High Power DC Supplies

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What's it all about?

- What constitutes a high power DC supply
- Problems of supplying high power DC
- Architecture of high power DC supplies
- Examples of high power commercial DC supplies
- DC-DC Converters
- Summary & Questions

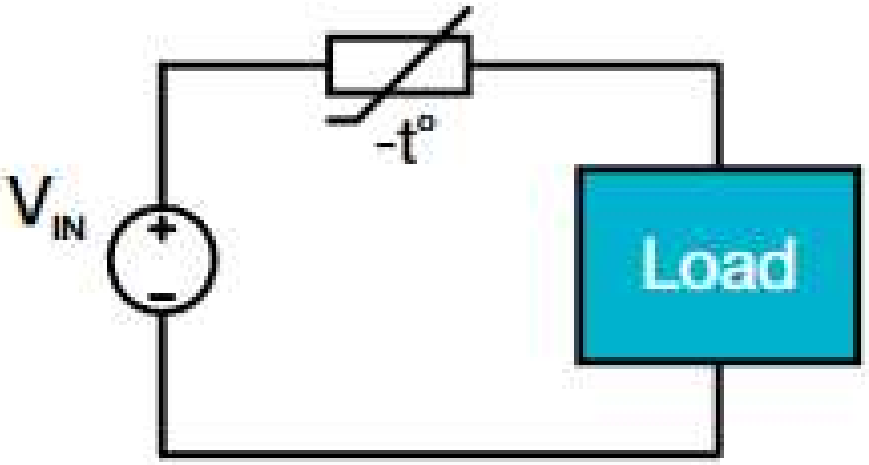
What is a High Power DC Supply

- Any AC to DC supply that can supply at a minimum 1000 Watts or more into a resistive load
- Factors that are inherent to this type of supply
  - Inrush Current
  - Power Factor
  - Protection
  - Flexibility

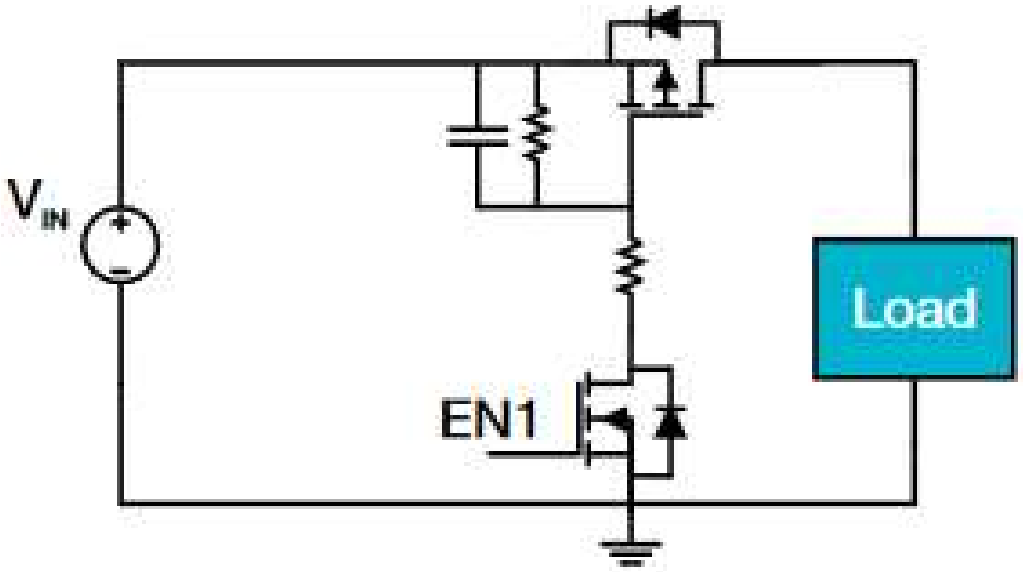
Inrush Current

- On AC side currents of 100A or more can occur for 100 msec or more
- Some form of inrush current protection is needed
- Present with linear as well as switch mode architectures
- Soft start mechanism is needed
  - An NTC (thermistor) shunted with a time delay switch
  - Passive LC network however L can be too large for high-power supplies
  - An N-channel series MOSFET with RC gate ramp network

