

A Grand Challenge for Power Electronics: Cheap, Efficient, and Ubiquitous Photovoltaics

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September 13th 2016



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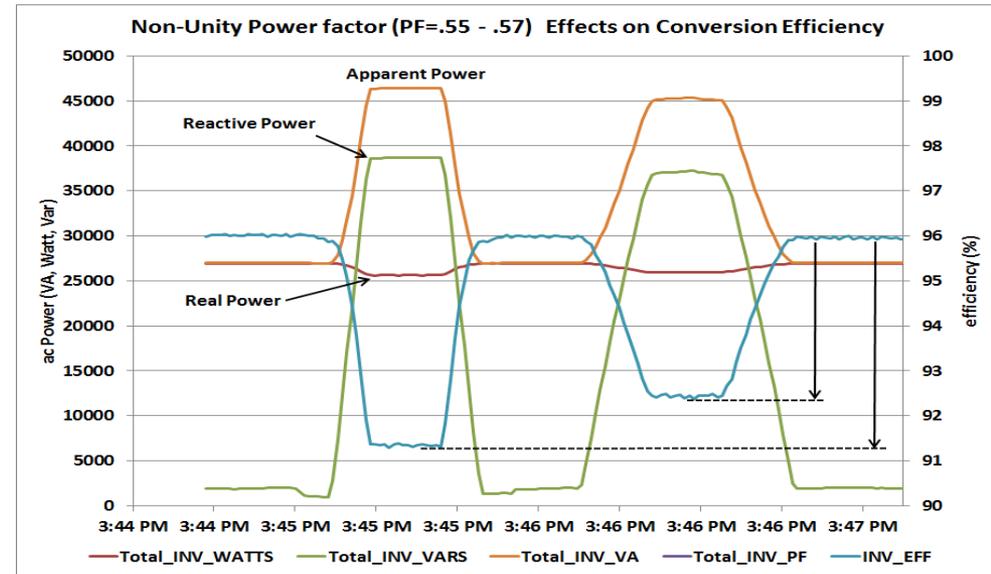
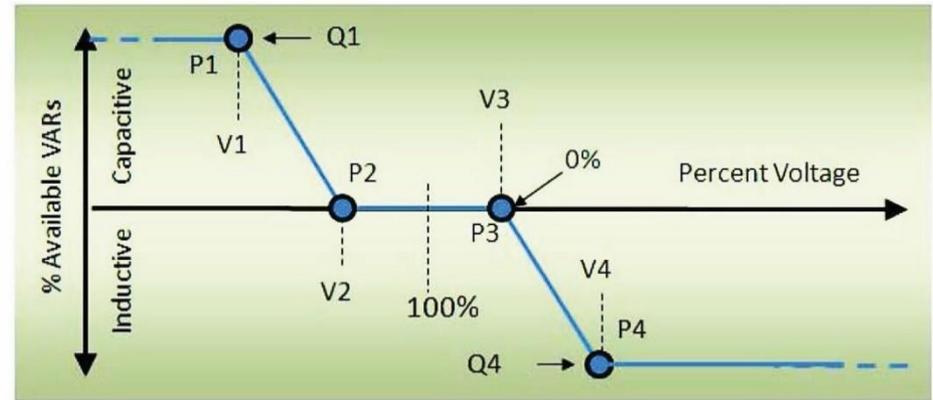
Objectives

- **The DOE SunShot Grand Challenge for Power Electronics ...**
 - <\$0.10/Watt installed cost for Power Electronic converter
 - <\$0.06/kWh levelized cost of electricity (LCOE)
 - PE power density >100 W/in³
 - PE and cabling >98% efficiency as measured using modified California Energy Commission (CEC) weighted efficiency criteria
 - 25-year lifetime (lifetime expected value using lifetime models)
 - IEEE 1547 compliance which includes active controls to provide “grid support”
- **Earliest Impact will be seen in states like Hawaii**

