AORUS

Z390 AORUS MASTER

AORUS Z390 DESIGN FOR 5 GHz+ ALL CORES

All Cores at 5GHz+ and other results may vary by CPU and cooling solution. Features may vary by model.

Z390 Overclocking Guide

GIGABYTE™

GIGABYTE AORUS Z390 Guide to Overclocking Intel 9000 series CPUs to 5GHz+

Chapter 1: Intro
Intel i9-9900K Overclocks to 5GHz on Z390 AORUS Boards

The core counts keep going up and this time Intel has come up with an 8 core, 16 thread processor. Along with it, Intel launched a mainstream chipset which supports this new generation of CPUs, the Z390. The best part is that there's backwards compatibility with the last chipset generation! Gaming and overclocking are better than ever without compromises!
Yes, 5 GHz and 8 cores is now reality!!!

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 i9-9900K

For reference we are using a GIGABYTE Z390 AORUS MASTER motherboard and an Intel i9-9900K CPU. Based on our testing many Intel i9-9900Ks can hit 5GHz using water-cooling and around 1.3-1.35Vcore. 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.

■ 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.)
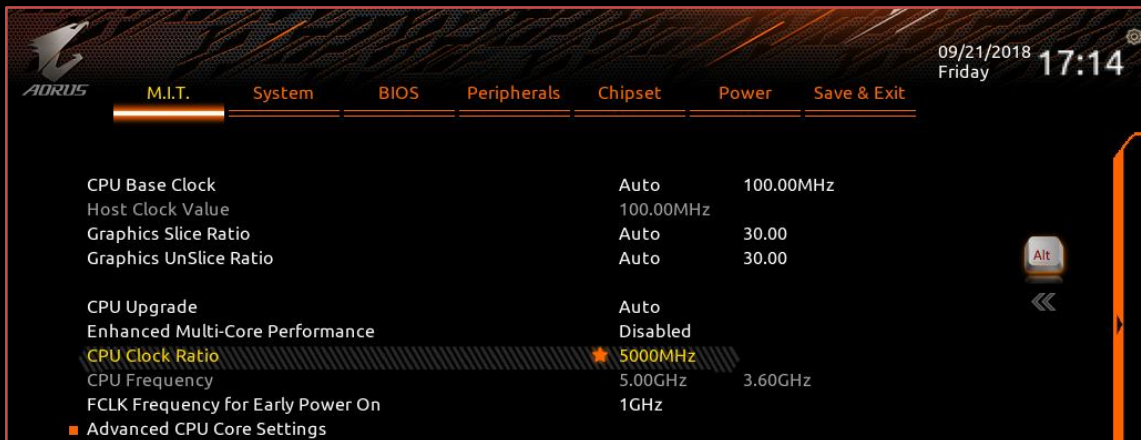
Enter "Advanced Frequency Settings"
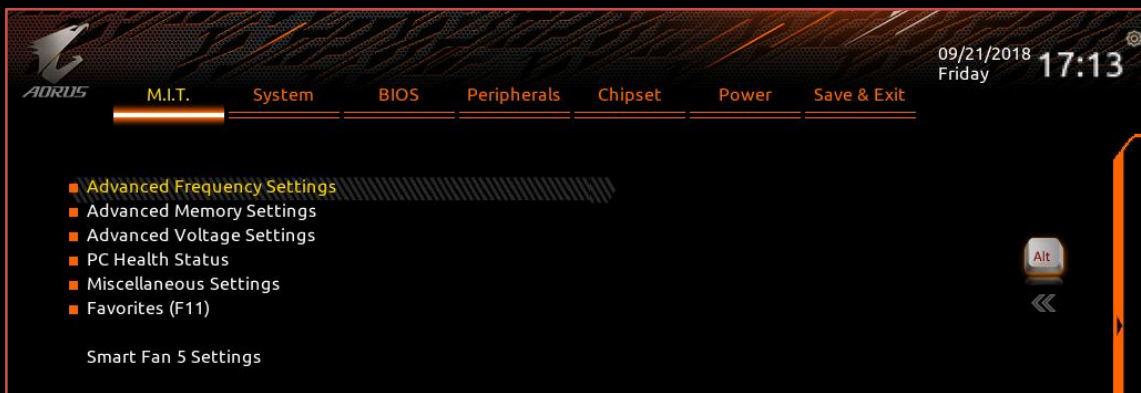
Here you see the "Extreme Memory Profile (X.M.P.)" option.
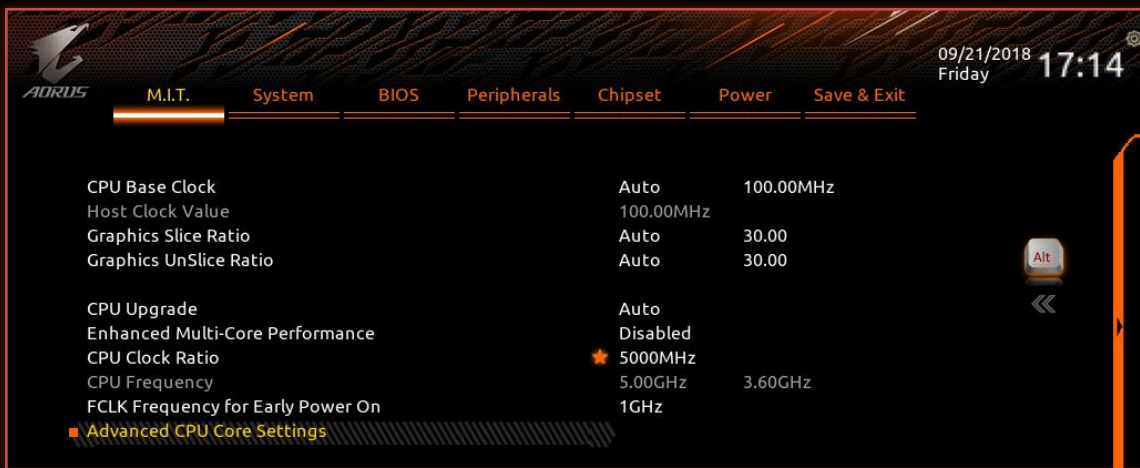Change it to "Profile 1". Depending on your RAM you might see a second X.M.P. profile.

