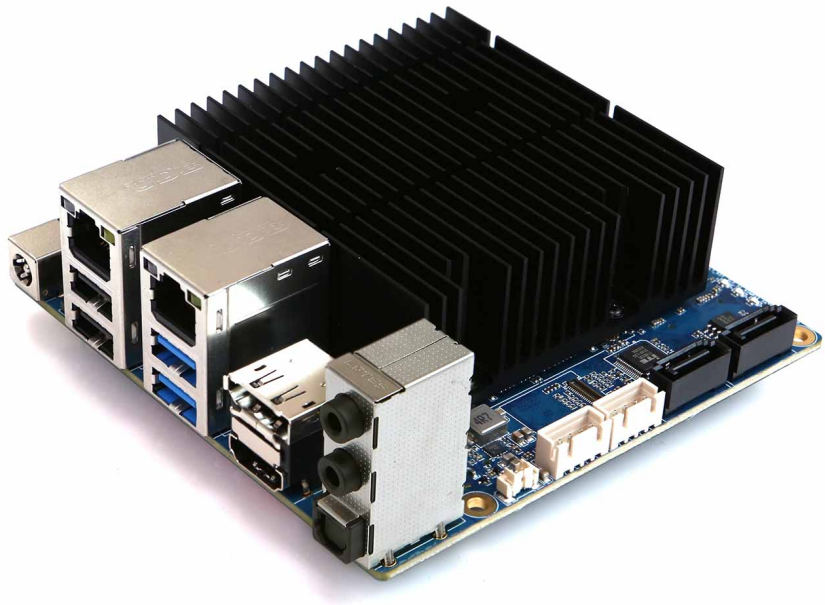
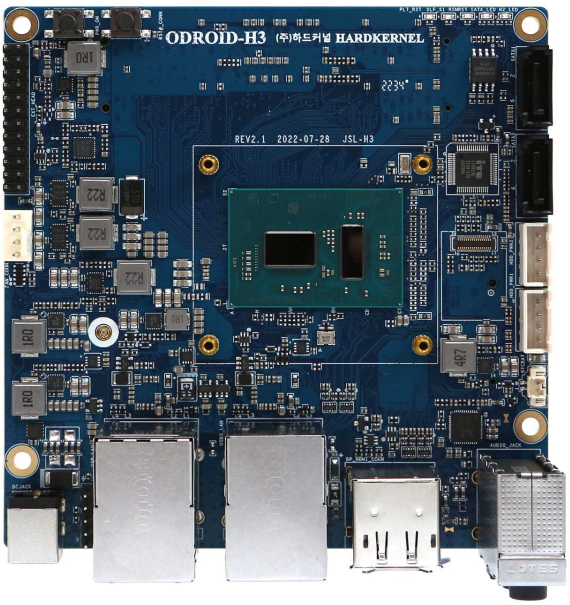
The ODROID H-series is back

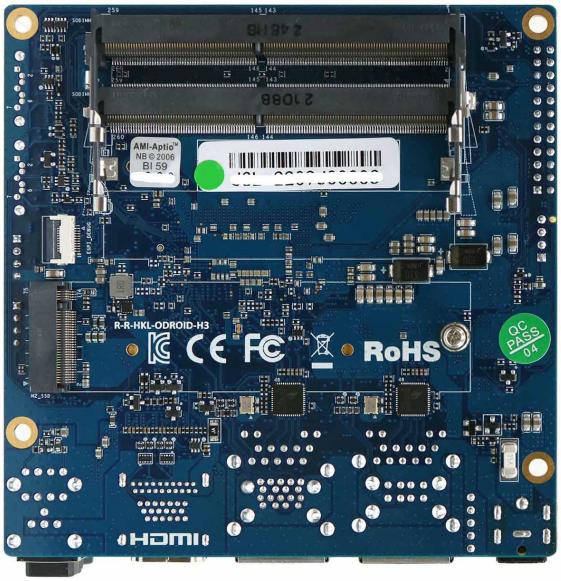
It is more powerful, offers higher performance and comes in two brand new models.

Introducing the ODROID-H3 and ODROID-H3+

Hardkernel is introducing the ODROID-H3 and H3+, which both have the same form factor and similar power efficiency as their predecessor, the ODROID-H2+.







The major characteristics of the ODROID-H3 and H3+ compared to the ODROID-H2+ are:

1. INTEL 10nm (INTEL 7) Jasper Lake vs. INTEL 14nm Gemini Lake processors.
2. Maximum memory (DDR4 2933MT/s) is 64GB vs. 32 GB (DDR4 2400MT/s).
3. Higher base and boost CPU frequencies and more powerful iGPU.
4. PCIe Gen 3 x4 NVMe vs. PCIe Gen 2.
5. An Unlimited Performance mode allowing the CPU to run in sustained turbo boost mode.

We also implemented little details following the ODROID-H2+ feedback we received from all of our users, this means you. Examples:

(a) The ODROID-H3 and H3+ use a standard PC 12V PWM fan. Yes, you can use whatever 3rd party fan you prefer and plug it into the board with zero hassles.
(b) The BIOS fTPM is enabled by default: Windows 11 compatibility out of the box.

Without further ado, let's look at the detailed table shown below.

	ODROID-H2+ ('2020 Jun)	**ODROID-H3 ('2022 Oct)**	**ODROID-H3+ ('2022 Oct)**
Processor			
CPU (INTEL)	Celeron J4115	**Celeron N5105**	**Pentium N6005**
Code name	Gemini Lake	**Jasper Lake**	**Jasper Lake**
Launch date	Q4'17	**Q1'21**	**Q1'21**
Lithography	14 nm	10 nm (Intel 7)	10 nm (Intel 7)
Microarchitecture	Goldmont Plus	Tremont	Tremont
Cores / Threads	4C4T	4C4T	4C4T
TDP	10W	10W	10W
Base Frequency (GHz)	1.8	**2.0 (11% more)**	**2.0 (11% more)**
Burst Frequency (GHz)	2.5	**2.9 (16% more)**	**3.3 (32% more)**
Memory			
Max. Memory address space (GB)	32	**64 (100% more)**	**64 (100% more)**
Max. Memory Speed (MT/s)	2400	**2933 (22% more)**	**2933 (22% more)**
iGPU (INTEL UHD Graphics)			
Base Frequency (MHz)	250	**450 (80% more)**	**450 (80% more)**
Burst Frequency (MHz)	750	**800 (7% more)**	**900 (20% more)**
Execution Units	12	**24 (100% more)**	**32 (167% more)**

PCIe (via M.2 NVMe slot)			
Generation	Gen 2	**Gen 3**	**Gen 3**
Lanes	4	4	4
Compatibility with optional 4-ports 2.5GbE NetCard	Yes	Yes	Yes
IO ports			
USB 2.0	2 ports	2 ports	2 ports
USB 3.0	2 ports	2 ports	2 ports
2.5GbE	2 ports	2 ports	2 ports
SATA III	2 ports	2 ports	2 ports
24pin IO Expansion ports	I2C x 2	I2C x 2	I2C x 2
	USB 2.0 x 1	**USB 2.0 x 3**	**USB 2.0 x 3**
	UART x 2	**UART x 1**	**UART x 1**
	HDMI-CEC x 1	HDMI-CEC x 1	HDMI-CEC x 1
	Ext. Power Button x 1	Ext. Power Button x 1	Ext. Power Button x 1
Others			
Optional Cooling Fan	92 mm 5Volt mini 4pin connector	92 mm **12Volt standard PC 4-pin**	92 mm **12Volt standard PC 4-pin**
Dimensions	110x110mm (4.3x4.3 in)	110x110mm (4.3x4.3 in)	110x110mm (4.3x4.3 in)
Recommended Power Supply 1	60W	60W	60W
Recommended Power Supply 2 for supporting booting with two 3.5" hard disks	133W	133W	133W
Unlimited Performance Mode	No	**Yes**	**Yes**
Security (TPM 2.0)	Couldn't be supported	**fTPM enabled (Will run Windows 11 out of the box)**	
Hardkernel H-series cases	DIY assembly Translucent Blue Acrylic	**DIY assembly The cases are made of solid and sturdy PCBs.**	
Certifications	FCC/CE/KC/RoHS	FCC/CE/KC/RoHS	FCC/CE/KC/RoHS
Pricing	$119	**$129**	**$165**

Notable Facts

Performance

While the CPU base frequency increases by 16% (H3) and 32% (H3+) compared to the H2+, the memory bandwidth increases by 22% and while the disk I/O increases by 97% compared to the H2+, one should not forget that the Jasper Lake generation also brings node intrinsic optimizations compared to the Gemini Lake generation. In addition both the H3 and H3+ can be set to run in turbo boost mode with no time limit, a mode we call *Unlimited Performance* and describe further.

As the saying goes the whole is greater than the sum of its parts: While running 300+ benchmarks, a great number of them being non synthetic, we witnessed a performance increase ranging in average from 45% to 73%, with maximum increases being more than twice faster.

Compatibility

The ODROID-H3 and H3+ boards use the same physical format as the H2+ board. As a consequence the H2+ blue acrylic cases and all the 3rd party cases, e.g. users 3D printed cases, are compatible with the ODROID-H3 and H3+. This also means that the ODROID H-series Net card works on the H2+, H3 and H3+ out of the box. Finally 3rd party PCIe cards (Network cards, RAID cards, Graphics cards) that one used and uses with the H2+ can also be used with the H3 and H3+.

