SAND2016-9304C

Smart GaN-Based Inverters for Grid-tied Energy Storage Systems

DOE SBIR Phase II

U.S. DOE/OE Energy Storage Program Peer Review

09/27/2016

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Acknowledgement

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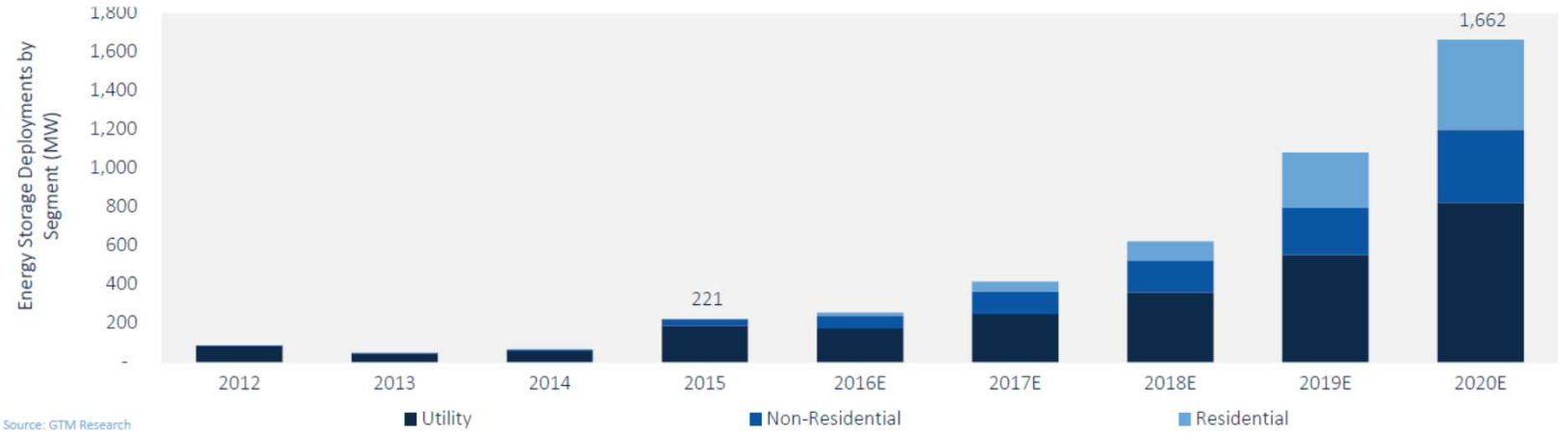
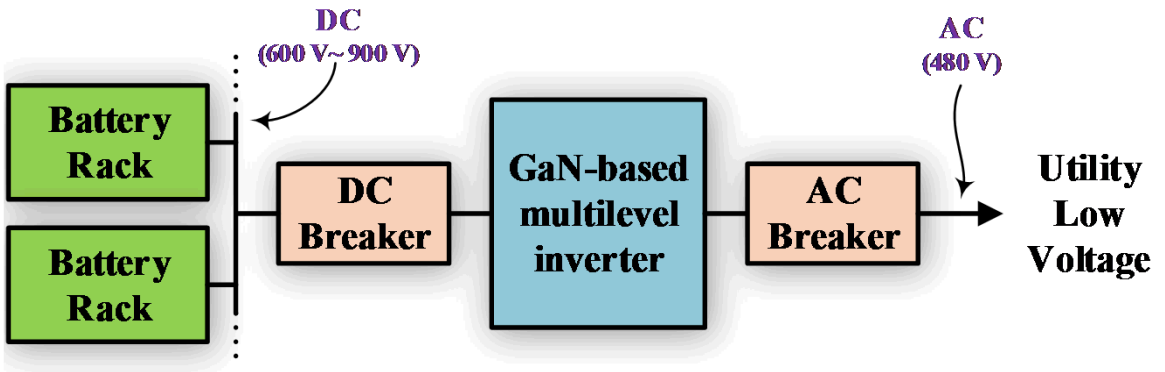
Motivation

