

# Report on Ryzen Z1 Extreme and Ryzen 5500

## Introduction

The purpose of this report is to compare two AMD processors used in different computing environments: the Ryzen Z1 Extreme and the Ryzen 5 5500. The Ryzen Z1 Extreme is a cutting-edge processor designed specifically for handheld gaming consoles, offering high performance with low power consumption and heat output – ideal for compact systems. In contrast, the Ryzen 5 5500 is a mid-tier desktop processor commonly found in budget-friendly PCs. From this comparison, you can see 2 different methodologies of designing chips:

Traditional desktop and modern mobile devices

## CPU Specification

Specs/Processors	AMD Ryzen 5500(code name Cezanne) 6-cores	AMD Z1 Extreme(code name phenix) 8-cores
ISA	X86-64	X86-64
Micro-Architecture	AMD Zen 3	AMD Zen 4
Fabrication technology	TSMC N7	TSMC N4
Cache	8-way set associative L1 64 KB (per core) L2 512 KB (per core) L3 16 MB(shared) 16-way set associative	8-way set associative L1 64 KB (per core) L2 1 MB (per core) L3 16 MB (shared) 16-way set associative
Memory bandwidth	dual-Channels DDR4: Rated Speed: 3200MT/s Bandwidth/Channel 51.2 GB/s	dual-Channels DDR4: Rated Speed: 5600 MT/s LPDDR5x Speed:7500 MT/s Bandwidth/Channel 89.6 GB/s

Integrated GPU	None	Radeon 780M
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### **AMD Ryzen Z1 Extreme**

The Ryzen Z1 Extreme is a high-performance mobile (handhelds) processor tailored for gaming handhelds and ultra-portable devices. Built on AMD's Zen 4 architecture and manufactured using TSMC's 4nm process, it aims to deliver efficiency and speed. It features 8 cores and 16 threads, with a maximum boost clock of 5.1 GHz. One of its standout features is the integrated Radeon 780M graphics, which enables solid gaming performance without the need for a discrete GPU. The chip supports LPDDR5 and DDR5 memory, making it ideal for bandwidth-intensive applications. Its cache configuration includes 16MB of L3 cache and 1MB of L2 cache per core.

### **AMD Ryzen 5 5500**

The Ryzen 5 5500, on the other hand, is a desktop-class processor aimed at budget-conscious users. It's built on the older Zen 3 architecture and fabricated using a 7nm process. With 6 cores and 12 threads, and a boost clock of up to 4.2 GHz, it offers reliable performance for everyday computing and gaming when paired with a dedicated GPU. Unlike the Z1 Extreme, it doesn't have integrated graphics, which limits its standalone capabilities. The processor supports DDR4 memory and includes 16MB of shared L3 cache and 512KB of L2 cache per core. While not as cutting-edge as the Z1 Extreme.

## Detailed Compare

### CISC (Complex Instruction Set Computer)

The two processors utilise the x86-64 CISC architecture, which allows them to execute complex instructions with fewer lines of code. This design is particularly beneficial for handling diverse workloads, from gaming to productivity applications. CISC enables efficient execution of high-level operations, making both CPUs suitable for environments where performance and compatibility with legacy software are important.

However, the X86-64 CISC on a handheld may not be the best choice for efficiency due to the complexity of the architecture and the numerous other functionalities that can't be integrated into the SoC (such as USB, Wi-Fi chip,...). They are wasting extra power by communicating with the CPU over the bus, resulting in high idle power. But considering compatibility, X86-64 CISC will be the only choice, sadly.

