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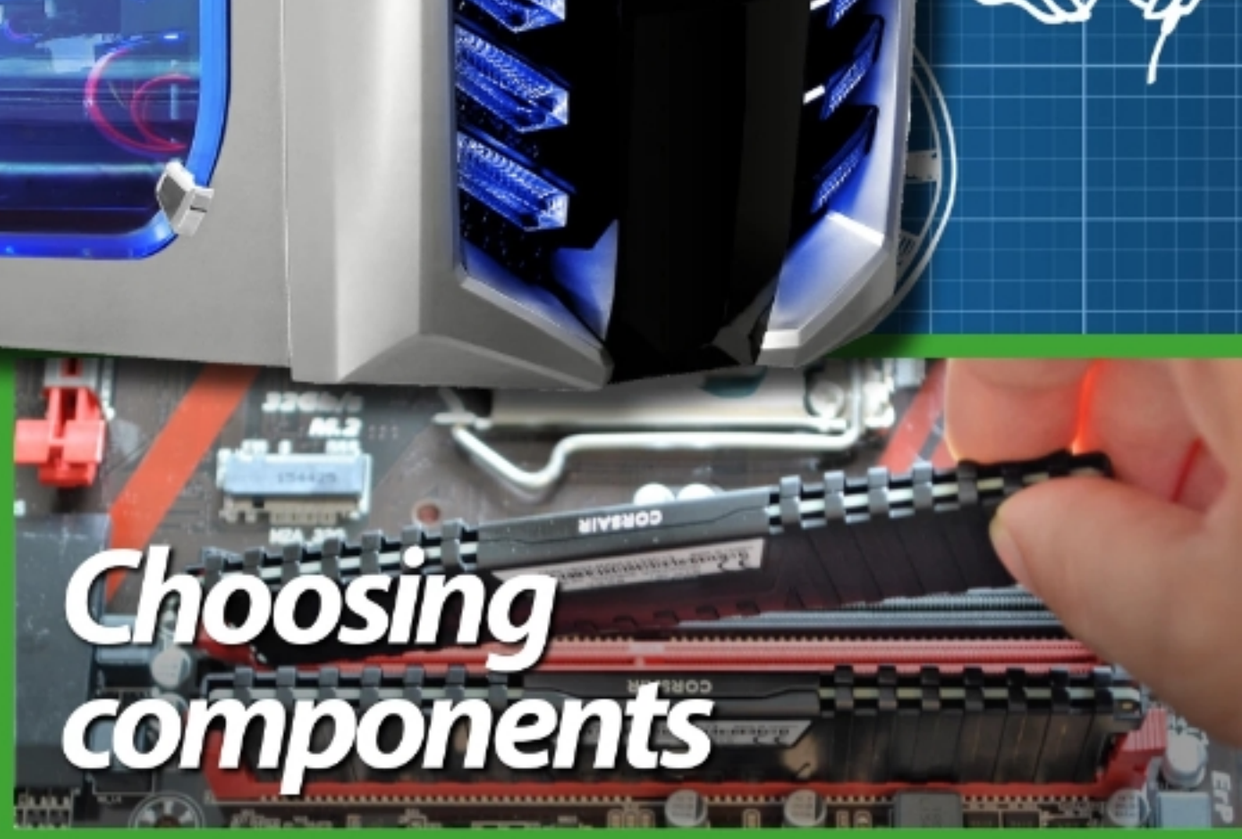
MAKE YOUR OWN PC

FOR BEGINNERS



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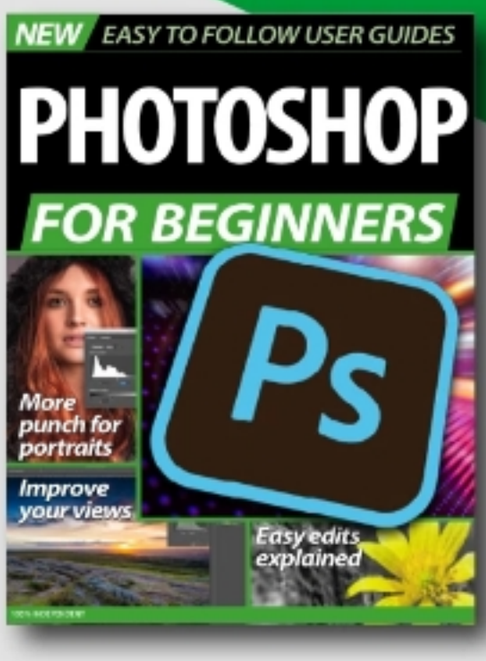
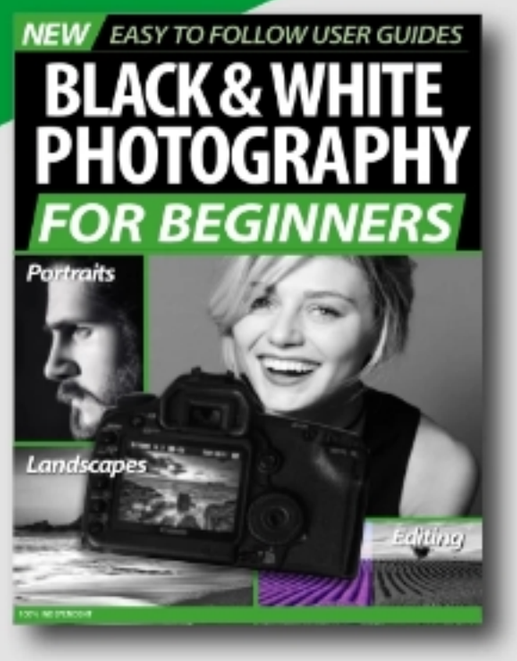
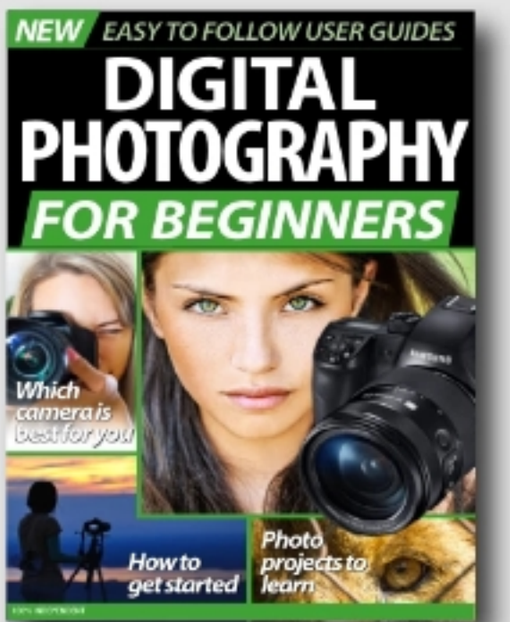






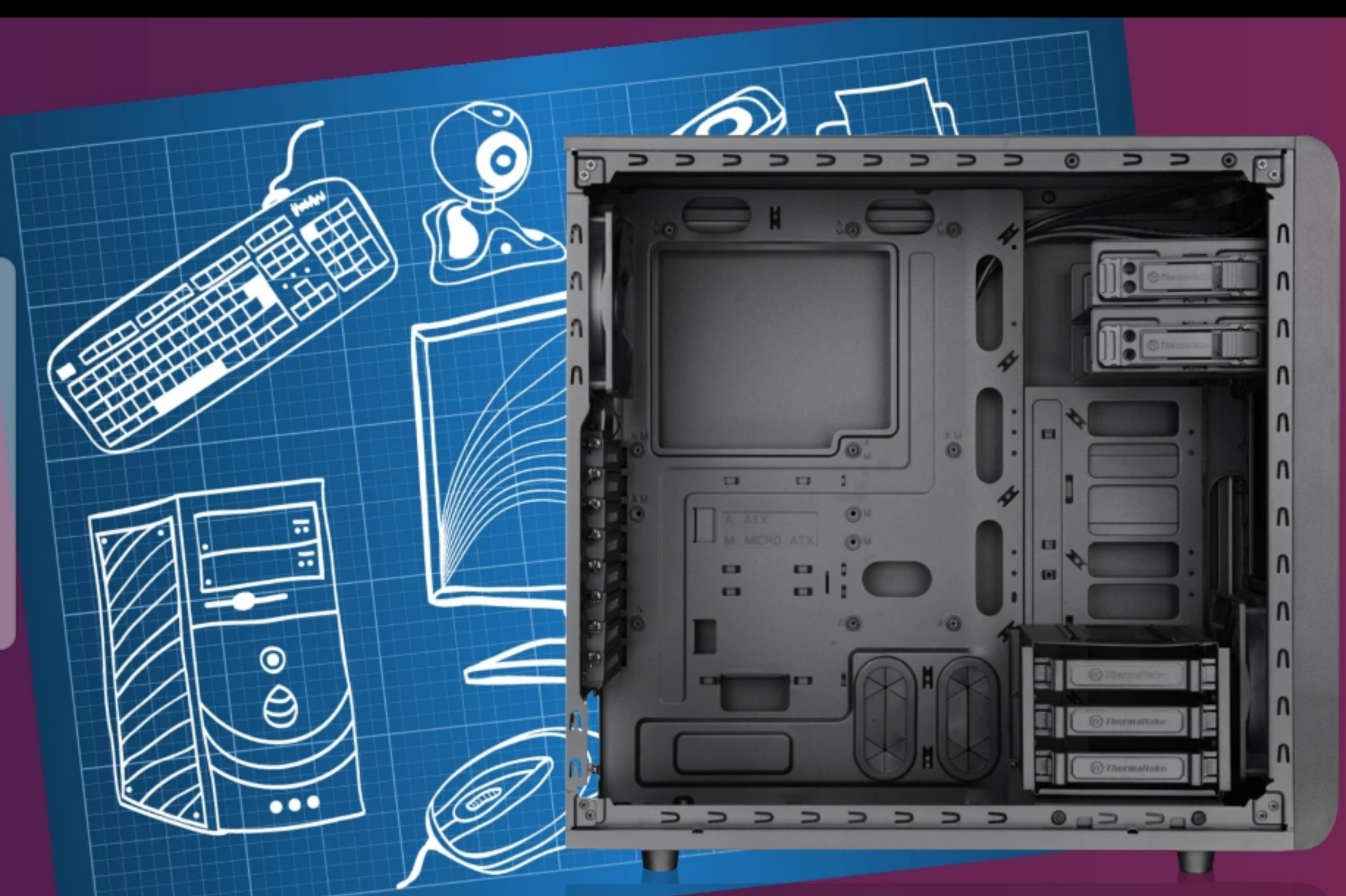
MAKE YOUR OWN PC

FOR BEGINNERS

Starting something new can be daunting. Learning a skill or mastering a new piece of hardware is tough. Even tougher if you have no-one at hand to help. Conversely as the complexity of our consumer technology increases, the size of the requisite instruction manual decreases or in some cases it simply disappears. At numerous times in our lives we have all been "beginners", there is no shame in that fact and rightly so. How many times have you asked aloud, "What does this button do?". "Why doesn't that work?". "What do you mean it doesn't do that?". "HELP!". At the start of any new journey or adventure we are all beginners but fortunately for you we are here to stand beside you at every stage.

Over this extensive series of titles we will be looking in great depth at the latest consumer electronics, software, hobbies and trends out of the box! We will guide you step-by-step through using all aspects of the technology that you may have been previously apprehensive at attempting. Let our expert guide help you build your technology understanding and skills, taking you from a novice to a confident and experienced user.

Over the page our journey begins. We would wish you luck but we're sure with our support you won't need it.



Contents

"your essential step-by-step guide to building your own computer from planning to completion…"

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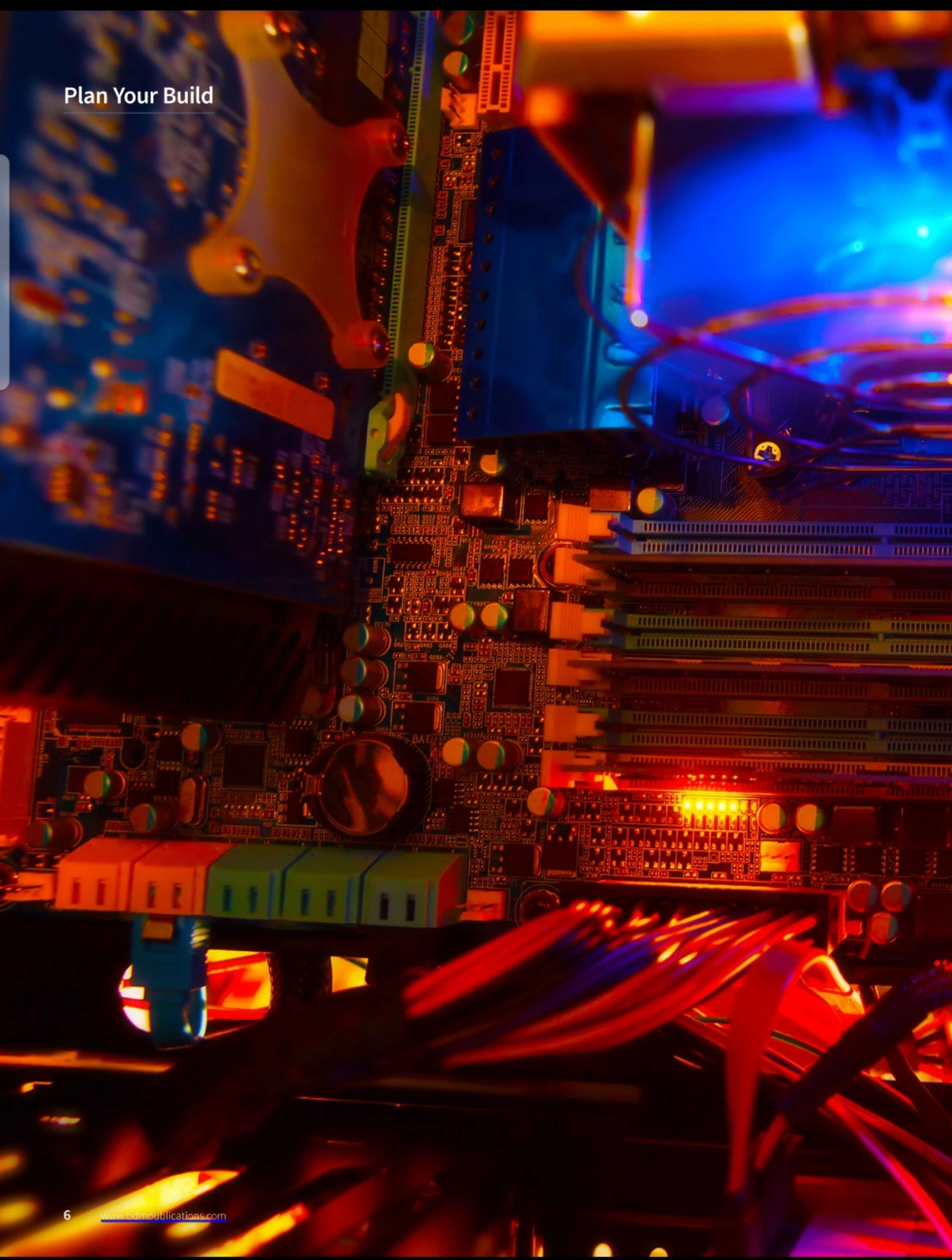
Plan Your Build



Plan Your Build

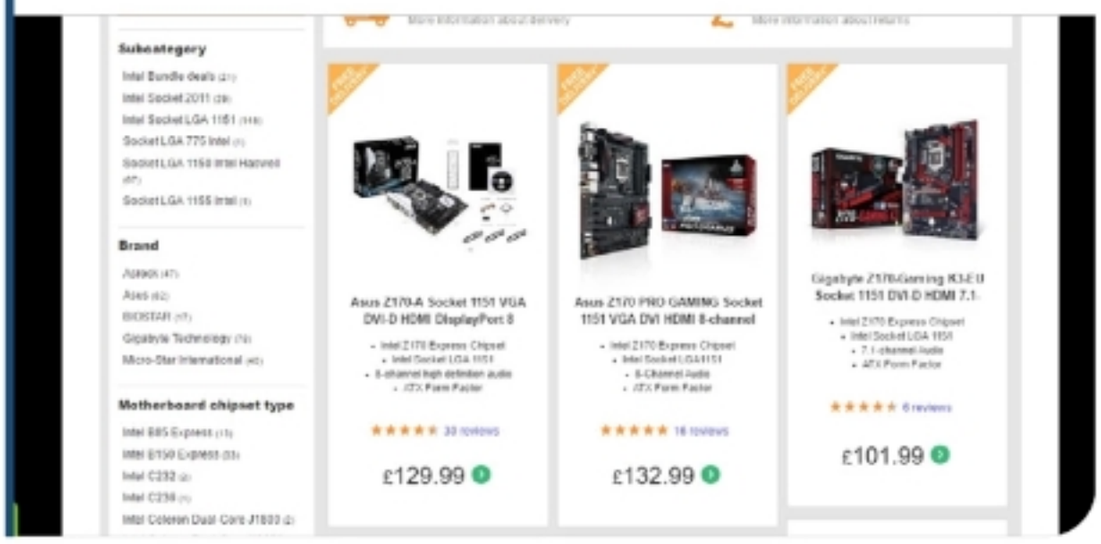
It is important before you start to build, that you make sure you have done some forward planning. Proper planning helps to ensure that you don't run into compatibility problems later, as well as allowing you to decide where you want to spend most of your budget. This section also helps you to better understand each main component of a PC build.

10 Reasons to Build Your Own PC

There are many reasons for building your own PC and if you took five different builders, all five might have a completely different reason for wanting to undertake this task. Here are our top ten reasons for choosing and enjoying to build PC after PC, in all shapes and sizes, for gaming, media and work.

1. PICK EXACTLY THE COMPONENTS YOU NEED

Shop around enough and throw enough money around and you will almost certainly be able to find a pre-built PC that matches your desired spec list. However, if you have a budget, and let's face it, many of us will have, finding an off-the-shelf PC that perfectly matches your needs is quite hard. Build your own and you can pick exactly the right parts you want, to best provide yourself with the capabilities required.



2. TAKE ADVANTAGE OF DEALS

If you are clever and shop around, pick the right time to buy and are prepared to perhaps wait a while for something to be reduced, you can definitely get more bang for your buck by building your own PC. We saved over £50 on our chosen CPU simply because one of the component retailers that sends us newsletters had a flash (1 day) sale. We could have just saved the money but instead added it to our graphics card budget.

3. THE SATISFACTION FACTOR

Nowadays, many people never really get the chance to build something for themselves but there really are few better feelings, than those you get from successfully planning and building something with your own hands. Even more so, with something as seemingly complicated as a PC. Even if you do not manage to save a huge amount of money, and massive savings aren't always possible in today's world of cheaper and cheaper pre-built systems, the satisfaction you can get certainly makes up for it.

4. UNDERSTANDING YOUR PC BETTER

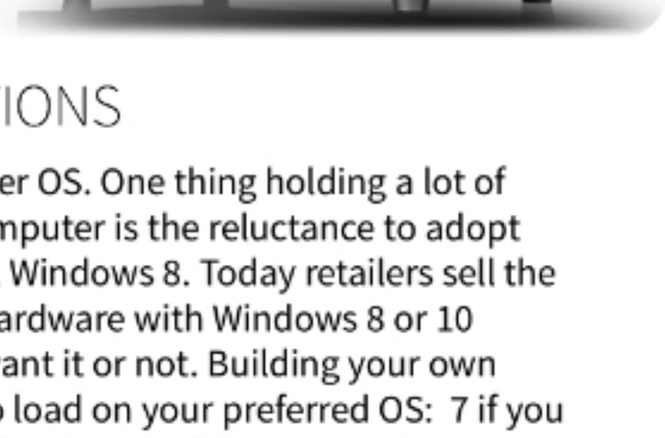
Building your own PC is a great learning process. You will learn skills and techniques that can only help you use your PC more efficiently and confidently throughout it's usable life. While you won't suddenly be an expert PC engineer, you will certainly understand how your PC works more clearly and be in a better position to notice if things go wrong later. It also makes the task of upgrading components less daunting.

5. SPREAD THE COST

If you are prepared to commit to building your own PC, you can spread the cost without resorting to getting credit. Buy a component each month for six months and you will have almost everything you need, all the major parts anyway, without having to lay out a lump sum. You can of course, buy the parts in any order but we suggest leaving the processor, motherboard and graphics card until last. These are the ones most likely to see technology updates over that time.

8. BETTER COOLING

Even fairly cheap cases now come with cable management options and with several places to add fans. This means that you can tuck away the PSU cables so that they do not impede airflow and you can add more fans later for increased cooling too. If you buy a mid-tier case, then you will typically get 2 or 3 fans, maybe more with a high-end one. Having good airflow, a good heatsink for the CPU and a graphics card with a good cooler means that all your components will be well cooled. That means better longevity.



6. AVOID BLOATWARE

When you buy a pre-made PC, especially from one of the big chain stores, it is likely to have software preinstalled. Some of this might be useful but often it is not. You will then either have to spend time cleaning this stuff off, if you are even initially aware it is there, or live with it on your PC. When you build your own PC, you choose what goes into it!

9. BETTER OS OPTIONS

You can utilise a slightly older OS. One thing holding a lot of people back from a new computer is the reluctance to adopt Windows 10 and previously, Windows 8. Today retailers sell the vast majority of their new hardware with Windows 8 or 10 preinstalled, whether you want it or not. Building your own machine offers the ability to load on your preferred OS: 7 if you would rather stick with the familiar, 10 if you are ready to make the jump or GNU/Linux if you really want something different.

ubuntu

7. PICK THE PERFECT CASE

You can buy pre-built PCs in a fairly wide range of styles, from LED-lit gaming towers to tiny media boxes. If however, you want a case that is more unusual, finding a pre-built computer is much harder. As long as you plan your build properly, you can use almost any of the thousands of different cases available, from bright orange statement towers, to camouflage painted portable LAN boxes.

