BUILDING A BASIC COMPUTER
by redwudz.

This is a project to assemble a basic home computer. From start to finish, it took me about 2 hours. This project creates a fairly up to date system. It uses an AMD AM2 CPU and DDR2 memory. It's an economy computer with on-board video, LAN and USB 2.0 connections, on a Micro-ATX motherboard. If you wanted to use this for video work, I would add a second hard drive and a second optical DVD drive. The 512MB memory is sufficient for most video work. The CPU in this project is a used one. It was replaced in the original motherboard by a dual core CPU, which I would definitely recommend. An Intel CPU and motherboard would use almost exactly the same process to construct. Another easy upgrade would be to install a PCI-E video card in place of the on-board video. This would benefit gaming mostly and would free up a little RAM, but really not change performance that much. For higher performance, use a faster CPU.

The parts and costs in October 2006 in US dollars, excluding taxes and shipping:

Hon-Hai TX346 Micro-ATX computer case with 300W power supply:	$ 38.00
AMD AM2 Athlon 64 3800+ CPU with included CPU cooler.	$160.00
ECS RS485M-M Micro-ATX motherboard w/video	$ 60.00
Samsung PC-6400 512MB DDR2 240-pin Memory	$ 60.00
Sony DW –Q120A 16X DL DVD-RW drive	$ 30.00
Maxtor 160GB SATA2 hard drive	$ 55.00
Windows XP Home Edition	$ 80.00

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	$483.00

Accessories not included in price

Keyboard	$ 7.00
Optical mouse	$ 5.00
Front intake fan	$ 4.00
Computer monitor	$?

These costs change almost daily, but for the most part seem to go down. Memory is a little high at present, but should be dropping. This project doesn't include the computer monitor, so that would need to be purchased also to make this complete. You may also need a modem if you are on dialup.

When you are choosing a motherboard, go to the motherboard manufacturer's site and download a copy of the motherboard manual. It will give you information about the MB that isn't obvious from the ads or MB descriptions. It's also a good idea to do a Google search for the name of your MB with 'reviews' added to the search words

to see if there are any reviews for it on the net. This MB was new enough at the time of purchase that no reviews were available. MB reviews may give you some good information about the motherboard you may not see elsewhere. Once you have decided on a MB and ordered it or purchased it, spend a day or two going over the manual and familiarizing yourself with it. This will save a lot of time and frustration when actually installing the MB and setting it up.

Photo 1. The parts stacked in front of the case container. (Some of these are representative, as I was assembling the computer at the time.) You will note there are about 6 basic parts. This is not a complex project.

Photo 2. The Micro-ATX case. I somewhat dislike the doors in front of the optical drive as you need to push on the DVD tray to close it instead of using the now hidden open/close button. I probably wouldn't use this type of case again. It is well built for my purpose, but I failed to note the type of 'doors' when I ordered it. You could also use a mini-tower case, which are only a few inches bigger all around. If you use a full size ATX motherboard, you will need the mini-tower size. They also have a little more room to work in, and have generally better cooling options.

Photo 3. Parts included with the motherboard. There are a couple of ATA cables, a SATA cable and the rear connector panel, along with a motherboard manual and a CD disc of motherboard drivers. The motherboard is underneath, wrapped in an anti-static bag.

Photo 4. The motherboard. It is sitting on the anti-static pad it came with. Keep this pad on the MB until you are ready to install it.

Photo 5. The CPU cooler. This is a Standard AMD model included with the CPU. This one is used. The hold down latch is slid out to one side. It's fairly quiet and sufficient for most uses.

Photo 6. The only tool you need. I like the replaceable tip Phillips #2. You definitely want a magnetic tip so you don't drop screws down into the case.

Photo 7. The AMD AM2 Athlon 3800+ CPU. It's sitting on an antistatic pad. This one is used. I cleaned off the old thermal compound with a fingernail and 99% isopropyl alcohol on a dampened Q-tip. Same for the cooler. Be careful not to scratch either surface. Don't get any fingerprints or oils on the CPU heat spreader or CPU cooler surface. Clean them off if you do.

Photo 8. The case with the four rear screws and the two side panels removed. It's a good quality case with an included power supply that is big enough for this type of computer. There are no sharp edges or poor fits that you may see with some cheaper cases. It has a rear exhaust fan included.

Photo 9. The parts included with the case. A line cord, a package of screws and an assembly instruction paper. Don't lose this. It has the front panel wiring diagram on it.

Photo 10. The case with all the wiring pulled out of the way, laid on its right side. This is the best way to work on it at this stage.

Photo 11. Checking the motherboard for fit and seeing where the mounting holes line up with the case.

Photo 12. The contents of the case screw package. The motherboard standoff mounts are to the top, below are the optical drive mounting screws and at the bottom, the motherboard mounting screws and the screws for the hard drive mounts. There is also a token zip tie. Get about 20 of these, in 4 inch length as you will need them later.
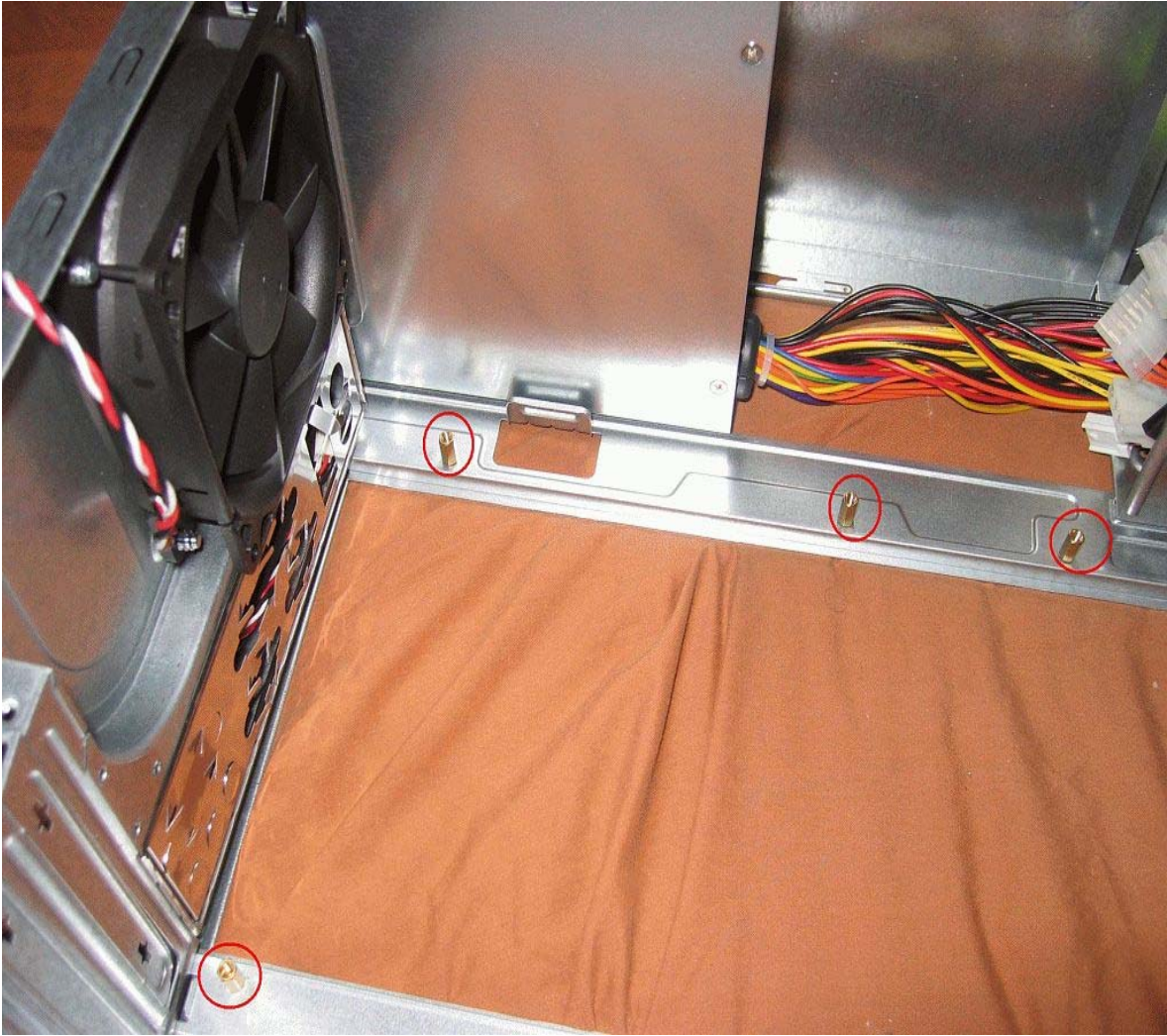
Photo 13. The motherboard standoff mounts placed in the proper holes in the case. Just tighten them with your fingers. They aren't going anywhere.

Photo 14. The generic motherboard connector panel. Just pop it inwards and use the one included with the motherboard.

Photo 15. The proper motherboard connector panel for the ECS motherboard. Try not to bend it when inserting and make sure it is seated evenly all around in the opening.

Photo 16. Not really needed, but I decided to install an intake case fan in front of the hard drive. The rear exhaust fan works with this and results in better case air flow and keeps the hard drive cooler. Check the orientation of the back exhaust fan and flip this one the opposite way for intake use. It comes with 4 special mounting screws. Ball bearing fans last longer in these applications. Avoid most sleeve bearing fans. This one was about $4.00. You need either a 4 pin Molex power supply plug on this or a smaller 3 pin plug if you want to plug it into the MB fan sockets. This MB only has one spare fan socket, so I will use a 3 pin to 4 pin Molex adapter.

Photo 17. This is the wiring diagram for the case front panel connections.

