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

DOE OE Peer Review, October 2021

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Innovation City, Power and Energy Solutions

DOE SBIR Phase IIB

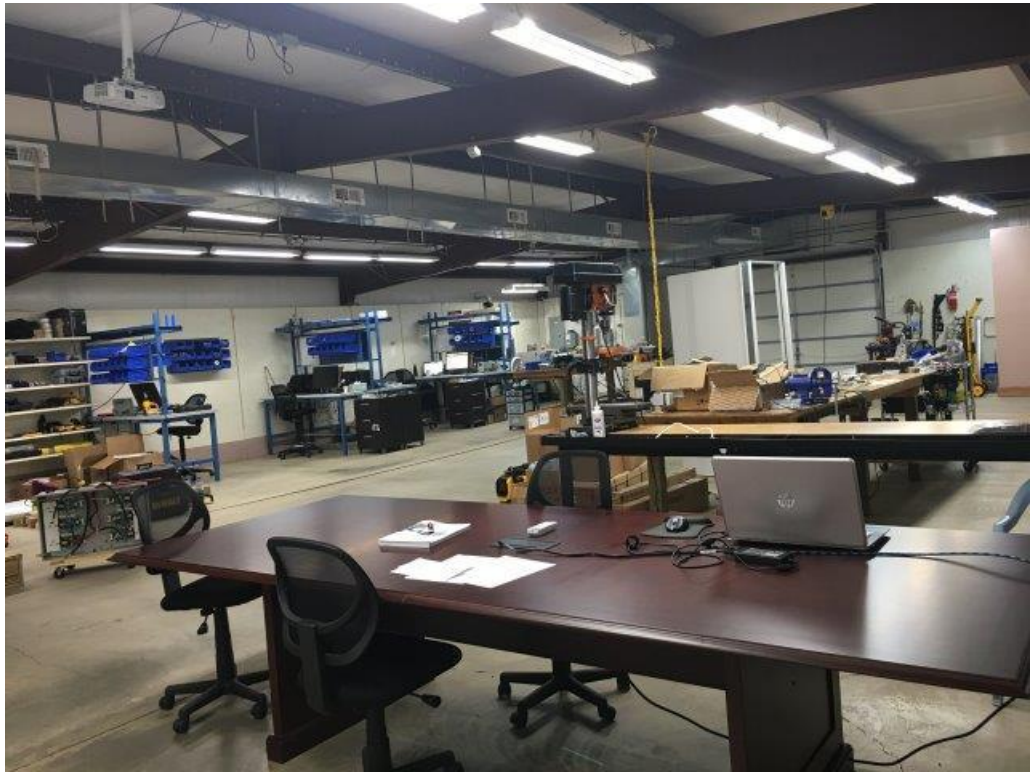
Year 2 start date: 09/1/2020

Year 2 end date: 08/31/2021

Who We Are

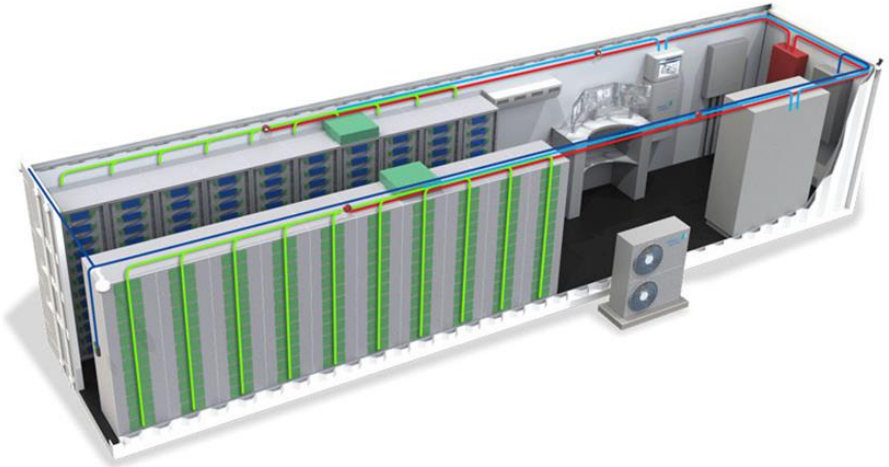
InnoCit

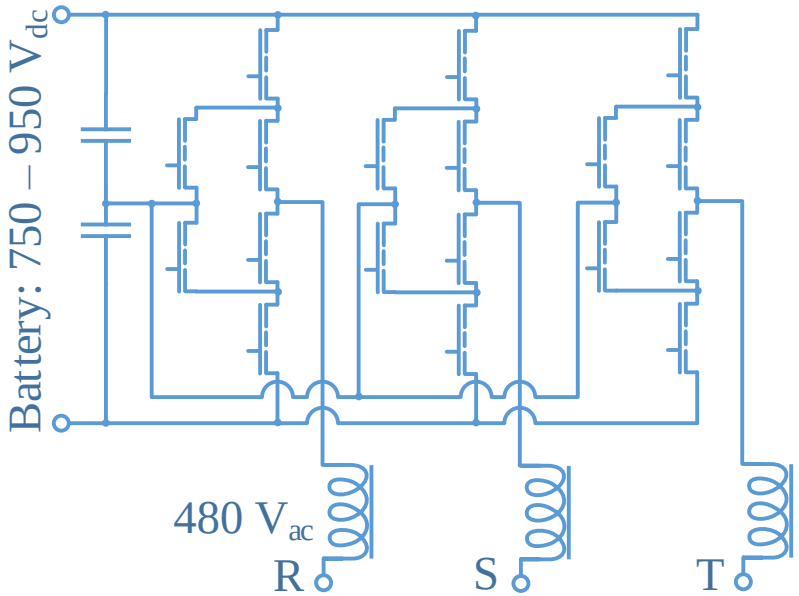
- **Founded in 2014**
- **Tech Transfer Startup**
- **4,000 sq. ft. research facility, 10 acre campus, solar farm, based in Missouri**
- **DOE SBIR Phase I, II, IIB, NSF SBIR Phase I**
- **Costume manufacturing**

