Cybenetics Chassis Test Protocol

Revision 1.1

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Revision History

Version	Release Date	Notes
1.0	September 2020	First draft
1.1	May 2021	Significant changes in testing methodology

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Prologue

Taking accurate noise and thermal measurements in chassis (PC enclosures) is a challenge, and besides experience, it also requires specialized equipment and proper facilities, especially for noise measurements. After extensive research in this subject, we came up with the methodologies we will analyze in the following paragraphs. It is a work in progress, meaning that we will constantly update the corresponding procedures until we develop the perfect methodologies. Since there is nothing perfect in this world, though, we will never settle down. On the contrary, we will always try to find the optimal testing procedures that will reveal every aspect of the device under test (DUT).

Test System For Noise Measurements

Before we start conducting our noise measurements, we must install a complete system into the chassis. We do this for two reasons, to thoroughly check the installation process and secondly, the parts minimize echoes inside the chassis. Like an empty room, an empty chassis will have echoes, notably affecting the noise measurements.

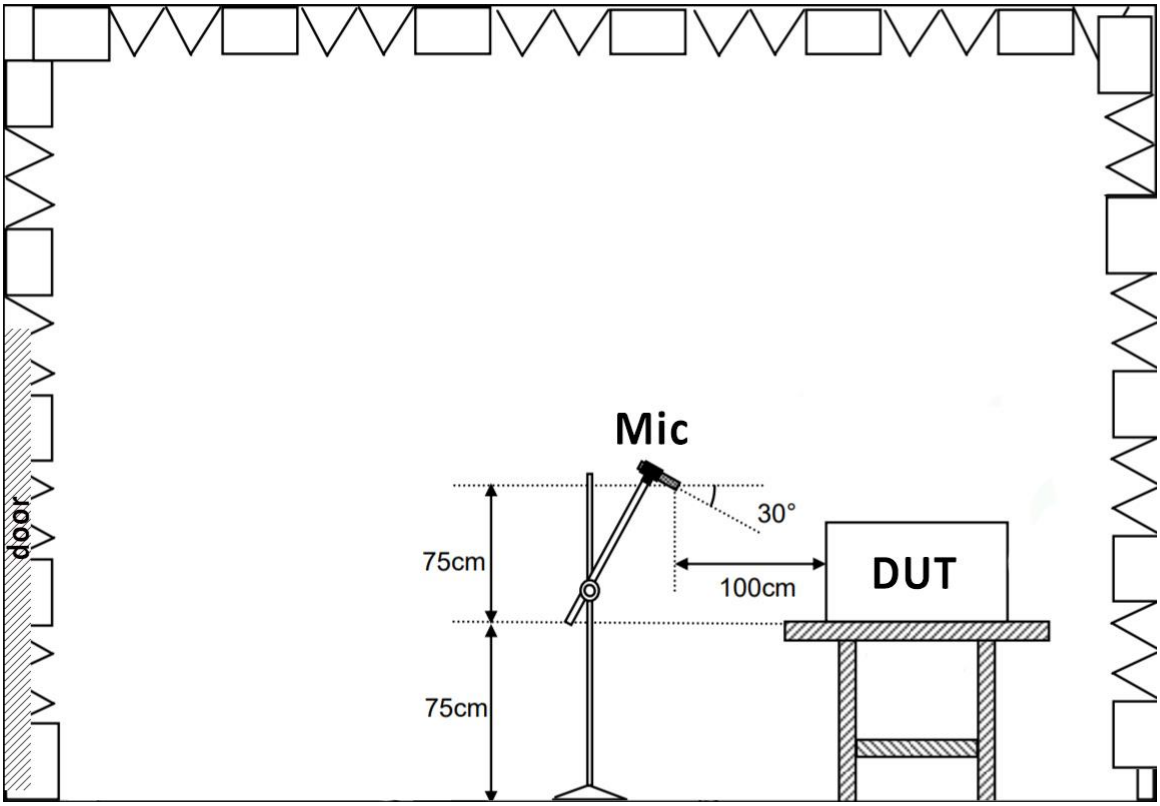
The test systems that we use for noise measurements are depicted in the following table. We use three different mainboards to retain compatibility with all cases, tiny, mid-size, and cave-size ones.

