
FORSYTHE TALKS

Understanding electrical power for POWER
Why it's time to go to POWER8

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<http://www.circle4.com/forsythe/powerforpower.pdf>
<http://www.circle4.com/forsythe/timeforpower8.pdf>

Agenda:

- Power for POWER
 - Terminology
 - PDUs and Line Cords
 - Architecting for power
 - Examples
- POWER8
 - Why it's time to migrate

THE ISSUE

- Servers are more powerful and draw more power
- Rules about PDUs and how to plan for power are confusing
- Planning versus what is actually being used
- Why can't I plan for just what I am using
- Why does IBM require so many PDUs?

POWER TERMINOLOGY

- Watts
 - Unit of power
 - 1 watt is defined as the current flow of one amp with voltage of one volt
- Volts
 - Measure of the strength of an electrical source at a given amperage
 - Similar to water pressure in a pipe
- kVA (kilo volt amps)
 - 1000 volt amps
 - Volt amp is the unit for apparent power in an electrical circuit
 - Volt amps are used with AC (alternating current) power
- Amps
 - Amperes is a measure of the total electrical current that can flow
 - Similar to water current
- BTU
 - British thermal unit. Equal to around 1055 joules or 1055 watt seconds.
 - The amount of energy needed to cool or heat one pound of water by one degree fahrenheit at 39F.

POWER FORMULAS

- <http://www.elec-toolbox.com/Formulas/Useful/formulas.htm>
- <http://www.rapidtables.com/electric/ampere.htm>
- Watts
 - (Amps x voltage)
 - Or (BTU/hour / 3.412141633)
- Volts
 - (Watts / Amps)
- Power Factor (PF)
 - The amount of power lost due to reactance in circuits, etc – typically around .95 to .98 for POWER servers
- kVA (kilo volt amps)
 - ((amps x voltage)/1000) if 1 phase
 - ((amps x voltage x 1.73 PF)/1000) if 3 phase
- Amps if kVA known
 - ((kVA x 1000)/voltage) if single phase
- BTU/hour if you know watts
 - (watts x 3.412141633)

PDUS AND LINE CORDS

- Power Planning must adhere to National Electrical Code
- In the US PDUs are derated by law
- Max for a 60 amp PDU is 48 amps or 9.6kVA
- Max for a 30 amp PDU is 24 amps or 4.8kVA
- IBM PDUs
 - 9188/7188 – regular PDU
 - 5889/7109 – intelligent PDU with monitoring capabilities
 - Each has 6 pairs (12 total) of IEC320-C13 outlets rated at 200-240 volts
 - Each of the 12 outlets is rated at 10 amps
 - Each pair has a circuit breaker for 20 amps (derated to 16 amps on 9188/7188 and 15 amps on 5889/7109)
 - Full amperage (derated) for the PDU is 16, 24 or 48 amps
 - The amperage for the PDU depends on the line cord chosen – the PDU remains the same
 - Single or 3 phase is also controlled by the line cord chosen
- Most common USA Line Cords
 - 6492 - 14' 200/240v/48A UTG0247 IEC309 60A
 - 6654 - 14' 200/240v/24A UTG0247 L6-30P 30A

The IBM 7188 or 9188 rack-mounted power distribution unit (PDU) contains 12 IEC 320-C13 outlets connected to six 20 A circuit breakers (two outlets per circuit breaker). The PDU employs an inlet current that allows a variety of power cord options that are listed in the following chart. Based on the power cord that is used, the PDU can supply from 4.8 kVa to 19.2 kVa.

Table 131. Power cord options

Feature code	Power cord description	kVa available
6489	Power cord, PDU to wall, 4.3 m (14 ft), 3-phase, Souriau UTG, IEC 60309 32 A 3P+N+E plug	21.0
6491	Power cord, PDU to wall, 4.3 m (14 ft), 200 - 240 V ac, Souriau UTG, IEC 60309 63 A P+N+E plug	9.6
6492	Power cord, PDU to wall, 4.3 m (14 ft), 200 - 240 V ac, Souriau UTG, IEC 60309 60 A 2P+E plug	9.6
6653	Power cord, PDU to wall, 4.3 m (14 ft), 3-phase, Souriau UTG, IEC 60309 16A 3P+N+E plug	9.6
6654	Power cord, PDU to wall, 4.3 m (14 ft), 200 - 240 V ac, Souriau UTG, Plug type 12 plug	4.8
6655	Power cord, PDU to wall, 4.3 m (14 ft), 200 - 240 V ac, Souriau UTG, Plug type 40 plug	4.8
6656	Power cord, PDU to wall, 4.3 m (14 ft), 200 - 240 V ac, Souriau UTG, IEC 60309 32 A P+N+E plug	4.8
6657	Power cord, PDU to wall, 4.3 m (14 ft), 200 - 240 V ac, Souriau UTG, Plug type PDL plug	4.8
6658	Power cord, PDU to wall, 4.3 m (14 ft), 200 - 240 V ac, Souriau UTG, Plug type KP plug	4.8

