WTX

Power Supply Design Guidelines

intel®

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Revision History

Revision 0.4	Initial release, WPG PSE
Revision 0.9	Reformatted, updated electrical data, added additional mechanical detail and cable info, J Day, WPG PSE

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1. Scope

This document provides a reference for the definition and specification of the *WTX Power Supply* that is compliant with the *WTX Workstation System Specification* and the *WTX Chassis Design Guide*. It is provided as a convenience only and is not intended to replace or supplement the user's independent design and validation activity.

This document includes the following information:

- Physical form factors
- Cooling requirements
- Connector configuration
- Electrical requirements
- Pertinent signal timing specification

It also provides power supply examples, although actual power requirements shall vary depending upon specific system configurations.

The WTX specification is a new board set and system form factor developed for the mid-range workstation market segment to support current and future Intel®-based 32 and 64-bit processor technologies. The power requirements for these systems are predicted to vary between approximately 350 W and 850 W depending upon system peripheral and I/O configuration, number of processors, chip-sets, and memory configurations.

In order to support these systems and the broad range of power requirements, two (2) new form factors have been defined (although an existing PS/2 can be utilized for lower system configurations).

In addition to these new form factors, new connector configurations have been defined that specifically address the higher load demands of elements such as AGP-Pro.

1.1 Power Distribution Structure

The WTX Power Supply distribution structure is illustrated in Figure 1. This structure is based upon the board and system configurations found in mid-range workstations whereby the basic system configuration (number of peripheral bays, PCI, and graphics) are constant across processor and chip-set platforms. The range of power requirements for the latter components is the basis for the WTX power supply structure through the addition of one or more +12 VDC outputs to support increased power needs (high end processors and larger memory cards). This approach provides the ability to comply with output power limitation requirements (240 VA) when necessitated by system requirements.

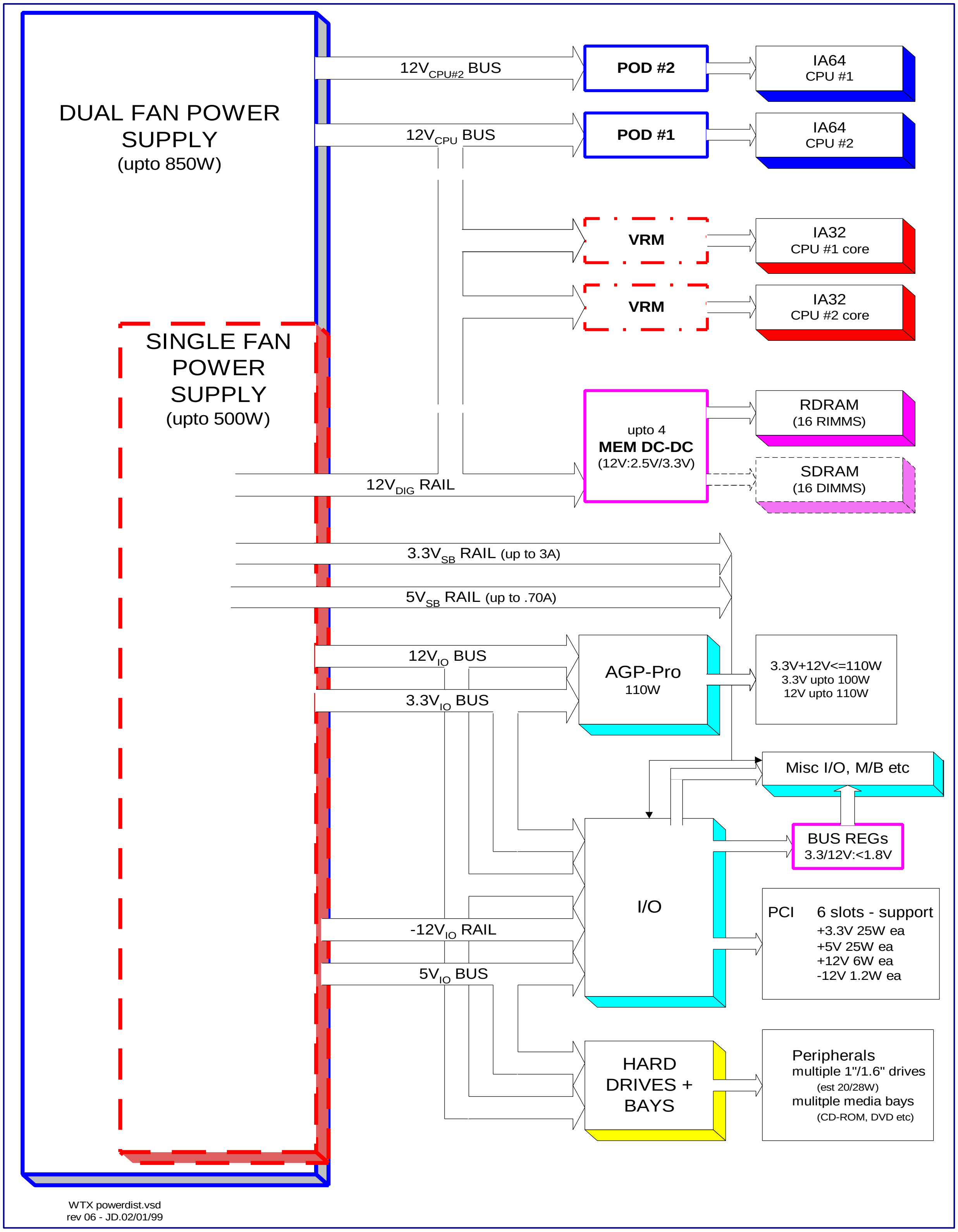


Figure 1. WTX Power Distribution Summary - 240VA

2. Reference 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.
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.
CFR 47, Part 15, Subpart B	FCC Rules.
CISPR 22:1997 3rd edition and EN 55022:1998	Limits and Methods of Measurements of Radio Interference Characteristics of Information Technology Equipment, Class B.
CSA C22.2 No.234, Level 3	Safety of Component Power Supplies. Intended for use with Electronic Data Processing Equipment and Office Machines.
EN60 950: plus A1,A2, A3, A4	Safety of Information Technology Equipment including business equipment.
EN55022:1998	Electromagnetic Compatibility/Generic Immunity Standard.
EN61000-3-2	Limits for Harmonic Current Emission, Class D.
EMKO-TSE(74-SEC)207/94	Nordic National Requirement in addition to EN60950.
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 950 plus A1, A2, A3, A4	Safety of Information Technology Equipment including Business Equipment.
IEC Publication 417	International Graphic Symbol Standard.
ISO Standard 7000	Graphic Symbols for use on Equipment.
Japan Electric Association	Guidelines for the Suppression of Harmonics in Appliances and General use Equipment.
MIL-STD-217F:	Reliability Predictions for Electronic Equipment.
MIL-STD-105K:	Quality Control.
MIL-C-5541:	Chemical Conversion Coatings on Aluminum and Aluminum Alloys.
UL 1950/CAN/CSA CSA C22.2 No. 950-95 without D3 Deviation: 3rd edition	Safety of, Information Technology Equipment including Electrical Business Equipment.

3. Electrical Specification

The electrical requirements that follow must be met over the environmental ranges specified in Section 5 unless otherwise noted.

3.1 AC Input Requirements

The power supply shall be capable of supplying full rated output power over two (2) input voltage ranges that are switch-selectable and rated 100-127 VAC and 200-240 VAC RMS nominal. The power supply shall employ automatic input line selection, active power factor correction and in addition, 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 90 VAC.

