高功率密度及高效能系統的電源設計解決方案

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高密度功率及高效能系統的電源設計解決方案

- 前端(Front End)/負載點(POL) 電源架構改變趨勢
- 創新拓撲(Topologies)及封裝散熱創新技術介紹
- Vicor PCDM (Power Component Design Methodology) 高功率密度及高效能系統電源模組解決方案介紹
- 成功應用分享
Power Solution Trend
› Wide Input Range and High Input Voltage
› High output Power
› High Efficiency
› Power Density
› Small size
› Low weight, “Power to weight” ratio
› Thermal Dissipation
› Telemetry
EV/ Self-driving EV Power Methodology

- **HVDC 365V**
- **13.8V**
- **+48V**
- **+12V** (Regulated)

- **VIM Chip DC-DC Converter**
- **PRM SiP Regulator**
- **Factorsized Bus (26 – 55 V)**
- **VTM ChiP Current Multiplier**
- **Motors drive…**
- **CPU/GPU/MEM 0.5-2V 50-300 A**
- **12V**
- **5V**
- **3.3V**
- **1.8V~2.5V**
- **3.3V~18V**

- **Charger**
- **HV BAT.**
- **LV BAT.**
- **BMS**
- **Motors Drive**
- **Motors**
- **Fuse**

- **PoL SiP Regulator**
- **PoL SiP Regulator**
- **PoL SiP Regulator**
- **PoL SiP Regulator**
- **PoL Isolated DC-DC Converter**

- **Fuse**
- **Doors**
- **A/V**
- **Lighting**
- **GPS**
- **AC**
Bi-directional Converter for energy storage application
Telecom 48V to System/CPU Power—2 Step to 1 Step

Advantage: High Efficiency and Small Size
Telecom 1 Step 48V to CPU Power

用 PRM/VTM實現高效率及減少傳輸損耗

- 48V, 2.572A (for 1V/100A)  
  81% efficiency
  23.46W  
  (for 1V/100A)

- 48V, 2.269A (for 1V/100A)  
  ~92% efficiency
  2.18W  
  K=1/48  
  (for 1V/100A)

- 48V, 2.22A (for 1V/100A)  
  6.72W  
  (for 1V/100A)
AC-DC Power Trend---Inside 1U/0.5U Equipment

Traditional AC to DC Power

Vicor AC to DC Power

Space for your system design

IEC Input + fuse + filtering

Rectifier + MOV

VIA PFM

Capacitor
AC UPS Datacenters

› In 2010, datacenters used 250BkWhr/yr\(^1\) costing $35B at $0.14/kWhr
› Data centers are one of the fastest growing users of electricity @ 2% of global electricity use
› US data centers to consume 140 billion kW-hrs by 2020
› Improvements in Server PUE (SPUE) for rapidly growing, massive Cloud infrastructures.

Source: NTT
48V Datacenters

Source: NTT
380V Datacenters / 380V Telecom

HVDC System (380 V)

- High efficiency (Few conversion steps)
- High reliability (Batteries directly supply power)
- Low Copper (Small current)
- Flexibility for placing ICT equipment (Long distance)

Source: NTT

Micro-grid: Solar, wind, flywheel, etc.
Data Center AC-DC/HVDC-DC Highest Power Density

- Smallest Size
- Highest Power
- Highest Power Density
- Redundant Design
- Regulation
- PMBUS Telemetry
Industrial/Datacom/Telecom Telemetry Requirement

4 Key Components Replace an Entire Collection of Conventional Devices

- PRM (Pre-regulation Module) regulates a 48 V line input
- VTM (Voltage Transformation Module) transforms the regulated 48 V to CPU power

- Cool-Power ZVS B8
- Inductor
- VTM

- PI3020 Digital Control
- PI3020 offers digital control, telemetry, and CPU communication

380 VDC (260-410 VDC)

- BCM VIA ChiP
- 1:8

48 V

- Digital Isolator
- Digital Supervisor

- PMBus™
- System Processor

LOAD
HV to LV Bus Converter to achieve highest Efficiency

- BCM 98% (380 VDC, 800W – 1.75kW)
- BCM 97% (380 VDC, 260-410 VDC, 48 VDC, 1:4 up to 1950W)
- UHV BCM 97% (540VDC, 1.5 kW)