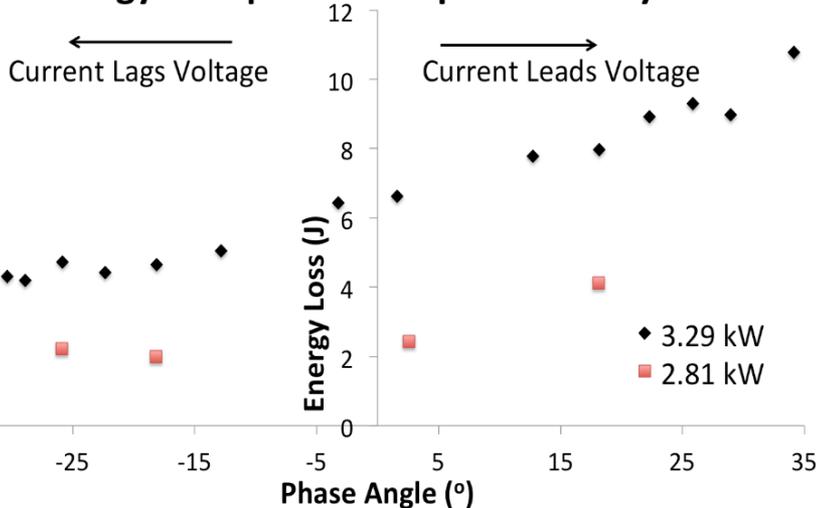


These are Challenging Goals

- These goals pose challenges in themselves but are also contra-indicated ...
- Consider the Volt-VAR Function and its effect on efficiency



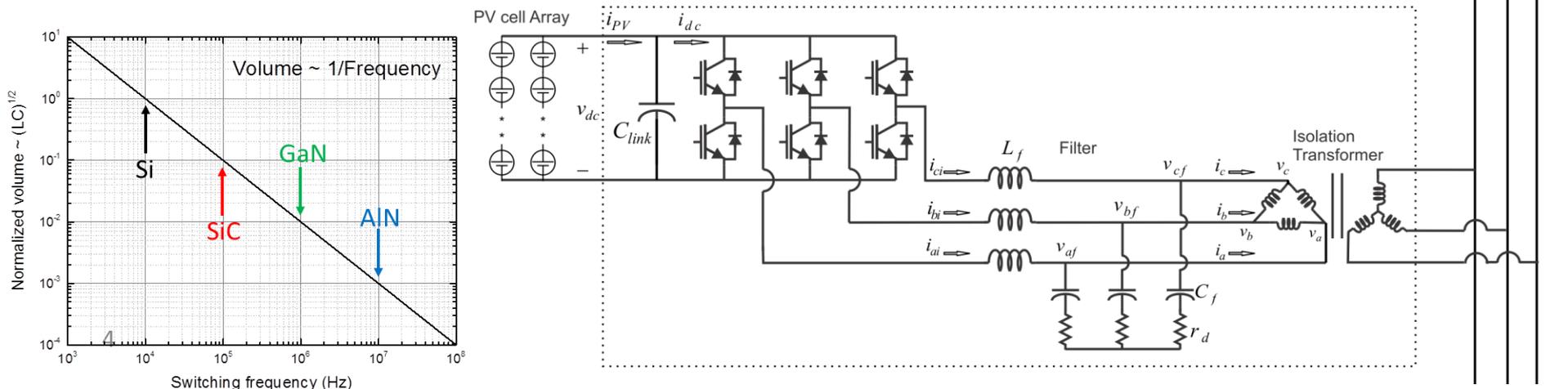
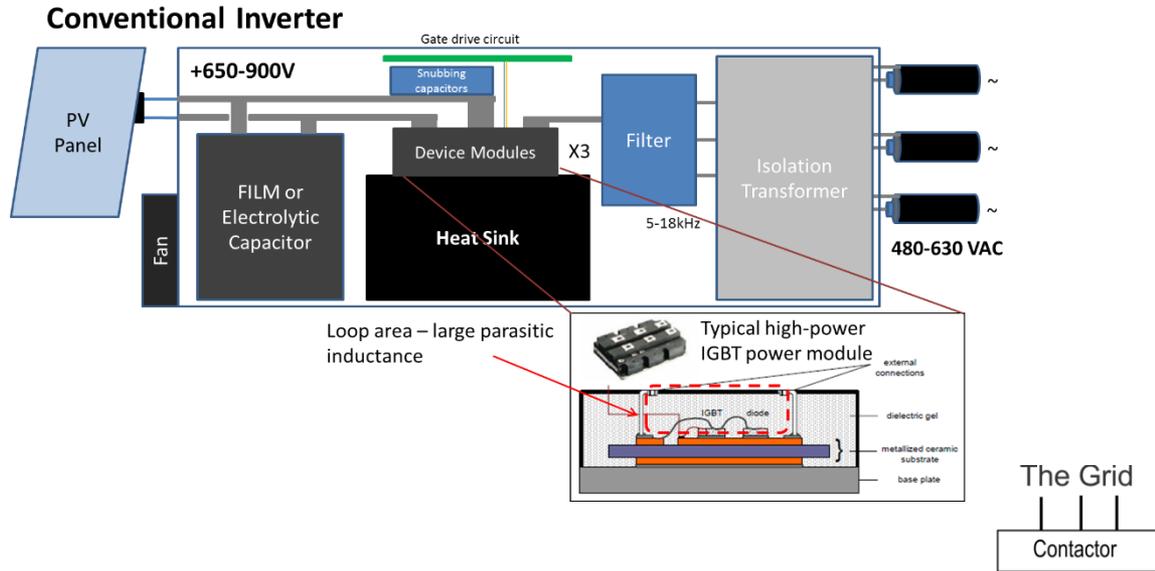
Energy Loss per Switch per 16 ms Cycle



