The Complete Cybenetics Test Protocol, Including Energy Efficiency, Output Noise, And Overall Performance Calculation of AC-DC Power Supplies

Revision 3.4

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Revision History

Version	Release Date	Notes
1.0	February 2020	First draft
1.1	March 2020	Overall Performance Algorithm Update
1.2	June 2020	Noise Measurements Procedure Update
1.3	July 2020	Added Background noise calculation
1.4	August 2020	Added Leakage Current Equipment & Updated EMI equipment
1.5	January 2021	Changes in some definitions
1.6	May 2021	Changes in load regulation calculation and other minor fixes
1.7	September 2021	Minor changes
1.8	September 2021	Fix an error in Eq10 description, PSU timings updated description, Change in Eq12
1.9	November 2021	Added efficiency and PF calculation for redundant PSUs and some more changes to introduce ATX12VO PSUs
2.0	May 2022	Added new transient response tests for ATX v3.0 compatible PSUs
2.1	June 2022	Fixed a typo in Eq 8
2.2	January 2023	Made changes to the performance calculation algorithm and the examples
2.3	February 2023	Changes to the performance calculation algorithm (ATX v3.0 Transient Response Bonus)
2.4	February 2023	Fixed some typos in the performance calculation examples
2.5	March 2023	ATX v3.0 Testing Procedure Updates
2.6	May 2023	5VSB CL test load changed to 3 W
2.7	January 2024	Change in OCP bonus
2.8	June 2024	Minor changes
2.9	September 2024	Added fan failure bonus points and ATX v3.1 reference. Hold-up time clarifications.
3.0	September 2024	Added background noise screenshot. Minor other changes.
3.1	April 2025	Added AC Input Protection Features Evaluation Tests.
3.2	June 2025	Added PSU Cable Gauge Requirements
3.3	August 2025	Added PSU Cable Types
3.4	August 2025	Added EMC-Precompliance and Uncertainty Calculations

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Definitions

AC Signal
A time-varying signal whose polarity varies with a period of time T and whose average value is zero. [1]

Ambient Temperature
The temperature of the ambient air immediately surrounding the unit under test (UUT). [1]

Apparent Power
The product of RMS voltage and current (VA). It is also known as total power.

AWG
AWG (American Wire Gauge) is a standardized system used in the United States to measure the diameter of electrically conducting wires. The gauge number inversely indicates the wire's thickness: the higher the AWG number, the thinner the wire. It's commonly used for electrical wiring in homes, electronics, and industrial applications.

Dc Signal
A signal of which the polarity and amplitude do not vary with time. [1]

Efficiency
The ratio, expressed as a percentage, of the total real output power to the real power input required to produce it, using the following equation:

$$\eta = \frac{P_{out}}{P_{in}} x\ 100$$

The input power (Pin) includes the power that the cooling fans of the UUT require.

PSU
Power Supply Unit converting one voltage to DC voltage output or outputs, depending on its type. For example, PSUs with multiple DC voltage outputs (rails) are mainly used in desktop PCs.

IEEE Std 1515-2000
The IEEE Std 1515 [1] is a primary specification language, providing parameter definitions, test conditions, and test methods. It does not attempt to standardize the specification itself. Instead, it provides the basis that allows everyone to speak the same language on a level playing field. This standard was withdrawn on 2019-11-07 [https://standards.ieee.org/standard/1515-2000.html], but we decided to use several of its definitions since they still apply.

ATX Spec

ATX (Advanced Technology eXtended) is a motherboard and power supply configuration specification developed by Intel in 1995 to improve on previous de facto standards like the AT design. [6]

Output Voltage Ripple

The maximum AC voltage present on a DC or low-frequency AC voltage stated in peak-to-peak voltage. The intent is to characterize the residual component associated with the switching action at the output switching frequency (or twice the output switching frequency).

True Power Factor

True power factor is the ratio of the active, or real, power (P) in Watts to the apparent power (S) in Volt-Amperes

$$PF = \frac{P}{S}$$

Crest Factor

The crest factor is the ratio of peak current to RMS current (or peak voltage to RMS voltage). For example, for a pure sinusoidal wave shape, the crest factor is 1.414, while for a pure constant DC load, the crest factor is 1.0.

Rail or DC Bus

Any of the DC outputs of the PSU which delivers power to the connected system. The standard rails for multi-rail PSUs are +12V, +5V, +3.3V, +5VSB, with -12V being optional by the latest ATX specs.

Rated AC Input Voltage Range

The input voltage range (minimum/maximum) is provided by the UUT manufacturer. It is shown on the power label of the UUT.

Rated DC Output Voltage(s)

Description

Rated DC Output Power and Current

The rated DC output power and current is the maximum load that a PSU can provide at a specified ambient temperature on its rails. The manufacturer provides the DC output power and current output for each of the PSU's rails, and it is depicted on its power label and the packaging. Therefore, if there is any difference, we always consider the power label on the PSU.

RMS (Root Mean Square)

The square root of the average of the square of the value of the function taken throughout the period. For instance, the RMS voltage value for a sine wave may be computed as:

$$Vrms = \sqrt{\frac{1}{T}\int_{0}^{T} V^2 (t)dt}$$

Where T is the period of the waveform,

V(t) is the instantaneous voltage at time t

VRMS is the RMS voltage value.[1]

Steady State

The operating condition of a system wherein the observed variable has reached an equilibrium condition in response to an input or other stimulus per the definition of the system transfer function. In the case of a power supply, this may involve the system output being at some constant voltage or current value. [1]

Total Harmonic Distortion (THD)

The total harmonic distortion (THD or THDi) [7] is a measurement of the harmonic distortion present in a signal and is defined as the ratio of the sum of the powers of all harmonic components to the power of the fundamental frequency.

UUT

UUT is an acronym for "Unit Under Test," which refers to the PSU sample under test.

Prologue

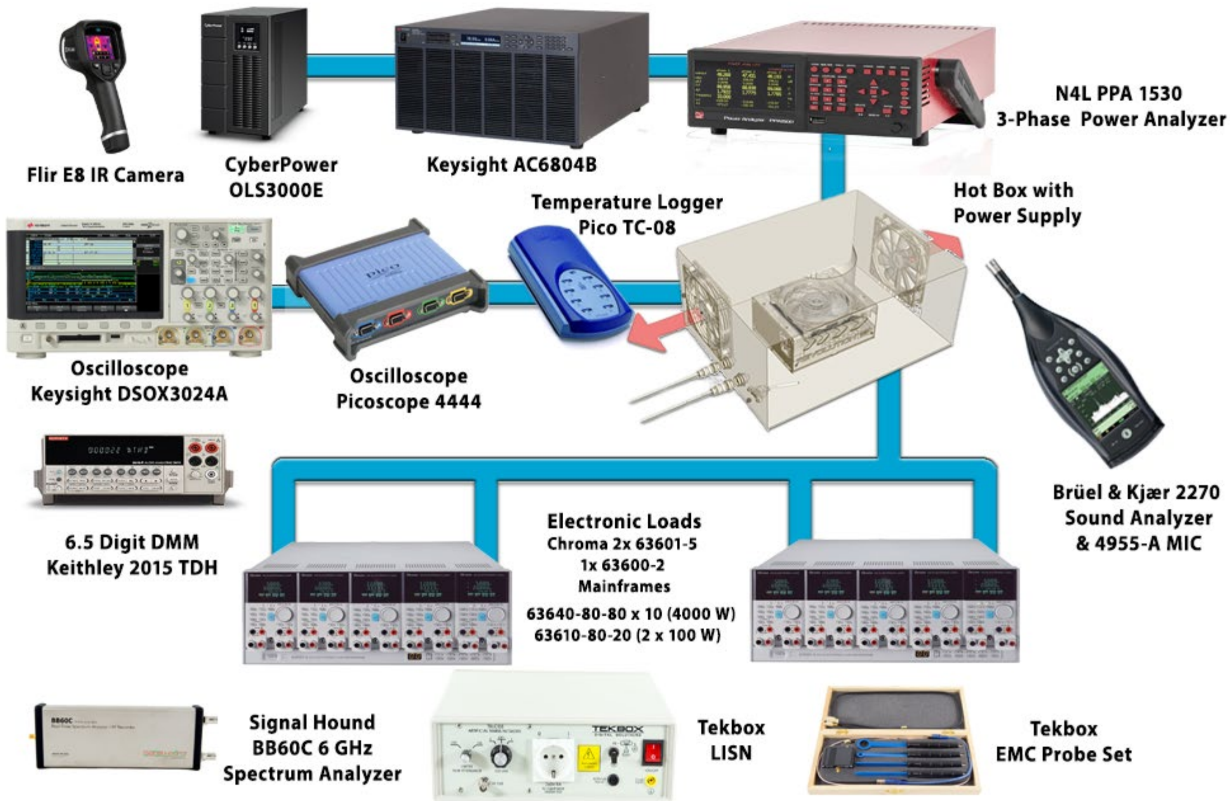
The purpose of this article is to explain our methodologies and testing procedures clearly, not only for efficiency and noise output results but for all significant performance aspects of a PSU, including ripple suppression, transient response, hold-up time, inrush current, etc.

This article will be a great source of information for all brands and manufacturers that want to check the compatibility of their products with our efficiency and noise standards (ETA and LAMBDA). Moreover, it will allow every laboratory with the proper equipment to verify our results, as the ISO17025:2017 [8] dictates. To elaborate more on this, two labs with calibrated equipment that have the same capabilities and can offer similar levels of accuracy in results should come up with identical results, given that they follow the same methodology. Cybenetics aims to become a certification body. It will accept all results coming from ISO17025-certified labs that follow the provided methodology for obtaining the necessary data, from which the ETA and LAMBDA certifications derive.

So far, the existing efficiency standards have had many flaws, which include, among others, the limited number of measurements (three to four), the very low ambient temperature at which the tests are conducted, the lack of any standby rail measurements, and the absent of mention to the equipment used to perform measurements. Especially the latter is of immense importance since every proper testing report should include the equipment used to conduct all measurements.

Test Setup & Measurement Conditions

Unless otherwise specified, all measurements are conducted with the equipment and the conditions mentioned below.