AORUS	M.I.T.　System　BIOS　Peripherals　Chipset　Power　Save & Exit	09/21/2018 Friday 14:40

CPU Base Clock	Auto	100.00MHz
Host Clock Value	100.00MHz	
Graphics Slice Ratio	Auto	30.00
Graphics UnSlice Ratio	Auto	30.00
CPU Upgrade	Auto	
Enhanced Multi-Core Performance	Enabled	
★ CPU Clock Ratio	5000MHz	
CPU Frequency	5.00GHz	3.60GHz
FCLK Frequency for Early Power On	1GHz	
■ Advanced CPU Core Settings		
Extreme Memory Profile(X.M.P.)	Profile1	
★ System Memory Multiplier	Auto	DDR4-3200
Memory Ref Clock	Auto	
Memory Odd Ratio (100/133 or 200/266)	Auto	
Memory Frequency(MHz)	3200MHz	2133MHz

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.

■ Step 3: Change your CPU Multiplier

The formula to calculate the frequency of your CPU is: CPU Base Clock * CPU Clock Ratio.
The Intel i9-9900K CPU has a Base Clock of 100 and CPU Clock Ratio of 47 for a frequency of 100 * 47 = 4700MHz. In this guide we will be overclocking to 5GHz for a 300MHz increase.
Set your CPU Clock Ratio to "50".

AORUS	M.I.T.　System　BIOS　Peripherals　Chipset　Power　Save & Exit	09/21/2018 Friday 17:14

|		
CPU Base Clock	Auto	100.00MHz
Host Clock Value	100.00MHz	
Graphics Slice Ratio	Auto	30.00
Graphics UnSlice Ratio	Auto	30.00
CPU Upgrade	Auto	
Enhanced Multi-Core Performance	Disabled	
★ CPU Clock Ratio	5000MHz	
CPU Frequency	5.00GHz	3.60GHz
FCLK Frequency for Early Power On	1GHz	
■ Advanced CPU Core Settings		

# ■ Step 4: Disable Power Management & VT-d settings

These power management settings may decrease the stability of your system. You can keep them enabled if you think you really need them but we suggest you disable them.

Disable the following power management settings: Intel® Speed Shift Technology, CPU Enhanced Halt (C1E), C3 State Support, C6/C7 State Support, C8 State Support and C10 State Support.
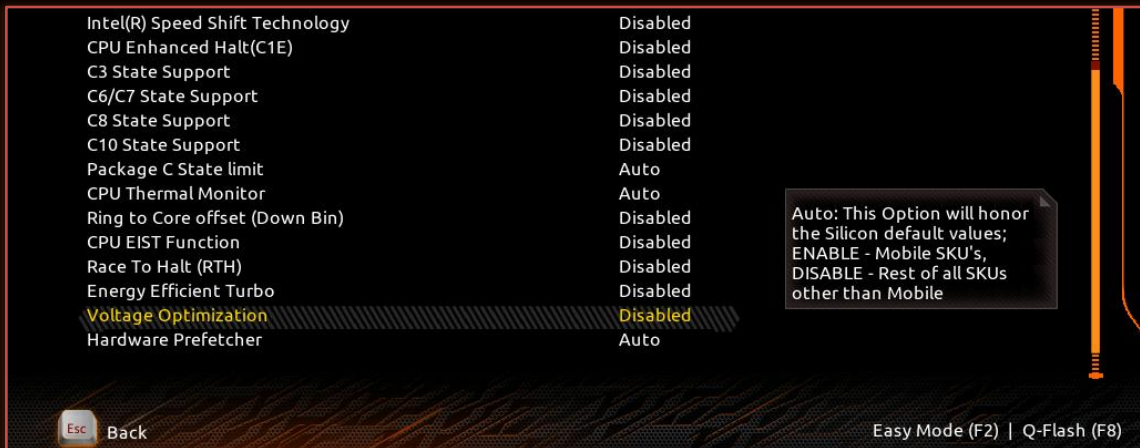
*Note: Alternatively, instead of disabling all these options you can simply just disable the "Enhanced Multi-Core Performance" under Advanced Frequency Settings.
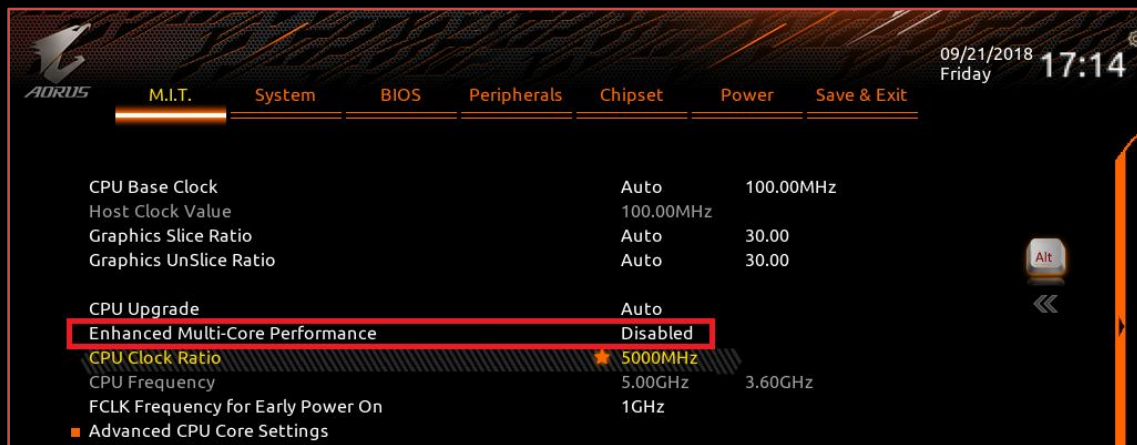
Step 5: Change Uncore Frequency

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

Uncore frequency is the frequency of the non-core parts of the CPU- IE cache, memory controller, etc. To start, set your uncore to 47 and continue on with the guide. After you have determined your CPU's highest overclock you can re-visit your uncore settings. In general higher uncore values do not produce meaningful performance differences, but they may improve benchmark score.
Set CPU Uncore to "47".