### Von Neumann architecture:

Both the Ryzen Z1 Extreme and Ryzen 5 5500 are built on the Von Neumann architecture, which is a foundational design in modern computing. This architecture uses a shared memory space for both instructions and data, simplifying processor design and enabling flexible execution of general-purpose tasks. It is worth noting that this model can introduce bottlenecks due to shared pathways; however, both processors mitigate these limitations through advanced caching and execution techniques. Which I will discuss later in Cache and Execution techniques

### Cache and Cache Structure

Cache design plays a vital role in processor responsiveness. The Z1 Extreme features 64 KB of L1 cache per core, 1 MB of L2 cache per core, and 16 MB of shared L3 cache.. The Ryzen 5 5500 also includes 64 KB of L1 cache per core, but only 512 KB of L2 cache per core, alongside the same 16 MB of L3 cache. The larger L2 cache on the Z1 Extreme improves latency and throughput for frequently accessed data, making it especially beneficial in gaming and mobile workloads.

## Pipelining

Pipelining is a core performance optimisation in both processors. The Ryzen Z1 Extreme, based on the Zen 4 architecture, features deep pipelining and advanced branch prediction, allowing it to maintain high throughput even in power-constrained mobile environments. The Ryzen 5 5500, built on the Zen 3 architecture, also employs pipelining and out-of-order execution, albeit with slightly less sophistication. These techniques enable both CPUs to execute multiple instructions simultaneously, thereby reducing idle cycles and enhancing overall efficiency.

## Fabrication Technology

The Ryzen Z1 Extreme is manufactured using TSMC's 4nm FinFET process, offering high transistor density and energy efficiency. This advanced node is ideal for compact systems, such as handheld consoles, where thermal and power constraints are particularly critical. In contrast, the Ryzen 5 5500 utilises TSMC's 7nm process, which, although still efficient, is less advanced and results in a higher power draw and lower performance per watt. As a budget desktop processor, it is not designed to achieve ultra-low power consumption, like the Z1 Extreme, nor ultra-high performance. Using the TSMC 7nm process is a good balance of cost, performance, and power consumption.

## Memory Bandwidth

Memory bandwidth is a key differentiator. The Z1 Extreme supports LPDDR5x-7500 and DDR5-5600 memory, achieving bandwidths up to 77 GB/s. This high-speed access is crucial for gaming and graphics-intensive applications. The Ryzen 5 5500 supports DDR4-3200 memory, with a maximum bandwidth of 51.2 GB/s, which is adequate for general desktop tasks but less suited for high-performance scenarios.

The support of LPDDR(low-power double data rate) on the Z1 Extreme is a brilliant choice for low-power mobile devices. LPDDR is a modern technology (first introduced in 2008) aimed at bringing similar performance but lower voltage DDR (double data rate) DRAM to mobile devices, which can achieve lower latency by being soldered directly onto the motherboard. As 5500, the support of only DDR4 is far enough, as it is not a power/heat-sensitive user case.

## Integrated GPU

The Z1 Extreme includes Radeon 780M integrated graphics based on RDNA 3, with 12 compute units and support for ray tracing and FSR. This enables it to run modern games without the need for a discrete GPU. The Ryzen 5 5500 lacks an integrated GPU entirely, requiring an external graphics card for any visual output, which adds cost and complexity to desktop builds.

Again, communicating on the external bus(PCIe here) between CPU and GPU is expensive (Time and power Consumption), having an On-Die integrated GPU can maximise the efficiency, although it may cant bring as powerful computing as a Nvidia RTX 5090.

## Instruction Set Extension Support

Instruction set extensions enhance processor capabilities. The Z1 Extreme supports AVX2, AVX-512, SSE4.2, FMA3, and other modern extensions, enabling it to handle advanced computational tasks efficiently. The Ryzen 5 5500 supports AVX2, SSE4.2, and FMA3, but lacks AVX-512 support, limiting its performance in certain high-throughput applications.