Inrush Current



NTC Thermister
Current Limiter

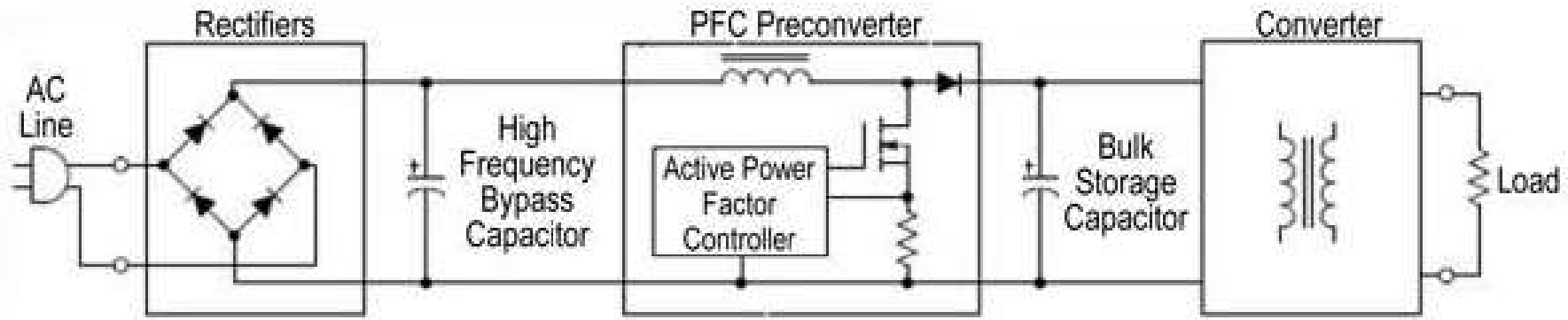


P-Channel MOSFET
Current Limiter

Power Factor Correction

- AC side of supply presents a highly reactive load PF < 0.7
- Required to have PF of 0.9 or better
- Two types of correction needed
  - Distortion of input voltage waveform which generates harmonic
  - Displacement occurs where input voltage and current are out of phase
- Two types of correction
  - Passive filters to remove harmonic content
  - Active uses electronics to to change current waveform to be in phase

Power Factor Correction



Active PF correction location in power supply architecture

Power Factor Correction

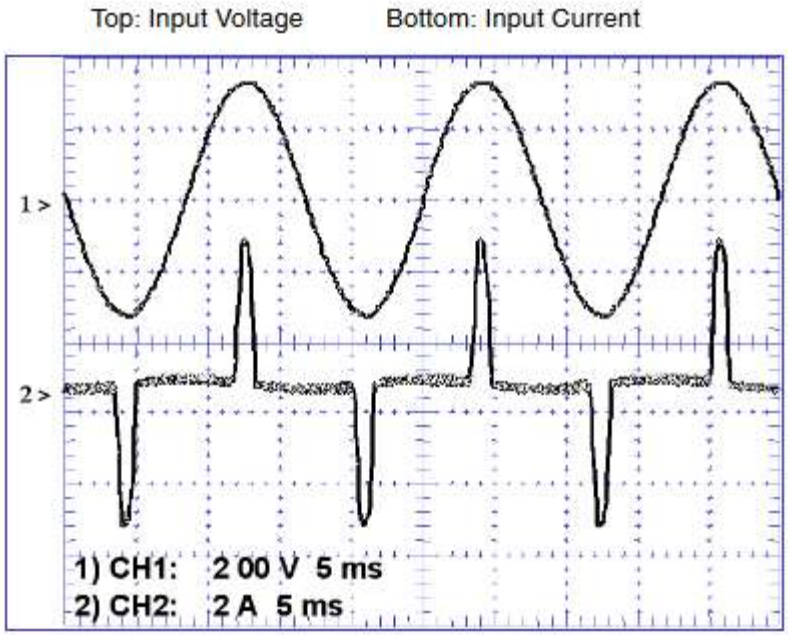


Figure 1–1. Input Characteristics of a Typical Switched-Mode Power Supply without PFC

