Desktop Platforms Power Supply

Test Plan

Revision 2.1

November 2023

Document Number: 338448

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Revision History

Document Number	Revision Number	Description	Revision Date
338448	1.0	• Initial Release	October 2018
	1.1	• Adding listing of which items will be tested and descriptions for difference for ATX12VO (12 Volt Only) plus updates for PSU DG Rev 1.43 and PSU DG Addendums for future processor support. • Added list of related Power Supply documents.	July 2020
	2.0	• Section 1.1 – Major change to language, PSU Test Plan Companion Calculator is described. • Section 1.2 - Table 1-3 is new, updated language throughout the section. Section 1.2.3 was removed. • Section 1.3 – Language changed to mention both DT and HE-DT/WS processors. Removed tables for specific processors, instead have generic instructions and reference PSU DG Addendum. • Dynamic Load section was removed, more details added to Section 4.7. PSU Test Plan Companion Calculator also provides calculation so not as much detail needed. • Section 1.4 – updated to list new tests including adding the de-coupling capacitor support column. • Section 2.1 – Lists both DT & HE_DT/WS CPU examples, also reference PSU DG Addendum for continual updates. Added test scenario for both DT & HE-DT/WS supported CPUs. • Section 2.2 – Added test for both test scenario for both DT & HE-DT/WS supported CPUs. • Section2.3 – Minor updates. • Chapter 3 – Completely new section. (PCIe AIC Peak Power) • Section 4.1 – Updated all +12V Voltage low range to 11.2V • Section 4.2 – Updated test condition #11 & 12 to have similar characteristics to other tests. These tests stress 3.3V rail, other rails are now all Min or Light. • Section 4.3 – Added mention to PSU Test Plan Companion Calculator, removed mention of 12 Watt load, other minor updates. • Section 4.4, 4.5, 4.6 – Minor updates. • Section 4.7 – New detail added here previously from Section 1, Table 4-17 is new, +12V tests have all changed. • Section 5.1 – Updates to match PSU DG rev 2.0. • Section 5.2 & 5.3 – Minor updates. • Chapter 6 – Completely new Section. (I_PSU%) • Chapter 7 – Very minor updates, Energy Hazard Safety Criteria changed to "Optional" and only tested by request. • Chapter 8 – Added Test Plan table for 250W, modified 300W table, removed 350W, 400W, 450W tables. • Section 9.1 – Table 9-2 – Updated to show new grouping of +12V DC Loads for Intel Lab equipment.	June 2022
338448	2.1	• The 12VHPWR connector's PCB Header's internal pin lengths have been modified therefore the connector has been given a	October 2023

Document Number	Revision Number	Description	Revision Date
		new name. 12V-2x6 connector name has been changed throughout the document to "12V-2x6". The "Cable Plug" side of the connector has not changed and is compatible with new PCB Header connector definition.12V-2x6 Connector's Sense0/1 definition change for 150W and add 0 watt levels • Any references to PCI-SIG document about PCIe CEM 5.0 changed to Rev 5.1. Previous ECNs have been removed as these changes have been included in Rev 5.1. • Supplemental PSU Test Plan Companion Calculator update to Rev 1.2 • Section 1.3 – Updated paragraph 3, Desktop Processor 12V Rest of Power (ROP) assumptions changed to be based on supported processor. • Table 2-1– Added Top row and last row – 150W and 35W Baseline CPU support is now listed. • Table 2-2 – Added more rows to match next generation of HE-DT / Workstation processors from the PSU Design Guide Addendum. • Table 3-4 – Fixed formula based on timing used for 8% Duty Cycle test. • Updated Section 3.3 and Table 3-6 to represent new Sense pin power limit definition for 150 wats and new power level of 0 watts. New test condition if both pins are OPEN have been added to check for the "Short" • Section 3.3 – Updated Ohm value for a Ground measurement was changed from <5 ohms to <50 ohms. • Section 4.7, Table 4-19, Table 4-21, Table 4-22– Added notes that Dynamic Load tests for a PSU with a 12VHPWR connector apply independently to all 12VHPWR connector present in the PSU. • Table 4-18 – Updated sample calculation to list average 12V System power based on CPU supported based on Section 2.1. • Updated Table 4-19, the -12V Rail Dynamic Load testing condition was change from Required to Recommended. • Updated Table 5-1 and Table 5-2 to new values for T5 Required and new Recommended value. Notes at the bottom of each table also updated. • Updated Section 5.3 and Table 5-5 for new Hold up test value and test conditions. • Figure 9-1, Figure 9-2, Figure 9-3, Figure 9-4– Updated names for all pictures	

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Related Power Supply Documents

- **ATX12VO Power Supply Design Guide – Single Rail**

  ATX12VO (12V Only) Desktop Power Supply Design Guide - 613768

- **Multi-Rail ATX12V PSU Design Guide**

  ATX Version 3 Multi Rail Desktop Platform Power Supply Design Guide - 336521

- **PSU DG Addendum**

  ATX12V and ATX12VO PSU Design Guide Addendum – 621484

- **Power Supply Test Plan**

  Desktop Platforms Power Supply Test Plan - 338448

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1 Introduction

1.1 Test Plan Introduction

Detailed design requirements for various desktop internal power supply form factors are provided in these documents: ATX Multi-Rail Desktop Power Supply Design Guide (#336521) and ATX12VO Desktop Power Supply Design Guide (#613768). In 2006, the many different desktop power supply requirements and recommendations were combined into one master document since the electrical design for Multi-Rail power supplies is the same regardless of the physical size. The ATX12VO (12 Volt Only) Desktop Power Supply Design Guide defines the single rail power supply design guidelines.

This ATX Power Supply Test Plan is a companion document for both Desktop Power Supply Design Guides: ATX Multi-Rail and ATX12VO single rail. This document takes the design parameters and turns them into a test plan for desktop power supplies. This Test Plan is used for compliance testing of power supplies that may be published as part of the Intel PSU Tested List. This PSU compliance testing is currently performed in the Intel lab in Folsom, California; mentioned in the Test Plan as the "Intel Lab". The list of compliant power supplies can be found at: https://www.intel.com/content/www/us/en/resellers/psu-selector.html and

https://compatibleproducts.intel.com/FeaturedLinks/PSU

The PSU Design Guide (PSU DG) lists design parameters as either *Required* or *Recommended*. For a power supply to be included on the Compliance List, it must pass all the Required items. In the published compliance list, the Recommended items that are tested are included to communicate that the power supply meets these guidelines.

All section references are to Revision 2.0 of both power supply design guides. The ATX12VO Desktop Power Supply DG does have a few additional sections, but the majority of the section numbers are the same between both design guides.

All tests performed in the Intel lab are done at ambient room temperature. This is typically around 25°C, ±5°C.

Calculation for specific loading criteria can be very complicated. To simply these calculations there is a ***PSU Test Plan Companion Calculator*** that is distributed with this document. There are two sheets in this spreadsheet. The first sheet titled – "Main Test Plan Companion" includes a place to enter basic PSU characteristics then provide loading conditions for the following items:

- Efficiency Loading Calculation
- CPU Peak Load Testing Conditions for both Desktop and Workstation CPUs
- CPU Continuous Load Testing Conditions
- PCIe* Gen 5 Power Excursion Testing Conditions
- Dynamic Load Test Conditions

The second sheet in the calculator is specifically the new I_PSU% feature specific to only ATX12VO power supplies. The three testing conditions defined in chapter 6 of this document, show the testing conditions as well as a place to enter measured data to determine if each of these criteria are passing their specifications.

The DC Voltage Range for all DC Outputs are the same for all tests and therefore listed in the introduction. This is referenced in PSU DG, Section 4.2.1 – DC Voltage Regulation.

Table 1-1: Multi-Rail DC Load Voltage Ranges

Outputs Voltage	Voltage Range (V)		
	Min	Typical	Max
+5V	4.75	5.0	5.25
+3.3V	3.13	3.3	3.47
-12V	-13.2	-12.0	-10.8
+5VSB	4.75	5.0	5.25
+12V1	11.2	12.0	12.6
+12V2	11.2	12.0	12.6

Table 1-2: ATX12VO DC Load Voltage Ranges

Outputs Voltage	Voltage Range (V)		
	Min	Typical	Max
+12V1	11.2	12.0	12.6
+12V2	11.2	12.0	12.6
+12VSB	11.2	12.0	12.6

1.2 Calculation of Loading Values

Throughout this document a few basic terms are used for the loading conditions for each test. One of these criteria is the “min” load or Minimum Load. The Minimum Load is meant to represent the smallest amount of loading a desktop computer would consume. Most of the time the minimum load for specific voltage rails is used while other voltage rails are being stressed.

Table 1-3: Minimum DC Load Test Condition

Outputs Voltage	Minimum DC Load Test Condition (A)
+5V	0.2
+3.3V	0.1
-12V	0.0

Outputs Voltage	Minimum DC Load Test Condition (A)
+5VSB / +12VSB	0.0
+12V1	0.1
+12V2	0.05

The "max" or Maximum Loading condition for a power supply is defined as what the sticker or rated current limit is for individual voltage rail.

Loading conditions for a PSU are calculated using two different methods:

1. Efficiency loading conditions.
2. Selection between Test Plan Table and Sticker loading conditions

The reason for two slightly different loading conditions is to optimize loading conditions and test results for all test items. Some power supplies may have the same loading conditions for both methods. Power supplies with one combined 12V rail will likely see the biggest differences. In this scenario, spreading the current load over as many connectors as possible increases efficiency results.

ATX12VO power supplies do not have Test Plan Tables and therefore this does not apply to those single rail power supplies.

1.2.1 Efficiency Loading Conditions

Efficiency loading conditions are always determined using the sticker values on the power supply. The Efficiency loading conditions are determined using the calculations that are described in Section 6.1.1 of the *Generalized Test Protocol for Calculating the Energy efficiency of Internal Ac-Dc and Dc-Dc Power Supplies Revision 6.7:* *https://www.clearesult.com/80plus/sites/80plus/files/2022-01/Test_Protocol.pdf*

The calculations mentioned in this document call the following Definitions, which are used in this Test Plan.

- Full Load = 100% Load
- Typical Load = 50% Load
- Light Load = 20% Load

A few tests do use specific values for individual voltage rails. These tests are all based on a percentage of the Full Load (100%) testing condition.

With Efficiency testing, the number of 12V rails listed on the power supply is factored into the calculations. When the power supply has multiple 12V rails detailed on the sticker, then the connectors that correspond to each 12V rail are derated loading according to the sticker values.

For Multi-Rail PSUs: When the power supply has one 12V rail detailed on the sticker, then the number of physical connections available on the power supply determine how the de-rating is accomplished. The main goal of this aspect for efficiency testing is to evenly split the total 12V rail current across all 12V rail connections. The first 12V rail, 12V1, is assumed to be the Main system power which includes the 24-pin main board connector and any HDD/SATA power connections.

12V2 is assigned to the processor power connectors, either the 2x2 or 2x4 processor power connectors. Lastly, the number of 12V PCI Express graphic card power cables with any number of connectors (2x3, 2x4, or 12V-2x6) are then assumed for 12V3 and 12V4 rail connections. Some test criteria in this document reference 12V3 when talking about the PCIe* Auxiliary Power Connectors specifically.

For Single Rail PSUs: ATX12VO power supplies only have 12 Volts so this is simpler. Connections are made according to how the PSU would be connected to a system. The main 10-pin connector and one 6-pin Extra Board connector are connected to 12V1. The CPU power connector is connected to 12V2. If there are additional 6-pin PCIe* Add-in-Card auxiliary power connections which would be connected to 12V3 or 12V4 power rails.

Depending on the test equipment used these voltage rails can be combined or split up. The Intel lab combines the 12V1 and 12V3/4 rails just explained into one 12V1 rail. The 12V2 (CPU Power connectors) is connected to a unique set of DC Loads during testing. It is recommended that as many power connector be connected to the test equipment and DC loads as possible because the best efficiency results are achieved. Also, with some test conditions requiring very high current loads the loading condition needs to be spread across as many connectors as possible. If a power supply has a different design, that would need to be described by the manufacturer before testing is started at the Intel Lab.

Details of the equipment and test fixture used in the Intel Lab are described in Chapter 9 of this document.

1.2.2 Test Plan Table Loading Conditions

A second method does exist – Test Plan Table loading conditions. If a Multi-Rail power supply is 300W or lower, then the loading conditions can be based on the Test Plan Tables in Chapter 8 of this document. The purpose of the Test Plan Tables is to provide guidance of the minimum current needed for each voltage rail in a typical desktop computer. If the Test Plan Table is used for loading calculations, the Full Load is defined and then the Typical Load (50%) and Light Load (20%) are calculated from the Full Load values.

If the power supply is 300W or greater and each of the voltage rails current ratings are equal to or larger than 300W Test Plan Table load values, then the sticker values are used for calculations to determine current loading values. If the sticker values are used then an efficiency type de-rating calculation, described above, is also used for these loading conditions.

The Intel lab has multiple connections available as detailed in Section 8 of this document. The Intel lab will plug in as many connectors into the test fixture as possible. Our equipment has seven DC Loads split between two different 12V planes. 12V1 includes the Main board connector, SATA power connectors and any PCIe* Auxiliary power connectors. The Intel lab 12V1 combines multiple type of connectors since majority of power supplies have one combined 12V rail, this way testing the combined 12V rail can be better split among all the connectors. Intel lab's 12V1 lab equipment has a 12V limit of 165 Amps. 12V2 includes all CPU Power connectors. Intel Lab's equipment has a 12V2 current limit of 66 Amps.

ATX12VO power supplies only follow the Sticker portion of this section and do not follow the Test Plan Table option. The purpose of the Test Plan tables was for typical

Desktop computers loading on each voltage rail. With only one voltage rail, the recommended loading values don't need to be split between multiple voltage rails.

