

Core i7 920 Overclocking Tutorial

Push your i7 920 to **4GHz** with the GA-EX58-EXTREME



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Core i7 920 Overclocking Tutorial

Step-by-step guide to push your Core i7 920 to **4GHz**

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Testing Equipment

First of all, allow me to introduce the main components of the X58 Platform. As you can see in the pictures below, the platform I will be using today includes the Intel CORE i7 920 processor, the GIGABYTE GA-EX58-EXTREME motherboard and CORSAIR TR3X6G1333C9 3 channel DDR3 memory. These 3 components are the main elements for overclocking. The CPU is the main executing unit. CPU overclocking involves raising the frequency in order to achieve performance gains for your applications. The Intel Core i7 has 3 different models, the i7 920, i7 940 and Extreme i7 965.



Intel Core i7 920, GA-EX58-EXTREME and Corsair TR3X6G1333C9

The goal of this article is to show how to make the Core i7 920 go to a higher frequency (overclock to 4GHz) while maintaining stable operation. Keep in mind, 4GHz is a higher frequency than the most expensive i7 Extreme 965 (3.2GHz) CPU. So, if you are able to increase the i7 920 stock frequency of 2.66GHz to 4GHz, you are able to achieve an almost 50% higher clock. Theoretically, this means your CPU will be able to calculate almost twice as fast as your stock CPU, which is almost double your stock performance.

So, let's take a look at how to do it.



Intel Core i7 920

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Testing Equipment

The Intel Core i7 920 is a native quad core processor with each core supporting 2 threads each (Hyper Threading). Core i7 CPUs are based on a 45nm process design and feature a new LGA 1366 socket. The i7 920 also features an 8MB L3 Smart Cache, integrated Memory Control Host (MCH) (previously built into the North Bridge), support for 3 channel DDR3 with 192bits, bus is up to 25.6GB/s. QPI (Quick Path Interconnect) replaces the FSB and the GA-EX58-EXTREME does support i7 920 with 6.4GT/s QPI.



INTEL Core i7 920 processor



Corsair TR3X6G1333C9
3channel memory

The CPU is the calculating unit based on x86 architecture. It is unable to read programs from the hard drive directly, as it must through memory. The memory acts as a register for processor. The more the memory capacity, the more programs you can use. The higher the memory speed, the less time it takes to communicate between the CPU and memory and then to the hard drive (or other storage device). Core i7 moves the MCH from the NB to on the CPU die, and supports 3 channel DDR3 memory, providing more bandwidth and lower delay time.

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Testing Equipment

On the GA-EX58-EXTREME are the North Bridge and South Bridge, the X58(Tylersburg) and ICH 10R respectively, both of which were designed to support the brand new Core i7 micro-architecture. The motherboard itself is also equipped with GIGABYTE's Ultra Durable 3 technology, which feature additional copper inner layers and higher quality components which help to lower PCB surface temperature. Onboard is also the new GIGABYTE Hybrid Silence Pipe 2, which includes a water block, cooler allowing end users to build a liquid cooling system, further helping to reduce the NB Temperature which helps when overclocking to the extreme.



GIGABYTE GA EX58 EXTREME Motherboard

Testing Platform	
Processor	INTEL CORE i7 920
Motherboard	GA EX58 EXTREME
BIOS	F4e
Memory	Corsair TR3X6G1333C9
CPU heatsink	Thermalright Extreme 120
CPU FAN	Delta 12cm 0.7a
Graphics	GV-R487D5-1GD
Hard drive	Seagate 7200.10 250GB
Power Supply	Silverstone ZU1200W



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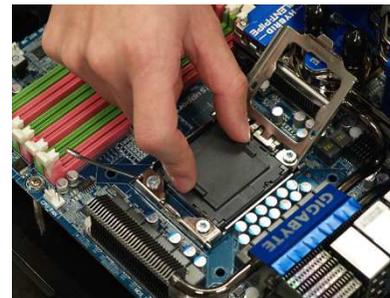
Install Hardware



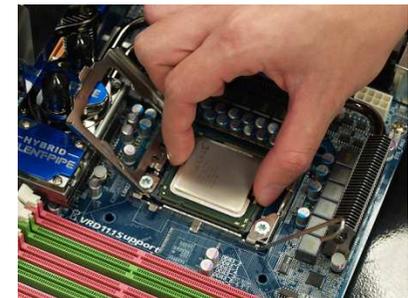
Thermalright Extreme 120

Directly affecting overclocking results is temperature. The lower the temperature of the processor, the higher the MHz users can obtain through overclocking. If you want get the best results, a good processor heatsink is essential. For this testing, we are using the Thermalright Extreme 120. It has 6 heatpipes and 52 fins for better cooling effect, along with the Delta 12cm 0.7a fan. If you were to ask me what the first and most important step of overclocking is, it would definitely be to ensure the best possible cooling.

Now let's install the system. First, take off the protector from the ILM, notice the triangle mark points the direction your processor needs to go. The CPU socket on the motherboard has 1366 pins. When you install the processor, you need to be very careful to avoid damaging the pins. If the pins get some thermal compound on them during the installation, don't use any paper or cotton cloth to clean the pins. The Z type pin is weak and can be easily damaged. Leave it as is or let a professional clean it.



Take off the protector



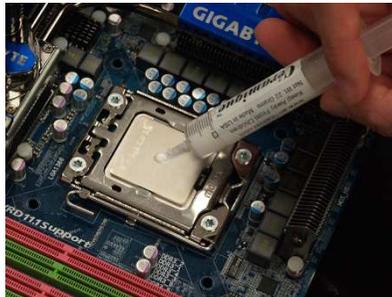
Install processor

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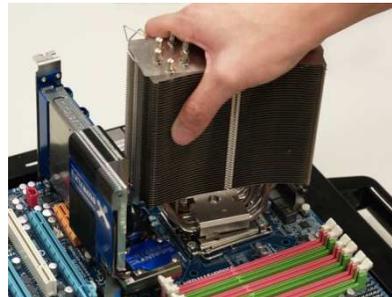
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Install Hardware

Dab a small mountain of compound on the backplate of the processor. I suggest using around 0.2 Grams of silicone-based compound to fully cover the ISH on the processor. Next install the heatsink and fan. You can twist the heatsink to fully spread the thermal compound



Dab compound



Install heatsink

Next install the memory. Install in the same colored slots. In the picture I am installing Corsair TR3X6G1333C9 3 channel memory in the green slots (GA-EX58-EXTREME production board, the slots are colored white). Continue to install graphics, hard disk and power supply. Once that is complete, you are ready to test!



Install the 3CH DDR3

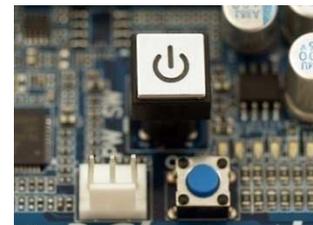


Final platform



Troubleshooting LED helps to debug

Click the power button on motherboard. The machine should boot. If not, the GA-EX58 series has troubleshooting LEDs which allow you to debug and figure out what the problem is.

