Overclocking is an art, a science, and a way of life. For those of you who have been overclocking everything since you first learned how, to those of you who just are getting into it, overclocking can give you grief while at the same time giving you satisfaction. Today I am putting forward a work in which users of all experience levels can learn a bit and take some advice from. So first we start out with Sandy Bridge-E, what makes it different from Sandy Bridge, and how that difference will affect our overclocking. Then we will venture into a theory of overclocking, and how frequency, voltage, and current are all inter-related and how they will affect your overclock. I will spell out how to overclock your SBe CPU. I will answer questions on memory bandwidth vs timings and whether high memory frequency will really impact normal daily computer usage, but at a basic level. I will give a walk-through of UEFI BIOS, especially catered towards GIGABYTE boards, but theory's which can be applied to many other boards. So I will cover basics that apply to all LGA2011 boards, then I will drill into the GIGABYTE board used for this OC guide. You can use this guide for any board and SBe CPU. Please be advised that locked CPU's will only be able to use their turbo multipliers and BLCK Straps to OC, and thus might not have the full CPU multiplier range above 39X. I like to approach overclocking and a scientific way, so if some part needs to be clarified and its importance pointed out, please feel free to say so. If you have any questions please contact me through PM or post in this thread and I will provide individual support to anyone who asks for it.

The Guide will be split accordingly, if you must skip you may:

Sandy Bridge-E Basics (Intel Specs, Voltage Description, PLL OV, SVID, What you need)

How much power does SBe Pull? (CPU Power Consumption Measured and Analyzed)

Overclocking Sandy Bridge-E, CPU Overclock Section (Steps to OC CPU walkthrough, Setting Voltage, Testing Stability, My Results)

BLCK Straps (Do straps provide increased performance?, Their purpose, Walkthrough, Tips, My Results)

Memory OC Section (Bandwidth Scaling, Timings Scaling, Walkthrough, My Results)

Digital PWM Power Settings (UEFI setting explanation/walkthrough, applies to many boards with Digital PWMs)

Extra OC Tips

Warning: Overclocking will reduce the lifespan of your CPU, it will void the warranty of your CPU and your Motherboard and most likely that of your memory too. It is harmful to components, and death of said components may occur. Higher voltages and temperatures can cause this death more readily. Of course nothing might die at all, but it is a risk every overclocker takes. If the risk is worth the reward to you then proceed. I take no responsibility if you break, harm, kill, or void your warranty by doing anything I say here on in. I have tested everything I talk about and recommend with great results, please be advised that your results may differ. I do not represent any company, and thus my word is my own and not a reflection upon any company of which I use their products or mention in this guide.

Sandy Bridge-E Basics

So let's begin with Sandy Bridge-E (SBe) and how it differs from Sandy Bridge(SB). First off the current SBe CPUs, the 3960X and 3930K, are both 6-core chips meaning that you have 2 extra cores. These 2 extra cores introduce some challenge as 2 more cores is 2 more cores that have to reach the same speeds. As your OC is limited by the maximum speed of the worst core, introducing 2 more cores doesn't help those probabilities. Next you have the issue of heat, there is a lot more heat with SBe, not only because of the 2 extra cores, but also because of the System Agent and QPI/VTT which both have increase maximum current ratings compared to SB. Here is a chart that I made using the Intel datasheets, I made them to help consolidate info:

Sandy Bridge-E Intel Current Specs @ TDP 130W...

Voltage/input	Typical Current 4/6C	Max Current 4/6C
VCC(Vcore)	115/135	150/165
CPU PLL	2/2.	2/2.
VTTD/A (QPI/VTT)	20/20	24/24
VSA (System Agent/I	20/20	24/24

Look at those high current ratings, those are all inside the CPU, and thus all contribute heat. You can even add them together for total values. When the 4-core SBe CPU's come out notice that their System Agent and VTT are basically the same.

We also have a change in the maximum voltage's from SB to SBe. MOST IMPORTANTLY Vcore has be reduced to 1.4v as VAbsolute. This shouldn't be taken lightly, but it might also be no surprise that SBe requires more voltage than SB for the same frequency.

