

How To Assemble A Desktop PC/Assembly

Now that you have selected your parts, you get to what is arguably the most fun part of the process: putting the parts together.

Tools and equipment

You won't need many tools to assemble your computer, in fact the only one you must have is the screwdriver, but if you can get most of the following together, you'll find things go a little easier.

Basic tools

Before you begin building or refitting a computer, you should have some basic tools:

1. #2 Phillips-head (cross-shaped) screwdriver
2. Needle-nose pliers
3. A large level working space
4. Brush



Combination flanged-hex/Phillips-head screw used in computers

Optional, but useful tools

Some other tools and equipment can come in handy as well, such as:

1. Anti-static Wrist Strap (**Highly Recommended**)
2. An Anti-static mat can help provide a safe place to set components down.
3. Spring action parts grabber.
4. Electrical tape
5. Wire or nylon ties
6. Flashlight, preferably hands-free
7. A second, working computer to swap parts, look for tips, ask for help on-line, download drivers and patches, etc. - very useful
8. A can of compressed air - useful when working with older parts that have collected dust. A better alternative but also more costly, is a vacuum cleaner designed for cleaning electronics.
9. Magnetic screwdriver
10. Zip ties or velcro ties for cable management



An anti-static wrist strap with crocodile clip.

Preparation

Proper preparation is the key to a successful build. Before you begin, make sure you have all the tools you will need, secure a clear, well-lit workspace, gather all the components you'll be using and unpack them one at a time, verifying that everything that is supposed to be there is actually present. At this point you should leave the parts themselves in their protective anti-static bags, and assemble all the accompanying manuals. Now I know you want to get started, but trust me, *read the manuals*, check the diagrams, make sure you understand where each part goes and how it attaches. If there is anything you don't understand, now is the time to do a little extra Internet research or call the manufacturer with your questions.

Find a dry, well-ventilated place to do your work. You should have plenty of light and if possible, you should choose an area without carpet on the floor, as carpet tends to generate a lot of static. An unfurnished basement is a good work location.



Safety precautions are important for your own security. Please read the safety precautions thoroughly.