Table 1. 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)			11.5	A_{rms}
I_{in} (230 VAC)			5.8	A_{rms}

3.1.1 Input Overcurrent Protection

The power supply shall incorporate primary fusing for input Overcurrent Protection. The Fuse must be a slow-blow type or equivalent to prevent nuisance trips.

3.1.2 Inrush Current Limiting

Maximum inrush current from power-on (with power on at any point on the AC Sine) includes, but is not limited to, three (3) line cycles. It shall be limited to a level below the surge rating of the input line cord, AC switch if present, bridge rectifier, fuse, PFC components 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.

3.1.3 Input Undervoltage

The power supply shall contain protection circuitry such that the application of an input voltage below the minimum specified in Table 1. shall not cause damage to the power supply unit.

3.1.4 Immunity

3.1.4.1 Slow Transients

The DC output(s) shall not exceed the limits specified in Section 3.2.1 as a result of the input power line noise defined in Table 2 under any load condition per *IEC 61000-4-11*.

Table 2. 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	50/60 Hz	No loss of function or performance
0 to 15 minutes	15%	Mid-point of Rated AC Voltages	50/60 Hz	No loss of function or performance
0 to ½ AC cycle	30%	Mid-point of Rated AC Voltages	50/60 Hz	No loss of function or performance
0 to 5 AC cycles	50% sag only	Mid-point of Rated AC Voltages	50/60 Hz	Loss of function acceptable, self-recoverable

3.1.4.2 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 capabilities, complying with the following conditions and exceptions. The power supply must meet the surge withstand test for the conditions of operation specified in Section 5.

The peak value of the injected unipolar waveform shall be 2.0 kV measured at the input of the power supply for the common and 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 deviations exceeding the limits of Section 3.2.1

3.1.4.2.1 Surge Immunity, IEC 61000-4-5

No unsafe operation must be allowed under any condition. No user noticeable performance degradation for 1 kV Differential Mode (DM) or 2 kV Common Mode (CM) must be allowed. However, automatic or manual recovery cycles are allowed for other conditions. The Surge Immunity specification must meet performance criteria B in the end-product.

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

No unsafe operation must be allowed under any condition. No user noticeable performance degradation up to 1 kV is allowed. However, automatic or manual recovery cycles are allowed for other conditions. The electrical fast transient/burst must meet performance criteria B in the end-product.

3.1.4.2.3 Ring Wave, ANSI C62.45-1992

The crest value of the first half-peak of the injected oscillatory wave is 3.0 kV open circuit with 200 and 500 Ampere short circuit currents 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.

3.1.4.2.4 Electrostatic Discharge, IEC 61000-4-2

In addition to *EN61000-4-2* 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.

3.1.4.2.5 Radiated Immunity, IEC 61000-4-3

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

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

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

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

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

3.1.4.2.8 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

3.1.5 Catastrophic Failure Protection

The primary circuit design and the components specified in the specification must be designed so that should if a component failure occurs, the power supply shall not exhibit any of the following physical factors:

- Flame
- Excessive smoke
- Charred PCB
- Fused PCB conductor
- Startling noise
- Emission of molten material

3.2 DC Output Requirements

3.2.1 DC Voltage Regulation

The DC output voltages shall remain regulated within the ranges shown in Table 3. 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 7.2 at any steady state temperature and operating conditions specified in Section 5.

Table 3. 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 %	+11.04	+12.00	+12.60	Volts
$+12_{CPU}$ VDC[2]	± 5 %	+11.04	+12.00	+12.60	Volts
$+12_{CPU2}$ VDC[2]	± 5 %	+11.04	+12.00	+12.60	Volts
+ 3.3 V_{AUX}	± 5 %	+3.14	+3.30	+3.47	Volts
+ 5 V_{SB}	± 5 %	+4.75	+5.00	+5.25	Volts

Note:

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

3.2.2 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.

The 12 V_{DIG} outputs may also utilize remote sensing in systems utilizing more powerful processors or memory configurations. Pins 4 and 8 of P3 are reserved for this consideration.

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.

3.3 Typical Power Distribution

Although power requirements depend upon specific system options and implementation, this section identifies several configurations reflective of the range of WTX mid-range power levels.

Table 4. Typical Power Distribution for a 460W Configuration

Output voltage	**Min. current (amps)**	**Max. current (amps)**	**Peak Current (amps)**	**Ripple & Noise**	**Notes:**
+3.3 V DC	0.0	45.0		50 mV_{PP}	Max continuous +5 V and +3.3 V output power is 200 W
+5 V DC	1.0	27.0		50 mV_{PP}	
-12 V DC	0.3	0.6		120 mV_{PP}	
+12 V_{IO}DC	0.0	16.0	18.2	120 mV_{PP}	Max continuous +5 V, +3.3 V and +12 V_{IO} output power is 300 W.
+12 V_{DIG}DC	0.0	18.0		120 mV_{PP}	
+5 V_{SB}*	0.0	0.72		50 mV_{PP}	
+3.3 V_{AUX}	0.0	3.0		50 mV_{PP}	

Note: Refer to the *460W-WTX PSU Design Guide* located at the following URL: www.wtx.org

Table 5. Typical Power Distribution for a 610W Configuration

Output voltage	**Min. current (amps)**	**Max. current (amps)**	**Peak Current (amps)**	**Ripple & Noise**	**Notes:**
+3.3 V DC	0.0	48.0		50 mV_{PP}	Max continuous +5 V and +3.3 V output power is 220 W
+5 V DC	1.0	25.0		50 mV_{PP}	
-12 V DC	0.3	0.6		120 mV_{PP}	
+12 V_{IO}DC	0.0	16.0	18.2	120 mV_{PP}	Max continuous +5 V, +3.3 V and +12 V_{IO} output power is 320 W.
+12 V_{DIG}DC	0.0	14.0		120 mV_{PP}	
+12 V_{CPU}DC	0.0	18.0		120 mV_{PP}	
+5 V_{SB}*	0.0	0.72		50 mV_{PP}	
+3.3 V_{AUX}	0.0	3.0		50 mV_{PP}	

Note: Refer to the *610W-WTX PSU Design Guide* located at the following URL: www.wtx.org

Table 6. Typical Power Distribution for a 800 W Configuration

Output voltage	Min. current (amps)	Max. current (amps)	Peak Current (amps)	Ripple & Noise	Notes:
+3.3 V DC	0.0	50.0		50 mV_{PP}	Max continuous +5 V and +3.3 V output power is 220 W
+5 V DC	1.0	25.0		50 mV_{PP}	
-12 V DC	0.3	0.6		120 mV_{PP}	
+12 V_{IO}DC	0.0	16.0	18.2	120 mV_{PP}	Max continuous +5 V, +3.3 V and +12 V_{IO} output power is 320 W.
+12 V_{DIG}DC	0.0	18.0		120 mV_{PP}	
+12 V_{CPU}DC	0.0	16.0		120 mV_{PP}	
+12 V_{CPU2}DC	0.0	16.0		120 mV_{PP}	
+5 V_{SB}*	0.0	0.72		50 mV_{PP}	
+3.3 V_{AUX}	0.0	3.0		50 mV_{PP}	

Note: Refer to the *800W-WTX PSU Design Guide* located at the following URL: www.wtx.org

3.3.1 Power Limit

Under short circuit or overload conditions, no output shall exceed 240 VA under any conditions including single component fault conditions per *IEC60 950 Specification* requirements.