1.3 12V2 Processor Support and Loading Determination

The 12V2 Peak Current loading value is one of the items detailed in the *PSU Test Plan Companion Calculator*. This section describes how the calculation is made.

For latest Intel processor current values required for a power supply please reference the Intel Power Supply Design Guide Addendum (#621484).

To determine the CPU TDP level a power supply is tested for the 12V2 Peak Current Load, the calculator looks at the 12V2 rail on the Sticker /Label for that power supply. When there is multiple +12V rails, the 12V2 rail is used. This is simple for Intel processors because the 12V2 rail is dedicated to supporting processor power. When the current rating for the 12V2 rail is equal or higher than the Continuous Current value on Table 2-1, then that TDP is selected, and the corresponding peak current value is used.

If the power supply has one combined 12V rail, then some assumptions are made to determine 12V current needed for all the components in the computer. Intel desktop processors can support integrated graphics, where Intel High End Desktop (HE-DT)/Workstation require a discrete graphics card. Each of these two scenarios requires a different assumption for how much 12V current can be dedicated to the processor and the main system power and/or discrete graphics. System designers can calculate more accurately the 12V main system power. For generic power supply support an average 12V power is assumed. The assumption for Intel Desktop Processors based designs are listed below:

- 150- and 125-watt processors use 8 Amps
- 65-watt processors use 4 Amps
- 35-watt Performance processors use 2 Amps
- 35-watt Baseline processors use 1.5 Amps

The assumption for Intel HE-DT/Workstation processor is 10 amps for main system power and 17 amps for the discrete graphics card (200W) card, which results in 27 Amps for non-CPU power. Therefore, CPU support for a power supply with one combined 12V rails takes its rated 12V current and subtracts the non-CPU power for each scenario, the remaining amount is then used to look up what 12V Continuous Power is required by each type of Intel processor.

The *PSU Test Plan Companion Calculator* also has one extra scenario for HE-DT/Workstation processor support. If a power supply has the 12V-2x6 connector the max power limit of that 12V-2x6 connector is used in replacement of the 200W Graphics card (17A) in the equation.

Examples for power supplies with one combined 12V rail:

- **Intel Desktop Processor:** Sticker rated max 12V current = 40 A.
  - Formula: $(PSU's\ Rated\ 12V\ Current) - (Main\ System\ 12V\ Current) = (12V\ Current\ for\ CPU)$
  - Example With Data: 40A -8A = 32A; 32A is ≥ 26A for 125W TDP processors

- **Intel HE-DT/Workstation Processor:** Sticker rated max 12V current = 65 A.
  - Formula: $(PSU's\ Rated\ 12V\ Current) - (Main\ System\ 12V\ Current) - (dGFx\ Current) = (12V\ Current\ for\ CPU)$
  - Example with data for – Generic 200w discrete graphics support
    65A – 10A – 17A = 38A; 38A is ≥ 37.2A for 300W TDP processors
  - Example with data for – 12V-2x6 Connector support for 300W
    65A – 10A – 25A = 30A; 30A is ≥ 27.9A for 225W TDP processors

1.4 Test Items Used for Multi-Rail versus ATX12VO & Order of Testing for Intel Lab

ATX12VO power supplies provide a single 12v main rail. As such, not all test items are applicable for a single rail power supply. The table below describes which test items are to be tested for both types of power supplies.

Below is the order of testing that is used, which was determined by a couple of variables. First variable is test items that can require manual connection or measurement and have been placed at the beginning of the total test sequence. The second reason is test items that require the Capacitive Load to be applied have been grouped together. The last reason is to order the potentially more destructive tests at the end of the test program.

The order of testing list below does not need to be followed; this is only provided for reference.

Table 1-4: Test Items – Order of Testing for Both Multi-Rail and ATX12VO

PSU DG Section	Test Item	Recommended or required	De-coupling Caps[4]	Multi-Rail Testing	ATX12VO Testing
6.2	I_PSU% Delay Test	Required	Yes		X
6.1	I_PSU% Accuracy	Required	Yes		X
6.3	I_PSU% Ripple Test	Required	Yes		X
3.3	12V-2x6 Sense 0/1 Sideband Signals	Required[3]	No	X	X
4.1	AC Line Regulation	Required	No	X	X
4.2	Load / Cross Regulation (Load 0-Load 16)	Required	No	X	Not All Load Conditions [1]
4.2	Load / Cross Regulation (FL1-FL4)	Recommended	No	X	
5.3	Hold Up Time	Required	No	X	X
5.1	Timing – T0 to T6	Required[2]	No	X	X
5.2	12V/5V/3.3V Power Sequencing Test	Required	No	X	
2.3	12V2 CPU Min Load 0A	Required	No	X	

PSU DG Section	Test Item	Recommended or required	De-coupling Caps[4]	Multi-Rail Testing	ATX12VO Testing
2.2	12V2 CPU Load Continuous Current	Required[2]	No	X	X
2.1	12V2 – CPU Peak Loading	Required[2]	Yes	X	X
4.7	Dynamic Load	Required	Yes	X	X
4.6	Ripple and Noise Test	Required	Yes	X	X
3.2	Peak Power Excursions	Required	Yes	X	X
4.3	Efficiency – Main Rail(s) On	Required[2]	No	X	X
4.5	Power Factor during Efficiency testing	Recommended	No	X	X
4.4	Efficiency – Standby Rail	Required	No	X	X
7.1	Short Circuit Protection	Required	No	X	X
7.2	Over Current Protection	Required	No	X	X
7.3	Energy Hazard Safety Criteria (240VA)	Optional	No	X	

NOTE: 1 - Load Cross tests performed for ATX12VO – Load 0, 4, 5, 6, 7, 8, 9, 13, 14, 15, 16

NOTE: 2 – These Required Items do have a Minimum Required Level with other Recommended levels.

NOTE: 3 – Only applicable if the power supply has a 12V-2x6 connector

NOTE: 4 – De-coupling Caps as described in Section 4.7.

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2 Processor Specific Tests

The Power Supply Design Guide references the Power Supply Design Guide Addendum for all Intel processor specific updates. The Power Supply Design Guide Addendum details the specific 12V2 (CPU) Continuous and Peak Current Levels needed for each Intel processor family. Refer to the Power Supply Design Guide Addendum for the latest values.

All of these tests are listed as Recommended because there are different levels a power supply can be tested based on the size and rating of the power supply. All power supplies must support at least the lowest processor requirements, so there is a required element for each of these tests.

2.1 12V2 Peak Loading Test – REQUIRED

Reference sections in Power Supply (PSU) Design Guide (DG) Rev 2.0 – Section 2.1 Processor Configurations.

ATX12V (Multi-Rail) vs. ATX12VO (Single Rail):

No differences between test scenarios.

Test Condition:

PSU Test Plan Companion Calculator provides information for this test condition.

- Test the power supply at specified AC input line.
- The test duration for 12V2 Peak Amp is 10ms with the load changing from Continuous Current to Peak Current in a maximal slew-rate 2.5A/µs or 5.0 A/µs as referenced in the PSU DG Rev 2.0 – Section 4.2.2 (DC Output Current) with a duty cycle of 25% and 50%. Total test is 10 seconds for both duty cycles.
- Different test conditions for Intel's Desktop processors vs. Intel's High-End Desktop (HE-DT) / Workstation CPUs because there is overlap between power supply needs. The specific Intel processor to test is determined by the Max rated current value on the Nameplate of the PSU sticker. The *PSU Test Plan Companion Calculator* provides processor power levels for specific power supplies.

Testing for HE-DT / Workstation processor is only applicable if the power supply meets the minimum criteria for these processors. Refer Table 2-2 or the PSU Design Guide Addendum (#621484) for more up to date processor requirements.

  - If the PSU has one combined 12V rail for all connectors, there must be some current allocated to both 12V1 (Main system & Graphics cards) and 12V2 (CPU). For more details, refer to section 1.3.

The below table lists the 12V2 Continuous and Peak Current levels. For updated information, reference the Power Supply Design Guide Addendum (#621484).

Table 2-1: Intel Desktop Processor Continuous and Peak Current Values

Processor TDP	Intel Desktop Processor	
	Continuous Current	Peak Current
150 W	33 A	60 A
125W	26 A	39 A
65W	23 A	34 A
35 W Performance	11 A	19 A
35 W Baseline[1]	8.5 A	14.5 A

Note: [1] Minimum Required Current for 12V2 (CPU) Peak Loading

Table 2-2: Intel HE-DT / Workstation Processor Continuous and Peak Current Values

Processor TDP	Intel High-End Desktop / Workstation	
	Continuous Current	Peak Current
350 W	43.3 A	83.8 A
330 W	40.9 A	83.8 A
300 W	37.2 A	77.6 A
270 W	33.5 A	68.4 A
250 W	31.0 A	59.2 A
225 W	27.9 A	50.4 A
200 W	24.8 A	42.8 A
175 W	21.7 A	37.3 A
130 W	16.1 A	26.8 A

Pass Criteria:

- The DC output voltages for 12V1/12V2/5V/3.3V/-12V/5VSB shall remain within the regulation ranges specified in the PSU Design Guide when measured at the load end of the output connectors.
- 12V1 and 12V2 output voltage shall also remain in the range from 11.2V~12.6V when 12V2 is under the Peak Amp loading.
- Power supply is REQUIRED to meet the Peak Load test scenario for the lowest TDP processor listed in Table 2-1.

Test Scenarios:

If power supply meets minimum criteria to support HE-DT / Workstation processors, the table below is repeated for both Desktop processor and HE-DT / Workstation processor supported.

Table 2-3: 12V2 Peak Load Test Scenarios

AC Voltage	Duty Cycle	Time	5V	3.3V	-12V	5VSB	12V1	12V2	Test Time
115 V / 60 Hz	25%	30 ms	Light					Continuous	10 s
		10 ms	Light					Peak	
	50%	10 ms	Light					Continuous	10 s
		10 ms	Light					Peak	
230 V / 50 Hz	25%	30 ms	Light					Continuous	10 s
		10 ms	Light					Peak	
	50%	10 ms	Light					Continuous	10 s
		10 ms	Light					Peak	

2.2 12V2 Load Continuous Current – REQUIRED

References Sections in PSU DG Rev 2.0 – Section 2.1 Processor Configurations.

ATX12V (Multi-Rail) vs. ATX12VO (Single Rail):

No differences between test scenarios.

Test Condition:

PSU Test Plan Companion Calculator provides information for this test condition.

- Test the power supply at specified AC input line.
- The Continuous Current for the supported Desktop and HE-DT/Workstation processor. HE-DT / Workstation processor support has minimum power supply requirements and is only tested as applicable. Test lasts for 1 minute while PSU is at its Full Rated Wattage.
  Loading is calculated to create the full rated wattage of the power supply. Four loads (5V, 3.3V, -12V, 5VSB) all use the calculated Full Load value used for efficiency. The 12V2 load is set to the supported processor continuous current. The 12V1 load value is then calculated by using the total 12V current at the Full Load (100%) then subtracting what the current based on the supported processor.
  - See the *PSU Test Plan Companion Calculator* for details about specific power supplies.

Pass Criteria:

The DC output voltages for 12V1/12V2/5V/3.3V/-12V/5VSB should remain within the regulation ranges specified in the PSU Design Guide when measured at the load end of the output connectors.

- Power supply is REQUIRED to meet the continuous load condition for the lowest TDP processor listed in Table 2-1.

Test Scenarios:

Depending on PSU DG revision that is being tested here are the different Continuous Test Scenarios available. The testing scenario for HE-DT / Workstation processors is only tested as applicable.

Table 2-4: 12V2 Load Continuous Test Scenarios

AC Voltage	5V	3.3V	-12V	5VSB	12V1	12V2	Test Time
115 V / 60 Hz	Full				Calculated	Supported Desktop CPU Value	1 min
230 V / 50 Hz	Full				Calculated	Supported Desktop CPU Value	1 min
115 V / 60 Hz	Full				Calculated	Supported Workstation CPU Value	1 min
230 V / 50 Hz	Full				Calculated	Supported Workstation CPU Value	1 min

2.3 12V2 Min Load 0A – REQUIRED

References Sections in PSU DG rev 2.0– Section 4.2.10 12V2 DC Minimum Loading.

ATX12V (Multi-Rail) vs. ATX12VO (Single Rail):

This section is not tested with ATX12VO (Single Rail) power supplies. The purpose of the test is to check if the power supply can handle zero current for 12V2 and minimum current for 12V1. With the whole system using 12 Volt rails the scenario is not applicable for ATX12VO.

Test Condition:

Test the power supply at specified AC input line and the specified loads.

- Step 1: 5V and 3.3V rails are set to Minimum Load criteria all other rails load set to 0A.
- Step 2: 12V2 load value 0A with 3V/5V running with max combine watt load mark on nameplate, while the other rails load min load as defined in the Test Plan Tables.

Pass Criteria:

The DC output voltages for 12V1/12V2/5V/3.3V/-12V/5VSB should remain within the regulation ranges specified in the PSU Design Guide when measured at the load end of the output connectors.

Test Scenarios:

Table 2-5: 12V2 Min Load 0A Test Scenarios

AC Voltage	5V	3.3V	-12V	5VSB	12V1	12V2	Test Time
115 V / 60 Hz	0.2A (min)	0.1A (min)	0A	0A	0A	0A	10 s
	Max Combine		Min			0A	10 s
230 V / 50 Hz	0.2A (min)	0.1A (min)	0A	0A	0A	0A	10 s
	Max Combine		Min			0A	10 s

NOTE: If the 5V and 3.3V rated combined load is larger than 120W on nameplate, we apply the 5 V and 3.3 V max load as 120W.

