Bench Automation Design for Estimation of Transient Thermal Resistance

ELECOMP Capstone Design Project 2018-2019

Sponsoring Company:

ON Semiconductor
1900 South County Trail
East Greenwich, RI 02818
www.onsemi.com

ON SEMICONDUCTOR is continuing their support of the Program they initiated last year
https://web.uri.edu/elecomp-capstone/project-details-by-team/on-semiconductor/

Company Overview:

ON Semiconductor (Nasdaq: ON) is driving energy efficient innovations, empowering customers to reduce global energy use. The company is a leading supplier of semiconductor-based solutions, offering a comprehensive portfolio of energy efficient power management, analog, sensors, logic, timing, connectivity, discrete, SoC and custom devices. The company's products help engineers solve their unique design challenges in automotive, communications, computing, consumer, industrial, medical, aerospace and defense applications. ON Semiconductor operates a responsive, reliable, world-class supply chain and quality program, a robust compliance and ethics program, and a network of manufacturing facilities, sales offices and design centers in key markets throughout North America, Europe and the Asia Pacific regions.

Technical Directors:

Kevin Toth (URI College of Engineering Class of 2010)
Senior Application Engineer
kevin.toth@onsemi.com
https://www.linkedin.com/in/kevin-toth-45607421/

Aakash Arora
Staff Applications Engineer
aakash.arora@onsemi.com
https://www.linkedin.com/in/aakash-arora-a706621b/

Project Motivation:

Accurate estimation of a device's transient thermal resistance has been a long standing challenge with regards to the automotive applications. Thermal overstresses, in the form of transient or continual temperature swings exceeding device's thermal capacity, are one of the most encountered failure modes in the field; especially for power devices that frequently observe these transients through their lifetime. This necessitates a comprehensive understanding of the thermal response of the device and the influences of the external factors, such as: the device mounting conditions, application boards, peripheral heat sources/sinks, etc.

The bench automation tool for transient thermal resistance measurements targeted in this work will be an easy-to-use setup for reasonable estimations of the thermal resistances or peak junction temperatures; observed in both discrete as well as self-protected FETs - consequential to a known power pulse.

Anticipated Best Outcome:

The focus of the tool development is to automate the existing manual process of thermal resistance measurement; thereby assisting multiple new product development cycles in parallel.

The outcome of the tool will be:

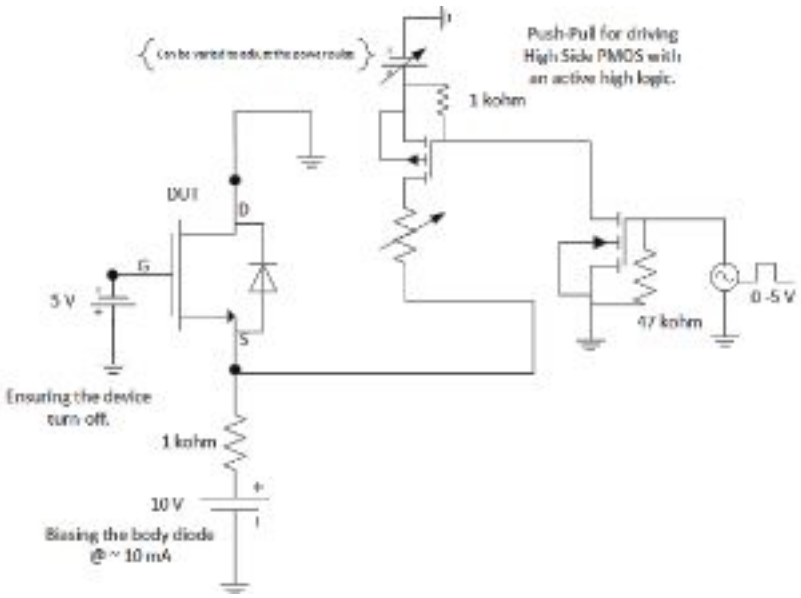
a) Validation of the thermal network simulation tools - complementing theoretical simulations with practical measurements.
b) Estimating "In-Application Thermal Resistances" on specific customer requests.
c) Comparing thermal performances across competitors while retaining similar application conditions for existing products as well as NPDs.