Photo 18. The motherboard, along with the CPU. Notice the retention arm is raised to a 90 degree angle, ready to accept the CPU.
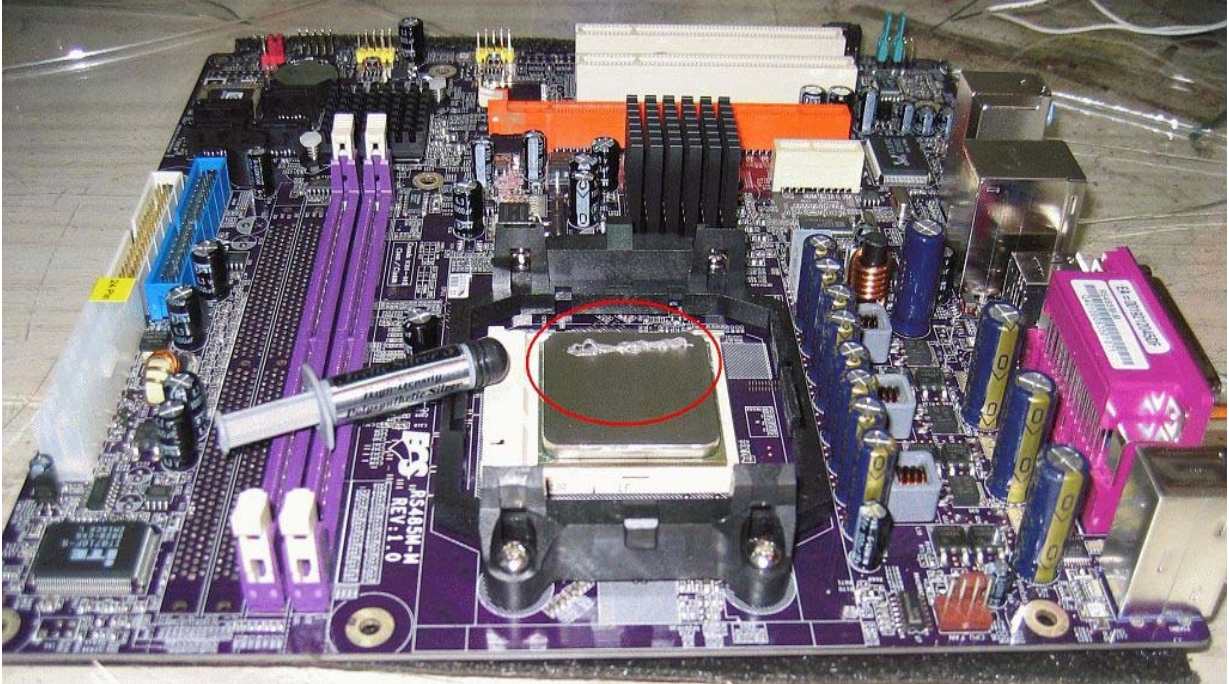
Photo 19. The CPU installed. These CPUs use a ZIF socket. (Zero Insertion Force.) You unlock the small arm and raise it to the 90 degree position. The CPU has a small mark on it you align with the socket. You place it over the socket and it should easily drop down into it. Don't use any kind of force!! I usually hold down on the CPU lightly, then lower and lock the arm to be sure it is fully seated. If you get any finger prints or oil or dust on the CPU heat spreader surface, clean it now with isopropyl alcohol and a dampened, lint free paper towel.

This was a used CPU and cooler, so I am using Artic Sliver thermal compound on it. Normally a new cooler will come with a thermal pad and that works fine. Make sure to remove the plastic cover from the thermal pad before placing against the CPU. These particular CPUs run relatively cool, so large CPU coolers or special cooling is not necessary. Using the factory cooler also gives you a 3 year warranty on your CPU, so it's definitely worth using. It's relatively quiet and will work with AMD and the motherboards 'Cool and Quiet' program to automatically control fan speed. You can see the bead of thermal compound placed on the CPU, I spread this out with a plastic card. One of those thin 'fake' credit cards you get in the mail work great for this. It took another bead about the same size to put enough compound on the CPU surface to fully cover it. Don't get it on anything else but the top surface of the CPU. You can clean off excess with a Q-tip dampened with isopropyl alcohol.
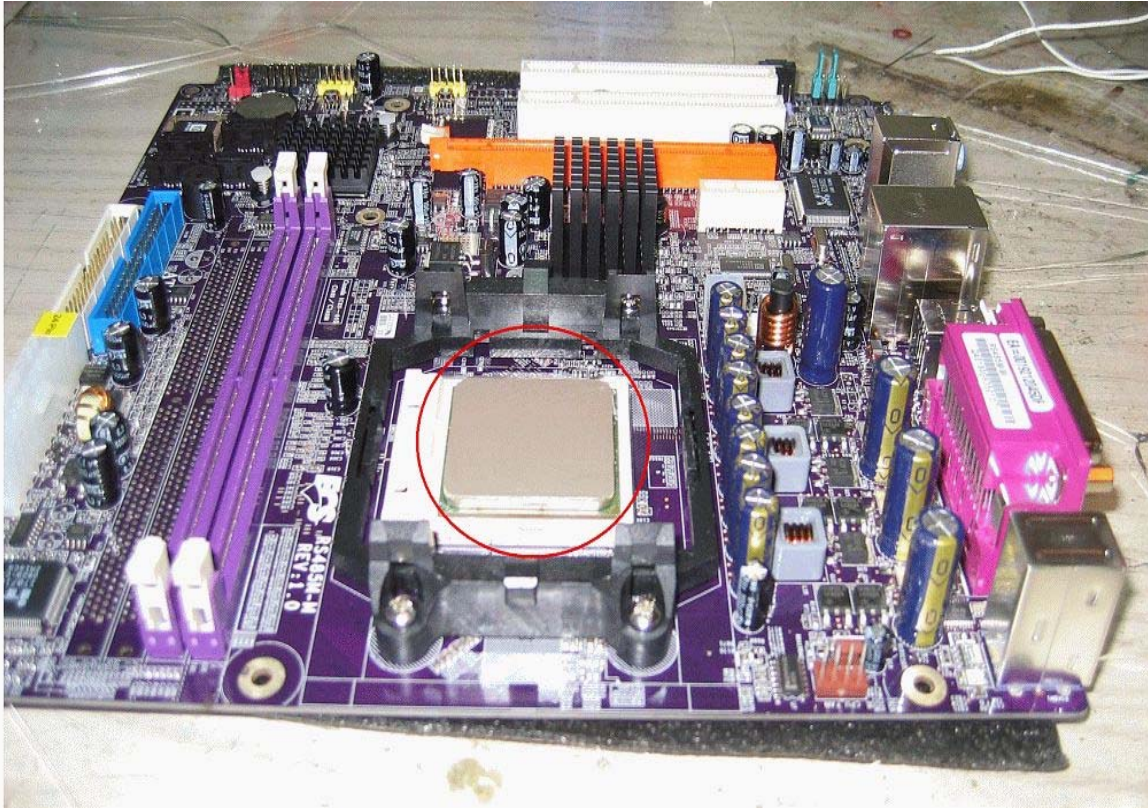
Photo 20. The thermal compound spread evenly over the surface of the CPU heat spreader. It's about the thickness of a magazine cover.
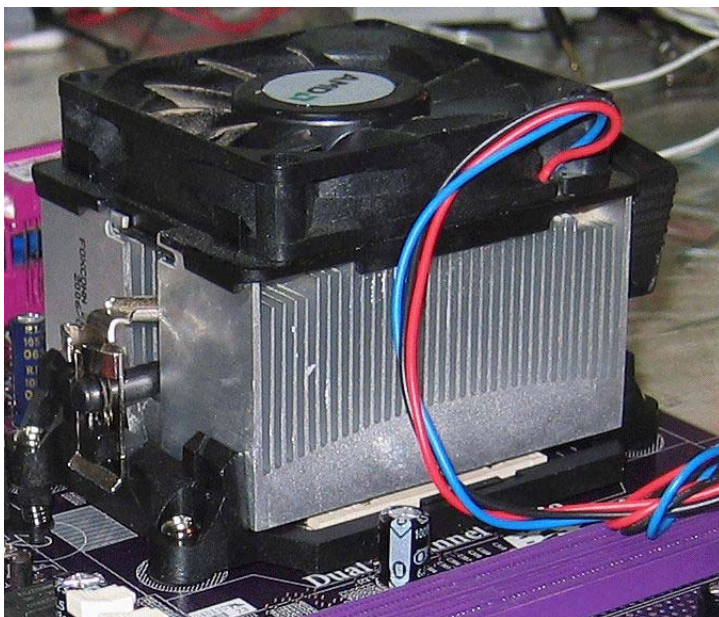

Photo 21. The CPU cooler in place. Make sure it's oriented properly. These coolers and this motherboard allow you two different directions, either will work, but I put the fan wiring near the fan power socket. Look at the photos in your motherboard manual for mounting information, also in the information that comes with the CPU. You should have studied all this before you started assembly. There are many

different types of CPU cooler mounts. Getting this right is critical to cool and stable operation.
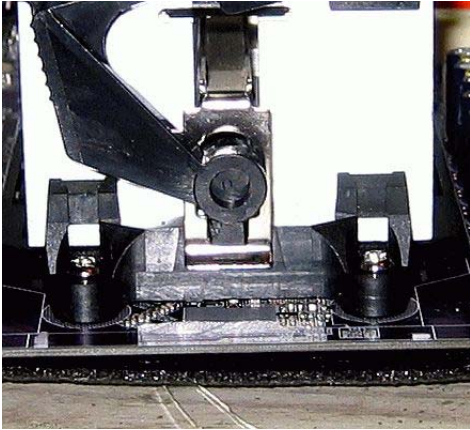

Photo 22. The CPU cooler latch is hooked over the pin that sticks out from the socket. Be careful not to move the cooler around, just slide the latch out and hook it. It takes a little force to hook the latch. Be careful here. Go slow and double check that it is hooked properly. This is very important! You may have to lightly hold down the CPU cooler by using the sides of the fan housing. Do not touch the fan blades or put any force on them. Refer to the CPU and the motherboard manual, or if you have an after market CPU cooler, study the manual that comes with it. When you do this operation, leave the antistatic pad under the motherboard and place it on a hard, flat surface. Do not do this with the motherboard in the case if you can any way avoid it. You will see why in the next steps.

Photo 23. Holding the CPU cooler in place by the edges of the fan housing, place the second clip down over the pin on the other CPU holder. Some of them have a slot that you can use a flat bladed screwdriver to extend out the latch and hook it over the pin. BE VERY CAREFUL with the screwdriver. Make sure it fits snugly in the holder or DON'T USE IT. Find one the proper size. This is important, because if that screwdriver slips, you can very easily destroy the motherboard. Been there, done that, felt bad and it cost me $50 for being in a hurry.

