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THE NEW KING OF GAMING

Z690 OVERCLOCKING GUIDE

GIGABYTE™

GIGABYTE AORUS Z690 Guide to Overclocking Intel 12th Gen. CPUs to 5GHz+

Chapter 1: Intro

Intel i9-12900K Overclocks to above 5GHz on Z690 AORUS Boards

We are very excited to see that the new CPUs come with some amazing changes. The 12900K features a hybrid core technology with a combination of high-performance and high-efficiency cores. This combination promises better multi-core performance but higher single-performance too. The new processors require a new 600-series motherboard to work. The Z690 motherboards feature the new PCI-e 5.0 interface and they introduce the DDR5 memory technology as well.
Yes, 5+ GHz is still possible and 12th Gen. CPUs want to maintain the title of being the king for hardcore gaming!

Beginner FAQ

What is overclocking?

Overclocking refers to pushing your computer components harder and faster than the manufacturer designed them to go. CPUs, video cards, and memory often have the capability to run faster than their rated speeds and overclocking takes advantage of that.

Why overclock?

Overclocking your CPU, VGA, and/or memory can result in higher frames per second in games, increase benchmark scores and provide better overall performance of your PC. There are three big reasons to consider overclocking: free performance, reducing FPS dip/stutter and unlocking full performance of high end GPUs.
One of the key areas where overclocking helps gaming is boosting the low/minimum FPS in games. It's those demanding moments in games with lots of action and textures that can cause a PC to momentarily slow down with FPS dipping to low digits under heavy load where CPU often needs to work very hard as running at faster speeds will improve FPS and the gaming experience. The second important aspect of overclocking is combining a fast CPU with a high end GPU. After a high end GPU is bottlenecked in games such as PUBG, a good example of this type of behavior, having a fast CPU combined with a decent graphics card will leave you fragging without FPS dips.
Overclocking gives you a free performance boost, why not give it a shot!

Is my notebook processor comparable to my desktop processor?

Desktops have much higher power requirements and better heat dissipation capabilities compared to notebooks. The same model processor in a desktop performs better than the mobile equivalent. CPU speed can have an impact on graphics performance and desktop CPUs will have superior performance because of that.

What can I overclock?

The most often overclocked components are the CPU, video card and memory. In this guide our focus is CPU overclocking.

Disclaimer: Overclock at your own risk!

Overclocking your CPU voids your warranty and it can also damage your CPU, especially if done incorrectly.

Chapter 2: How to Overclock Your Intel i9-12900K

For reference we are using a GIGABYTE Z690 AORUS MASTER motherboard and an Intel i9-12900K CPU.
Based on our testing some Intel i9-12900Ks can hit 5.1-5.2GHz using water-cooling and around 1.3-1.35ish Vcore. This is our experience with the CPUs we've tested. You may find that your CPU will overclock better (or worse) than our samples so keep that in mind when doing the testing.
For ease, we will only overclock the high-performance cores on this guide but with exactly the same way you can overclock the high-efficiency cores if you want. You can do that simultaneously but we recommend to overclock them after you stabilize your overclocking with the high-performance cores first.

▪ Step 1: Enter the BIOS by pressing the “delete” button

If you have never been inside your BIOS before, welcome! There is no need to worry, we will guide you step by step with screenshots.

■ Step 2: Load your Extreme Memory Profile (X.M.P.)

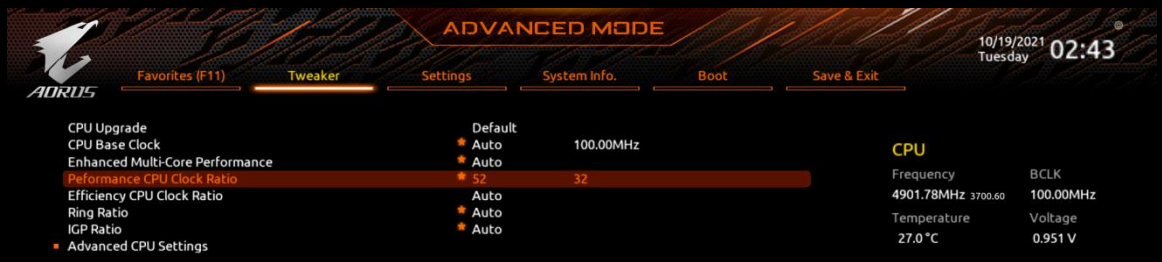
Enter BIOS and go to the “Tweaker” tab. Scroll down until you see the “Extreme Memory Profile (X.M.P.)” option.

Change it to “Profile 1”. Depending on your RAM you might see a second and a third X.M.P. profile. X.M.P. profiles are a quick way to get optimal performance for your memory without having to tweak the settings manually. These settings are verified by the memory manufacturer so you don’t have to worry about stability.

* The “Gear Mode” option has been added. We suggest to use Auto. Gear Mode will affect the IMC clock.

