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Challenges and Solutions in Multi Vendor Inter op

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Presentation Agenda

Interop Objective

Key challenges

Key Challenges addressed in this presentation

- Peak Loading
- Thermal Interoperability

Next Steps

Summary

Power Interop Objective

Interoperation (Interop): To allow PSUs and/or other components such as Power Shelf, BBU, etc., from different vendors to function compatibly in the same system together.

True dual/multi-vendor sourcing

Electrical Challenges

- Current Sharing and Dynamic Response
- Input and Output Interface Circuitry
- Power Up
- Recovery from AC Loss and or OCP
- Firmware compatibility for Monitoring, Control and Communication

***Interoperability of Mixed Supplier PSUs in An Open Rack Power Shelf**
– David Sun (May 2018)

Mechanical and Thermal Challenges

- Dimensions and tolerances
- Connectors, Pins and Pin types, Pin length
- Latching and Ejectors
- LED color details, Intensity
- Fan Performance, Fan speed control algorithms
- Thermal considerations with multiple vendors

***Interoperability of Mixed Supplier PSUs in An Open Rack Power Shelf**
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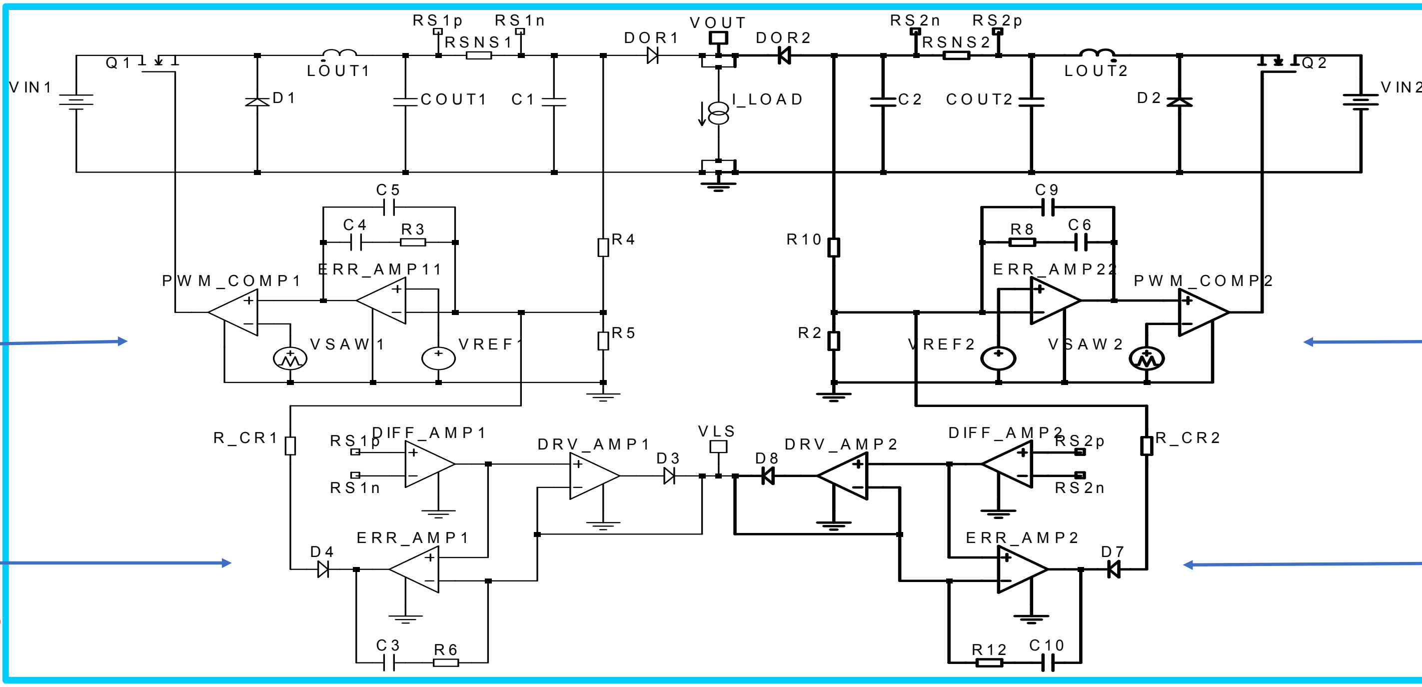
Current Sharing and Dynamic Response