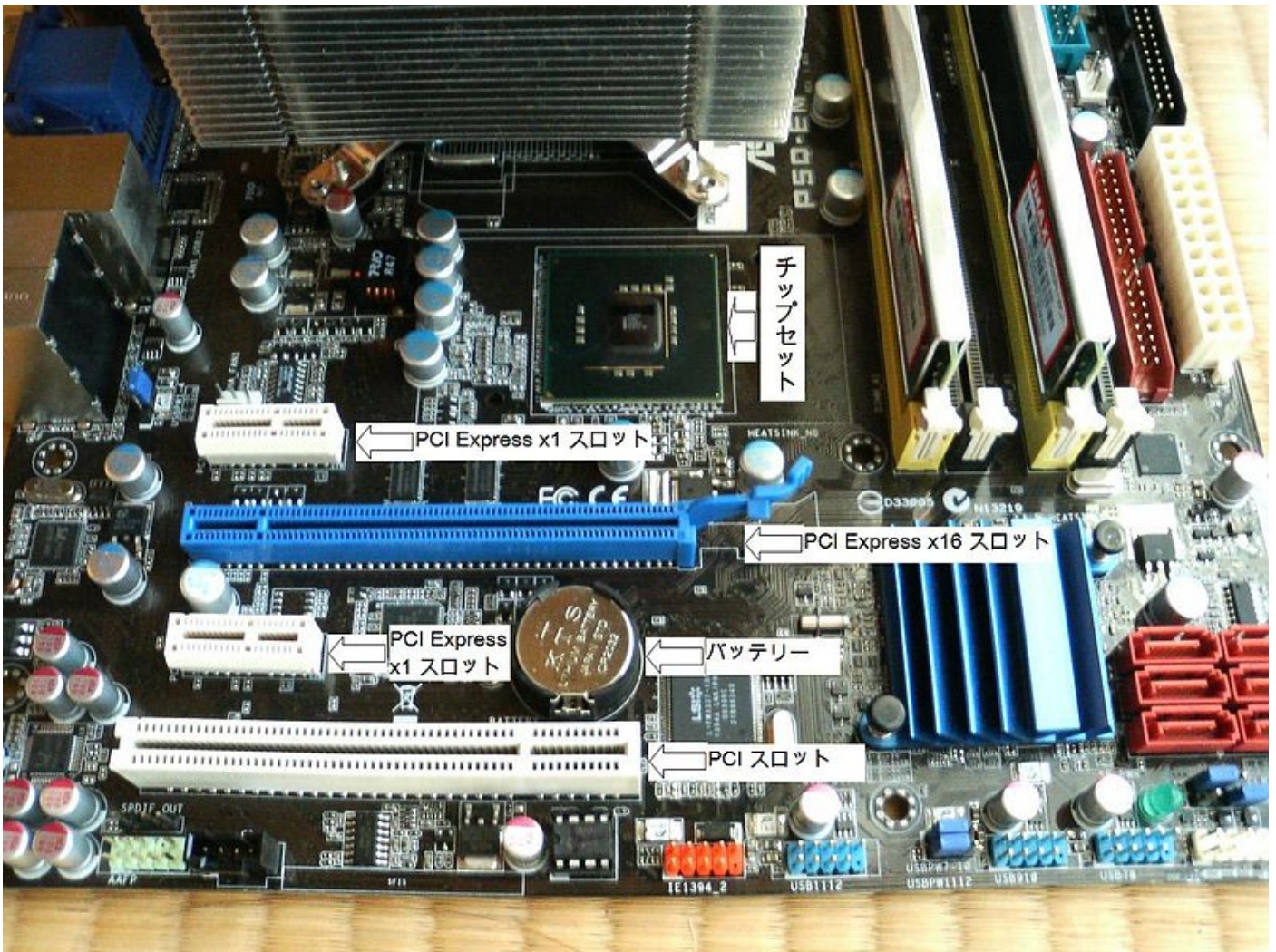
Safety precautions

1. Static electricity is the biggest danger to the expensive parts you are about to assemble. Even a tiny shock, which is much too small for you to feel, can damage or ruin the delicate electronic traces many times smaller than a human hair that make up your CPU, RAM and other chips. It's important to use your anti-static wrist strap to prevent damage to these components. Once you have the power supply installed in the case, clip the end of the wrist strap to the outside of the power supply. (Never plug your computer in while you are connected to it by a wrist strap.) This will ensure that you, the case and the power supply are all connected to a common ground, in other words there will be no inequality of charge that will allow a spark to jump from you to the case. It's also helpful to have an anti-static mat to set the case and other components on.
2. Nobody but you is at fault if you shock your components with static electricity. Make sure that you take the precautions in the previous paragraph to ground yourself from static electricity. (Note: if you really must work on a computer and have not got proper anti-static equipment, it is *usually* OK if you make sure that you do not move about much; are not wearing any static-prone clothing; handle components by the edges; and regularly (once a minute or so), touch a grounded object.). The *case metal* of your PC's power supply will usually be a suitable grounded object (please note that the metal must be unpainted). As noted above, touch it every few minutes while you are working on your PC if you haven't got a wrist strap.
3. Turn off your computer and switch off your Power Supply at the wall before installing or removing any components - if power is flowing to components as they are installed or removed, they can be seriously damaged. In order to have a computer properly grounded, you need it plugged in at the wall but turned off at the power supply and at the wall. The neutral line may be earthed.
4. Never cut the grounding pin off your power cord. This "safety ground" stands between you and potentially lethal voltages inside the power supply.
5. Be wary of sharp edges! Many lower-end PC cases have sharp, unfinished edges. This is especially so on interior surfaces, and where the case has been cut or punched-out. Use care and take your time to avoid cutting your hands. If your case has this problem, a little time with some sandpaper before you begin construction can spare you a lot of pain. Be extra careful not to cut yourself when installing the I/O Shield.
6. Dismantling discrete electronic components such as your Power Supply or Monitor is dangerous. They contain high voltage capacitors, which can cause a severe electric shock if you touch them. These hold a charge even when the unit is not plugged in and are capable of delivering a fatal shock.