10. SELF-BUILDING IS FUN!

Owning a self-built PC is great fun. The process is full of packages arriving, opening packages, putting things together and learning what goes where and why and how. Discovering a new trick for routing cables better or learning about a faster type of transfer cable becomes exciting! You will love your new rig more than you could ever love one from a store because it takes you beyond mere hardware ownership and bestows hardware familiarity.

Choosing the System Type

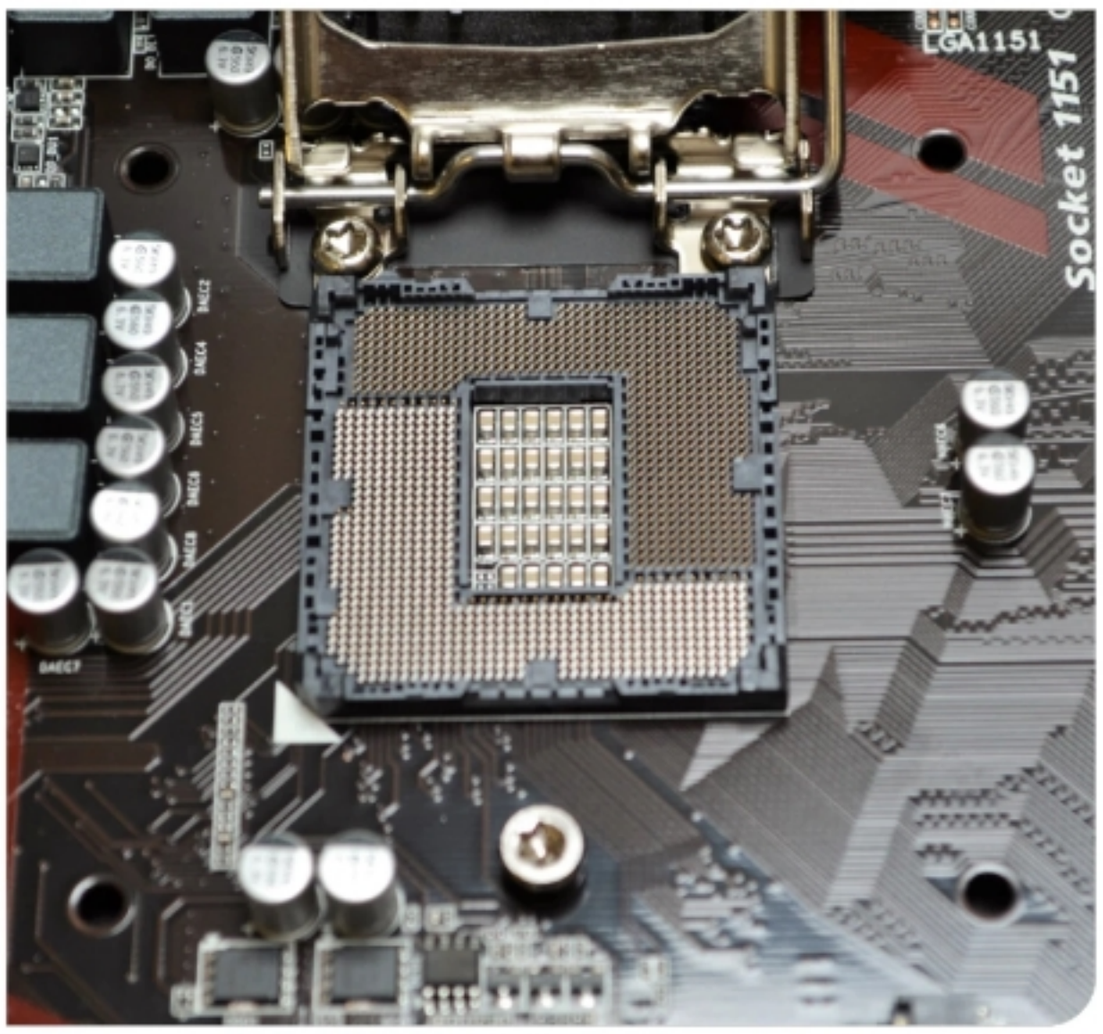
For most people who want to build their own PC, there are only two real choices when it comes to the system type, Intel or AMD. There are advantages to choosing either one of these options, which might not be immediately obvious to the very new builder. It might also not be obvious that compatibility problems can occur if you don't understand the difference between these two PC platforms. Your choice here will definitely influence every major component purchase you make later.

Why Choose Intel?

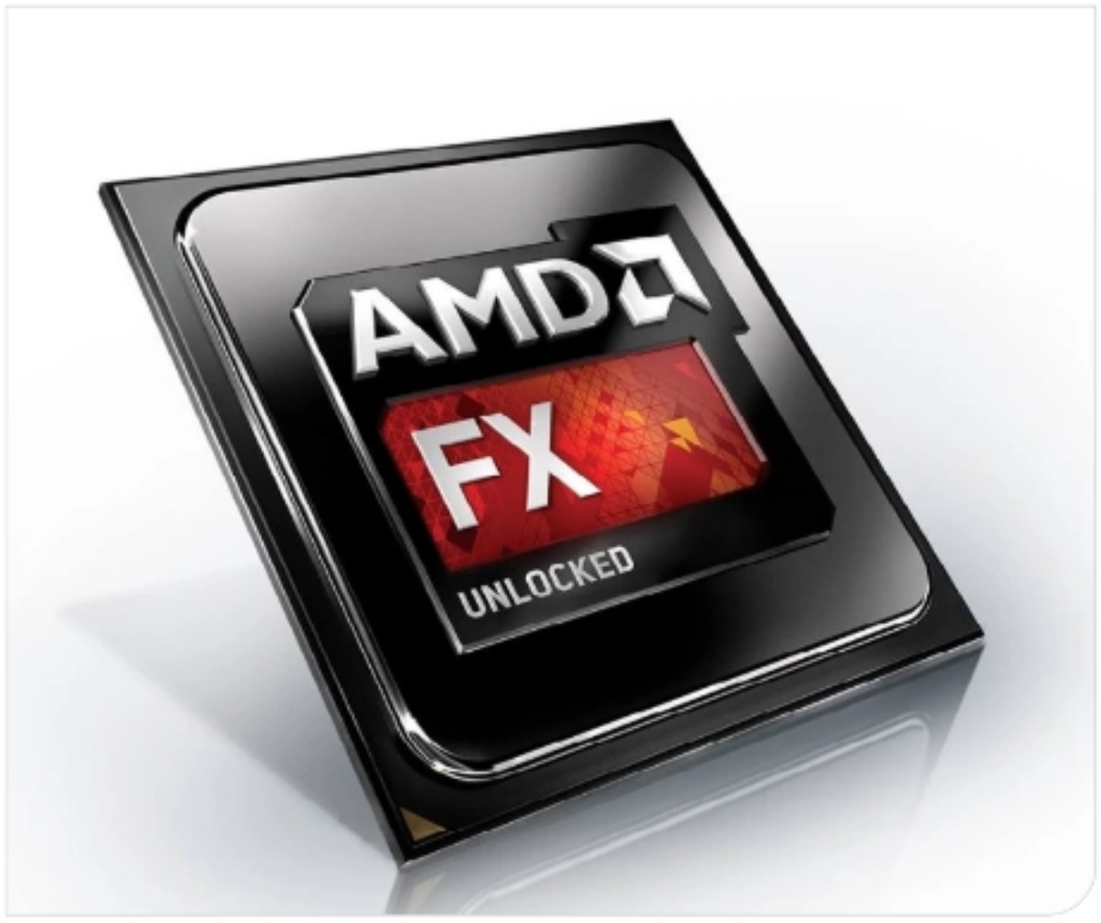
Intel is probably the better known PC platform and almost certainly has a larger following amongst PC builders around the globe. This is largely because they lead the world in processor development, offer a wider range of chips and are better supported by other component manufacturers. Although Intel's advances in CPU technology has slowed in recent years, they are still constantly improving and refining their chips.

If you are building a gaming or multimedia PC, Intel is probably the better choice and not only because their processors generally offer better speed and power, along with good overclocking properties on the K-series processors, for the money. The choice of CPU dictates the choice of motherboard (or vice versa) and some of the best gaming motherboards are made for Intel chips, so it makes sense to go down this route.

Trying to keep up with the latest developments from Intel is expensive, as you will always pay a premium for the latest chip and will also then need to make sure that you choose a motherboard with a compatible socket. However, advances in chip design also means that predecessor chips become more affordable and give you opportunities to find a powerful bargain.



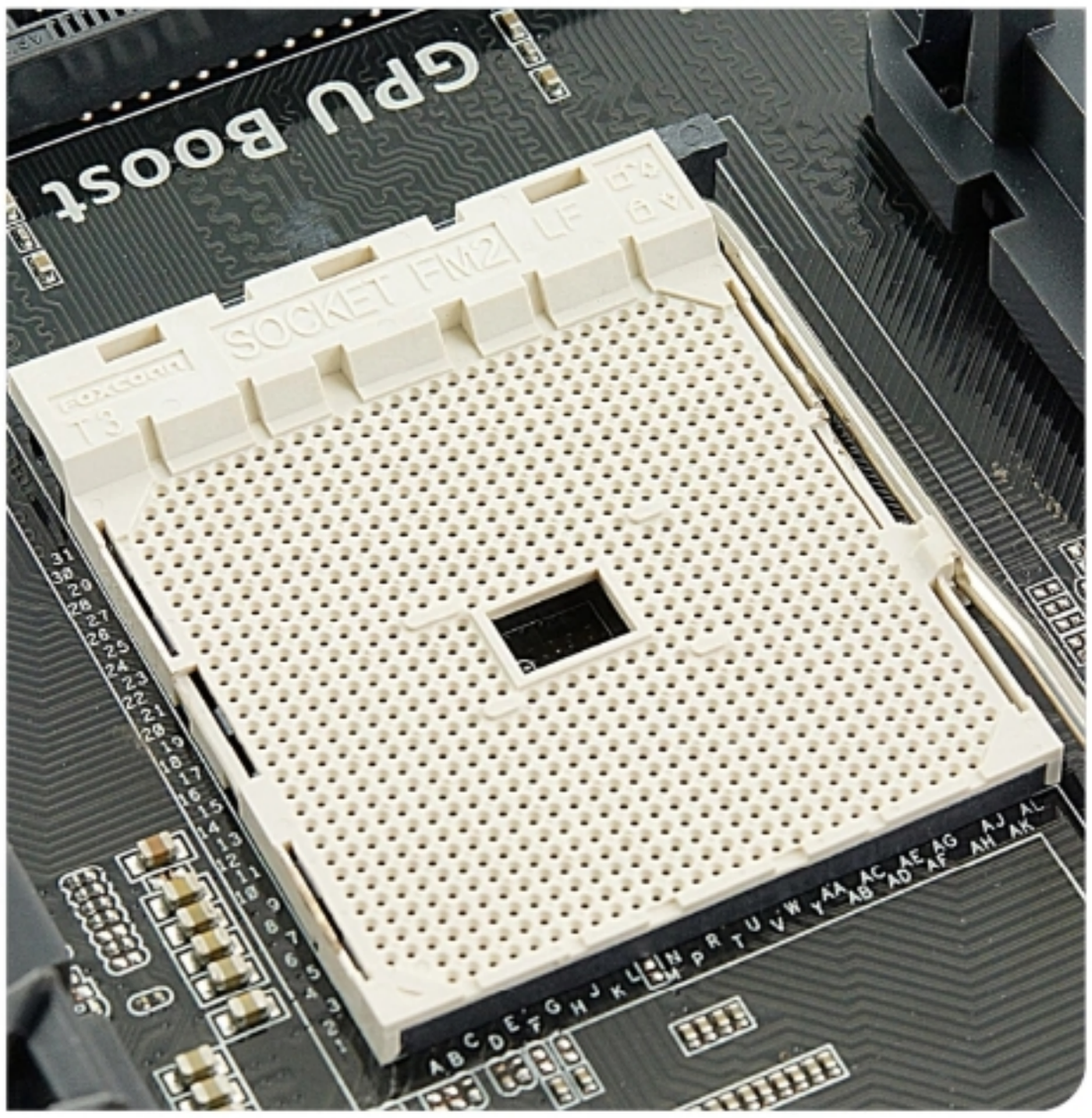
Why Choose AMD?



If you are building on a budget, or if you are not worried about your PC being able to handle more taxing processing actions such as gaming or video editing, AMD could be for you. Not only are AMD processors and motherboards usually cheaper than Intel, they also give you the option to combine the CPU and a GPU in a single unit: the APU.

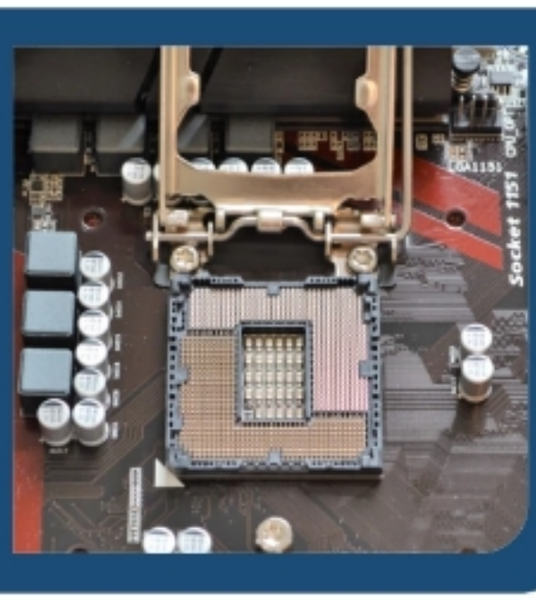
That isn't to say that AMD processors are completely unsuitable for gaming rigs, because some of the higher-end Ryzen CPUs now offer similar performance to Intel i5, i7 or even i9, but if you are going for pure power, AMD may not be the best choice. There is also a smaller choice with AMD and some of the processor architecture still available to buy is getting near to the end of its effective life.

The latest AMD gaming processors, in the AM4 Ryzen family, include something for everyone and every budget. Ryzen 3 are the cheapest and lowest-powered, followed by the Ryzen 5 and Ryzen 7. All include X versions (e.g. 2700X) which allow for overclocking. The Ryzen family also includes a high-end version called the Threadripper, which uses a different socket (TR4) to allow up to a huge 32 cores and 64 threads. AMD also recently launched the EPYC range of CPU's, although these are aimed more at servers and other HPC workloads.



PC COMPONENT COMPATIBILITY

Whichever platform you choose, and both can result in a great first PC, you need to make sure that you understand the difference between them when buying components. An Intel processor will need a motherboard with an Intel socket and the correct Intel socket for that processor, such as LGA 1155 or 2011. An AMD processor will need a motherboard with an AMD socket, such as AM3+ or FM2. You also need to be aware that the newer and more expensive the CPU and motherboard, the more features they will have. Cheaper boards, suitable for older processors, might not offer everything you need. Be aware of compatibility at every step of your planning, buying and building process and if you are unsure, check forums or contact the retailer to ensure each part will work well with the others.



Choosing a PC Case

Although they may not have seen the sort of massive changes that most other PC components have, the choice of case for your build is now much wider than it was just a few years ago. From simple black boxes, to LED-lit windowed showcases, there is a case style out there for everyone. However, choosing a case should be about more than just looks. Quality and features vary greatly and getting this key component right can mean the difference between a good and a great first build.

START BUILDING

Case: Thermaltake Core V31
Build: Turn to page 56 to start preparing your PC case

Making Your Choice

As with any purchase, there are several things you need to consider before you choose a case. Getting things wrong here could mean a difficult build or additional expense later.

CASE SIZE

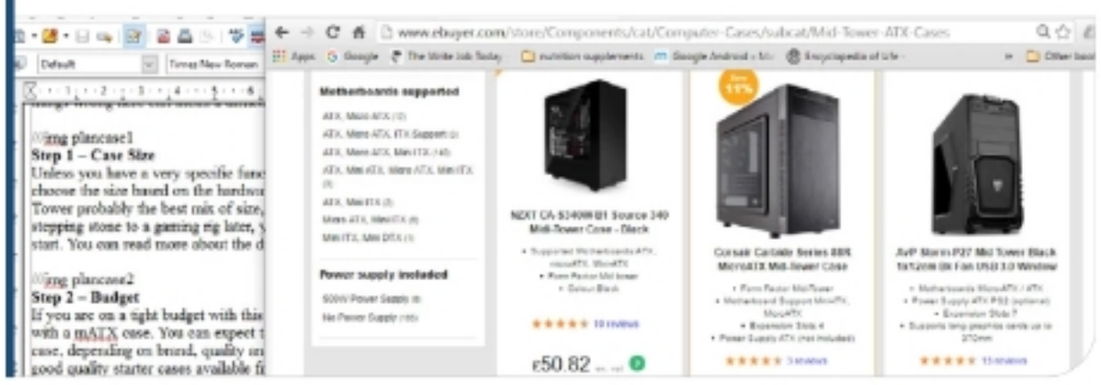
Unless you have a very specific function planned for your PC, media Box or portable, it is best to choose the size based on the hardware you want to fit inside. For most first time builders, a mid size tower is probably the best mix of size, budget and range of styles available. If your initial build is a stepping stone to a gaming rig, you might want to think about getting an E-ATX case from the start. You can read more about the different case sizes available on the next page.

STYLE

This is very much a personal choice. Some builders will like the windowed, vented and LED-lit gamer-style cases; others will prefer the understated black box style. There are cases in almost every style imaginable but just make sure that you don't choose style over substance. If a case is cheap but seems to have a lot of external design elements, it could well be that the quality on the inside is lacking. Our Thermaltake Core V31 is a nice mix of understated and modern gamer, with a window to show off the inside, a sleek mesh front and great build quality and all for just £40 ($45).

BUDGET

If you are on a tight budget with this build, you are probably going to get better value for money with a mATX case. You can expect to pay anything from £25 to £300 ($30 to $350) for a mATX case, depending on brand, quality and features. You really don't need to spend a fortune, as really good quality starter cases are available from around £40 ($45). You can expect to pay closer to £100 ($115) for a half decent E-ATX case and double that for a high-spec one. Our advice is to go for a cheaper big name case: Thermaltake, Coolermaster, Corsair, Antec etc. rather than a flashy one from a lesser-known brand.



FEATURES

Although this should probably be higher up the list, we have found that it usually isn't. It is very easy to find two very similarly priced and externally styled cases that differ hugely in the more technical features they provide. A good case should, in our opinion, include at least two 120mm or 140mm fans, a usable front panel with USB, audio etc. and should be made mainly of metal. Be careful that the metal isn't wafer thin though. It should ideally be toolless and have removable drive bays too.

CASE AND PSU

As you browse the online stores for a PC case that suits your needs and wants, you will likely see cases that come with a PSU. These can seem like good value but our advice is to be wary. Cases that are bundled with a power supply usually fall more into the budget category, as does the power supply that is thrown in. You can shave your budget slightly by buying like this but just be cautious and check the spec of each before you buy.

PC Case Sizes

There are several different case sizes available, from Mini ITX to full tower. Styles and sizes vary within these form factors but certain rules always apply.

FULL TOWER (E-ATX)

Full tower, or Extended ATX, cases are generally larger than the standard ATX cases and almost always the most expensive off-the-shelf cases you can buy. E-ATX cases are mostly designed to be gaming or server cases, with lots of room inside for massive graphics cards (some high end GFX cards are up to 30cm long), water cooling radiators and case fans. Full tower cases usually have more expansion slots at the back, at least two, and up to four, front fans and a side panel window. These large cases are normally only suitable for E-ATX and ATX motherboards.

MICRO ATX

Micro ATX, which are often labelled as mATX or cube cases, are perfect for those with a lack of space and who don't need to fit high end GFX cards, water cooling, etc. Just as with any other type of case, mATX cases are available in a range of styles and at a range of prices. Smaller doesn't need to mean cheaper and less innovative. Building a PC with a mATX case takes a bit more planning than the previous two sizes we have discussed. Most graphics cards that will fit in an ATX or E-ATX case, without you having to think about it, won't fit in many mATX cases. The same applies to large CPU coolers.