Current Share Circuit Overview

Vendor 1

Vendor 2



Voltage Loop

Voltage Loop

Current Share Loop

Current Share Loop

All need to work seamlessly together

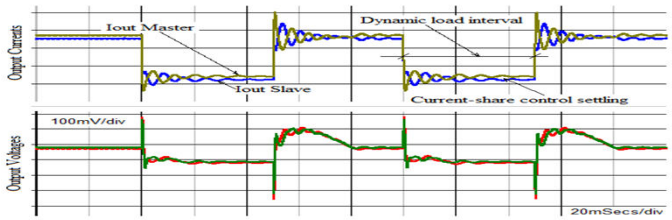
Current Sharing Interoperability

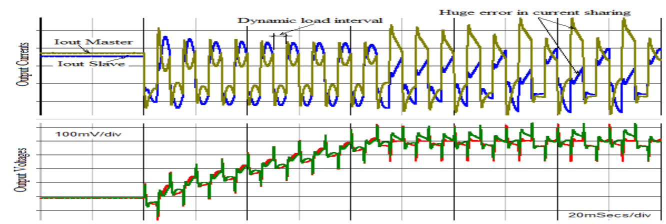
Possible Modes of Operation :

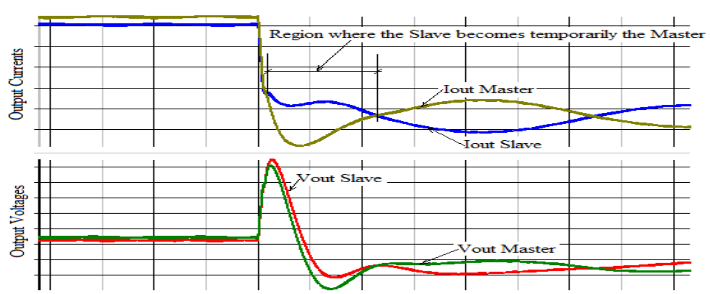
- Load Dynamic Change is slower than the Current Share Loop Bandwidth.
- Load Dynamic Change is faster than the Current Share Loop Bandwidth.
- Master PSU Voltage-loop response is slower than Slave PSU Voltage-loop response.
- Master PSU Voltage-loop response is faster than Slave PSU Voltage-loop response.

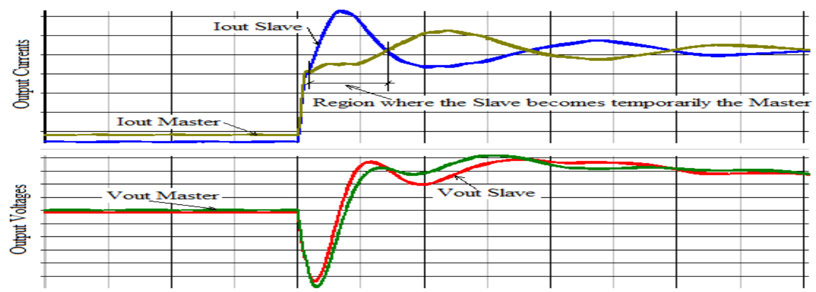
Current Sharing Interoperability

Possible Modes of Operation :









Reversal of Master/Slave roles and instability in the current-share loop results in loss of desired sharing

Current Sharing/Dynamic Response Interoperability Recommendations

Current Share bandwidth Loop:

100-200 Hz bandwidth at full load

Low Share loop bandwidth is preferred

Share loop Margin >60 Degrees to ensure:

- Best Performance for Hot Plug
- Best Performance for AC loss and AC return
- Best Performance for Hot Swap

If it can be agreed that the load dynamic change is slower than
<u>the settling time of current-share loop response,</u>
the majority of the issues and proprietary solutions can be avoided.