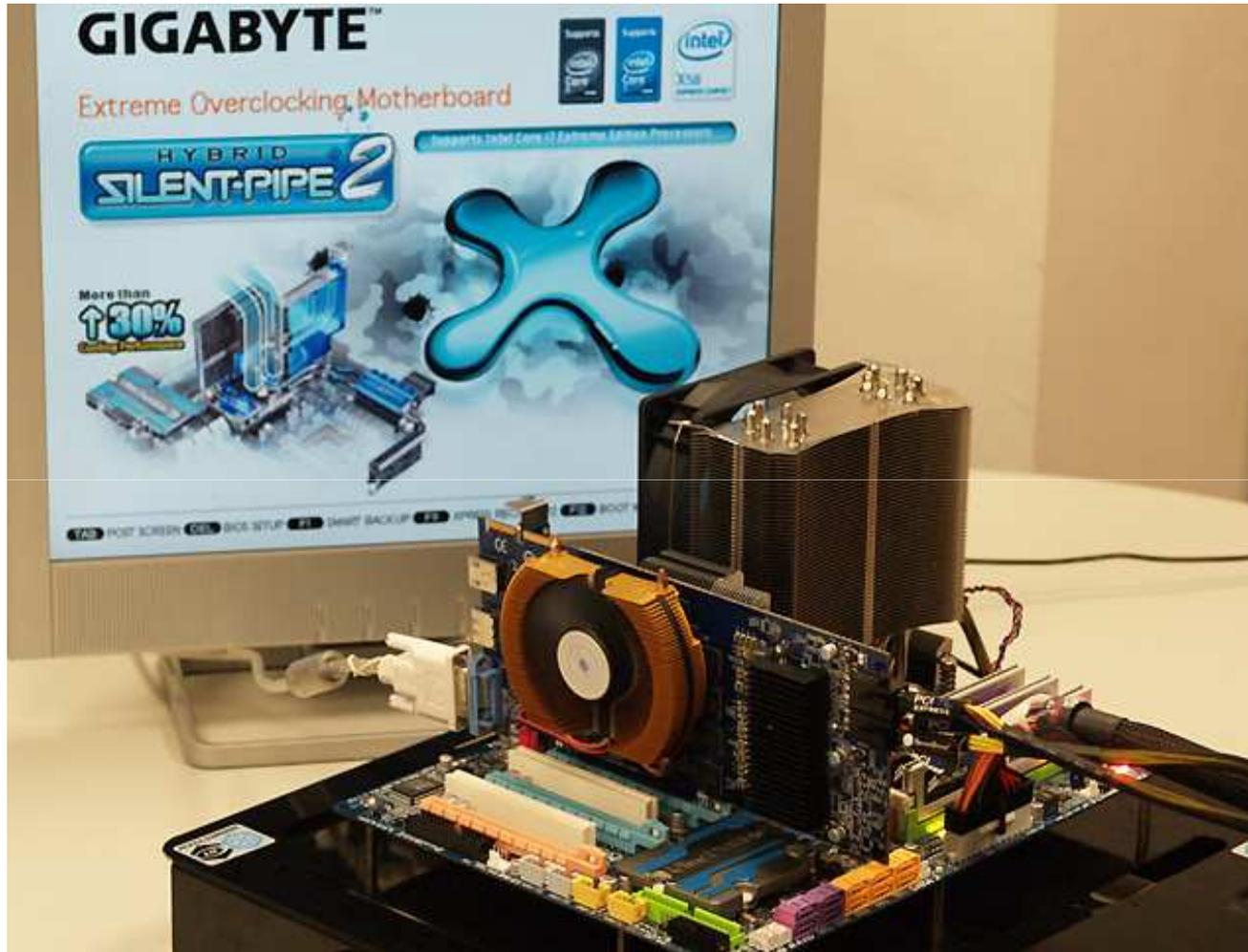


Left picture is reset and power buttons. Right picture is clear CMOS.

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Install Hardware



After firing up the machine, take some time to test the temperature of your CPU both at idle and at full loading. This will help you to determine if your heatsink is good enough for overclocking.

BIOS Hotkeys

F7 Load optimized default

F8 Run Q-FLASH tool

F9 Display system information

F10 Save and exit

F11 Save profile

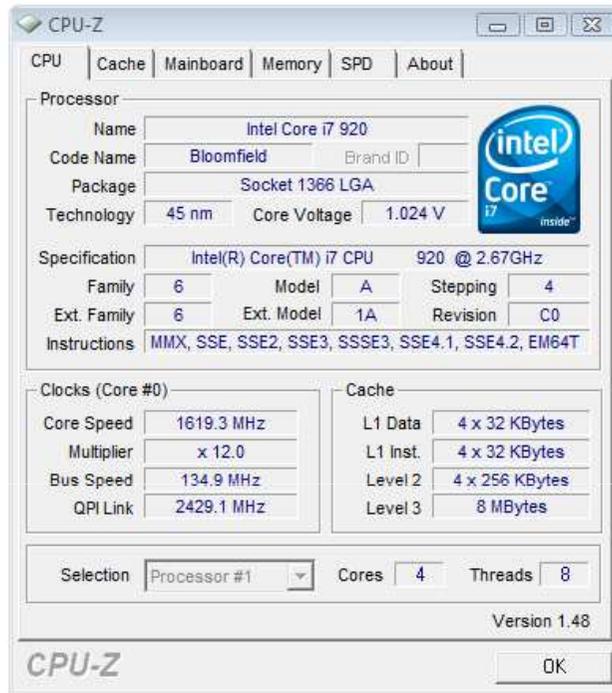
F12 Load profile

i7 920 + EX58 EXTREME system

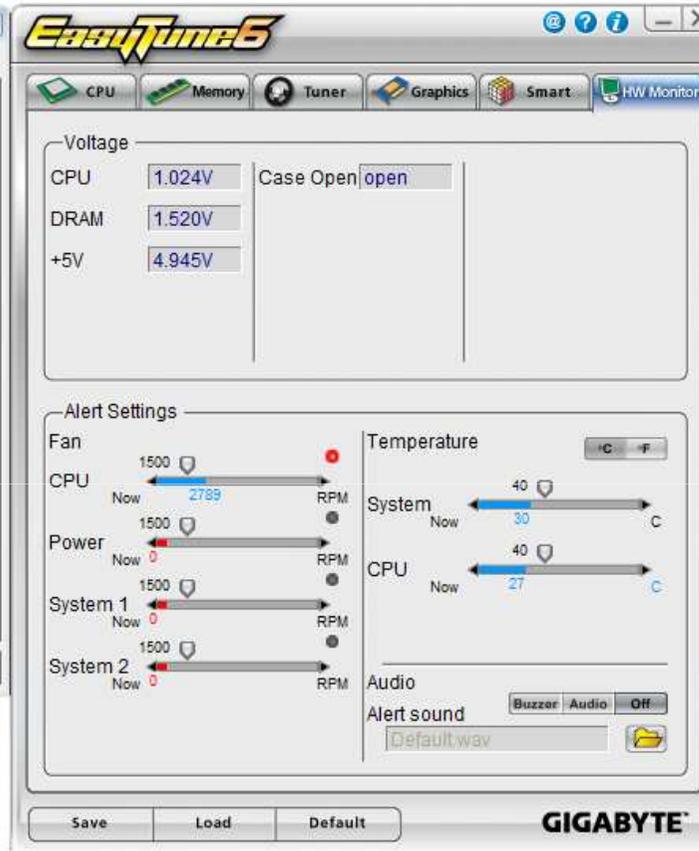
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Basic understanding the performance & temperature of core i7 920



Regular 920 idle temperature is just 27°C



Want to know if your heatsink is up to the task? Using default BIOS settings, open the EASY TUNE 6 overclocking utility that is included with your GIGABYTE motherboard. Go to the Hardware Monitor to see the current CPU temperature. In the picture on the right, the temperature is 27°C, only 2°C higher than ambient. Therefore my cooling is adequate at idle loading.