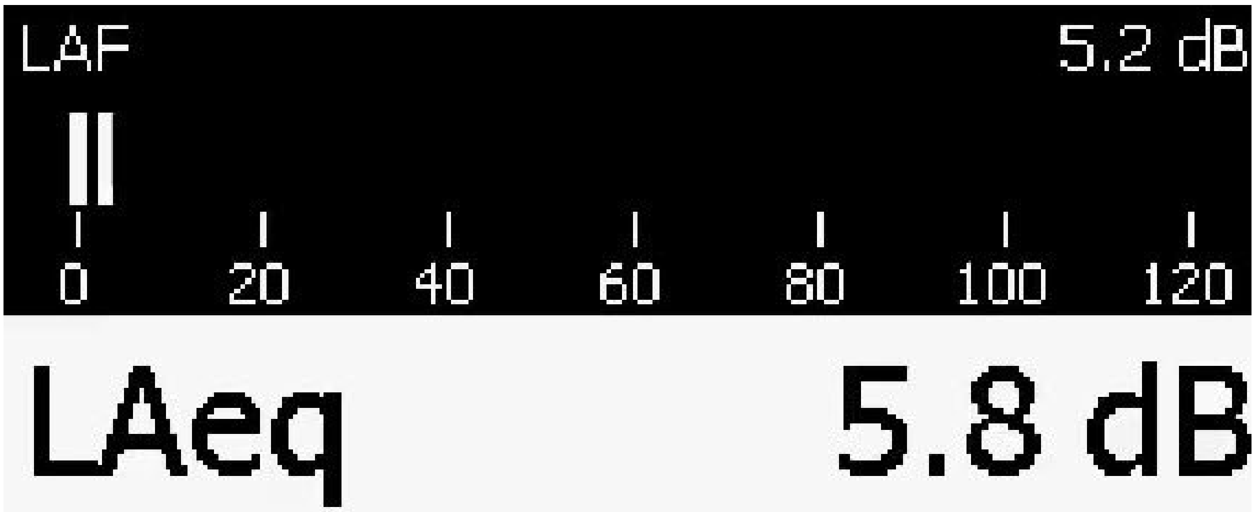


Measuring Equipment

All measurements are performed using several fully-equipped Chroma 63600 stations. Each can deliver more than 4 kW of load and includes two 63601-5 and one 63600-2 mainframes. In addition, each of the mainframes mentioned above hosts ten 63640-80-80 [400 W] electronic loads along with two 63610-80-20 [100 W x2] modules. Finally, we have one Chroma 6314 station, which is currently held as a backup. It can deliver up to 2500 W of load and consists of two 6314A mainframes equipped with the following electronic loads: six 63123A [350 W each], one 63102A [100 W x2], and one 63101A [200 W].

The AC sources that we use are a Chroma 6530, capable of delivering up to 3 kW of power, a Chroma 61604 used in our inrush current test station, with 2 kW max capacity, and two Keysight AC6804B with 4 kW max power. All AC sources are connected to the mains network through powerful isolation transformers. Finally, we protect the AC sources with CyberPower OLS3000E online UPS devices.

The rest of our equipment consists of three Picotech TC-08 thermocouple data loggers, two Fluke multimeters (models 289 and 175), a Keysight U1273AX multimeter, a Keithley 2015 THD 6.5 digit bench DMM, and three lab-grade N4L PPA1530 3-phase power analyzers, featuring 0.05% basic accuracy. In addition, for backup purposes, we have a Yokogawa WT210 power analyzer and a GW Instek GPM-8212. Finally, we also have a highly accurate N4L PPA5530 3-phase power analyzer with 0.01% basic accuracy used in our inrush current test station.



The noise measurements are conducted with Class 1 Bruel & Kjaer sound analyzers (2270 G4 and 2250-L G), equipped with type 4955-A low-noise and free-field microphones, which can measure down to 5 dB(A) (we also have type 4189 microphones that features a 16.6-140 dBA-weighted dynamic range). The sound analyzers are installed into a hemi-anechoic chamber, with a close to 6 dB(A) noise floor. A Bruel & Kjaer Type 4231 is used before every noise measurement to calibrate the sound analyzers.

We can conduct Electromagnetic Compatibility (EMC) evaluations since our lab is equipped with a Rigol RSA3015E-TG Spectrum Analyzer (9kHz -1.5GHz), featuring the EMI option. We also use a Tekbox TBLC08 LISN to isolate the power mains from the device in this test (DUT). Our second Spectrum Analyzer is a Signal Hound BB60C, and we also keep a Rigol DSA815-TG in reserve. Finally, to identify the EMI source should the need arise, we have at our disposal a set of Tekbox EMC probes (TBPS01) and a TBWA2 wide-band amplifier.

For measuring leakage current, we use a GW Instek GPT-9804 electrical safety tester instrument. Besides leakage current, this tester can also conduct the following measurements:

- AC Withstanding
- DC Withstanding
- Insulation Resistance
- Ground Bod

Measuring Software – Faganas ATE

An essential part of our methodology is the control and monitoring software connected to all equipment we use, even the hotbox. This application is developed for the past ten years, and it consists of thousands of lines of code. We recently coded the application again in C# to keep it in line with the modern coding trends.

Besides gathering all data, storing it, and allowing it to extract it in any possible form, which meets our requirements, one of its most vital functions is that it also allows us to average all readings that we get. Usually, we check each different load level for four to ten minutes, and during this period, we don't just take any random readings, but we gather all of them and take the average readings as the final result. This is the only way to have highly accurate results. Furthermore, as the heat increases at the internals of the power supply and the resistance of the PSU's gauges changes, it is natural to have voltage, load, and load and efficiency differences due to the temperature difference. So the best way is to take all readings throughout a test into account and accept the average as the final result.

Input Voltage & Max Watt Output

Besides 115 V and 230 V, we also conduct testing at 100 V to check the PSU's performance with a lower voltage input. Since we push all PSUs hard at high ambient temperatures close to 45°C, we avoid testing with an even lower voltage input (e.g., 90V) since a PSU failure can also damage the power analyzer directly connected to it. However, by cranking up the heat inside the hotbox and dialing higher loads than the nominal ones, we already apply massive stress to the DUT, especially with 100 V input, simulating some of the worst real-life scenarios.

We use the PSU's label to check on the max Watt output. We also conduct a test with 110% load of the PSU's max-rated capacity with the operating temperature exceeding 45°C, in PSUs claiming to deliver continuous full load output at 50°C.

Test Conditions

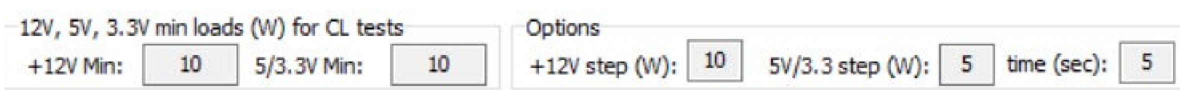
The ambient during the efficiency and noise output testing is 30°C (+-2C°). We also conduct tests at higher ambient temperatures within the 35-45°C range (+-2°C).

Efficiency Measurements Procedure

Contrary to existing methodologies, which only take three to four measurements, we apply more than 1450 different load combinations in the DUT. The whole procedure lasts about two and a half hours in total. The overall or average efficiency is the average of all measurements, covering the PSU's entire operating range, except redundant PSUs where we take 2-100% of the PSU's operating range. This way, it is impossible for a manufacturer to tune its products to meet some specified load levels since, in essence, we take under consideration the efficiency levels under a higher number of different load combinations, evenly spread throughout the entire load range. Besides efficiency, we also take voltage, ripple, power factor, noise, and temperature measurements.

For ATX12V PSUs, we try to have at least 20 different load levels at 5V and 3.3V. At the same time, we also set an appropriate load step at +12V, which can deliver at least 1450, in total, load combinations at +12V, 5V, and 3.3V. Finally, we apply a steady load of 0.6A at 5VSB while we don't deal with the -12V, which is not required anymore by the newest ATX spec.

In redundant and ATX12VO units with a single main rail and a standby one only, we increase the load on the latter rail by 1W, so if this rail has 15W capacity, we apply 15 different load levels (1W increase each time) while setting an appropriate load step on the main rail to allow for at least 1450 different load combinations.



A description of the algorithm used to derive the load levels on the rails of an ATX12V PSU is provided below in code form. A simpler algorithm is used for units with only two rails (main and standby). The output table contains all possible load combinations, given the +12V and 5V/3.3V Watt step output that we select. We also have an entry for the minimum applied load on the rails. Some older PSUs with a group-regulation scheme on the secondary side cannot operate appropriately with zero load at +12V and full load on the minor rails (and vice versa). Finally, the load at 5VSB remains the same throughout these tests. We chose this for two reasons: this is a standby rail, so most likely, it won't be utilized while the PSU is in operation, and secondly, if we also employed this rail in the algorithm shown below, the corresponding testing would last much longer.

```
Max_12V_load =  PSU_12V_max_power - V12_min_load
Max_5V_load = (Minor_Rails_Max_Combined_Load /5) *3
Max_33V_load = (Minor_Rails_Max_Combined_Load /5) *2

Load_steps_12V := round(Max_12V_load / Watts_12V_step)
Load_steps_5V := round(Max_5V_load / Watts_5V_33V_ step)
Load_steps_33V := round(Max_33V_load / Watts_5V_33V_ step)

for i := 0 to Load_steps_12V do
      for k := 0 to Load_steps_5V do
      {

        l := k;
        if l > Load_steps_33V then l := Load_steps_33V

        total12V:= V12_min_load + Watts_12V_ step * i
        total5V = V5_V33_min_load + Watts_5V_33V_ step * k
        total33V = V5_V33_min_load + Watts_5V_33V_ step * l

        if total12V + total5V + total33V <= PSU_Max_Power then
        {
          j = j + 1;
          //Row Number
          Load_combinations_table.Cells[0, j] = j
         // 12V load
          Load_combinations_table.Cells[1, j] = total12V
          // 5V load
          Load_combinations_table.Cells[2, j] = total5V
           // 3.3V load
          Load_combinations_table.Cells[3, j] = total33V

        }
       }
```

The massive load of data that our methodology provides allows us to quickly modify our efficiency certification program, should this be required. Finally, we start our tests at close to 30 °C with the PSU inside a hotbox, simulating a case environment. At the end of the test, the ambient temperature inside the box reaches up to 32-34 °C, close to real-life conditions.