Intel Official Voltage Specification Chart Chart Rev 1.0 for SBe OC Guide

Voltage	Low	Typical	Maximum	Absolute Max	Units	Controlled(SVID Max)
VCC(Vcore)	0.6	VID	1.35	1.4	Voltage	SVID(1.52v)
CPU PLL	1.719	1.8	1.881	2	Voltage	VR
VTTD/A (QPI/VTT)	1.005	1.05	1.095	1.4	Voltage	VR
VSA (System Agent/IMC	0.6	0.965	1.2	1.4	Voltage	SVID (1.365)
VDIMM	1.35	1.5	1.65	1.85	Voltage	VR/VID
VCCLL(Load Line Slope)	0	0.8	board	board	mΩ	VR

Now there are a few other things that have changed, first off CPU PLL can be taken to 2v, but I wouldn't go over 1.95v. QPI/VTT(VTTD/A) and System Agent(IMC/VCCSA) can both be increased to 1.4v. This is much more than SB. I tossed up the load line slope in there, not for any other reason than to establish

that the rating for the VCCLL is a slope, which is also a mOHM rating. Now remember back in high-school when you took geometry/Algebra? A lot closer to 1 is a vertical nice and a Slope closer to 0 is a horizontal line. Think of that line as the drop in voltage under load, so 0 slop would be no drop, and 1 would be all drop. This is only important for GIGABYTE boards as the slope is given as percent rating, so users can understand the meaning behind the percent.

Voltage+Description Tables
Sin's SB-E OC Guide Rev 1.0

Info provided by Intel Datasheets, and general use

Voltage	Description	Max Air	Max H2O	LN2/DICE
VCC(Vcore)	Voltage for the Processor Cores, Ring Bus, Cache, and Home Agent. This voltage is the primary one to be increase for overclocking the CPU frequency.	1.4-1.45v	1.4-1.5v	1.55v+
CPU PLL	The CPU PLL Voltage, the voltage fed to phase lock loop in the CPU, this voltage is "trimmed" by and on-die "filter", CPU PLL Overvoltage lessens that amount of internal trimming/filering . Has no direct affect on CPU PLL Voltage Override Setting. For SBe increasing this voltage can help with processor core's stability at higher frequencies.	1.9	2	N/A
VTTD/A (QPI/VTT)	The digital and analog voltage supply to the I/O of the DMI2 and the PCI-E controller, better known as uncore voltage. Also supplies voltage to the PECI	1.2	1.4	1.4+
VSA (System Agent/IMC)	System Agent Voltage, provided by a VID and controlled by SVID on the fly, this voltage now more strongly corresponds to the internal memory controller, the PCU(power control unit), and logic input voltage for the I/O controller.	1.2	1.4	1.4+
VDIMM	Memory Voltage, same as before, you can use 1.65v memory without issue, and you can even increase voltages upwards of 1.85v.	1.85	1.85	1.85+

So I made this chart, to explain the voltages as well as what they correspond with. I like to know what I am pumping voltage through, I am sure some of you would like to know too. Now those maximum rating are subjective, many will pump more or less into their CPU depending on how they feel and how long they want their CPU to last. I will give my suggested voltage ranges in a little bit. VTTD provides voltage to the PECI, the PECI is the part of the CPU that connects the cores and chipset to external logic devices that need readouts like temperature. It contains the DTS(digital thermal sensor) which are implemented as analog to digital converters and calibrated at the factory. Unlike with SB where the System Agent voltage was useless to a point, with SBe it is all but very important for memory OC. GIGABYTE went as far as to call it the IMC (Internal Memory Controller) Voltage. We still have QPI/VTT and it is important still as well. So now with SBe both System Agent and VTT need to be raised for memory OC.

CPU PLL Voltage Override (Overvoltage): What the Heck does it do?

So I asked that question to an Intel Overclocking Engineer his explanation was roughly: We went through the BIOS settings trying to find setting that if changed could help overclock our CPUs further. We came across this setting. Think of the CPU PLL voltage as a voltage that is provided to the CPU, but

then “clipped” down to an approximate voltage. No matter what that input is whether 1.3v or 1.9v it is clipped (hypothetically let’s say 800mv after clipping (he didn’t say how much)) that way other devices can use the PLL voltage and clip to what they need. The CPU PLL Overvoltage allows for less clipping of that voltage. It can also reduce the lifespan of the CPU, but nothing noticeable.

So those of you who think that increasing your PLL voltage will help with that setting, it really doesn’t. But with SBe I have found that increased CPU PLL can help stabilize higher frequency overclocks. That wasn’t the case with SB.

What is SVID and how does it affect Overclocking?

SVID is a 3-wire digital communication protocol between the CPU and the PWM, it allows for the CPU to change its VID on the fly to fit the frequency selected. That is why you can increase the base frequency +/- 6-7 multipliers and the CPU remains stable, because SVID is increasing the VID without you knowing. Now this doesn’t stop unless you manually set the voltage, so when users use DVID offset, they should be aware that their stock VID really isn’t constant. That is why I do not recommend DVID with SB or SBe, at least not above 1.4v. SVID potentially can increase voltage to 1.52v on its own, but that has never really been seen. SB and SBe both have this 1.52v max for SVID. Now with SBe we also have the System Agent voltage, VCCSA or the IMC (internal memory controller) voltage, and this voltage now has SVID! Although I haven’t seen much automatic change to this voltage, it can happen.