■ Step 3: Change your CPU Multiplier

The formula to calculate the frequency of your CPU is: CPU Base Clock * CPU Clock Ratio. The Intel i9-12900K CPU has a Base Clock of 100 and CPU Clock Ratio of 49 for a frequency of 100 * 49 = 4900MHz. In this guide we will be overclocking to 5.2GHz for a 300MHz increase. Since we overclock the Performance cores, set your Performance CPU Clock Ratio to “52”.



■ Step 4: Disable TVB

Enter the “Advanced CPU Settings” submenu in the “Tweaker” tab. Disable both the TVB options.

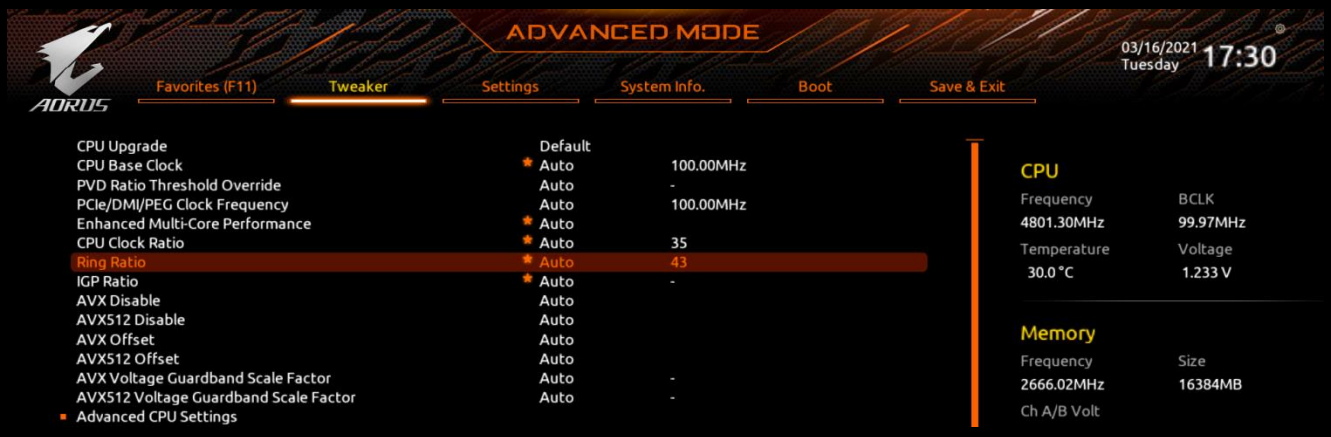
The Thermal Velocity Boost is a really nice feature but when you overclock your processor the temperatures will rise. You don’t want TVB to kick in and down clock your processor when the CPU temperature goes over 70 degrees.

*Note: Alternatively, instead of disabling all these options you can simply just disable the “Enhanced Multi-Core Performance” under “Tweaker” tab.

■ Step 5: Change Ring Frequency

The formula for Ring frequency is CPU Base Clock * Ring Ratio = Ring Frequency.

Ring frequency is the frequency of the non-core parts of the CPU- IE cache, memory controller, etc. After you have determined your CPU’s highest overclock you can re-visit your Ring settings. In general higher Ring values do not produce meaningful performance differences, but they may improve benchmark score.



*Note: You may find that you lose stability at 5.2GHz CPU clocks if you raise the Ring frequency really high. Start with Ring at “Auto” and if your system is stable then raise it to a higher frequency. Experiment with Ring frequency after you find the max clocks for both Performance and Efficiency cores.

**Note: Please disable the “Ring to Core offset (Down bin)”.

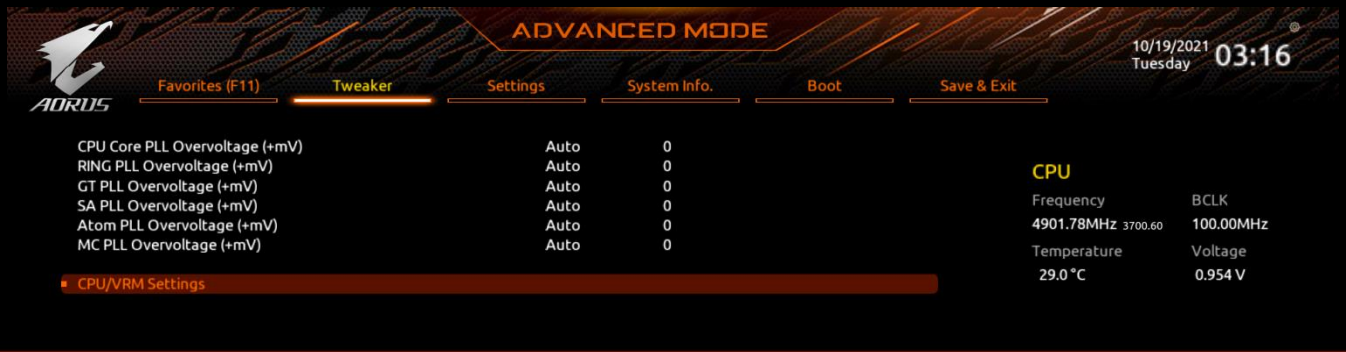
**Here you can disable settings or features which may not be necessary in your daily operation. VT-d is used for virtualization. If you don't plan on using any virtual machines you can disable it. The same stands for the Internal Graphics. Both those options can be found in the "Settings" tab.