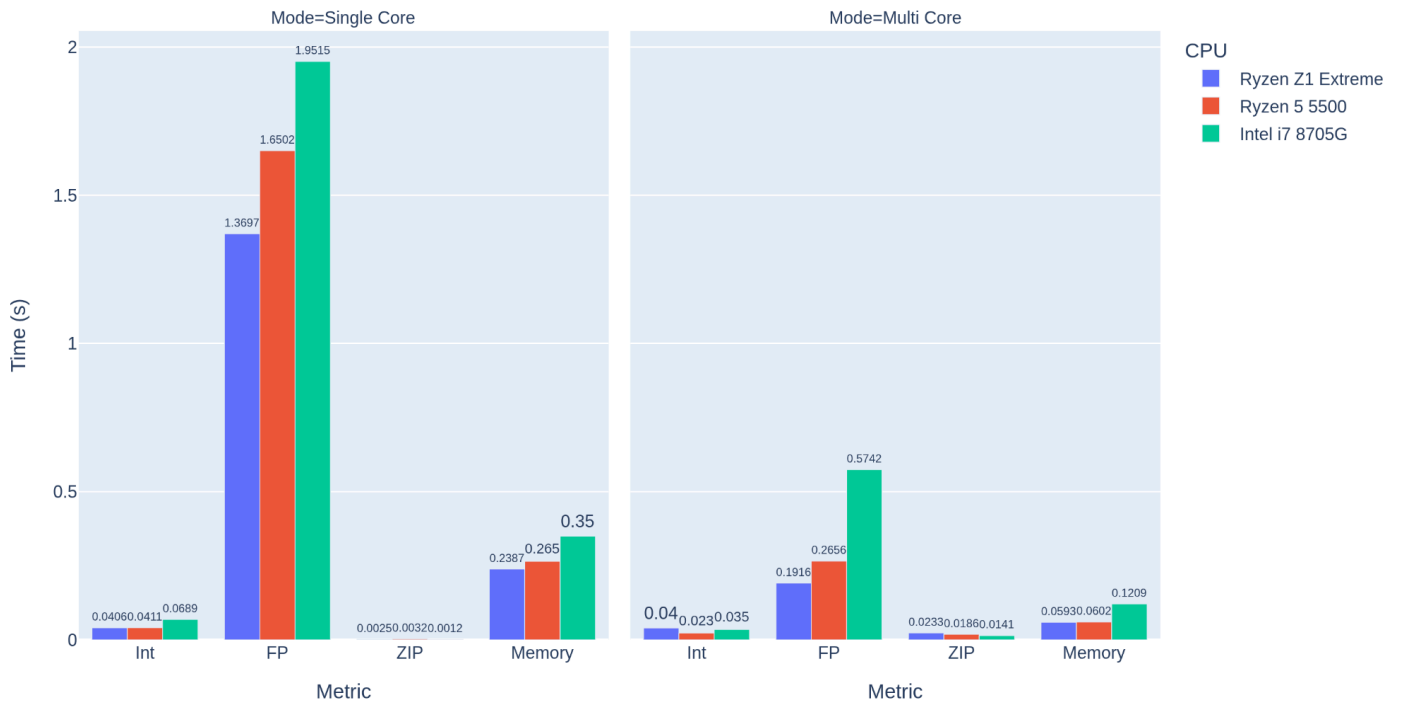
## Power Consumption

Power efficiency is a defining trait of the Z1 Extreme, with a configurable TDP ranging from 9W to 30W. This makes it ideal for battery-powered devices and environments with thermal constraints. The Ryzen 5 5500 has a fixed TDP of 65W, making it suitable for desktop systems with active cooling, but less efficient in terms of performance per watt. The performance later reveals a terrible energy efficiency of the Z1 Extreme, as it almost beats the 5500 at all tests with half the wattage. To whom it may concern, I have uploaded all files to GitHub, here's the link → [https://github.com/Xiayang-Peter/CPU\\_benchmark](https://github.com/Xiayang-Peter/CPU_benchmark)

