A Simplified Way To Predict The Cybenetics Efficiency Ratings

Revision 1.2

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Revision History

Version	Release Date	Notes
1.0	September 2022	First draft
1.1	September 2022	Additions and various grammatical error corrections
1.2	June 2024	Grammatical error corrections

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Prologue

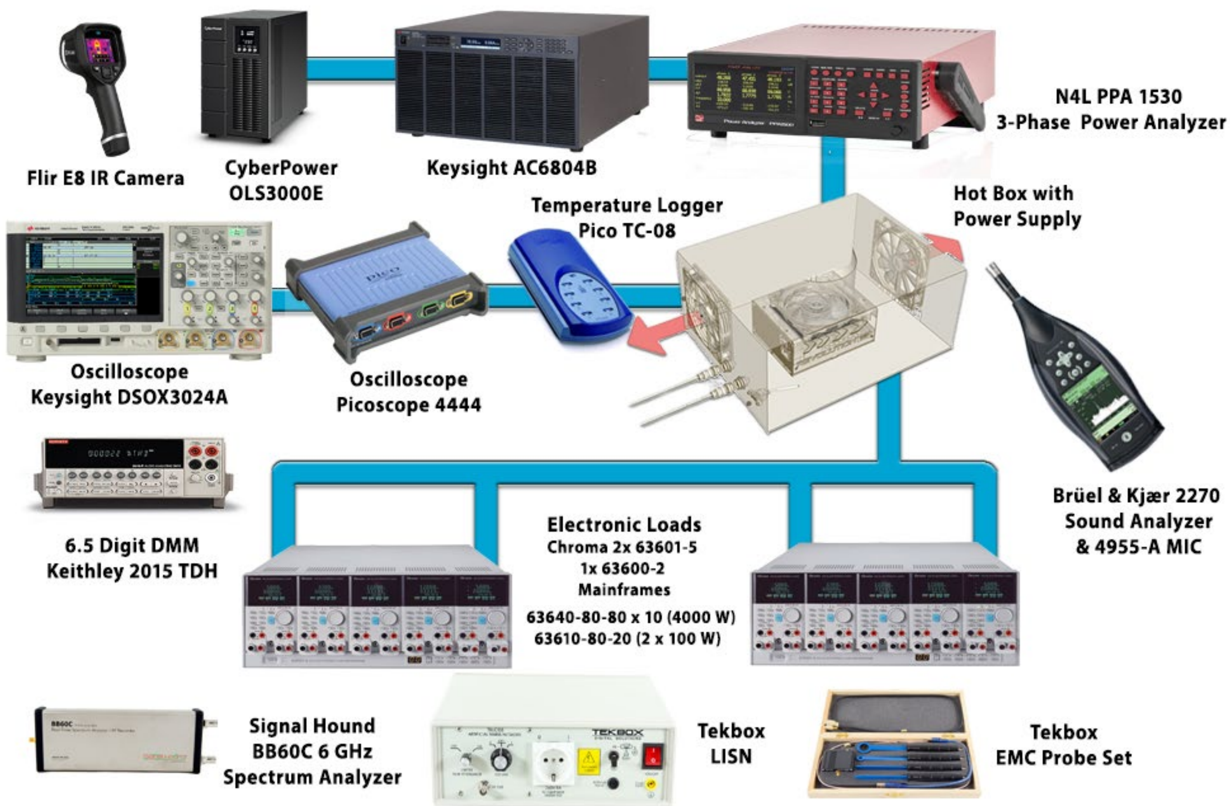
This article aims to provide an easier way for manufacturers, brands, and other interested parties with the necessary equipment to accurately predict the Cybenetics efficiency ratings.

Typically, Cybenetics applies more than 1450 load combinations, covering the entire load range of a power supply, to calculate the efficiency (ETA) and noise (LAMBDA) ratings, but this is not easy to do for the majority of external labs. Cybenetics uses in-house software to achieve that, making the whole procedure fully automatic and easy to handle. Still, the process takes several hours to finish. In the case of manual measurements, this would take days, so it is imperative to find a way to predict the Cybenetics efficiency rating, for starters, through much fewer measurements.

Before we proceed to the description of the methodology you could follow, we should emphasize that the used equipment should be certified and calibrated, if required, to ensure accurate results. Otherwise, you won't be able to exploit the methodology we describe. We will provide information in the following paragraphs about our equipment to let you know what is required. Generally, every lab following the ISO/IEC 17025 [3] guidelines in the corresponding field can get accurate results following the suggested methodology.