Connections:
- BCM 98% output: 48 V (32.5 – 51.3 V)
- BCM 97% output: 12 V (8.1 – 12.8 V)
- BCM 97% output: 12 V (9 – 15 V)
- UHV BCM output: 33.75 V (25 – 43.75 V)

Conversion ratios:
- 1:8
- 1:32
- 1:16

Loads:
- 0.7 – 55 V
- 20 – 55 V
- LOAD

Notes:
- VTM
- PRM
- PO
- POL

Voltage ranges:
- 36 – 60 VDC
- 25 – 43.75 V
- 8 – 15 V
- 0.7 – 55 V
Redundant power design

Vicor advantage: Easy Parallel operation
Video Wall with 48V Distribution

Why Change
- Reduction in energy consumption
- Maximized image availability
- Reduce power supply complexity and cost

<table>
<thead>
<tr>
<th>Power Supply Specifications</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Input</strong></td>
</tr>
<tr>
<td>84 – 264 V&lt;sub&gt;AC&lt;/sub&gt;, 1 kW</td>
</tr>
<tr>
<td><strong>Output</strong></td>
</tr>
<tr>
<td>48V Bus driving 5V, 150W per panel</td>
</tr>
<tr>
<td><strong>Load</strong></td>
</tr>
<tr>
<td>LED Array via LED Driver Chips</td>
</tr>
</tbody>
</table>
Vicor Power Topologies Improvement to achieve highest Efficiency, highest Power Density and Low Noise

**ZVS Regulator**
*Non-isolated, DC-DC regulator*
- Pre-Regulator Module (PRM)
- Cool-Power ZVS
  - Buck, Boost, Buck-Boost

**Double-Clamped ZVS (DC-ZVS)**
*Isolated, regulated, DC-DC or AC-DC converter*
- DC Converter Module (DCM)
- Cool-Power Converters
- Power Factor Module (PFM)

**Sine Amplitude Converter (SAC)**
*Isolated, fixed-ratio, DC-DC transformer*
- Bus Converter Module (BCM)
- Intermediate Bus Converter (IBC)
- Voltage Transformation Module (VTM)
  (current multiplier)
Topology Comparison

Vicor Proprietary
正弦振幅轉換器（Sine Amplitude Converter™, SAC™）拓撲結構

SAC拓撲結構是一個處於BCM模組核心位置的動態、高效能引擎。SAC是基於變壓器的串聯諧振拓撲結構，在等於初級側儲能電路諧振頻率的固定頻率下工作。初級側的開關FET鎖定為初級的自然諧振頻率，在零交叉點開關，從而可消除開關中的功耗，提高效率，顯著減少高階雜訊諧波的產生。初級諧振回路是純正弦曲線（圖上所示），從而可減少諧波內容，提供更乾淨的輸出雜訊頻譜。由於SAC的高工作頻率，可使用較小的變壓器來提高功率密度和效率。
Factorized Power Architecture (FPA)

Why Factorized Power Architecture
- Conventional approach combines Regulation & Conversion functions in a single design
- For high current/power applications there are some costs
  - Distribution losses from on board distribution
  - Every voltage rail must have its own complete converter with both regulation and conversion.
  - Efficiency penalty due to redundant regulation and conversion stages and less optimized design
Factorized Power Architecture (FPA)

- **What is Factorized Power Architecture**
  - Separation of power conversion stages: Regulation & Voltage Transformation
  - Reduces distribution losses in a system
  - Reduces duplicated functions in the DC-DC conversion path
  - Reduces power dissipation at the Point-of-Load while increasing total system efficiency
  - Allows individual functions of Regulation and Transformation to be optimized
封裝散熱創新技術——ChiP(Converter housed in Package)