Construction

Start by putting your case down on your work surface, with the case door facing up, and open the case.

Motherboard

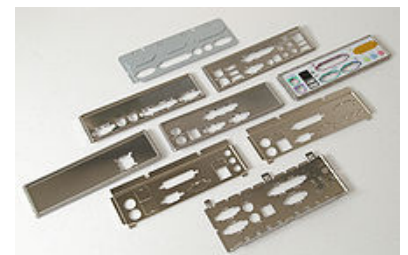


Find the motherboard standoffs (spacers) that should have come with the case. They are screws, usually brass, with large hexagonal heads that are tapped so you can fasten screws into the top. These hold the motherboard up off the case preventing a short-circuit. Set these aside.

Remove the I/O Shield from the back of the case where the ports on the back of the motherboard will fit, and put in the I/O Shield that came with your motherboard. There may be small metal tabs on the inside of this face plate, if so you may have to adjust them to accommodate the ports on the back of the motherboard.

Some case styles make it difficult to install the motherboard or the CPU with the power supply installed. If the power supply is in your way, take it out and set it aside (we'll put it back in later).

Now locate the screw holes on your motherboard and find the corresponding holes on the motherboard plate (or tray) in the case. Put a standoff in each of these holes on the tray and position the motherboard so that you can see the holes in the top of the standoffs through the screw holes in the motherboard.



A variety of io shields. Make sure to install this before installing the motherboard!

Now is the time to make sure the ports on the motherboard are mating with the backplate you just installed, and make any necessary adjustments. The small metal tabs are intended to make contact with the metal parts of the connections on the back of the motherboard and ground them, but you may have to bend these tabs a bit to get the ports all properly mounted, this is where those needle-nose pliers may come in handy.



If you have trouble lining up the screw holes, double check that you have the standoffs in the proper holes on the tray. With lower quality cases there are sometimes alignment problems and you may have to forgo one or two screws. If this is the case, make sure you remove the corresponding standoffs. Some combinations of

motherboards and cases may also use different types of screws in different places or provide non-matching screw holes that cannot be used in a specific case. The motherboard can possibly be damaged if you try to push it into position with the wrong set of standoffs underneath or when trying to use the wrong set of screw holes.

Now fasten a screw through each of the motherboard screw holes into the standoffs underneath. These screws should be snug but not tight, there is no reason to torque down on them, hand tight is fine, otherwise you can damage the motherboard.

Once the motherboard is installed, it is time to plug the other components.

CPU

Installing the CPU, and the CPU's heat-sink and fan, are by far the most difficult steps you'll have to complete during your build. Here, more than anywhere else, it will pay to read the instructions carefully, look at the parts, study the diagrams that came with your CPU and/or third party cooling solution, and make sure you thoroughly understand what you are going to do *before you try to do it*. During the process, if anything does not seem to fit or make sense, put the parts down and look things over carefully before you proceed. Some operations, especially installing the heat-sink/fan combination, can require pretty firm pressure, so don't be afraid to push a little harder if you're sure everything is set up correctly.

The details of the installation process differ in slight but important ways for each manufacturer's processors, and even within a manufacturer's product line. Therefore, for these details, you should rely on the instructions that are provided with the CPU.