3.3.2 Efficiency

The efficiency of the power supply shall be met over the AC input range defined in Table 1. under the load conditions defined in Section 3.3, and the temperature and operating conditions defined in Section 5. The minimum efficiencies for these typical configurations are;

- Single fan 400 W - 460 W output range 68% minimum
- Dual fan 550 W - 620 W output range 70% minimum
- Dual fan 700 W - 850 W output range 71% minimum

3.3.2.1 Energy Star requirements (until June 30th, 2000)

WTX power supplies used in "Energy Star" compliant systems must be a minimum of 55% efficient and draw input power equal to or less than 15% of the rated output power when subject to the conditions defined in Table 7.

Table 7. Energy Star Load Conditions

Output	Load Conditions
+3.3 V_{AUX}	1.0 A
+5 V_{SB}	0.2 A
+12 V_{DIG}DC	$[(P_{OUT(RATED)} \times 0.0825 – 4.3)/12]$A
All other outputs	0.0 A
SLEEP#	Low state
PS-ON	Low state

For example, when the 115 VAC input power of a 460 W WTX power supply is 69 W (as measured by a true RMS watt-meter placed on the input AC line cord), the total DC output power shall not exceed 37.9 W.

3.3.2.2 Energy Star Requirements (Effective July 1st, 2000)

WTX power supplies used in "Energy Star" compliant systems shall be a minimum of 50% efficient and draw input power equal to or less than 10% of the rated output power when subject to the conditions defined in Table 8.

Table 8. Y2k Energy Star Load Conditions

Output	Load Conditions
+3.3 V_{AUX}	1.0 A
+5 V_{SB}	0.2 A
+12 V_{DIG}DC	$[(P_{OUT(RATED)} \times 0.05 – 4.3)/12]$A
All other outputs	0.0 A
SLEEP#	Low state
PS-ON	Low state

For example, when the 115 VAC input power of a 460 W WTX power supply is 46 W (as measured by a true RMS watt-meter placed on the input AC line cord), the total DC output power must not exceed 23 W.

3.3.2.3 Standby Efficiency

The Standby supply efficiency should be a minimum of 40% with the AC input voltage at 230VAC at 50Hz, with the main outputs off and with PS-ON# high.

3.3.3 Output Ripple/Noise

The following output ripple/noise requirements must be met throughout the load ranges specified in Section 3.3, and under all input voltage conditions as specified in Section 3.1.

Ripple and noise are defined as periodic or random signals over a 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 0.1 µF ceramic disk capacitor and a 10 µF electrolytic capacitor to simulate system loading.

Table 9. DC Output Noise/Ripple

Output	Max.
+3.3 V DC	50 mV_{pp}
+5 V DC	50 mV_{pp}
-12 V DC	120 mV_{pp}
+12 V_{IO}DC	120 mV_{pp}
+12 V_{DIG}DC	120 mV_{pp}
+12 V_{CPU}DC	120 mV_{pp}
+12 V_{CPU2}DC	120 mV_{pp}
+5 V_{SB}*	50 mV_{pp}
+3.3 V_{AUX}	50 mV_{pp}

3.3.4 Output Transient Response

The output voltage must remain within the regulation limits of Table 3. (inclusive of over/undershoot). For instantaneous load changes, limited to the maximum individual steps per Table 10, output capacitive loading per Table 11, over the AC input range is defined in section 3.1 and may include simultaneous load steps on the $+12_{IO}$ VDC, +5 VDC, and +3.3 VDC outputs. All load changes must occur in the same direction. The transient response measurements must be made with a load changing repetition rate of 50 Hz to 10 kHz. The load slew rate must not be greater than 2.5 A/µs. The power supply must be stable under all transient conditions from any steady state load.

The conditions in Table 10 and Table 11 reflect typical WTX system configurations. System developers must evaluate individual requirements to ensure performance expectations are met.

Table 10. Maximum Individual Load Steps

Output	Max load step
+3.3 V DC	10 A
+5 V DC	6 A
-12 V DC	10 A
+12 V_{IO}DC	14 A
+12 V_{DIG}DC	14.5 A
+12 V_{CPU}DC	14.5 A
+12 V_{CPU2}DC	0.1 A

3.3.5 Closed Loop Stability

The power supply must be unconditionally stable under all line/load/transient load conditions including capacitive loads as specified in Table 11. A minimum of 45° phase and 10 dB-gain margin are required. The power supply vendor must 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 as applicable.

3.3.6 Capacitive Load

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

Table 11. Capacitive Load

Output Voltage:	-12 VDC	+3.3 VDC	+5 VDC	$+12_{IO}$ VDC	$+12_{DIG}$ VDC	$+12_{CPU\#}$ VDC	3.3 V_{AUX} / 5 V_{SB}
Capacitive load (mF):	350	6,000	10,000	1,000	1,000	2,000	350

3.3.7 Output Power Sequencing

The +5 V, 12 V_{DIG} and 12 $V_{CPU\#}$ (when applicable) output levels must be equal to or greater than the 3.3 V output at all times during power up and normal operation. The time between the +5 V, 12 V_{DIG} and 12 $V_{CPU\#}$ outputs reaching their minimum in regulation level and the +3.3 V reaching its minimum regulation level must be less than or equal to 20ms.

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

3.3.8 Voltage Hold-up Time

The power supply must maintain output regulations per Section 3.2.1 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 applicable for a minimum of one input AC cycle.

