Current-Modulation Electronic Power Converters

NIST/DOD Workshop
Power Conditioning System Architectures
for Plugin-Vehicle Fleet as Grid Storage
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IDEAL POWER CONVERTERS

Hybrid Intelligent Power
for Forward Operating Bases

AC grid or generator(s)

Reduces diesel fuel requirements by up to 40%

208V AC Wye
4 wire, 3-phase, balance or unbalanced

Intelligent loads
- shedding
- prioritizing

AC 4-wire Interface
- 30kW
- 208V 3-ph or 120/240 1-ph
- real & reactive
- supply & load
- phase balancing

HI Power Microgrid Converter

High Volt DC port
- 30kW
- 224-325V
- Bi-directional
- 22 lbs

DC interface to:
- **Local batteries**
- **PV Array**
- **Asynchronous microgrids**

IPC - develops HI Power Microgrid Converter, low level controls
Lockheed Martin – converter packaging, system controls, testing

Bidirectional Battery Inverter/Charger

Applications

- **Stationary Batteries**
  - 30 kW, 480 VAC three phase 60 A
  - 0 to 700 volts DC
  - Bi-directional, power-to-grid

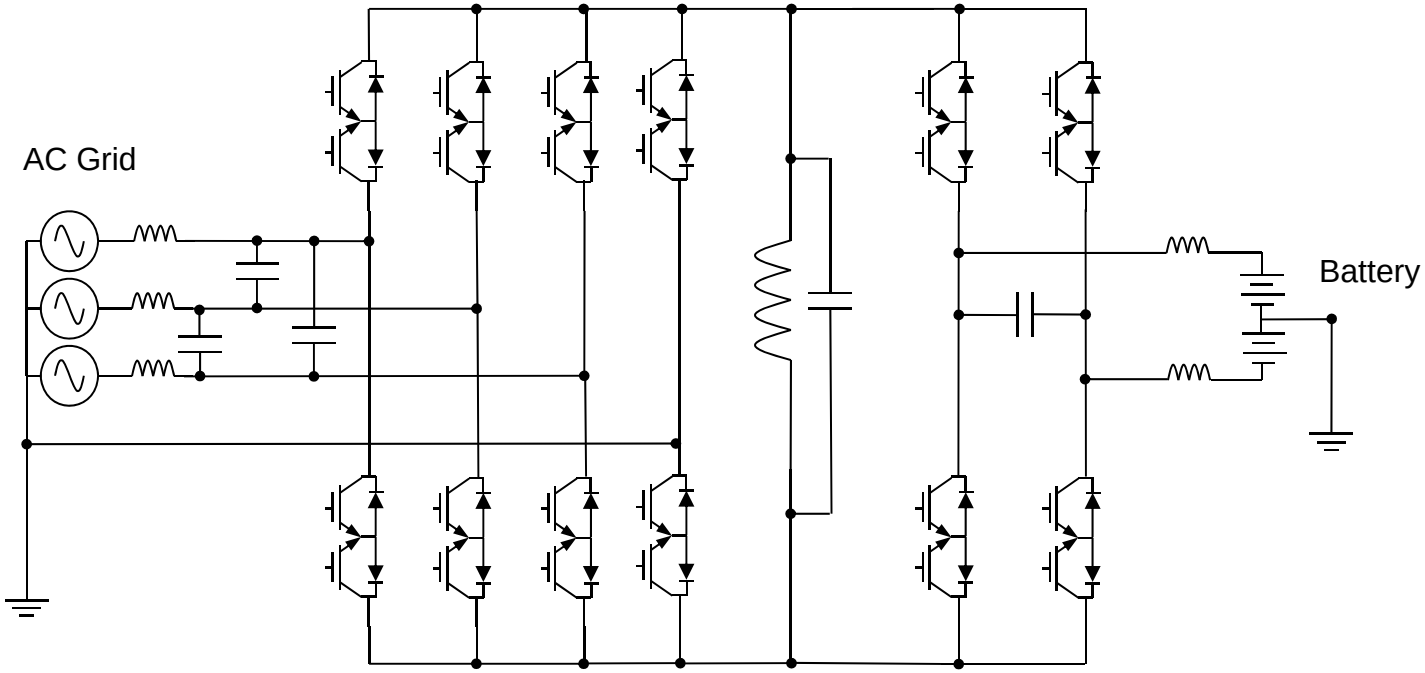
- **Vehicle Batteries**
  - Bidirectional Level 3 DC charger
  - Power-to-grid
  - Common mode isolated or full isolation

30kW 480VAC battery inverter
80lbs, wall-mount
97% efficiency

Bidirectional Battery Inverter with Microgrid

4-wire 3-phase grid interface

- Support Micro-grid – Intentional Islanding
- Support unbalanced loads & phase balancing
- Similar to 4-wire interface for HI Power
- Common Mode isolation



