Desktop Platform Form Factors Power Supply

Test Plan

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Revision History

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1 Test Plan Overview

1.1 Test Plan Introduction

Intel has a document that details design suggestions for various desktop internal power supply form factors. This document is titled "Power Supply Design Guide Desktop Form Factors". In 2006, Intel combined the many different desktop power supply suggestions into one master document since the electrical design for all form factors is the same even when the physical size might be different.

The document is a companion document for Intel Power Supply Design Guide "Desktop Platform Form Factors Power Supply Design Guide. This Test Plan takes the design parameters and turns them in to a test plan for desktop power supplies. This Test Plan is used by Intel for testing of power supplies that are part of the Intel PSU Tested List. This testing is currently performed in the Intel Folsom, California lab, mentioned in the test Plan as the Intel Folsom lab. Current web location for this list: https://www.intel.com/content/www/us/en/resellers/psu-selector.html

Since 2017 there has been a few revisions of Intel Power Supply Design Guide. The Folsom lab performs testing for different revisions (Rev 1.40 and Rev 1.42). If there is a difference in testing between these revisions, then a table for each one is listed.

The PSU DG lists design parameters as either Required or Recommended. For a power supply to be put on the list it must pass all of the Required items. In the published list the Recommended items are then included to show if the power supply meets these guidelines.

The sections in this Test Plan are listed in the same order they appear in the Power Supply Design Guide (PSU DG). All section references are to Revision 1.42 of the PSU DG document.

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

The DC Voltage Range for all DC Output outputs are the same for all tests and therefore listed in the introduction. This is referenced in PSU DG, Section 3.2.1 – DC Voltage Regulation.

Table 1-1. DC Load Voltage Ranges

Outputs Voltage	Voltage Range (V)		
	Minimum	Typical	Maximum
+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	11.4	12.0	12.6

Outputs Voltage	Voltage Range (V)		
	Minimum	Typical	Maximum
+12V2	11.4	12.0	12.6

1.2 Calculation of Loading Values

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

1. Efficiency loading conditions
2. A 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 might have the same loading conditions for both methods. Power supplies with one large 12V rail sees the biggest differences.

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.*

(http://www.plugloadsolutions.com/docs/collatrl/print/Generalized_Internal_Power_Supply_Efficiency_Test_Protocol_R6.7.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

With Efficiency testing, the number of 12V rails list 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 de-rated loading according to the sticker values.

When the power supply has one 12V rail detailed on the sticker then the number of physical connections available on the power supply determines how the de-rating is accomplished. The main goal of this for efficiency testing is to evenly split the total 12V rail current to all 12V rail connections. The first 12V rail, 12V1, is assumed to be the 24 pin main board connector and any HDD/SATA power connections. 12V2 is assigned to the 2x2 or 2x4 processor power connectors. The number of 12V PCI Express graphic card power cables with any number of connectors (2x3 or 2x4) are then assumed for 12V rail connections. An example would be a power supply with two unique PCI Express* graphic card cables from the main power supply results in 4 – 12V rail connections to the Intel Test Fixture. In this scenario the total 12V rail current is divided by four and each 12V rail connection uses that amount for the de-rating calculation.

Details of the equipment and test fixture used in the Intel Folsom lab are described in Section 7 of this document.

1.2.2 Test Plan Table or Sticker Loading Conditions

For the second method – Sticker or Test Plan Table loading conditions, the overall Wattage output rating of the power supply determines which type of loading conditions are used. If the power supply is 450W or lower, then the loading conditions are based on Test Plan Tables in Section 6 of this document. The purpose of the Test Plan Tables are to provide guidance of the 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 above 450W and each of the voltage rails current ratings are equal to or larger than 450W 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.

When the sticker de-rating is used, the main difference for these calculations and efficiency calculations is when the power supply has only one 12V rail. For the sticker calculation when the power supply has one 12V rail, the Test Plan loading condition treats the power supply as having only one 12V rail. This can result in requiring a different physical connection between the two different types of loading conditions. Section 1.2.3 details how to follow each type of loading condition.

The only exception for this is if the de-rating of the 12V rail is larger than the Intel Folsom Lab's DC Load equipment limit of 66A. In this case, the total 12V rail current is split in half between 12V1 and 12V2. Any PCI Express* graphic card connections are then put evenly on the 12V1 and 12V2 connections of the Test Fixture.

1.2.3 Test Items by Test Conditions

Based on the loading conditions described in the previous two sections, test items can use either Efficiency Loading Conditions or Test Plan Table / Sticker Loading Conditions. Following is a list of what Test Items use which type of calculations for their loading conditions:

Test Plan Table / Sticker Loading Conditions

2.1 12V2 - Peak Load

3.1 AC Line regulation

3.2 Load / Cross Regulation - Load 0-16

3.6 Ripple and Noise Test

3.7 Dynamic Load

4.1 Timing T0 to T6

4.2 12V/5V/3.3V Power Sequencing Test

4.3 Hold Up Time

5.2 Over Current Protection - Static and Sticker

Efficiency Loading Conditions

2.2 12V2 Load 16A/21A Continues

3.2 Load / Cross Regulation - FL1-4

3.3 Efficiency - Main Rails On

3.4 Efficiency - 5VSB

3.5 Power Factor during Efficiency testing

Both

2.3 12V2 Min Load 0A - 120 - (Maximum 5V and 3.3V is defined as maximum condition of 120W for this condition)

Static Load Values

5.1 Short Circuit Protection

5.3 Energy Hazard Safety Criteria (240VA)

1.3 12V2 Peak Current Loading Determination

The 12V2 Peak Current loading value is one of the Test Items that has specific load calculations that need to be detailed. This is also different based on the Power Supply Design Guide Revision that is being used for testing the Power Supply. Tables for Design Guide Revisions 1.40, 1.41, 1.42, and 1.43 are listed.

To determine what CPU TDP level that a power supply is tested at for the 12V2 Peak Current Load the software looks at the 12V2 rail on the Sticker or Test Plan Table being used for that power supply. When there are multiple +12V rails, then the 12V2 rail is used. This is pretty simple for CPU TDP levels at 95W and below. When the current rating for the 12V2 rail is equal to or higher than the Continuous Current value on Table 2-1, then that TDP is chosen and the appropriate peak current value is used.

The 140W and 165W TDP levels for a CPU get more complicated. These processors from Intel do not have internal graphics so a discrete graphics card is required. Therefore there must be at least three 12V rails or one large 12V rail. If the power supply has three or more 12V rails than the 140W and 165W TDP processors are chosen the same as the 95W TDP or lower TDP processors described above using Table 2-1

If the power supply has one large 12V rail then some assumptions are made of what 12V current is needed for all the components in the computer. If the CPU TDP is 95W or lower, those Intel processors have integrated graphics, so no discrete graphic card is assumed. The rest of the system also can consume 12V power and is usually made up of the motherboard and any hard drives in the system. For all types of desktop computers the motherboard, memory, and storage drive (s) power (system power) is assumed to be at least 8 Amps. This power can be higher based on the configuration, but for power supply sizing we are assuming 8 Amps for system power.