Room temperature is 25°C

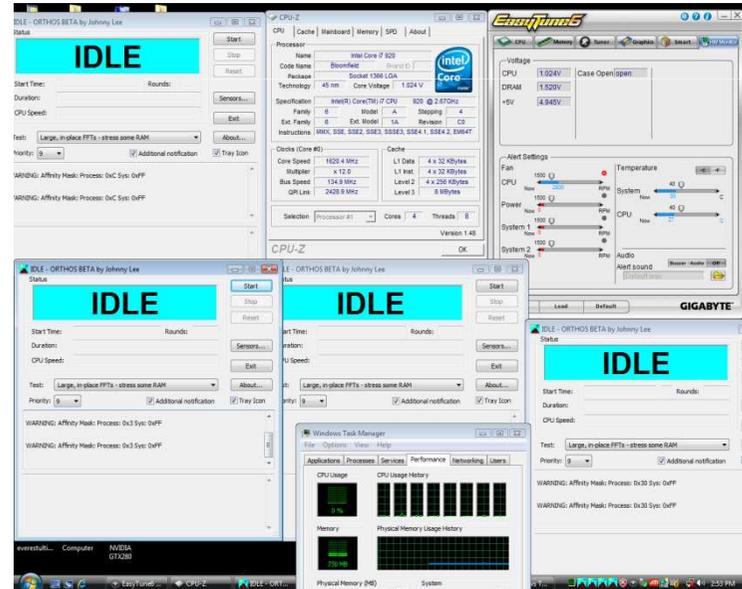
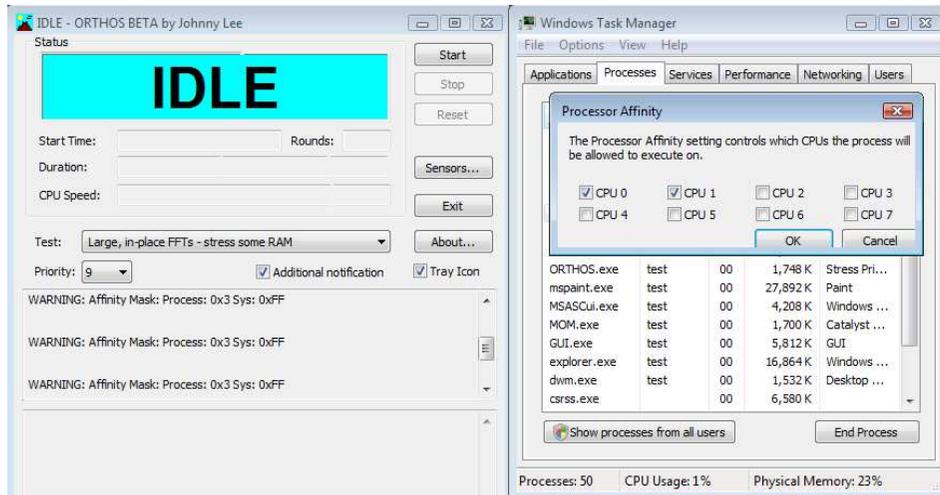
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Basic understanding the performance & temperature of core i7 920



Next open 4 SP2004 programs (burn-in tool used to fully load the CPU), set Large, in-place FFTs and priority to 9. This mode will stress the maximum heat of the processor, and will quickly determine if the CPU is stable or not. Next open the task manager. Because SP2004 only supports 2 threads (the i7 920 has 8 threads in total), you need to run 4 SP2004 programs and assign 2 cores (threads) to each SP2004.



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Set program to each thread to fully load the CPU.

Basic understanding the performance & temperature of core i7 920

The image shows a composite screenshot of three Windows applications. On the left is CPU-Z, displaying processor details for an Intel Core i7 920 (Bloomfield, Socket 1366 LGA, 45 nm, 1.168 V) running at 2.67GHz. The 'Cache' tab shows L1 Data (4 x 32 KBytes), L1 Inst. (4 x 32 KBytes), L2 (4 x 256 KBytes), and L3 (8 MBytes). The 'CPU-Z' window is set to 'U-Z' mode. In the center is HWMonitor, showing voltage levels (CPU: 1.168V, DRAM: 1.520V, +5V: 4.919V) and alert settings for fan speeds and temperatures. The temperature section shows System at 40°C, CPU at 38°C, and another CPU sensor at 38°C. On the right is Windows Task Manager, showing the 'Performance' tab with 'CPU Usage' at 100%.

From the task manger, you can see the processor is already under full loading. On CPUz, the I7 920 frequency shows 2833MHz. That's because Intel Turbo boost is turned on. When TDP is lower than the limit, Turbo Boost lets the CPU run at a bit higher frequency than rated.

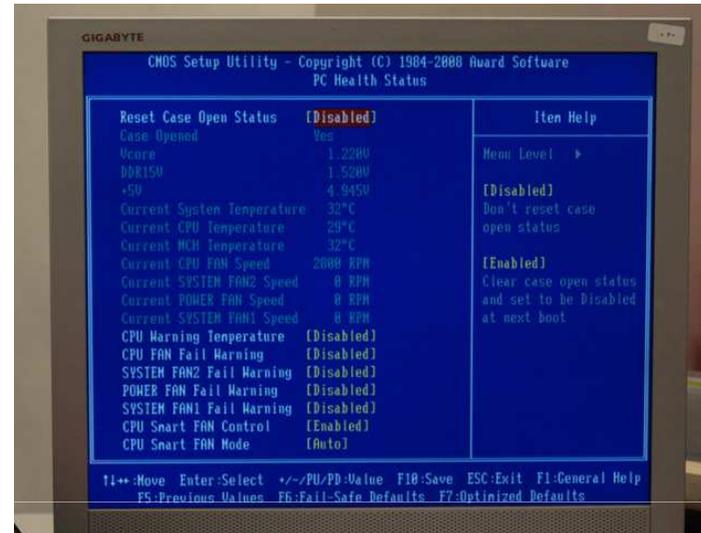
In the Hardware Monitor of EASY TUNE 6, the processor temperature shows 38°C. This is quite low, meaning the CPU heat sink performs well, and will be able to keep the CPU cool enough during a 4GHz overclock. If your heat sink right now is above 70°C, don't try any overclock, as the heat sink you have is not sufficient enough.

Loading temperature is just 38°C, ensuring your cooling is adequate for overclocking.

BIOS Settings to achieve 4GHz overclock



BIOS main page



System voltage and temperature status

If this is the first time changing BIOS settings, relax. Just follow my instructions. Once your machine starts to boot, click “DEL.” Your computer should enter the BIOS main page. In the main page, you can see many settings. All the overclocking settings are located in the MB Intelligent Tweaker (M.I.T.). Before we go there, first click on “PC Health Status”. Like the picture on the right, you should be able to see the voltages of the processor, DDR3, and temperatures of the processor and North Bridge. This page helps you to watch the current system status.

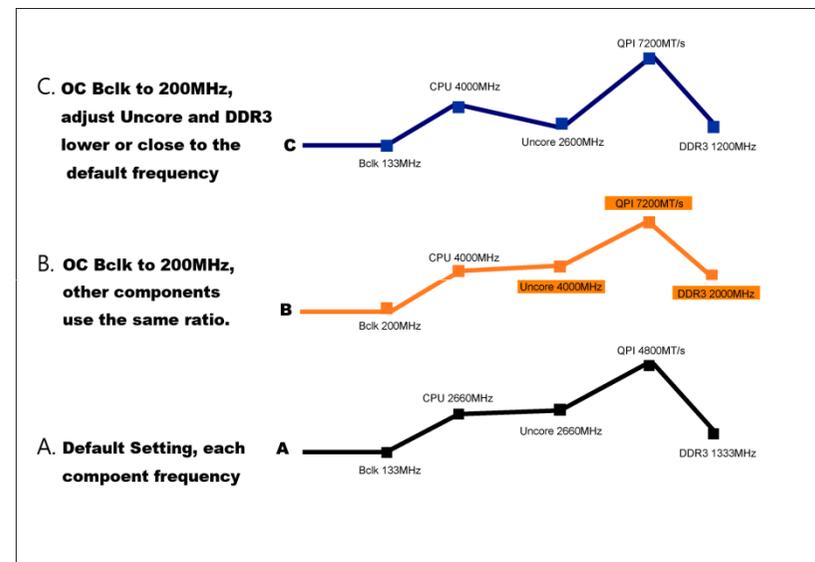
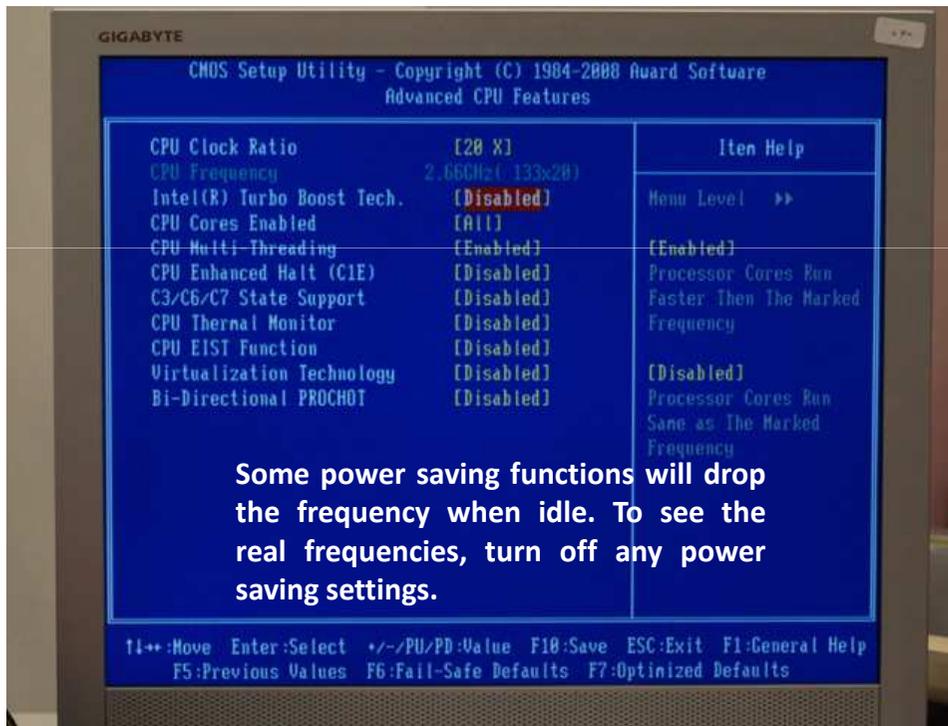
Next go to M.I.T. and we will begin our quest for 4GHz. With the Core i7 platform, the CPU clock is calculated by multiplier times Bclk. For example, the i7 920 is rated 2.66GHz, (20X133MHz = 2660MHz). 133MHz is the Bclk, 20 is the multiplier. For the i7 920, the multiplier is locked by Intel, so there is only one way to raise the frequency of the i7 920, and that is to raise the Bclk!. So for our goal of 4GHz, Bclk must be 200MHz. with i7 architecture, when you change Bclk, you also automatically change the other components frequency such as QPI Speed, Memory Speed and Uncore frequency.