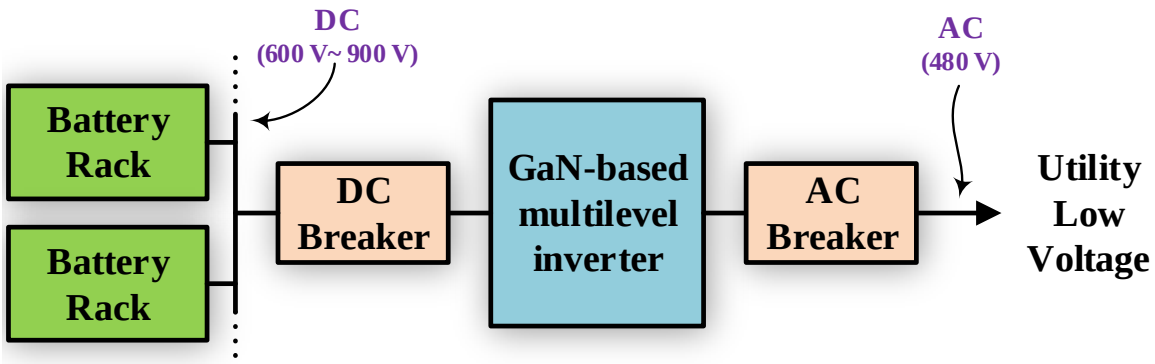


System Specifications

- **GaN-based multilevel inverter**
- **Nominal input voltage: 900V**
- **Output voltage: 3-phase 480V**
- **Power rating: 20kW to 200kW**



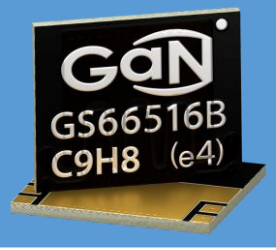




Specific Objectives

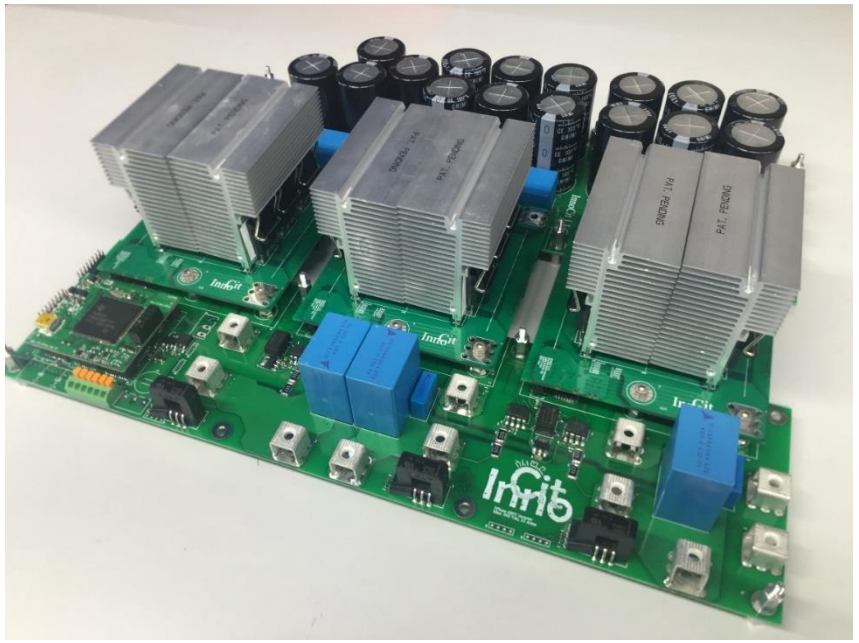
- **Designing 3U rack-chassis-based enclosures for inverter modules**
- **Controls and hardware for hot-swap capabilities**
- **Efficiency of at least 98.6%, weight < 2.2 lb./kW, volume <0.1 ft^3/kW, noise <45 dBa**
- **Reliability testing including active bypass and hot-swap features**
- **IEEE 1547, UL 1741, and 1741-SA testing for islanding and fault ride-through**
- **UL certification testing**
- **Remote control and monitoring backbone structure development**

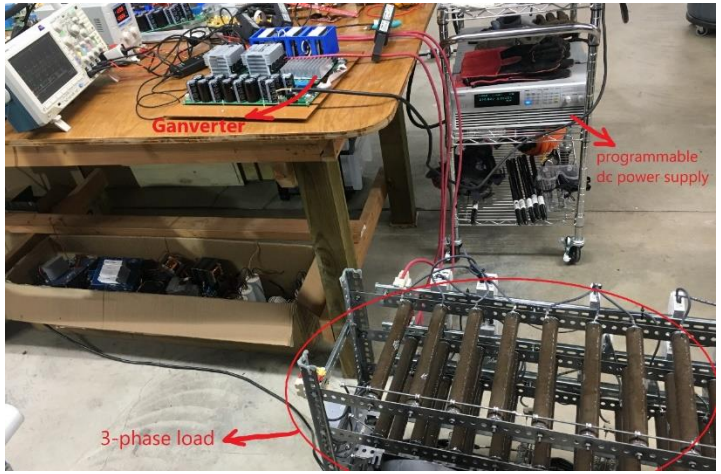
Fast-Paced Technology

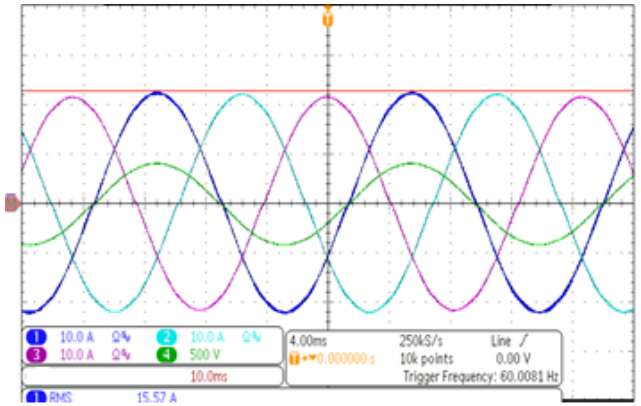
Technology / manufacturer	GaN systems 	GaN systems 
Project Phase	Phase II	Phase II-B
Switch topology	Enhancement mode FET	Enhancement mode FET
Material	GaN	GaN
Part number	GS66508T	GS66516B
Cooling	Top	Bottom
Voltage	650 V	650 V
Current	30 A	60 A
Rds-on @ 150°C	0.050 Ω	0.025 Ω
CRSS (Reverse transfer)	1.5 pF	5.9 pF
Heatsink Plate	Cooled from the top	Cooled from the bottom side of the PCB