*Note: You may find that you lose stability at 5GHz CPU clocks if you raise the uncore frequency really high. Start with uncore at 4.7GHz and if your system is stable then raise it to a higher frequency.

**Note: Please disable the "Ring to Core offset (Down bin)" under the Advanced CPU Core Settings. Under the "Chipset" tab disable VT-d.
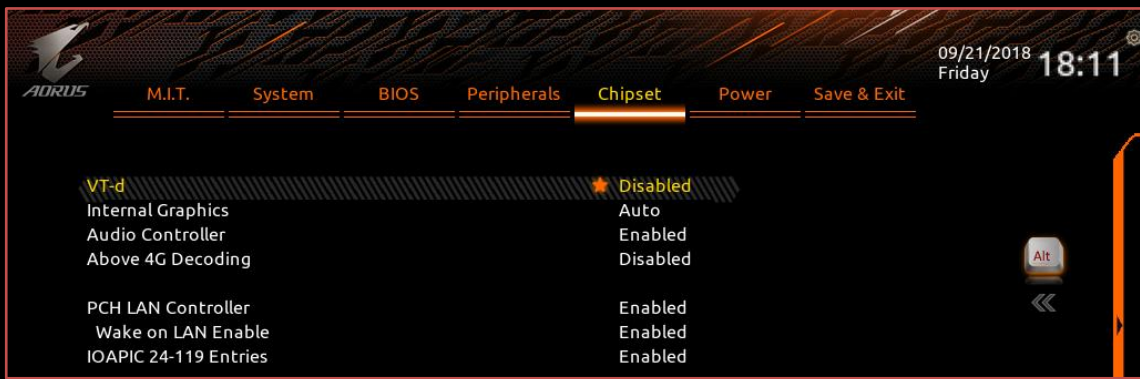
Here you can disable settings or features which may not be necessary in your daily operation. VT-d is used for virtualization. If you don't plan on using any virtual machines you can disable it. The same stands for the Internal Graphics.

■ Step 6: Adjust Your Voltage Settings

Now that we have set our memory XMP profile, Uncore, 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 (M.I.T.) and select the "Advanced Voltage Settings" option.
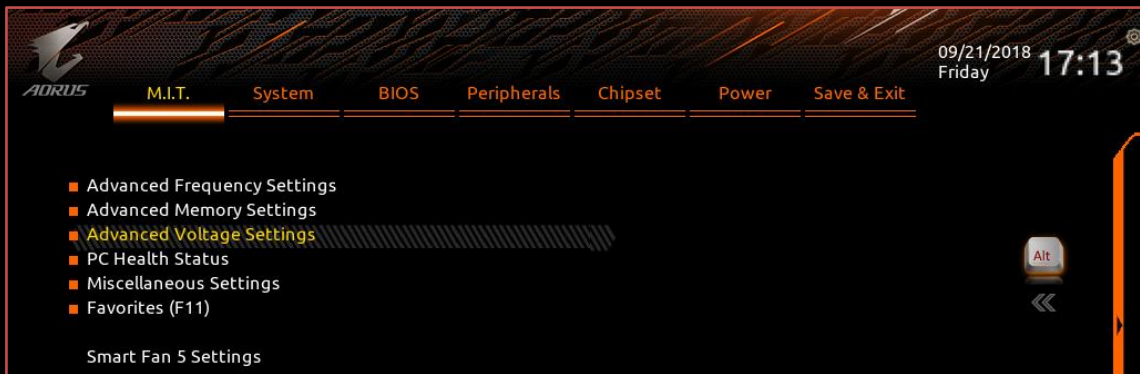
Select the "Advanced Power Settings" Option
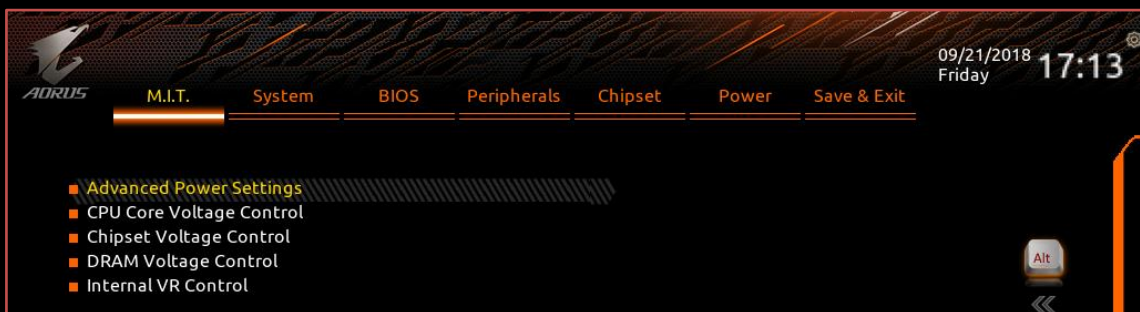
(Optional) CPU Vcore Loadline Calibration

AORUS Z390 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 "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