Loading requirements

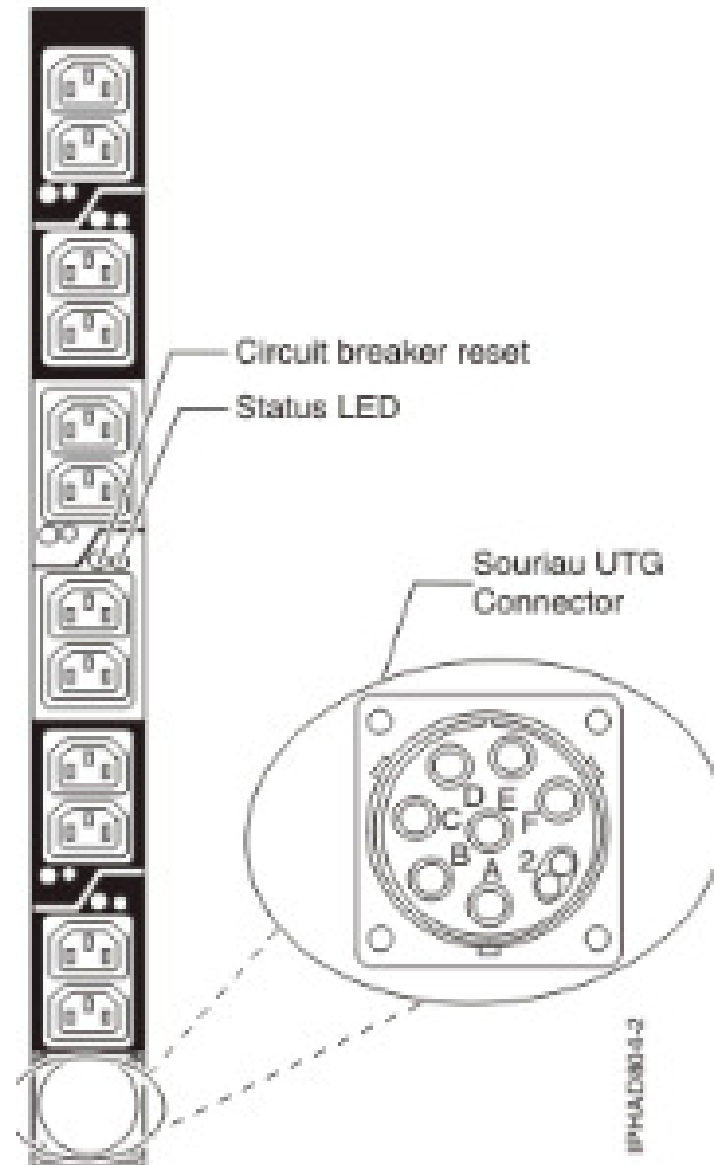
The power loading of the 7188 or 9188 PDU must follow these rules:

1. Total power load connected to the PDU must be limited to below the kVa listed in the table.
2. Total power load connected to any one circuit breaker must be limited to 16 A (derating of circuit breaker).
3. Total power load connected to any one IEC320-C13 outlet must be limited to 10 A.

Note: The load on the PDU when a dual line configuration is used will only be half the total load of the system. When calculating the power load on the PDU, you must include the total power load of each drawer even if the load is distributed over two PDUs.