The two things that go wrong the most often and most expensively (minimum of a killed CPU, sometimes more) in building one's own computer are both related to the CPU and its cooler:

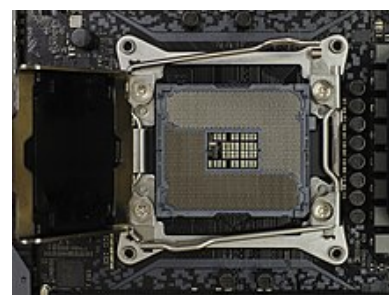
1. Switching the computer on "just to see if it works" before adding any CPU cooling unit. Without cooling, CPUs heat up at extreme rates (a CPU heats up anywhere between ten times and a thousand times as fast as a cooking area on your stove!). By the time you see the first display on the screen, your CPU will already be severely overheating and might be damaged beyond repair.
2. Mounting the CPU cooler improperly. Read the instructions that came with your CPU and cooler very carefully and ensure you are using all components in the correct order and correct place.

If you buy a third party cooling solution for your CPU make sure you get one that is compatible with the CPU you have. "Compatibility" here just means, "Can you fit it in next to your RAM or whatever else is sticking up in the neighborhood." Most brands come with multiple mounting brackets that will suit many different chipsets, but it is best to check for compatibility just in case.

After the CPU is installed in the socket and secured in place, it's time to add thermal paste and then install the cooler. The plain metal back of the CPU, which is what you're now seeing, is exactly matched by the bottom plate of the cooler. You add thermal paste *only* on the CPU, *never* on the cooler's surface. Very little is needed. The two flat metallic surfaces will spread the paste between them, and it will spread a bit more when it becomes hot. (The cooler surface may have a protective piece of film over it; don't forget to remove it. But see below for the possibility of "thermal pad" being supplied, instead of paste. This is rare nowadays, but *read the instructions*.) A pea-sized dot is the amount usually advised, though some people make a thin "X" on the CPU surface, and some draw a line. (There are numerous videos on YouTube advocating one or another, some with photos using glass plates.) Don't overdo -- you don't want paste squeezing out the edges. Some people suggest spreading paste over the whole surface, then cleaning it off with a razor blade, then adding the pea. The idea is to close invisible imperfections in the metal. This is probably overkill, and involves extra handling of the CPU, never a good idea. Try not to touch the mating surfaces of the CPU and cooler -- the oils from your skin will impede heat transfer. You should receive a tube or applicator of thermal paste in the CPU or cooler package, some CPU coolers come pre-applied with thermal paste (such as AMD's wraith cooler), you can optionally add your own to the CPU as extra or continue



Some motherboard CPU sockets come with a plastic protector. This should be removed before the CPU is inserted, and saved for later.



An example of a Intel CPU socket, LGA2066.



An AM4 socket for AMD processors

with the pre-applied compound. If your CPU didn't come with thermal paste and the cooler didn't have any pre-applied, thermal paste is readily available from most computer retailers.

See *Arctic Silver Instructions* (<http://www.arcticsilver.com/instructions.htm>) for more info on how to apply and remove thermal paste/grease. (It was written to be specifically for Arctic Silver paste, but the same techniques can be applied to other brands of thermal paste.)

If using a thermal pad supplied with your cooler, make sure you remove any protective tape from the die just before installing and do not get it dirty - and do not combine thermal pads with thermal paste, it is either one or the other. Then, check that you install the cooler in the right orientation and that you set it flat on the CPU die without exerting undue pressure on any edges or corners - the latter can make small pieces of the die break off, killing the CPU.

One option you may consider, before installing the heat-sink, is to "lap" the heat-sink, which means to smooth out the bottom surface. To do this, you will need a very flat surface; a piece of thick window glass will work. Fasten your sandpaper on the flat surface, invert the heat-sink on the sandpaper and sand in small circles, applying minimum pressure. Check frequently and when you see a uniform pattern of scratches, switch to finer grained sandpaper (the numbers go up as the sandpaper is finer, so something such as 220 is coarse while 2000 will be very fine.) Remember that you are not trying to remove any material, just polish out surface irregularities. If you get it right, you should have a surface which feels completely smooth to the touch (but don't touch it, the oil in your fingers can cause corrosion of the fresh surface) with a mirror finish. Some companies producing heat-sinks lap the surface themselves, so if the surface already looks like a perfect mirror, leave it alone. A lapped heat-sink is more effective as it will have better surface contact with the chip.

