Programmable Load Slammer

ELECOMP Capstone Design Project 2020-2021

Infineon is continuing their support of the Program for the 3rd year

Sponsoring Company:

Infineon Technologies Americas Corp.
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Company Overview:

We make life easier, safer and greener – with technology that achieves more, consumes less and is accessible to everyone. Microelectronics from Infineon is the key to a better future.

A world leader in semiconductor solutions

Infineon Technologies AG is a world leader in semiconductor solutions that make life easier, safer and greener. Microelectronics from Infineon is the key to a better future. In the 2019 fiscal year (ending 30 September), the company reported sales of around €8 billion with about 41,400 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. Link to additional company information: Infineon

You will be working with an Infineon team located at our Warwick design center. This team creates concepts and develop power management products used to power your digital world, from high performance CPU/GPU/ASIC (Central/Graphics Processing Unit, Application Specific Integrated Circuit) used in data center servers, to mobile communications and consumer products.

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Project Motivation:

Background: Our applications team and customers need a programmable electronic load to emulate a CPU/GPU/ASIC load signatures. Typical commercial electronic loads cannot emulate the 1000 A/µsec load transients that are typical in our systems. Our team has developed such "Slammer" AC loads which utilize a function generator to control the AC current profile.

Motivation: Since we utilize several of these electronic loads in our labs and ship these loads to customers, we would like to introduce a programmable load controller directly onto our load-slammers. This will reduce test equipment costs (no function generator required), increase test system density, provide repeatability with stored load waveform patterns, implement current feedback to ensure the correct load pattern is generated, and provide an easy-to-use customer graphical interface with the ability to run various load scripts.

Anticipated Best Outcome:

A functional microcontroller-based load controller shall have a minimum 50A load step in 1µsec capability with a duty cycle from 10% to 90%, up to 1 MHz. The load controller shall also support DC loads and programmable load current slope profiles such as triangle, saw tooth, and sinusoidal with a minimum frequency of 10 kHz. The load controller shall utilize current feedback to calibrate the load current and ensure the correct load profile is applied, removing the need for manual tweaking. Load profiles shall be stored on the load board with the ability to be enabled directly from the load board or through a digital control path.

A Graphical User Interface (GUI) application shall allow a user to create piece-wise-linear current profiles and dynamically control the load. The application shall read and store current profiles into the microcontroller. The application shall be self-contained without the need for special support drivers and shall be easily transportable between compute platforms.

Project Details:

We will begin the project reviewing the requirements and objectives. The first few meetings will be used to architect the system while students research the component datasheets and run initial circuit simulations of the system in Cadence.

Students will be introduced to our existing electronic load systems in our lab to solidify their understanding of the project.

A project schedule will be planned and tracked on a weekly basis.

Below is a system diagram of our Voltage Regulator under test and a representation of our electronic load. The electronic load is used to emulate the eventual real-life load which we intend to supply power to. The load lets us characterize system performance to find issues or areas of improvement.

Our load boards utilize high current MOSFETS as linear load switches to control load transients. Series low-ohmic resistors limit the current and provide a voltage sense feedback. A reference signal provided to an op-amp defines an Amp / Volt transconductance of the system, in combination with the value of the low ohmic sense resistor. The op-amp drives the MOSFET Vgs such that the feedback current sense voltage is equivalent to the reference signal. The op-amp bandwidth limitations need to be considered -- note the feedback delay in the blue waveform and the resulting current infidelity.

The voltage regulator attempts to hold tight regulation through the various load slew rates. Note the larger overshoot and out-of-spec undershoot which can result with fast load transients in the order of 50A/microsecond.

