ATX12V and ATX12VO PSU

Design Guide Addendum

Revision 005

April 2023

Document Number: 621484-005

You may not use or facilitate the use of this document in connection with any infringement or other legal analysis. You may not use or facilitate the use of this document in connection with any infringement or other legal analysis concerning Intel products described herein. You agree to grant Intel a non-exclusive, royalty-free license to any patent claim thereafter drafted which includes subject matter disclosed herein.

No license (express or implied, by estoppel or otherwise) to any intellectual property rights is granted by this document.

All information provided here is subject to change without notice. Contact your Intel representative to obtain the latest Intel product specifications and roadmaps.

All product plans and roadmaps are subject to change without notice.

The products described may contain design defects or errors known as errata, which may cause the product to deviate from published specifications. Current characterized errata are available on request.

Intel technologies' features and benefits depend on system configuration and may require enabled hardware, software or service activation. Performance varies depending on system configuration. No computer system can be absolutely secure. Check with your system manufacturer or retailer or learn more at intel.com.

Intel disclaims all express and implied warranties, including without limitation, the implied warranties of merchantability, fitness for a particular purpose, and non-infringement, as well as any warranty arising from course of performance, course of dealing, or usage in trade.

© Intel Corporation. Intel, the Intel logo, Intel Core, Xeon, and other Intel marks are trademarks of Intel Corporation or its subsidiaries.

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

Copyright© 2020-2023, Intel Corporation. All rights reserved.

Contents

Tables

Revision History

Document Number	Revision Number	Description	Revision Date
621484	001	• Initial Release	April 2020
	002	• Updated Section 2.1.3 to cover 10th and 11th generation processor configurations.	May 2021
	003	• Added Section 2.1.4 12th Gen Processor Configurations	February 2022
	004	• Removed section for 6th and 7th Gen Intel® Core™ Processor Families • Updated Chapter 1 Introduction with PL4.app information • Added Section 2.1.5 Intel® Xeon® W-2200 and Intel® Xeon® W-3300 Processor Configurations • Added Chapter 3 – Channel PSU Guidance	June 2022
	005	• Updated Table 2-3 with latest 12th Gen Intel processor family information. • Added Section 2.1.6 13th Gen Processor Configurations • Added Section 2.1.7 Intel® Xeon® W-2400 and Intel® Xeon® W-3400 Processor Configurations • Added Table Table 3-1 12th Gen / 13th Gen Intel Core Processor Family PSU Compatibility Guidelines	April 2023

§ §

1 Introduction

This document provides additional design details to supplement multiple desktop internal power supply form factors design guides. This addendum focuses on the power requirements needed by the processor's Voltage Regulator (VR) usually specified as 12V2 in a desktop power supply design. Different generations of Intel processors have different power consumption needs and therefore the power supply needs to be able provide the power to the processor's VR.

Intel processors specify their power consumption in multiple levels. This document will translate the general processor power needs and covert them to what a power supply will need to provide. Generic power levels of Intel processors:

- **Thermal Design Power** (**TDP**): Power level defined as the long-term power consumption limit of a processor that the processors' thermal solution will need to provide cooling for. This can also be referenced as **Power Level 1** (**PL1**)

- **Power Level 2** (**PL2**): Intel® Turbo Boost Technology will increase the ratio of application power towards TDP and allows an increase in power above TDP as high as PL2 for short periods of time.
  - The period of time that a processor can stay above the TDP level and at PL2 power levels is usually less than 1 minute. This time can vary with processors and system level designs. When power supplies need to provide power beyond a few seconds that is considered a long time and therefore the PL2 power level has been defined as the "**Continuous Current**" level in the PSU Design Guide.

Note: Intel® Turbo Boost Technology may not be available on all SKUs.

- **Power Level 4** (**PL4**): Intel defines a Max Power (Current) consumption for each of its processors. This power level can only last a short amount of time, normally ≤ **10 ms**. The PSU Design Guide specifies this value as **Peak Current**

- **Power Level 4 Application** (**PL4.app**): **PL4.app** is less than **PL4** and is the electrical power drawn by the CPU representing a typical user realistic application(s) scenario at an all core turbo frequency. PL4.app represents worst case power with real world workloads. PL4.app will sustain for ≤ **10 ms**.

Intel's PSU Test Plan recommends testing the peak current value as "Peak Current FVM" for CPUs that have this value. If "Peak Current FVM" value is not provided, then Intel's Test plan will recommend using the "Peak Current" value.