## Benchmark and Conclusion

CPU	Mode	Int	FP	ZIP	Memory
Ryzen Z1 Extreme(30W)	Single Core	0.0406	1.3697	0.0025	0.2387
Ryzen Z1 Extreme(30W)	Multi Core	0.04	0.1916	0.0233	0.0593
Ryzen 5 5500(65W)	Single Core	0.0411	1.6502	0.0032	0.265
Ryzen 5 5500(65W)	Multi Core	0.023	0.2656	0.0186	0.0602
Intel i7 8705G(80W)	Single Core	0.0689	1.9515	0.0012	0.35
Intel i7 8705G(80W)	Multi Core	0.035	0.5742	0.0141	0.1209

Benchmark Comparison Across CPUs (Lower is Faster)



Since I have Ryzen 5 5500 and AMD Z1 Extreme, I wrote a benchmark script in Python on aspects of Int, FP operation, compression and memory. including single-core and all-core performance. Both processors will be running at the max boost frequency under default factory TDP, and a freshly installed Ubuntu 24.04.3 LTS (I also included i7-8705G as a bit of flavour, which is an ancient architecture, TDP is 80Watt)

## **Single-Core Performance**

Single-core performance plays a vital role in workloads that depend on the speed of an individual core, such as gaming, web browsing, and applications that are not optimized for multi-core processing. In the single-core tests, the Ryzen Z1 Extreme consistently outperformed the Ryzen 5 5500 across all measured workloads.

For integer operations, Z1 Extreme recorded 0.0406s, slightly ahead of Ryzen 5 5500's 0.0411s, giving Z1 Extreme a marginal 1.2% advantage. The gap widened significantly in floating-point tasks, where Z1 Extreme achieved 1.3697s compared to 5500's 1.6502s, representing a 17% improvement. In file compression, Z1 Extreme completed the task in 0.0025s, outperforming the 5500's 0.0032s by 21.9%. Memory operations also favoured Z1 Extreme, with 0.2387s versus 0.2650s, a 9.9% advantage.

These results highlight Z1 Extreme's superior single-core performance, making it more suitable for workloads that rely on fewer threads or require high responsiveness, such as gaming and lightly-threaded professional software.

## **Multi-Core Performance**

Multi-core performance was assessed using workloads designed to fully utilize all available processor cores and threads. Here, the Ryzen Z1 Extreme again demonstrated strong performance, though the competition was closer in certain areas.

In floating-point operations, Z1 Extreme completed tasks in 0.1916s, outperforming Ryzen 5 5500's 0.2656s by 27.8%, showing its strength in compute-heavy workloads. Memory performance was nearly identical, with Z1 Extreme at 0.0593s and 5500 at 0.0602s. Interestingly, Ryzen 5 5500 took the lead in integer operations, finishing in 0.0230s compared to Z1 Extreme's 0.0400s, a 42.5% advantage. Compression tasks also slightly favoured the 5500, with a time of 0.0186s versus Z1 Extreme's 0.0233s, a 20.1% advantage.

These results suggest that while Z1 Extreme dominates floating-point and memory-heavy workloads, Ryzen 5 5500 offers competitive multi-core performance and even excels in integer-heavy tasks, making it a strong contender for users focused on such workloads.

### **Conclusion:**

From the brief investigation of the processor, we can conclude on two complete paths and the tradeoff of processors. Z1 Extreme utilises the latest fabric technology and enhancements to the pipeline, cache, and memory, paired with a powerful iGPU that delivers high performance with minimal heat and power consumption. Making this processor a great mobile powerhouse. On the other hand, R5 5500 has a balance between cost(older fabric technology), performance, and power consumption(compared to other desktop CPUs). Making it a great budget choice



## Works Cited:

Lam, Chester. *AMD's Zen 4 Part 1: Frontend and Execution Engine*.

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## CPU database:

AMD Z1 EXtreme: <https://www.techpowerup.com/cpu-specs/ryzen-z1-extreme.c3276>

AMD Ryzen 5 5500: <https://www.techpowerup.com/cpu-specs/ryzen-5-5500.c2756>