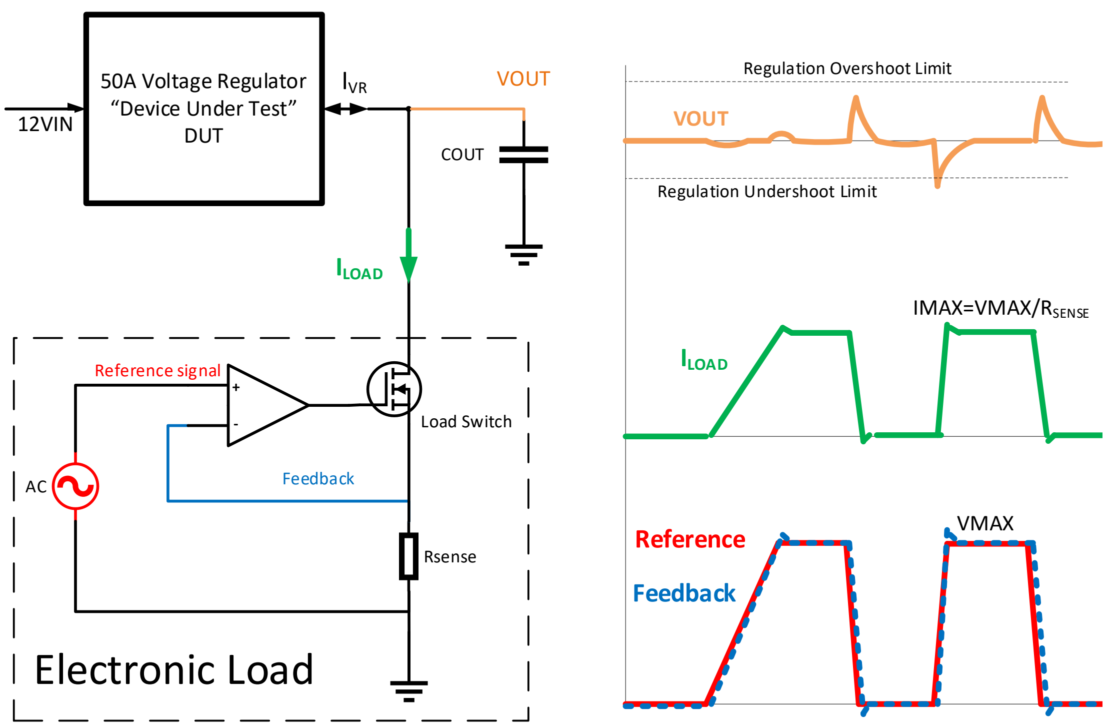
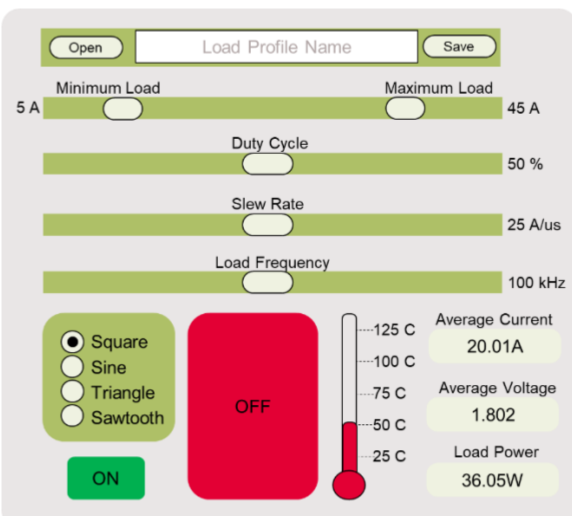


Figure 1. Electronic Load System and Voltage Regulator Response

In order to accelerate system hardware prototyping of the architected system, two Cypress PSOC-5 demonstrator boards will be available for the candidates. Much of the system can be designed and optimized remotely in the URI labs to maximize social distancing. Infineon will also provide a load board system to optimize hardware interfaces. Once the hardware prototype activity is complete, candidates will submit their new system load-board schematic to our PCB layout team with the goal of assembled PCBs before Christmas break. Once the board returns, the candidates need to validate their new system with an actual voltage regulator and provide a detailed report and design errata if needed.