Once both latches are over their pins, double check them and check the CPU cooler to see it is properly seated in the socket and against the CPU and centered properly over it. Takes lots of time here, this is very important.
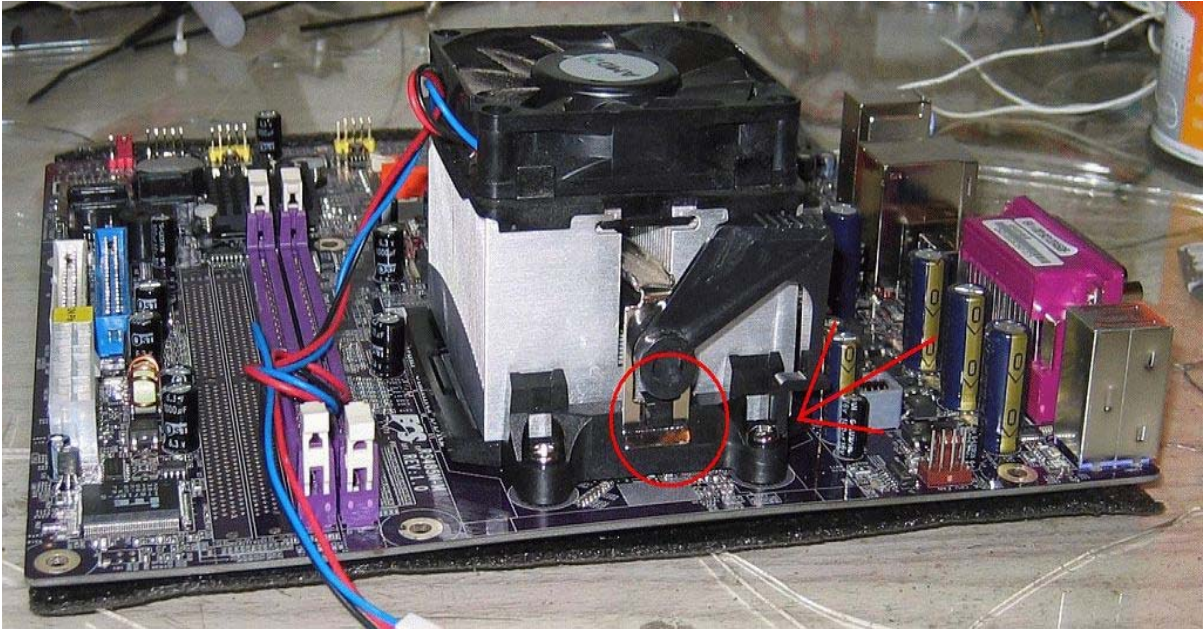
Photo 24. This photo shows the hold down lever in the latched position. Before you latch it, it will be somewhat vertical and the latches will be loose. Holding down on the edges of the CPU fan housing, rotate the lever over to the latched position. This will take a fair amount of force. Now you know why you want to do this on a hard, flat surface. The cooler will put from 25-30 pounds of force against the CPU surface to ensure full contact. This is why the thermal compound doesn't have to be very thick. It will squeeze out the sides if you use too much. Once you have the hold down lever in the latched position and the cooler latches are correct and the CPU cooler is fully seated, you can take a break. This is probably the most difficult part of assembling a computer and you have to do it right. You can take the CPU cooler by the fan housing and try to lightly twist it to ensure that it is properly seated. It may not move, don't force it. It may move just a little. But it won't be loose. If it moves a little, it will tighten up when the CPU warms up.
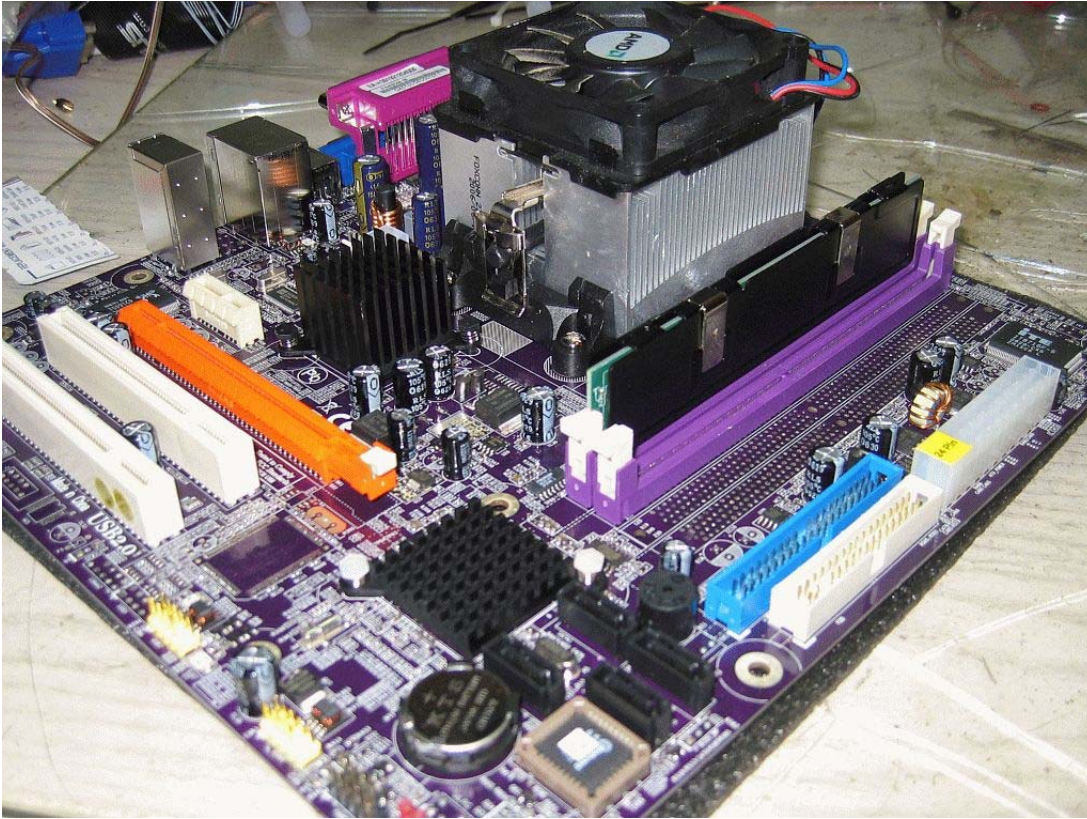
Photo 25. The CPU cooler in place, the CPU fan plugged into the proper socket, and the memory module in place. You don't have to install the memory at this point, but it's usually easier. Before I plug in the fan lead for the CPU, I usually loop it into a loose knot so it doesn't flop around. But you can do this later if needed.
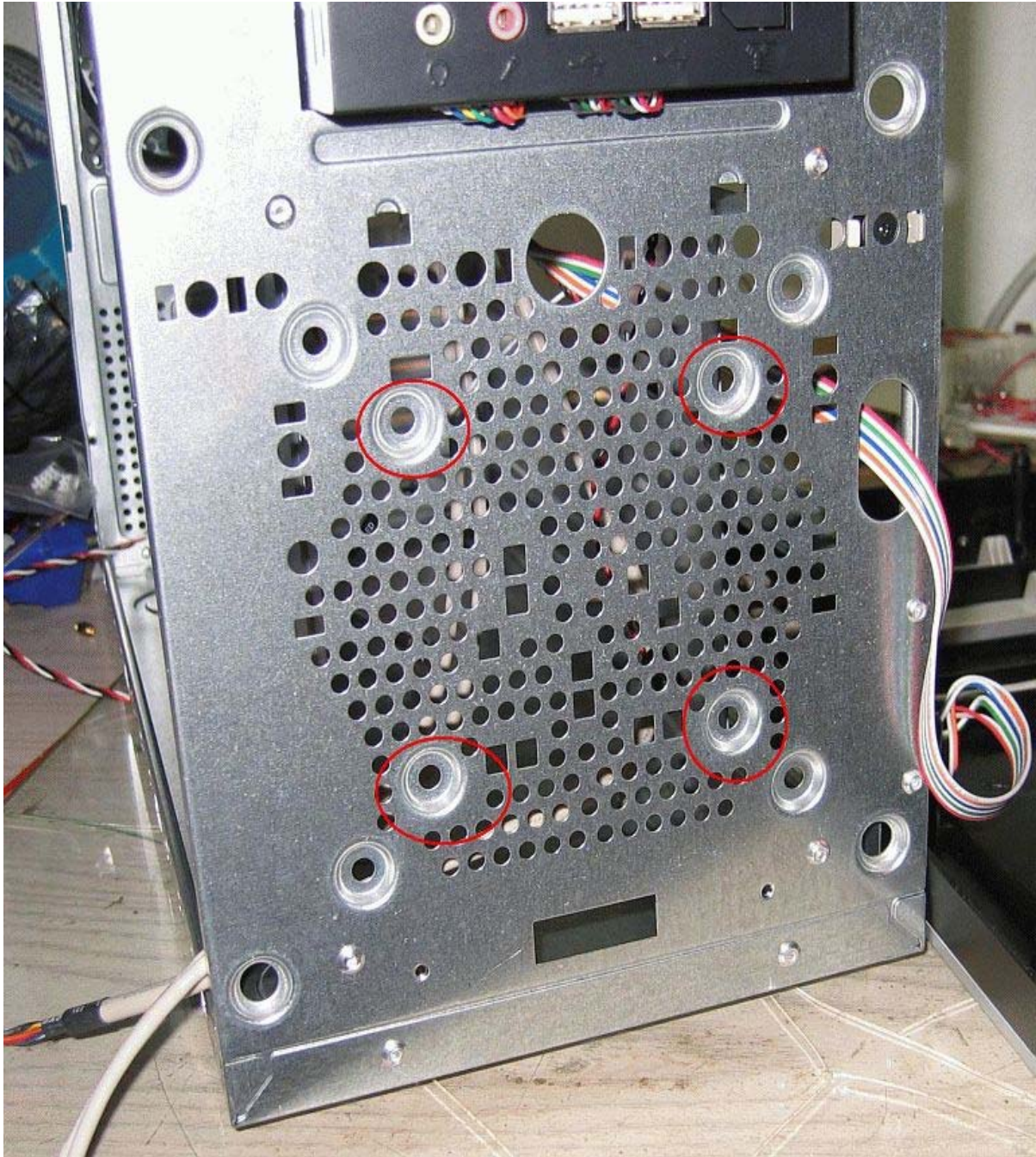
Photo 26. Installing the front case fan. You will usually need to unclip the front panel from the case. On this case, it has six latches you squeeze to release the front panel. Cases vary, so spend a little time finding how yours comes off. The four circled recesses are for an 80mm fan. The next ones out are for a 120mm fan. The 120mm fans are a better choice if your case can use them. They generally turn slower and move more air and are quieter than the 80mm fans. Place the fan on the inside of the case and line up the four screw sockets to the case fan screw recesses. Make sure you turn the fan in the right direction. It should be the opposite direction from the rear exhaust fan. Worst case, if you get it backwards, you will have to remove the hard drive, pull off the front cover and reverse it. You don't want it to

