Semiconductor Technologies for High Power Applications

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Low Power vs. High Power Applications

Thermal Requirements





- Computing, Consumer, Telecom
- Ac-Dc or Dc-Dc (some Dc-Ac)
- Short development time
- Cost, Efficiency, Reliability
- >1-2 % efficiency improvement worth the effort
- "Low Profile"

Low-Medium Power (<~2 kW)



High Power (> ~5 kW)

- Industrial, Automotive
- Dc-Ac or Dc-Dc
- Long development time



- Reliability, Efficiency, Cost
- >0.1-0.2% efficiency improvement worth the effort
- "High Profile"











We need more power!

- 300M photos uploaded each day
- 300 hours uploaded every minute
- 10B hours watched per month

- More data movement = more power
- Faster processing = more power
- Same/smaller space = higher power density

"Ten years ago, average power draw per cabinet was probably 700 to 800 watts," said Jason Black, VP of data center services at Cosentry. "Five years ago, it was 1.5 kW. Now, 3 kW. On current trend, we'll see five or six kilowatt average power draw in five years."













Automotive Growth





- Electrified, Autonomous, and Shared
 - Implications for power electronics Electrification solutions and adopting Changing reliability







EV Charging Power Content







Dramatic Increases in Power Semiconductor Content



中 玉 田





平房常压热水锅炉

Standards Driving a Surge in Semiconductor Content



A Power Technology Roadman

Government Regulation Timeline



Power Device Technology Positioning



IGBT Technologies Evolution



IGBT at 750V and 1200V IGBTs are most suited for drivetrain electrification at its current development stage

Higher Power in development

Field Stop IGBT Features & Performance

- Low conduction and switching losses
- Positive temperature coefficient for easy parallel operation
- Maximum junction temperature : Tj = 175°C
- Tight parameter distribution
- Large SOA (Safe Operating Area)







IGBT Technology for Safe Operations

The IGBT Triangle Trade-off Relationships E_{off} On-state Turn-off Power Voltage Loss Efficiency Drop Gen.1 V_{ce-sat} Gen.2 Reliable Rugged-Operation ness **1** 50

- Technology evolution = moving towards the trade-off chart origin
- Technology optimization = application specific tuning
- Technology Trend (in Auto) = Gain performance but maintain system ruggedness in short circuit and latch-up performance







IGBT Innovation Through Package

• Benefits of Integrated Power Modules

- Increase Integration
- Reduces footprint
- Lower stray inductance
- Minimize switching losses
- Better Thermal
- Improve reliability
- Simplifies assembly
- Easy control with reference driver board
- Smart IGBT features
 - On die or on board current sense
 - Over-current detection with soft-shutdown
 - Under-voltage lockout
 - Temperature sense for safe operations
- Other Automotive modules in development
 - Optimized cooling with innovative modules



Automotive High Power Half Bridge Module



Three Phase Motor Control Power Module



Traction Inverter Market Trend

- Traction inverter has an aggressive cost cutting roadmap
 - Cut \$/kW
 - $\circ~$ Cut weight
 - \circ Cut volume
- To meet market demand, ON Semiconductor is determined to:
 - Develop innovative module packaging with high performance thermal solution
 - Utilize its **best in class silicon** technologies
 - Provide comprehensive reference designs
 - Offer high reliability automotive qualified products







EV PIMs Power Module Platforms



TECHNOLOGY EVOLUTION







Automotive Expectations for Reliability

- Design-in Quality/Reliability
 - Not limited to component reliability testing. Requirements from development through and past End-of-Life



- High Performance Electronics
 - System integration on package level
 - System in Package (SiP)
 - Higher integration/Multichip Modules
 - Power Integrated Modules (PIM)
 - Intelligent Power Modules (IPM)
 - Automotive Power Modules (APM/AHPM)





Approach to Provide Better Value to Customers



中国电源

CHINA POWER SUPPLY SOC



Industrial Modules for Solar Applications

- Distributed systems (80-150 kW) gaining acceptance
- 1500V solar panels => 950/1000V IGBT nodes
- Multi-level topologies for higher efficiency
- Fast switching IGBTs & Unique topologies => Easier with modules
- Hybrid or Full WBG modules on horizon









Key Package Platforms

Transfer Molded Power Integrated Module (TMPIM)

• TMPIM: transfer molded module for medium power application





Features

Transfer molded

- Robust
- Corrosion resistant
- DBC substrate
 - Low thermal resistance
- Leadframe with pin selective removable
 - Design flexible
- No IC integration
 - Cost effective







Summary: Market/Application Trends







田

CHINA POWER SUPPLY

中国

Trends

- High performance EVs
- Fast Charging (High voltage)

- High Power (>200 kW) Traction/OBC
- China labor shortages
- MFG in high cost regions (Tariffs)
- Automation, Robotics (Servo motors)
- Alt Energy + storage (个 ROI)
- Fast Charging (Hi-pwr EVC)
- Higher Data center PUEs (High Eff UPS)
- High power Custom PIMs

Scalable DSC Module (100kW – 200kW – 350kW)



Integrated Power Modules (IPM)



Application Specific PIMs



ON Semiconductor



Thank You



Questions?