For CPUs that have a 140W or 165W TDP value, they require a discrete graphics card. A graphics card used with this type of system can consume between 180 to 300 Watts. To determine the minimum total 12V current required to support these processors, the lower end of the above assumption is then used (180 Watts). Therefore, 15 Amps was chosen as 15A x 12V = 180W). Graphics card power for optimal performance of this class of products might be higher than 180 Watts, but for minimum power supply sizing 180 Watts is used. The rest of the desktop computer system 12V power (motherboard, memory and storage drive power) uses the above described assumption of 8 Amps.

Using Table below, the software choses the Processor TDP row based on if the single 12V rail sticker rating is equal to greater than the value in the "Total Current for 12V rail" column.

Table 1-2. 12V2 Peak Current Loading Assumptions for One 12V Rail PSU DG Rev 1.40

Processor TDP	System Power (12V1)	CPU Power (12V2)	Graphics Card (12V3)	Total Current for 12V Rail
165W	8A	29A	15A	52A
140W	8A	25A	15A	48A
95W	8A	16A	0A	24A
65W	8A	14A	0A	22A
35W	8A	10A	0A	18A

Table 1-3. 12V2 Peak Current Loading Assumptions for One 12V Rail PSU DG Rev 1.42

Processor TDP	System Power (12V1)	CPU Power (12V2)	Graphics Card (12V3)	Total Current for 12V Rail
165W	8A	37.5A	15A	60.5A
140W	8A	28A	15A	51A
95W	8A	22A	0A	30A
65W	8A	21A	0A	29A
35W	8A	13A	0A	21A

1.4 Dynamic Load Determination

Dynamic Load testing in the Power Supply Design Guide specifies a different percentage of the full load value for each 12V rail. When the power supply has multiple 12V rails the loading calculations are simple and follow the tables specified in Section 3.7. This is also different based on the Power Supply Design Guide Revision that is being used for testing the Power Supply. Tables for Design Guide Revisions 1.40, 1.41, 1.42, and 1.43 are listed.

When the power supply has one large 12V rail, the determination of the percentage of the full load to be tested is not as simple. This is because each 12V rail, as defined in PSU DG Rev 1.42 Section 3.2.2 and Table 3-3, have different step size percentage values of Full Load of that 12V rail that are used for Dynamic Load testing. To accomplish Dynamic Load testing of a power supply with one 12V rail assumptions need to be outlined.

The 12V1 rail needs to be tested at two different values. The required value is minimum to 40% of Maximum value and 60% of maximum to Maximum value. The recommended value is minimum to 70% of Maximum and then 30% of maximum to Maximum value. 12V1 testing calculation is done based on the sticker value of the total 12V rail. That is unless the total 12V current rating is higher than the equipment current limit, in that case the equipment current limit is used. The Intel Folsom equipment current limit is 66A for one 12V rail.

The CPU 12V rails (12V2) and graphic card rails (12V3 and 12V4) both use different loading percentages therefore this is much more complicated. Table 1-3 shows the assumptions across all of these components that can use 12V power.

System power (Board / Storage) represented as 12V1 starts at the low end as 8A, same as described in Section 1.3. 12V1 is not tested to these values, this is only for assumptions of what is left for other components using 12V connectors.

Processor Power, 12V2, gets its values from Table 2-1 based on the CPU power it supports. The bottom three rows in Table 1-3 is the same as Table 1-2. The value in the 12V2 column is then used as the Maximum value in the calculations mentioned in Section 3.7.

For Graphics Card power (both 12V3 and 12V4), the Dynamic Load Maximum value comes from Table below for minimum support levels. When the total 12V current rating on the sticker gets high enough the assumption is that higher power graphics cards are going to be used. Therefore as these 12V current ratings get high enough the graphic card power is tested at 25 Amps to represent 300 watt cards (25A x 12V = 300W).

Table 1-4. Dynamic Load Current Loading Assumptions for One 12V Rail PSU DG Rev 1.40

Processor TDP	Total Current for 12V Rail	System Power (12V1)	Processor Power (12V2)	Graphics Card (12V3)	Graphics Card (12V4)
165W	≥97	18A	29A	25A	25A
165W	≥72	18A	29A	25A	

Processor TDP	Total Current for 12V Rail	System Power (12V1)	Processor Power (12V2)	Graphics Card (12V3)	Graphics Card (12V4)
165W	≥52	8A	29A	15A	
140W	≥48	8A	25A	15A	
95W	≥24	8A	16A		
65W	≥22	8A	14A		
35W	≥18	8A	10A		

Table 1-5. Dynamic Load Current Loading Assumptions for One 12V Rail PSU DG Rev 1.42

Processor TDP	Total Current for 12V Rail	System Power (12V1)	Processor Power (12V2)	Graphics Card (12V3)	Graphics Card (12V4)
165W	≥105.5	18A	37.5A	25A	25A
165W	≥80.5	18A	37.5A	25A	
165W	≥60.5	8A	37.5A	15A	
140W	≥51	8A	28A	15A	
95W	≥30	8A	22A		
65W	≥29	8A	21A		
35W	≥21	8A	13A		

1.5 Test Items Order of Testing for Intel Folsom Lab

At the Intel Folsom Testing lab this is the order of testing which was determined by a couple of variables. The first variable that is used is to sort the test Items by method of load calculation. The reason to split the test items by either Efficiency or Sticker / Test Plan Table is because if the power supply has one single 12V rail then some physical connections might need to be moved to optimize results, spread the current evenly amount multiple DC Loads (Efficiency) or moving all 12V connections to the 12V1 DC Load (Sticker). The final reason is that the more destructive tests are put at the end of the test program.

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

Efficiency Based Load Calculations

2.2 12V2 Load 16A/21A Continues

2.1 12V2 - Peak Load

3.2 Load / Cross Regulation (FL1-FL4)

3.3 Efficiency - Main Rails On

3.5 Power Factor during Efficiency testing

3.4 Efficiency - 5VSB

Sticker/TPT or Static Based Load Calculations

3.1 AC Line regulation

3.7 Dynamic Load

3.2 Load / Cross Regulation (Load 0-Load16)

3.6 Ripple and Noise Test

4.3 Hold Up Time

4.1 Timing T0 to T6

4.2 12V/5V/3.3V Power Sequencing Test

2.3 12V2 Minimum Load 0A

5.1 Short Circuit Protection

5.2 Over Current Protection

5.3 Energy Hazard Safety Criteria (240VA)

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2 Processor Specific Tests

One of the biggest difference in the latest Power Supply Design Guide Revisions is a change to the 12V2 (CPU) Continuous and Peak Current Levels. For the Test Plan, power supplies can be tested to different revisions of the Design Guide. This Chapter shows the testing differences for each PSU Design Guide Revision.

2.1 12V2 Peak Loading Test RECOMMENDED

Refer to the Sections in Power Supply (PSU) Design Guide (DG) Rev 1.42 – Section 2.1 Processor Configurations.

Test Condition:

- Test the power supply at specified AC input line.
- The test duration for 12V2 Peak Amp is 10mS with the load changes from Continuous Current to Peak Current in a maximal slew-rate 1.0 A/us as referenced in the PSU DG Rev 1.42 - Section 3.2.2 (DC Output Current).
- Testing level is determined by the Maximum rated current value on the Nameplate of the sticker of the PSU for the 12V2 rail.
- If the PSU has one combined 12V rail for all connectors, then there has to be some current allocated for both 12V1 and 12V2. More details in Section 1.3.

