Innovative 48V Direct Conversion

APEC 2016
Novel 48V Direct Conversion

- Innovative 48V Direct Conversion Architecture
  Fully Compliant to Intel VR13 Requirements

- Fully Isolated, Scalable, High Efficiency (ZVS, ZCS), Energy Proportional Ideal for “Any POL”

- Flexible Architecture Extendable to 400V Direct Conversion Bus
Innovative 48V Direct Conversion

System Description

Main Features

Experimental Intel VR13 Results

Available Reference Designs
System Description

Innovative, Isolated 48V to 0.5V-12V Architecture

- **STRG02** Single wire controlled Synchronous Rectifier able to zero voltage and zero current working

- **STRG04** 100V Full Bridge Driver with programmable predictive control for zero voltage operations in constant phase shift control

- **STRG06** Multiphase Resonant Constant On Time Digital Controller supporting up to 6 interleaved converters (automatically turned on/off by load request) with PMBUS and output voltage between 0.5V to 12V
Main Features

- **Isolated Resonant Direct Conversion**
  - from 48V to $V_{\text{CORE}}(1.\times\text{V}) / V_{\text{DDR}}(1.2\text{V}) / V_{\text{SOC}}(1\text{V}) / V_{\text{IBC}}(12\text{V}, 5\text{V}, 3.3\text{V})$

- **Efficiency**
  - ZVS and ZCS at any $V_{\text{in}}[36\text{V} – 72\text{V}]$ and $V_{\text{out}}[1.\times\text{V} – 12\text{V}]$
  - Energy Proportional Management $\Rightarrow$ Pskip and Dynamic Cell Management
  - No Active Clamps needed

- **Scalable and Flexible**
  - Converters paralleled and interleaved
  - Scalability according to the power demand
  - Variable Frequency in CCM and DCM
  - Instantaneous turn-on of resonant converters when load increases

- **Any Digital Load**
  - High Bandwidth
  - Easy to compensate as a non isolated Buck converter
  - Up and down reference transitions $\Rightarrow$ Sink mode required

- **High Power Density, Telemetry, Auto-Tuning**
  - >160W/inch2
  - Fully configurable and accessible through PMBusTM
  - To minimize time and effort for compensation, optimizing application design time

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**New Resonant Topology**

**Energy Proportional**

**Scalable**

**Digital Load and IBC**

**Power Density**

**Telemetry, Auto-Tuning**
Intel VR13 Reference Design

Intel VR13 165W CPU Power Delivery

Features:
• Compliancy to VR13 165W CPU
• Minimal PCB area with 4 cells
• Efficiency peak 91%, flat until TDC (88A)
• Integrated magnetics
• MLCC output filter

Bill of materials:
• Magnetic electrical data:
  • Transformer turn ratio=5
  • Lres=1.9uH
  • Lout=120nH
• Cres: 2 x 100nF between phases, 33nF from each phase to GND
• Cout: 120 x MLCC 47uF 4V 0805
Intel VR13 Efficiency Performances

- 4 cells voltage regulator for VR13 165W
- DPM enabled w/ IM rev X1
- 4th Cell enable in Turbo Mode (>TDC)
### Prototype spec:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>$V_{in}$</td>
<td>40V to 72V</td>
</tr>
<tr>
<td>$V_{in,nom}$</td>
<td>54V</td>
</tr>
<tr>
<td>$V_{out,nom}$</td>
<td>12V +/-1%</td>
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<tr>
<td>$P_o$</td>
<td>500W</td>
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<tr>
<td>Output current</td>
<td>42A</td>
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<tr>
<td>Frequency of operation</td>
<td>200-250KHz</td>
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<tr>
<td>Power density</td>
<td>160W/inch2</td>
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<tr>
<td>Actual Peak Efficiency</td>
<td>97%</td>
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<tr>
<td>Load regulation</td>
<td>&lt;0.1%</td>
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<tr>
<td>Line regulation</td>
<td>&lt;0.1%</td>
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<tr>
<td>Board size</td>
<td>1.8 x 1.8 inch2</td>
</tr>
</tbody>
</table>

**54V → 12V, 500W**
54V → 3.3V, 150W (Prototype)

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<td>$V_{in}$</td>
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</tr>
<tr>
<td>$V_{in,nom}$</td>
<td>54V</td>
</tr>
<tr>
<td>$V_{out,nom}$</td>
<td>3.3V +/-1%</td>
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<tr>
<td>$P_o$</td>
<td>150W</td>
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<td>Output current</td>
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<td>Frequency of operation</td>
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<td>Actual Peak Efficiency</td>
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<td>Line regulation</td>
<td>&lt;0.1%</td>
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<tr>
<td>Board size</td>
<td>3.3 x 0.9 inch2</td>
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</tbody>
</table>
54V → 1.21V, 50W (Prototype)

- Dual Cell Design: 54V to 1.2V
- 50A TDC at 1.21V
- 93.8% Peak Efficiency