OCP SUMMIT

March 20-21
2018
San Jose, CA

OPEN. FOR BUSINESS.

Google 48V Update: Flatbed and STC

Scott McCauley, Electrical Eng., Google
Shuai Jiang, Power Eng. Google

Agenda

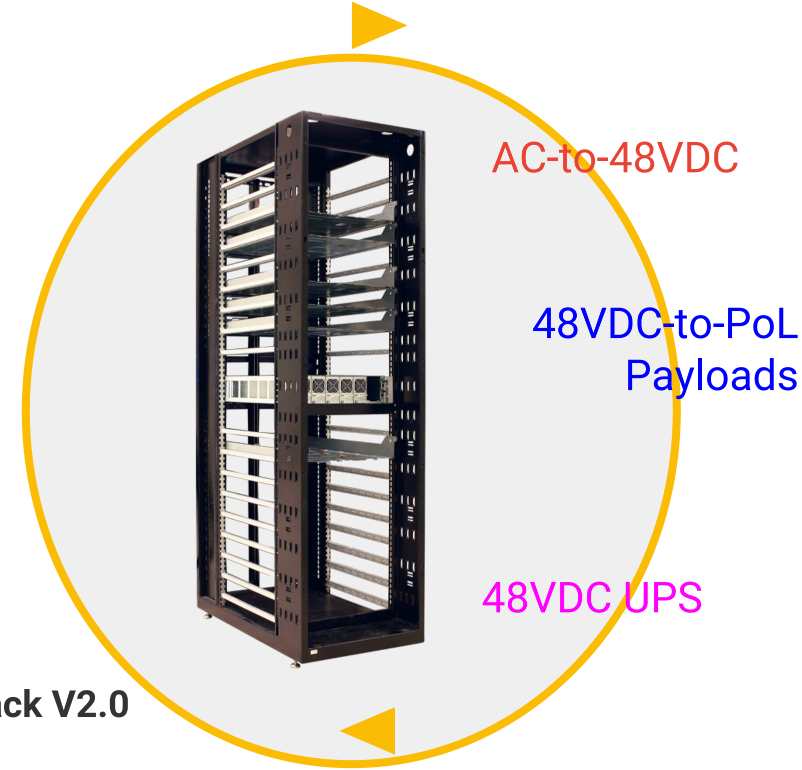
- Google’s 48V OCP journey update
- Flatbed 48V to 12V Adaptor Kit
    - Use Case, Advantages
    - High-level Overview
    - Server Payload Requirements
    - Mechanical Implementation Options
        - Shelf and Busbar
        - Compliance
- Fixed-Ratio 48V to 12V Conversion
    - Use Case, Advantages
    - 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]



Open Rack V2.0

Why 48V Power Architecture?

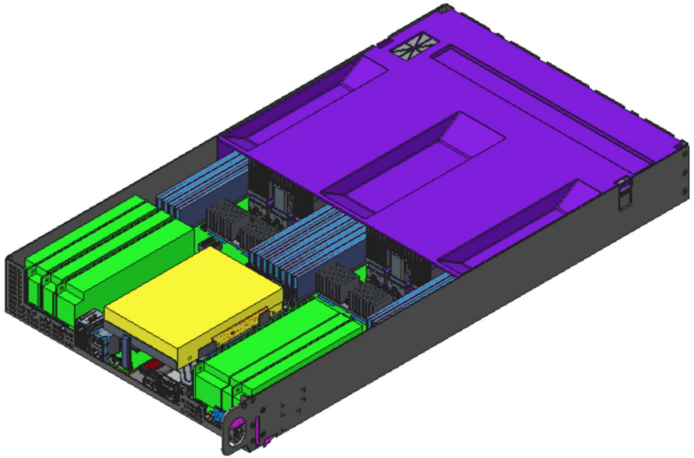
- Supports higher power
- Lower distribution losses & voltage drop - Reduction of 16X (I2R losses)
- Higher efficiency
- Better deployment flexibility
- 48V telecom ecosystem
- Cost effective in-rack UPS
- “Safe” voltage