ChiP等效電路熱模型

突破性封裝技術——轉換器級封裝（ChiP）技術
為了實現更高的功率效率、功率密度和設計靈活性，功率組件封裝技術必須持續改良，因此，ChiP的推出可優化電氣和熱效能。
ChiP產品的設計在PCB兩面都有功率組件，可減少寄生導致的損耗，從而不僅可對整個封裝均勻徹底地散熱，而且還可利用頂部和底部表面進行散熱。
ChiP產品封裝在熱增強型模壓化合物中，不僅可降低溫差，而且還可為便捷使用熱管理配件（散熱器、冷板和熱管等）提供平整的模組頂部和底部表面。
Semiconductor Wafers >>> ChiP Panels

The “ChiP” packaging platform is a key enabling technology allowing Vicor to address power conversion projects with critical requirements for:

• High Power Density
• Small Size
• High efficiency
• Low Cost
“ChiP” Power Component Platform
Converter housed in Package
(Package Nomenclature: expressed in mm)

› ChiP is Flexible (topologies, applications)
  – AC-DC with PFC
  – DC-DC conversion (regulated, unregulated)
  – Buck, Boost, and Buck-Boost regulation
  – PoL current multiplication
  – Available in through hole packages
  › Surface mount (SMChiP) coming in 2017

› ChiP is Scalable (size, power)
  – Heights as low as 4.9 mm
  – 1323 to 6123 and expanding
  – Up to 180 A, 430 V, 1.8 kW and rising
封裝散熱創新技術——VIA(Vicor Integrated Adapter)

VIA封裝技術提供業界領先的功率密度。它外形小巧，寬僅為35.5 毫米，長度範圍為72 毫米至141 毫米，高僅為9.3 毫米。電路板安裝或底座安裝兩種版本之封裝都有提供，有助於工程師在最有效率的便捷位置安裝組件。

高效率雙面散熱外殼可將熱量從VIA封裝內的組件上下部散發，但只需從一面散熱就夠了，從而可在優化散熱的同時，簡化散熱設計。電源系統所需的空間可通過底座安裝版本進一步最小化，讓系統底座成為散熱設計的一部分，並且在許多應用中無需用到風扇，因而可在提升系統可靠性的同時，進一步減少所需的空間。
“VIA” Power Component Platform

Vicor Integrated Adapter
(Package nomenclature: expressed in inches X 10)

- A thermally adept, flexible, dense, housing for front-end power conversion.
  - Board-Mount or Chassis-Mount form-factors
- Ease-of-Use is built-in:
  - Integrated filtering and/or companion filter accessories
  - Inrush protection
  - Analog and Digital (w/ PMBus) control
- Focus on “Power Component Methodology”
Vicor Power Component Design Methodology
An Optimized Approach to Power Design

Optimized, modular system building blocks
› Isolated, non-isolated
› AC-input, DC-input
› Regulated, non-regulated
› High voltage, low voltage

An IC approach to higher power system integration
› Integrated power modules from 25 W to over 1,000 W
› Input operating voltages from 8 V to over 700 V (per module)

Example Power Chain Option Using Power Component Design Methodology
AC/HVDC to -48V/48V/24V

Front end

Single Phase AC
85 – 264 V

HVDC
260 – 400 V

HVDC
160 – 420 V

VIA PFM

VIA AIM

PRM SiP
Regulator

VTM ChiP
Current Multiplier

PoL
1 V, 130 A

PoL
+5 V, 20 A

PoL
-5 V, 20 A

Factorized
Bus (26 – 55 V)

VTM ChiP
Current Multiplier

VTM ChiP
Current Multiplier

12V

5V

3.3V

1.8V~2.5V

3.3V~18V

PoL Isolated
DC-DC
Converter

PoL SiP
Regulator

PoL SiP
Regulator

PoL SiP
Regulator

PoL SiP
Regulator

PoL SiP
Regulator
DC Modules (DCM) in a ChiP package

- Converter housed in Package (ChiP) power component platform
- Isolated, regulated DC-DC converters
- \( V_{\text{IN}} \): 24, 28, 30, 48, 270, 275, 290 and 300 V\(_{\text{DC}}\) nominal inputs
- \( V_{\text{OUT}} \): Predefined outputs from 3.3 to 48 V\(_{\text{DC}}\)
- Power capability:
  - Up to 600 W – 4623 ChiP
  - Up to 320 W – 3623 ChiP
- Over 93% efficient

