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SAND2014-17617PE

2014 DOE OE Energy Storage Program Peer Review

60kW Inverter with Built-In Isolation Using GaN Devices

(SBIR Phase I – DOE Energy Storage Program, Dr. Imre Gyuk and Technical POC Dr. Stan Atcitty, Sandia National Laboratories)

Frank Hoffmann, PhD

princetonpower.com | info@princetonpower.com | @PrincetonPower1

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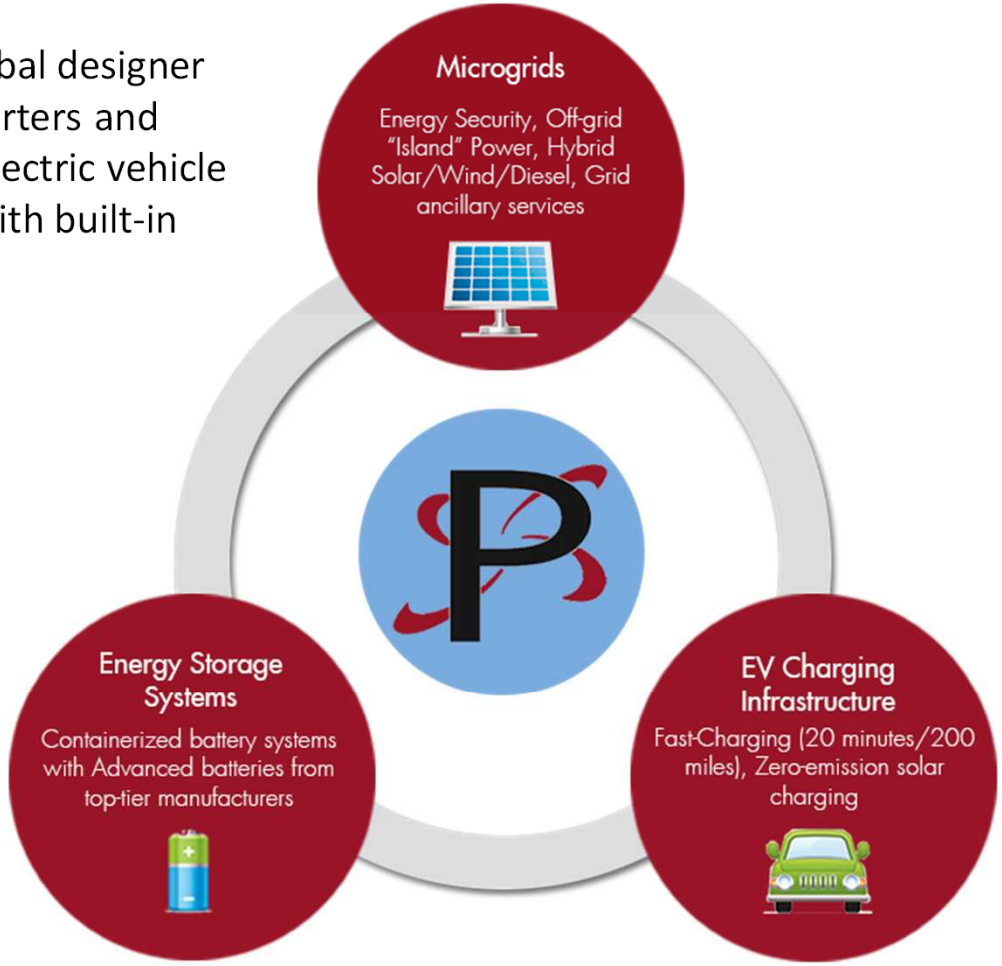
Project Team: PPS

Princeton Power Systems is a leading global designer and manufacturer of bi-directional converters and energy storage systems for microgrids, electric vehicle (EV) charging, and advanced batteries, with built-in functions for Smart Grid Services.