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BIOS Settings to achieve 4GHz overclock

To avoid causing system instability or a failed overclock, I use a process of elimination to make sure the frequencies set will work with my hardware. When Bclk is 200MHz (auto setting), the memory will go over 2000MHz. In this case I am using Corsair DDR3-1333, so I don't know if my memory will work at 2GHz. Not wanting to waste time, I drop the frequency of the memory to 1333MHz or lower. After I ensure the CPU at 4GHz is stable, I can then raise the memory with specific ratios to see if the memory can go higher. Same for QPI and Uncore. By this process of elimination, we try to keep the components at default to see first if that can reach our 4GHz target.

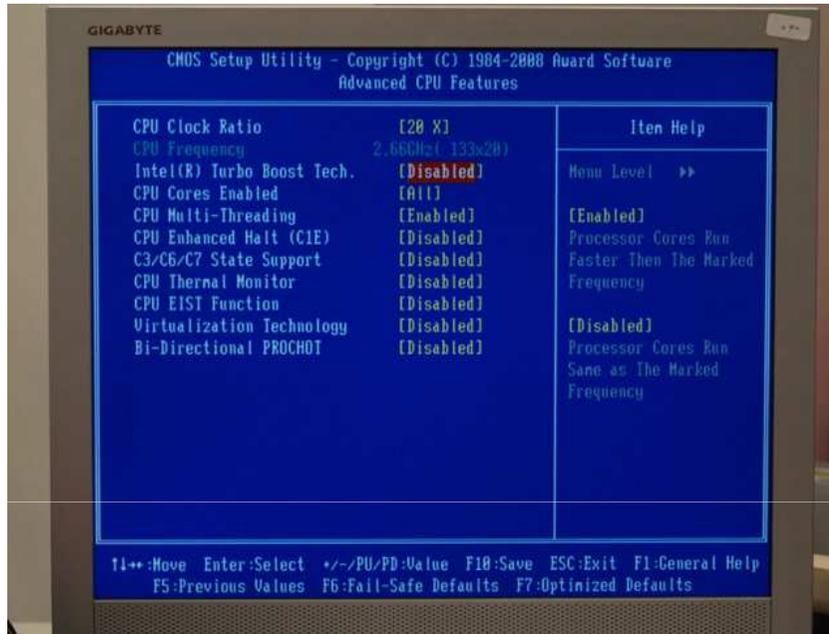


When raising Bclk to 200MHz, if other components keep the same ratio, Uncore, QPI and DDR3 will go up as well. As diagram C shows, Uncore and DDR3 are near to default level. If the 4GHz overclock fails, you know it is either the Bclk or QPI settings causing it to fail.

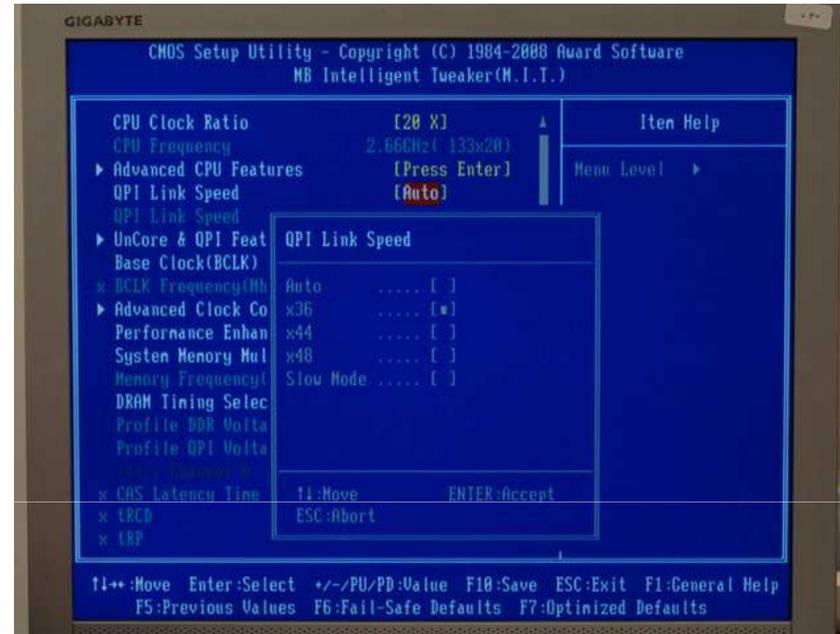


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BIOS Settings to achieve 4GHz overclock



Disabled Turbo Boost



Adjust QPI LINK SPEED ratio to X36

Now, follow my settings. First, in Advanced CPU features, I disabled some functions related to power savings and Turbo Boost. Enabling these features causes the CPU frequency to be adjusted according to loading. This will cause confusion about real-time frequency, so disable them first. Then go the M.I.T. and change the QPI Link Speed to x36. With Bclk at 200MHz, QPI speed will 7.2GT/s, which is much higher than the default of 4.8GT/s. Don't worry, later we will add some voltage to QPI to make it stable.

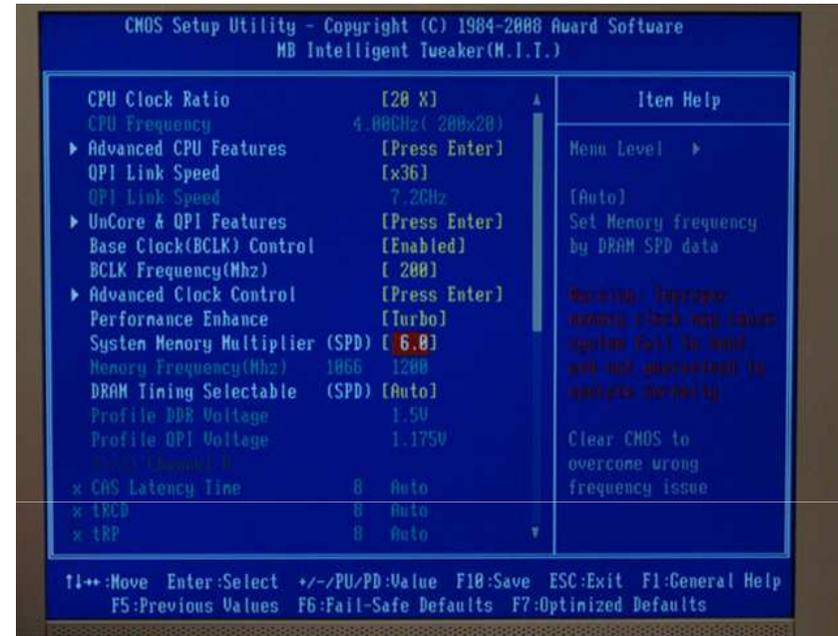
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BIOS Settings to achieve 4GHz overclock



