Modular High-Efficiency GaN Power Converter for Bus Power Conversion

Introduction

- Advances in semiconductor technology and power converter design have greatly improved power converter performance in the past decade
  - 2011: Non-isolated conversion efficiency >96% with power density ~100W/in^3
  - 2021: Non-isolated conversion efficiency >98% with power density ~400W/in^3
  - 50% reduction in power dissipation
  - 90% reduction in volume
- Changes system level design trades
  - Peak power tracking versus direct energy transfer
  - Secondary bus voltages

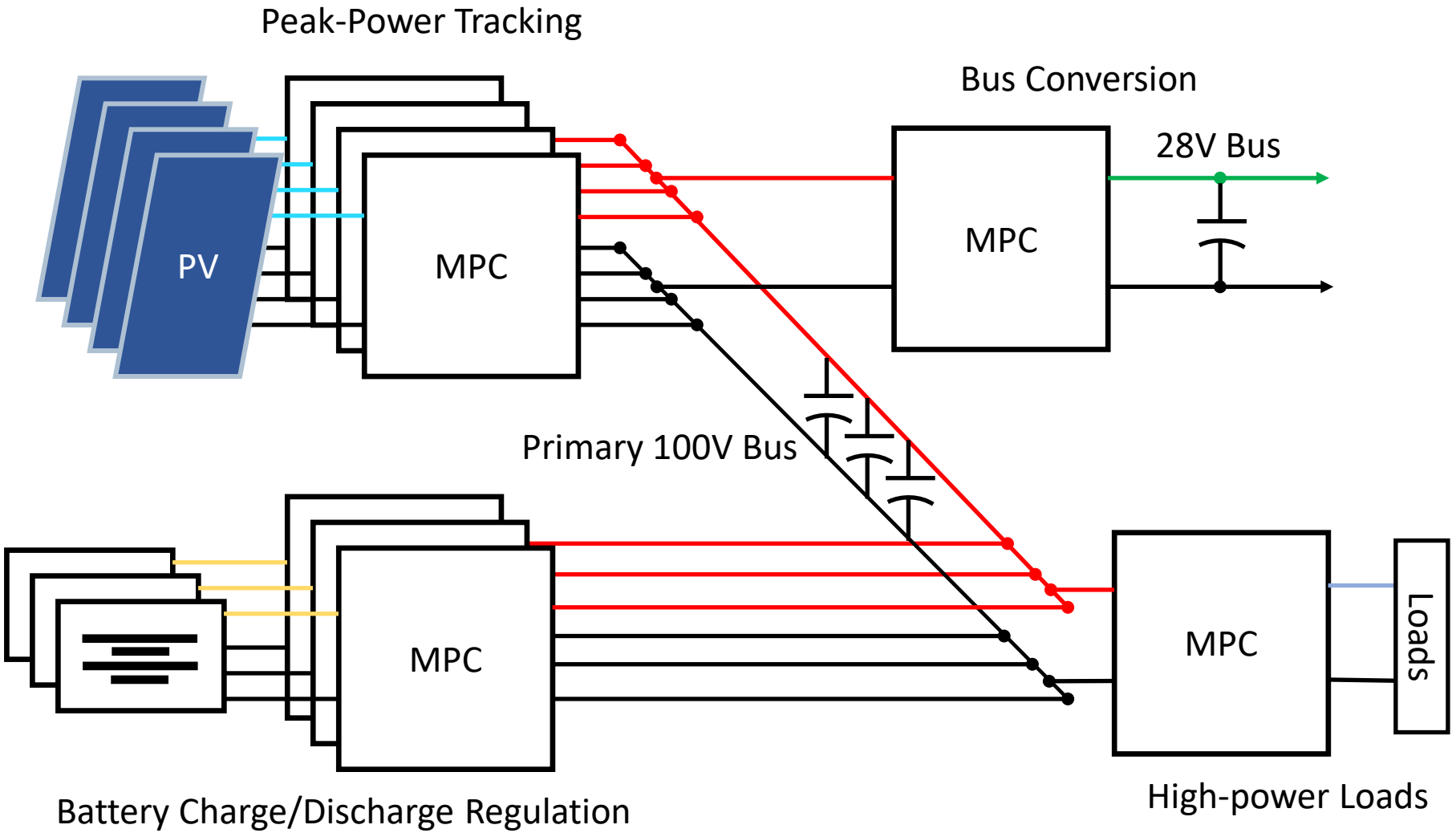
Modular Power Converter (MPC)