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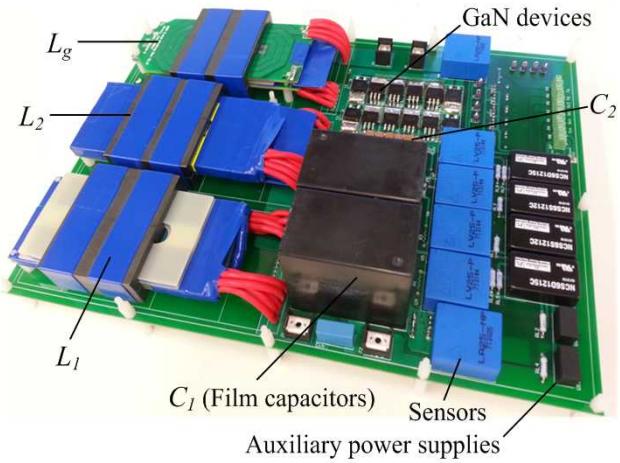
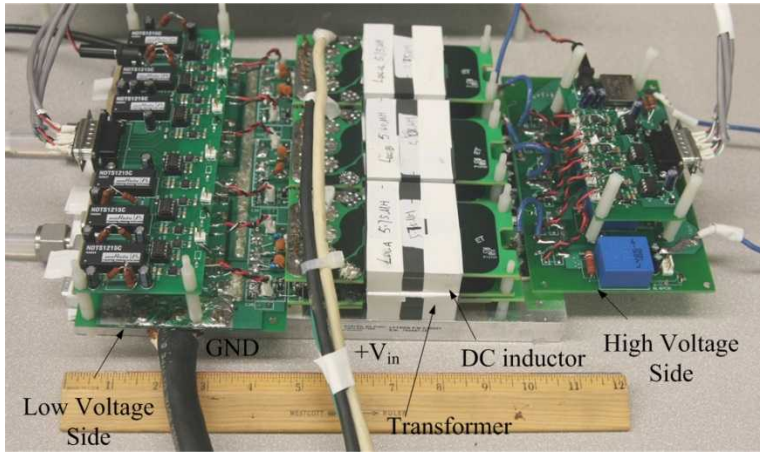
Project Team: Florida State University/PE Group

FSU/PE group has rich experience about WBG devices application in grid-connected PV converters. The group has successfully developed GaN based PV Module-Integrated Converter (MIC) and SiC based high power PV converters for grid-interactive application to achieve high power density and high power efficiency. The high frequency operation performance of GaN and SiC devices has been investigated and evaluated.



GaN based Module-integrated PV converter



Three-port 5kW grid-tie PV converter

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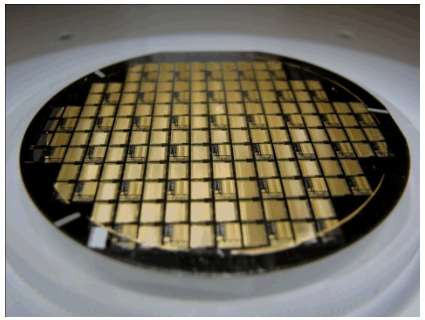
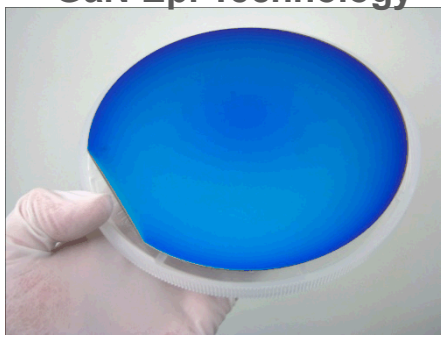
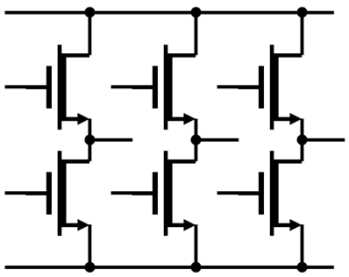
Project Team: Transphorm – GaN Technology

Device eng & Fab

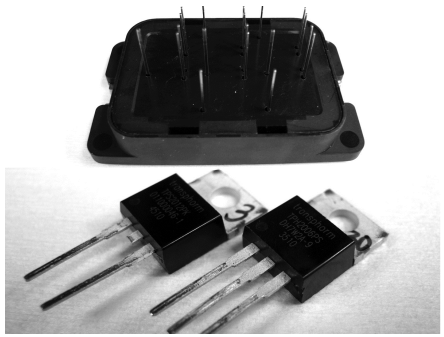


GaN Epi Technology

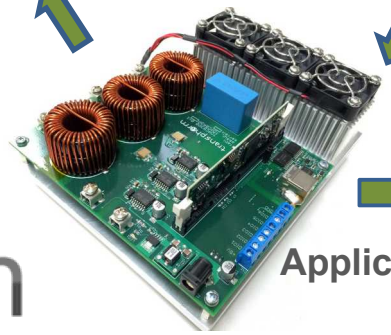




Product design



Discretes & Modules



Application demos

transphorm

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Why are we doing this ?

