HOW TO OVERCLOCK NEHALEM CPUS – CYB3RGLITCH TUTORIALS

Overclocking is the wonderful process of exceeding the manufacturers recommended clock speed, and thus improving the performance of said device (in this case, the new Nehalem CPUs). The art of overclocking has grown rapidly over the last couple of years, and the difficulty of such action has become steadily easier due to the advent of motherboard manufacturers creating enthusiast hardware with specific overclocking functions. This tutorial will delve into the new and mystical world of the Nehalem CPU platform created by Intel. Grab a cup of coffee (or a cuppa if your preference leans that way), and enjoy what this guide has to offer.

The Risks

Due to the fact that overclocking as a process of exceeding manufacturer recommendations for clock speed and voltage, there are some risks involved. Increasing the CPU clock speed excessively can cause system instability. This issue can be solved by lowering it again, or by increasing the voltage. On the other hand, increasing voltage can do permanent damage. To prevent this issue from arising, follow this guide carefully, and adjust everything in small increments. I am not liable for any damage you may incur while following this guide.

Penryn vs Nehalem - What's the difference?

Penryn is now Intel's previous consumer range, based on the Core architecture, and commonly known as 'Core 2' i.e. the 'Core 2 Duo' and 'Core 2 Quad' range. Penryn is the last Intel CPU generation to feature a FSB (Front Side Bus) and an external MCH (Memory Controller Hub). These major changes alter the overclocking process in Nehalem CPUs quite extensively, so much that they resemble closer to modern AMD CPU architecture. Nehalem features an onboard MCH, a QPI (QuickPath Interconnect) bus, an Uncore clock, and a base bus frequency which constitutes each of the other component clock speeds. More on these components are explained below.

Nehalem Overclocking Theory

Nehalem is slightly more complicated to overclock than the Penryn generation. However, the process gives us more control over the CPU components than any previous generation. The following information will describe each component, and the way their clock speed is derived. Please note that motherboard manufacturers often use alternate terminology in their BIOSs. For assistance, please ask in our forums here.

Bclock

Bclock is much like the reference clock found in AMD CPUs. The Bclock is the base clock of the Uncore, memory clock, QPI clock and CPU clock. Because of its influence on all of these components, increasing it will overclock everything at once (similar to the FSB of yesteryear). The Bclock has a stock frequency of 133MHz.

Uncore

Uncore is the exceptionally creative term Intel developed to describe clock speeds which aren't the 'core' (in reference to the CPU core). The Uncore clock determines the speeds of the L3 cache and the on-die MCH (Memory Controller Hub). The Uncore clock speed is found by the following equation:

Uncore clock speed = Bclock x Uncore multiplier

The Uncore clock must always be equal or greater than double the memory clock. i.e.

Uncore clock speed >= 2 x memory clock speed

Since both the memory and Uncore clock share the same reference clock (Bclock), all that needs to be remembered is that the Uncore multiplier must be twice that (or greater) than the memory multiplier. In some instances, the memory multiplier will be in the form of a memory divider. Most motherboard will adjust the Uncore multiplier to be double the memory multiplier automatically.

For example, let:
Bclock = 133MHz
Memory clock = 1600MHz
Memory multiplier = 12

Uncore = 133MHz (Bclock) x24 (Uncore multiplier) = 3192MHz

Notice how the Uncore multiplier is double that of the memory multiplier to ensure it complies with the rule outlined above.

Memory clock

The memory clock refers to RAM (Random Access Memory) speeds. The memory clock speed is found by:

Memory clock speed = memory multiplier x Bclock

If you're an existing overclocker, you may notice that DDR (Double Data Rate) is not factored into the equation. Why this is so, I'm not entirely sure, however I'd hazard a guess that each multiplier integer has the value of '2' to compensate.

For example, let:
Bclock = 133MHz
Memory multiplier = 12

Memory clock = 133MHz (Bclock) x 12 (memory multiplier)

QPI clock

QPI (QuickPath Interconnect) is Intel's latest communication bus architecture. The QPI clock speed determines the bandwidth available to all the components connected to it, such as RAM, GPUs, the CPU, etc. The QPI should be left at stock speeds since the bandwidth is already quite large for consumer systems. The QPI clock speed can be found by the following equation:

QPI clock speed = Bclock x QPI multiplier

For example, let:
Bclock = 133MHz
QPI multiplier = 18

QPI clock speed = 133MHz (Bclock) x 18 (QPI multiplier) = 2394MHz

Since the QPI bus should be kept close to stock speeds, the QPI multiplier would have to be lowered in the case that the Bclock is raised, to balance the equation. At this point in time, 18x is the lowest multiplier available.