MIDI TOWER (ATX)

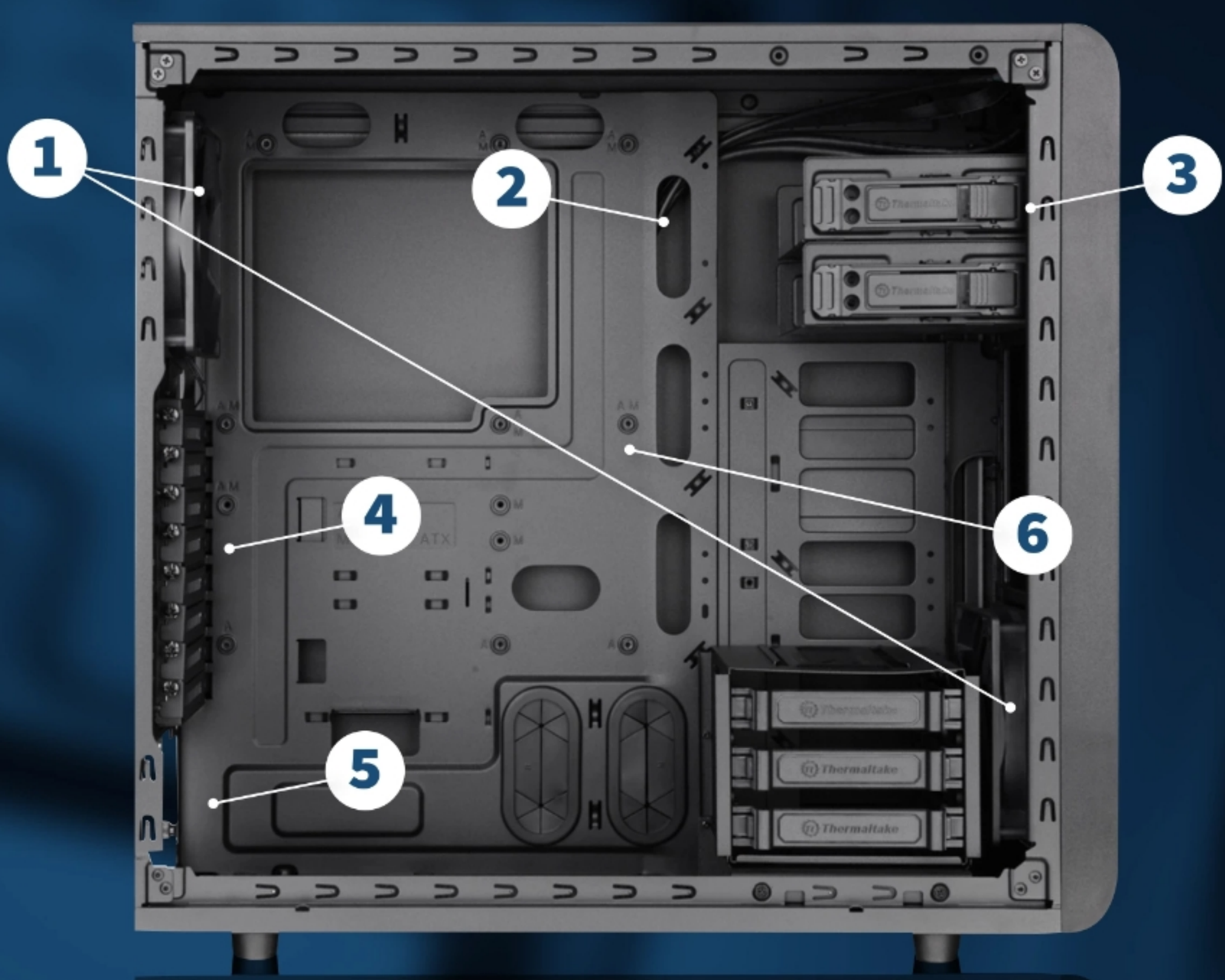
Midi tower or mid tower were originally known simply as tower or ATX cases but since the arrival of E-ATX, the more descriptive name is used to show that they are between full and mini towers. Mid tower cases are where you will find the most choice, and probably the best value for money. You can spend a little or a lot and as long as you choose carefully, still get a case perfect for your build. ATX cases will usually accept ATX, Mini ATX and Micro ATX motherboards but it is worth double-checking before purchase. Our case is a midi tower.

MINI ITX

The smallest of the four main case form factors, ITX or Mini ITX are most often cubes but you can also find some that are like mini tower cases. These allow for very compact builds, for media PCs and often include features that allow them to be moved around easily with carrying handles, etc. You will have to use a special ITX motherboard with this type of case but you should be able to fit a mid-size graphics card into many of them. The ITX form factor is a fairly recent addition to the PC case ranges and because they are quite specialist, your choice of styles will be slightly more limited than with more common sizes.

Inside Your Case

Here we take a look inside the Thermaltake Core V31 case that we are using in our build and check out some of the features that made us choose it.



1 PREINSTALLED FAN

The Core V31 comes with two fans installed, one at the front and one at the back, both of which are important for airflow. There are mounting holes for two more.

2 CUT OUTS FOR CABLES OR PIPES

As you can see, the back (or side) panel of our case is full of cut outs, ideal for managing all of the power cables or water cooling pipes we could possibly need.

3 TOOLLESS DRIVE TRAYS

The optical drive tray at the top and the HDD tray at the bottom are both toolless designs, so no screws to undo. Both of these trays can also be moved or removed as required.

4 EXPANSION SLOTS

The case provides the standard eight expansion slots that ATX cases usually have. These, like all other parts of the case, are toolless and held in place by thumb screws.

5 VENTED PSU MOUNT

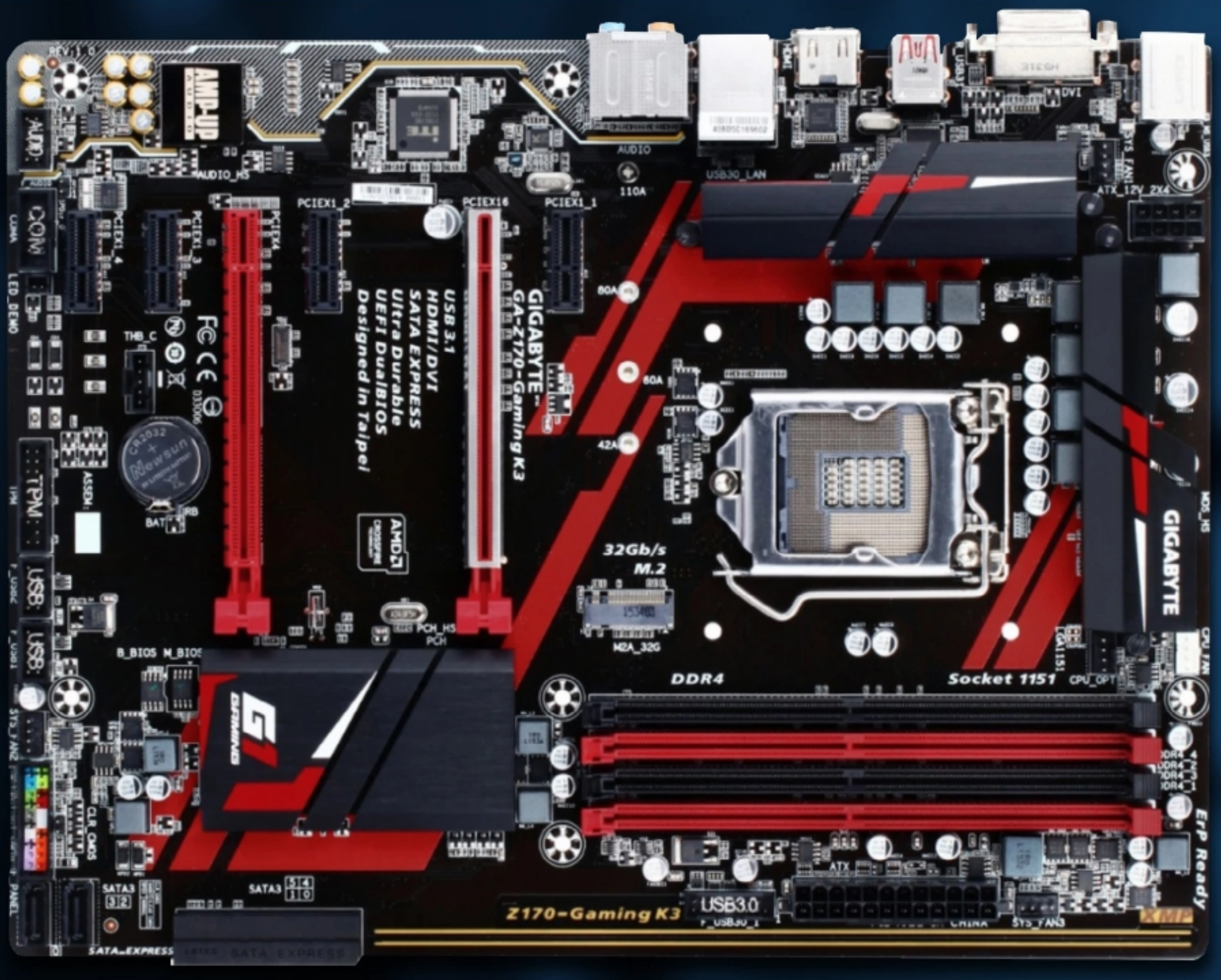
This case positions the power supply at the bottom; some cases put this at the top. What you can't see in this image are the air intake vent and rubber anti-vibration mounts.

6 ATX AND MATX

As you can see this case provides mounting for two sizes of motherboard, ATX and Micro ATX, simply by moving the risers to the required positions.

Motherboards

It might seem that your choice of motherboard is fairly straightforward; Intel or AMD compatible, depending on the CPU you are going to use. However, if you want to get the best out of your new PC, you really need to choose a motherboard based on your main usage aims. A gaming motherboard will offer very different features to one designed for general use or office work. Over the next few pages we will look at the many different motherboard options available to you.



START BUILDING

Motherboard: Gigabyte Z170-Gaming K3 (Intel, ATX)
Build: Turn to page 68 to start installing your motherboard

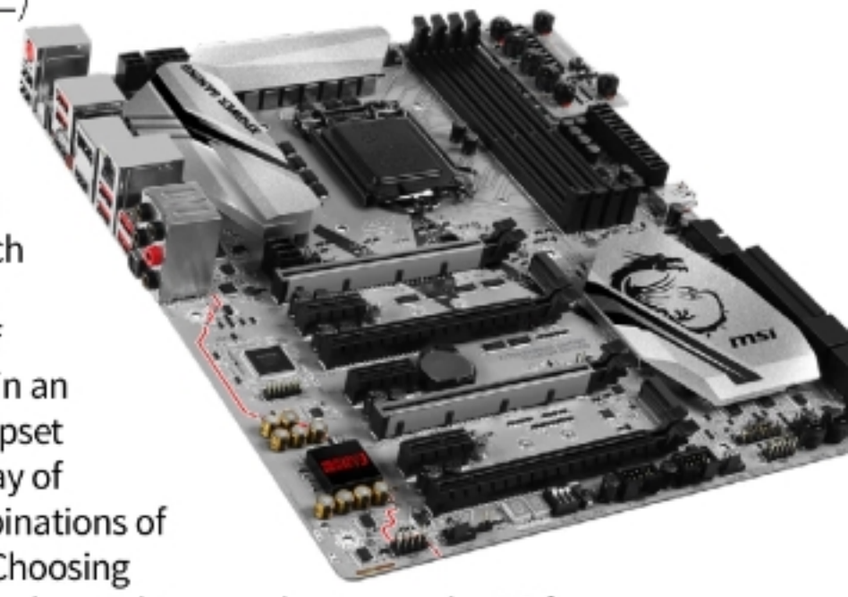
Choosing a Motherboard

The motherboard (or mainboard) in your PC is the foundation of everything else you plan to add, so it makes sense to ensure you choose the best one possible.

INTEL OR AMD

Your only real choice of processor is going to be between Intel and AMD and so your choice of motherboard is going to be based initially, on which processor type you have decided to go with. Intel are the market leaders, with the fastest and most powerful processors among their range. However, AMD make some very good processors and they tend to be considerably cheaper; so if you are on a very tight budget, this could be an option. Once you have decided which to use, your search for a motherboard can be narrowed down slightly.

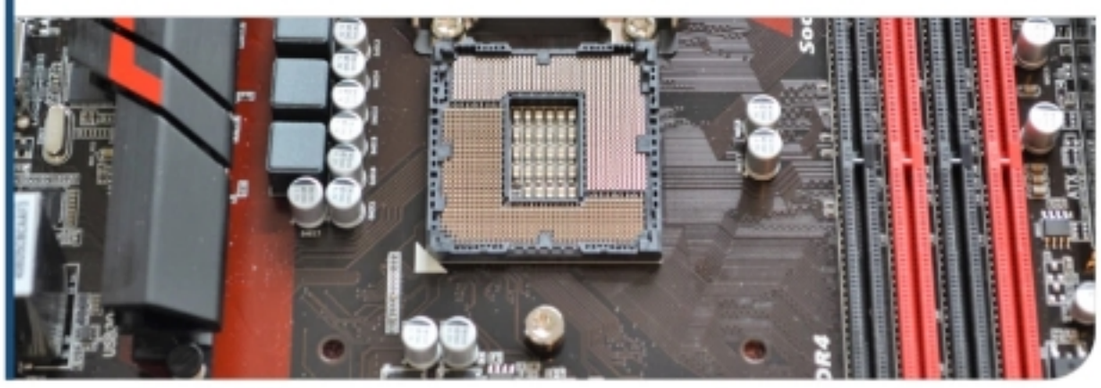
CHIPSET (INTEL)



Assuming you have chosen to build with an Intel CPU, the next step to narrowing down your motherboard search is to choose a chipset. A chipset is simply a set of electronic components in an integrated circuit, so chipset types are really just a way of denoting different combinations of motherboard features. Choosing between them is usually about what you plan to use the PC for mainly. Gaming chipsets like Z170 and Z97 Express tend to allow overclocking and multiple graphics cards. H chipsets (H97, H110, etc.) are usually more mainstream, losing the overclocking feature for example. Q and B chipsets are aimed more at business or non-media builds.

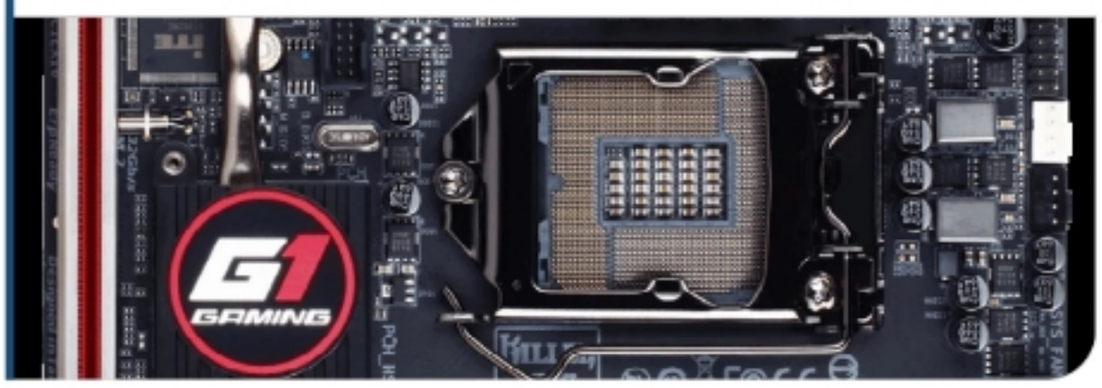
SOCKET TYPE

Although all processors might look, on the outside, pretty identical they are almost continually being improved and updated, and will only fit into certain sockets. Once more your motherboard choice is going to be dictated by the processor you plan to use. We are using an Intel Core i5-6600K processor in our build, so our motherboard had to have an LGA 1151 socket. It wouldn't have fitted into the slightly newer LGA 2011 socket used by an Intel Core i7-6800K. AMD use a different but similar system. Here your choice will be between AM1, AM3+, FM2 and FM2+. Whichever you go for, make sure the motherboard socket matches your CPU, or it will be an expensive mistake.



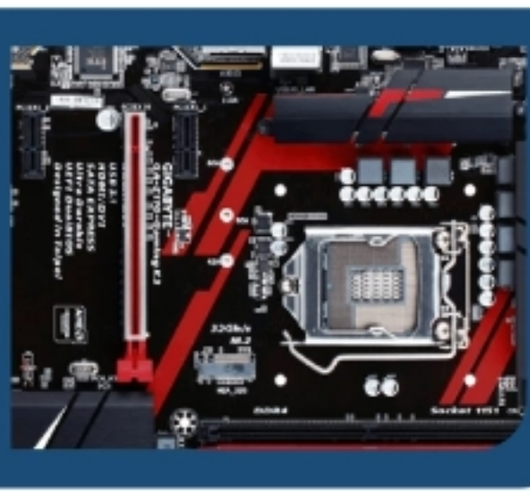
FORM FACTOR

Hopefully you now know the socket and chipset type you want your motherboard to have, so now it is time to decide on the size or form factor of the board. Motherboards are unequally divided into four main sizes (largest to smallest): E-ATX, ATX, mATX and ITX (or Mini ITX). Whilst it is possible to find boards in each size with a full complement of features, this is more about matching the motherboard to the case you are using, or vice versa. E-ATX boards will only fit in E-ATX cases; ATX will fit in ATX and often E-ATX; mATX will fit in ATX and mATX cases; and ITX normally only fits in ITX cases. ATX is the most standard of the sizes, so you will have a better choice and be more likely to get a good deal.



MOTHERBOARD FEATURES

Most current motherboards offer a broadly similar range of sockets, ports and features. Most if not all, will include multi-channel on-board audio, multiple SDRAM sockets, PCIe sockets, basic on-board graphics, LAN port, HDMI and DVI support, and much more. However, and as with everything, the more you spend the more you can expect. Gaming motherboards may feature lighting and on-board cooling; media boards may give you 7.1 channel HD audio and extra USB 3 connections. Think about what you want to do with your PC and try to find a board that offers the level of features you want.

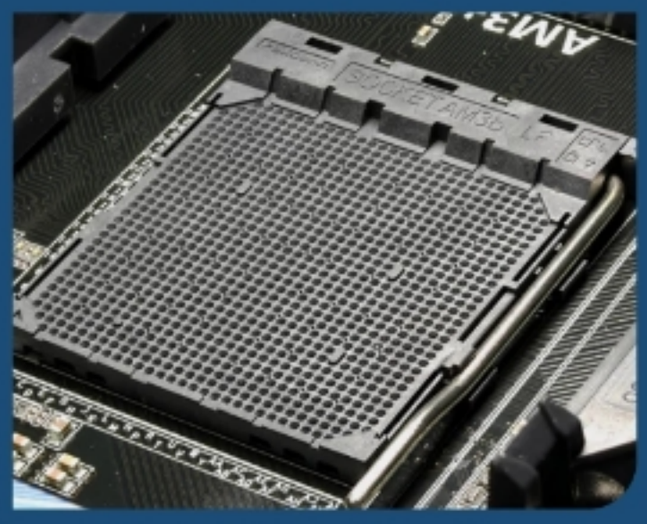


CPU SOCKET COMPARISON

Intel and AMD processors use completely different types of socket, so an Intel CPU won't fit into AMD motherboard.

Intel LGA 1151 Socket
Intel processors are built with the contact pads on the bottom of the chip and the pins that connect to those contacts are in the socket on the motherboard.

AMD AM3+ Socket
AMD processors are made the other way around, with the pins on the bottom of the processor, which fit into individual contact points in the motherboard socket.



Recommended Minimum Specification

The motherboard you choose for your build needs to be up to a variety of tasks, be able to support a number of components and be suitable for your daily use. The exact specification you need may well be different to the specification another builder needs but there is certainly a base level of features you should look out for when you make your choice.

GAMING/MEDIA BUILD

With a gaming or media build, you'll be needing support for HD displays, faster memory, etc.

- 4 x DDR3 or DDR4 DIMM sockets supporting up to 64 GB of system memory
- Dual channel memory architecture
- Support for DDR3 1600/1333 MHz memory (minimum)
- Support for Extreme Memory Profile (XMP) memory modules
- Integrated Graphics Processor - Intel HD Graphics support
- Sli or CrossFire Support
- 1 x D-Sub port, 1920x1200@60 Hz
- 1 x DVI-D port, 1920x1200@60 Hz
- 1 x HDMI port, 4096x2160@24 Hz
- High Definition Audio 2/4/5.1/7.1 channel
- High Speed LAN chip (10/100/1000 Mbit)
- 1 x PCI Express x16 slot, running at x16 (PCIEX16)
- 1 x PCI Express x16 slot, running at x4 (PCIEX4)
- 2 x PCI Express x1 slots
- 2x PCI slots
- 1 x M.2 Socket 3 connector
- 3 x SATA Express connectors
- 6 x SATA 6Gb/s connectors
- Support for RAID 0, RAID 1, RAID 5 and RAID 10
- up to 8 x USB 3.0/2.0 ports
- 6 x USB 2.0/1.1 ports

WHAT IS BIOS?

The BIOS (Basic Input/Output System) is an often overlooked but absolutely vital part of your computer system. The BIOS is particular to each type of motherboard and is provided by the motherboard manufacturer. You see it every time you switch your computer on and it's responsible for those lines of text that flash up on the screen before Windows launches, listing things like installed RAM and other hardware details.

It's the core software of your system and boots up the computer, launches Windows and in some cases allows Windows and other apps to access things like hard drives, the keyboard, USB connections and other hardware components. The BIOS is built in to your system and is stored on a type of flash memory chip on your computer's motherboard. For this reason it is often referred to as "firmware", since it is in part both software and hardware.

You can see which version of the firmware your particular motherboard ships with by looking for the label printed on the board itself. You can then check on the manufacturer's website to see if you will need to update the BIOS after installation.

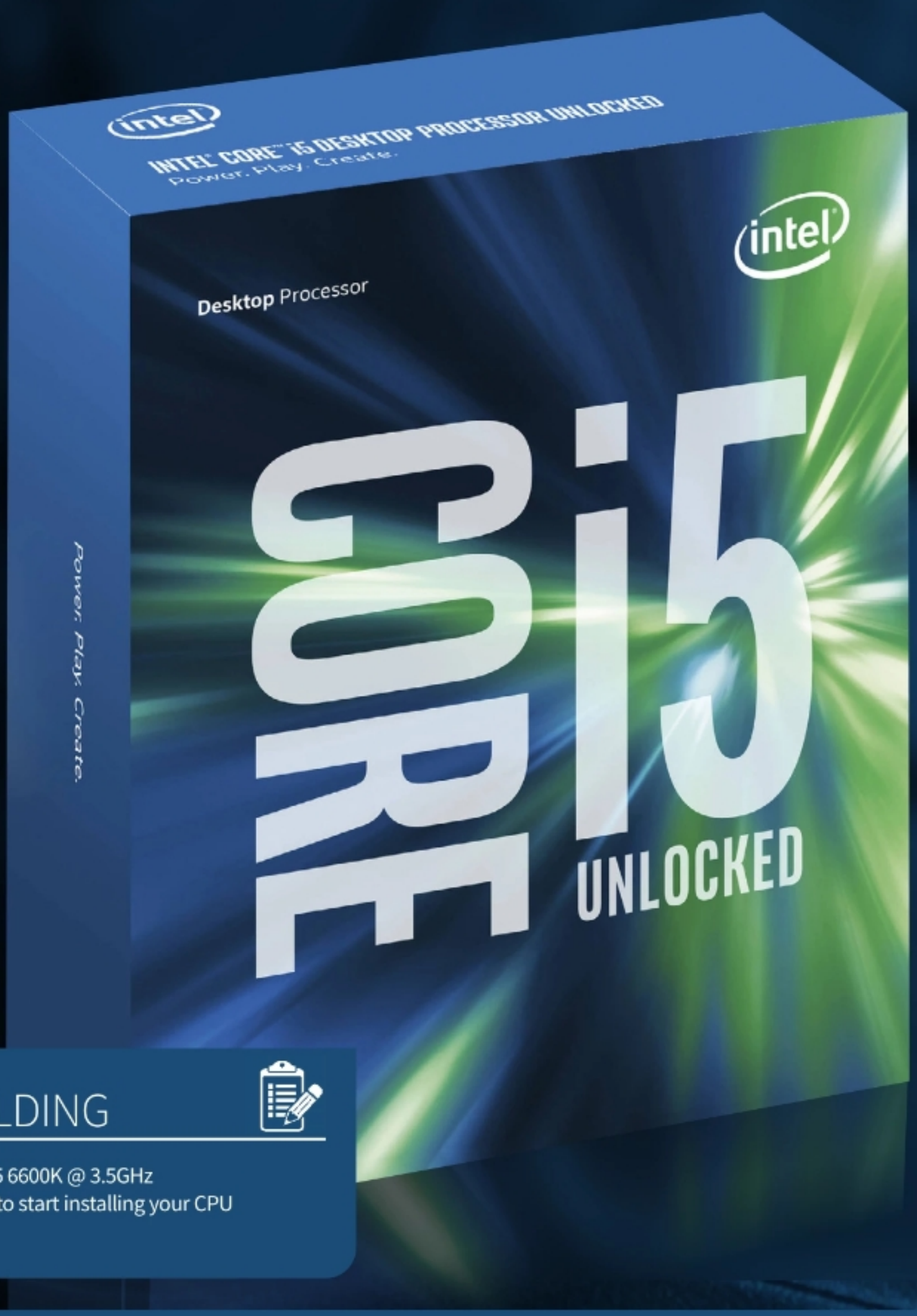
GENERAL/BUSINESS BUILD

Although a motherboard designed for gaming will work in a general build, if you don't plan on doing any gaming, you can save money on those features.

