

ATX12V

Power Supply Design Guide

Version 2.01

IMPORTANT INFORMATION AND DISCLAIMERS

INTEL CORPORATION (AND ANY CONTRIBUTOR) IS PROVIDING THIS INFORMATION AS A CONVENIENCE AND ACCORDINGLY MAKES NO WARRANTIES WITH REGARD TO THIS DOCUMENT OR PRODUCTS MADE IN CONFORMANCE WITH THIS DOCUMENT.

THIS DOCUMENT IS PROVIDED "AS IS" AND INTEL DISCLAIMS ALL EXPRESS AND IMPLIED WARRANTIES, INCLUDING THE WARRANTY OF MERCHANTABILITY AND FITNESS FOR PARTICULAR PURPOSE. IN ADDITION, INTEL (AND ANY CONTRIBUTOR) DOES NOT WARRANT OR REPRESENT THAT THIS DOCUMENT OR ANY PRODUCTS MADE IN CONFORMANCE WITH IT WILL OPERATE IN THE INTENDED MANNER, ARE FREE FROM ERRORS OR DEFECTS, OR ARE SAFE FOR USE FOR ITS INTENDED PURPOSE. ANY PERSON USING THIS DOCUMENT OR MAKING, USING, OR SELLING PRODUCTS IN CONFORMANCE WITH THIS DOCUMENT DOES SO AT HIS OR HER OWN RISK.

INTEL DISCLAIMS ALL LIABILITY ARISING FROM OR RELATED TO USE OR IMPLEMENTATION OF THE INFORMATION PROVIDED IN THIS DOCUMENT, INCLUDING LIABILITY FOR INFRINGEMENT OF ANY INTELLECTUAL PROPERTY RIGHTS RELATING TO THE INFORMATION OR THE IMPLEMENTATION OF INFORMATION IN THIS DOCUMENT. INTEL DOES NOT WARRANT OR REPRESENT THAT SUCH DEVICES OR IMPLEMENTATION WILL NOT INFRINGE SUCH RIGHTS.

INTEL IS NOT OBLIGATED TO PROVIDE ANY SUPPORT, INSTALLATION OR OTHER ASSISTANCE WITH REGARD TO THE INFORMATION OR PRODUCTS MADE IN ACCORDANCE WITH IT. THE INFORMATION IN THIS DOCUMENT IS SUBJECT TO CHANGE WITHOUT NOTICE.

THE INFORMATION REFERRED TO IN THIS DOCUMENT IS INTENDED FOR STANDARD COMMERCIAL USE ONLY. CUSTOMERS ARE SOLELY RESPONSIBLE FOR ASSESSING THE SUITABILITY OF THE INFORMATION FOR USE IN PARTICULAR APPLICATIONS. THE INFORMATION IS NOT INTENDED FOR USE IN CRITICAL CONTROL OR SAFETY SYSTEMS, MEDICAL OR LIFE SAVING APPLICATIONS, OR IN NUCLEAR FACILITY APPLICATIONS.

NO LICENSE, EXPRESS OR IMPLIED, BY ESTOPPEL OR OTHERWISE, TO ANY INTELLECTUAL PROPERTY RIGHTS IS GRANTED HEREIN.

Intel and Pentium are registered trademarks of Intel Corporation or its subsidiaries in the United States and other countries.

Other names and brands may be claimed as the property of others

Copyright © 2004 Intel Corporation.

Revision History

Version	Release Date	Notes
1.0	Feb, 2000	<ul style="list-style-type: none"> Public release
1.1	Aug, 2000	<ul style="list-style-type: none"> Increase 3.3 V current; add more explanation for power sharing; do minor edits and format fixes
1.2	Jan, 2002	<ul style="list-style-type: none"> Typical Power Distribution. Change +5V loading on all power supplies distribution tables defined in DG to 0.3A PS_ON# Add text "The power supply should not latch into a shutdown state when PS_ON# is driven active by pulses between 10ms to 100ms during the decay of the power rails." Remove -5V from all power distribution tables.
1.3	April, 2003	<ul style="list-style-type: none"> Update Power and Current guidance Added efficiency guidance at typical and light load Increased min efficiency at full load from 68% to 70% Serial ATA* connector definition added Acoustic levels added for low noise power supply design Reformat and update revision table Update Disclaimers Remove guidelines for ATX Remove guidance for -5V rail Updated guidance for Energy Star and stand by efficiency
2.0	February, 2003	<ul style="list-style-type: none"> Added Terminology section Updated power and current guidance Includes 250W, 300W, 350W, and 400W guidance Updated cross regulation graphs Updated load tables Updated required efficiency targets. Added recommended efficiency targets. Increased required minimum efficiency at typical and light load. Main Power Connector changes to 2x12. Aux power connector removed. Required Serial ATA Connector. Isolated current limit on 2x2 connector for 12V2 rail.
2.01	June, 2004	<ul style="list-style-type: none"> Updated 3.3 V remote sense pin # on the main power connector Updated 12V2 DC Output Noise/Ripple information Removed -5V reference Updated 5Vsb maximum current step

Contents

1. Introduction	7
1.1. Scope.....	7
1.2. Key Changes for ATX12V Version 2.0 as Compared with ATX Power Supply	7
1.2.1. Increased +12 VDC output capability	7
1.2.2. Minimum Efficiency.....	7
1.2.3. Main Power Connector:	8
1.2.4. Separate current limit for 12V2 on the 2x2 connector:	8
1.3 Terminology.....	8
2. Applicable Documents.....	9
3. Electrical	10
3.1. AC Input.....	10
3.1.1. Input Over-current Protection	10
3.1.2. Inrush Current Limiting	10
3.1.3. Input Under-voltage	11
3.1.4. Regulatory	11
3.1.5. Catastrophic Failure Protection	12
3.2. DC Output.....	12
3.2.1. DC Voltage Regulation	12
3.2.2. Remote Sensing	13
3.2.3. Typical Power Distribution	13
3.2.4. Power Limit / Hazardous Energy Levels	18
3.2.5. Efficiency.....	18
3.2.6. Output Ripple/Noise.....	20
3.2.7. Output Transient Response.....	22
3.2.8. Capacitive Load	22
3.2.9. Closed-loop Stability	23
3.2.10. +5 VDC / +3.3 VDC Power Sequencing	23
3.2.11. Voltage Hold-up Time	23
3.3. Timing / Housekeeping / Control	23
3.3.1. PWR_OK	24
3.3.2. PS_ON#.....	24
3.3.3. +5 VSB.....	25
3.3.4. Power-on Time	26
3.3.5. Risetime	26
3.3.6. Overshoot at Turn-on / Turn-off.....	26
3.3.7. Reset after Shutdown	26
3.3.8. +5 VSB at AC Power-down	26
3.4. Output Protection.....	27
3.4.1. Over-voltage Protection.....	27
3.4.2. Short-circuit Protection	27

3.4.3. No-load Operation	27
3.4.4. Over-current Protection	27
3.4.5. Over-temperature Protection	28
3.4.6. Output Bypass	28
4. Mechanical	29
4.1. Labeling / Marking	29
4.2. Physical Dimensions	29
4.3. Airflow / Fan	32
4.4. AC Connector	33
4.5. DC Connectors	33
4.5.1. ATX Main Power Connector	35
4.5.2. +12 V Power Connector	36
4.5.3. Peripheral Connector(s)	36
4.5.4. Serial ATA Power Connector	37
4.5.5. Floppy Drive Connector	37
5. Environmental	38
5.1. Temperature	38
5.2. Thermal Shock (Shipping)	38
5.3. Humidity	38
5.4. Altitude	38
5.5. Mechanical Shock	38
5.6. Random Vibration	39
5.7. Acoustics	39
6. Electromagnetic Compatibility	40
6.1. Emissions	40
6.2. Immunity	40
6.3. Input Line Current Harmonic Content and Line Flicker	41
6.4. Magnetic Leakage Fields	41
7. Reliability	42
7.1. Component De-rating	42
8. Safety	43
8.1. North America	43
8.2. International	44
8.3. Proscribed Materials	44