- Ibeos has developed a non-isolated buck-boost converter module for bus power conversion
  - 20-130V input
  - 20-130V output
  - Step-up/Step-down operation
  - 500W rated power
  - Peak efficiency >98%
  - 400W/in^3 power density
  - Parallel operation allows > 10 kW system power
  - Radiation hardened to ≥100 krad TID, 80MeV-cm^2 /mg

MPC Applications

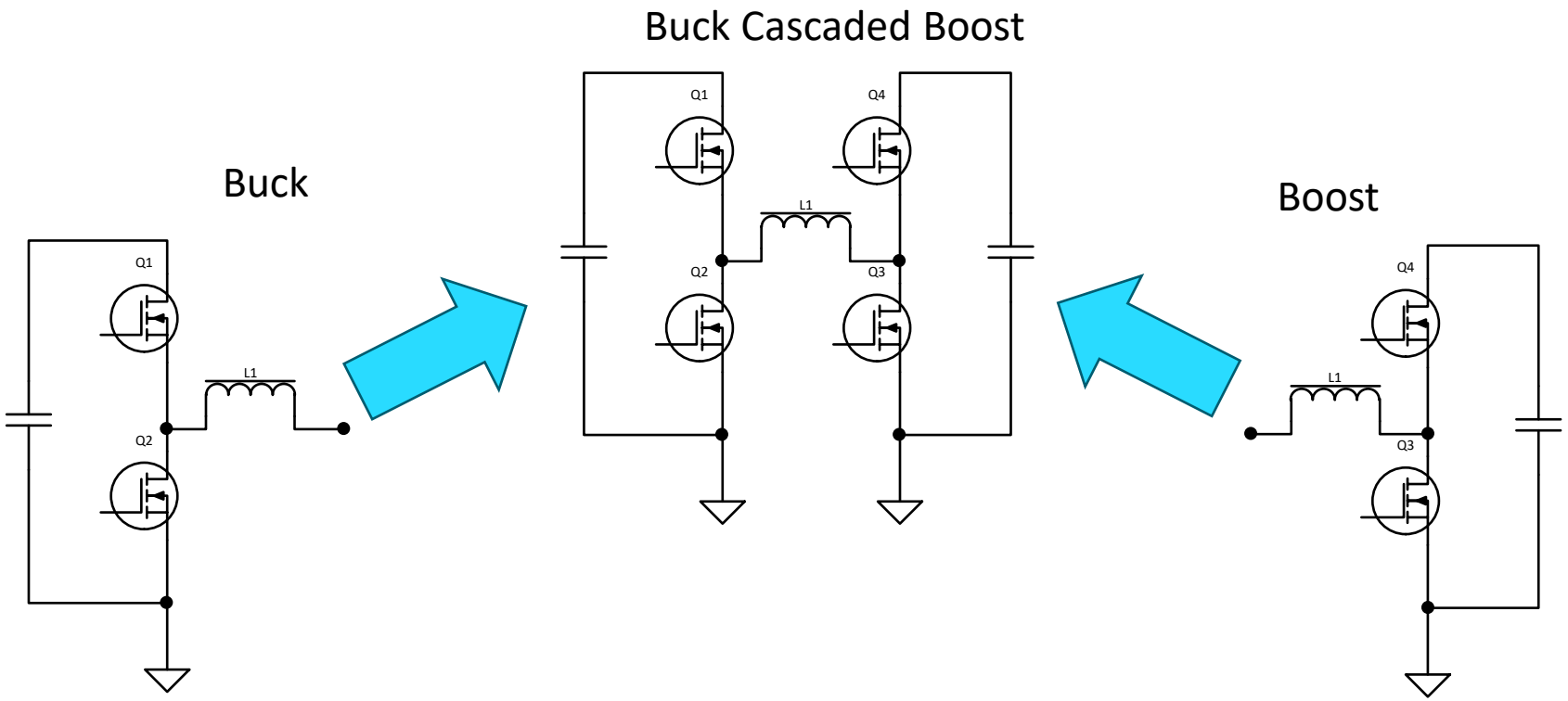
- High module efficiency due to GaN devices allows for general use of MPC
  - Solar Array Peak-Power-Tracker
  - Battery Charge/Discharge Regulators
  - Bus Converter
- Higher efficiency yields higher power density
- Modules can be paralleled to increase power capability
- Carrier cards can be standardized to allow for scalable-power designs
  - Add or remove MPCs as necessary