<table>
<thead>
<tr>
<th>Nom. Input</th>
<th>Vin Range</th>
<th>Output Voltages</th>
<th>Max power</th>
<th>ChiP Package</th>
<th>Availability</th>
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<tbody>
<tr>
<td>300</td>
<td>200 – 420</td>
<td>48, 28, 24, 12</td>
<td>600</td>
<td>4623</td>
<td>NOW</td>
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<tr>
<td>48</td>
<td>36 – 75</td>
<td>48, 36, 28, 24, 15, 12, 5</td>
<td>320</td>
<td>3623</td>
<td>NOW</td>
</tr>
<tr>
<td>24</td>
<td>18 – 36</td>
<td>48, 36, 28, 24, 15, 12, 5</td>
<td>320</td>
<td>3623</td>
<td>NOW</td>
</tr>
<tr>
<td>290</td>
<td>160 – 420</td>
<td>13.8</td>
<td>600</td>
<td>4623</td>
<td>NOW</td>
</tr>
<tr>
<td>270</td>
<td>160 – 420</td>
<td>48, 28, 24, 15, 12, 5, 3.3</td>
<td>500</td>
<td>4623</td>
<td>NOW</td>
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<tr>
<td>28</td>
<td>16 – 50</td>
<td>48, 28, 24, 15, 12, 5, 3.3</td>
<td>320</td>
<td>3623</td>
<td>NOW</td>
</tr>
<tr>
<td>30</td>
<td>9 – 50</td>
<td>48, 28, 24, 15, 12, 5, 3.3</td>
<td>160</td>
<td>3623</td>
<td>NOW</td>
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<tr>
<td>275</td>
<td>120 – 420</td>
<td>48, 28, 24, 12, 5, 15, 3.3</td>
<td>375</td>
<td>4623</td>
<td>3Q17</td>
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<tr>
<td>100</td>
<td>43 – 154</td>
<td>48, 28, 24, 15, 12, 5, 3.3</td>
<td>240</td>
<td>3623</td>
<td>3~6 Months</td>
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<tr>
<td>42</td>
<td>9 – 75</td>
<td>48, 28, 24, 15, 12, 5, 3.3</td>
<td>80</td>
<td>3623</td>
<td>3~6 Months</td>
</tr>
</tbody>
</table>
DC Modules (DCM) in a VIA package

› VIA Power Component Platform – a ‘better brick’
  – Isolated, regulated DC-DC converters
  – Easy to use, robust and reliable, thermally adept, integrated filtering
  – Chassis or PCB mounting options, secondary side controls, low profile

› VIN: 28, 48, 270 and 300 VDC nominal inputs, more to follow

› VOUT: Predefined outputs from 5 to 48 VDC, regulated, isolated

› Power capability:
  – Up to 600 W – 3714 platform
  – Up to 320 W – 3414 platform

› Over 93% efficient

› M grade (-55 C operation) available on selected models

<table>
<thead>
<tr>
<th>Package/Input voltage</th>
<th>Output Voltage/Power</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>5 V</td>
</tr>
<tr>
<td>3714/300 Vin (200-420 V)</td>
<td></td>
</tr>
<tr>
<td>3714/270 Vin (160-420 V)</td>
<td>250 W</td>
</tr>
<tr>
<td>3414/28 Vin (16-50 V)</td>
<td>180 W</td>
</tr>
<tr>
<td>3414/48 Vin (36-75 V)</td>
<td>160 W</td>
</tr>
</tbody>
</table>

* Release 3Q17
^ M grade versions available
MIL-COTS MFM™ Filter Modules

28 and 270 Nominal Input Voltages
› 270 V\textsubscript{DC} (160 – 420 V) nominal input, provides MIL-STD-461/704 compliance
   – Up to 640 W – compatible with 270 V\textsubscript{IN} VIA DCM modules
› 28 V\textsubscript{DC} (16 – 50 V) nominal input, provides MIL-STD-461/704/1275 compliance
   – Up to 350 W
   – 28 V\textsubscript{IN} versions will need to be paired with the 28 V\textsubscript{IN} VIA DCM modules for MIL-STD-1275 transient protection
   – Provides operation down to -55°C
› 28 and 270 Vin filters are designed for use with the VIA DCMs, additional filtering will be needed with DCM ChiP products
   – Contact Applications for guidance

