Power Delivery for Modern Data Center

ST Developer Conference
September 2019
Power Delivery for Modern Data Center

1° Stage (IBC*)
- Intermediate Bus Conversion
  - STC (Stacked Buck Converter)
  - STBuck (*)
  - Transformer Based (*) (Isolation Supported)
  - (*) ST Patent

2° Stage (12V)
- Switched Digital Controller
- SPS (Switched Power Supply)

48V
- Unregulated
- Regulated

Direct Conversion
- Transformer Based Power Stamp Alliance (PSA) (Isolation Supported)
- V_CPU/DDR/ASCI

Stacked Buck (STB) Converted from 48V
- Regulated Conversion

Switched Tank Converter (STC) Unregulated Conversion

Digital Power Distribution from 12V Bus

Direct Conversion from 48V to POL

48V
- Unregulated
- Regulated

(*) ST Patent
STC (4:1): 48V to 12V
IBC Unregulated Conversion
Switched Tank Converter (STC)  
Unregulated Conversion  

Un-Regulated Intermediate Bus Architecture up to 1KW

- Input Voltage Range: 40V-60V
- 4:1 Conversion Ratio
- Up to 1KW Thermal Design Power (TDP)
- High Power Density
- Maximizes Conversion Efficiency
- Low Profile Solution (<5mm)
- ZCS Operation for all Mosfet
- Off-the-Shelf Components
1KW STC Efficiency Results

~98% Peak Efficiency @ 360W

1/8th Brick Form Factor
STBuck (STacked Buck): 48V to 12V
IBC Regulated Conversion
Stacked Buck (STB)

Regulated Conversion

Regulated Intermediate Bus Scalable Architecture up to 3.2KW

- Input Voltage Range: 36V-60V
- 12V Vout Adjustable by PMBus
- 800W Thermal Design Power (TDP)
- High Power Density
- 800W 1/8 Brick From Factor Cell
- Scalable Solution up to Four Cells
- Maximizes Conversion Efficiency
- Off-the-Shelf Components
STB Efficiency Results

STB 12V Regulated (Driving Losses Included)

![Graph showing efficiency results for STB 12V Regulated with driving losses included. The graph displays efficiency percentages against power output (POUT) in watts. The lines represent different voltage levels: 48V, 54V, and 40V, with their respective efficiencies marked at various power levels.](image-url)
Thermal Measurements (1)

- AirFlow 70 CFM for 5min @ 500W
- No AirFlow for 10min @ 500W

Wait Thermal Stability:
- 10min: Max Temp @ 93 C
- 5min: Max Temp @ 55 C

T\text{AMB} = 25 \text{ C}
Thermal Measurements (2)

AirFlow 70 CFM for 5min @ 600W

Max Temp @ 64 C

Wait Thermal Stability 5min

T_{AMB} = 25 C
Direct Conversion 48V to POL
Direct Conversion from 48V to POL

Scalable, Flat Efficiency, High Density, Isolated or Non-Isolated Direct Conversion

- Input Voltage Range: 40V-60V
- Vout: Intel VR13HC (1.8V_{Typ}), DDR (1.2V_{Typ})
- Full Compliance to Intel Test Plan
- Vout Load Line: 0.9mOhm
- 205W TDP, 413W Max
- Iout Max: 228A
- Switching Frequency: 570KHz
- Power Density: 100W/inch²
- Solution Size: 1.6” x 2.60”
54V to CPU, VR13.HC – 205W TDC
Resonant Design

93%+ Peak and Flat Efficiency, Cell Shedding

Dynamic Cell Shedding
### Specifications

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>$V_{IN}$</td>
<td>40V to 60V (54V_TYP)</td>
</tr>
<tr>
<td>$V_{OUT}$</td>
<td>1.2V +/-1%</td>
</tr>
<tr>
<td>$P_o$</td>
<td>150W (@$V_{IN}$=40V)</td>
</tr>
<tr>
<td>Output current</td>
<td>125A (@$V_{IN}$=40V)</td>
</tr>
<tr>
<td>Frequency of operation</td>
<td>215KHz (@$V_{IN}$=54V)</td>
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<tr>
<td>Power density</td>
<td>71W/inch²</td>
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<tr>
<td>Actual Peak Efficiency</td>
<td>93.2%</td>
</tr>
<tr>
<td>Load and Line regulation</td>
<td>&lt;0.1%</td>
</tr>
<tr>
<td>Solution size (Active area)</td>
<td>2.1 inch²</td>
</tr>
</tbody>
</table>
Power Stamp Alliance (PSA)

Power Stamp Alliance defines a standard product footprint and functions that provide a multiple-sourced, standard modular board-mounted solution for power conversion for 48Vin to low-voltage, high-current applications.

- Multiple-sourced standard footprint units for CPU, DDR, ASIC, among others.
- All members have high-volume manufacturing capability with industry-standard processes and components.
- Energy Proportional, the operating units are automatically optimised to the load required for optimal efficiency.
- Has been mechanically and electrically sized to meet the demands of server applications.
- PMBus AVS and SVID Compliant

100 A/cell
12V CPU & DDR Power Delivery
Digital Power Distribution from 12V Bus

Complete Multiphase Digital Solution for CPU and DDR

- 12V Input Voltage, Vout range: 0.5 to 2.5 V
- CPU and DDR Power Distribution
- PMBusTM rev 1.2 at 400 kHz
- High-Performance Digital Control Loop (Digital STVCOTTM)
- Autonomous Dynamic Phase Shedding
- Remote Sense with <0.5% Vout Accuracy
- Current monitor signal with calibration
- Programmable Voltage Positioning
- OV, UV and FB Disconnection Protection
PM6779/4: VR13.HC (P+ STK, 8 DIMM)
Summary

- Power Demand from Digital ASICs (CPU, GPU, TPU) is Rising
- 12V Power Distribution Bus is Exhibiting Some Limitations
- 48V (54V) Power Distribution Provides Better Overall Efficiency
- Several Architectures Are Available to Distribute Power from 48V
  - Two Step Conversion: Unregulated (STC) or Regulated (STB)
  - Direct Single Step Conversion (Power Stamp Alliance)
- Each Solution Offers Different Benefits Allowing to Optimize System Power Delivery Based on Specific Design Priorities
Thanks!

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