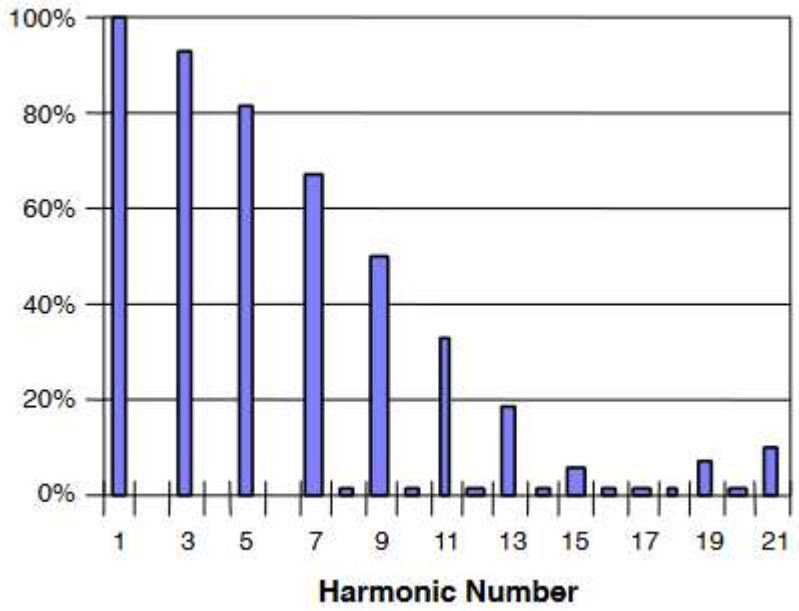


Figure 1–2. Harmonic Content of the Current Waveform in Figure 1–1

Power Factor Correction

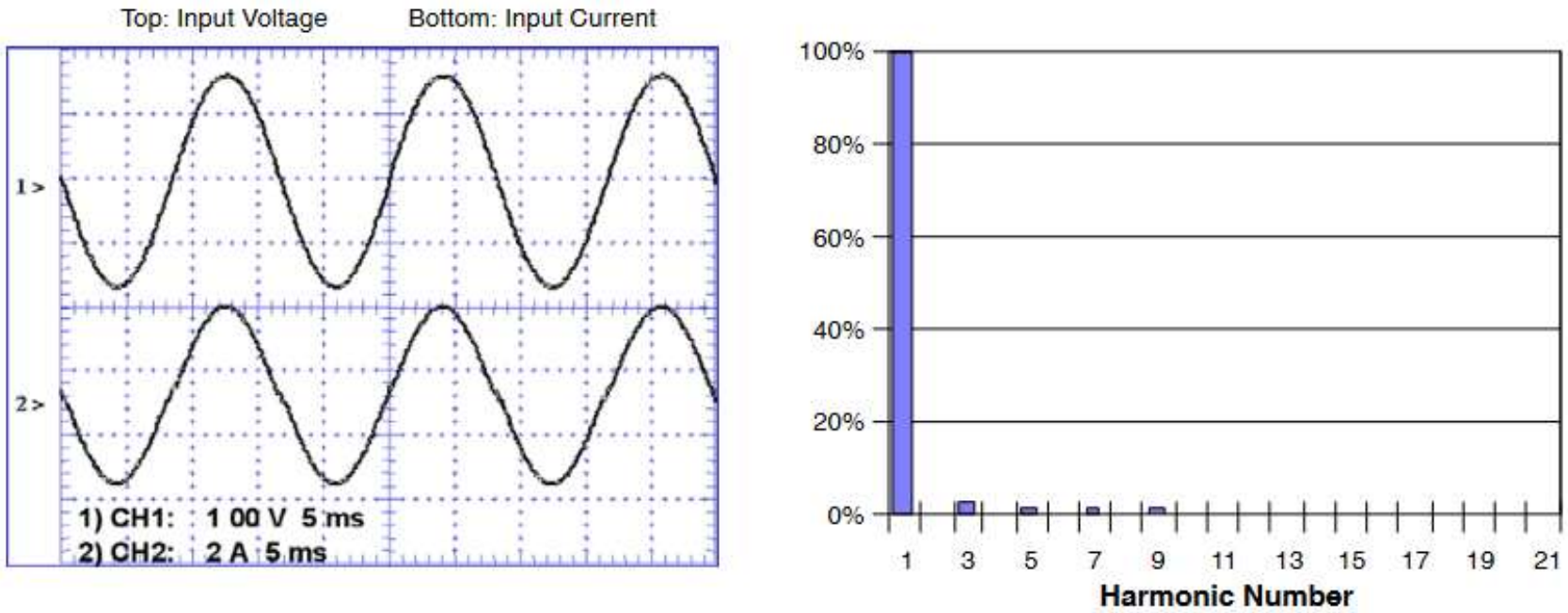


Figure 1–3. Input Characteristics of a Power Supply with Near-Perfect PFC

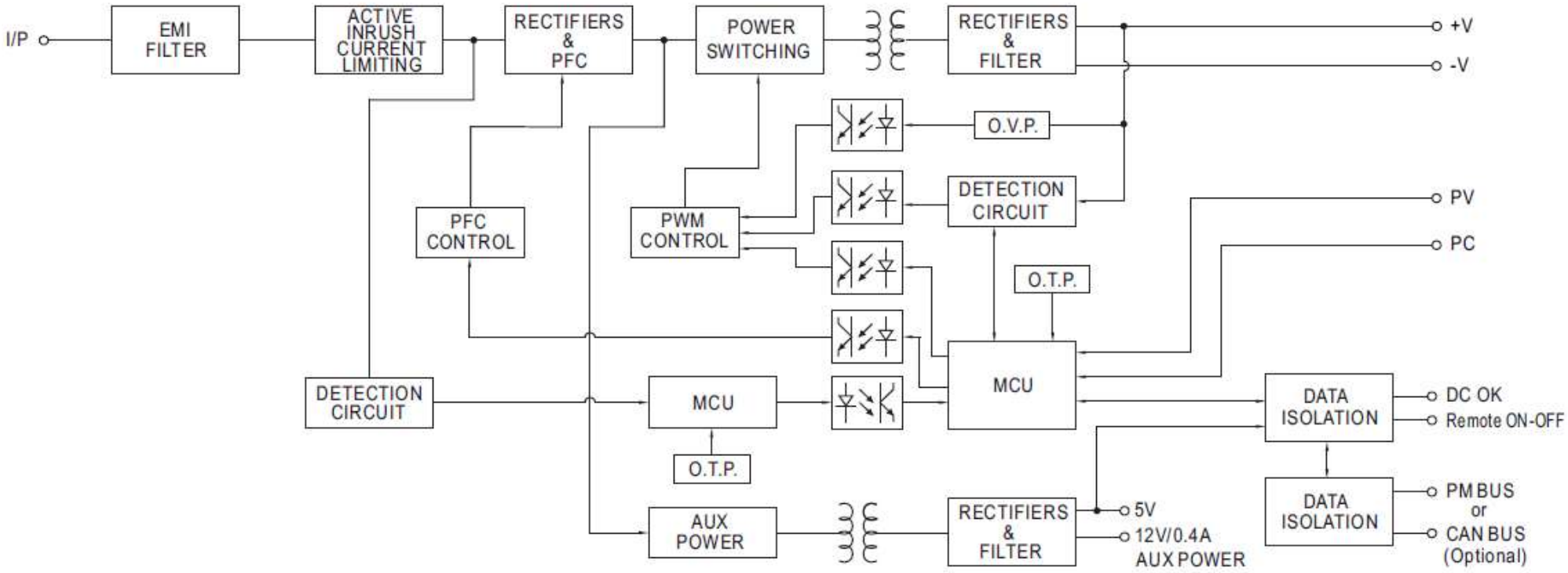
Protection

- Over voltage and over current needed
- Over current protections:
  - Circuit breakers/fuses too slow to react
  - Feedback to switching regulator to shutdown
- Over voltage protections:
  - SCR triggered crowbar too slow and can damage the supply
  - Feedback to switching regulator to lower voltage via PWM changes

Flexibility

- Parameterised specifications to tailor to working environment
- Ability to monitor and manage system remotely
- Parallel connect supplies for more current capability and/or reliability
- Ability to work with different power sources (Mains, Generator, Solar)
- Support for common industrial bus interconnects (CAN, PM)

Switch Mode Power Supply Architecture



Examples – ELTEK FlatPack2 48/2000

AC Input	
AC Voltage	85-300 VAC (Nominal 185 – 275 VAC)
Frequency	45 to 66Hz
Maximum Current	12.5 A_{rms} maximum at nominal input and full load
Power Factor	> 0.99 at 50% load or more
DC Voltage	120-275VDC (Rated 140 – 250VDC)
Input Protection	Varistors for transient protection Mains fuse in both lines Disconnect above 300 VAC