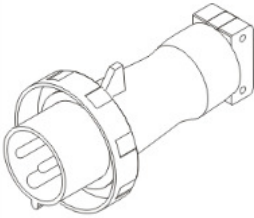
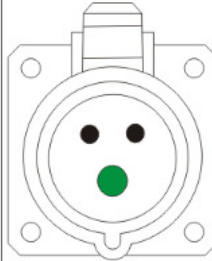
PDUS AND LINE CORDS

- PDU



PDUs AND LINE CORDS

- 6492 IEC309 60amp (48 derated)

6492	Power cord, PDU to wall <ul style="list-style-type: none"> • 200 - 208 V ac or 240 V ac • 48 A • Single phase • 9.6 kVA • 4.3 m (14 ft) • IEC 309, 2P+G 	Plug type 360P6W  	Connector type 360C6W 	39M5417	United States, Canada, Latin America, Japan, and Taiwan
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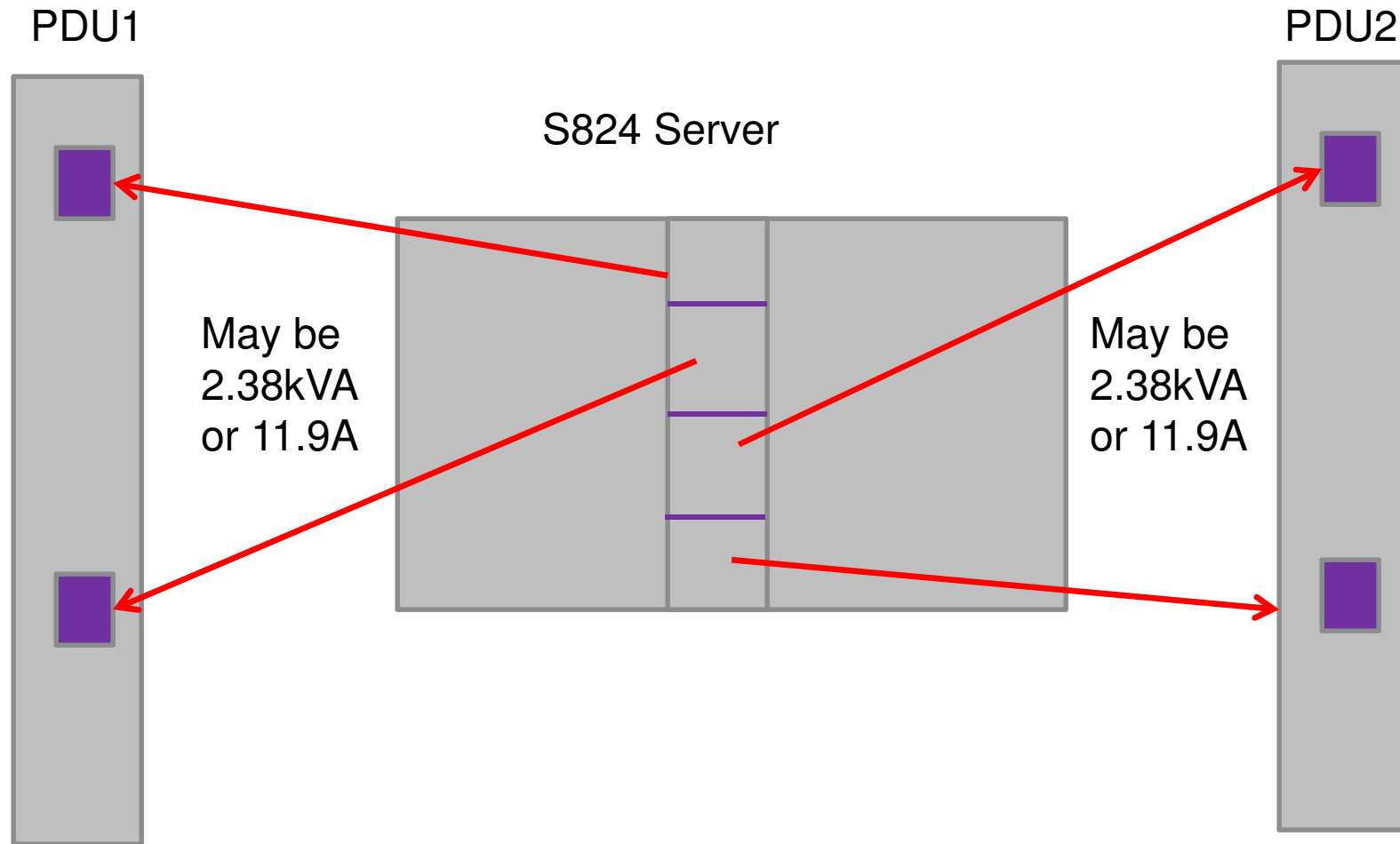
- 6654 L6-30P 30amp (24 derated)

