WTX

460W Power Supply Design Guide

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Version 1.0

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Revision History

Revision 1.0	Initial release, J Day, WPG PSE

CONTENTS

Table of Figures

Table of Tables

1. SCOPE

The scope of this document is limited to the recommendations for a 460W multiple-output switching power supply for worldwide use in Information Technology Equipment. This document is intended to provide the **minimum** set of features required to power a 19" rack compliant Mid-Range IA32™ WTX Workstation. This document is not intended to define a specific power supply; rather the intent is to provide guidelines for power supply manufacturers to work with their final system customers. Specific computer OEMs may have additional requirements that are needed for their specific systems. The power supply should have the following features: auto-select input line capability with active PFC, remote ON/OFF, thermal fan speed control, standby voltages ("V_{SB}" and "V_{AUX}"), and electrical characteristics per Table 1 and Table 2

All specifications are applicable under all operating conditions when installed in the end use system, unless otherwise stated.

2. SUPPLY OVERVIEW

This document is intended to provide electrical design suggestions as a reference for power supply manufacturers and computer OEMs for a typical Mid-Range WTX workstation.

Table 1 - Power Supply Overview

	Comments
PFC	Japan & European Harmonic Reduction (PFC) – PFC > 0.98 @ 100VAC
Form-factor:	150mm X 230mm X 86mm, WTX
Power:	460 Watts max. Continuous 480 Watts Peak (15 seconds, 5 minute duty cycle)
Efficiency:	≥ 68% at full load ≥ 55% for current "Energy Star" requirement or 50% for future requirement (refer to Section 4.2.7.1.)

Table 2 - Electrical Characteristics Overview

Output voltage	Regulation	Min current (amps)	Max current (amps)	Peak Current (amps)
+3.3 VDC	±4%	1.0	45.0	
+5 VDC:	±4%	1.0	27.0	
$+12_{IO}$ VDC:	±5%	0.5	16.0	18.2
-12 VDC:	±10%	0.0	0.6	
12_{DIG} VDC:	±5%	0.1	18.0	
+3.3 V_{AUX}:	±5%	0.0	3.0	
+5 V_{SB}:	±5%	0.0	0.72	

Note:

1. +5 V_{SB} and $3.3V_{AUX}$ are SELV standby voltages that are always present when AC mains voltage is present.
2. Max continuous +5V, +3.3V and $+12V_{IO}$ output power is 300W.
3. Max continuous +5V and +3.3V output power is 200W

3. APPLICABLE DOCUMENTS

The latest revision in effect of the following documents forms a part of this document to the extent specified:

AB13-94-146	EACEM European Association of Consumer Electronics Manufacturers. Hazardous Substance List / Certification.
ANSI C62.41-1991:	IEEE Recommended Practice on Surge Voltages in Low-Voltage AC Circuits.
ANSI C62.45-1992:	IEEE Guide on Surge Testing for Equipment Connected to Low-Voltage AC Power Circuits.
MIL-STD-105K:	Quality Control.
MIL-STD-217F:	Reliability Predictions for Electronic Equipment.
MIL-C-5541:	Chemical Conversion Coatings on Aluminum and Aluminum Alloys.
CSA C22.2 No.234, Level 3	Safety of Component Power Supplies. Intended for use with Electronic Data Processing Equipment and Office Machines.
UL 1950/CAN/CSA CSA C22.2 No. 950-95 without D3 Deviation: 3rd edition	Safety of, Information Technology Equipment including Electrical Business Equipment.
EN60 950: plus A1,A2, A3, A4	Safety of Information Technology Equipment including business equipment.
EMKO-TSE(74-SEC)207/94	Nordic National Requirement in addition to EN60950.
CISPR 22:1997 3rd edition and EN 55022:1998	Limits and Methods of Measurements of Radio Interference Characteristics of Information Technology Equipment, Class B.
ANSI C63.4 – 1992	American National Standard for Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz for EMI testing.
EN55022:1998	Electromagnetic compatibility/generic immunity standard.
EN61000-3-2	Limits for Harmonic Current Emission, Class D.
Japan Electric Association	Guidelines for the Suppression of Harmonics in Appliances and General use Equipment.
IEC 61000-4	Electromagnetic compatibility for industrial-process measurement & control equipment. Part - 2 ESD Requirements. Part - 3 Immunity to Radiated Electromagnetic Fields. Part - 4 Electrical Fast Transients/Burst Requirements. Part - 5 Surge Immunity Requirements. Part - 6 Radio frequency common mode test standard Part - 8 Power frequency magnetic field test standard Part - 11 Voltage dips and interruptions test standard
IEC Publication 417	International Graphic Symbol Standard.
ISO Standard 7000	Graphic Symbols for use on Equipment.
CFR 47, Part 15, Subpart B	FCC Rules.

4. ELECTRICAL SPECIFICATION

The electrical requirements that follow are to be met over the environmental ranges specified in Section 6 unless otherwise noted.

4.1 AC Input Requirements

The power supply shall be capable of supplying full rated output power over two input voltage ranges that are switch selectable and rated 100-127 VAC and 200-240 VAC RMS nominal. The power supply shall automatically recover from AC power loss. The input voltage, current, and frequency requirements for continuous operation are stated below. (Note that nominal voltages for test purposes are considered to be within ±1.0 V of nominal.) The power supply must be able to start up under peak loading at 90V AC.

Table 3 - AC Input Line Requirements

Parameter	Min	Nom	Max	Unit
V_{in} (115 VAC)	90	115	135	VAC_{rms}
V_{in} (230 VAC)	180	230	265	VAC_{rms}
V_{in} Frequency	47	--	63	Hz
I_{in} (115 VAC)			7.5	A_{rms}
I_{in} (230 VAC)			3.75	A_{rms}

4.1.1 Input Over Current Protection

The power supply shall incorporate primary fusing for input Over Current Protection. Fuse should be slow blow type or equivalent to prevent nuisance trips.

4.1.2 Inrush Current Limiting

Maximum inrush current from power-on (with power on at any point on the AC Sine) and including, but not limited to, three line cycles, shall be limited to a level below the surge rating of the input line cord, AC switch if present, bridge rectifier, fuse, PFC and EMI filter components. Repetitive ON/OFF cycling of the AC input voltage should not damage the power supply or cause the input fuse to blow.

4.1.3 Input Under Voltage

The power supply shall contain protection circuitry such that the application of an input voltage below the minimum specified in Section 4.1, Table 3 shall not cause damage to the power supply unit or exceed the steady state current ratings of any EMI or PFC component.

4.1.4 Immunity

4.1.4.1 Slow Transients

The DC output(s) shall not exceed the limits specified in Section 4.2.1 as a result of the input power line noise defined in Table 4 under any load condition per IEC 61000-4-11.

Table 4 - Line Voltage Transient Limits

AC Line slow transients:				
Duration	Sag / Surge	Operating AC Voltage	Line Frequency	Performance Criteria
0 to 500 msec	10%	Rated AC Voltages	50/60Hz	No loss of function or performance
0 to 15 minutes	15%	Mid-point of Rated AC Voltages	50/60Hz	No loss of function or performance
0 to ½ AC cycle	30%	Mid-point of Rated AC Voltages	50/60Hz	No loss of function or performance
0 to 5 AC cycles	50% sag only	Mid-point of Rated AC Voltages	50/60Hz	Loss of function acceptable, self-recoverable

4.1.4.2 Surge Voltages

Input Surge Withstand Capability (Line Transients). The power supply shall meet the IEC 61000-4-5 Level 1; Level 2, and Level 3 criteria for surge withstand capability, with the following conditions and exceptions. The power supply must meet the surge withstand test for the conditions of operation specified in Section 6.

The peak value of the injected unipolar waveform shall be 2.0kV measured at the input of the power supply for the common and the normal modes of transient surge injection.

The surge withstand test must not produce:

- Damage to the power supply
- Disruption of the normal operation of the power supply
- Output voltage deviation exceeding the limits of Section 4.2.1.