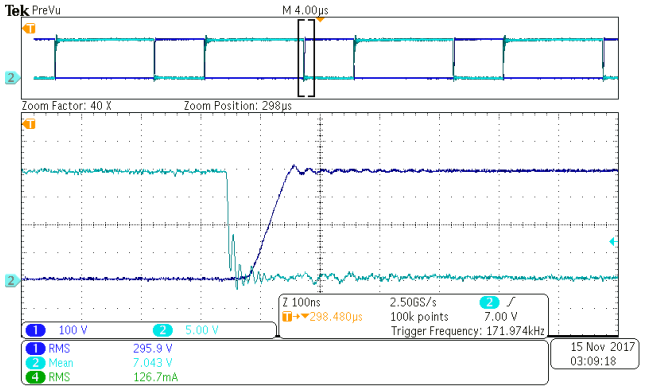
Achievements

- **First ever floating supply integrated GaN gate driver + switch (commercialized)**
- **First ever modular GaN-based 20-kW inverter (TRL-6)**



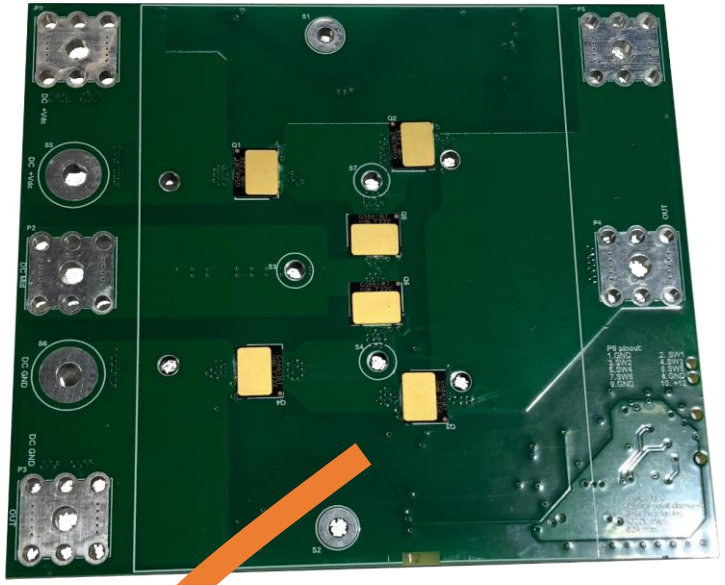


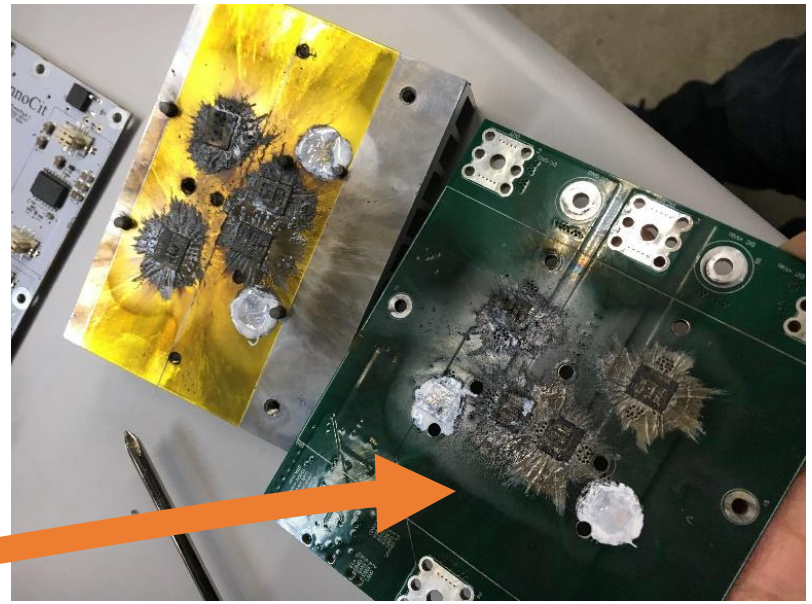


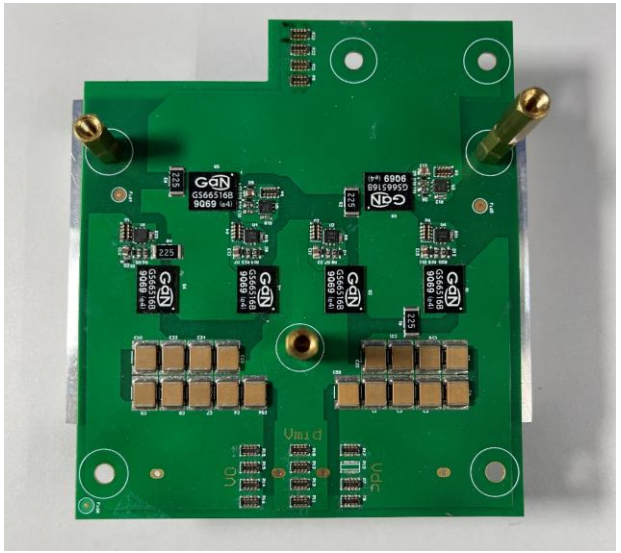


Switch Reliability
Why did we shift to bottom cooled devices?