3.4 Timing / Housekeeping / Control

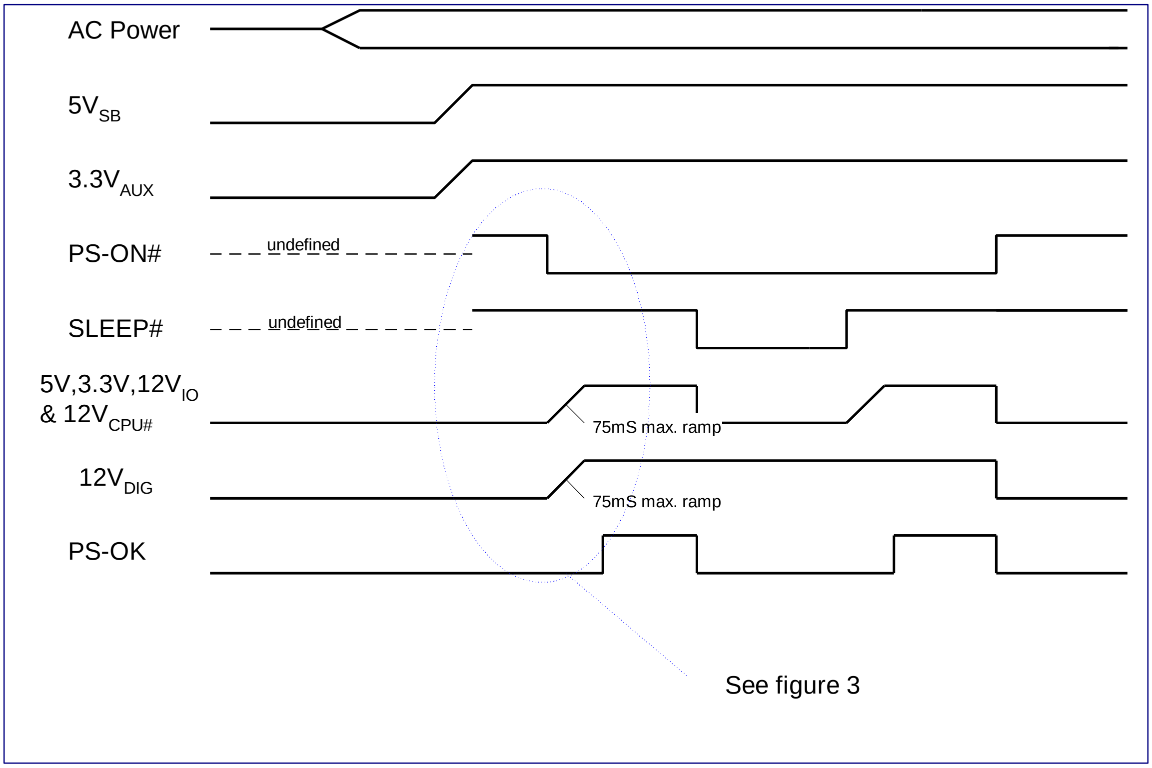


Figure 2. Power Sequencing

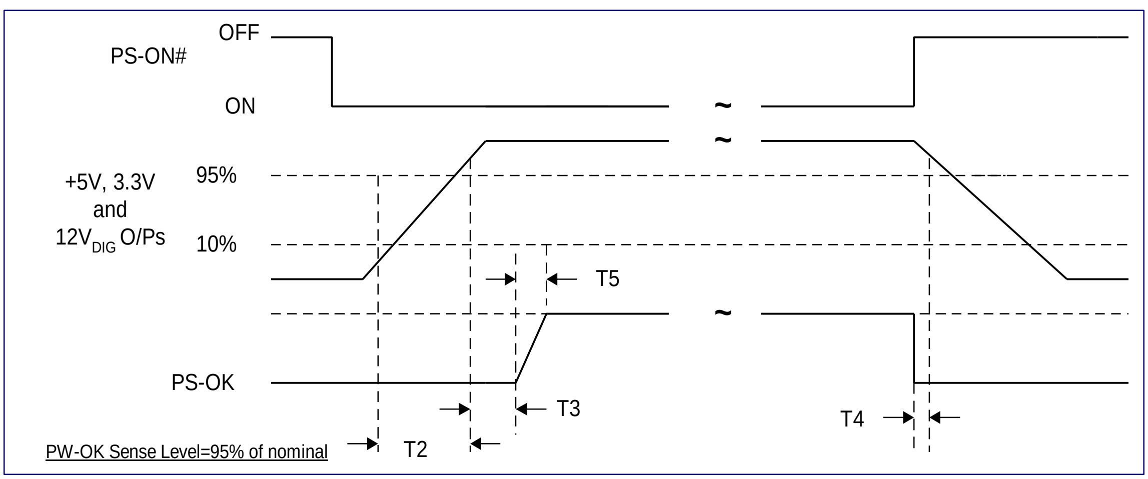


Figure 3. Power Supply Timing

Note: T2 is defined in Section 3.4.5

T3, T4, and T5 are defined in Table 12

3.4.1 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, +12 V_{DIG} and 12 $V_{CPU\#}$ outputs exceed the under-voltage thresholds listed in Section 3.2.1. 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 3.3.8. Conversely, when one of these output voltages falls below the under-voltage threshold, or when the primary power has been removed too long to guarantee power supply operations beyond that time, the POK is held low. The electrical and timing characteristics of the POK signal are given in Figure 2 and in Figure 3. The voltage sequence and timing relationships are illustrated in Figure 2.

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

Table 12. 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

3.4.2 Sleep State (SLEEP#)

The power supply DC outputs (with the exception of the +3.3 V_{AUX}, +5 V_{SB} and +12 V_{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 +3.3 V_{AUX} via a 10kΩ resistor within the power supply.

In addition, this signal shall cause one (of the two) fans in a dual fan power supply to be turned off (only applicable to the two (2) fan form factor). Selection of the active fan shall be at the discretion of the power supply vendor.

During this state the +12 V_{DIG} load current must be per Table 7. (or Table 8, effective July 1st, 2000) max.

Table 13. SLEEP#/PS-ON# Relationship

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

3.4.3 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 and off at startup.

Table 14. Remote On/Off and Sleep Signal 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		3.47V

3.4.4 Power On Time

The power on time is defined as the time the PS-ON# is pulled low to when the +3.3V, +5V, $12V_{DIG}$ and $12V_{CPU\#}$ outputs are within the regulation ranges specified in section 3.2.1. 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.

3.4.5 Rise-time

The output voltages must rise from <=10% of nominal to within the regulation ranges specified in Section 3.2.1 within 0.1 to 70 ms. (0.1 ms $\leq T_2 \leq$ 70 ms).

3.4.6 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 3.1, 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 3.2. A 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.

3.4.7 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 and ON with a minimum OFF time of 1 second.

3.4.8 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 3 A at 3.3 Vdc ±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 5 Vdc ±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.

3.4.9 Standby Voltage Turn-Off

Following the removal of AC power, the $3.3V_{AUX}$ and $5V_{SB}$ (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 be no other perturbations of this voltage at or following removal of AC power.

3.4.10 Fan Control Override

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(s) 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 3.4.2), one power supply fan must assume a minimum speed operation (6 V across the fan). In a two (2) fan power supply, the second fan must turn off (<1V across the fan); the inactive fan shall be determined by the power supply manufacturer. During a Remote Off state (para 3.4.3), the power supply fans should be off. The power supply must comply with the fan requirements of para 4.2.

3.4.11 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. In a dual fan power supply, this signal may come from either one of the fans. In all instances, the signal stops cycling, in either a high or low level, during a lock rotor state on any 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 4.

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

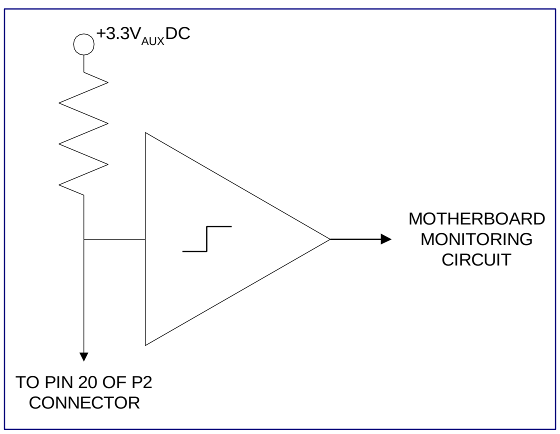


Figure 4. Fan Monitor Circuit

3.5 Output Protection

3.5.1 Overvoltage Protection

The overvoltage sense circuitry and reference resides 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 overvoltage condition on any or all outputs. The supply must then provide latch-mode Overvoltage Protection as defined below.

Table 15. 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
+12 V_{CPU}DC	13.4	15.0	15.6	V
+12 V_{CPU2}DC	13.4	15.0	15.6	V
+3.3 V_{AUX}	3.76	4.2	4.3	V

3.5.2 Short Circuit Protection

An output short circuit is defined as any output impedance of less than 0.005 ohms. The power supply must shutdown and latch off for shorting +3.3V, +5V, +12_{IO}V, +12V_{DIG} or either of the +12V_{CPU} rails to return or any other rail (other than rails of equal voltage). Shorts between main output rails and standby outputs (3.3V_{AUX} and 5V_{SB}) must not cause damage to the power supply. The power supply must either shutdown and/or latch off for shorting on the –12V 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 by cycling the PS-ON#. The power supply must then be capable of withstanding a continuous short-circuit to the output without damage or over-stress of the unit (components, PCB traces, and connectors) under the input conditions specified in Section 3.1 above. The maximum short-circuit energy in any output must not exceed 240 VA.