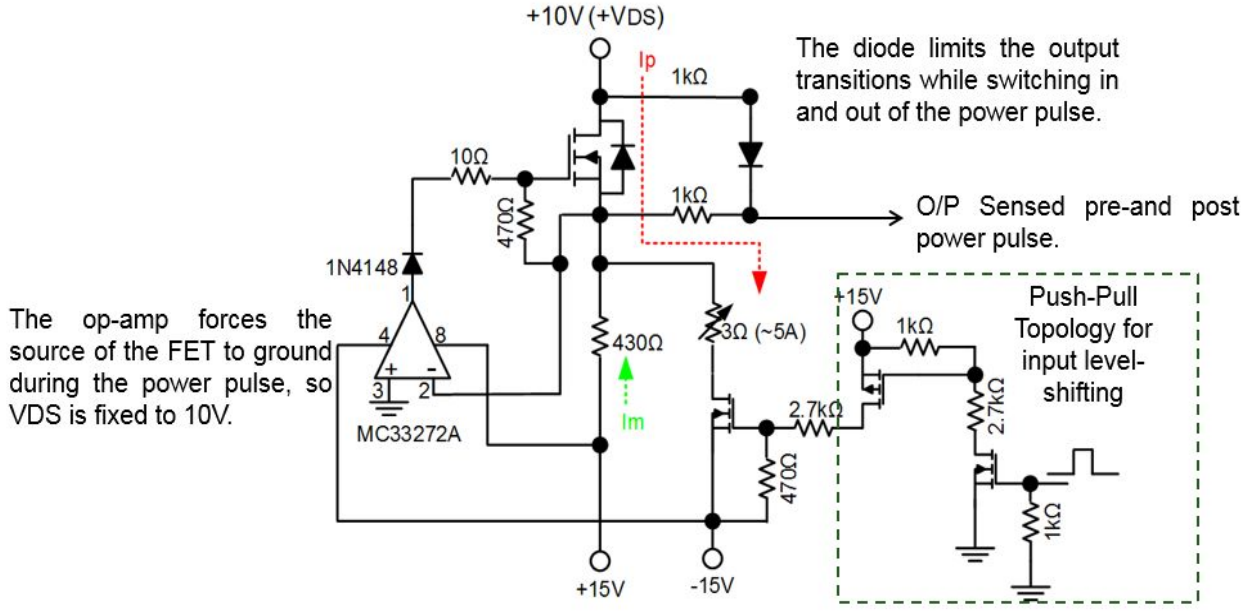
Project Details:

Measurement Principle:

The measurement principle is to employ an on-chip temperature sensor, an intrinsic diode for instance, as a calibrated thermometer and then record the changing electrical parameters of this sensor during a transient power dump event, which are then processed into differential temperature changes.

Circuit Diagrams:





The two topologies presented above will be accommodated on the same PCB with options to switch between discrete and protected FETs. Some system compensation/signal filtering may be added later on during the course of project development.

Hardware Tasks:

1. Set up and interface the required measurement equipment, power supplies, oscilloscopes, waveform generators, source meters etc., to the circuit board.
2. Integrate Arduino based waveform generation.
3. Perform measurements to calibrate the thermometers- on chip sensors for several devices.
4. Perform dVF measurements on devices across time intervals ranging from microseconds to hundreds of seconds to validate the setup.

Software/Computer Tasks:

1. Board design and layout for testing both discrete and Smart-FETs.
2. Designing VB interface GUI for the measurement tool and equipment interfacing.
3. Develop the logic for distinguishing electrical noise from background thermal profile.
4. Code for thermal resistance calculation from dVF measurements and output the results in csv/excel format.

Composition of Team:

1 Electrical Engineer & 1 Computer Engineer

Skills Required:

Electrical Engineering Skills Required:

- PCB Layout
- Understanding of circuit operation and FET operation principles.
- Familiarity with lab equipments- power supply, signal generators, source meters, multimeters, oscilloscopes etc.

Computer Engineering Skills Required:

- Visual Basic/LabView Programming
    - Object Oriented Programming, Circuit Simulation Software
- Understanding of Arduino-based programming
- Basic knowledge of MS Office tools

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

The automation tool will support multiple New Product Development (NPD) activities in parallel, reducing the man-hours spent in manual measurements of these devices. At present, one device on one application board takes around 24~32 man-hours that slows the application evaluation process. The complete thermal assessment of a device requires 2~3 weeks. With a dedicated automation setup, the same time can be spent on supporting rigorous in-application evaluation and designing application use-cases. Qualitatively, the tool helps in designing thermally superior devices by providing comparison across competition during different stages of product development.

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

As an industry standard, understanding of thermal response of automotive power switches relies heavily on simulations that create mathematical models fit to standard measurements in an idealized controlled lab environment that does not mimic the application behavior. This tool will render a set of application specific measurements that will corroborate or challenge the validity of simulation tools adapted by the industry and likely bring them closer to actual measurements, thereby improving understanding of thermal response amongst the consortium of automotive component suppliers.