

Intel® Server System S9200WK

Liquid Cooled Rack Reference Design Guide

Guidelines and requirements to design rack and cabinet level solutions with the Intel® Server System S9200WK in a liquid cooled environment.

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1. Introduction

This reference design guide provides an overview of the architecture components, guidelines, and other requirements for designing a rack or cabinet solution with the Intel® Server System S9200WK in a liquid cooled environment.

For the purpose of this guide, the concepts of "Rack", "Cabinet", and "Cluster" are referred to in the following context:

- **Rack:** A Server system rack configured with liquid cooled 2U 4-compute module systems, Ethernet switches, high speed QSFP switches, Power Distribution Units (PDUs) and a liquid cooling manifold.



Figure 1. Rack concept

- **Cabinet:** Two racks according to the definition presented in this guide, accompanied by an Air Handler Unit (AHU) between them.



Figure 2. Cabinet concept

- **Cluster:** A group of three or more racks or cabinets according to the definition presented in this guide.

For the rack and cabinet solution described within this guide, Intel has selected Stulz* liquid cooling products. This guide includes information concerning the hardware inside the rack, the power, cooling and network infrastructure, and the physical space it occupies.

1.1 Usage disclaimer

This guide includes references to both Intel and non-Intel products, but have been tested and are compatible as described. It is the responsibility of the integrator that decides against using the recommended products herein described to consult vendor datasheets and operating parameters to determine the compatibility and viability of a solution for their specific application and operating environment.

Intel Corporation cannot be held responsible for the performance of the resulting IT infrastructure configuration, failure of non-Intel components, or if any components do not operate correctly when used outside of the parameters described within this guide.

1.2 Target audience

The information contained in this guide is intended for IT professionals with advanced knowledge of thermal, electrical and compute performance analysis for datacenter IT infrastructure deployments. The terminology used in this guide requires that the reader has experience performing this type of analysis and planning for datacenter IT infrastructure.

2. Components Overview

This chapter provides an overview of the components installed inside the reference rack and cabinet as well as the power and cooling requirements to be met when designing the reference rack and cabinet configuration.

2.1 Rack and Cabinet Configuration

The solution described within this guide is presented in two different configurations: rack and cabinet. The following is a high level overview of the major components in both configurations:

Rack configuration:

- 24 server systems
- 4 – Power distribution units (PDU)
- 2 – Ethernet management switches
- 4 – Intel® Omni-Path edge switches
- 1 – Liquid cooling rack manifold

Cabinet configuration:

- 2 – Racks in accordance with the rack configuration
- 1 – Air handler unit (AHU)
- 1 – Rack frame for AHU

The following tables show the recommended hardware configuration when populating a rack or cabinet. Table 1 shows the configuration for a 48U rack with 24 chassis, Ethernet switches and Intel® Omni-Path Edge Switches, enabling an optimal configuration with the shortest cables. Table 2 and Table 3 show the configuration for the cabinet.

Table 1. Reference rack layout

U	Front View		Rear View	
48	Module 95	Module 96	2U 4-compute module system (Rear)	Cool Liquid Inlet Manifold - 24 x Quick Disconnect
47	Module 93	Module 94	2U 4-compute module system (Rear)	
46	Module 91	Module 92	2U 4-compute module system (Rear)	
45	Module 89	Module 90	2U 4-compute module system (Rear)	
44	Module 87	Module 88	2U 4-compute module system (Rear)	
43	Module 85	Module 86	2U 4-compute module system (Rear)	
42	Module 83	Module 84	2U 4-compute module system (Rear)	
41	Module 81	Module 82	2U 4-compute module system (Rear)	
40	Module 79	Module 80	2U 4-compute module system (Rear)	
39	Module 77	Module 78	2U 4-compute module system (Rear)	
38	Module 75	Module 76	2U 4-compute module system (Rear)	
37	Module 73	Module 74	2U 4-compute module system (Rear)	
36	Module 71	Module 72	2U 4-compute module system (Rear)	
35	Module 69	Module 70	2U 4-compute module system (Rear)	
34	Module 67	Module 68	2U 4-compute module system (Rear)	
33	Module 65	Module 66	2U 4-compute module system (Rear)	
32	Module 63	Module 64	2U 4-compute module system (Rear)	
31	Module 61	Module 62	2U 4-compute module system (Rear)	
30	Module 59	Module 60	2U 4-compute module system (Rear)	
29	Module 57	Module 58	2U 4-compute module system (Rear)	
28	Module 55	Module 56	2U 4-compute module system (Rear)	
27	Module 53	Module 54	2U 4-compute module system (Rear)	
26	Module 51	Module 52	2U 4-compute module system (Rear)	
25	Module 49	Module 50	2U 4-compute module system (Rear)	
24	Module 47	Module 48	2U 4-compute module system (Rear)	
23	Module 45	Module 46	2U 4-compute module system (Rear)	
22	Module 43	Module 44	2U 4-compute module system (Rear)	
21	Module 41	Module 42	2U 4-compute module system (Rear)	
20	Module 39	Module 40	2U 4-compute module system (Rear)	
19	Module 37	Module 38	2U 4-compute module system (Rear)	
18	Module 35	Module 36	2U 4-compute module system (Rear)	
17	Module 33	Module 34	2U 4-compute module system (Rear)	
16	Module 31	Module 32	2U 4-compute module system (Rear)	
15	Module 29	Module 30	2U 4-compute module system (Rear)	
14	Module 27	Module 28	2U 4-compute module system (Rear)	Hot Liquid Outlet Manifold - 24 x Quick Disconnect
13	Module 25	Module 26	2U 4-compute module system (Rear)	
12	Module 23	Module 24	2U 4-compute module system (Rear)	
11	Module 21	Module 22	2U 4-compute module system (Rear)	
10	Module 19	Module 20	2U 4-compute module system (Rear)	
9	Module 17	Module 18	2U 4-compute module system (Rear)	
8	Module 15	Module 16	2U 4-compute module system (Rear)	
7	Module 13	Module 14	2U 4-compute module system (Rear)	
6	Module 11	Module 12	2U 4-compute module system (Rear)	
5	Module 9	Module 10	2U 4-compute module system (Rear)	
4	Module 7	Module 8	2U 4-compute module system (Rear)	
3	Module 5	Module 6	2U 4-compute module system (Rear)	
2	Module 3	Module 4	2U 4-compute module system (Rear)	
1	Module 1	Module 2	2U 4-compute module system (Rear)	

Table 2 and Table 3 show the configuration for a cabinet comprised of 2 racks with systems and a cooling rack in between.

Table 2. Reference cabinet layout – front view

IT Rack - 1				Cooling Rack		IT Rack - 2			
U	Front View			Front View		U	Front View		
48	Module 95	Module 96				48	Module 95	Module 96	
47	Module 93	Module 94				47	Module 93	Module 94	
46	Module 91	Module 92				46	Module 91	Module 92	
45	Module 89	Module 90	1U OPA Edge 48 ports Switch-3			45	Module 89	Module 90	1U OPA Edge 48 ports Switch-4
44	Module 87	Module 88				44	Module 87	Module 88	
43	Module 85	Module 86				43	Module 85	Module 86	
42	Module 83	Module 84				42	Module 83	Module 84	
41	Module 81	Module 82				41	Module 81	Module 82	
40	Module 79	Module 80				40	Module 79	Module 80	
39	Module 77	Module 78				39	Module 77	Module 78	
38	Module 75	Module 76				38	Module 75	Module 76	
37	Module 73	Module 74				37	Module 73	Module 74	
36	Module 71	Module 72				36	Module 71	Module 72	
35	Module 69	Module 70				35	Module 69	Module 70	
34	Module 67	Module 68				34	Module 67	Module 68	
33	Module 65	Module 66				33	Module 65	Module 66	
32	Module 63	Module 64				32	Module 63	Module 64	
31	Module 61	Module 62				31	Module 61	Module 62	
30	Module 59	Module 60				30	Module 59	Module 60	
29	Module 57	Module 58	1U 48 Port 1G Mgmt Switch-1	Air Handler (700mm Wide 1457mm Deep Empty Rack + Stulz* CyberRow) Cold Air Supply to both sides of the Compute racks		29	Module 57	Module 58	1U 48 Port 1G Mgmt Switch-2
28	Module 55	Module 56				28	Module 55	Module 56	
27	Module 53	Module 54				27	Module 53	Module 54	
26	Module 51	Module 52				26	Module 51	Module 52	
25	Module 49	Module 50				25	Module 49	Module 50	
24	Module 47	Module 48				24	Module 47	Module 48	
23	Module 45	Module 46				23	Module 45	Module 46	
22	Module 43	Module 44				22	Module 43	Module 44	
21	Module 41	Module 42				21	Module 41	Module 42	
20	Module 39	Module 40				20	Module 39	Module 40	
19	Module 37	Module 38				19	Module 37	Module 38	
18	Module 35	Module 36				18	Module 35	Module 36	
17	Module 33	Module 34				17	Module 33	Module 34	
16	Module 31	Module 32				16	Module 31	Module 32	
15	Module 29	Module 30				15	Module 29	Module 30	
14	Module 27	Module 28	1U OPA Edge 48 ports Switch-1			14	Module 27	Module 28	1U OPA Edge 48 ports Switch-2
13	Module 25	Module 26				13	Module 25	Module 26	
12	Module 23	Module 24				12	Module 23	Module 24	
11	Module 21	Module 22				11	Module 21	Module 22	
10	Module 19	Module 20				10	Module 19	Module 20	
9	Module 17	Module 18				9	Module 17	Module 18	
8	Module 15	Module 16				8	Module 15	Module 16	
7	Module 13	Module 14				7	Module 13	Module 14	
6	Module 11	Module 12				6	Module 11	Module 12	
5	Module 9	Module 10				5	Module 9	Module 10	
4	Module 7	Module 8				4	Module 7	Module 8	
3	Module 5	Module 6				3	Module 5	Module 6	
2	Module 3	Module 4				2	Module 3	Module 4	
1	Module 1	Module 2				1	Module 1	Module 2	