- 2 x DDR3 DIMM sockets supporting up to 32 GB of system memory
- Dual channel memory architecture
- Support for DDR3/DDR3L 1600/1333 MHz memory modules
- Support for ECC UDIMM 1Rx8/2Rx8 memory modules (operate in non-ECC mode)
- Support for non-ECC UDIMM 1Rx8/2Rx8 memory modules
- On-board Graphics - Integrated Graphics Processor
- 1 x D-Sub port, supporting a maximum resolution of 1920x1200@60 Hz
- 1 x DVI-D port, supporting a maximum resolution of 1920x1200@60 Hz
- High Definition Audio 2/4/5.1/7.1 channel
- Support for S/PDIF Out
- High Speed LAN chip (10/100/1000 Mbit)
- 1 x PCI Express x16 slot, running at x16 (PCIEX16)
- 1 x PCI Express x1 slot
- 2 x PCI slots
- 4 x SATA 6Gb/s connectors
- 4 x USB 3.0/2.0 ports
- 8 x USB 2.0/1.1 ports

Choosing a Processor

The CPU (Central Processing Unit) of your computer is likely to be the most expensive single component, especially if you are trying to future-proof your build as much as possible. When it comes to choosing a processor, faster and newer is almost always better. However, does the average PC builder really need a 4GHz Core i7? Does having a faster CPU always mean having a faster computer overall? What is hyper-threading? Read on to find the answers to these questions and many more.



START BUILDING

Processor: Intel Core i5 6600K @ 3.5GHz
Build: Turn to page 62 to start installing your CPU

Making Your Choice

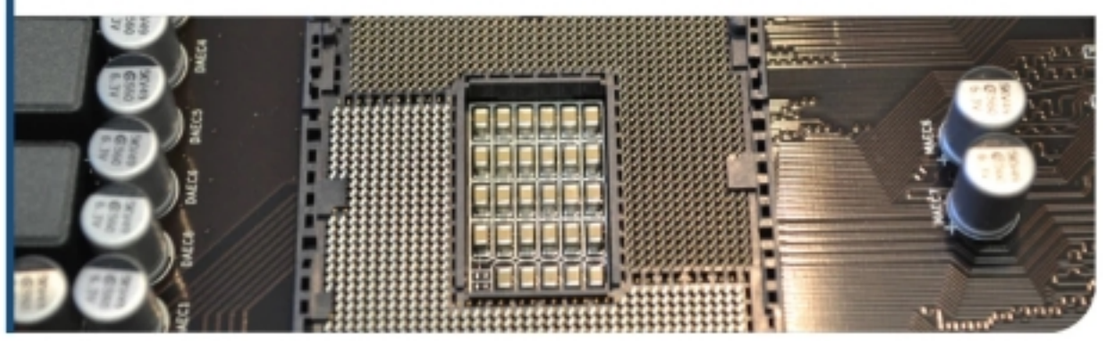
For many PC builders the choice of processor is key to the whole project and will largely dictate the rest of the components required.

INTEL OR AMD

Although your only two choices of processor manufacturers are Intel or AMD, there are several different categories of processor from each of these chip makers. Intel is by far the market leader, offers the widest range both in terms of speed/power and price and tends to be ahead in terms of features and technological advances. AMD make some great processors too and they are generally cheaper to buy, and a good choice if you are on a very tight budget. Our choice, and our recommendation, is Intel. More specifically one of the Skylake Core i5 range that offers good speed, power and value for money.

SOCKET TYPE

As processors improve, the number of pins or connectors usually increases as well. This means that an Intel processor designated LGA 1150 (the Haswell family) won't fit into a socket designed for a LGA 2011 (the numbers here refer to the number of pins on the chip). These are called processor generations and it is always better to buy the newest generation if you can afford it. This provides a degree of futureproofing but probably won't be the best value for money. You can only futureproof so much anyway. If you plan to have your computer for more than a couple of years, it is unlikely that any CPUs released after this time will fit anyway. Just ensure that the processor you choose matches the motherboard socket or vice versa.

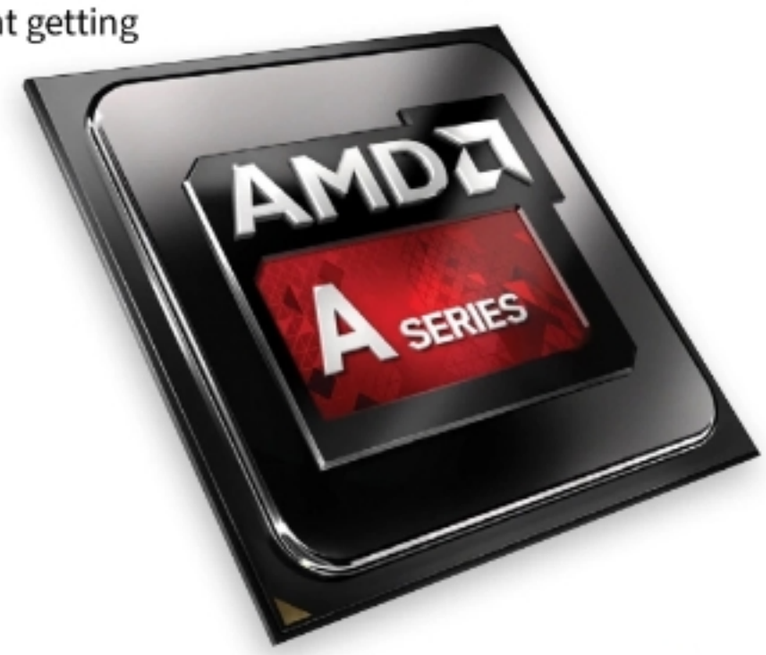


PROCESSOR SPEED

Both Intel and AMD processors are sold as being a certain speed. Our Intel Core i5 runs at 3.5GHz but as it is a K model, it is possible to overclock it using additional software. The speed of a processor refers to Clock Speed or Clock Rate, which used to be a simple way to compare two different chips. Faster clock speed meant a faster chip and this is still true if comparing two chips from the same family (two Intel Skylake CPU's for example). As a general rule go for the CPU with the fastest speed in the family you want to use. Just be aware that higher clock speed also means higher price, possibly with only a small performance increase.

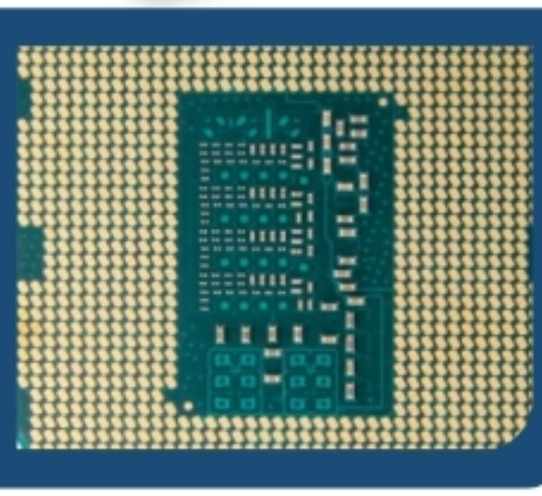
CPU OR APU

CPUs, or Central Processing Units, have been the norm in computers for a long time, but a couple of years ago AMD launched a range of APUs. APU, or Accelerated Processing Unit, is a processor and graphics accelerator on a single chip. The PlayStation 4 and Xbox One both use a type of APU. The latest version of the AMD APU is called Carrizo. For most general builds, we would suggest that getting a dedicated graphics card is a better option but if you are on a very tight budget, this can make sense. It is also an option if you are building a very small ITX-based computer such as a media box.



WHAT'S NEXT FOR CPU'S?

As mentioned previously, trying to keep up with the latest processor generation is about as easy as herding kittens. It is also an expensive proposition but that doesn't mean that it isn't worth keeping an eye on what the market is doing. When new generations are released, the generation that went before normally drops in price quite quickly, meaning that there are good deals to be had. The next generation of Intel processors is codenamed Kaby Lake and due to arrive in late 2016. AMD's newest chip generation will be called Zen, also due at the end of the year.



The Processors we Considered

These are the four processors we considered while planning our PC build, two from Intel and two from AMD, with their relative strengths and weaknesses.

AMD RYZEN 5 2400G

FROM: £146.00 $180.00 €145.00

Pros

- Budget quad-core CPU
- Low power usage
- Built-in Vega 11 GFX

Cons

- Only 4MB L3 Cach
- Not built for gaming
- No overclocking

AMD RYZEN 7 2700X

FROM: £290.00 $310.00 €290.00

Pros

- 8 cores and 16 threads
- High turbo clock speed
- Wraith cooler included

Cons

- Too expensive for budget
- Some gaming limitations
- High power usage

INTEL CORE I7 6700 3.4GHZ

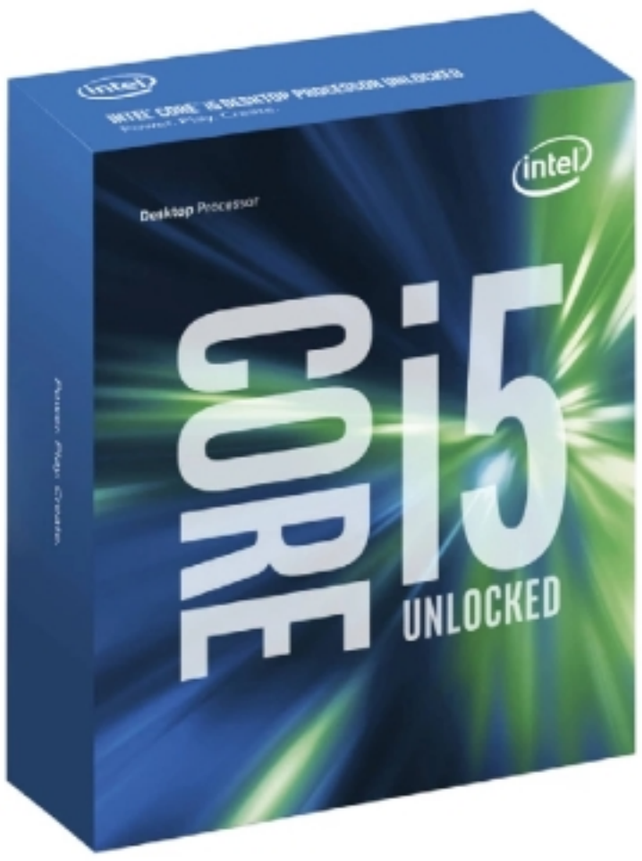
FROM: £270.00 $305.00 €300.00

Pros

- Good clock rate
- Supports hyper-threading
- Low power requirements
- Latest generation Intel

Cons

- Too expensive for the budget
- Locked clock rate



INTEL CORE I5-6600K 3.5GHZ

FROM: £150.00 $180.00 €175.00

Pros

- Good value for speed
- Intel Skylake
- Unlocked clock rate
- Good benchmarks

Cons

- Can run slightly hot
- Only 6MB L3 Cache

DO YOU NEED HYPER-THREADING?

The answer to that question depends very much on what you plan to be doing on your computer in the future. Intel Hyper-Threading Technology (or HT Technology) uses processor resources more efficiently, enabling multiple threads to run on each core. As a performance feature it also increases processor throughput, improving overall performance on threaded software.

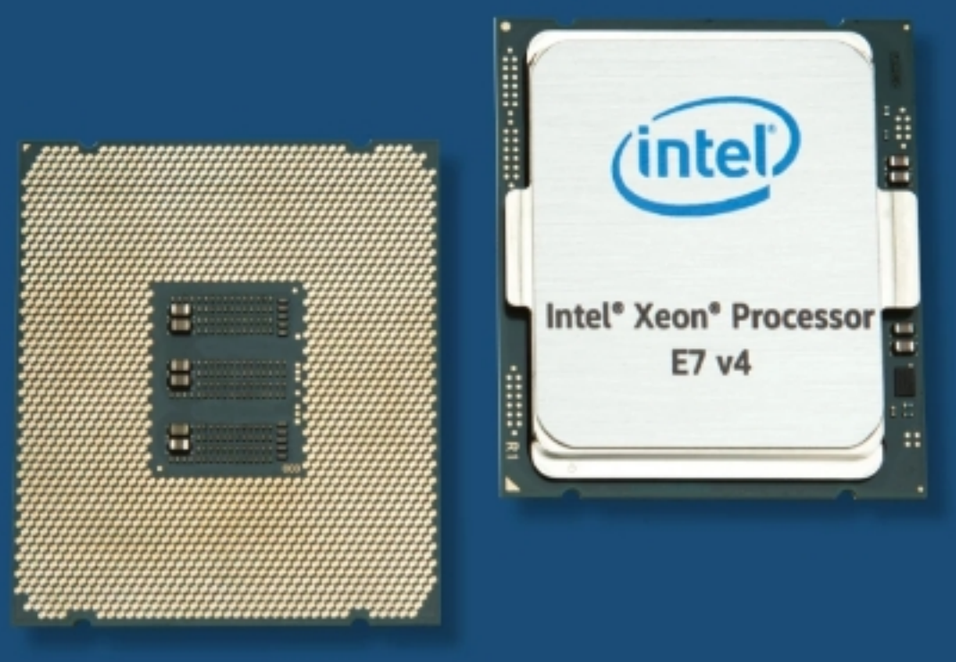
Intel HT Technology is available on the Intel Core processor family, the Intel Core M processor family and the Intel Xeon processor family. By combining one of these Intel processors and chipsets with an operating system and BIOS supporting hyper-threading, you can run demanding applications simultaneously whilst maintaining system responsiveness. Then create, edit and encode graphically intensive files while running background applications, such as virus protection software, without compromising system performance.

MULTI-CORE CPUS

Processing performance of computers is increased by using multi-core technology. This essentially is plugging two or more individual processors (called cores in this sense) into one integrated circuit. Ideally, a dual core processor would be nearly twice as powerful as a single core processor. In practice the performance gain is far smaller, only about 50%, due to imperfect software algorithms and implementation.

Increasing the number of cores in a processor, dual-core, quad-core, etc. increases the workload that can be handled. This means that the processor can now handle numerous asynchronous events, interrupts, etc. which can take a toll on the CPU when overwhelmed.

These cores can be thought of as different sections in a factory, with each section handling a different task. Sometimes, these cores will handle the same tasks as cores adjacent to them if a single core is not enough to handle the information.



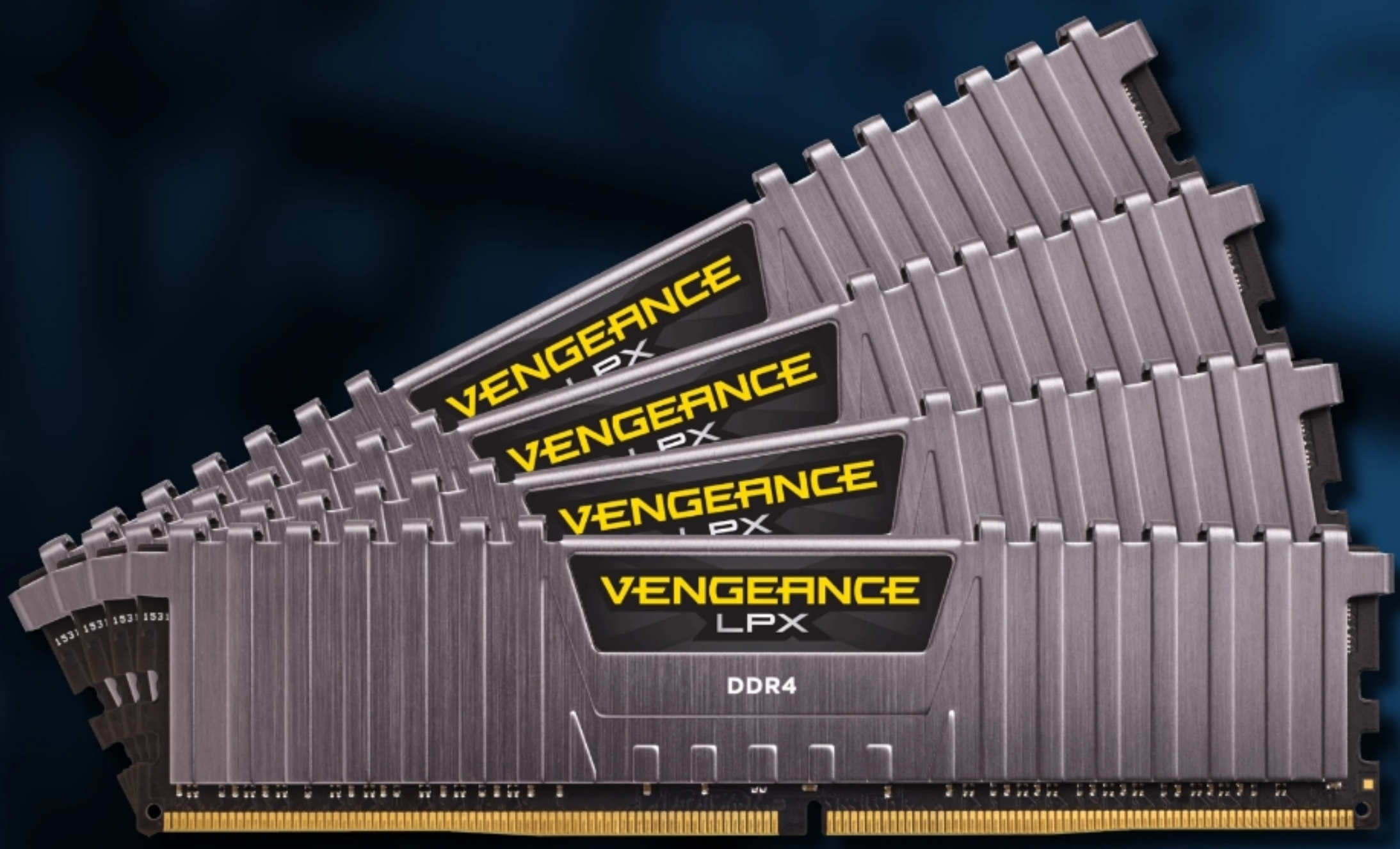
OVERCLOCKING THE CPU

Most modern CPUs have their clock rate locked, so that they cannot go over a certain speed and burn out. However, understanding the need for some PC builders to want to tinker with every component, there are CPUs available in each generation which have their clock rate unlocked. For both Intel and AMD chips, this is shown by a K in the name (such as our i5 6600K) and AMD often call CPUs that can be overclocked “Black Edition”.

Overclocking has been made easier in recent years by the release of overclocking software and tools. It is, however, not something that the novice PC builder should try without some serious research and after taking every possible precaution. This would include having a third-party CPU cooler installed, which you can read more about later in this guide.

The Right RAM

A fast and easy way to add a performance boost to your PC is to install high quality, fast RAM (Random Access Memory). DDR4 is the latest variation of PC memory and is the fastest and most efficient yet but just like many other components in your build, RAM isn't quite as simple as it might at first seem. Different motherboards support different maximum amounts, as do different operating systems and it is available in many different speeds and configurations.



START BUILDING

RAM: 16GB Corsair Vengeance DDR4 2133MHz
Build: Turn to page 66 to start installing your RAM

Making Your Choice

A lack of RAM has the potential to be a real power and speed bottleneck for your PC build, so getting it right is just as important as choosing the right CPU or graphics card.

HOW MUCH RAM?

Before we even look at speeds and channels, we should look at exactly how much RAM we need and how much our build can support. First stop should be the motherboard information sheet or website, as this will show the maximum amount of RAM it can take. General purpose motherboards might have two slots and a maximum of 16GB, whereas a media or gaming motherboard will normally have four slots, capable of taking 32-64GB. Next you need to check what your planned OS can support (see the table below). We recommend no less than 8GB but ideally 16GB, of fast SDRAM.