Table below lists the 12V2 Continuous and Peak Current levels that can currently be tested:

Table 2-1. PSU 12V2 (CPU) Continuous and Peak Current Recommendations all PSU DG Revisions

Processor TDP	PSU DG R1.40		PSU DG R1.42	
	Continuous Current	Peak Current	Continuous Current	Peak Current
165W	29 A	40 A	37.5A	45A
140W	25 A	34 A	28A	39A
95W	16 A	18 A	22A	29A
80W	14 A	18 A	--	--
65W	14 A	18 A	21A	28A
35W	10A	13.5 A	13A	16.5A

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 11.4V~12.6V (5%) when 12V2 is under the Peak Amp loading.

Test Scenarios:

Table 2-2. 12V2 Peak Load Test Scenarios

AC Voltage		5V	3.3V	-12V	5VSB	12V1	12V2
115V / 60Hz	Loading 1 (Continuous)	Light					Maximum
	Loading 2 (Peak) 10ms	Light					Peak
230V / 50Hz	Loading 1 (Continuous)	Light					Maximum
	Loading 2 (Peak) 10ms	Light					Peak

2.2 12V2 Load Continuous Current RECOMMENDED

Refer to the Sections in PSU DG rev 1.42 – Section 2.1 Processor Configurations.

Test Condition:

- Test the power supply at specified AC input line.
- The Continuous Current of that of a 95W TDP Processor and tested for **x** seconds 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 22 Amp. The 12V1 load value is then calculated by using 22 Amps on the 12V2 rail for a wattage of 264 watts. The rest of the combined 12 Volt rail Wattage is then subtracted from 264 watt and then divided by 12 to determine the 12V1 load.

— Example – combined 12V rail wattage is 348 watts. 12V2 uses 22A for 264 watts. 12V1 = (348 – 264) / 12 = 84 / 12 = 7 Amps

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.

Test Scenarios:

Depending on PSU DG revision that is being tested here are the different Continuous Test Scenarios available.

Table 2-3. 12V2 Load Continuous Test Scenarios by PSU DG Revision

PSU DG Revision	12V2
Rev 1.40	16 A
Rev 1.42	22 A

Table 2-4. 12V2 Load Continuous Test Scenarios

AC Voltage	5V	3.3V	-12V	5VSB	12V1	12V2
115V / 60Hz	Full				Calculated	Table 2-6 value
230V / 50 Hz	Full				Calculated	Table 2-6 value

2.3 12V2 Minimum Load 0A RECOMMENDED

This test is consistent for all PSU DG Revisions.

Refer to the Sections in PSU DG rev 1.42 – Section 3.2.10 12V2 DC Minimum Loading.

Test Condition:

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

Step1: 5V and 3.3V rails are set to Minimum Load criteria all other rails load set to 0A.

Step2: 12V2 load value 0A with 3V/5V running with maximum combine watt load mark on nameplate, while other rails load minimum load as defined in the Test Plan Tables.

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.

Test Scenarios:

Table 2-5. 12V2 Minimum Load 0A Test Scenarios

<table>
<tr><th>AC Voltage</th><th>5V</th><th>3.3V</th><th>-12V</th><th>5VSB</th><th>12V1</th><th>12V2</th></tr>
<tr><td rowspan="2">115V / 60Hz</td><td>0.2A (minimum)</td><td>0.1A (minimum)</td><td>0A</td><td>0A</td><td>0A</td><td>0A</td></tr>
<tr><td colspan="2">Maximum Combine</td><td colspan="3">Minimum</td><td>0A</td></tr>
<tr><td rowspan="2">230V / 50 Hz</td><td>0.2A (minimum)</td><td>0.1A (minimum)</td><td>0A</td><td>0A</td><td>0A</td><td>0A</td></tr>
<tr><td colspan="2">Maximum Combine</td><td colspan="3">Minimum</td><td>0A</td></tr>
</table>

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

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3 Electrical

3.1 AC Line Regulation REQUIRED

Refer to the Sections in PSU DG rev 1.42 – Section 3.1 AC Input and Section 3.2.1 DC Voltage Regulation.

Test Condition:

- Test the power supply at specified AC input line and the specified loads.
- Specification of DC Voltage Range for all DC voltage outputs.

Table 3-1. DC Load Voltage Ranges

Output Voltage	Voltage Range (V)		
	Minimum	Typical	Maximum
+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	11.4	12.0	12.6
+12V2	11.4	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 3-2. AC Line Regulation Test Scenarios

Criteria	DC Load	AC Line Regulation Voltage / Frequency	Required or Recommended
1	Typical Load	90V / 60 Hz	Required
2	Typical Load	135V / 60 Hz	Required
3	Typical Load	180V / 50 Hz	Required
4	Typical Load	265V / 50Hz	Required
5	Typical Load	90V / 47 Hz	Recommended
6	Typical Load	90V / 63 Hz	Recommended
7	Typical Load	135V / 47Hz	Recommended

Criteria	DC Load	AC Line Regulation Voltage / Frequency	Required or Recommended
8	Typical Load	135V / 63 Hz	Recommended
9	Typical Load	180V / 47Hz	Recommended
10	Typical Load	180V / 63 Hz	Recommended
11	Typical Load	265V / 47Hz	Recommended
12	Typical Load	265V / 63 Hz	Recommended

3.2 Load / Cross Regulation REQUIRED

Refer to the Sections in PSU DG rev 1.42 – Section 3.2.1 DC Voltage Regulation and Section 3.5.3 No Load Situation.

Test Condition:

- All Testing done at both 115V / 60 Hz and 230V / 50 Hz.

DC Loads are determined to test a wide variety of conditions between low and high loading for each rail.

Test Scenarios:

Table 3-3. Load / Cross Regulation Test Scenarios REQUIRED

<table>
<tr><th colspan="7">Loading</th></tr>
<tr><th>Load</th><th>+5V</th><th>+3.3V</th><th>-12V</th><th>+5VSB</th><th>+12V1</th><th>+12V2</th></tr>
<tr><td>0</td><td colspan="6">Minimum</td></tr>
<tr><td>1</td><td>Light</td><td colspan="5">Minimum</td></tr>
<tr><td>2</td><td>Typical</td><td colspan="5">Minimum</td></tr>
<tr><td>3</td><td>Full</td><td colspan="5">Minimum</td></tr>
<tr><td>4</td><td colspan="4">Minimum</td><td>Light</td><td>Minimum</td></tr>
<tr><td>5</td><td colspan="4">Minimum</td><td>Typical</td><td>Minimum</td></tr>
<tr><td>6</td><td colspan="2">Light</td><td colspan="2">Minimum</td><td>Full</td><td>Minimum</td></tr>
<tr><td>7</td><td colspan="5">Minimum</td><td>Light</td></tr>
<tr><td>8</td><td colspan="5">Minimum</td><td>Typical</td></tr>
<tr><td>9</td><td colspan="2">Light</td><td colspan="3">Minimum</td><td>Full</td></tr>
<tr><td>10</td><td>Minimum</td><td>Light</td><td colspan="4">Minimum</td></tr>
<tr><td>11</td><td>Minimum</td><td>Typical</td><td colspan="4">Typical</td></tr>
<tr><td>12</td><td>Light</td><td>Full</td><td colspan="4">Full</td></tr>
<tr><td>13</td><td colspan="6">Light</td></tr>
<tr><td>14</td><td colspan="6">Typical</td></tr>
</table>

Loading						
Load	**+5V**	**+3.3V**	**-12V**	**+5VSB**	**+12V1**	**+12V2**
15	Full					
16	No Load					

Adding FL1 to FL4 below. These tests are recommendation only and stress the Maximum rating for 5V, 3.3V, 12V1, and 12V2 while the DC output equals a Full Load value. FL3 and FL4 is only tested if the power supply has two 12V rails. If the power supply has only one combined 12V rail or more than two 12V rails, then FL3 and FL4 are not tested.