blow air out of the case; you want to blow air <u>into</u> the case with this fan. Place the fan with the wires toward the bottom and snug it down evenly with all four self tapping screws. Replace the front cover.
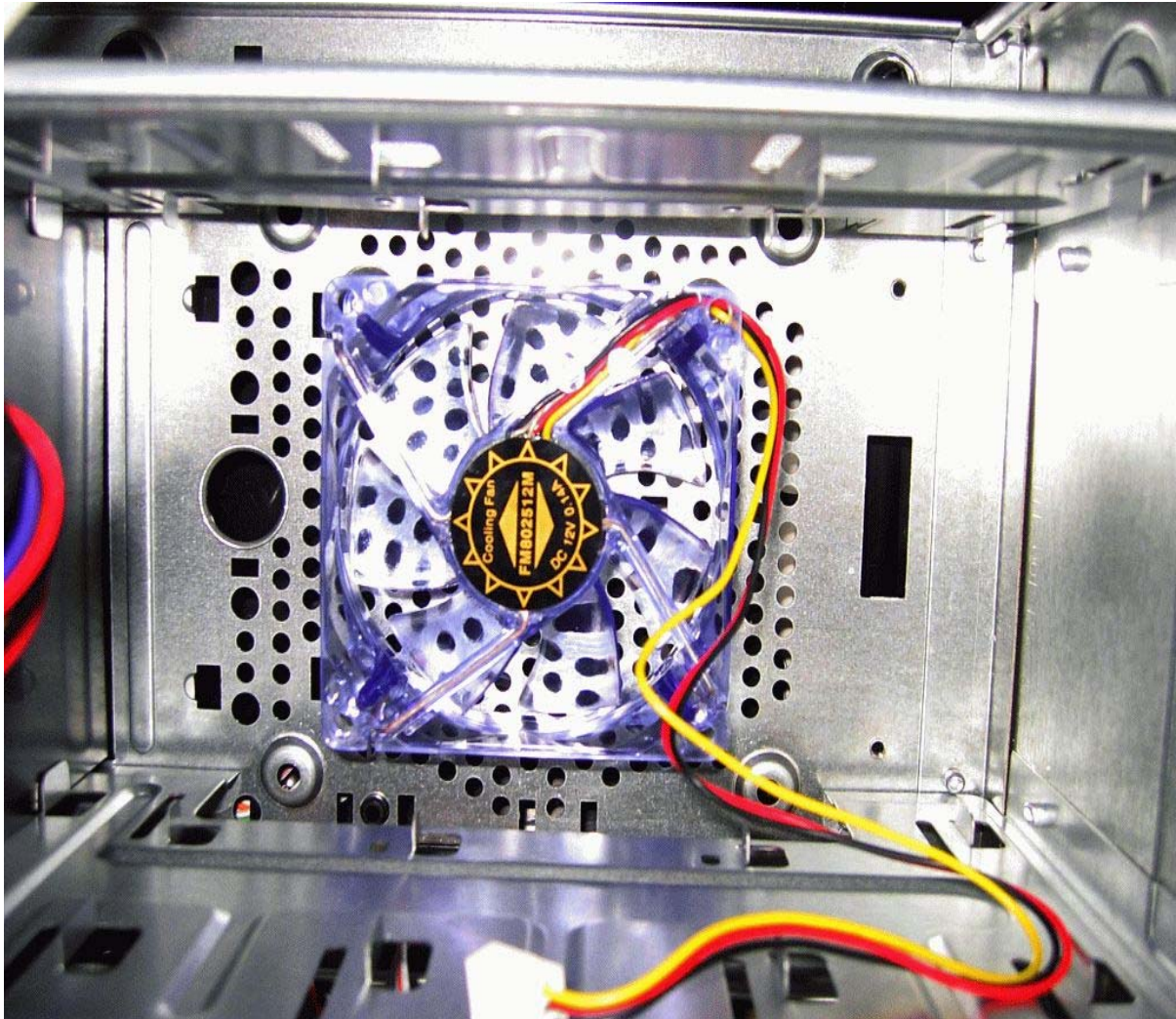

Photo 27. The fan installed.

Photo 28. Installing the motherboard in the case. For anti-static safety, touch the metal part of the case and a metal part of the motherboard, usually the exposed metal on the input output connectors, both at the same time to equalize any static charges. My location doesn't have much in the way of static electricity, because of the humidity, so I tend to forget anti-static safety. If you are in a dry climate and have static electricity problems, you might want to invest in an antistatic wrist strap. You should be able to find them at most electronics stores or Radio Shack for a few dollars,

 With the case still on its side and all wires pulled out of the way, lower the motherboard, minus its anti-static pad, down into the case. Be very careful not to scratch the bottom of the motherboard against the standoffs. You may need to angle it upward towards the front of the case so you can get the connectors on the upper left to fit properly into the rear panel openings. This takes a bit of finesse and adjustment. You can rest the motherboard against the standoffs while assessing the fit, just don't move it when it is sitting on them unless it is very close to the final position. You should see the top of the standoffs through the motherboard mounting holes. Once you have it properly positioned against the rear connection panel, check

it from the outside to make sure none of the grounding fingers on the connector panel are in front of the connectors. If so, try again. They bend easily and need to be in contact with the metal parts of the connectors. Once you get the motherboard very close to the final position, get one of the mounting screws ready on the end of your magnetic screwdriver. Push the motherboard from the right edge till the upper left standoff is centered under the motherboard mounting hole. Insert the screw but leave it a little loose. Do the same thing with the bottom of the motherboard and the left side lower most screw. At this point all screw holes and standoffs should line up. You can move it a small amount for adjustment if you left the first two screws a little loose. Put in the rest of the motherboard mount screws. Check the positioning, and if OK, tighten each screw down snug. By 'snug' I mean about the amount of force you would use by holding the screwdriver with just the tip of your thumb and forefinger. Don't over tighten. Take another break. The hard part is over.
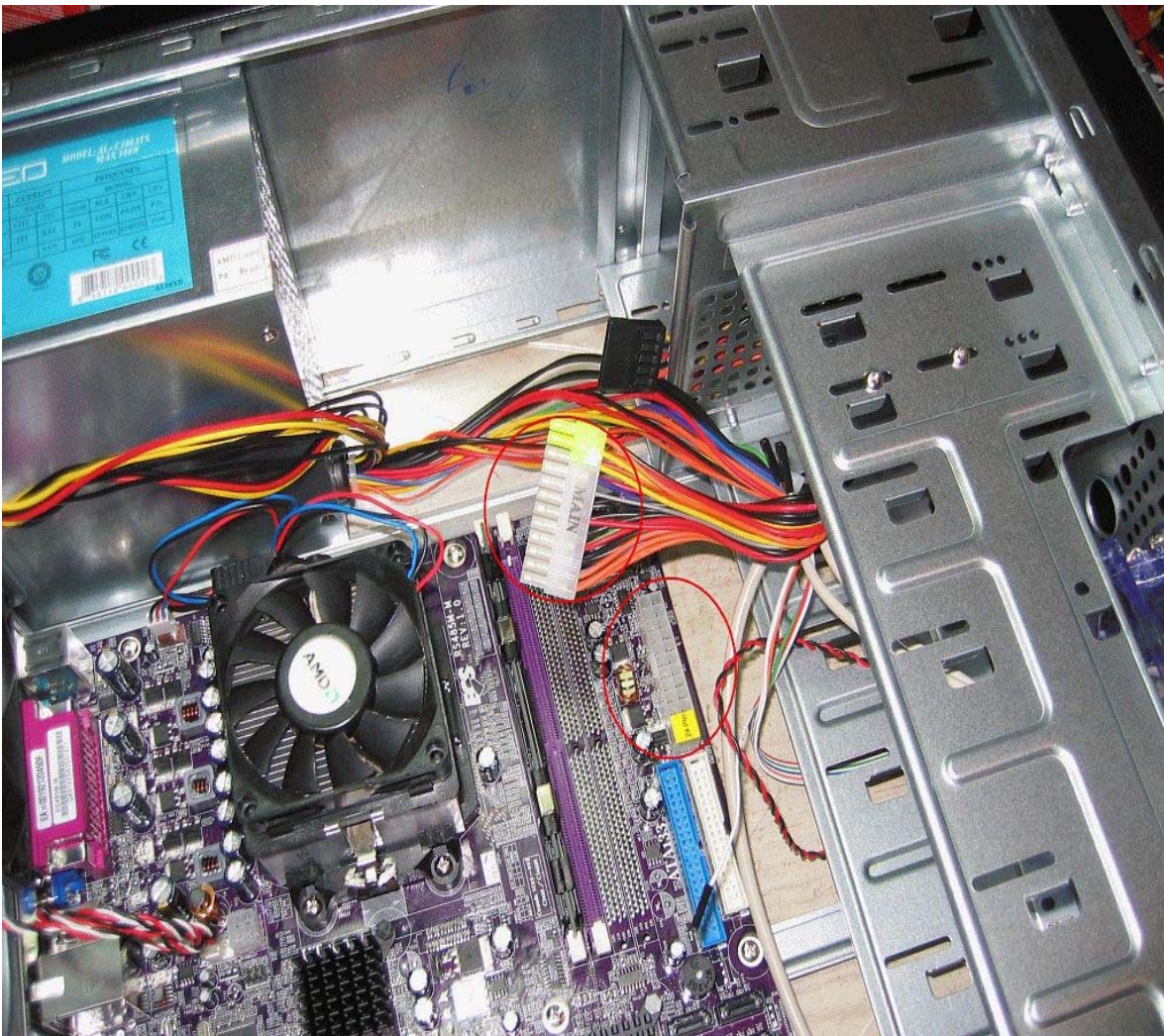