Current Sharing Illustration

Current Sharing Test Example:

Testing is extensive must be automated

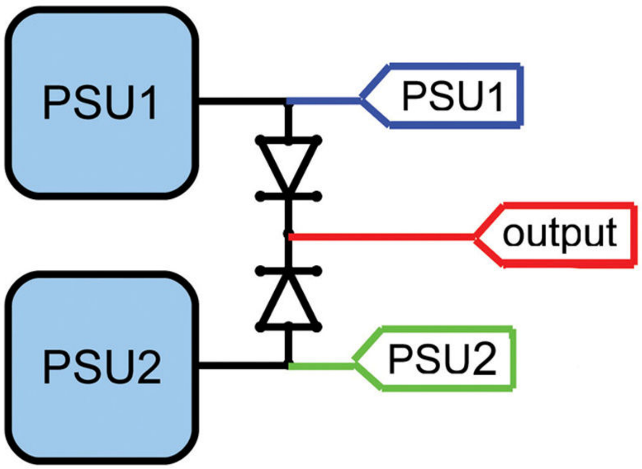


Table 2. Sharing Accuracy for 1+1 @ 230Vac (UUT1 trimmed 12.024V; UUT2 trimmed to 11.976V)

% Load	Load (A)	Bus Voltage (V)	Artesyn Load (A) UUT1	Artesyn Loading (A) UUT2	Total Load (A)	Ishare_V (V)	Accuracy (Artesyn - Artesyn) (A)	5% Limit	Remarks
0%	0.00	12.249	0.53	0.02	0.55	0.232	0.51	No requirement	
10%	4.13	12.230	2.89	1.62	4.51	0.664	1.27	2.06	PASS
20%	8.25	12.222	4.69	2.98	7.67	0.928	1.71	2.06	PASS
30%	12.38	12.215	7.22	5.63	12.85	1.271	1.59	2.06	PASS
40%	16.50	12.211	9.27	7.67	16.94	1.680	1.60	2.06	PASS
50%	20.63	12.207	11.34	9.75	21.09	2.089	1.59	2.06	PASS
60%	24.75	12.204	13.40	11.84	25.24	2.480	1.56	2.06	PASS
70%	28.88	12.201	15.56	13.80	29.36	2.884	1.76	2.06	PASS
80%	33.00	12.197	17.51	15.87	33.38	3.279	1.64	2.06	PASS
90%	37.13	12.195	19.51	17.89	37.40	3.685	1.62	2.06	PASS
100%	41.25	12.189	21.38	20.38	41.76	4.048	1.00	2.06	PASS

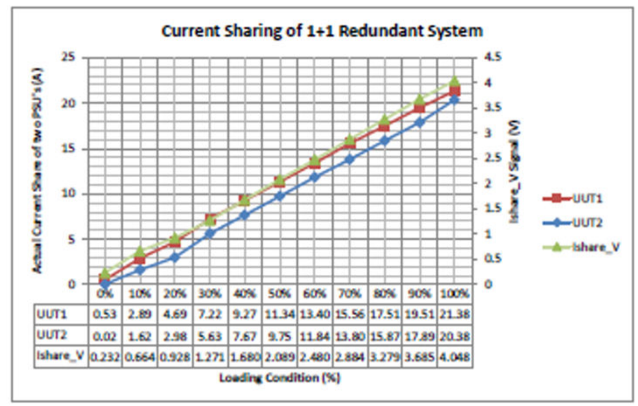


Figure 3. Current Sharing of Artesyn PSU's (Max and Min Vout Trim) in 1+1 Redundant System

Current Activities

- Peak Loading Operation and challenges
- Mechanical and thermal considerations

Peak Load Operation

Requirements –

12.6V Output

- 120% for 18 Secs
- 170% for 3 Secs

During Interop PSU's should be able to meet required performance and not shut down.

Peak Load Operation (Open Rack V2 Spec)

12.6V Output
120% for 18 Secs

Units Designed with Interop Considerations

Voltage

Current

Units Designed without Interop Considerations

During 120% Peak loading Output disappears without Proper Interop Consideration

Peak Load Operation (Open Rack V2 Spec)

12.6V Output
170% for 3 Secs

Units Designed with Interop Considerations

Voltage

Current

Units Designed without Interop Considerations

During 170% Peak loading Output disappears without Proper Interop Consideration

Peak Loading Issue

Cause:

Droop levels are different for both units

Solution:

Droop needs to be defined under peak loading conditions similar to how its defined under normal operation

What is thermal interoperability?