RAM SPEED

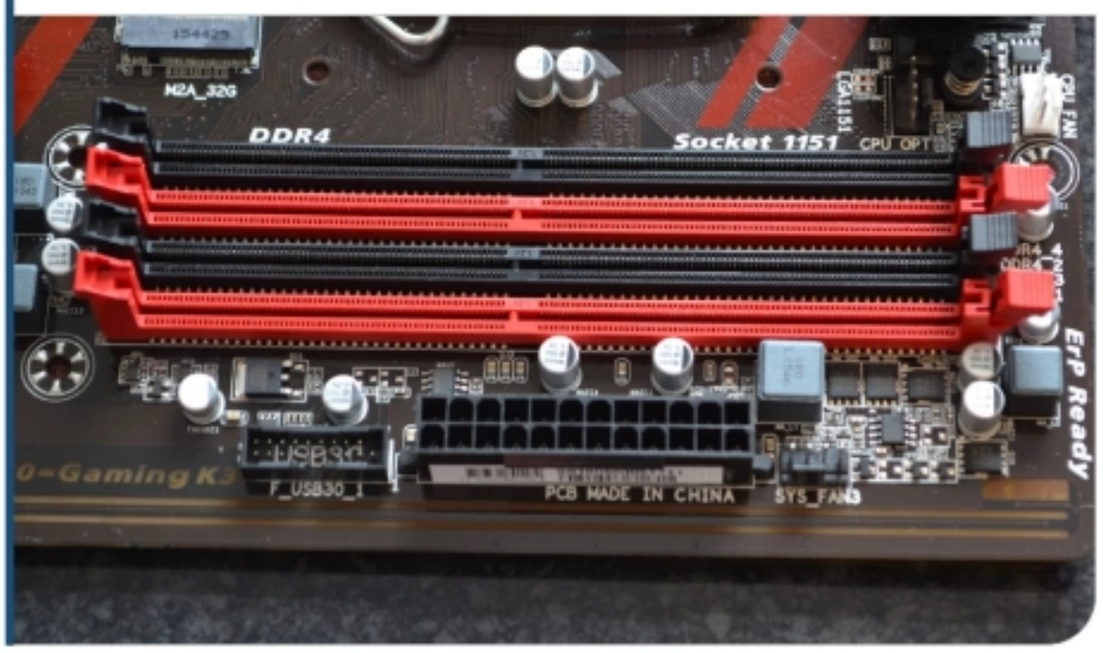
RAM is often talked about as if just putting more into your computer will magically make it run faster and smoother. This simply isn't the case. It is true that the RAM that is installed can be a performance bottleneck but just adding more isn't a guaranteed fix. If your motherboard supports it, it is probably better to have a single 8GB module of DDR4 3400MHz than 12 or 16GB of DDR3 1866MHz spread over two or three modules. If your motherboard and BIOS supports it, it can also be worth looking for SDRAM, as this will automatically overclock. If you do follow this route, make sure that the DIMM has a heat spreader.

DOUBLE DATA RATE

Double Data Rate or DDR memory has been the norm in PCs for more than 15 years. Each version of the DDR memory standard has improved on the last, with the current version being DDR4. Assuming that the motherboard you have chosen to use is fairly recent, your choices will be DDR3 or DDR4. There is not a huge performance increase between DDR3 2000MHz and DDR4 2133MHZ, so if you are planning to use the slowest DDR4, it might be better value to get the fastest DDR3. If your motherboard supports it however, DDR4 can go up to as high as 3400MHz; then you really will see a performance boost.

MATCHED PAIRS

Dual-channel architecture is a motherboard technology that essentially doubles the amount of available memory bandwidth. It's generally a good idea to match the two memory modules for best compatibility and many modules are sold as paired kits. If one module is rated at a slower speed than the other, for example if one is 1600MHz and the other is 2133MHz, both will run at the slower speed in dual-channel mode. If you're installing four modules they don't all need to be identical but make sure pairs match up accordingly and are installed in their respective slots. If your motherboard supports dual-channel the slots will be colour-coded.



WINDOWS MEMORY LIMITS

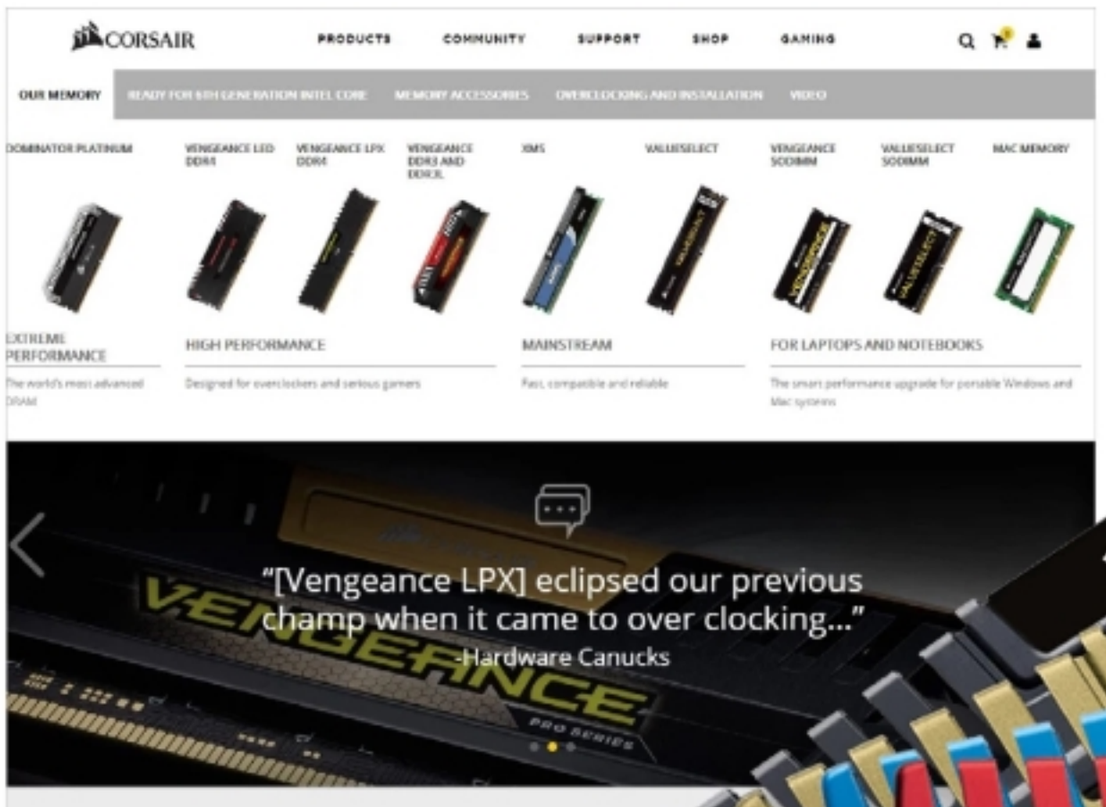
Assuming you are planning to install a 64-bit version of Windows on your new computer, you don't really need to worry about OS limits. If however, you are installing a 32-bit version, limits very much apply.

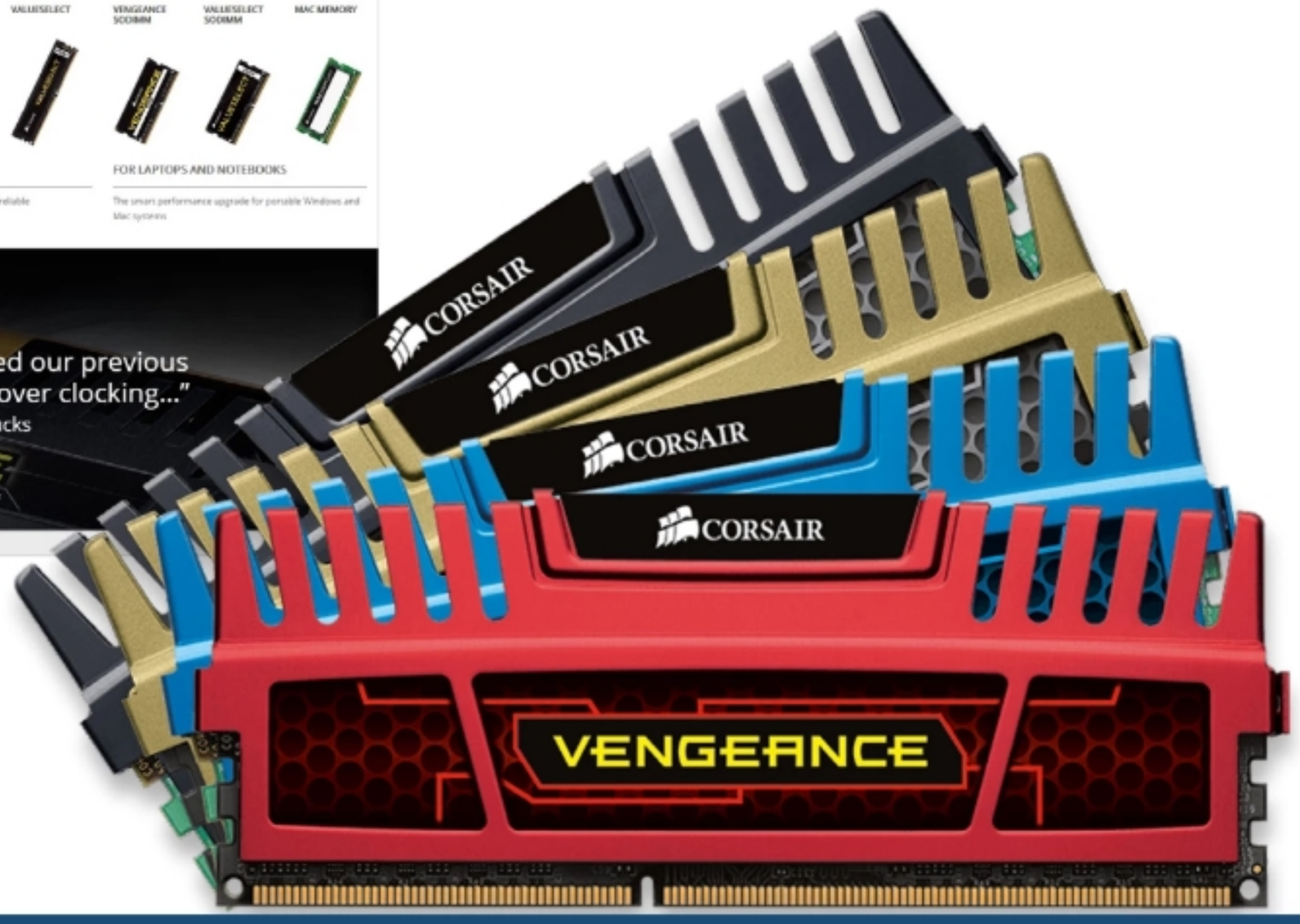
Windows Version	Limit for 32-bit	Limit for 64-bit
Windows 10 (Pro)	4GB	2TB
Windows 10 (Home)	4GB	128GB
Windows 8 (all versions)	4GB	128GB
Windows 7 (Home)	4GB	8GB
Windows 7 (Home Premium)	4GB	16GB
Windows 7 (all other)	4GB	192GB
Windows Vista	1 - 4GB	8 to 128GB

LATENCY TIMINGS

When you are comparing different SDRAM options for your build, you will almost certainly see some numbers like 14-16-16-31. This is the CL or CAS Latency. Column Access Strobe (CAS) latency is the delay time between the moment a memory controller tells the memory module to access a particular memory column on a RAM module, and the moment the data from the given array location is available on the module's output pins.

The memory timings are given through a series of numbers. For instance: 4-4-4-8, 5-5-5-15, 7-7-7-21 or 9-9-9-24. As a general rule, the smaller the numbers, the faster the memory; but we are talking about tiny amounts of time here. Don't get too hung up on CL timings when choosing memory. It can be a good way to choose between two otherwise similar matched pairs but unless you are building a very high spec rig, anything below CL 14 (in DDR4 memory) should be perfectly good. As with anything, the faster something is the more you tend to pay for it.





Memory Modules – A Closer Look

A memory module is another name for a RAM chip. It is often used as a general term used to describe SIMM, DIMM, and SO-DIMM memory. Whilst there are several different types of memory modules available, they all serve the same purpose and that is storing temporary data while the computer is running.

1 HEAT SPREADER

Many memory modules now feature heat spreaders, designed to help dissipate heat as the memory is put under load. The design of the heat spreaders varies greatly, with some featuring fins and vents. You can even buy memory modules with built-in LEDs.

2 SOCKET CONTACTS

These are the parts that connect the memory module to the motherboard socket. You should try to avoid touching the contacts during installation but if they are dirty of dusty, it is safe to carefully wipe them with a dry finger (after ensuring you have earthed yourself).

3 ALIGNMENT SLOT

This cutout is a feature of all current memory modules. It is slightly offset from the middle, allowing you to use it as a guide for fitting the module into the motherboard socket. DIMM's will only install one way and the slot prevents mistakes.

THE MEMORY IN OUR BUILD

As we wanted our build to be able to handle a variety of tasks, we went for some fairly high performance SDRAM. Vengeance LPX memory is designed for high performance overclocking. The heat spreader is made of pure aluminium for faster heat dissipation and the eight layer PCB helps manage heat and provides superior overclocking headroom.

The DDR4 form factor is optimised for the latest Intel X99 and 100 Series motherboards and offers higher frequencies, greater bandwidth and lower power consumption than DDR3 modules. There's XMP 2.0 support for trouble-free automatic overclocking and, the modules are available in multiple colours to match your motherboard, your components or just your style.

Technical Specifications:

- Density: 16GB (2x8GB)
- Speed: 2133MHz
- Tested Latency: 13-15-15-28
- Voltage: 1.2V
- Format: Unbuffered DIMM
- Pin Out: 288 Pin
- Intel XMP 2.0
- Heat spreader: anodised aluminium

HDD, SSD or Both?

The storage capacity of your PC will be dictated by what you will be doing with it but even if you don't think you will need much storage, the cost of storage has come down so much in recent years that it makes sense to choose more than you might need right now. The bigger question with storage these days is whether to go for a HDD, an SSD or perhaps both. Let's take a look at the pros and cons of all these component choices.

START BUILDING

Hard Drive: Seagate 2TB Desktop SSHD
Build: Turn to page 72 to start installing your CPU

Making Your Choice

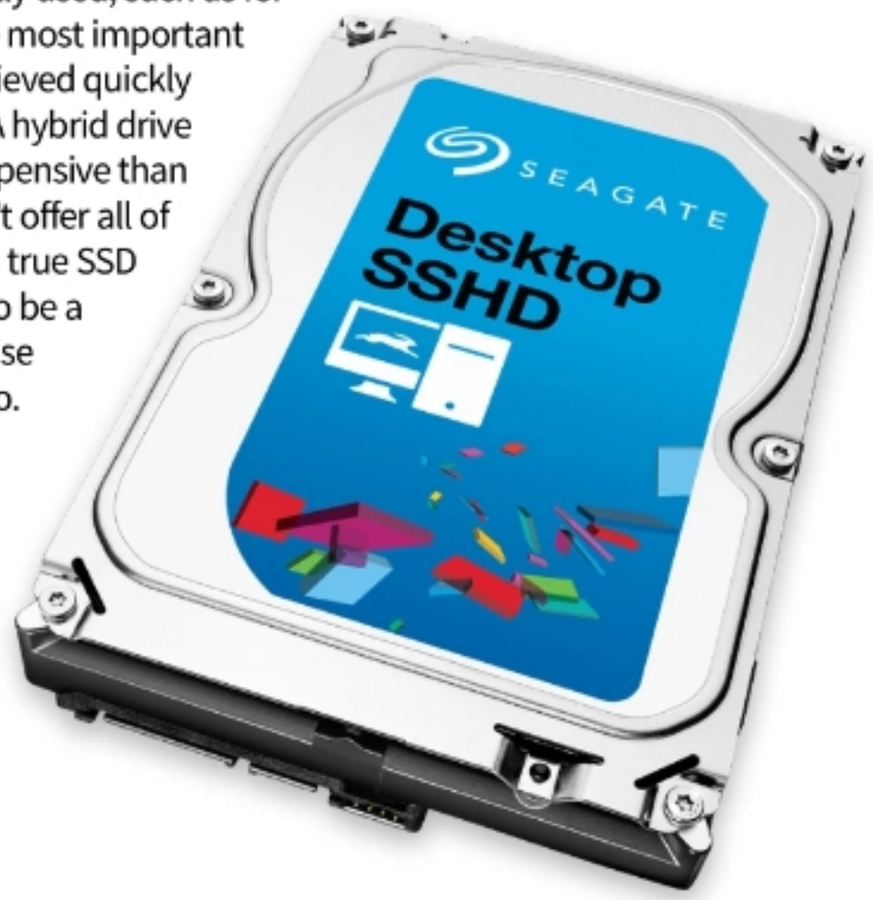
It is very likely that in a couple of years, Solid State Drives (SSDs) will be cheap enough to completely replace Hard Disk Drives (HDDs) but for most PC builders now, a compromise will need to be made between cost and storage capacity.

HARD DISK DRIVES

Standard hard disk drives work by writing data onto a stack of spinning discs within the case of the drive. These spin at certain maximum speeds and the faster the spin speed (RPM), the faster the data is written to and read from the discs. Most currently available HDDs work at a maximum of 7200rpm, but both slower (5400rpm) and faster (10000rpm) are available. A HDD is always the cheapest mass storage option for a PC build but it isn't the fastest, nor the most efficient. Unless you need, for whatever reason, super quick read/write speeds, a SATA connected 7200rpm hard disk drive will be fine for first time builders.

HYBRID SSHD

A more recent option, and the one we have chosen for our build, is a hybrid drive or SSHD. This combines a traditional HDD with a small amount of solid state memory. The SSHD can potentially improve performance as the SSD part of the drive is a cache for the data that is most frequently used, such as for booting and the most important data can be retrieved quickly and efficiently. A hybrid drive are still more expensive than a HDD and won't offer all of the features of a true SSD but they seem to be a good compromise between the two.

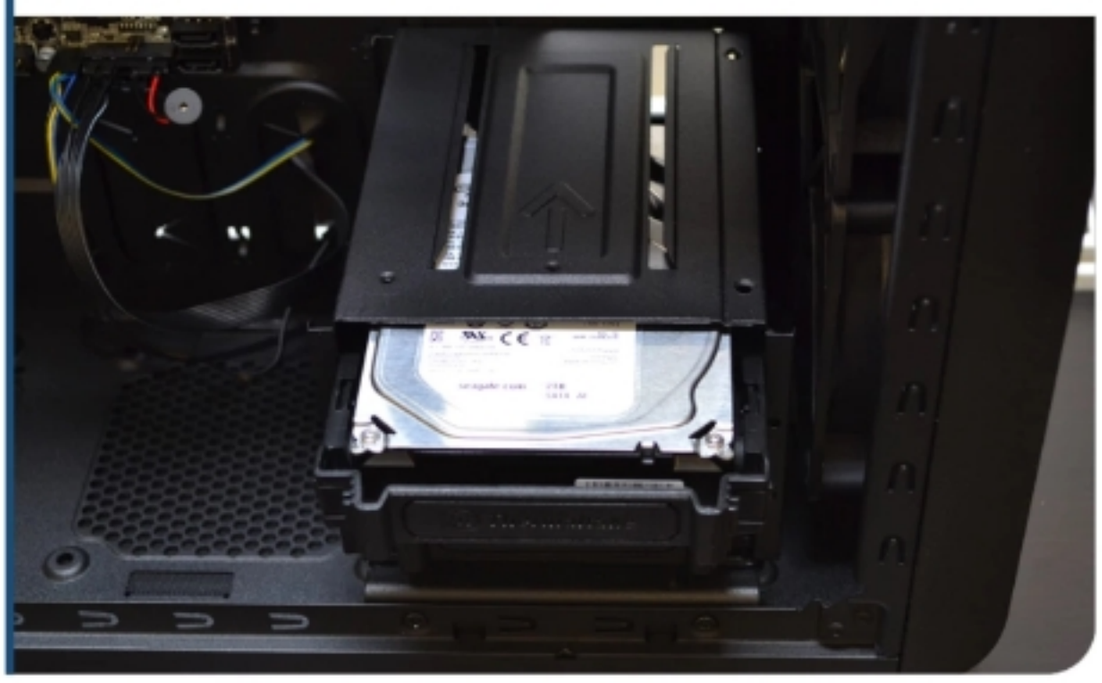


SOLID STATE DRIVES

Solid state drives (SSDs) differ from hard disk drives in that they do not contain moving parts, i.e. the stack of discs or platters, and store data on integrated circuit assemblies. There is no "spin-up" time, so data transfer is faster, with less latency. They are great when building a PC that needs to be quiet, as their operation is virtually silent. The downside of them, as with almost all upgraded technology, is the cost. As an example, a 1TB SSD will cost about 4 times as much as a 1TB HDD. There are SSDs available from 64GB right up to 3 or 4 TB.

BOTH HDD AND SSD

The last and possibly best option is to install both a HDD and an SSD separately within a PC system. This gives you the freedom to have a large amount of storage (at a reasonable cost) but install programs and data which need or benefit from faster access onto a smaller SSD. This is a little more complicated to set up than any of the previous options but you end up with a faster system that has lots of storage. You could buy a 240GB SSD fairly cheaply and combine that with a 750GB or 1TB HDD for example. This would probably cost about half that of a single 1TB SSD.



Hard Disk Drives vs Solid State Drives

Aside from cost, SSDs are more appealing to PC builders in almost every single way. The table below shows how the two types of storage drive compare in a variety of ways.

	Hard Disk Drive	Solid State Drive
Start Up Time	Disk spin-up may take several seconds. A system with many drives may need to stagger spin-up, taking even longer.	Almost instantaneous, no mechanical components to prepare.
Random Access Time	Ranges from 2.9 (high-end server drive) to 12 ms (laptop HDD) due to the need to move the heads and wait for the data to rotate under the read/write head.	Typically under 0.1 ms. As data can be retrieved directly from various locations of the flash memory, access time is usually not a big performance bottleneck.
Data Transfer Rate	Once the head is positioned, when reading or writing a continuous track, a modern HDD can transfer data at about 200 MB/s.	In consumer products the maximum transfer rate typically ranges from about 200 MB/s to 1500 MB/s, depending on the disk.
Read Latency	Much higher than SSDs. Read time is different for every seek.	Generally low because the data can be read directly from any location.
Read Performance	If data from different areas of the platter must be accessed, as with fragmented files, response times will be increased.	Read performance does not change based on where data is stored on an SSD.
Noise Level	HDDs have moving parts (heads, actuator and spindle motor) and make characteristic sounds of whirring and clicking; noise levels vary between models but can be significant.	SSDs have no moving parts and therefore are basically silent, although on some low-grade SSDs, high pitch noise from the high voltage generator (for erasing blocks) may occur.
Installation and Mounting	Should be mounted to protect against vibration and shock. Some HDDs should not be installed in a tilted position.	Not sensitive to orientation, vibration, or shock. Usually no exposed circuitry.
Reliability and Longevity	HDDs have moving parts and are subject to potential mechanical failures from the resulting wear and tear. The storage medium itself (magnetic platter) does not essentially degrade from read and write operations. Expect between 6 and 11 years of use.	SSDs have no moving parts to fail mechanically. Each block of a flash-based SSD can only be erased and therefore written a limited number of times before it fails. The controllers manage this limitation so that drives can last for many years under normal use.