Versatility

We have seen and still see an incredible broad range of ODROID-H2+ usage from users like you. We expect to witness the same range with ODROID-H3 and H3+. But we also expect to see users add more use cases thanks to the higher CPU performance as well as graphics and PCIe increased performance which definitely bring new opportunities. The doubling of the maximum memory from 32GB to 64GB offers new possibilities too. We believe the success of the ODROID H-series is in part due to its original DIY design goal with a board that does not restrict you to one kind of application, e.g. TV box. Let us recall the common features through all the ODROID H-series models:

Design An SBC design that makes sense: All the connectivity is on the rear side, simplifying case design and reducing footprint on a desk.

H-series Net Card Using the NVMe port, provides 4 additional 2.5 GbE ports, thus tripling the number of 2.5 GbE ports to 6 ports.

Do It Yourself The ODROID H-series offers you a lot of freedom. You are free to chose:
1. The amount and brand of memory. No soldered memory.
2. The size of the eMMC (including not using one). No soldered eMMC.
3. The size of the NVMe PCIe Gen 3 x4 SSD (including not using one)(*).
4. To transform the NVMe slot into a PCIe Gen 3 x4 slot for using PCIe cards via optional adapter cable(*).
5. The size of the 1 or 2 SATA III disks or SSDs (including not using them).
6. A case among 7 types of Hardkernel cases or use a custom one you or another user designed (**).
7. Hardkernel cases allow the usage of an optional silent 92mm fan for optimal thermal performance.
8. Any x86-64 flavor of Windows, Linux or BSD operating systems, etc. Plus Android.
9. To upgrade the hardware later with more memory, more NVMe or SSD or hard disk space.

(*) PCIe Gen 2 on the H2/H2+.
(**) The acrylic blue cases can be used with the H3/H3+ and conversely the new PCB cases can be used with the H2/H2+.

Comparing the H3 and H3+ to the H2+

In order to evaluate the performance of the H3 and H3+ and compare them to their predecessor, the H2+, we proceeded with real application benchmarks rather than synthetic ones. To do so we ran a battery of Phoronix testing suites. These testing suites are listed below:

- Compilation
- Compression
- Java
- Python
- Imaging
- Audio Encoding
- Databases
- Unigine GPU
- Cryptography
- Video Encoding

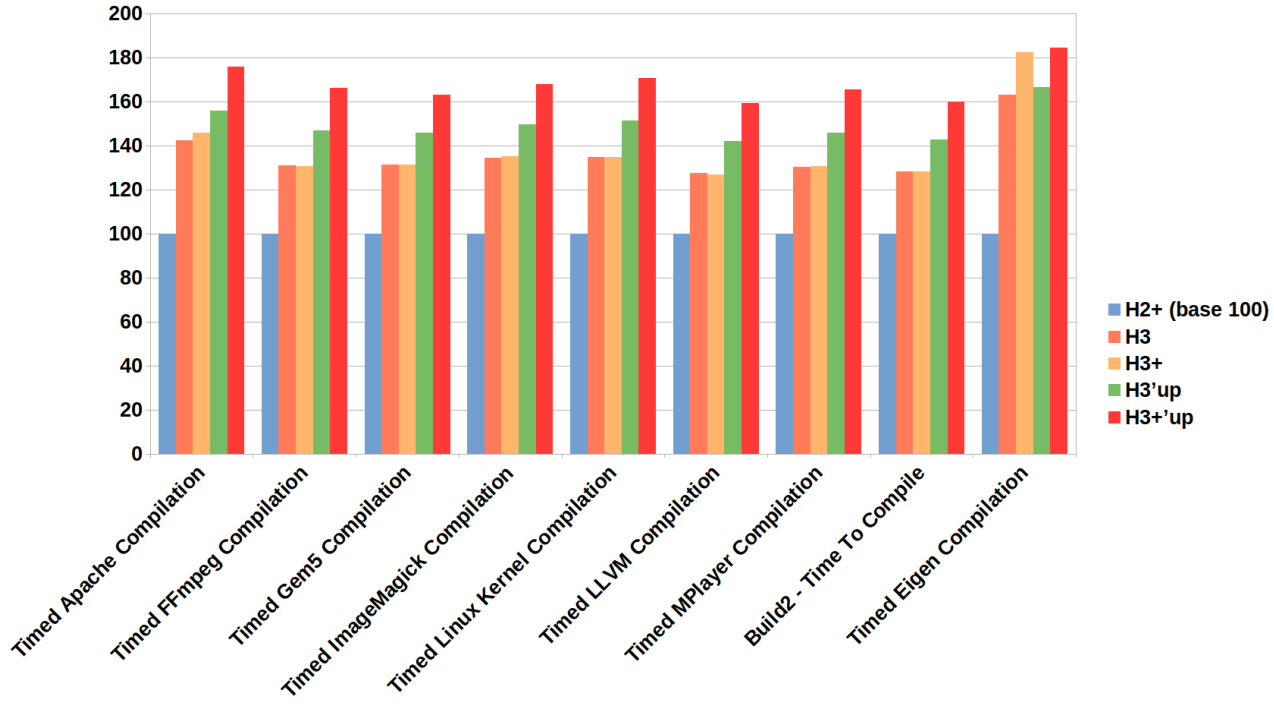
The Phoronix Testing Suite is available here: https://www.phoronix-test-suite.com/. As stated on its web site, we quote: "The Phoronix Test Suite [is an OSS project that] makes the process of carrying out automated tests incredibly simple. The Phoronix Test Suite will take care of the entire test process from dependency management to test download/installation, execution, and result aggregation."

Let us examine the results we obtained with tables and charts showing the H2+ as base 100. Example: Using the line *Timed Eigen Compilation* in the *Compilation Benchmark* table shown below, the H3 is 63% faster, the H3+ 83%, the H3'up 67% and the H3+'up 85%.

What are the H3'up and H3+'up?
The suffix *'up* is a shortcut notation to indicate that the CPU is running in "Unlimited Performance Mode". This is a mode where the CPU can run in Turbo Boost mode with no time limit, hence the name. The Unlimited Performance Mode is described in the next section.

Compilation Benchmark

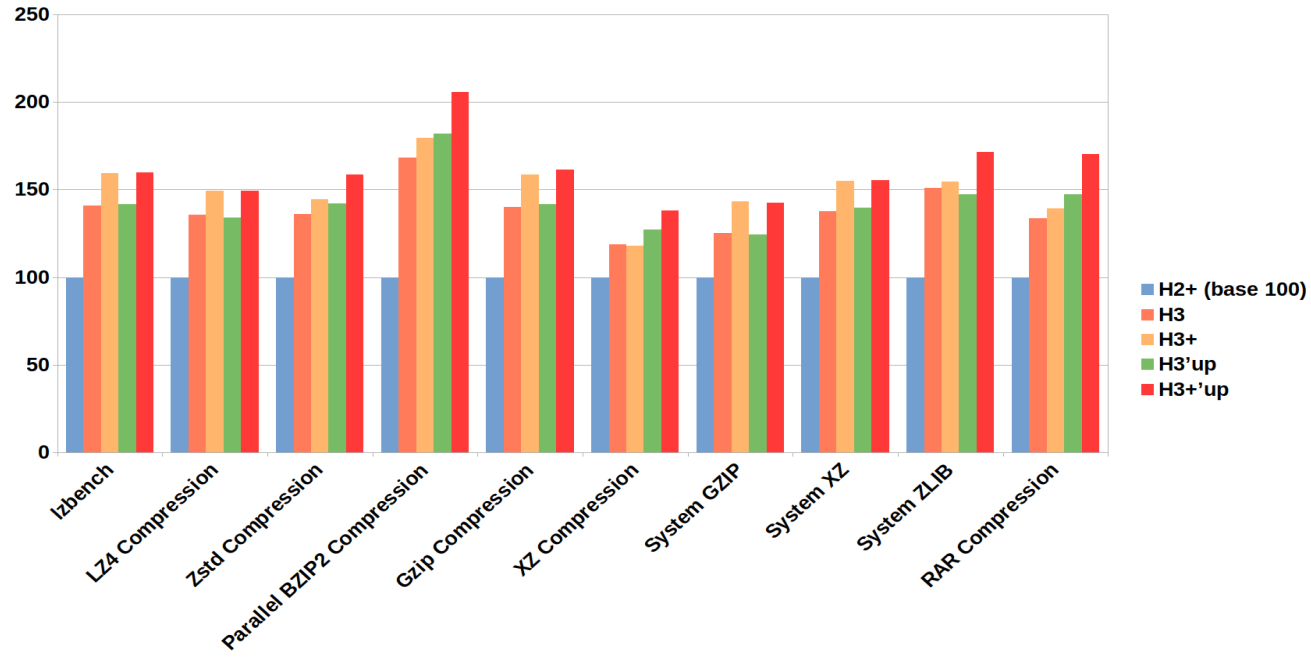
	H2+ (base 100)	H3	H3+	H3'up	H3+'up
Timed Apache Compilation	100	143	146	156	176
Timed FFmpeg Compilation	100	131	131	147	166
Timed Gem5 Compilation	100	131	131	146	163
Timed ImageMagick Compilation	100	134	135	150	168
Timed Linux Kernel Compilation	100	135	135	151	171
Timed LLVM Compilation	100	128	127	142	159
Timed MPlayer Compilation	100	130	131	146	166
Build2 - Time To Compile	100	128	128	143	160
Timed Eigen Compilation	100	163	183	167	185
All Compilation					
Average	**100**	**135**	**137**	**149**	**168**
Min	**100**	**127**	**127**	**142**	**159**
Max	**100**	**163**	**183**	**167**	**185**