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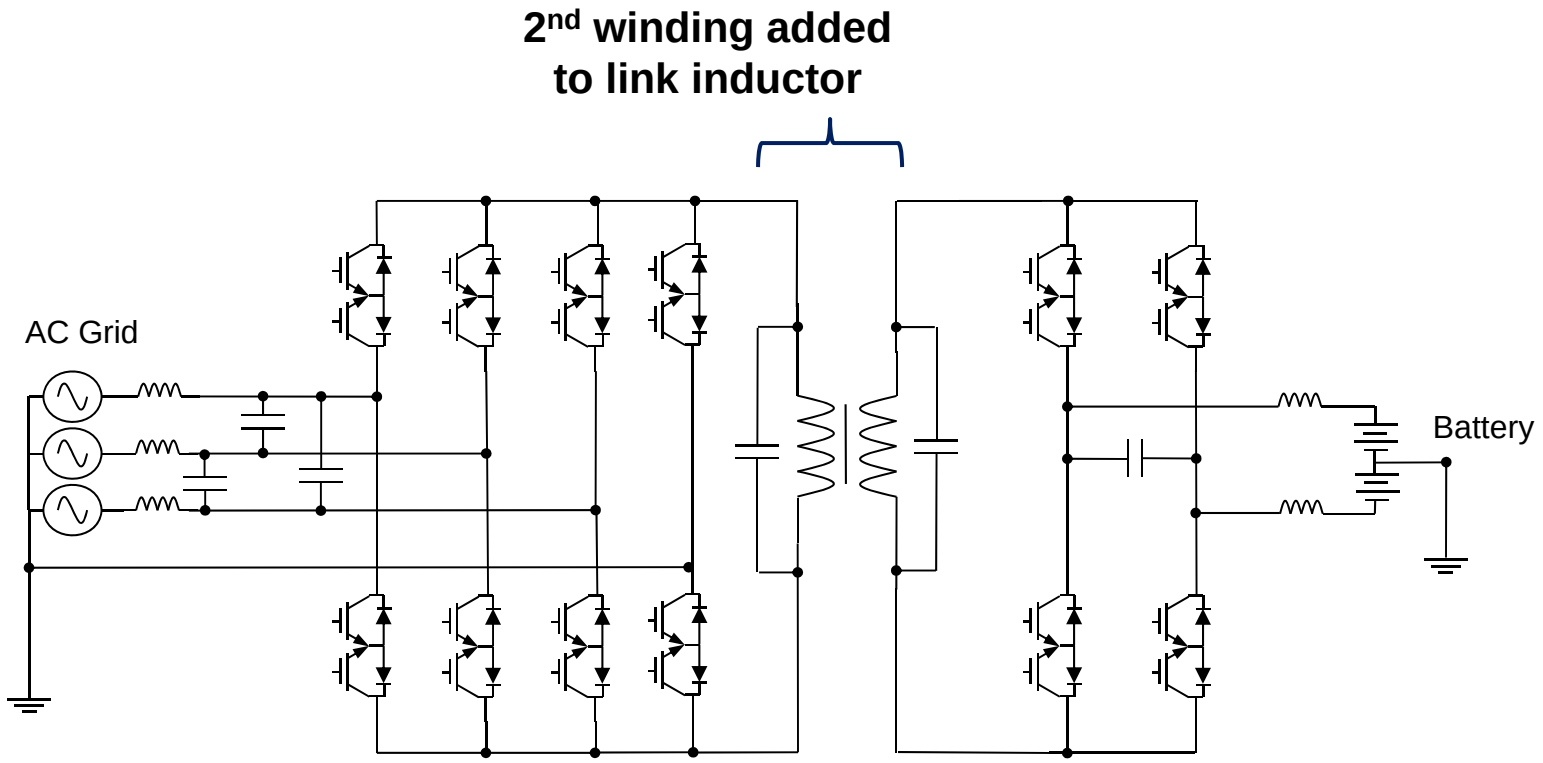
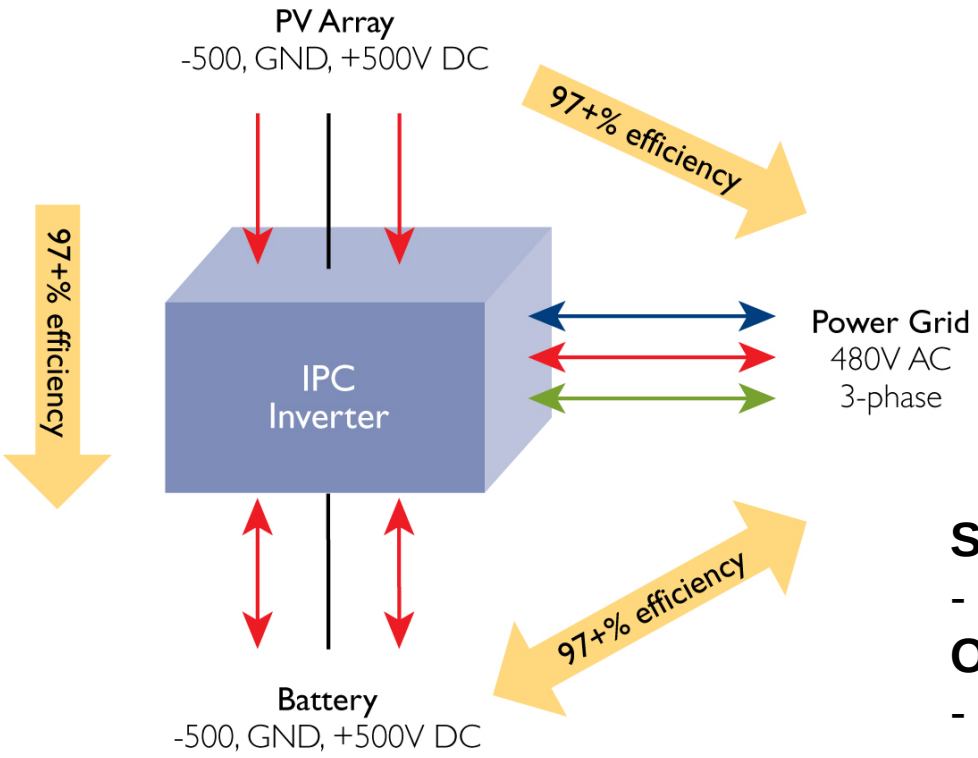
Bidirectional Battery Inverter with Galvanic Isolation