Figures

Figure 1. Cross Loading Graph for 250W Configuration 14
 Figure 2. Cross Loading Graph for 300W Configuration 15
 Figure 3. Cross Loading Graph for 350W Configuration 16
 Figure 4. Cross Loading Graph for 400W Configuration 17
 Figure 5. Differential Noise Test Setup 21
 Figure 6. Power Supply Timing..... 23
 Figure 7. PS_ON# Signal Characteristics..... 25
 Figure 8. Power Supply Dimensions for Chassis That Does Not Require Top Venting..... 30
 Figure 9. Power Supply Dimensions for Chassis That Require Top Venting..... 31
 Figure 10. ATX12V Power Supply Connectors..... 34
 Figure 11. Serial ATA Connector 37

Tables

Table 1. AC Input Line Requirements..... 10
 Table 2. DC Output Voltage Regulation 12
 Table 3. Typical Power Distribution for a 250 W ATX12V Configuration 14
 Table 4. Typical Power Distribution for a 300 W ATX12V Configuration 15
 Table 5. Typical Power Distribution for a 350 W ATX12V Configuration 16
 Table 6. Typical Power Distribution for a 400 W ATX12V Configuration 17
 Table 7. Minimum Efficiency Vs Load..... 18
 Table 8. Loading Table for Efficiency Measurements 19
 Table 9. Energy Star Input Power Consumption 20
 Table 10. DC Output Noise/Ripple..... 21
 Table 11. DC Output Transient Step Sizes..... 22
 Table 12. Output Capacitive Loads..... 22
 Table 13. PWR_OK Signal Characteristics 24
 Table 14. PS_ON# Signal Characteristics 25
 Table 15. Overvoltage Protection 27
 Table 16. Harmonic Limits, Class D Equipment 41

1. Introduction

1.1. Scope

This document provides design suggestions and reference specifications for a family of power supplies that comply with the *ATX Specification, Version 2.03*[†] for motherboards and chassis. It includes supplementary information not expressly detailed in the *ATX Specification*, such as information about the physical form factor of the power supply, cooling requirements, connector configuration, and pertinent electrical and signal timing specifications.

This document is provided as a convenience only and is not intended to replace the user's independent design and validation activity. It should not be inferred that all ATX12V power supplies must conform exactly to the content of this document. The design specifics described herein are not intended to support all possible system configurations. System power supply needs vary widely depending on factors such as the application (that is, for desktop, workstation, or server), intended ambient environment (temperature, line voltage), or motherboard power requirements.

1.2. Key Changes for ATX12V Version 2.0 and later as Compared with ATX and Pervious Versions of ATX12V Power Supply

This section briefly summarizes the major changes made to this document that now defines ATX12V power supply. With the move to 12V voltage regulators for the processor, ATX guidelines for 5V as main power are no longer provided.

1.2.1. Increased +12 VDC output capability

System components that use 12V are continuing to increase in power. In cases where expected current requirements is greater than 18A a second 12 V rail should be made available. ATX12V power supplies should be designed to accommodate these increased +12 VDC currents.

1.2.2. Minimum Efficiency

Minimum measured efficiency is required to be 70% at full and typical (~50%) load and 60% at light (~20%) load. New recommended guidance has been added to provide direction for future requirements.

[†] 2.03 is the current version of the *ATX Specification* as of this writing. Future references to the *ATX Specification* in this document imply version 2.03 or later, as applicable.

1.2.3. Main Power Connector:

The 2 x 10 main power connector has been replaced by a 2 x 12 connector. This was made to support 75 watt PCI Express*requirements. Pinout assignments are based on the SSI recommendation.

With the added 12V, 5V, and 3.3V pins the need for an Aux Power connector is no longer needed and the guidance for this connector has been removed.

1.2.4. Separate current limit for 12V2 on the 2x2 connector:

The 12V rail on the 2 x 2 power connector should be a separate current limited output to meet the requirements of UL and EN 60950.

1.3 Terminology

The following terms are used in this document:

Term	Description
Required	The status given to items within this design guide, which are required to meet design guide and a large majority of system applications.
Recommended	The status given to items within this design guide, which are not required to meet design guide, however, are required by many system applications.
Optional	The status given to items within this design guide, which are not required to meet design guide, however, some system applications may optionally use these features.
BA	Declared sound power, LwAd. The declared sound power level shall be measured according to ISO* 7779 for the power supply and reported according to ISO 9296.
CFM	Cubic Feet per Minute (airflow).
Monotonically	A waveform changes from one level to another in a steady fashion, without intermediate retracement or oscillation.
Noise	The periodic or random signals over frequency band of 0 Hz to 20 MHz.

2. Applicable Documents

The following documents support this design guide as additional reference material.

Document Title	Description
FCC Rules Part 15, Class B	Title 47, Code of Federal Regulations, Part 15
ICES-003: 1997, Class B	Interference-Causing Equipment Standard – Digital Apparatus
EN 55022: 1998 + Amendment A1:2000 Class B	Information Technology Equipment – Radio disturbance characteristics – Limits and methods of measurement
CISPR 22: 1997, Class B	Information Technology Equipment – Radio disturbance characteristics – Limits and methods of measurement
AS/NZS 3548:1995, Class B	Information Technology Equipment – Radio disturbance characteristics – Limits and methods of measurement
EN 55024:1998	Information Technology Equipment – Immunity Characteristics – Limits and methods of measurement
IEC 60950, 3 rd ed., 1999	Safety of Information Technology Equipment
EN 60950: 2000	Safety of Information Technology Equipment
UL 60950, 3 rd ed., 2000	Safety of Information Technology Equipment
CSA 22.2 No. 60950-00	Safety of Information Technology Equipment

3. Electrical

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

3.1. AC Input

Table 1 lists AC input voltage and frequency requirements for continuous operation. The power supply shall be capable of supplying full-rated output power over two input voltage ranges rated 100-127 VAC and 200-240 VAC RMS nominal. The correct input range for use in a given environment may be either switch-selectable or auto-ranging. The power supply shall automatically recover from AC power loss. The power supply must be able to start up under peak loading at 90 VAC.

Table 1. AC Input Line Requirements

Parameter M	Minimum	Nominal+	Maximum	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

+Note: Nominal voltages for test purposes are considered to be within ± 1.0 V of nominal.

3.1.1. Input Over-current Protection

The power supply shall incorporate primary fusing for input over-current protection to prevent damage to the power supply and meet product safety requirements. Fuses should be 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) 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, 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.

[‡] . For Denmark and Switzerland international safety requirements, if the internal over-current protective devices exceed 8A for Denmark and 10A for Switzerland, then the power supply must pass international safety testing to EN 60950 using a maximum 16A over-current protected branch circuit, and this 16A (time delay fuse) branch circuit protector must not open during power supply abnormal operation (output short circuit and component fault) testing.

3.1.3. Input Under-voltage

The power supply shall contain protection circuitry such that the application of an input voltage below the minimum specified in Section 3.1, Table 1, shall not cause damage to the power supply.