Benchmark description: https://openbenchmarking.org/suite/pts/compilation

Compression Benchmark

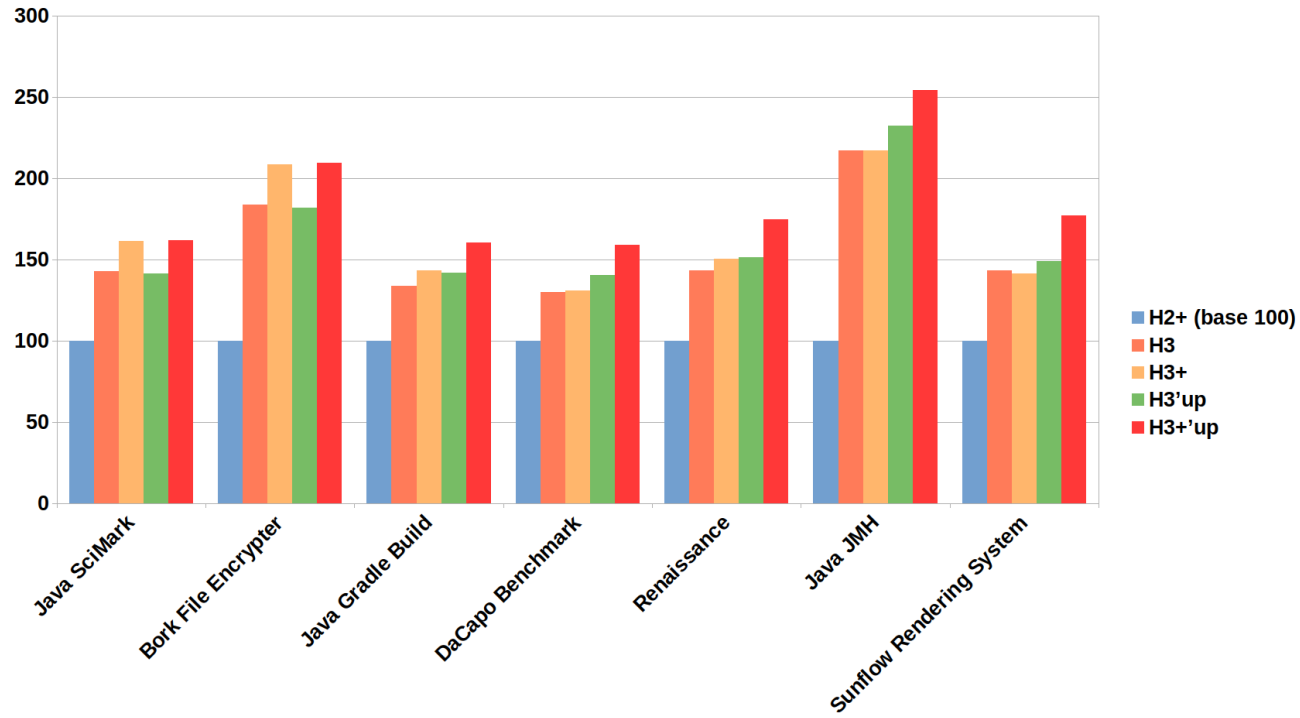
	H2+ (base 100)	H3	H3+	H3'up	H3+'up
lzbench	100	141	159	142	160
LZ4 Compression	100	135	149	134	150
Zstd Compression	100	136	144	142	159
Parallel BZIP2 Compression	100	168	180	182	206
Gzip Compression	100	140	159	142	161
XZ Compression	100	119	118	127	138
System GZIP	100	125	143	124	143
System XZ	100	138	155	140	155
System ZLIB	100	151	155	147	172
RAR Compression	100	134	139	147	170
All Compression					
Average	100	138	152	141	158
Min	100	112	112	122	138
Max	100	168	180	182	206



Benchmark description: https://openbenchmarking.org/suite/pts/compression

Java Benchmark

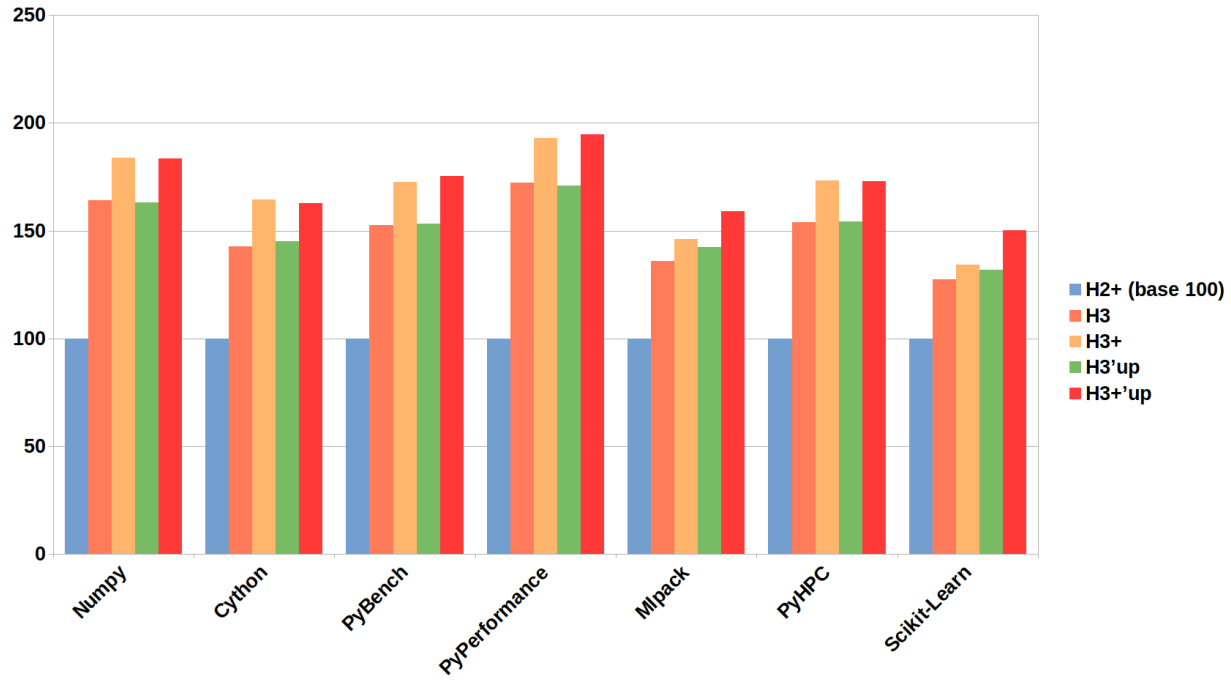
	H2+ (base 100)	H3	H3+	H3'up	H3+'up
Java SciMark	100	143	161	142	162
Bork File Encrypter	100	184	208	182	209
Java Gradle Build	100	134	143	142	161
DaCapo Benchmark	100	130	131	140	159
Renaissance	100	144	151	151	175
Java JMH	100	217	217	233	254
Sunflow Rendering System	100	143	142	149	177
All Java					
Average	**100**	**145**	**154**	**151**	**173**
Min	**100**	**107**	**113**	**116**	**137**
Max	**100**	**217**	**217**	**233**	**254**



Benchmark description: https://openbenchmarking.org/suite/pts/java

Python Benchmark

		H2+ (base 100)	H3	H3+	H3'up	H3+'up
	Numpy	100	164	184	163	183
	Cython	100	143	164	145	163
	PyBench	100	153	172	153	175
	PyPerformance	100	172	193	171	195
	Mlpack	100	136	146	142	159
	PyHPC	100	154	173	154	173
	Scikit-Learn	100	127	134	132	150
All Python						
	Average	**100**	**159**	**178**	**159**	**180**
	Min	**100**	**118**	**120**	**125**	**145**
	Max	**100**	**292**	**311**	**275**	**317**