The document is an addendum to the following the documents:

- Multi Rail Desktop Power Supply Design Guide
  - Desktop Platform Form Factors Power Supply Design Guide (#336521)

- Single Rail Desktop Power Supply Design Guide
  - Single Rail Power Supply Design Guide – ATX12VO (12V Only) (#613768)

§ §

2 12V2 Current Rating Definition

Power supply 12V2 current rating needs are different based on the each generation of processors supported by a system level design and associated power supply. All of the current values are based on peak and continuous current published in the most recent processor datasheet at publication of this document. Information found in the platform Electrical Design Specification (EDS supersedes the values for future revisions of the processors.

2.1 12V2 Capability Calculation Reference Equation

The 12V2 PSU rail voltage has a nominal voltage of 12 volts. The lowest acceptable voltage for this rail is 11.4 V which can include reduction from the wire's loss and Motherboard power planes loss. Motherboard VR efficiency assumption is 85% at PL2 Power, 80% at PL4 Power, and PL4_PSU Power (AKA IccMax) Motherboard plane resistance is 1.1 mΩ. If the power supply supports the 240VA Energy Hazard protection requirement, then Current levels for the 12 Volt rail above 18 Amps should be split into multiple 12V rails.

- 12V2 Peak Current = (PL4.app Power / VR efficiency) / 11.4 V
- 12V2 Continuous Current = (PL2 Power / VR efficiency) / 11.4 V
- The PL2 Power duration time as below equation:

$$PL2\ duration\ time = -(PL1tau) \times LN(1 - (PL1/PL2))$$

  - Tau values can be found in the Platform EDS listed in the Intel's Reference Documents for each processor.
- PL1 tau is CPU thermal solution dependent.
- Customers can size PSU by using the above equation only when CPU thermal PL1 tau is known.

2.1.2 8th and 9th Intel® Core™ Gen Processor Configurations

The below table is associated with 8th and 9th Gen Intel® Core™ Processor Families desktop processors for 35W, 65W, 95W, 140W and 165W. Any future revisions of the processors Datasheet would supersede these values.

The 8th and 9th Gen Intel® Core™ Processor Families peak power and current specification can be found in 8th and 9th Gen Intel® Core™ Processor Families Datasheet.

Table 2-1: 8th and 9th Gen Intel® Core™ Processor Configurations – 12V2 Current

PSU 12V2 Capability Recommendations		
Processor TDP	**Continuous Current**	**Peak Current**
165W	37.5 A	45.0 A
140W	28.0 A	39.0 A
95W	22.0 A	29.0 A
65W	21.0 A	28.0 A
35W	13 A	16.5 A

2.1.3 10th and 11th Gen Intel® Core™ Processor Configurations

The below table is associated with 10th and 11th Gen Intel® Core™ Processor Families desktop processors for 35W, 65W, 125W and 165W. Any future revisions of the processors Datasheet would supersede these values.

The 10th and 11th Gen Intel® Core™ Processor Families peak power and current specification can be found in 10th and 11th Gen Intel® Core™ Processor Families Datasheet.

Table 2-2: 10th and 11th Gen Intel® Core™ Processor Configurations – 12V2 Current

PSU 12V2 Capability Recommendations		
Processor TDP	**Continuous Current**	**Peak Current**
165W	37.5 A	40.0 A
125W	26 A	34 A
65W	23 A	30 A
35W	13 A	16.5 A

2.1.4 12th Gen Intel® Core™ Processor Configurations

The below table is associated with 12th Gen Intel® Core™ Processor Families desktop processors for 35W, 65W, 125W. Any future revisions of the processors Datasheet would supersede these values.

The 12th Gen Intel® Core™ Processor Families peak power and current specification can be found in 12th Gen Intel® CoreTM Processor Families Datasheet.

Table 2-3: 12th Gen Intel® Core™ Processor Configurations – 12V2 Current

PSU 12V2 Capability Recommendations		
Processor TDP	**Continuous Current**	**Peak Current**
125W	25.0 A	39.5 A
65W	21.0 A	34.5 A
35W	11.0 A	19.5 A

2.1.5 Intel® Xeon® W-2200 and Intel® Xeon® W-3300 Processor Configurations

The below table is associated with Intel® Xeon® W-2200 and Intel® Xeon® W-3300 Processor Families desktop processors. Any future revisions of the processors Datasheet would supersede these values.