Cybenetics Test Setup & Measurement Conditions

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

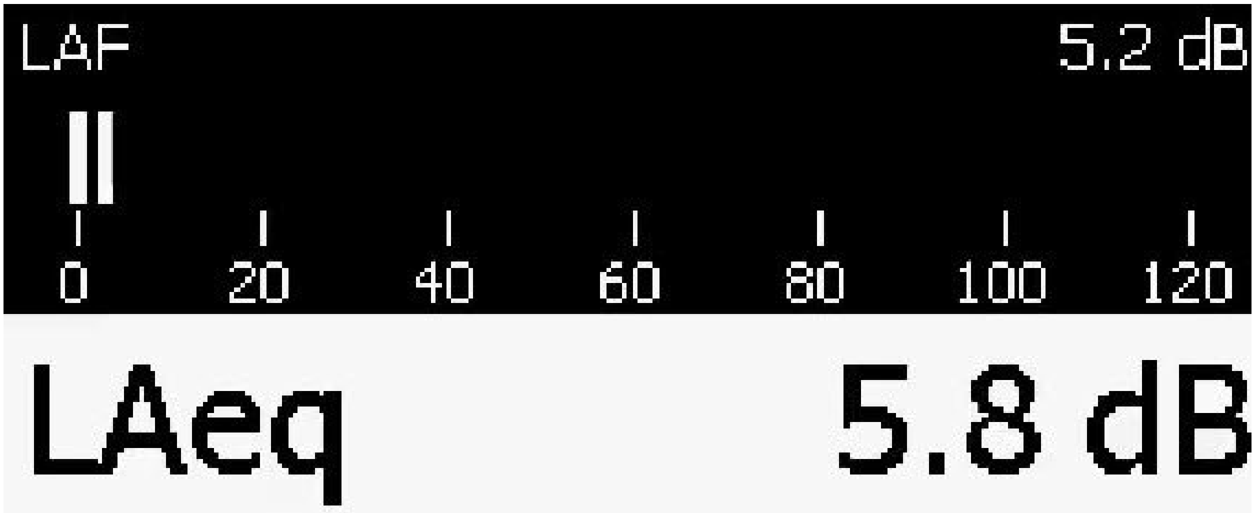


Measuring Equipment

All measurements are performed using multiple 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.

Chroma, Keysight, and APM Technologies provide the AC sources that we use. All AC sources are connected to the mains network through powerful isolation transformers. Finally, we protect the AC sources with online UPS devices.

The rest of our equipment consists of Picotech TC-08 thermocouple data loggers, Fluke, Keysight, and Keithley multimeters, and N4L PPA1530 3-phase power analyzers, featuring 0.05% basic accuracy. We recently started using R&S HMC8015 power analyzers, which are more affordable yet highly capable. 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.

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 was first developed about 15 years ago and consists of thousands of lines of code. We coded the application again in C# to keep it in line with modern coding trends.

Besides gathering all data, storing it, and allowing it to extract it in any possible form, that meets our requirements, one of its most vital functions is that it allows us to average all readings 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.

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) and we will guide you on how to use the results at high temperatures, to achieve two goals at once, have the PSU pushed hard to check if it can handle the heat and extract efficiency results that will help you predict its Cybenetics efficiency rating.

The Cybenetics Efficiency Measurements Procedure

Contrary to existing methodologies, which only take three to four measurements, we apply more than 1450 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 specified load levels since, in essence, we take 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, with load combinations at +12V, 5V, and 3.3V. Finally, we apply a steady load of 1A 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 only a single main rail and a standby one, 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 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 a significant part of the day, the PSUs just consume energy without doing anything useful. We evaluate each PSU by following EN 50564:2011 and IEC 62301 [1] 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 standby rail's average efficiency. 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.

The Cybenetics 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 external noise sources, including the electronic loads' noise.

We make a table with the fan speed in RPM and the corresponding noise at that speed, an example of which can be found below. Afterward, our software looks into all data gathered during the load tests and assigns a decibel value to each fan speed value with the help of the table mentioned above.

Once we have a dBA value for each of the tests that 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.

Cybenetics Efficiency (ETA) Grades & Requirements – 115V

Before diving into the alternative and easier way to predict the ETA ratings, let's first look at the efficiency levels and the corresponding requirements.