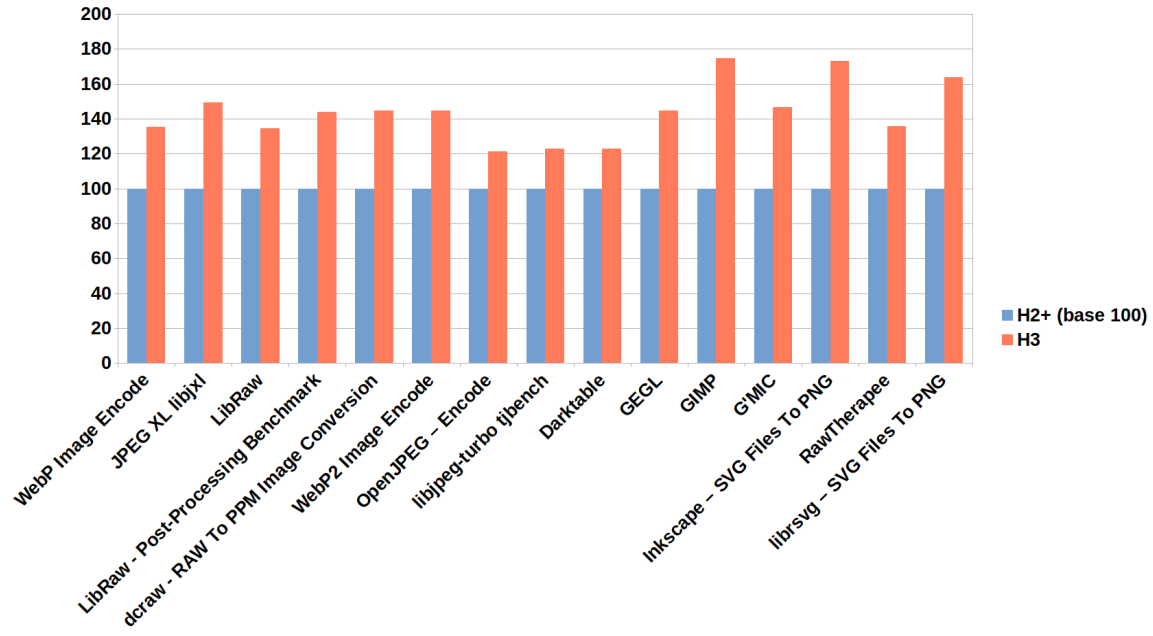


Benchmark description: https://openbenchmarking.org/suite/pts/python

Imaging Benchmark

Note: we only ran the Imaging benchmark on the H2+ and H3.

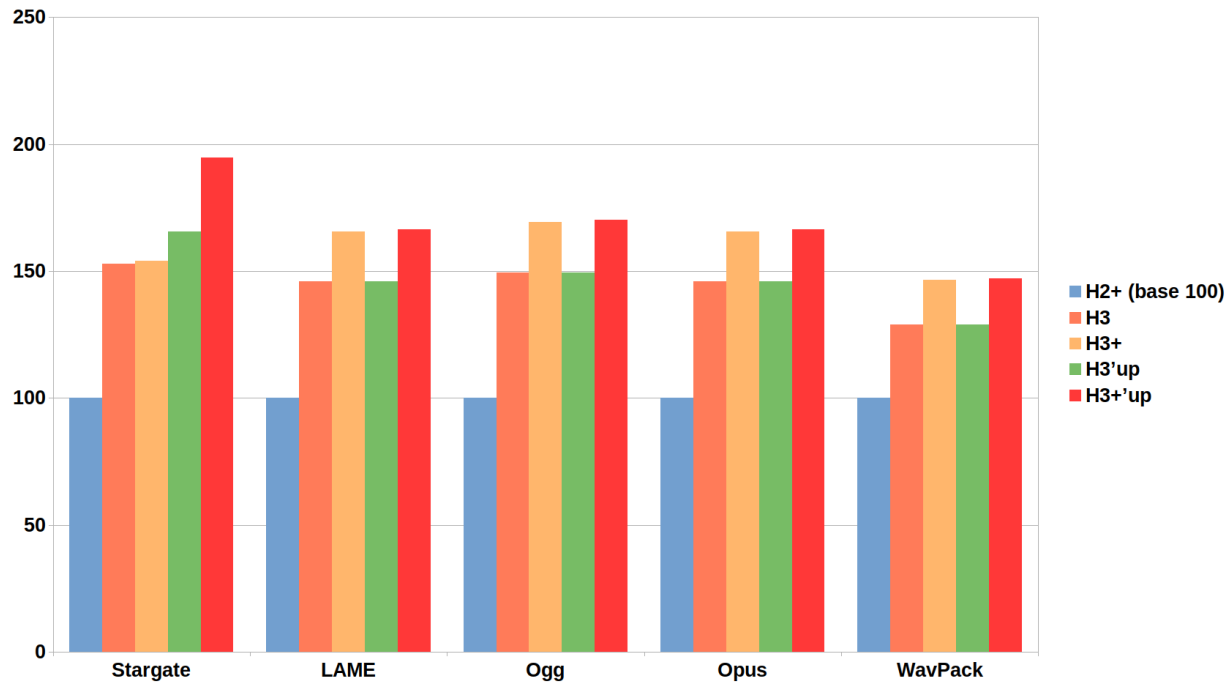
	H2+ (base 100)	H3
WebP Image Encode	100	135
JPEG XL libjxl	100	149
LibRaw	100	135
LibRaw - Post-Processing Benchmark	100	144
dcraw - RAW To PPM Image Conversion	100	145
WebP2 Image Encode	100	145
OpenJPEG – Encode	100	121
libjpeg-turbo tjbench	100	123
Darktable	100	123
GEGL	100	145
GIMP	100	175
All Imaging		
Average	**100**	**143**
Min	**100**	**111**
Max	**100**	**179**



Benchmark description: https://openbenchmarking.org/suite/pts/imaging

Audio Encoding Benchmark

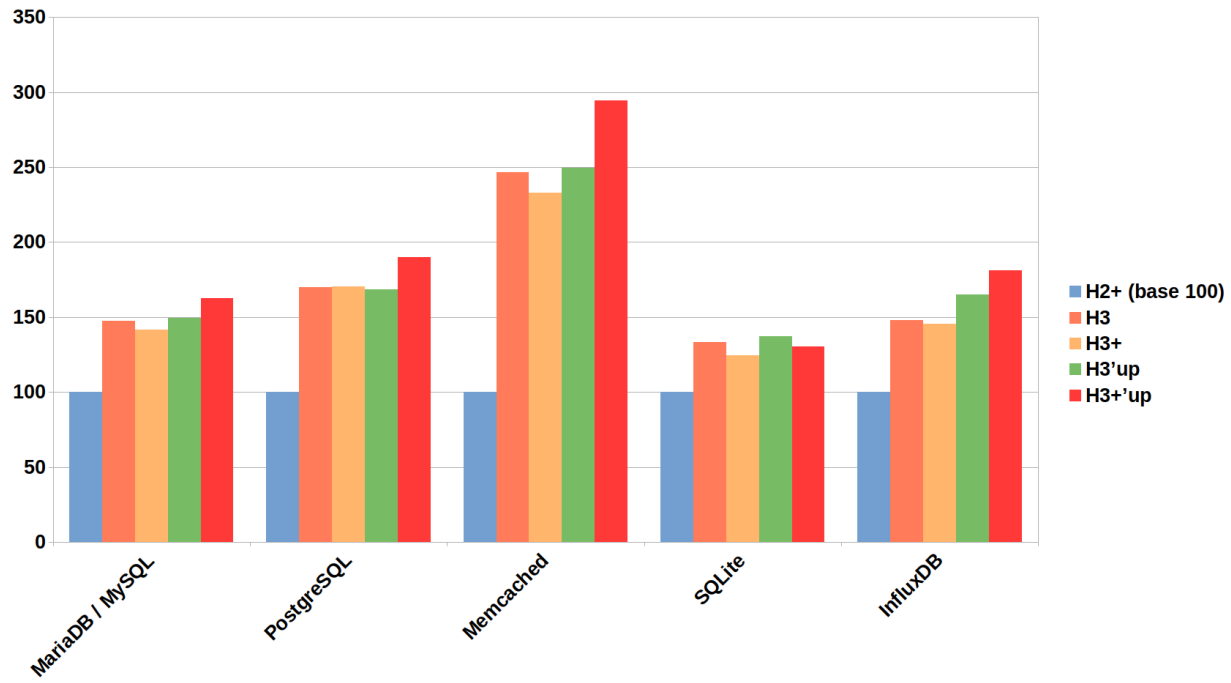
		H2+ (base 100)	H3	H3+	H3'up	H3+'up
	Stargate	100	153	154	166	195
	LAME	100	146	166	146	166
	Ogg	100	149	169	149	170
	Opus	100	146	166	146	166
	WavPack	100	129	147	129	147
All Audio Encoding						
	Average	**100**	**150**	**157**	**158**	**184**
	Min	**100**	**129**	**147**	**129**	**147**
	Max	**100**	**157**	**169**	**171**	**200**



Benchmark description: https://openbenchmarking.org/suite/pts/audio-encoding

Databases Benchmark

	H2+ (base 100)	H3	H3+	H3'up	H3+'up
MariaDB / MySQL	100	148	142	150	163
PostgreSQL	100	170	171	168	190
Memcached	100	246	233	250	294
SQLite	100	134	124	137	130
InfluxDB	100	148	145	165	181
All Databases					
Average	**100**	**168**	**165**	**169**	**188**
Min	**100**	**105**	**102**	**107**	**105**
Max	**100**	**260**	**245**	**261**	**311**