4.1.4.2.1 Surge Immunity, IEC 61000-4-5

No unsafe operation allowed under any condition. No user noticeable performance degradation for 1kV Differential Mode (DM) or 2kV Common Mode (CM) is allowed. Automatic or manual recovery allowed for other conditions. Must meet performance criteria B in the end product.

4.1.4.2.2 Electrical Fast Transient/Burst, IEC 61000-4-4

No unsafe operation allowed under any condition. No user noticeable performance degradation up to 1kV is allowed. Automatic or manual recovery allowed for other conditions. Must meet performance criteria B in the end product.

4.1.4.2.3 Ring Wave, ANSI C62.45-1992

The crest value of the first half peak of the injected oscillatory wave will be 3.0 kV open circuit with 200 and 500 Ampere short circuit current for the common and the normal modes of transient surge injection. The peak value of the injected unipolar wave form shall be 2.0 kV measured at the input of the power supply for the common and the normal modes of transient surge injection.

4.1.4.2.4 Electrostatic Discharge, IEC 61000-4-2

In addition to *IEC61000-4-2* the following ESD tests must be conducted. Each surface area of the unit under test is subjected to twenty- (20) successive static discharges, at each of the following voltages: 2 kV, 3 kV, 4 kV, 5 kV, 6 kV, 8 kV, 10 kV, 15 kV, and 25 kV.

Performance Criteria:

All power supply outputs shall continue to operate within the parameters of this specification, without glitches or interruption, while the supply is operating as defined and subjected to 2 kV through 15 kV ESD pulses. The direct ESD event shall not cause any out of regulation conditions such as overshoot or undershoot. The power system shall withstand these shocks without nuisance trips of the Overvoltage Protection, Overcurrent Protection or the remote +5 VDC shutdown circuitry.

The power supply, while operating as defined, shall not have a component failure when subjected to any discharge voltages up to and including 25 kV. Component failure is defined as any malfunction of the power supply, which causes component degradation or failure requiring component replacement to correct the problem. Must meet performance criteria B for discharges within *IEC 61000-4-2* limits.

4.1.4.2.5 Radiated Immunity, IEC 61000-4-3

Frequency	Electric Field Strength	Performance Criteria
80 MHz to 1000 MHz, 80% AM (1kHz)	3V/m	B

4.1.4.2.6 Immunity to Conducted Disturbances, IEC 61000-4-6

Frequency	Electric Field Strength	Performance Criteria
.15 to 80 MHz, 80% AM (1kHz)	3V	A

4.1.4.2.7 Power Frequency Magnetic Field, IEC 61000-4-8

Frequency	Electric Field Strength	Performance Criteria
50Hz	1A/m	A

4.1.4.2.8 Voltage Dips & Interruptions, IEC-61000-4-11

Level	Performance Criteria
>95% reduction for 0.5 periods	B
30% reduction for 25 periods (dips)	C
>95% reduction for 250 periods (interrupts)	C

4.1.5 Catastrophic Failure Protection

The primary circuit design and the components specified in the same should be such that should a component failure occur, the power supply shall not exhibit any of the following:

A) Flame

B) Excessive smoke

C) Charred PCB

D) Fused PCB conductor

E) Startling noise

F) Emission of molten material

4.2 DC Output Requirements

4.2.1 DC Voltage Regulation

The DC output voltages shall remain regulated within the ranges shown in Table 5 when measured at the load end of the output connectors under all line, load, and environmental conditions. The voltage regulation limits shall be maintained under continuous operation for a period of time equal to or greater than the MTBF specified in Section 8.2 at any steady state temperature and operating conditions specified in Section 6.

Table 5 - DC Output Voltage Regulation

Parameter	Range	Min.	Nom.	Max.	Unit
$+12_{IO}$ VDC[1]	± 5 %	+11.40	+12.00	+12.60	Volts
+ 5 VDC	± 4 %	+4.80	+5.00	+5.20	Volts
+3.3VDC	± 4 %	+3.17	+3.30	+3.43	Volts
-12 VDC	± 10 %	-10.80	-12.00	-13.20	Volts
$+12_{DIG}$ VDC[2]	± 5 %	+11.40	+12.00	+12.6	Volts
+ 3.3 V_{AUX}	± 5 %	+3.14	+3.30	+3.47	Volts
+ 5 V_{SB}	± 5 %	+4.75	+5.00	+5.25	Volts

NOTES:

1. At +12V surge, regulation can go to ±10%.
2. This output provides power to DCDC converters

4.2.2 Remote Sensing

The 3.3 V and 5 V outputs shall have provisions for remote sensing to compensate for various system cable, connector & PCB trace drops.

The 5 V sense shall be connected to pin 1 of P1 with the 5 V sense returned to pin 12.

The 3.3 V sense shall be connected to pin 2 of P1 with the 3.3 V sense returned to pin 13.

In all instances, the power supply should draw no more than 10 mA through the remote sense line to keep DC off set voltages to a minimum.

4.2.3 DC Output Current

The following power distribution tables are based upon minimum and reference system configurations. The maximum loading scenario is based upon a dual processor, full system memory, four PCI slots, AGP-Pro and six peripheral bays.

Table 6 - Load Range 1, Minimum system loading

VOLTAGE	MINIMUM CONTINUOUS	MAXIMUM CONTINUOUS	PEAK
+3.3V	1A	10A	
+5V	1A	8A	
$+12_{IO}$VDC	0.5A	4A	N/A
-12V	0A	0.4A	
$+12_{DIG}$ VDC	0.1A	5A	
+3.3 V_{AUX}	0A	3A or rated	
+5V V_{SB}	0mA	720mA or rated	

Table 7 - Load Range 2, Nominal Loading

VOLTAGE	MINIMUM CONTINUOUS	MAXIMUM CONTINUOUS	PEAK
+3.3V	2A	40A	
+5V	2A	16A	
$+12_{IO}$VDC	1A	17A	18.2A[4,5]
-12V	0A	0.4A	
$+12_{DIG}$ VDC	0.1A	10A	
+3.3 V_{AUX}	0A	3A or rated	
+5V V_{SB}	0mA	720mA or rated	

Table 8 - Load Range 3, Maximum 3.3V Loading

VOLTAGE	MINIMUM CONTINUOUS	MAXIMUM CONTINUOUS	PEAK
+3.3V	2A	45A[2,3]	
+5V	2A	18A[2,3]	
$+12_{IO}$VDC	1A	13A[3]	16A[4,5]
-12V	0A	0.6A	
$+12_{DIG}$ VDC	0.1A	18A	
+3.3 V_{AUX}	0A	3A or rated	
+5V V_{SB}	0mA	720mA or rated	

Table 9 - Load Range 4, Maximum 5V/12V_{IO} Loading

VOLTAGE	MINIMUM CONTINUOUS	MAXIMUM CONTINUOUS	PEAK
+3.3V	2A	27A[2,3]	
+5V	2A	27A[2,3]	
+12$_{IO}$VDC	1A	16A[3]	18.2A[4,5]
-12V	0A	0.6A	
+12$_{DIG}$ VDC	0.1A	18A	
+3.3 V_{AUX}	0A	3A or rated	
+5V V_{SB}	0mA	720mA or rated	

Notes:

1. Maximum continuous total DC output power should not exceed 460 Watts.
2. Maximum continuous combined load on +3.3VDC and +5VDC outputs shall not exceed 200 Watts.
3. Maximum continuous combined load on +3.3VDC, +5VDC and +12V_{IO} outputs shall not exceed 300 Watts.
4. Max. Peak total DC output power should not exceed 480 Watts.
5. Peak +12$_{IO}$VDC output power not to exceed 15 seconds in duration.
6. +3.3V_{AUX} and +5V_{SB} shall remain above minimum regulation levels in a DC fault condition.

4.2.4 Output Power

The power supply shall be capable of continuously supplying 460W under all specified conditions. The power supply shall be capable of supplying 480W peak output power for 15 seconds under all specified conditions. The 3.3V, 5V and 12V_{IO} outputs shall be capable of supplying a combined output power of 300W. The 3.3V and 5V outputs shall be capable of supplying a continuous combined power of 200W.

4.2.5 Power Limit

Under short circuit or overload conditions, no output shall continuously exceed 240 VA under any conditions including single component fault conditions per EN60 950 requirements.