NAND FLASH |

As of 2016, most SSDs use MLC NAND-based flash memory; this is a type of non-volatile memory that retains data when power is lost. For applications requiring fast access but not necessarily data persistence after power loss, SSDs may be constructed from random-access memory (RAM). Such devices may employ batteries as integrated power sources to retain data for a certain amount of time after external power is lost.

HDD FORM FACTORS |

The benefit of using a current HDD form factor would be to take advantage of the extensive infrastructure already in place to mount and connect the drives to the system. These traditional form factors are known by the size of the rotating media, e.g. 5.25-inch, 3.5-inch, 2.5-inch, 1.8-inch, not by the dimensions of the drive casing.

SSD RAID ARRAYS |

Since SSDs are currently generally of smaller capacity than HDDs, one solution to increase your storage capacity while still enjoying the speed and durability benefits of solid state technology is to use a RAID array. RAID stands for redundant array of independent disks (sometimes inexpensive disks) and is a way of making Windows tie several SSDs together and treat them as one single drive. This has many advantages, not least because the read and write times of a RAID array are frequently faster than for a single drive. Setting up a RAID array is not too difficult. For now, if you'd like to know more visit https://support.microsoft.com/en-us/kb/100110.

WHAT IS NAS? |

Network Attached Storage (NAS) allows multiple users to store and share files in a centralised location rather than individuals storing files on their own computers. By using Network Attached Storage, documents, reports, music and videos can be shared with anyone who has access to the network.

Think of NAS as a standalone hard drive that can be connected to all the computers in the home or business. This network of users can then store and access files on the NAS so that anyone can retrieve them. For businesses this makes data management so much simpler especially when a team is working on a joint project. Documents and other digital media no longer need to be emailed around the office but can be easily placed on the NAS for sharing.

A huge plus point in favour of Network Attached Storage is that it is possible to set up remote access. Forgotten that report you needed to work on at home? No problem. Just remotely log into NAS and retrieve the file.

Choosing a Graphics Card (GPU)

If you are building a PC to be able to play games, the graphics card or Graphical Processing Unit (GPU) will probably be one of the most expensive components after the CPU. GPUs seem to be improved and updated at a faster pace than almost any other item you will fit into your computer and keeping up with the latest cutting edge tech can be very expensive. For our build we have chosen a card which offers a good mix of features and at a reasonable price.

START BUILDING

GPU: Sapphire Nitro Radeon R9 380 4 GB
Build: Turn to page 76 to start installing your graphics card

Making Your Choice

Choosing a graphics card can be a very confusing business. For a start, there is the naming system, which is distinctly unintuitive, then there are the power and performance statistics to get your head around. Hopefully this guide will make your choice easier.

NVIDIA OR AMD

Although there used to be a few other options when it came to graphics card chip makers, the choice is now between just two, Nvidia and AMD. This is a continual arms race, with each improved card from one camp being bettered by an upgraded card from the other camp just weeks or months later. For the average gamer or indeed the average PC user, there is little to choose between them. If you are a hardcore gamer who wants to drop a couple of weeks wages on a cutting edge card, Nvidia is probably the way to go right now, with their incredibly powerful GTX 1080 architecture.

VIDEO MEMORY (VRAM)

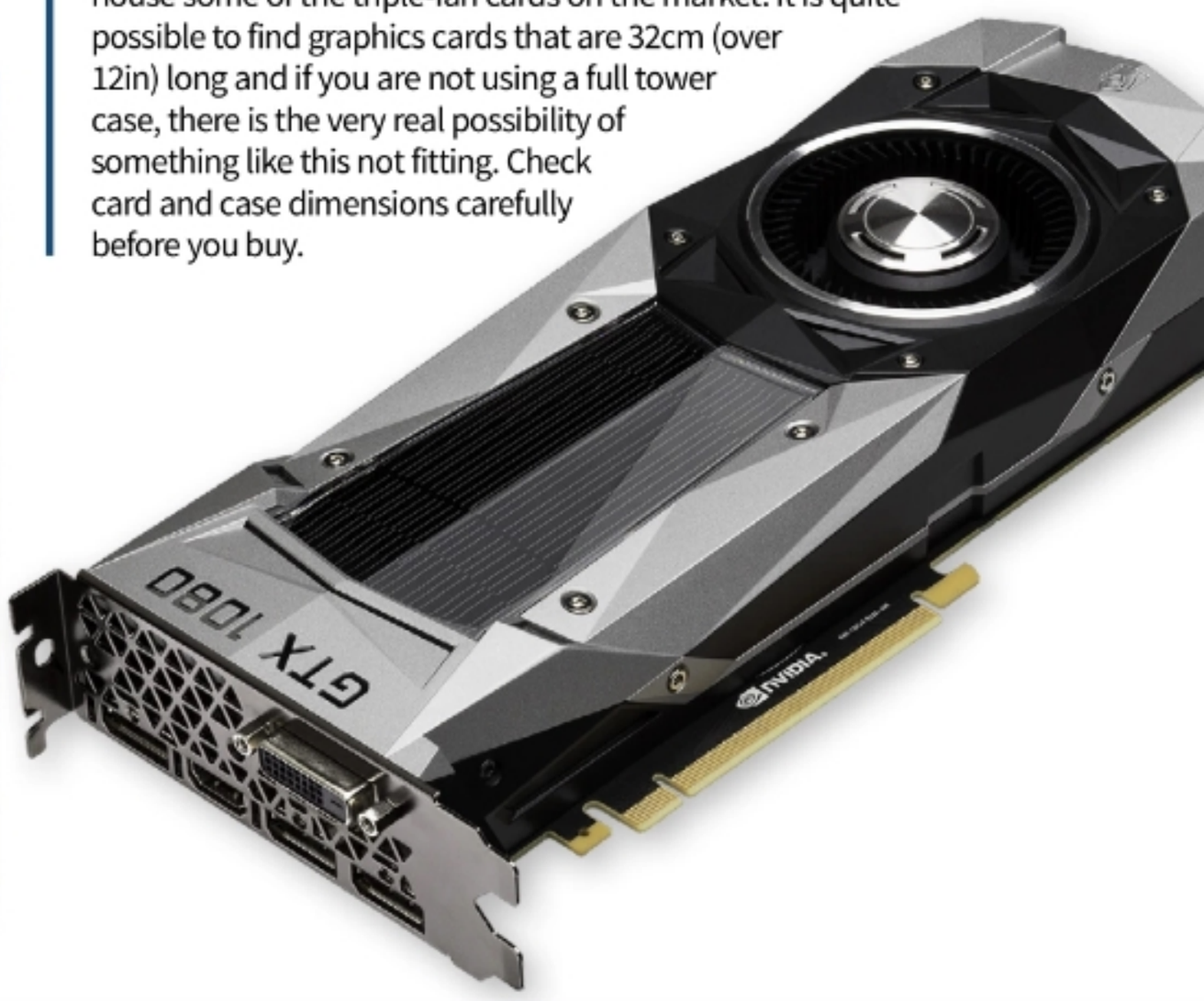
Although you should aim to buy a graphics card which offers the most on-board RAM for your buck, the amount isn't the only consideration. A card with 2GB of GDDR5 RAM is probably a better option than a similarly priced card with 4GB of GDDR3 RAM. It is currently possible to buy graphics cards with 8GB of GDDR5X RAM, which is the newest version of VRAM available, and costs a quite staggering amount of memory. You will of course, pay a premium for this sort of card specification. As a minimum, look for at least 2GB of GDDR5 RAM on a graphics card.

CLOCK SPEED AND MEMORY BUS

Although there are dozens of different specs to look at when choosing a graphics card, graphics core clock speed and the size of the memory bus along with the amount of VRAM, are probably the most important for gamers. The core clock speed tells you how fast the GPU can work, whilst the memory bus size (256-bit is a good size to look for) controls how much data can be sent through at once. A card with a clock speed of 1000MHz and a memory bus of 256-bit, is probably a better choice than one with a clock speed of 1200MHz but a memory bus of 128-bit. Don't base your choice solely on these three specs but they are a good place to start comparing.

PHYSICAL SIZE

Finding the perfect graphics card to run your favourite games is all well and good but if that card won't physically fit inside your case, you have a big problem. Graphics cards not fitting is a fairly new problem, unless you were trying to build a LAN box or other small, custom set up. But these days, even midi tower cases can struggle to house some of the triple-fan cards on the market. It is quite possible to find graphics cards that are 32cm (over 12in) long and if you are not using a full tower case, there is the very real possibility of something like this not fitting. Check card and case dimensions carefully before you buy.



MODEL NUMBERS

The world of graphics cards is dominated by model numbers. By model number we mean, as examples, the Radeon **R9 380X** or Geforce **GTX 780 Ti**. It is one of the easiest ways to tell if one card will be more powerful than another from the same family, i.e. AMD or Nvidia. Graphics cards normally change model number when there is a significant increase in clock rate and memory bandwidth or with a newer generation of the GPU itself. So a high-end Radeon **R9 380** may not be as fast as a basic Radeon **R9 390**. As a general rule, go for a card from the newest generation you can afford but always compare the specification we talked about above first.

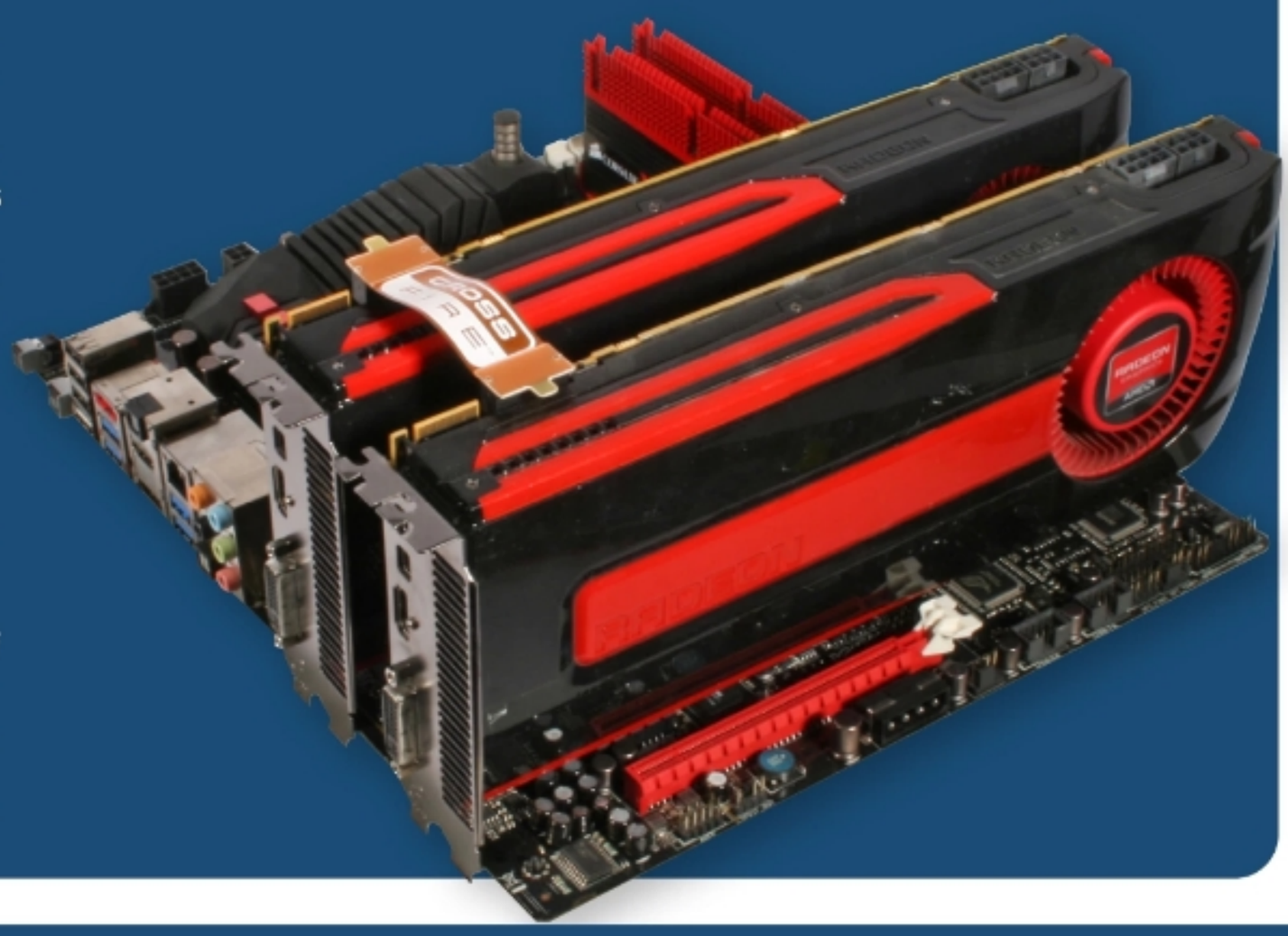
POWER ON DEMAND

If you are going for a high-end graphics card, you will need to consider the problem of the increased power it will need. As a general rule of thumb, if you assume that each graphics card requires a maximum of around 250W and that a regular system also uses around 250W. This will vary based on the components you are using. This means that for any modern gaming PC you will want around 600W as a minimum and it's always best to have around 100W in reserve. Most graphics card manufactures will list the wattage used (as TDP) so you can do the calculation yourself.

SLI AND CROSSFIRE

Both Nvidia and AMD offer a feature that allows two graphics cards to be run side-by-side within a single system (CrossFire for AMD cards and SLI on Nvidia cards) but before you consider doubling up on the GPU, you should understand the limitations of doing so. It sounds like a great idea but scaling graphical performance by doubling GPUs is not as smooth a proposition as it might seem. A second graphics card does not increase performance by a factor of two; it's more realistic to expect a 25-50 per cent increase.

It also requires a lot of power to run two cards, so your PSU is going to cost more. Not all power supply units even feature two PCIe cables. There are other problems too, including the possibility of inconsistent performance, incompatibilities and lots of noise. For a first time PC builder, we would recommend avoiding this option and instead spending the extra money on a better single card.



Anatomy of a graphics card

Modern graphics cards can be expensive and slightly intimidating bits of kit. Let's take a look at the standard parts of a high-end card, to help you feel more comfortable handling one.

1 PCIE CONNECTOR

Running along the bottom of the card is the connector for the PCIe x16 socket on your motherboard. PCIe is now the standard, replacing AGP or Advanced Graphics Port several years ago. This must be firmly seated into the motherboard and will be held in place by a clip or slide on the socket. The cut out helps to line it up correctly.

2 OUTPUT PORTS

You will need to remove one, or more likely two, blanking plates from the back of your case (the expansion slots) to allow for the external plate to fit. This is where you connect your monitor to the graphics card and will usually feature DVI and HDMI but may also include DisplayPort and other outputs.

3 EXHAUST VENT

This exhaust vent, again on the externally facing plate, helps to get some of the massive amounts of heat generated by a card like this out of the case. Not all cards will have this vent but many of the more powerful cards will. Check this is not blocked regularly.

4 COOLING FANS

It is possible to buy cards without fans and just a heatsink but if you want a high-performance card you are going to have to expect anything from one to three cooling fans to be whirring away inside your case. Without these, the chip could overheat and die in a matter of minutes.

5 CROSSFIRE CONNECTOR

Not all cards have this, or may have a slightly different CrossFire connector if using AMD, but on this card, the SLI connector is on the top edge. If your card is SLI (or CrossFire) compatible, you will often get the small connector bridges along with the card itself.

6 POWER SUPPLY PORT

You cannot see it on this card but there will be a power input connector on almost every graphics card you buy nowadays. The amount of power a card needs can vary, as can the type of power connector. This card, the MSI Geforce GTX 1080, requires a 6-pin and 8-pin connector.

7 SPEED CONTROLLER SWITCH

This switch cannot be seen on this card and not all cards will have one but many have a tiny speed controller switch for the fans. The card will still decide the fan speed needed but you can control the controller if there is generally more or less airflow.

Need More Power?

The role of a PC power supply unit is to convert the AC electric power that comes from the mains to the DC power that the computer requires. However, it can do much more than that. A good quality power supply can make your system more efficient, stable and reliable. The power supply is often the first component to fail in an older system, so making sure you understand the full role of the PSU in your build is very important.

START BUILDING

PSU: Aerocool Integrator 700W
Build: Turn to page 78 to start preparing your PC case

Making Your Choice

As with any purchase, there are several things you need to consider before you choose a power supply. Getting things wrong here could mean a difficult build or additional expense later.

PC POWER REQUIREMENTS

The first thing to consider is exactly how much power your PC build will require as a minimum. The exact power requirement will vary depending on the components you have chosen. If you are using a 4GHz i7 processor and an Nvidia GTX 1080 graphics card, you will need to look for a PSU with a higher wattage than if you are using a 3.2GHz i5 and a GTX 750. As a basic rule of thumb, add up the power requirements for CPU, GPU and HDD; you can find this in the documentation or on the manufacturer's website. Then add on 250W, which is the average power requirement of a base system, and finally add on 100W.

POWER CONNECTORS

The selection of power connectors your chosen PSU has is more of a concern if you are using a wired unit. The main things to check are whether it has the correct connector for the CPU power socket (4 or 8-pin) and that it has the correct connections for your chosen graphics card. Many modern graphics cards will need two PCIe power connections and they could be either 6 or 8-pin, and even one of each. You will normally have a lot more options with a modular PSU but even if you buy a wired power supply with the wrong connectors, you might be able to buy an adaptor.

WIRED OR MODULAR

A modular power supply is simply one that has the cables separate to the main unit. This allows the end user to pick and choose the exact cables they need to attach (a large selection will be supplied with the PSU) and avoid the problem of excess cables. A modular power supply is usually more expensive than a wired counterpart, although this is usually down to the convenience it will offer rather than build quality. You can also buy semi-modular PSUs, which have the main power cable wired in and then several ports for connecting other cables.

POWER EFFICIENCY

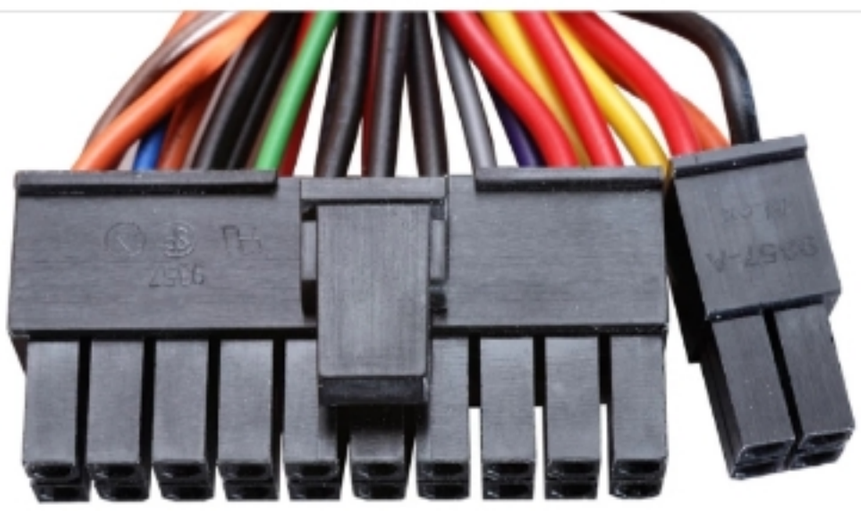
It's not all about the wattage of a power supply. Efficiency is also important, although probably less so if you are on a tight budget, so look for PSUs that have the 80 Plus certification. This indicates that the PSU will be 80 per cent or more energy efficient. This type of power supply saves money by wasting less power; as a result they use less electricity and also emit less heat. The benefits of using an efficient power supply are more substantial in computers that use a lot of power.

Power Connections

The following are the power connectors that our build requires. Although this is a good example of a standard set of connections, you should always check your build doesn't need different ones.

THE 20+4 PIN CONNECTOR

This is the main power connector for the motherboard, providing power for most of the on-board features. If you are using an ATX or mATX motherboard, you will need to use all 24 pins. Some motherboards will only need the 20 pin part so check with your motherboard manual or manufacturers website. Ensure it is lined up correctly and press it home, supporting the board as you do this.



THE PCIE 6 PIN CONNECTOR

This cable is for providing dedicated power to your GPU (graphics card). Older cards were able to draw power from the motherboard but almost all modern GFX cards will need their own supply. The PCIe connector is normally an 8-pin, that can split into a 6 plus a 2-pin. In our build the Radeon R9 card requires two 6-pin connections, which we were careful to ensure our PSU had.

THE 4+4 PIN CONNECTOR

This is the power for the processor only and on modern motherboards which have modern CPUs, this will be an 8-pin connector that can split into two 4-pin connectors. If your motherboard or CPU only require a 4-pin 12v connection, just use either of the two. In some cases the PSU will only have a single 4-pin 12v connector. As before, line up the pins and press firmly into place.

THE MOLEX CONNECTOR

Almost universally known as Molex, these connectors were widely used in older PCs to provide power to hard drives, CD drives, etc. but have now been almost totally replaced by SATA connectors. You will almost certainly still see a couple of Molex connectors if you are using a wired PSU. On a modular PSU, you can simply leave them in the box if they are not required.