Gonzalez, S.; Neely, J.; Ropp, M.; "Effect of Non-unity Power Factor Operation in Photovoltaic Inverters Employing Grid Support Functions"; IEEE Photovoltaics Specialists Conference (PVSC 2014); Denver, Colorado; 8-13, June 2014.

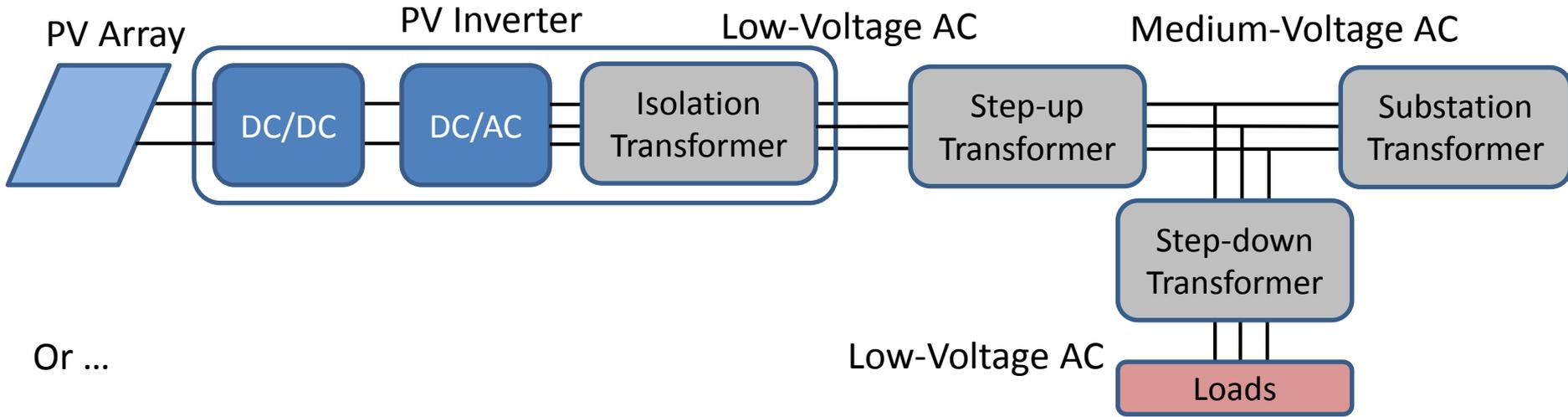
Can we Solve the Challenges with WBG Devices?

