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Welcome To Overclocking

Squeeze More Life Out Of That PC

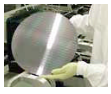
Overclocking isn't for everyone, and in many cases, it results in only marginal performance improvements. But it can be a viable way to squeeze more life out of a machine that you're ready to toss on the scrap heap. Let's take a look at what overclocking is, why it works, and some important concepts you'll need to know before your first overclocking experience.

What Is Overclocking?

All of your computer's operations are controlled by a system clock that determines how quickly components work and the speed at which they send and receive data. For a device to work correctly and remain stable, its speed is drawn from the system clock and balanced with the speed of the other devices in the system.

Overclocking is the process of running certain components at speeds faster than that at which they were originally certified to run. Most overclocking involves the CPU and the FSB, but your memory and video graphics card are also good candidates for overclocking.

So, why isn't your computer already running at its fastest speed? To help keep production costs down, processors are fabricated together in large sheets called **wafers**. To determine their speed rating, each processor in a batch is tested at different frequencies until the top stable frequency is determined. Although you'd think processors in the same batch would all rate the same, they don't, and it's not uncommon for a processor ranked at 2.6GHz to come off the same batch as one rated at 2.4GHz.



Processors fabricated in the same wafer often have different stable processing speeds when tested.

In addition, because most manufacturers are conservative, they often take a processor's stable speed and lower the rating even more. So a chip that safely tested at 2.6GHz might end up rated at only 2.4GHz. Thus, many processors have the potential of running at speeds in excess of their certified speed, and this is what the overclocker takes advantage of.

Over the past 20 years, an entire overclocking subculture has emerged within the PC world, and today overclocking is a standard part of **modding**, or modifying stock computer components to get better performance and/or a better-looking machine. Certainly not all modding involves overclocking, but by definition, all overclocking is modding.

The typical overclocker is a computer aficionado who is used to opening his case and tweaking the system BIOS. To these individuals, overclocking is as much an art form or hobby as it is a way to improve performance. But it also appeals to those of us not as well-versed in PC technology. Maybe we want a little more speed out of our computer without having to add any new components, perhaps we have a new game or application that needs a slightly higher processor speed, or maybe we just want to learn more about our computer equipment.

But there are some dangers. Remember, overclocking is, by definition, pushing the speed of your components past what was intended by the manufacturer, which almost always voids your warranty. Overclocking also stresses most of your system components, even the ones you don't directly overclock, reducing their lifespan and generating large amounts of heat that can damage delicate circuits. The bottom line is this: If you decide to overclock, you do so at your own risk.

Clock Speeds 101

To get a better grasp on overclocking, you need to learn some basics about system clock speeds and how they relate to the various motherboard components typically involved in the overclocking process.

CPU & FSB speed. All of the primary computer components are controlled and synchronized by the system clock. In addition, the components are connected together and communicate across an electronic pathway called a bus. The FSB, which is also commonly called the system bus or host bus, connects the CPU to the system's motherboard chipset. The chipset, in turn, is connected to the system memory, all the PCI expansion cards, the AGP video card, and also to any IDE devices such as optical disc drives and hard drives.

The base clock frequency (speed) of the FSB is important because it determines the clock speed of the CPU, as well as all the other clock speeds on the motherboard, including memory, PCI, and AGP. In the early days of personal computing, most CPUs ran at exactly the same speed as the FSB. With the release of the Intel 486DX2 and –DX4 CPUs, processors began running at multiples of the FSB speed. For example, the 486DX2 ran at twice the FSB frequency, and the –DX4 ran at four times the FSB speed.

The Intel 486DX2 processor was the first to run at multiples of the FSB speed.

Today, the clock speed of a CPU is calculated by multiplying the base FSB clock frequency by a multiplier. As you might guess, increasing the CPU speed by changing the multiplier or FSB frequency is the most popular type of computer overclocking.