Table 3. Reference cabinet layout – rear view

[illegible]

2.2 Facility Power

The following table lists the requirements for the facility in which the rack or cabinet will be installed:

Table 4. Facility power requirements

Requirement	Details
Rack input power	400VAC 3P
Power receptacles	IEC 60309 3P+N+E 63A/60A OR Terminal Block
Max input current	63 A
Single Rack power load	127 KW maximum

See Section 3.1 for details on the power budget for rack and cabinet configurations

2.3 Configuration Components

The following table lists the recommended components for each rack and cabinet configuration.

Table 5. Recommended rack and cabinet configuration components

Vendor	Item Type	Description	QTY per Rack	QTY per Cabinet
Chatsworth*	Rack Frame	48U 800mm Wide 1457mm Deep Rack - Solid Doors	1	2
Chatsworth*	Rack Frame	48U 700mm Wide 1457mm Deep Rack - Solid Doors	0	1
Stulz*	Air Handler	Cyber Row Cooling for Air in Cabinet	0	1
Intel	Server	2U, 4-compute module system	24	48
Enlogic*	EU Std certified PDU	400V 3Ph 45.36 KVA 63A 50Hz PDU	4	8
Raritan*	US Std certified PDU	400V 3Ph 55.4 KVA 80A 50Hz PDU	4	8
Cisco*	Switch - Base Unit	Catalyst 2960 1Gb Network Switch	2	4
	Fan Assembly	Switch Fan (front to back)	2	4
	PSU	Redundant PSU	4	8
Intel	100G Switch	Intel® Omni-Path Edge Switch 100 Series 48 Port 2 PSU	4	8
CoolIT*	Liquid Cooling part	Inlet Vertical Manifolds (Cold Water)	1	2
		Outlet Vertical Manifolds (Hot Water)	1	2
Intel	QSFP Cables	Intel Omni-Path 100G QSFP Cables	96	192
Amphenol*	Ethernet Cable	CAT6 Cable - Blue	100	200
Bizlink*	Power Cable	C13-C14 Power Cord	84	168
---	Power Cable	C14 - DIN Type 2508 Power Cord	1	2
King Slide*	Rail	Rack mount rail kit	24	48
Stulz*/CoolIT*	Coolant Distribution Unit (CDU)	Liquid to Liquid Cooling from Rack	0	1
Chatsworth*	Rack Frame	48U 700mm Wide 1457mm Deep Rack - Solid Doors	0	1

2.4 Server System Configuration Requirements

The rack and cabinet solutions described in this guide are built around the capabilities of the Intel® Server System S9200WK.

A liquid cooled server system configured with 1U 48C 350W compute modules is recommended for a typical HPC application. However, other configurations can be utilized based on application and workload requirements. For other SKU options, contact your local Intel representative.

The following table lists the recommended configuration for the Intel® Server System S9200WK when selected to be installed in the reference rack or cabinet.

Table 6. Intel® Server System S9200WK configuration

Description	Qty. per Node	Qty. per System
Intel Server System S9200WK		1
Consisting of:		
Intel® Server Chassis FC2000 Liquid-Cooled (2100W)		1
Intel® Compute Module S9200WK 1U Half-Width Liquid-Cooled CPU 48C 350W		4
Memory: DDR4 16GB 2R 2933 RDIMM	24	96
Storage: Intel SSD DC DCP4101 Series, M.2 PCIe Gen3 x4 512GB 22x80mm SSDPEKKA512G801	1	4
Fabric: Intel Omni-Path Host Fabric Interface Adapter 100 Series, 1 Port PCIe x16, Low Profile 100HFA016LS	1	4
2U system Rail kit		2

For more details on each configuration and other specifications, refer to the *Intel® Server System S9200WK Technical Product Specification*.

3. Electrical Specifications

This chapter provides information on power budget for the:

- Rack
- Air handling unit (AHU)
- Cooling distribution unit (CDU)
- Power distribution unit (PDU) planning and selection
- Power mapping for all equipment
- Network switch mapping

3.1 Overall Power Budget

Table 5 lists the recommended components for each rack and cabinet configuration. The total de-rated power for a rack is 159.6KVA, and the total available power in-rack is 220KW divided into 4 PDUs at 55KW each. The following tables list the estimated power budget for both the rack and cabinet. The values are based on the following assumptions:

- Node configuration: 2 x 350W CPUs, 24 X 14W DIMMs, 2 x 15W PCIE cards
- Cluster Configuration: 5 Cabinets = 10 Racks with 24 Servers each, 4 Nodes per Server, 3 end-of-row CDUs in Parallel
- Secondary Fluid: 25% Propylene Glycol Water (PG25)
- Connection Points: CBG20 QD at Rack level and SCG06 at Chassis level.
- Primary Fluid: ASHRAE W3 (32°C) Water at 360lpm per each end-of-row-based CDU.
- 3CDUs recommended for every 960 nodes (10 racks with 24 chassis each)
- 4.4lpm per Server, 1.1lpm per Node, Sever exit temp = 50°C.

Table 7. Rack power budget

Compute Rack		Qty. per rack	Device Power	Aggregate Power	Amps @ 240V
1	2U four node server system	24	5225W	125,400W	21.7708333
2	Intel Omni-Path Edge 48-port Switch	4	230W	920W	1
3	Cisco* 2960 Catalyst 1G Network Switch	2	125W	250W	0.54
	Total			126,570W	
	De-rated power			159,625VA	
	Available power in rack per PDU capacity	4	55,000W	220,000W	

Table 8. Cabinet power budget

L11 Cabinet (MDC - 2 x Compute IT Racks + 1 x Cooling Rack)		Qty per cabinet	Device Power	Aggregate Power
1	Compute Rack - 1 (24 x server systems)	2	127000W	254,000W
2	Air Handler (Cooling Rack)	1	6,100W	6,100W
	Total			260,100W
	De-rated power			325,125VA
Cluster level Power consumption				
1	Coolant Distribution Unit (CDU CHx750)	3	7500W	22,500W
2	L11 Cabinet	5	260,100W	1,300,500W
	Total			1,323,000W
	De-rated power			1,653,750VA

3.2 Power Distribution Unit (PDU) Selection

PDU selection is a crucial step in system design. When selecting a PDU, consider both the physical attributes (mechanical dimensions, mounting features, cord length, etc.) and electrical attributes (voltage type, power capacity, circuit breaker counts, etc.).

To power a single rack with 24 x 2U/4-Compute module systems, the PDU must be three-phase 400/415 V rated and have a power capacity range between 38 kVA to 46 kVA with 12 or more circuit breakers/branches. A higher power capacity, three-phase 400 V rated PDU is also acceptable.

With an estimate of the total actual power for all equipment around 127 kW in a single rack, the de-rated power budget for the rack is 159 kVA. A 20% safety margin is added into the rack level power design.

The following table lists the recommended components for each rack and cabinet configuration.

Table 5 for recommended PDUs for the rack or cabinet configurations

3.2.1 EU Standards Compliant PDU

Table 9. EU PDU

Manufacturer	Enlogic* 3 Phase WYE
Model #	EN 1185
PDU remote management	YES (Non-Switched PDU)
Power cord length	3.0 m
Plug type & quantity	IEC309 563p6
Output receptacle/socket	36 outlets - 24 x C13, 12 x C19
Rated Input voltage	380V - 415V
Nominal Input voltage	400V
Input Frequency	50 Hz
Input Power Capacity	45.36 kVA
Input current (derated/max)	63A

3.2.2 US Standards Compliant PDU

Table 10. US PDU

Manufacturer	Raritan*
Model #	PX3-5157XU-01V2
PDU remote management	YES (Switched PDU)
Power cord length	N/A
Plug type & quantity	Terminal Block
Output receptacle/socket	48 x C13 (12A)
Rated Input voltage	380V - 415V
Nominal Input voltage	400V
Input Frequency	50/60 Hz
Input Power Capacity	52.7 kVA@380V, 57.5kVA@415V
Input current(derated/max)	80A

3.3 Power Mapping

The configuration consists of approximately 84 connections for individual power supply units for servers and switches. The power load must be distributed equally across the PDUs for the entire rack.

