Cybenetics Chassis Test Protocol

Revision 1.0

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Revision History

Version	Release Date	Notes
1.0	September 2020	First draft

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Prologue

Taking accurate noise and thermal measurements in chassis is a challenge and besides experience, it also requires specialized equipment and proper facilities, especially for the noise measurements. After extensive research in this subject we came up with the methodologies that we are going to analyze in the following paragraphs. This is still a work in progress, meaning that we will constantly update the corresponding procedures till we come up with 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

Before we start conducting our noise measurements, we have to install first a complete system into the chassis. We do this for two reasons, to apply a real life scenario and secondly to minimize echoes inside the chassis. Similar to an empty room, an empty chassis will have echoes and this will notably affect, of course, the noise measurements.

The test systems that we use 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We are aware of course that we use outdated hardware, especially the GPU, but this doesn't matter since all we care about is the thermal load that these parts can deliver. And the GTX 970 draws more than 170W at the worst case scenario, matching the power requirements of an RTX 2060 Super. We have a complete GPU power consumption (and noise) database where you will find details on all popular graphics card, so you won't have to guess about their power consumption and noise levels.

For all 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 30o to 45o degrees angle with the horizontal axis and its vertical distance from the object of measurement is one meter.

The detailed noise measurements procedure is the following

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 so that we 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 1).

Picture 1

We repeat the same measurements, that is, we measure the noise output that the speaker produces at the aforementioned frequencies. 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' noise dampening performance in a wide frequency range along with pink, white and chirp noises.

Pink noise is random noise that has equal energy per octave, so it is widely used for equalizing loudspeakers in rooms and auditoriums. This is why we selected it as the main performance factor, for our noise dampening standard in chassis, called DELTA. From our experience, Pink and White (noise containing many frequencies with equal intensities) noise provide exactly the same noise dampening results.

Noise measurements produced by chassis' fans

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

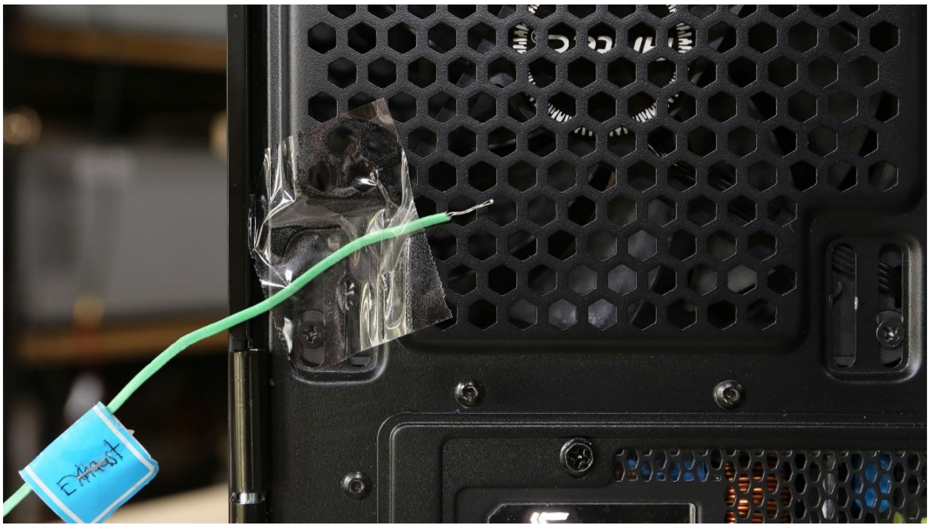
Our software allows for precise fan sped adjustments in both RPM and percentage. Hence, we can set individually for each fan, a percentage of the speed e.g. in a fan with a maximum speed of 1000 RPM if we set 50% in our program, the fan will rotate to 500 RPM (±1%).

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 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, installed in the chassis, and we turn off all the fans except the ones that are 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%, 58%, 60%, 70%, 75%, 80%, 90% and 100% while measuring and logging noise output.

Thermal Performance

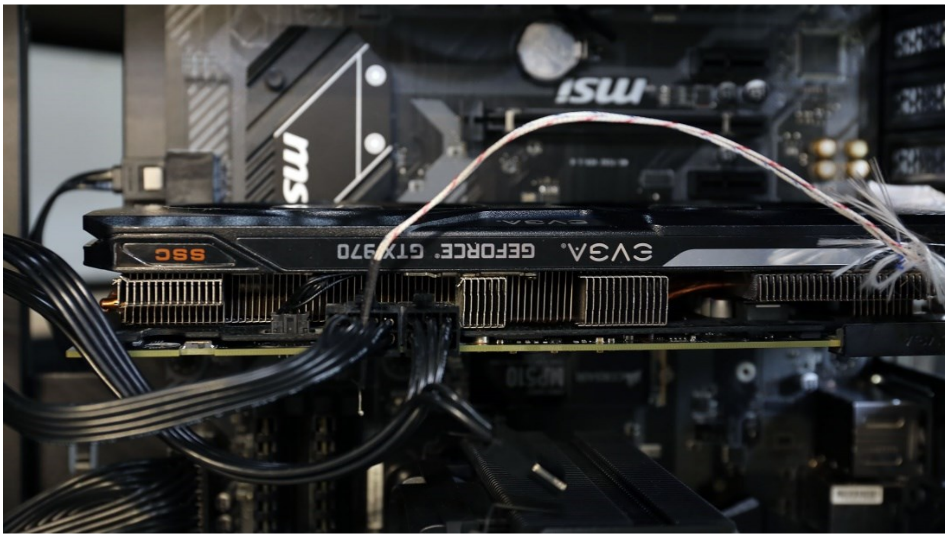
To implement the thermal performance tests, we use the same (custom-made) software that we described above along with the measurements we took during the noise tests. This is why we conduct noise testing first. Specifically, we use the fan speeds we recorded for 35, 30, 25 dBA noise output levels along with the maximum speed for all fans in the chassis. The GPU’s fans speed is fixed at 58% while the graph below shows the setting of the CPU’s fan speed.