In modern processors such as the Pentium 4 and Athlon XP families, the FSB actually runs faster than its base clock speed. For example, the Athlon XP 2600+ runs with a base FSB speed of 133MHz, but the FSB is DDR (double-data-rate) and effectively runs at 2 x 133Mhz, or 266MHz. With a Pentium 4 2.4GHz processor, an FSB with a base speed of 133MHz is used, but with a QDR (quad data rate) bus, its effective speed is 4 x 133MHz, or 533MHz.

Memory. Memory is normally synchronous with the FSB, meaning it runs at the same clock speed, or at a ratio of 1:1. For example, PC2100 DDR SDRAM, also called DDR266, has a base clock speed of 133MHz, which matches the FSB speed of many current Pentium 4 and Athlon XP processors. Although memory can itself be overclocked, that's rare. Instead, memory overclocking often occurs as a side effect when overclocking the CPU by increasing the FSB speed. (For more information, see "Overclocking Memory" on page 15.)

Video graphics cards. Modern graphics cards have two elements that are commonly involved in overclocking. First there's the GPU, which is an onboard processor that takes a lot of the video burden away from the CPU and provides much faster video effects and screen drawing. The other main component, video memory, supports the GPU and helps free system memory from having to be used for display purposes.

Many modern video card manufacturers, including NVIDIA (www.nvidia.com), provide utility programs that let you overclock the GPU and video memory. Other companies, such as ATI (www.ati.com) and Matrox (www.matrox.com)

don't provide utilities, but third-party utilities, such as PowerStrip (www.entechtaiwan.com/ps.htm), are available for such cards.

Overclocking Dilemmas

As we mentioned earlier, the most common way to overclock a computer is to increase the CPU speed, which is accomplished by increasing the FSB frequency, CPU multiplier, or both. Starting with the Pentium II family, most Intel and many AMD processors have locked multipliers that can't be changed, which leaves us with only the FSB speed to consider for most CPU overclocking.

But there's a problem. Increasing the FSB frequency affects not only the CPU speed but also the speed of every other device connected to the bus, including PCI devices, AGP cards, and even your hard drive. Pushing any of these components past their safe operating speed can lead to instability, which can result in lockups and even data loss. Whether your particular devices work at an overclocked speed depends entirely on your system, which means there are no set formulas for success, and you'll have to approach overclocking on a case-by-case basis.

On the positive side, slight increases in voltage will sometimes stabilize an overclocked component, and the BIOS of many motherboards provides ways to change voltage on certain elements, including the CPU and memory. **VCore**, also called core voltage, is the amount of voltage required to run the CPU. VCore for most CPUs runs between 1.5V and 1.65V, but voltages vary from processor to processor. For memory, the voltage is called either **VDimm** or **VMem**, and with DDR SDRAM, usually runs about 2.5V. If you do decide to increase CPU or memory voltage in hopes of making the components more stable for overclocking, take baby steps instead of giant leaps. Many experienced overclockers suggest increasing VCore only 0.025V at a time, never going beyond 0.2V above the original voltage. For memory, use increments of 0.1V and again, don't go beyond 0.2V over the base voltage.

Remember that increases in speed and voltage result in a corresponding rise in heat, which can quickly damage circuitry and burn out components. To combat this problem, overclockers carefully watch temperatures and routinely add additional cooling devices to their equipment.

Preparing To Overclock

As with any other project, the more up-front work you do, the easier the job

becomes, and this is certainly true of overclocking. Here are the most important pre-overclocking steps to take.

Back everything up. Before you do anything, back up all your important data as if you were expecting the worst. If this is your first overclocking attempt, instead of starting out with your main computer, experiment with a noncritical machine, such as an old one you have in the garage or basement. Once you get the feel for balancing your component speeds, you'll be more prepared to try overclocking your primary computer.

Do your homework. The more you know about your particular machine and its components, the better you'll be at making the right decisions and understanding the results. This means you'll want to find the computer manual and scour it for information about your motherboard, BIOS settings, processor, and memory. If you can't find the manual, try visiting the manufacturer's Web site to see if there's a PDF version you can download. Also check out freeware utilities such as CPU-Z (www.cpuid.com), which provide detailed info about your processor, motherboard, and memory.

