Cybenetics Cooling Solutions Test Protocol

Revision 1.2

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Revision History

Version	Release Date	Notes
1.0	December 2020	First draft
1.1	May 2021	Grammatical edits
1.2	June 2021	Minor fixes

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Prologue

Evaluating the performance of cooling solutions on real hardware might be the easiest and most widely used method, but it has many shortcomings. For example, you cannot dial the desired load for starters, and you cannot keep it steady, too. Moreover, you are bound to hardware changes, and once the need arises to move to a new platform, you need to erase your entire database and start fresh since the results from the new hardware won't be compatible with the previous ones. All the issues mentioned above and some other smaller ones led us to build a test system for evaluating cooling solutions, which we call Jalapeno.

Jalapeno uses resistors as heating elements connected to a powerful bench power supply that can deliver up to 1200 W of power if required. Since no cooler would cope with such a high thermal load, we restrict Jalapeno to "only" 500 W. The critical component in Jalapeno is the control software, which allows for fully automatic testing without any intervention from the user, so human errors are minimized. All coolers are tested under precisely the same conditions, and we use delta temperature differences (compared to the ambient) in all of our results to be as accurate as possible.

Test Equipment

We use the following equipment for the evaluations of cooling systems

- Jalapeno (our custom thermal loader)
- Corsair Commander Pro (Fan controller) [1]
- Pico TC-08 (Thermocouple data logger) [2]
- Aim TTi QPX600DP (Programmable DC power supply) [3]
- Custom made software

We use a hemi-anechoic chamber with an extremely low noise floor for all measurements 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^{o} to 45^{o} degrees angle with the horizontal axis and its vertical distance from the object of measurement is one meter.

Noise Measurements Procedure In Detail

We turn on the sound meter Bruel & Kjaer G-4 Type 2270 [4], 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 [5].

We install the CPU cooler in the chamber vertically to the microphone, in a fixed position (see Photo 1) to have the same conditions in each measurement. In all tests, the cooler's fan(s) pushes air opposite from the microphone direction.

Photo 1

We utilize a Corsair Commander Pro [1] to control the cooling fan(s), using custom software developed by our team. In addition, 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 fan(s) at 40% - 100% of their maximum speed in 10% steps. Next, we change the fan speed by reversing the measurements' logic to achieve 20, 25, 30, and 35 dBA noise output. We write down, of course, the corresponding speeds.

Thermal Performance Evaluation: Procedure

To conduct 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 need to conduct noise testing first. Specifically, we use the fan speed measurements we got from the 20, 25, 30, and 35 dBA noise output levels and the maximum fan speed. If the cooler has more than one fan, we take the readings from all fans.

We install the Device Under Test (DUT) in a controlled environment where the temperature is set at approximately 25°C (77°F). Then, we connect the Pico TC-08 thermocouple data logger [2] to several thermal probes, with two being the most important ones: the probe that measures the temperature of the metallic plate, which comes in touch with the DUT's base, and another one that measures the ambient temperature.

To ensure that the cooler's base is seated correctly on Jalapeno, we use a torque wrench. We also ensure that it makes a proper contact by inspecting it after the tests are finished to see if the thermal paste covers the entire surface evenly.

Speaking of thermal paste, we use the same in all of our tests to have compatible results. Our choice is Arctic Cooling MX-4.