6654	Power cord, PDU to wall <ul style="list-style-type: none"> • 200 - 208 V ac or 240 V ac • 24 A • Single phase • 4.8 kVA • 4.3 m (14 ft) • NEMA L6-30 	Plug type NEMA L6-30P  	Receptacle type NEMA L6-30R 	39M5416	United States, Canada, Latin America, Japan, and Taiwan
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ARCHITECTING FOR ELECTRICAL POWER

- Confusion is due to the way redundant power supplies work
- Redundant Power cords on server
- S824 is rated at 2.38 kVA (around 11.9 amps)
- It has 4 power cords (2 redundant pairs)
- 2 cords go to one PDU and 2 to a second PDU
- That way if a circuit fails or a PDU fails the server continues to run
- Although 2 of the cords will not be drawing power most likely, we have no control over which PDU the server draws power from
- So although you only need 2.38kVA maximum you need to plan for either PDU having to take that load
- If you overcommit assuming a PDU or circuit will never fail then you run the risk of an outage due to overloading if there is a failure.
- Note the kVA and watts and BTU I use for planning purposes are the maximums listed in the redbooks. That way if I add cards or the server gets busy I am not at risk.

S824 POWER EXAMPLE



S824 OPERATING ENVIRONMENT INFORMATION

1.2 Operating environment

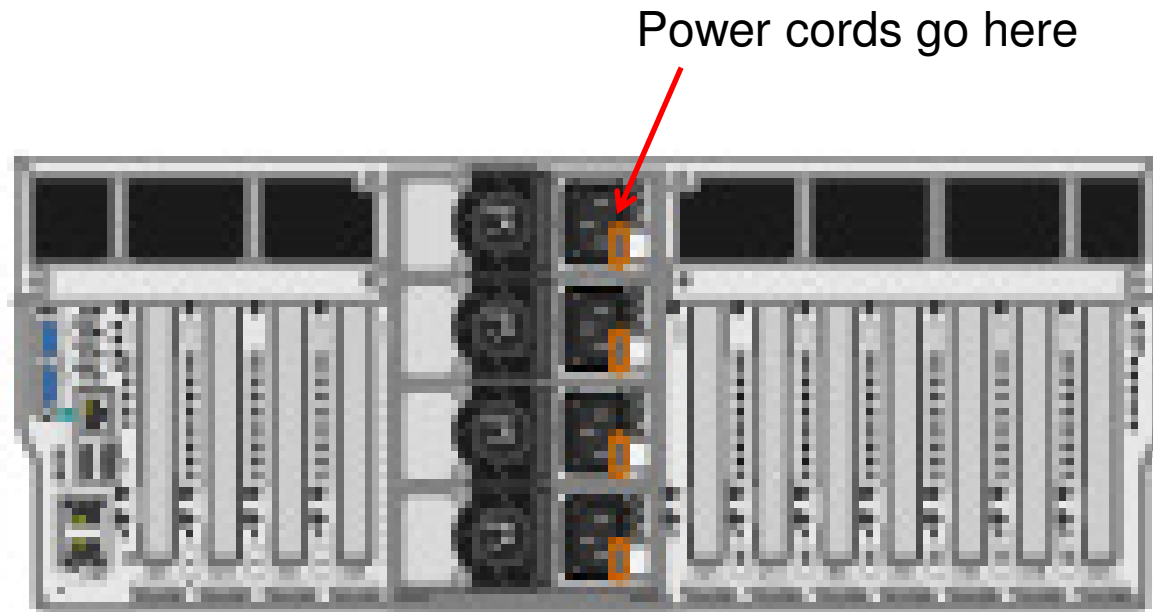
Table 1-1 lists the operating environment specifications for the servers.

Table 1-1 Operating environment for Power S814 and Power S824

Power S814 and Power S824 operating environment				
Description	Operating		Non-operating	
	Power S814	Power S824	Power S814	Power S824
Temperature	Allowable: 5 - 35 ^a degrees C (41 - 95 degrees F) Recommended: 18 to 27 degrees C (64 to 80 degrees F)		5 - 45 degrees C (41 - 113 degrees F)	
Relative humidity	8 - 80%		8 - 80%	
Maximum dew point	28 degrees C (84 degrees F)		N/A	
Operating voltage	900W Power Supply (tower only): 100 - 127 V AC or 200 - 240 V AC 1400W Power Supply (rack only): 200 - 240 V AC	900W Power Supply (rack only): 100 - 127 V AC or 200 - 240 V AC	N/A	
Operating frequency	47 - 63 Hz		N/A	
Power consumption	1420 Watts maximum	2300 Watts maximum	N/A	
Power source loading	1.48 kVA maximum	2.38 kVA maximum	N/A	
Thermal output	4845 BTU/hour maximum	7848 BTU/hour maximum	N/A	