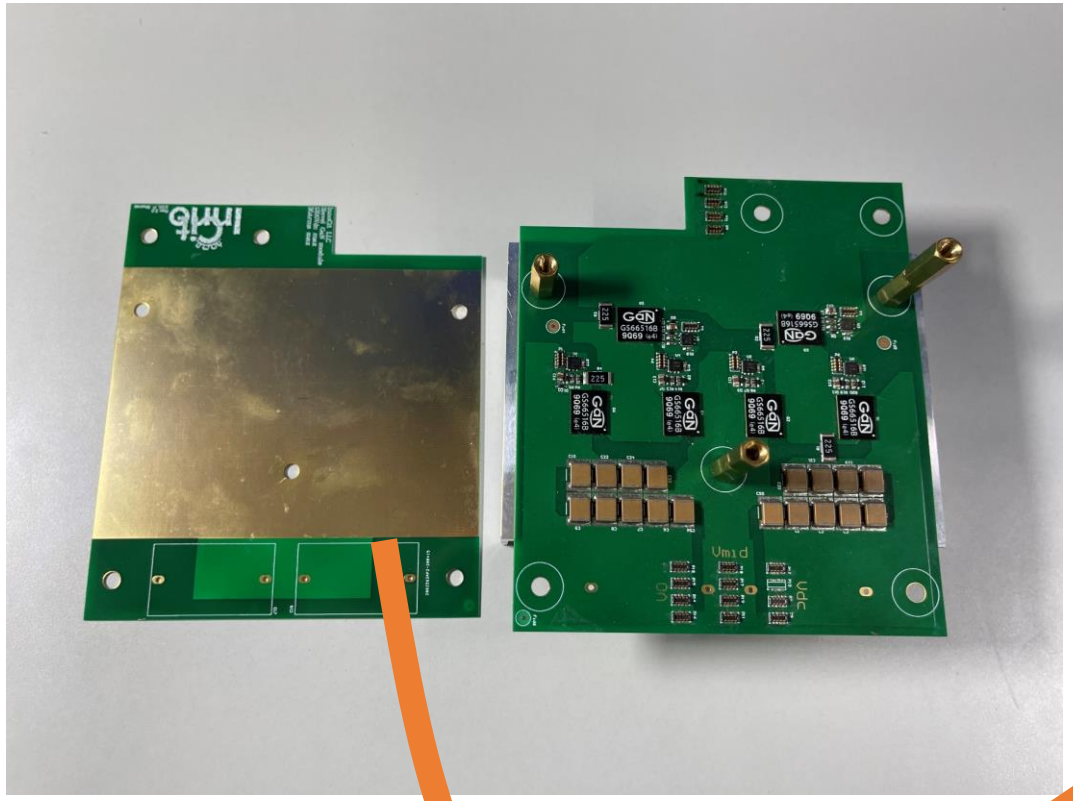
- **Soldering tolerance:** 6 switches had to be soldered with their top plate ending at the same height