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

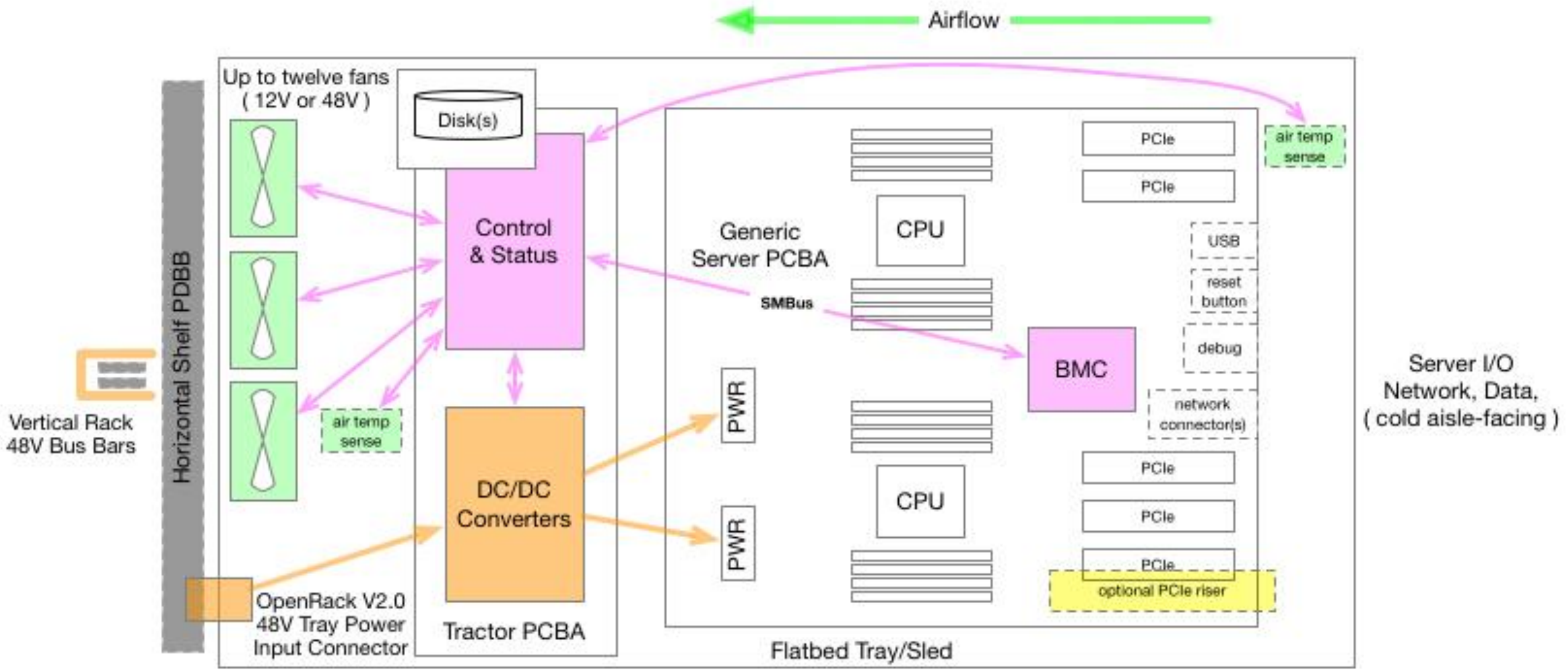
Motivations for Flatbed

- 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?

