Gen-2 SPEC Tester (System Power Extended Cycling)

ELECOMP Capstone Design Project 2018-2019

Sponsoring Company:

Infineon Technologies Americas Corp.
Rhode Island Design Center
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Company Overview:

We make life easier, safer and greener

Infineon Technologies is a global leader in semiconductor solutions with worldwide headquarters located in Neubiberg, Germany, near Munich. Infineon Technologies Americas is headquartered in El Segundo, CA, near Los Angeles. Infineon Technologies reported sales of about €6.5 billion in 2017, and has 36,300 employees worldwide.

Semiconductor and system solutions from Infineon contribute to a better future – making our world easier, safer and greener. These tiny, barely visible electronic components have become an indispensable part of our daily lives.

Infineon acquired the Rhode Island design center with the purchase of International Rectifier in 2015. The Rhode Island design center opened in 2001 and has since been developing power management digital controller ICs, integrated power stages and point-of-load solutions. These products power high performance and artificial intelligence servers, internet datacenter and network backbones, high end desktops, laptops, graphics, gaming computers, and cellular telecommunication systems. Our local team of 35 engineers and technicians solve Power Electronic system needs for the world's most advanced microprocessors, GPUs and ASICs.

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Project Motivation:

As Infineon continues to drive advancements in Power Electronics efficiencies and power densities, we need to ensure these state-of-the-art devices can withstand the test of time without degradation or failure. For example, our 5x6 mm Powerstage devices can provide 100 A dc, powering high performance computer and artificial intelligence processors with up to 800 A dc when paralleled with our Digital Multiphase controllers. Our products are used in ultra-reliable server systems which are the backbone of our financial, internet and mission-critical infrastructures.

Our project goal is to expand the capabilities of our 2nd Generation long term reliability test system to ensure we provide the world's most robust power conversion systems. We are seeking a team of talented EE and CE students to validate and develop a hardware and software interface that meets the system requirements while, offering flexibility for future expansion.

Anticipated Best Outcome:

A functional system able to test 60 individual voltage converters under 100 A dc load transients. Thermal management by automated fan control, dynamic transient load control, and complete system telemetry for all 60 devices will be managed in 6 individual "neighborhoods". Each neighborhood will consolidate telemetry and transfer to a local system terminal where data will be processed. A custom graphical user interface will be in constant communication with external devices under test and instrumentation to automatically manage system faults, set system environments such as supply voltages, loads, switching frequencies, output voltages and thermal management settings.

Project Details:

To continue the efforts of a second generation long-term system reliability tester by integrating hardware and software to enable the testing of various voltage regulator systems. The main focus of this Capstone effort is to interface the 6x mainboards hardware with software to increase flexibility through improved telemetry management, monitoring and control. The 6x mainboards will interface with a laptop connected to an internal network for remote monitoring and data transfers.

Much of the following hardware description is reuse of our Gen-1 system which supports up to 60 individually controlled and monitored voltage regulators under loads up to 100 A each. The system, housed in a standard 42U server rack, includes:

- 6x 1000 W remotely adjustable DC-DC power supplies,
- 2x triple output DC-DC power supplies which will also be remotely controlled,
- 6x 120-channel data acquisition systems with telemetry,
- 60x electronic loads capable of static and transient loading up to 100 A. Onboard fan control, temperature telemetry, fault detection/communication/management will be improved in this project.
- 6x main "neighborhood" boards which acts as the main interface for 10x systems under test. Each mainboard accommodates 10 channels of the following:
    - E-fuse isolation of a faulty channel
    - Flexible Controller Device Under Test (DUT) card
    - Flexible Powerstage or Point of Load (POL) DUT card
    - Accurate current sensing (<0.5% if possible)
    - DUT fan with control
    - Programmable 100 A transient/dc load with onboard fan and control

Figure 1: Front and Back view of test system rack. 4 of 6 main boards are mounted to the front for easy DUT accessibility. DC-DC supplies and data acquisition equipment are mounted in the rear.