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3 PCIe* Add-in Card Power Excursions

Section 3 of the Power Supply Design Guides defines considerations for power supplies specific to PCI Express (PCIe*) Add-in Cards. This section outlines unique tests to support these PCIe* Add-in cards. This includes testing for Power Excursion allowance and new Sense line requirements.

3.1 PCIe* Add-in Card Power Excursions Background

PCI Express* Card Electro-Mechanical (CEM) specifications prior to Revision 5.1 did not provide any provision an Add-in Card to exceed the TDP power for its designated power range. This effectively constrained the absolute power consumption of each Add-in Card to a hard limit such as 10W, 75W, 150W, 225W, or 300W, even when it would be advantageous for it to make short-duration high-current demands on a power rail in support of short burst power requirements for the AIC.

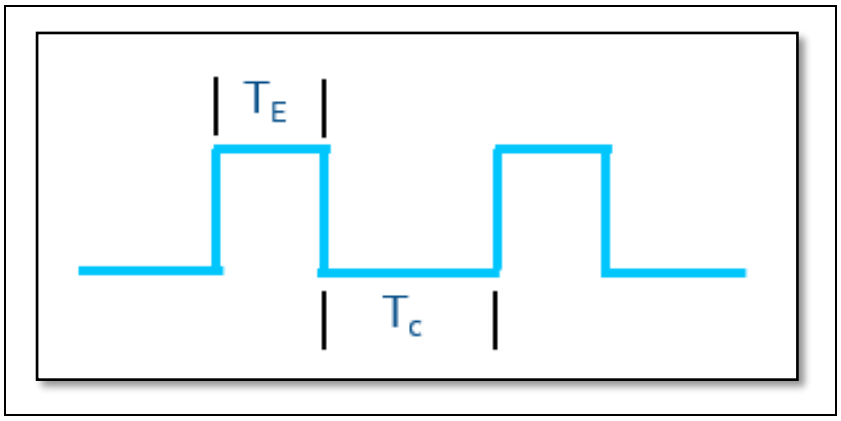
These strict limits to the PCIe* power requirements made testing a Power Supply much simpler with predefined Power Levels. However, now that Power Excursions have been defined by PCIe* CEM and the Power Supply Design Guide has translated these requirements to what a Power Supply needs to provide, testing is very important to ensure a power supply can meet these requirements.

There are many factors to decide what kind of Peak Power Requirements apply to specific power supplies. These factors include:

- Presence of 12V-2x6 Connector
  - Power excursion not available with legacy 2x3 and 2x4 Auxiliary Power Connectors.
- Does PSU provide I_PSU% signal.
- Wattage rating of Power Supply

Both Power Supply Design Guides have the same Table 3-1 for a power supply without I_PSU%. This tables will be used to help determine the test conditions for a specific power supply. It also defines the Peak Power Values and the time for the Power Excursion (T_E) that all power supplies must meet comply with. Figure 3-1 is a visual representation of the peak power excursion test to be performed.

Figure 3-1: Duty Cycle Definition



3.2 Peak Power and Excursions Testing (REQUIRED)

Table 3-1: PCIe* AIC and PSU Power Budget used for Peak Power Excursion

Power Excursion % of PSU Rated Size PSU ≤ 450 Watts & PSUs without 12V-2x6 Connector	Power Excursion % of PSU Rated Size PSU > 450 Watts & 12V-2x6 Connector present	Time for Power Excursion (T_E)	Testing Duty Cycle
150%	200%	100 µs	5%
145%	180%	1 ms	8%
135%	160%	10 ms	12.5%
110%	120%	100 ms	25%
100%	100%	Infinite	--

In below table the Duty Cycle Example Test Criteria for a 1000W PSU – RMS. This table shows an example of the testing values for power excursion of a 1000 Watt power supply. Table 3-4 shows the formulas for defining the Power @ T_C for specific power supplies.

Table 3-2: Duty Cycle Example Test Criteria for a 1000W PSU – RMS

Duty Cycle	Time Constant (T_C)	Time for Power Excursion (T_E)	Power @ T_C	Power @ T_E
5%	1900 µs	100 µs	918W	2000W
8%	11.5 ms	1 ms	897W	1800W
12.5%	70 ms	10 ms	882W	1600W
25%	300 ms	100 ms	924W	1200W

NOTES:

1. The Capacitive Load mentioned in Section 4.7 is expected to be applied to this test scenario.

2. Total Test time for each Power Excursion testing time is expected to last until thermal saturation occurs in the PSU.

All power supplies need to do a similar calculation to Table 3-4. The T_E value is calculated based on the size of the power supply and Table 3-1 or Table 3-3. The T_C value can be calculated using the formulas in Table 3-4.

If a power supply support Psys and provides the I_PSU% signal than the peak power requirements are different. Table 3-3 shows the different peak power requirements for a power supply with I_PSU%.

Table 3-3: PCIe* AIC and PSU Power Budget used for Peak Power Excursion

Power Excursion as a % of PSU Size			Time for Power Excursion (T_E)	Testing Duty Cycle
≤450 Watts or any PSU without a 12V-2x6 connector	450 Watts < PSU < 1000 Watts	≥1000 Watts		
150%	200%	200%	110 µS	5%
130%	130%	150%	1mS	8%
120%	120%	120%	10mS	12.5%
110%	110%	110%	100mS	25%
100%	100%	100%	Infinite	--

In the table below, "PSU_W" = PSU rated Wattage and % is the Peak Power requirement based on the above Tables. The "%" value is the Power Excursion as a % of PSU size as listed in either Table 3-1 or Table 3-3: PCIe* AIC and PSU Power Budget used for Peak Power Excursion.

Table 3-4: Peak Power Testing Formulas – RMS

Duty Cycle	Time for Power Excursion (TE)	Time for Power Constant (TC)	Power @ TE	Power @ TC
5% without I_PSU%	100 µs	1900 µs	% * PSU_W	$\sqrt{\left(\frac{20-\%^2}{19} * PSU\_W^2\right)}$
5% With I_PSU%	110 µs	1890 µs	% * PSU_W	$\sqrt{\left(\frac{2000-110*\%^2}{1890} * PSU\_W^2\right)}$
8%	1 ms	11.5 ms	% * PSU_W	$\sqrt{\left(\frac{12.5-\%^2}{11.5} * PSU\_W^2\right)}$

Duty Cycle	Time for Power Excursion (TE)	Time for Power Constant (TC)	Power @ TE	Power @ TC
12.5%	10 ms	70 ms	% * PSU_W	$\sqrt{\left(\frac{8-\%^2}{7} * PSU\_W^2\right)}$
25%	100 ms	300 ms	% * PSU_W	$\sqrt{\left(\frac{(4-\%^2}{3} * PSU\_W^2\right)}$

In the above table, the total power for the Peak Power events is defined. The final step for testing is translating the total power/current to each. Voltage rail: The *PSU Test Plan Companion Calculator* spreadsheet provide a mechanism to determine both the total power and individual voltage rail current during all of the Te & Tc peak power events. The *PSU Test Plan Companion Calculator* is based on the following criteria.

- These Voltage rails stay the same between T_E and T_C
  - 5V and 3.3V voltage rails (ATX Multi-Rail power supplies only) start at 80% of full load criteria.
    - This can be derated if the 12V Main System power requirement is not maintained.
  - -12V voltage rails is set to 0 Amps as this is a legacy voltage rail and not expected to be used in most of today's systems
  - Standby power rail (5VSB or 12VSB) is set to 20% of full load criteria.
- Total 12V power rail accounts for the difference during the peak power events because CPU and PCIe* Add-in-Card will use the peak power events, which use 12V power from the power supply. The *PSU Test Plan Companion Calculator* breaks out the 12V power into two different current ratings. Based on the test equipment used or power supply design, these current values can be kept separate or combined into one 12V current for each testing criteria.
  - Based on the CPU supported by the power supply the 12V2 current is defined for both T_E and T_C.
  - In the *PSU Test Plan Companion Calculator*, the rest of the 12V power is combined as 12V1. This consists of 12V Main System power and 12V PCIe* Add-in-Card power.
    - The 12V Main System power is constant between the T_E and T_C. This 12V Main System minimum power is determined by the size of the power supply and is included in the *PSU Test Plan Companion Calculator*.

      This minimum power level is important to ensure the total 12V1 calculation is representative of a real system. This will limit the 5V and 3.3V power to an expected system value and make sure that realistic PCIe* Add-in-Card 12V power allowance is as close to real peak events as defined by the PCIe* CEM Rev 5.1.

- The 12V PCIe* Add-in-Card power is different between T_E and T_C event. This power is calculated as the remaining power needed to reach the total power as defined by the peak power event and duty cycle RMS Calculations.

References Sections in PSU DG Rev 2.0 – Section 3.1.2 PSU Power Excursion.

ATX12V (Multi-Rail) vs. ATX12VO (Single Rail):

All ATX12VO power supplies are required to have the I_PSU% therefore the Peak Power % will use Table 3-3: PCIe* AIC and PSU Power Budget used for Peak Power Excursion

All ATX Multi-Rail power supplies will use Table 3-4: Peak Power Testing Formulas – RMS to define the Peak Power %.

Test Condition:

All test conditions are described previously in Section 3.1 of this document and specific values for each power supply are calculated in the *PSU Test Plan Companion Calculator*.

Pass Criteria:

The DC output voltages shall remain within the regulation ranges specified in the above PSU specification when measured at the load end of the output connectors.

Test Scenarios:

As defined in multiple tables in this section there will be 4 peak power events test scenarios. Each of the 4 testing scenarios shall be tested at both standard AC power: 115V / 60 Hz and 230V / 50 Hz. Each test scenario shall be performed for 1 minute.

Table 3-5: Peak Power Excursion Test Scenarios

AC Voltage	Time for Power Excursion (T_E)	Time for Power Constant (T_C)	Testing Duty Cycle	Test Time
115 V / 60 Hz	100 µs / 110 µs	1900 µs / 1890 µs	5%	1 min
	1 ms	11.5 ms	8%	1 min
	10 ms	70 ms	12.5%	1 min
	100 ms	300 ms	25%	1 min
230 V / 50 Hz	100 µs / 110 µs	1900 µs / 1890 µs	5%	1 min
	1 ms	11.5 ms	8%	1 min
	10 ms	70 ms	12.5%	1 min
	100 ms	300 ms	25%	1 min

3.3 12V-2x6 Connector Sense0/1 Testing (REQUIRED*)

A power supply is required to provide 2 out of the 4 sideband signals for the 12V-2x6 connector If a power supply leaves SENSE0/1 as OPEN/OPEN then any PCIe Add-in Card that requires this connector will not be able to draw any power on the 12V-2x6 connector.

The power supply is required to label the 12V-2x6 connector (or modular power supplies can include this on the rating sticker) with the power level it can support through the 12V-2x6 connector. This power level will be needed to know what the condition of the sense lines needs to be based on the information in Table 3-6. This Table provides the power level in the far-right column – "Maximum Sustain Power after Software Configuration" and the Sense line voltage level in the first 2 columns.

Table 3-6: PCI Express* 12V-2x6 Connector Power Limits

SENSE0	SENSE1	Initial Permitted Power at System Power Up	Maximum Sustain Power after Software Configuration
Ground	Ground	375 W	600 W
Open	Ground	225 W	450 W
Ground	Open	150 W	300 W
Short		100 W	150 W
Open	Open	0 W	0 W

ATX12V (Multi-Rail) vs. ATX12VO (Single Rail):

Applies to any power supply with a 12V-2x6 Connector.

Test Condition:

Based on the power level supported by the power supply to the 12V-2x6 connector the sense lines continuity / resistance levels and/or Voltage level needs to be verified.

Once the power supply is turned on (PS_ON# is asserted) and under minimum load condition the 12V-2x6 Connector Sense0 & Sense1 lines must be measured to verify the continuity / resistance levels and/or Voltage level

Required test condition:

1. Measure continuity between each of the Sense0 and Sense1 pins of the 12V-2x6 connector to a ground pin.
2. If both Sense0 & Sense1 read an "Open" value, then measure the resistance between the 2 pins (resistance between Sense0 to Sense1).

Optional Test Condition: Measures the voltage level between each of the Sense 0 and Sense1 pins of the 12V-2x6 connector to a ground pin. This would simulate what a PCIe Add-in Card would do to read the Sense pins. The Test Fixture needs to provide a 4.7k resistor pulled up to +3.3V. The voltage is measured on the Sense pin side of the 4.7k resistor.

Pass Criteria:

Required: Based on power level supported by the power supplies' 12V-2x6 connector the voltage levels will be as follows:

- Check #1
  - Ground < 50 ohms
  - Open – Infinite impedance or > 1 M ohms
- Check #2 (if both pins are "Open" with resistance measurement to ground)
  - Resistance measurement from Sense0 to Sense1 < 1 ohm

Optional Voltage Check:

- Ground <= 0.3 Volts
- Open > 3.0 Volts, should be 3.3V

Test Scenarios:

Test scenario follows Table 1-3 – Minimum Load condition at 115V / 60Hz then measure the Sense0/1 as described in the Test Condition section.

3.4 12V-2x6 Connector Other Side Band Signals Testing (OPTIONAL)

The 12V-2x6 Connector has 2 sideband signals that are optional for the power supply to support.

- CARD_PWR_STABLE
- CARD_CBL_PRES#

Because these are optional sideband signals a future revision of the PSU Test Plan will cover test scenarios for these items. For more details about these signals reference the PCIe Card Electromechanical (CEM) Revision 5.1 Specification.

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4 Electrical

4.1 AC Line Regulation – REQUIRED

References Sections in PSU DG Rev 2.0 – Section 4.1 AC Input and Section 4.2.1 DC Voltage Regulation.

ATX12V (Multi-Rail) vs. ATX12VO (Single Rail):

No differences between test scenarios.