<http://www.redbooks.ibm.com/redpapers/pdfs/redp5097.pdf>

REAR OF S824



The Power S824 supports the following power supplies:

Four 900 Watt 100-127 Volt or 200-240 Volt AC options (#EB2L) power supplies supporting a rack chassis

One power supply is required on the one socket system for normal system operation, the second is for redundancy.

Two power supplies are required for normal system operation on a two socket system, the third and fourth power supply are for redundancy.

E870/E880 OPERATING ENVIRONMENT INFORMATION

1.2 Operating environment

Table 1-1 details the operating environment for the Power E870 and E880 servers.

Table 1-1 Operating environment for Power E870 and Power E880

Power E870 and Power E880 operating environment				
Description	Operating		Non-operating	
	Power E870	Power E880	Power E870	Power E880
Temperature	5 to 35 degrees C (41 to 95 F)		5 to 45 degrees C (41 to 114F)	
Relative humidity	20 - 80%		8 - 80%	
Maximum dew point	29 degrees C (84 F)		28 degrees C (82 F)	
Operating voltage	200 to 240 V AC		N/A	
Operating frequency	47 - 63 Hz		N/A	
Maximum power consumption	4150 Watts per enclosure		N/A	
Maximum power source loading	4.2 kVA per enclosure		N/A	
Maximum thermal output	14,164 BTU/hour per enclosure		N/A	
Maximum altitude	3,048 m (10,000 ft.)		N/A	
Noise level	TBD		N/A	

<http://www.redbooks.ibm.com/Redbooks.nsf/RedbookAbstracts/redp5137.html?Open>

E870/E880 POWER PLANNING

System node power

Four AC power supplies are required for **each system node** enclosure. This arrangement provides 2+2 redundant power with dual power sources for enhanced system availability. A failed power supply can be hot swapped but must remain in the system until the replacement power supply is available for exchange.

Four AC power cords are used for each system node (one per power supply) and are ordered using the AC Power Chunnel feature (#EBAA). The chunnel carries power from the rear of the system node to the hot swap power supplies located in the front of the system node where they are more accessible for service.

System control unit power

The system control unit is powered from the system nodes. UPIC cables provide redundant power to the system control unit. Two UPIC cables attach to system node drawer 1 and two UPIC cables attach to system node drawer 2. They are ordered with #ECCA and #ECCB. The UPIC cords provides N+1 redundant power to the system control unit.

ARCHITECTING FOR ELECTRICAL POWER

- E870/E880 have higher power requirements
- Maximum per node is 4.2 kVA
- So for a single node on a 30 amp (24 amp derated or 4.8 kVA) PDU you can only support ONE E870/E880 node per PDU pair
- As you move to POWER7 and POWER8 you should seriously consider moving to 60 amp (48) PDUs to reduce the number of PDUs and circuits you will require

E870 AND E880 POWER NEEDS

Each CEC has 4 power supplies (2 main and 2 redundant)

Per enclosure operating needs:

	E870/E880	versus 770D	780D
	4.2 kVA	1.649 kVA	1.959 kVA
	4150 watts	1600 watts	1900 watts
	14164 BTU/hr	5461 BTU/hr	6485 BTU/hr
220v	About 19.1 amps	About 7.5 amps	About 8.9 amps

SCU draws its power from the nodes

Remember 20 amps is the circuit breaker for a pair of sockets in the PDU

Weight

CEC	167lb	155lb
SCU	52lb	N/A
I/O drawer	52lb	105lb (5877)

2 node + SCU complex requires 12U

Each node is 5U & SCU is 2U

I/O drawer is 4U

Plus don't forget to add space for EXP24 if you need internal disks

FROM TDA

Two possible PDU ratings are supported: 60A/63A (orderable in most countries) and 30A/32A:

- The 60A/63A PDU supports **four system node power supplies** and one I/O expansion drawer or eight I/O expansion drawers. **Basically means 2 nodes per 2 PDUs**
- The 30A/32A PDU supports **two system node power supplies** and one I/O expansion drawer or four I/O expansion drawers. **Basically means 1 node per 2 PDUs**

Rack-integrated system orders require two of either feature 7109 or 9188/7188. Each PDU requires one PDU to Wall Power Cord. Supported power cords include the following features: 6489, 6491, 6492, 6653, 6654, 6655, 6656, 6657, and 6658.