4.2.6 Output Grounding

The Power Supply output returns shall be common and AC coupled to a single point on the power supply chassis via a 0.1uF capacitor.

4.2.7 Efficiency

The efficiency of the power supply shall be met over the AC input range defined in Table 3, under the load conditions defined in Section 4.2.3 and the temperature and operating conditions defined in Section 6. The power supply shall be a minimum of **68%** efficient under maximum load (see Table 9).

4.2.7.1 Energy Star

4.2.7.1.1 Energy Star requirement (thru June 30th, 2000)

The "Energy Star" efficiency of the power supply shall be a minimum of 55%. In the Energy Star state, the AC input power shall be limited to 15% of maximum continuous power or $69W_{RMS}$ when subject to the following load limitations;

Table 10 - 15% Energy Star load condition

Output	Load condition
$+3.3V_{AUX}$	1.0A
$+5V_{SB}$	0.2A
$+12V_{DIG}$	2.78A
All other outputs	0A

That is, when the 115 VAC input power = 69 W (as measured by a true RMS watt-meter placed on the input AC line cord), the total DC output power shall be at least 37.7 W.

4.2.7.1.2 Energy Star requirement (after July 1st, 2000)

The "Energy Star" efficiency of the power supply shall be a minimum of 50%. In the Energy Star state, the AC input power shall be limited to 10% of maximum continuous power or $46W_{RMS}$ (as measured by a true RMS watt-meter placed on the AC line cord) when subject to the following load limitations;

Table 11 - 10% Energy Star load condition

Output	Load condition
$+3.3V_{AUX}$	1.0A
$+5V_{SB}$	0.2A
$+12V_{DIG}$	1.05A
All other outputs	0A

That is, when the 115 VAC input power = 46 W (as measured by a true RMS watt-meter placed on the input AC line cord), the total DC output power shall be at least 16.9 W.

4.2.8 Output Ripple/Noise

The following output ripple/noise requirements shall be met throughout the load ranges specified in Section 4.2.3 and under all input voltage conditions as specified in Section 4.1.

Ripple and noise are defined as periodic or random signals over frequency band of 10 Hz to 20 MHz. Measurements shall be made with an oscilloscope with 20 MHz bandwidth. Outputs shall be bypassed at the connector with a 0.1µF ceramic disk capacitor and a 10 µF electrolytic capacitor to simulate system loading.

Table 12 - DC Output Noise/Ripple

Output	Max.
$+12_{IO}$ VDC	$120mV_{pp}$
+5 VDC	$50mV_{pp}$
+3.3 VDC	$50mV_{pp}$
-12 VDC	$120mV_{pp}$
$+12_{DIG}$ VDC	$120mV_{pp}$
$+3.3V_{AUX}$	$50mV_{pp}$
+ 5 V_{SB}	$50mV_{pp}$

4.2.9 Output Transient Response

The output voltage shall remain within the regulation limits of Table 5 (inclusive of over/undershoot) for instantaneous load changes limited to the maximum individual steps per Table 13, output capacitive loading per Table 14, over the AC input range defined in section 4.1 and may include simultaneous load steps on the $+12_{IO}$VDC, +5 VDC, and +3.3 VDC outputs. All load changes shall occur in the same direction. The transient response measurements shall be made with a load changing repetition rate of 50 Hz to 10 kHz. The load slew rate shall not be greater than 2.5 A/µs. The power supply shall be stable under all transient conditions from any steady state load.

Table 13 - DC Output Transient Response

Parameter	Max. load step
$+12_{IO}$VDC	10A
+5VDC	6A
+3.3VDC	10A
$+12_{DIG}$VDC	12A
-12VDC	0.1A

Note: Voltage regulation range is specified in Table 5.

4.2.10 Closed Loop Stability

The power supply shall be unconditionally stable under all line/load/transient load conditions including capacitive loads specified in Section 4.2.11. A minimum of 45 degrees phase and 10dB-gain margin is required. The power supply vendor shall provide proof of the unit's closed-loop stability with local sensing through the submission of Bode plots. Closed-loop stability must be ensured at the maximum and minimum loads specified in Section 4.2.3.

4.2.11 Capacitive Loads

The power supply should be able to power up and operate normally with the following capacitance simultaneously present on the DC outputs:

Table 14 - Output Capacitive Loads

Output Voltage:	-12 VDC	+3.3 VDC	+5 VDC	$+12_{IO}$ VDC	$+12_{DIG}$ VDC	$3.3V_{AUX}$ / $5V_{SB}$
Capacitive load (µF):	350	6,000	10,000	1,000	3,000	350

4.2.12 Output Power Sequencing

The +5V and $12V_{DIG}$ output level must be equal to or greater than the 3.3V output at all times during power up and normal operation. The time between the +5V and $12V_{DIG}$ output reaching its minimum in regulation level and the +3.3V reaching its minimum regulation level must be less than or equal to 20ms.

In addition, the +5V output level must be equal to or greater than the 3.3V output at all times during power down. This may be implemented using a clamping diode between +5V and +3.3V outputs.

4.2.13 Voltage Hold-Up Time

The power supply shall maintain output regulation per Section 4.2.1 despite a loss of input power at the low-end nominal range (Low = 115 or 230 VAC_{RMS}, 47 Hz) at maximum continuous output load as specified in Section 4.2.3 for a minimum of one input AC cycle.