Set Bclk to 200MHz



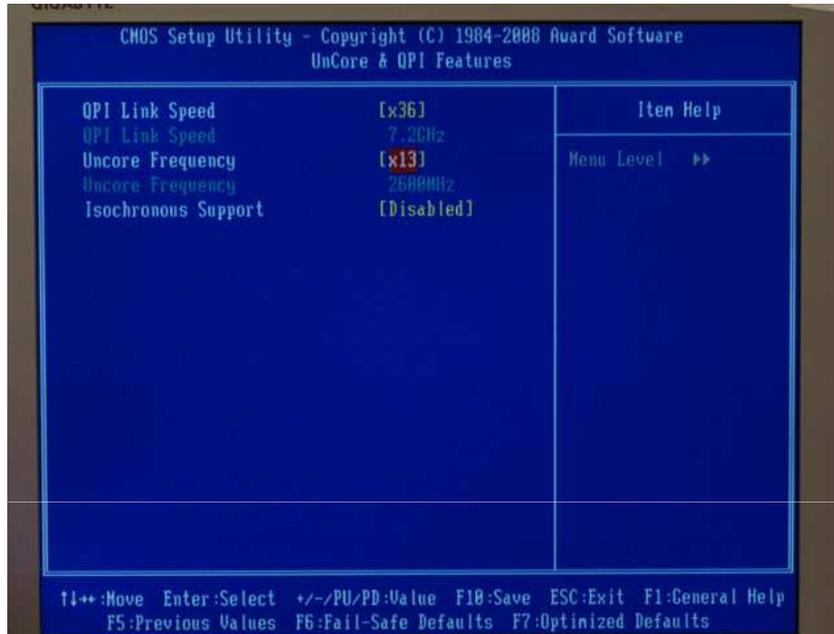
Change the System Memory Multiplier to 6.0 to force the DDR3 to run at 1200MHz

Next, set Bclk frequency to 200MHz. The GIGABYTE BIOS calculator will automatically calculate the other components frequency, and you can see the settings in blue. CPU clock is 4.00GHz, yes that's our goal. QPI link speed is 7.2GT/s, memory frequency is 1600MHz. Using Corsair DDR3-1333MHz, if running with 1600MHz, I am not sure if it will be stable or cause system fail, and memory needs more time to test for stability, so I drop the memory ratio to 6x, forcing the memory to run DDR3-1200MHz. Yes, this is lower than rated, so I am sure with this memory frequency that won't be the reason to cause my 4GHz overclock to fail.



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BIOS Settings to achieve 4GHz overclock



Uncore set to x13 (DDR3 SPEED 2X+1)



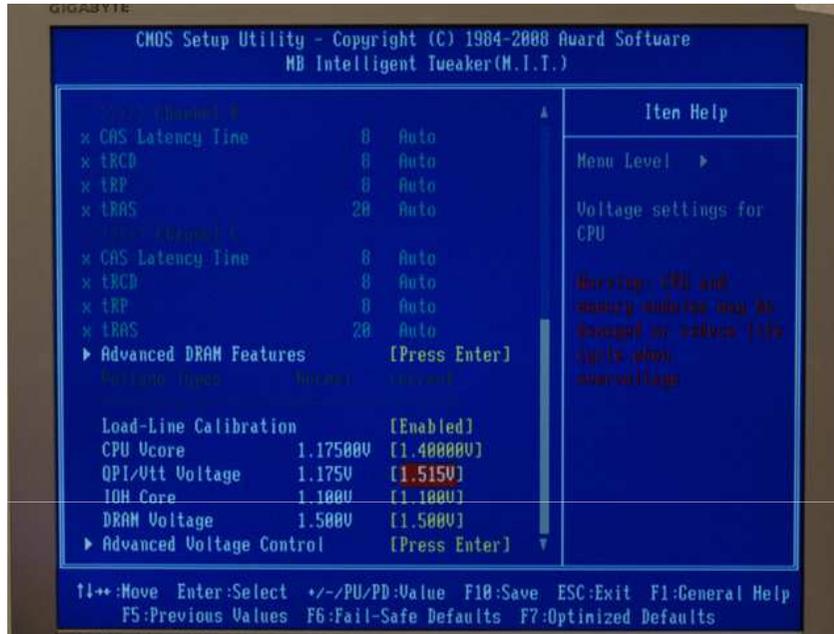
Memory forced to DDR3-1200MHz

For Uncore Frequency, the BIOS allows users to change the ratio to what they want, but the i7 processor still has some limits, because it still needs to follow some logic formula from Core i7. The formula is, Uncore speed needs to be 2x speed of memory or ratio of 2x+1. In theory, the higher the Uncore speed, the better the performance because it gives memory and other components inside the processor a boost and more bandwidth. I use the same way to avoid Uncore settings causing instability, so the safe way is to force the Uncore to run at 2.4GHz (2x of DDR3 speed). But, I soon figure out that the i7 can't accept this ratio due to a logic bug, so I raise the ratio to 2x+1. Uncore is now running at 2.6GHz. The same for memory, so I now know that Uncore will not cause the 4GHz overclock to fail. So recapping, I set Bclk to 200MHz, CPU is 4GHz, Uncore 2.6GHz and DDR3 at 1200MHz. Uncore and DDR3 is lower than default rated speed, so I know we are giving them enough voltage to operate.

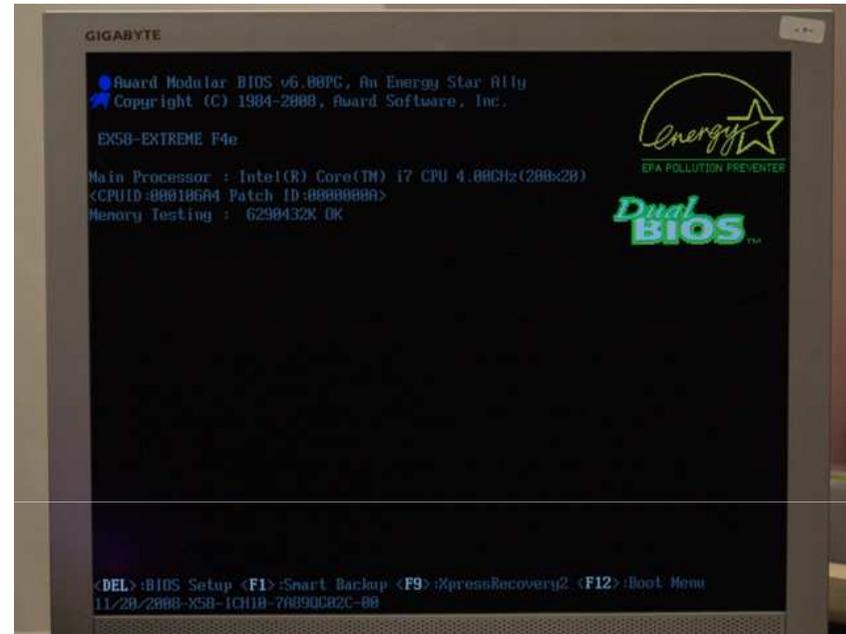
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BIOS Settings to achieve 4GHz overclock



Setting voltages usually requires some experience. If your settings don't work , adding higher voltage may help)



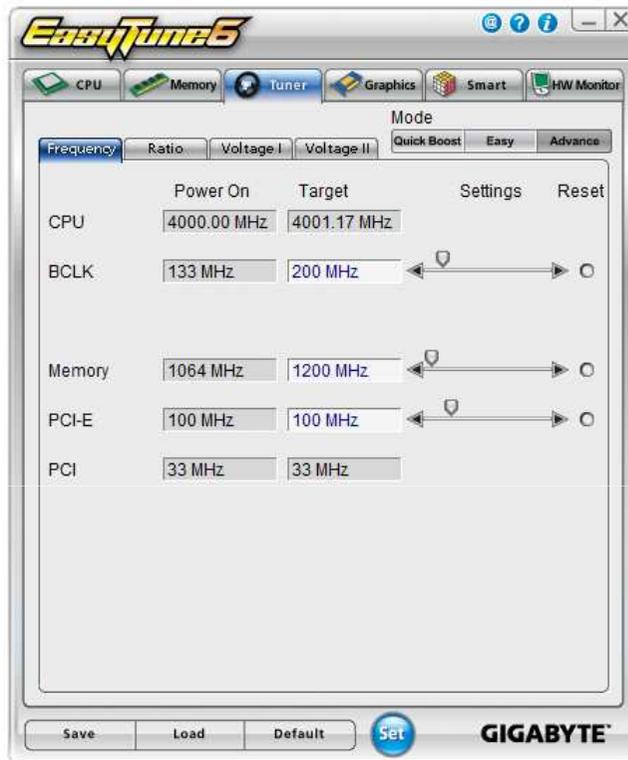
Core i7 920 boots at 4GHZ

We just set up all our frequencies, so the next step is to change voltage. Bclk is 200MHz, and CPU 4GHz, so only CPU vcore voltage is affected. For this parameter set it to 1.4000v or higher. QPI speed will be affected by QPI/VTT and QPI PLL voltages. Usually QPI/VTT will affect more. Set QPI/VTT to 1.515v, and leave QPI PLL to auto or default. For the other voltages, keep at auto. Then click F10 to save settings and leave BIOS. After rebooting, the screen shows our overclock was successful. Our Core i7 920 now is 20x200MHz, or 4GHz.