EXAMPLES

- System consists of one S824 and a 3 node 770 MMD with HMC and Monitor
- Check Technical Overview Redbook operating environment section

• Each 770 node	1.649 kVA	1600 watts	2 power cords
• S824	2.38 kVA	2300 watts	4 power cords
• HMC	0.55 kVA	523 watts	1 or 2 power cords

	kVA	Power Plugs
3 node 770	4.947	6 (3 pairs)
S824	2.38	4 (2 pair)
HMC	0.55	2 (HMC) + 1
monitor		
TOTAL	7.877 kVA	

- REMEMBER if you have a 30 amp (24 derated) line cord then you can only plan for 4.8 kVA per PDU pair so this would need 4 PDUs minimum (2 pairs)

POWER7 REQUIREMENTS

		24	48	6654 I6-30p		6492 IEC309 60
		kva*1000		Servers	Servers	Servers
		/volt (220)		div by	per PDU	div by
POWER7	kVa	Amps		24	Pair	48
710B - 8231-e1b	0.663	3.01		7.240	7	14.480
710C - 8231-e1c	0.765	3.48		6.275	6	12.549
710D - 8231-e1d	0.944	4.29		5.085	5	10.169
720B - 8202-e4b	0.765	3.48		6.275	6	12.549
720C - 8202-e4c	0.857	3.90		5.601	5	11.202
720D - 8202-e4d	1.015	4.61		4.729	4	9.458
730B - 8231-e2b	1.122	5.10		4.278	4	8.556
730C - 8231-e2c	1.286	5.85		3.733	3	7.465
730D - 8231-e2d	1.396	6.35		3.438	3	6.877
740B - 8205-e6b	1.429	6.50		3.359	3	6.718
740C - 8205-e6c	1.602	7.28		2.996	2	5.993
740D - 8205-e6d	1.664	7.56		2.885	2	5.769
750B - 8233-e8b	2.000	9.09		2.400	2	4.800
750D - 8408-e8d	2.450	11.14		1.959	1	3.918
760D - 9109-rmd	2.450	11.14		1.959	1	3.918
770B 9117-mmb per CEC/Node	1.649	7.50		2.911	2	5.822
770C 9117-mmc per CEC/Node	1.649	7.50		2.911	2	5.822
770D 9117-mmd per CEC/Node	1.649	7.50		2.911	2	5.822
780B 9179-mhb per CEC/Node	1.959	8.90		2.450	2	4.900
780C 9179-mhc per CEC/Node	1.959	8.90		2.450	2	4.900
780D 9179-mhd per CEC/Node	1.959	8.90		2.450	2	4.900
HMC 7042-cr6	0.700	3.18		6.857	6	13.714
HMC Cr7 (0.7kva) with 7316-tf3	0.720	3.27		6.667	6	13.333
5877 or 5802 I/O Drawer	0.531	2.41		9.040	9	18.079

POWER8 REQUIREMENTS

		24	48	6654 I6-30p		6492 IEC309 60	
		kva*1000		Servers	Servers	Servers	Servers
		/volt (220)		div by	per PDU	div by	per PDU
POWER8	kVa	Amps		24	Pair	48	Pair
P8-s824 - 8286-42a	2.380	10.82		2.017	2	4.034	4
P8-S814 - 8286-41a	1.480	6.73		3.243	3	6.486	6
P8-S822 - 8284-22a	1.880	8.55		2.553	2	5.106	5
P8-S812L - 8247-21I	1.880	8.55		2.553	2	5.106	5
P8-S822L - 8247-22I	1.880	8.55		2.553	2	5.106	5
P8-E870/E880	4.200	19.09		1.143	1	2.286	2
HMC 7042-CR8	0.550	2.50		8.727	8	17.455	17
7316-TF4							

30 (24) AMP EXAMPLE FOR PDU LAYOUT

Analysis of PDU requirements for a T42 rack holding (5)P8 S822 servers
using FC 6654 L6-30P PDUs and all with redundant power
in US derated to 24A so max is 24Amps or 4.8kVa per PDU single phase
Power here
is 208V