Table 3-4. Load / Cross Regulation Test Scenarios RECOMMENDATION

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

3.3 Efficiency Main Rails On (ENERGY STAR* and CEC)

Refer to the Sections in PSU DG rev 1.42 – Section 3.5.8 Overall Power Supply Efficiency Levels and Section 3.5.9 Power Supply Efficiency for Energy Regulations

<u>**Test Condition:**</u>

- 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 Folsom Lab is only provided in the test report. The listing for the power supply on the Intel Tested List website reflects the 80 plus rating received for that model from the 80plus.org website.
- <u>**Low Load Efficiency:**</u> The Lowest load point is determined based on new 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 than 2% Load is used for the Low Load Efficiency measurement.

Table 3-5. 12W and 10W Load Condition for PSU Less Than 500 Watts

Load	+5V	+3.3V	-12V	+5VSB	+12V1	+12V2
12W	0.79	0.31	0.0	0.1	0.34	0.23
10W	0.50	0.15	0.0	0.1	0.33	0.22

Pass Criteria:

- The power supply shall meet the Intel minimum percentage efficiency under specified loading.
- **Low Load Efficiency:** The pass criteria for a power supply to be listed on the Intel Test List for Low Load Efficiency is meeting 60% efficiency @ 12W load. The 10W load efficiency is recommended to be 70% by 2020. To continue to help encourage Low Load Efficiency improvement the Intel Tested List details 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 Energy Regulations there are different levels of efficiency that are required.

— Energy Star Computers Version 7.0 requires 80 Plus Bronze for power supplies of 500 Watts or less. Above 500 Watts the PSU must meet the 80 Plus Gold levels.

— CEC's Computer Standard has a power supply efficiency requirements for High Expandability Computers. Depending on how the computer classifies as a High Expandability Computer the requirement is that a power supply above 600 Watts must be 80 Plus Gold. Refer to the CEC Computer Standard website for details.

- Test results shows which 80 plus level the power supply reaches for both 115V and 230V.

Test Scenarios:

Test Report highlights in yellow what efficiency level is reached during testing for each load point.

Table 3-6. Example Efficiency Table From Test Report – 115V

Load	115V Efficiency	Intel Minimum (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	N/A	N/A	N/A	**86%**	**90%**	**ENERGY STAR*** only
5%		N/A	N/A	N/A	N/A	N/A	N/A	N/A	
12W/ 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 3-7. Example Efficiency Table From Test Report – 230V

Load	230V Efficiency	Intel Minimum (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%**	**94%**	**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	

3.4 Efficiency 5VSB [Europe (ErP Lot 3/6) and Alternative Sleep Mode (ASM)]

Refer to the Sections in PSU DG rev 1.42 – Section 3.2.4 Other Low Power System Requirements.

Test Condition:

- Test the power supply with nominal line voltage and the following loads.
- Measured with the main outputs off (PS_ON# high state), 5VSB Voltage rail only.

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 3-8. 5VSB Efficiency Targets and Test Scenarios

5VSB Load Target	5VSB Actual Load	Efficiency Target (Both 115V and 230V Input)	Remarks
Maximum / Label	3.0A /Label	75%	Recommended
1.5 A		75%	ASM and ErP* Lot 3 2014
1.00 A		75%	Recommended
0.55 A		75%	ASM and ErP* Lot 3/6 2014
0.25 A			
100 mA			
90 mA		45%	ErP* Lot 3/6 2010
70 mA			
45 mA		45%	ErP* Lot 3/6 2013
20 mA			

3.5 Power Factor

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. For Energy Regulations of ENERGY STAR* and CEC when they have Efficiency requirements they also include a Power Factor requirement at certain levels.

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 3-9. 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** (600w and 80 Plus Gold or higher)
Short Idle (10W/ 2%)			**Value is reported**

ENERGY STAR* for Computers Version 7.0 changed the Power Factor requirement for internal Power Supplies. In Version 6.1 the 0.90 Power Factor was required for 100% Load. Version 7.0 moved the 0.90 Power Factor requirement to 50% load to match the 80 Plus program.

CEC Computers Standard requires that during Short Idle testing for all computers the power factor is reported in the system level test report. There is no requirement at this time. The 10W or 2% Low Load testing levels are designed to replicate this for power supplies. Refer to the PSU DG Rev 1.42 - Section 3.5.8 Overall Power Supply Efficiency Levels.

3.6 Ripple and Noise Test REQUIRED

Refer to the Sections in PSU DG rev 1.42 – Section 3.2.5 Output Ripple Noise, Section 3.3.1 PWR_OK, and Section 3.3.3 PS_ON#.

Test Condition:

- Test the power supply at AC input line, and measured the PSU under load condition shown in the below table.
- Add a 0.1uF ceramic capacitor in parallel with 10uF electrolytic capacitor at the output connector terminals.

Pass Criteria:

- The ripple of power supply should be within the specification.

Table 3-10. Ripple and Noise Pass Criteria

Output	Maximum Ripple and Noise (mV p-p)
+5V	50
+3.3V	50
-12V	120
+5VSB	50
+12V1	120
+12V2	120

Output	Maximum Ripple and Noise (mV p-p)
PWR_OK	400
PS_ON	400

Test Scenarios:

Table 3-11. 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

3.7 Dynamic Load REQUIRED

Refer to the Sections in PSU DG rev 1.42 – Section 3.2.6 Capacitive Load and Section 3.2.2 DC Output Current.

Test Condition:

- Test the power supply at AC input line and the following load changes with a 1A/µs slew-rate for +5V, +12V and +3.3V, 0.2 A/µs for +5Vsb and 0.05 A/µs for -12V; also with 50% duty cycle at both 50Hz and 10KHz.