3.5.3 No Load Operation

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

3.5.4 Overcurrent Protection

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

4. Mechanical Requirements

4.1 Physical Dimensions/Markings

The power supply is enclosed and must meet the physical outline of one of two form factors shown in Figure 5 and Figure 6 respectively. The form factor shall be selected based upon the power output requirement for the system. It is anticipated, but not expected, than that the single form fan form factor (Figure 5) satisfies the requirements for units with continuous output power not exceeding 500 W. The dual fan form factors (Figure 6) satisfy all power levels.

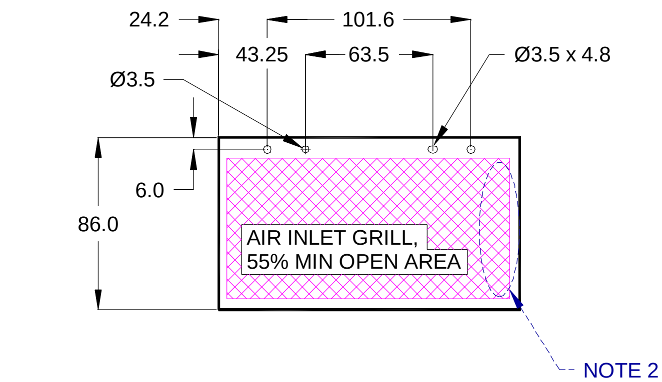
In order to provide for both tower and rack mount chassis configurations, two- (2) output cable exit configurations are specified for each form factor, refer to Figure 7 thru Figure 9.

Note: Open exit areas must be minimized for the Single fan side exit option (Figure 7) and for the Dual fan underside exit option (Figure 8) to minimize stray air intake. Stray air intake impedes system and/or power supply cooling performance. It is recommended that grommets be utilized for this function.

In addition, each supply shall be marked as shown in the following section.

4.1.1 Warning Label

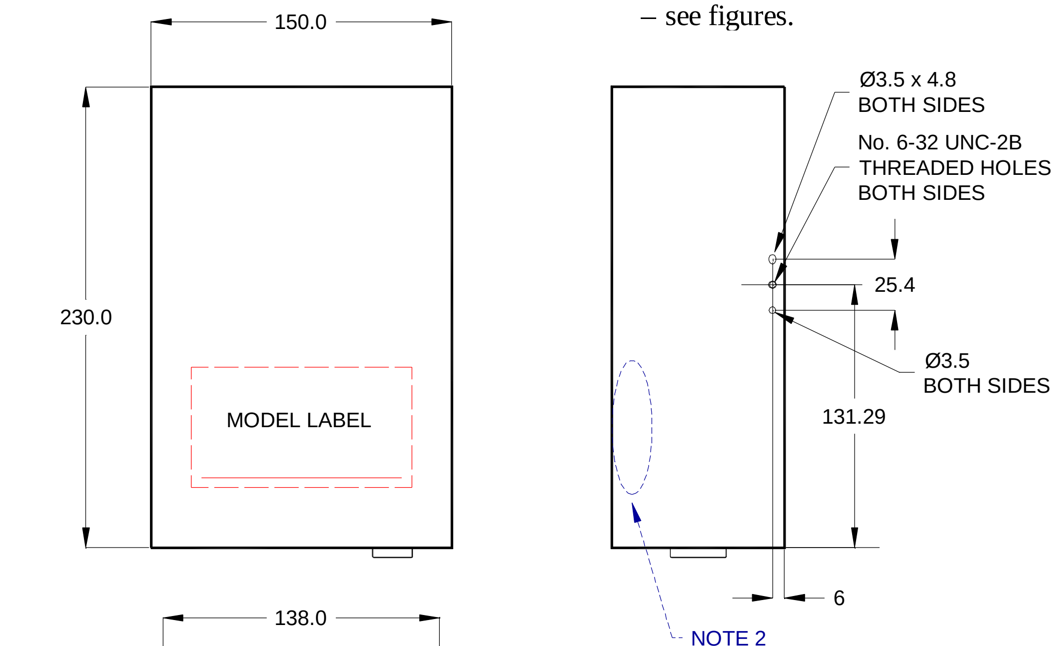
- A warning label stating the following **"Do not remove this cover. Trained service personnel only. No user serviceable components inside."** Must be in English, German, Spanish, French, Chinese, and Japanese along with universal warning markings.
- Manufacturer's Label
- Manufacturer's name, part number, and lot date code in user-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 8.
- DC output voltages and current ratings.

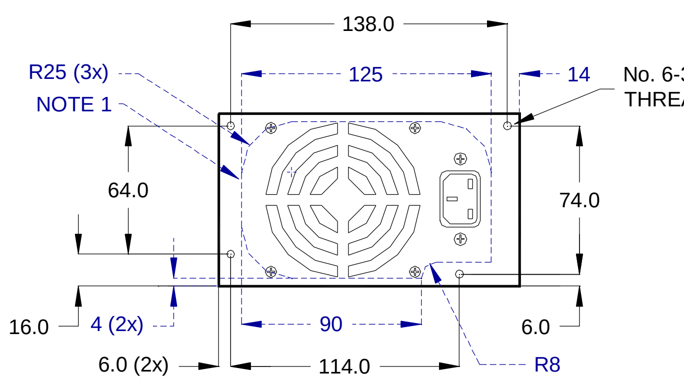


Note 1: Fan grill detail shown for illustration only. Actual detail must be optimized for EMI, acoustic and airflow considerations.

Fan grill and AC receptacle position shown for illustration only. Fan and AC must be positioned within the area shown. Fan detail and all screw heads must be flush to the surface of the power supply.

Note 2: Optional location for cable exit – see figures.



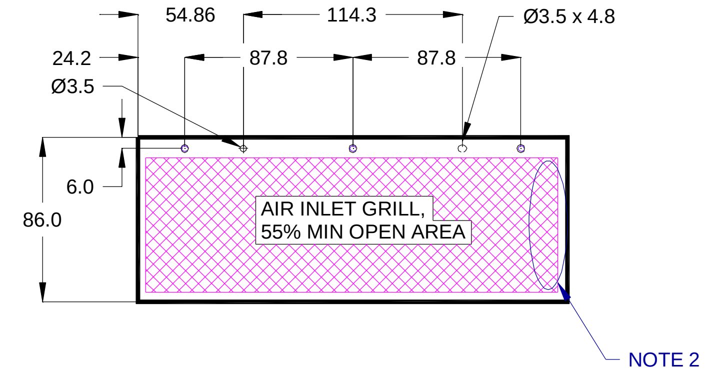


Unless otherwise specified all dimensions are in mm. Tolerances:

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

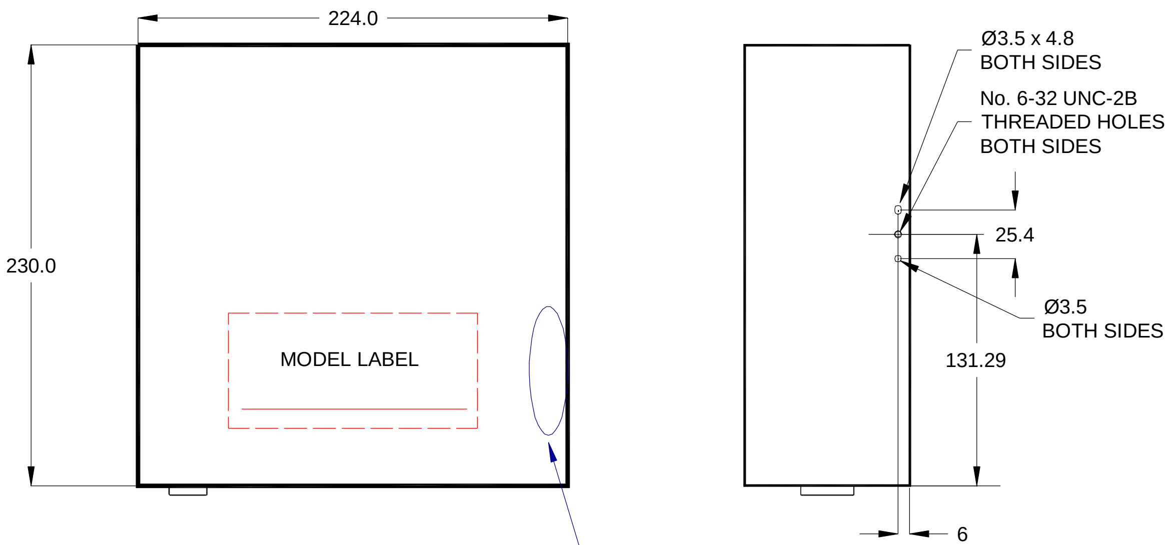
Figure 5. Single Fan WTX Power Supply Form Factor

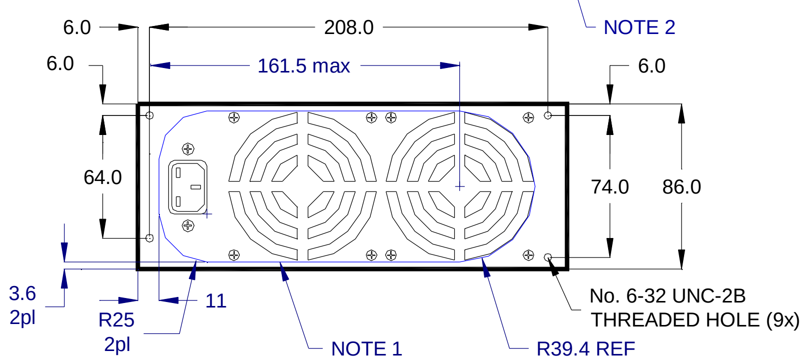


Note 1: Fan grill details shown for illustration only. Actual details must be optimized for EMI, acoustic and airflow considerations.

Fan grills and AC receptacle positions shown for illustration only. Fans and AC must be positioned within the area shown. Fan details and all screw heads must be flush to the surface of the power supply.

Note 2: Optional location for cable exit – see figures.





Unless otherwise specified all dimensions are in mm.
Tolerances:

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 6 - Dual Fan WTX Power Supply Form Factor

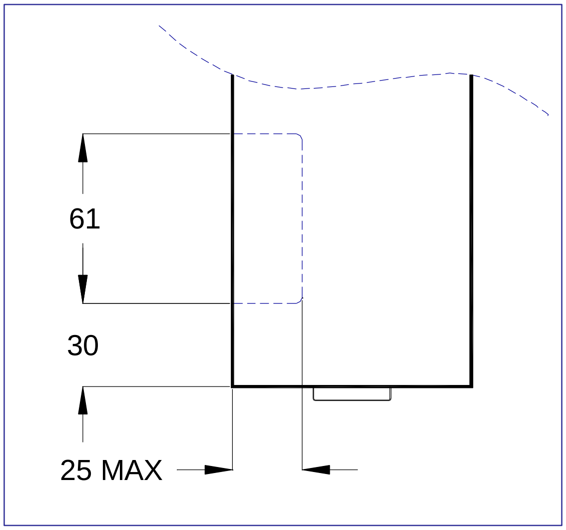


Figure 7. Single Fan (ONLY) Side Cable Exit Option

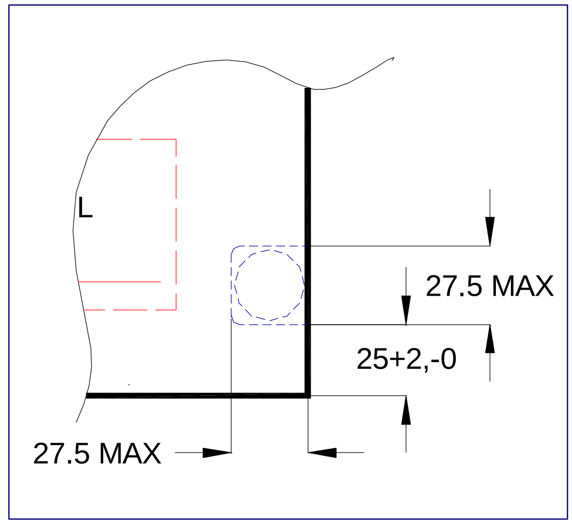


Figure 8. Dual Fan (ONLY) Underside Cable Exit Option

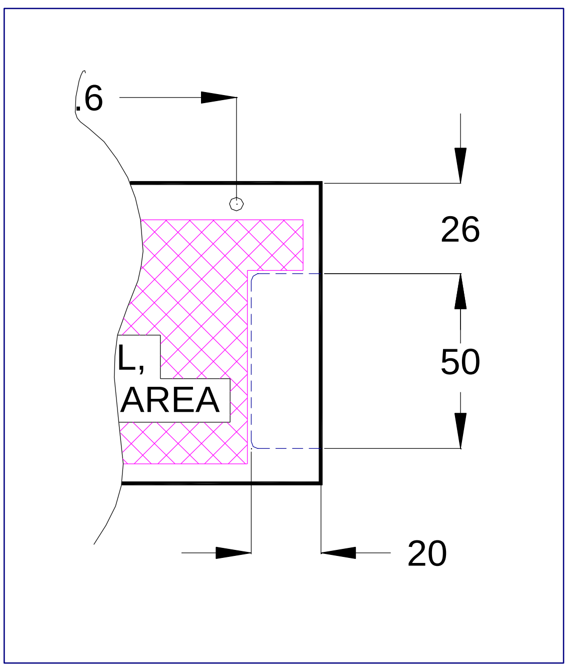


Figure 9. Single and Dual Fan Rear Cable Exit Option

4.2 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. For the dual fan power supply, this circuitry can be either common to, or separate from, each fan.

The fan speed control and monitoring requirements are defined in sections 3.4.10 and 3.4.11, 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 8. 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.

4.3 AC Connector Requirements

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

4.4 DC Connector Requirements

Due to the range of power in WTX workstations, several connectors are used for power delivery, refer to Figure 10 through Figure 13.

4.4.1 Primary 2x12 connector, P1

This connector provides the necessary 3.3 V and 5 V power to the board set(s) including 3.3 V_{AUX} and 5 V_{SB}. The board set(s) connector may be implemented with a Molex 39-29-9242 or equivalent.

This interfaces with the P1 power supply connector Molex 39-01-2240 or equivalent.

It is recommended that Molex HCS 44476-1111 terminal crimp (or equivalent) be used for this connector.

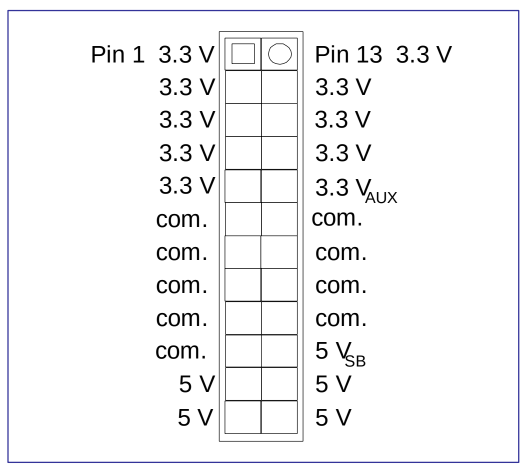


Figure 10. P1, 2x12 Power Connector

4.4.2 Primary 2x11 connector, P2

This connector provides the remaining power voltages (12 VIO and –12 V) in addition to the necessary control and monitoring signals to the board set(s).