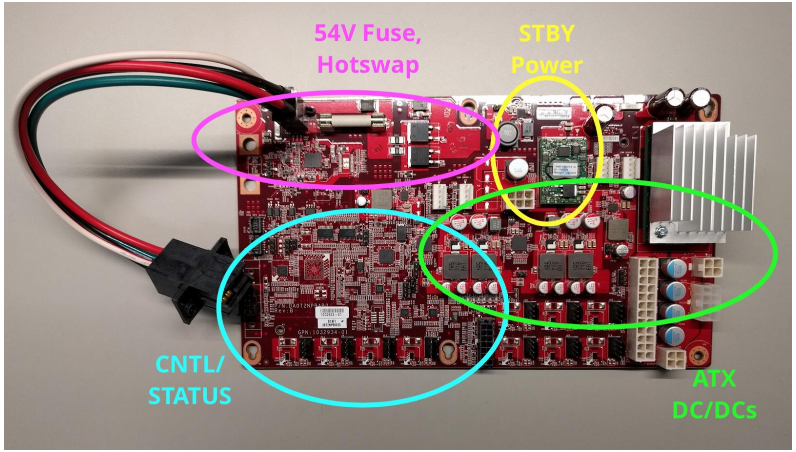


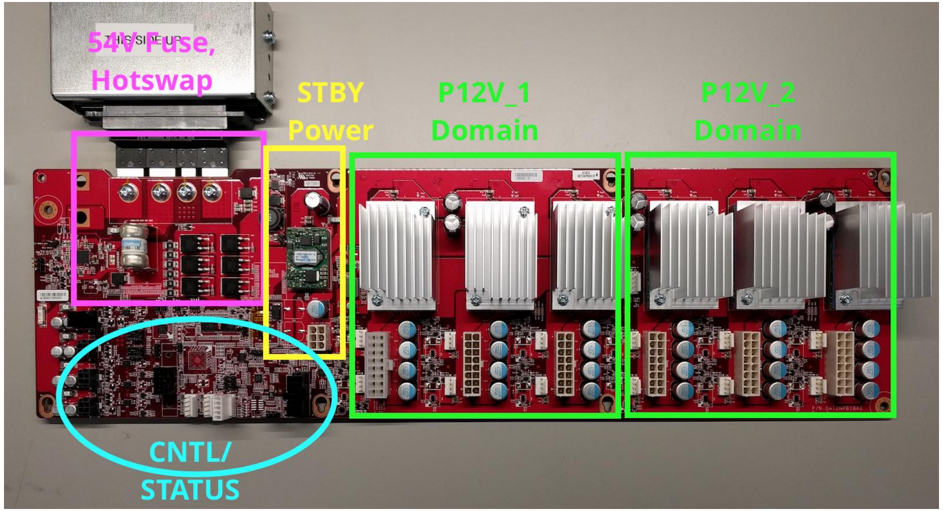
Flatbed Current Developments

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

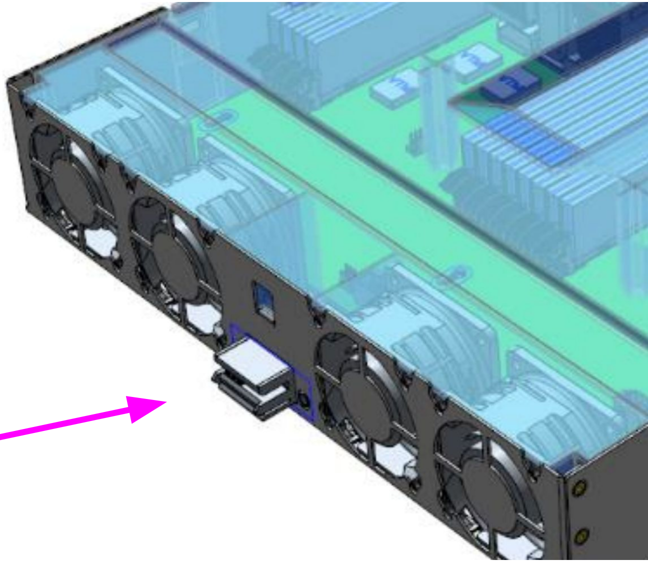
- Maximum mechanical dimensions
  - Width: up to 19.5”
  - Depth for “co-planar” tray layouts:
    - Up to 15.9” depth for shallow ORv2.0 option (30” Rack depth)
    - Up to 21.4” depth for deep ORv2.0 option
  - Height agnostic
- Front-to-rear airflow direction (DIMMs, PCIe slots, heatsink fins)
- CPU 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)