Table 3-12. Dynamic Load Test Conditions

Output	De-coupling Capacitors	Voltage limits (V)		Load Change		Required
		Minimum	Maximum	Low Load	High Load	
+5V	3,300uF	4.75	5.25	Minimum to 30% of Maximum	70% of Maximum to Maximum	Yes
+3.3V	3,300uF	3.14	3.47	Minimum to 30% of Maximum	70% of Maximum to Maximum	Yes
-12V	330uF*	-13.2	-10.8	0A to 0.1A	0.2A to 0.3A	Yes
+5VSB	3,300uF	4.75	5.25	0A to 0.5A	2.0A to 2.5A	Yes
+12V1	3,300uF	11.4	12.6	Minimum to 40% of Maximum	60% of Maximum to Maximum	Yes
+12V1	3,300uF	11.4	12.6	Minimum to 70% of Maximum	30% of Maximum to Maximum	Recommended
+12V2	3,300uF	11.4	12.6	Minimum to 85% of Maximum	15% of Maximum to Maximum	Yes
+12V3/12V4 PCIe* GFX	3,300uF	11.4	12.6	Minimum to 80% of Maximum	20% of Maximum to Maximum	Recommended

+12V3/12V4 PCIe* GFX, based on Graphics card recommendations. This is not an Intel requirement and so it is treated as a recommendation during testing.

Note: PSU DG Rev 1.42 had an error in Capacitive Load for -12VDC. All rails except -12V should be 3,300 uF. The -12V rail should be 330 uF as listed in PSU DG Rev 1.4.

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 3-13. 115V/60Hz @ 50 Hz Dynamic Load Test Scenarios

Frequency	AC Input	DC Output						
		5V	3.3V	-12V	5VSB	12V1	12V2	12V3/V4
50 Hz	115V/ 60Hz	Minimum to 30% of Maximum	Minimum					
		70% of Maximum to Maximum	Light					
		Light	Minimum to 30% of Maximum	Minimum				
		Light	70% of Maximum to Maximum	Light				
		Minimum		0A to 0.1A	Minimum			
		Light		0.2A to 0.3A	Light			
		Minimum			0A to 0.5A	Minimum		
		Light			2.0A to 2.5A	Light		
		Light	Minimum			Minimum to 40% of Maximum	Minimum	
		Light				60% of Maximum to Maximum	Light	
		Light	Minimum			Minimum to 70% of Maximum	Minimum	
		Light				30% of Maximum to Maximum	Light	

Frequency	AC Input	DC Output						
		5V	**3.3V**	**-12V**	**5VSB**	**12V1**	**12V2**	**12V3/V4**
		Light	Minimum				Minimum to 85% of Maximum	Minimum
		Light					15% of Maximum to Maximum	Light
		Light	Minimum					Minimum to 80% of Maximum
		Light						20% of Maximum to Maximum

Table 3-14. 230V/50Hz @ 50 Hz Dynamic Load Test Scenarios

Frequency	AC Input	DC Output						
		5V	3.3V	-12V	5VSB	12V1	12V2	12V3/V4
50 Hz	230V/ 50Hz	Minimum to 30% of Maximum	Minimum					
		70% of Maximum to Maximum	Light					
		Light	Minimum to 30% of Maximum	Minimum				
		Light	70% of Maximum to Maximum	Light				
		Minimum		0A to 0.1A	Minimum			
		Light		0.2A to 0.3A	Light			
		Minimum			0A to 0.5A	Minimum		
		Light			2.0A to 2.5A	Light		
		Light	Minimum			Minimum to 40% of Maximum	Minimum	
		Light				60% of Maximum to Maximum	Light	
		Light	Minimum			Minimum to 70% of Maximum	Minimum	
		Light				30% of Maximum to Maximum	Light	

<table>
<tr><th rowspan="2">Frequency</th><th rowspan="2">AC Input</th><th colspan="7">DC Output</th></tr>
<tr><th>5V</th><th>3.3V</th><th>-12V</th><th>5VSB</th><th>12V1</th><th>12V2</th><th>12V3/V4</th></tr>
<tr><td rowspan="4"></td><td rowspan="4"></td><td>Light</td><td colspan="4">Minimum</td><td>Minimum to 85% of Maximum</td><td>Minimum</td></tr>
<tr><td colspan="5">Light</td><td>15% of Maximum to Maximum</td><td>Light</td></tr>
<tr><td>Light</td><td colspan="5">Minimum</td><td>Minimum to 80% of Maximum</td></tr>
<tr><td colspan="6">Light</td><td>20% of Maximum to Maximum</td></tr>
</table>

Table 3-15. 115V/60Hz @ 10 kHz Dynamic Load Test Scenarios

Frequency	AC Input	DC Output						
		5V	3.3V	-12V	5VSB	12V1	12V2	12V3/V4
10 KHz	115V/ 60Hz	Minimum to 30% of Maximum	Minimum					
		70% of Maximum to Maximum	Light					
		Light	Minimum to 30% of Maximum	Minimum				
		Light	70% of Maximum to Maximum	Light				
		Minimum		0A to 0.1A	Minimum			
		Light		0.2A to 0.3A	Light			
		Minimum			0A to 0.5A	Minimum		
		Light			2.0A to 2.5A	Light		
		Light	Minimum			Minimum to 40% of Maximum	Minimum	
		Light				60% of Maximum to Maximum	Light	
		Light	Minimum			Minimum to 70% of Maximum	Minimum	
		Light				30% of Maximum to Maximum	Light	
		Light	Minimum				Minimum to 85% of Maximum	Minimum

Frequency	AC Input	DC Output						
		5V	3.3V	-12V	5VSB	12V1	12V2	12V3/V4
		Light					15% of Maximum to Maximum	Light
		Light	Minimum					Minimum to 80% of Maximum
		Light						20% of Maximum to Maximum

Table 3-16. 230V/50Hz @ 10 kHz Dynamic Load Test Scenarios

Frequency	AC Input	DC Output						
		5V	**3.3V**	**-12V**	**5VSB**	**12V1**	**12V2**	**12V3/V4**
10 KHz	230V/ 50Hz	Minimum to 30% of Maximum	Minimum					
		70% of Maximum to Maximum	Light					
		Light	Minimum to 30% of Maximum	Minimum				
		Light	70% of Maximum to Maximum	Light				
		Minimum		0A to 0.1A	Minimum			
		Light		0.2A to 0.3A	Light			
		Minimum			0A to 0.5A	Minimum		
		Light			2.0A to 2.5A	Light		
		Light	Minimum			Minimum to 40% of Maximum	Minimum	
		Light				60% of Maximum to Maximum	Light	
		Light	Minimum			Minimum to 70% of Maximum	Minimum	
		Light				30% of Maximum to Maximum	Light	
		Light	Minimum				Minimum to 85% of Maximum	Minimum

<table>
<tr><th rowspan="2">Frequency</th><th rowspan="2">AC Input</th><th colspan="7">DC Output</th></tr>
<tr><th>5V</th><th>3.3V</th><th>-12V</th><th>5VSB</th><th>12V1</th><th>12V2</th><th>12V3/V4</th></tr>
<tr><td rowspan="3"></td><td rowspan="3"></td><td colspan="5">Light</td><td>15% of Maximum to Maximum</td><td>Light</td></tr>
<tr><td>Light</td><td colspan="5">Minimum</td><td>Minimum to 80% of Maximum</td></tr>
<tr><td colspan="6">Light</td><td>20% of Maximum to Maximum</td></tr>
</table>

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4 Timing

4.1 Timing T0 to T6 REQUIRED

Refer to the Sections in PSU DG Rev 1.42 – Section 3.3 Timing, Housekeeping, and Control; Section 3.3.1 PWR_OK; Section 3.3.5 Power-On Time; Section 3.3.6 Rise Time.