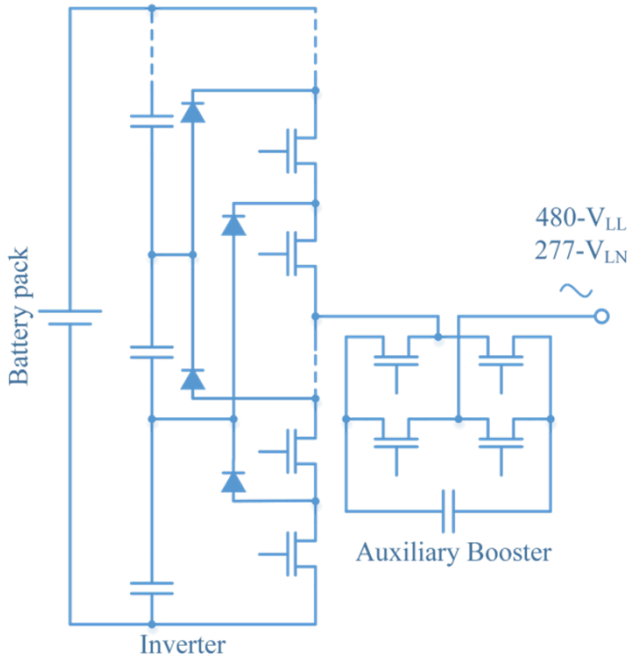
- **Energy storage systems and high-power bidirectional converters are the backbone of the future grid.**
- **Si technology has relatively high conduction losses compared to wide bandgap switches.**
- **GaN switches can operate at higher switching frequencies.**
- **By 2022, over 40 GW of energy storage systems will be installed in grid-connected applications.**

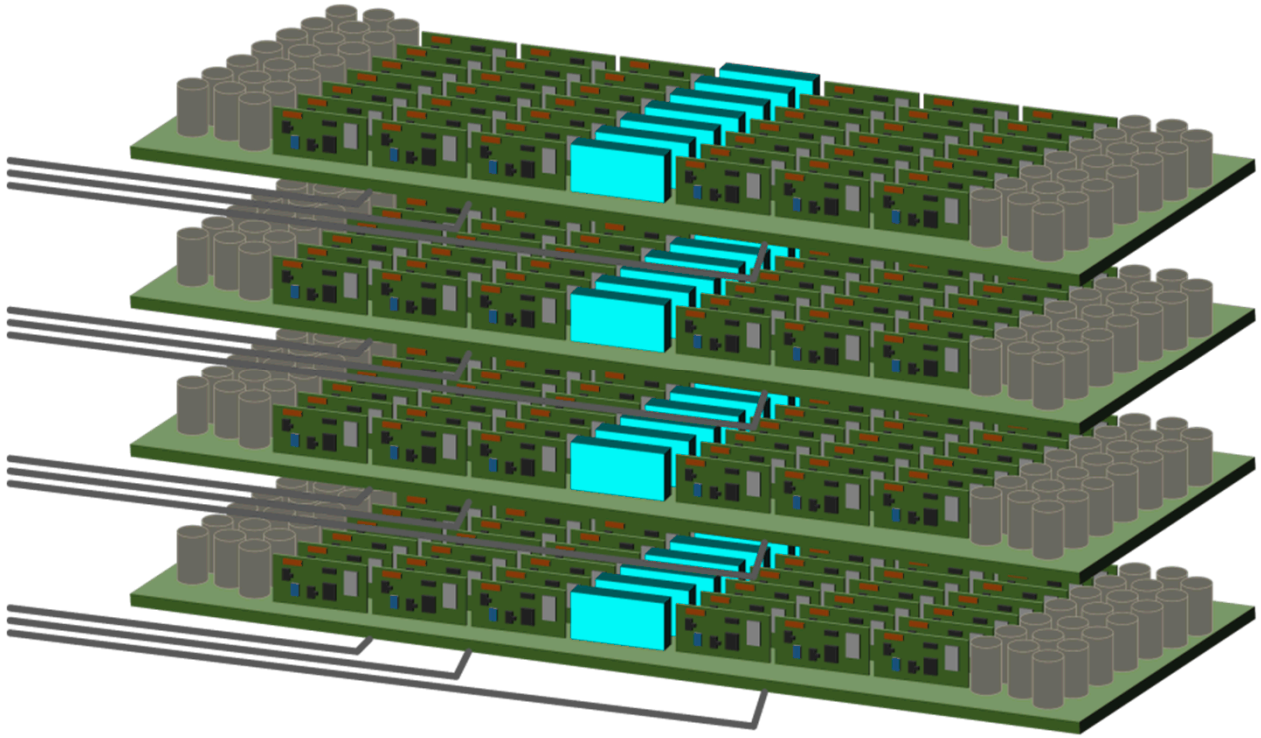


System Specifications

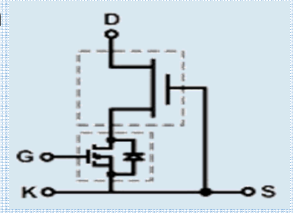
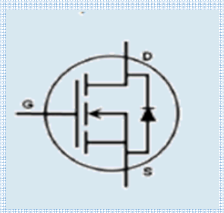
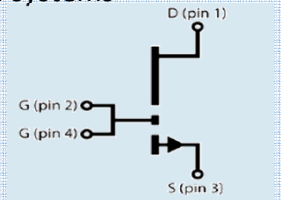
- **GaN-based multilevel inverter**
- **Nominal input voltage: 900V**
- **Output voltage: 3-phase 480V**
- **Power rating: 75kW and 100kVA**





