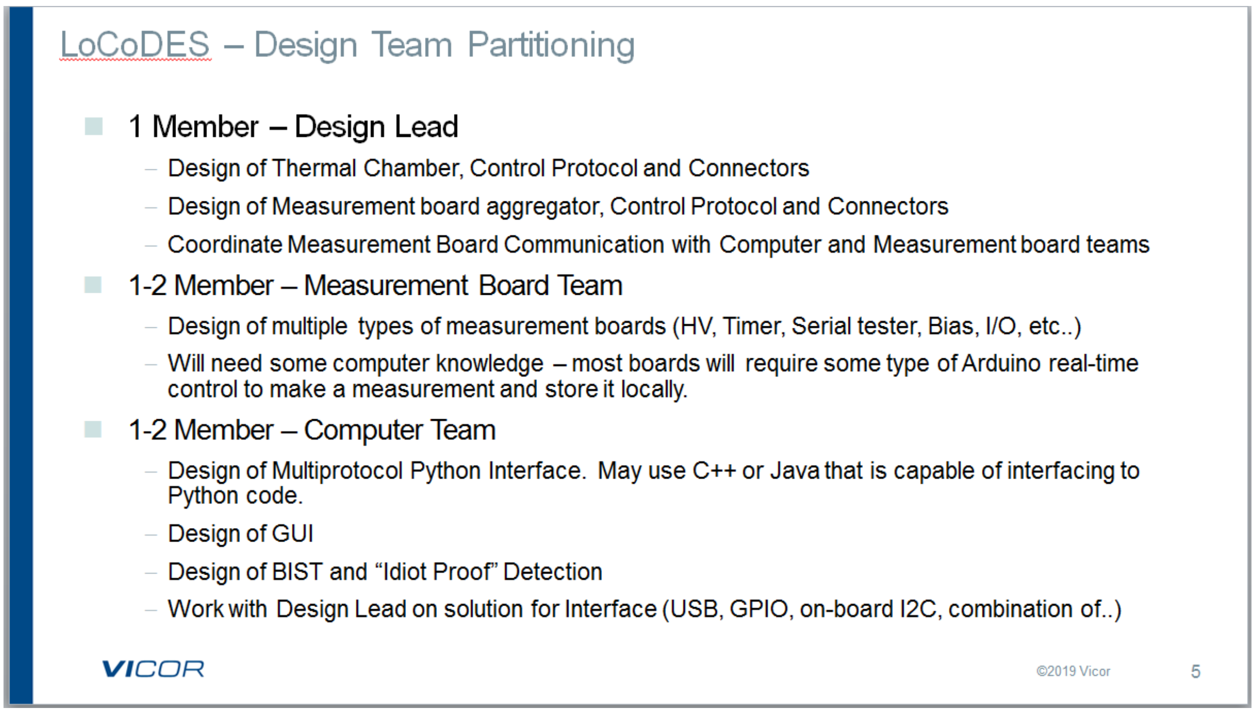
Composition of Team:

The composition of the team will include:

- Two (2) Electrical Engineers (ELE)
- One (1) Computer Engineer (CPE)

Preference will be given to seniors taking Mike Smith's course on PCB Design on Thursday evenings.



Skills Required:

Electrical Engineering Skills Required:

- Interested in building protected voltage and current regulators (100V, 5A maximum)
- Interested in using precision ADC/DAC IC's (10 uV resolution, 5V maximum)
- Interested in building high speed timers (10 ps resolution)
- Experienced in circuit design for precision current and voltage measurements (i.e. – more than one high level analog design class with labs)
- Experienced with PCB layout

- Experienced with closed loop control systems
- Experienced with mechanical enclosures, sockets, hardware, etc.

Computer Engineering Skills Required:

- Experienced with C++, Java, Python, Debian (Unix), Windows 10 drivers
- Experienced with Arduino and Raspberry Pi computing systems
- Experienced with GUI interfaces on Unix/Windows
- Interested in Real Time computing and data acquisition systems
- Interested in Serial Bus protocols
- Interested in self-diagnostic, self-calibrating, 'idiot-proof' systems

Anticipated Best Outcome's Economic Impact on Company's Business:

The business impact here is indirect. That is, having a compact, portable, low cost evaluation tool will not directly affect the bottom line. What it will do is allow Vicor to service customers much faster. They will get new products with complete datasets. They will get timely answers to field returns. In addition, both new product evaluation and product return service will not require the use of an expensive production tester. Taking a production tester off-line to do evaluation work is extraordinarily costly. And finally, testing that is difficult for production testers and/or unique to the Vicor product line can be integrated into the evaluation process more readily.

Broader Implications of the Best Outcome on the Company's Industry:

For our company, the broader implications are uncertain. However, for the team, if successful, the Evaluation Unit itself would be a huge disruptor to the Lab Test market. There is simply nothing like it. If one looks at the hodge-podge of Data Acquisition products on the market – from National Instruments and the like – there is not a single unit dedicated to the low-cost evaluation of analog IC's. In fact, there are many examples of companies that have developed this technology in-house. Vicor itself has many proprietary testers for the main business of power supply modules. Really, this effort extends the Vicor test philosophy into the IC domain. The difference is that because the IC business is more standardized, there may be business opportunities for this class of evaluation unit (cost/performance/form factor) outside of Vicor.