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 95% of its final set point.

Pass Criteria:

Table 4-1. Timing (T0 to T6) Pass Criteria

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

[1] 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.

[2] T3 time is allowed to be lower than 100ms to allow faster computer “turn on” time, but might break backward compatibility. For Intel testing being less then 100ms will not result in failing timing.

[3] T3 time is measured on all rails, but the Pass criteria is only 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 20 ms of the 3.3V rail (Section 4.2).

[3] T5 and T6 are recommended for Intel Tested List. Hold Up time is a combination of T5 + T6 which is required.

Test Scenarios:

Table 4-2. Timing (T0 to T6) Test Scenarios (Gray Boxes No Pass 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		Yes	Yes
		-12V							
		+5VSB	Yes						
		+12V1		Yes	Yes			Yes	Yes
		+12V2		Yes	Yes			Yes	Yes
		PWR_OK					Yes		
	Full (100%)	+5V		Yes	Yes			Yes	Yes
		+3.3V		Yes	Yes	Yes		Yes	Yes
		-12V							
		+5VSB	Yes						
		+12V1		Yes	Yes			Yes	Yes
		+12V2		Yes	Yes			Yes	Yes
		PWR_OK					Yes		
230V / 50Hz	Light (20%)	+5V		Yes	Yes			Yes	Yes
		+3.3V		Yes	Yes	Yes		Yes	Yes
		-12V							
		+5VSB	Yes						
		+12V1		Yes	Yes			Yes	Yes
		+12V2		Yes	Yes			Yes	Yes
		PWR_OK					Yes		
	Full (100%)	+5V		Yes	Yes			Yes	Yes
		+3.3V		Yes	Yes	Yes		Yes	Yes
		-12V							
		+5VSB	Yes						
		+12V1		Yes	Yes			Yes	Yes
		+12V2		Yes	Yes			Yes	Yes
		PWR_OK					Yes		

4.2 +12VDC/+5VDC/+3.3VDC Power Sequencing Test REQUIRED

Refer to the Sections in PSU DG Rev 1.42 – Section 3.2.8 +5V DC / +3.3V DC Power Sequencing.

Test Condition:

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

Pass Criteria:

- The +12VDC and +5VDC output levels must be equal to or greater than the +3.3VDC output at all times 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 <= 20ms.

Test Scenarios:

Table 4-3. 12VDC/5VDC/3.3VDC Power Sequencing Test Scenarios

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

4.3 Hold Up Time REQUIRED

Refer to the Sections in PSU DG rev 1.42 – Section 3.2.9 Voltage Hold-Up Time.

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 17ms, comes from (T5) 16ms + (T6) 1ms, at maximum continuous output load condition when AC Power is removed.

Test Scenarios:

Table 4-4. Hold Up Time Test Scenarios

AC Input	DC Output Load Conditions
115V / 47 Hz	Full (100%) Load
230V / 47 Hz	Full (100%) Load

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5 Output Protection

5.1 Short Circuit Protection (SCP) REQUIRED

Refer to the Sections in PSU DG rev 1.42 – Section 3.5.2 Short Circuit Protection

Test Condition:

- Test the power supply at AC input line and carry out these test 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 Folsom Lab only test each rail shorted to ground. Each voltage rails shorted to another voltage rails is a recommended test, but it is not tested at the Intel Folsom lab at this current time, that is why these cells are not grayed out, but are shown as "Not Tested". Gray cells are not recommended to be tested.

Table 5-1. Short Circuit Protection Test Scenarios

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

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

5.2 Over Current Protection (OCP) REQUIRED

Refer to the Sections in PSU DG rev 1.42 – Section 3.5.4 Over Current Protection.

Test Condition:

- The load is increased on one output from its maximum value at increments of 0.1A, to the maximum 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 **10A/sec** starting from rated load.

Pass Criteria:

- Overload currents applied to each tested output rail causes the output to latch into the shutdown state and no damaged occurs to the PSU. As tested by it is able to turn back on after the test.

Test Scenarios:

Table 5-2. Over Current Protection Test Scenarios

<table>
<tr><th>AC Input</th><th>5V</th><th>3.3V</th><th>-12V</th><th>5VSB</th><th>12V1</th><th>12V2</th></tr>
<tr><td rowspan="6">115V / 60Hz</td><td>Maximum</td><td colspan="5">Minimum</td></tr>
<tr><td>Minimum</td><td>Maximum</td><td colspan="4">Minimum</td></tr>
<tr><td colspan="2">Minimum</td><td>Maximum</td><td colspan="3">Minimum</td></tr>
<tr><td colspan="3">Minimum</td><td>Maximum</td><td colspan="2">Minimum</td></tr>
<tr><td colspan="4">Minimum</td><td>Maximum</td><td>Minimum</td></tr>
<tr><td colspan="5">Minimum</td><td>Maximum</td></tr>
<tr><td rowspan="3">230V / 50Hz</td><td>Maximum</td><td colspan="5">Minimum</td></tr>
<tr><td>Minimum</td><td>Maximum</td><td colspan="4">Minimum</td></tr>
<tr><td colspan="2">Minimum</td><td>Maximum</td><td colspan="3">Minimum</td></tr>
</table>

<table>
<tr><th>AC Input</th><th>5V</th><th>3.3V</th><th>-12V</th><th>5VSB</th><th>12V1</th><th>12V2</th></tr>
<tr><td rowspan="3"></td><td colspan="3">Minimum</td><td>Maximum</td><td colspan="2">Minimum</td></tr>
<tr><td colspan="4">Minimum</td><td>Maximum</td><td>Minimum</td></tr>
<tr><td colspan="5">Minimum</td><td>Maximum</td></tr>
</table>

5.3 Energy Hazard Safety Criteria (240VA) RECOMMENDED

Refer to the Sections in PSU DG – None.

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 **10A/sec** starting from rated load.
- For each rail's output current reaching the power of 240VA, here is the reference value.

Table 5-3. DC Load Current Values to Reach 240VA

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

Pass Criteria:

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

Test Scenarios:

Table 5-4. Energy Hazard Safety Criteria (240VA) Test Scenarios

<table>
<tr><th>AC Input</th><th>5V</th><th>3.3V</th><th>-12V</th><th>5VSB</th><th>12V1</th><th>12V2</th></tr>
<tr><td rowspan="4">115V / 60Hz</td><td>240VA</td><td colspan="5">Minimum</td></tr>
<tr><td>Minimum</td><td>240VA</td><td colspan="4">Minimum</td></tr>
<tr><td colspan="4">Minimum</td><td>240VA</td><td></td></tr>
<tr><td colspan="5">Minimum</td><td>240VA</td></tr>
<tr><td rowspan="4">230V / 50Hz</td><td>240VA</td><td colspan="5">Minimum</td></tr>
<tr><td>Minimum</td><td>240VA</td><td colspan="4">Minimum</td></tr>
<tr><td colspan="4">Minimum</td><td>240VA</td><td></td></tr>
<tr><td colspan="4">Minimum</td><td></td><td>240VA</td></tr>
</table>

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6 Test Plan Tables and Test Criteria RECOMMENDED

The Intel Test Plan Tables are used for two main purposes. The first purpose is to show what loading criteria of what Intel uses for these four sizes of power supplies as part of this Test Plan. This leads to the second purpose of the tables, these are recommended loading values between the six voltage rails of an ATX Power Supply at these total power levels. We understand that power supplies with a smaller or larger wattage level do exist, but these tables are recommended for standard, mainstream desktop computers. Smaller power supplies can be great options for purpose built computers with minimal expandability. Larger power supplies can leverage the 450 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 450 Watts the power supply is 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 450 watt levels detailed for each PSU DG revision. If the power supply has a total power rating over 450 watts, but one or more current values of an individual rail are lower than Table for 450 Watts of that revision, then loading follows the 450 Watt table for that revision.