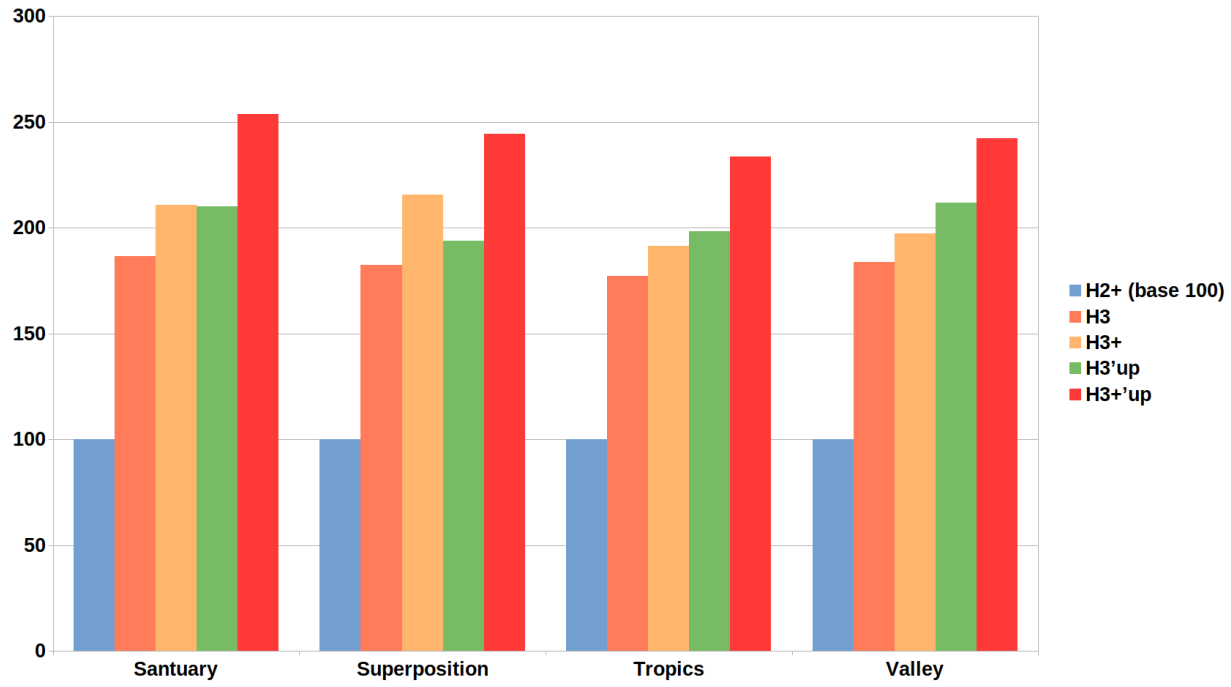


Benchmark description: https://openbenchmarking.org/suite/pts/database (note: we only ran a subset)

Unigine GPU Benchmark

Note: This benchmark was run in 1280x720 resolution.

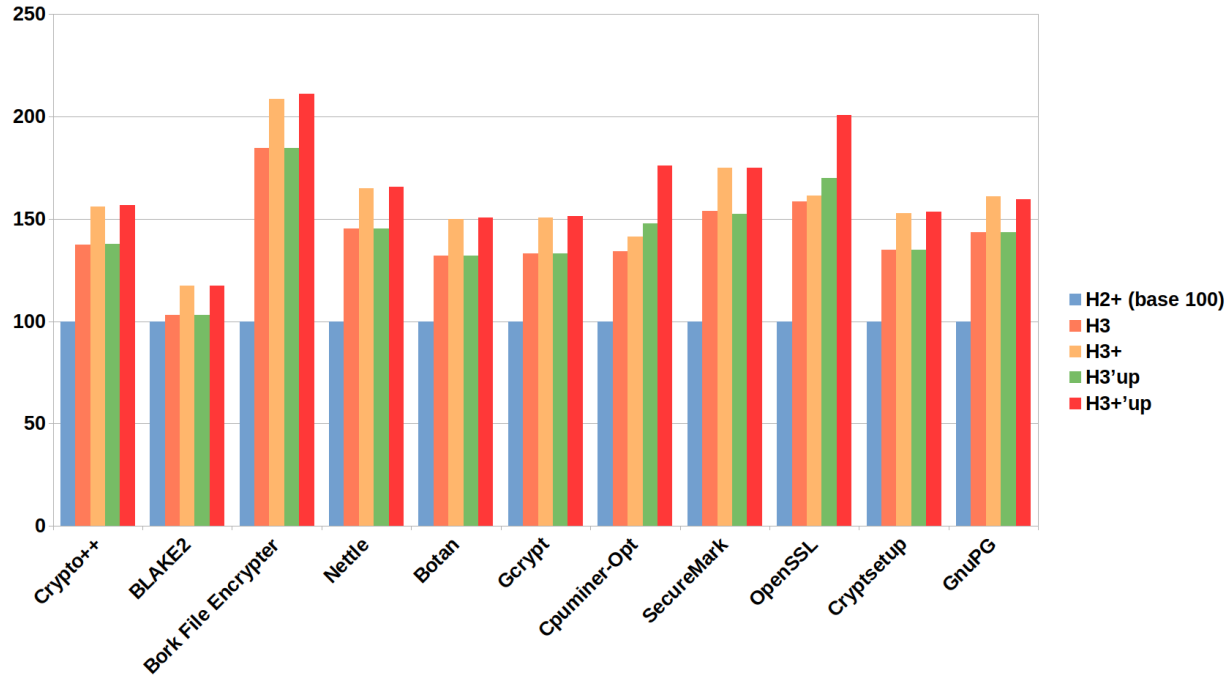
		H2+ (base 100)	H3	H3+	H3'up	H3+'up
	Santuary	100	187	211	210	254
	Superposition	100	182	216	194	244
	Tropics	100	177	191	198	234
	Valley	100	184	197	212	242
All Unigine						
	Average	**100**	**182**	**209**	**199**	**244**
	Min	**100**	**164**	**184**	**180**	**218**
	Max	**100**	**200**	**250**	**212**	**275**



Benchmark description: https://openbenchmarking.org/suite/pts/unigine

Cryptography Benchmark

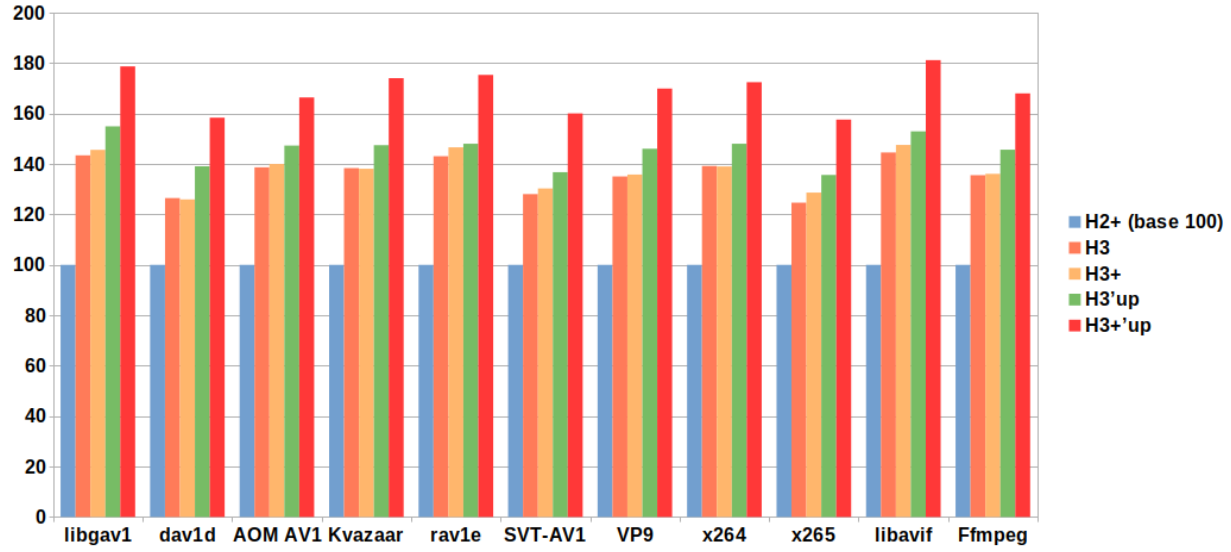
	H2+ (base 100)	H3	H3+	H3'up	H3+'up
Crypto++	100	138	156	138	157
BLAKE2	100	103	117	103	117
Bork File Encrypter	100	185	209	185	211
Nettle	100	145	165	145	166
Botan	100	132	150	132	151
Gcrypt	100	133	151	133	151
Cpuminer-Opt	100	134	141	148	176
SecureMark	100	154	175	153	175
OpenSSL	100	159	161	170	201
Cryptsetup	100	135	153	135	154
GnuPG	100	143	161	144	159
All Cryptography					
Average	**100**	**137**	**152**	**141**	**162**
Min	**100**	**103**	**113**	**103**	**117**
Max	**100**	**226**	**256**	**226**	**257**



Benchmark description: https://openbenchmarking.org/suite/pts/cryptography

Video Encoding Benchmark

	H2+ (base 100)	H3	H3+	H3'up	H3+'up
libgav1	100	143	146	155	179
dav1d	100	126	126	139	158
AOM AV1	100	139	140	147	166
Kvazaar	100	138	138	147	174
rav1e	100	143	147	148	175
SVT-AV1	100	128	130	137	160
VP9	100	135	136	146	170
x264	100	139	139	148	172
x265	100	125	129	136	158
libavif	100	145	148	153	181
Ffmpeg	100	136	136	146	168
All Video Encoding					
Average	**100**	**137**	**138**	**146**	**169**
Min	**100**	**123**	**123**	**135**	**155**
Max	**100**	**200**	**200**	**200**	**200**



Benchmark description: https://openbenchmarking.org/suite/pts/video-encoding

Summary Benchmark

To summarize, we completed 313 benchmarks on the H2+ and H3 and 259 on the H3+, H3'up and H3+'up. The *Average* line in the table shown below is the flat average on all the tests. For each platform H3/H3+ system, we counted the number of tests where the optimization was more than 25% up to more than 150%.