4.3 Timing / Housekeeping / Control

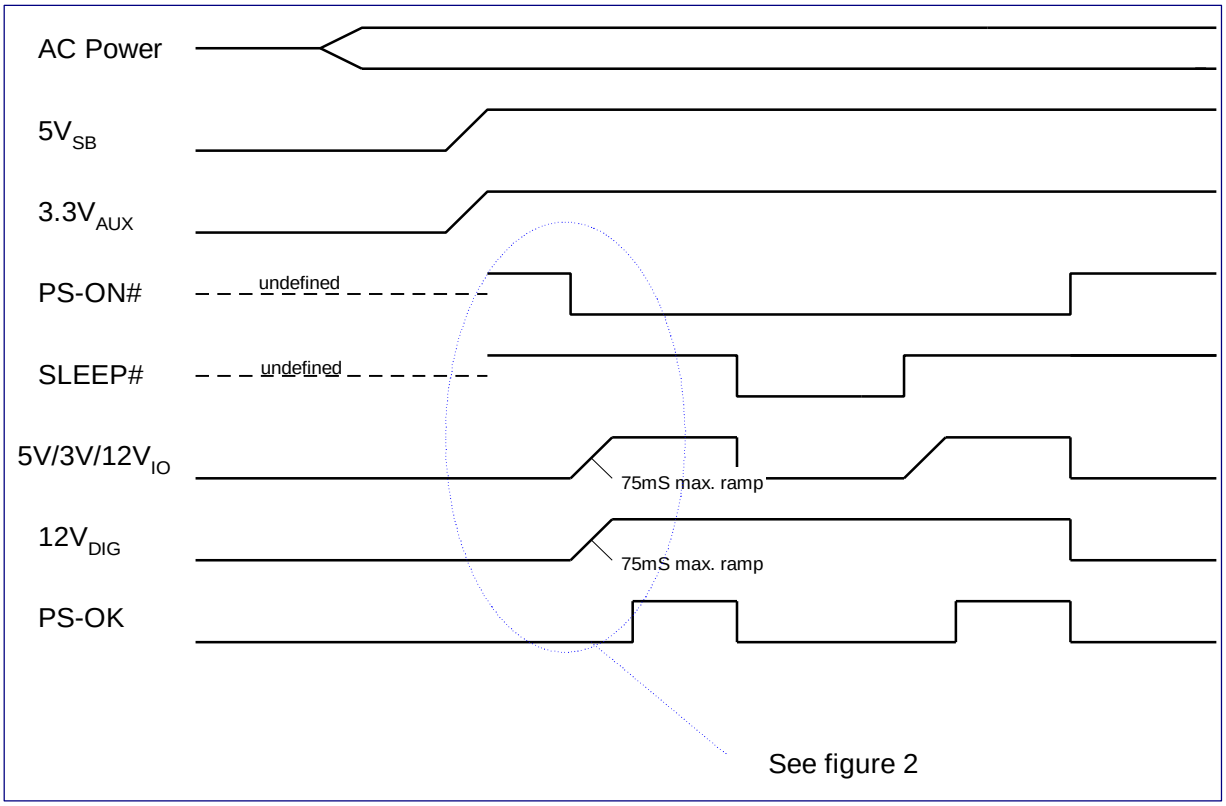


Figure 1 - Power Sequencing

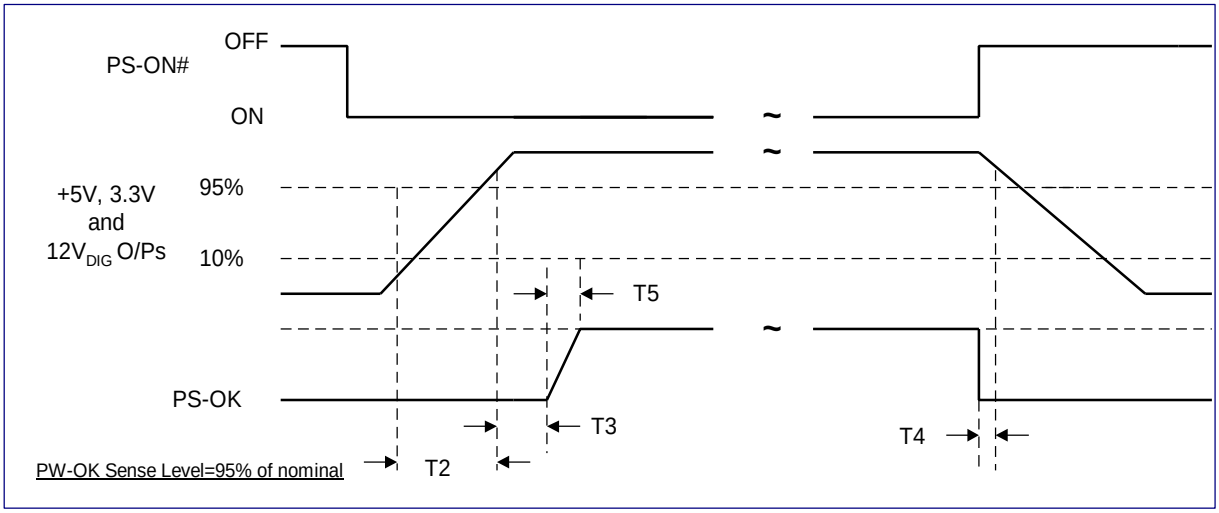


Figure 2 - Power Supply Timing

Note: T2 is defined in Section 4.3.5
T3, T4, and T5 are defined in Table 15

4.3.1 Power Good Signal, PS-OK

A "Power Good" signal, PS-OK, is asserted (i.e., high) by the power supply to indicate that the +3.3 VDC, +5 VDC and +12 V_{DIG} outputs exceed the under-voltage thresholds listed in Section 4.2.1. It also indicates that sufficient primary energy is stored by the converter to guarantee continuous power operation within specification for at least the duration specified in "Hold Up Time" Section 4.2.13. Conversely, when one of these output voltages falls below the under-voltage threshold, or when the primary power has been removed for a time sufficiently long enough to no longer guarantee power supply operations beyond the hold-up time, the POK is held low. The electrical and timing characteristics of the POK signal are given in Table 15 and in Figure 2. The voltage sequence and timing relationships are illustrated in Figure 1.

The PS-OK pin shall be pulled up to +5 V via a 5.1 kΩ resistor within the power supply.

Table 15 - PS-OK Signal Characteristics

Signal Type:	+5 VDC, TTL compatible
Logic level low:	< 0.4 V while sinking 4 mA
Logic level high:	Between 2.4 VDC and 5 VDC output while sourcing 200 µA
High state output impedance:	1 KΩ from output to common
POK delay:	100 ms < T_3 < 500 ms
POK rise time	$T_5 \leq$ 10ms
Power down warning:	T_4 > 1 ms

4.3.2 Sleep State (SLEEP#)

The power supply DC outputs (with the exception of the +3.3V_{AUX}, +5V_{SB} and +12V_{DIG}) must be disabled with an active low, TTL compatible signal ("SLEEP#"). The default signal (high 3.3V or unconnected) must keep the outputs enabled. The SLEEP# pin must be pulled up to +3.3V_{AUX} via a 10kΩ resistor within the power supply.

During this state the +12 V_{DIG} load current must be per 4.2.7.1.1 (or 4.2.7.1.2 – effective July 1st, 2000) max.

Table 16 - SLEEP#/PS-ON# Relationship

PS-ON#	SLEEP#	Power Supply / System Function
0	0	Main PSU Off 12 V_{DIG}, 3.3V_{AUX} and 5V_{SB} only present
0	1	PSU on – System running normally
1	1	PSU Off – System off 3.3V_{AUX} and 5V_{SB} only present
1	0	Invalid state

4.3.3 Remote On/Off Control (PS-ON#)

The power supply DC outputs (with the exception of $+3.3V_{AUX}$ and $+5V_{SB}$) must be enabled with an active-low, TTL-compatible signal ("PS-ON#"). The PS-ON# pin must be pulled up to $+3.3V_{AUX}$ via a 10 kΩ resistor within the power supply.

- The $+3.3V_{AUX}$ and $5V_{SB}$ must be on whenever the AC power is present.
- When PS-ON# is pulled to TTL low, the DC outputs are to be enabled.
- When PS-ON# is pulled to TTL high ($3.3V_{AUX}$) or open circuited, the DC outputs are to be disabled.
- The DC output enable circuit shall be SELV compliant.

In application, the PS-ON# signal may be activated either by electronic means or by a mechanical switch. Provision for de-bouncing the mechanical switch must be included in the PS-ON# circuitry to prevent the power supply from oscillating on/off at startup.

Table 17 - PS-ON#, SLEEP# and FanC Characteristics

	MIN	MAX
Vil, Input Low Voltage	0.1V	0.8V
Iil, Input Low Current, Vin = 0.4V		-0.4mA
Vih, Input High Voltage, Iin = -200uA	2.0V	
Vih open circuit, Iin = 0		3.47

4.3.4 Power On Time

The power on time is defined as the time the PS-ON# is pulled low to when the +3.3V, +5V and $12V_{DIG}$ outputs are within the regulation ranges specified in section 4.2.1. The power on time must be less than 500 mS.

The $3.3V_{AUX}$ and $5V_{SB}$ must have a power on time of 2 seconds maximum after application of valid AC voltages.

4.3.5 Rise-time

The output voltages must rise from <=10% of nominal to within the regulation ranges specified in Section 4.2.1 within 0.1 to 70 ms. ($0.1 \text{ ms} \leq T_2 \leq 70 \text{ ms}$).

4.3.6 Overshoot At Turn-On/Turn-Off

The output voltage overshoot upon the application or removal of the input voltage under the conditions specified in section 4.1 must be less than 10% above the nominal voltage. There must be a smooth and continuous ramp of each DC output voltage from 10% to 90% of its final set point within the regulation band, while loaded as specified in Section 4.2. The smooth turn-on requires that during the 10% to 90% portion of the rise time the slope of the turn-on waveform must be positive and have a value of between 0 V/msec. and (Vout Nominal)/2 msec. Additionally, for any 5 ms segment of the 10% to 90% rise-time waveform, a straight line drawn between the end points of the waveform segment must have a slope ≥ (Vout Nominal)/20 ms. No voltage of opposite polarity must be present on any output during turn-on or turn-off.

4.3.7 Reset After Shutdown

If the power supply latches into a shutdown state due to a faulty condition on its outputs, the power supply must return to normal operation only after the fault has been removed and the PS-ON#, or AC input, has been cycled OFF/ON with a minimum OFF time of 1 second.