Photo 29. Now comes the wiring. Fortunately, most all the connectors in a computer are coded and will only plug in one way. First come the power supply plugs. This PS has a 20/24pin ATX plug and so does the motherboard. If you look to the PS connector on this motherboard, it has a yellow tape over the 24 pin part of the

socket. Remove this to use a 24 pin PS plug. If your motherboard just has a 20 pin ATX PS socket, the PS connector will split and you don't use the extra 4 pin part. With a Micro-ATX board, it's not really needed. It's mostly to spread the power and not overload the connector and cause it to overheat with higher power graphics cards. The PS plug has a clip that attaches to the socket. Check which side the clip is on before plugging it into the socket. The plug will only go one way and should snap into place when seated.
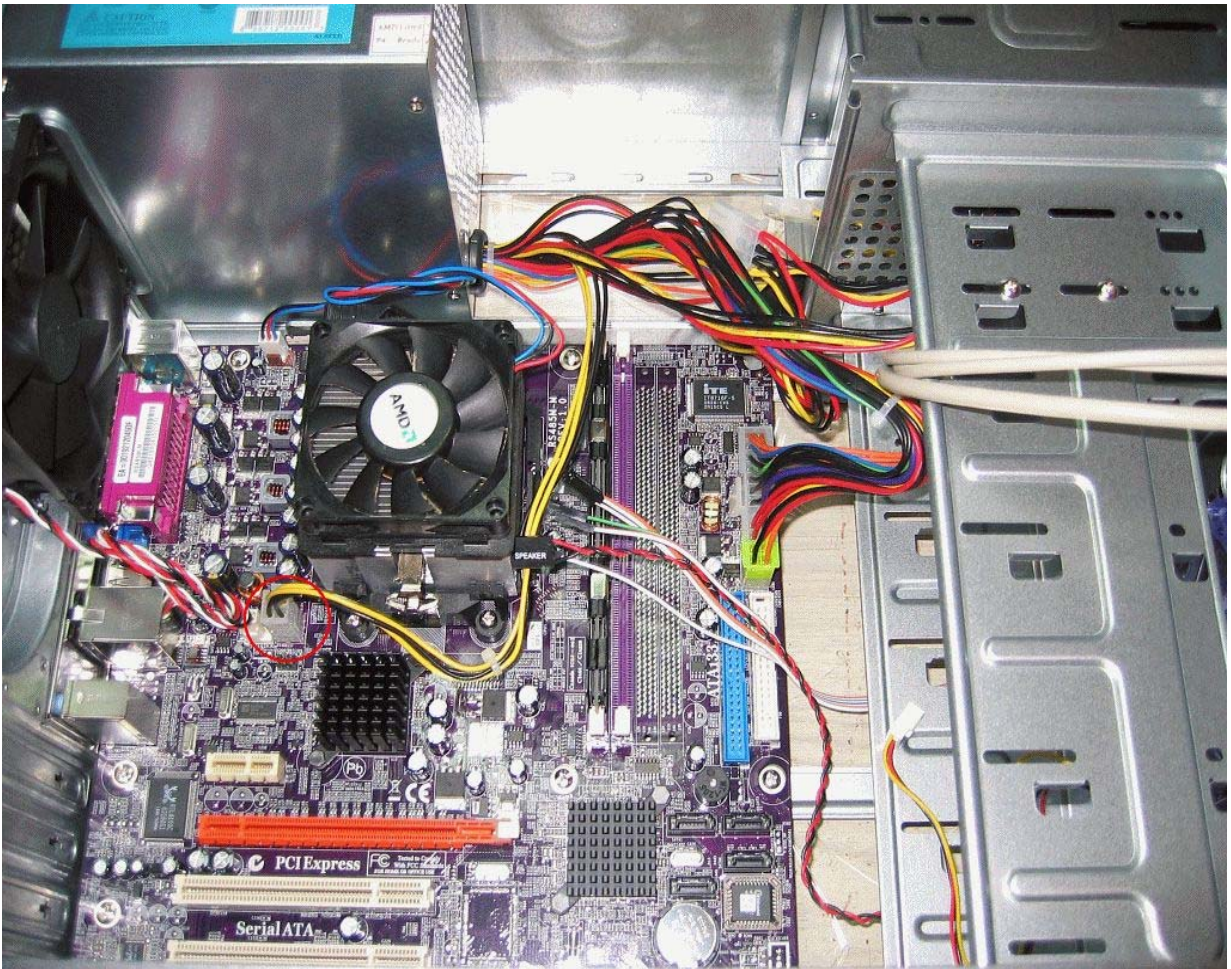

Photo 30. This motherboard also has a separate plug for the CPU regulated power. It's a 4 pin plug, not to be confused with the extra 4 pins on the ATX PS plug. It has a clip on it that aligns with the 4 pin socket. Don't worry too much about the wiring placement; you may move things around later to clean it up. But it will be better to keep the PS wiring close to its final position to make things easier later. You can also see the front control panel wires lying loosely to the center of the photo.

Now that the PS is plugged into the motherboard, most all grounding should be complete and you should have no problems with the possibility of static electricity damage from this point on.

Photo 31. Front panel connections. This part can be difficult, but there is no easy way to do it until the motherboard is installed. I usually open the motherboard manual, and have the case wiring paper handy for this. It's almost always cramped where the panel connectors are, usually near the bottom right side of the motherboard. It helps sometimes to turn the case around to be able to see in there better. Lots of light helps also. Fortunately, most front panel cables are labeled. And the good news is even if you get every one of them wrong, it won't cause any damage to the motherboard or the case. Pay attention mostly to the + and – markings for the LED indicators or they won't work. The switches and speaker connections won't be a problem for polarity.
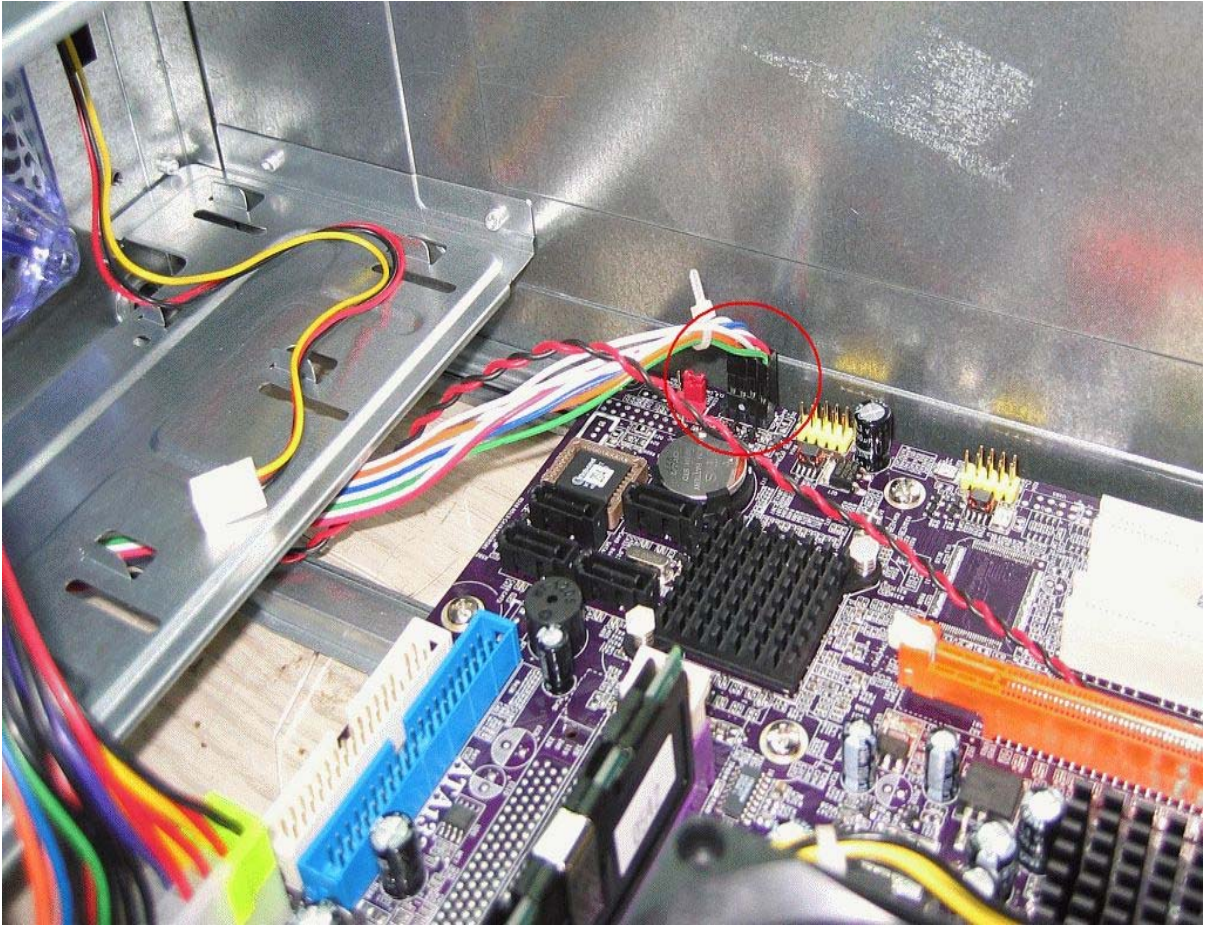
Photo 32. Here they are all plugged in after about 5 minutes of painstaking effort. I use a small wire tie to secure them together after I'm sure they are correct. It takes comparing the motherboard page for the socket connections, along with tiny labels on the connectors, to get them all right. If you get any of them wrong, you can fix them at a later stage, don't worry about them. The red and black wire laying there is for the case speaker, but this motherboard has a built in speaker, so I won't use it. The other connector to the top is for the front case fan.
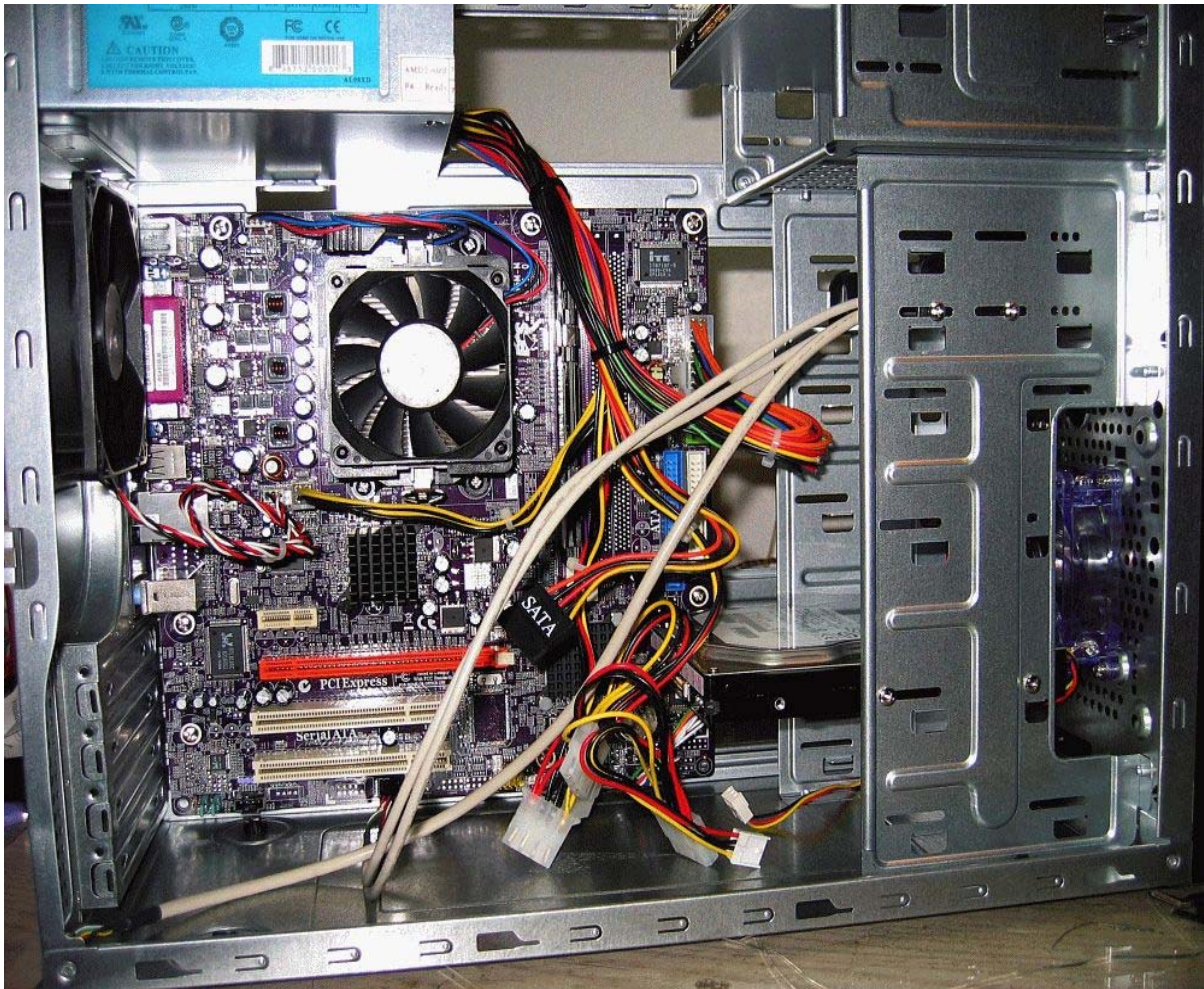
Photo 33. Next you can set the case upright and mount the optical and hard drives. I do this last as they can get in the way of mounting the motherboard. Before mounting, you need to set the jumpers on the PATA drives, in this case, the optical drive. Since it will be the only PATA drive, I set the jumper to 'Master'. The SATA drive doesn't have jumper settings. If it was a PATA drive instead, you would set it to 'Master' on IDE1 and the optical drive to 'Master' on IDE 2. This MB only has IDE 1, so the second PATA drive would have to be set to 'Slave'. There are other configurations, depending on how many drives you have.