The Intel® Xeon® W-2200 and Intel® Xeon® W-3300 Processor Families peak power and current specification can be found in Intel® Xeon® W-2200 and Intel® Xeon® W-3300 Processor Families Datasheet.

Table 2-4: Intel® Xeon® W-2200 and Intel® Xeon® W-3300 Processor Configurations – 12V2 Current

PSU 12V2 Capability Recommendations			
Intel Processor Family	**Processor TDP**	**Continuous Current**	**Peak Current**
Intel® Xeon® W-3300 Processors	270 W	33.5 A	68.5 A
	250 W	31.0 A	60.0 A
	220 W	27.0 A	50.5 A
Intel® Xeon® W-2200 Processors	165 W	20.5 A	33.5 A
	140 W	17.5 A	26.0 A

2.1.6 13th Gen Intel® Core™ Processor Configurations

The below table is associated with 13th Gen Intel® Core™ Processor Families desktop processors for 35W, 65W, 125W, 150W. Any future revisions of the processors Datasheet would supersede these values.

The 13th Gen Intel® Core™ Processor Families peak power and current specification can be found in 13th Gen Intel® CoreTM Processor Families Datasheet.

Table 2-5: 13th Gen Intel® Core™ Processor Configurations – 12V2 Current

PSU 12V2 Capability Recommendations		
Processor TDP	**Continuous Current**	**Peak Current**
150W	33.0 A	60.3 A
125W	26.5 A	38.5 A
65W	23.0 A	34.0 A
35W	11.0 A	19.0 A

2.1.7 Intel® Xeon® W-2400 and Intel® Xeon® W-3400 Processor Configurations

The below table is associated with Intel® Xeon® W-2400 and Intel® Xeon® W-3400 Processor Families desktop processors. Any future revisions of the processors Datasheet would supersede these values.

Latest Intel® Xeon® W-2400 and Intel® Xeon® W-3400 Processor Families peak power and current specification can be found in Intel® Xeon® W-2400 and Intel® Xeon® W-3400 Processor Families Datasheet.

Table 2-6: Intel® Xeon® W-2400 and Intel® Xeon® W-3400 Processor Configurations – 12V2 Current

PSU 12V2 Capability Recommendations			
Core SKU	**Processor TDP**	**Continuous Current**	**Peak Current**
Intel® Xeon® W-3400 Processors	350W	43.3 A	83.8 A
	330W	40.9 A	83.8 A
	300W	37.2 A	77.6 A
	270W	33.5 A	68.4 A
Intel® Xeon® W-2400 Processors	250W	31.0 A	59.2 A
	225W	27.9 A	50.4 A
	200W	24.8 A	42.8 A
	175W	21.7 A	37.3 A
	130W	16.1 A	26.8 A

§ §

3 Channel PSU Guidance

Intel's Channel partners may have less control over motherboard and power supply design and need to follow industry standards to build their systems. Based on that premise, this chapter includes guidance using the most recent Intel CPUs and provides a table for a Power Supply characteristics to support socket compatible designs.

The table's included in this document are used as the foundation for power supply compliance with PSUs listed on the Intel Power Supply Selector website: https://www.intel.com/content/www/us/en/collections/topics/power-supply-selector.html and https://compatibleproducts.intel.com/FeaturedLinks/psu.

Table 3-1: 12th Gen / 13th Gen Intel Core Processor Family PSU Compatibility Guidelines – 12V2 Current

PSU 12V2 Capability Recommendations				
Core SKU	**Processor TDP**	**VR Design**	**Continuous Current**	**Peak Current**
12th & 13th Gen Intel Core Processor Families	150 W	Extreme	33 A	60 A
	125 W	Performance	26 A	39 A
	65 W	Performance	23 A	34 A
	35 W	Performance	11 A	19 A

Picking a power supply for any system requires planning and consideration for components used in the system. All of the information in this document provides a current that power supplies need to provide to the 12V rail for the CPU Power connectors. This information is necessary when choosing an appropriate power supply.

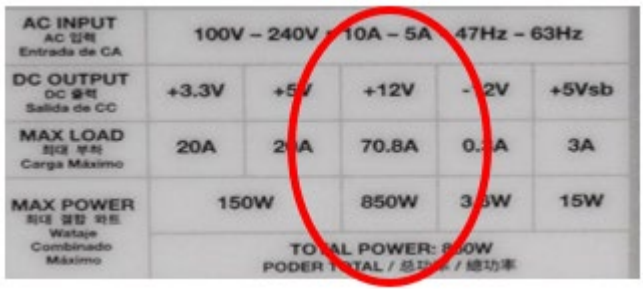
The following sections provide guidance for general power budgeting using the information included in this document for either a Desktop or HE-DT/Workstation based system.