CPU clock

CPU clock speed is the main component people want to enhance. The CPU clock can be found using the following equation:

CPU clock speed = Bclock x CPU multiplier

For example, let:
Bclock = 133MHz
CPU multiplier = 25

CPU clock speed = 133MHz x 25 (CPU multiplier) = 3325MHz (3.325GHz)

Voltages

Voltages are increased to remove instability when overclocking, however they are only effective to a point. Increasing this value increments heat output, and may cause permanent damage if raised too high. It is recommended that research is performed regarding your particular model of CPU to see what is considered a safe maximum voltage. Research can be conducted via a search engine such as Google. It's better to learn from other peoples mistakes than finding out the hard way.

vCore = the voltage being fed to the CPU cores
vTT = the voltage value for the Uncore and MCH
vdimm = RAM module voltage

Locked/Unlocked Multipliers

Low to mid-range CPUs often have locked CPU multipliers. This means the multiplier cannot be raised above a particular level. In this case, the only way to overclock the CPU cores further is to increase the Bclock. Locked multipliers can still be lowered, only increasing the value is limited.

Cooling

Increasing the voltage of CPU components will always generate extra heat. The Nehalem platform performs quite well on air cooling devices while overclocked; however there will be a point where the heat becomes excessive. The temperature shouldn't exceed 65c under load (you can determine this by running a stress test). Temperature

can be determined via BIOS temperature readouts, or software applications such as Real Temp within Windows. For cases of extreme overclocking, there are equally extreme cooling methods. These include (in order of effectiveness), water cooling, vapour phase, dice (Dry Ice) and Ln2 (liquid Nitrogen). Apart from water cooling, these methods should only be attempted once you're confident with the overclocking process.

Stress Testing

To determine whether the CPU is stable, stress tests can be performed via Windows. Software that achieves this includes Prime95 and OCCT. Instability will often cause the computer to crash, behave erratically, or prevent it from booting at all. In the case of instability, either the voltage must be increased, or the clock speed must be decreased for the culprit component.

Turbo Mode and HyperThreading

Turbo Mode is a feature where unused cores are disabled so that the extra power can be supplied to active areas. The active cores are then adjusted, or overclocked, so that they perform faster. This is particularly useful for applications which only utilise one core. Whether this feature will effect manual overclocking, I'm not certain, however current results suggest that overclocking is fine with it activated.
HyperThreading is essentially Intel's prodigal son. Introduced with the Pentium 4 range, HT skipped the Core/Core 2 generation completely, and has found its way into Nehalem. You may have to experiment overclocking with it on/off to see if it has any effect.

Finding Maximum Clocks

Finding the limit of your CPU requires a bit of mathematical juggling. Using the rules and equations above, we must target a particular component, e.g. the CPU core clock, and attempt to find its maximum clock speed without hitting instability on other components. This is achieved by either raising the respective multiplier, or lowering the multipliers of the other components while the Bclock is increased. Here are some examples:

Please note that this is a general guide. Different model CPUs may benefit from different methods.

Max CPU clock speed

For unlocked multiplier:
1. Raise the multiplier by one.
2. Check for instability and temperature.
3. Repeat 1 and 2 until unstable.
4. Increase vCore until stable (make sure this isn't an excessive amount).
5. Check temperatures.
6. Repeat steps 1-5 until vCore increases don't help, or they're becoming excessive. Or if the temperatures exceed 65c under load.

For locked multiplier:
1. Lower the QPI multiplier to 18x.
2. Ensure the CPU multiplier as at its maximum.
3. Check for instability and temperature.
4. If unstable, raise the vCore and repeat, otherwise continue.
5. Increase the Bclock by 10MHz.
6. Check for instability and temperature.
7. Repeat 5-6 until unstable.
8. Increase vCore (if safe to).
9. Repeat 5-8 until vCore is too high, or vCore has no effect on stability.
10. If the QPI and/or Uncore are overclocked at this stage, increase the vTT, or try lowering the Uncore multiplier.
11. Repeat 5-10 until the temperature is too hot, or the voltages are becoming excessive.

There is a lot of experimentation during overclocking, so treat these steps as a mere guide. They're not a definite step-by-step process. To help calculate all these different components, you can download the application NehalemCalc by icrontic.

Final Word

From the look of preliminary results, the Nehalem platform is quite the overclocker. Whether this is a reflection of the majority of chips, or just the engineering samples, we're yet to find out. Nevertheless, it's looking to be an impressive advancement from the Penryn range.
This guide has been constructed based on information gathered by other enthusiasts, and those who have had the opportunity to attempt overclocking on this awesome platform. For this reason, there may be errors or inaccuracies. Please report any issues at our forum. Thank you. - *Vito Cassisi*