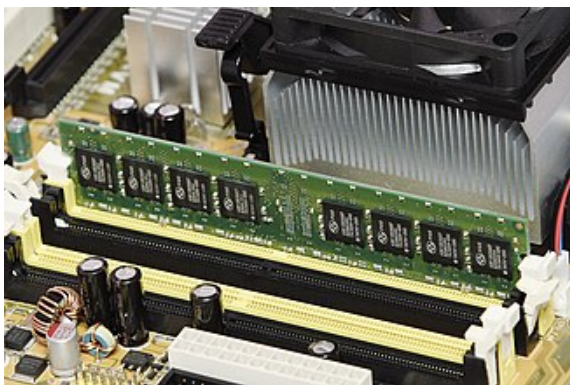
Tighten the cooler using only the specified holding devices - if you did everything right, they will fit. If they do not fit, check your setup - most likely something is wrong. After mounting the cooler, connect any power cables for the fan that is attached to the cooler.

As an aside to the instructions above, it has been my personal experience that fitting the CPU and heat sink is best done on a supportive surface (a telephone directory on a table in my case) prior to installation, to avoid excessive flexing of the motherboard.

A last note: if something goes wrong and the cooler has to be removed (like maybe you realize you didn't take the protective film off the cooler surface), the paste will have to be removed from the CPU for the restart. *Don't panic!* All it takes is a coffee filter (not paper towels or anything else that will leave fibers) and a little isopropyl alcohol (from the drugstore). Thermal paste removes easily with a little gentle rubbing. Work from the outside edge in.

If you've got the CPU and its cooler installed, and the motherboard in the case, you're over the hump, there are just a few more easy pieces to go before that momentous first power-up.

Memory slots



RAM module in a socket

Next, you will need to install your RAM (random access memory). Find the RAM slots on your motherboard; they will look something like the picture on your left. To install the RAM modules, first push on the levers (white plastic in the picture) on either side of the DIMM socket, so that they move to the sides. Do not force them, they should move fairly easily.

Put the RAM module in the socket. Line up the notch in the center of the module with the small bump in the center of the RAM socket, making sure to insert it the right way. Push down on the module until both levers move up into the notches on the sides of the module. There should be a small "snap" when the module is fully seated. Although this does require a fair bit of force, do not overdo it or you may break the RAM module.



The base of a CPU heatsink. Remove any plastic film on the bottom of the heatsink before installation.

Take a good look at your seated RAM, if one side seems to be higher than the other, odds are it is improperly seated - take it out and try again. As you handle the RAM, try not to touch the copper stripes you can see along the bottom edge, as doing so is the best way to damage the part.



Motherboards often use color coded slots to indicate which slot corresponds to which RAM channel

Start adding RAM at the slot labeled "Bank 0" or "DIMM 1". If you do not have a stick in "Bank 0" or "DIMM 1" the system will think there is no RAM and will not boot.

On motherboards with 4 slots, you'll see alternating colours. For example, slot 1 is blue, slot 2 is black, slot 3 is blue, slot 4 is black.

If you were to put 4 gigabyte of RAM in your personal computer, it is best to use dual channel 2 GBx2 sticks. Put the first 2 GB stick in **slot 1**, and put the 2nd stick in **slot 3** (the two slots that are blue) - leaving slot 2 empty. This will give you better performance, than putting 4 GB in slot 1 alone.

Power supply

Installing your power supply is pretty straightforward, if it came with your case it was pre-installed and if you took it out earlier to get the motherboard in, now is the time to put it back. Otherwise a few moments of screwdriver work will get the job done. Generally there will be a bracket on the top of the case where the power supply is mounted and a few screws used to fix it in place. Some cases place the Power Supply differently, see the documentation that came with yours.