3.1.4. Regulatory

The power supply is required to be tested and comply with the most current version of the following regulatory specification requirements and/or standards

PRODUCT SAFETY

UL* 60950, 3rd Edition –CAN/CSA-C22.2-60950-00,

EN*60 950, 3rd Edition

IEC*60 950, 3rd Edition (CB Report to include all national deviations)

EU* Low Voltage Directive (73/23/EEC) (CE Compliance)

GB4943-90 CCIB* (China)

ELECTROMAGNETIC COMPATIBILITY

FCC*, Class B, Part 15 (Radiated & Conducted Emissions)

CISPR* 22 / EN55022, 3rd Edition (Radiated & Conducted Emissions)

EN55024 (ITE Specific Immunity)

EN 61000-4-2 – Electrostatic Discharge

EN 61000-4-3– Radiated RFI Immunity

EN 61000-4-4– Electrical Fast Transients.

EN 61000-4-5 – Electrical Surge

EN 61000-4-6 – RF Conducted

EN 61000-4-8 – Power Frequency Magnetic Fields

EN 61000-4-11 – Voltage Dips, Short Interrupts and Fluctuations

EN61000-3-2 (Harmonics)

EN61000-3-3 (Voltage Flicker)

EU EMC Directive ((8/9/336/EEC) (CE Compliance)

Other Certifications and/or Declarations

GB925 (China/CCC*), CNS13438 (Taiwan/BSMI*),

AS/NZ3548 (Australia/C-tick* based on CISPR22)

3.1.5. Catastrophic Failure Protection

Should a component failure occur, the power supply should not exhibit any of the following:

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

3.2. DC Output

3.2.1. DC Voltage Regulation

The DC output voltages shall remain within the regulation ranges shown in Table 2 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 any steady state temperature and operating conditions specified in Section 5.

Table 2. DC Output Voltage Regulation

Output Range	Regulation	Min.	Nom.	Max.	Unit
+12V1DC ± 5	%	+11.40	+12.00	+12.60	Volts
+12V2DC ⁽¹⁾ ± 5	%	+11.40	+12.00	+12.60	Volts
+5VDC ± 5	%	+4.75	+5.00	+5.25	Volts
+3.3VDC ⁽²⁾ ± 5	%	+3.14	+3.30	+3.47	Volts
-12VDC ± 10	%	-10.80	-12.00	-13.20	Volts
+5VSB ± 5	%	+4.75	+5.00	+5.25	Volts

⁽¹⁾ At +12 VDC peak loading, regulation at the +12 VDC output can go to $\pm 10\%$.

⁽²⁾ Voltage tolerance is required at main connector and S-ATA connector (if used).

3.2.2. Remote Sensing

The +3.3 VDC output should have provisions for remote sensing to compensate for excessive cable drops. The default sense should be connected to pin 13 of the main power connector. The power supply should draw no more than 10 mA through the remote sense line to keep DC offset voltages to a minimum.

3.2.3. Typical Power Distribution

DC output power requirements and distributions will vary based on specific system options and implementation. Significant dependencies include the quantity and types of processors, memory, add-in card slots, and peripheral bays, as well as support for advanced graphics or other features. *It is ultimately the responsibility of the designer to derive a power budget for a given target product and market.*

Table 3 through Table 5 and Figure 1 through Figure 3 provide sample power distributions and a graphical recommendation for cross loading. It should not be inferred that all power supplies must conform to these tables, nor that a power supply designed to meet the information in the tables will work in all system configurations.

3.2.3.1. ATX12V Configurations

Table 3. Typical Power Distribution for a 250 W ATX12V Configuration

Output	Min. Current (amps)	Max. Current (amps)	Peak Current (amps)
+12 V1DC ^(1, 2)	1	8	10
+12 V2DC ^(1, 2)	1	14	
+5 VDC	0.3	18	
+3.3 VDC	0.5	17	
-12 VDC	0	0.3	
+5 VSB	0	2	2.5

Note: Total combined output of 3.3 V and 5 V is $\leq 115W$

Peak currents may last up to 17 seconds with not more than one occurrence per minute

⁽¹⁾12V1DC and 12V2DC should have separate current limit circuits to meet 240VA safety requirements.

⁽²⁾12V2 supports processor power requirements and must have a separate current limit

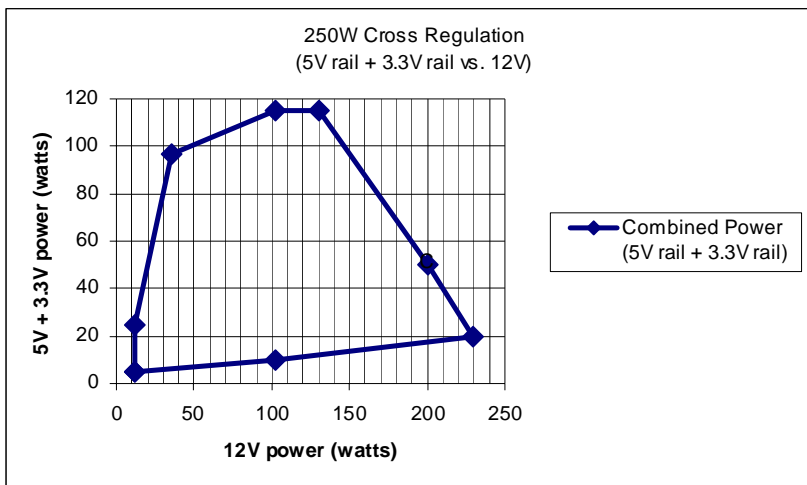


Figure 1. Cross Loading Graph for 250W Configuration

Table 4. Typical Power Distribution for a 300 W ATX12V Configuration

Output	Min. Current (amps)	Max. Current (amps)	Peak Current (amps)
+12 V1DC ^(1,2)	1.0	8.0	10.0
+12 V2DC ^(1,2)	1.0	14.0	
+5 VDC	0.3	20.0	
+3.3 VDC	0.5	20.0	
-12 VDC	0.0	0.3	
+5 VSB	0.0	2.0	2.5

Note: Total combined output of 3.3 V and 5 V is ≤ 120 W

Peak currents may last up to 17 seconds with not more than one occurrence per minute

⁽¹⁾12V1DC and 12V2DC should have separate current limit circuits to meet 240VA safety requirements.

⁽²⁾12V2 supports processor power requirements and must have a separate current limit

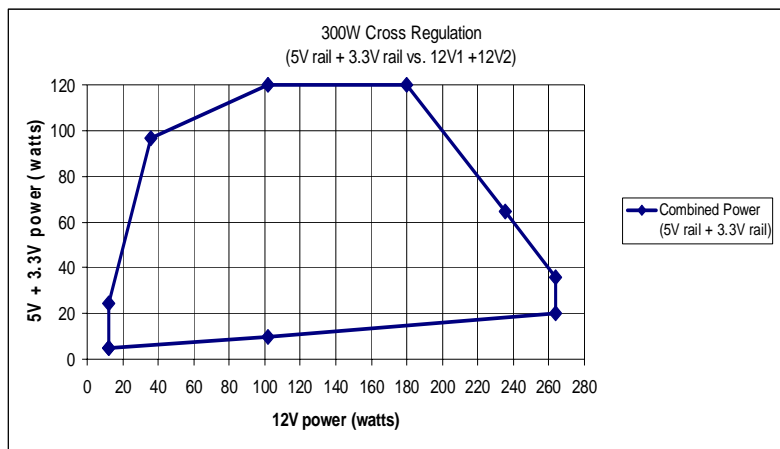


Figure 2. Cross Loading Graph for 300W Configuration

Table 5. Typical Power Distribution for a 350 W ATX12V Configuration

Output	Min. Current (amps)	Max. Current (amps)	Peak Current (amps)
+12 V1DC ^(1,2)	1	10	12
+12 V2DC ^(1,2)	1	15	
+5 VDC	0.3 2	1	
+3.3 VDC	0.5 2	2	
-12 VDC	0.0 0.3		
+5 VSB	0.0	2.0	2.5

Note: Total combined output of 3.3 V and 5 V is ≤ 130 W

Peak currents may last up to 17 seconds with not more than one occurrence per minute

⁽¹⁾12V1DC and 12V2DC should have separate current limit circuits to meet 240VA safety requirements.