The drive mounting method varies by case. This one just uses slots for the mounting screws and tabs to support the hard drive and optical drive before inserting the screws. Insert the hard drive from inside the case. The HD seems to be sticking out a bit. That is because of the front case fan forces it to use a more rearward mounting position. This is not a problem, but make sure you can use all four screws for mounting each drive. You will also see why I removed both side panels as the mounting screws for the other side of the drives are accessible now. Hard drives use the courser threaded screws and the optical drive the finer threaded screws. They should all thread in easily, with no excess force needed. The drive mounting screws should be snugged down just a little tighter than the motherboard screws, but don't overdo it.

The optical drive needs to be positioned so it fits flush with the outside of the case. It is inserted from the front of the case. You will have to remove the blank panel before doing this. Some cases also have a metal shield behind the panel that needs to be removed. This case has a drive door, so the position needs to fit to that. Again, use four screws and don't over tighten.

This is an economy computer, and not necessarily for video work, so it has only one hard drive and one optical DVD drive. More are easily added using the same method. I don't install floppy drives any more, but you could also put one of those in.
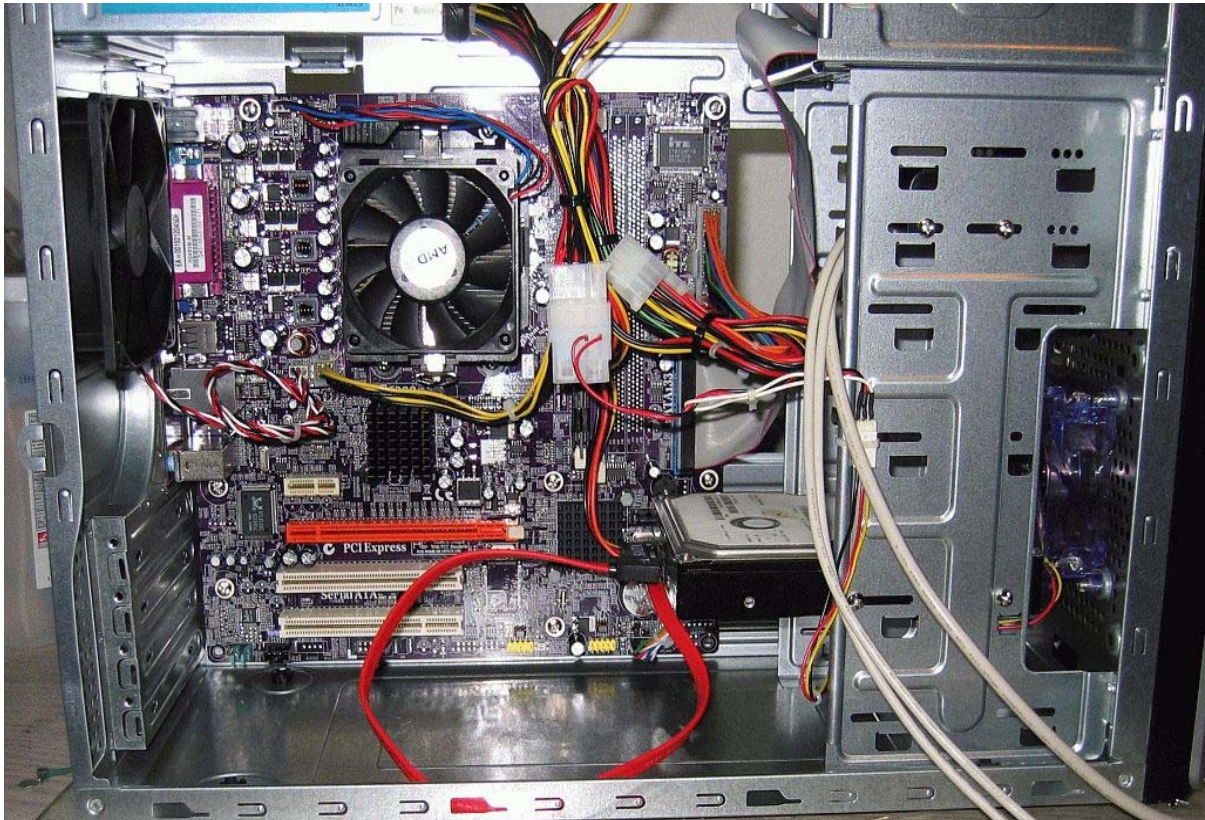

Photo 34. The drives are mounted and drive connectors plugged in. The DVD drive ATA cable is plugged into the IDE 1 motherboard socket and the other end of the ATA cable is plugged into the drive. That is the normal 'Master' plug on the cable. The convention is, the blue plug goes to the motherboard socket, the grey plug is for the 'slave' drive and the black one is for the 'Master' drive. With the SATA boot drive it doesn't matter which way the cable goes. You might spend a little time here finding a good arrangement for those flat cables. I tuck the excess into one of the unused drive slots. Round ATA cables are helpful to tidy things up. I would use them if I had more drives in this computer. But the ones that came with the motherboard will work fine here.

At this point I usually plug in the power connectors for the drives. The SATA drive has a special PS connector already available. Some SATA drives also have a 4 pin

Molex plug like the optical drive has. This is also a good time to adjust your power supply cabling to tidy things up. With the DVD drive, I've chosen a Molex connector that seems to be suited for the upper part of the case. Since I'm not using any of the other Molex 4 pin power connectors, except for the front fan, I will rearrange them and start using wire ties to clean up all the unused loose PS connectors. There are always some extra connectors when building a computer.

Photo 35. Here's the computer with the wiring cleaned up. I have also plugged in the front audio connectors and the front USB connectors to the motherboard. A word of caution here. Not all motherboards and all cases use the same connector arrangement. DON'T PLUG ANY OF THESE IN UNTIL YOU ARE ABSOLUTELY SURE THEY ARE CORRECT OR YOU CAN DAMAGE YOUR MOTHERBOARD!! Be careful here. If in doubt, leave them till later or don't use them at all. Especially watch the power pins for the USB and FireWire front connections. I had to modify one of the rear panel connectors so the pins would be in the proper order. Don't take it for granted that they are.

I added an extra rear USB connector that fits in a PCI slot. I had this from another computer and reused it for this one.

Now is the time to take another break. After the break, you need to check every connection in the completed computer one last time before powering up. Make sure all connectors are seated and all the fans are plugged it. Double check everything as this is you last chance to catch an error. Also take the case and turn it upside down and lightly shake it. You are listening for any loose screws that may have been dropped in the case. These can get lodged and short out the motherboard. This only takes a few seconds and is easily done. I also learned this the hard way.

In this photo the computer is powered up and running. The camera just makes the CPU fan look like it's not moving.