- **Technology Development:**
  - Demonstrate use of Wide-band-gap devices in a real application
  - Devices need to be used to become cheaper

Device need to become cheaper to be used

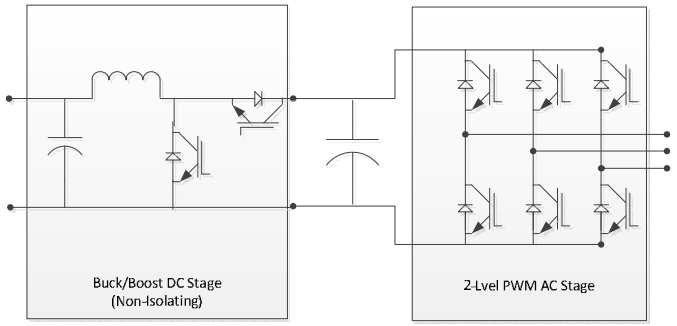
- **Product / Application Development**
  - Reduce cost & size of grid-tied energy storage installations by eliminating bulky grid-side isolation transformers
  - Improve efficiency
  - Reduce noise (by switching at frequencies outside the audible range)

Project Steps

- **Phase I : Design 60kW inverter for grid-tied storage applications**
  - **Base design on existing PPS 100kW inverter**
  - **Incorporate DC side isolation by using Dual-Active-Bridges (DAB) using GaN devices**
  - **Demonstrate DAB functionality**
- **Phase II : Build prototype inverter**
  - **Modify an existing GTIB inverter with design from Phase I**
  - **Demonstrate inverter functionality**

PPS Grid-Tied Inverter (GTIB-100)

- 100kW grid-tied inverter
  - Buck/boost DC stage
  - 2-level PWM AC stage
  - 6.5kHz switching frequency
- Proven technology, used in a number of grid-tied energy storage applications
  - 'Two-Ups' for Tesla
  - WPD project with GE in the UK
- No internal isolation -> typically requires external transformer



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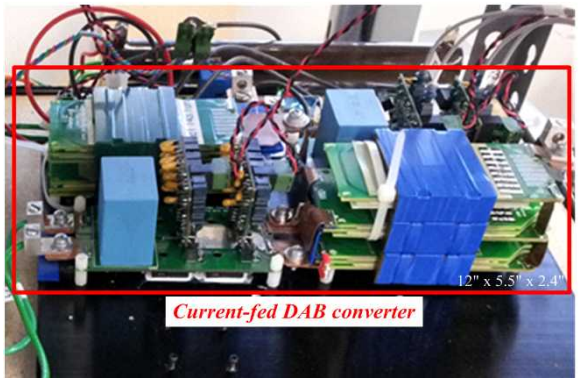
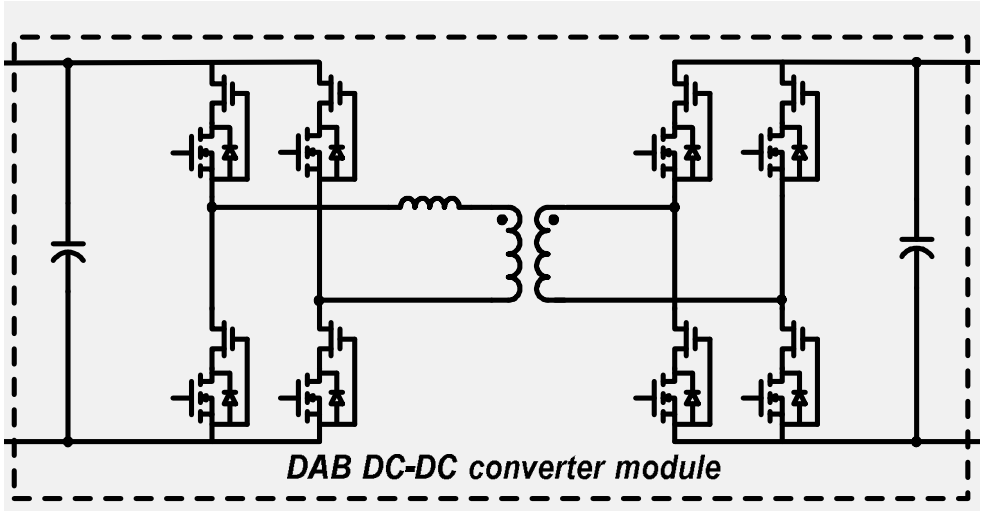
Dual-Active Bridge DC-DC Converter (FSU)

- **High-frequency switching (proven in lab at FSU)**
  - **Drastically decreases size of DC port components**
- **Built-in galvanic isolation**
  - **Eliminates grid-side transformer, increasing overall system power density**





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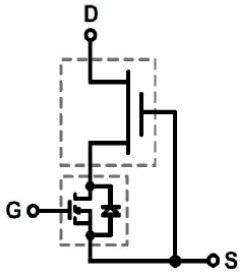
High Voltage GaN HEMT