Mainboard	MSI B450M MORTAR / MSI B450 TOMAHAWK MAX
CPU	AMD Ryzen 7 2600 (3.8 GHz)
CPU Cooler	Be Quiet Dark Rock Slim
GPU	EVGA GeForce GTX 970 SC GAMING ACX 2.0 (PN: 04G-P4-2974-KR)
Fan Controller	Corsair Commander Pro
HDD	Seagate ST3000DM001
SSD	Corsair Force Series MP510 240GB
Extra Fans*	2x Noctua NF-S12B
Power Supply	Fractal Design Ion+ 660P [Comparison Cases] (Cybenetics ETA-A, LAMBDA-A++) / Fractal Design Ion+ 760P [Comparison Cases] (Cybenetics ETA-A, LAMBDA-A++)

We are aware, of course, that we use outdated hardware, especially the GPU, but this doesn't matter since we run all of our thermal tests using another system, which we will describe in detail in the following paragraphs.

For all noise measurements, we use a hemi-anechoic chamber with an extremely low noise floor, at around 6 dBA. The DUT is installed in the chamber, and the schemes provide a detailed overview of the mic and DUT's positions inside the chamber.

The measuring microphone is positioned in such a way so that it forms a 30° to 45° degrees angle with the horizontal axis and its vertical distance from the object of measurement is one meter.



Picture 1

Noise Measurements Procedure Walkthrough

We turn on the sound meter Bruel & Kjaer G-4 Type 2270 [1], 15 to 30 minutes before starting the measurements to allow it to reach operational temperature.

Before we start the measurements, we calibrate the sound meter using the Bruel & Kjaer Sound Calibrator Type 4231 [2].

We place a speaker in the measuring position in which we measure its intensity at the following frequencies: 100Hz, 250Hz, 500Hz, 1KHz, 2KHz, 3KHz, 4KHz, 5KHz, 6KHz, 7KHz, 8KHz, 9KHz, 10KHz, 11KHz 13Kz, 12KH 14KHz, 15KHz, 16KHz, 17KHz, 18KHz, 19KHz, 19.5KHz, 20KHz. We also measure Chirp [3] signal, Pink [4], and White [5] noise.
We use the above measurements as a reference for the volume of the speaker in the open air.

We install the chassis in the chamber vertical to the microphone, in the intended position to have the same conditions in each measurement. Next, we install the speaker that we have already measured in an open field inside the chassis. We try to place it as close as possible to the side, which the microphone points at without touching the side pane. At the same time, we pay close attention to have the speaker as close as it can be to the chassis floor (see Picture 2).

Picture 2

We repeat the exact measurements; that is, we measure the noise output that the speaker produces at the frequencies above. Our goal is to find the differences between open-air noise measurements and with the speaker inside the chassis. These differences provide us with a detailed picture of the chassis' soundproofing performance in a wide frequency range along with pink, white, and chirp noises.

Pink noise is random noise with equal energy per octave, so it is widely used to equalize loudspeakers in rooms and auditoriums. This is why we selected it as the primary performance factor for our soundproofing performance standard in chassis, called DELTA. Pink and White (noise containing many frequencies with equal intensities) noise provide precisely the same soundproofing performance results from our experience.

Noise Measurements Produced by Chassis' Fans

We use Corsair's Commander Pro [6] to control the chassis fans, using custom software developed by our team. The Commander Pro is driven by another passively operating system that doesn't affect the chamber's noise floor.

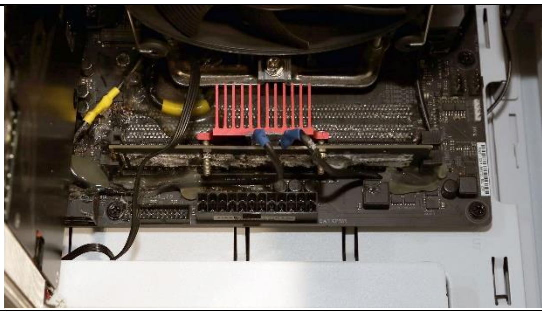
Our software allows for precise fan sped adjustments in both RPM and percentage. Hence, we can set individually for each fan a portion of the speed, e.g., in a fan with a maximum speed of 1000 RPM, if we put 50% in our program, the fan will rotate to 500 RPM (±1%).

We measure the noise produced by the fans at 40%, 50%, 60%, 70%, 75%, 80%, 90%, 100% of their maximum speed. Next, by reversing the measurements' logic, we change the fan speed

to achieve 35, 30, and 25 dBA noise output. We write down, of course, the corresponding speeds.
The last noise measurement deals with the graphics card. We use the EVGA GeForce GTX 970 SC GAMING ACX 2.0 graphics card (PN: 04G-P4-2974-KR) in all builds. In this test, we activate the system, install it in the chassis, and turn off all the fans except those used by the CPU and GPU cooling systems. We keep the CPU's fan speed at the lowest setting, to not alter our measurements, and change the speed of GPU fans to 40%, 50%, 60%, 70%, 75%, 80%, 90%, and 100% while measuring and logging noise output.