When the entire rack is used for a high-performance computing (HPC) application, all nodes consume approximately the same amount of power in a typically loaded configuration. The common redundant power supply units used in the Intel® Server System S9200WK operate at the higher end of their capability by

splitting the load equally or accordingly when running at maximum power. Generally, if each system chassis is plugged into three different PDUs, a single PDU failure prevents all systems from running at full power. However, if two or three PSUs within the same system are plugged into one PDU and phases are balanced by evenly loading all PDUs from top to bottom, a single PDU failure affects fewer systems in the rack.

Serviceability of the server rack is improved if the chassis is plugged into power at the same unit level in the rack using the shortest possible power cable routes. The tables in this section show the recommended mapping between power supply modules and power outlets, beginning with the rack and then passing to the different PDUs. The tables are color coded for convenience.

The Intel® S9200WK Server Systems were typically configured for both the 4 PDU and 3 PDU design concepts. The configuration and measured power is shown in Table 11 below.

Table 11. Typical Intel® Server System S9200WK Configuration

Intel® Server System S9200WK Configuration	Calculated Power Consumption (WAC)	Measured Power Consumption - typical ambient (WAC)	Measured Power Consumption - worst ambient (WAC)	+5% guard band (WAC)
CPUs- 2 x 48C DIMM- 24 x 16GB 2933MTs Fabric- 1 x OPA	4500W	4000W	4160W	4370W

Note: Deviation from the typical configuration to higher TDP configurations could result in the loss of additional server systems during PDU failures. It will require power budgeting recalculations due to the increased loading of the greater TDP configuration.

3.4 4 PDU Reference Design Power Mapping

In the 4 PDU design concept, eight Intel® S9200WK Server Platforms are connected to a single PDU. Each system power supply is connected to a different phase, e.g. PSU1 (phase 1), PSU2 (phase 2), and PSU3 (phase 3). With this distribution, the loading and phases across the PDUs are well balanced and offers the greatest redundancy and uptime during a PDU failure (refer to the 4 PDU configuration images). During a single PDU failure, it is expected that the 3 remaining operational PDUs will provide enough power to the impacted server systems to remain operational without impact to system performance.

Table 12. Power supply layout for 4 PDU design reference

		U#	Rear View of the Rack		
P D U 3	P D U 1	48	Liquid		
		47		PSU 1	PSU 2
		46	Liquid	PSU 3	
		45		PSU 1	PSU 2
		44	Liquid	PSU 3	
		43		PSU 1	PSU 2
		42	Liquid	PSU 3	
		41		PSU 1	PSU 2
		40	Liquid	PSU 3	
		39		PSU 1	PSU 2
		38	Liquid	PSU 3	
		37		PSU 1	PSU 2
		36	Liquid	PSU 3	
		35		PSU 1	PSU 2
		34	Liquid	PSU 3	
		33		PSU 1	PSU 2
		32	Liquid	PSU 3	
		31		PSU 1	PSU 2
		30	Liquid	PSU 3	
		29		PSU 1	PSU 2
		28	Liquid	PSU 3	
		27		PSU 1	PSU 2
		26	Liquid	PSU 3	
		25		PSU 1	PSU 2
		24	Liquid	PSU 3	
		23		PSU 1	PSU 2
		22	Liquid	PSU 3	
		21		PSU 1	PSU 2
		20	Liquid	PSU 3	
		19		PSU 1	PSU 2
		18	Liquid	PSU 3	
		17		PSU 1	PSU 2
		16	Liquid	PSU 3	
		15		PSU 1	PSU 2
		14	Liquid	PSU 3	
		13		PSU 1	PSU 2
		12	Liquid	PSU 3	
		11		PSU 1	PSU 2
		10	Liquid	PSU 3	
		9		PSU 1	PSU 2
		8	Liquid	PSU 3	
		7		PSU 1	PSU 2
		6	Liquid	PSU 3	
		5		PSU 1	PSU 2
P D U 2	P D U 4	4	Liquid		
		3		PSU 1	PSU 2
		2	Liquid		
		1		PSU 3	

Table 13. Power mapping detail for 4 PDU design reference (PDUs 1 and 3)

PDU 3											PDU 1											
Cable Length	Amp@ 230V	Port type	Port #	Port #	Port type	Amp@ 230V	Cable Length	Cable Length	Amp@ 230V	Port type	Port #	Port #	Port type	Amp@ 230V	Cable Length	Cable Length	Amp@ 230V	Cable Length				
3 ft	7.54	Circuit 2	C19	1		6	C19	7.54	3 ft	Circuit 1	C19	1		6	C19	7.54	3 ft	7.54	3 ft			
			C19	2		7	C19				C19	2		7	C19							
			C13	3	U45 - PSU1	U45 - PSU3	8				C13	C13	3	U41 - PSU1	U41 - PSU3					8	C13	
			C13	4			9				C13	C13	4							9	C13	
2 ft	7.54	Circuit 2	C13	5	U37 - PSU1	U37 - PSU3	10	C13	7.54	2 ft	Circuit 2	C13	5	U33 - PSU1	U33 - PSU3	10	C13	7.54	3 ft			
			C13	6				C13				6				C13	6					
6-8 ft	1.00	Circuit 4	C19	11		16	C19	15.07	4 ft	Circuit 3	C19	11		16	C19	15.07	4 ft	7.54	4 ft			
			C19	12			17				C19	C19	12							17	C19	
			C13	13		U45 - PSU2	18				C13	C13	13		U41 - PSU2					18	C13	
			C13	14	OPA4 - PSU2		19				C13	C13	14	OPA4 - PSU1						19	C13	
			C13	15		U37 - PSU2	20				C13	C13	15		U33 - PSU2					20	C13	
			C19	21			26				C19	C19	21							26	C19	
6-8 ft	0.54	Circuit 6	C19	22		27	C19	1.00	6-8 ft	Circuit 5	C19	22		27	C19	1.00	6-8 ft	1.00	6-8 ft			
			C13	23			28				C13	C13	23							28	C13	
			C13	24	ETH2 - PSU2	OPA2 - PSU2	29				C13	C13	24	ETH2 - PSU1	OPA2 - PSU1					29	C13	
			C13	25			30				C13	C13	25							30	C13	
3 ft	7.54	Circuit 8	C19	31		36	C19	1.00	4 ft	Circuit 7	C19	31		36	C19	1.00	3 ft	7.54	3 ft			
			C19	32			37				C19	C19	32							37	C19	
			C13	33	U29 - PSU1	U29 - PSU3	38				C13	C13	33	U25 - PSU1	U25 - PSU3					38	C13	
			C13	34			39				C13	C13	34							39	C13	
3 ft	7.54	Circuit 8	C13	35	U21 - PSU1	U21 - PSU3	40	C13	7.54	3 ft	Circuit 7	C13	35	U17 - PSU1	U17 - PSU3	40	C13	7.54	3ft/2ft			
			C19	41			46	C19				C19	41			46	C19					
2 ft	7.54	Circuit 10	C19	42		47	C19	15.07	3 ft	Circuit 9	C19	42		47	C19	15.07	3 ft	7.54	3 ft			
			C13	43	U13 - PSU3	U29 - PSU2	48				C13	C13	43	U9 - PSU3	U25 - PSU2					48	C13	
			C13	44			49				C13	C13	44							49	C13	
			C13	45	U5 - PSU3	U21 - PSU2	50				C13	C13	45	U1 - PSU3	U17 - PSU2					50	C13	
3 ft	7.54	Circuit 12	C19	51		56	C19	15.07	3 ft	Circuit 11	C19	51		56	C19	15.07	3 ft	7.54	3 ft			
			C19	52			57				C19	C19	52							57	C19	
			C13	53	U13 - PSU2	U13 - PSU1	58				C13	C13	53	U9 - PSU2	U9 - PSU1					58	C13	
			C13	54			59				C13	C13	54							59	C13	
2 ft	7.54	Circuit 12	C13	55	U5 - PSU2	U5 - PSU1	60	C13	7.54	1.5/2ft	Circuit 11	C13	55	U1 - PSU2	U1 - PSU1	60	C13	7.54	1.5ft/2ft			
			PDU 3											PDU 1								
		Phase 1		46.22	Amp				Phase 1		46.22	Amp				Phase 1		46.22	Amp			
		Phase 2		46.22	Amp				Phase 2		46.22	Amp				Phase 2		46.22	Amp			
		Phase 3		45.76	Amp				Phase 3		45.76	Amp				Phase 3		45.76	Amp			