Vampire power (power consumption with no load on the 5VSB rail) is of high importance in ATX12V and ATX12VO units since all this amount of energy goes wasted, and most PC systems aren't kept in operation 24/7, meaning that for a significant part of the day, the PSUs just consume energy without doing anything useful. We evaluate each PSU by following the EN 50564:2011 and IEC 62301 [2] measurement guidelines closely. If the DUT doesn't meet our standards, it will be automatically downgraded to the next lower efficiency certification level. The whole procedure is easy to follow, in case you have an advanced power analyzer. With the PSU installed on one of our load testers and powered through one of our AC sources, we have it in standby mode and run the corresponding application, automatically collecting all vampire power readings and providing us the full report in 15 minutes. During the process, if the TDH readings of the AC input go out of spec, the result is rendered as not valid by the application.

Besides all the above, ETA will also consider the average efficiency of the standby rail. We measure efficiency on this rail per 0.05 A steps up to its max current output, and the average of all measurements is the final efficiency result. Thus, we expect all PSUs to deliver over 70% average efficiency output on this rail, with this threshold set even higher for units that fall into the top categories of the ETA program.

Output Noise Measurements Procedure

As we already mentioned in the efficiency measurements procedure, we apply at least 1450 different load combinations on the rails of the DUT while at the same time monitoring all vital data, including the fan speed. With the fan speed range data in hand, we take noise measurements with as small intervals as possible, have high accuracy, and cover the entire range. For example, if the fan speed range is 400-2000 RPM, we take noise measurements per 50 RPM intervals.

The noise measurements are taken in a hemi-anechoic chamber with the DUT switched off and its fan connected to an external power supply, applying the voltage required to achieve the desired fan speeds. Moreover, the fan speed is continuously monitored by a tachometer. This way, we can eliminate third-party noises, including the noise of electronic loads.

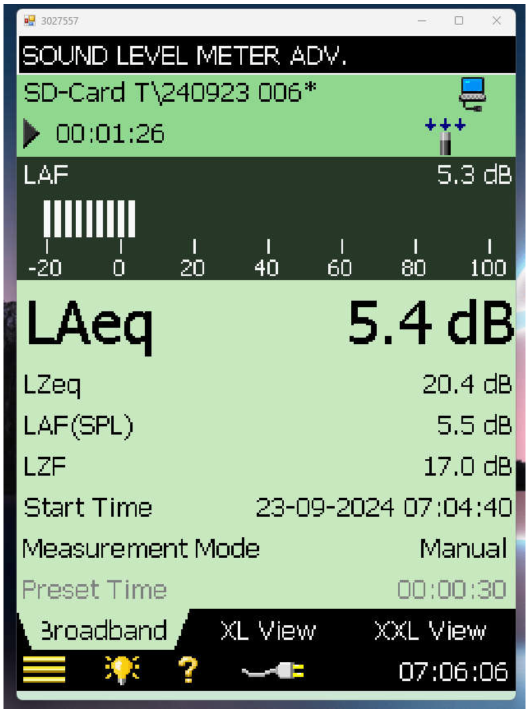
We make a table with the fan speed in RPM and the corresponding noise at that speed. Afterward, our software looks into all data gathered during the load tests and assigns a decibel value to each fan speed value using the table above.

Once we have a dBA value for each of the tests we conducted with multiple load combinations, we convert the dBA values to SPL to average them, and once this is done, we reverse the outcome to dBA again. This procedure allows us to have a single number describing the DUT's average noise output with at least 1450 load combinations. According to this number, we tax the DUT into one of the LAMBDA categories.

Besides the fan's noise, we also check for electronic noise (coil whine) by applying a combination of loads to the DUT while it is installed in the hemi-anechoic chamber, using a passively-cooled load tester. If we find any electronic noise that exceeds 6-6.5 dBA, we must consider if the lowest fan noise levels are within a 10 dBA range because it affects noise measurements. The easier way to do this is by conducting the corresponding fan noise measurements with a load applied to the DUT to create the conditions that generate electronic noise. Based on our testing results so far, it is rare to find a power supply with higher than 6.5 dBA electronic noise at a one-meter distance, using a resistor-based load. Thus, in most cases, coil whine noise is due to a combination of system parts. Finally, the applied scenario, which forces the PSU to emit electronic noise, plays a notable role. Because a PSU might have electronic noise while it is switched on and without any load on its rails, this is not a real-life scenario, so we don't consider it (but still, we write down the results and notify the manufacturer about this issue). The same goes for operation with only the 3.3V rail having a load, or the 5V rail or both the minor rails (in PSUs with DC-DC converters, though, for the generation of the minor rails, this means that the +12V rail is also in use since it powers the converters as mentioned above). On the contrary, we take into account scenarios where the load is only applied at +12V or 5VSB (with the PSU in standby mode).

Background Noise Calculation

The background noise in our chamber can range from 5.5 dBA to 8 dBA, depending on the external conditions. Therefore, to obtain the best possible conditions, we prefer to take our noise measurements at night, when the ambient noise is lower than during the day.



In no case can the background noise exceed the sound of interest, and in practice, the output level of the DUT has to be at least 3 dBA higher than the background noise for the measurement to be accurate. Still, a correction has to be applied to get the correct result. The background noise correction is defined as K1 [9] [11], and it is the amount the measured source level is reduced to obtain the background noise-corrected source level.

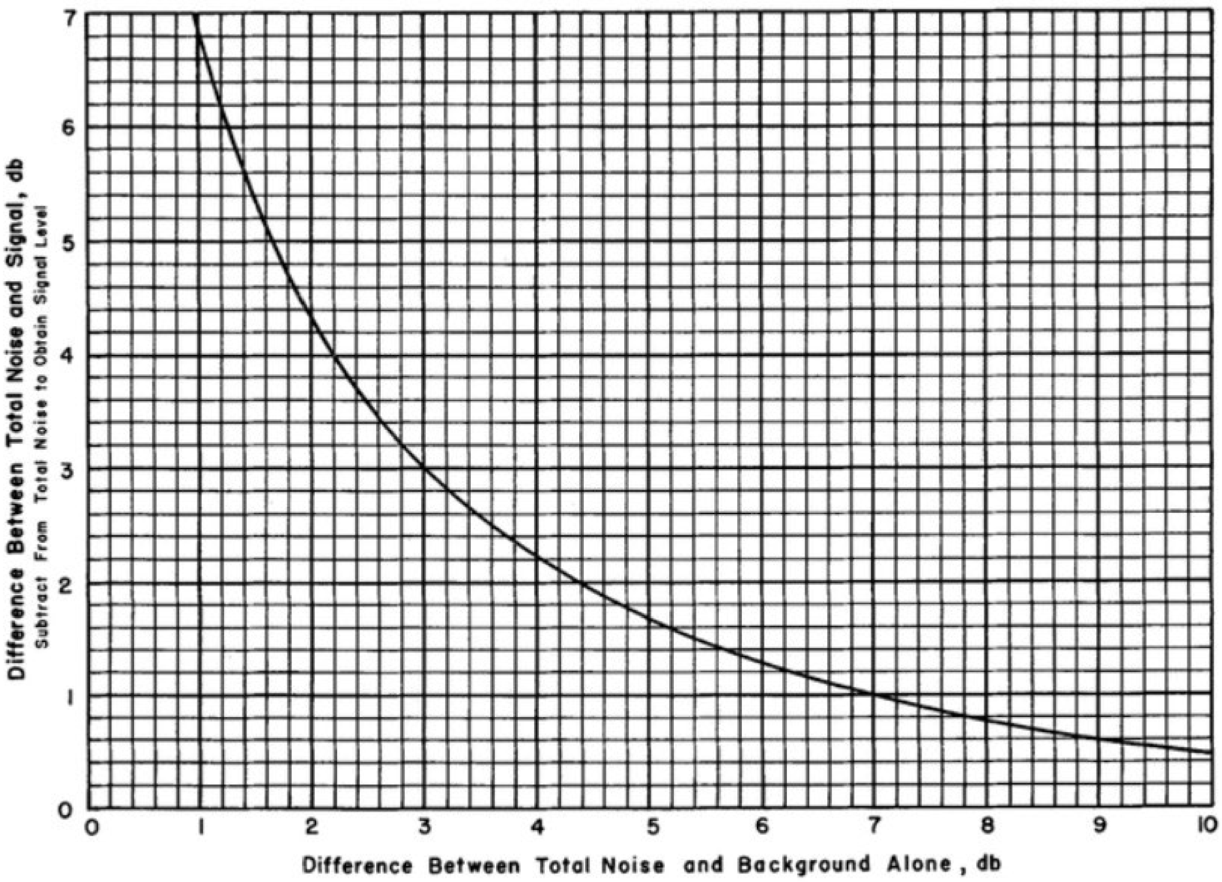
The procedure for measuring a DUT's noise output is the following:

- Measure the total noise level (L_{DUT} + L_{BG}) with the DUT in operation, paying extra attention to its lowest noise output mode.
- Measure the background noise level (L_{BG}) with the DUT switched off.
- Calculate the difference between the two readings mentioned above (L_{DUT} - L_{BG}). If it is less than 3 dBA, the background noise is too high to measure accurately. If it is within a 3-10 dBA range, a correction has to be applied. There is no need for correction if the difference is greater than 10 dBA, but we still use it for up to 20 dBA differences.