6.1 Test Plan Tables for PSU DG Rev 1.40

Table 6-1. Test Plan Tables and Test Criteria PSU DG Rev 1.40 – 300 Watt

Output Rail	5V	3.3V	-12V	5VSB	12V1	12V2
Minimum Load	0.2	0.1	0	0	0.1	0.05
Full (100%) Load	8.5	9.1	0.24	2.4	6.4	11.3
Maximum / Rated Load	15	16	.3	3	8	14
Peak Load				3.5		18

Total Combined output of 3.3V and 5V is 90W.

Total Combined Output of both 12V Rails is 264W.

Table 6-2. Test Plan Tables and Test Criteria PSU DG Rev 1.40 – 350 Watt

Output Rail	5V	3.3V	-12V	5VSB	12V1	12V2
Minimum Load	0.2	0.1	0	0	0.1	0.05
Full (100%) Load	9.5	10.2	0.24	2.4	8.2	13.0
Maximum / Rated Load	15	16	.3	3.0	10	16
Peak Load				3.5		18

Total Combined output of 3.3V and 5V is 100W.

Total Combined Output of both 12V Rails is 312W.

Table 6-3. Test Plan Tables and Test Criteria PSU DG Rev 1.40 – 400 Watt

Output Rail	5V	3.3V	-12V	5VSB	12V1	12V2
Minimum Load	0.2	0.1	0	0	0.1	0.05
Full (100%) Load	10.0	13.3	0.24	2.35	11.8	12.5
Maximum / Rated Load	15	20	.3	3.0	15	16
Peak Load				3.5		18

Total Combined output of 3.3V and 5V is 120W.

Total Combined Output of both 12V Rails is 372W.

Table 6-4. Test Plan Tables and Test Criteria PSU DG Rev 1.40 – 450 Watt

Output Rail	5V	3.3V	-12V	5VSB	12V1	12V2
Minimum Load	0.2	0.1	0	0	0.1	0.05
Full (100%) Load	10.5	14.0	0.25	2.5	14.8	13.2
Maximum / Rated Load	15	20	.3	3.0	18	16
Peak Load				3.5		18

Total Combined output of 3.3V and 5V is 120W.

Total Combined Output of both 12V Rails is 408W.

6.2 Test Plan Tables for PSU DG Rev 1.42

Table 6-5. Test Plan Tables and Test Criteria PSU DG Rev 1.42 – 300 Watt

Output Rail	5V	3.3V	-12V	5VSB	12V1	12V2
Minimum Load	0.2	0.1	0	0	0.1	0.05
Full (100%) Load	8.0	8.5	0.23	2.27	5.0	13.1
Maximum / Rated Load	15	16	.3	3	8	21
Peak Load				3.5		28

Total Combined output of 3.3V and 5V is 90W.

Total Combined Output of both 12V Rails is 288W.

Table 6-6. Test Plan Tables and Test Criteria PSU DG Rev 1.42 – 350 Watt

Output Rail	5V	3.3V	-12V	5VSB	12V1	12V2
Minimum Load	0.2	0.1	0	0	0.1	0.05
Full (100%) Load	9.3	9.9	0.24	2.4	6.9	14.5
Maximum / Rated Load	15	16	.3	3.0	10	21
Peak Load				3.5		28

Total Combined output of 3.3V and 5V is 100W.

Total Combined Output of both 12V Rails is 324W.

Table 6-7. Test Plan Tables and Test Criteria PSU DG Rev 1.42 – 400 Watt

Output Rail	5V	3.3V	-12V	5VSB	12V1	12V2
Minimum Load	0.2	0.1	0	0	0.1	0.05
Full (100%) Load	9.8	13.1	0.23	2.3	9.9	14.5
Maximum / Rated Load	15	20	.3	3.0	15	22
Peak Load				3.5		29

Total Combined output of 3.3V and 5V is 120W.

Total Combined Output of both 12V Rails is 380W.

Table 6-8. Test Plan Tables and Test Criteria PSU DG Rev 1.42 – 450 Watt

Output Rail	5V	3.3V	-12V	5VSB	12V1	12V2
Minimum Load	0.2	0.1	0	0	0.1	0.05
Full (100%) Load	10.2	13.6	0.24	2.4	12.7	15.6
Maximum / Rated Load	15	20	.3	3.0	18	22
Peak Load				3.5		29

Total Combined output of 3.3V and 5V is 120W.

Total Combined Output of both 12V Rails is 425W.

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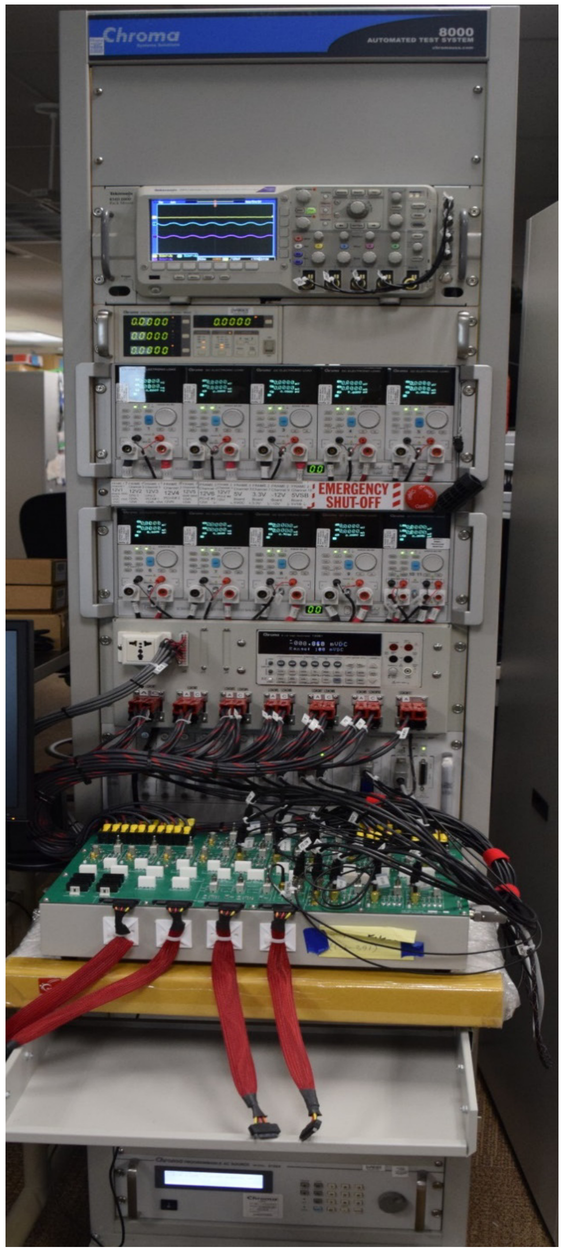
7 Intel Test Lab Test Equipment