THE SATA CONNECTORS

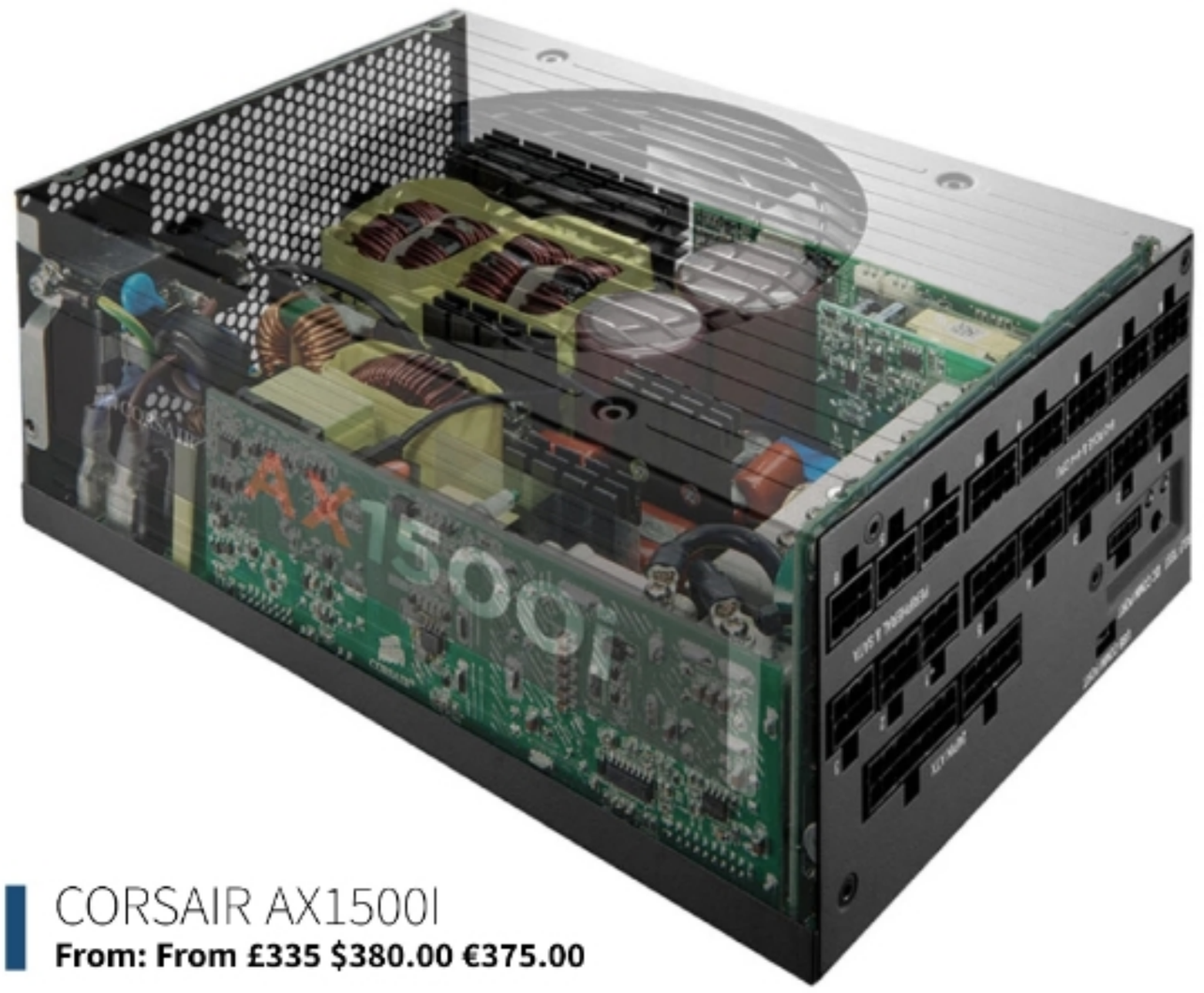
This kind of plug is used to provide power to Serial ATA (SATA) devices such as hard disk drives and optical disk drives. If your power supply doesn't have enough of these plugs for your system, you can convert any standard peripheral power plug (known as Molex) into a SATA power plug through the use of an adapter. SATA connectors are often daisy-chained on the same cable.

MODULAR PSU

A modular power supply provides a detachable cable system, offering the ability to remove unused connections at the expense of a small amount of extra electrical resistance introduced by the additional connector. This reduces clutter, removes the risk of dangling cables interfering with other components and can improve case airflow. Many modular supplies have some permanent multi-wire cables with connectors at the ends, such as PC main and four-pin Molex, although newer supplies marketed as "Fully Modular" allow even these to be disconnected.

High Performance PSU

As with any of the components in your build, it is possible to spend large amounts of cash to get very high performance power supply units. One such PSU is the Corsair AX1500i Digital ATX Power Supply Unit. It provides 1500 Watts of continuous, digitally controlled power on 15 Amp circuits of 115V or higher; and 80 PLUS certification with an incredible 94 per cent efficiency rating. Zero RPM Fan mode ensures silent operation at low and medium loads and the fully modular, low profile cable set makes for easy installation and great looking builds. Corsair Link integration lets you monitor power usage and efficiency and customise performance, directly from your Windows desktop.



CORSAIR AX1500I

From: From £335 $380.00 €375.00

EFFICIENCY RATINGS EXPLAINED

There is a considerable difference between the lowest and highest efficiency ratings you will find on power supply units. It effects not only how much power your PC will use, but how well that power is distributed to components.

Do You Need an Optical Drive?

Building a PC a few years ago without an optical drive would have seemed like madness. It would have made using the PC fairly difficult as most software was supplied on discs and Internet speeds were not really up to the task of downloading large files such as games. Nowadays, almost everything you might want to install on your PC can be bought electronically and discs are becoming somewhat obsolete. So do you actually need to install a CD/DVD drive?

START BUILDING

Optical Drive: LiteOn iHAS124 24X DVD Writer
Build: Turn to page 74 to install your optical drive

Making Your Choice

The optical drive is one of the first non-essential components we have looked at in this guide. Deciding whether you need or want one is down to your user requirements.

CD OR DVD DRIVE?

In all honesty, buying a CD writer drive is fairly pointless, seeing as you can burn audio just as easily with a DVD writer that only costs a few pounds extra. CD writers are actually quite hard to find if you like shopping at the large online component retailers. So if you want the ability to burn discs on the PC, pick up a DVD writer drive.

BLU-RAY DRIVES

You can of course, choose to add a Blu-ray drive instead of, or as well as your DVD drive. These drives are still surprisingly expensive, especially if you want one that is a writer drive, considering how long the format has been available. You can expect to pay about £50.00 for a Blu-ray writer drive, compared to around £15.00 for a DVD writer.

CASE STYLE

Most DVD writers have black front panels, to blend with the majority of PC cases. If you have a case with a coloured front that doesn't hide drives behind a door panel, you might struggle to find one to match. Some cases with a brightly coloured front panel come with snap on facias for optical drives but you will probably be restricted to certain makes and models.

EXTERNAL DRIVES

The alternative is simply to get an external drive that you can connect to your PC as and when you need it. External DVD writers are slightly more expensive but generally smaller and sleeker and designed to sit on top of a case unobtrusively. They also have the advantage of being fully portable and can often be linked directly to a TV or monitor.

YOUR DRIVE-LESS PC

If you do decide to go for a build without an optical drive (you can always add one later of course), you should at least make sure that you have a few things in place. If you are going to be streaming or downloading software, you will need to ensure that your Internet connection is a good speed. It is also worth thinking about storage. If you have software on a disc, you could install and delete it as required to save space on the hard drive; but if you are getting all of your software digitally, you might need extra space to store it. Burned discs are also portable but having a 16/32Gb USB flash drive handy might also be a good idea if you think you may need to move software around.

Expansion Cards and Extras

Expansion cards are technically any printed circuit board that can be added to the system to add functionality or features. This means that a graphics card is an expansion card, albeit a fairly fancy one, and you can run a PC without including one, assuming the motherboard has on-board graphics. Here we will look at some of the other expansion card options you may want or need in your build.

START BUILDING

Expansion Card: None Installed
Build: Learn more about installing an expansion card here

Making Your Choice

Expansion cards, of which a graphics card is one type, are used to add specific functionality to a PC. You might not even know you need one until you understand some of the options available.

DO YOU NEED ONE?

Expansion cards used to be much more prevalent, especially sound cards and LAN cards. This is because motherboards either didn't have these features on-board or the ones that were on the motherboard were basic versions. So if, for example, you wanted 5.1 channel audio on your PC, an expansion card could give it to you. So before you buy an expansion card, other than a graphics card, check that you actually need it.

DO YOU HAVE SPACE?

Unless you are building a Mini ITX PC, it is very likely that you will have several spare PCI sockets for use with expansion cards but it is certainly worth checking that the motherboard you want to use in your build has enough PCI sockets for the amount of expansion cards you plan to add. It is also worth checking that the PCI slots available, will support the cards as there are several different types of PCI socket.

FAN CONTROLLER

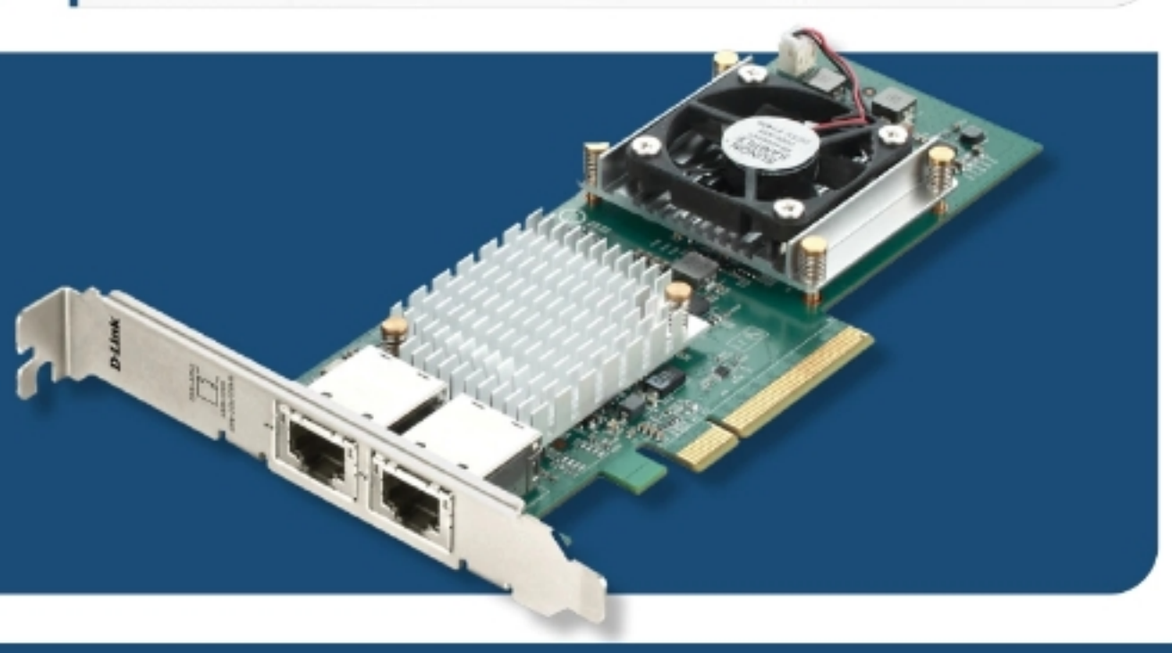
Another additional extra that you may want to think about, especially if you are building a gaming PC that will need good ventilation, is a fan controller panel. These are usually fitted into one of the optical drive slots on the front of the case and will either have dials or buttons to speed up or slow down the internal fans. If you are planning on adding a fan controller, check that your motherboard supports it.

STORAGE CARD READER

Another useful option for some builders is a card reader hub, which again can be fitted into the front optical drive slots of a case but can also be bought to fit into an expansion slot at the back. These usually feature slots for SD cards, USB flash drives, MicroSD and more. Obviously a front fitted hub is more convenient if you use storage cards regularly but a rear hub is good if your case doesn't have lots of optical drive slots.

NETWORK CARDS

If your motherboard network port is not as fast as you need, a network card could be the answer. The Tenda Gigabit Network Interface Card is easy to use and economical, making it a great choice for you to connect to a Gigabit network. Other options include the Intel Gigabit Pro/1000CT PCIe Desktop Adapter - OEM version, which can enhance network performance and increase end-user productivity.



CPU and Case Cooling

The days of having a single exhaust fan in your PC case and a stock cooler on the CPU are well and truly behind us. It is not unusual to see cases being sold with three, four and even six fans, particularly if you are looking for a gaming enclosure. As components get more powerful, they generally produce more heat and getting that heat away and out of the case is a very important way of protecting your computer.

START BUILDING

Coolers: Arctic Cooling Freezer 7 Pro and Arctic Cooling F12 120mm Case Fan
Build: Turn to page 64 to install your CPU Cooler

Making Your Choice

Most cases feature at least two fans, and your CPU will be supplied with a stock cooler, but if you want to build this PC properly, you really need to upgrade both of those components.

STOCK COOLER?

A stock cooler, meaning a standard CPU cooler supplied by the chip maker, may be perfectly fine. However, this will depend on the CPU you have chosen and the amount of load you think it might have to deal with. Generally the more powerful the chip, the more heat it will produce; too much heat, that isn't properly drawn off and expelled, could mean a shortened life for the processor. For a fairly small amount of money, an after market CPU cooler could see temperature drops of 10-15 degrees centigrade compared to a stock item.

AIR CPU COOLER

Air coolers, those that use a fan and heatsink to draw heat directly from the CPU, have been the norm in PCs for years. They can be pretty efficient, depending on their specification and they are not very expensive. There is a lot of choice out there but on the downside they are quite big and unless the fan used is high quality, they can add another layer of noise when your PC is running. Any heat drawn off the CPU has to be dealt with by the case fans. It is possible instead to buy CPU water coolers.

WATER CPU COOLER

These work by pumping water in a closed loop between a heatsink attached to the CPU and a radiator. Fans on the radiator cool the water heated by the CPU and pump it back round as cool water, ready to draw off more heat. These are considered much more efficient than the air coolers but are also much more expensive to buy. The cooling radiator is normally positioned so that the fans draw air from outside the case but this often means the case needs specific radiator mounting points.

EXTRA CASE FANS

Whether you need to upgrade the case fans, or add more, depends on your component list and what you plan to use the PC for. If your build is geared towards gaming or graphically intensive tasks, adding more fans is almost certainly a good idea. Unless you go very high-end, most cases will only have two fans, even gaming cases. However, there are lots of cases available that provide mounting locations for several more. Just make sure you check sizes (120mm, 140mm, etc.) and look for less than 15dB noise.

THE IMPORTANCE OF AIRFLOW |

The fans that are in your case aren't just about pumping cool air in or dragging warm air out. Each of these processes on their own makes little sense. Pumping cool air into a case that can't expel warm air is pointless. So too is sucking warm air out but not pulling in cool. What matters is airflow through the case, usually front to back and this is not just down to having fans in the right positions. It also has a lot to do with case design, component layout and cable management. You can read more about each of these considerations throughout this guides' pages but for now just remember, a healthy PC needs good airflow.

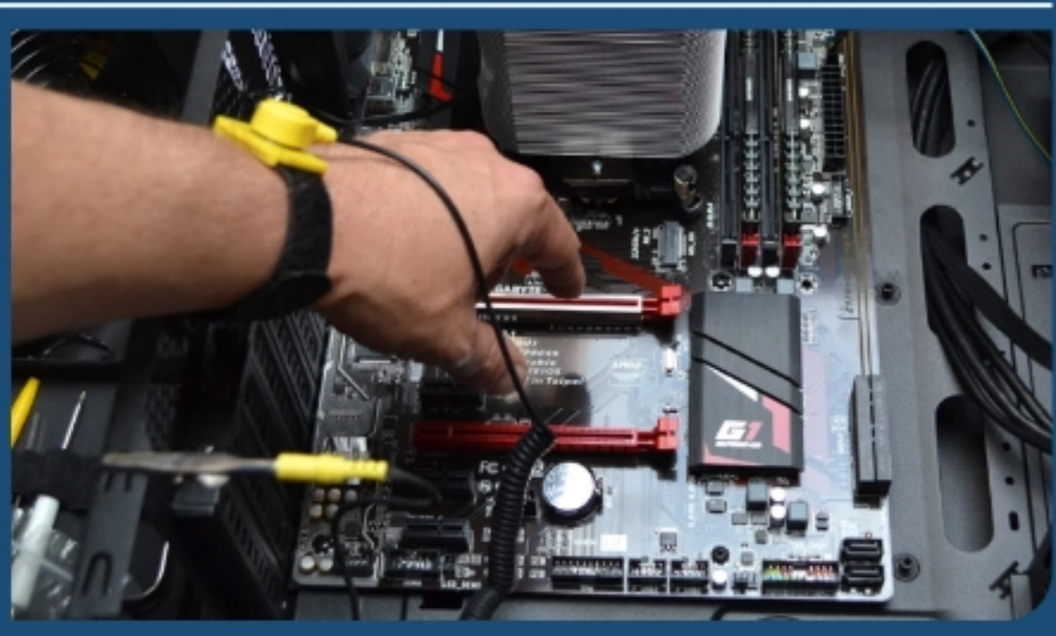
Before You Build - Precautions

Nothing will spoil the joy of building your own PC faster than damaging a critical component before you have even fitted it inside the case. Although there is no need to be scared of a first-time build, there are simple things you can do to prepare for it. Some of the main concerns include electrostatic discharge, dropped parts and damage caused by forcibly fitting together parts or scratched circuits.

ELECTROSTATIC DISCHARGE

Whenever we move around, particularly on certain surfaces like carpet, our bodies pick up tiny amounts of electricity. This can then be released when we touch conductive surfaces such as metal. Accidental electrostatic discharge can destroy PC hardware but in practice you only need to take the most basic precautions.

You can buy grounded wrist straps fairly cheaply and while they are a little over the top, they can give the novice builder peace of mind. The most basic precaution is to occasionally touch a ground, such as a metal office desk or the metal case of a plugged-in system, to discharge your body. However, even when ESD does occur, it's more likely to follow the component's ground plane rather than blow its most sensitive parts.



ELECTRIC SHOCK

When working on your PC or any mains powered equipment, always disconnect it completely from the mains wall socket. Never dismantle the actual PSU in your PC. This unit contains potentially lethal mains voltages, even when it is disconnected from the supply. They are not user repairable. If it fails, replace it with a new one.

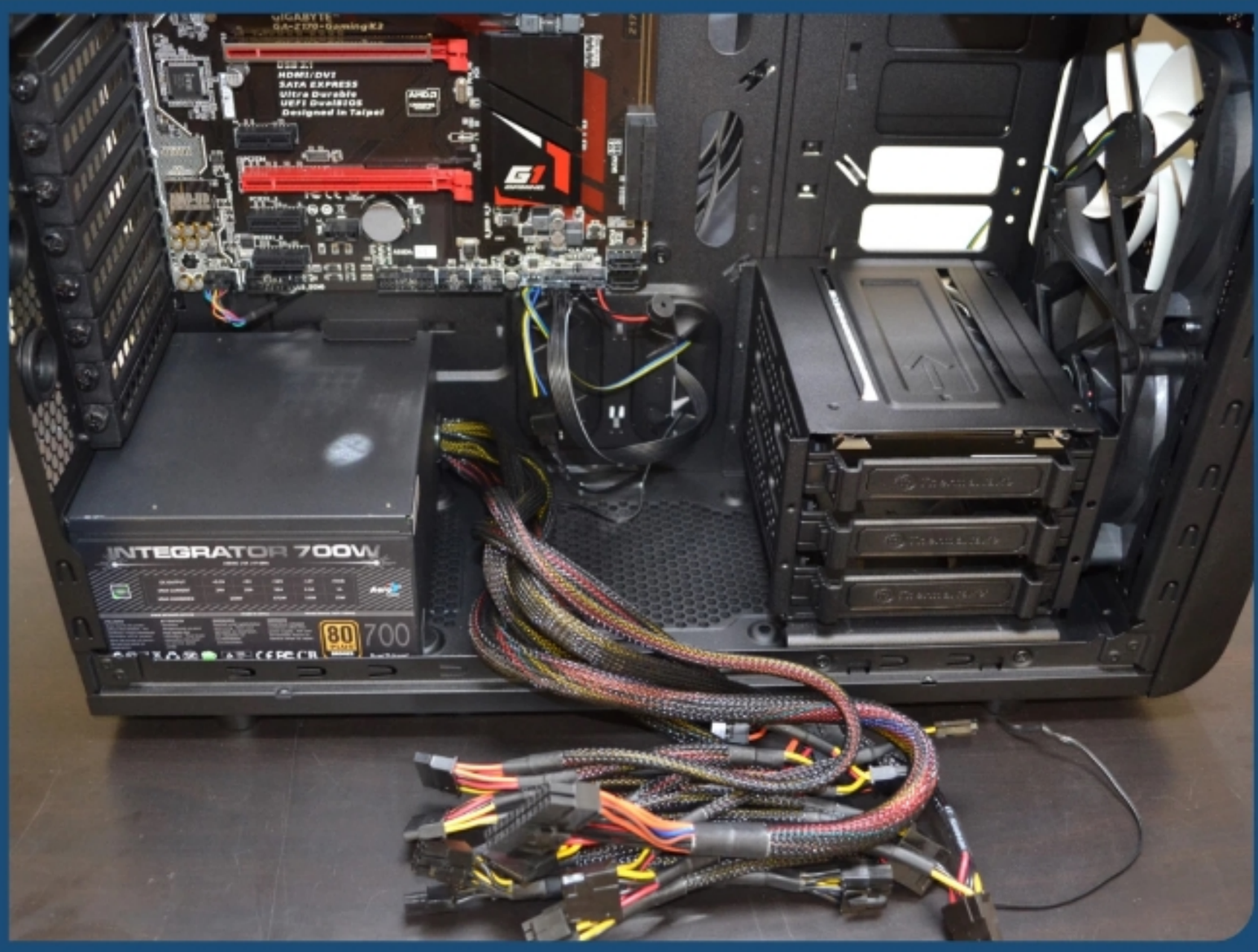
CONNECTIONS

Always remember to completely disconnect the power before connecting or disconnecting components or cables. When making cabling connections of any kind, use firm, even pressure but never excessive force. Small signal pins are very easily damaged if connected incorrectly. If it just won't fit, try to establish a reason rather than giving it a 'hopeful' shove. Most connectors have some kind of alignment system to prevent incorrect connection.