DC Output	
Voltage	53.5VDC (adj. range: 43.5-57.6VDC)
Output Power	2000 W at nominal input
Maximum Current	41.7 Amps at 48 VDC and nominal input
Current Sharing	±5% of maximum current from 10% to 100% load
Static voltage regulation	±0.5% from 10% to 100% load
Dynamic voltage regulation	±5.0% for 10-90% or 90-10% load variation, regulation time < 50ms
Hold up time	> 20ms; output voltage > 43.5 VDC at 1500W load
Ripple and Noise	< 100 mV peak to peak, 30 MHz bandwidth < 0.96 mV rms psophometric
Output Protection	Overvoltage shutdown Blocking diode Short circuit proof High temperature protection

Other Specifications	
Efficiency	Typical 92%, min. 91% at 40-90% load
Isolation	3.0 KVAC – input and output 1.5 KVAC – input earth 0.5 KVDC – output earth
Alarms:	Low mains shutdown High temperature shutdown Rectifier Failure Overvoltage shutdown on output Fan failure, one or two fans. Low voltage alarm at 43.5V CAN bus failure
Warnings:	Low temperature shutdown Rectifier in power derate mode Remote battery current limit activated Input voltage out of range, flashing at overvoltage Loss of CAN communication with control unit, stand alone mode
Visual indications	Green LED: ON, no faults Red LED: rectifier failure Yellow LED : rectifier warning
Operating temp	-40 to +75°C (-40 to +158°F)
Storage temp	-40 to +85°C (-40 to +185°F)
Cooling	2 fans (front to back airflow)
Fan Speed	Temperature and current regulated
MTBF	> 350, 000 hours Telcordia SR-332 Issue I, method III (a) (Tambient : 25°C)
Acoustic Noise	< 55dBA at nominal input and full load ($T_{ambient}$ < 30°C)
Humidity	Operating: 5% to 95% RH non-condensing Storage: 0% to 99% RH non-condensing
Dimensions	109 x 41.5 x 327mm (wxhxd) (4.25 x 1.69 x 13")
Weight	1.9 kg (4.19lbs)

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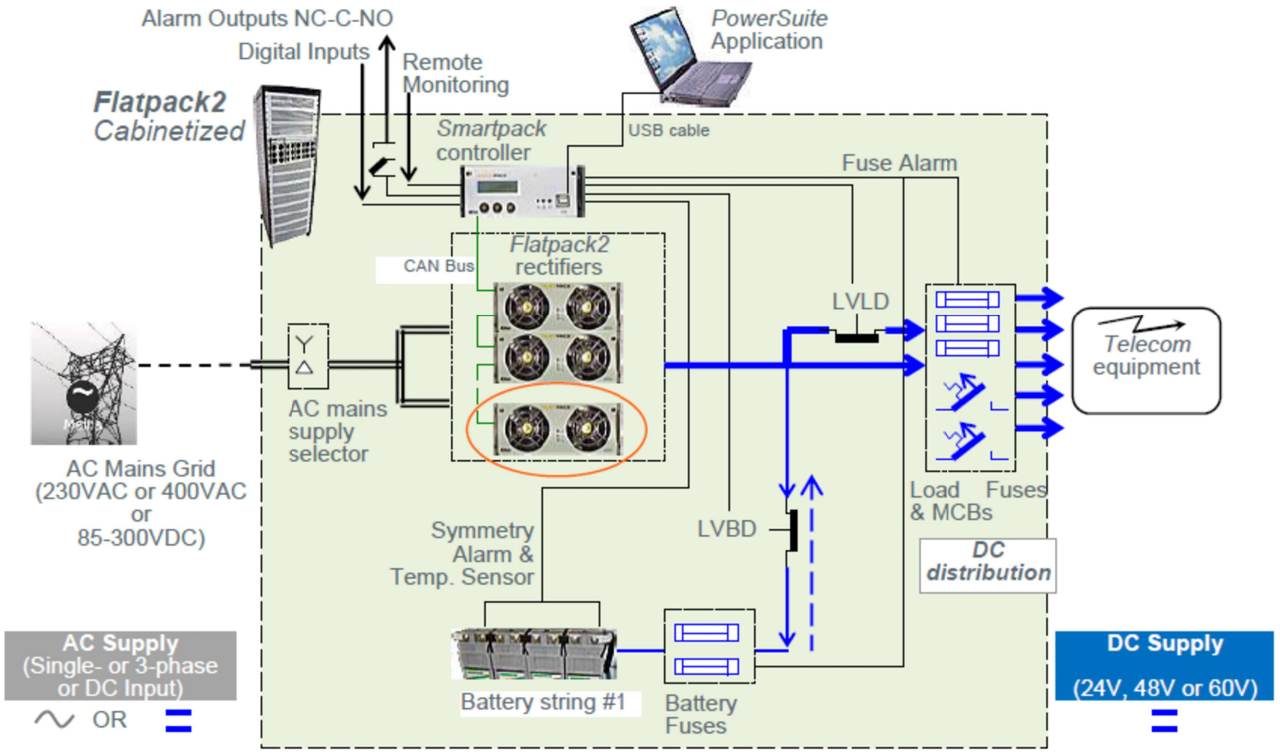