	H2+ (base 100)	**H3**	**H3+**	**H3'up**	**H3+'up**
Count	313	313	259	259	259
Average	100	145	154	151	173
>= +25%		271	241	237	255
>= +50%		90	125	94	221
>= +75%		28	45	29	90
>= +100%		11	17	15	27
>= +125%		4	10	7	19
>= +150%		3	2	3	10

Benchmarks Configuration

The same WD BLACK 500GB SN750 NVMe was used on all systems.

ODROID-H2+

Ubuntu 22.04, 32GB of DDR4 2400MT/s memory.

ODROID-H3, H3+, H3'up, H3+'up

Ubuntu 22.04, 64GB of DDR4 2933MT/s memory.

PCIe Gen 3 vs. PCIe Gen 2

To illustrate the quasi double performance of the PCIe bus on the ODROID-H3 and H3+ compared to the ODROID-H2+, we ran *iozone3* tests with relatively big data blocks:

iozone -e -I -a -s 100M -r 512k -r 1024k -r 16384k -i 0 -i 1 -i 2

The two tables shown below list the relative I/O acceleration on the H3 and H3+. One can see that the bigger the data block the closer we get to twice the speed, within margin of error, plus a few % points because the CPUs also run faster.

H3 vs. H2+

kB	reclen	write	rewrite	read	reread	random read	random write
102400	**512**	**49.46%**	**65.79%**	**62.03%**	**84.77%**	**48.14%**	**62.63%**
102400	**1024**	**70.70%**	**99.87%**	**58.19%**	**67.46%**	**79.31%**	**107.46%**
102400	**16384**	**93.56%**	**113.06%**	**85.47%**	**94.45%**	**95.42%**	**103.81%**

H3+ vs. H2+

kB	reclen	write	rewrite	read	reread	random read	random write
102400	**512**	**51.59%**	**70.76%**	**61.64%**	**83.67%**	**46.05%**	**64.59%**
102400	**1024**	**75.33%**	**99.44%**	**68.33%**	**76.21%**	**70.57%**	**108.20%**
102400	**16384**	**95.12%**	**99.99%**	**78.06%**	**87.37%**	**91.42%**	**103.63%**

The 3 tables shown below list the benchmark transfer speed values (in bytes):

Odroid H2+

kB	reclen	write	rewrite	read	reread	random read	random write
102400	512	1190434	1084538	1162659	1065556	1207191	1136235
102400	1024	1253288	1053801	1312651	1308492	1215101	1001957
102400	16384	1286232	1249370	1448607	1494140	1499929	1249510

Odroid H3

kB	reclen	write	rewrite	read	reread	random read	random write
102400	512	1779229	1798036	1883841	1968851	1788334	1847871
102400	1024	2139356	2106255	2076440	2191177	2178772	2078681
102400	16384	2489598	2661898	2686789	2905301	2931117	2546662

Odroid H3+

kB	reclen	write	rewrite	read	reread	random read	random write
102400	512	1804601	1851983	1879341	1957072	1763145	1870151
102400	1024	2197332	2101720	2209620	2305690	2072582	2086091
102400	16384	2509677	2498635	2579417	2799642	2871111	2544367

Introducing the Unlimited Performance Mode

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.

The ODROID-H3 and H3+ 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 10W.

Using the Unlimited Performance mode (annotated 'up) with the H3 and H3+ enables the CPU to turbo boost indefinitely: 2.6 GHz all cores and 2.9 GHz one core for the H3 , 2.8 GHz all cores and 3.3 GHz one core for the H3. This results in a significant increase in performance, especially for the H3+. You can see the effect in the benchmarks we included above. In a few cases the H3'up can reach and pass double performance for the same task compared to the H2+.

As you may expect the CPU will get hot quickly (in a matter of minutes) and get close to its T Junction (Tj) temperature which will trigger the 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 H3/H3+ heat sink to make it very efficient: (a) you do not need a fan in Balanced mode and (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 is difficult for us to publish 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 and 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 20+ Watts. 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 constantly throttle down.

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

The official 92x92x25mm 12V PWM cooling fan or a similar 3rd party cooling fan should be mounted on the official cases venting hole to avoid thermal throttling of the CPU in Unlimited Performance mode. We have tested the following 3rd party cooling fan samples.

- Noctua NF-A9 PWM
- Noctua NF-A19x4 PWM
- Noctua NF-B9 REDUX PWM
- Thermalright TL-9015W

Here is the ODROID Stock Fan and a 3rd Party Fan (a Noctua):

Demo video

To test the top CPU computing power and GPU rendering speed of the ODROID-H3/H3+, we tested running **Wii U and PS2 games emulation**.

This emulation is still very difficult to run on a low power SBC. The games were extremely slow and very far from a playable level on the ODROID-H2+.

On the other hand, during our testing, we enjoyed playing PS2 games on the ODROID-H3+ running in Unlimited Performance mode 💪👍😃

We will publish a video showing the ODROID-H3+ in Unlimited Performance mode running the Wii U and PS2 emulation.

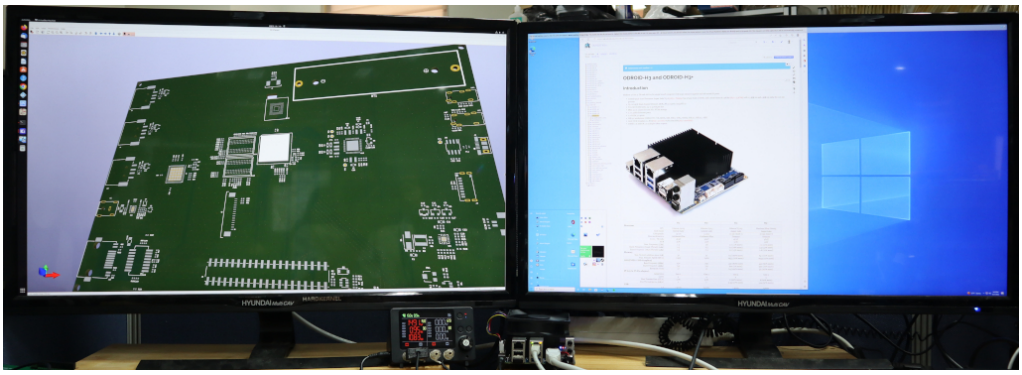
[Demo video on YouTube]

Dual Head 4K Monitor Demo

We can connect two 4K/60Hz monitors to the H3 for both fun and productive work. Thanks to hardware virtualization, Linux and Windows can be operated at the same time. Note also that with a maximum memory of 64GB running guest OSes is no problem.

Picture 1 : Two different 4K YouTube videos flawlessly and simultaneously with Chrome browser on Ubuntu desktop.

Picture 2 : The monitor on the left shows Ubuntu Desktop host OS and the one on the right shows Windows 10 running as a guest OS, using the hardware virtualization VT-x technology.



Picture 3 : The monitor on the left shows the PCB designing KiCAD application running in Ubuntu while the monitor on the right shows the Edge browser in Windows running as a guest OS.

New Cases

The blue acrylic cases we have made so far had the advantage of being translucid, enabling you to see the inside of the system. However we witnessed too many occurrences of broken or cracked panels due to external impact during delivery.

Accordingly, we developed new cases using a relatively thin and rigid PCB made of glass fiber epoxy to prevent these issues. We have seven types of new cases as listed in the table shown below:

Case Type	Color	Net Card	Disks
1	Satin Black	No	Space for 2 x 3.5” SATA drives
2	Satin Black	No	No space for SATA storage.
3	Satin Black	No	Space for 2 x 2.5” SATA drives (max. 15mm thick)
4	Satin Black	No	Space for 1 x 3.5” SATA drive or 2 x 2.5” SATA drives
5	Satin Black	Yes	Space for 2 x 3.5” SATA drives
6	Glossy Royal Blue	Yes	No space for SATA storage.
7	Satin Black	Yes	Space for 2 x 2.5” SATA drives (max. 15mm thick)

Case Type 1

No Net card and space for 2 x 3.5” SATA drives.

Case Type 2

No Net card, no space for SATA storage.

Case Type 3

No Net card and space for 2 x 2.5” SATA drives (max. 15mm thick).

Case Type 4

No Net card and space for 1 x 3.5” SATA drive or 2 x 2.5” SATA drives.

Case Type 5

Space for Net card and 2 x 3.5” SATA drives.