EFFICIENCY LEVELS (115V INPUT)	EFFICIENCY (1) (2)	PF (3)	5VSB EFFICIENCY (1) (3) (4)	VAMPIRE POWER (3)
DIAMOND	⩾93% overall efficiency	⩾0.985	>79%	<0.10W
TITANIUM	⩾91% & <93% overall efficiency	⩾0.980	>77%	<0.13W
PLATINUM	⩾89% & <91% overall efficiency	⩾0.975	>76%	<0.16W
GOLD	⩾87% & <89% overall efficiency	⩾0.970	>75%	<0.19W
SILVER	⩾85% & <87% overall efficiency	⩾0.960	>73%	<0.22W
BRONZE	⩾82% & <85% overall efficiency	⩾0.950	>71%	<0.25W

Table 1: Cybenetics ETA Requirements

5VSB Load	EFFICIENCY TARGET (115V & 230V)
3A or Full Load	75%
1.5A	75%
1.0A	75%
0.55A	75%
90mA	45%
45mA	45%

Table 2: Cybenetics ETA 5VSB Efficiency Requirements

(1) If the PSU is close enough to the limits (0.1%), we will ask its manufacturer if it is willing to send a second sample for re-evaluation. If the second sample registers a significant performance difference compared to the first one (>0.5%), we will ask for a third one to verify the test results. Moreover, if the difference with the upper limit is <= 0.05% (e.g., 91.95%), we will round the number to the second digit, and the PSU will be taxed to the higher category.

(2) We conduct several load tests with 230V input to make sure that the under-evaluation PSUs meet all requirements mentioned in the (EU) No 617/2013 regulation:

- 85% efficiency at 50% of rated output power
- 82% efficiency at 20% and 100% of rated output power
- power factor >= 0.9 at 100% of rated output power

(3) If the PSU fails in any of those requirements, it will lose one class and drop to the lower one (especially for the PF, it will drop to the class that meets the corresponding requirements),

despite its efficiency. In any case, vampire power must be lower than 0.25 W, even with 230 V input.

(4) The 5VSB rail should also achieve the required efficiency levels listed in Table (2) to meet various requirements, including the CEC and ErP Lot 6/3 ones. Those requirements are also listed and recommended by the Power Supply Design Guide for Desktop Platform Form Factors, v3.0 (February 2022) [2]. In the 45mA load test, we allow for a 5% deviation (40-45% range) due to the very low applied load, and the 0.55 A to 1.5 A load tests, where we also allow for the same 5% deviation (70-75% range).

Our Approach To Simplifying ETA Predictions

Besides 1450, at least different load combinations, Cybenetics conducts a series of tests, including 10-100% load levels, with a 10% load step, at operating temperatures starting from 35°C and up to 45-47°C. Since we already have the results of the 1450 different load combinations and the results of the tests we conduct at higher temperatures, which are notably less, we thought to analyze them. Our goal was to find a relationship that would help us provide some guidelines and predict the final efficiency ratings based on the 10-100% results.

We analyzed the results of 55 power supplies with various capacities following an equal distribution. The results that we need to extract are the following:

- Average Efficiency - 10-100% Load with a 10% step
- Average PF - 10-100% Load with 10% step
- AVG 5VSB Efficiency
- Vampire Power Consumption

Average Efficiency

From the 55 PSUs of our sample, the mean efficiency from the 1450 different load combinations at 28-32°C is 89.025%, while the average efficiency from 10-100% load tests is 89.473%. The latter is notably higher. This is expected because we leave out the light loads region (below 10%), where efficiency is low.

Given the above, the average efficiency in the 10-100% load tests, with a 10% step, at high operating temperatures (35-47%), should be 0.5% higher than the minimum average efficiency required by each ETA level.

EFFICIENCY LEVELS (115V INPUT)	Min AVG Efficiency (1450x load combinations)	Min AVG EFFICIENCY (10-100% load combinations with 10% step)
DIAMOND	93%	93.5%
TITANIUM	91%	91.5%
PLATINUM	89%	89.5%
GOLD	87%	87.5%
SILVER	85%	85.5%
BRONZE	82%	82.5%

Table 3: Average Efficiency Requirements

Besides the efficiency levels described in the table above, every power supply has to meet the following requirements, with 230V input, to receive a Cybenetics efficiency badge.

- 85% efficiency at 50% of rated output power
- 82% efficiency at 20% and 100% of rated output power

- Power factor >= 0.9 at 100% of rated output power

These requirements are not tough for most modern platforms. Still, we include them because they are mentioned in the (EU) No 617/2013 regulation.

Average PF

From our pool sample of 55 PSUs, the mean PF in the 1450 load combinations is 0.9871. In the 10-100% load tests, with a 10% step, the mean PF is 0.9886, so the difference is at 0.0015. To be safe, we suggest having 0.002 higher PF in the 10-100% load tests than the Cybenetics efficiency ratings require.