4.3.8 Standby/Auxiliary Voltages

The $+5V_{SB}$ and $+3.3V_{AUX}$ are "standby" supply output voltages that are active whenever AC power is present. It provides a power source for circuits that must remain operational when the five main DC output rails are in a disabled state. Example uses include soft power control, wake-on-LAN, wake-on-modem, intrusion detection or suspend (sleep) state activities. $+3.3V_{AUX}$ is required for compliance to ACPI.

The $+3.3V_{AUX}$ output must be capable of delivering a minimum of 3A at 3.3Vdc ±5% for external circuits that includes $3.3V_{AUX}$ support for up to six- (6) PCI slots.

The $+5V_{SB}$ output must be capable of delivering a minimum of 720 mA at 5Vdc ±5% for external circuits.

Overcurrent protection is required on both $+3.3V_{AUX}$ and $+5V_{SB}$ outputs to ensure that the power supply is not damaged if external circuits draw excessive currents.

4.3.9 Standby Voltage Turn-Off

Following the removal of AC power, the 3.3 V_{AUX} and 5 V_{SB} (standby voltages) output must remain at its steady state value until such time as it begins to decrease in voltage. The decrease must be monotonic in nature dropping to 0.0 volts. There must not be other perturbations of this voltage at or following removal of AC power.

4.3.10 Fan Control Override (FanC)

The power supply fan control is a request signal and must not be used as a direct control for the fan. The power supply must receive an active low TTL signal to the FanC pin (pin 9) of P2. This pin is then pulled to the $3.3V_{AUX}$ internal to the power supply via a 10 kΩ resistor. This signal over-rides the power supply internal thermal control circuit thereby causing the power supply fan to operate at maximum speed. When running, the voltage across the fan must not be lower than 6 V under any condition.

It is expected that during the "sleep state" (para 4.3.2), the power supply fan must assume a minimum speed operation (6 V across the fan). During a Remote Off state (para 4.3.3), the power supply fans should be off. The power supply must comply with the fan requirements of para 5.2.

4.3.11 Fan Monitor

The power supply must provide an open collector, at 2 pulse per revolutions tachometer signal from the power supply fan to the system via the Fan M pin (pin 20) of P2. The signal must stop cycling, in either a high or low level, during a lock rotor state on the power supply fan.

This signal allows the system to monitor the power supply for fan speed or failures. Implementation of this signal permits the system to gracefully power down in the case of a critical fan failure.

The motherboard uses between a 1 kΩ to 10 kΩ pull-up resistors for this signal and connects to a high impedance gate as illustrated in Figure 3.

If this signal is not implemented within the system, it should not impact power supply operation.

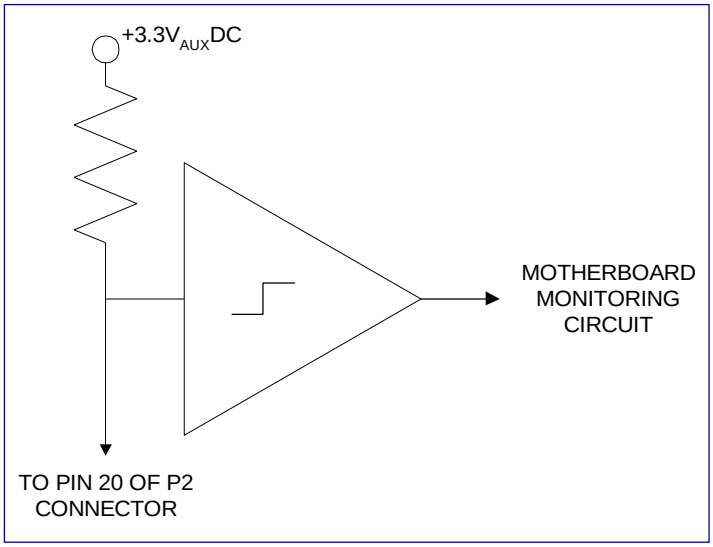


Figure 3 - Fan Monitor Circuit

4.4 Output Protection

4.4.1 Over Voltage Protection

The over voltage sense circuitry and reference shall reside in packages that are separate and distinct from the regulator control circuitry and reference. No single point fault shall be able to cause a sustained over voltage condition on any or all outputs. The supply shall provide latch-mode Over Voltage Protection as defined below.

Table 18 - Over Voltage Protection

Parameter	Min.	Nom.	Max.	Unit
+3.3 VDC	3.76	4.2	4.3	V
+5 VDC	5.74	6.3	7.0	V
+12 V_{IO}DC	-	-	15.6	V
+12 V_{DIG}DC	13.4	15.0	15.6	V
+3.3V_{AUX}	3.76	4.2	4.3	V

4.4.2 Short Circuit Protection

An output short circuit is defined as any output impedance of less than 0.005 ohms. The power supply shall shutdown and latch off for shorting +3.3V, +5V, +12$_{IO}$ VDC or +12V_{DIG} rails to return or any other rail (except rails of equal voltage). Shorts between main output rails and standby outputs (3.3V_{AUX} and 5V_{SB}) shall not cause any damage to the power supply. The power supply shall either shutdown and latch off for shorting on the –12VDC rails. The 3.3V_{AUX} and 5V_{SB} must be capable of being shorted indefinitely but when the short is removed, the P/S shall recover automatically or by cycling the PS-ON#. The power supply shall be capable of withstanding a continuous short-circuit to the output without damage or over stress to the unit (components, PCB traces, connectors, etc.) under the input conditions specified in Section 4.1 above. The maximum short-circuit energy in any output shall not exceed 240 VA.

4.4.3 No Load Operation

No damage or hazardous condition will occur with all the DC output connectors disconnected from the load. The power supply may latch into the shutdown state.

4.4.4 Over Current Protection

Overload currents applied to each tested output rail will cause the output to trip before they reach or exceed 240 VA. For testing purposes, the overload currents should be ramped at a minimum rate of 10 A/s starting from full load.

5. MECHANICAL REQUIREMENTS

5.1 Physical Dimensions/Markings

The supply shall be enclosed and meet the physical outline shown in Figure 3. In addition, each supply shall be marked with the following:

5.1.1 Warning Label

A warning label ("Do not remove this cover. Trained service personnel only. No user serviceable components inside.") in English and universal warning markings.

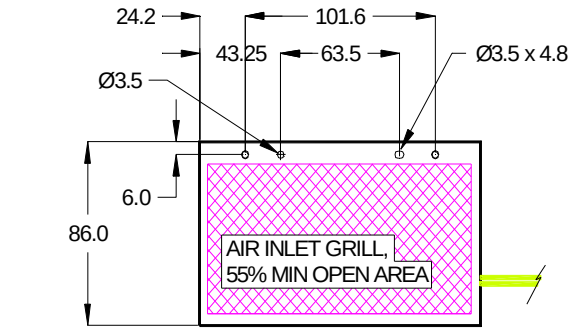
- Manufacturer's Label
- Manufacturer's name, part number, and lot date code in human-readable text format.
- Nominal AC input operating voltages (100-127 VAC and 200-240 VAC) and current rating certified by all agencies specified in Section 9.
- DC output voltages and current ratings.

5.2 Fan Requirements

The power supply fans draw air from the workstation system enclosure and exhaust through a grill located on the rear panel. It is recommended that a high-speed 80 mm ball bearing fan with thermal fan speed control be used. The thermal fan speed control circuitry must sense the temperature of the internal power supply heat sink or incoming ambient air.

The fan speed control and monitoring requirements are defined in sections 4.3.10 and 4.3.11 respectively.

The intake and exhaust grills of the power supply must remain suitably free of obstructions to not hinder airflow (i.e., no objects within 0.5" of the intake or exhaust areas). The opening must be sufficiently protected to meet the safety requirements described in Section 9. The grill pattern must have a minimum of 55% free area. A flush mount wire fan grill is used to maximize airflow and minimize acoustic noise.