The board set(s) connector may be implemented with a Molex 39-29-9222 or equivalent.

This interfaces with the P1 power supply connector Molex 39-01-2220 or equivalent.

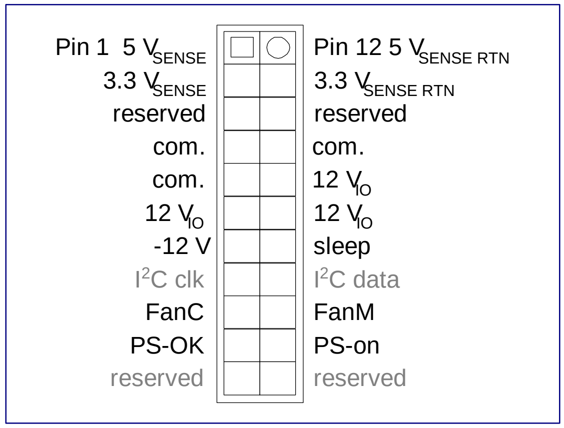


Figure 11. P2, 2x11 Power/Signal Connector

4.4.3 Primary 2x4 connector, P3

This connector provides the 12 V_{DIG} voltage to the board set(s) intended to support WTX memory D2D (DC to DC converters), refer to *WTX Memory D2D Design Guide* www.wtx.org, and processor VRMs (Voltage Regulation Modules).

The board set(s) connector may be implemented with a Molex 39-29-9082 or equivalent.

This interfaces with the P1 power supply connector Molex 39-01-2080 or equivalent.

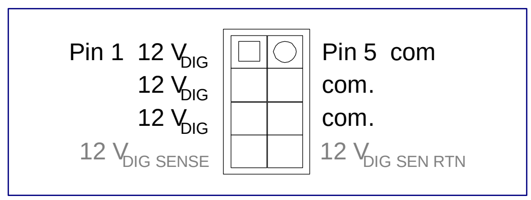


Figure 12. P3, 2x4 Power Connector

4.4.4 Primary 2x3 connectors, P4,P5

This connector provides the 12 VCPU voltage to the board set(s) or direct to the Power Pods to support higher power processor converter requirements.

The board set(s) connector may be implemented with a Molex 39-29-9082 or equivalent. The Power Pod input connector may be implemented with Molex 39-30-1060 or equivalent).

This interfaces with the P1 power supply connector Molex 39-01-2060 or equivalent.

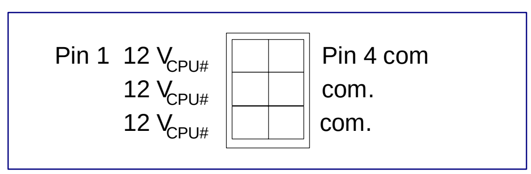


Figure 13. P4/5, 2x3 Power Connector

4.4.5 HDD PERIPHERAL CONNECTORS

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

4.4.6 FDD PERIPHERAL CONNECTORS

Connectors should be AMP 171822-4 or approved equivalent.

4.5 Power Supply Wiring Recommendations

Listed or recognized component appliance wiring material (AVLV2), CN, rated for a minimum of 80° C, 300 Vdc must be used for all output wiring.

There is no specific requirement for lengths or coloring of wiring from the power supply. The length is determined by the particular chassis motherboard combination. A suggested wire color- coding used by many vendors is detailed in the following sections, but this color-coding is ***NOT*** required.