Go back one page (ESC) or from the main BIOS page (M.I.T) select "Advanced Voltage Control" Select "CPU Core Voltage Control"
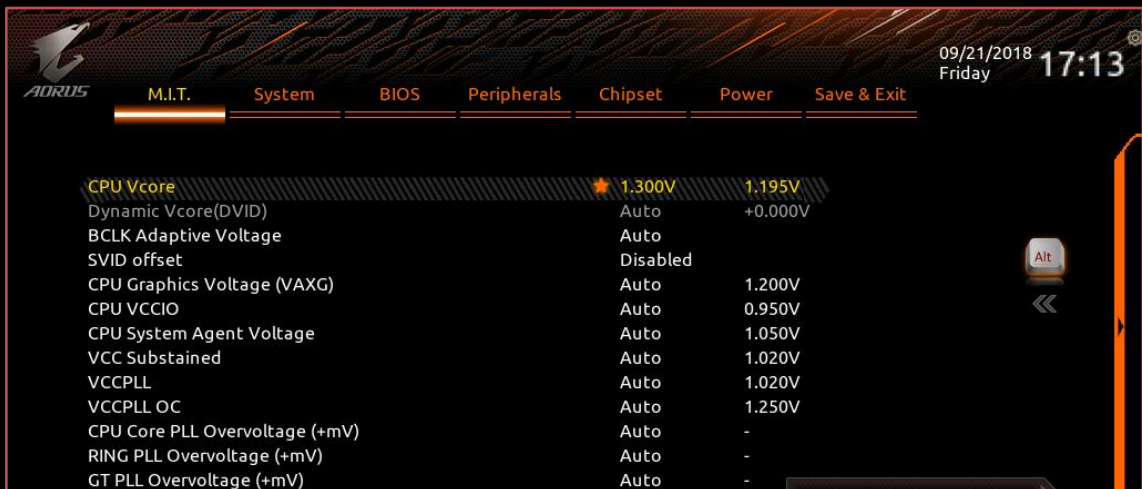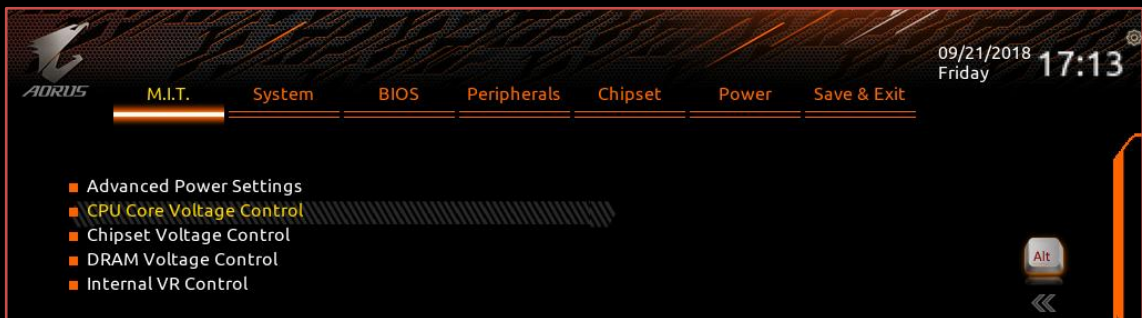
CPU Vcore: Raising this helps keeps the system stable at higher CPU frequencies. However, it also increases the amount of heat your CPU produces. We suggest you keep Vcore under 1.35V depending on your CPU cooling solution. Most CPU's should be able to overclock to 5GHz on all the cores at this voltage, however CPUs are not all created equally. Some may need more voltage, some less.

Set Vcore to "1.30" to start. If you system is not stable raise the voltage in increments of .01 with a maximum of 1.40V.

*Note that changing Vcore voltage also changes your Uncore voltage since they share the same power rail.

(Optional) Advanced Settings

The following are settings are optional and might sometimes be needed when overclocking on air or water. There are additional voltages settings not covered here—they are used mostly when trying to hit overclocking records while using liquid nitrogen.

CPU VCCIO and CPU System Agent Voltage: Both of these settings help with DRAM frequency overclocking. Values up to 1.3-1.35V are high but they are ok if you are using aircooling. Since we used X.M.P. profiles for our memory these voltages will be automatically set.
BCLK Adaptive Voltage: This setting helps when you raise the "CPU Base Clock" frequency. You should not need to adjust it because we left "CPU Base Clock" at the default value of 100.