⁽²⁾12V2 supports processor power requirements and must have a separate current limit



Figure 3. Cross Loading Graph for 350W Configuration

Table 6. Typical Power Distribution for a 400 W ATX12V Configuration

Output	Min. Current (amps)	Max. Current (amps)	Peak Current (amps)
+12 V1DC	1	14	16
+12 V2DC	1	15	
+5 VDC	0.3	28	
+3.3 VDC	0.5	30	
-12 VDC	0	3	
+5 VSB	0	2	2.5

Note: Total combined output of 3.3 V and 5 V is ≤ 130 W
 Peak currents may last up to 17 seconds with not more than one occurrence per minute
 12V1DC and 12V2DC should have separate current limit circuits to meet 240VA safety requirements.

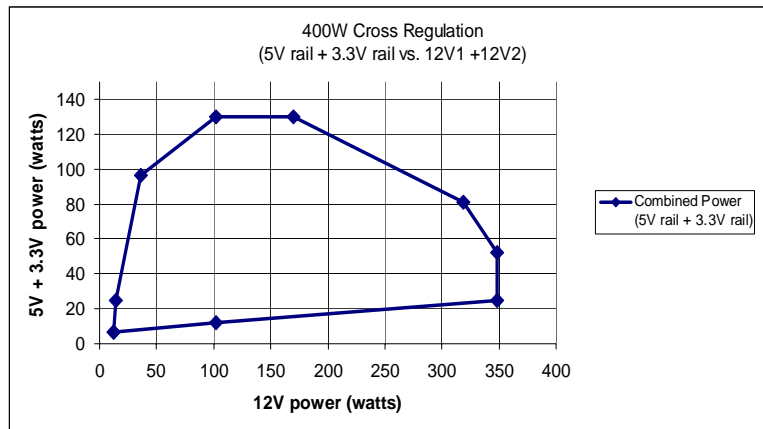


Figure 4. Cross Loading Graph for 400W Configuration

3.2.4. Power Limit / Hazardous Energy Levels

Under normal or overload conditions, no output shall continuously provide more than 240 VA under any conditions of load including output short circuit, per the requirement of UL 1950/CSA 950 / EN 60950/IEC 950.

3.2.5. Efficiency

3.2.5.1. General

The power supply required minimum is 70% efficient under “Full” load, 70% under “typical” load, and 60% in a “light” load or idle condition. The efficiency of the power supply should be tested at nominal input voltage of 115VAC input and/or 230VAC input, under the load conditions defined in Table 7 and Table 8, and under the temperature and operating conditions defined in Section 5. The loading condition for testing efficiency shown in Table 8 represents a fully loaded system, a ~50% (typical) loaded system, and a ~20% (light) loaded system.

Table 7. Minimum Efficiency Vs Load

Loading	Full load	Typical load	Light load
Required Minimum Efficiency	70% 7	0%	60%
Recommended Minimum Efficiency	75% 8	0%	68%

Table 8. Loading Table for Efficiency Measurements

250W (loading shown in Amps)						
Loading	+12V1	+12V2	+5V	+3.3V	-12V	+5Vsb
Full 4		11.5	6.8	6.5	0.3	1.0
Typical 3		5	3	4	0.1	1.0
Light 2		2.4	0.3	0.5	0.0	1.0
300W (loading shown in Amps)						
Loading	+12V1	+12V2	+5V	+3.3V	-12V	+5Vsb
Full 7		12	8	7.5	0.2	1.0
Typical 4		8	3	4	0.1	1.0
Light 2		2	0.5	1.5	0.0	1.0
350W (loading shown in Amps)						
Loading	+12V1	+12V2	+5V	+3.3V	-12V	+5Vsb
Full 10		13	9	10	0.3	1.0
Typical 5		9	3	5	0.1	1.0
Light 3		3	1.0	2.0	0.0	1.0
400W (loading shown in Amps)						
Loading	+12V1	+12V2	+5V	+3.3V	-12V	+5Vsb
Full	12	14	9	11	0.3	1.0
Typical 5		9	3	5	0.1	1.0
Light 3		3	1	3	0.0	1.0

3.2.5.2. Energy Star*

The “Energy Star” efficiency requirements of the power supply depend on the intended system configuration. In the low-power / sleep state (S1 or S3) the system should consume power in accordance with the values listed in Table 9.

Table 9. Energy Star Input Power Consumption

Maximum Continuous Power Rating of Power Supply	RMS Watts from the AC line in sleep/low-power mode
≤ 200 W	≤ 15 W
> 200 W ≤ 300 W	≤ 20 W
> 300 W ≤ 350 W	≤ 25 W
> 350 W ≤ 400 W	≤ 30 W
> 400 W	10% of the maximum continuous output rating

Note: To help meet the “Energy Star” system requirements, it is recommended that the power supply have > 50% efficiency in standby mode.

3.2.5.3. Other Low Power System Requirements

For power supplies designed for low standby power, the following provides some general guidance. Requirements will vary with geographic region and target end user market.

To help meet the Blue Angel*, RAL-UZ 78, US Presidential executive order 13221, future EPA requirements, and other low Power system requirements, it is recommended that the +5 VSB standby supply should be as efficient as possible. Standby efficiency is measured with the main outputs off (PS_ON# high state). Standby efficiency should be greater than 50% with a minimum loading of 100mA.

3.2.6. Output Ripple/Noise

The output ripple/noise requirements listed in Table 10 should be met throughout the load ranges specified in Section 3.2.3 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 should be bypassed at the connector with a 0.1 μF ceramic disk capacitor and a 10 μF electrolytic capacitor to simulate system loading. See Figure 5.

Table 10. DC Output Noise/Ripple

Output	Max. Ripple & Noise (mV _{pp})
+ 12 V1DC	120
+ 12 V2DC	120
+5 VDC	50
+3.3 VDC	50
- 12 VDC	120
+5 VSB	50

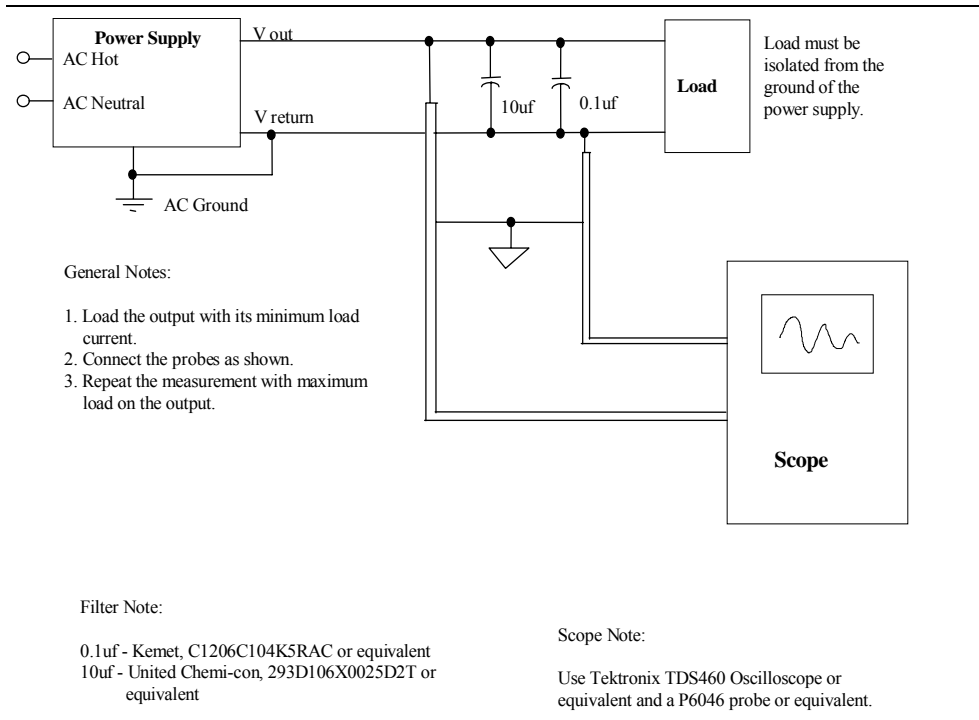


Figure 5. Differential Noise Test Setup

3.2.7. Output Transient Response

Table 11 summarizes the expected output transient step sizes for each output. The transient load slew rate is = 1.0 A/μs.