- High Switching Frequency : 10x of Si devices for smaller Q_g, C_{oss} & Q_{rr}
- Low R_{ds_on}: V_B^2/R_{on}=5000 (40 for Si)
- High temperature operation > 200 C
- Third quadrant operation: Eliminates free-wheeling diode
- Normally-off operation: Safe for high voltage/power



TO-220 Package

Ron	Vds,max	Imax(pulse)	Imax(CW)
mohm	V	A	A
30	*900*	*240*	*70*
Rth	Qg	Qoss	Qrr
°C/W	nC	nC	uC
0.2	*25*	*320*	*0.35*
*Per switch			

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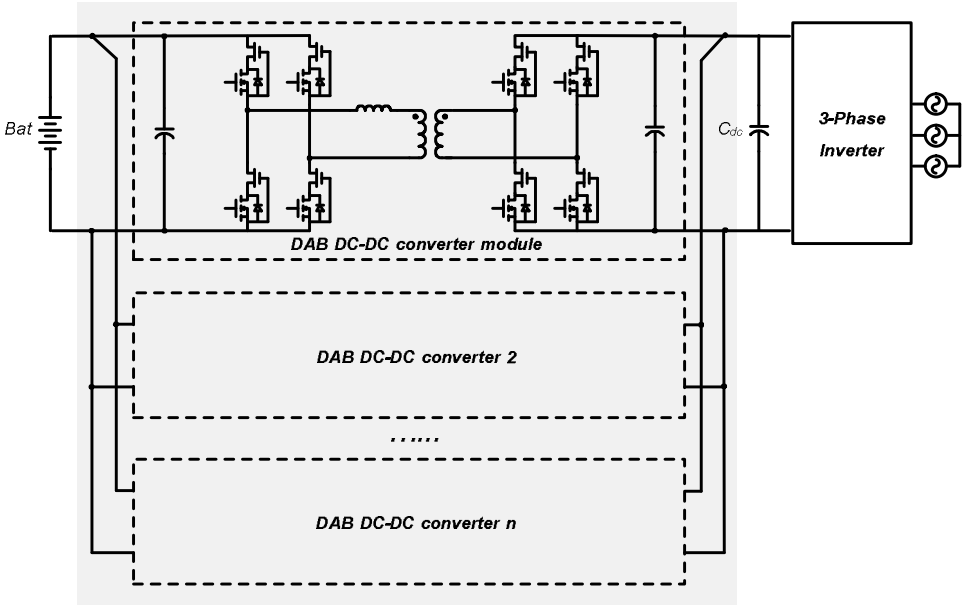
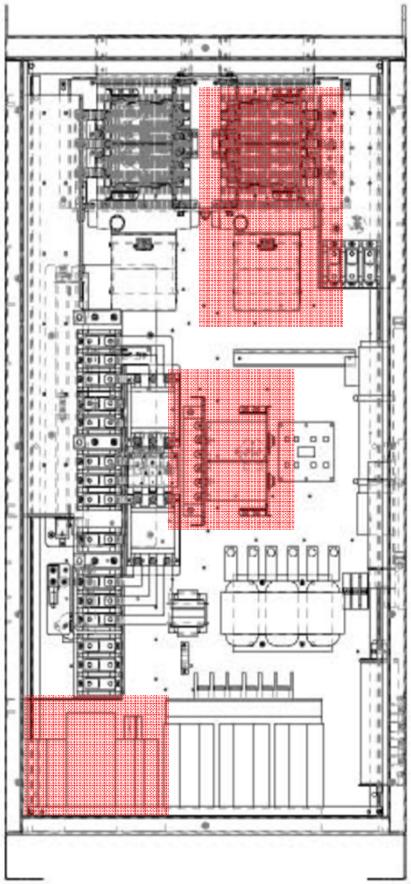
Target System Architecture

- Keep existing AC stage of GTIB inverter
  - Focusing on main project aspect
- DC stage will consist of multiple DAB converters
  - Allows interleaving, to reduce current ripple
  - Avoids challenges from having to parallel GaN devices



Design Goals

- DC-DC Stage Efficiency >= 98%
- Increase overall power density of installation by 40%
- Reduce overall system cost by 20%
  - Eliminate grid-side isolation transformer (-20% total system cost)
  - Reduce cost of reactive components for DC side by estimated 50% (-6% total system cost)



Removable DC port Components

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This project is funded by the DOE Office of Electricity.

We thank Dr. Imre Gyuk for his funding support and

Dr. Stan Atcitty for his technical contributions.

Thank you

Frank Hoffmann
fhoffmann@PrincetonPower.com
www.PrincetonPower.com

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