The formula for calculating the noise source without the influence of the background noise is the following:

$$L_{DUT} = 10\ x\ log(\frac{10_{LDUT}}{10} - \frac{10_{LBG}}{10})$$

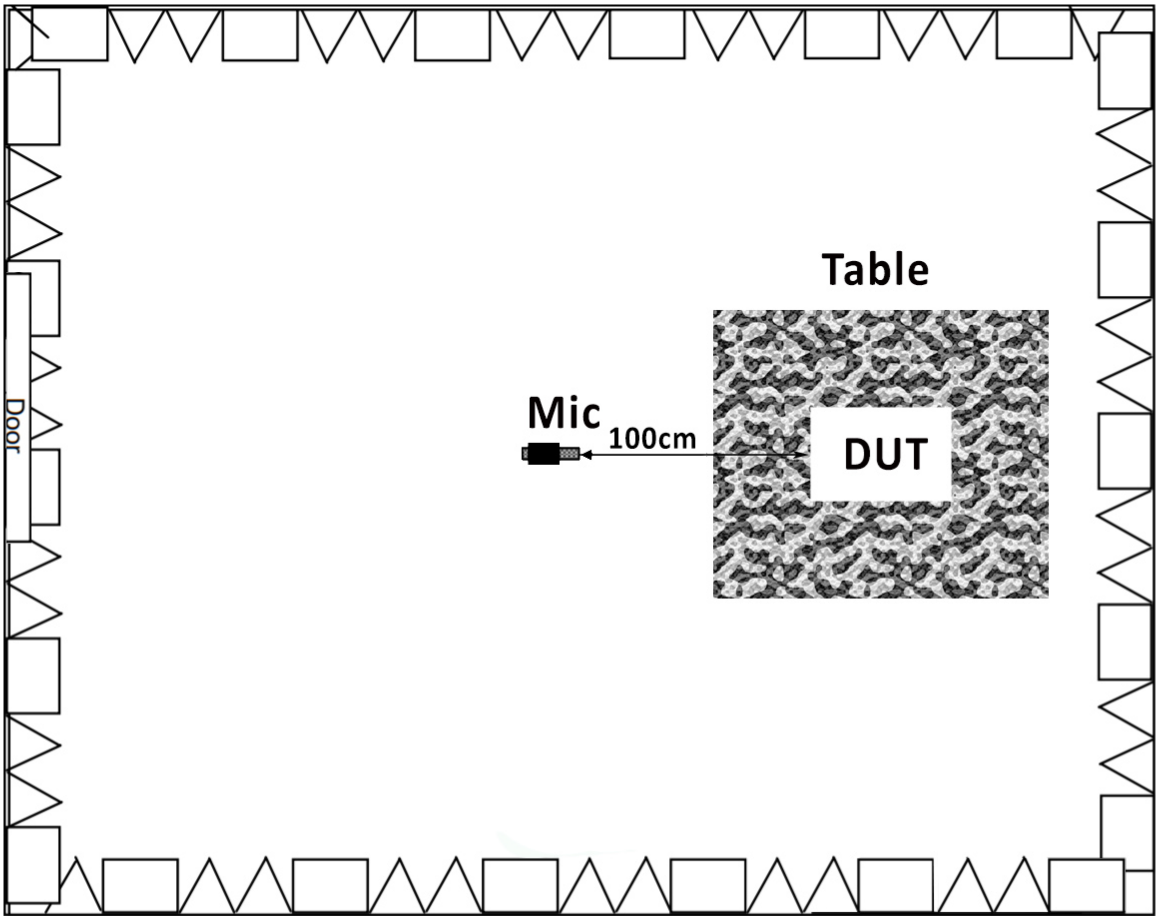
In a spreadsheet, the formula above can be given as 10*log(10^(LDUT/10)-10^(LBG/10))



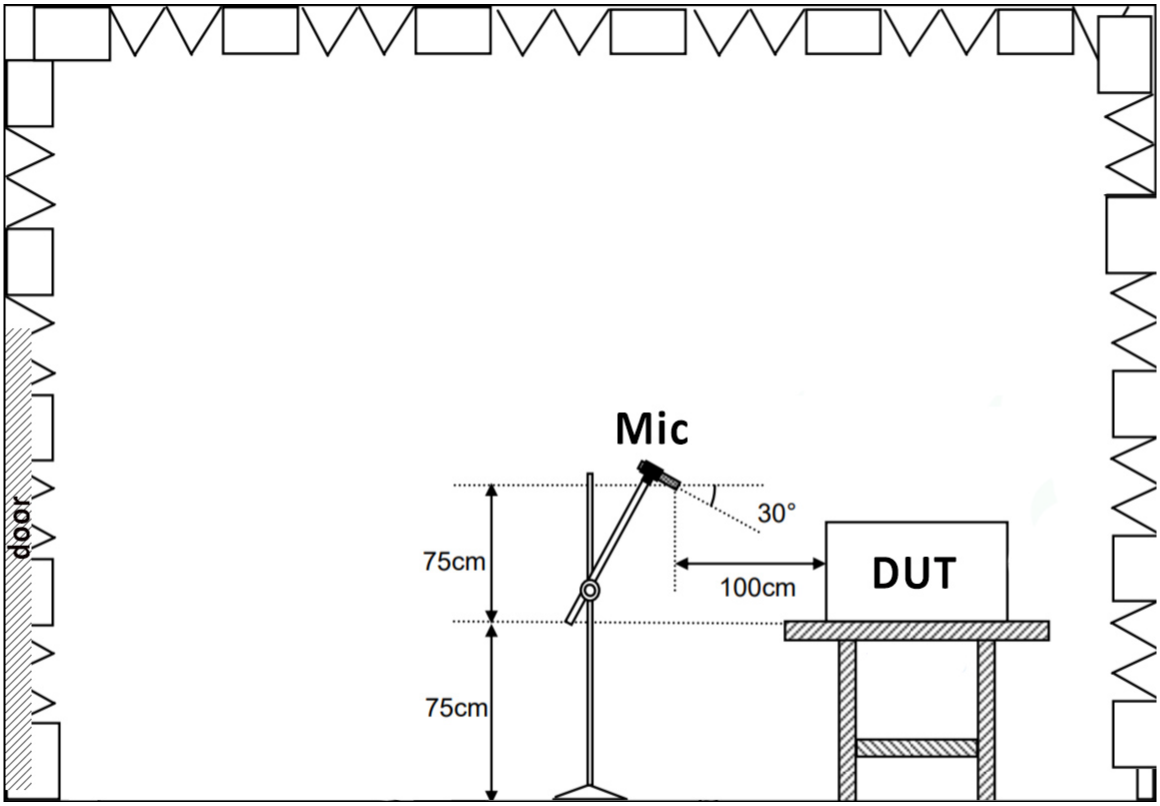
The chart above can be used to make background noise corrections to the source signal.

Output Noise Measurements Test Set-Up

In the schemes below, you will find an outline of our hemi-anechoic chamber with the exact placement of the MIC and the DUT. We strictly follow the corresponding ISO Standards [9][10].



Top View



Side View

EMC Pre-Compliance – Explanation & Equipment

Every electronic device, including PSUs, can be an EMI source, which, depending on the amount of EMI emitted, can affect the proper operation of nearby devices. EMI can, in some extreme cases, even render them unusable. Some standards have been established to minimize electromagnetic interference (EMI) noise. The corresponding standards for IT (Information Technology) products are CISPR 32 and its derivative, EN 55032, which applies to products sold in the EU. In the EU, every product bearing the "CE" marking must comply with the EN 55032 standard. CISPR 32 and EN 55032 standards categorize devices into two classes: A and B. Class B equipment is intended for domestic environments. Hence, its permitted EMI emissions are significantly lower than those of A-class devices.

The equipment we use to obtain EMI readings:

- Rohde & Schwarz FPC1500 (loaded with all options)
- Tekbox TBLC08 LISN
- Tekbox TBFL1 transient limiter
- Tekbox EMCview software

EMC Pre-Compliance – Profficieny Testing & Cybenetics Certificate

A proficiency test (PT) in ISO 17025 is an external evaluation where a laboratory's test or calibration results are compared with those of other labs on the same sample. It is essential because it verifies the accuracy and reliability of a lab's results, demonstrates technical competence, and provides evidence of compliance with ISO 17025 requirements, which is critical for maintaining accreditation and customer trust. Below you will find the results in the EMI PT test that we conducted.

RVEP 245100 Conducted disturbance
CISPR 16-2-1 - EN 55016-2-1 - EN 55011

Deutsches
Referenzbüro für
Ringversuche und
Referenzmaterialien

CERTIFICATE FOR PARTICIPATION

DRRR Proficiency Testing

The participant

Cybenetics LTD
Aristeidis Bitziopoulos
Syrou 6
2231 Latsia/ Nicosia
Cyprus

Customer number: *17498*

lab code number: *5*

gets for the above mentioned quantitative proficiency testing the following valuation:

excellent performance

To the above mentioned proficiency testing the corresponding report contains the statistical evaluations.

Kempten, 23.05.2025

Deutsches Referenzbüro für Ringversuche und Referenzmaterialien

Thorsten Helbig

Valuation:

If the mean of z'-scores of all evaluated results is smaller than 2 or equal and single z'-scores are smaller than 2 or equal you will get the valuation: „excellent performance“

If the above criteria for the rating "excellent performance" are not fulfilled, you will receive the rating: "participated".

For all mean value calculations of the z'-score in this certificate, only their amounts are used.

EMC Pre-Compliance – CISPR 32 / EN55032 Limits

CISRP 32 / EN 55032 Class A Conducted EMI Limit		
Frequency of Emission (MHz)	Conducted Limit (dBuV)	
	Quasi-peak	Average
0.15 - 0.50	79	66
0.50 - 30.0	73	60

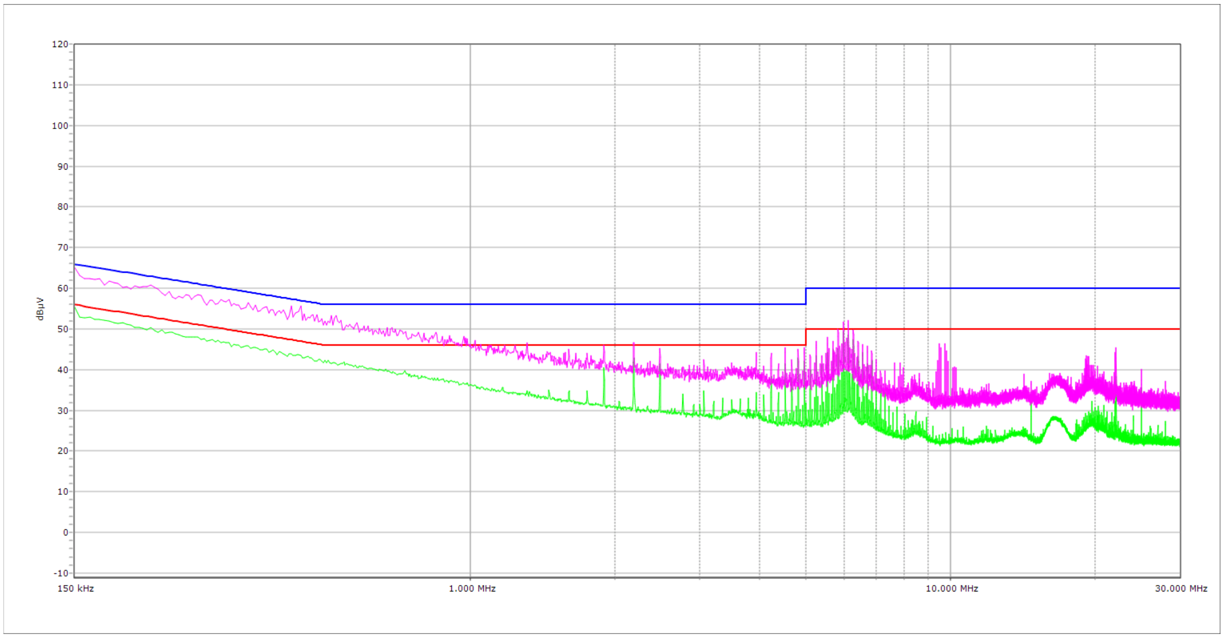
CISPR 32 / EN 55032 Class B Conducted EMI Limit		
Frequency of Emission (MHz)	Conducted Limit (dBuV)	
	Quasi-peak	Average
0.15 - 0.50	66 - 56	56 - 46
0.50 - 5.00	56	46
5.00 - 30.00	60	50