Case Type 6

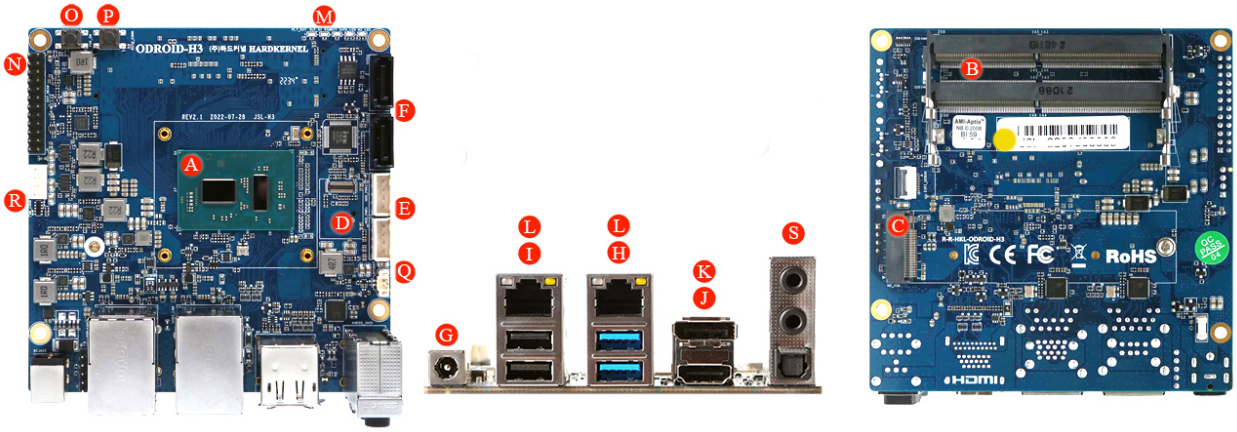
Space for Net card, no space for SATA storage.

Case Type 7

Space for Net card and 2 x 2.5” SATA drives (max. 15mm thick).

Hardware Details

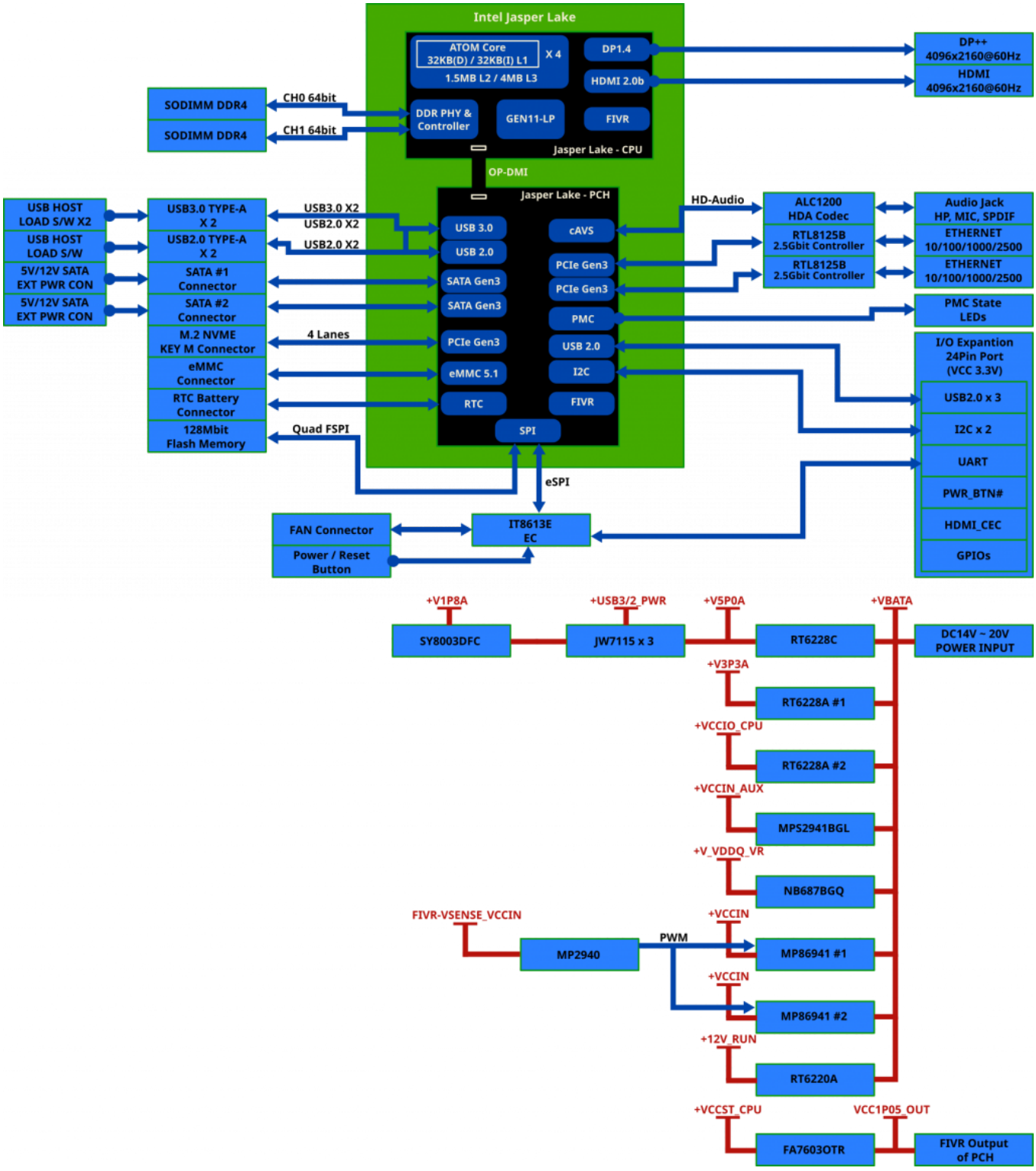
Board Description



- A. CPU (Intel Celeron N5105(H3+: N6005))
- B. 2 x DDR4 SO-DIMM slots (Dual channel memory support)
- C. 1 x M.2 PCI Express Module Socket (NGFF-2280)
- D. 1 x eMMC (Embedded Multimedia-Card) Socket
- E. 2 x SATA Power Connectors (2.5mm pitch, JST-XH compatible connector)
- F. 2 x SATA3 6.0 Gb/s Data Connectors
- G. 1 x DC Power Jack
- H. 2 x USB 3.0
- I. 2 x USB 2.0
- J. 1 x HDMI 2.0
- K. 1 x DisplayPort 1.2
- L. 2 x RJ45 Ethernet Ports (10/100/1000/2500)
- M. 5 x System LED Indicators
- N. 1 x Peripheral Expansion Header (24-pin)
- O. 1 x Power Switch
- P. 1 x Reset Switch
- Q. 1 x Backup Battery Connector (2-pin)
- R. 1 x Active Cooling Fan Connector (4-pin)
- S. 1 x Audio out, 1 x Audio in, 1 x SPDIF out

On the H3+ board, a yellow round sticker is attached on the product serial label, and on the H3 board, a green round sticker is attached.

Block diagram



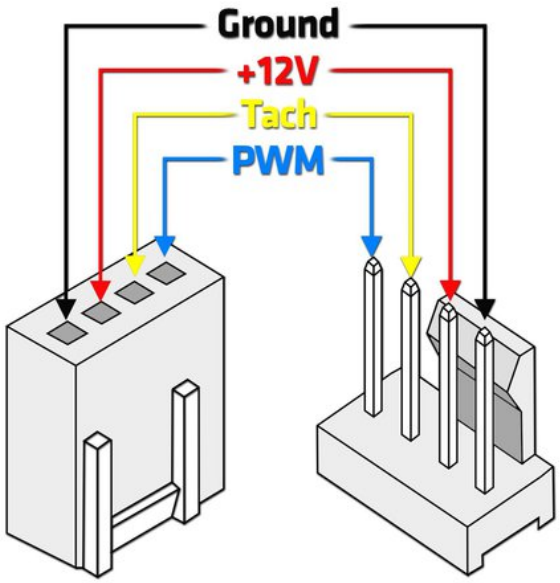
Specifications

Processor	Intel Celeron N5105(H3+: N6005) Processor (10nm, Quad-Core, TDP 10W) H3(N5105) : up to 2.9Ghz H3+(N6005) : up to 3.3Ghz 4MB L2 Cache Intel UHD Graphics (24/32 EU up to 900MHz)
Memory	2 x DDR4 1.2V SO-DIMM slots Dual Channel, up to 2933 MT/s (DDR4-PC23400) Max memory capacity 64GB *DDR3/DDR5 are not supported*
Storage	1 x eMMC connector (bootable and selectable on BIOS) Various eMMC modules can be purchased at Hardkernel store 2 x SATA3 6Gbps 1 x M.2 slot (PCIe 3.0 x 4, supports NGFF-2280 cards) *M.2 SATA SSD is not supported*
Networking	2 x GbE LAN ports (RJ45, supports 10/100/1000/2500 Mbps) Realtek RTL8125B Supports Wake-On-Lan LED indicators (Green: Link, Amber: Traffic)
Video	1 x DisplayPort 1.2 (up to 4K@60Hz) 1 x HDMI 2.0 (up to 4K@60Hz) Dual simultaneous display support
Audio	1 x Audio out (3.5mm jack) 1 x Audio in (3.5mm jack) 1 x SPDIF out (ALC1200, HDA codec) * HDMI & DP have audio output too.
External I/O	2 x USB 3.0 Host ports 2 x USB 2.0 Host ports 1 x Peripheral Expansion Header (24-pin, 2.54mm pitch) – 1 x DC 5V, 1 x DC 3.3V, 5 x GND – 1 x UART (TXD/RXD/RTS/CTS) – 2 x I2C (SCL/SDA) – 3 x USB 2.0 (D+/D-) – 1 x External Power Button – HDMI CEC, 5VA+ (always on) – All 3.3V I/O signal level
Other features	Passive Heatsink BIOS Backup Battery – Maintains system time and BIOS settings Power Button Reset Button System LEDS Indicators: – Red (PWR) - Solid light when DC power is supplied – Blue (left, SLEEP) - turns off only when the system enters into suspend mode – Blue (right, PMIC) - turns on only when the major power rails are working – Amber (SATA) - Flashes when SATA data transfers – Green (NVMe) - Flashes when NVMe data transfers Active Cooling Fan Connector (12V 4-pin, PWM input + TACHO output) – Active Cooling Fan is optional – Connector (4-pin, 2.54mm pitch)