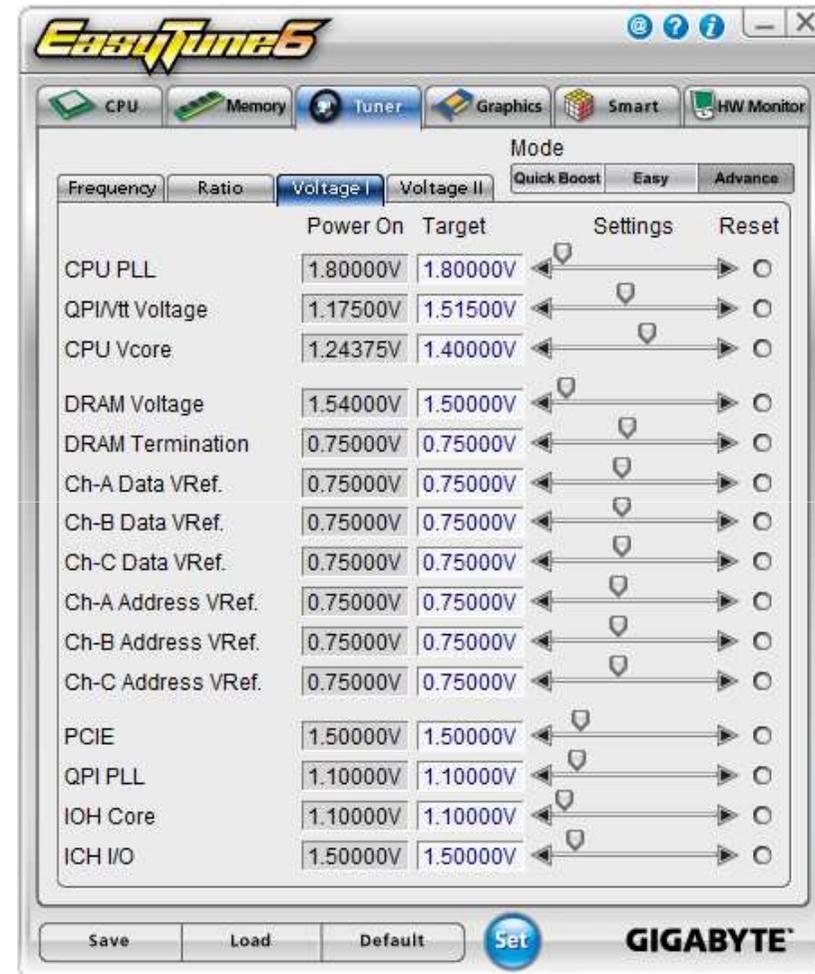
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4GHz i7 920 Performance and Temperature



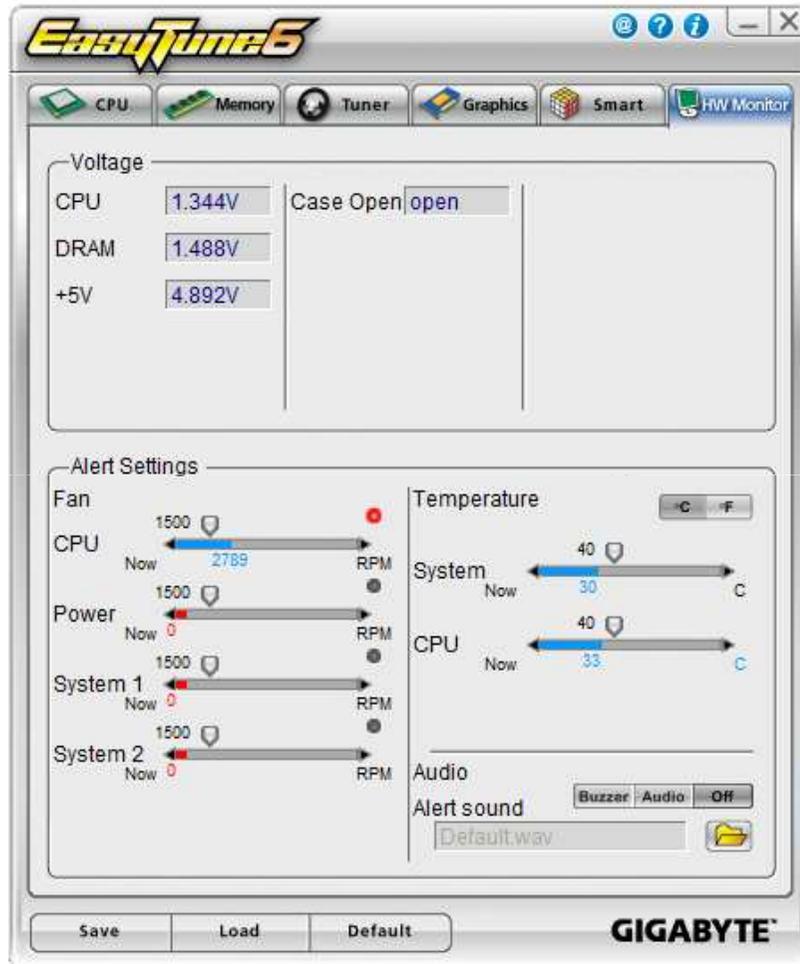
Check Easy Tune 6 to see the real CPU clock speed and also check the voltages to see if they are what we set with the BIOS settings.



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4GHz i7 920 Performance and Temperature



4GHz Core i7 920 idle temperature only 33°C

In Easy Tune 6, the idle temperature of the CPU is only 33°C. This is acceptable, so now we should test performance with 3DMark Vantage to see if our overclock is stable and if there are any performance gains.

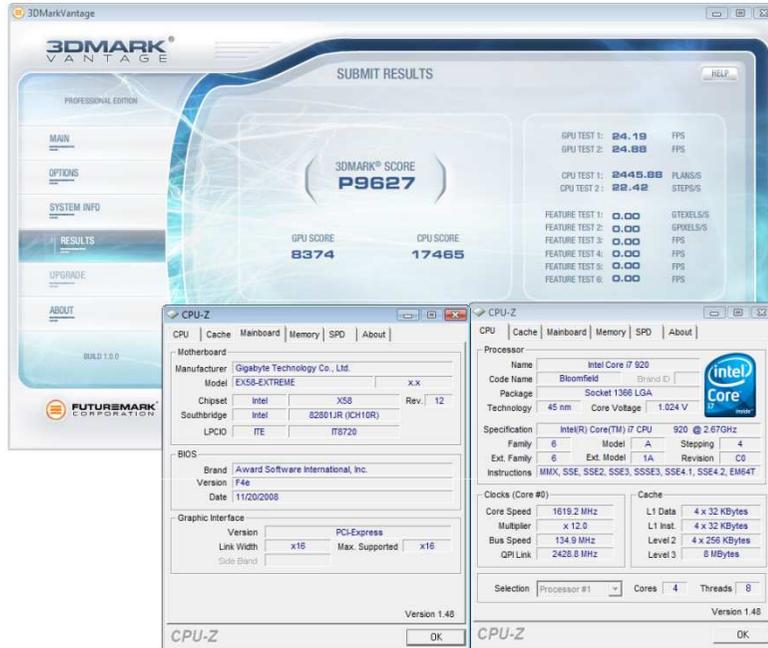


Successfully passing the test, 4GHz seems to be stable. Regarding the performance improvement, from our default score of 17465 we have now reached 23931, a 37% improvement (4GHz VS. 2.83GHz with Turbo boost default enabled).

