CORSAIR

CORSAIR DDR5 PRIMER

Preparing for the Next-Generation of Memory

INTRODUCTION

It's been over six years since DDR4 hit the market, with top-end speeds now reaching 5000MHz+ on high-end overclocked kits. DDR5 is now on the horizon bringing with it some key improvements for your current and future computing needs.

THE CURRENT STATE OF DESKTOP PCS

What has changed in the PC landscape since DDR4 hit the PC desktop market back in 2014? To put it simply, more cores and higher memory bandwidth needs. Core-count has drastically increased on mainstream platforms. Quad-core parts have been surpassed by six-cores (on what would now be considered mid-range builds) with many recommended build configs seeing anywhere between eight to sixteen cores for hybrid gaming/content creation machines, while the high-end desktop/workstation space is seeing configurations with processors of up to sixty-four cores!

All these cores mean that an increasing number of users are doing more things at once with their PCs. Using the gaming space as an example, it is not unheard of for someone to play a game at very high settings on one display and on their other displays have streaming software running with multiple graphic overlays and effects while also interacting with their audience all from a single machine. These cores and threads need to be fed information as fast as possible and DDR4 has kept up for the most part, but this train is about to make its last stop as we hit not just speed and density ceilings, but overall bandwidth ceilings as the number of cores packed into a single system continues to increase.

A QUICK RECAP OF DDR4

The transition from DDR3 to DDR4 was slow and steady, with many kits at launch starting at just 2400MHz effective clock speeds and topping out with speeds hitting up to 5000MHz in recent months. In terms of capacity, the overall density of single DDR4 memory modules has jumped from 4GB (initially) to 16GB on standard-sized modules (with up to 32GB in 2019 on the largest UDIMMs).

SO WHAT IS DDR5?

Just like with new generations of processors and graphics cards increasing core/thread count and clock speeds, new memory generations come along to raise the ceiling, allowing applications to do even more things at once and typically resulting in more efficient computing. The transition from DDR4 to DDR5 keeps to this playbook, raising the cap so that the computing space can grow unimpeded.

WHY DO WE NEED IT?

Scalability, large-enterprise style installations of servers aren't going away (in fact they're more in demand than ever) and are constantly being driven to scale up to handle more users and more content. Improvements in overall bandwidth and density allow for more tasks to be done at once with one server than before.

This trickles down to desktops as well, allowing for system configurations with previously unthinkable amounts of extremely fast memory, making it easier to build out high-capacity, memory-intensive workstations and lowering the barrier to entry for hybrid gaming/content creation machines. To use traditional creative professionals that regularly eat up memory with massive illustrative/photo-editing/3D/video projects as an example, a single stick of DDR5 memory could initially have up to 32GB with the standard supporting up to 128GB capacities, allowing for much larger digital canvases.

INCREASING BANDWIDTH

It's already been mentioned that overall memory bandwidth will increase, but by how much? The JEDEC spec for DDR4 tops out at 3200MT/s, up from its initial 2133MT/s at launch in terms of max data rate (this of course increases when using an overclocked kit of DDR4 memory), that baseline has been upped to 4800 MT/s on DDR5 which will naturally increase as higher-clocked kits come to market throughout the life of DDR5.

