Designing High Performance Power Systems
Fast, low risk, method for designing a complete AC-DC system
The importance of time

› Power Systems take fixed time to design; that time can be split among multiple resources (taking less time but requiring more money) or consolidated to a single resource (taking longer)
› Reducing time for free increases risk (e.g. cutting corners)
› Increasing risk leads to lost time if risks do not resolve favorably

\[
\text{时间} = \text{金钱}
\]
Power Systems are complex

- Complicated sources and sophisticated loads yield significant power system complexity
- Many design steps require significant time
  - System design
  - Design verification
  - System verification
  - Safety approvals

Examples of Power System considerations

- Input Source requirements
  - Operating Range
  - Power requirements over line
  - Voltage Surge/Dropout
    - Clamp vs. survive
    - Shut down vs. Ride through
  - EMI Filtering
  - Fusing/Protection
- Battery backup required?
- Negative Impedance (downstream regulators)
- Capacitive or pulsed power loading?
- Peak versus average power required
- Telemetry
  - Requirements
  - Protocol
- Loads
  - Single voltage setpoint or trimmable?
  - Isolated or non-isolated
  - Negative voltage needed?
  - Regulated voltage or regulated current
  - Transient requirements
    - Response time
    - Maximum undershoot/overshoot
  - Load protection requirements
  - Steady state vs. peak power/current requirements
  - Output voltage ripple and noise
  - Startup and sequencing
- Thermals
  - Conduction or fan cooling?
  - Maximum ambient temperature
  - Efficiency; Maximum power dissipation
- Agency Approvals/Standards
  -...
Risk is undesirable

- Cutting corners or skipping steps is unacceptable
- Designing a complex system with minimal risk without adding more time is difficult

<table>
<thead>
<tr>
<th>Potential Issue</th>
<th>Required Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>All system considerations and requirements are met</td>
<td>Need more time to design</td>
</tr>
<tr>
<td>System will meet performance targets</td>
<td>Need more time to analyze</td>
</tr>
<tr>
<td>The system will work</td>
<td>Need more time to qualify</td>
</tr>
</tbody>
</table>
Conventional approach to lowering power system design risk

- **Break it into two parts:**
  - Front end (power supply)
  - Point of load (POL)
- **Reduces complexity by dividing considerations**
- **Saves time by introducing parallel processing**

- **Input Source requirements**
- **Battery backup required?**
- **Negative Impedance (downstream regulators)**
- **Capacitive or pulsed power loading?**
- **Peak versus average power required**
- **Telemetry**
- **Loads**
- **Thermals**
- **Agency Approvals/Standards**
  - ...
But...

- Increases resources required to design the system
- The partitioning of the system becomes a barrier
  - Different manufacturers
  - Different designers
- Adds complexity by introducing a new point of interface
- Still does not reduce the time needed to get safety approvals
- Duplicates some considerations
- Still must pay to reduce risk

Front End
- Input Source requirements
- Battery backup required?
- Negative Impedance (downstream regulators)
- Capacitive or pulsed power loading?
- Peak versus average power required
- Telemetry
- Thermals
- Agency Approvals/Standards

Point of Load
- Loads
- Telemetry
- Thermals
- Agency Approvals/Standards

Interface between partitions must be engineered

Duplicated design considerations
What’s needed

› **Save time without increasing risk or paying more**
  – Typical system prototype time is 6 weeks
  – Typical system design time is 6-9 months (2-3 months for safety approvals alone)

› **Reduce complexity without adding redundancy**

› **Be able to design a power system with fewer (not more) resources**

Making the power system design process a win-win and not a tradeoff
**Power Component Design Methodology (PCDM)**

A proven approach for timely, low resource, low risk, high performance power systems design

- **The components** (or products) for complete system design
- **The tools** for being able to quickly and effortlessly apply them
- **The support** for being able to insure success - now
Power Component Design Methodology – How does it work?

› Power system is divided into two parts: front end and point of load
› Front end and point of load functions are implemented using power components – modular power converters specifically optimized for a power conversion function
› These components are engineered to interface with each other; yielding infinite flexibility in designing the system
Power Component Methodology Summary

**Front End**
Vicor Power Systems

- Single Phase AC 85 – 264 V
  - AIM
  - PFM
  - 1714 VIA
  - 4414 VIA

- HVDC 260 – 400 V
  - BCM
  - 4414 VIA

- HVDC 160 – 420 V
  - DCM
  - 3714 VIA

**Point of Load**
Vicor Power Components

- PRM
- Full-chip
- V_F
- +5 V, 20 A
- VTM
- Full-chip
- -5 V, 20 A

- Buck-Boost
- LGA SIP
- V_F
- +0.9 V, 200 A
- VTM
- 1323 Chip

- Buck
- LGA SIP
- V_F
- +15 V, 3.3 A
- VTM
- 1323 Chip
- +5 V, 10 A

- ZVS Bucks
- +5 V, 15 A
- +3.3 V, 15 A
- +1 V, 15 A
- +48 V, 10 A

*Breadth of products that support the Power Component Design Methodology*
Vicor Power Systems: Front-End Modules