■ Step 6: Adjust Your Voltage Settings

Now that we have set our memory XMP profile, Ring, and CPU multiplier we must also adjust the CPU voltage (Vcore). In order for the CPU to operate at higher frequencies more voltage will be required.

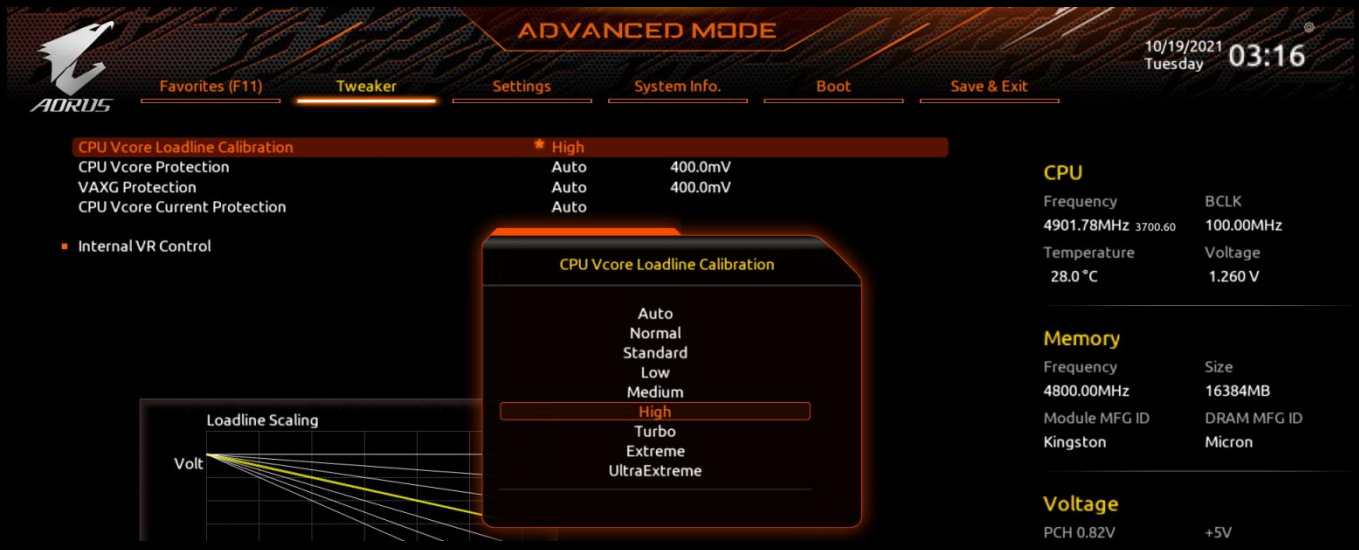
Go to the starting BIOS page (Tweaker) and select the "Vcore Voltage Mode". Here we added a new option, the Adaptive mode. Although, in this guide we will go with the Fixed Vcore Mode.

Enter the "Advanced Power Settings" submenu and then enter the "CPU/VRM Settings" submenu.



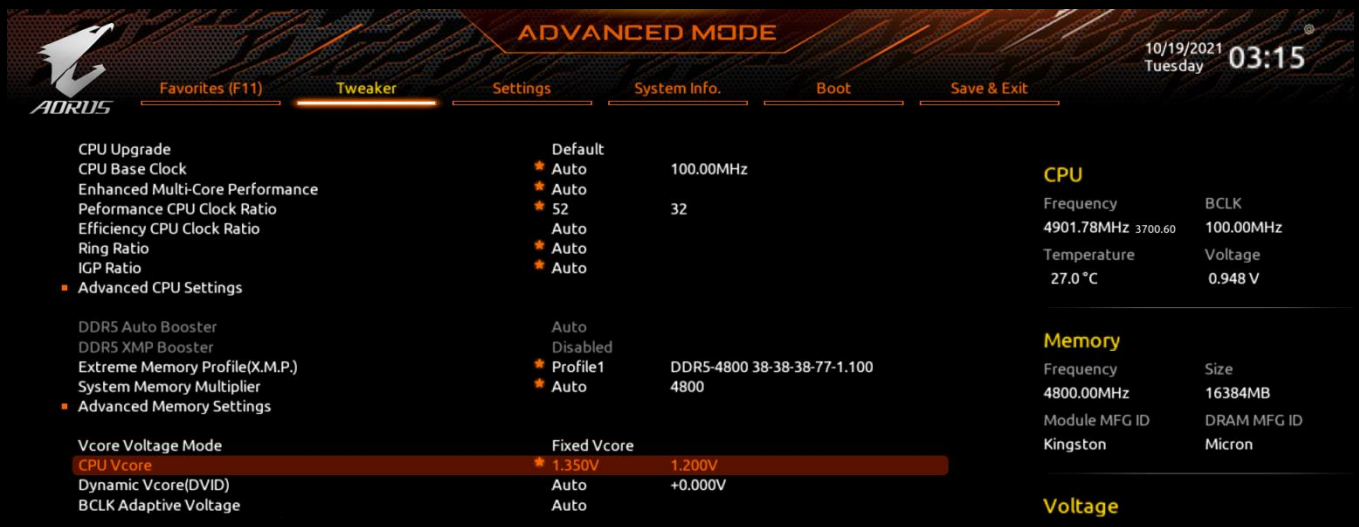
(Optional) CPU Vcore Loadline Calibration