- We expect WBG devices will reduce converter size and cost and improve efficiency
- Keeping with existing topologies is one option
- WBG devices should provide a size/cost/loss reductions in key components

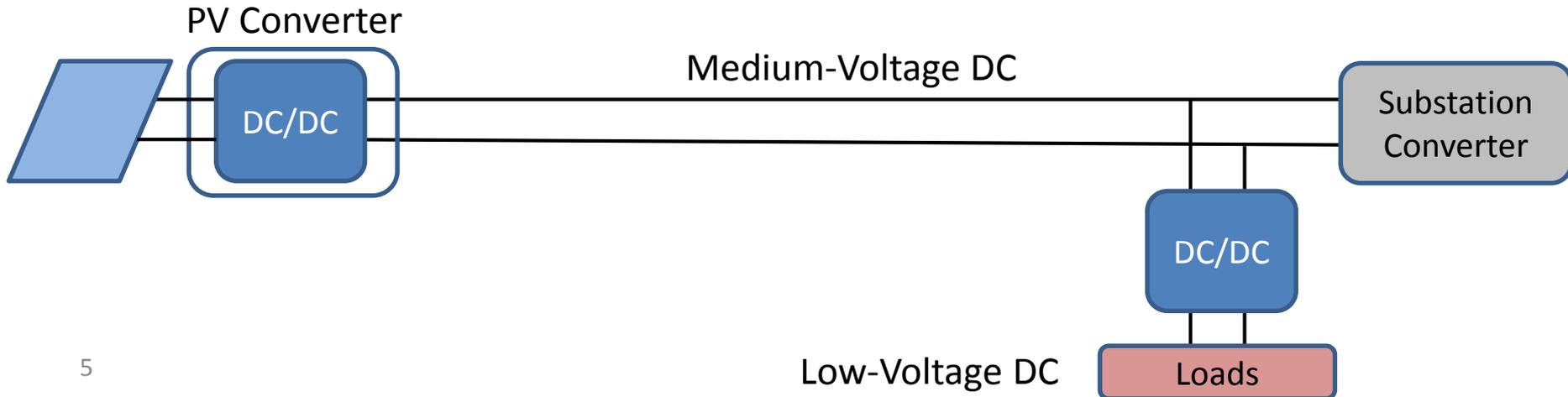


We may also consider new architectures altogether ...

– At Grid Scale, there are a couple directions to go ...