MPC Enables Scalable Systems



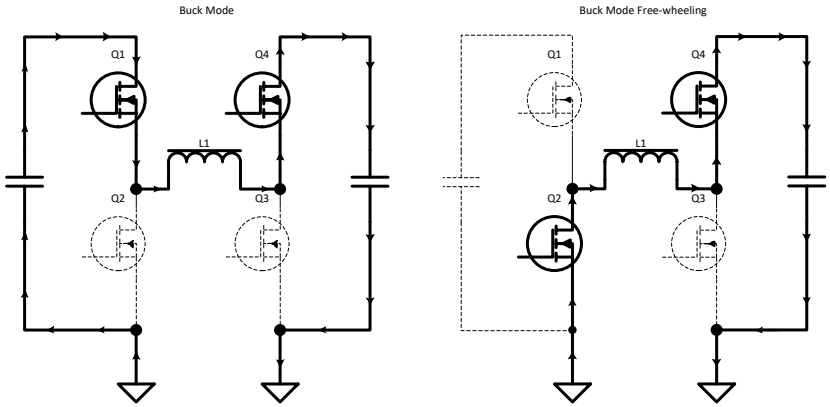
MPC Architecture

- Modular Power Converter (MPC) consists of Gallium-Nitride (GaN) based Buck-and-Boost converters
  - Only one power stage is switching at a time
  - Complementary stage held in a “pass” configuration
  - Common Inductor is used for both power stages