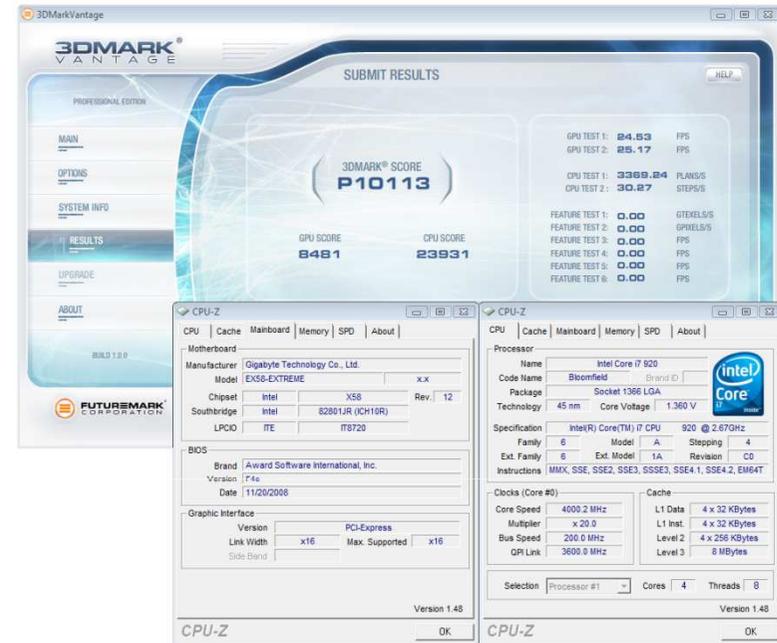
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4GHz i7 920 Performance and Temperature



Default i7 920 2.66GHz ~ 2.83GHz(Turbo Boost enabled)
3DMARK VANTAGE CPU Score is 17465

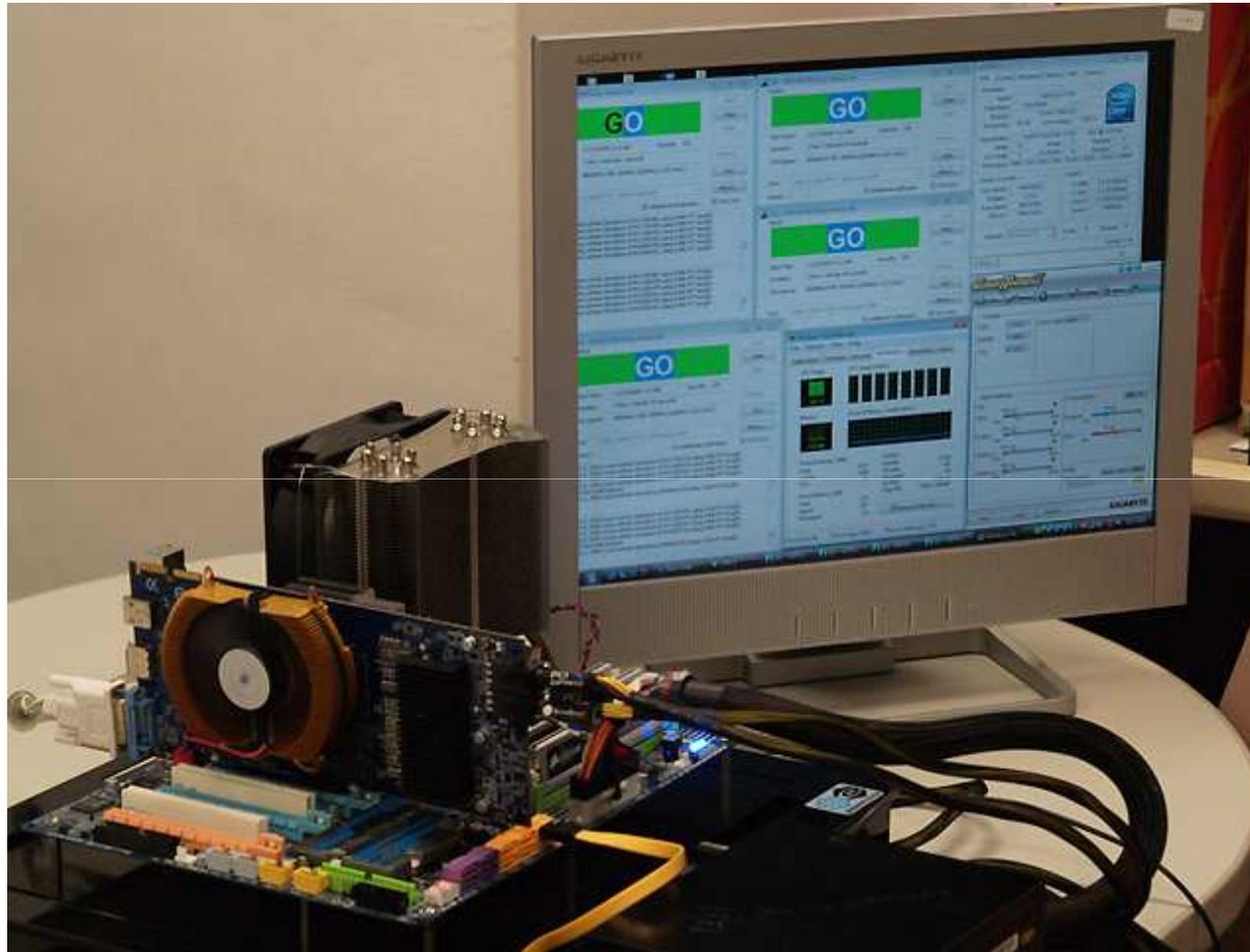


i7 920 2.66GHz overclock to 4GHz (Turbo Boost disabled)
3DMARK VANTAGE CPU score is 23931 (37% increase)

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4GHz i7 920 Performance and Temperature



i7 920 2.66GHz overclock to 4GHz and running SP2004 stress program

i7 920 2.66GHz overclock to 4GHz has passed 3DMARK VANTAGE testing, proving our overclock has some level of stability.

Next, stress the CPU by running SP2004 and fully stress for i7 920 at 4GHz.



4GHz at full loading temperature is 53°C

4GHz i7 920 Performance and Temperature



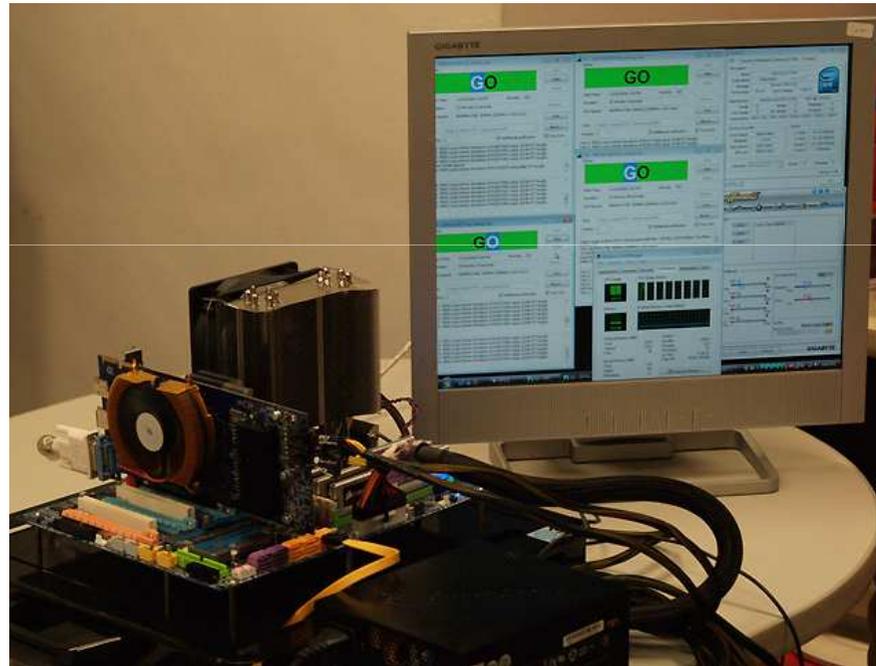
Room temperature is 25°C



Running the stress program, the temperature of North Bridge is 33°C

22

After burn-in stress test for half hour, using a laser temperature meter, our North Bridge temperature is only 33°C , only 8°C higher than ambient . Its easy to see the thermal performance of the GA-EX58-EXTREME with Hybrid Silence Pipe 2 keeps the temperatures low even during overclock conditions.