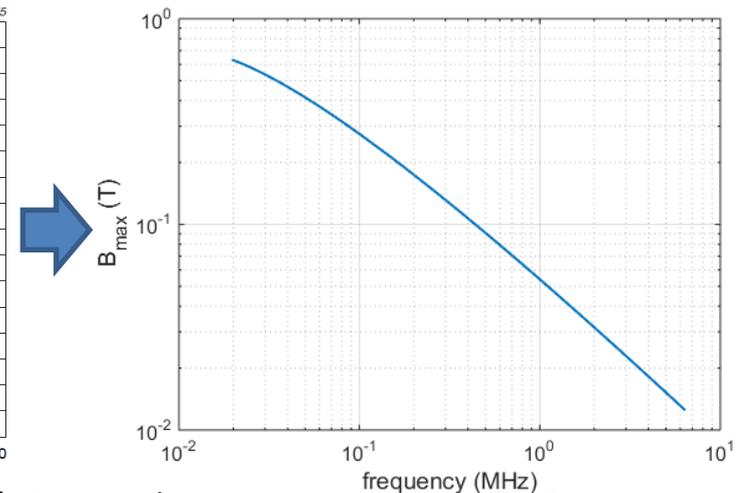
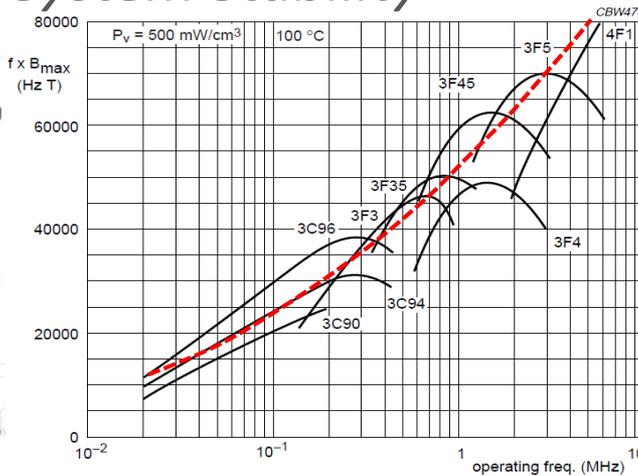
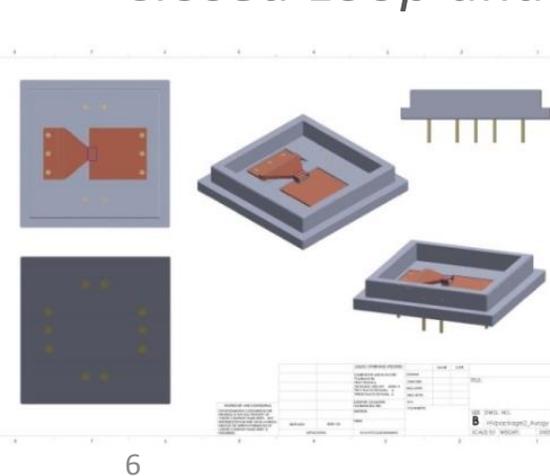
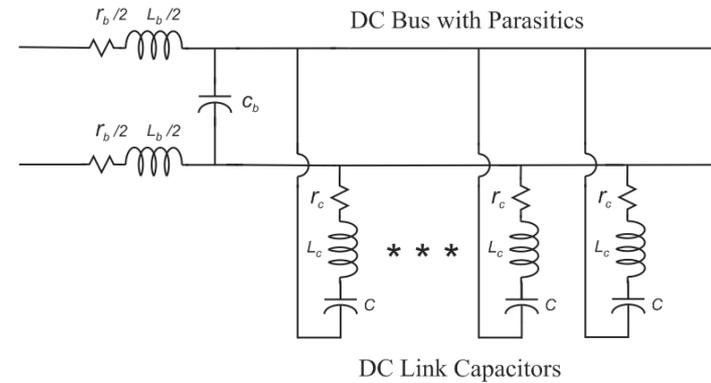


Or ...



Some Component Considerations ...

- Can we achieve the voltage we need in GaN Transistors
- As wide bandgap materials enable higher voltage, higher frequency, higher temp, can the balance of the system (BoS) perform ?
- *Package / Module parasitics*
- *Package / Module thermal management*
- *High Frequency Magnetic Materials*
- *Capacitor parasitics*
- *Closed Loop and System Stability*



“Soft Ferrites and Accessories, Data Handbook”; Ferroxcube, A Yageo company 2013

Summary...

- **Aggressive goals for PV Demand Improvements to Power Electronic Design**
- **One approach is to improve existing topologies through incorporation of WBG devices, but the BoS must be improved also**
- **Greatest benefit is gained if the utilities can “meet us half way” through adoption of simpler grid topologies**
- **DC only power conversion systems offer flexibility for creative solutions**
- **High-frequency switching may still cause more challenges down the road**