Table 11. DC Output Transient Step Sizes

Output	Max. step size (% of rated output amps per Sec 3.2.3) ⁽¹⁾	Max. step size (amps)
+1 2 V1DC	40%	
+12 V2DC	60%	
+5 VDC	30%	
+3.3 VDC	30%	
-12 VDC		0.1 A
+5 VSB		0.5 A

⁽¹⁾ For example, for a rated +5 VDC output of 18 A, the transient step would be 30% × 18 A = 5.4 A

Comment: Different than SFX or TFX which state 0.5

Output voltages should remain within the regulation limits of Section 3.2.1, and the power supply should be stable when subjected to load transients per Table 11 from any steady state load, including any or all of the following conditions:

- Simultaneous load steps on the +12 VDC, +5 VDC, and +3.3 VDC outputs (all steps occurring in the same direction)
- Load-changing repetition rate of 50 Hz to 10 kHz
- AC input range per Section 3.1
- Capacitive loading per Table 12.

3.2.8. Capacitive Load

The power supply should be able to power up and operate normally with the following capacitances simultaneously present on the DC outputs. This capacitive loading should be used to check stability and should not be included for noise testing.

Table 12. Output Capacitive Loads

Output A	TX12V Capacitive load (μF)
+12 V1DC	5,000
+ 12 V2DC	3,000
+ 5 VDC	6,000
+ 3.3 VDC	6,000
- 12 VDC	350
+ 5 VSB	350

3.2.9. Closed-loop Stability

The power supply shall be unconditionally stable under all line/load/transient load conditions including capacitive loads specified in Section 3.2.8. A minimum of 45 degrees phase margin and 10 dB gain margin is recommended at both the maximum and minimum loads.

3.2.10. +5 VDC / +3.3 VDC Power Sequencing

The +12 VDC and +5 VDC output levels must be equal to or greater than the +3.3 VDC output at all times during power-up and normal operation. The time between the +12 VDC or +5 VDC output reaching its minimum in-regulation level and +3.3 VDC reaching its minimum in-regulation level must be ≤ 20 ms.

3.2.11. Voltage Hold-up Time

The power supply should maintain output regulation per Section 3.2.1 despite a loss of input power at the low-end nominal range—115 VAC / 47 Hz or 230 VAC / 47 Hz—at maximum continuous output load as applicable for a minimum of 17 ms.

3.3. Timing / Housekeeping / Control

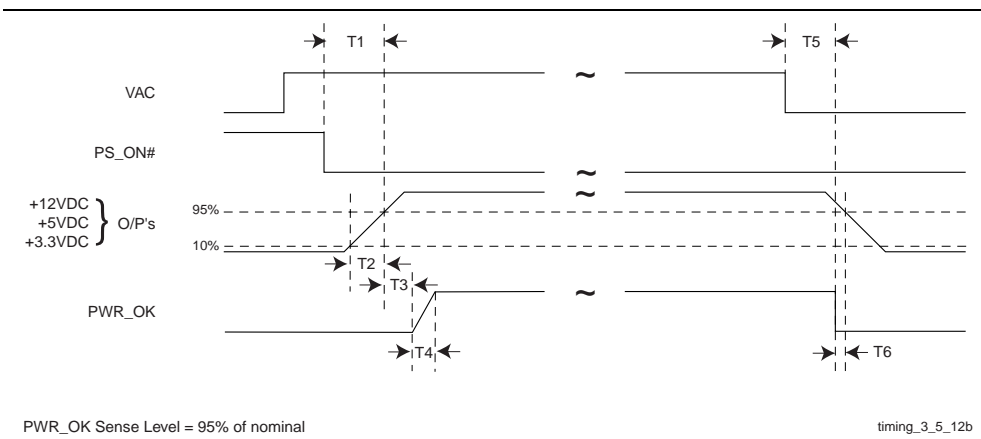


Figure 6. Power Supply Timing

Notes: T1 is defined in Section 3.3.4. T2 is defined in Section 3.3.5. T3, T4, T5, and T6 are defined in Table 13

3.3.1. PWR_OK

PWR_OK is a “power good” signal. It should be asserted high by the power supply to indicate that the +12 VDC, +5VDC, and +3.3VDC outputs are above the under-voltage thresholds listed in Section 3.2.1 and that sufficient mains energy is stored by the converter to guarantee continuous power operation within specification for at least the duration specified in Section 3.2.11, “Voltage Hold-up Time.” Conversely, PWR_OK should be de-asserted to a low state when any of the +12 VDC, +5 VDC, or +3.3 VDC output voltages falls below its under-voltage threshold, or when mains power has been removed for a time sufficiently long such that power supply operation cannot be guaranteed beyond the power-down warning time. The electrical and timing characteristics of the PWR_OK signal are given in Table 13 and in Figure 6.

Table 13. PWR_OK Signal Characteristics

Signal Type	+5 V TTL compatible
Logic level low	< 0.4 V while sinking 4 mA
Logic level high	Between 2.4 V and 5 V output while sourcing 200 μ A
High-state output impedance	1 k Ω from output to common
PWR_OK delay	100 ms < T_3 < 500 ms
PWR_OK risetime	$T_4 \leq 10$ ms
AC loss to PWR_OK hold-up time	$T_5 \geq 16$ ms
Power-down warning	$T_6 \geq 1$ ms

3.3.2. PS_ON#

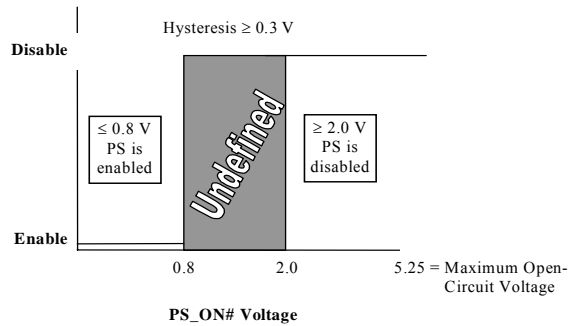
PS_ON# is an active-low, TTL-compatible signal that allows a motherboard to remotely control the power supply in conjunction with features such as soft on/off, Wake on LAN*, or wake-on-modem. When PS_ON# is pulled to TTL low, the power supply should turn on the four main DC output rails: +12VDC, +5VDC, +3.3VDC and -12VDC. When PS_ON# is pulled to TTL high or open-circuited, the DC output rails should not deliver current and should be held at zero potential with respect to ground. PS_ON# has no effect on the +5VSB output, which is always enabled whenever the AC power is present. Table 14 lists PS_ON# signal characteristics.

The power supply shall provide an internal pull-up to TTL high. The power supply shall also provide de-bounce circuitry on PS_ON# to prevent it from oscillating on/off at startup when activated by a mechanical switch. The DC output enable circuitry must be SELV-compliant.