Video cards, such as the Matrox Parhelia, have a GPU and memory that can be overclocked.

As part of your research, you'll want to find out how to change the FSB frequency, CPU multiplier, VCore voltage, and VDimm voltage. With older machines, you'll probably have to open the computer and set jumpers or DIP switches to change these settings. Newer computer motherboards let you change the settings in the BIOS setup, which you typically enter by pressing DEL, F2, or some other key as the computer boots. (Your manual will tell you the specific key to use and should also contain information about where to go in the BIOS menus to make the changes.)

You should also take the time to find the BIOS reset switch or "clear CMOS" jumper on the motherboard. If you should make BIOS changes that prevent the computer from booting, you'll need to reset the CMOS to the default settings so that you can get the machine back up and running. If you can't find the reset switch, learn how to remove the CMOS battery, which will also reset the BIOS. Finally, take note of all the original settings and switches, so that when things go wrong, you can get things back to the way they were.

Go online. Chances are someone has already overclocked a machine just like yours and has related the experience on one of the many overclocking Web sites, including Overclockers (www.overclockers.com), OCWorkbench

(www.ocworkbench.com), Extreme Overclocking (www.extremeoverclocking.com), and Overclockers Club (www.overclockersclub.com). Information you get from user forums on these sites can be invaluable, but always remember to correctly match your motherboard and CPU with the exact one being discussed. For example, keep in mind that there are several variations of Athlon XP, including Palomino, Thoroughbred, Thoroughbred B, and Barton. And even processors with the same name and core may be revised during the manufacturing process, which can result in CPU performance differences. These revisions, commonly called **steppings**, are indicated by special codes or operation numbers printed on top of the processor. To get the best information, you'll want to match your exact steppings with those of the message board user.

Update the BIOS. Motherboard manufacturers commonly release free BIOS upgrades that fix problems or add new functionality. Make a point to visit the manufacturer's Web site and download any updates or patches before you start your overclocking mission. You'll also want to make sure you have the latest Windows patches and the latest drivers for your video card.

Cool it off. Keeping components cool as you increase their speed or voltage is one of an overclocker's main concerns. Even before you start the process, you should run a temperature monitoring program such as Motherboard Monitor (http://mbm.livewiredev.com) or Hmonitor (www.hmonitor.com) to make sure your current cooling mechanisms are working. These programs take advantage of temperature sensors found in modern processors and display real-time information. Your goal is to make sure the temperature is well below the processor's maximum safe temperature, which ranges from between 65 degrees and 78 degrees Celsius for Pentium 4s and 90 degrees to 95 C for some of the Athlon models. You'll want to consult the Intel (www.intel.com) and AMD (http://www.amd.com) Web sites to get your processor's temperature information.

Most computers are cooled by air flowing into the case from vent holes, through the CPU fan to the heatsink, and then out of the case through exhaust fans. Most experienced overclockers suggest adding at least two extra case fans, one for intake and one for other exhaust, and upgrading the stock CPU heatsink and fan with one that has a larger heatsink area and faster fan.

For extreme CPU cooling you can even get an "active" cooler that uses electrical power or liquid to draw heat away from the processor. Another advanced cooling technique, called **lapping**, is also popular: To "lap" your CPU, you sand the CPU surface and/or heatsink to obtain a flatter, smoother surface that more efficiently transfers heat away from the chip. Most modern processors are inherently smooth, so lapping is normally recommended only for older CPUs.

Sites that carry cooling equipment and have more information on cooling include

the Heatsink Guide (www.heatsink-guide.com), Thermaltake (www.thermaltake.com), and Global Win Technology (www.globalwinusa.com). For more information on coolins, check out "Cooling Options" (pg. 8) and "Coolers Compared" (pg. 122) in this issue.