Table 14. Power mapping detail for 4 PDU design reference (PDUs 2 and 4)

PDU 2										PDU 4									
Cable Length	Amp@ 230V	Port type	Port #	Port #	Port type	Amp@ 230V	Cable Length	Cable Length	Amp@ 230V	Cable Length	Amp@ 230V	Port type	Port #	Port #	Port type	Amp@ 230V	Cable Length	Cable Length	Amp@ 230V
2 ft	7.54	C19	1		6	C19	7.54	2 ft	7.54	3 ft	7.54	C19	1		6	C19	7.54	3 ft	7.54
		C19	2		7	C19						C19	2		7	C19			
		C13	3	U43 - PSU1	U43 - PSU3	8						C13	3	U47 - PSU1	U47 - PSU3	8			
		C13	4			9						C13	4			9			
2 ft	7.54	C13	5	U35 - PSU1	U35 - PSU3	10	7.54	2 ft	7.54	3 ft	7.54	C13	5	U39 - PSU1	U39 - PSU3	10	7.54	2 ft	7.54
		C19	11			16						C19	11			16			
		C19	12			17						C19	12			17			
		C13	13		U43 - PSU2	18						C13	13		U47 - PSU2	18			
6-8 ft	1.00	C13	14	OPA1 - PSU1		19	7.54	2 ft	7.54	3 ft	7.54	C13	14	OPA1 - PSU2		19	7.54	3 ft	7.54
		C13	15		U35 - PSU2	20						C13	15		U39 - PSU2	20			
		C19	21			26						C19	21			26			
		C19	22			27						C19	22			27			
6-8 ft	0.54	C13	23			28	1.00	6-8 ft	0.54	6-8 ft	0.54	C13	23			28	1.00	6-8 ft	0.54
		C13	24	ETH1 - PSU1	OPA3 - PSU1	29						C13	24	ETH1 - PSU2	OPA3 - PSU2	29			
		C13	25			30						C13	25			30			
		C19	31			36						C19	31			36			
4 ft	7.54	C19	32			37	7.54	3 ft	7.54	4 ft	7.54	C19	32			37	7.54	3 ft	7.54
		C13	33	U27 - PSU1	U27 - PSU3	38						C13	33	U31 - PSU1	U31 - PSU3	38			
		C13	34			39						C13	34			39			
		C13	35	U19 - PSU1	U19 - PSU3	40						C13	35	U23 - PSU1	U23 - PSU3	40			
3 ft	7.54	C19	41			46	7.54	3 ft	7.54	3 ft	7.54	C19	41			46	7.54	3 ft	7.54
		C19	42			47						C19	42			47			
		C13	43	U11 - PSU3	U27 - PSU2	48						C13	43	U15 - PSU3	U31 - PSU2	48			
		C13	44			49						C13	44			49			
2 ft	7.54	C13	45	U3 - PSU3	U19 - PSU2	50	7.54	2 ft	7.54	2 ft	7.54	C13	45	U7 - PSU3	U23 - PSU2	50	7.54	2 ft	7.54
		C19	51			56						C19	51			56			
		C19	52			57						C19	52			57			
		C13	53	U11 - PSU2	U11 - PSU1	58						C13	53	U15 - PSU2	U15 - PSU1	58			
2 ft	7.54	C13	54			59	7.54	2 ft	7.54	3 ft	7.54	C13	54			59	7.54	3 ft	7.54
		C13	55	U3 - PSU2	U3 - PSU1	60						C13	55	U7 - PSU2	U7 - PSU1	60			
1.5/2 ft	7.54						7.54	2 ft	7.54	2 ft	7.54						7.54	3 ft	7.54
	15.07						15.07		15.07		15.07						15.07		15.07
PDU 2										PDU 4									
Phase 1		46.22	Amp				Phase 1			46.22		Amp				Phase 1			
Phase 2		46.22	Amp				Phase 2			46.22		Amp				Phase 2			
Phase 3		45.76	Amp				Phase 3			45.76		Amp				Phase 3			

3.5 3 PDU Reference Design Power Mapping

In a 3PDU design, there is an increased risk of losing additional server systems due to the loading and mapping of the PDUs. In this design, both the Ethernet and OPA switches are connected in a redundant fashion across different PDUs. However, for this configuration the switches share power with several server systems, thereby increasing risk of losing the switches during a single PDU failure. This risk is mitigated in the 4 PDU rack design since power to the switches is separate from the server systems.

In theory, during a single PSU failure, the 2 remaining PSUs will support all system loading unless throttling triggers (e.g. OC or OT CLST) or shutdown (e.g. OCP) occurs. The increased current drawn by the remaining PSUs will increase current loading for each PDU and its associated phase. Ideally, loss of a single PSU (and single phase) will increase loading to other 2 phases, thereby reaching the input current OC trigger. Secondly, each PDU circuit breaker is set to 20A which means that as PSU loading increases, the risk for a circuit breaker trip increases as well.

Two power mappings have been considered depending on the availability of the main power lines. Table 16 and Table 17 show the power mapping when the power lines come from the top of the reference rack. Table 18 and Table 19 show the power mapping when the power lines come from the bottom of the reference rack.

Table 15. Power supply layout for 3 PDU design reference rack

U#	Rear View of the Rack				
48	Liquid				Liquid
47		PSU 1	PSU 2	PSU 3	
46	Liquid				Liquid
45		PSU 1	PSU 2	PSU 3	
44	Liquid				Liquid
43		PSU 1	PSU 2	PSU 3	
42	Liquid				Liquid
41		PSU 1	PSU 2	PSU 3	
40	Liquid				Liquid
39		PSU 1	PSU 2	PSU 3	
38	Liquid				Liquid
37		PSU 1	PSU 2	PSU 3	
36	Liquid				Liquid
35		PSU 1	PSU 2	PSU 3	
34	Liquid				Liquid
33		PSU 1	PSU 2	PSU 3	
32	Liquid				Liquid
31		PSU 1	PSU 2	PSU 3	
30	Liquid				Liquid
29		PSU 1	PSU 2	PSU 3	
28	Liquid				Liquid
27		PSU 1	PSU 2	PSU 3	
26	Liquid				Liquid
25		PSU 1	PSU 2	PSU 3	
24	Liquid				Liquid
23		PSU 1	PSU 2	PSU 3	
22	Liquid				Liquid
21		PSU 1	PSU 2	PSU 3	
20	Liquid				Liquid
19		PSU 1	PSU 2	PSU 3	
18	Liquid				Liquid
17		PSU 1	PSU 2	PSU 3	
16	Liquid				Liquid
15		PSU 1	PSU 2	PSU 3	
14	Liquid				Liquid
13		PSU 1	PSU 2	PSU 3	
12	Liquid				Liquid
11		PSU 1	PSU 2	PSU 3	
10	Liquid				Liquid
9		PSU 1	PSU 2	PSU 3	
8	Liquid				Liquid
7		PSU 1	PSU 2	PSU 3	
6	Liquid				Liquid
5		PSU 1	PSU 2	PSU 3	
4	Liquid				Liquid
3		PSU 1	PSU 2	PSU 3	
2	Liquid				Liquid
1		PSU 1	PSU 2	PSU 3	

Table 16. Power mapping detail for 3 PDU design reference (PDUs 3 and 1)**TOP FEED ORIENTATION**

Amp@ 230V		PDU3 - Top											
		Port type				Port #		Port #				Port type	
6.52	Circuit 2	C19	1					6	C19	Circuit 1	6.52		
		C19	2					7	C19				
		C13	3	U47 - PSU1	U47 - PSU3	8	C13						
		C13	4			9	C13						
6.52	Circuit 4	C13	5	U41 - PSU1	U41 - PSU3	10	C13	Circuit 3	6.52				
13.04		C19	11			16	C19			13.04			
6.52		C19	12			17	C19			6.52			
		C13	13	U35 - PSU3	U47 - PSU2	18	C13						
6.52	Circuit 6	C13	14			19	C13	Circuit 5	6.52				
		C13	15	U29 - PSU3	U41 - PSU2	20	C13						
13.04		C19	21			26	C19			13.04			
6.52		C19	22			27	C19			6.52			
	C13	23	U35 - PSU2	U35 - PSU1	28	C13	0.54						
6.52	Circuit 8	C13	24		ETH2-PSU2	29	C13	Circuit 7	6.52				
6.52		C13	25	U29 - PSU2	U29 - PSU1	30	C13			6.52			
13.04		C19	31			36	C19			13.58			
6.52		C19	32			37	C19			6.52			
	C13	33	U23 - PSU1	U23 - PSU3	38	C13	6.52						
6.52	Circuit 10	C13	34			39	C13	Circuit 9	6.52				
		C13	35	U17 - PSU1	U17 - PSU3	40	C13			6.52			
13.04		C19	41			46	C19			13.04			
6.52		C19	42			47	C19			6.52			
	C13	43	U11 - PSU3	U23 - PSU2	48	C13	6.52						
6.52	Circuit 12	C13	44			49	C13	Circuit 11	6.52				
		C13	45	U5 - PSU3	U17 - PSU2	50	C13			6.52			
13.04		C19	51			56	C19			13.04			
6.52		C19	52			57	C19			6.52			
	C13	53	U11 - PSU2	U11 - PSU1	58	C13	6.52						
6.52	Circuit 11	C13	54	OPA1-PSU2		59	C13	6.52					
		C13	55	U5 - PSU2	U5 - PSU1	60	C13		6.52				
13.04										13.04			