CISRP 32 / EN 55032 Class A 10-Meter Radiated EMI Limit	
Frequency of Emission (MHz)	Field Strength Limit (dBuV/m)
30 - 88	39
88 - 216	43.5
216 - 960	46.5
> 960	49.5

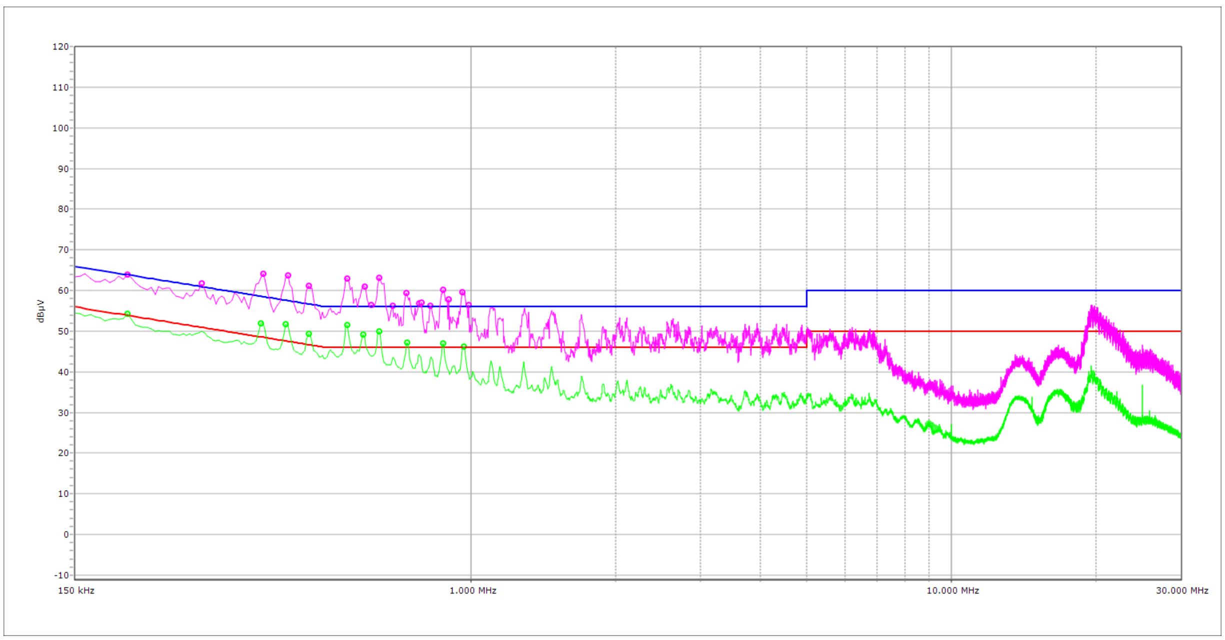
CISRP 32 / EN 55032 Class B 3-Meter Radiated EMI Limit	
Frequency of Emission (MHz)	Field Strength Limit (dBuV/m)
30 - 88	40
88 - 216	43.5
216 - 960	46.0
> 960	54.0

Please note that the ATX spec allows a 4 dB margin for conducted and radiated emissions. This means that if a PSU exceeds the limits but stays within the 4 dB margin, it meets the corresponding ATX spec requirement (8.1 Emissions). The CISPR 32 / EN55032 limits don't provide this margin, though.

EMC Pre-Compliance –EMI Results (Pass/Fail Examples)



In this graph, with green are the average EMI detector's result and with purple the peak EMI detector's results. The average detector has to remain below the red line and the peak detector below the blue one. To save time we run the peak EMI detector, which provides the worst-case scenario, and if the PSU fails, we run the quasi-peak EMI detector which takes much longer, but it smoothens out the peaks so the PSU might pass the tests without failing. In this graph the PSU clearly pass both detectors with success.



These are the results of a PSU failing both the average and quasi-peak detectors. Both have to be a "pass" for the PSU to meet the CISPR 32 / EN55032 requirements.

Another note, we run two sets of EMI tests, one checking the Phase and one checking the Neutral. The phase wire is at a varying voltage (positive and negative), whereas the neutral wire is designed to be at zero potential relative to the ground. Think of the phase as the "supply" and the neutral as the "return path" for the current.

PSU Cabling Requirements

The thicker the wires on the PSU's cables, the lower the voltage drops at high loads, hence the higher the efficiency and the better the load regulation, but thicker gauges are also more expensive, than thinner gauges with the same material. This is why the ATX specification sets some minimums regarding gauge thickness which as Cybenetics not only we follow, but in some cases, we become even stricter.

In general, our minimum requirements for gauge thickness for all wires transferring the power lines are as below:

- Main Power Connector: 18AWG (for the power gauges; 22AWG for sense)
- EPS: 18AWG
- PCIe 6+2 pin: 18AWG (for the power gauges; 20AWG for sense)
- PCIe 12+4 pin: 16AWG (for the power gauges; 28AWG for sense)
- SATA: 18AWG
- Molex 4-pin: 18AWG

About the 12+4 pin 12V-2x6 (or 12VHPWR) cable there are some arguments, that from the moment some PSUs have the respective connector set at lower levels than 600W (450W or 300W), why the use of 16AWG is required, from the moment 18AWG gauges could handle the lower power settings. This is because this specific cable is the only one compatible for all PSUs, regardless of brand and maker, from the moment they use a native 12+4 pin header on their modular boards. So users can use any of these cables to any ATX v3.1 PSU with a native header, meaning that if the power transfer gauges are thinner than 16AWG, there can be issues at the full power setting of this connector (600W).

The requirement of 16AWG gauges for the power transfer wires ensures the compatibility and safety under all usage scenarios and cases. Given that this is a safety issue, both Intel and Cybenetics suggest the use of 16AWG gauges on 12V-2x6 or 12VHPWR cables (they are the same, only the name changes) regardless of the PSU and the setting of its corresponding header.

Besides gauge thickness other factors affect the resistance and power handling of cables, including of course the material used for the conductor. Copper is preferred instead of aluminum which has notably lower conductivity. The only issue here is that aluminum costs less and this is why it is frequently used in the cables of affordable PSUs.

Cybenetics will evaluate from now (August 2025) the type of conductors that the PSU under test use and classify them into the following categories:

- Pure Copper

- CCA (Copper-Clad Aluminum)
- CCS (Copper-Clad Steel)

There is another category, called CCC (Copper-Clad Copper) but it is not easy to identify such cables.

In any case Pure Copper cables are preferred, since copper has lower resistance than aluminum and steel. On top of that, CCA cables are prone to fatigue because of mechanical weaknesses. Aluminum is more prone to breakage and corrosion than copper. CCS cables are stronger than CCA ones, but they are less flexible so cable routing will be tougher. Moreover, steel cores are susceptible to corrosion, leading in notable performance degradation over time.

Cable insulation is also critical and can play a vital role in the protection features section. A heat resistant, flexible and resistant to abuse external shell protecting effectively the conductors.

Another thing that should be avoided is to have two high-power connectors on the same cable. For example, using two EPS connectors on the same cable can lead to problems if both of these connectors are heavily utilized and at high operating temperatures. In general EPS connectors should be installed on dedicated cables (one on each cable) and ideally this should also be the case for 6+2 pin connectors. When you need to power a graphics card equipped with two or more 6+2 PCIe sockets, it is preferred to use dedicated PCIe cables.

Overall Performance Calculation

It is challenging to characterize the overall performance of a complex product like a power supply with a single number since we conduct a vast number of tests, and far too many factors must be considered. Nonetheless, we have completed thousands of power supplies so far, and our database includes enormous amounts of data, which allowed us to find the best, up so far, algorithm for this job. We strive to improve our methodology continually, so it is highly probable in the future to proceed with changes in this algorithm to make it even more accurate. Given that we already have all the data in hand, it is easy to calculate all the PSUs' overall performance scores in our database in every change we make in the performance algorithm.

Our overall performance algorithm takes into account all major performance factors:

- Load regulation
- Ripple suppression
- Transient Tests Response Deviation
- Voltage overshoots during Turn-On Transient tests
- Average efficiency
- The efficiency with 2% load
- Average efficiency of the standby rail
- Standby Power consumption
- Average Power Factor
- Hold-up time
- Power-ok signal

- Max Power
- PSU Timings
- PSU Protection Features

Load Regulation

A PSU would maintain a constant voltage level regardless of load in an ideal world, but there is always a voltage drop on each rail as the load increases in real-life scenarios. In our tests, voltage regulation shows the difference between the initial voltage readings with 20W of load (and not with no load at all since many PSUs don't work well with no load on their rails and some others feature no-load protection) and the voltage readings on all rails with a full load.

We calculate the voltage regulation rating of all ratings using the following equation:

$$\boldsymbol{Eq_1 = 1.2\ x\ V.Reg_{+12V} + 0.6\ x\ (V.Reg_{+5V} + V.Reg_{+3.3V}) + 0.3\ x\ V.Reg_{5VSB}}$$

The formula above shows that 5V and 3.3V have a lower weighting factor and 5VSB the lowest. This is because the +12V rail is by far the most important in a system, and its stability is crucial. We use the same approach in the other formulas below, too.