AORUS Z690 motherboards are already optimized to reduce voltage fluctuation. These voltage fluctuations are built into standard voltage management to reduce power consumption but can also have adverse effects during overclocking as you need a stable fixed voltage to ensure consistency in power delivery. To begin leave LLC on AUTO. If you experience any shutdowns while stress testing set LLC to “High” or “Turbo” and test again. If you still experience shutdowns set LLC to “Extreme”. Make sure you also keep an eye out on the CPU load temperature to prevent overheating.



■ Step 7: Change CPU Vcore Settings

On the main BIOS page (“Tweaker” tab) scroll down until you see the “CPU Vcore”.



CPU Vcore: Raising this helps keeps the system stable at higher CPU frequencies. However, it also increases the amount of heat your CPU produces. We suggest you keep Vcore under 1.4V depending on your CPU cooling solution. Some CPU's should be able to overclock to 5.1-5.2GHz on all the cores at this voltage, however CPUs are not all created equally. Some may need more voltage, some less.

Set Vcore to "1.35" to start. If you system is not stable raise the voltage in increments of .01-.02 with a maximum of 1.40V.

Step 8: Save Your Settings

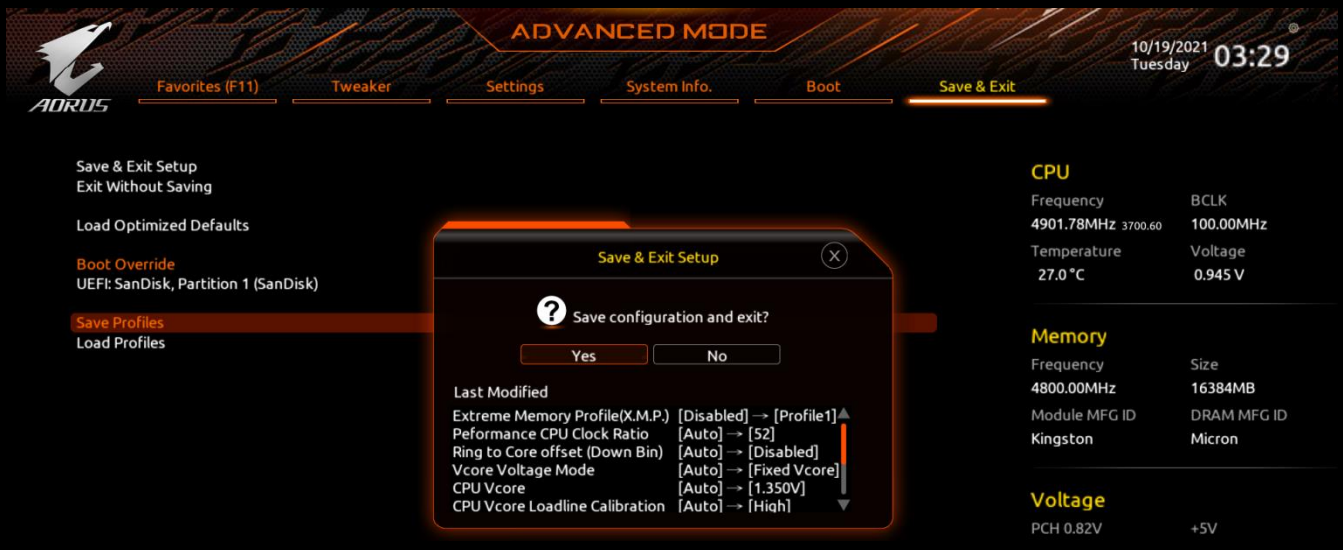
Before rushing off to test your new overclock we suggest saving your profile. You will find this option on the last page of the BIOS named "Save & Exit".

Select the option "Save Profiles" and select and name the profile.

Using the "Load Profiles" option you can load the profiles you've previously saved.
This is very useful when you need to clear the CMOS due to an overly aggressive overclock in which you've lost all of your previous settings.

Step 9: Save & Exit

Last step is to select the “Save & Exit Setup” and click yes on the pop-up window. This will reboot your motherboard and apply all the settings that you have changed.