**VIA PFM AC Front End**
- 85 to 264 V_{AC-IN}
- V_{OUT} = 48 V
- Power = 400 W

**BCM Isolated Fixed Ratio DC-DC Converters**
- 400, 380, 350, 270, 48 V_{IN} nominal
- V_{OUT} = 3 to 50 V
- Power = Up to 1.75 kW per module

**DCM Isolated DC-DC Converters**
- 300 V and 28 V_{IN} nominal
- V_{OUT} = 48, 28, 24, 13.8, 12 and 5 V
- Power = Up to 600 W per module
Vicor Power Components: Point-of-Load Solutions

**Cool-Power ZVS Buck Regulators**
- Best-in-class density and efficiency
- 12 V, 24 V and 48 \( V_{in} \) nominal buck regulators
- LGA and ChiP packaged

**Cool-Power ZVS Buck-Boost Regulators**
- Over 98% efficiency
- 8 \( V_{in} \) - 60 \( V_{in} \) nominal buck-buck regulators
- General purpose and VTM compatible versions
- LGA and ChiP packaged

**VI Chip PRM ZVS Buck-Boost Regulators**
- Regulated, non-isolated buck-boost operation
- 24, 28, 36, 48 \( V_{in} \)
- Up to 98% efficiency
- Up to 250/600 W (parallelable) in half/full VI Chip package

**VI Chip VTM ZVS/ZCS Current Multipliers**
- Fixed-ratio solutions for high current delivery
- Used with PRM and ZVS Buck-Boost products for complete regulated DC-DC converter
- VI Chip and ChiP packaged
Power Component Design Methodology Advantages

› **Products**
  - Lower risk by providing proven interfaces between front end and point of load conversion functions
  - Reduce complexity by providing power conversion building blocks
    › No need to design a power stage – use a power stage
    › Each building block has agency approvals – facilitating the approval of the power system as a whole

› **Tools**

› **Support**
Problem: How to use the Power Component Design Methodology

› Understanding all the options offered by Vicor requires significant effort
  – Thousands of products
  – Dozens of product lines
  – Many terms and three letter acronyms
  – Constantly expanding product offerings

› Saving time in designing a system is not an option if it takes as much if not more time to identify the options for a system

› In order for the PCDM to be a useful, it needs more than just products; it needs tools
Power System Designer: Tools for designing a power system

› Web based tool for generating power systems using PCDM
› Enables a user to view options for power systems based on their requirements and choose an optimal solution based on Vicor products.
› Allows the user to assess key features of each option
  – System Efficiency
  – Power footprint
  – Cost
  – Component Count
Power System Designer: Saves Time

› Takes the place of sifting through datasheets of dozens of Vicor products
› Does not require expert knowledge of Vicor’s topologies, architectures, or many TLA’s
› Performs hundreds of calculations, pulls thousands of data points, draws a complete block diagram, all in a matter of seconds.
› Provides a drawn-to-scale representation of the complete system without the need to consult mechanical drawings or create a CAD file.
Power System Designer: Reduces risk

› Systems are created using proven configurations of components that are engineered to work together
› Systems are created based on user entered requirements – removing the risk of incorrect interpretation of datasheet or design
› Critical performance and mechanical attributes of the system can be known up front
Power System Designer Demo
Support: Save time and reduce risk

› Development kit for physical evaluation of complete power system
  – Power up your system before you start a single board layout
  – Verify your power system performance before starting your design cycle

› FAE support
  – Talk with experts familiar with your power system before they have seen it
  – Get valid feedback on your design without training an expert

› Sample availability
  – Receive samples quickly to be able to rapidly prototype your system
  – Reduce prototyping time by using modules instead of discretes
Power Component Methodology: Save time, reduce risk

› **Products**
  – Complete power conversion components – not discretes
  – Verified, proven, in mass production, widely used elsewhere – not new
  – Safety approvals in place

› **Tools**
  – Design a system without being an expert in all of the product offerings
  – Find the optimal solution in minutes – not days
  – Know that you’ve picked a valid solution – not subject to misinterpretation

› **Support**
  – Use a development kit to physically evaluate your complete system
  – Consult with experts familiar with your system – even if they have never seen it before

Use the Power Component Methodology to cut your risk and design time in half
Thank You!