Ripple Suppression

Ripple represents the AC fluctuations (periodic) and noise (random) found in the DC rails of a PSU. We take the ripple readings of all rails from the 100% load test and combine them in the equation below.

$$\boldsymbol{Eq_2 = 0.08\ x\ Ripple_{+12V} + 0.04\ x\ (Ripple_{+5V} + Ripple_{+3.3V}) + 0.02\ x\ Ripple_{5VSB}}$$

Transient Response

How well a power supply reacts to sudden changes in load is an excellent indication of the unit's power quality. Therefore, we take the maximum deviation that each rail registered in all Transient Response tests we conduct to calculate the performance.

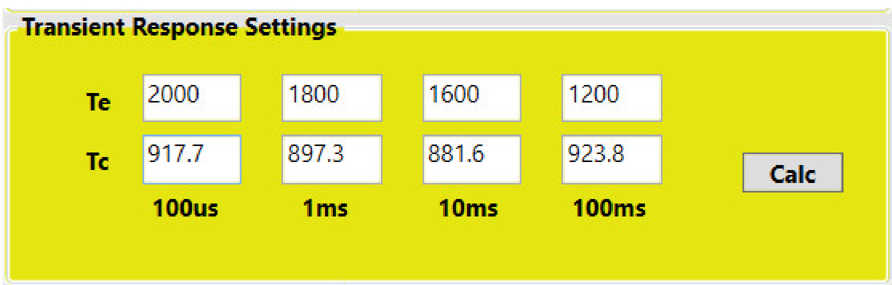
We conduct a variety of transient tests. Below you will find the standard ones, which we use in PSUs that are not compliant with the ATX v3.x spec and its future revisions:

- While the PSU operates at a 20 percent load state, a transient load is applied to the PSU for 20ms (15A at +12V, 6A at 5V and 3.3V, and 0.5 A at 5VSB).
- While working at 50 percent load, the PSU is hit by the same transient load.
- Again, we use the same starting points, 20 and 50 percent load states, in the following tests. In addition, however, we increase the load-changing repetition rate from 50 Hz (20ms) to 1 kHz (1ms). This way, we push even harder the PSU.
- In all tests, we measure the voltage drops that the sudden load change causes. The voltages should remain within the ATX specification's regulation limits.

In PSUs that meet the ATX v3.x spec's requirements [12][13] we conduct an additional and more stressful set of transient response tests, which are depicted in the aforementioned specification.

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

To calculate the power levels for the constant levels (Power @ T_C) and the power levels during the power excursions (power @ T_E) we use a special application that we developed, based on the most recent Intel Test Plan.



We should also note that the ATX v3.x spec allows for up to -8% voltage drops on the PCIe connectors, and up to -7% on the other connectors, at 12V, because of the new power excursion requirements. Manufacturers are also able to increase the nominal voltage on this rail to 12.1V or 12.2V, to avoid low voltage levels.

To retain compatibility with previous tested PSUs, we will use the following equation with data from both standard and ATX v3.x transient response tests. Nonetheless, for PSUs that meet the stricter ATX v3.x transient response requirements, there will be a bonus of 0.5 points.

$$\begin{aligned} \boldsymbol{Eq_3} &= \mathbf{2}\ \boldsymbol{x}\ \boldsymbol{Max.Tran.Response_{+12V}} \\ &\quad + \mathbf{0.2}\ \boldsymbol{x}\ (\boldsymbol{Max.Response_{+5V}} + \boldsymbol{Max.Tran.Response_{+3.3V}}) \\ &\quad + \mathbf{0.1}\ \boldsymbol{x}\ \boldsymbol{Max.Tran.Response_{5VSB}} + \boldsymbol{ATX\ v3.0\ Bonus}\ (\mathbf{0.5}) \end{aligned}$$

Turn On Transient Voltage Overshoots

Performance calculation in these tests is relatively simple since we use only the rough value of the registered spike compared to the nominal value of +12V and 5VSB rails. At +12V, we use only the higher voltage overshoot and ignore the other one (if there is any, of course). To give an example: if the higher registered voltage overshoot at +12V is +12.5V, then the spike is 0.5V (12.5V – 12.0V), so we use this value in our equation.

$$\boldsymbol{Eq_4} = \mathbf{1.25}\ \boldsymbol{x}\ (\boldsymbol{Turn\_On\_Spike_{+12V}} + \boldsymbol{Turn\_On\_Spike_{5VSB}})$$

Average Efficiency

We applied the average of all load combinations (>1450) to obtain the PSU's average efficiency for the ETA certification.

$$Eq_5 = 0.8\ x\ (100 - \ AVG\_Efficiency\_Score)$$

Efficiency at 2% of the max-rated-capacity load *or* 10W (for <500W PSUs)

According to the ATX spec [reference], the lowest DC load at Idle Mode is determined to be 10 Watts for mainstream computers. Computers with PSU larger than 500 Watts are also expected to have more components, and therefore the Idle Mode will be at a higher DC Load. The PSU above 500 Watts will use the Low Load Efficiency set at the 2% level.

$$Eq_6 = 0.03\ x\ (100 - \ Efficiency\_with\_2\%\_or\_10W\_load)$$

Average 5VSB Efficiency

The average of all load combinations that we applied to obtain the 5VSB rail's average efficiency for the ETA certification.

$$Eq_7 = 0.1\ x\ (100 - \ 5VSB\_AVG\_Efficiency\_Score)$$

Standby Power Consumption

The power a PSU needs in standby is called vampire or phantom power, since it's consumed without the power supply doing anything. This power is mostly lost on the PSU's standby circuit.

$$Eq_8 = 6\ x\ Vampire\_Power$$

Average PF

The average of all load combinations (>1450) that we applied is used to obtain the PSU's average PF score for the ETA certification.

$$Eq_9 = 50\ x\ (1 - Average\_PF\_Score)$$

Hold-up Time

Hold-up time represents the amount of time, usually measured in milliseconds, that a PSU can maintain output regulations defined by the ATX specification without input power. Put simply, hold-up time is the amount of time that the system can continue to run without shutting down or rebooting during a power interruption. The ATX specification till v3.0 sets the minimum hold-up time to 17ms with the maximum continuous output load. The ATX v3.1 changed the minimum hold-up time to 12ms, but we will keep for our performance algorithm the increased period of 17ms.

$$Eq_{10} = 0.15\ x\ (17 - \ Hold\_up\_time)$$

Power-ok Signal

According to the ATX spec, the PWR_OK is a "power good" signal. Therefore, this signal should be asserted high, at 5V, by the power supply to indicate that the +12V, 5V, and 3.3V outputs are within the regulation thresholds and that the APFC converter stores sufficient mains energy to guarantee continuous power operation within specification for at least 17ms. Conversely, PWR_OK should be de-asserted to a low state, 0V, when any of the +12V, 5V, or 3.3V output voltages falls below its under-voltage threshold, or when mains power has been removed for a time sufficiently long such that power supply operation cannot be guaranteed. In addition, the AC loss to PWR_OK minimum hold-up time is set at 16ms, a lower period than the hold-up time, and ATX spec also sets a PWR_OK inactive to DC loss delay, which should be more than 1ms. This means that in any case, the AC loss to PWR_OK hold-up should be lower than the overall hold-up time of the PSU, and this ensures that in no case the power supply will continue sending a power good signal, while any of the +12V, 5V, and 3.3V rails is out of spec.

Given all the above, when the PWR_OK signal is higher than the hold-up time, we have a fake report by the PSU's power ok signal, and our overall performance calculation algorithm deducts performance points. The PWR_OK signal's hold-up time also has to be at least 1ms lower than the actual hold-up time to provide enough time for the system to shut down before the voltage rails go out of spec.

If the PWR_OK signal is accurate, we use the following equation:

$$\boldsymbol{Eq_{11} = 0.15\ x\ (PWR\_OK\_Hold\_up\_time - (Hold\_up\_time - 1))}$$

There are three scenarios here:

- The PWR_OK_Hold_up_time is exactly 1ms lower than the Hold_up_time, so the outcome is zero, meaning no difference to the overall score.
- The PWR_OK_Hold_up_time has a larger than 1ms difference from the Hold_up_time, so the outcome is beneficial for the overall score.
- The PWR_OK_Hold_up_time is higher than the (Hold_up_time – 1ms) period, so points are deducted from the overall score.

We should note that we don't deduct points in this equation for lower than 16ms PWR_OK hold-up time because, in Eq_{10}, we already remove points for lower than 17ms hold-up periods, and in Eq_{11}, the hold-up time is also involved. And the hold-up time is closely related to the PWR_OK hold-up time.

Capacity

The comparison is anything but fair when you directly compare the load regulation, efficiency, or ripple readings of a 400W unit to those of a 1500W model.

For example, when looking at voltage regulation at a 40W load, the regulation range for a 400W PSU is 360W (= 400W - 40W). However, it is much more significant when testing a 1500W model:

1460W (= 1500W - 40W). Naturally, the smaller capacity unit will most likely register much better voltage regulation or ripple with such a huge difference. So, we added a normalization that would set things right. This factor is directly derived from the rated power of each unit.

$$Eq_{12} = 0.4\ x \left(\frac{Capacity}{100}\right)$$

PSU Timings

To meet the Alternative Sleep Mode, the Power-on time (T1) needs to be lower than 150ms, while the PWR_OK delay (T3) must be within the 100-150ms range. Moreover, the T3 minimum time must not be faster than 100ms. There is a bonus for all units that meet the above requirements and have higher than 16ms AC loss to PWR_OK hold-up time and higher than 1ms PWR_OK inactive to DC loss delay. We conduct the T1 and T3 measurements with two different load levels, 20%, and 100%. Each PSU needs to meet the requirements above in both cases.

$$If\ T1 < 150ms\ \&\ (T3 > 100ms\ \&\ T3 < 150ms)$$

$$\&\ PWR\_OK \geq 16ms$$

$$\&\ PWR\_OK\ inactive\ to\ DC\ loss\ delay \geq 1ms$$

$$then\ PSU\_Timings\_Result = 1$$

PSU Protections

Every power supply should be equipped with a proper protection scheme, allowing it to operate safely, even under harsh conditions, without breaking or causing any trouble to the system that it feeds with power.