Download the tools. Benchmarking your system before and after you overclock gives you a detailed look at how your components are reacting to the overclock and provides performance stats for judging your success. A list of popular utilities (such as SiSoftware's Sandra [www.sisoftware.net] can be found at the Benchmarking HQ (www.benchmarkinghq.ru/english.html).

Once you've started the overclocking process, you can use the temperature monitors we mentioned previously to keep an eye on the heat being generated by the speed or voltage increases, but you'll also want to "stress" your system with such tools as Prime95 (www.mersenne.org/freesoft.htm), MemTest (www.memtest86.com), and (for video) 3DMark03 (www.futuremark.com). Stressing your system for two to three hours after each overclock is a good way to check component stability.

Overclocking Candidates

The best computers for overclocking are those you build yourself, using quality parts and a motherboard and processor that have flexible options. For the motherboard, you'll want one that provides BIOS settings for FSB frequency, CPU multiplier, VCore, VDimm, and other component parameters. Some of the motherboard manufacturers that support these overclocking controls include Abit (www.abit-usa.com), Micro-Star (www.msicomputer.com), ASUS (usa.asus.com), and EPoX (www.epox.com).

Note that most brand-name computers limit what you can change in the BIOS setup and often prevent you from changing the FSB frequency. However, in some cases you can still make the changes using third-party utilities such as CPUFSB and CPUCool, both from Podien (http://www.cpufsb.de/). These utilities work only on specific motherboards, but they let you directly access and change the FSB speed very easily.

Remember that both Intel and AMD lock the CPU multiplier, so for CPU overclocking, you'll primarily be working with the FSB frequency. However, with the AMD Athlon CPUs, there are tricks you can use to unlock the multiplier, making Athlons a popular overclocking choice. For example, with the Athlon Thunderbird, if you use a conductive pencil and connect the L-1 traces on top of the processor, the multiplier unlocks. The same goes for the Palomino chip, except that you must first use nonconductive material to bridge the L-1 gaps, and then connect the traces. The Athlon Barton already has the L-1 traces connected, and all you need do is connect the L-3 trace. HighSpeed PC

(www.highspeedpc.com) has step-by-step instructions on unlocking the Athlons and even sells an unlocking kit.

Get Ready For An Adventure

Overclocking is definitely not for everyone. Doing it right takes some work, as well as a fair amount of time and commitment. But if you're looking for a challenge and have a computer you'd love to squeeze a bit more speed out of, overclocking just might be the adventure you're looking for. ■

by John Lortz and Susan Leavitt

All About Multipliers

CPU clock speed is based upon the speed of the FSB and is calculated by multiplying the FSB frequency times a value called a "multiplier." The specifications for both Intel and AMD processors list the multiplier, so you can always find what it is for your particular CPU. You can also use a program such as CPU-Z, which displays information about your processor, including the multiplier value.

For example, let's say you have a CPU with a multiplier of 16 and an FSB frequency of 133MHz. To determine the CPU speed, you take 16 x 133MHz = 2,128MHz, or about 2.13GHz. If you decide to overclock your CPU by increasing the FSB speed through your BIOS settings and increase the FSB to 150MHz, your new CPU speed will be 16 x 150MHz = 2,400MHz or 2.4GHz.

Most processors have locked multipliers that can't be changed, but with some CPUs you can change the multiplier value, giving you an additional way to overclock. Expanding on the previous example, if instead of increasing the FSB speed we increase the multiplier from 16 to 17, our new CPU speed is 17 x 133MHz = 2,261MHz or 2.27GHz.

Besides CPU speed, multipliers are used to calculate the speed of other system components relative to the FSB speed, including the PCI bus, which normally runs at 33MHz, and the AGP bus, which runs at 66MHz.

Since both run more slowly than the typical FSB, the multiplier is a fraction and is called a divider. For example, in a system with an FSB speed of 133MHz, the divider for the PCI bus speed is 0.25, making the speed 0.25 x 133MHz = 33MHz. For the AGP bus the divider is 0.50, making the speed 0.50 x 133Mhz = 66MHz.