3-port PV & Battery Inverter



4-wire 3-phase grid interface
- Microgrid – Intentional Islanding
- Support unbalanced loads

Single-Stage Conversion
- Higher efficiency

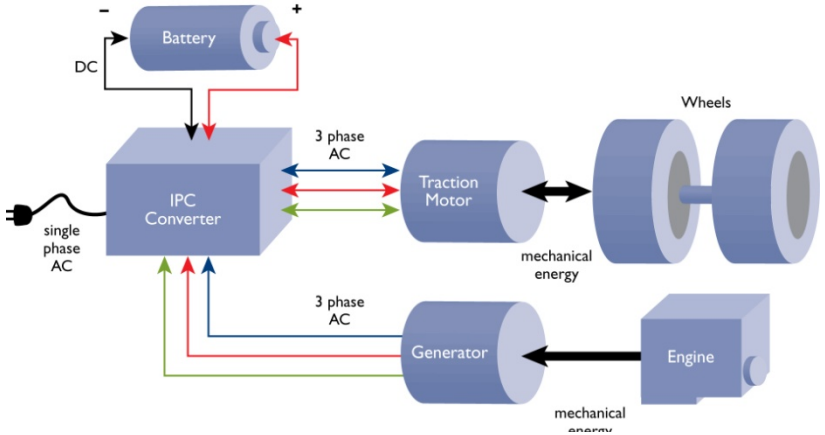
Operates during faults
- Grid faults
- Communications faults

DC charging of EV during peaks
- Reduce peak load/transmission

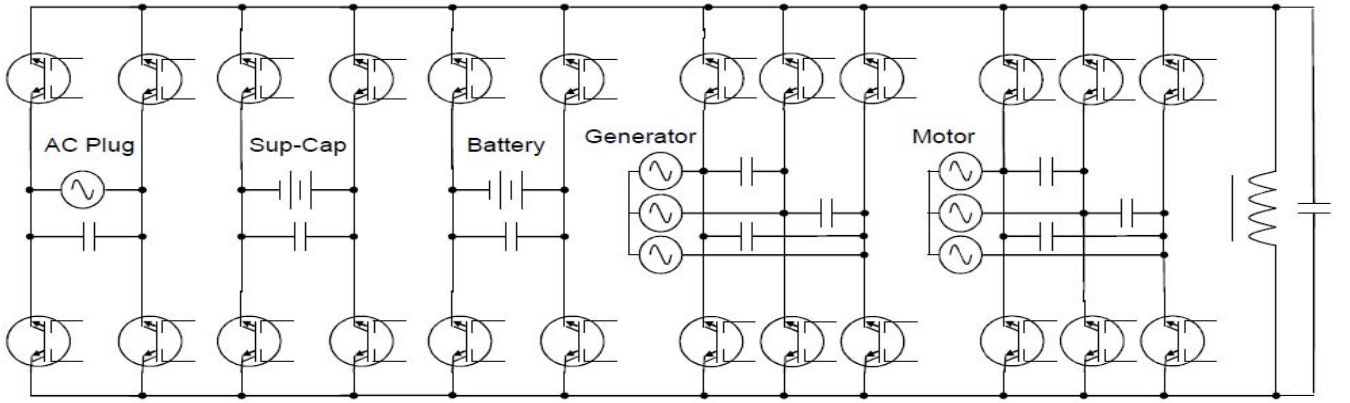
Station Battery
- PV smoothing and peak shaving
- UPS capabilities