Some power supplies come with modular cables, so you can plug in only those you'll be using; now is a good time to figure out what you'll need and plug them in. Other power supplies have all the cables hardwired in, you'll want to separate out the ones you'll need and neatly coil the remainder somewhere out of the way.

If your power supply has a switch to select 115 V or 220 V make sure it is set properly, this is important. Many newer power supplies can automatically select and don't have such a switch.

Once you get the power supply installed make sure you check the motherboard documentation carefully for the location of the power sockets. You may then connect the main power, a 20 or 24 pin plug, into the motherboard. There may also be an additional four or eight pin power lead that needs to be plugged in to the motherboard (the CPU power connector) usually located near the processor socket.

Graphics card

If your motherboard or CPU has a built-in graphics adapter you want to use (like Intel HD Graphics), skip this section.

If you have a PCI Express video card, install it into the PCI Express socket. Your computer will have a few of them, but choose the one which is most convenient for you and will allow you to fit it into the desktop case easily. Check your motherboard manual for instructions.

When your card is properly installed the line formed by the top of the card will be exactly perpendicular to the motherboard, if one side seems to be higher than the other, chances are that it is not fully inserted, press a little harder on the high side or pull it out and try again.



Insert the card into a matching slot on the motherboard.

Installing drives

Next install the storage drive and optical drives.

How a drive is physically installed will depend on the case.

Most drives are SATA (Serial ATA) which use simple, small cables for a data connection. The ends of the cables are L shaped, just look carefully at the cable ends and the connector on the drive and match them up. Only one drive can be connected to each SATA port on the motherboard.

Next install the SATA power cable. Some SATA drives also have a molex power connector - make sure you connect **only one** of these ports to the power supply, connecting both can damage the drive.

Newer SSD's will often use the PCI Express standard; for those, follow the same instructions as you would do for a PCI Express graphics card.

Other connections

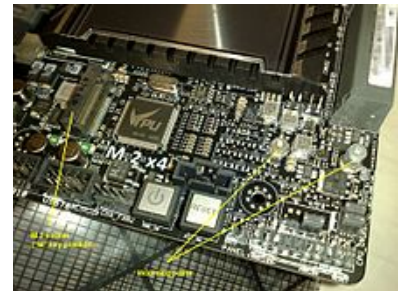
In order to turn the computer on, you will need to connect the power button and while you are at it, you might as well do the reset buttons and front panel lights as well.

There will be a set of pins, usually near the front edge of the motherboard to which you will attach the cables sometimes already connected to the front of the case, or if needed to be supplied with the motherboard. Most of the time the plugs will be labeled as the pins they will connect to in the motherboard, there they can be difficult to read since the print is very small or you may not be in the right orientation to do so. The documentation that came with your case and motherboard should tell where these connectors are.

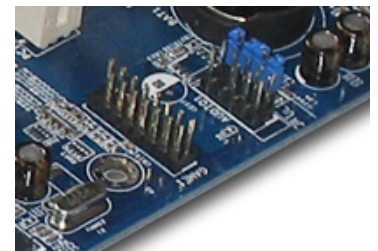
In addition, you can connect any case-specific ports if they are supported by the motherboard. Many cases have front mounted USB ports and audio jacks.



A Serial ATA connector



A M.2 slot on a motherboard with mounting posts highlighted



Some cables are attached to pins on a board (e.g. motherboard or extension card)



Other connections of this type to remember can be power for the CPU fans, various temperature sensors and Wake-on-LAN cables (if the feature is supported) from the network card to the motherboard.

Prepare for power up

Some people will put power to a system several times during assembly and for experienced builders this may serve some purpose. For first timers though, it's best to assemble a minimal complete system before powering up. Minimal because that way there are comparatively few potential sources of trouble, complete so that you can test everything at once and because the fewer times you have to put power to an open machine, the better..