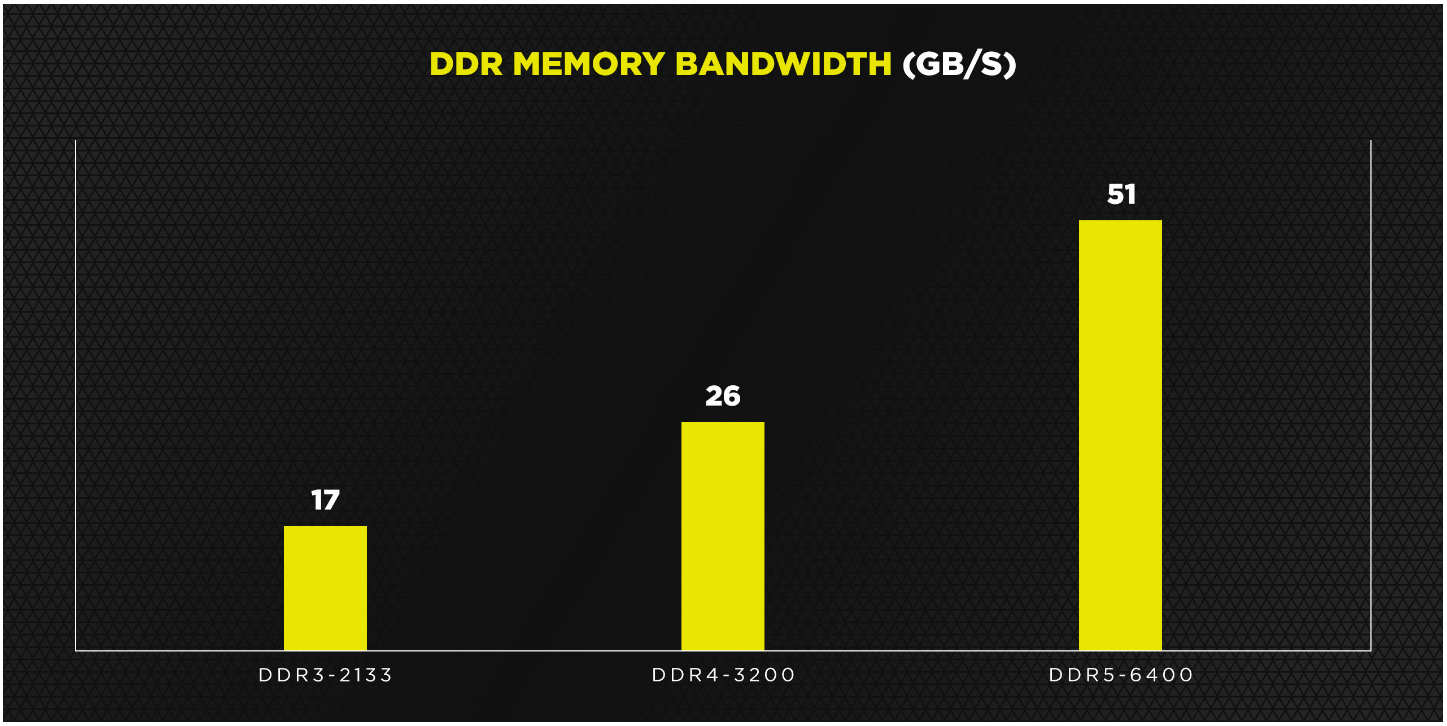

Figure 1: DDR Memory Bandwidth at GB/s.

But how has bandwidth been increased? One of the first things we should talk about is burst length or how many bits of data can be read per cycle. On DDR5 this has been doubled to 16-bits (from just 8-bits on DDR4). With double data rate memory (DDR) that means 32-bits per channel and a full cache line of 64-bits total per module.

FURTHER REFINEMENTS

With DDR5, individual modules are split into two separate channels by design, allowing for shorter traces that contribute to less latency and higher speeds when it comes to communicating with individual memory ICs on a memory module. This also allows for what's referred to as command/address mirroring since the signal from the CPU has to travel a shorter overall path to access specific banks of memory whereas in DDR4 a command/address signal had to travel through all banks of memory in a longer chain.

On DDR4, when a single bank of memory needed to be refreshed, the CPU had to wait for all banks of memory on a module to refresh before doing another read or write. With DDR5, we've got double the bank groups and when a bank needs to be refreshed only the same bank of each group is refreshed, allowing for the other memory bank groups to be accessed without the CPU having to wait.

Overall single access latency with DDR5 is relatively unchanged, while CAS Latency has increased, the overall latency of a top-tier DDR5 kit will be similar to previous generations of DRAM clocking in at 14-15ns thanks to the improvements we previously mentioned.

ON-DIE ECC

Reliability goes down as process technologies shrink, resulting in higher latency and looser timings overall at higher speeds. DDR5 features on-die ECC as part of its spec, helping to reduce errors and allow for memory ICs to operate at higher frequencies. To be clear, this doesn't mean that mainstream DDR5 is using a full-fledged ECC implementation, there'll still be unregistered modules for typical consumer applications and ECC modules for enterprise/research applications.

MORE POWER TO THE MODULE

DDR5 memory ICs also require less power with Vdd dropping from 1.2v for DDR4 to 1.1v for DDR5, this isn't exactly meaningful to most desktop users, but it does result in better overall power efficiency for portable devices such as gaming notebooks and smartphones (note that some flagship smart phones are shipping with over 12GB of LPDDR5 already).