The power supply shall not latch into a shutdown state when PS_ON# is driven active by pulses between 10ms to 100ms during the decay of the power rails.

Table 14. PS_ON# Signal Characteristics

Min.		Max.
V_{IL} , Input Low Voltage	0.0 V	0.8 V
I_{IL} , Input Low Current ($V_{in} = 0.4$ V)		-1.6 mA
V_{IH} , Input High Voltage ($I_{in} = -200$ μ A)	2.0 V	
V_{IH} open circuit, $I_{in} = 0$		5.25 V

**Figure 7. PS_ON# Signal Characteristics**

3.3.3. +5 VSB

+5 VSB is a standby supply output that is active whenever the 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 state activities.

The +5 VSB output should be capable of delivering a minimum of 2.0 A at +5 V \pm 5% to external circuits. The power supply must be able to provide the required power during a "wake up" event. If an external USB device generates the event, there may be peak currents as high as 2.5A lasting no more than 500mS.

Overcurrent protection is required on the +5 VSB output regardless of the output current rating. This ensures the power supply will not be damaged if external circuits draw more current than the supply can provide.

3.3.4. Power-on Time

The power-on time is defined as the time from when PS_ON# is pulled low to when the +12 VDC, +5 VDC, and +3.3 VDC outputs are within the regulation ranges specified in Section 3.2.1. The power-on time shall be less than 500 ms ($T_1 < 500$ ms).

+5 VSB shall have a power-on time of two seconds maximum after application of valid AC voltages.

3.3.5. Risetime

The output voltages shall rise from $\leq 10\%$ of nominal to within the regulation ranges specified in Section 3.2.1 within 0.1 ms to 20 ms ($0.1 \text{ ms} \leq T_2 \leq 20 \text{ ms}$).

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 3.2.3. 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/ms and $[V_{\text{out,nominal}} / 0.1]$ V/ms. Also, for any 5 ms segment of the 10% to 90% risetime waveform, a straight line drawn between the end points of the waveform segment must have a slope $\geq [V_{\text{out,nominal}} / 20]$ V/ms.

3.3.6. Overshoot at Turn-on / Turn-off

The output voltage overshoot upon the application or removal of the input voltage, or the assertion/deassertion of PS_ON#, under the conditions specified in Section 3.1, shall be less than 10% above the nominal voltage. No voltage of opposite polarity shall be present on any output during turn-on or turn-off.

3.3.7. Reset after Shutdown

If the power supply latches into a shutdown state because of a fault condition on its outputs, the power supply shall 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.

3.3.8. +5 VSB at AC Power-down

After AC power is removed, the +5 VSB standby voltage output should remain at its steady state value for the minimum hold-up time specified in Section 3.2.11 until the output begins to decrease in voltage. The decrease shall be monotonic in nature, dropping to 0.0 V. There shall be no other perturbations of this voltage at or following removal of AC power.

3.4. Output Protection

3.4.1. 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 in Table 15.

Table 15. Overvoltage Protection

Output Min.	Nom.	Max.	Unit	
+12 V1DC & +12V2DC	13.4	15.0	15.6	Volts
+5 VDC	5.74	6.3	7.0	Volts
+3.3 VDC	3.76	4.2	4.3	Volts

3.4.2. Short-circuit Protection

An output short circuit is defined as any output impedance of less than 0.1 ohms. The power supply shall shut down and latch off for shorting the +3.3 VDC, +5 VDC, or +12 VDC rails to return or any other rail. The +12 V1DC and +12V2DC should have separate short circuit and overload protection. Shorts between main output rails and +5 VSB shall not cause any damage to the power supply. The power supply shall either shut down and latch off or fold back for shorting the negative rails. +5 VSB must be capable of being shorted indefinitely, but when the short is removed, the power supply shall recover automatically or by cycling PS_ON#. The power supply shall be capable of withstanding a continuous short-circuit to the output without damage or overstress to the unit (for example, to components, PCB traces, connectors) under the input conditions specified in Section 3.1. The maximum short-circuit energy in any output shall not exceed 240 VA, per IEC 60950 requirements.

3.4.3. No-load Operation

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

3.4.4. Over-current Protection

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

3.4.5. Over-temperature Protection

The power supply may include an over-temperature protection sensor, which can trip and shut down the power supply at a preset temperature point. Such an overheated condition is typically the result of internal current overloading or a cooling fan failure. If the protection circuit is nonlatching, then it should have hysteresis built in to avoid intermittent tripping.

3.4.6. Output Bypass

The output return may be connected to the power supply chassis. The return will be connected to the system chassis by the system components.

4. Mechanical

4.1. Labeling / Marking

The following is a non-inclusive list of suggested markings for each power supply unit. Product regulation stipulations for sale into various geographies may impose additional labeling requirements.

- Manufacturer information: manufacturer's name, part number, and lot date code, etc., in human-readable text and/or bar code formats
- Nominal AC input operating voltages (100-127 VAC and 200-240 VAC) and current rating certified by all applicable safety agencies (Section 8)
- DC output voltages and current ratings
- Access warning text (“Do not remove this cover. Trained service personnel only. No user serviceable components inside.”) in English, German, Spanish, French, Chinese, and Japanese with universal warning markings

4.2. Physical Dimensions

The supply shall be enclosed and meet the physical outline shown in either Figure 8 or 9, as applicable.