PDU 3

Phase 1	52.17	Amp
Phase 2	52.71	Amp
Phase 3	52.17	Amp

Amp@ 230V		PDU1 - Top											
		Port type				Port #		Port #				Port type	
6.52	Circuit 2	C19	1					6	C19	Circuit 1	6.52		
		C19	2					7	C19				
		C13	3	U43 - PSU1	U43 - PSU3	8	C13						
		C13	4		OPA1-PSU2	9	C13	1.00					
6.52	Circuit 4	C13	5	U37 - PSU1	U37 - PSU3	10	C13		C13	6.52			
13.04		C19	11					16	C19	Circuit 3	14.04		
		C19	12					17	C19				
		C13	13	U31 - PSU3	U43 - PSU2	18	C13	6.52					
6.52		C13	14					19	C13	Circuit 5	6.52		
		C13	15	U25 - PSU3	U37 - PSU2	20	C13	6.52					
		13.04	C19	21					26			C19	Circuit 6
C19	22						27	C19					
C13	23		U31 - PSU2	U31 - PSU1	28	C13	6.52						
0.54	Circuit 6	C13	24	ETH2-PSU1	ETH1-PSU2	29	C13		C13	0.54			
6.52		C13	25	U25 - PSU2	U25 - PSU1	30	C13		C13	6.52			
13.58		C19	31					36	C19	Circuit 7	13.58		
	C19	32					37	C19					
	6.52	C13	33	U19 - PSU1	U19 - PSU3	38	C13		C13			6.52	
6.52	Circuit 8	C13	34					39	C13	Circuit 9	6.52		
		C13	35	U13 - PSU1	U13 - PSU3	40	C13	6.52					
		13.04	C19	41					46			C19	Circuit 10
C19	42						47	C19					
6.52	C13		43	U7 - PSU3	U19 - PSU2	48	C13	6.52					
6.52	Circuit 10	C13	44		OPA2-PSU1	49	C13		C13	1.00			
		C13	45	U1 - PSU3	U13 - PSU2	50	C13		C13	6.52			
		13.04	C19	51					56	C19	Circuit 11	14.04	
C19	52						57	C13					
6.52	C13		53	U7 - PSU2	U7 - PSU1	58	C13	6.52					
6.52	Circuit 12	C13	54					59	C13	Circuit 12	6.52		
		C13	55	U1 - PSU2	U1 - PSU1	60	C13	6.52					
		13.04											13.04

PDU 1

Phase 1	53.17	Amp
Phase 2	52.71	Amp
Phase 3	53.71	Amp

Total Phase Amp per Rack

Phase 1	158.52
Phase 2	159.60
Phase 3	158.60

Table 17. Power mapping detail for 3 PDU design reference (PDU 2)**TOP FEED ORIENTATION**

Amp@		PDU2 - Top					
230V		Port type		Port #	Port #		Port type
6.52	1.00	Circuit 2	C19	1			6 C19
			C19	2			7 C19
			C13	3	U45 - PSU1	U45 - PSU3	8 C13
			C13	4	OPA1-PSU1		9 C13
			C13	5	U39 - PSU1	U39 - PSU3	10 C13
13.04	6.52	Circuit 4	C19	11			16 C19
			C19	12			17 C19
			C13	13	U33 - PSU3	U45 - PSU2	18 C13
			C13	14			19 C13
			C13	15	U27 - PSU3	U39 - PSU2	20 C13
13.04	6.52	Circuit 6	C19	21			26 C19
			C19	22			27 C19
			C13	23	U33 - PSU2	U33 - PSU1	28 C13
			C13	24	ETH1-PSU1		29 C13
			C13	25	U27 - PSU2	U27 - PSU1	30 C13
13.58	6.52	Circuit 8	C19	31			36 C19
			C19	32			37 C19
			C13	33	U21 - PSU1	U21 - PSU3	38 C13
			C13	34			39 C13
			C13	35	U15 - PSU1	U15 - PSU3	40 C13
13.04	6.52	Circuit 10	C19	41			46 C19
			C19	42			47 C19
			C13	43	U9 - PSU3	U21 - PSU2	48 C13
			C13	44	OPA2-PSU2		49 C13
			C13	45	U3 - PSU3	U15 - PSU2	50 C13
14.04	6.52	Circuit 12	C19	51			56 C19
			C19	52			57 C19
			C13	53	U9 - PSU2	U9 - PSU1	58 C13
			C13	54		OPA1-PSU1	59 C13
			C13	55	U3 - PSU2	U3 - PSU1	60 C13

PDU 2

Phase 1	53.17	Amp
Phase 2	54.17	Amp
Phase 3	52.71	Amp

Table 18. Power mapping detail for 3 PDU design reference (PDUs 3 and 1)**BOTTOM FEED ORIENTATION**

PDU3 - Bottom							Amp@ 230V	PDU1 - Bottom							Amp@ 230V	
Port type		Port #	Port #		Port type			Port type		Port #	Port #		Port type			
6.52	Circuit 11	C13	60	U47 - PSU1	U47 - PSU3	55	C13	6.52	Circuit 11	C13	60	U43 - PSU1	U43 - PSU3	55	C13	6.52
		C13	59			54	C13			C13	59		OPA1-PSU2	54	C13	1.00
6.52	Circuit 11	C13	58	U41 - PSU1	U41 - PSU3	53	C13	6.52	Circuit 11	C13	58	U37 - PSU1	U37 - PSU3	53	C13	6.52
		C19	57			52	C19			C19	57			52	C19	
13.04	Circuit 11	C19	56			51	C19	13.04	Circuit 11	C19	56			51	C19	14.04
6.52	Circuit 9	C13	50	U35 - PSU3	U47 - PSU2	45	C13	6.52	Circuit 9	C13	50	U31 - PSU3	U43 - PSU2	45	C13	6.52
		C13	49			44	C13			C13	49			44	C13	
6.52	Circuit 9	C13	48	U29 - PSU3	U41 - PSU2	43	C13	6.52	Circuit 9	C13	48	U25 - PSU3	U37 - PSU2	43	C13	6.52
13.04		C19	47			42	C19	13.04		C19	47			42	C19	13.04
	C19	46			41	C19		C19	46			41	C19			
6.52	Circuit 7	C13	40	U35 - PSU2	U35 - PSU1	35	C13	6.52	Circuit 7	C13	40	U31 - PSU2	U31 - PSU1	35	C13	6.52
		C13	39		ETH2-PSU2	34	C13	0.54		C13	39	ETH2-PSU1	ETH1-PSU2	34	C13	0.54
6.52	Circuit 7	C13	38	U29 - PSU2	U29 - PSU1	33	C13	6.52	Circuit 7	C13	38	U25 - PSU2	U25 - PSU1	33	C13	6.52
13.04		C19	37			32	C19	13.58		C19	37			32	C19	13.58
	C19	36			31	C19		C19	36			31	C19			
6.52	Circuit 5	C13	30	U23 - PSU1	U23 - PSU3	25	C13	6.52	Circuit 5	C13	30	U19 - PSU1	U19 - PSU3	25	C13	6.52
		C13	29			24	C13			C13	29			24	C13	
6.52	Circuit 5	C13	28	U17 - PSU1	U17 - PSU3	23	C13	6.52	Circuit 5	C13	28	U13 - PSU1	U13 - PSU3	23	C13	6.52
13.04		C19	27			22	C19	13.04		C19	27			22	C19	13.04
	C19	26			21	C19		C19	26			21	C19			
6.52	Circuit 3	C13	20	U11 - PSU3	U23 - PSU2	15	C13	6.52	Circuit 3	C13	20	U7 - PSU3	U19 - PSU2	15	C13	6.52
		C13	19			14	C13			C13	19		OPA2-PSU1	14	C13	1.00
6.52	Circuit 3	C13	18	U5 - PSU3	U17 - PSU2	13	C13	6.52	Circuit 3	C13	18	U1 - PSU3	U13 - PSU2	13	C13	6.52
13.04		C19	17			12	C19	13.04		C19	17			12	C19	14.04
	C19	16			11	C19		C19	16			11	C19			
6.52	Circuit 1	C13	10	U11 - PSU2	U11 - PSU1	5	C13	6.52	Circuit 1	C13	10	U7 - PSU2	U7 - PSU1	5	C13	6.52
		C13	9			4	C13			C13	9			4	C13	
6.52	Circuit 1	C13	8	U5 - PSU2	U5 - PSU1	3	C13	6.52	Circuit 1	C13	8	U1 - PSU2	U1 - PSU1	3	C13	6.52
13.04		C19	7			2	C19	13.04		C19	7			2	C19	13.04
	C19	6			1	C19		C19	6			1	C19			