The Over Current Protection (OCP) in all significant rails (+12V, 5V & 3.3V) along with the Over Power Protection (OPP) needs to be set within an acceptable range and not too high. When those protections are set high, the PSU might survive at normal temperatures, but there is a good chance that it will break at higher operating temperatures. Moreover, lots of stress is applied to its circuits at high temperatures, so the OCP and OPP triggering points should be appropriately set. Indeed, a PSU has to withstand high power spikes, usually deriving from GPUs and highly clocked CPUs, but at the same time, its protection features should ensure that its components are up to the task and not overloaded. According to our experience so far, the OCP for single +12V rail PSUs and OPP triggering points should be set within 130% of the respective nominal values. For PSUs with multiple +12V rails, we increase the allowed range to 135%.

Over Temperature Protection (OTP) is among the most crucial protection features for each power supply. Most PSU failures are due to high operating temperatures, so there has to be a properly working OTP, which should be set according to the platform's characteristics. Usually, in PSUs with a semi-passive operation, OTP is set slightly higher than PSUs lacking passive function.

The PWR_OK signal is of enormous importance to PSU protection features. Nonetheless, we already consider it in Eq_{10}, so there is no need to provide a bonus again.

Short Circuit Protection (SCP): If there is an output short circuit, which, according to the ATX spec, is defined as any output impedance of less than 0.1 ohms, the PSU should shut down. The only exception is the 5VSB rail, where the PSU is already in standby mode. Once the short circuit at 5VSB is removed, the PSU should return to operation without any problems.

Surge and inrush protections (SIP) are highly important, and the PSU should be equipped with the right parts to include those two protections. Usually, surge protection is offered through a MOV (Metal Oxide Varistor). In contrast, inrush protection involves an NTC thermistor, usually supported by a bypass relay, to enhance protection levels.

The fan failure protection is crucial since if the PSU's fan stops operating, its internal temperatures can reach critical levels. Until the over-temperature protection is engaged, if there is one, of course, the PSU's parts will be highly stressed, so their lifetime will be notably affected. The fan failure protection should be present in any PSU, and this is why we decided to provide a bonus for it, to push all manufacturers to implement it.

AC Input: According to the ATX spec v3.1 (section 4.1) a PSU must be able to start up under full loading at 90 VAC. We push this a bit further by applying a full load for five minutes at 90 VAC. For PSUs with 200-240 VAC range, we dial 180 VAC. Moreover, a PSU should not break if the input voltage drops below 90 VAC (for wide voltage input range PSUs) and below 180 VAC (for 200-240 VAC input range PSUs). To check that, we dial either 80 VAC or 170 VAC and we expect the PSUs to survive (meaning to operate normally once the nominal AC input is applied).

We provide bonus points for each one of the following cases.

- 0.25 bonus: OCP at +12V, 5V, and 3.3V within 130% of the respective max-rated capacity of the rail either from the factory or through software (if the PSU allows for software control). For PSUs with multiple +12V rails, we allow for up to 135% OCP triggering points. This bonus applies to any of the aforementioned rails and it is independent, meaning that a PSU might have over the limit 12V OCP, but within limits OCP on the minor rails. In this case it will get the OCP bonus for both minor rails.
- 0.25 bonus: OPP within 130% either from the factory or through software.
- 0.25 bonus: OTP that is shutting down the PSU at <190 degrees Celsius on the secondary heat sink or the secondary side in general
- 0.25 bonus: SCP on all rails. The PSU should work adequately after prolonged and repetitive SCP evaluation tests.
- 0.25 bonus: The PSU should be equipped with a MOV or a TVS diode (or a combination of both)
- 0.25 bonus: The PSU should be equipped with an NTC thermistor **and** a bypass relay
- 0.25 bonus: The PSU should have fan failure protection

If a PSU fails during the protection features evaluation testing within the conditions described above (e.g., with a load within 130% of its max-rated capacity or with less than 190 degrees Celsius heat on the secondary side), no point will be awarded for the respective category that led to the PSU's failure. On the other hand, a PSU that meets all the above requirements gets 1.75 bonus points.

Overall Performance Rating Calculation

Now that we have calculated all the above factors, it's time to combine them to calculate the final performance rating (13). Again, we take 100 as the perfect score, subtract results (1-11), and finally consider the capacity (12) and the PSU Timing and Protection Features bonus points.

$$\boldsymbol{Eq_{13} = 100 - \sum_{k=1}^{11} Eq_k + Eq_{12} + ATX\ v3.0\ Compatibility\ Bonus + PSU\ Timing\ Bonus + PSU\ Protection\ Bonus}$$

The result of (13) is the unit's overall Performance Rating.

Overall Performance Rating Calculation Examples

Example A

For this example, we will use the **Wentai Aidan T1616** with 115V input:

$$\boldsymbol{Eq_1} = 1.2\ x\ 0.3 + 0.6\ x\ (1.48 + 2.4) + 0.3\ x\ 2.44 = 0.36 + 2.328 + 0.732 = 3.42\ \ (Load\ Regulation)$$

$$\boldsymbol{Eq_2} = 0.08\ x\ 27.46 + 0.04\ x\ (10.28 + 12.88) + 0.02\ x\ 14.44 = 2.1968 + 0.9264 + 0.2888 = 3.412\ (Ripple\ Supression)$$

$$\boldsymbol{Eq_3} = 2\ x\ 0.49 + 0.2\ x\ (1.63 + 3.05) + 0.1\ x\ 1.54 + 0 = 0.98 + 0.936 + 0.154 = 2.07\ (Transient\ Response)$$

$$\boldsymbol{Eq_4} = 1.25\ x\ (0.12 + 0) = 0.15\ (Turn - on\ Transient\ Response)$$

$$\boldsymbol{Eq_5} = 0.8\ x\ (100 - 92.713) = 5.8296\ (Average\ Efficiency)$$

$$\boldsymbol{Eq_6} = 0.03\ x\ (100 - 77.432) = 0.67704\ (Efficiency\ with\ 2\%\ load)$$

$$\boldsymbol{Eq_7} = 0.1\ x\ (100 - 82.381) = 1.7619\ (Average\ 5VSB\ Efficiency)$$

$$\boldsymbol{Eq_8} = 6\ x\ 0.0404641 = 0.242785\ (Standby\ Power\ Consumption)$$

$$\boldsymbol{Eq_9} = 50\ x\ (1 - 0.99) = 0.5\ (Average\ PF\ score)$$

$$\boldsymbol{Eq_{10}} = 0.15\ x\ (17 - 26.2) = -1.38\ (Hold - up\ time)$$

$$\boldsymbol{Eq_{11}} = 0.15\ x\ (25.2 - (26.2 - 1)) = 0\ (Power\ Ok\ signal\ hold - up\ time)$$

$$\boldsymbol{Eq_{12}} = 0.4\ x\ \left(\frac{1616}{100}\right) = 6.464\ (Capacity)$$

ATX v3.x Compatibility Bonus: 0

PSU Timings Bonus: 0 (since T1 > 150ms in the 20% load test and T3>150ms in both tests)

PSU Protections Bonus: OCP: 0.25 (since 12V4 OCP > 135% and 5V OCP > 130%. Only 3.3V OCP < 130%), **OPP:** 0.25 (within 130%), **OTP:** 0.25 (<190°C), **SCP:** 0.25, **MOV:** 0.25, **NTC Thermistor & Relay:** 0.25

Performance Rating = 100 – 3.42 – 3.412 – 2.07 – 0.15 – 5.8296 – 0.67704 – 1.7619 – 0.242785 – 0.5 – (–1.38) – 0+ 6.464 + 0 + 0 + 1.5 = 91.280675

Example B

For this example, we will use the **Corsair AX1600i** with 115V input:

$$\boldsymbol{Eq_1} = 1.2\ x\ 0.24 + 0.6\ x\ (0.9 + 0.3) + 0.3\ x\ 1.32 = 0.288 + 0.72 + 0.396 = 1.404\ \ (Load\ Regulation)$$

$$\boldsymbol{Eq_2} = 0.08\ x\ 10.33 + 0.04\ x\ (6.24 + 14.98) + 0.02\ x\ 6.62 = 0.8264 + 0.8488 + 0.1324 = 1.8076\ (Ripple\ Supression)$$

$$\boldsymbol{Eq_3} = 2\ x\ 0.64 + 0.2\ x\ (1.4 + 2.87) + 0.1\ x\ 1.28 + 0 = 1.28 + 0.854 + 0.128 = 2.262\ (Transient\ Response)$$

$$\boldsymbol{Eq_4} = 1.25\ x\ (0 + 0.024) = 0.03\ (Turn - on\ Transient\ Response)$$

$$\boldsymbol{Eq_5} = 0.8\ x\ (100 - 92.221) = 6.2232\ (Average\ Efficiency)$$

$$\boldsymbol{Eq_6} = 0.03\ x\ (100 - 78.233) = 0.65301\ (Efficiency\ with\ 2\%\ load)$$

$$\boldsymbol{Eq_7} = 0.1\ x\ (100 - 81.807) = 1.8193\ (Average\ 5VSB\ Efficiency)$$

$$\boldsymbol{Eq_8} = 6\ x\ 0.0457394 = 0.274436\ (Standby\ Power\ Consumption)$$

$$\boldsymbol{Eq_9} = 50\ x\ (1 - 0.992) = 0.4\ (Average\ PF\ score)$$

$$\boldsymbol{Eq_{10}} = 0.15\ x\ (17 - 26.7) = -1.455\ (Hold - up\ time)$$

$$\boldsymbol{Eq_{11}} = 0.15\ x\ (24.5 - (26.7 - 1)) = -0.18\ (Power\ Ok\ signal\ hold - up\ time)$$

$$\boldsymbol{Eq_{12}} = 0.4\ x\ \left(\frac{1600}{100}\right) = 6.4\ (Capacity)$$