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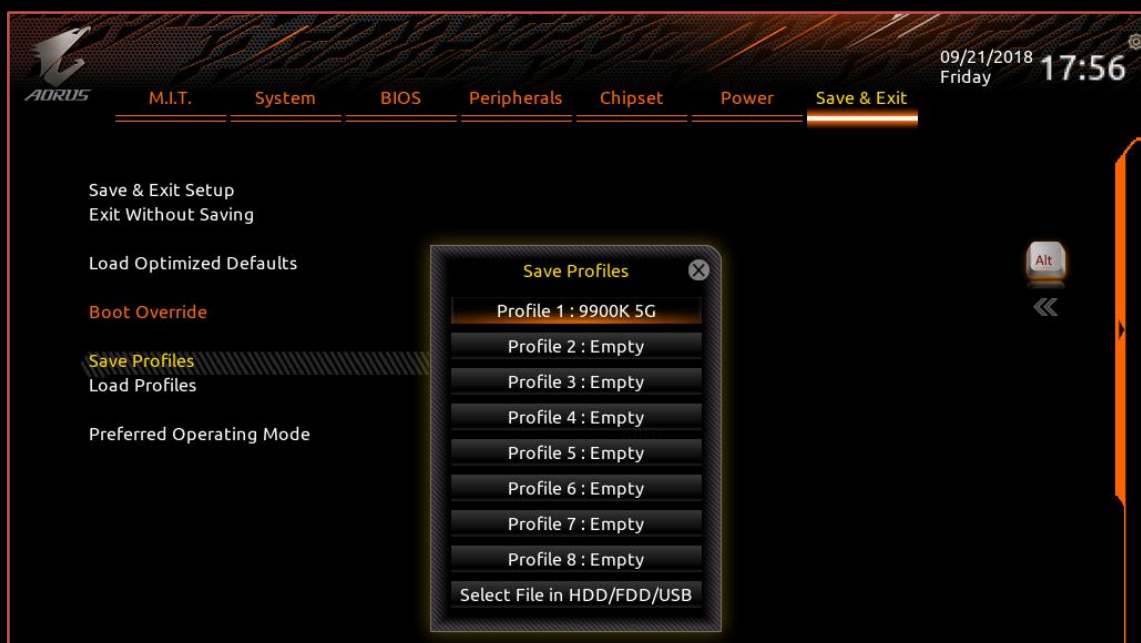
Select the option "Save Profiles" and select and name the profile.
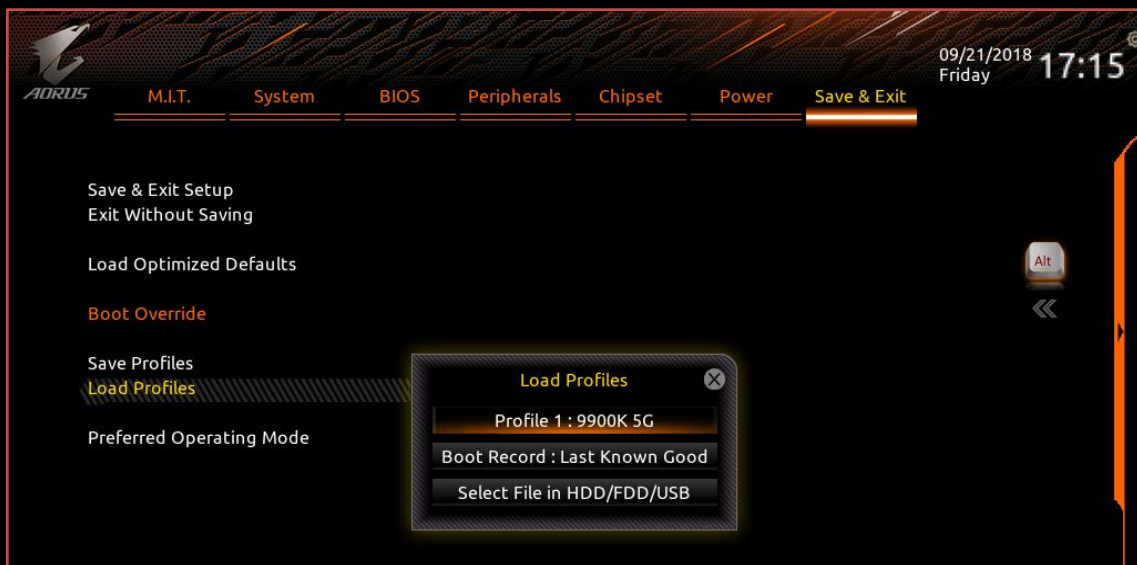
Using the "Load Profiles" option you can load the profiles you've previously saved.
This is very useful when you need to clear the CMOS due to an overly aggressive overclock in which you've lost all of your previous settings.

■ 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.
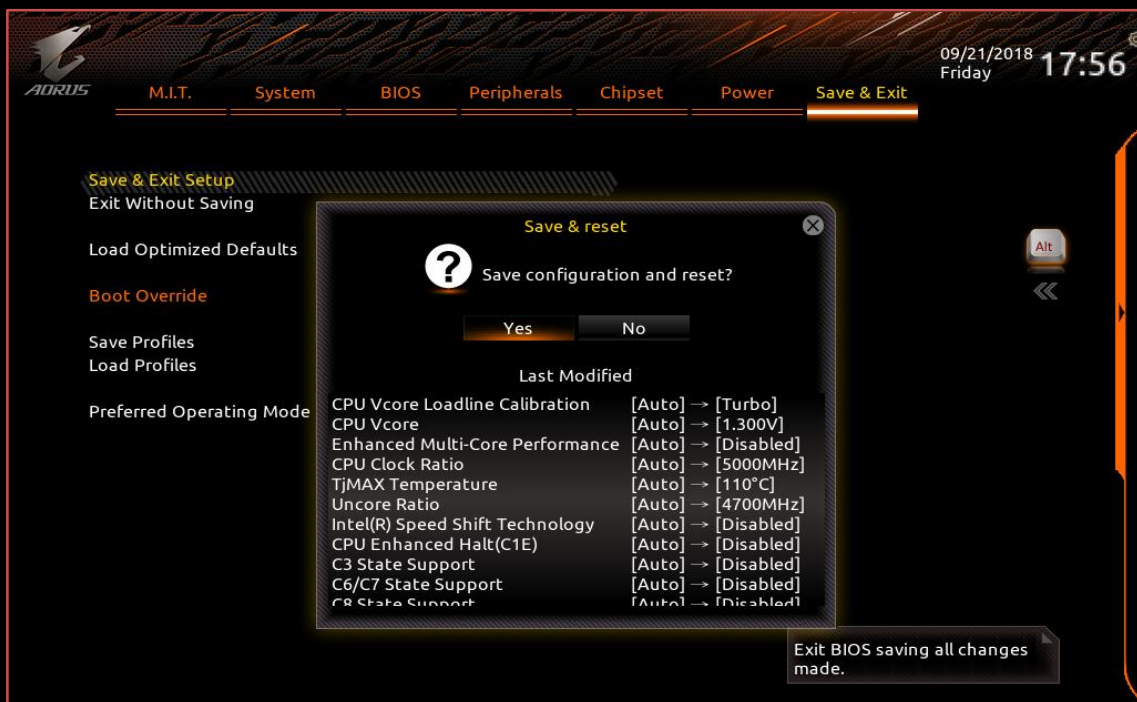
Chapter 3: Stability Testing