PDU 3

Phase 1	52.17	Amp
Phase 2	52.71	Amp
Phase 3	52.17	Amp

PDU 1

Phase 1	53.71	Amp
Phase 2	52.71	Amp
Phase 3	53.17	Amp

Total Phase Amp per Rack

Phase 1	158.60
Phase 2	158.60
Phase 3	158.52

Table 19. Power mapping detail for 3 PDU design reference (PDU 2)
BOTTOM FEED ORIENTATION

Amp@
230V

PDU2 - Bottom

	Port type		Port #	Port #		Port type	
6.52	C13	60	U45 - PSU1	U45 - PSU3	55	C13	6.52
1.00	C13	59	OPA1-PSU1		54	C13	
6.52	C13	58	U39 - PSU1	U39 - PSU3	53	C13	6.52
	C19	57			52	C19	
14.04	C19	56			51	C19	13.04
6.52	C13	50	U33 - PSU3	U45 - PSU2	45	C13	6.52
	C13	49			44	C13	
6.52	C13	48	U27 - PSU3	U39 - PSU2	43	C13	6.52
13.04	C19	47			42	C19	13.04
	C19	46			41	C19	
6.52	C13	40	U33 - PSU2	U33 - PSU1	35	C13	6.52
0.54	C13	39	ETH1-PSU1		34	C13	
6.52	C13	38	U27 - PSU2	U27 - PSU1	33	C13	6.52
13.58	C19	37			32	C19	13.04
	C19	36			31	C19	
6.52	C13	30	U21 - PSU1	U21 - PSU3	25	C13	6.52
	C13	29			24	C13	
6.52	C13	28	U15 - PSU1	U15 - PSU3	23	C13	6.52
13.04	C19	27			22	C19	13.04
	C19	26			21	C19	
6.52	C13	20	U9 - PSU3	U21 - PSU2	15	C13	6.52
1.00	C13	19	OPA2-PSU2		14	C13	
6.52	C13	18	U3 - PSU3	U15 - PSU2	13	C13	6.52
14.04	C19	17			12	C19	13.04
	C19	16			11	C19	
6.52	C13	10	U9 - PSU2	U9 - PSU1	5	C13	6.52
	C13	9			4	C13	
6.52	C13	8	U3 - PSU2	U3 - PSU1	3	C13	6.52
13.04	C19	7			2	C19	13.04
	C19	6			1	C19	

PDU 2

Phase 1	52.71	Amp
Phase 2	53.17	Amp
Phase 3	53.17	Amp

4. Management Network Specifications

This chapter provides recommendations on the network mapping for the reference rack. With the cabinet being comprised of racks, the information for the reference cabinet is covered as well.

All network switches can be mounted on the side of the rack with special cutouts on the rack's EIA vertical rail. The following tables show the required port mappings for six vertically mounted switches (two Ethernet switches and four Intel® OPA switches), and the cabling layout for the rack as seen from the front. The tables are listed starting from the top of the rack and are color coded for convenience.

Table 20. Network cable length reference layout

QSFP28	CAT6	U	Front View		CAT6	QSFP28
1.0 M	6 FT	48	Compute Module 95	Compute Module 96	6 FT	1.0 M
1.0 M	6 FT	47	Compute Module 93	Compute Module 94	6 FT	1.0 M
0.5 M	6 FT	46	Compute Module 91	Compute Module 92	6 FT	0.5 M
0.5 M	6 FT	45	Compute Module 89	Compute Module 90	6 FT	0.5 M
0.5 M	6 FT	44	Compute Module 87	Compute Module 88	6 FT	0.5 M
0.5 M	6 FT	43	Compute Module 85	Compute Module 86	6 FT	0.5 M
0.5 M	6 FT	42	Compute Module 83	Compute Module 84	6 FT	0.5 M
0.5 M	6 FT	41	Compute Module 81	Compute Module 82	6 FT	0.5 M
0.5 M	6 FT	40	Compute Module 79	Compute Module 80	6 FT	0.5 M
0.5 M	6 FT	39	Compute Module 77	Compute Module 78	6 FT	0.5 M
0.5 M	6 FT	38	Compute Module 75	Compute Module 76	6 FT	0.5 M
0.5 M	6 FT	37	Compute Module 73	Compute Module 74	6 FT	0.5 M
0.5 M	3 FT	36	Compute Module 71	Compute Module 72	3 FT	0.5 M
0.5 M	3 FT	35	Compute Module 69	Compute Module 70	3 FT	0.5 M
1.0 M	3 FT	34	Compute Module 67	Compute Module 68	3 FT	1.0 M
1.0 M	3 FT	33	Compute Module 65	Compute Module 66	3 FT	1.0 M
1.0 M	3 FT	32	Compute Module 63	Compute Module 64	3 FT	1.0 M
1.0 M	3 FT	31	Compute Module 61	Compute Module 62	3 FT	1.0 M
1.0 M	3 FT	30	Compute Module 59	Compute Module 60	3 FT	1.0 M
1.0 M	3 FT	29	Compute Module 57	Compute Module 58	3 FT	1.0 M
1.0 M	3 FT	28	Compute Module 55	Compute Module 56	3 FT	1.0 M
1.0 M	3 FT	27	Compute Module 53	Compute Module 54	3 FT	1.0 M
1.0 M	3 FT	26	Compute Module 51	Compute Module 52	3 FT	1.0 M
1.0 M	3 FT	25	Compute Module 49	Compute Module 50	3 FT	1.0 M
1.0 M	3 FT	24	Compute Module 47	Compute Module 48	3 FT	1.0 M
1.0 M	3 FT	23	Compute Module 45	Compute Module 46	3 FT	1.0 M
1.0 M	3 FT	22	Compute Module 43	Compute Module 44	3 FT	1.0 M
1.0 M	3 FT	21	Compute Module 41	Compute Module 42	3 FT	1.0 M
1.0 M	3 FT	20	Compute Module 39	Compute Module 40	3 FT	1.0 M
1.0 M	3 FT	19	Compute Module 37	Compute Module 38	3 FT	1.0 M
1.0 M	3 FT	18	Compute Module 35	Compute Module 36	3 FT	1.0 M
1.0 M	3 FT	17	Compute Module 33	Compute Module 34	3 FT	1.0 M
1.0 M	6 FT	16	Compute Module 31	Compute Module 32	6 FT	1.0 M
1.0 M	6 FT	15	Compute Module 29	Compute Module 30	6 FT	1.0 M
0.5 M	6 FT	14	Compute Module 27	Compute Module 28	6 FT	0.5 M
0.5 M	6 FT	13	Compute Module 25	Compute Module 26	6 FT	0.5 M
0.5 M	6 FT	12	Compute Module 23	Compute Module 24	6 FT	0.5 M
0.5 M	6 FT	11	Compute Module 21	Compute Module 22	6 FT	0.5 M
0.5 M	6 FT	10	Compute Module 19	Compute Module 20	6 FT	0.5 M
0.5 M	6 FT	9	Compute Module 17	Compute Module 18	6 FT	0.5 M
0.5 M	6 FT	8	Compute Module 15	Compute Module 16	6 FT	0.5 M
0.5 M	6 FT	7	Compute Module 13	Compute Module 14	6 FT	0.5 M
0.5 M	6 FT	6	Compute Module 11	Compute Module 12	6 FT	0.5 M
0.5 M	6 FT	5	Compute Module 9	Compute Module 10	6 FT	0.5 M
0.5 M	6 FT	4	Compute Module 7	Compute Module 8	6 FT	0.5 M
0.5 M	6 FT	3	Compute Module 5	Compute Module 6	6 FT	0.5 M
1.0 M	6 FT	2	Compute Module 3	Compute Module 4	6 FT	1.0 M
1.0 M	6 FT	1	Compute Module 1	Compute Module 2	6 FT	1.0 M

Cable Type	Length	Left Side	Right Side
QSFP28 Cables	0.5 m	24	24
	1.0 m	24	24
CAT6 Ethernet cables	3 ft	20	29
	6 ft	28	28