Test Condition:

- Test the power supply at specified AC input line and loads.
- Specification of DC Voltage Range for all DC voltage outputs.
- Test time for each test scenario = 1 second

Table 4-1: DC Load Voltage Ranges for ATX12V (Multi-Rail)

Outputs Voltage	Voltage Range (V)		
	Min	Typical	Max
+5V	4.75	5.0	5.25
+3.3V	3.14	3.3	3.47
-12V	-13.2	-12.0	-10.8
+5VSB	4.75	5.0	5.25
+12V1	11.2	12.0	12.6
+12V2	11.2	12.0	12.6

Table 4-2: DC Load Voltage Ranges for ATX12VO (Single Rail)

Outputs Voltage	Voltage Range (V)		
	Min	Typical	Max
+12V1	11.2	12.0	12.6
+12V2	11.2	12.0	12.6
+12VSB	11.2	12.0	12.6

Pass Criteria:

The DC output voltages shall remain within the regulation ranges specified in the above PSU specification when measured at the load end of the output connectors.

Test Scenarios:

Table 4-3: AC Line Regulation Test Scenarios

Criteria	DC Load	AC Line Regulation Voltage/Frequency	Required or Recommended	Test Time
1	Typical Load	90V / 60 Hz	Required	1 s
2	Typical Load	135V / 60 Hz	Required	1 s
3	Typical Load	180V / 50 Hz	Required	1 s
4	Typical Load	265V / 50Hz	Required	1 s
5	Typical Load	90V / 47 Hz	Recommended	1 s
6	Typical Load	90V / 63 Hz	Recommended	1 s
7	Typical Load	135V / 47Hz	Recommended	1 s
8	Typical Load	135V / 63 Hz	Recommended	1 s
9	Typical Load	180V / 47Hz	Recommended	1 s
10	Typical Load	180V / 63 Hz	Recommended	1 s
11	Typical Load	265V / 47Hz	Recommended	1 s
12	Typical Load	265V / 63 Hz	Recommended	1 s

4.2 Load/Cross Regulation – REQUIRED

References Sections in PSU DG rev 2.0 – Section 4.2.1 DC Voltage Regulation and Section 4.5.3 No Load Situation.

ATX12V (Multi-Rail) vs. ATX12VO (Single Rail):

ATX12VO tests only 12 Volt rails. Full Load 1 to Full Load 4 are not applicable for a 12 Volt Only power supply. Refer test scenarios section for details.

Test Condition:

- All Testing done at both 115 V/60 Hz and 230 V/50 Hz.
- DC Loads are determined to test a wide variety of conditions between low and high loading for each rail.
- Power supplies that one combined 12V rail do not need to test scenarios 7, 8, 9.
- Test time for each test scenario = 1 second

Test Scenarios:

Table 4-4: Load/Cross Regulation Test Scenarios for ATX12V (Multi-Rail) – REQUIRED

Loading						
Load	**+5V**	**+3.3V**	**-12V**	**+5VSB**	**+12V1**	**+12V2**
0	Min					
1	Light	Min				
2	Typical	Min				
3	Full	Min				
4	Min				Light	Min
5	Min				Typical	Min
6	Light		Min		Full	Min
7	Min					Light
8	Min					Typical
9	Light		Min			Full
10	Min	Light	Min			
11	Min	Typical	Min			
12	Light	Full	Light			
13	Light					
14	Typical					
15	Full					
16	No Load					

Table 4-5: Load/Cross Regulation Test Scenarios for ATX12VO (Single Rail) – REQUIRED

Loading			
Load	**+12VSB**	**+12V1**	**+12V2**
0	Min		
4	Min	Light	Min
5	Min	Typical	Min
6	Min	Full	Min
7	Min	Min	Light
8	Min	Min	Typical
9	Min	Min	Full
13	Light		
14	Typical		

Loading			
Load	**+12VSB**	**+12V1**	**+12V2**
15	Full		
16	No Load		

Full Load test scenarios are below. These Full Load test scenarios are recommendation only for ATX12V (MR) and stress the Max rating for 5V, 3.3V, 12V1, and 12V2 while the DC output equals a Full Load value. FL3 and FL4 will only be tested if the Multi-Rail power supply has two or more independent 12V rails. If the Multi-Rail power supply has only one combined 12V rail, then FL3 and FL4 are not tested.

Table 4-6: Load/Cross Regulation Test Scenarios for ATX12V (Multi-Rail) – RECOMMENDATION

Loading						
Load	**+5V**	**+3.3V**	**-12V**	**+5VSB**	**+12V1**	**+12V2**
FL1	(Left over w/3.3V)	Max (nameplate)	Full			
FL2	Max (Nameplate)	(left over with 5V)	Full			
FL3	Full				(Max)	(Leftover with 12V1)
FL4	Full				(Leftover with 12V2)	Max

4.3 Efficiency – Main Rails On (ENERGY STAR and CEC) (Required)

References Sections in PSU DG rev 2.0 – Section 4.5.8 Overall Power Supply Efficiency Levels and Section 4.5.9 Power Supply Efficiency for Energy Regulations

ATX12V (Multi-Rail) vs. ATX12VO (Single Rail):

Differences include the loading condition for 10W load for ATX12VO designs. Also, the Low Load Efficiency Pass criteria for ATX12VO designs.

Test Condition:

PSU Test Plan Companion Calculator provides more detailed information for this test condition.

- Before starting Efficiency testing a Burn In (testing at 100% Load) is required for a minimum of 15 mins. Each required efficiency level is to be tested for 5 minutes.
- Test the power supply with nominal line voltage and the following loads.
  - DC Loading Conditions calculated using Section 6.1.1 of the Generalized Test Protocol for Calculating the Energy efficiency of Internal Ac-Dc and Dc-Dc Power

Supplies Revision 6.7. 100% Load condition is otherwise known as Full Loading in the Test Plan.

- Other DC Output load conditions are determined to match up with the 80 Plus program, or to provide more information as how efficiency drops off at the low load condition.
  - Efficiency test results from the Intel Lab will only be provided in the test report. The listing for the power supply on the Intel Tested PSU List website will reflect the 80 plus rating received for that model from the 80plus.org website.
- **Low Load Efficiency:** The Lowest load point is determined based on computers Idle DC Load. The 10W DC Load values are the same for all PSU that are less than 500W. If the PSU is 500W or greater, then the 2% Load will be used for the Low Load Efficiency measurement.

Table 4-7: 10W Load Condition for ATX12V (Multi-Rail) PSU Less Than 500 Watts

Load	+5V	+3.3V	-12V	+5VSB	+12V1	+12V2
10W	0.50	0.15	0.0	0.1	0.33	0.22

Table 4-8: 10W Load Condition for ATX12VO (Single Rail) PSU Less Than 500 Watts

Load	+12VSB	+12V1	+12V2
10W	0.04	0.6	0.2

Pass Criteria:

- The power supply shall meet the Intel minimum percentage efficiency under specified loading as shown in Table 4-9, Table 4-10, Table 4-11, and Table 4-12.
- **Low Load Efficiency:**
  - ATX12V (Multi-Rail) pass criteria for a power supply to be listed on the Intel Tested List for Low Load Efficiency is meeting 60% efficiency @ 10W load. The 10W load efficiency is recommended to be 70%. The Intel Tested PSU List will detail the 10 Watt / 2% Load efficiency on the public list for all passing power supplies. This requirement only applies to testing at AC Voltage of 115V/60Hz.
  - ATX12VO (Single Rail) pass criteria for a power supply to be listed on the Intel Tested PSU List for Low Load Efficiency is meeting 70% efficiency @ 10W/ 2% load. The Intel Tested PSU List will detail the 10 Watt / 2% Load efficiency on the public list for all passing power supplies. This requirement only applies to testing at AC Voltage of 115V/60Hz

Note: For different government energy regulations there are different levels of efficiency that are required.

- ENERGY STAR* Computers Ver 8.0 requires 80 Plus* Bronze for power supplies of 500 Watts or less. Above 500 Watts the PSU must meet the 80 Plus* Gold levels. Reference ENERGY STAR for Computers website for latest information (www.energystar.gov).
  California Energy Commission's (CEC) Computer Standard has power supply efficiency requirements for High Expandability Computers. Depending on how the computer classifies as a High Expandability Computer, the requirement prescribes a power supply above 600 Watts must be 80 Plus* Gold. Reference the CEC Computer Standard website for details.

- Test results will show which 80 Plus* level the power supply reaches for both 115V and 230V.

Test Scenarios:

Test Report will fill in the 2nd Column with measured values – under header "115V Efficiency" or "230V Efficiency" in the examples below.

Table 4-9: Example Efficiency Table from Test Report – 115V – ATX12V (Multi-Rail)

Load	Intel Min (Required)	80 Plus*	80 Plus* Bronze	80 Plus* Silver	80 Plus* Gold	80 Plus* Platinum	80 Plus* Titanium	Applicable Specification
			ENERGY STAR* Required ≤500W		ENERGY STAR* Required >500W	ENERGY STAR* Adder possible	ENERGY STAR* Adder possible	
100%	70%	80%	82%	85%	87%	89%	90%	80 Plus* and ENERGY STAR*
50%	72%	80%	85%	88%	90%	92%	94%	
20%	65%	80%	82%	85%	87%	90%	92%	
15%	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
10%	N/A	N/A	80%	80%	80%	86%	90%	ENERGY STAR* only
5%	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
10W/ 2%	60% Required	N/A	N/A	N/A	N/A	N/A	N/A	
10W/ 2%	70% Recommend	N/A	N/A	N/A	N/A	N/A	N/A	

Table 4-10: Example Efficiency Table from Test Report – 115V – ATX12VO (Single Rail)

Load	Intel Min (Required)	80 Plus* Bronze	80 Plus* Silver	80 Plus* Gold	80 Plus* Platinum	80 Plus* Titanium	Applicable Specification
		ENERGY STAR* Required ≤500W		ENERGY STAR* Required >500W	ENERGY STAR* Adder possible	ENERGY STAR* Adder possible	
100%	82%	82%	85%	87%	89%	90%	80 Plus* and ENERGY STAR*
50%	85%	85%	88%	90%	92%	94%	
20%	82%	82%	85%	87%	90%	92%	
15%	N/A	N/A	N/A	N/A	N/A	N/A	
10%	N/A	80%	80%	80%	86%	90%	ENERGY STAR* only

Load	Intel Min (Required)	80 Plus* Bronze	80 Plus* Silver	80 Plus* Gold	80 Plus* Platinum	80 Plus* Titanium	Applicable Specification
		ENERGY STAR* Required ≤500W		ENERGY STAR* Required >500W	ENERGY STAR* Adder possible	ENERGY STAR* Adder possible	
5%	N/A	N/A	N/A	N/A	N/A	N/A	
10W / 2%	70% Required	N/A	N/A	N/A	N/A	N/A	

Table 4-11: Example Efficiency Table from Test Report – 230V – ATX12V (Multi-Rail)

Load	Intel Min (Required)	80 Plus*	80 Plus* Bronze	80 Plus* Silver	80 Plus* Gold	80 Plus* Platinum	80 Plus* Titanium	Applicable Specification
			ENERGY STAR* Required ≤500W		ENERGY STAR* Required >500W			
100%	**70%**	**82%**	**85%**	**87%**	**89%**	**90%**	**91%**	**80 Plus* and ENERGY STAR***
50%	**72%**	**85%**	**88%**	**90%**	**92%**	**94%**	**96%**	
20%	**65%**	**82%**	**85%**	**87%**	**90%**	**92%**	**94%**	
15%	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
10%	N/A	N/A	N/A	N/A	N/A	N/A	**90%**	
5%	N/A	N/A	N/A	N/A	N/A	N/A	N/A	

Table 4-12: Example Efficiency Table from Test Report – 230V – ATX12VO (Single Rail)

Load	Intel Min (Required)	80 Plus* Bronze	80 Plus* Silver	80 Plus* Gold	80 Plus* Platinum	80 Plus* Titanium	Applicable Specification
		ENERGY STAR* Required ≤500W		ENERGY STAR* Required >500W			
100%	**82%**	**85%**	**87%**	**89%**	**90%**	**91%**	**80 Plus* and ENERGY STAR***
50%	**85%**	**88%**	**90%**	**92%**	**94%**	**96%**	
20%	**82%**	**85%**	**87%**	**90%**	**92%**	**94%**	
15%	N/A	N/A	N/A	N/A	N/A	N/A	
10%	N/A	N/A	N/A	N/A	N/A	**90%**	

Load	Intel Min (Required)	80 Plus* Bronze	80 Plus* Silver	80 Plus* Gold	80 Plus* Platinum	80 Plus* Titanium	Applicable Specification
		ENERGY STAR* Required ≤500W		ENERGY STAR* Required >500W			
5%	N/A	N/A	N/A	N/A	N/A	N/A	

4.4 Efficiency – Standby Rail [Europe (ErP Lot 3/6) and Alternative Low Power Mode (ALPM)] (REQUIRED)

References Sections in PSU DG rev 2.0 – Section 4.2.4 Other Low Power System Requirements.

ATX12V (Multi-Rail) vs. ATX12VO (Single Rail):

Similar testing is done for both ATX12V and ATX12VO for the same reasons, but the testing conditions and Pass Criteria are different.

Test Condition:

- Test the power supply with nominal line voltage and the following loads.
- Measured with the main output voltages off (PS_ON# high state), Standby Voltage rail only (5V or 12V).
- Before starting Efficiency testing a Burn In (testing at 100% Load on the Standby rail) is required for a minimum of 15 mins. Each required efficiency level is to be tested for 5 minutes.

Pass Criteria:

- The power supply shall be a minimum percentage efficiency under specified loading.
- Pass levels are determined based on multiple Energy Regulations and what loading is needed from a complete system level is then split between PSU loss and system DC load to meet the AC Wattage limit.

Test Scenarios:

Extra testing is done to see the whole curve for 5VSB Voltage Rail efficiency.