Power	DC jack : outer (negative) diameter 5.5mm, inner(positive) diameter 2.1mm DC 14V ~ 20V (up to 60W) – DC 15V/4A power adapter is recommended if you don't use two 3.5“ HDDs – DC 19V/7A power adapter is recommended if you two 3.5” HDDs together Power consumption: – IDLE : ≈1..9W – CPU Stress : ≈15W – CPU+GPU Stress : ≈18W – Power-off : ≈0.25W – Suspend : ≈0.6W
Form Factor	110mm x 110mm x 47mm Approx.

Fan Connector

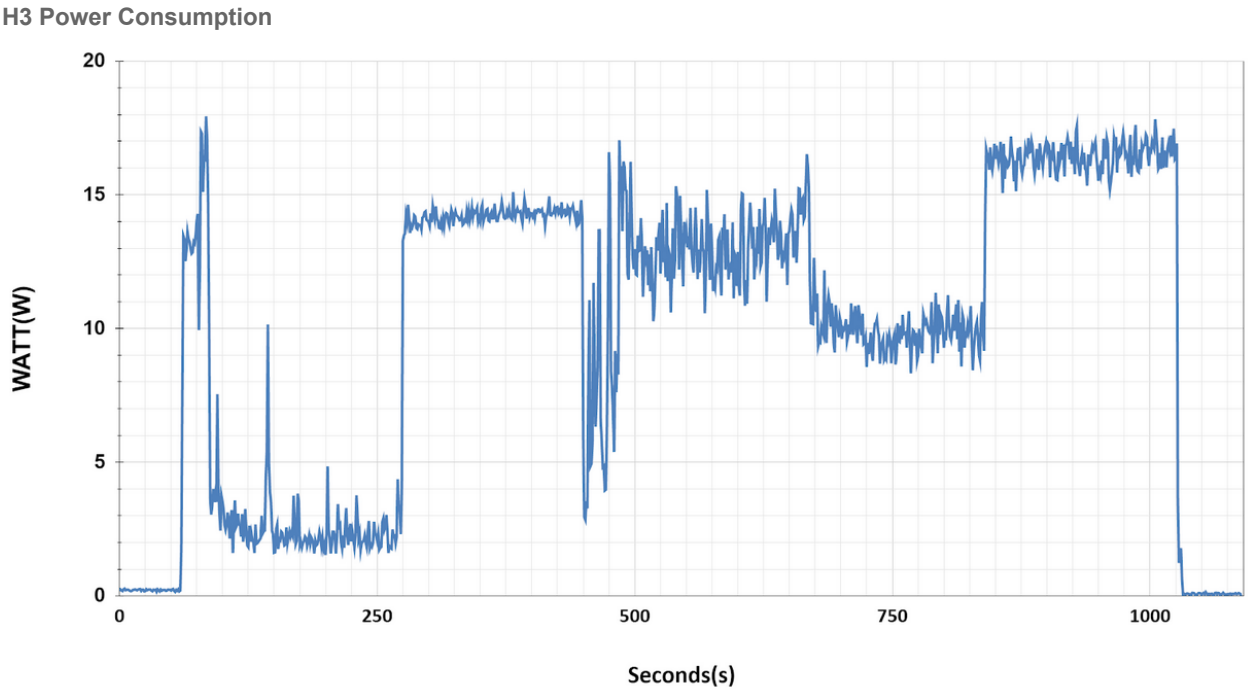
The ODROID-H3 and H3+ use a PC standard 12V PWM 4-pin connector instead of the proprietary 5V mini connector used on the H2/H2+. Therefore, anyone can install a third-party cooling fan that can be easily purchased in the market.



Power consumption

We used our SmartPower3 (see https://www.hardkernel.com/shop/smartpower-iii/) to test and measure the ODROID-H3 power consumption while performing specific activities. We used an M.2 NVMe storage device, 4K HDMI monitor, Ethernet cable and USB combo keyboard + mouse while measuring the power consumption. The table shown below and its corresponding chart detail the power consumption we witnessed:

Activity	**Power Consumption in Watt**
Power Off	0.21
Ubuntu Desktop Booting	12.36
Desktop Idle	2.52
CPU stress	14.17
4K YouTube play on Chrome Browser	12.02
WebGL aquarium demo on Chrome Browser	10.00
WebGL + CPU Stress	16.38
Power Off	0.21
Sleep (Suspend to RAM)	0.85



Notes

- In headless mode, the idle state power consumption should be lower than 2 Watt.
- If one runs the H3+ in Unlimited Performance mode and stresses the CPU to its maximum, the system peak power consumption can be near 22 Watt.

The Making of the ODROID-H3 and ODROID-H3+

Until the introduction of the ODROID-H2, we were well-known for our ARM-based SBC such as the XU-4, C-series, N-series and more recently the M-1.

However the x86 platform brings many advantages:

- Most GPU and VPU hardware acceleration drivers are working perfectly fine on the latest Linux Kernel releases and GNU software out of the box.
- Large scale memory expandability, up to 64GB of DDR4 RAM.
- We can have stable and more hardware connectivity: two 2.5GbE ports, two SATA III ports, four lanes of PCIe Gen 3, etc.
- Hardware virtualization VT-x powered virtual machines allow a user to run different operating systems, test applications, and experiment with specific features without worrying about system crashes related to specific hardware differences.
- On the ARM platform, it takes non-trivial human and time resources to port the mainline kernel to a level where the GPU and VPU hardware acceleration functions work properly. In contrast, on the x86 platform, you can usually run the latest operating system with full hardware acceleration.
- As a journalist wrote about the ODROID-H2+, we quote: “x86 tends to do very well with legacy support. We cannot predict the future, but there is a good chance that 5-7 years from now, the hardware we have on the ODROID-H2+ will still be well supported and OSes will be installed out-of-the-box. That is not necessarily the same for the ARM maker board ecosystem to date.”(*)

(*) Quoted from https://www.servethehome.com/odroid-h2-with-h2-net-card-cheap-6x-2-5gbe

Obviously, the ARM platform has numerous benefits of its own and a large number of applications in many markets: usually low cost, very low power allowing usage in millions of devices running on battery (e.g. smartphones, remote controls, sensors, tiny robots, etc) as well as 24x7 appliances where energy consumption must be as low as possible (e.g. TV boxes, home NAS, gateways, home routers, etc). Finally ARM-based SBCs enable DIY users like you or industrial users to design custom boxes, servers, instrumentation devices with sensors, etc. This is why Hardkernel makes a lot of ARM-based SBC.

Our first endeavor into the x86 world with the ODROID-H2 and H2+ was both an engineering and commercial success. This was reflected in multiple articles at https://www.cnx-software.com/ as well as at STH (see link cited above).

Due to the continuous shortage of semiconductors during the COVID-19 pandemic, we had no choice but to discontinue the popular ODROID-H2+ at the end of last year.

However, there has been continued customer demand for the x86 platform. So, earlier this year, we started developing new ODROID-H series models which leverage 11th-gen Intel processors made with an advanced 10nm (Intel 7) semiconductor fab and other key components that we can purchase much more reliably.

Many of our B2B customers have requests for long-term stable supply.

The previous generation processor J4115 package size was 25x24mm with 1090 BGA pins while the new N5150 and N6005 package size is 35mmx24mm with 1338 pins. Due to the big difference of the SoC packages, we had a very hard time keeping the same PCB form factor and connectors' positions while we designed the hardware. We have achieved backward compatibility through this difficult design process and efforts.

Thanks to this mechanical and electrical compatibility, H2 series cases and the ODROID H-series Net card can be used on the H3/H3+ as well. Since Intel doesn't guarantee the period of availability, we can't say about the longevity of the H3 series. Perhaps we can only supply the H3 series for 2~3 years in the worst case.

However, we will always do our best to maintain mechanical and electrical compatibility when Intel's next-generation low-power processors are released. We believe that this method enables long-term supply in other ways.

So here we are today with the ODROID-H3 and ODROID-H3+!