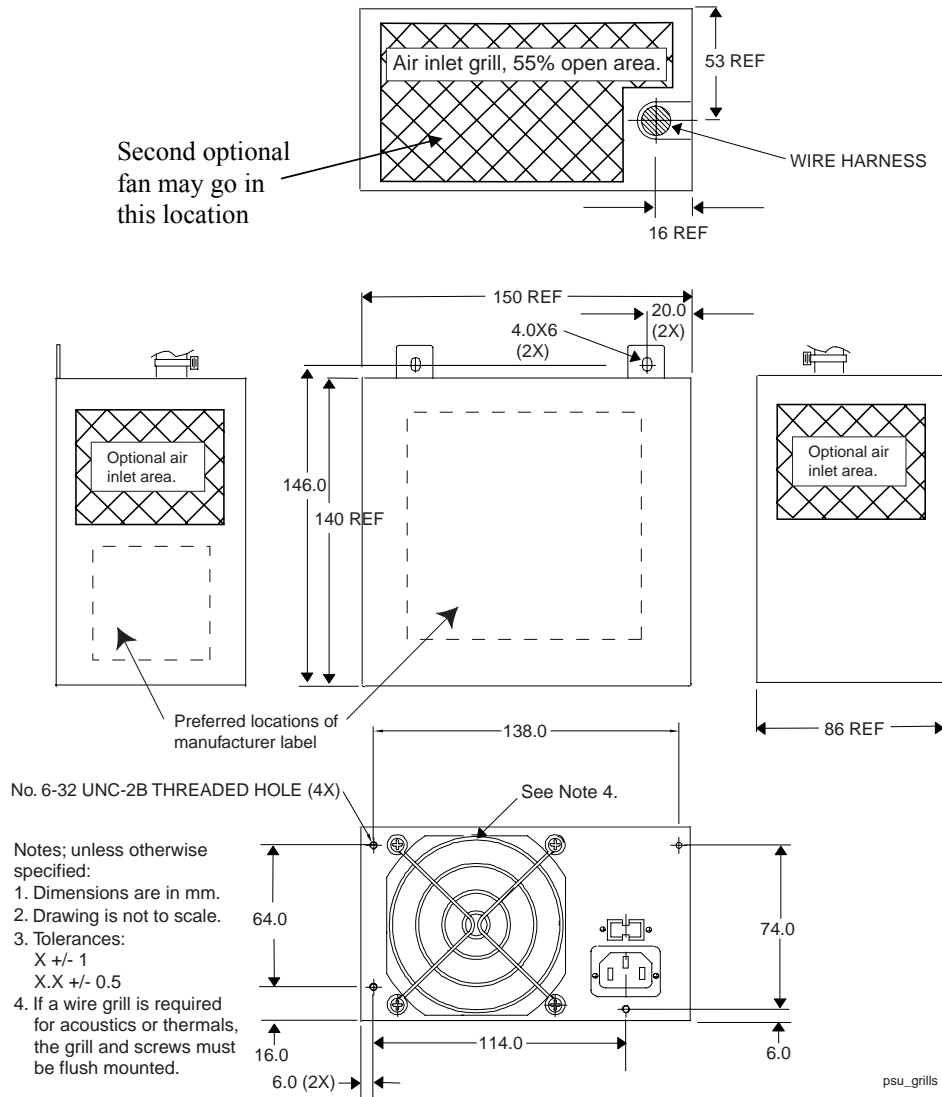


Figure 8. Power Supply Dimensions for Chassis That Does Not Require Top Venting

4.3. Airflow / Fan

The *ATX Specification* allows for numerous (and often confusing) possibilities for power supply fan location, direction, speed, and venting. The designer's choice of a power supply cooling solution depends in part on the targeted end-use system application(s). At a minimum, the power supply design must ensure its own reliable and safe operation.

Fan location/direction. In general, exhausting air from the system chassis enclosure via a power supply fan at the rear panel is the preferred, most common, and most widely applicable system-level airflow solution. Other solutions are permitted, including fans on the topside of figure 5 and the Wire harness side of figure 4 or 5. Some system/chassis designers may choose to use other solutions to meet specific system cooling requirements.

Fan size/speed. An 80 mm or larger axial fan is typically needed to provide enough cooling airflow through an average ATX system. Exact CFM requirements vary by application and end-use environment, but 25-35 CFM is typical for the fan itself.

For consumer or other noise-sensitive applications, it is recommended that a thermally sensitive fan speed control circuit be used to balance system-level thermal and acoustic performance. The circuit typically senses the temperature of an internal heatsink and/or incoming ambient air and adjusts the fan speed as necessary to keep power supply and system component temperatures within specification. Both the power supply and system designers should be aware of the dependencies of the power supply and system temperatures on the control circuit response curve and fan size and should specify them very carefully.

The power supply fan should be turned off when PS_ON# is de-asserted (high). In this state, any remaining active power supply circuitry must rely only on passive convection for cooling.

Venting. In general, more venting in a power supply case yields reduced airflow impedance and improved cooling performance. Intake and exhaust vents should be as large, open, and unobstructed as possible so as not to impede airflow or generate excessive acoustic noise. In particular, avoid placing objects within 0.5 inches of the intake or exhaust of the fan itself. A flush-mount wire fan grill can be used instead of a stamped metal vent for improved airflow and reduced acoustic noise.

There are three caveats to the venting guidelines above:

- Openings must be sufficiently designed to meet the safety requirements described in Section 8.
- Larger openings yield decreased EMI-shielding performance (see Section 6).
- Venting in inappropriate locations can detrimentally allow airflow to bypass those areas where it is needed.

The *ATX Specification* offers two options for venting between the power supply and the system interior:

- The venting shown in Figure 8 provides the most effective channeled airflow for the power supply itself, with little regard for directly cooling any system components. This venting method is nearly always used in conjunction with a fan that exhausts out the rear of the power supply.
- The venting shown in Figure 9 allows designers to more directly couple the power supply airflow to system components such as the processor or motherboard core, potentially cooling all critical components with a single fan. Both the power supply fan location and direction may vary in this case. The trade-off is usually one of reduced system cost versus narrower design applicability.

4.4. AC Connector

The AC input receptacle should be an IEC 320 type or equivalent. In lieu of a dedicated switch, the IEC 320 receptacle may be considered the mains disconnect.

4.5. DC Connectors

Figure 10 shows pinouts and profiles for typical ATX power supply DC harness connectors.

Listed or recognized component appliance wiring material (AVLV2), CN, rated min 85 °C, 300 VDC shall be used for all output wiring.

There are no specific requirements for output wire harness lengths, as these are largely a function of the intended end-use chassis, motherboard, and peripherals. Ideally, wires should be short to minimize electrical/airflow impedance and simplify manufacturing, yet they should be long enough to make all necessary connections without any wire tension (which can cause disconnections during shipping and handling). Recommended minimum harness lengths for general-use power supplies are 280 mm for the +12 V power connector and 250 mm for all other wire harnesses. Measurements are made from the exit port of the power supply case to the wire side of the first connector on the harness.

NOTE

Details of the 2x3 “Optional Power Connector” mentioned in the ATX 2.03 Specification are omitted from this design guide until such time as the signals on that connector are more rigidly defined.

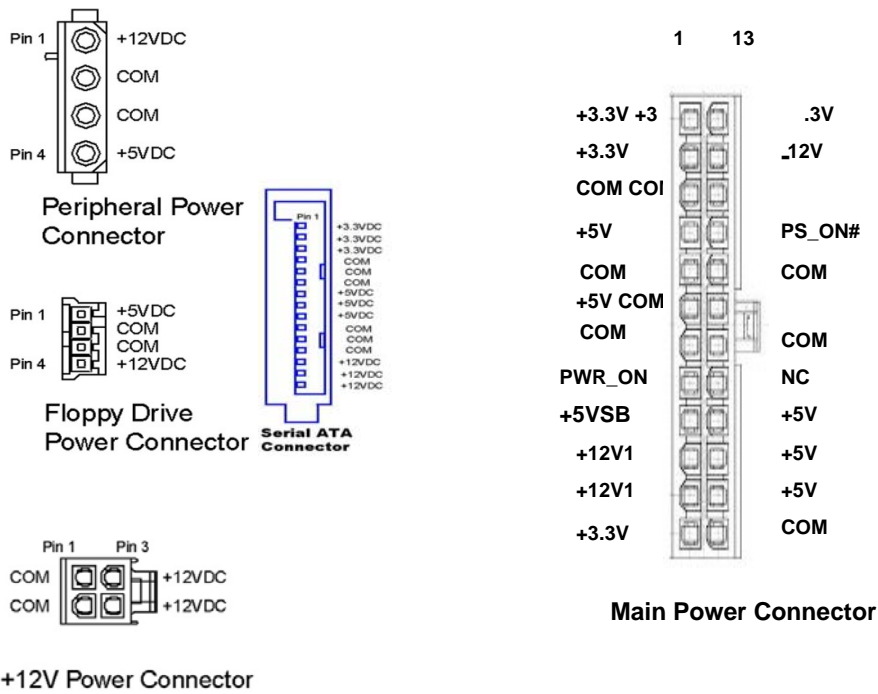


Figure 10. ATX12V Power Supply Connectors
(Pin-side view, not to scale)

4.5.1. ATX Main Power Connector

Connector: MOLEX* housing: 24 Pin Molex Mini-Fit Jr. PN# 39-01-2240 or equivalent

(Mating motherboard connector is Molex 44206-0007 or equivalent)

18 AWG is suggested for all wires except for the +3.3 V sense return wire, pin 13 (22 AWG). For 300 W configurations, 16 AWG is recommended for all +12 VDC, +5 VDC, +3.3 VDC, and COM.