During breaks in hardware development, GUI design and development can occur. WebEx meetings will monitor software related progress and maximize social distancing as much as possible. The software application needs to be portable and not require special drivers to utilize. Below is a GUI concept the team can use as an initial concept. Note the requested voltage, current and temperature telemetry along with options for various load waveforms. Limit errors will issue user alerts as needed. It is desired for the GUI to continuously monitor and report over-temperature/over-power events to prevent catastrophic damage to the load hardware. A 3D load script is desired, where output voltage variation is plotted against duty cycle and load frequency for a maximum current step and minimum slew rate. This script can save hours of work and expose system weaknesses.



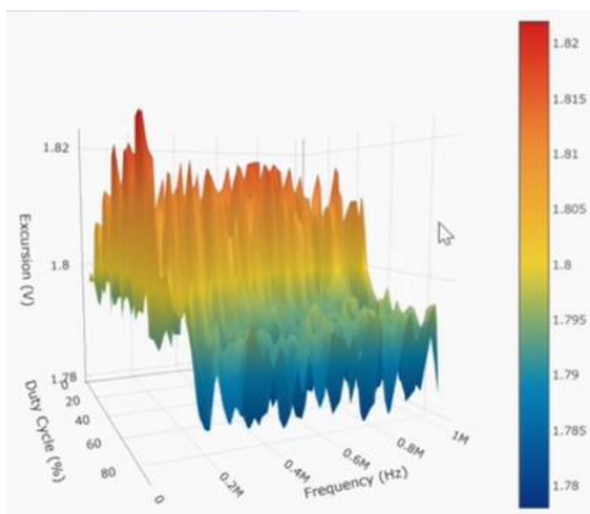


Figure 2. Example of a GUI

Figure 3. Example of a 3D Output Voltage Excursion

Electrical Specifications:

	MIN	TYP	MAX	
Max Current	50			A
Current Resolution		10		mA
Over Current Limit		100		A
Square Wave Slew Rate Range	1		50	A/us
Square Wave Max Frequency	1			MHz
Duty Cycle	10		90	%
Triangle, Sine, Sawtooth Max Frequency	10			kHz
Load Voltage Range	0.25		5.5	V
Peak Power Dissipation		200		W
Average Power Dissipation		10		W
Over Temperature Limit	100			C

Composition of the Team:

1-2 Electrical Engineers and 1 Computer Engineer.

In addition, the team will be mentored by 2 Infineon Technical Directors, backed by 20+ Warwick based engineers, including PCB Designers, Design Engineers, Applications Engineers, Test Engineers and Technicians.

Skills Required:

Electrical Engineering Skills Required:

- Analog (ADC, DAC, OPAMP)
- Digital logic
- Feedback Control Theory
- Microprocessor familiarity

Computer Engineering Skills Required:

- Application creation with graphical Interface architecture and data management
- Digital logic
- Feedback Control Theory
- Microprocessor familiarity

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

This project will reduce the number of function generators required with today's load boards, a savings of approximately $10,000 for the next few years. This project will also save valuable engineer, technician and customer validation time by simplifying setup and storing pre-loaded transient profiles on our demonstration boards. The 3D transient feature will help find weaknesses in designs, further saving validation time and customer relationship impacts due to marginal systems. Our Field Application Engineers will receive these tools to enable customer validation. This tool can enable our customers with their own electronic loads, which can lead to customers buying our products. Lastly, we promote our Cypress PSOC products to students and customers through this load tool. Validation time savings, preventing marginal customer problems and sell enablement could exceed $50,000 annually.

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

Our Infineon Rhode Island IC Design Center team is interested in engaging with the University of Rhode Island professors to help grow a strong and local talent base of Analog IC Engineers, Digital Integration Engineers, Automated Test Engineers and Power Application Engineers.

We have several URI alumni on our team who could get involved in guest lectures. There are several other power semiconductor companies located in RI that could benefit from a strong VLSI and power program.