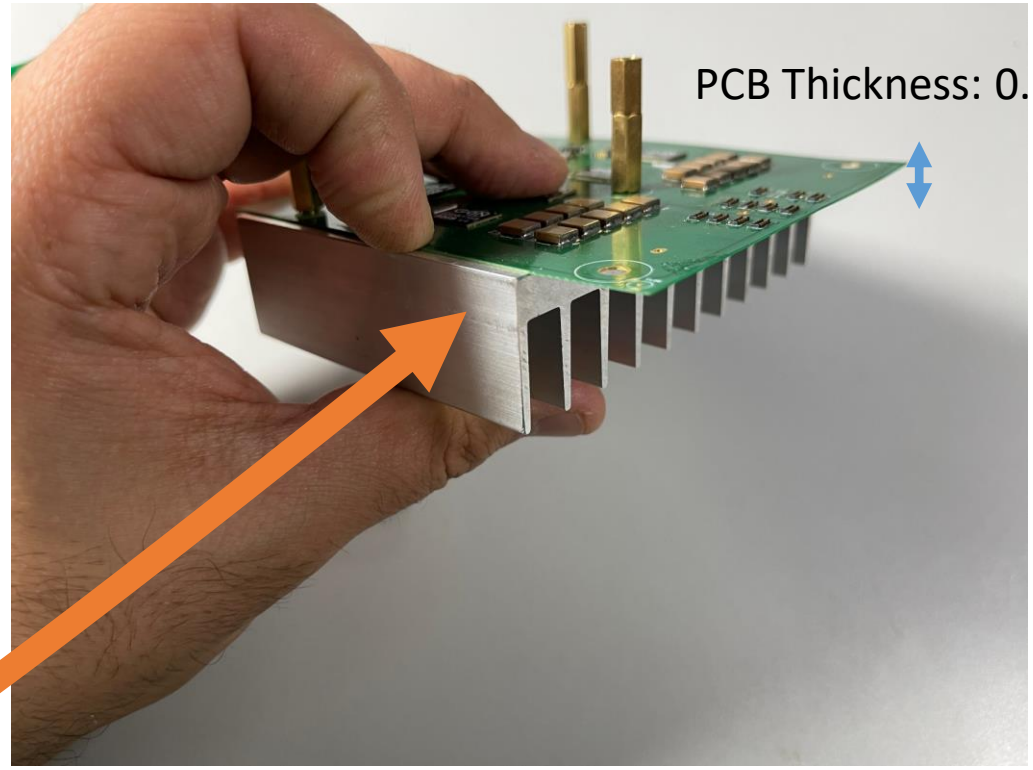






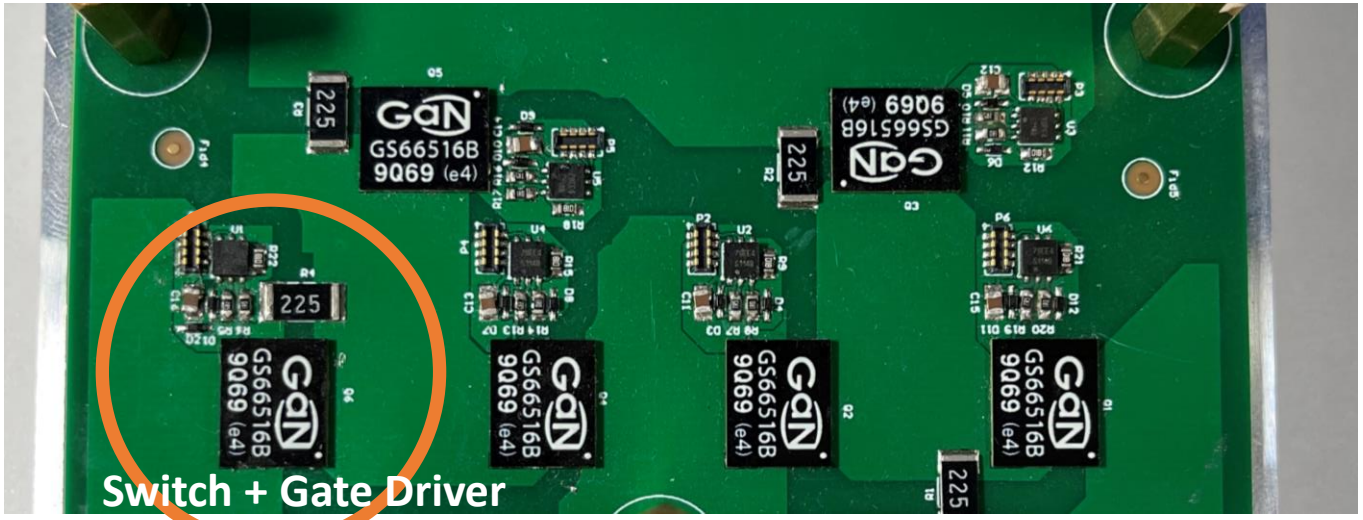
Bottom-Cooled GaN Switch

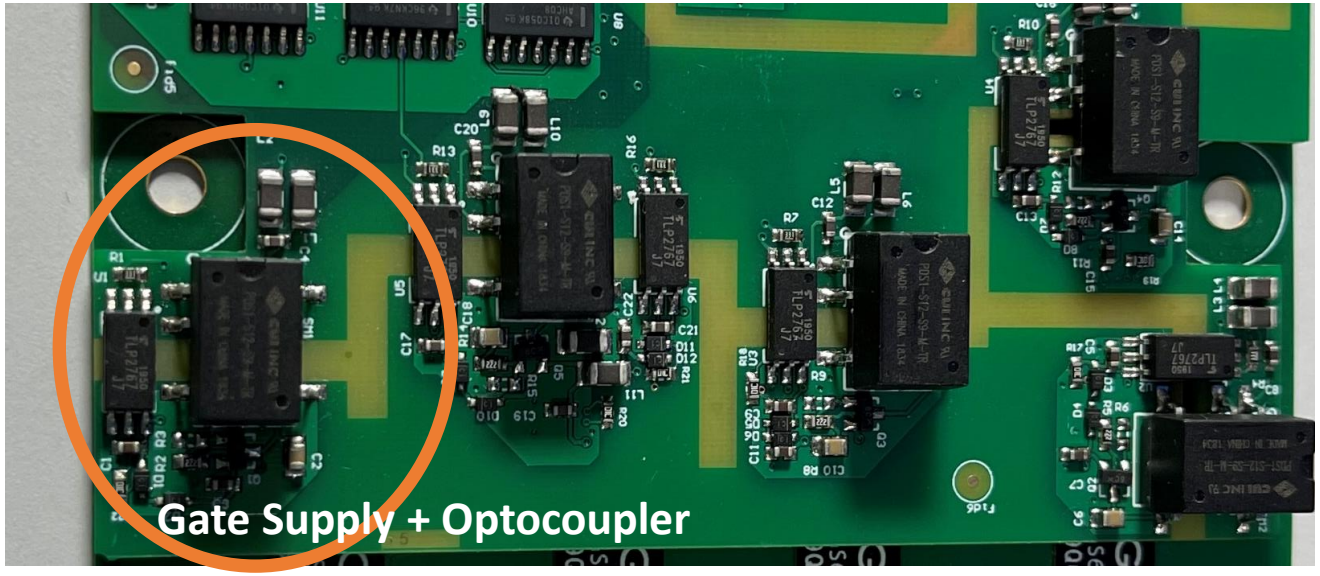


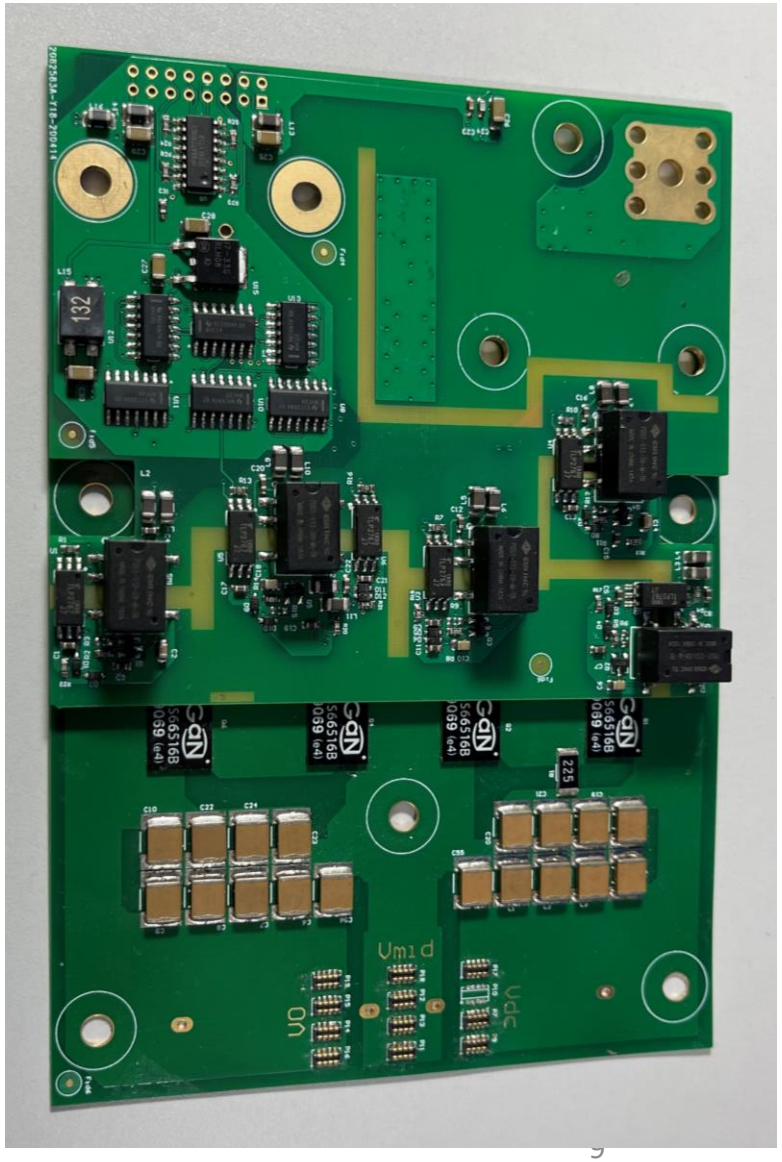


PCB is glued to the sink using thermally conductive epoxy

Bottom-Cooled GaN Switch

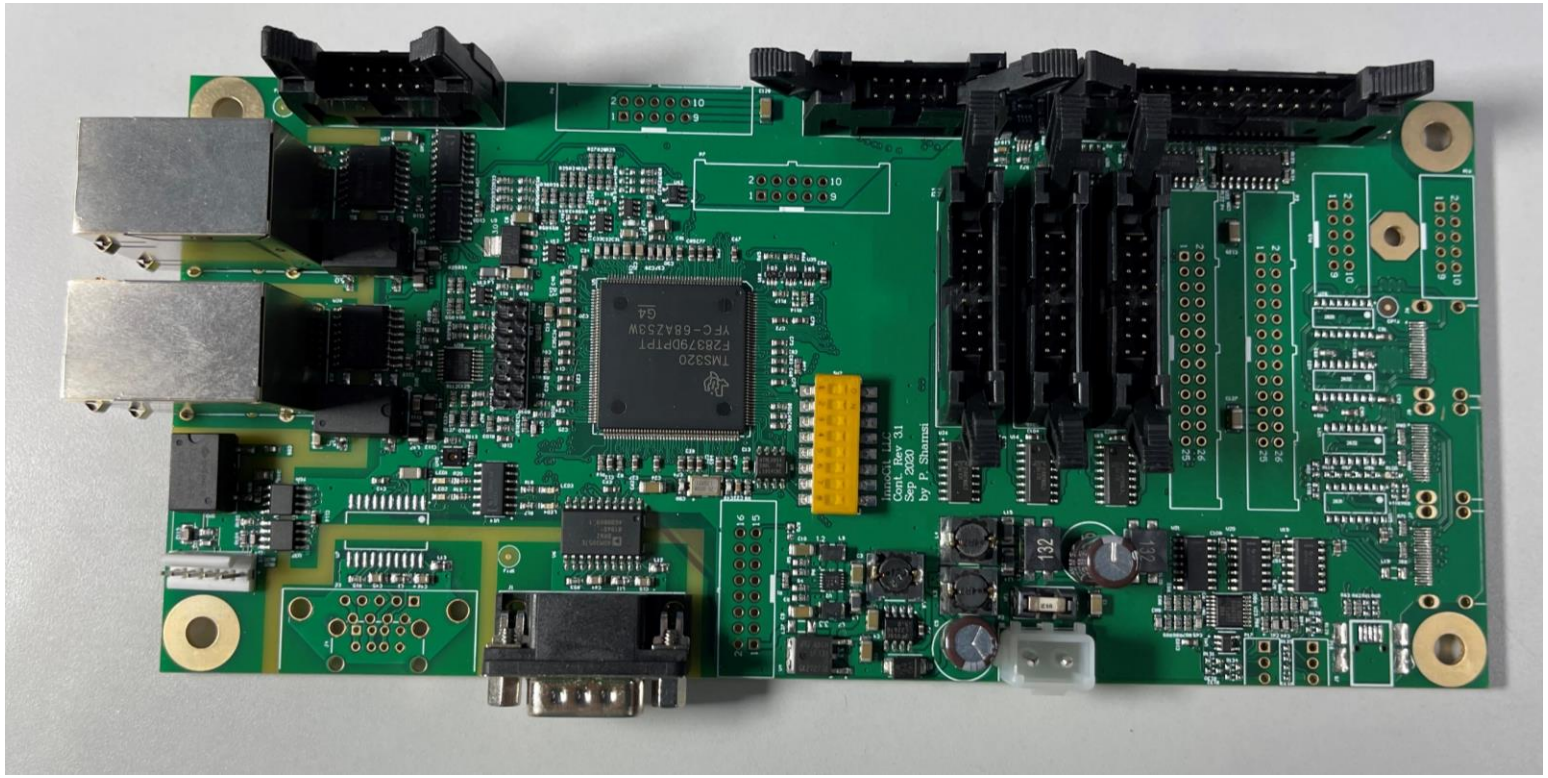


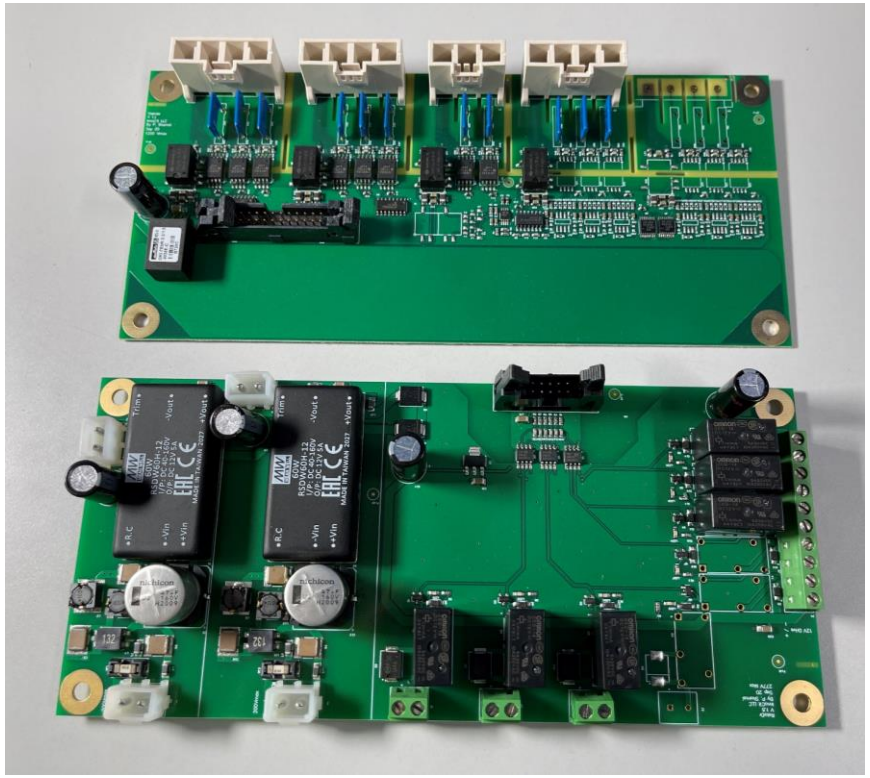




Final System