EFFICIENCY LEVELS (115V INPUT)	Min AVG PF (1450x load combinations)	Min AVG PF (10-100% load combinations with 10% step)
DIAMOND	0.985	0.987
TITANIUM	0.980	0.982
PLATINUM	0.975	0.977
GOLD	0.970	0.972
SILVER	0.960	0.962
BRONZE	0.950	0.952

Table 4: Average PF Requirements

5VSB Efficiency

The following table shows the load levels that you need to check at 5VSB.

Test #	5VSB Load (Amperes)
1	0.1
2	0.25
3	0.55
4	1.0
5	1.5
6	Full Load

Table 5: 5VSB Test Loads

In our 55-sample pool, the average efficiency at 5VSB with 0.05A step is 79.344%. With the loads shown in Table (5), with the same operating temperatures, 28-32°C, the mean efficiency is 78.716%. The difference is 0.628%, with the average efficiency with six loads being notably lower. Because there can be high deviations in the results on this rail, depending on the measurement equipment, because of the light loads in the first two tests, it is safe to have an average efficiency equal to or higher than the minimum requirement by each Cybenetics ETA level.

EFFICIENCY LEVELS (115V INPUT)	Min AVG Efficiency (1450x load combinations)	Min AVG Efficiency (6x load combinations)
DIAMOND	78%	78%
TITANIUM	76%	76%
PLATINUM	75%	75%
GOLD	74%	74%
SILVER	72%	72%
BRONZE	70%	70%

Table 6: Average 5VSB Efficiency Requirements

Besides the efficiency levels described above, a PSU should meet the efficiency thresholds shown in table (7). If it doesn't, it cannot meet the requirements of any Cybenetics ETA level.

5VSB Load	Min Efficiency Target (115V & 230V)
3A or Full Load	75%
1.5A	70%
1A	70%
0.55A	70%
90mA	45%
45mA	40%

Table 7: 5VSB Minimum Efficiency Requirements

Vampire Power

For the standby power measurements, we strictly follow the internationally recognized IEC 62301 standard [3]. For measurements with a current as low as 1mA, external current shunts can be helpful, but their use isn't necessary for IEC 62301 testing. External shunts make the measurement procedure more complex and lead to measurement errors. Advanced power analyzers can test IEC 62301 by relying only on their internal current shunts. Generally, lab-grade power analyzers with a large enough dynamic range don't need external current shunts to measure standby (or vampire) power.

According to the IEC 62301 standard, the standby power measurements should be made with the Total Harmonic Content of the AC source (up to and including the 13th harmonic) must be less than 2%. In addition, the Voltage Crest Factor should be between 1.34 and 1.49. You can find more info about the standby power measurement procedure according to the IEC 62301 standard by reading this application note, which Newtons4th provides.

The vampire power levels according to the ETA level are described in Table (1). Power supplies with 0.25W or more vampire power, with either 115V or 230V input, do not get a Cybenetics ETA rating. Finally, Cybenetics conducts vampire power measurements at 28-32°C operating temperatures.

Epilogue

The purpose of this article was to provide a relatively straightforward to calculate the Cybenetics ETA (Efficiency) ratings, taking a fraction of the measurements that Cybenetics takes. You can follow the guidelines described in this article to have a very close estimation of the Cybenetics ETA badge your product will receive before sending it out for testing to our lab. To wrap up the findings of this article:

- Aim for 0.5% higher average efficiency in the 10-100% load tests at 35°C and up to 47°C operating temperatures, compared to the efficiency level you aim for (e.g., Gold, Platinum, etc.)
- Aim for 0.002 higher average PF in the 10-100% load tests at 35°C and up to 47°C operating temperatures.
- Aim for at least the same 5VSB average efficiency with 0.1A, 0.25A, 0.55A, 1A, 1.5A, and full load at 28-32°C operating temperatures.
- Meet the standby power consumption (vampire power) of each level at 28-32°C operating temperatures. In any case, vampire power should be below 0.25W with either 115V or 230V input.

References

[1] IEC 62301 International Standard: https://webstore.iec.ch/preview/info_iec62301%7Bed2.0%7Db.pdf. Accessed on 22 September 2022.

[2] Intel Introduces New ATX PSU Specifications: https://www.intel.com/content/www/us/en/newsroom/news/intel-introduces-new-atx-psu-specifications.html#gs.d5qj04. Accessed on 22 September 2022.

[3] ISO/IEC 17025:2017, General requirements for the competence of testing and calibration laboratories, November 2017.