Table 22. Port mapping reference for Intel Omni-Path switches 3 and 4

[illegible]

R45																									SFP+	
Port #	1	3	5	7	9	11	13	15	17	19	21	23	25	27	29	31	33	35	37	39	41	43	45	47	49	51
Server	U48/S36	U47/S94	U46/S92	U45/S90	U44/S88	U43/S86	U42/S84	U41/S82	U40/S80	U39/S78	U38/S76	U37/S74	U24/S48	U23/S46	U22/S44	U21/S42	U20/S40	U19/S38	U18/S36	U17/S34	U16/S32	U15/S30	U14/S28	U13/S26	PDU1	CDU
Port #	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48	50	52
Server	U36/S72	U35/S70	U34/S68	U33/S66	U32/S64	U31/S62	U30/S60	U29/S58	U28/S56	U27/S54	U26/S52	U25/S50	U12/S24	U11/S22	U10/S20	U9/S18	U8/S16	U7/S14	U6/S12	U5/S10	U4/S8	U3/S6	U2/S4	U1/S2	AHU	PDU3
Top server's ethernet cable routing direction													Bottom server's ethernet cable routing													

QSF28																	
Port #	MGMT	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48
Server		Empty	Empty	Empty	Empty	Empty	Empty	Empty	Empty	Empty	Empty	Empty	Empty	Empty	Empty	Empty	Empty
Port #	USB	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
Server		U24/S1D48	U23/S1D46	U22/S1D44	U21/S1D42	U2/S1D4	U1/S1D2	U10/S1D20	U9/S1D18	U20/S1D40	U19/S1D38	U18/S1D36	U17/S1D34	U16/S1D32	U15/S1D30	U4/S1D8	U3/S1D6
Port #		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Server		U14/S1D28	U13/S1D26	Empty	Empty	U12/S1D24	U11/S1D22	Empty	Empty	U8/S1D16	U7/S1D14	Empty	Empty	U6/S1D12	U5/S1D10	Empty	Empty

QSP28																	
Port #	MGMT	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48
Server		Empty	Empty	Empty	Empty	Empty	Empty	Empty	Empty	Empty	Empty	Empty	Empty	Empty	Empty	Empty	Empty
Port #	USB	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
Server		U15/SLD29	U16/SLD31	U17/SLD33	U18/SLD35	U19/SLD37	U20/SLD39	U7/SLD13	U8/SLD15	U21/SLD41	U22/SLD43	U11/SLD21	U12/SLD23	U23/SLD45	U24/SLD47	U1/SLD1	U2/SLD3
Port #		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Server		U3/SLD5	U4/SLD7	Empty	Empty	U5/SLD9	U6/SLD11	Empty	Empty	U9/SLD17	U10/SLD19	Empty	Empty	Empty	Empty	U13/SLD25	U14/SLD27

5. Mechanical Specifications

This chapter provides dimensions, weight and other mechanical specifications for some of the mentioned components used in the reference rack and cabinet configurations. Information on crating is also included.

5.1 Rack Dimensions

Dimensions for the rack described in this guide are 800mm x 1450mm x 48U.

5.2 PDU

The following tables list the mechanical specifications for the EU and US reference Power Distribution Units

Table 25. EU Compliant PDUs

Manufacturer	Enlogic* 3 Phase WYE
PDU weight	11.5 Kg
PDU dimensions(W x D x L)	59mm x 100mm x 1981mm; 2.3" x 3.9" x 78"
PDU mounting	Tool-less button

Table 26. US Compliant PDUs

Manufacturer	Raritan*
PDU weight	11.5 Kg
PDU dimensions(W x D x L)	59mm x 100mm x 1981mm; 2.3" x 3.9" x 78"
PDU mounting	Tool-less button

5.3 Management Switch

The following table lists the Management Switch's mechanical specifications

Table 27. Management Switch Spec

Manufacturer	Cisco
Model	2690
Dimensions	17.5in (W) x 16.94 in (D) x 1.75 in (H)
Weight	12.9 lbs. (5.8 Kg)

5.4 Data Switch (Fabric)

The following table lists the Data Switch's mechanical specifications

Table 28. Management Switch Spec

Manufacturer	Intel
Model	Intel® Omni-Path Edge Switch 100 Series 48
Dimensions	17.15 in x 17.3 in x 1.72 in
Weight	13.64 lb.(6.2 kg)

5.5 Liquid Cooling Manifold

The following table lists the features of the recommended liquid cooling manifold for the rack and cabinet configurations:

Table 29. Liquid cooling manifold features

Feature	Description
Ports	24 ports 90 degree SCG06 Stäubli* liquid quick disconnects on tubes affixed to barbed fittings on manifolds
Feed Orientation	Can be configured for either a top or bottom feed configuration. The bottom feed includes a Shrader* valve on top of the inlet (cold) manifold.
Leak Mitigation	Includes a solenoid on the inlet manifold (cold) and a check valve on output (hot).
Mounting	The liquid cooling manifold uses mounting plates provided by CoolIT*. The mounting plates are then affixed to both the inner side of the rack and the manifolds.

5.6 Equipment Weight Data

The following tables list the weight estimates for both the rack and cabinet:

Table 30. Rack weight estimates

#	Part name	Weight in lbs.	Qty per Rack	Total (lbs.)	Total (kg)
1	48U Rack Frame (Solid Doors)	685	1	685	311
2	Server system(2U / 4N)	116	24	2784	1263
3	OPA Edge Switch	15	2	30	14
4	Cisco 2690 Switch	13	2	26	12
5	PDU	20	4	80	36
6	Accessories - Rails, Brackets etc	100	1	100	45
7	Cables	50	1	50	23
8	Rack manifold	50	2	100	45
	Populated compute rack		Total	3855	1766

Table 31. Cabinet weight estimates

#	Part name	Weight in lbs.	Qty per Rack	Total (lbs.)	Total (kg)
1	Populated compute rack	3839	2	7678	3483
2	CyberRow*	792	1	792	359
3	Empty 700mmW 1457mmD Rack	250	1	250	113
	Complete L11 Cabinet		Total	8720	3955

5.7 Crating

All crate materials are approved per SPEC ISTA-2B. The following steps are recommended when crating the server rack:

1. Inspect the rack caster prior to loading the rack into the crate.
2. Inspect the crates before loading the rack, noting any structural defects (per factory quality specifications).

Note: Crate includes minimum padding material to ensure a tight fit of the rack product.

3. Ensure straps are included to facilitate rack unloading. Metal straps are required for shipping.
4. Place at least 2 tilt and shock indicators inside the crate rear and side panels.
5. Place at least 1 tilt and shock indicator on external side panels.
6. Ensure pallet bolts are secured.
7. Load the rack into crate front side first.
8. Ensure crate locks are secured properly.

Note: Add accelerometers or GPS devices if required.

5.7.1 Crate Compliance Guidelines for Shipping

The crate will comply with certification requirements for overseas shipment and any certification labels required per shipping logistics will be added. Treatment and marking of the pallet must conform to the International Standards for Phytosanitary Measures, Publication no. 15 (ISPM 15) guidelines for regulating wood packaging materials in international trade.

5.8 Drawings and CAD

Drawings and CAD files may be supplied upon request and on an as needed basis. Please contact your Intel support representative for details.

6. Thermal Specifications and Requirements

This chapter provides guidelines and recommendations based on end-of-row CDU measured and cooling simulation data for cabinet configurations.

The information presented considers differences in heat produced by system memory, the power requirements presented in Chapter 3, as well as the combination of the liquid coolant flow rate with the ambient temperature. These factors directly impact the number of supported systems per rack, thus affecting the number of supported systems per cabinet.

6.1 Assumptions

The following is a list of assumptions considered for the rack and cabinet configurations:

- 48U rack with 24 server system+
- Direct Liquid Cooling with a Heat Capture Rate (HCR) > 80%
- Computer Room Air Conditioning Unit (CRAC) to cool ~15 to 20% of heat for rack configurations
- Air Handler Unit (AHU) for cabinet configurations
- Fluid: 25% Propylene Glycol Water (PGW) on the secondary loop and water in the primary loop of the heat exchanger.
- Heat generated per memory DIMM: a minimum of 6W and a maximum of 14W
- Facilities flow rate for primary fluid loop: 360lpm for an end-of-row CDU.
- Server systems fluid exit temperature (Tfluid): below 65°C

The chassis minimum flow rate and maximum inlet temperature numbers are shown in the following figures and should not be exceeded. For example, a combination of 10°C inlet temperature and 1lpm passes but 30C and 1lpm automatically fails.