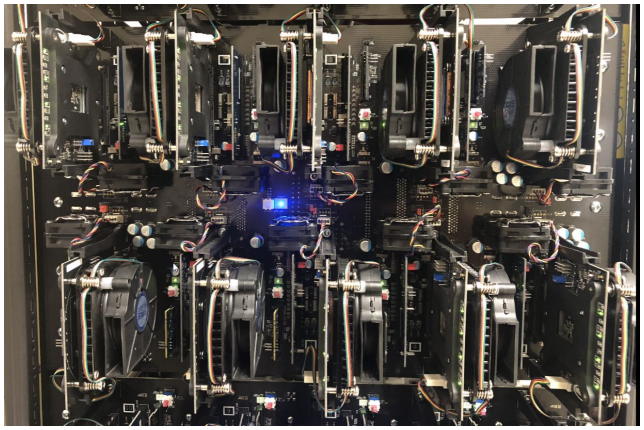

Figure 2: One of six main "neighborhood" boards. Showing load, phase DUT, voltage regulator controller at voltage regulator site #1. 10 voltage regulator systems can be tested on one main board.

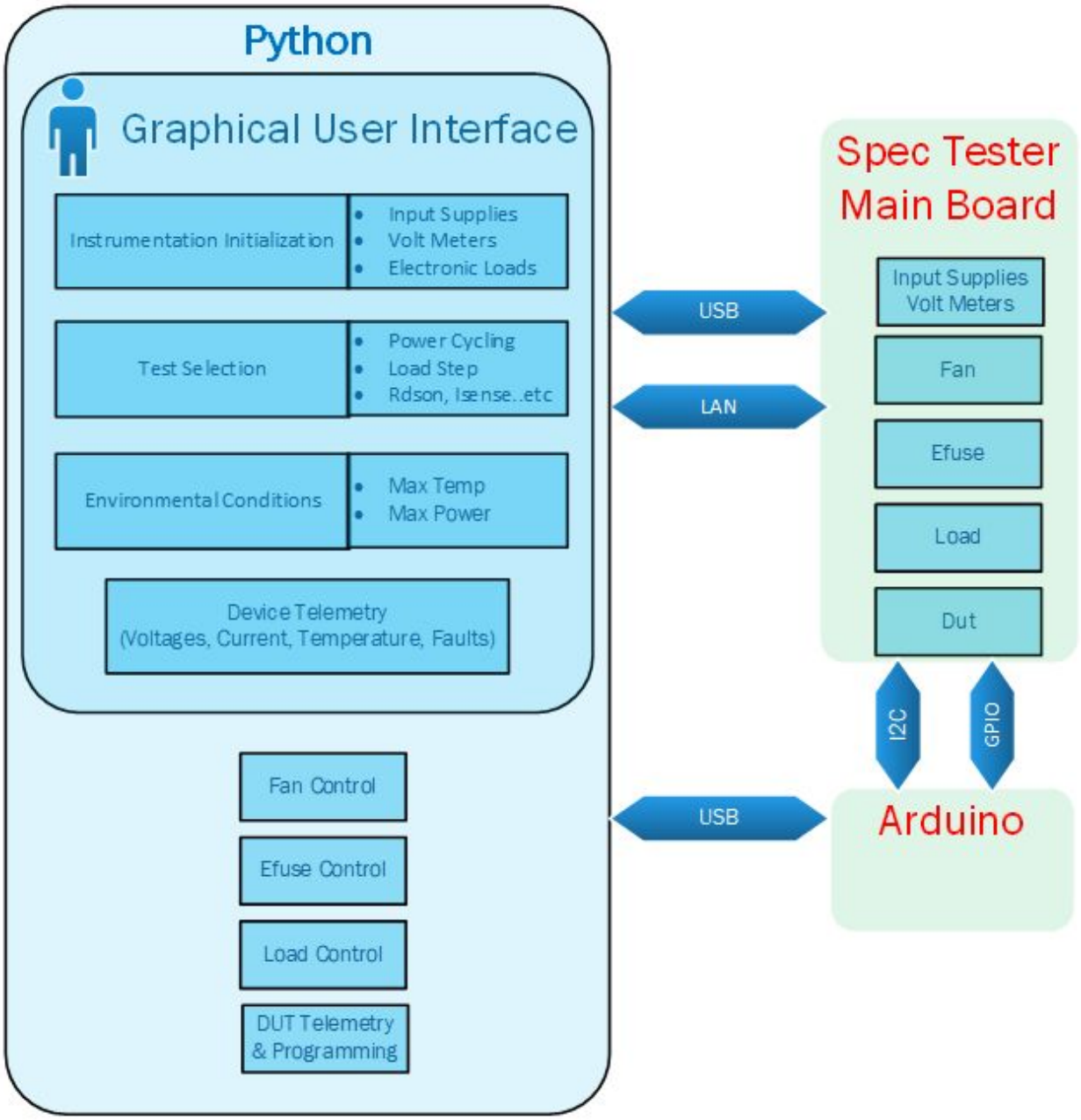

Figure 3: Software Layer Diagram and Communication Protocols

Hardware/Electrical Tasks:

The hardware goal of this project is the addition of an onboard Arduino to manage the local mainboard "neighborhood".

- Manage telemetry data consolidation
    - There are 60+ I2C devices to control and read.
    - Desire local main board management of all I2C based telemetry including currents, voltages, temps, faults
- Manage local thermal management of fans
    - closed loop control of DUT temp and load temps to achieve equal temperatures across all 10 DUT
    - Manage average fan speeds to match between six different mainboards
- Fault management
    - Manage boundary conditions to isolate a bad channel and report faults to systems.

Firmware/Software/Computer Tasks:

- GUI control of mainboard
    - Create a flexible environment for different DUT tests and different types of tests
        - Long term reliability environments
        - Efficiency testing
        - Trim correlation
        - Target DUT: Powerstage, Point-of-Load, µPOL, µPhase and Digital Controllers
    - Control, settings, data collection and selection
    - Manage local power supply, channel enabling/disabling, and load control
        - Support different cycling modes for input power, channel enabling/disabling under various loads
        - Manage independent system tests such as per-channel efficiency sweeps, current sense accuracy sweeps
    - Manage output telemetry files for easier post processing.
    - Ensure ease of software modifications after the project is completed for added system reconfiguration flexibility.
    - Allow system fault alert reporting via email or text.

Composition of Team:

- 2 Infineon Technical Directors backed by 20+ Warwick based resources including PCB Designers, Design Engineers, Applications Engineers, Test Engineers and Technicians
- 1 Electrical Engineer
- 1 Computer Engineer