When you have everything properly hooked up, plug in the keyboard, the mouse and the monitor, then attach the line cord to the PS and push the front start button. Make sure the PS switch is in the on position if it has one. Leave off the side covers for now and make sure all the fans are turning. If not, shut down and fix them, especially the CPU fan. You should see the DVD drive light flash briefly and hear the hard drive spin up. Check the case front power and drive indicators. The drive light may not show much activity without the operating system installed.
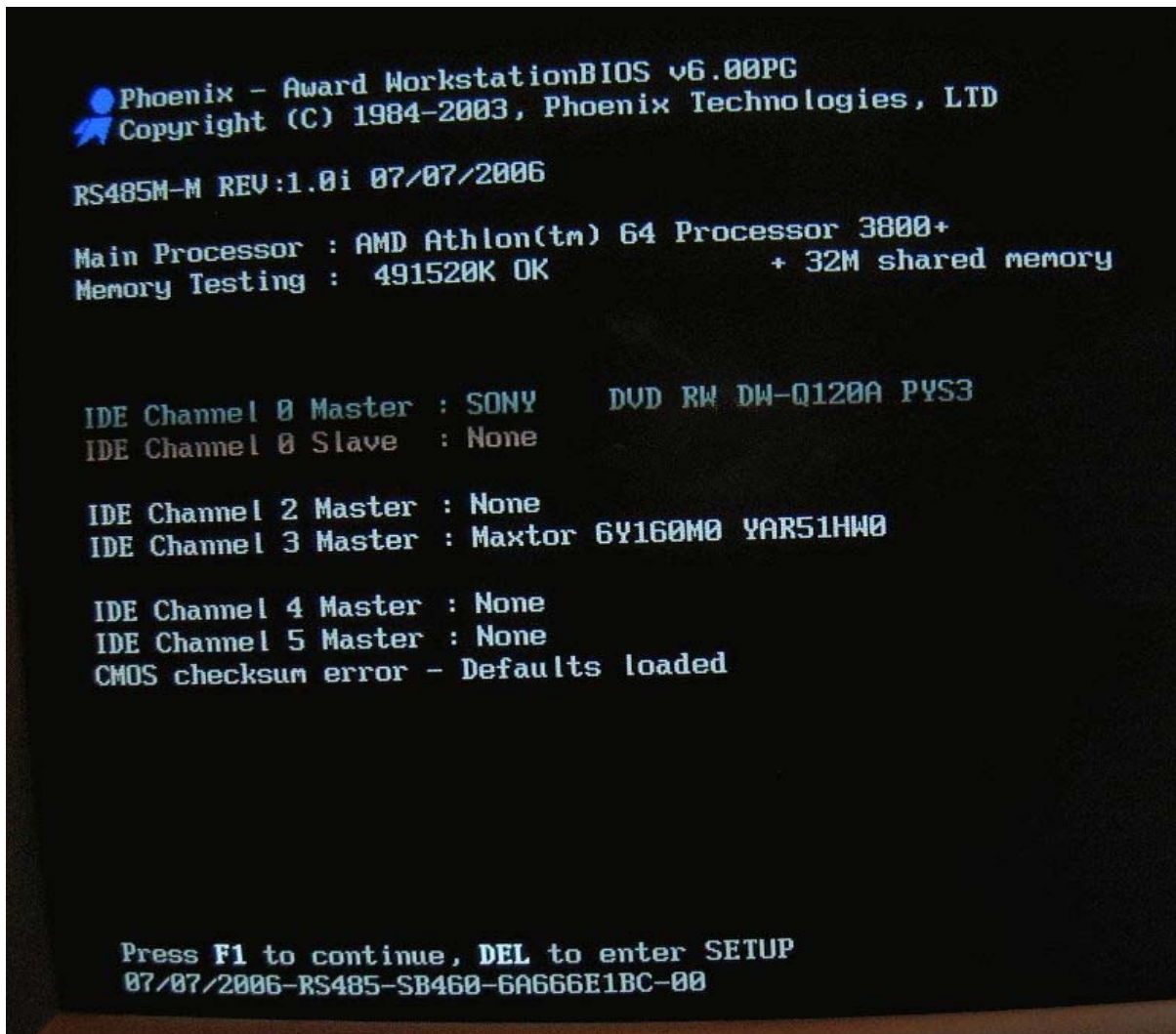
Photo 36. Because there is no OS installed, you will see the black BIOS boot screen first. The first three lines are the motherboard and BIOS information. Line 4 is the CPU information. It should identify your CPU properly. Line 5 is the memory test results. This computer has one stick of DDR2 memory, 512MB. The 32M shared memory is for the on-board video.

The drive information is next. Since the boot drive is a SATA drive, the IDE channel 0 is the DVD drive, correctly identified here in the 'Master' position. This motherboard only has one PATA IDE channel for 2 drives.

The SATA boot drive is on IDE channel 3 because the other connectors were partially blocked by the hard drives position. If I needed more hard drives, I would have to change the position of that drive to expose the other connectors. This is because of the case design and the motherboard SATA connector positions. I could have put the SATA drive on any SATA connector from 2 to 5. That's one advantage of SATA drives. You set the boot drive in BIOS.

Further down you will see a CMOS checksum error. That's because this is the first time the MB has been booted. This will be OK on the next boot.

The bottom two lines tell you which keys to enter BIOS or skip to the rest of the boot sequence. Since there is no OS installed, you can only go to the BIOS. The last line is the BIOS version. You may want to write this down now, as during a regular boot, it disappears fairly quickly.

That's all from this page, don't spend much time here. A quick look is enough. You need to go to the BIOS screen to check the system. Press the 'Delete' key on your keyboard or the one shown on your screen to enter the BIOS setup.
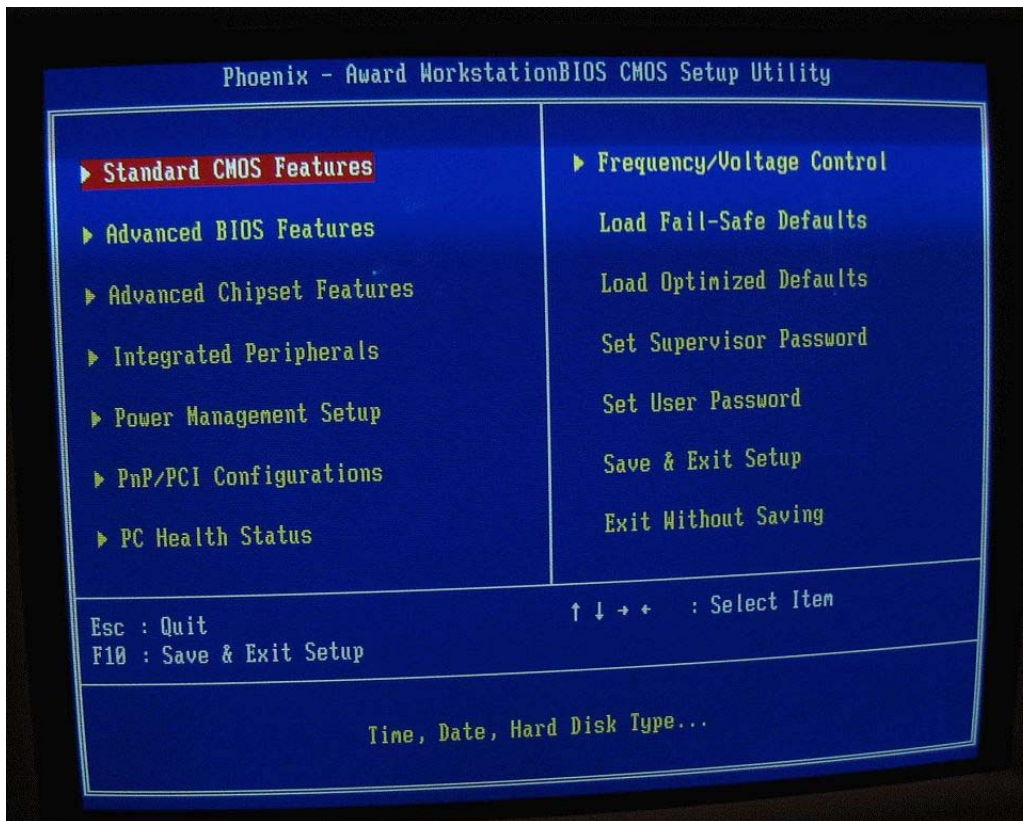