Table 4-13: 5VSB Efficiency Targets and Test Scenarios – ATX12V (Multi-Rail)

5VSB Load Target	5VSB Actual Load	Efficiency Target (Both 115 V and 230 V Input)	Remark
Max / Label	3.0 A /Label	75%	Recommended
1.5 A		75%	ALPM and ErP* Lot 3 2014
1.00 A		75%	Recommended

5VSB Load Target	5VSB Actual Load	Efficiency Target (Both 115 V and 230 V Input)	Remark
0.55 A		75%	ALPM and ErP* Lot 3/6 2014
0.25 A			
100 mA			
90 mA			
70 mA			
45 mA		45%	ErP* Lot 3/6 2013
20 mA			

Table 4-14: 12VSB Efficiency Targets and Test Scenarios – ATX12VO (Single Rail)

12VSB Load Target	12VSB Actual Load	Efficiency Target (Both 115 V and 230 V Input)	Remark
Max / Label	1.5A /Label	75%	Recommended
1.0 A			
0.625 A		75%	ALPM and ErP Lot 3 2014
400 mA		75%	Recommended
230 mA		75%	ALPM and ErP* Lot 3/6 2014
100 mA			
50 mA			
38 mA			
29 mA			
19 mA		45%	ErP* Lot 3/6 2013

4.5 Power Factor - RECOMMENDED

There are multiple programs that require Power Factor values as part of the Efficiency Test levels of Full Load (100%) and Typical Load (50%). The 80 Plus program has the same Power Factor requirement at different testing levels based on the program. Efficiency requirements from ENERGY STAR and CEC also include a Power Factor requirement at certain levels.

ATX12V (Multi-Rail) vs. ATX12VO (Single Rail):

No difference between test scenarios.

Test Condition:

Test the power supply with nominal line voltage and the following loads.

Pass Criteria:

The power supply shall be a minimum Power Factor under specified loading.

Test Scenarios:

Table 4-15: Power Factor During Efficiency Testing

Load	80 Plus Required	ENERGY STAR* Required	CEC – Computers
100%	0.90 – 80 Plus only	N/A	N/A
50%	0.90 = Bronze and higher	0.90	0.90 (Required - 600W and 80 Plus Gold or higher)
Short Idle (10W/ 2%)			Value is reported (Reference)

CEC Computers Standard requires that during Short Idle (screen on) testing for all computers, the power factor will be reported in the system level test report. There is no pass/fail requirement for Power Factor at this current time. The 10W or 2% Low Load testing levels are designed to replicate the Short Idle testing for power supplies. Reference PSU DG Rev 2.0 - Section 3.5.8 Overall Power Supply Efficiency Levels.

4.6 Ripple and Noise Test – REQUIRED

References Sections in PSU DG rev 2.0 – Section 4.2.5 Output Ripple Noise, Section 4.3.1 PWR_OK, and Section 4.3.3 PS_ON#.

ATX12V (Multi-Rail) vs. ATX12VO (Single Rail):

Similar testing is done for each appropriate voltage output.

Test Condition:

- Test the power supply at AC input line and measured the PSU under load condition shown in the below table.
- Add a 0.1µF ceramic capacitor in parallel with 10µF electrolytic capacitor at the output connector terminals.
- Test time for each test condition is to be at least 250 milli-seconds.

Pass Criteria:

The ripple of power supply should be within the specification.

Table 4-16: Ripple and Noise Pass Criteria

Output	Maximum Ripple and Noise (mV p-p)	ATX12V (MR) or ATX12VO (SR)
+5V	50	ATX12V (MR)
+3.3V	50	ATX12V (MR)

Output	Maximum Ripple and Noise (mV p-p)	ATX12V (MR) or ATX12VO (SR)
-12V	120	ATX12V (MR)
+5VSB	50	ATX12V (MR)
+12VSB	120	ATX12VO (SR)
+12V1	120	ATX12V (MR) & ATX12VO (SR)
+12V2	120	ATX12V (MR) & ATX12VO (SR)
PWR_OK	400	ATX12V (MR) & ATX12VO (SR)
PS_ON	400	ATX12V (MR) & ATX12VO (SR)

Test Scenarios:

Table 4-17: Ripple and Noise Test Scenarios

Criteria	DC Load	AC Line Regulation Voltage/Frequency
1	Light (20%) Load	115V / 60 Hz
2	Full (100%) Load	115V / 60 Hz
3	Light (20%) Load	230V / 50 Hz
4	Full (100%) Load	230V / 50 Hz

4.7 Dynamic Load – REQUIRED

References Sections in PSU DG rev 2.0 – Section 4.2.6 Capacitive Load and Section 4.2.2 DC Output Current.

ATX12V (Multi-Rail) vs. ATX12VO (Single Rail):

Same testing is done for each appropriate voltage output.

Test Condition:

Detailed Dynamic Load testing values are shown in the *PSU Test Plan Companion Calculator* distributed with this document.

The 12V Voltage rail tests have multiple tests because of all the components that use 12V in a desktop computer which are described below. There are 3 main type of 12V voltage tests:

1. Total 12V System Power
2. Processor Specific Tests
   a. Desktop processor
   b. HE-DT/Workstation processor

3. PCIe* Add-in-Card Tests
   a. PSU without 12V-2x6 connector
   b. PSU with 12V-2x6 connector
      a. Test criteria depends on the number of 12V-2x6 connectors and each 12V-2x6 connector Power limit that is included with the PSU. Each 12V-2x6 connector in the system must get loaded independently and tested at the same time for the Dynamic Load test. The *PSU Test Plan Companion Calculator* shows calculations of test criteria for up to two 12V-2x6 connector included with a power supply.

How these loading conditions apply to each power supply is related to the design of the power supply and how many 12V voltage rails are present. Refer Table 4-18 below for more details on each test scenario is determined.

Table 4-18: 12V Dynamic Tests based on PSU type

Type of 12V Dynamic Test	PSU with Multiple 12V Rails	PSU with one combined 12V Rail
Total 12V System Power	Rated 12V1 current	Rated Total +12V current
Processor Specific	Rated 12V2 current	Based on processors support calculated in Section 2.1
PCIe* Add-in-Card without 12V-2x6 Connector	Rated 12V3/V4 current	Based on calculation: Total 12V Current – DT CPU Cont. Current – (Average 12V system power – see list in Section 1.3) = PCIe* AIC rated power Example calculation: 60A – 26A – 8A = 26A
PCIe* Add-in-Card with 12V-2x6 Connector	Power level supported for 12V-2x6 connector	Power level supported for 12V-2x6 connector

Tests at AC input line and the following load changes with a 2.5A/µs or 5A/µs (based on presence of 12V-2x6 connector) slew-rate for +12V. Slew Rate for all other voltage will follow Table 4-4 in the PSU DG Rev 2.0. Testing will be done at a 50% duty cycle at both 50 Hz and 10 kHz.

Table 4-19: Dynamic Load Test Conditions

Output	De-coupling Capacitors	Voltage Limits (V)		Load Change		Required
		Min.	Max.	Low Load	High Load	ATX12V (MR) or ATX12VO (SR)
+5V	3,300µF	4.75	5.25	Min to 30% of Max	70% of Max to Max	Yes – ATX12V(MR)
+3.3V	3,300µF	3.14	3.47	Min to 30% of Max	70% of Max to Max	Yes – ATX12V(MR)
-12V	330µF	-13.2	-10.8	0A to 0.1A	0.2A to 0.3A	Recommended – ATX12V(MR)

Output	De-coupling Capacitors	Voltage Limits (V)		Load Change		Required
		Min.	Max.	Low Load	High Load	ATX12V (MR) or ATX12VO (SR)
+5VSB	3,300µF	4.75	5.25	0A to 0.5A	0.5A less than Max Rated Value to Max Rated value	Yes – ATX12V(MR)
+12VSB	3,300µF	11.2	12.6	0A to 0.5A	0.5A less than Max Rated Value to Max rated value	Yes – ATX12VO (SR)
Total +12V System	3,300µF	11.2	12.6	Min to 40% of Max	60% of Max to Max	Yes - Both
Total +12V System	3,300µF	11.2	12.6	Min to 70% of Max	30% of Max to Max	Recommended – Both
+12V DT CPU Connectors	3,300µF	11.2	12.6	Min to 85% of Supported CPU Continuous	15% of Supported CPU Continuous to Supported CPU Continuous	Yes - Both
+12V WS CPU (if applicable)	3,300µF	11.2	12.6	Min to 85% of Supported CPU Continuous	15% of Supported CPU Continuous to Supported CPU Continuous	Yes - Both
PCIe** GFX without 12V-2x6	3,300µF	11.2	12.6	Min to 80% of PCIe* AIC Power	20% of PCIe* AIC Power to PCIe* AIC Power	Recommended - Both
PCIe** GFX with 12V-2x6 (test criteria dependant on number & Power level for 12V-2x6 connectors)	3,300µF	11.2	12.6	10% of Supported 12V-2x6 power to Supported 12V-2x6 power	Supported 12V-2x6 power (T_C) to 3x Supported 12V-2x6 power (T_E) **Note:** Testing Frequency is different for this test only	Yes (if 12V-2x6 connector present) - Both

Pass Criteria:

The DC output voltages shall remain within the regulation ranges specified in Section 4-1 when measured at the load end of the output connectors for the complete test time of at least 10 seconds each test scenario.

Test Scenarios:

Test most of the scenarios in the table below in 4 overall setting

- 115V / 60 Hz + 50 Hz Dynamic Test
- 115V / 60 Hz + 10 kHz Dynamic Test

- 230V / 50 Hz + 50 Hz Dynamic Test
- 230V / 50 Hz + 10 kHz Dynamic Test

Table 4-20: Dynamic Load Test Scenarios

<table>
<tr><th colspan="6">DC Output</th></tr>
<tr><th>5V</th><th>3.3V</th><th>-12V</th><th>5VSB/
12VSB</th><th>Total 12V</th><th>12V CPU Connectors</th></tr>
<tr><td>Min to 30% of Max</td><td colspan="5">Min</td></tr>
<tr><td>70% of Max to Max</td><td colspan="5">Light</td></tr>
<tr><td>Light</td><td>Min to 30% of Max</td><td colspan="4">Min</td></tr>
<tr><td>Light</td><td>70% of Max to Max</td><td colspan="4">Light</td></tr>
<tr><td colspan="2">Min</td><td>0A to 0.1A</td><td colspan="3">Min</td></tr>
<tr><td colspan="2">Light</td><td>0.2A to 0.3A</td><td colspan="3">Light</td></tr>
<tr><td colspan="3">Min</td><td>0A to 0.5A</td><td colspan="2">Min</td></tr>
<tr><td colspan="3">Light</td><td>0.5A less than Max Rated Value to Max rated value</td><td colspan="2">Light</td></tr>
<tr><td>Light</td><td colspan="3">Min</td><td>Min to 40% of Max</td><td>Min</td></tr>
<tr><td colspan="4">Light</td><td>60% of Max to Max</td><td>Light</td></tr>
<tr><td>Light</td><td colspan="3">Min</td><td>Min to 70% of Max</td><td>Min</td></tr>
<tr><td colspan="4">Light</td><td>30% of Max to Max</td><td>Light</td></tr>
<tr><td>Light</td><td colspan="4">Min</td><td>Min to 85% of Supported CPU Continuous</td></tr>
<tr><td colspan="4">Light</td><td>10% Load</td><td>15% of Supported CPU Continuous to Supported CPU Continuous</td></tr>
</table>

If power supply has any PCIe Auxiliary Power connector then test scenarios detailed in Table 4-21 or Table 4-22 are required.

The 12V PCIe AIC with 12V-2x6 connector "High Load" test criteria are expected to go above the rated power of the power supply. Therefore, this test criteria can't be tested at the above frequency of 50 Hz and 10kHz. This test must be tested at the same time detailed in the top row of Table 3-4.

- Time for Power Constant (T_C) = 1900 us (1.9 ms)
- Time for Power Excursion (T_E) = 100 us

Table 4-21: Dynamic Load Test Scenarios – Multiple 12V Rails

DC Output						
5V	**3.3V**	**-12V**	**5VSB/ 12VSB**	**Total 12V**	**12V CPU Connectors**	**12V PCIe* AIC**
Light	Min			10% Load	Min	Min to 80% of PCIe* AIC Power
Light						20% of PCIe* AIC Power to PCIe* AIC Power
Light	Min			10% Load	Min	10% of Supported 12V-2x6 power to Supported 12V-2x6 power
Light						**Supported 12V-2x6 power to 3x Supported 12V-2x6 power for each 12V-2x6 connector

Table 4-22: Dynamic Load Test Scenarios – Combined 12V Rails

DC Output					
5V	**3.3V**	**-12V**	**5VSB/ 12VSB**	**12V CPU Connectors**	**12V PCIe* AIC**
Light	Min			10% Load	Min to 80% of PCIe* AIC Power
Light					20% of PCIe* AIC Power to PCIe* AIC Power
Light	Min			10% Load	10% of Supported 12V-2x6 power to Supported 12V-2x6 power
Light					**Supported 12V-2x6 power (T_C) to 3x Supported 12V-2x6 power (T_E) for each 12V-2x6 connector

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5 Timing

5.1 Timing – T0 to T6 – REQUIRED

References Sections in PSU DG Rev 2.0 – Section 4.3 Timing, Housekeeping, and Control; Section 4.3.1 PWR_OK; Section 4.3.4 +5VSB; Section 4.3.5 Power-On Time; Section 4.3.6 Rise Time.

ATX12V (Multi-Rail) vs. ATX12VO (Single Rail):

Same testing is done for each appropriate voltage output.

Test Condition:

- Test the power supply at AC input line and Full/Light loadings.
- There must be a smooth and continuous ramp of each DC output voltage from 10% to 90% of its final set point.