- 1 Dual Major Electrical / Computer Engineer

Skills Required:

Electrical Engineering Skills Required:

- Familiarity with fundamentals of switch-mode power supplies and power conversion
- Fundamental understanding of analog and digital control systems
- Familiarity with Arduino integration and code development
- Fundamental understanding of Op Amps and DACs
- Power supply characterization, performance testing and validation
- Familiarity with the I2C bus protocol and UARTs
- PCB and schematic design experience would be beneficial

Computer Engineering Skills Required:

- Experience with creating GUIs (Graphical User Interfaces) in the Python language and the Qt IDE
- Familiarity with the I2C/PMBus protocol as well as UART, USB, and LAN
- Familiarity with Arduino integration and code development
- Database design and development
- Developing code to interface and control external hardware and test instrumentation

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

Deployment of a more flexible test system will ensure product robustness and reduction of field issues. A successful system will be reproduced and distributed to sites worldwide to enable other Infineon groups to extensively validate their products without the need to consult and purchase an off the shelf system from an outside manufacturer. The end result is a custom system that can be tailored to our needs. In addition, there is a significant cost reduction of $400K pre system.

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

Our Warwick, RI team is also interested in engaging with the University of Rhode Island professors and students to build a strong and local talent base in support of our switch-mode power electronics development activities. Skills required by our team include

- Power Electronics Applications Engineering,
- Analog and Digital IC Design Engineering, and
- Test Automation Engineering.

Infineon Technologies is not alone. Rhode Island has a very strong and competitive Power Semiconductor industry including companies such as ON/Fairchild Semiconductor, Texas Instruments, IDT and the Picor Corporation who would benefit from RI based Power Electronics curriculum.