Small Size
› 1714 package
› 1.76 \times 1.40 \times 0.36 \text{ in.} (44.6 \times 35.5 \times 9.2 \text{ mm})
High Power DCM5614 in VIA package

- Provides voltage transformation, isolation, and regulation
  - Wide input voltage range: 260V-420V(380V), 180-420V(270V,330V)
  - High Output Power (11.5V-15.5V/130A, 43V-55V/33A)
  - High Output Power (22V-36V/36A, 11.5V-15.5V/100A)
  - Benchmark efficiency & power density
  - Parallel capability
  - Outputs can be stacked for higher $V_{OUT}$
  - Integrated filtering, inrush/transient protection
  - Analog or Digital Communication
  - Support for high capacitance loads

- Available Packages
  - Announced: Board Mount & Chassis Mount VIA
  - Future: SMT Chip and Super-Brick

- Target markets:
  - Telecom/Data Center Front End (DC-DC)
  - 3 Phase Industrial Front End (DC-DC)
  - 3 Phase Military Power Systems

<table>
<thead>
<tr>
<th>Input Range</th>
<th>Output Range</th>
<th>Package</th>
</tr>
</thead>
<tbody>
<tr>
<td>260-420V (380V)</td>
<td>11.5 - 15.5V</td>
<td>5614 VIA</td>
</tr>
<tr>
<td>260-420V (380V)</td>
<td>43.0 – 55.0V</td>
<td>5614 VIA</td>
</tr>
<tr>
<td>180-420V (270V)</td>
<td>22.0 – 36.0V</td>
<td>5614 VIA</td>
</tr>
<tr>
<td>180-420V (330V)</td>
<td>11.5 – 15.5V</td>
<td>5614 VIA</td>
</tr>
</tbody>
</table>
AIM/PFM: Lowest profile AC-DC power system components

› The PFM is an isolated, regulated converter in a VIA package
  – Input: Rectified single phase AC
  – Output: regulated 24 or 48 Volts
  – Chassis or board mount, C & T grades
  – Available in 400 W

› The AIM is filtering & rectification in a VIA package
  – Input: Single Phase AC
  – Output: Rectified single phase AC

› The AIM + PFM meet required safety and conducted EMI standards
  – Class B per EN55022
  – External TMOV required for EN61000-4-5 compliance for surge immunity

<table>
<thead>
<tr>
<th>Product</th>
<th>Tested w/AIM?</th>
<th>V\textsubscript{OUT}</th>
<th>EN55022</th>
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<tbody>
<tr>
<td>PFM4914</td>
<td>NO</td>
<td>48</td>
<td>Class A</td>
</tr>
<tr>
<td>PFM4914</td>
<td>NO</td>
<td>24</td>
<td>Class A</td>
</tr>
<tr>
<td>AIM1714 &amp; PFM4414</td>
<td>YES</td>
<td>48</td>
<td>Class B</td>
</tr>
<tr>
<td>AIM1714 &amp; PFM4414</td>
<td>YES</td>
<td>24</td>
<td>Class B</td>
</tr>
</tbody>
</table>
BCM – ChiP Packages
High Power and PMBus™ Digital Management Interface

Vicor’s New BCM ChiPs sets new bar for power density
› Power: Up to 2.4 kW in a 2.2 in² footprint
› Power Density: Up to 5,500 W/in³

Digital telemetry to Vicor’s ChiP BCMs
› PMBus compatible management interface for real time monitoring and control
  – Current PMBus chipset includes Vicor Digital Supervisor + Isolator companion chips + ChiP BCM
  – New single chip Point-of-Load Isolator (PLI) will integrate digital supervisor and isolator functions (available in 3~6 Months).
  – Digital control available for both ChiP and SM ChiP form-factors
  – Secondary referenced control interface enables real time power system telemetry
BCM – VIA Packages
Themally Enhanced, Integrated Functionality
› Unique packages integrate key functions
› Thermally adept housing simplifies thermal design
› Integrated filtering to help achieve required conducted emissions
› Integrated PMBus with secondary-side control for real time monitoring and communication
› Transient voltage suppression, surge protection
› PCB mount and chassis mount options