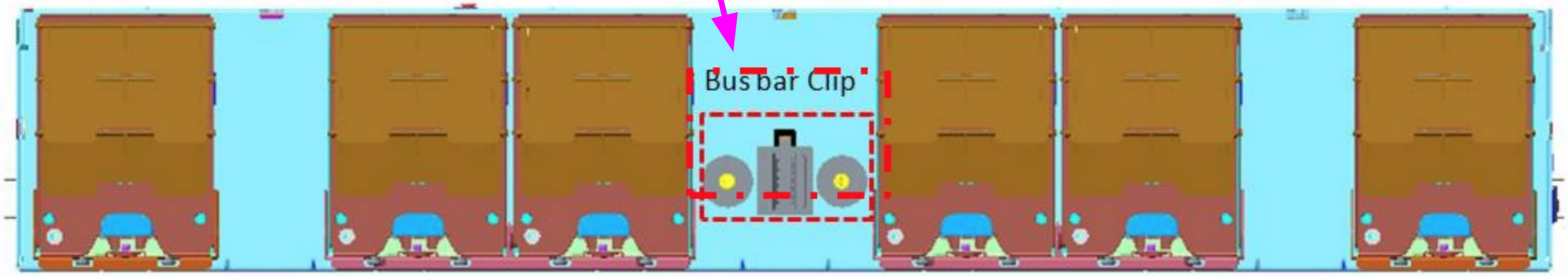
Minimum Required Features:
Server Payloads - **Electrical** Requirements

- 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)

Figure: Sled/Shelf Bus Bar Top View

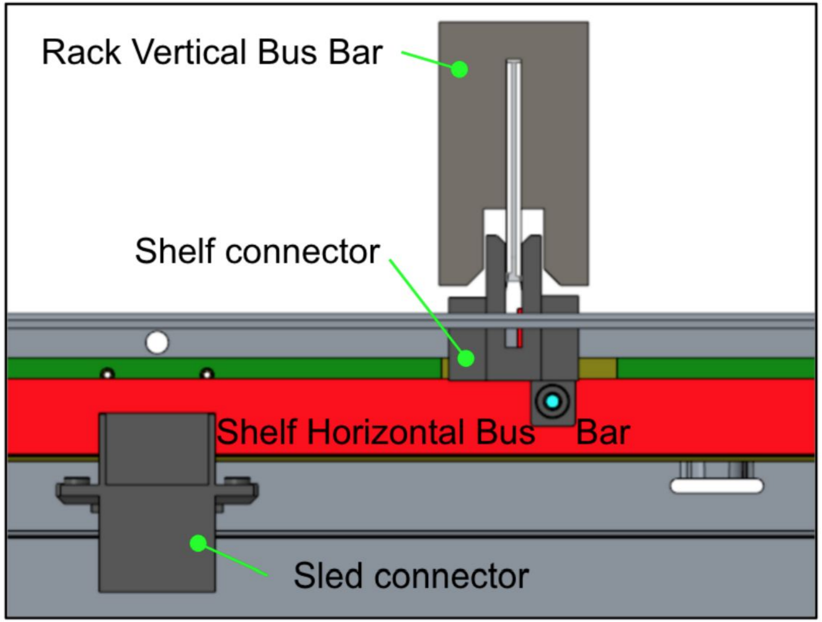
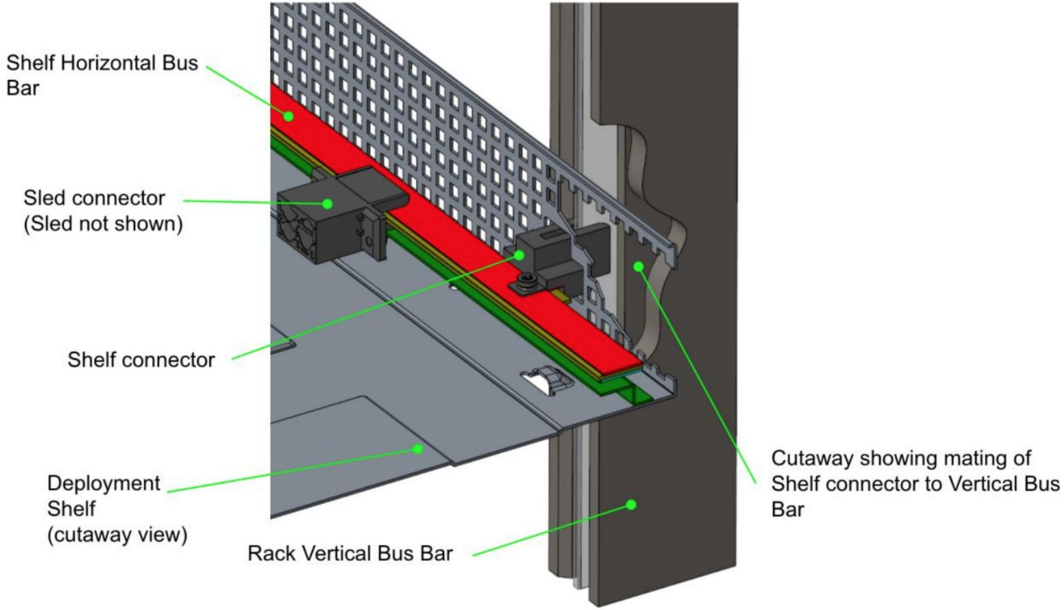