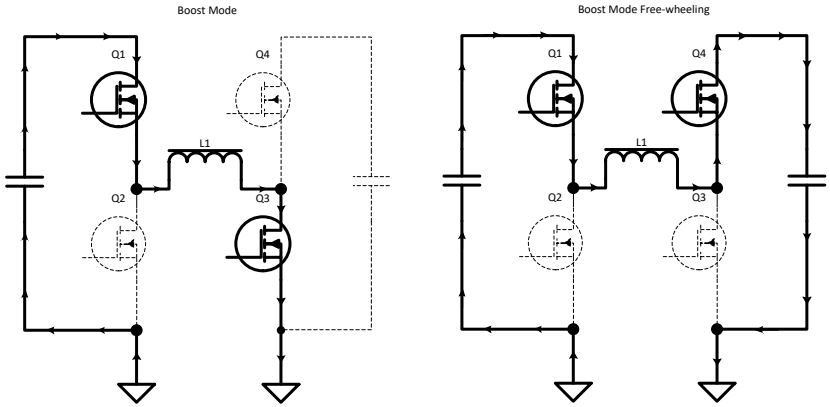


MPC Operation

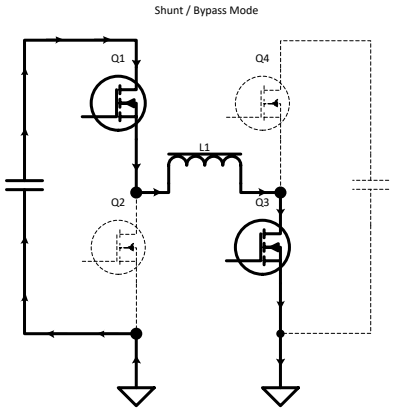
- Buck mode operation



- Boost mode operation

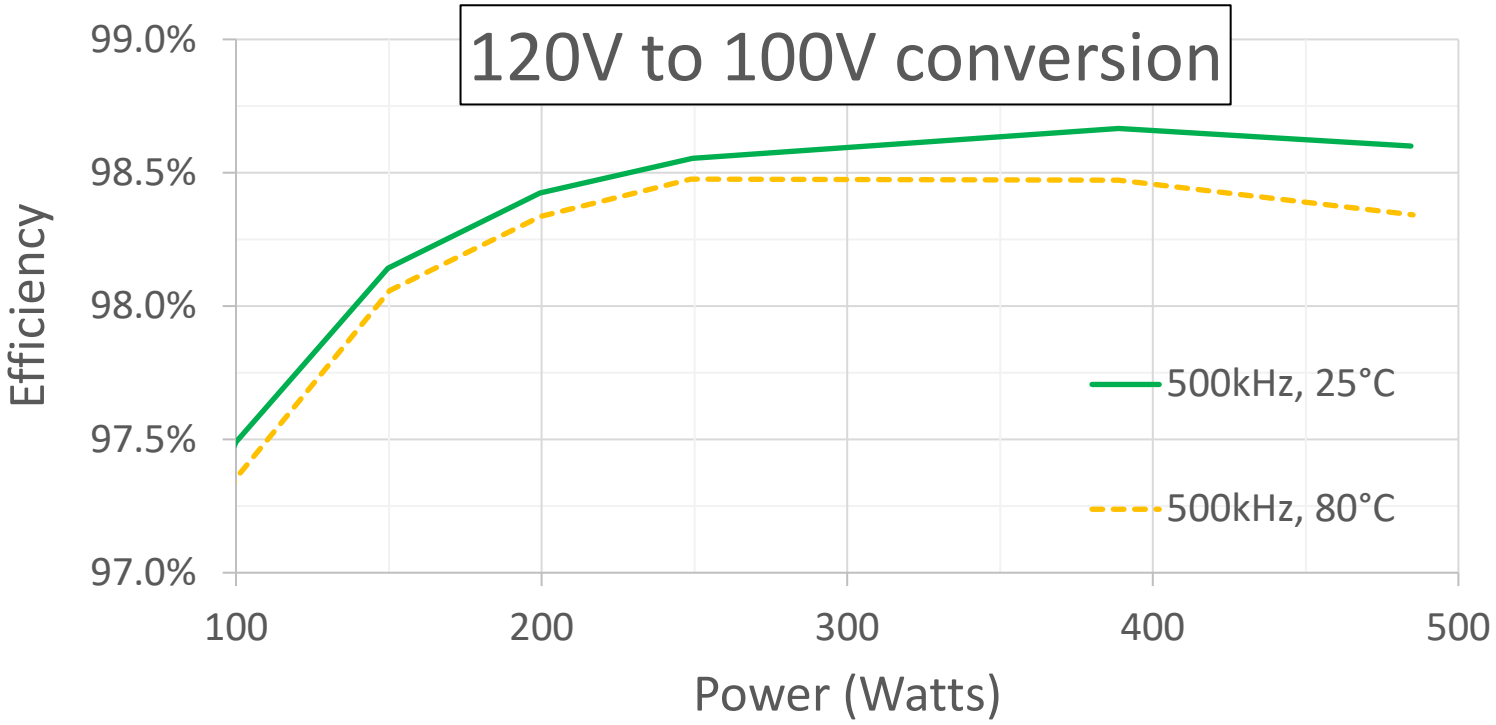


- Bypass / Shunt mode



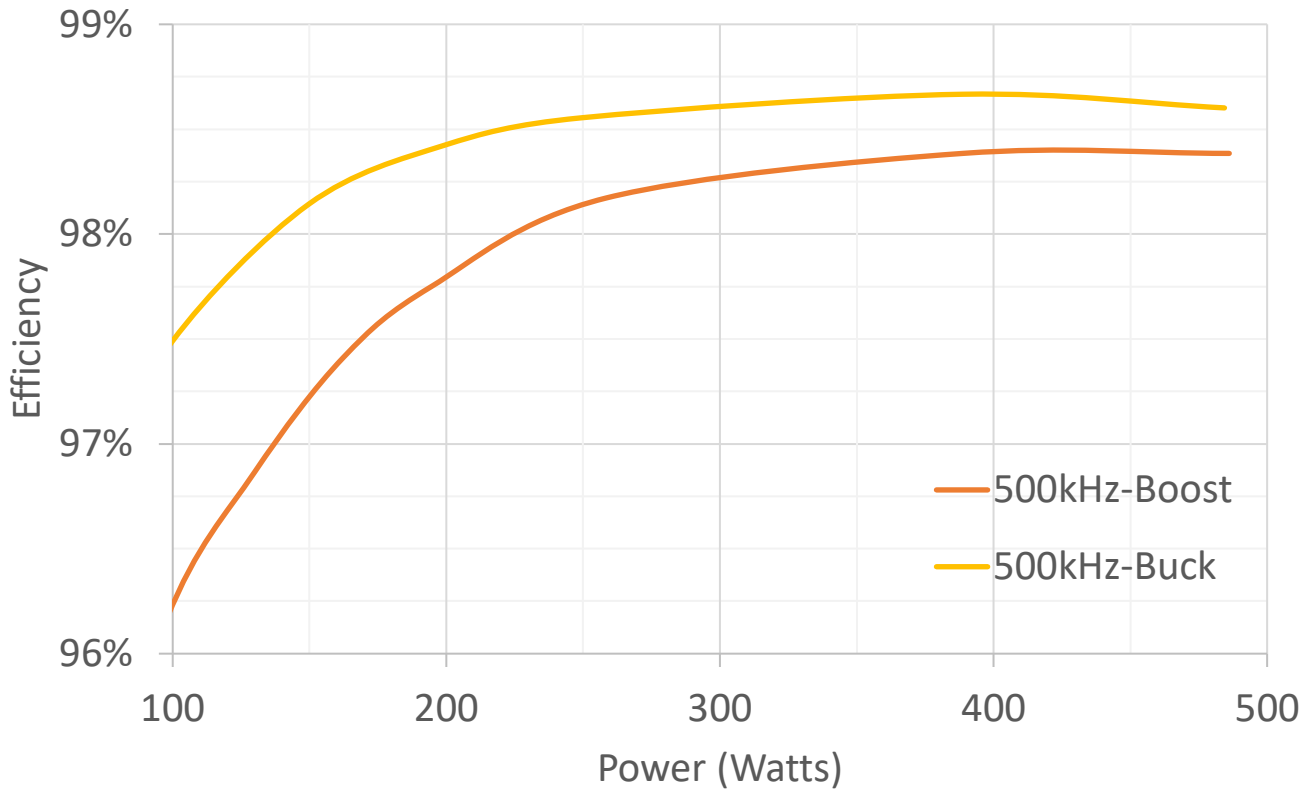
S/A to 100V Bus MPC Efficiency

- Buck-mode measured efficiency from $120V_{in}$ to $100V_{out}$
- 98.7% Peak efficiency @ 400W
- > 98% Efficiency from 30% to 100% load
- Only 0.25% drop in efficiency when increasing thermal-interface temperature from 25°C to 80°C