Pass Criteria:

Table 5-1: Timing (T0 to T6) Pass Criteria – ATX12V (MR)

Parameter	Description	Value		
		Legacy Timings[1]	Required	Recommended
T0	5VSB Power On time after AC Power[7]		<2s	-
T1	Power-on time	< 500 ms	< 200 ms	<150 ms[8]
T2	Rise time		0.2 – 20 ms	-
T3	PWR_OK delay[3]	100[2] – 500 ms	100[2] – 250 ms	100 ms[2] – 150 ms[8]
T4	PWR_OK rise time		< 10 ms	-
T5	AC loss to PWR_OK hold-up time[4]		> 11 ms[5]	> 16 ms[6]
T6	PWR_OK inactive to DC loss delay[4]		> 1 ms[4]	-

NOTES:

1. Value in the Legacy column from table above list timings for power supplies designed before the year 2020. In 2020, the T1 and T3 timings have moved from the Legacy timing to the new
   Required column for all new power supply designs.
2. T3 time is allowed to be lower than 100 ms to allow faster computer "turn on" time, but might break backward compatibility. For Intel testing being less than 100ms will not result in failing timing.

3. T3 time will be measured on all rails, but the Pass criteria will only be based on the 3.3V rail. T3 = +3.3V @ 95% Voltage to PWR_OK Rising (1.0 Volts). This is because the rise time for 3.3V, 5V, and +12V rails have a sequencing requirement that requires the 5V and +12V rails to be within 20ms of the 3.3V rail (Section 4.2).
4. T5 and T6 are recommended for Intel Tested List. Hold Up time is a combination of T5 + T6 which is required.
5. T5 Required value to be tested at both max/min load condition. Intel Testing is done at 100% load only.
6. T5 Recommended value is tested at 80% of full load condition.
7. Name of T0 has been updated from Intel PSU DG Rev 1.42 to provide better clarity of what T0 measurement really is. This was based on feedback from PSU vendors.
8. Timing values recommended for systems that use ALPM.

Table 5-2: Timing (T0 to T6) Pass Criteria – ATX12VO (SR)

Parameter	Description	Value	
		Required	Recommended
T0	12VSB Power On time after AC Power[5]	<2 s	-
T1	Power-on time	< 150 ms	<100 ms
T2	Rise time	0.2 – 20 ms	-
T3	PWR_OK delay	1[1] – 150 ms	1[1] – 100 ms
T4	PWR_OK rise time	< 10 ms	-
T5	AC loss to PWR_OK hold-up time[2]	> 11 ms[2, 3]	> 16 ms[2, 4]
T6	PWR_OK inactive to DC loss delay[2]	> 1 ms[2]	-

NOTES:

1. T3 time is recommended to be at least 1 ms. For Intel testing being less than 1ms will not result in failing timing.
2. T5 and T6 are recommended for Intel Tested List. Hold Up time is a combination of T5 + T6 which is required.
3. T5 Required value to be defined for both max/min load condition. Intel Testing is performance at 100% load only.
4. T5 Recommended value is defined for 80% of full load condition.
5. Name of T0 has been updated from Intel PSU DG Rev 2.0 to provide better clarity of what T0 measurement really is. This was based on feedback from PSU vendors.

Test Scenarios:

Below table lists test scenarios of the applicable voltages for both ATX12V (MR) and ATX12VO (SR).

Table 5-3: Timing (T0 to T6) Test Scenarios – (Gray Boxes - No Pass/Fail Criteria)

AC Input	DC Load	Voltage Rail	T0	T1	T2	T3	T4	T5	T6
115V / 60 Hz	Light (20%)	+5V		Yes	Yes			Yes	Yes
		+3.3V		Yes	Yes	Yes - MR		Yes	Yes

AC Input	DC Load	Voltage Rail	T0	T1	T2	T3	T4	T5	T6
230V / 50Hz	Full (100%)	-12V							
		+5VSB	Yes						
		+12VSB	Yes						
		+12V1		Yes	Yes	Yes-SR		Yes	Yes
		+12V2		Yes	Yes			Yes	Yes
		PWR_OK					Yes		
	Full (100%)	+5V		Yes	Yes			Yes	Yes
		+3.3V		Yes	Yes	Yes - MR		Yes	Yes
		-12V							
		+5VSB	Yes						
		+12VSB	Yes						
		+12V1		Yes	Yes	Yes-SR		Yes	Yes
		+12V2		Yes	Yes			Yes	Yes
		PWR_OK					Yes		
	Light (20%)	+5V		Yes	Yes			Yes	Yes
		+3.3V		Yes	Yes	Yes - MR		Yes	Yes
		-12V							
		+5VSB	Yes						
		+12VSB	Yes						
		+12V1		Yes	Yes	Yes-SR		Yes	Yes
		+12V2		Yes	Yes			Yes	Yes
		PWR_OK					Yes		
	Full (100%)	+5V		Yes	Yes			Yes	Yes
		+3.3V		Yes	Yes	Yes - MR		Yes	Yes
		-12V							
		+5VSB	Yes						
		+12VSB	Yes						
		+12V1		Yes	Yes	Yes-SR		Yes	Yes
		+12V2		Yes	Yes			Yes	Yes
		PWR_OK					Yes		

5.2 +12VDC/+5VDC/+3.3VDC Power Sequencing Test – REQUIRED

This requirement references sections in PSU DG Rev 2.0 – Section 4.2.8 +5V DC / +3.3V DC Power Sequencing.

ATX12V (Multi-Rail) vs. ATX12VO (Single Rail):

This test condition only applies to ATX12V (MR).

Test Condition:

Test the power supply at AC input line and carry out these tests under Full/Typical/Light loads.

Pass Criteria:

- The +12VDC and +5VDC output levels must be equal to or greater than the +3.3VDC output always during power-up (rise time) and normal operation.
- Measure the rise time for +3.3V, +5V, +12V voltage rails independently. The end of the test time is the minimum in-regulation value listed in Table 1-1. The time between +12VDC/+5VDC output reaching its minimum in-regulation level and +3.3VDC reaching its minimum in-regulation level must be <=20 ms.

Test Scenarios:

Table 5-4: 12VDC/5VDC/3.3VDC Power Sequencing Test Scenarios

AC Input	DC Output Load Conditions
115 V/60 Hz	Light (20%) Load
	Typical (50%) Load
	Full (100%) Load
230 V/50 Hz	Light (20%) Load
	Typical (50%) Load
	Full (100%) Load

5.3 Hold Up Time – REQUIRED

References Sections in PSU DG Rev 2.0 – Section 4.2.9 Voltage Hold-Up Time.

ATX12V (Multi-Rail) vs. ATX12VO (Single Rail):

Same testing is done for each appropriate voltage output.

Test Condition:

Test the power supply at 115VAC/47Hz and 230VAC/47Hz inputs and carry out these tests under full loads.

Pass Criteria:

All DC voltage rails shall stay above minimum value (Table 1-1) for a time greater than or equal to the values listed in Table 5-5, which comes from T5 + T6, when AC Power is removed.

Test Scenarios:

Table 5-5: Hold Up Time Test Scenarios

AC Input	DC Output Load Conditions	Pass Conditions	Required / Recommended
115 V / 47 Hz	Full (100%) Load	< 12 ms	Required
115 V / 47 Hz	80% of Full Load	< 17 ms	Recommended
230 V / 47 Hz	Full (100%) Load	< 12 ms	Required
230 V / 47 Hz	80% of Full Load	< 17 ms	Recommended

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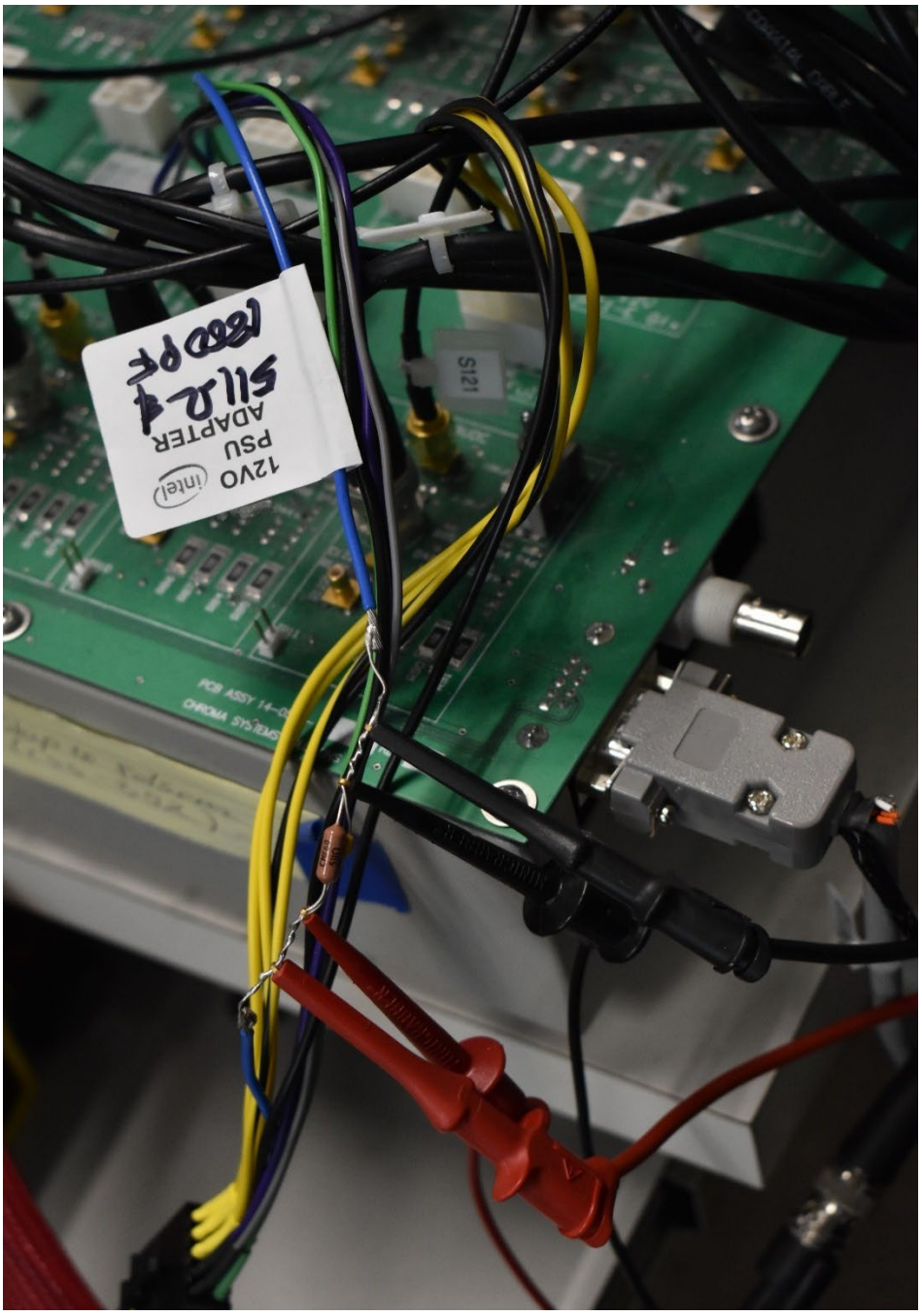
6 I_PSU% Testing

This section applies only to ATX12VO (Single-Rail) power supplies. ATX12VO power supplies have a new innovation, which includes a signal from the power supply to the desktop system to provide the percentage (%) of rated power being used by the system at all times.

To perform testing as defined in this section, the power supply test equipment must include a pull-down resistor and capacitor on the I_PSU% signal to simulate how a desktop system will be designed to use this signal. The test equipment must be able to measure the voltage across the resistor/capacitor during each of these tests. Refer Figure 6-1 for an example of how to do the measurement. The ATX12VO power supply design guide in Table 4-11 specifies that there are two resistor/capacitor combinations that must be tested each of the tests in this section.

- Low voltage scenario, full voltage = 1 Volt
  - RL_Low = 511 ohms, 1%
  - CL_Low = 1800 pF, 5%
- High voltage scenario, full voltage = 3.3 Volt
  - RL_Low = 1.65K ohms, 1%
  - CL_Low = 560 pF, 5%

Figure 6-1: Test Fixture Example Measurement Location for I_PSU% Signal



The *PSU Test Plan Companion Calculator* includes a sheet that shows the test conditions for each test and allows entry of test data to show if each test reaches the pass criteria.

6.1 I_PSU% Accuracy - REQUIRED

References Sections in PSU DG rev 2.0 – Section 4.3.7 I_PSU% Signal

ATX12V (Multi-Rail) vs. ATX12VO (Single Rail):

Only applies to ATX12VO power supplies.

Test Condition:

PSU Test Plan Companion Calculator provides more detailed information for this test condition.

- Test the power supply at 115VAC/60Hz
- Testing is conducted at a static load from 10% to 110%/120% of rated power.
- Testing is conducted at a dynamic load from 110%/120% of rated power.
  - 110%/120% is determined on each power supplies capability. If the power supply can stay on during the short time for a static load at 110% or 120% then a static load can be used. If dynamic load is needed for each of these power levels, then test must be conducted with that method.
  - Testing is required to be tested to at least 130% of rated power. Intel lab will test to 150% of rated power.
  - When testing for Dynamic Load the test time for each condition is listed in Table 6-1 & Table 6-2. Make sure to choose the correct option based on the PSU attributes shows in Table 6-2.