Burn-in stress program with SP2004

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4GHz i7 920 Performance and Temperature



After 1 hour stressing by SP2004, 4GHz of Core i7 920 is very stable.

TURBO BOOST function to reach 4.2GHz

When the processor is under stress and full loading, the processor is only at 53°C temperature. This is quite low. The temperature of the North Bridge is only 33°C as well. This is a good sign that our CPU can go higher than 4GHz.

So, in Easy Tune 6, I pulled the CPU vcore to 1.5v , and in BIOS turned on Turbo Boost. The multiplier climbed to 21x, and CPU frequency becomes 4.2GHz. After running 3DMARK VANTAGE , our CPU score is 24772.

The image is a collage of several screenshots from different software applications:

- GO - ORTHOS BETA:** Two screenshots showing a stress test in progress. The status bar indicates "GO" and "Start Time: 11/16/2008 3:53 PM". The CPU speed is shown as "4000MHz FSB: 200MHz [200MHz x 20.0 est.]".
- CPU-Z:** A screenshot showing the processor details for an Intel Core i7 920. The core speed is 3999.8 MHz, multiplier is x 20.0, and the bus speed is 200.0 MHz. The QPI Link speed is 3600.1 MHz. The temperature is shown as 53°C.
- EasyTune6:** A screenshot showing the CPU Vcore set to 1.50000V. Other settings like CPU PLL, GPU Voltage, and DRAM Voltage are also visible.
- 3DMARK VANTAGE:** A screenshot showing the "SUBMIT RESULTS" screen with a "3DMARK SCORE" of 24772.
- Windows Task Manager:** A screenshot showing the Performance tab with CPU usage at 100%.

4.2GHz passes 3DMARK VANTAGE CPU TEST

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Reload Profile with EZ-Share BIOS

From our testing, our GA-EX58-EXTREME can overclock the Core i7 920 to 4GHz, passing benchmark and stress testing. The GA-EX58-EXTREME comes with Hybrid Silence Pipe 2 and 2oz copper PCB inner layers, allowing system temperature to remain very low, which is critical for having a successful overclock. As I just showed, our North Bridge, without water cooling and no fan on it, the temperature was just 8°C higher than ambient .

Now you have chance to try your Core i7 920 by overclocking! For those confused by my instructions, you can download my BIOS profile and it will automatically use the same settings I just talked about. Even you don't know how to set the options in BIOS, just enter BIOS, then press F12 to reload my profile. Then you can easy to make your processor overclock to 4GHz. If your processor is not stable with 4GHz, adding more CPU vcore or QPI/VTT voltage will help the stability.

Download my overclock 4GHz profile here:



In BIOS, press F12 to load the profile

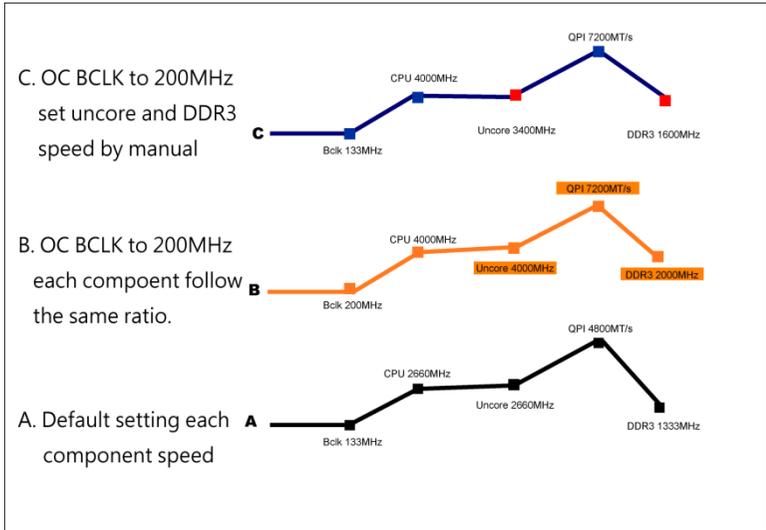
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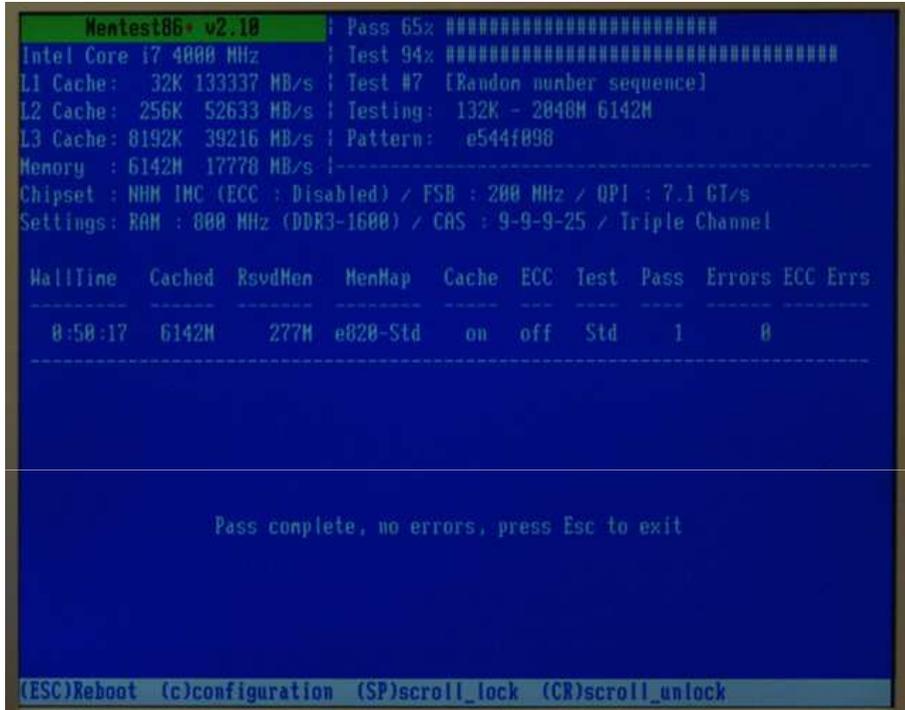
Advanced Over Clock Uncore & DDR3 Frequency

After successfully overclocking our i7 920 to 4GHz, I did some fine tuning to overclock the memory. First, I used the process of elimination to make sure 4GHz was stable at the lower DDR3 and Uncore frequencies. After stress testing, we found it was stable. So next I am going to try to overclock the memory and Uncore frequencies.

Like in picture C, raising the memory divider ratio to 8x, DDR3 will overclock to DDR3-1600MHz. Remember, raising the memory means we need to raise the Uncore frequency as well. In this case, I set the Uncore frequency to 3.4GHz and kept the same DDR3 voltage at 1.5V. Then I tested using Memtest. As the picture on the right side shows, Memtest was able to complete with no errors, meaning, our overclocking settings were successful.



Go to advanced overclocking, adjust DDR3 memory and Uncore speed, Corsair TR3X6G1333 C9 oc to 1600MHz)



Corsair TR3X6G1333 C9 oc 1600MHz and pass MEMTEST without error



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Final Words

Intel Core i7 processors provide outstanding overclocking potential. Combined with the GIGABYTE GA-EX58-EXTREME motherboard, you can be assured of the highest levels of overclocking performance, along with the lowest system temperatures.

INTEL CORE i7 is a brand new desktop platform with its own unique architecture. Try taking some time to understand this architecture. Find out what affects the CPU frequency and the relationship between the various components. Like we learned earlier, changing Bclk settings will also affect QPI, Uncore and DDR3 frequencies. If you know how to control the balance of those components, you will be able to get the maximum performance from your system. Try using the process of elimination to change the settings of each component, one by one. Try using differing voltage settings. This way, you learn the art of overclocking.