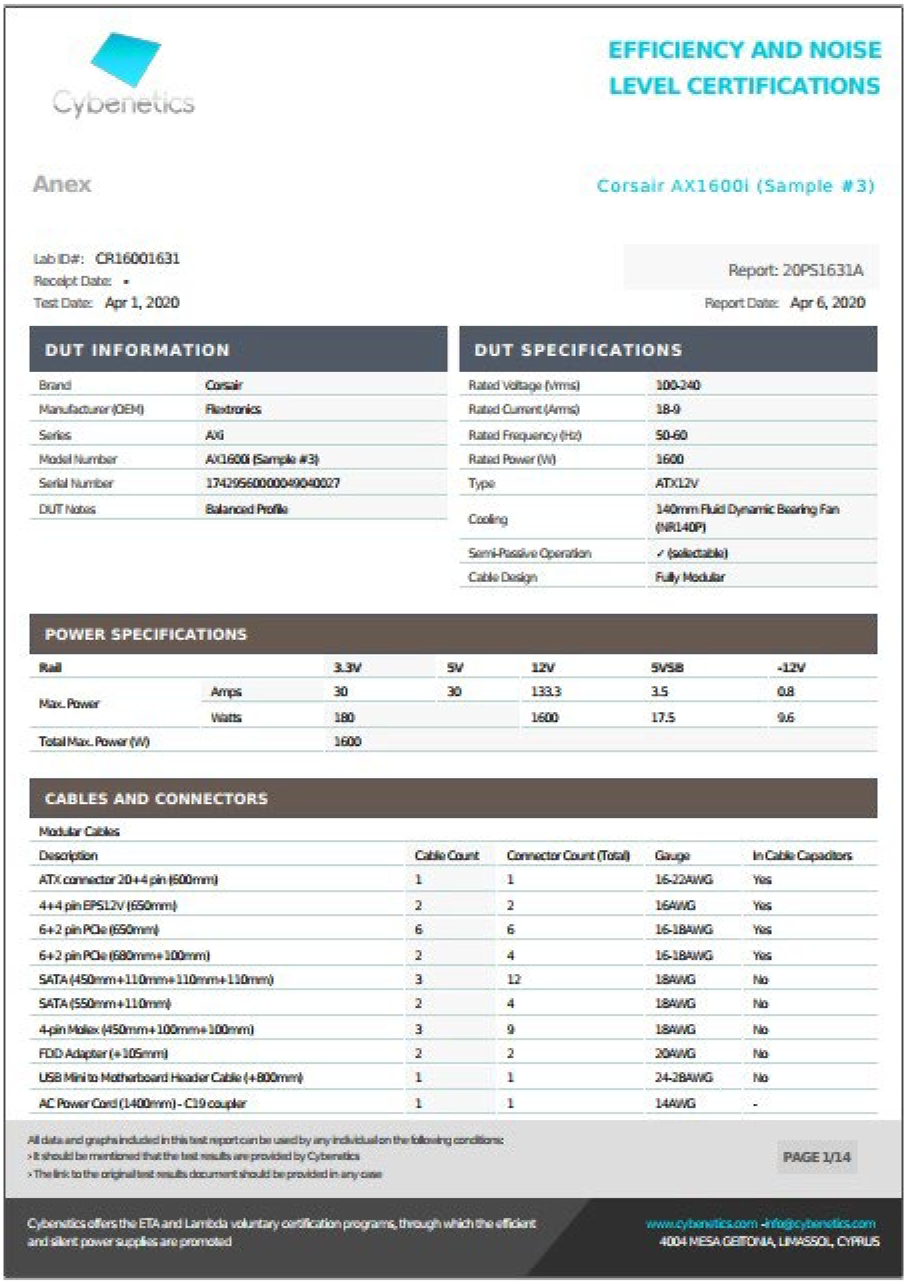
ATX v3.x Compatibility Bonus: 0

PSU Timings Bonus: 0 (since T1 > 150ms in the 20% load test and T3>150ms in both tests)

PSU Protections Bonus: OCP: 0.50 (since 12V does not exceed 135% and 3.3V is below 130%, zero points for 5V), **OPP:** 0.25 (within 130%), **OTP:** 0.25 (<190°C), **SCP:** 0.25, **MOV:** 0.25, **NTC Thermistor & Relay:** 0.25

Performance Rating = 100 – 1.404 – 1.8076 – 2.262– 0.03 – 6.2232 – 0.65301 – 1.8193 – 0.274436 – 0.4 – (–1.455) – (– 0.18) + 6.4 + 0+ 0 + 1.75 = 94.911454

Test Report Example



Cybenetics

EFFICIENCY AND NOISE LEVEL CERTIFICATIONS

Anex

Corsair AX1600i (Sample #3)

Lab ID#: CR16001631
Receipt Date: -
Test Date: Apr 1, 2020

Report: 20PS1631A
Report Date: Apr 6, 2020

DUT INFORMATION

Brand	Corsair
Manufacturer (OEM)	Flextronics
Series	AXi
Model Number	AX1600i (Sample #3)
Serial Number	17429560000049040027
DUT Notes	Balanced Profile

DUT SPECIFICATIONS

Rated Voltage (Vrms)	100-240
Rated Current (Arms)	18-9
Rated Frequency (Hz)	50-60
Rated Power (W)	1600
Type	ATX12V
Cooling	140mm Fluid Dynamic Bearing Fan (NR140P)
Semi-Passive Operation	✓ (selectable)
Cable Design	Fully Modular

POWER SPECIFICATIONS

Rail		3.3V	5V	12V	5VSB	-12V
Max. Power	Amps	30	30	133.3	3.5	0.8
	Watts	180		1600	17.5	9.6
Total Max. Power (W)		1600				

CABLES AND CONNECTORS

Modular Cables

Description	Cable Count	Connector Count (Total)	Gauge	In Cable Capacitors
ATX connector 20+4 pin (600mm)	1	1	16-22AWG	Yes
4+4 pin EPS12V (650mm)	2	2	16AWG	Yes
6+2 pin PCIe (650mm)	6	6	16-18AWG	Yes
6+2 pin PCIe (680mm+100mm)	2	4	16-18AWG	Yes
SATA (450mm+110mm+110mm+110mm)	3	12	18AWG	No
SATA (550mm+110mm)	2	4	18AWG	No
4-pin Molex (450mm+100mm+100mm)	3	9	18AWG	No
FDD Adapter (+105mm)	2	2	20AWG	No
USB Mini to Motherboard Header Cable (+800mm)	1	1	24-28AWG	No
AC Power Cord (1400mm) - C19 coupler	1	1	14AWG	-

All data and graphs included in this test report can be used by any individual on the following conditions:
› It should be mentioned that the test results are provided by Cybenetics
› The link to the original test results document should be provided in any case

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Cybenetics offers the ETA and Lambda voluntary certification programs, through which the efficient and silent power supplies are promoted

www.cybenetics.com - info@cybenetics.com
4004 MESA GEITONIA, LIMASSOL, CYPRUS

Uncertainty Estimations – Efficiency/Noise/EMI

Measurement uncertainty is the quantified doubt about a measurement result. It shows the range within which the true value is expected to lie, considering possible errors and variations. It is important because it reflects the reliability of measurements and allows fair comparison between results.

The Efficiency Measurement's Uncertainty is **±0.15%**

The reported expanded uncertainty (U) was derived as the product of the combined standard uncertainty (u) and the coverage factor k = 2, corresponding to a confidence interval of approximately 95%. Measurement uncertainty was determined in accordance with GUM [14]. The estimate of the reported uncertainty pertains to values obtained during the measurements and does not account for possible long-term changes.

Efficiency Measurement Uncertainty Budget

Source of Uncertainty	**Standard Uncertainty, $u(x_i)$**	**Relative Standard Uncertainty, $u(x_i)/x_i$**
Intralab Reproducibility	0.0310	0.00031
Electronic loads Calibration	0.0500	0.00050
Power Analyzer Calibration	0.0250	0.00025
Operator and Test Fixture	0.0350	0.00035
Relative Combined Standard Uncertainty (RSS):	0.00073	
% Expanded Uncertainty U (*k*=2, norm):	0.15	

The Noise Measurement's Uncertainty is **±1.23 dBA**

The reported expanded uncertainty (U) was derived as the product of the combined standard uncertainty (u) and the coverage factor k = 2, corresponding to a confidence interval of approximately 95%. Measurement uncertainty was determined in accordance with GUM [14]. The estimate of the reported uncertainty pertains to values obtained during the measurements and does not account for possible long-term changes.

Noise Output Measurement Uncertainty Budget

Source of Uncertainty	**Standard Uncertainty, $u(x_i)/x_i$ (dBA)**
Intralab Reproducibility	0.031
Mic Calibrator 4231 calibration	0.200

Microphone frequency response	0.577
Temperature	0.12
Position error	0.058
Relative Combined Standard Uncertainty (RSS):	0.61
Expanded Uncertainty U (*k*=2, norm):	1.23

The Conducted EMI Emissions Measurement's Uncertainty is **±1.75 dB**

The reported expanded uncertainty (U) was derived as the product of the combined standard uncertainty (u) and the coverage factor k = 2, corresponding to a confidence interval of approximately 95%. Measurement uncertainty was determined in accordance with GUM [14]. The estimate of the reported uncertainty pertains to values obtained during the measurements and does not account for possible long-term changes.

Conducted EMI Measurement Uncertainty Budget

Source of Uncertainty	**Standard Uncertainty, $u(x_i)/x_i$ (dB)**
Spectrum Analyzer total measurement uncertainty	0.250
Spectrum Analyzer calibration	0.500
Noise and Signal Quality	0.577
Bandwidth and Resolution Bandwidth (RBW)	0.289
Measurement time and Averaging	0.115
Environmental Factors	0.115
Relative Combined Standard Uncertainty (RSS):	0.87
Expanded Uncertainty U (*k*=2, norm):	1.75

Epilogue

The purpose of this article was to explain the methodology that we follow for our efficiency and noise measurements, from which the ETA and LAMBDA certifications derive. Furthermore, we want to share the knowledge we acquired after numerous PSU evaluations and help other laboratories with the proper equipment and the corresponding ISO certification (17025), proving that all procedures will be followed in detail and tested against our standards.

Besides providing a complete insight into our efficiency and noise methodology, we decided to take one more (big) step and update and present our overall performance algorithm. Through this algorithm, someone can make highly detailed comparisons between any number of power supplies, considering all crucial factors, including protection features, besides pure performance. The development of this algorithm, which we will continue to update based on new data and experiences that we gather through time, is a challenging task. Nevertheless, we plan to use this algorithm in our beta evaluations. We will also share it with some media/review sites, including Hardware Busters to help them provide more accurate comparison results.

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