Google 48V Update: Flatbed and STC
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Agenda

● Google’s 48V OCP journey update
● Flatbed 48V to 12V Adaptor Kit
  ○ Use Case, Advantages
  ○ High-level Overview
  ○ Server Payload Requirements
  ○ Mechanical Implementation Options
    ■ Shelf and Busbar
    ■ Compliance
● Fixed-Ratio 48V to 12V Conversion
  ○ Use Case, Advantages
  ○ STC: a 2-stage conversion architecture
Google’s OCP Journey
2016 - Announced 48V architecture
2017 - Released OpenRack Version 2.0 spec
Specification available on OCP OpenRack Wiki

Why 48V Power Architecture?
• Supports higher power
• Lower distribution losses & voltage drop - Reduction of 16X (I^2R losses)
• Higher efficiency
• Better deployment flexibility
• 48V telecom ecosystem
• Cost effective in-rack UPS
• “Safe” voltage
Plans For The Road Ahead In 2018: Payloads

1. **Flatbed**: Supports 12V payloads in 48V rack.
   - “Flatbed” helps integrate 12V payloads in “48V ORv2.0”
   - Re-usable “kit” of shim components & SW

2. **STC**: Ease the conversion of 12V payloads to 48V power train design.
   - Provides a cost efficient and simple architecture
   - Rapid scalability and customization
Flatbed

Presenter: Scott McCauley
Motivations for Flatbed

- Flatbed provides an incremental migration path from 12V to 48V racks using existing, proven 12V IT payloads
- Fast implementation of a broader range of payloads in OpenRack v2.0
- OpenBMC & re-usable HW adapters ease SW re-use by focusing on bridging between open, standard interfaces.
What Flatbed Revision 1.0 Supports

● Flexibility, Unique Configurations
  ○ Heterogeneous mixes of off-the-shelf servers in a 48V ORv2.0 rack
  ○ Supports an evolving mixes of payloads in a single rack, including servers with 48V-to-PoL regulated or fixed-ratio IBC (STC, other architectures) conversion

● Ease of Deployment
  ○ Single flavor of rack can be more easily used/re-used across multiple payload generations
  ○ Commonality of thermal management and power monitoring scheme(s) across fleet
    ■ OpenBMC as a key component

● Reliability and Serviceability
  ○ Rack-level AC/DC conversion and UPS can be N+1 or 2N redundant
  ○ Hot-swappable service and repair of power infrastructure with all server payloads on-line

● High Peak Rack Power Capacity with Low IR Losses
What Is a “Typical” Flatbed Implementation?
Flatbed Current Developments

1. Flatbed Specification 1.0 approved by IC and released to OCP 2018-01-18
2. Tractor PCBA *initial prototypes* developed in conjunction with Quanta, currently in verification.

Tractor PCBA designs are fitted to specific use cases:

- Large 12V payload trays
- uATX payload trays
Minimum Required Features:  
Server Payloads - **Mechanical** Requirements

- **Maximum mechanical dimensions**
  - Width: **up to 19.5”**
  - Depth for "co-planar" tray layouts:
    - Up to 15.9” depth for shallow ORv2.0 option (30” Rack depth)
    - Up to 21.4” depth for deep ORv2.0 option
  - Height agnostic

- **Front-to-rear airflow direction** (DIMMs, PCIe slots, heatsink fins)

- **CPU socket and retention mechanism** match vendor reference designs
  - Standardized heatsink interface details

- “Most” PCIe slots located at front (those used for NIC and other external I/O)
Minimum Required Features:
Server Payloads - **Electrical Requirements**

- PCIe slots
  - PCIe RSVD pin usage generally fits under “soft” requirements.
- 100Base-TX compatible RJ45 connector routed to BMC for NC-SI
- At least one “clean” SMBus accessible on a header for Tractor PCBA interface
  - Clean = empty address space. Existing I2C EEPROMs, expanders, and cascaded muxes on the Payload are particularly difficult to work around.
- BMC that can boot Linux, support OpenBMC
  - Upgrade via software
- Power input must be **12V + 12V_STBY or ATX/EPS12V**
ORv2.0 Rack Busbar Interface