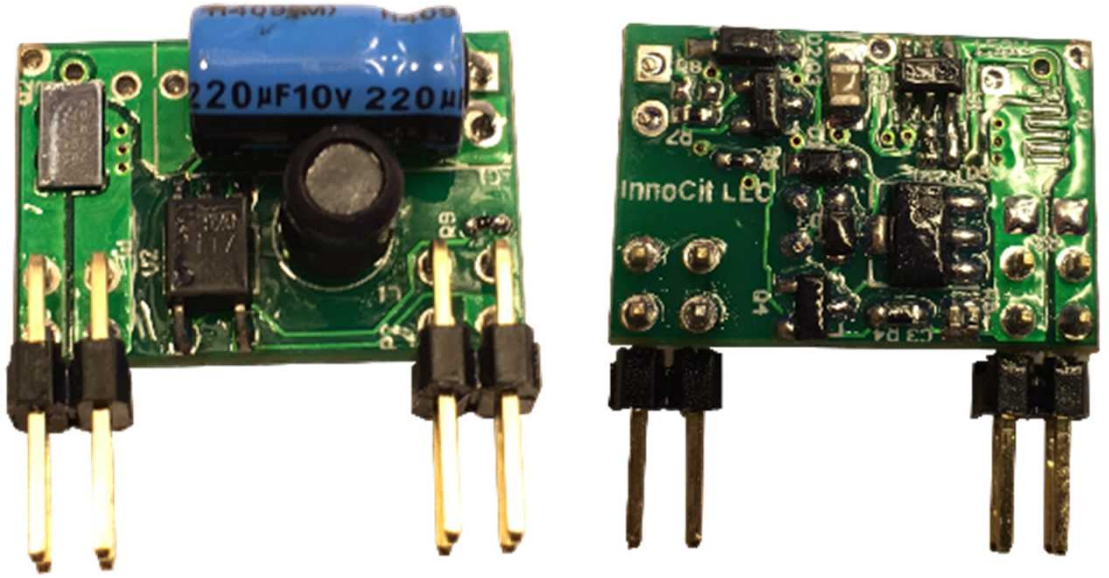


Fast-Paced Technology

Technology / manufacturer	Transphorm 	EPC 	GaN systems  
Switch topology	Cascode: GaN JFET + Si MOSFET	Enhancement mode FET	Enhancement mode FET
Material	GaN + Si	GaN	GaN
Part number	TPH3205WS	EPC2034	GS66508T
Voltage	600 V	200 V	650 V
Current	36 A	31 A	30 A
Rds-on @ 150˚C	0.10 Ω	0.015 Ω	0.050 Ω
CRSS (Reverse transfer)	17.5 pF	5 pF	2 pF (this is the fastest power GaN commercialized capable of operating up to 100MHz)
Heatsink Plate		no	Yes
Unit price	$12	$5.02 @ 500 units	$12

Achievements

- **First ever floating supply integrated GaN gate driver + switch (commercialized)**
- **First ever modular GaN-based 7.5-kW inverter (TRL-4)**



Final System

- **GaN-based inverter using the commercially available switches**
- **75-kW output power using ten modular 7.5-kW inverter units**
- **Flexible multi-chemistry input supporting any combination of 1 to 10 individual racks**
- **Peak efficiency of at least 99%**
- **Volume of 7.5 ft^3 and weight of 300 lbs. for the 75-kW inverter**
- **Noise level < 45 dBa**
- **Estimated cost: $10,500.00 or $0.140/W ($2,000.00 lower than the expected cost using EPC)**

Commercial Competitiveness

Features	InnoCit's GaN Inverter	GTIB-100 Princeton Power	MPS-100 Dynapower	EssPro c250 ABB
Peak Efficiency	>99.1%	>96.5%	>96.5%	>96%
CEC Efficiency	>98.5%	>94.5%	>94%	93.9%
End-user Price	$15,500 $0.205/w	$37,000 $0.296/w	$58,000 $0.58/w	$130,000 $0.65/w
Modularity at 7.5-kW level	Yes	No	No	No
Noise (dBA)	<45	<75	<60	<80
Weight (lb)	300	1,020	1,545	2,100
Volume (ft^3)	7.5	28	48	41
Material	GaN	Si	Si	Si

Work Plan

- **Design of the central controller, auxiliary supply, and user interface**
- **Finalizing the design of individual modules of 7.5-kW GaN inverters**
- **Development of 20 7.5-kW prototypes**
- **Development of the central controller**
- **Programing and communication handling**
- **Testing and TRL-5 verification of the GaN inverter modules**
- **Design of the stack drawers**
- **Design of the main inverter rack**
- **Selection of connectors, main bus-bar, ventilation, and thermal analysis**
- **Development of two complete prototypes**
- **TRL-6 testing**
- **Testing in a relevant environment (TRL-7 testing)**
- **Demonstrations and fine tuning**