If you've been working along with us you should now have such a minimal system put together. Briefly this includes a case with a motherboard in it, a processor (and its cooling unit) and some RAM plugged into the motherboard, hard and floppy drives installed, and some kind of video available. If your motherboard has built-in video, you might want to use that for this first try, even if you are going to install a video card later.

For this test, you'll want to have the computer open, so that you can see all of the fans, and you'll need to connect a monitor and a keyboard and a mouse (OK, you don't really need the mouse . . .)

Monitors will either have a VGA, DVI, HDMI (see picture, as they are a lot less apparent than PS/2 / USB by comparison) or for newer ones, a Thunderbolt 3/USB 3.1 plug. Most monitors use HDMI connectors, and so most graphics cards have HDMI output. If you have one type of plug and the graphics card has another, you can easily buy an adapter. Some cards even come with one.



Comparison of VGA, DVI and HDMI

There are two standard connectors for mice and keyboards; PS/2 connectors and the more modern USB connectors. Plug the mouse and keyboard in the appropriate slot.

Note: If you intend to install an operating system from a boot CD or floppy, or modify BIOS settings you will need to use either a PS/2 keyboard, a USB to PS/2 converter, or a motherboard that supports USB devices. Otherwise your keyboard will not work until the operating system has loaded USB drivers.

Once you have this all set up, it's time to double check, then triple check that you have made all the necessary connections and that you haven't left any foreign objects (where's that screwdriver?) in the case.

Power up

Take a moment to check one more time that everything is as it should be . On the first power up, you will be observing the computer itself to confirm the cooling system is working correctly, making sure that your fans work. The first thing to look for is that the CPU cooler fan spins up, if it does not, cut the power immediately. This fan should start up right away. If it does not, then something is wrong and you should shutdown the computer immediately. When you are ready remove your wrist strap, turn on the monitor, then press the power button, and observe the inside of the open machine. (*Do not touch any part of the inside of the machine while it is powered up*)

If the CPU fan spins up, check that all the other fans that should be spinning – case fans and fans on the power supply and video card (if installed) are also spinning. Some of these fans may not spin up until a temperature threshold is passed, check your documentation if anything is not spinning.

If the fans spin, you can turn your attention to the monitor, what you are hoping to see is the motherboard's splash-screen, usually featuring the manufacturer's logo. If you see this, take a moment to bask in the glow, you've built a computer!

If this happy event does not occur, if smoke appears, or if the computer does not do anything, unplug the power cord immediately and check the steps above to make sure you have not missed anything. Give special attention to the cables and power connections. If the computer does appear to come on, but, you hear beeps, listen carefully to the beeps, turn the computer off, and refer to your motherboard's manual for the meaning of the beeps. Some boards have an optional diagnostic device, usually a collection of LEDs, which when properly plugged in will inform you of the nature of the problem. Instructions for installing this as well as the meaning of its display should be in the manual for the motherboard. If the computer turns on but the only thing that comes on is your power supply, turn it off. This probably means something is shorted, and leaving it on could damage the parts.

If all is well it is time to turn the computer off, and close it up. Then you may want to turn it on again and set certain options in the computer's BIOS/UEFI (usually by pressing 'F1' or 'Del' a few seconds after boot.) These options will be explained in the motherboard manual. In general, the default options are OK, but you may wish to set the computer's hardware clock to the correct time and date. The BIOS/UEFI is also where you determine the default boot order of the system, typically F\floppy, then CD-ROM, then Hard Disc.

If you want a further quick test before you install an operating system, you may find a bootable Disk or USB flashdrive such as Knoppix extremely useful.

Additional hardware and peripherals

Now that you have a working system it's time to think about installing an operating system, which is covered in the next section. It's best to leave the installation of additional components (like expansion cards, and second video cards) and peripherals (printers, joysticks, etc.) until after the OS install in order to allow the plug n' play features of the OS to do their trick.

References

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