Congratulations! You are now running at 5GHz, 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.
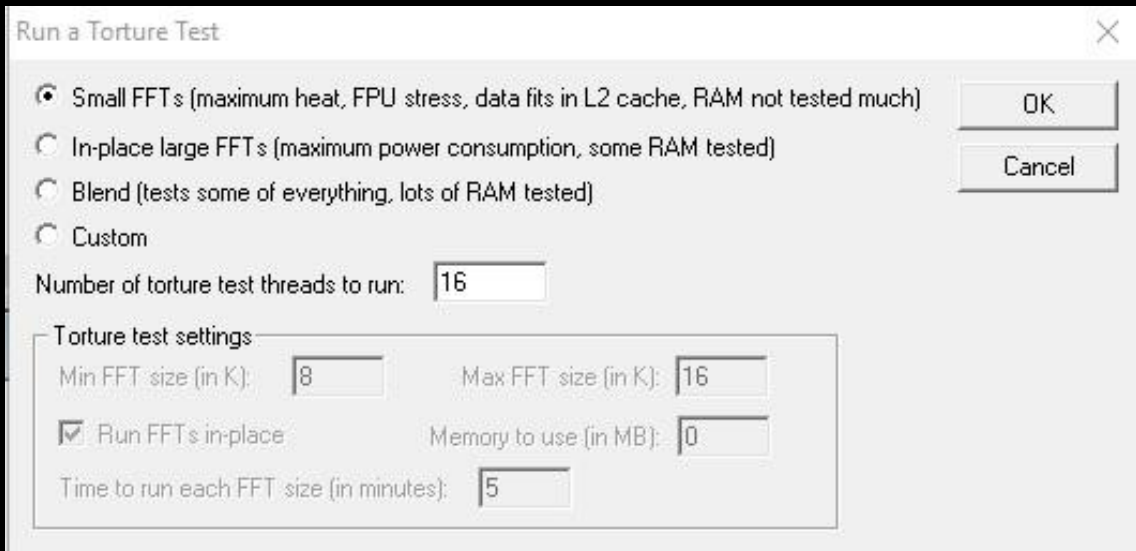
Prime95 Version 27.9 Build 1– This is used to stress test our CPU in order to ensure that it's stable in the most taxing of conditions. This particular version of Prime95 uses AVX instructions which push our CPU to the absolute max.

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

CoreTemp– Used to monitor idle, load, and loading temperatures.
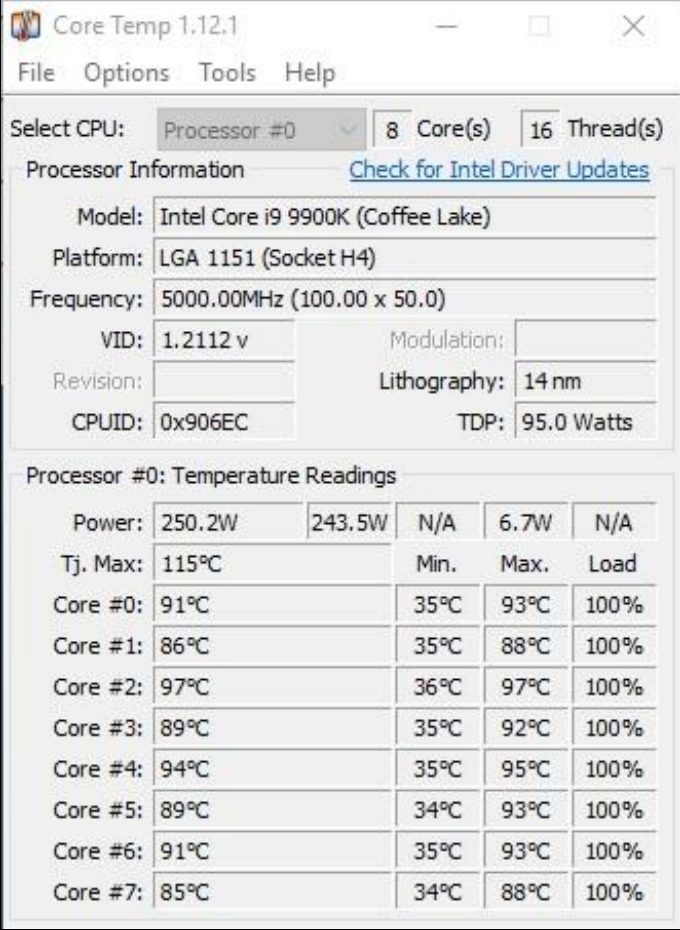
How to Stability Test

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

Step 2: Start Prime95 and look at "CPU Load" in the CoreTemp 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 Temp 1.12.1				— ☐ ✕
File Options Tools Help				

Select CPU: Processor #0 ⌄ 8 Core(s) 16 Thread(s)

Processor Information Check for Intel Driver Updates

Model:	Intel Core i9 9900K (Coffee Lake)
Platform:	LGA 1151 (Socket H4)
Frequency:	5000.00MHz (100.00 x 50.0)
VID:	1.2112 v	Modulation:	
Revision:		Lithography:	14 nm
CPUID:	0x906EC	TDP:	95.0 Watts

Processor #0: Temperature Readings

Power:	250.2W	243.5W	N/A	6.7W	N/A
Tj. Max:	115°C		Min.	Max.	Load
Core #0:	91°C		35°C	93°C	100%
Core #1:	86°C		35°C	88°C	100%
Core #2:	97°C		36°C	97°C	100%
Core #3:	89°C		35°C	92°C	100%
Core #4:	94°C		35°C	95°C	100%
Core #5:	89°C		34°C	93°C	100%
Core #6:	91°C		35°C	93°C	100%
Core #7:	85°C		34°C	88°C	100%

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 1.35 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 5GHz 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 5GHz it will run at 4.8GHz during Prime95.