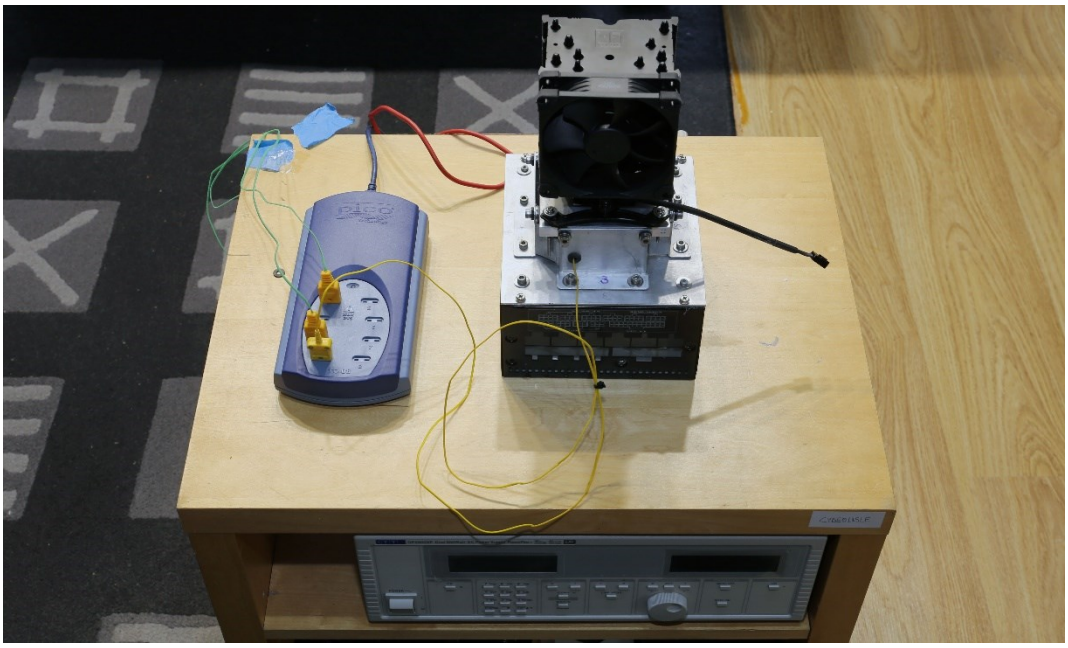

Photo 1

The DUT's fans are connected to the Corsair Commander Pro to have complete control over them. Both the Corsair Commander Pro and the Pico TC-08 are controlled and monitored by our software.

All tests run automatically through our software without the intervention of a test engineer, except for the initial settings that are made at the very beginning of the procedure. The testing procedure for each fan speed scenario consists of five tests that run for 15 minutes each. There is an intermediate five-minute cool-off period between each test.

We use two different test sessions, one for high-performance cooling solutions and one for mainstream coolers. Below you will find the tests in detail for both categories.

High-Performance Cooler Tests

20 dBA: 200 W and 400 W load
25 dBA: 200 W and 400 W load
30 dBA: 200 W and 400 W load
35 dBA: 400 W and 500 W load
Full Fan Speed: 400 W and 500 W

Mainstream Cooler Tests

20 dBA: 100 W and 200 W load
25 dBA: 100 W and 200 W load
30 dBA: 100 W and 200 W load
35 dBA: 200 W and 300 W load
Full Fan Speed: 200 W and 300 W

Thermal Performance Evaluation: Details

Some cooling solutions don't go up to 35 dBA at a one-meter distance, and in some cases, we have measured coolers that don't even reach 30 dBA. This is why it is essential to compare these coolers with all the rest at the same noise output level. It makes sense when a noisy cooler equipped with strong fans achieves better temperatures than a low-noise cooler, but what happens when we normalize noise output and force both of them to operate with the same noise output levels? This is where things get interesting, and you can compare apples to apples.

Thermal Performance Evaluation: Duration & Results

The average duration of all thermal performance tests is approximately three and half hours, depending on how many output noise levels the DUT can achieve. For example, noisy coolers can run all noise output scenarios, from 20 dBA up to 35 dBA, and we also have to add the full fan speed test.

Once all tests are finished, we enter the results into our database for further analysis. All results are gathered automatically and can be exported in various formats.

Thermal Performance: Data analysis

We don't only compare the coolers at maximum fan speed and full load, but we also make comparisons at lower fan speeds and lower loads. This is of immense importance, especially for affordable coolers which might have a hard time with 400 W – 500 W loads but perform way better with 200 W. We are also able to extract valuable conclusions by checking the performance of each cooler at various fan speeds and noise levels and by comparing it, of course, with other cooling solutions in the same price range. Such a comparison shows how

effective the design is and whether the cooler relies on increased airflow to achieve higher performance.

Epilogue

Evaluating the performance of cooling solutions is far from easy and straightforward since many factors come into play: from the thermal paste that you will use to install the cooling system on the CPU or the test loader. Every detail counts, and on top of that, real CPUs can have notable thermal deviations, which affect the results. Furthermore, it is not easy, if not impossible, to keep a steady load using a real CPU since there are frequent voltage deviations. The major disadvantage is that you cannot dial a load level that you desire, so you cannot simulate many possible scenarios but only one.

Moreover, it is of enormous importance to consider the cooler's output noise because it is only natural that a noisy cooler can have better performance compared to a dead silent one. However, more and more users seek quiet cooling solutions, some of them proceeding to fan changes to achieve this. So it is crucial to be able to include the output noise into the testing results and not just run tests at full fan speed.

References

[1] 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* 31 December 2020)
[2] https://www.picotech.com/data-logger/tc-08/thermocouple-data-logger (*last accessed on* 31 December 2020)
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[4] 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)
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