“The PMBus name SMIF, Inc. and logo are trademarks of SMIF, Inc.”
Released: 4414 Ultra High Voltage BCM VIA
Modules provide voltage transformation and isolation

› Two UHV Models:
  1. 400 – 700V, K=1/16, 1.60kW, 97% efficiency, Released
  2. 500 – 800V, K=1/16, 1.60kW, 97% efficiency, 3~6 Months

› Features/Benefits:
  – Unique “Ultra-High-Voltage” Input Range
  – Up to 40A continuous current
  – Industry benchmark efficiency & power density
  – Parallel capability
  – 4414 VIA Board-mount & Chassis-mount form-factor
  – Integrated filtering, inrush/transient protection
  – PMBus™ Communication
  – C/T-Grade Available now, M-Grade to release 3~6 months

› Target Applications:
  – DC-DC section of 3Φ AC-DC converter
    › 400-700V$_{IN}$ for 380V$_{RMS}$ & 400V$_{RMS}$
    › 500-800V$_{IN}$ for 480V$_{RMS}$

400-700V$_{IN}$ Part Numbers

<table>
<thead>
<tr>
<th>Part Numbers</th>
<th>Description</th>
</tr>
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<tbody>
<tr>
<td>BCM4414VGOF4440C02</td>
<td>Chassis Mount, C-Grade</td>
</tr>
<tr>
<td>BCM4414VGOF4440T02</td>
<td>Chassis Mount, T-Grade</td>
</tr>
<tr>
<td>BCM4414BGOF4440C06</td>
<td>Board Mount, C-Grade, Short Pin</td>
</tr>
<tr>
<td>BCM4414BGOF4440T06</td>
<td>Board Mount, T-Grade, Short Pin</td>
</tr>
<tr>
<td>BCM4414BGOF4440C10</td>
<td>Board Mount, C-Grade, Long Pin</td>
</tr>
<tr>
<td>BCM4414BGOF4440T10</td>
<td>Board Mount, T-Grade, Long Pin</td>
</tr>
</tbody>
</table>
PRM/VTM Solutions

High power density load point (POL) power solutions

- Single Phase AC: 85 – 264 V

- VIA PFM
- VIA AIM

- PRM SIP Regulator
- Factorized Bus (26 – 55 V)
- VTM Chip Current Multiplier
- VTM Current Multiplier

- Pol SiP Regulator
- Pol SiP Regulator
- Pol SiP Regulator
- Pol Isolated DC-DC Converter

- 48 VDC
- 48 VDC
- 48 V, 24 V DCC

- 12V
- 5V
- 3.3V
- 1.8V~2.5V
- 3.3V~18V

PoL 1 V, 130 A
+5 V, 20 A
-5 V, 20 A

Factorized Bus (26 – 55 V)
Factorized Power Architecture

- Set Factorized bus (PRM output) voltage, Choose appropriate K-factor VTM according to output requirement.
- Special (non-standard) output voltage can be achieved by trimming PRM output voltage
The “Factorized” (FPA V*I ChiP) Advantage

PRM: Zero Voltage Switching (ZVS) Buck-boost regulator

VTM: Broadband ZVS and Zero Current Switching (ZCS) DC Transformer

Voltage Feedback (Remote Sense)

Control / Feedback

48V → Cool-Power ZVS BB → Inductor → VTM → CPU GPU

98% 96% 99.9%

The "Factorized" (FPA V*I ChiP) Advantage

高功率密度負載點(POL)電源解決方案
The VR13 with 48V Direct to CPU

PRM and Controller placed on board edge

Only VTM itself placed by CPU
Vicor VR13/P9/GPU/ARM-based/Memory Solution

› PRM
  - Input Voltage: 38 – 60 V
  - Output Voltage: 20 – 55 V
  - Max. Output Power: 400 W
  - Peak switching Frequency: >2MHz