■ 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 "M.I.T" -> "Advanced CPU Core Settings"

■ 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 5GHz i9-9900K on water-cooling:
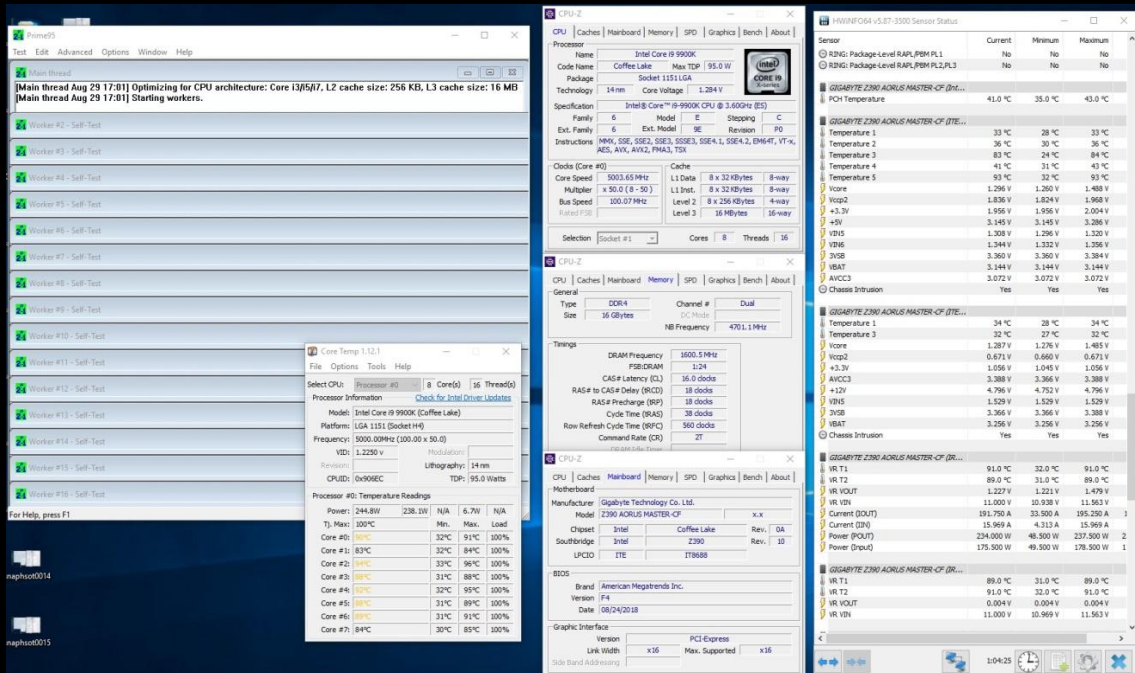
Thermals

As you can tell from the last screenshots, the CPU temperature of an overclocked i9-9900k is quite high. This is something that we've noticed on many of the processors.

If you concern for high CPU temperature we suggest you to use a custom water-cooling or a high-end AIO and adjust the TjMAX Temperature to 110°C.

You will find the "TjMAX Temperature" option under the Advance CPU Core Settings submenu in M.I.T tab.
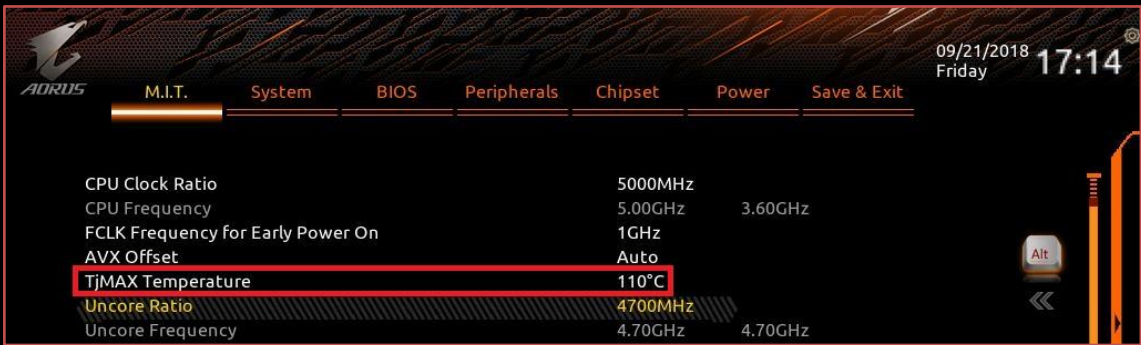
Results

We've increased frequency from 4.7GHz to 5GHz—a 300MHz increase! The results of our overclocks can be seen in the Intel® Extreme Tuning Utility benchmark below.

Intel Core i9-9900K Default Settings	Intel Core i9-900K @ 5GHz	Intel Core i9-900K @ 5.2GHz
3233 Marks	3450 Marks	3524 Marks
Maximum Processor Frequency 4.91 GHz	Maximum Processor Frequency 5.00 GHz	Maximum Processor Frequency 5.20 GHz
Highest CPU Temperature 72 °C	Highest CPU Temperature 99 °C	Highest CPU Temperature 83 °C

From stock to 5GHz we jump 217 marks from 3233 to 3450.
From 5GHz to 5.2GHz we gain an additional 74 Marks.

Chapter 5: Pushing Past 5GHz

Although, 5GHz was our initial target some CPUs can reach a higher frequency and still be stable. Here is an example on an i9-9900K tuned for 5.1GHz. Keep in mind that the CPU temperature is going to be even higher than before and that's something you should take into consideration before you start trying to increase CPU clocks.

We recommend using a custom water-cooling build for the best results. Even some AIOs are not capable of dissipating the high temperature that the CPU produces under AVX load.

For the specific steps please refer to the overclocking guide above. The specific settings for a 5GHz overclock are listed below.