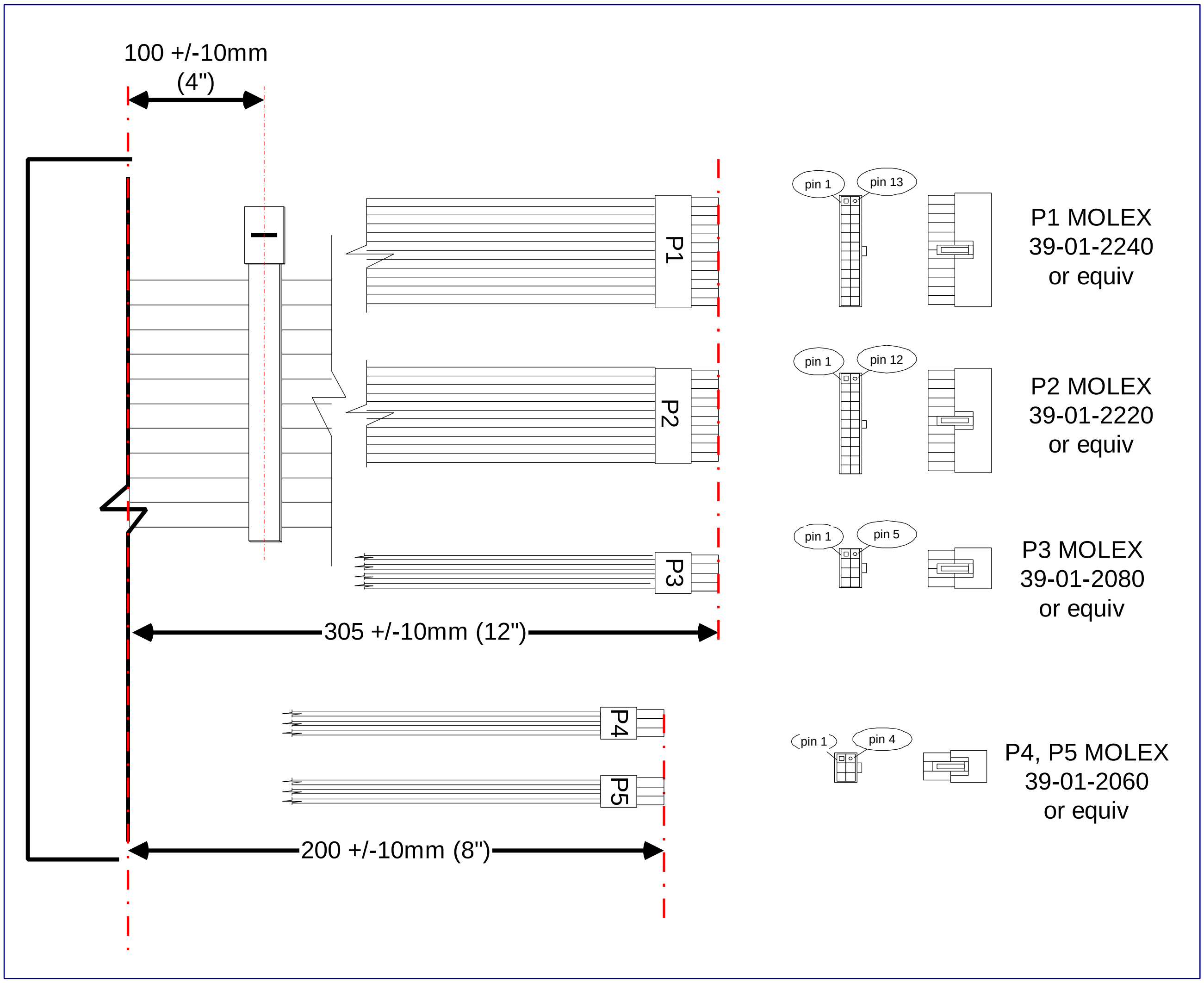


Figure 14. Suggested Wire Lengths

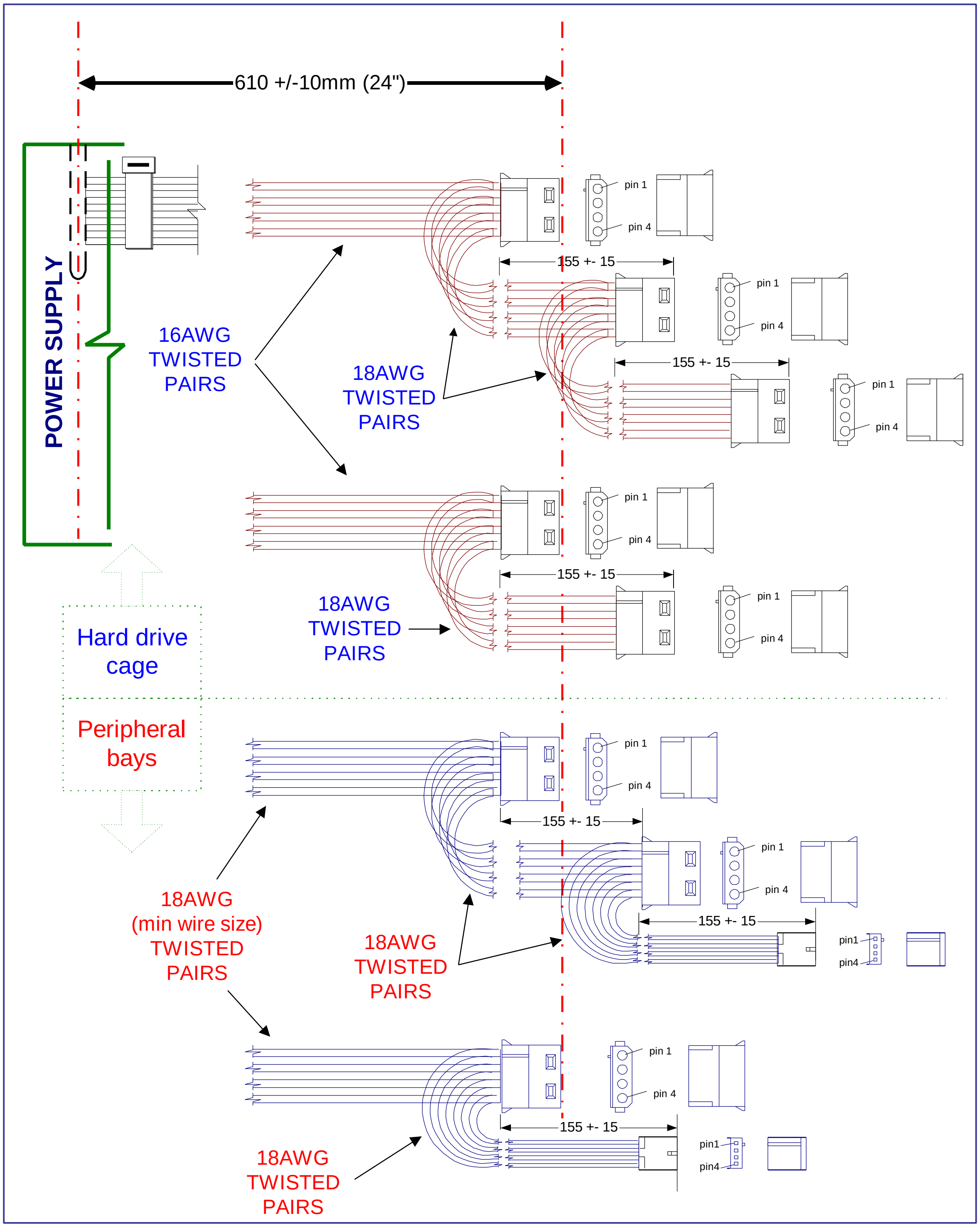


Figure 15. Suggested wire lengths for HDD/FDD connectors

4.5.1 Suggested wire size/colours

4.5.1.1 P1: suggest wire size/colours

Connector: Molex 39-01-2240, or equivalent

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

4.5.1.2 P2: suggest wire size/colours

Connector: Molex 39-01-2220, or equivalent

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		

4.5.1.3 P3: suggest wire size/colours

Connector: Molex 39-01-2080, or equivalent

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		

4.5.1.4 P4/5: suggested wire size/colours

Connector: Molex 39-01-2060, or equivalent

AWG	Wire Colour	Signal	Pin	Pin	Signal	Wire Colour	AWG
18	BLACK	COM	4	1	$+12V_{CPU\#}$	WHITE	18
18	BLACK	COM	5	2	$+12V_{CPU\#}$	WHITE	18
18	BLACK	COM	6	3	$+12V_{CPU\#}$	WHITE	18

4.5.1.5 HDD Peripheral connectors: suggested wire size/colours

Connector: AMP 1-480424-0 or Molex 8981-04P or equivalent

Contacts: AMP 61314-1 terminals or equivalent

Refer to Figure 15. Suggested wire lengths for HDD/FDD connectors. It is recommended for cable lengths over 460mm (18”) that cables be twisted at 1.5 twists/inch, yellow with black and red with black.

Pin	Signal	Wire Colour	AWG
1	$+12V_{IO}$	YELLOW	16
2	COM	BLACK	16
3	COM	BLACK	16
4	+5Vdc	RED	16

4.5.1.6 FDD Peripheral connectors: suggested wire size/colours

Connector: AMP 171822-4, or equivalent

Refer to Figure 15. Suggested wire lengths for HDD/FDD connectors. It is recommended for cable lengths over 460mm (18”) that cables be twisted at 1.5 twists/inch, yellow with black and red with black.

Pin	Signal	Wire Colour	AWG
1	+5Vdc	RED	18
2	COM	BLACK	18
3	COM	BLACK	18
4	$+12V_{IO}$	YELLOW	18

5. Environmental Requirements

5.1 Temperature

Operating Ambient: +10° C min.

+50° C max.

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

Non-Operating Ambient: -40° C to +70° C

(Maximum rate of change is 20°C/hour.)

5.2 Humidity

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

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

Note: 95% relative humidity. is achieved with a dry bulb temperature of 55°C and a wet bulb temperature of 54°C.

5.3 Altitude

Operating: to 10,000 ft

Non-Operating: to 50,000 ft

5.4 Mechanical Shock

Non-Operating: 50 G Trapezoidal Wave, Velocity change = 170 in. / sec. Three- (3) drops in each of six- (6) directions are applied to each of the samples.

5.5 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 gRMS. The duration shall be 10 minutes per axis for all three- (3) axes on all samples.

5.6 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.

5.7 Ecological Requirements

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

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

5.8 Catastrophic Failure

The power supply must be designed to fail without creating a startling noise or excessive smoke.

5.9 Acoustics

Acoustic requirements will be set by the final computer OEM system requirements.

6. Electromagnetic Compatibility

6.1 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.

6.2 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 16 for the harmonic limits.

Table 16. 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
$15 \le n \le 39$	3.85/n	0.15X(15/n)

Note:

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

6.3 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 while in the end-use chassis.

7. Reliability

7.1 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 $3.3V_{AUX}$.

7.2 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.

8. Safety Requirements

8.1 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*.

8.2 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