We install the chassis in a controlled environment where the temperature is set at approximately 25o C (77o F). We connect the Pico TC-08 thermocouple data logger [7] installing its thermal probes in designated places inside and outside of the chassis. Specifically, we put the probes on 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 inlet and outlet of the power supply airflow, while we also place a probe outside and near the chassis to measure the ambient temperature, without affecting anyhow the rest of the measurements. (see pictures 2, 3, 4)



Picture 1

Picture 2



Picture 3

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 excecuted 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 20 minutes each. There is an intermediate five-minute cool off period between each test while we allow the system to remain at idle for ten minutes, before we gather all temperature information

The benchmarks that we use are the Prime95 [8], Furmark [9] and 3DMark Firestrike [10] and a torture test in which we run Prime95 and Furmark at the same time.

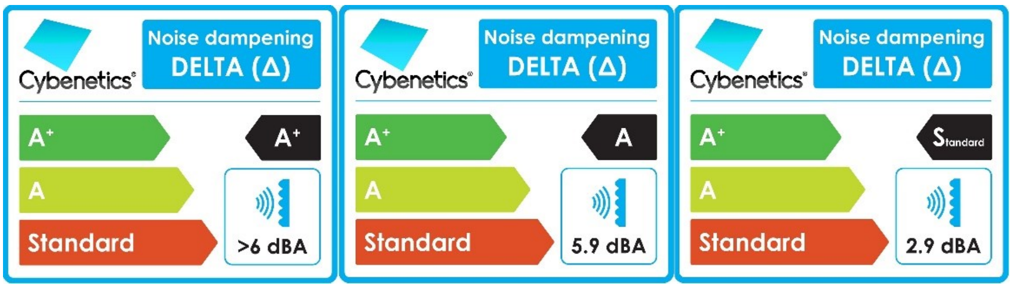
To explain the whole procedure that we follow thoroughly, we input to the program the corresponding case fan speeds for 35, 30 and 25 dBA noise output, which we received during the noise measurements. We also apply one more scenario, all case fans operating to full speed (100%). By using the noise output as a standard for all chassis, we are able to put all relevant products under the same exactly 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 ones 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 to our database for further analysis. All results are gathered automatically and can be exported in various formats.

Data analysis

At this stage, using the scientific literature [11] [12] over sound, furthermore the measurement experience we gained after conducting dozens of tests in PC cases, our data is being analyzed.
As we mentioned in the first part, when measuring the chassis noise dampening, 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 but also at which ones it does more damping. The materials used to make the chassis play a major part in this since each implementation has different behavior. We also measure the damping that the chassis has in three important 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, ie 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 be able 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, as well as due to 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 as straightforward as it gets, the methodology that we follow in our chassis evaluations. 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. It goes without saying that experience only comes after a great 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 do know that there is nothing perfect in this word (cats excluded, of course), we will continue on searching new methodologies and ways that will allow us to explore more aspects on this subject. Our goal is to be able at some point to make a proper load tester which will be used instead of a real system. The problem with real systems is that they get outdated fast so you hear complains about why you use such an old system, although what matters is the thermal output and not pure performance since we evaluated temperatures and not benchmark results. Moreover, with a load tester you can adjust the load with great precision and simulate many scenarios that reflect multiple real system configurations.

References

[1] https://www.bksv.com/en/products/sound-and-vibration-meters/sound-level-meters-and-vibration-meters/2270-series/Type-2270-S (*last accessed on* 18 June 2020)
[2] https://www.bksv.com/en/products/transducers/acoustic/calibrators/4231
(*last accessed on* 18 June 2020)
[3] https://www.sciencedirect.com/topics/engineering/chirp-signal
(*last accessed on* 18 June 2020)
[4] http://www.acoustic-glossary.co.uk/definitions-p.htm#pink-noise
(*last accessed on* 18 June 2020)

[5] http://www.acoustic-glossary.co.uk/definitions-w.htm#white-noise
(*last accessed on* 18 June 2020)
[6] https://www.corsair.com/eu/en/Categories/Products/Accessories-%7C-Parts/iCUE-CONTROLLERS/iCUE-Commander-PRO-Smart-RGB-Lighting-and-Fan-Speed-Controller/p/CL-9011110-WW(*last accessed on* 18 June 2020)
[7] https://www.picotech.com/data-logger/tc-08/thermocouple-data-logger
(*last accessed on* 18 June 2020)
[8] https://www.mersenne.org/(*last accessed on* 18 June 2020)
[9] https://geeks3d.com/furmark/ (*last accessed on* 18 June 2020)
[10] https://www.3dmark.com/ (*last accessed on* 18 June 2020)
[11] Standard ECMA-74 Measurement of Airborne Noise emitted by Information Technology and Telecommunications Equipment
https://www.ecma-international.org/publications/standards/Ecma-074.htm
(*last accessed on* 18 June 2020)
[12] ISO 9296:2017 Acoustics - Declared noise emission values of information technology and telecommunications equipment https://www.iso.org/standard/32303.html
(*last accessed on* 18 June 2020)