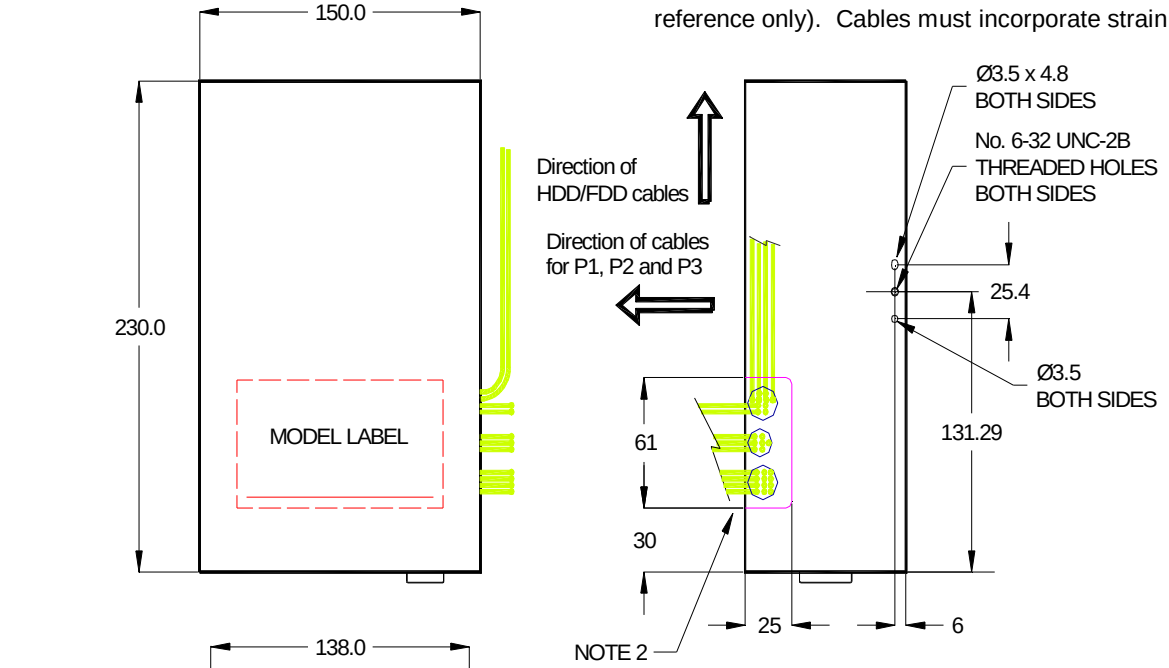
Notes: Unless otherwise specified

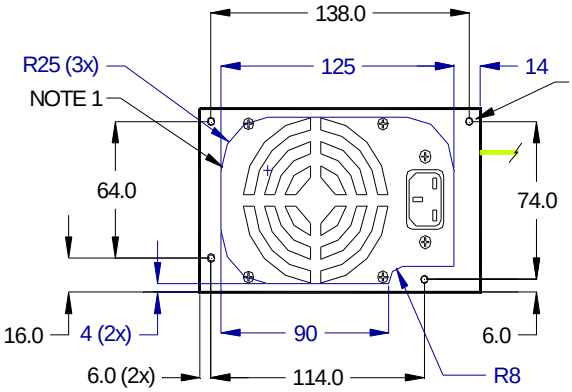
1. Fan grill detail shown for illustration only. Actual detail should be optimized for EMI, acoustic and airflow considerations.

   Fan grill and AC receptacle position shown for illustration only. Fan and AC must be positioned within the area shown.

   Fan detail and all screwheads must be flush to the surface of the power supply.

2. Cables must exit within area shown. Open area must be minimized to reduce stray air intake (grommets are recommended and shown for reference only). Cables must incorporate strain





All dimensions are in mm. Tolerances, unless otherwise specified;

xx. ± 1

x.x ± 0.5

Reference note: All 6-32 screws (8x) used to mount the power supply shall be 3/8" max length.

Figure 4 - Mechanical Outline

5.3 AC Connector Requirements

The AC input receptacle shall be an IEC 320 type or equivalent. The IEC 320 receptacle is considered the mains disconnect.

5.4 DC Connector Requirements

Listed or recognized component appliance wiring material (AVLV2), CN, rated for a minimum of 80°C, 300 Vdc shall be used for all output wiring. See figures 5 and 6 – Output Wiring Harness

Output wires should be formed to permit the cables to exit the power supply and route approximately as shown in figure 4.