Table 6-1: I_PSU% Accuracy Test – Dynamic Test Time Values – 110% to 130%

Time	110% Load	120% Load	130% Load
Current Low	900 ms	90 ms	19 ms
Current High	100 ms	10 ms	1 ms

Table 6-2: I_PSU% Accuracy Test – Dynamic Test Time Values – 140% & 150%

Reason for Option	Time	140% Load	150% Load
PSU ≥ 1000 Watts & 12V-2x6 Connector	Current Low	20 ms	20 ms
	Current High	1 ms	1 ms
450 Watts < PSU < 1000 Watts & 12V-2x6 Connector	Current Low	20 ms	20 ms
	Current High	400 µs	300 µs
≤450 Watts or any PSU without a 12V-2x6 connector	Current Low	20 ms	20 ms
	Current High	200 µs	110 µs

Pass Criteria:

The measured accuracy must stay within expected value range as specified:

- ≤20% at 20 to 39% of rated power

- ≤10% at 40% to 79% of rated power
- ≤2.5% at 80% to 120% of rated power
- ≤5% at 121% to 200% of rated power

Test Scenarios:

Test all measurement values in the following scenarios with both RL & CL combinations:

- RL_low = 511 Ohms 1% for 1V @ 200% loading
- CL_low = 1800pF, 5% for 1V @ 200% loading
- RL_high = 1.65K ohm 1% for 3.3V @ 200% loading
- CL_high = 560 pF, 5% for 3.3V @ 200% loading

Table 6-3: I_PSU% Accuracy Test Scenarios

% of Rated Power	Error Rate Margin
10%	±30%
20%	±20%
30%	±20%
40%	±10%
50%	±10%
60%	±10%
70%	±10%
80%	±2.5%
90%	±2.5%
100%	±2.5%
110%	±2.5%
120%	±2.5%
130%	±5%
140%	±5%
150%	±5%

6.2 I_PSU% Delay Test - REQUIRED

References Sections in PSU DG rev 2.0 – Section 4.3.7 I_PSU% Signal

ATX12V (Multi-Rail) vs. ATX12VO (Single Rail):

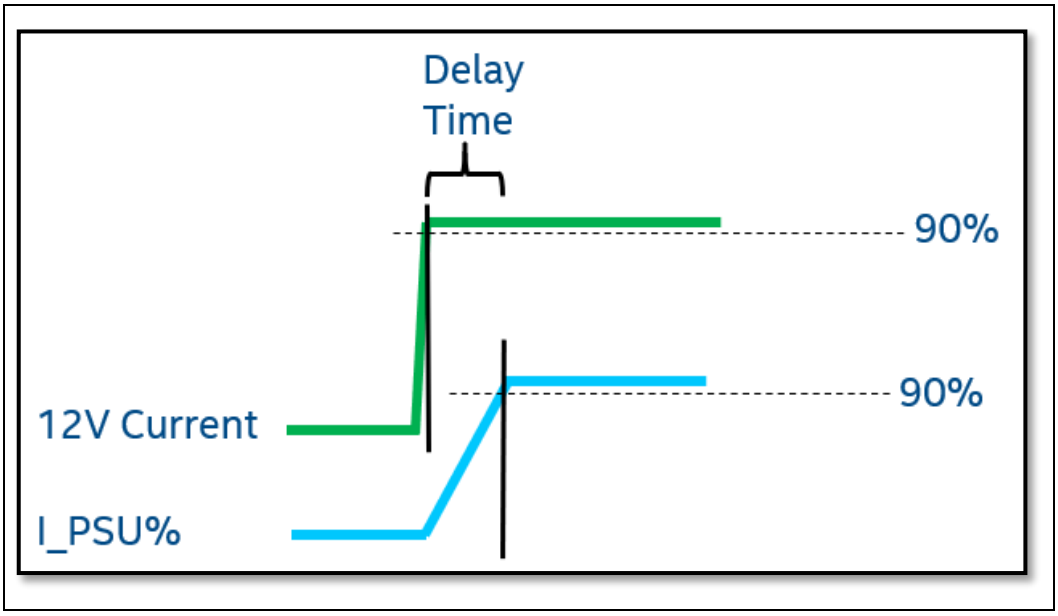
Only applies to ATX12VO power supplies.

Test Condition:

PSU Test Plan Companion Calculator provides more detailed information for this test condition.

- Test the power supply at 115VAC/60Hz.
- The capacitive load described in the PSU DG Rev 2.0 - Table 4-7 is applied to this test.
- Testing is conducted at a dynamic load from 30% (Imin) to 120% (Imax) of rated power.
- The test duration for Imax is 10ms with the load changing from Imin to Imax in a maximal slew-rate 2.5A/µs or 5.0 A/µs as referenced in the PSU DG Rev 2.0 - Section 4.2.2 (DC Output Current) with a duty cycle of 50%.
- Capture the waveform of the actual 12V workload and I_PSU% voltage and cursor the delay time between 90% of these two signals. Refer Figure 6-2 below for an example.

Figure 6-2: I_PSU% Delay Time Diagram



Pass Criteria:

The measured delay time must within expected value range as specified:

- Required: <100 uSec
- Recommended: <60 uSec

Test Scenarios:

Test all measurement values in the following scenarios.

Table 6-4: I_PSU% Delay Time Test Scenarios

Item	Test Condition 1	Test Condition 2
RL	511 Ohm, 1%	1.65K ohm, 1%
CL	1800 pF, 5%	560 pF, 5%
Imin	30% of Full Load	30% of Full Load
Imax	120% of Full Load	120% of Full Load
Dynamic Test Duty Cycle	12.5%	12.5%
Low Time	10 ms	10 ms
High Time	70 ms	70 ms

6.3 I_PSU% Ripple Test - REQUIRED

References Sections in PSU DG rev 2.0 – Section 4.3.7 I_PSU% Signal

ATX12V (Multi-Rail) vs. ATX12VO (Single Rail):

Only applies to ATX12VO power supplies.

Test Condition:

PSU Test Plan Companion Calculator provides more detailed information for this test condition.

- Test the power supply at 115VAC/60Hz.
- The capacitive load described in the PSU DG Rev 2.0 - Table 4-7 is applied to this test.
- Testing is conducted at a static load from 20% to 120% of rated power.
- Capture the waveform of the I_PSU% voltage and position the cursor to its peak-to-peak voltage.
- Test time for each test condition is to be at least 250 milli-seconds.

Pass Criteria:

The measured ripple test must be within expected value range as specified at the 100% Load:

- Required: <10% of full-scale voltage
- Recommended: <7% of full-scale voltage

Test Scenarios:

Test all measurement values in the following scenarios with both RL & CL combinations:

- RL_low = 511 Ohms 1% for 1V @ 200% loading

- CL_low = 1800pF, 5% for 1V @ 200% loading
- RL_high = 1.65K ohm 1% for 3.3V @ 200% loading
- CL_high = 560 pF, 5% for 3.3V @ 200% loading

Table 6-5: I_PSU% Ripple Test Scenarios

% of Rated Power	Scenario Low Margin (mV p-p)	Scenario High Margin (mV p-p)	Required / Reference
20%	±102.2	±330	Reference
40%	±102.2	±330	Reference
60%	±102.2	±330	Reference
80%	±102.2	±330	Reference
100%	±102.2	±330	**Required**
120%	±102.2	±330	Reference

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7 Output Protection

7.1 Short Circuit Protection (SCP) – REQUIRED

References Sections in PSU DG rev 2.0 – Section 4.5.2 Short Circuit Protection

ATX12V (Multi-Rail) vs. ATX12VO (Single Rail):

Same testing is done for each appropriate voltage output.

Test Condition:

- Test the power supply at the AC input line and carry out these tests under minimum loads.
- Basic testing is each DC Output Voltage rail shorted to ground. Advanced testing is each DC Output Voltage rails shorted to another voltage rail.

Pass Criteria:

- The main outputs shall shutdown and latch off, but the +5VSB shall remain normal, if any of the outputs are shorted to the secondary common (R < 0.1Ω) or if outputs are shorted between other outputs. All outputs shall be shut down if there is a short circuit on the +5VSB. Capable of a continuous short circuit and no damage shall result.
- To prove that no damage has resulted, the unit must turn back on after Short Circuit testing is complete.

Test Scenarios:

The Intel Lab only tests that each rail is shorted to ground. Voltage rails shorted to another voltage rail are a recommended test, but it is not tested at the Intel Lab. Hence, these cells are not grayed out but are shown as "Not Tested" in Table 7-1. Gray cells shown in the table below are not recommended to be tested.

Table 7-1: Short Circuit Protection Test Scenarios

Ac Input	Short Rail To	5V	3.3V	-12V	5VSB	12VSB	12V1	12V2
115 V/ 60Hz	GND	Tested	Tested	Tested	Tested	Tested	Tested	Tested
	3.3V	Not Tested						
	-12V	Not Tested	Not Tested					
	5VSB		Not Tested	Not Tested				
	12VSB					Not Tested		
	12V1	Not Tested	Not Tested	Not Tested	Not Tested	Not Tested		
	12V2	Not Tested	Not Tested	Not Tested	Not Tested	Not Tested		

Ac Input	Short Rail To	5V	3.3V	-12V	5VSB	12VSB	12V1	12V2
230 V/ 50Hz	GND	Tested	Tested	Tested	Tested	Tested	Tested	Tested
	3.3V	Not Tested						
	-12V	Not Tested	Not Tested					
	5VSB		Not Tested	Not Tested				
	12VSB					Not Tested		
	12V1	Not Tested	Not Tested	Not Tested	Not Tested	Not Tested		
	12V2	Not Tested	Not Tested	Not Tested	Not Tested	Not Tested		

7.2 Over Current Protection (OCP) – REQUIRED

References Sections in PSU DG rev 2.0 – Section 4.5.4 Over Current Protection.

ATX12V (Multi-Rail) vs. ATX12VO (Single Rail):

Same testing is done for each appropriate voltage output.

Test Condition:

The load is increased on one output from its maximum value at increments of 0.1A to the max rated current value for the equipment used for testing. This is done while the other outputs are kept to the minimum value. The test is repeated at different input voltages. For testing purposes, the overload currents should be ramped at a minimum rate of 1A/sec starting from rated load.

Pass Criteria:
Overload currents applied to each tested output rail will cause the output to latch into the shutdown state and no damage will occur to the PSU. To prove that no damage has resulted, the unit must turn back on after each Over Current test is complete.

Test Scenarios:

Table 7-2: Over Current Protection Test Scenarios – ATX12V (MR)

Ac Input	5V	3.3V	-12V	5VSB	12V1	12V2
115 V/ 60 Hz	Max	Min				
	Min	Max	Min			
	Min		Max	Min		
	Min			Max	Min	
	Min				Max	Min
	Min					Max
	Max	Min				

Ac Input	5V	3.3V	-12V	5VSB	12V1	12V2
230 V/ 50 Hz	Min	Max	Min			
	Min		Max	Min		
	Min			Max	Min	
	Min				Max	Min
	Min					Max

Table 7-3: Over Current Protection Test Scenarios – ATX12VO (SR)

Ac Input	12VSB	12V1	12V2
115 V / 60 Hz	Max	Min	
	Min	Max	Min
	Min		Max
230 V / 50 Hz	Max	Min	
	Min	Max	Min
	Min		Max

7.3 Energy Hazard Safety Criteria (240VA) - OPTIONAL

References Sections in PSU DG – None. Testing is only done at the Intel Labs when requested by the manufacturer because this is an optional item.

ATX12V (Multi-Rail) vs. ATX12VO (Single Rail):

Testing only performed on ATX12V (MR) designs.

Test Condition:

- The load is increased on one output from its rated value to an estimated current value which reaches 240VA output power in several steps and maintain at that power for 60s, while the other outputs are kept to the minimum value. The test is repeated at different input voltages. For testing purposes, the overload currents should be ramped at a minimum rate of 1A/sec starting from rated load.
- For each rail's output current reaching the power of 240VA, the reference value is shown in Table 7-5.

Table 7-4: DC Load Current Values to Reach 240VA

Rail	5 V	3.3 V	12V1	12V2
Current Setting to reach 240VA	48 A	73 A	20 A	20 A

Pass Criteria:

The output power cannot reach 240VA or be maintained at 240VA for 60s and therefore shuts down before it reaches the 60 second limit. Unit and all DC Voltage rails must also turn back after the test.

Test Scenarios:

Table 7-5: Energy Hazard Safety Criteria (240VA) Test Scenarios

Ac Input	5V	3.3V	-12V	5VSB	12V1	12V2
115 V / 60 Hz	240VA	Min				
	Min	240VA	Min			
	Min				240VA	Min
	Min					240VA
230 V / 50 Hz	240VA	Min				
	Min	240VA	Min			
	Min				240VA	Min
	Min					240VA

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8 Test Plan Table and Test Criteria - RECOMMENDED

The Test Plan Table only applies to ATX12V (Multi-Rail) designs and are only used as baseline minimum requirement. It is understood that power supplies with a smaller or larger wattage levels do exist. This table is recommended for standard, mainstream desktop computers. Smaller wattage power supplies can be options for purpose-built computers with minimal expandability. Larger wattage power supplies can leverage the 300-Watt table as a minimum level for each power rail and then expand beyond that based on the loading conditions of computers that need that much power.

If the PSU is equal to or greater than 300 Watts, the power supply will be tested according to the sticker (Nameplate) value on the power supply so long as all current levels for each individual rail are equal to or above the 300-Watt levels detailed for each PSU DG revision. If the power supply has a total power rating over 300 Watts, but one or more current values of an individual rail are lower than Table for 300 Watts of that revision, then loading will follow the 300-Watt table for that revision. If the Multi-Rail power supply has one 12 Volt rail instead of two 12V Voltage rails (like what is listed in sections 8.1 and section 8.2), the recommended minimum for +12V will be the 12V1 + 12V2 current values.

8.1 Test Plan Tables for 250W PSU

Table 8-1: Test Plan Tables and Test Criteria PSU DG Rev 2.0 – 250 Watt

Output Rail	5V	3.3V	-12V	5VSB	12V1	12V2
Min Load	0.2	0.1	0	0	0.1	0.05
Full (100%) Load	7.37	7.37	0.22	1.84	6.64	8.11
Max / Rated Load	10	10	.3	2.5	9	11
Peak Load				3.0		19

NOTES:
1. Total Combined output of 3.3 V and 5 V is 90W
2. Total Combined Output of both 12 V Rails is 240W.