Table 7-1. 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 maximum
Chroma*	63630-80-60	High Speed DC Loads –(300 Watt maximum)
Chroma*	63630-80-20	High Speed DC Loads – used for 5VSB and -12V rails (100W maximum each side)
Chroma*	12061	Digital Multi Meter
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

7.1 Test Rack Picture

Figure 7-1. FM2 Rack Picture



7.2 Test Fixture Picture

Figure 7-2. No PSU Connected

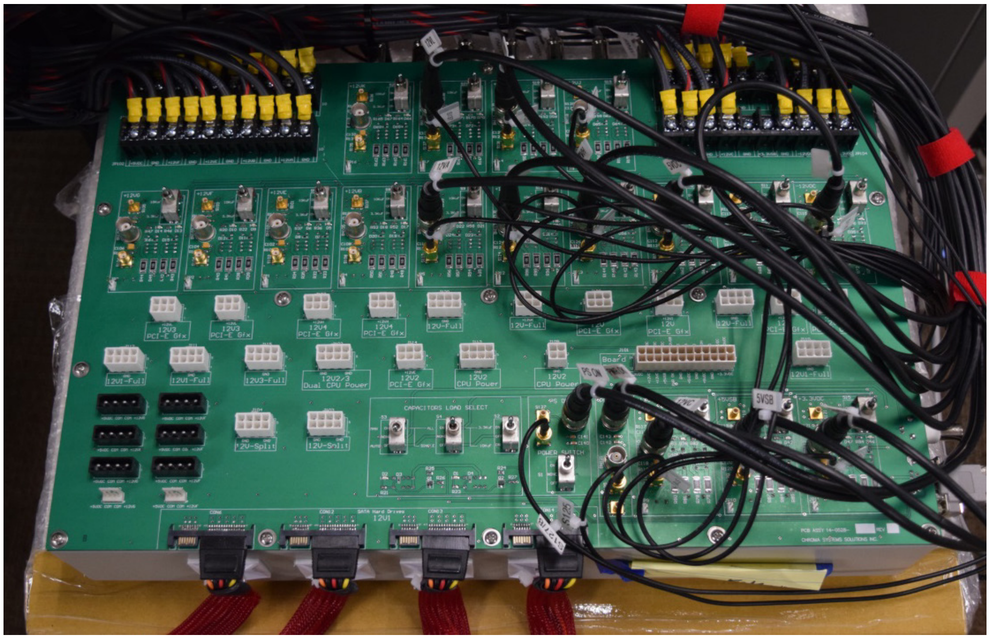
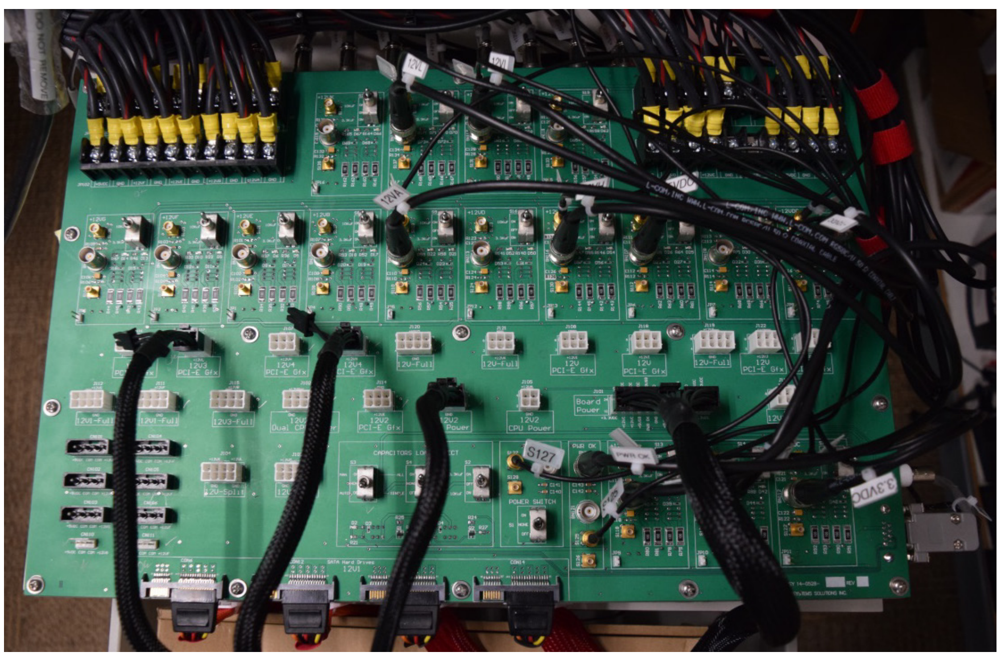


Figure 7-3. Standard ATX Power Supply Connected



7.3 Test Fixture Loading Table

The Table below shows how the rack of test equipment is setup.

Table 7-2. DC Channel Load Assignments, Nine Voltage Rails (5–12V Rails)

Rail Name	5V	3.3V	5VSB	-12V	12V1	12V2	12V3	12V4	12V5
Main Purpose	**ATX - 24 Pin Connector**					**CPU1**	**CPU2 or PCI-E* Gfx #1**	**CPU3 or PCI-E* Gfx #2**	**PCI-E* Gfx #3**
DC Load	Model 63630-80-80	Model 63630-80-80	Model 63630-80-20	Model 63630-80-20	Model 63630-80-80 **Qty2 – 800W**	Model 63630-80-80 **Qty2 – 800W**	Model 63630-80-80	Model 63630-80-80	Model 63630-80-80
DC Load location	2 – 5	2 - 7	2 – 10	2 – 9	1 – 1 and 1 – 3	1 – 5 and 1 – 7	1 – 9	2 – 1	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	**12VB –** 2x4-J115; 2x4 (half) J102	**12VH –** 2x3-J106; 2x3-J107	**12VI -** 2x3-J108; 2x3-J118 2x4-J119
					12VF – 2x4 -J111; HDD and SATA CN111, 104, 105, 106; CON13,14	**12VE –** 2x4 -J114; 2x4 (half) J103	**12VL -** 2x4 (half) J104 2x4-J110; 2x3-J116; 2x3-J117	**12VK –** 2x4 (half) J104; 2x3-J121	**12VJ –** 2x3-J109; 2x3-J122
					12VG – 2x4 -J112; HDD and SATA CN110,101,102, 103;CON6,12			**12VD –** 2x4 (half) J103; 2x4-J120	

When a power supply with one large 12V rail is tested, the CPU (2x4) and PCI-E* Graphics connectors (2x3) are plugged into J110, J111, J112 for Test Items that follow use the "Sticker/TPT or Static based load Calculations" per Section 1.5 of this document.

Then for Test items that follow the "Efficiency based Load Calculations", per Section 1.5, the power supply 12V connectors are spread out as much between DC Loads (12VA – 12VL) to spread the current load and IR loss between as many connectors as possible.

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