- Horizontal and vertical pitch agnostic
  - Allows multiple tray width/height form factors to exist in single rack
- Shortpin-based tray hotswap enable on horizontal 48V IT connectors
  - Minimizes connector arcing, contact wear
  - Minimizes 48V bus voltage transients during hotswaps (deployment or repair)
- Vertical or horizontal busbar connections supported for IT Gear
  - Barreleye-Zaius “sled” uses a horizontal connector
  - Barreleye-Zaius “shelf” uses a vertical clip, contains Zaius sled
Vertical ORv2.0 Busbar to Horizontal IT Shelf PDBB

(From OCP Barreleye G1 Hardware Specification)
Flatbed Compliance Highlights

- Tray designs need to match deployment environmental requirements
- “Open” trays optimized for BOM and labor cost, configurability, speed of repair
- “Enclosed” trays optimized for EMC emissions, deployment to any location
Flatbed Compliance:
Examples of “Open” vs. “Enclosed” Sleds

(From OCP Barreleye G1 Hardware Specification)
Fixed-Ratio 48V Bus to Intermediate Bus Conversion
Update: Switched-Tank Converter

Presenter: Shuai Jiang
# 48V v.s. 12V for Today’s Board Power Design

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<th>Efficiency</th>
<th>Density</th>
<th>Scalability</th>
<th>Cost</th>
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<tr>
<td><strong>48V systems</strong></td>
<td>~93%-94% (1.8V)</td>
<td>Varies significantly across architectures</td>
<td>Custom components with long lead time limit time to market</td>
<td>High cost with custom components and design complexity</td>
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<td>~90%-92% (sub-1V)</td>
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<td>Limited solution availability to support a variety of needs</td>
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<td>Magnetic designs dictate overall efficiency performance</td>
<td>Extremely challenging on magnetics miniaturization</td>
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<tr>
<td><strong>12V systems</strong></td>
<td>~95%-96% (1.8V)</td>
<td>Keep increasing with higher frequency, higher A/phase and reduced decoupling caps</td>
<td>Extraordinary scalability in terms of controller &amp; power stage availabilities, phase count flexibility, standardized components, and fast time to market</td>
<td>Low cost with simplicity of design/components and wide availabilities in the market</td>
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<td>~92%-93% (sub-1V)</td>
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<td>Best leverage of power stage technology advancement</td>
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Revisit 2-Stage 48V-to-PoL Architecture

Ultra high efficiency high density fixed-ratio bus converters
- Google’s Switched Tank Converter (STC) technology (free IP to the industry)
- Other fixed-ratio converters from the market

Higher power bus converter also gives lower $/W

Leveraging industry’s continuous advancement and ecosystem of multi-phase VR technologies for best optionality and TCO

2-stage architecture for 48V-to-PoL power delivery consolidates 48V and 12V ecosystems to meet future data center high power demand
STC Topology Highlights

Technological Features

- Very high efficiency and density
- Fast transient response with very high peak power capability
- Low voltage FETs only
- Full soft charging & soft switching
- Tightly controlled resonant operation over a wide range
- Strong immunity to capacitor tolerances and board parasitics.
- Inherent droop current sharing for parallel operation

Scalability and Cost Advantages

- Easy to scale for different ratio and power level with minimal custom design & qualification effort
- Low cost onboard chipset solution with standardized components
- Free IP to the industry for enabling 48V ecosystem
- Strong leverage of the advanced 12V VR technologies on the second stage

(STM powertrain with 600W TDP, 900W peak)
600W 4-to-1 STC EVM Board (Google design)

- Input buck starter/protector (100% duty, 99.9% efficiency)
- STC powertrain, 600W
- STC controller and drivers (to be integrated)
To Summarize….

Google continues to develop and advance 48V rack and power architectures in 2018.

- The Flatbed tray architecture and Switched-Tank DC/DC converter help ease the transition path from 12V-based racks to 48V-based racks
- Flatbed speeds development and adoption of payloads early in the development lifecycle
- STC provides BOM cost and efficiency improvements for high volume payloads along with easy, streamlined design customization
Questions?