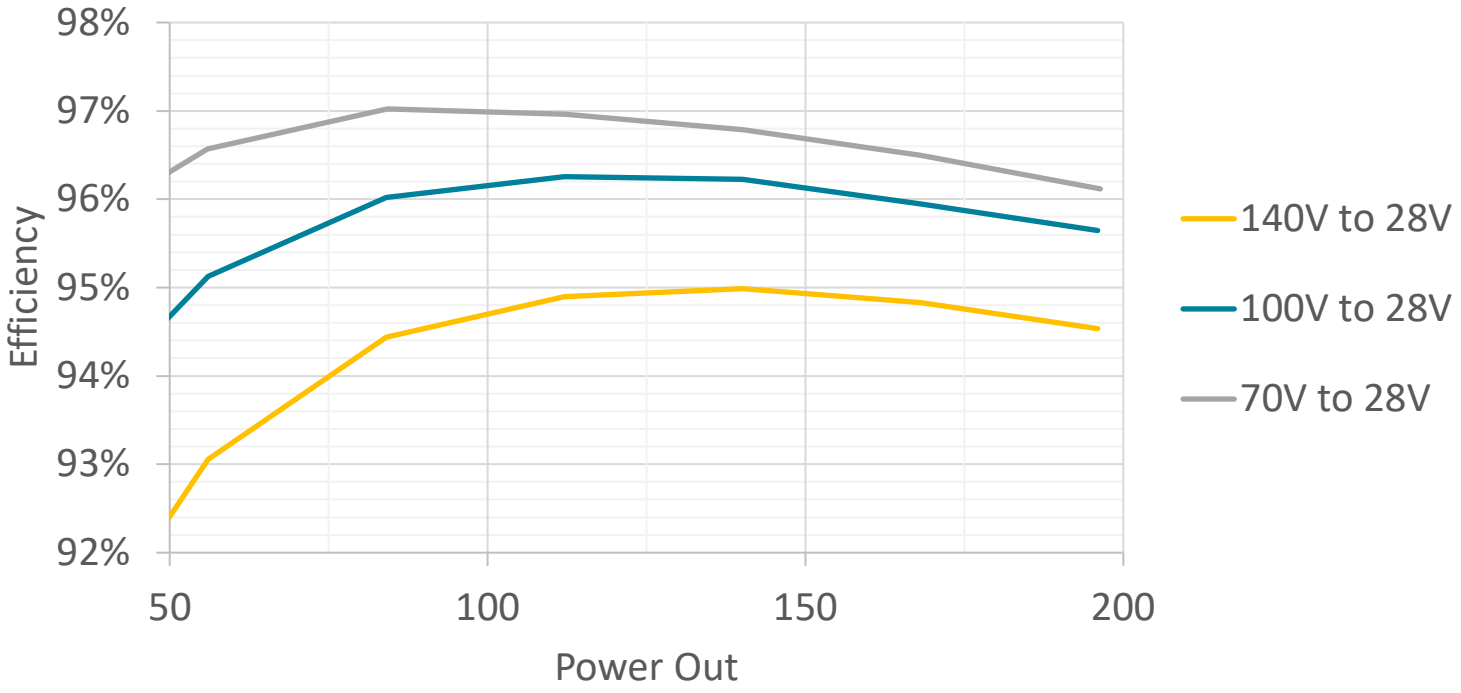
Buck / Boost Efficiency

- Buck-mode measured efficiency from $130V_{in}$ to $100V_{out}$
- Boost-mode measured efficiency from $100V_{in}$ to $130V_{out}$
  - For the same input/output voltages, boost-mode is slightly lower efficiency because of increased RMS current



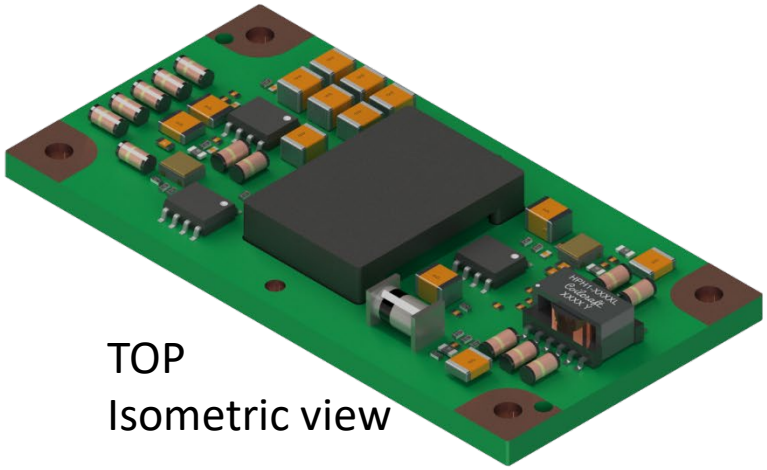
28V Bus MPC Efficiency

- High-efficiency over wide range of operating conditions with a single converter module
- Power handling limited by current-rating of GaN device at low voltage
- Efficiency & power-handling at lower voltages can be improved with optimized part selection
  - Tested configuration optimized for 100V output