8.2 Test Plan Tables for 300W PSU

Table 8-2: Test Plan Tables and Test Criteria PSU DG Rev 2.0 – 300 Watt

Output Rail	5V	3.3V	-12V	5VSB	12V1	12V2
Min Load	0.2	0.1	0	0	0.1	0.05
Full (100%) Load	8.25	8.25	0.23	1.9	2.7	15.5
Max / Rated Load	11	11	.3	2.5	4	23
Peak Load				3.0		34

NOTES:
1. Total Combined output of 3.3 V and 5 V is 90W
2. Total Combined Output of both 12 V Rails is 288W.

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9 Intel Test Lab Test Equipment

Table 9-1: Intel Test Lab Test Equipment

Manufacturer	Model #	Description
Chroma*	CSS8000-252B CSS8000-291 CSS8000-292	Complete Rack
Chroma*	66202	AC Digital Power Meter
Chroma*	61604	Programmable AC Source
Chroma*	63600-5	DC Load Mainframe
Chroma*	63640-80-80	High Speed DC Loads – (400-Watt max)
Chroma*	63630-80-60	High Speed DC Loads – (300-Watt max)
Chroma*	63610-80-20	High Speed DC Loads – used for 5VSB and -12V rails (100W max each side)
Chroma*	12061	Digital Multimeter
Chroma*	80612	Short Circuit-OVP Tester
Chroma*	80611	Timing and Noise Analyzer
Chroma*	80611N	Noise Card
Chroma*	62006P-600-8	Programmable DC Power Supply
Tektronix*	DPO 2024B	Oscilloscope

Figure 9-1: Intel Test Lab – Complete Rack Picture

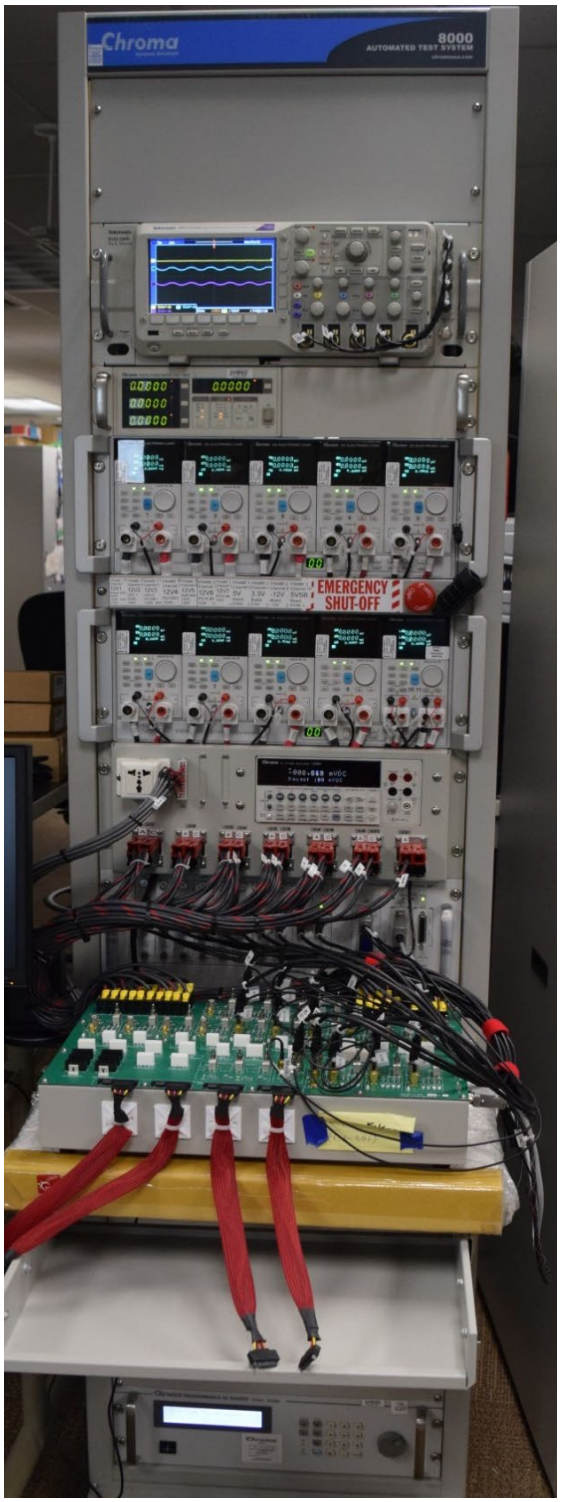


Figure 9-2: Intel Test Lab – Test Fixture Picture – No PSU Connected

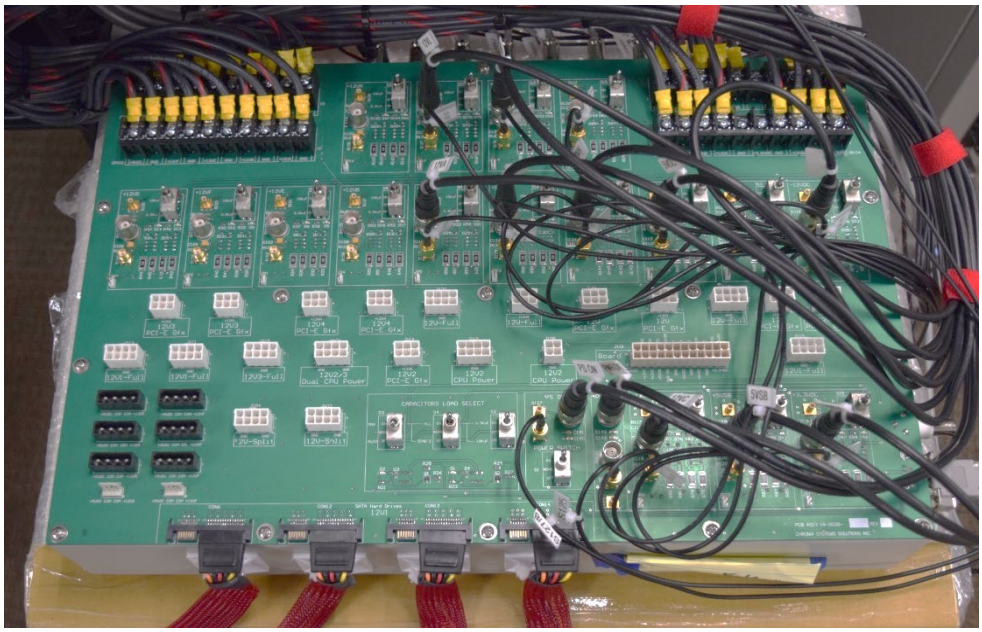


Figure 9-3: Intel Test Lab – Test Fixture Picture – Standard ATX12V (MR) Power Supply Connected

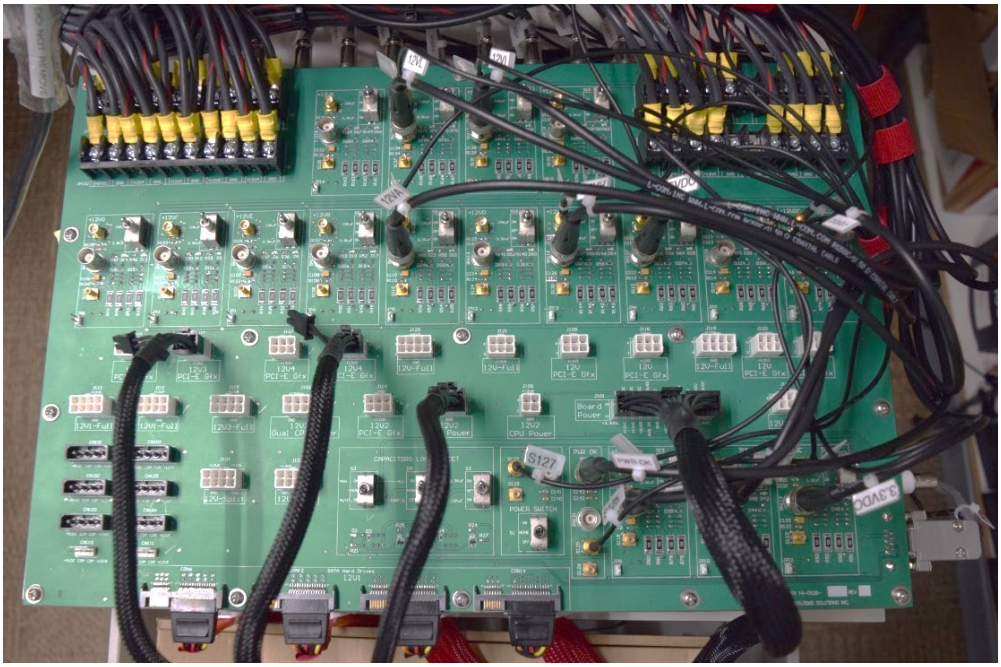
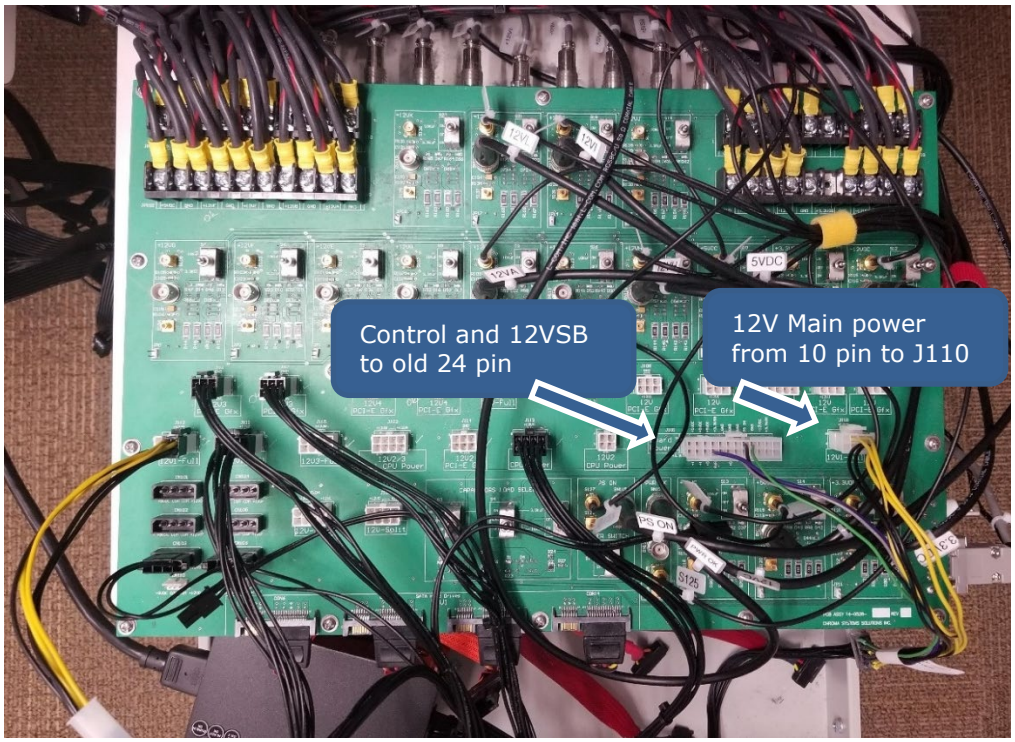


Figure 9-4: Intel Test Lab – Test Fixture Picture – ATX12VO (SR) Power Supply Connected:



NOTE: Test Fixture does not have a 10-pin connector, so an adapter cable is used to convert the 10 pin Main Power connector control signals and 12VSB to the old 24 pin connector (J101) and 12V Main Power rails connected to another 12V1 connector (J110).

9.1 Test Fixture Loading Table

The table below shows how the rack of test equipment is setup in the Intel Lab. All available connectors from a power supply are connected to following connectors. Using all available connectors helps to spread current load and IR loss to achieved the best results possible.

Table 9-2: DC Channel Load Assignments, 9 Voltage Rails (5–12V Rails)

Rail Name	5V	3.3V	5VSB	-12V	12V1	12V2
Main Purpose	ATX - 24 Pin Connector + SATA + PCIe* Auxiliary Power Connectors					CPU Power Connectors
DC Load	Model 63640-80-80	Model 63640-80-80	Model 63610-80-20	Model 63610-80-20	Model 63640-80-80 Qty5 – 2000W	Model 63640-80-80 Qty2 – 800W

Rail Name	5V	3.3V	5VSB	-12V	12V1	12V2
DC Load location	2 – 5	2 - 7	2 – 10	2 – 9	1–1, 1–3, 1-5, 1-7, 1-9	2 –1 and 2 –3
Test Fixture (Green Board)	5VDC 2x12-J101	3.3VDC 2x12-J101	5VSB 2x12-J101	-12V 2x12-J101	12VC - 2x12-J101; 2x4 -J110	12VA - 2x2-J105; 2x4-J113; 2x4 (half) J102
					12VF – 2x4 -J111; HDD and SATA - CON111, 104, 105, 106; CON13,14	12VB – 2x4-J115; 2x4 (half) J102
					12VG – 2x4 -J112; HDD and SATA CON110,101, 102,103; CON6,12	12VD – 2x4 (half) J103; 2x4-J120
					12VH –2x3-J106; 2x3-J107	12VE – 2x4 -J114; 2x4 (half) J103
					12VI - 2x3-J108; 2x3-J118 2x4-J119	
					12VJ – 2x3-J109; 2x3-J122	
					12VK – 2x4 (half) J104; 2x3-J121	
					12VL - 2x4 (half) J104 2x4-J110; 2x3-J116; 2x3-J117	

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