Control, relay driver, and voltage sensing circuitry:



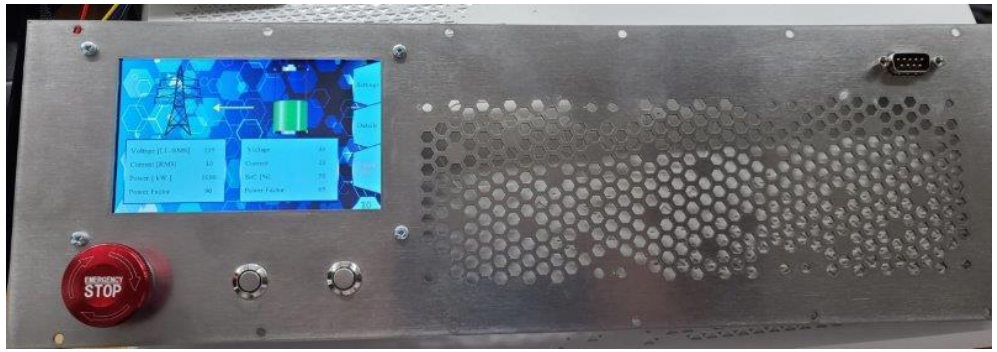


Supported communications: Isolated CAN, Isolated RS-485

Upcoming communication: Wifi and LTE using Digi Modules

Final System

Interface Panel: Currently we are using Nextion LCDs



Auxiliary Supply: We needed a 400-1500Vdc to 48/12V supply for system startup without the grid/support during fault ride through.

