How to enable Unlimited Performance on ODROID-H4

Introduction

Starting with the Core 10th generation Intel introduced Power Limit 4 (PL4) and made it user configurable via the BIOS. What is it? PL4 is the SoC's maximum power limit at the package level. No matter what the CPU is actually doing, it will not pass this limit. The interesting side of the story is that as a user you can set it to 0, which means no limit.

Fortunately, Intel carried it with the Alder Lake-N processors.
The ODROID-H4, H4+ and H4 Ultra BIOS allows you to set this limit to 0. This is what we call Unlimited Performance mode. The default value is 30,000 corresponding to the Balanced mode, meaning around a SoC's maximum power limit of 12W for the N97 of the ODROID H4 and H4+, and 15W for the N305 of the H4 Ultra.

Using the Unlimited Performance mode (annotated UP) with the ODROID-H4, H4+ and H4 Ultra enables the CPU to turbo boost indefinitely: 2.9 GHz all cores and 3.6 GHz one core for the H4 and H4+ , 3.0 GHz all cores and 3.8 GHz one core for the H4 Ultra.

As you may expect the CPU will get hot quickly (in a matter of minutes) and get close to his T Junction (Tj) temperature which will trigger its emergency shutdown as thermal protection. But the CPU will not reach Tj because it will automatically throttle down when it is about 5 degrees Celsius away from Tj (we tested this multiple times). As soon as the CPU thermally throttles down you start losing the increased performance you were aiming at while still consuming more power compared to the Balanced mode. Not ideal.

In order to prevent thermal throttling when using the Unlimited Performance mode, the solution is simple: **active cooling with a fan**.

We designed the H4, H4+ and H4 Ultra heat sink to make it very efficient: (a) you do not need a fan in Balanced mode (b) it has a high rate of thermal exchange when coupled with a fan.

Using a fan will decrease the maximal CPU temperature by about 25 to 30 degrees Celsius depending on factors such as the ambient temperature. It it difficult for us to give you precise temperature values because what one witnesses depends on many factors: as already mentioned the ambient temperature, the CPU BGA soldering thickness error, the heat sink assembly tolerance, the type of thermal paste and quantity applied, the cooling fan speed RPM error margin (which can be as high as 5 to 10%). All of these factors can result in a 10+ degrees Celsius difference between one setting and another.

The important point is that with active cooling you get the increased performance you aim at while the CPU stays just comfortably warm while turbo boosting indefinitely, way below temperatures close to Tj. In other words the fan active cooling brings you the best of both worlds. This is what we witnessed and validated while performing many tests in different locations.

Last point: in Unlimited Performance mode, the CPU (and the fan) use more power than they do in Balanced mode, easily reaching 23+ W with the ODROID-H4+ and 34+ W with the ODROID-H4 Ultra.