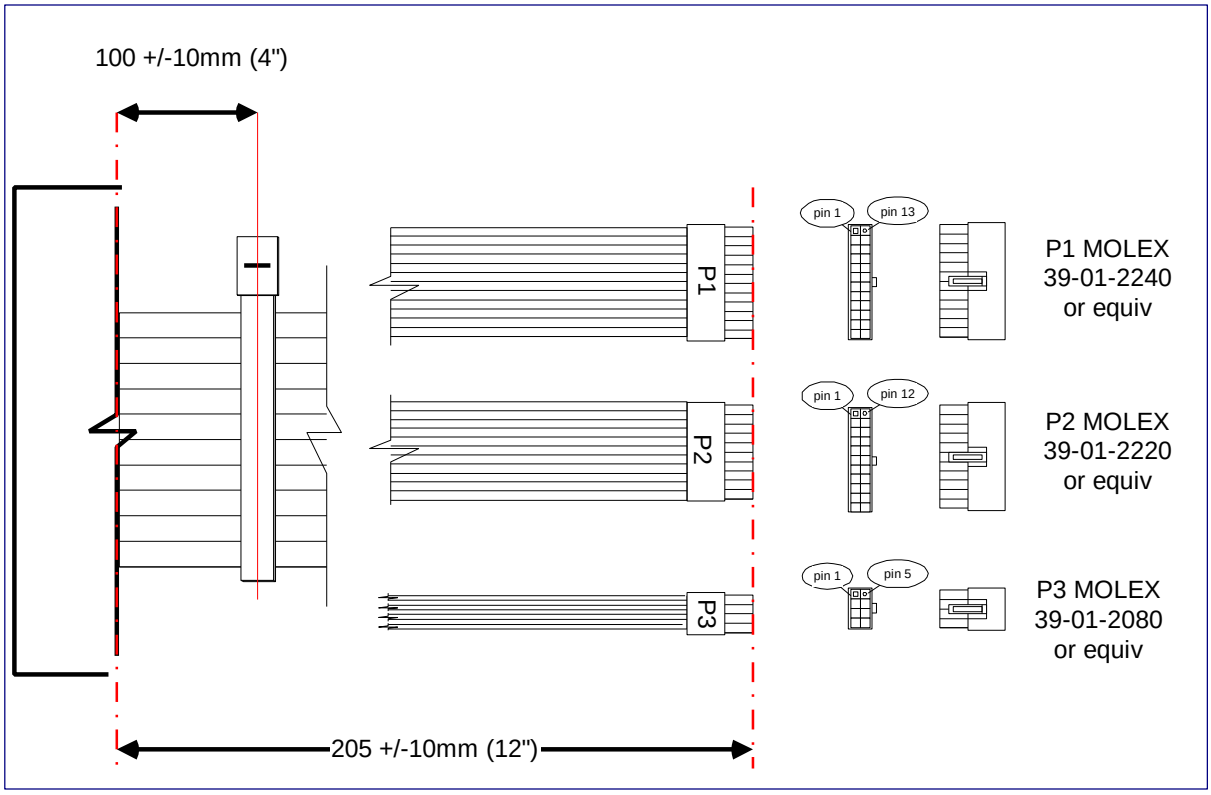


Figure 5 - Motherboard connector harness

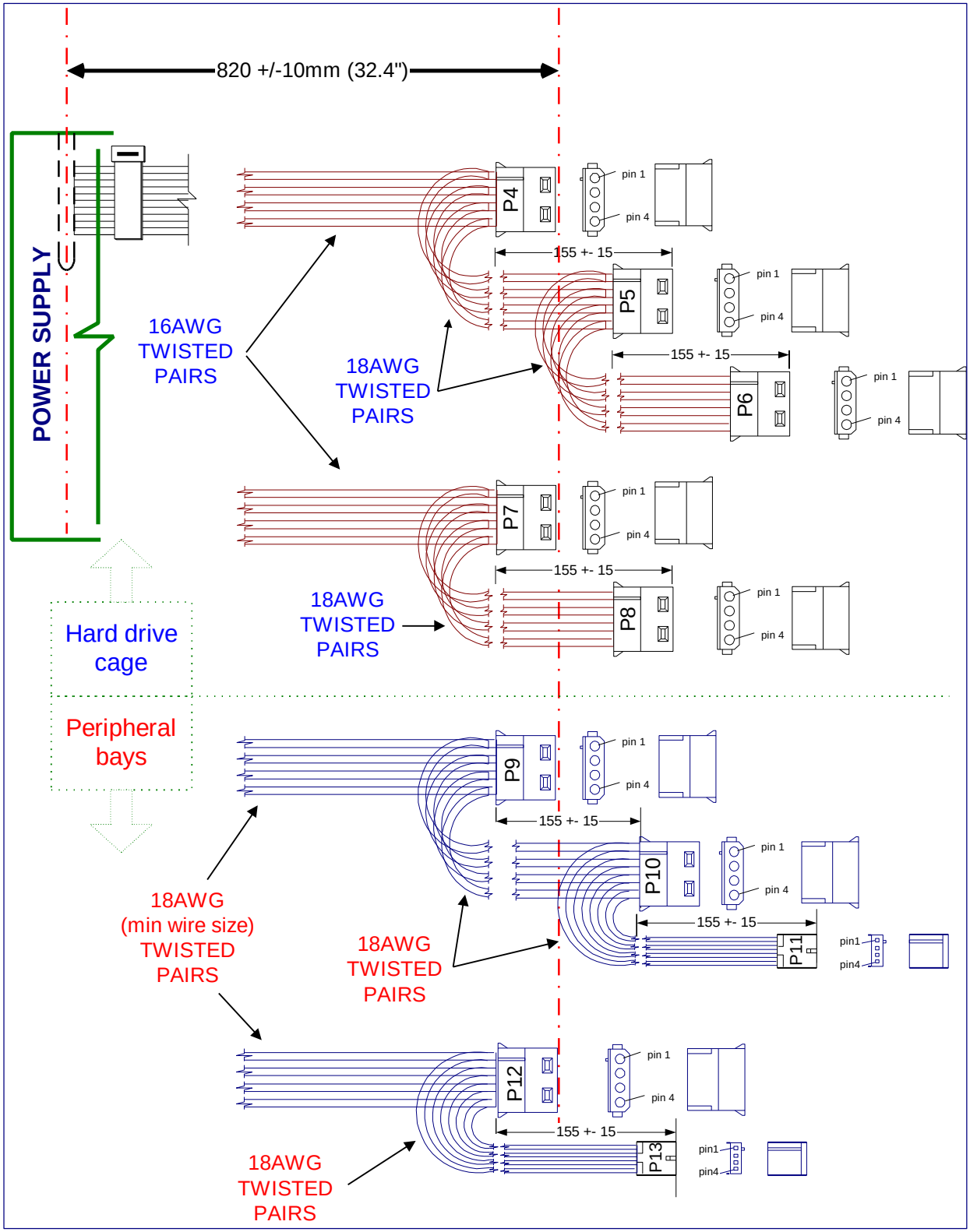


Figure 6 - Output Wiring Harness (HDD/FDD connectors)

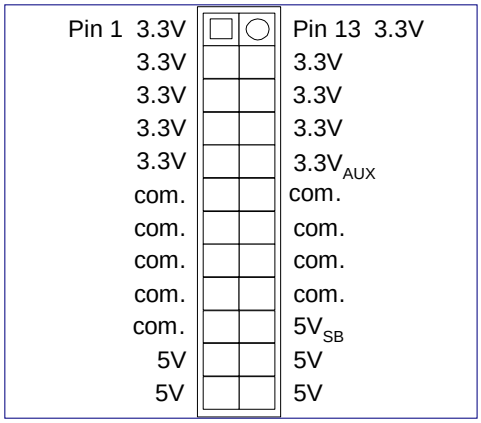
5.4.1 First Baseboard Connector – P1

24pin MOLEX 39-01-2240 or approved equivalent.

MOLEX HCS 44476-1111 terminal crimp is recommended

The pin reference designations shall be as illustrated right.

Refer to Figure 5 - Motherboard connector harness



AWG	Wire Colour	Signal	Pin	Pin	Signal	Wire Colour	AWG
18	ORANGE	+3.3Vdc	1	13	+3.3Vdc	ORANGE	18
18	ORANGE	+3.3Vdc	2	14	+3.3Vdc	ORANGE	18
18	ORANGE	+3.3Vdc	3	15	+3.3Vdc	ORANGE	18
18	ORANGE	+3.3Vdc	4	16	+3.3Vdc	ORANGE	18
18	ORANGE	+3.3Vdc	5	17	$+3.3V_{AUX}$	BROWN	20
18	BLACK	COM	6	18	COM	BLACK	18
18	BLACK	COM	7	19	COM	BLACK	18
18	BLACK	COM	8	20	COM	BLACK	18
18	BLACK	COM	9	21	COM	BLACK	18
18	BLACK	COM	10	22	$+5V_{SB}$	PURPLE	20
18	RED	+5Vdc	11	23	+5Vdc	RED	18
18	RED	+5Vdc	12	24	+5Vdc	RED	18

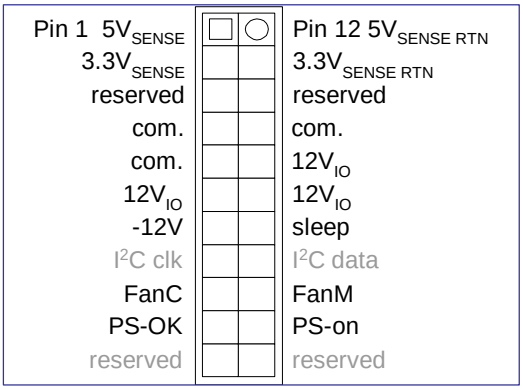
5.4.2 Second Baseboard Connector – P2

22pin MOLEX 39-01-2220 or approved equivalent

The pin reference designations shall be as illustrated right.

NOTE: I^2C clk and I^2C data are not used

Refer to Figure 5 - Motherboard connector harness



AWG	Wire Colour	Signal	Pin	Pin	Signal	Wire Colour	AWG
22	RED	$+5V_{SENSE}$	1	12	$+5V_{SEN\ RTN}$	BLACK	22
22	ORANGE	$+3.3V_{SENSE}$	2	13	$+3.3V_{SEN\ RTN}$	BLACK	22
		RESERVED	3	14	RESERVED		
18	BLACK	COM	4	15	COM	BLACK	18
18	BLACK	COM	5	16	$+12V_{IO}$	YELLOW	18
18	YELLOW	$+12V_{IO}$	6	17	$+12V_{IO}$	YELLOW	18
18	BLUE	-12V	7	18	SLEEP#	WHITE	18
		RESERVED	8	19	RESERVED		
22	PURPLE	Fan-C	9	20	Fan-M	BROWN	22
22	GRAY	PS-OK	10	21	PS-ON#	GREEN	22
		RESERVED	11	22	RESERVED		

5.4.3 $12V_{DIG}$ Baseboard Connector – P3

8 pin MOLEX 39-01-2080 or approved equivalent

The pin reference designations shall be as illustrated right.

NOTE: $12V_{SENSE}$ and $12V_{SENSE\ RTN}$ are not used

Refer to Figure 5 - Motherboard connector harness

AWG	Wire Colour	Signal	Pin	Pin	Signal	Wire Colour	AWG
18	BLACK	COM	5	1	$+12V_{DIG}$	WHITE	18
18	BLACK	COM	6	2	$+12V_{DIG}$	WHITE	18
18	BLACK	COM	7	3	$+12V_{DIG}$	WHITE	18
		RESERVED	8	4	RESERVED		

5.4.4 HDD Peripheral Connectors – P4 thru P10 and P12

AMP 1-480424-0 OR MOLEX 8981-04P or approved equivalent. Contacts should be AMP 61314-1 terminals or equiv.