Pin	Signal	Color	Pin	Signal	Color
1 +	3.3VDC	Orange	13	+3.3VDC	Orange
			[13]	[+3.3 V default sense]	[Brown]
2 +3	.3VDC	Orange	14	-12VDC	Blue
3	COM Bla	ck	15	COM B	lack
4 +5	VDC	Red	16	PS_ON#	Green
5	COM Bla	ck	17	COM B	lack
6 +5	VDC	Red	18	COM	Black
7	COM Bla	ck	19	COM B	lack
8 P	WR_OK	Gray	20	Reserved	N/C
9 +5	VS _B	Purple	21	+5VDC	Red
10 +1	2 V1DC	Yellow	22	+5VDC	Red
11	+12 V1DC	Yellow	23	+5 VDC	Red
12 +3	.3 VDC	Orange	24	COM	Black

4.5.2. +12 V Power Connector

Connector: MOLEX 39-01-2040 or equivalent
(Mating motherboard connector is Molex 39-29-9042 or equivalent)

Pin	Signal	18 AWG Wire	Pin	Signal	18 AWG Wire
1	COM	Black	3	+12V2DC	Yellow /Black Stripe
2	COM	Black	4	+12V2DC	Yellow/ Black Stripe

4.5.3. Peripheral Connector(s)

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

Contacts: AMP 61314-1 or equivalent.

Pin	Signal	18 AWG Wire
1 +	12V1DC	Yellow
2	COM	Black
3	COM	Black
4 +	5VDC	Red

4.5.4. Serial ATA Power Connector

This is a required connector for systems with Serial ATA* devices.

The detailed requirements for the Serial ATA Power Connector can be found in the “Serial ATA: High Speed Serialized AT Attachment” specification, Section 6.3 “Cables and connector specification”. <http://www.serialata.org/>

Assembly: Molex 88751 or equivalent

Wire	Signal	18 AWG Wire
5 +3	.3 VDC	Orange
4 C	OM	Black
3	+5 VDC	Red
2 C	OM	Black
1 +1	2 V1DC	Yellow

Molex Housing #675820000 or equivalent
Molex Terminal #675810000 or equivalent

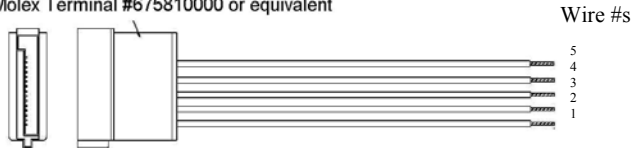


Figure 11. Serial ATA Connector

4.5.5. Floppy Drive Connector

Connector: AMP 171822-4 or equivalent

Pin	Signal	20 AWG Wire
1 +	5VDC	Red
2	COM	Black
3	COM	Black
4 +	12V1DC	Yellow

5. Environmental

The following subsections define recommended environmental specifications and test parameters, based on the typical conditions to which an ATX12V power supply may be subjected during operation or shipment.

5.1. Temperature

Operating ambient	+10 °C to +50 °C (At full load, with a maximum temperature rate of change of 5 °C/10 minutes, but no more than 10 °C/hr.)
Non-operating ambient	-40 °C to +70 °C (Maximum temperature rate of change of 20 °C/hr.)

5.2. Thermal Shock (Shipping)

Non-operating	-40 °C to +70 °C
15	°C/min \leq dT/dt \leq 30 °C/min Tested for 50 cycles; Duration of exposure to temperature extremes for each half cycle shall be 30 minutes.

5.3. Humidity

Operating	To 85% relative humidity (non-condensing)
Non-operating	To 95% relative humidity (non-condensing)
	Note: 95% RH is achieved with a dry bulb temperature of 55 °C and a wet bulb temperature of 54 °C.

5.4. Altitude

Operating	To 10,000 ft
Non-operating	To 50,000 ft

5.5. Mechanical Shock

Non-operating	50 g, trapezoidal input; velocity change \geq 170 in/s Three drops on each of six faces are applied to each sample.
---------------	--

5.6. Random Vibration

Non-operating 0.01 g²/Hz at 5 Hz, sloping to 0.02 g²/Hz at 20 Hz, and maintaining 0.02 g²/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 axes on all samples.

5.7. Acoustics

For power supplies designed for low noise, the following provides some general guidance.

Guidelines Sound Power: The power supply assembly shall not produce a declared sound power level greater than 4.0 BA. Sound power determination is to be performed at 43C, 50% of maximum rated load, at sea level. This test point is chosen to represent the environment seen inside a typical system at the idle acoustic test condition, with the 43C being derived from the standard ambient assumption of 23C, with 20C added for the temperature rise within the system (what is typically seen by the inlet fan). The declared sound power level shall be measured according to ISO 7779 and reported according to ISO 9296.

Pure Tones: The power supply assembly shall not produce any prominent discrete tone determined according to ISO 7779, Annex D.

6. Electromagnetic Compatibility

The following subsections outline sample product regulations requirements for a typical power supply. Actual requirements will depend on the design, product end use, target geography, and other variables. Consult your company's Product Safety and Regulations department for more details.

6.1. Emissions

The power supply shall comply with FCC Part 15, EN55022: 1998 and CISPR 22: 1997, meeting 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 shall be adjusted as follows for three tests: No load on each output; 50% load on each output; 100% load on each output. Tests will be performed at 100 VAC 50Hz, 120 VAC 60 Hz, and 230 VAC 50 Hz power.

6.2. Immunity

The power supply shall comply with EN 55024:1998.

6.3. Input Line Current Harmonic Content and Line Flicker

For sales in EU (European Union) or Japan 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 Equipment

Harmonic Order n	<i>Per: EN 61000-3-2</i>	<i>Per: JEIDA MITI</i>
	Maximum permissible Harmonic current at <u>230 VAC / 50 Hz</u> in Amps	Maximum permissible Harmonic current at <u>100VAC / 50 Hz</u> in Amps
	Odd harmonics	
3	2.3	5.29
5	1.14	2.622
7	0.77	1.771
9	0.4	0.92
11	0.33	0.759
13	0.21	0.483
$15 \leq n \leq 39$	$0.15 \times (15/n)$	$0.345 \times (15/n)$

6.4. Magnetic Leakage Fields

A PFC choke magnetic leakage field should not cause any interference with a high-resolution computer monitor placed next to or on top of the end-use chassis.

7. Reliability

7.1. Component De-rating

The de-rating process promotes quality and high reliability. All electronic components should be designed with conservative device de-ratings for use in commercial and industrial environments.

8. Safety

The following subsections outline sample product regulations requirements for a typical power supply. Actual requirements will depend on the design, product end use, target geography, and other variables. Consult your company's Product Safety and Regulations department for more details.

8.1. North America

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

- The supply must be recognized for use in Information Technology Equipment including Electrical Business Equipment per UL 60950, 3rd edition, 2000. The certification must include external enclosure testing for the AC receptacle side of the power supply. (see Figures 8 and 9).
- The supply must 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-mentioned standard.

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 de-rating. The insulation system shall not have temperatures exceeding their rating when tested in the end product.

The certification mark shall be marked on each power supply.

The power supply must be evaluated for operator-accessible secondary outputs (reinforced insulation) that meet the requirements for SELV and do not exceed 240 VA under any condition of loading.

The proper polarity between the AC input receptacle and any printed wiring boards connections must be maintained (that is, brown=line, blue=neutral, green or green/yellow=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 3rd ed., 1999.

8.2. International

The vendor must provide a complete CB certificate and test report to IEC 60950: 3rd ed., 1999. The CB report must include ALL CB member country national deviations. CB report must include evaluation to EN 60950: 2000. All evaluations and certifications must be for reinforced insulation between primary and secondary circuits.

8.3. Proscribed Materials

Cadmium should not be used in painting or plating.

No quaternary salt electrolytic capacitors shall be used.

Mercury shall not be used.

The use of CFCs or HFCs shall not be used in the design or manufacturing process.