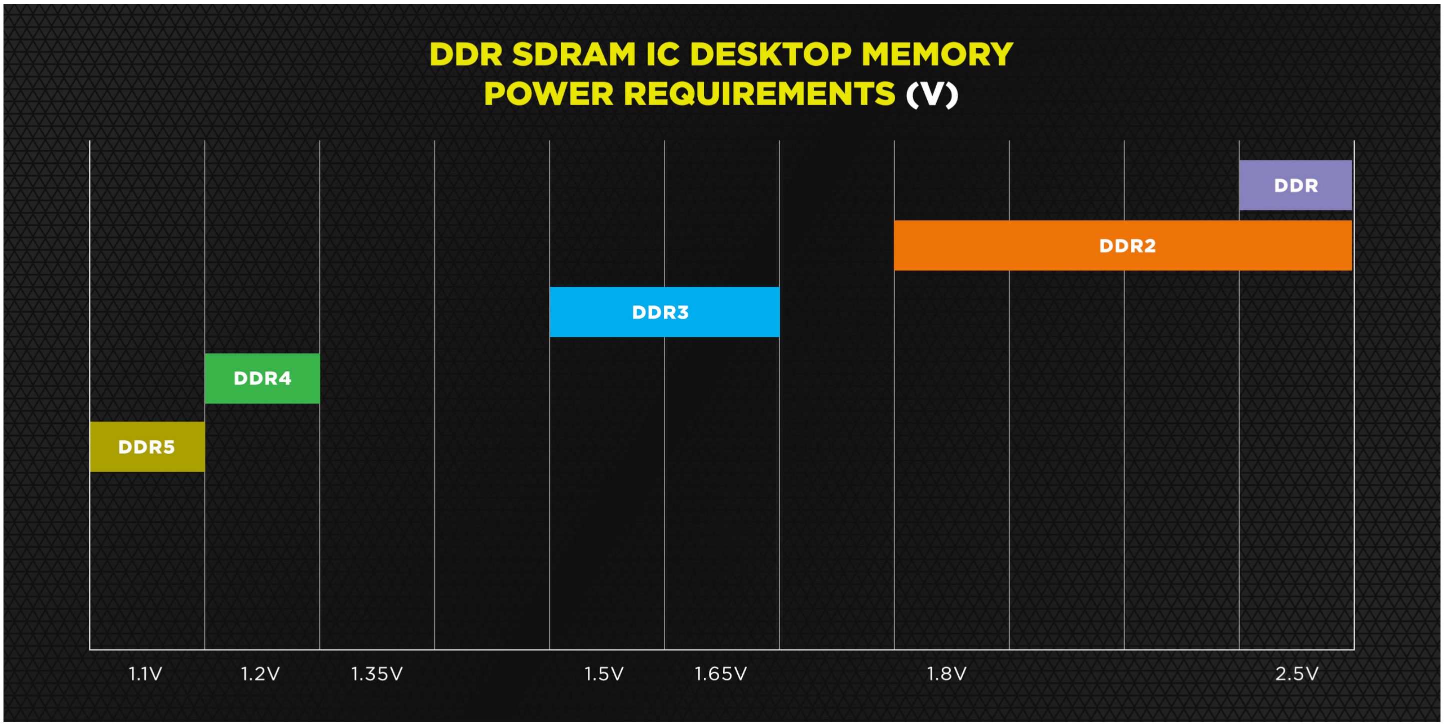

Figure 2: SDRAM Desktop Power Requirements.

Lower overall voltage requirements for DDR5 is only part of the picture, voltage regulation has been shifted from its current location on desktop motherboards to the individual modules by the inclusion of a power management integrated circuit (PMIC). This results in better overall voltage regulation for each module and improved DRAM IC yields which is great for overclocking and overall memory efficiency.

DENSELY PACKED

DDR4's density cap per module is already being hit at 32GB with a small selection of high-end kits and DDR5 promises to raise this to a theoretical maximum of 128GB per module (or four times the density of DDR4 currently). This allows for a single user to work with larger, more memory intensive projects and potentially allow for more immersive gaming experiences as game studios take advantage of the general increase in available memory for features and assets in their games.

Using a "mainstream" desktop configuration which currently can accommodate up to four modules as an example, this could mean that high-end desktop systems on similarly kitted out mainstream motherboards could be equipped with 512GB of DDR5 (with even higher-end platforms hitting 1024GB) in the future.