Interoperability is the freedom to replace any device in a system with the equivalent device from an alternate source without noticeable effect on the other components of the system or the system itself

- i.e. the ability to freely swap devices from different manufacturers

Thermal Interoperability refers to the ability of devices to be swapped at a thermal level

- i.e. the sub-set of Interoperability requirements that relate to the thermal characteristics that must be controlled to ensure Interoperability: temperature, airflow, pressure, etc. as appropriate

Objective and Methodology

Interoperability requirements should be fully specified at the component level

- Allows the component design (PCD or Power Shelf) to proceed without knowledge of the rest of the system or alternate sources

Interoperability requirements should be verifiable at the component level using standard equipment

- Allows early verification and independent qualification of compliance to requirements

Avoiding dependencies on other systems or sources is generally good practice to minimise issues and development schedules

Enable inter changeability of Power Components without unduly constraining design approach

Thermal Interop considerations for Power Supply

Specification	Advantages	Limitations
Shelf impedance	Characterises shelf.	Typically small (almost negligible) compared to the PSU impedance. Does not control the PSU airflow.
Airflow v load	Controls the downstream (shelf) airflow rate. May limit maximum exhaust air temperature depending on minimum efficiency requirements.	May drive efficiency and/or layout considerations. Requires the shelf impedance to be meaningful. Only considers a single ambient condition.
Exhaust air temperature rise v load	Controls the downstream (shelf) ambient temperature. May limit extreme airflow rates depending on the efficiency requirements.	Does not by itself control the airflow, only the balance between airflow and efficiency.
Fan speed v load		Does not by itself control the airflow. Very restrictive.
PCD PQ curve	Allows the PSU to be treated somewhat like an AMD.	Does not by itself control the airflow.
Fan control algorithm	Well defined control mechanism.	Only exposes the capability of the hardware.
Many others	?	?

Proposed Considerations for PSU

PSU PQ curve

- This basically treats the PSU as an AMD(Air moving device) and permits the PSU/ shelf supplier freedom to trade-off AMD performance and layout
- The airflow rate must still be set for some reference condition to establish an equivalent speed for the AMD(s)
- It is anticipated PCDs with a similar PQ curve perform similarly at different percentages of the reference speed assuming the PCD impedance follows a square law (*)
- The accuracy of this needs to be validated with real impedances which more typically have an index of around 1.7 to 1.9

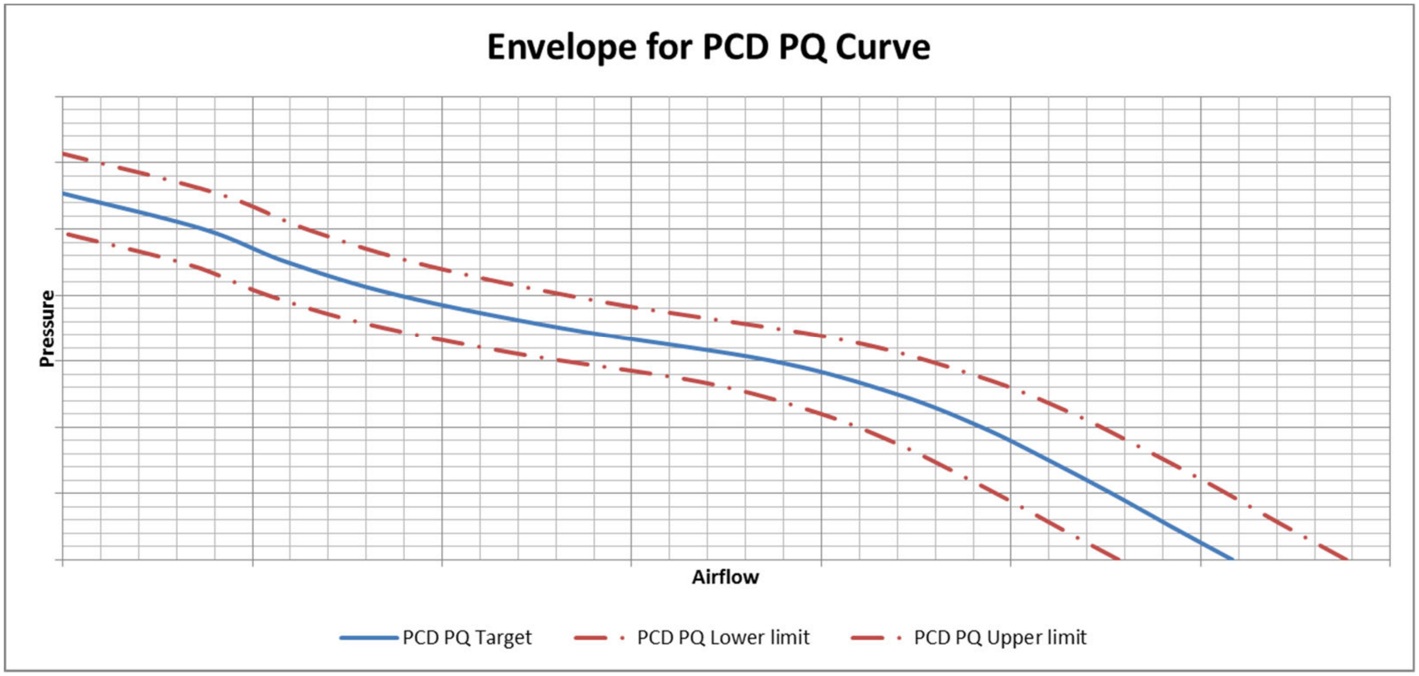
PSU average exhaust air temperature at worst case condition