Pin	Signal	Wire Colour	AWG[NOTE]	NOTES
1	$+12V_{IO}$	YELLOW	16	TWIST PIN 1 AND 2 WIRES, 1.5 TWISTS/IN
2	COM	BLACK	16	
3	COM	BLACK	16	TWIST PIN 3 AND 4 WIRES, 1.5 TWISTS/IN
4	+5Vdc	RED	16	

Note: 16 AWG to first HDD connector – 18AWG thereafter

Refer to Figure 6 - Output Wiring Harness

5.4.5 FDD Peripheral Connectors – P11 and P13

AMP 171822-4 or approved equivalent.

Pin	Signal	Wire Colour	AWG	NOTES
1	+5Vdc	RED	18	TWIST PIN 1 AND 2 WIRES, 1.5 TWISTS/IN
2	COM	BLACK	18	
3	COM	BLACK	18	TWIST PIN 3 AND 4 WIRES, 1.5 TWISTS/IN
4	$+12V_{IO}$	YELLOW	18	

Refer to Figure 6 - Output Wiring Harness

6. ENVIRONMENTAL REQUIREMENTS

6.1 Temperature

Operating Ambient: +10°C min
+50°C max.

(At full load, with a maximum rate of change between 5°C/10minutes and 10°C/hr)

Non-operating Ambient: -40°C to +70°C

(Maximum rate of change of 20°C/hour)

6.2 Humidity

Operating: To 85% relative humidity (non-condensing)

Non-Operating: To 95% relative humidity (non-condensing)

(NOTE: 95% R.H. is achieved with a dry bulb temp. of 55°C and a wet bulb temp. of 54°C.)

6.3 Altitude

Operating: to 10,000 ft
Non-Operating: to 50,000 ft

6.4 Mechanical Shock

Non-Operating: 50 G Trapezoidal Wave,
Velocity change = 170 in. / sec. Three drops in each of six directions are applied to each of the samples.

6.5 Random Vibration

Non-Operating 0.01G² per Hz at 5 Hz, sloping to 0.02G² per Hz at 20 Hz and maintaining 0.02G² per Hz from 20 Hz to 500 Hz. The area under the PSD curve is 3.13 g_{RMS}. The duration shall be 10 minutes per axis for all three axes on all samples.

6.6 Thermal Shock (Shipping)

Non-operating: -40°C to +70°C, 50 cycles, 30°C/min. ≥ transition time ≥ 15°C/min., duration of exposure to temperature extremes for each half cycle shall be 30 minutes.

6.7 Ecological Requirements

The following materials must not be used during design and/or manufacturing of this product.

- Cadmium shall not be used in painting or plating.
- No quaternary salt or PCB electrolytic capacitors shall be used.
- No CFC's or HFC's shall be used in the design or manufacturing process.
- Mercury shall not be used.

6.8 Catastrophic failure

The power supply shall be designed to fail without startling noise or excessive smoke.

6.9 Acoustics

Sound Power: The power supply assembly shall not produce a sound power level greater than 40db(A) in an 1/3 octave frequency band, when measured over the frequency range of 100 to 10kHz at 28^{o}C ambient. Sound power determination to be performed in accordance with ISO7779.

Pure Tones: The maximum permissible sound power variation between adjacent 1/3 octave bands may not exceed 10db(A). Sound power determination to be performed in accordance with ISO7779.

7. Electromagnetic Compatibility

7.1 EMI

The power supply must comply with *CISPR 22, Class B* for both conducted and radiated emissions with a 4 dB margin. Tests shall be conducted using a shielded DC output cable to a shielded load. The load must be adjusted as follows for three- (3) separate tests:

? No load on each output
? 50% load on each output
? 100% load on each output.

Tests are performed at 100 VAC/ 50 Hz, 120 VAC /60 Hz, and 220 VAC/ 50 Hz power.

7.2 Input Line Current Harmonic Content

The power supply shall meet the requirements of *EN61000-3-2 Class D* and the Guidelines for the *Suppression of Harmonics in Appliances* and *General Use Equipment Class D,* for harmonic line current content at full rated power. See Table 19 for the harmonic limits.

Table 19 - Harmonic Limits, Class D

Harmonic Order N	Maximum permissible harmonic current per watt (mA/W)	Maximum permissible Harmonic current (Amps)
3	3.4	2.30
5	1.9	1.14
7	1.0	0.77
9	0.5	0.40
11	0.35	0.33
13	0.30	0.21
15≤n≤39	3.85/n	0.15X(15/n)

Note: PFC: Apply Table 12 limits as shown for 230 V operation and multiply limits by 230/100 for 100 V operation for world-wide requirements in both EU and Japan, respectively.

7.3 Magnetic Leakage Fields

The PFC choke magnetic leakage field shall not cause any interference with a high-resolution computer monitor placed next to, or on top of, the end use chassis. The end system vendor determines the final acceptable leakage field strengths. This is done during the system level testing in the end use chassis.

8. Reliability

8.1 Component Derating

The following component derating guidelines shall be followed:

- Semiconductor junction temperatures must not exceed 110° C with an ambient of 50° C. Any exceptions are subject to final approval by the system designer.
- Inductor case temperatures shall not exceed safety agency requirements.
- Capacitor case temperatures shall not exceed 95% of rated temperature.
- Resistor wattage derating shall be > 30%.
- Component voltage and current derating shall be > 10% at 50° C. Any exceptions are subject to final approval by the system designer.
- Magnetic saturation of inductors and transformers are not allowed under any line, load, startup, or transient condition including 100% transients on the main outputs, $5V_{SB}$ or $3.3V_{AUX}$.

8.2 Mean Time Between Failures (MTBF)

The MTBF of the power supply is calculated utilizing the Part-Stress Analysis method of *MIL-HDBK-217F* using the quality factors listed in *MIL-HDBK-217F*. The calculated MTBF of the power supply shall be greater than 100,000 hours under the following conditions:

? Full rated load
? 120V AC input
? Ground Benign
? 25°C ambient.

The calculated MTBF of the power supply must be greater than 30,000 hours under the following conditions:

? Full rated load
? 120 VAC input
? Ground Benign
? 50 °C ambient.

9. Safety Requirements

9.1 North America

The power supply must be certified by NRTL (Nationally Recognized testing Laboratory) for use in the USA and Canada under the following conditions:

- For use in Information Technology Equipment including Electrical Business Equipment per *UL 1950/CAN/CSA C22.2 No. 950-95, 3rd Edition*, without D3. The certification must include external enclosure testing for the AC receptacle side of the power supply.
- Have a full complement of tests conducted as part of the certification, such as input current, leakage current, hi-pot, temperature, energy discharge test, transformer output characterization test (open circuit voltage, short circuit current and maximum VA output), and abnormal testing (to include stalled fan tests and voltage select switch mismatch).
- The enclosure must meet fire enclosure mechanical test requirements per clauses 2.9.1 and 4.2 of the above standard.
- The Supplier must supply the complete certification Report including Test Record. Production hi-pot testing must be included as a part of the certification and indicated as such in the Certification report.
- There must not be unusual or difficult "Conditions of Acceptability" such as mandatory additional cooling or power derating. The insulation system shall not have temperatures exceeding their rating when tested in the end product.
- The certification mark shall be affixed on each power supply.
- A list of the minimum temperature ratings of all AC mains connected components and the printed wiring board(s) shall be provided. The PSU must be evaluated for operator accessible secondary outputs (reinforced insulation), that meets the requirements for SELV and does not exceed 240 VA continuous output under any condition of loading.
- The proper polarity between the AC Input receptacle and any Printed Wiring Boards connections must be maintained. (i.e. brown=line, blue=neutral, green=earth/chassis)
- Failure of any single component in the fan speed control circuit shall not cause the internal component temperatures to exceed the abnormal fault condition temperatures per *IEC 60950*.

9.2 International

The vendor must provide a complete CB certificate and test report to *IEC60 950, 2nd Edition + A1, A2, A3, & A4*. The CB report must include ALL CB member country national deviations. The CB report must include evaluation of *EN60 950, + A1, A2, A3, A4* and *EMKO-TSE (74-SEC) 207/94*.

- All evaluations and certifications must be for reinforced insulation between primary and secondary circuits.
- It is highly recommended that the CB report be issued by NEMKO. North America