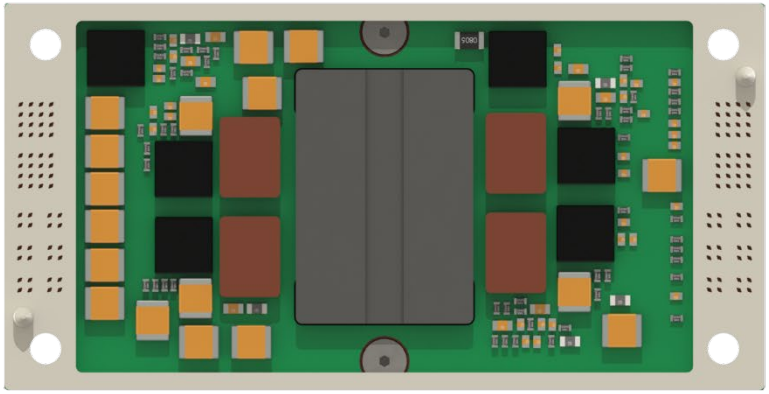


Module Design

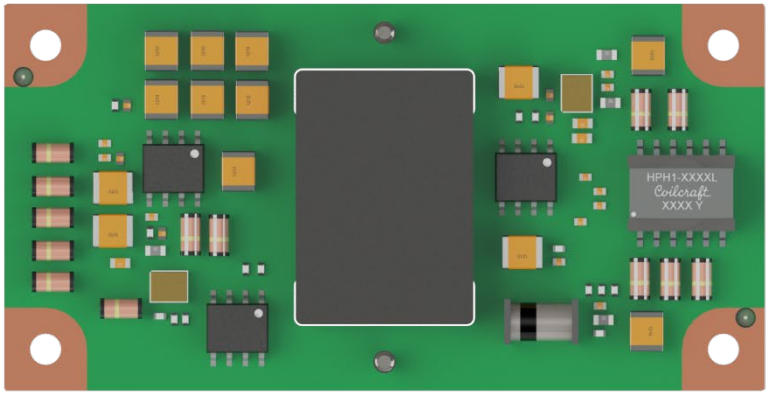
- Integrated Planar Magnetic
- Integrated heat spreaders for thermal management
- Interposer for low-impedance connection to carrier card
  - Facilitates scalability – modules can be added & removed easily
  - Solderless assembly



TOP
Isometric view



BOTTOM

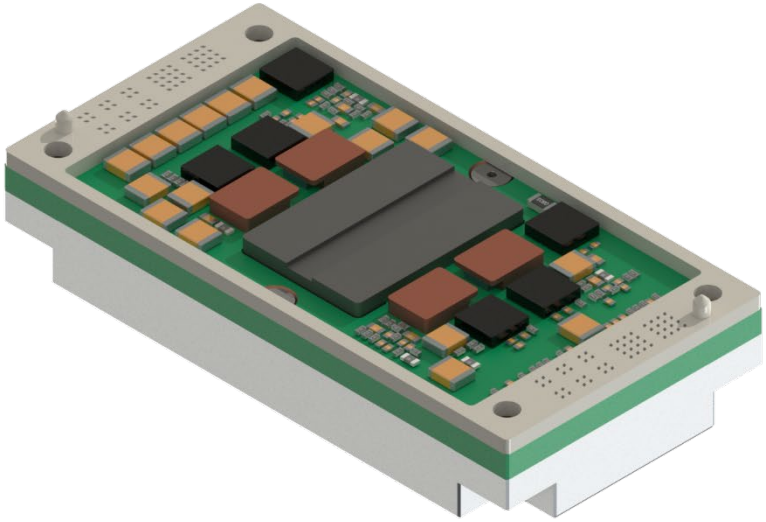


TOP

Packaging and Interposer

- Top-side aluminum acts as heatspreader and stiffener
- Bottom-side interposer has integrated alignment pins and electrical contacts

Top with Heat spreader



Bottom with Interposer

- Thermal-interface from bottom-side to carrier board accomplished with standard insulating thermal-interface pads

Next Steps

- 100V Unit Qualification Scheduled for 2021 Q2
- 100V Engineering/Flight Units Available for Order 2021 Q3
- 28V Design in Roadmap for Q3/4 2021
  - 300W target module power