Vehicle Battery
- Bi-directional Level 3 DC charger

IPC PHEV Architecture



- Multi-port, multi-directional converter
- Superior efficiency, weight/size, cost
- Simplified cooling systems
- Supports inductor generator/motor
  - No PM or rare earths



120/240V single phase input charging

optional caps or 12V aux battery

high voltage Li-Ion battery

generator from internal combustion engine

drive motor with re-generative charging

link inductor

(note line capacitors not shown)

IDEAL POWER CONVERTERS

Backup Slides

IDEAL POWER CONVERTERS

Business Overview

- **Developed new electronic power converter technology**
  - 2 US patents issued, additional US and international patents pending
  - Applications: photovoltaic, wind, battery, VFD and PHEV

- **Licensed to Lockheed Martin for military & vehicle mkts**
  - Developing new microgrid converter for forward military bases

LOCKHEED MARTIN

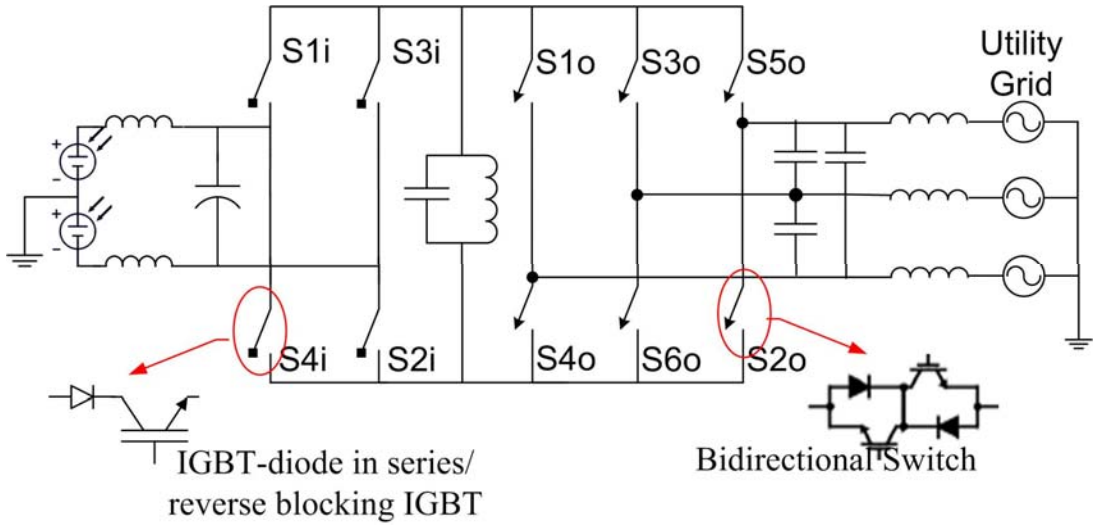
- **Received funding**
  - Texas Emerging Technology Fund
  - Battery Venture

BV

- **Initial product is 30kW PV inverter**
  - for US commercial-scale / flat rooftop installations
  - customers are commercial PV design & installation firms

IPC Topology Characteristics

- **Soft-switched, buck-boost, current-modulated converter**
- **All power transfer is through a link inductor (not resonant link)**
- **Link operates at 7 kHz at full power, AC current/voltage**
- **Precise current control reduces output harmonics**
- **Link capacitor acts as loss-less snubber for ZVS**
- **Zero voltage turn-on, low di/dt reverse recovery**
- **Inherent isolation between input and output, no transformer needed**



Military Funded R&D

- **Development contracts from Lockheed Martin**
  - Funded by DOD and LMC internal R&D budgets
  - Developing Intelligent Microgrid Solution under DOD/LMC contract

  "Reduces diesel fuel requirements up to 40% by improving microgrid efficiency for Forward Operating Bases" -Lockheed Martin

- **Technology License to Lockheed Martin**
  - Exclusive rights to military & automotive (specific) markets
    - IPC retains rights to sell commercial-of-the-shelf to military
  - Generates royalty from LM sales and sub-licensee sales
    - Minimum royalties escalates annually
  - Validates & strengthens IPC patents
    - IPC retains all IP ownership
    - Royalty free rights to LMC improvements