Thermal Performance

We use a custom-made loader for thermal performance evaluation, which uses heating elements in the CPU, VGA, VRM, NVMe, RAM, Chipset, and HDD areas. We install the chassis in a controlled environment where the temperature is set at approximately 25° C (77° F). We connect the Pico TC-08 thermocouple data logger [7] to get data from all thermal probes installed in designated places inside and outside of the chassis. Specifically, we have probes at the center of the CPU and GPU blocks, at the exhaust grill at the rear of the chassis, at the inside of the chassis, and at its center so as that is not anywhere near the CPU's fan airflow, at the NVMe slot, inside the hard disk drive, at the middle of one of the mainboard's VRMs. We also place a probe outside and near the chassis to measure the ambient temperature without affecting the rest of the measurements.

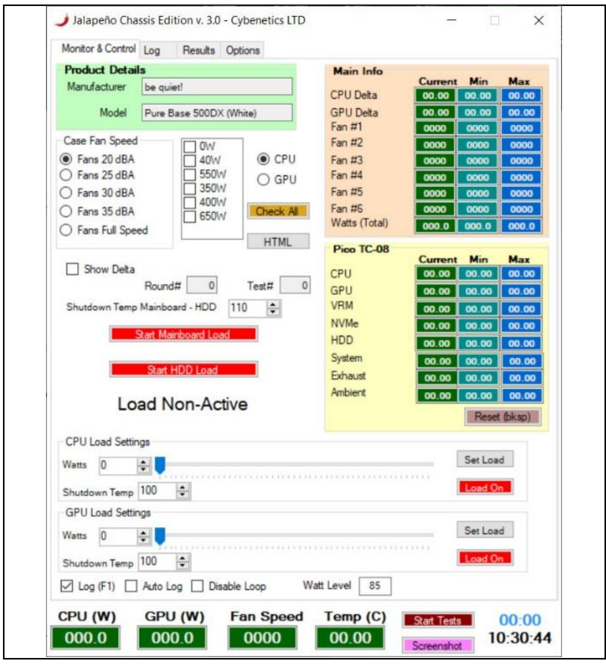



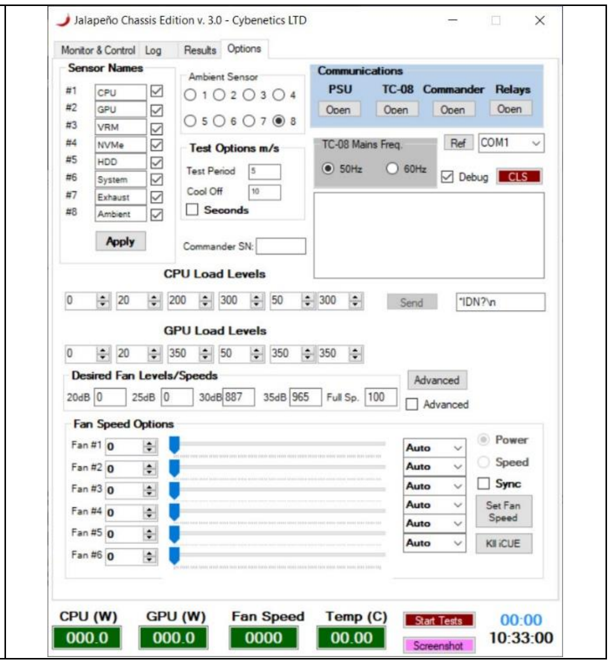
Pictures 3, 4

We apply a combination of different load (see table below) and fan speed scenarios to consider a wide operating range.

Test #1	CPU (W)	GPU (W)	VRM, RAM, Chipset, NVMe, HDD (Combined W)
1	20	20	50
2	200	350	50
3	300	50	50
4	50	350	50
5	300	350	50

We utilize the same (custom-made) software (Pictures 4 and 5) that we described above using the measurements we took during the noise tests for all thermal performance tests. This is why we have to conduct noise testing first. Specifically, we use the fan speeds we recorded for 25, 30, 35 dBA noise output levels and the maximum speed for all fans in the chassis. The CPU's and GPU's fans receive 12V and 7V, respectively, throughout all test sessions.





Pictures 4, 5

All case fans are connected to the Corsair Commander Pro so that we have complete control over them. Both the Corsair Commander Pro and the Pico TC-08 are controlled and monitored by our software.

All tests are executed automatically through our custom software without the intervention of a test engineer, except for the initial settings that are made at the very beginning of the procedure. The thermal tests consist of a set of five tests which run for ten minutes each. There is an intermediate 15-minute cool-off period between each test while we allow the system to remain idle for ten minutes before we gather all temperature information.