DROPPED COMPONENTS

It doesn't take much of a fall to break some of the delicate components you will be working with and this is probably a more likely route to killing a graphics card or hard drive than ESD. If possible, reduce the risk of dropped parts by keeping them away from the edge of your build space. Leaving them in their boxes until you are ready to fit them is also a good idea.

Now, one physical issue that even the most cautious of us can't prevent 100% of the time comes from dropping processors into their interfaces at a slight angle. This problem is specific to Intel's latest LGA interfaces because the contact pins have become thinner as the company has added more of them. Intel's pins act like springs, so that even the slightest damage can cause insufficient contact pressure.

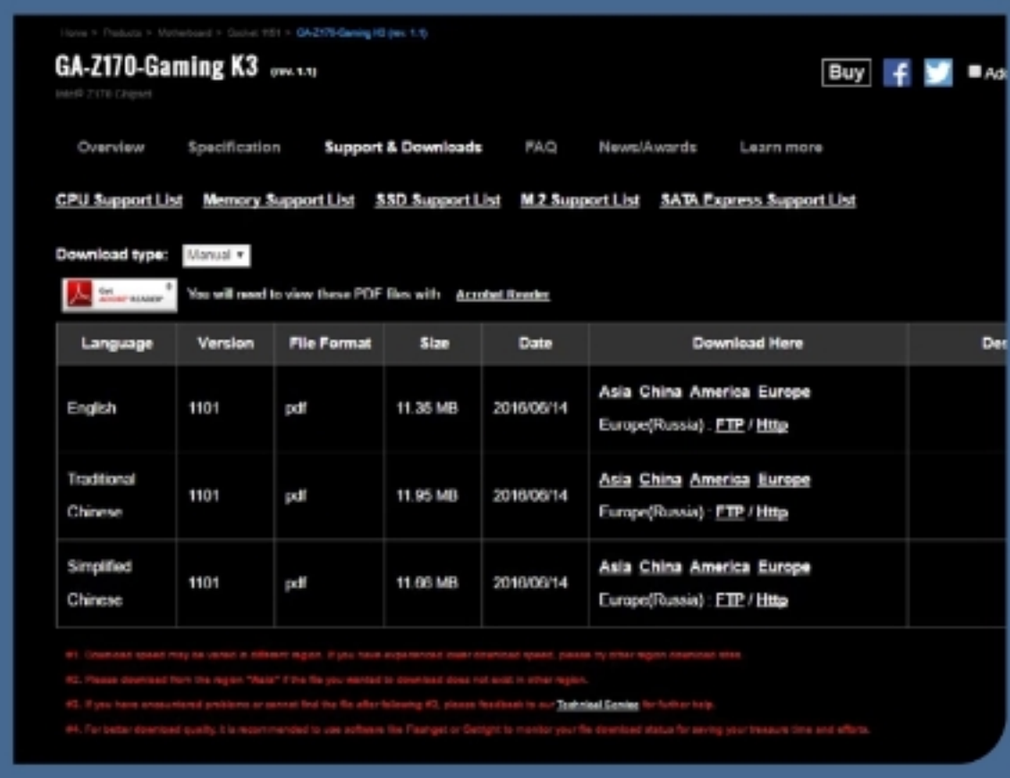


CLEANING COMPONENTS

With the exception of the exterior of the case, never try to clean any part of your system with any liquid detergents or cloths. If you find a build-up of dust inside the machine after some time, disconnect the unit completely, remove the case sides and use an Air Duster to blow out the dust from the case. Air Duster should be available from most electronic supply shops and is basically a can of clean, compressed air.

COMPONENT MANUALS

Always read the manuals, even if they are really thin, that come with the various components, particularly if you are completely new to building PCs. There is often vital information that can prevent you from plugging something into the wrong place and damaging the whole build. Your motherboard manual is particularly critical. If you don't get a manual in the box, you will be able to find one on the manufacturer website.



Build Your Own PC - Jargon Buster

When you start on anything to do with building computers, you will soon see that there are weird phrases and acronyms used all over the place. Whilst this is not a complete list, it does explain most of the more common terms new builders will encounter when putting together their first system.

A...

AGP
Accelerated Graphics Port - a high-speed point-to-point channel for attaching a video or graphics card to a computer's motherboard. Largely superseded by PCI-e now.

ATX
Advanced Technology eXtended - a motherboard form factor specification developed by Intel in 1995 to improve on previous factor standards like AT.

B...

Bandwidth
Bandwidth refers to how much data you can send through a network or modem connection. It is usually measured in bits.

BIOS
Stands for Basic Input/Output System. The BIOS is a program preinstalled on Windows-based computers that the computer uses to start up.

Boot
In simple terms, to boot a computer is to turn it on. Once the computer's power is turned on, the "boot process" takes place. This involves loading the startup instructions.

Boot Disk
A boot disk is a disk that a computer can start up or "boot" from (see above). The most common type of boot disk is an internal hard drive, which is what most computers use.

Bus
A communication system that transfers data between computer components inside a computer or between computers. An example is USB (Universal Serial Bus).

Blu-ray Drive
An optical disc drive capable of reading Blu-ray discs. Available as internal and external versions for use with a PC system.

C...

Cache
A hardware or software component that stores data so future requests for that data can be served faster. Data might be the result of an earlier computation or the duplicate of data stored elsewhere.

Case
Case is variously known as the computer chassis, enclosure, tower, box or system unit. The variety of different case styles is huge. Case form factor is determined by motherboard size.

CD-ROM
Compact Disc Read-Only Memory - a pre-pressed optical compact disc that contains data or music playback.

Chip
A miniaturised electronic circuit that has been manufactured in the surface of a thin substrate of semiconductor material.

Chipset
A group of integrated circuits or chips, that are designed to work together. They are usually sold as a single product.

Clock Cycle
A clock cycle or clock tick, is one increment of the CPU clock, during which the smallest unit of processor activity can be performed. Common clock cycle activities include load, store and jump operations.

Clock Speed
The clock speed of a processor is measured in clock cycles per second or hertz. For example, a CPU that completes three billion clock cycles per second has a clock speed of 3,000 megahertz, or 3GHz.

CMOS
Stands for Complementary Metal Oxide Semiconductor. The low power consumption of CMOS allows the memory to be powered by a simple Lithium battery for many years.

Core
A portion of a CPU which actually performs arithmetic and logical operations. A CPU may have multiple cores. An example would be a quad-core processor.

CPU
A Central Processing Unit is the electronic 'brain' of a computer that carries out the instructions of a computer program by performing the basic arithmetic, logical, control and I/O operations.

D...

DDR
Stands for Double Data Rate and is an advanced version of SDRAM, a type of computer memory. It can transfer data twice as fast as regular SDRAM chips. DDR2, DDR3, DDR4 are all newer, faster versions.

Disk Drive
A device that reads and/or writes data to a disk. It can refer

to your internal hard disk drive, as well as optical drives that read removable CDs and DVDs.

DIMM
Dual In-line Memory Module. A DIMM is a small circuit board that holds memory chips. DIMMs have faster data transfer capabilities than SIMMs and have pretty much replaced SIMMs.

DVI
Stands for Digital Video Interface. Most DVI ports support analogue and digital displays. If the display is analogue, the DVI connection converts the digital signal to an analogue one.

DRAM
Dynamic Random Access Memory is the most common type and is synchronous; SDRAM is a faster version of standard DRAM.

E...

EIDE
EIDE is short for Enhanced Integrated Drive Electronics and is an improved version of the IDE drive controller standard.

Expansion Card
Any printed circuit board installed into a PC to add functionality. For example, a user may add a USB card with extra ports to allow the addition of more external devices.

F...

FAT32
Refers to the way Windows stores data on your hard drive. FAT stands for File Allocation Table; it is an improvement to the original FAT system.

Firmware
Firmware is a software program or set of instructions programmed on a hardware device. It provides the necessary instructions for how the device communicates with the other computer hardware.

Flash Memory
Flash memory is a type of electrically erasable programmable read-only memory (EEPROM). A common use of flash memory is when storing the BIOS settings in a computer's ROM.

FSB
Frontside Bus. The FSB connects the computer's processor to the system memory (RAM) and other components on the motherboard.

G...

GDDR
Graphics Double Data Rate. This is the type of memory that is used in graphics cards. The current specification is GDDR5 which has a maximum transfer rate of 20GB/s.

Gigabyte
A gigabyte is 1,024 megabytes and precedes the terabyte unit of measurement. Hard drive sizes are typically measured in gigabytes or terabytes.

Gigahertz
One gigahertz is equal to 1,000 megahertz (MHz). It is commonly used to measure computer processing speeds.

GPU
Graphics Processing Unit. The GPU is used primarily for computing 3D functions. This includes things such as lighting effects, object transformations and 3D motion.

GUI
Graphical User Interface. It refers to the graphical interface of a computer that allows users to click and drag objects with a mouse instead of entering text at a command line.

H...

Hard Disk
Also known as the Hard Drive. The hard disk is housed inside the hard drive, which reads and writes data to the disk. The hard drive also transmits data back and forth between the CPU and the disk.

HDD
HDD is short for "hard disk drive." An HDD is a storage device used to store data.

HDMI
High-Definition Multimedia Interface. HDMI is a digital interface for transmitting audio and video data in a single cable. It is supported by most HD TVs and related components.

Heatsink
The heatsink is made out of metal, such as a zinc or copper alloy and is attached to the processor with a thermal material that draws the heat away from the processor towards the heatsink.

Hyper-threading
Hyper-threading is a technology developed by Intel. It enables the a processor to execute two threads, or sets of instructions, at the same time.

I...

I/O
Input/Output. The ports on the outside of a computer are commonly referred to as I/O ports because they are what connect input and output devices to the computer.

IGP
Integrated Graphics Processor. An IGP is a graphics chip that is integrated into part of a computer's motherboard.

Input Device
An input device is any device that provides input to a computer. This includes things like a mouse or keyboard.

J...

Jumper
A small metal connector that acts as an on/off switch. A jumper is usually placed over 2 wires, which makes a connection and turns the connection "on". Jumpers are mainly found on motherboards, but can occasionally still be found on IDE hard drives and DVD drives.

K...

Kbps
Kilobits Per Second. Often confused with Kilobytes per second, which is 8 times more data per second.

Kilobyte
A kilobyte is 1,024 bytes. Most small files on your computer are measured in kilobytes.

L...

LAN
Local Area Network. A LAN is a computer network limited to a small area such as an office building, university or even a residential home.

Latency
Amount of time it takes a packet of data to move across a network connection. Latency and bandwidth are the two factors that determine your network connection speed.

Linux
Linux is a free, open source operating system. Widely used by Web hosting companies and has many other specialised applications.

M...

MBR
Master Boot Record. This is the first sector on a hard drive. The MBR holds the partition tables and bootstrapping information that allows the operating system to take over operations during initial boot up.

Mbps
Megabits Per Second. One megabit is equal to one million bits or 1,000 kilobits. Used to measure data transfer speeds of high bandwidth connections.

Megahertz
The most common area you will see Megahertz used is in measuring processor clock speed.

Memory
Generally used to refer to any electronic data storage facility in a computer system.

Memory Module
A memory module is another name for a RAM chip. It is often used as a general term used to describe SIMM, DIMM and SO-DIMM memory.

Microprocessor
More often referred to as a processor, it is the brains of a computer. Common microprocessors include the Intel Core i5 and i7 range, and the AMD FX processors.

Multithreading
Multithreading is similar to multitasking but enables the processing of multiple threads at one time, rather than multiple processes.

N...

NIC
Network Interface Card. Pronounced "nic", this is the card that connects your computer to a network cable and through that to the Internet. These cards come in speeds of 10, 100, and 1000 T-Base configurations. Meaning they can transfer data at 10, 100, and 1000Mbps.

NTFS
New Technology File System. NTFS is a file system introduced by Microsoft with Windows NT and is supported by subsequent versions of Windows.

Northbridge
The Northbridge is a chip inside a computer that connects the central processing unit (CPU) to other primary components in the system.

O...

OEM
Original Equipment Manufacturer. This refers to a company that produces hardware to be marketed under another company's brand name.

Operating System
Also known as OS. The software that communicates with computer hardware on the most basic level. Without an operating system, no software programs can run.

Optical Drive
Some common types of optical drives include CD-ROM, CD-RW, DVD-ROM, DVD-RW and Blu-ray.

Overclocking
Overclocking involves increasing the clock speed of the computer's CPU past the rate at which it was originally designed to run.

P...

Parallel Port
This 25-pin connector interface is found on the back of older PCs and is used for connecting external devices such as printers or scanners.

Partition
A partition is a section of a hard disk. You can create multiple partitions on a hard disk. The computer will recognize each partition as a separate disk.

PCI
Peripheral Component Interconnect. Most add-on cards such as SCSI, Firewire and USB controllers use a PCI connection.

PCI Express
An improved version of PCI. PCI Express can be abbreviated as PCIe.

Peripheral
A peripheral is any device that provides an external function for the computer. Examples are printer, monitor and speakers.

Platform
Platform can refer to a computers operating system or, when building a PC, can refer to the combination of motherboard, CPU and memory.

Port
There are several different uses for the word "port" but when looking at hardware (and building), it generally means the sockets where peripherals are connected to the PC.

POST
Power On Self Test. A test performed by the computer at boot up that tests the memory, CPU and various I/O devices. On a correctly working PC, you should not even know this test is taking place.

Processor
Sometimes referred to as the microprocessor or CPU, the processor does all the computations such as adding, subtracting, multiplying and dividing.

Q...

Quad-core
Quad-core CPUs have four processing cores. These cores act as separate processors but are contained in a single chip.

R...

RAID
Redundant Array of Independent Disks. When hard disks are arranged in a RAID configuration, the computer sees them all as one large disk.

RAM
Random Access Memory. RAM is made up of small memory chips that form a memory module.

ROM
Read Only Memory. ROM is memory that is written to once and cannot be changed. It is used in computers mainly for the BIOS instructions when booting up.

S...

SATA
Serial Advanced Technology Attachment or Serial ATA. An interface used to connect ATA drives to a computer's motherboard.

SDRAM
Synchronous Dynamic Random Access Memory. SDRAM is an improvement to standard DRAM because it retrieves data alternately between two sets of memory.

SLI
Scalable Link Interface. SLI is a technology developed by NVIDIA that allows multiple graphics cards to work together in a single computer system.

Socket
Socket refers to several things in computing but when building it normally refers to the places on the motherboard where components such as the CPU are plugged in.

Southbridge
The Southbridge is a chip that connects the Northbridge to other components inside the computer, including hard drives and network connections.

SSD
Solid State Drive. An SSD serves the same purpose as a hard drive but uses flash memory rather than a spindle of magnetic disks.

T...

Terabyte
A terabyte is 1,024 gigabytes. Many modern hard drives are now measured in multiple terabytes, which is a huge amount of storage.

TCP-IP
Transmission Control Protocol - Internet Protocol. These 2 protocols allow computers to communicate over networks. The TCP portion verifies the delivery of the packets (clumps of information), and the IP portion determines where the packet needs to be sent.

U...

USB
Universal Serial Bus. A very common type of PC port. It can be used to connect keyboards, mice, game controllers, printers, scanners, digital cameras and removable media drives.

V...

VGA
Video Graphics Array. The VGA standard was originally developed by IBM in 1987 and allowed for a display resolution of 640x480.

Virtual Memory
Virtual memory is memory that is located on your hard drive. Virtual memory is used if your computer runs out of space in its RAM. Virtual memory is much slower than RAM.

X...

X86
X86 is the generic name for Intel processors released after the original 8086 processor. These include the 286, 386, 486, and 586 processors.

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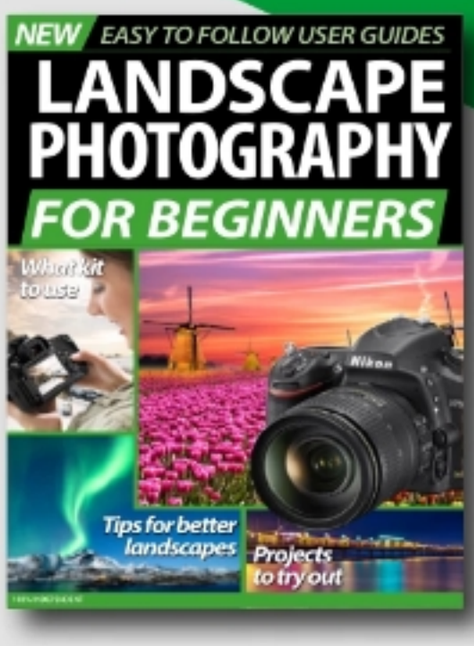

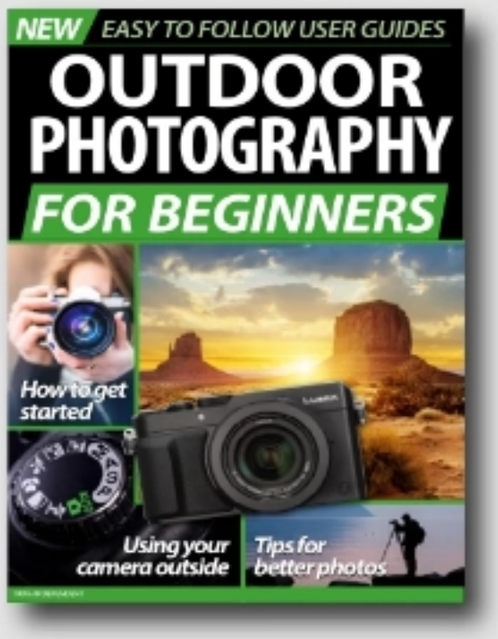

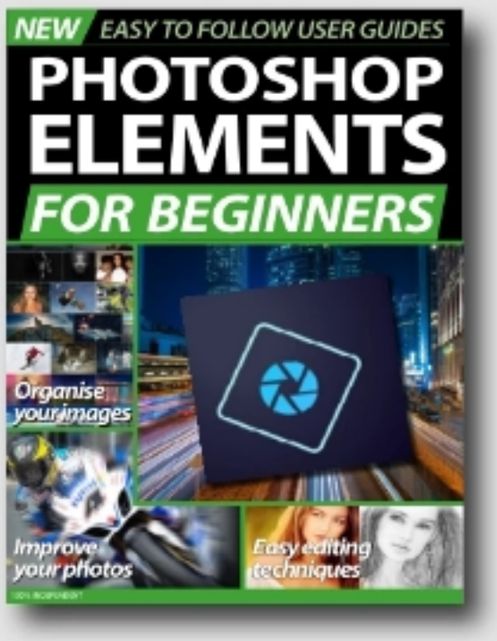

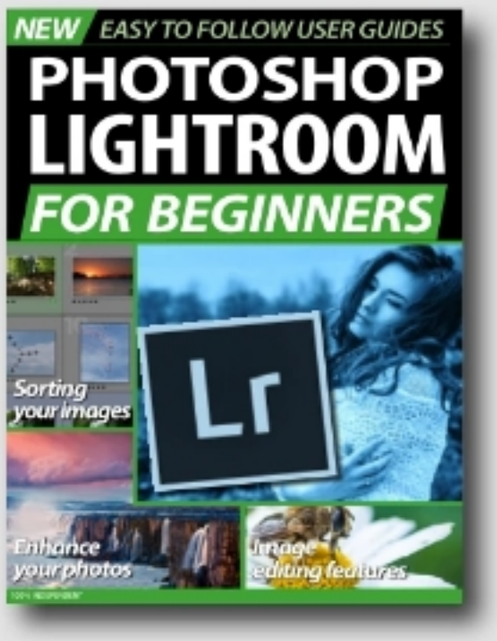

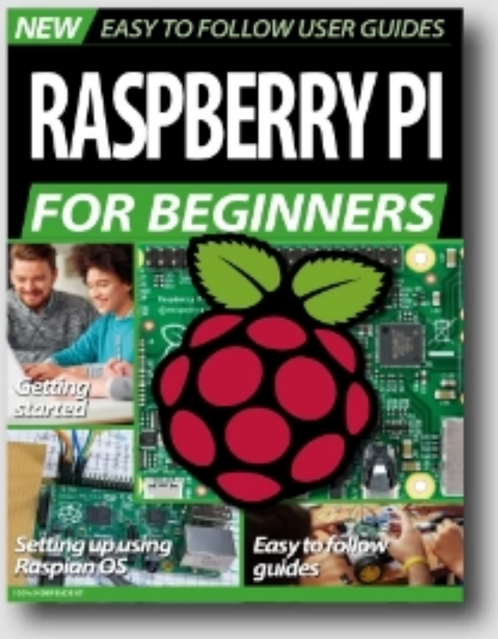

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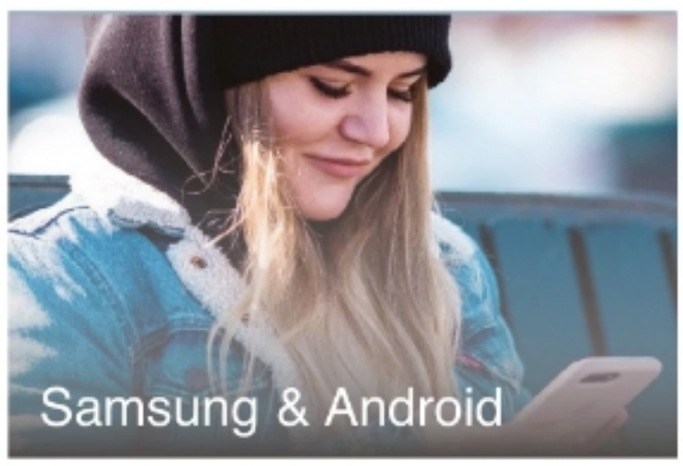

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