- This requirement can set the reference speed and limits the maximum ambient temperature for downstream shelf components
- Typically the worst case condition will be full load at low line
- This will effectively set the maximum fan speed
- Discrepancies will appear more at low speeds where they are possibly less sensitive
- Average exhaust temperature is difficult to measure directly and should be referred to a standard calculation based on measured power dissipation and airflow rate
- If required $\Delta T_{exhaust}$ could be specified as a function of load, or constant irrespective of load
- This could address (*) above

Sample PSU PQ curve requirement

An example of a PSU PQ curve is shown below

- The requirement would be for the actual PSU PQ curve to lie everywhere between the upper and lower bounds



Thermal Interop considerations for Power Shelf

Specification	Advantages	Limitations
Shelf impedance	Sets a maximum “back pressure” for the PSU. Can be used with PSU PQ curve to determine airflow at the reference condition.	Not normally significant. Does not control the environment for shelf components.
Minimum airflow	Defines the worst case airflow for cooling shelf components.	May result in overdesign of the shelf.
Maximum air temperature	Defines the worst case air temperature for cooling shelf components.	May result in overdesign of the shelf.
Minimum airflow v load	Defines available airflow in a consistent way that is useful to the shelf designer.	Minimum airflow at a particular load may not relate to maximum temperature at that load. May result in slight overdesign.
Maximum temperature v load	Defines temperature in a consistent way that is useful to the shelf designer.	Maximum temperature at a particular load may not relate to minimum airflow at that load. May result in slight overdesign.
Many others	?	?

Proposed Considerations for Shelf

Impedance curve

- Required only to set an upper limit and ensure control on the shelf impedance
  - Not normally a significant factor

Minimum Airflow v Load

- Allows thermal design of the shelf when specified with an air temperature
- The shelf design will be independent of the PSU (assuming the PSU requirements are fixed) and therefore thermally interchangeable

Maximum Air Temperature v Load

- Allows thermal design of the shelf when specified with an airflow
- The shelf design will be independent of the PSU (assuming the PSU requirements are fixed) and therefore thermally interchangeable

Next Steps

Update feasibility Specifications to include

Key Electrical and Mechanical Parameters:

- Current share circuit recommendation
- Current loop bandwidth
- Voltage loop bandwidth
- Peak loading
- Mechanical outline with tolerances, materials, feature definition such as mounting, airflow direction
- Connector definition including terminal assignments, short pin/long pin features, etc.

Interface and Communication

- Include Interface Circuits
- Definitions of output response and timing for start-up, shut down, dynamic and fault conditions
- LED Response (blinking rates, Intensity, wavelength)
- Communication architecture and spec
- Synchronization turn on/turn off sequence
- Firmware update compatibility requirements

Update Design Specification to include Interop recommendations

Call to Action

- We need your help and this group can benefit from your experience.
- We still have about 6 months to go before publishing specification
- You can find more details of project here

  https://www.opencompute.org/wiki/Rack-%26-Power
- You can find more details on V2 Specifications here

  https://www.opencompute.org/wiki/Open-Rack/SpecsAndDesigns

Thank You!

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OCP Global Summit | March 14–15, 2019

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