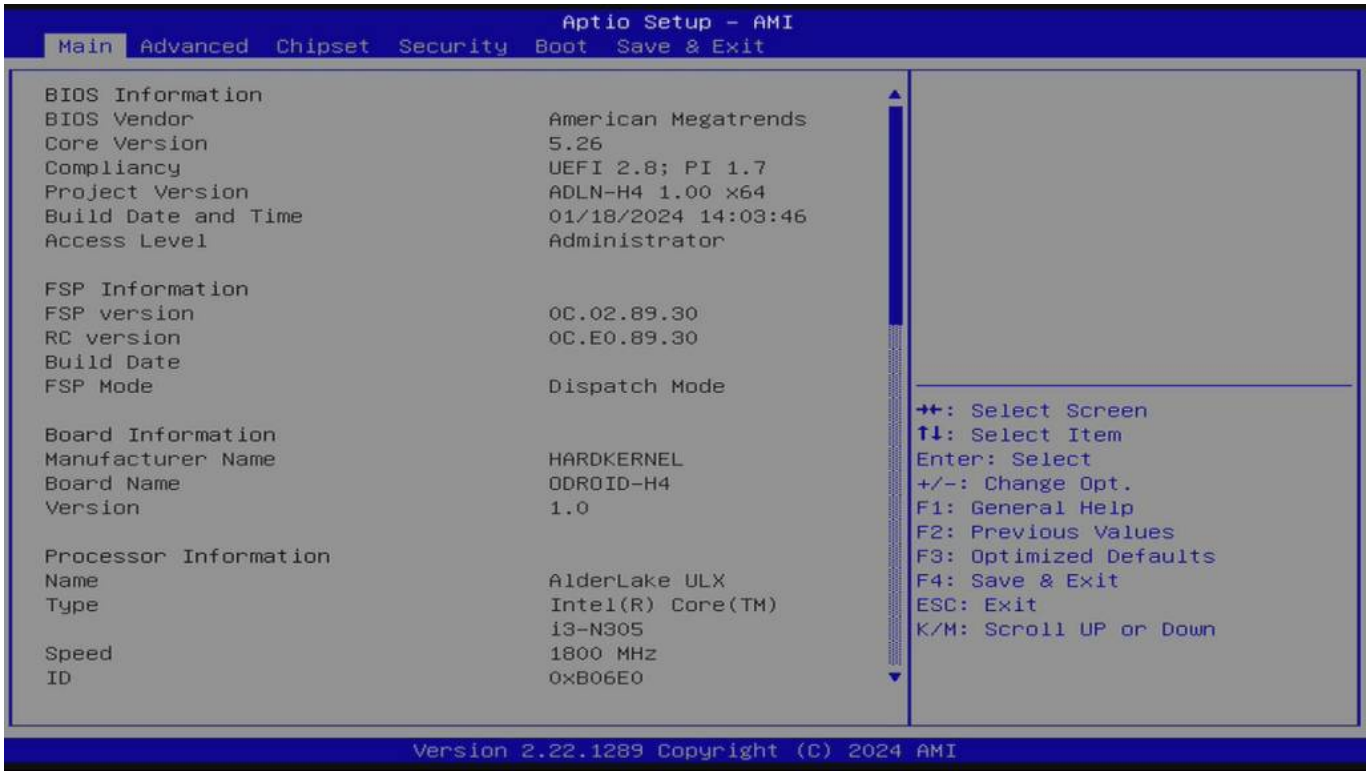
However this happens only when the CPU is indeed turbo boosting. When idle, the system will use the same power as in Balanced mode. If your goal is to minimize energy consumption, use Balanced mode. If your goal is to maximize performance use Unlimited Performance mode and again use active cooling with a fan to avoid the CPU to be constantly throttling down.

For learning how to change PL4 in the BIOS, as well as change the fan settings, please refer to the related Wiki page.

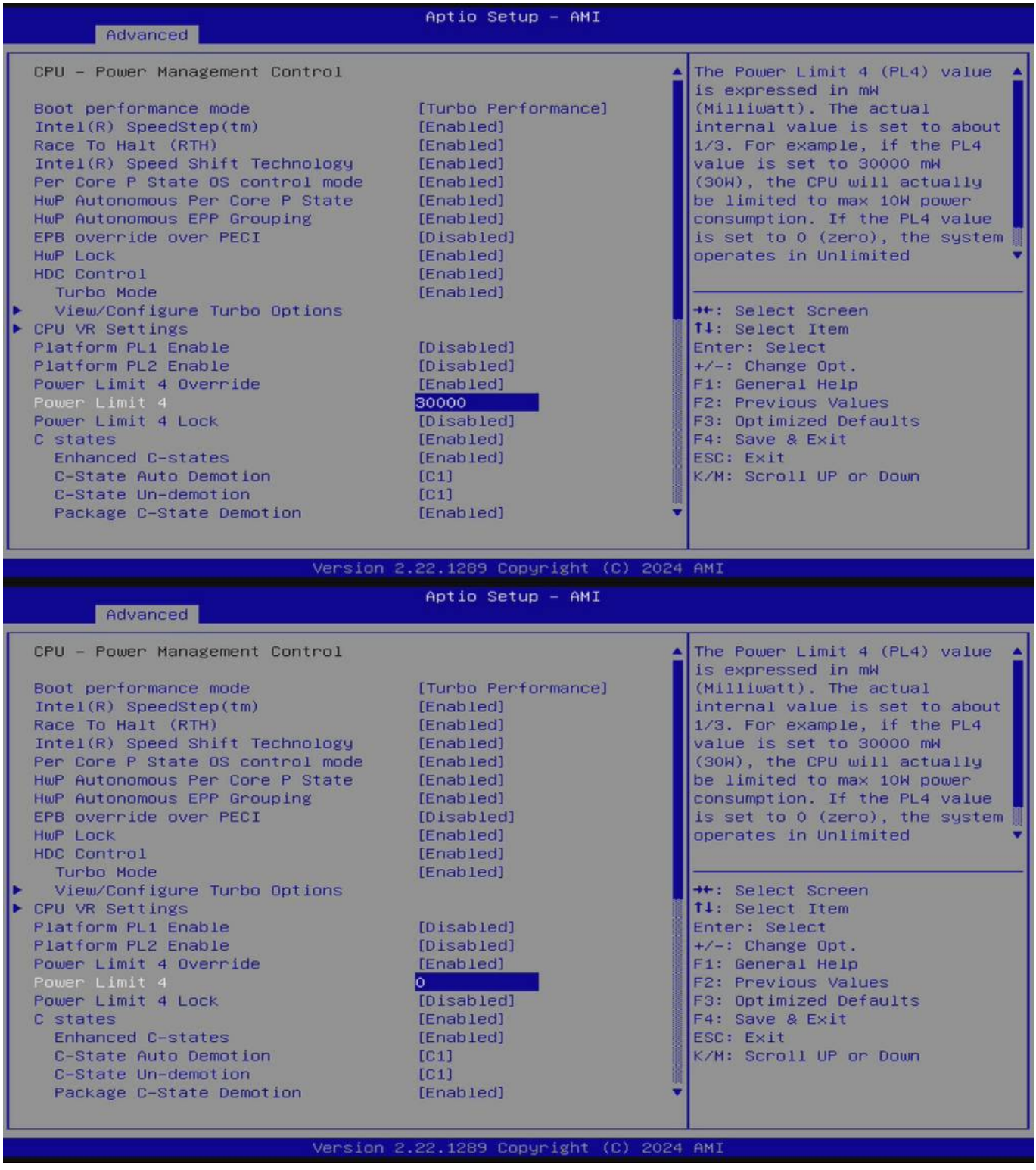
- PWM_FAN
- How to Control FAN Speed via CPU Temperature