Chapter 3: Stability Testing

Congratulations! You are now running at 5.2GHz, which is nothing to scoff at. Now it's time to make sure that it's stable. We're going to use the software below to monitor our system, test stability, and adjust our overclocks.

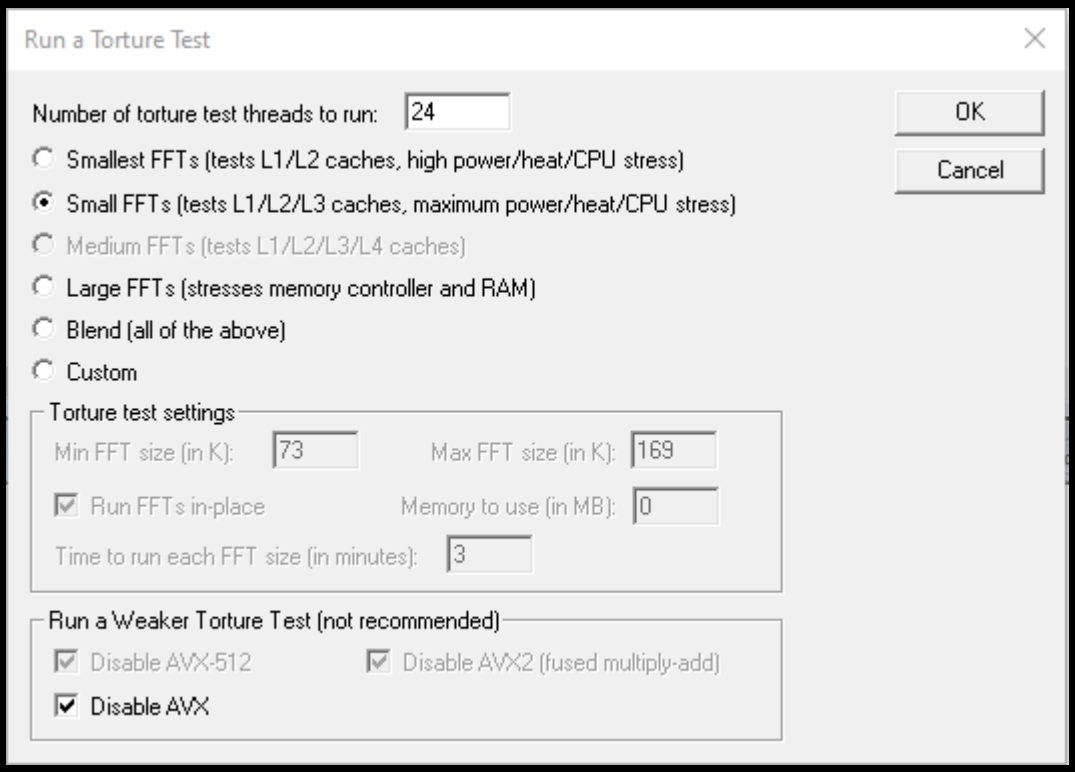
Prime95– This is used to stress test our CPU in order to ensure that it's stable in the most taxing of conditions.

CPU-Z– Used to monitor our CPU frequencies and Vcore settings.

Hwinfo64– Used to monitor idle, load, and loading temperatures.

How to Stability Test

■ **Step 1:** Open up CPU-Z, Hwinfo64, and Prime95. Make sure Prime95 is configured. Click the "Small FFTs" preset, disable the AVX instructions and then press OK to start.



Step 2: Start Prime95 and look at “CPU Load” in the Hwinfo64 app. If one of your cores is not at 100%, your system gets the blue screen of death or just freezes, that means your settings were too aggressive and your CPU has failed the stability test. We normally test for 1 hour. You can keep it running overnight for increased assurance.

Core Usage	100.0 %	0.0 %	100.0 %
P-core 0 T0 Usage	100.0 %	0.0 %	100.0 %
P-core 0 T1 Usage	100.0 %	0.0 %	100.0 %
P-core 1 T0 Usage	100.0 %	0.0 %	100.0 %
P-core 1 T1 Usage	100.0 %	0.0 %	100.0 %
P-core 2 T0 Usage	100.0 %	0.0 %	100.0 %
P-core 2 T1 Usage	100.0 %	0.0 %	100.0 %
P-core 3 T0 Usage	100.0 %	0.0 %	100.0 %
P-core 3 T1 Usage	100.0 %	0.0 %	100.0 %
P-core 4 T0 Usage	100.0 %	0.0 %	100.0 %
P-core 4 T1 Usage	100.0 %	0.0 %	100.0 %
P-core 5 T0 Usage	100.0 %	0.0 %	100.0 %
P-core 5 T1 Usage	100.0 %	0.0 %	100.0 %
P-core 6 T0 Usage	100.0 %	0.0 %	100.0 %
P-core 6 T1 Usage	100.0 %	0.0 %	100.0 %
P-core 7 T0 Usage	100.0 %	0.0 %	100.0 %
P-core 7 T1 Usage	100.0 %	0.0 %	100.0 %
E-core 8 T0 Usage	100.0 %	0.0 %	100.0 %
E-core 9 T0 Usage	100.0 %	0.0 %	100.0 %
E-core 10 T0 Usage	100.0 %	0.0 %	100.0 %
E-core 11 T0 Usage	100.0 %	0.0 %	100.0 %
E-core 12 T0 Usage	100.0 %	0.0 %	100.0 %
E-core 13 T0 Usage	100.0 %	0.0 %	100.0 %
E-core 14 T0 Usage	100.0 %	0.0 %	100.0 %
E-core 15 T0 Usage	100.0 %	0.0 %	100.0 %