Typical Flatpack2 PS *system for DC power supply of telecom equipment*

Example – Meanwell UHP-2500

MODEL		UHP-2500-24	UHP-2500-36	UHP-2500-48
OUTPUT	DC VOLTAGE	24V	36V	48V
	RATED CURRENT	104.2A	69.4A	52.1A
	RATED POWER	2500.8W	2498.4W	2500.8W
	RIPPLE & NOISE (max.) Note.2	300mVp-p	360mVp-p	480mVp-p
	VOLTAGE ADJ. RANGE	By built-in potentiometer, SVR		
		24~28.8V	36~43.2V	48~57.6V
	VOLTAGE TOLERANCE Note.3	±1.0%	±1.0%	±1.0%
	LINE REGULATION	±0.5%	±0.5%	±0.5%
	LOAD REGULATION	±1.0%	±1.0%	±0.5%
	SETUP, RISE TIME Note.4	1800ms, 60ms/230VAC 1800ms, 60ms/115VAC at full load		
	HOLD UP TIME (Typ.) Note.4	16ms/230VAC at 75% load 10ms/230VAC at full load ; 16ms/115VAC at 75% load 10ms/115VAC at full load		
INPUT	VOLTAGE RANGE Note.4	90 ~ 264VAC 250 ~ 370VDC		
	FREQUENCY RANGE	47 ~ 63Hz		
	POWER FACTOR (Typ.) Note.4	PF≥0.95/230VAC PF≥0.99/115VAC at full load		
	EFFICIENCY (Typ.)	95%	95.5%	96%
	AC CURRENT (Typ.)	15A/115VAC 14.3A/230VAC		
	INRUSH CURRENT (Typ.)	Cold start 30A/115VAC 60A/230VAC		
	LEAKAGE CURRENT	<0.75mA / 240VAC		
PROTECTION	OVERLOAD	105 ~ 115% rated current		
		Protection type : Constant current limiting, shut down O/P voltage after 5 sec. After O/P voltage falls, re-power on to recover		
	OVER VOLTAGE	30 ~ 35V	45 ~ 51V	60 ~ 67V
		Protection type :Shut down O/P voltage,re-power on to recover		
	OVER TEMPERATURE	Protection type :Shut down O/P voltage, recovers automatically after temperature goes down		
FUNCTION	OUTPUT VOLTAGE PROGRAMMABLE(PV) Note.5	Adjustment of output voltage is allowable to 50 ~ 120% of nominal output voltage Please refer to the Function Manual.		
	OUTPUT CURRENT PROGRAMMABLE(PC) Note.5	Adjustment of constant current level is allowable to 20 ~ 100% of rated current. Please refer to the Function Manual.		
	REMOTE ON/OFF CONTROL	Power ON : Short circuit Power OFF : Open circuit		
	AUXILIARY POWER	12V@0.4A tolerance±10%, ripple 150mVp-p		
	DC-OK SIGNAL	The TTL signal out, PSU turn on = 4.5 ~ 5.5V ; PSU turn off = -0.5 ~ 0.5V. Please refer to the Function Manual.		

Surplus Server Supplies

- Widely available online
- Limited to 12 VDC systems
- High DC currents possible >40 A
- Very inexpensive <$50
- Multiple Manufacturers (IBM, DELL, HP)
- Sources eBay and others
- Some conversion work needed //www.rcgroups.com/forums/showthread.php?1292514-How-to-convert-Server-Power-Supplies

High Power DC–DC Converters

- Similar architectures to switch mode power supplies
- Can be thought of as ‘DC Transformers’
- Buck converters to step down voltages
- Boost converters to step up voltages

Summary

- Gone are the days of linear power supplies being the only choice for high-power DC supplies
- Low noise and high efficiency switching supplies are readily available
- These are complex but reliable supplies
- Price is generally a good indication of quality
- Cheap switchers are JUNK!

Questions?