Figure: Tray/Shelf Bus Bar Isometric Cutaway View

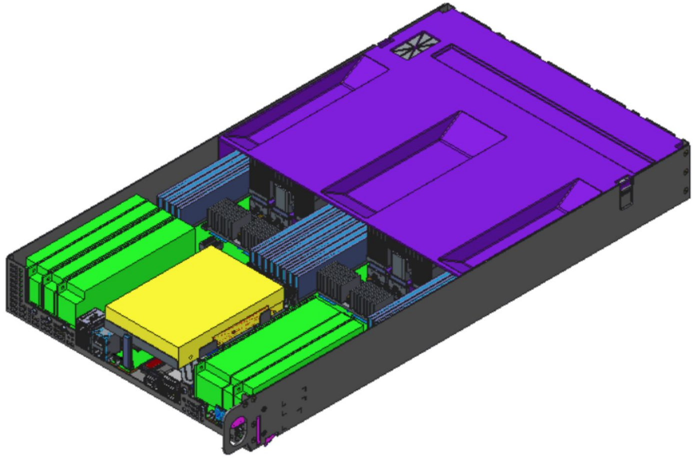


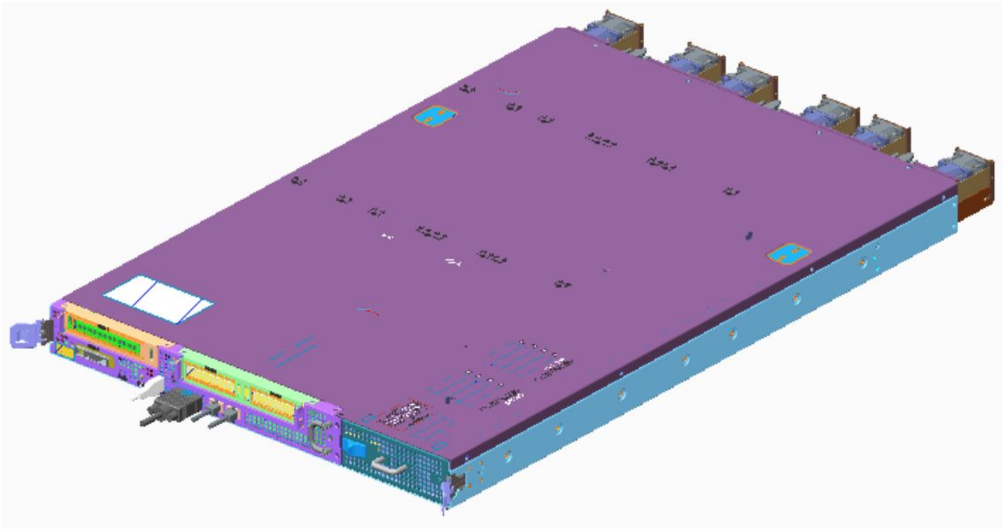
Flatbed Compliance Highlights

- 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

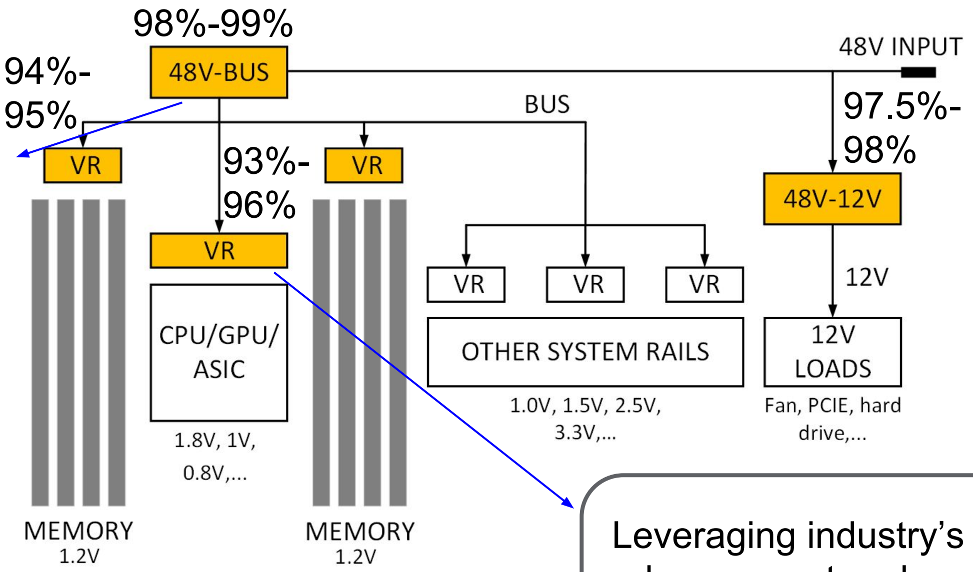
	Efficiency	**Density**	**Scalability**	**Cost**
48V systems	~93%-94% (1.8V) ~90%-92% (sub-1V) Magnetic designs dictate overall efficiency performance	Varies significantly across architectures Extremely challenging on magnetics miniaturization	Custom