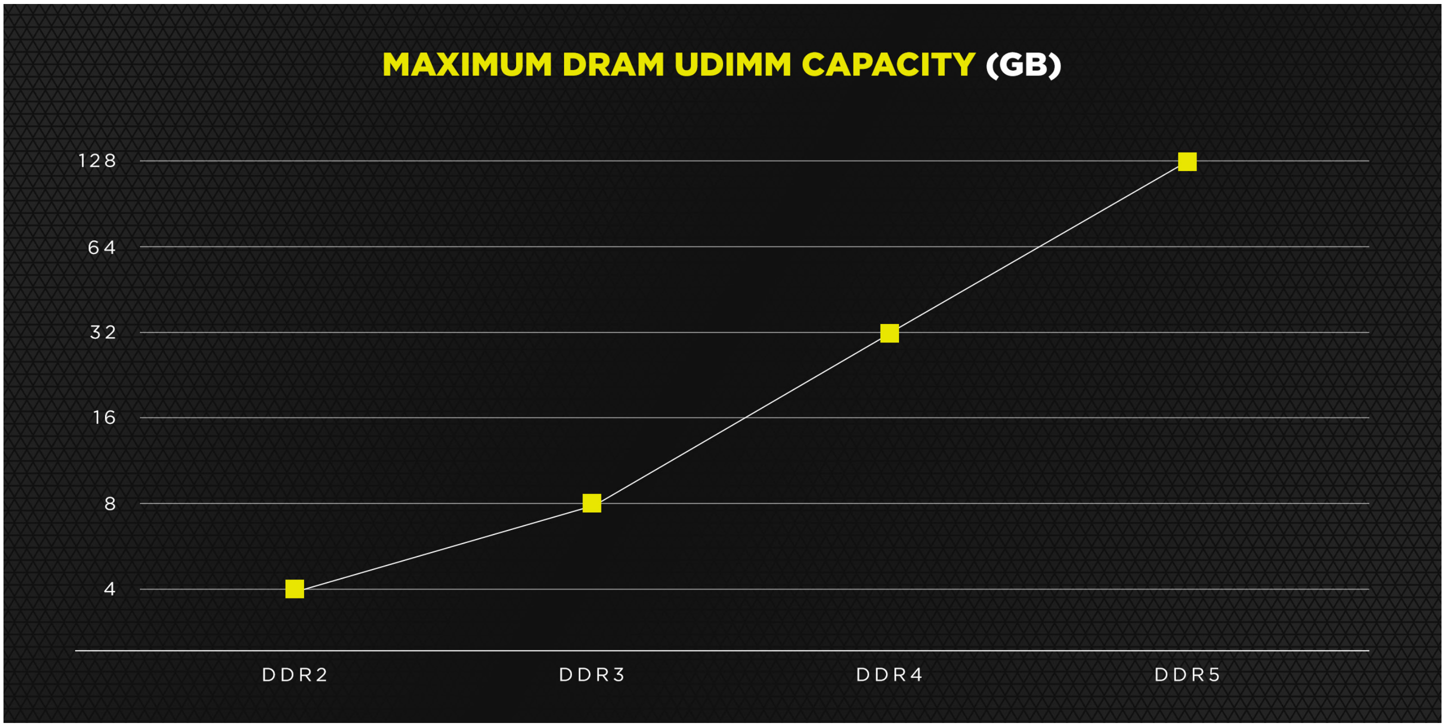

Figure 3: Maximum DRAM Capacity.

CONCLUSION

DDR5 is coming in fast and is set to bring PC builders a performance boost in the form of higher clock speeds and overall bandwidth, improved power efficiency, and much larger memory capacities to handle the workloads of today and tomorrow. CORSAIR has long been a leader in the PC hardware space and we're hard at work to bring the next generation of memory technology to our customers.

SPECIFICATION	DDR5	DDR4
Max Die Density	64 Gbit	16 Gbit
Max UDIMM Size	128 GB	32 GB
JEDEC Max Frequency	6400 MHz	3200 MHz
Channels Per Module	2	1
Total Width	64-bit (2 x 32-bit)	64-bit
Banks (Per Group)	4	4
Bank Groups	8	4
Same Bank Refresh	Yes	No
Burst Length	BL16	BL8
Voltage (Vdd)	1.1v	1.2v
DIMM Power	PMIC On DIMM (5V Bulk)	On Motherboard (VDD, VDDQ, VDDSPD, Vref, VTT)
Command / Address	28-bit (2 x 14)	24-bit
Command / Address Mirroring	All Address signals mirrored, handled by DRAM	Some Address signals mirrored, handles by system and SPD
On Die ECC	Yes	No
Number of Pins	288	288

Figure 4: Specification comparisons.