■ Step 1: Adjust CPU Clock Ratio

Previously we set our CPU Clock Ratio to 50 and now it's a simple adjustment to 51. Since this overclock is more difficult than the previous 5GHz overclock, we suggest you change these settings through the BIOS.
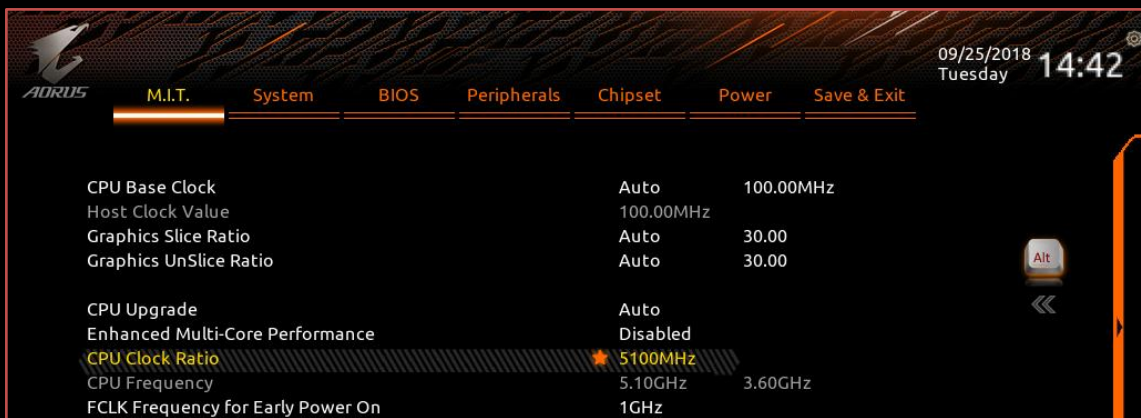
■ Step 2: Adjust CPU Vcore

Just like before we will set the Vcore at 1.3V. Aiming for higher frequency means you might have to increase the Vcore. Depending on how lucky you were in the CPU lottery the CPU Vcore setting can range from 1.3V to 1.35V. Our particular CPU needed 1.3V to be stable.
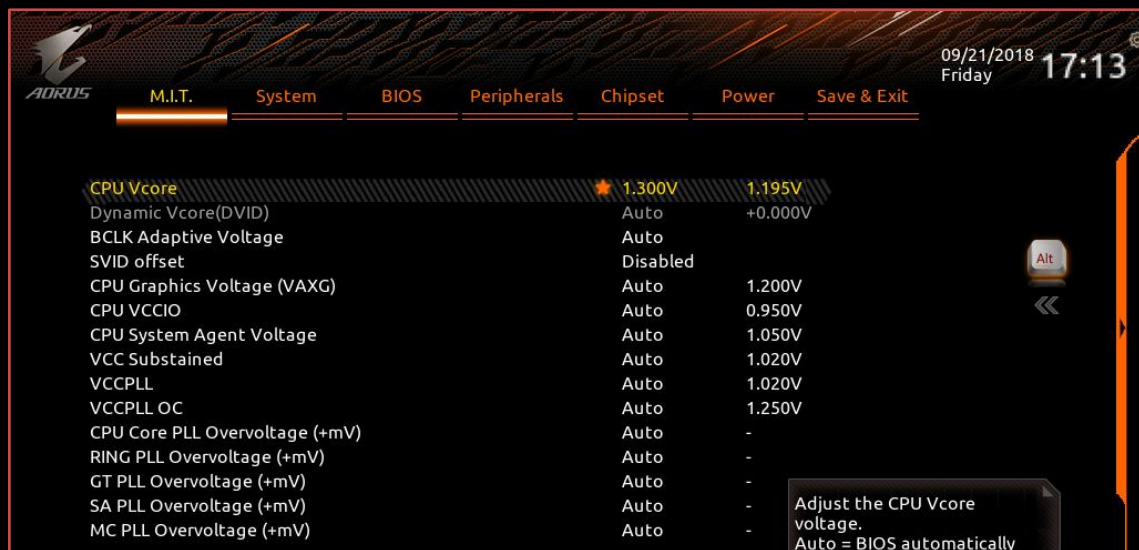
■ Step 3: Change CPU Vcore Loadline Calibration

In order to reduce any possible Vdroop that interferes with our stability when overclocking set LLC to "Turbo". If the system is not stable or you're experiencing shut downs set the LLC to "Extreme".
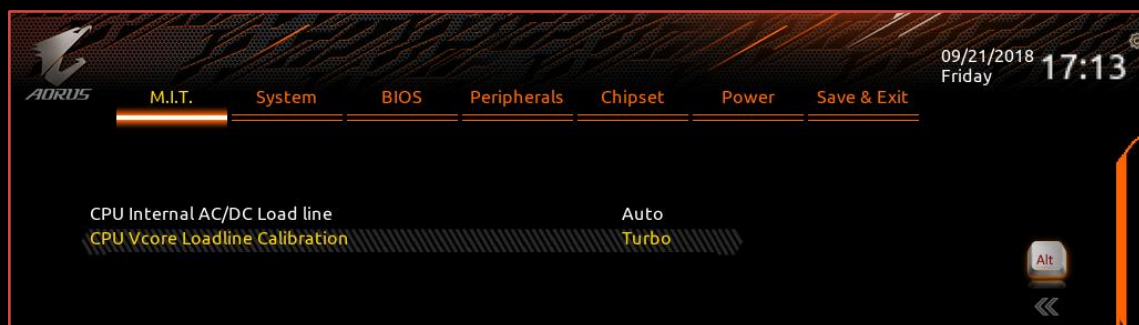
■ Step 4: **Stability Testing**

Test the stability of these new settings by following the steps under "How to Stability Test".

Below is an example of an Intel Core i9-9900K using a Bitspower water-cooling kit.

AVX Offset: AVX Offset ranges from 0 to 31. When you set an AVX offset it will reduce the multiplier by 0-31 (whatever you set it to) when running AVX instruction sets.

If you aren't stable at 5.1GHz on Prime95 you can try setting AVX offset to "2". This will lower your CPU multiplier by 2x. For instance if your CPU is set at 5.1GHz it will run at 4.9GHz during Prime95.

AVX offset is found under M.I.T -> Advanced

*Note: The processors can be stable at higher frequencies if the load applied doesn't have AVX extensions. For example this specific CPU is stable at 5.3GHz without AVX load. That means in this case we have 2 options. Either we overclock the CPU at 5.1GHz for all types of loading or we overclock it at 5.3GHz with the AVX option at 2.