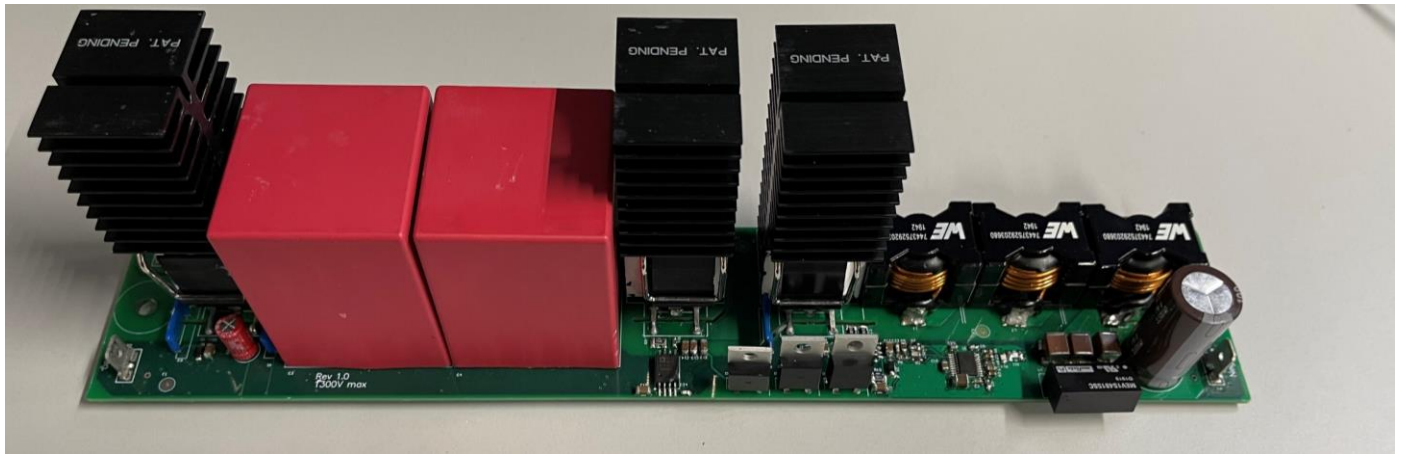
P: 400W

V: 400-1500 to 48

Non-isolated

SiC-based

Supports 10×20kW GaN chargers



Final System

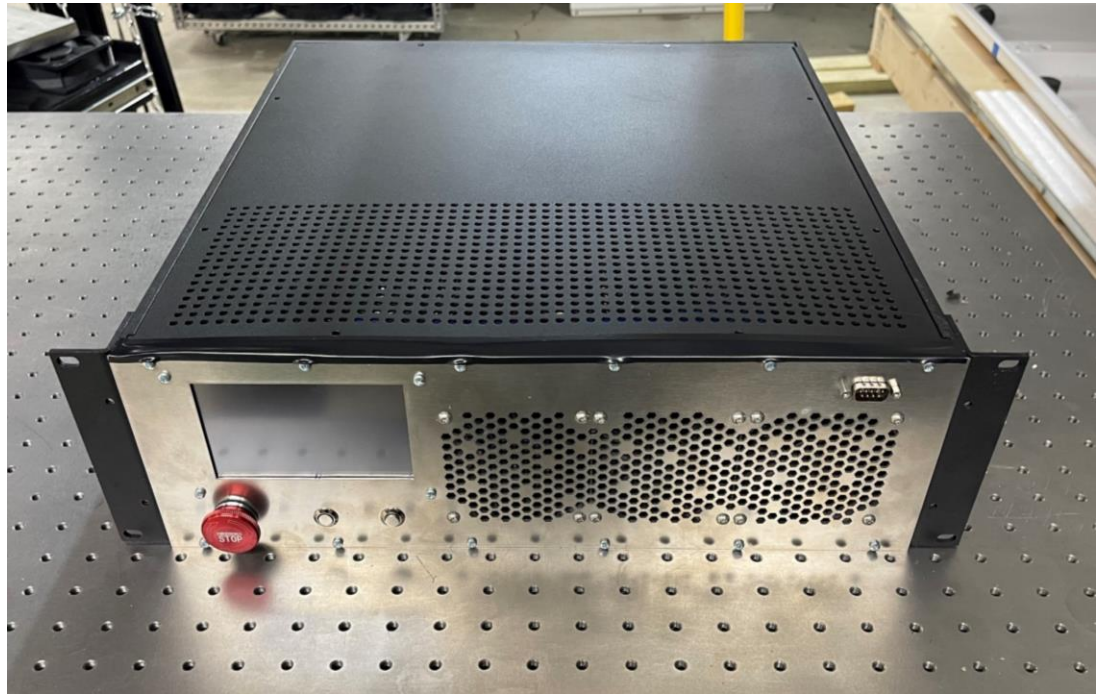
Ongoing Tasks:

1. Some minor mechanical redesign to make sure our front panel fits without gaps.

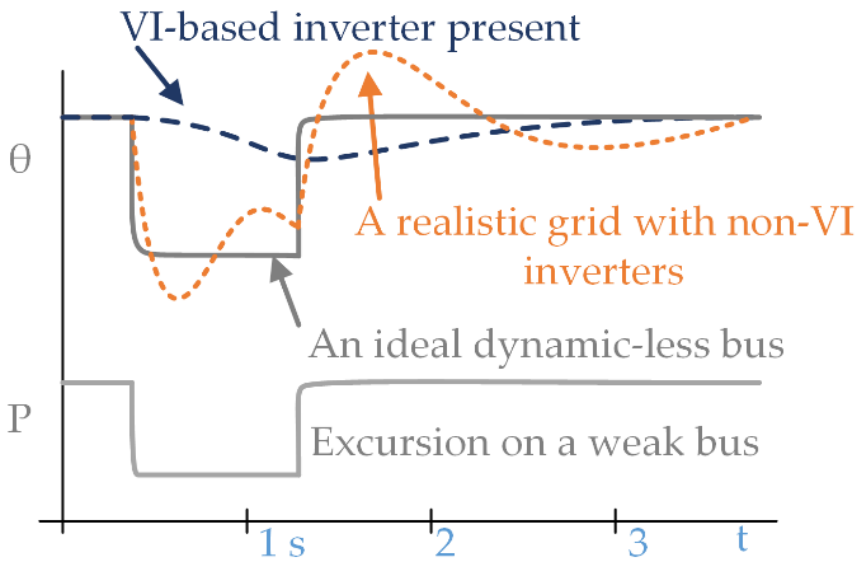
2. Working towards getting the UL certification.

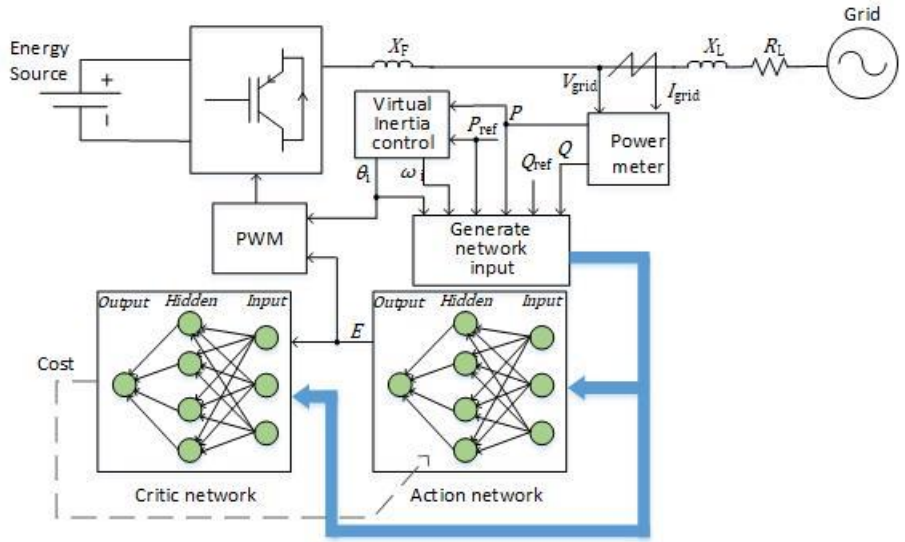
3. Adding the upgraded Digi communication module with support for Wi-Fi and LTE remote monitoring/control.

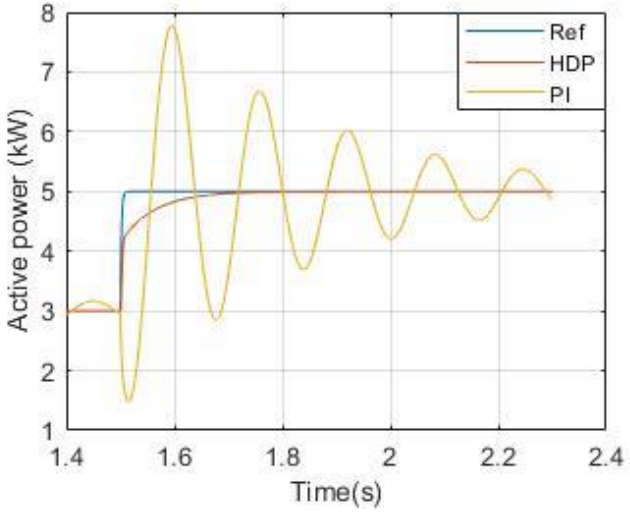
4. Securing a sheet metal manufacturing partner for chassis and rack manufacturing.

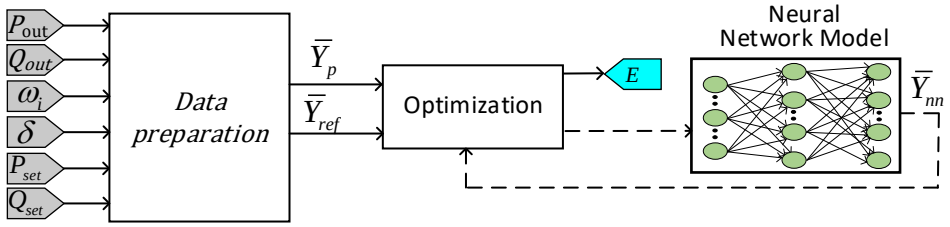


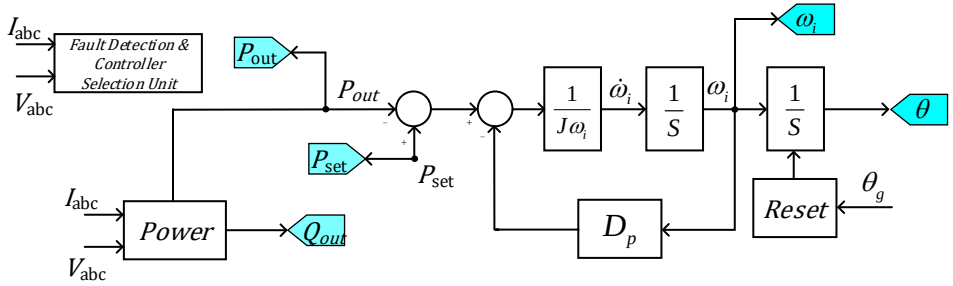
Intelligent Inverter











Commercial Competitiveness

Features\Manufacturer	InnoCit Ganverter (10 units)	Princeton Power BIGI-250	ABB ESSpro-C250	DynaPower MPS-100
Total Power Rating (S)	200-kVA	265-kVA	200-kVA	100-kVA
CEC Efficiency	98.4%	94.5%	>94%	93.9%
Volume	30-ft^3 (full system + rack)	150-ft^3	41-ft^3	48-ft^3
Weight	540-lbs. (full system + rack)	3500-lbs.	2100-lbs.	1545-lbs.
Current THD	<2%	<5%	<5%	<5%
End-user Price per VA	$0.13/VA	$0.44/VA	$0.58/VA	$0.52/VA

Acknowledgement

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