Step 3a (If Prime95 Fails): Close Prime95 by right clicking the Prime95 icon on the tray bar in the lower right side of your screen and selecting “Exit”. This closes Prime95.

Step 3b (If Prime95 Fails): Now it’s time to adjust your frequency or voltage settings. You can do this either through the BIOS or using EasyTune which is available through the GIGABYTE App Center. You have two options: Either increase CPU Vcore or decrease CPU Clock Ratio. We recommend you to keep CPU Vcore below 1.4 volts if possible. After making an adjustment, go back to Step 1. If it continues to fail, dial down your CPU Clock Ratio until you pass stability testing.

Step 3C (If Prime95 Fails): If you aren’t stable at 5.2GHz on Prime95 you can try setting AVX offset to “2”. This will lower your CPU multiplier by 2x when running AVX instruction sets. For instance if your CPU is set go 5.2GHz it will run at 5GHz during Prime95. Although, since we are not running AVX instructions we simply need to reduce the CPU multiplier.

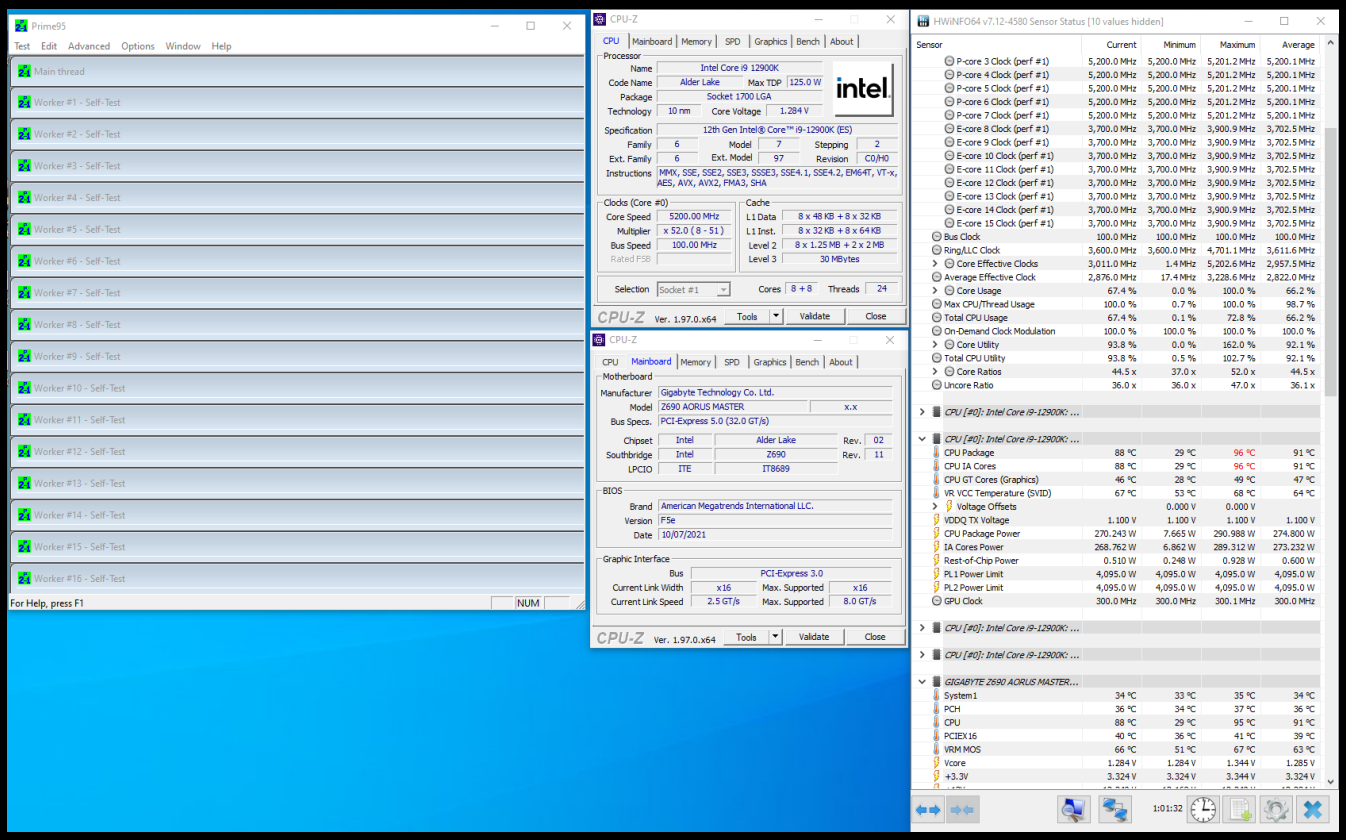
■ AVX Offset: AVX Offset ranges from 0 to 31. When you set an AVX offset it will reduce the multiplier by 1-31 (whatever you set it to) when running AVX instruction sets. You can find this setting under “Adavnced CPU Settings” at the “Tweaker” tab.