PDU1				PDU2			
12 outlets		Box	Amps	12 outlets		Box	Amps
16 amp per pair	1	822-1A	9.04	16 amp per pair	1	822-1B	9.04
derated from 20	2			derated from 20	2		
	3	822-2A	9.04		3	822-2B	9.04
	4				4		
	5	HMC-1A	2.64		5	HMC-1B	2.64
	6	7316			6		
	7				7		
	8				8		
	9				9		
	10				11		
	11				10		
	12				12		
24 amp max			20.72	24 amp max			20.72

6654 L6-30P Line Cord - in US derated to 24A so max is 24Amps or 4.8kVa per PDU single phase

6492 IEC309 60a Line Cord - in US derated to 48A so max is 48Amps or 9.6kVa per PDU single phase

Note: 822-1A signifies the first power supply cord and -1B the second. One cord to PDU1; one to PDU2.

60 (48) AMP EXAMPLE FOR PDU LAYOUT

Analysis of PDU requirements for a T42 rack holding (5) S822 servers and an HMC and monitor
Using FC 6692 IEC309 60amp PDUs and all with redundant power
in US derated to 48A so max is 48Amps or 9.6kVa per PDU single phase – again power is 208V

PDU1				PDU2			
12 outlets		Box	Amps	12 outlets		Box	Amps
16 amp per pair	1	822-1A	9.04	16 amp per pair	1	822-1B	9.04
derated from 20	2			derated from 20	2		
	3	822-2A	9.04		3	822-2B	9.04
	4				4		
	5	822-3A	9.04		5	822-3B	9.04
	6				6		
	7	822-4A	9.04		7	822-4B	9.04
	8				8		
	9	HMC-1A	2.64		9	HMC-1B	2.64
	10	7316			11		
	11	822-5A	9.04		10	822-5B	9.04
	12				12		
48 amp max			47.84	48 amp max			47.84
6654 L6-30P Line Cord - in US derated to 24A so max is 24Amps or 4.8kVa per PDU single phase							
6492 IEC309 60a Line Cord - in US derated to 48A so max is 48Amps or 9.6kVa per PDU single phase							

AVOIDING ISSUES

- Plan for POWER before ordering anything
- Insist on a TDA (technical delivery assurance)
- Mandatory for all E870/E880 installs and upgrades
- Also mandatory for all POWER7 -770 and above
- Recommended for POWER7-750 and 760
- Required for first in Enterprise
- Should include:
 - Summary of configuration
 - Items to confirm
 - Power and cooling requirements
 - Pre-sales and pre-install checklists
 - Reference information
 - Copy of the full configuration
- May also include:
 - LPAR layouts and Memory overhead

The purpose of the TDA is to avoid problems with POWER, rack space, ethernet and HBA types and so on – this is the best 60-90 minutes you can spend

POWER REFERENCES

Article on power

<http://www.ibmssystemsmag.com/aix/administrator/systemsmanagement/pdu-rules/>

Useful Power Formulas

<http://www.elec-toolbox.com/Formulas/Useful/formulas.htm>

<http://www.rapidtables.com/electric/ampere.htm>

Power cord details

<http://www.quail.com/>

Supported PDU Power Cords (IBM)

[http://www-](http://www-01.ibm.com/support/knowledgecenter/api/content/POWER8/p8had/p8had_pdupowercords.htm?locale=en)

[01.ibm.com/support/knowledgecenter/api/content/POWER8/p8had/p8had_pdupowercords.htm?locale=en](http://www-01.ibm.com/support/knowledgecenter/api/content/POWER8/p8had/p8had_pdupowercords.htm?locale=en)

IBM PDUs and Power Cord Options

[http://www-](http://www-01.ibm.com/support/knowledgecenter/api/content/POWER8/p8had/p8had_specsheetpdu.htm?locale=en)

[01.ibm.com/support/knowledgecenter/api/content/POWER8/p8had/p8had_specsheetpdu.htm?locale=en](http://www-01.ibm.com/support/knowledgecenter/api/content/POWER8/p8had/p8had_specsheetpdu.htm?locale=en)

IBM System Energy Estimator

<http://www-947.ibm.com/systems/support/tools/estimator/energy/index.html>

QUESTIONS?

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<http://www.circle4.com/forsythe/powerforpower.pdf>