› VTM
  - Has specs pushed up to 95A DC and 228A peak for VR13
  - Up to 330A TDC for P9
  - Peak switching ripple frequency: >3MHz
  - Truly isolated VTM

› Controller
  - Digital Controller
  - SVID
  - AVS
  - SVI-2
Cool Power: Isolation/Non-Isolation

Single Phase AC
85 – 264 V

HVDC
260 – 400 V

HVDC
160 – 420 V

Front end

PRM SiP Regulator

Factorized Bus (26 – 55 V)

VTM ChiP Current Multiplier

VTM Current Multiplier

VIA PFM

Sel

+5 V, 20 A

-5 V, 20 A

48 VDC

48 VDC

48V, 24V VDC

PoL 1 V, 130 A

PoL SiP Regulator

PoL SiP Regulator

PoL SiP Regulator

PoL Isolated DC-DC Converter

5V

3.3V

1.8V~2.5V

3.3V~18V
48V to PoL Power: ZVS Buck – PI352x

- Wide input voltage range of 30V to 60V
- Parallel capable with single wire current sharing
- Input Over/Under voltage Lockout (OVLO/UVLO)
- Output Overvoltage Protection (OVP)
- Over temperature Protection (OTP)
- Fast and slow current limits
- Differential amplifier for output remote sensing
- User adjustable soft-start & tracking
- -40° C to 125° C operating range (TJ)

<table>
<thead>
<tr>
<th>Device</th>
<th>Output Voltage</th>
<th>Iout Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>PI3523-00-LGIZ</td>
<td>3.3V, 2.2 to 4.0V</td>
<td>22A</td>
</tr>
<tr>
<td>PI3525-00-LGIZ</td>
<td>5.0V, 4.0V to 6.5V</td>
<td>20A</td>
</tr>
<tr>
<td>PI3526-00-LGIZ</td>
<td>12V, 6.5V to 14V</td>
<td>18A</td>
</tr>
</tbody>
</table>
48V to PoL Power: PI354x Series
48Vin Optimized ZVS Buck Regulator

- Wide input voltage range of 36V to 60V
- 10x10mm LGA SiP package
- Parallel capable with single wire current sharing
- Input Over/Under Voltage Lockout (OVLO/UVLO)
- Output Overvoltage Protection (OVP)
- Over Temperature Protection (OTP)
- Differential amplifier for output remote sensing
- Wide -40°C to 125°C operating range
Wide Output Cool-Power ZVS Buck-Boost – PI3740

- Operates from wide 8-60Vin to wide 10-50Vout
- Up to 96% efficiency
- 50–140W continuous output power
- Parallel capable with single wire current sharing
- External frequency synchronization / interleaving
- High Side Current Sense Amplifier
- General Purpose Amplifier
- Lighting / Constant Current Mode (LGH)
- Input Over / Undervoltage Lockout (OVLO / UVLO)
- Output Overvoltage Protection (OVP)
- Overtemperature Protection (OTP)
- Fast and slow current limits
- -40° C to 115° C operating range (Tj)
- Excellent light load efficiency

Minimal external components required.
Cool-Power ZVS Buck-Boost – PI3741

- 21V to 60V Input operating range
- Up to 97% efficiency
- 150W of continuous output power (for specific conditions)
- Fast transient response
- Parallel capable with single wire current sharing
- External frequency synchronization / interleaving
- High Side Current Sense Amplifier
- General Purpose Amplifier
- Input Over/Under voltage Lockout (OVLO/UVLO)
- Output Overvoltage Protection (OVP)
- Over Temperature Protection (OTP)
- Fast and slow current limits
- -40°C to 115°C operating range (TJ)
- Excellent light load efficiency

<table>
<thead>
<tr>
<th>Device</th>
<th>Output Voltage Set</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>PI3741-00-LGIZ</td>
<td>24 V</td>
<td>21 to 36 V</td>
</tr>
<tr>
<td>PI3741-01-LGIZ</td>
<td>48 V</td>
<td>36 to 54 V</td>
</tr>
</tbody>
</table>
Vicor PFM Family - Target Applications and Benefits