To explain the whole procedure that we follow thoroughly, we input to the program the corresponding case fan speeds for 35, 30, and 25 dBA noise output, which we received during the noise measurements. We also apply one more scenario. All case fans operating to full speed (100%). By using the noise output as a standard for all chassis, we can put all relevant products under the same strictly operating conditions because it would be unfair to compare cases with super strong and noisy fans to other ones with not as strong fans. There is always, of course, the full fan speed test for those that don't care about noise output but only want to know the thermal performance in the best-case scenario.

The average duration of the thermal performance tests is approximately eight hours, and after we gather all results, we enter them into our database for further analysis. All results are collected automatically and can be exported in various formats.

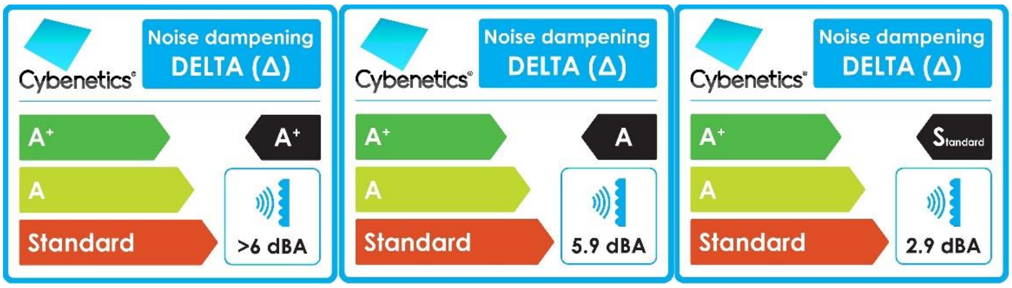
Data analysis

Using the scientific literature [11] [12] over sound, the measurement experience we gained after conducting dozens of tests in PC cases, our data is being analyzed.

As mentioned in the first part, when measuring the chassis soundproofing performance, we measure the chassis behavior in many frequencies. We do this because we want to see at what frequencies the chassis can tune in and be inferred as a noise amplifier and at which ones it does more damping. The materials used to make the chassis play a significant part in this since each implementation has different behavior. We also measure the chassis' damping in three necessary signals in Chirp, Pink noise, and White noise. In more details:

- The Chirp signal is commonly used in radar, sonar, etc. applications.
- Pink noise is a signal most common in biological systems. It includes all audio frequencies (20Hz - 20kHz), and its power is inversely proportional to its frequency, i.e. the higher the signal frequency, the lower its power.
- White noise is the random noise with a continuous spectrum whose spectral power density is independent of frequency.

To compare the results of different PC cases, we use the difference between an open field and the ones we got from each chassis (Delta). Cybenetics has created special badges for this purpose; the Delta Badges, with which we can easily categorize the chassis in terms of the noise attenuation they manage to achieve.



We have decided to use the Pink noise Delta to make the above categorization. This is because Pink noise includes all audio frequencies (20Hz - 20kHz), and so we have overall damping for the range we are interested in and the uniform power it has between the octaves.

NOISE DAMPENING LEVELS	NOISE DAMPENING REQUIREMENTS
A+	≥6 dB(A)
A	≥3 dB(A) & <6 dB(A)
STANDARD	<3 dB(A)

We apply the DELTA difference logic that we used above to the thermal tests. In particular, by using the room temperature that we record in real-time while performing the measurements, we find the difference with the respective temperature measurement point per test. In this way, we can make a direct comparison of the thermal efficiency at each point of measurement between our samples and extract safe results for their thermal behavior.

Epilogue

In this article, we tried to explain the methodology that we follow in our chassis evaluations as straightforward as it gets. There are a couple of things required in every sound test procedure: reliable, accurate, and calibrated above all, equipment, knowledge on how to use this equipment, and experience to discover as early as it gets problems and measurement errors. Experience only comes after a significant number of test sessions. Thankfully, the members of the Cybenetics team deal with chassis for more than a decade now, and their combined knowledge on this subject led to the complete testing protocol that we follow. Since we are after perfection, although we know that there is nothing perfect in this word (cats excluded, of course), we will continue searching for new methodologies and ways that will allow us to explore more aspects on this subject.

Our goal is to keep on improving our custom-made load tester, which provides tons of advantages over a real system. Besides not accurate and controllable loads, another significant problem with real systems is that they get outdated fast, so you hear complaints about using such an old system. Moreover, with a load tester, you can adjust the load with great precision and simulate many scenarios that reflect multiple real system configurations.

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