Power supplies come in two standard ways to define the current provided by 12V power rails.

3.1 Power Supplies with 12V Rails Listed Together

Most of today's power supplies have all of the 12V rails listed together. Figure 3-1 shows an example of a power supply label for this scenario.

Figure 3-1: PSU Label with One 12V Rail



To understand if a power supply supports a specific processor in this scenario, basic power budgeting must be calculated for the rest of the system to determine if there is sufficient 12 Volt Current available for the processor. For this type of evaluation, the rest of platform power will set a basic minimum level. There can be many other scenarios where the rest of platform power will be different which can affect what processor can be supported by a specific power supply.

A basic desktop system 12 Volt Power Budget includes power to fans, storage, PCIe Add-In-Cards, LEDs and other components on the motherboard – Rest of Platform (ROP). A basic system's 12V Power requirement can range from 2 Amps to 30 Amps. For these calculations 4, 8, and 14 Amps for rest of 12V Platform power will be used as an example for Desktop systems. As noted, it is expected that each system configuration will be different.

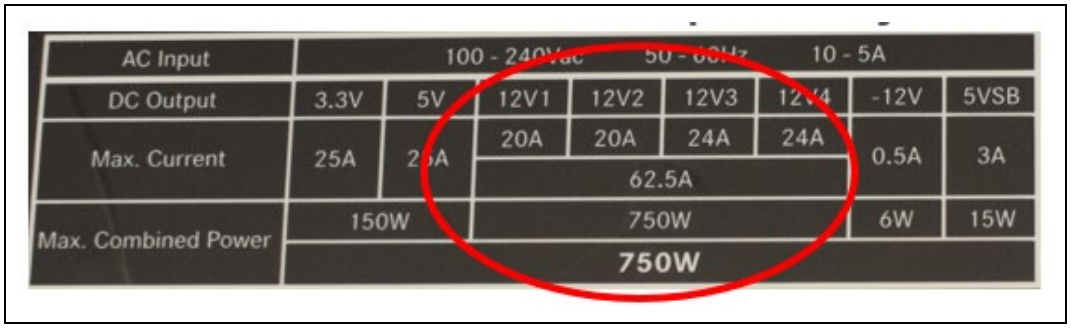
- Example calculation with integrated graphics:
  - CPU = 23A (Intel® 12th Gen Core™ Processor family 65 W TDP)
  - ROP = 4A (Simple DT ROP)
  - Total = 23A + 4A = 27 A
  - Conclusion: Choose a power supply with at least 27 A in this example.
- Example calculation with discrete graphics card power
  (need to know expected sustained power of discrete graphics card):
  - CPU = 26 A (Intel® 12th Gen Core™ Processor family 125 W TDP)
  - dGFX = 300 W = 300w/12v = 25 A
  - ROP = 8 A (median DT ROP)
  - Total = 26 + 25 + 8 =59A
  - Conclusion: Choose a PSU with at least 59 Amps for this example
- Example Calculation for Workstation processor with discrete graphics card power, Rest of Platform also increases:
  - CPU = 31 A (Intel® Xeon® W-3300 Processors processor 250 W TDP)
  - dGFX = 450 W = 450w/12v = 37.5 A
  - ROP = 14 A (median WS ROP)
  - Total = 31 + 37.5 + 14 =82.5A
  - Conclusion: Choose a PSU with at least 82.5 Amps for this example

3.2 Power Supplies with 12V Rails Listed Separately

Some power supplies list multiple 12V Rails. Most of the time these power supplies are concerned with meeting 240VA Safety requirements, and to meet these Safety

requirements, the PSU provides multiple 12V rails. Figure 3-2 is provided as an example of this type of power supply.

Figure 3-2: PSU Label with Multiple 12V Rails



Power supplies with multiple 12 Volt rails follow these breakdowns for each 12V rail:

- 12V1 = Main Board and storage power connectors,
- 12V2 = processor power connectors,
- 12V3 and 12V4 = discrete graphics card power.

In this scenario, determining CPU support it is very simple: look at the current rating for the 12V2 rail and determine if it is able to provide enough continuous current for the processor to be used.

§ §