components with long lead time limit time to market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

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

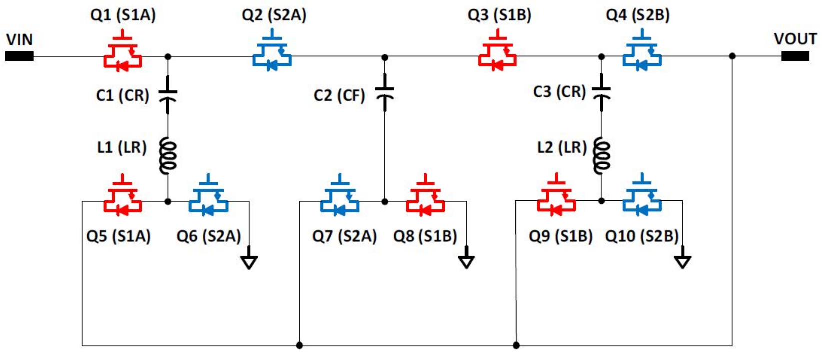
Higher power bus converter also gives lower $/W

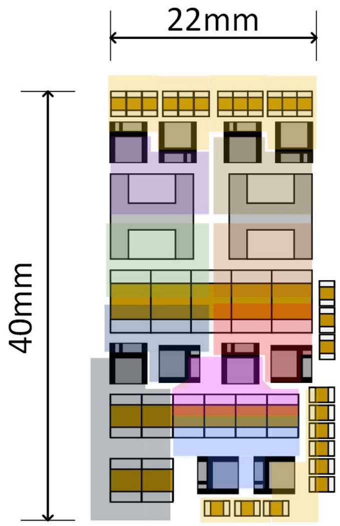


Leveraging industry's continuous advancement and ecosystem of multi-phase VR technologies for best optionality and TCO

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





(STC powertrain with 600W TDP, 900W peak)