The following table lists the specific equipment used in testing the thermal requirements:

Table 32. Equipment used for simulation

Part type	Vendor	Model
Quick disconnect for the chassis	Staubli*	SCG06
Quick disconnect for the rack	Staubli*	SCG20
End-of-row heat exchanger	CoolIT*	CHX750

6.2 Rack Boundary Tables

The following is a list of assumptions considered for the rack and cabinet:

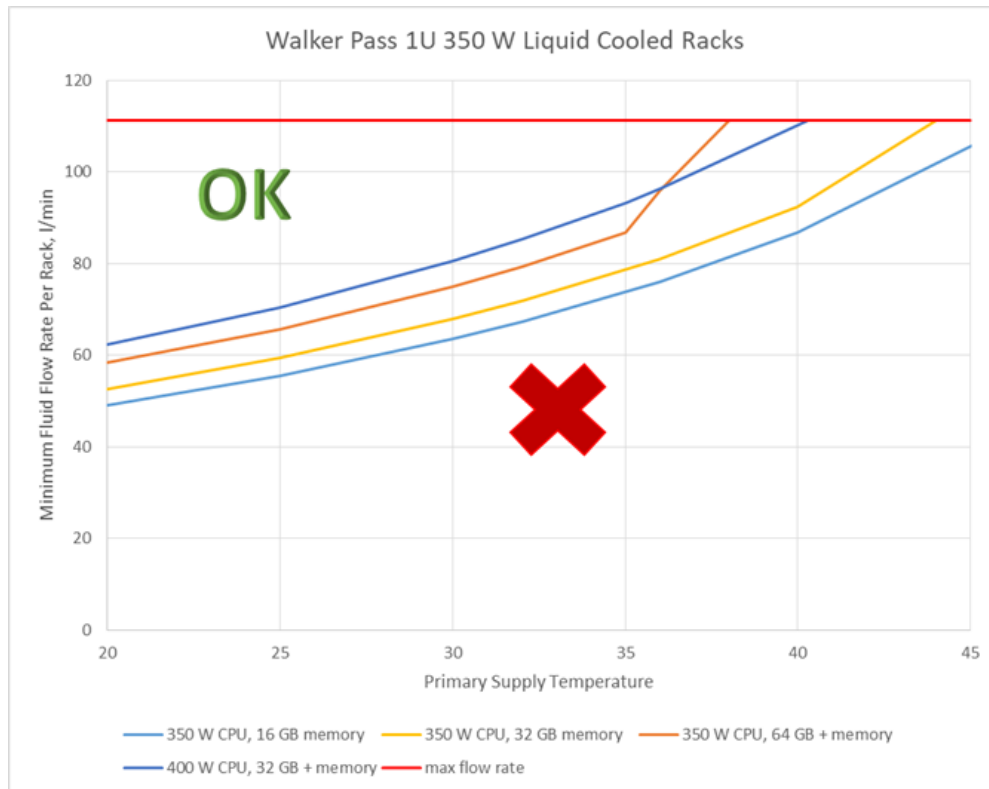


Figure 3. Fluid flow requirement per system at each inlet

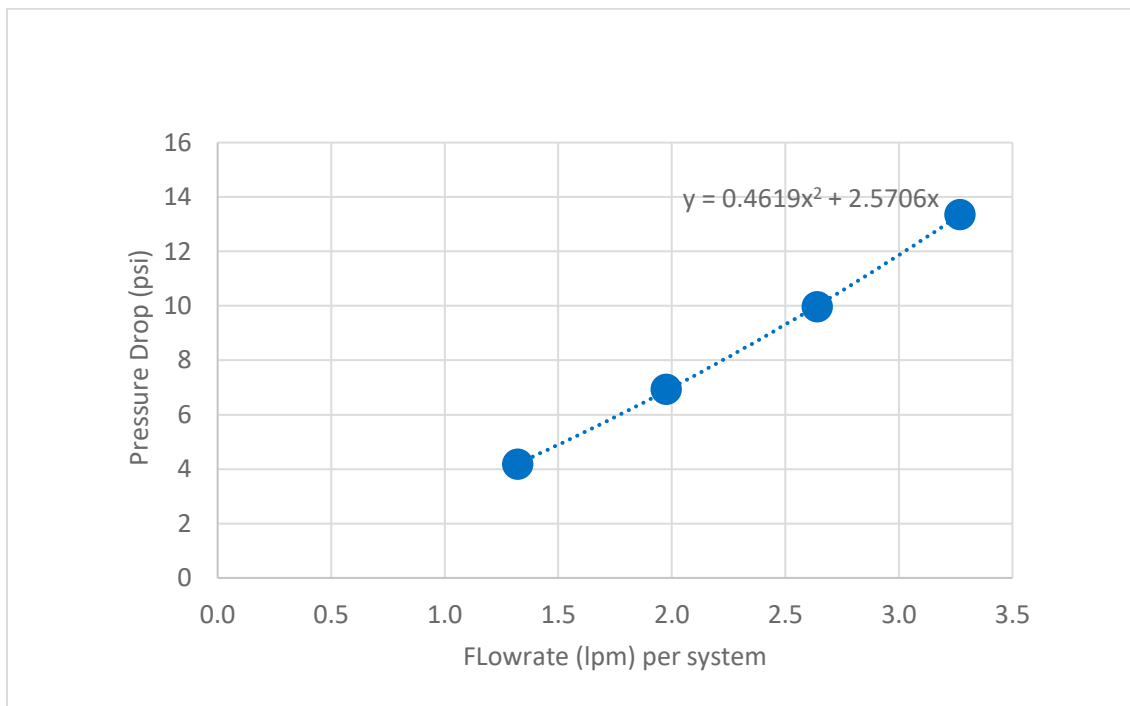


Figure 4. Pressure impedance per system

Note: Pressure drop from rack manifold quick connects are not included in figure 5.

6.3 Thermal Requirements Based on CDU Selection (End of Row-Based)

The tables in this section show the maximum number of chassis that can be cooled using a single end-of-row CDU at different ASHRAE W conditions for facility water.

6.3.1 End-of-row CDU

When installed in an ASHRAE W3 compliant facility, the end-of-row CDU (CoolIT* CHx750) can cool between 7 to 9 racks with 24 systems each based on DIMM thermal power. The following tables list the details of the required parameters for each DIMM type's configuration. The values in the tables apply for racks with perforated or solid doors, and cabinet configurations where the AHU is on a separate fluid loop where it does not affect the CDU supply temperature.

Table 33. End-of-row CDU cooling for systems with 6W DIMMs

Parameter	Value / Description	Value / Description	Value / Description
Facility Fluid Temp	W1 (17 deg C)	W2 (27 deg C)	W3 (32 deg C)
Server (2U 4N system) inlet temp (deg C)	17	27	32
Number of supported racks (350W CPU, 6W DIMM)	8	8	8
Liquid coolant flow rate inside server (lpm)	2.4	3.2	3.8
Liquid coolant flow rate in the rack (lpm)	57.6	76.8	91.2
CDU heat load (KW)	692	692	692
Total thermal power (KW)	802	802	802

Table 34. End-of-row CDU cooling for systems with 14W DIMMs

Parameter	Value / Description	Value / Description	Value / Description
Facility Fluid Temp	W1 (17 deg C)	W2 (27 deg C)	W3 (32 deg C)
Server (2U 4N system) inlet temp (deg C)	17	27	32
Number of supported racks (350W CPU, 14W DIMM)	7	7	6
Liquid coolant flow rate inside server (lpm)	2.7	3.8	4.4
Liquid coolant flow rate in the rack (lpm)	64.8	91.2	105.6
CDU heat load (KW)	738	738	632
Total thermal power (KW)	856	856	733

6.4 Air cooling recommendations

The reference rack and cabinet configurations described assume 84% of the heat generated is captured by the liquid cooling elements. It is recommended to select an adequate air cooling solution to capture the remaining heat. The following is a list of requirements for air cooling planning:

- Minimum system inlet temperature: 5°C
- Maximum system inlet temperature: 35°C
- Maximum system exit temperature: 55°C (from nodes into power supplies)
- Air flow rate per system:
 - Systems with 1U compute modules: 145 cfm
 - Systems with 2U compute modules: 168 cfm
- 88 cubic feet per minute (cfm) per system = 52m³/hr. (at 35°C ambient temperature)
- Maximum supported cfm at 100% fan speed is ~290 per chassis = 171 m³/hr.

Glossary

Term	Definition
2U	Two rack units (3.5 in.)
AHU	Air Handler Unit
Cabinet	Two racks with an Air Handler Unit
CDU	Cooling distribution unit
Chassis	Casing containing the server compute modules and fans/liquid cooling plumbing
Cluster	A group of three or more racks or cabinets
CRAC	Computer Room Air Conditioning Unit
DIMM	Dual inline memory module
HCR	Heat Capture Rate
HPC	High Performance Computing
PDU	Power Distribution Unit
PGW	Propylene Glycol Water
PSU	Power Supply Unit
Rack	A server system rack
TDP	Thermal Design Power