Partnership

• 谢谢 CPSS-PSMA Workshop
Power Sources Manufacturers’ Association

- Promotes the interests of the Power Electronics industry
- Sponsors conferences, workshops, research
- On-line industry standards database
- Power Technology Roadmap (PTR)
- PSMA is 35 years old in 2019
- Congratulations to CPSS for 35 years in 2018!
Conferences, Workshops
Power Technology Roadmap (PTR)

• Guidance on
  • Product metrics
  • Technology
  • Applications
  ...for the next 3-5 years

• 17 presentations from industry on trends, new technologies

• Industry commentary on product applications and component technology

• Started 1994, now every 2 years. 2019 = 670 pages

• Based on surveys of PSMA & CPSS members - 謝謝
  • Metrics include cost, efficiency, power conversion density
  • Drivers and barriers to change are identified
Roadmap:
Application Trends

• Automotive / Electric Vehicle
• Battery Charging
• Data Center and Cloud Computing
• Energy Harvesting
• LED Lighting
• Variable Speed Motor Trends in HVAC and Appliance
• Renewable Energy / Grid Storage
• Safety and Compliance
Roadmap: Component Technologies

- Prismatic Aluminum Electrolytic Technology
- The Future of Magnetics
- Low Voltage MOSFETs
- Silicon Super Junction MOSFETs
- Isolated Gate Drivers
- SiC Diodes and MOSFETs Overview
- GaN Devices and Integrated Circuits
- Packaging in High Power
- First-Time-Right Discrete Power Electronic Design
Power Supply & Converter Trends

• AC-DC Front-End Power Supplies
• AC-DC External Power Supplies
• Isolated DC-DC Converters
• Non-Isolated DC-DC Converters
• Power Supply on a Chip (PSiP)
• Power Supply on a Chip (PwrSoC)
• A Subsection of Non-Isolated DC-DC Converters

• Note: % = number of designs (not production quantity)
AC-DC Front-End Power Supplies (200-2,000W)

• Market: “Efficiency!” → “Power Density!”
  • Platinum → Titanium...? Cost?

• HVDC input
  • 2019 = 9% → 2021 = 16%

• Bridgeless Topologies (AC/PFC)
  • 2019 = 11% → 2021 = 24%

• Wide Band Gap
  • Big Increase in SiC, GaN
  • Reduction in Si FETs, IGBTs

• Digital, digital, digital control
AC-DC External Power Supplies

• Market:
  • USB-A and custom connector $\rightarrow$ USB-C, USB-PD/PPS
  • Bigger phone batteries (and 5G) $\rightarrow$ higher power chargers
  • “One-for-all” & more 2-/3-output chargers

• Efficiency up, Power Density up
  • 2x smaller, 2x lighter

• Topology, Frequency
  • CrCM PFC (BLB?), QRF, ACF, LLC, buck...
  • 65 kHz – 600 kHz
  • Bobbin $\rightarrow$ planar transformer

• Wide Band Gap
  • Si $\rightarrow$ GaN
  • Aftermarket $\rightarrow$ In-box
Isolated DC-DC Converters

- Full brick $\rightarrow$ half $\rightarrow$ quarter $\rightarrow$ custom?
- More ‘narrow’ $48V_{IN}$ (2019 = 12% $\rightarrow$ 2023 = 21%)
- More HVDC (26% $\rightarrow$ 30%)
- 150 kHz $\rightarrow$ 500 kHz $\rightarrow$ 1 MHz
- Wide Band Gap (primary switch)
  - Si 2019 = 70% $\rightarrow$ 2021 = 26%
  - GaN 2019 = 4% $\rightarrow$ 2021 = 54%
Non-Isolated DC-DC Converters

- Load V down ~25 mV / year, but A & W up 10% / year
  - 1.2 V to stay ~25%, also 1.8 V for Intel (FIVR on-board regulators)
  - Others moving from ~1 V to ~0.6 V<sub>OUT</sub>
- Focus was power density, EMI, noise
  - now power density, transient response & heat (efficiency)
- 12 V<sub>IN</sub> → 48 V<sub>IN</sub> (high-end server, automotive)
- Very slow Si → GaN conversion (cost)
- PSiP (Power Supply in Package (<=1 in<sup>3</sup>, include L, C)
  - Most ~12 V<sub>IN</sub>, 3-10 A<sub>OUT</sub> can be 100 A (1.2 V)
  - Focus power density, easy-to-use
- PwrSoC (Power Supply on Chip)
  - Embedded L, C (e.g. FIVR, iVRM)
  - Early research into GaN integration
“The Research Lab Today Holds The Future’s New Products”
International University Research

25 universities invited to participate, 13 responded

Special thanks
## Responding University Data

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Most Common Research Areas

• Renewable energy related power electronics
  • Converters for solar, wind and energy storage
  • AC and DC microgrids: systems, converters, controls

• Electrification of transportation
  • Converters for electric vehicle drive systems
  • Battery chargers and battery management systems
  • Power electronics for aerospace & marine applications

• Application of wide bandgap devices (SiC, GaN)
  • Medium voltage converters incl. motor drives and solid-state transformers

• Advanced packaging and integration
  • High power modules
  • Power Supply on Chip (PwrSoC)
  • Power Supply in Package (PSiP)
  • Integration of power devices with drivers and control

• Drivers: “Follow the money”
• Most government-funded, focus:
  • Climate change
  • Economic, industrial competitiveness
  • Emphasis on electric transportation and renewable energy
Least Common

• Wide band gap devices
• MHz+ converters
• Switched capacitor converters
• Robotics
• Server/data center power
• Digital power (0)

Unique Topics

• Ohio State
  • Converters, motor drives operating at the high end of medium voltage (69 kV)
• ETH Zurich
  • Automating the design process (optimize vs. efficiency, power conversion density, initial cost, and life cycle cost)
• University of Texas – Austin
  • Gallium oxide (GaO) power semis for very HV switching devices
Industrial Sponsorship Of Research is Small

- Power supply companies are ahead of academia
- Difference in research goals
  - Academia: publications
  - Industry: ready-to-manufacture product / revenue
- Conflict over IP (including patents)
  - Universities: “we thought it up, we own it”
  - Industry: “we paid for it, we own it”

The differences can be resolved but each side has to give something
Thank you,