You’re able to completely disable the AVX instructions to the CPU so you won’t live with the fear that it might crash when it will be called to run AVX applications.

▼ AVX Settings	User Defined
AVX Disable	Auto
AVX Offset	2
AVX Voltage Guardband Scale Factor	Auto

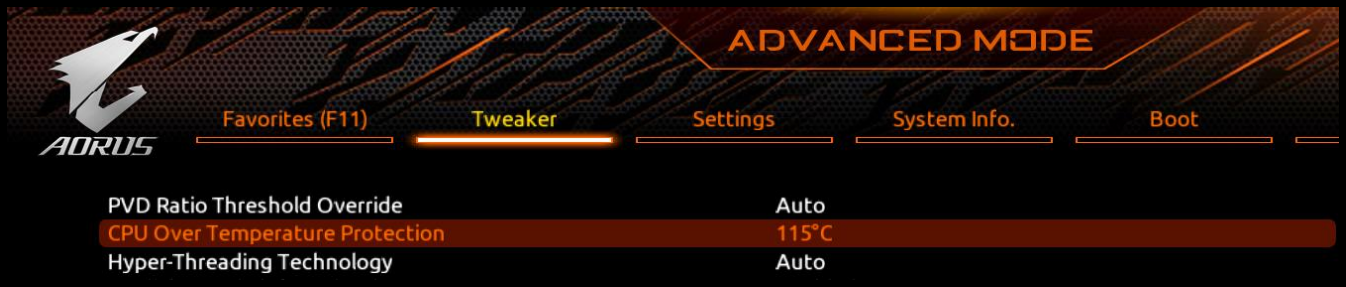
■ Step 4 (Success): Congratulations, your current overclock is stable. You may want to try for a higher frequency. To do so, experiment with raising your CPU Clock Ratio and CPU Vcore settings either in BIOS or EasyTune and go back to Step 1 to ensure that it’s stable.

Example of a 5.2GHz i9-12900K on water-cooling:



Thermals

As you can tell from the last screenshot, the CPU temperature of the i9-12900k is at the high level even for an overclocked CPU.
For this reason we suggest you to use a custom water-cooling and adjust the TjMAX Temperature to 115˚C.
You will find the “TjMAX Temperature” option under the Advanced CPU Settings submenu in Tweaker tab.



Results

We’ve increased frequency from 4.9GHz to 5.2GHz—a 300MHz increase! The results of our overclocks can be seen in the Cinebench R23 benchmark below.

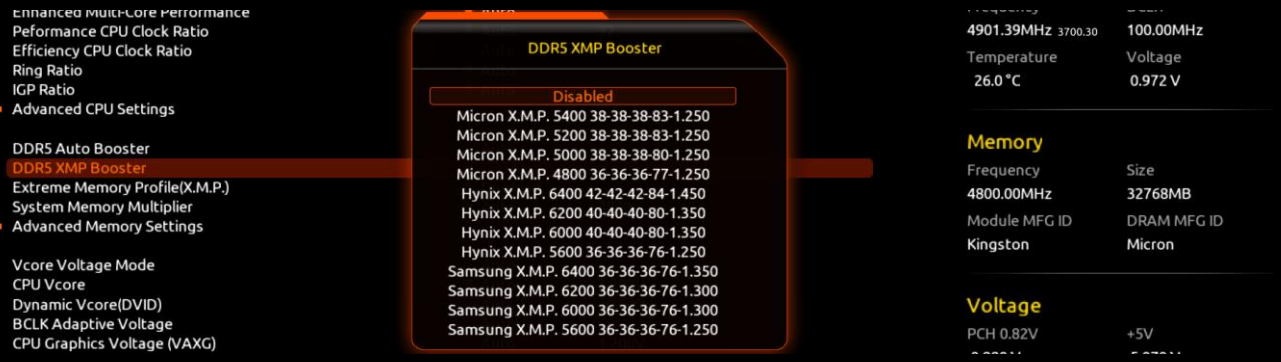
Intel Core i9-12900K Default Settings	Intel Core i9-12900K @ 5.2GHz
	

From stock to 5.2GHz we jump 2713 marks from 26218 to 28931 points!