Features and Benefits

- Small size and low profile
- Low weight and Easy thermal dissipation
- Rugged VIA packaging
- Integrated filtering, transient protection, inrush protection
- High efficiency
- Power factor correction
- Universal input
- Combines with AIM1714

LED Lighting

Small Cell Base Station

Industrial Power Systems
Vicor Solution for Wireless Infrastructure

- Regulators products which can support both 28V LDMOS and 48V GAN FET PA architectures
- Small Cell Wireless

Remote Radio Units
Deployed with Antenna/PI3525
Consideration parameters for power solution:
Size, Weight and Power density…and cost - SWaP/C
Electric Vehicles (EV) 應用

365V to 13.8V/1.8 kW EV & HEV DC-DC Converter

Customer Advantage
- High power density/small size
- Wide input range (160V~420V input for DCM290)
- Excellent efficiency
- Easy parallel operation
- Low noise
- Ease of cooling
- Reliability

Efficiency vs. Load

1 DCM Active
2 DCMs Active
3 DCMs Active
4 DCMs Active

ECO Array
Simple DCM Array
Applications: Electric Vehicles

HV Battery 160V – 450V  2-Stage DCM  13.8V  LV Battery
Tethered UAV/ Balloon/Under water robot/ Phase array system

3 Phase

AIM
540VDC
(400-700 VDC)
(500-800 VDC)
1.5 kW

UHV BCM
1:16
33.75 V
(25 – 50 V)

PRM
26 – 55 V

VTM
0.7 – 55 V

LOAD
Customer Advantage

**DESIGN TIME**
using the PCDM and our supporting tools.

**CABLING BY 16X**
by switching from 12V to 48V distribution.

**Shipping and Installation**
by using higher integrated modules.

**OPERATION EXPENSES**
when your system runs more efficiently and you save energy.

**THE BOTTOM LINE OF THE BOM**
by using fewer, more flexible modular components.
電源配置：典型方法 vs 平均方法

900瓦的週期性負載，25%的佔空比

典型方法：320Wx3
平均方法：320Wx1 with Cap
Customer Advantage

- Optimize efficiency, size and cost effectiveness
- Optimal and flexible architecture for changing requirements
- High efficiency, small size, low cost, and bi-directional power (regulation and transformation) are all deemed critical requirements

Unique capability of the BCM Bus Converter to operate in reverse
- High density of BCM
- High efficiency of BCM
- PMBus™ for control and system monitoring
Automated Test Equipment (ATE)

Customer Advantage

- Benchmark power density
- Proven reliability
- Low profile packaging
- Advanced architecture to minimize power distribution losses.
- Low noise
- Modular approach for fast designs
High Power Solution in Railway Applications

- Component filtering solutions for railway applications – providing transparent protection, inrush current limiting, and EMI filtering
- Wide input voltage range to meet railway standards
- Robust packaging for harsh railway environments
- Vicor ZCS/ZVS topology-high power density/efficiency and low noise
- Power expansion by paralleling easily

EN50155
RIA12

43V-154Vdc

EMI filter
DC-DC Converter

14V-68Vdc

12V, 24V, 48Vout

Cool-Power 2VS Buck
PI3xx/PI34xx/PI35xx

12V, 24V, 48Vout

1 - 24 Vout

VI/VE-J00
VI/VE-200
Mini/Micro/Maxi
2223DCM 3623DCM

PI3xx/PI34xx/PI35xx

Cool-Power 2VS Buck

For 43 – 110 Vdc
66 – 154 Vdc

Customer Advantage
About Vicor

› Founded in 1981 on a platform of innovation
  – Head Quarter and factory facilities based on Andover, MA, USA.
  – 155+ patents on power trains, control systems, components and packaging technology
  – 16% of gross revenue re-invested in R&D
  – Nasdaq listed “vicr”

› High density, high efficiency modular solutions to power system requirements
  – From the power source to the point of load
  – Architectural options, optimal component selection and online simulation tools
End

Thank You