Photo 37. The first BIOS screen. Go directly to 'PC Health Status' or whatever your MB calls your hardware monitoring page.
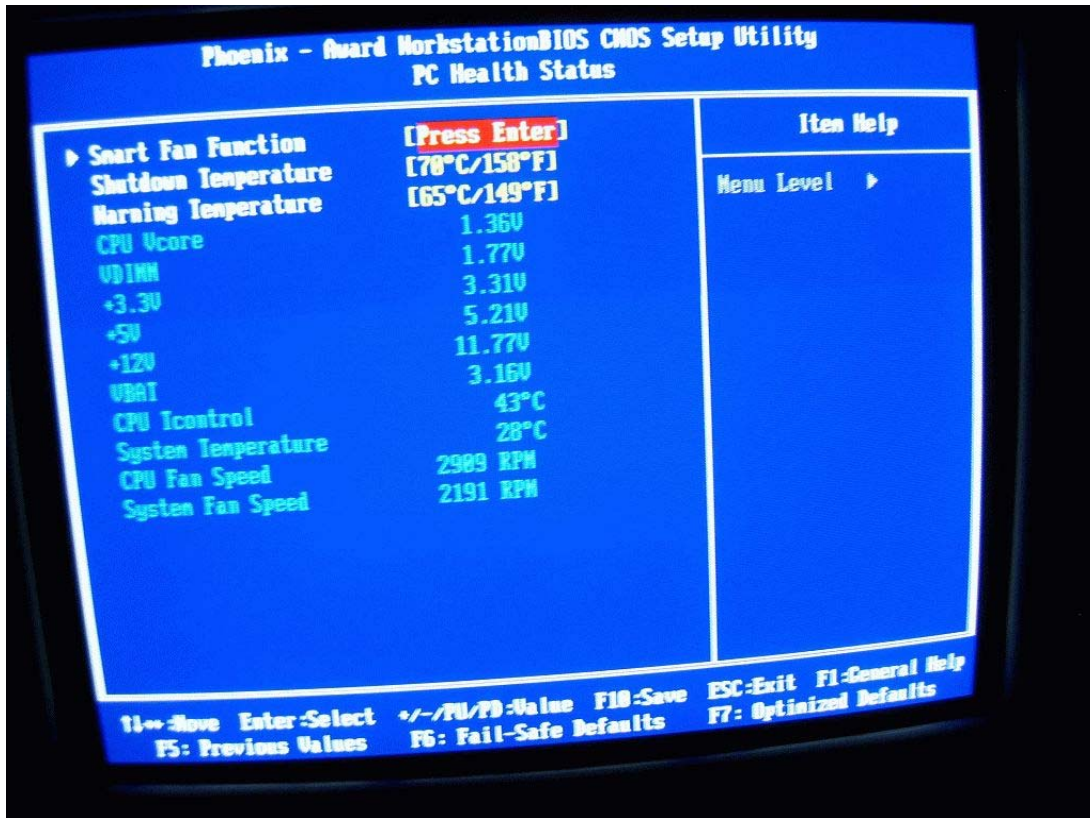
Photo 38. Hardware monitoring. Check the CPU temp first. It may be a little high initially, but shouldn't be much over 45C with this CPU and cooler. It will drop as the CPU cooler seats in against the CPU and the OS is set up. Check the voltages and compare them to your motherboard manual. Let the system run for at least ten minutes while you monitor temperature and voltages. When you are satisfied, click 'Escape' on your keyboard and return to the main BIOS page. If you want, you can select 'Load Optimized Defaults', then check the rest of the BIOS features. I wouldn't make any other changes if your drives are recognized and everything seems OK. Plenty of time for that later. Finally, select 'Save & Exit Setup'. Click 'Yes' and the computer should reboot back to the black BIOS boot screen. Insert your OS CD in the optical drive and click the 'F1' key. This may vary by motherboard.
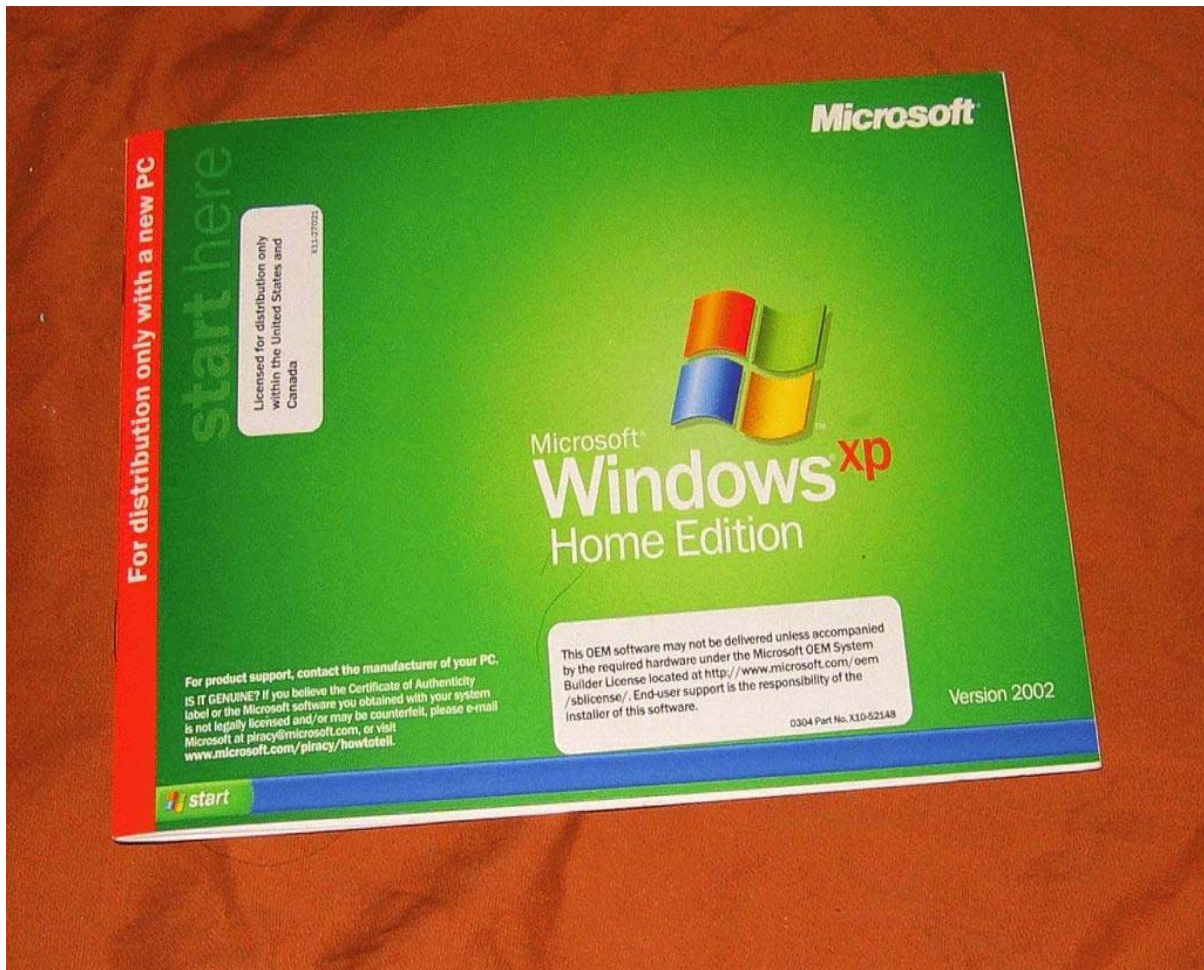
Photo 39. Windows XP Home Edition. You can buy this from most suppliers if you purchase a motherboard and a CPU at the same time.

The XP setup screen should come up and lead you through partitioning and formatting your hard drive and installing XP. You will want to return to the BIOS at some point and set your boot drive to be the first boot selection. If you don't use a floppy, like me, disable the floppy drive in BIOS. While you are there, check the temperatures and voltages once again, then reboot and you should be done with most everything.

Photo 40. Double check your wiring and fans one last time and put the side covers on the case.

Reboot into XP and install your motherboard drivers. Check BIOS once again as your CPU temperatures should drop down a little more with the MB drivers installed.

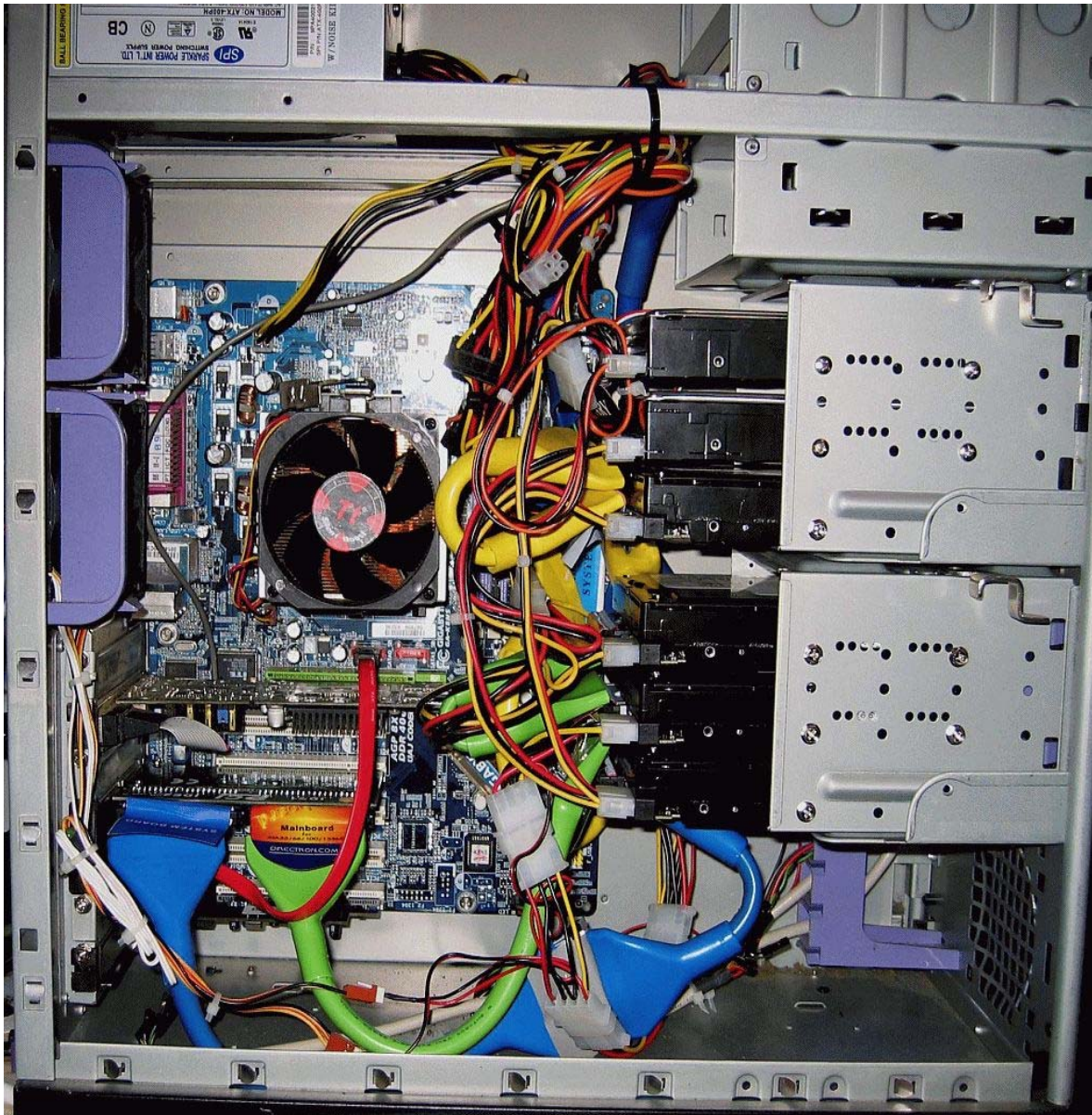If everything is working, then install your programs and enjoy your new accomplishment.

Photo 41. Just to illustrate a little more complex computer build, this one is a video server in a full tower case. It's hooked into my LAN system with a gigabit LAN card. It has 1.6TB of hard drive space and I will probably upgrade it to 2TB by putting two more HDs in the unused 5.25 slots near the top of the case. I have some 5.25 to 3.50 drive adapters. This 400W PS runs them all easily. There are two intake fans in front of the hard drives and two exhaust fans to the rear. It all runs fairly cool, but noisy. A fan controller will be added. The motherboard is an Asus with a AMD 64 Socket 754, 3000+ Sempron processor, 512MB DDR RAM. It doesn't need much CPU power for this application. You can see why round ATA cables are needed with this many ATA cables. It does help with cooling compared to a lot of flat ATA cables. The computer resides in a back room under a desk and is switched off and on remotely through the LAN from the front room.

Next part: Troubleshooting the system in case of problems.