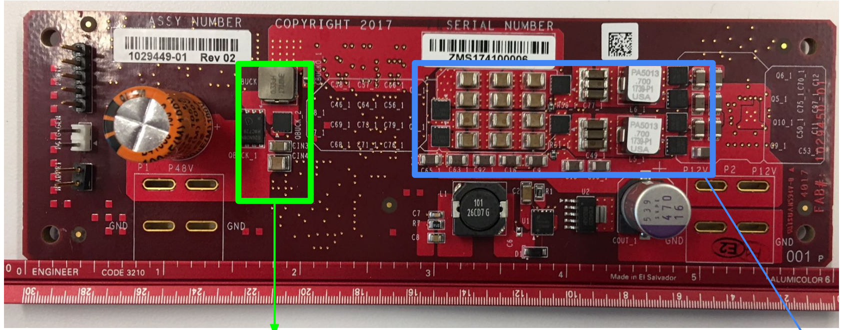
Technological Features

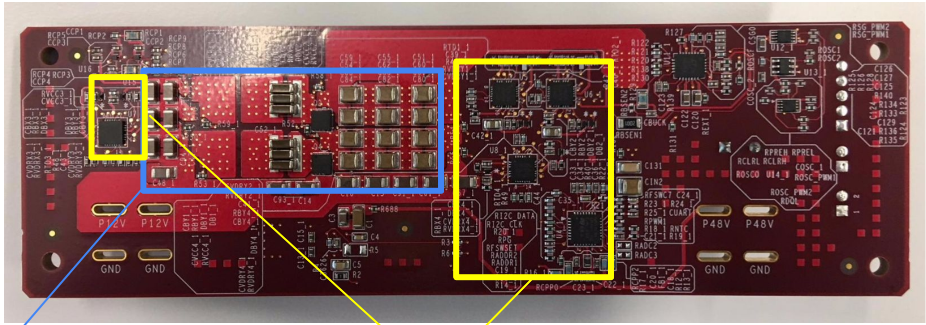
- Very high efficiency and density
- Fast transient response with very high peak power capability
- Low voltage FETs only
- Full soft charging & soft switching
- Tightly controlled resonant operation over a wide range
- Strong immunity to capacitor tolerances and board parasitics.
- Inherent droop current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

600W 4-to-1 STC EVM Board (Google design)

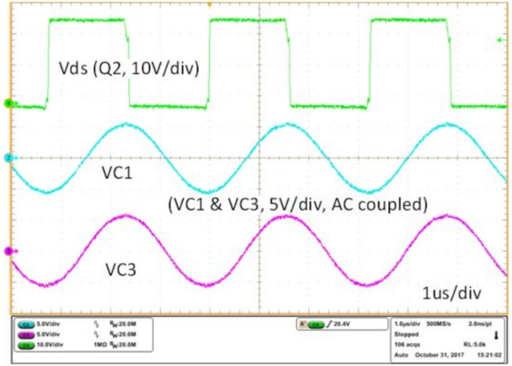


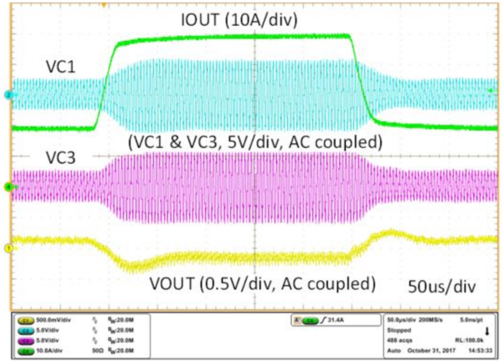


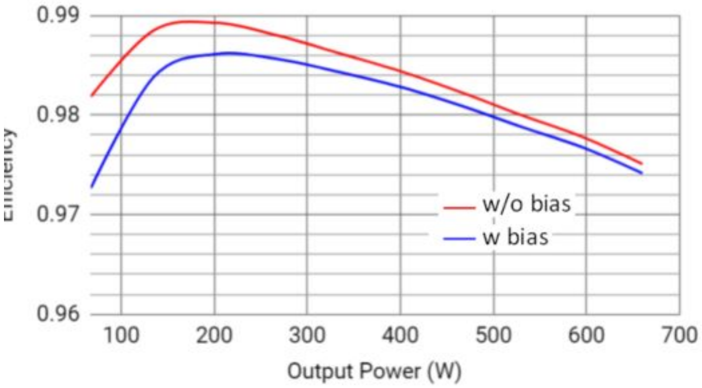
Input buck starter/protector
(100% duty, 99.9% efficiency)

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?

OCP
SUMMIT