Entering the BIOS

1. Power off your **ODROID-H4**.
2. Press the Power button on your **ODROID-H4**, then Press “DEL” key while booting. You will get access to the BIOS screen shown below.



3. Go Advanced Tab, Power & Performance, and CPU - Power Management Control followed then you can see the “Power Limit 4” line.



TO BE EDITED: The PL4 value is 30000 by default. Note that the actual internal value is 10000(10Watt) while the displayed value is 30000(30Watt). If you change the value to 0 or 48000, the actual power limit value will be 16Watt which is the maximum power to sustain the burst clock frequency 3.8Ghz of the ODROID-H4-Ultra. We will fix the cosmetic issue in a future BIOS update to be released.

So the value one enters is 3 x times the actual wattage the boards uses.

30,000 → 10W 48,000 → 16W

Other example would:

37500 → 12.5W

I guess they use the 3 x times mechanism to allow setting PL4 with a decimal part while using an integer for data entry.

which means one could force the CPU to slow down by entering:

15,000 → 5W

Yes?

If we set the value to 15000(5Watt), the maximum CPU clock frequency was only 2.1~2.3Ghz. The actual system power consumption was around 6~7Watt due to DRAM, NVMe, Ethernet, USB, Video output and other minor things. But we need more researches the PL4 vs the max clock ratio was not clearly linear.

We will check the whole system power consumption, SoC temperature and max clock freq with the following numbers to double check. - 9000 (3Watt) - 15000 (5Watt) - 21000 (7Watt) - 30000 (10Watt) –> default value - 48000 (16Watt) - 0 (16Watt)

We've tested it. Refer to the following table. When I looked at the test result, it was judged that the error displayed as a triple value actually exists. In the stress-ng test, the power limit of 5 watts (15000) limits the sustained CPU clock to 800Mhz and the temperature was around 30 degrees.

PL4 value Sustained Max freq. (multi-thread) System Power consumption (**) CPU temperature with a cooling fan (50% duty) 9000(3W) 0.4Ghz 3.9W 26°C 15000(5W) 0.8Ghz 5.9W 30°C 21000(7W) 2Ghz 10.0W 37°C 30000(10W) 2.6Ghz 13.8W 48°C 48000(16W) 3.3Ghz 21.1W 70°C 0 3.3Ghz 21.6W 71°C

Some chips are saturated even when the PL4 value is set to 45000(15W). Other chips are saturated when the PL4 value is about 48000(16W), and other chips are saturated when the PL4 value is about 50000(16.6W). This is probably due to the silicon deviation phenomenon, where the power-heating-clock characteristics vary slightly from chip to chip.

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