Increased Power Density Through Capacitive Conversion

Revolution Enabled

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Presenter Bio

• President and CEO of Smart Prong Technologies, Inc. (dba Helix Semiconductors)

• 15 Years Consulting to Tier 1 Chip & Technology Companies, former CEO of multiple high tech companies

• Company perfected switched-capacitor power-transfer techniques for highest efficiency with > 40 Patents
Three Key Messages

- Power Density is King
- Capacitive Voltage Conversion is Real
- Capacitive Isolation Devices Approved
The Problem

Ubiquitous Use of Electronics Demands More Power

Demand for More Power Cries Out for Improved Efficiency

• Transformers have been in use for > 100 years

• What is Next? More of the same?

Increasing Power Density and High Conversion Efficiency

and Transformers are Contradictions in Terms!
Power Density – 5-10X Better

Benchmark Module
PD = 0.5W/cm³ to 1W/cm³

Switched Cap Module Example
PD = Up to 7W/cm³
Revolution – Step 1

• **Basic Switched-Capacitor Topology**
  • Single or Multiple Stages
  • Multiple Gain/Conversion Ratios

*Capacitors lay the foundation for true Revolution!!*
Voltage Conversion

• Capacitors and Switches Scale the Input Voltage for Best Efficiency

• Optimized Switching Frequencies - reduced clock rates possible

• Advantages over Inductive Converters
  • High efficiency – full load to no-Load/light-load
  • Low Static Power ➔ Lowest No-Load (“Vampire”) Power ➔ Zero Power
Enhanced Efficiency

• Highest system efficiency across varying loads, especially light load and no load
Isolation – The Final Frontier!

**Galvanic Isolation** – “I wish I could eliminate transformers, but it’s always been done that way?”

- **Who** - UL, IEC, ANSI, others
- **What** - isolate human and other sensitive electronics from transients
- **Why** - User safety, system reliability

*Traditional Method – transformer and optical isolation*
Revolution – Step 2

**Capacitive Isolation**

- What are the barriers and why are companies slow to adopt?
- UL has cleared the way
- It takes a revolutionary leader to make it happen!
Relevant UL / IEC Standards

• **IEC 60950 – Safety of Information Technology Equipment**
  • Summarizes use of $X^2$, $Y^3$ Capacitors in the application

• **IEC 60384-14 – Fixed Capacitor Standard**
  • Summarizes use of $X^1$, $Y^2$ Capacitors
  • Prescribes preferred Capacitor ratings / specifications

• **UL 1283 – Electromagnetic Interference Filters**
Approved and Certified

- **Class X²** - across the AC Line, tested to 2500V

- **Class Y²** - Power Transfer or Grounded Capacitors, tested to 5000V - designed to fail ‘open’ instead of ‘short’

- **UL-Certified Y² Capacitors Available Today**
  - ≤ 2nF meet Touch Current and Creepage Requirements
Meeting UL Isolation Requirements

“The Isolation Transformer Can Be Replaced With Capacitors”

• UL-Certified Y² Capacitors Must Bridge the Isolation Barrier
• A Touch Current Limit of 250µA will not be exceeded for a UL-Certified capacitor
• The capacitor must have 4mm of Creepage distance

“Two Capacitors in Series Required to Meet 5kV”

• The NovaCap P/N ES2215 1nF Y² Capacitor meets all the UL requirements for Touch Current and Creepage
• The UL Report – Ref. #3146C527792926 documents these findings
Power Module Using $Y^2$ Cap

- AC Input
- Isolation Barrier
- $Y^2$ Capacitor
- DC Output
Example Reference Design

- Submitted for UL Review – prelim approval
Conclusion

• Power Density is King

• Capacitive Voltage Conversion is Real

• Capacitive Isolation Devices Approved