DDR5

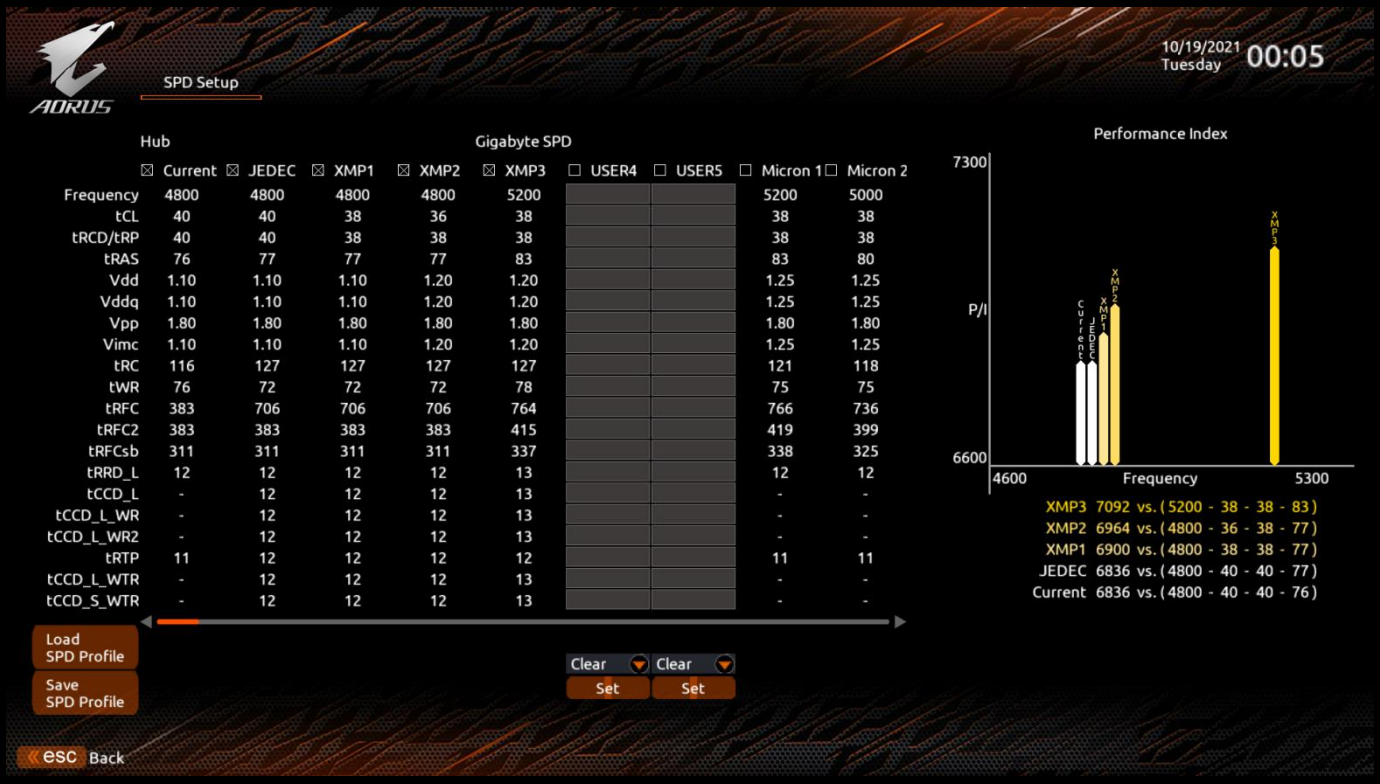
With the introduction of the DDR5 technology we've added some new options in BIOS.
Through those options users can quickly get some extra and free performance compared to the default settings.
DDR5 memory kits will need some time to mature so we hope these options will come in handy until then.

■ **DDR5 Auto Booster:** This option boosts the memory kit from its stock frequency to the boosted frequency of 5000 MHz. It's ideal for native speed DDR5 memory kits that don't have higher than 5000MHz XMP.



■ **DDR5 XMP Booster:** Predefined profiles for Micron, Hynix and Samsung IC manufacturers. Most of the times these profiles should work without a problem but it's not guaranteed. You can find your DRAM IC manufacturer at the right side of the bios screen and select one of the suitable profiles.

■ **SPD Setup:** You can find this option under the Advanced Memory Settings menu. The user can now write 2 custom profiles in the SPD. Basically, you can now write your own XMP and use it every time without having to type all the settings one by one after each reset.
Even on memory kits without XMP, the user can still use those 2 empty profiles to make his own profile or copy some of the predefined profiles.
Using the options at the bottom and by clicking “Set” you can write or clear the profiles on your memory sticks.
In order for the profiles to be written or cleared you need to save and exit from the bios and on the next reboot the extra profiles will show up at the Extreme Memory Profile(X.M.P.) option.
Make sure that you set the “Memory Boot Mode” to “Disable Fast Boot” for SPD Setup to work correctly.



We’ve added Save and Load Profile options so you can save or load a profile that you made in a USB drive and share it with other users in the internet! Sharing is caring!!