Now that we have covered some basics let’s move to required hardware.

So what do you need to OC?

Processor: Any "K" Series or X series Processor will have unlocked multiplier, which is pretty important. With SBe we will see a 4-core CPU, that has a locked multiplier. So with that CPU the BLCK dividers can be used, which can also provide a decent overclock. I used a **3960X.**

Motherboard: You need an X79 chipset board with a LGA2011 socket. It is nice to have a board with voltage read points, but it isn't really required at all for 24/7 users. It is also nice to have POST code Port 80H POST code read out display, but you can also buy one. The VRM is important with SBe, as is overall spacing. I am not going to go into it, but I used an **X79-UD7**.

Memory: SBe can clock trashy memory like it was that $500 kit. More stick=harder to OC to higher frequency. Higher density is the same thing. 2400 MHz is the goal for many users, I used 2 pairs of cheap Corsair non-dominator 2000 MHz cas9 2T memory and I was able to hit 2400 MHz. Please be aware memory clock is VERY dependent on the CPU. Unlike SB where every CPU could do 2133mhz, with SBe not many can do 2400mhz. You CAN mix and match memory, you can even set their timings differently, and their voltage, but it is very much recommended to use the same memory. It is also recommended that you buy a quad channel kit rated for your target clock. G.Skill, Corsair, and Kingston have some kits. SBe can run dual channel with 2 sticks, triple channel with 3 sticks, and quad channel with 4 sticks. I used Corsair I used **CMX4GX3M2B2000C9**.

Cooler: Water-cooling or top-notch air cooling is recommended for any OC over 4.5ghz with SBe. Please take note that many coolers used on socket LGA1366 can fit on LGA2011 with adjustment. SBe socket has holes at the same dimensions and placement as LGA1366, but instead of being thru-hole it instead has screw holes built into the socket. Anyways I was able to get my **Antec Kuhler 920** to work, and it was because of two reasons. First of all the screw holes on the socket are a bit bigger than standard size, but they are a standardized size. They also don't bottom out, they are open ended so if you have a screw thinner than the hole you can thread it through. Next you can go to Home Depot (hardware store) and buy some screws that fit the new socket, which is what I did. Also for reference, the Coolermaster Hyper 212+ fits the new socket's screw holes perfectly. The R4E has a socket that can be changed out to allow for older LGA1366 coolers.

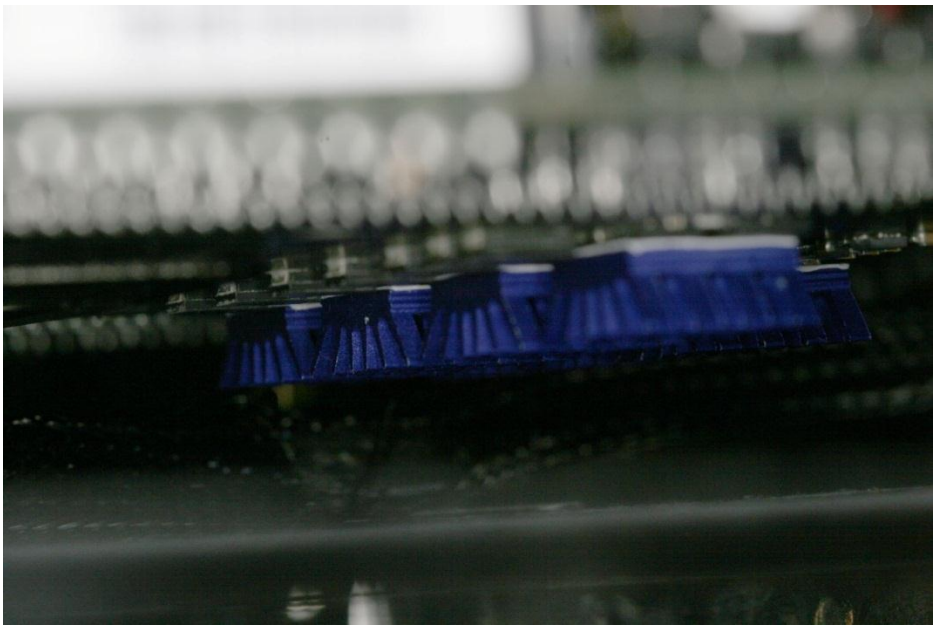
PSU: This is important with SBe unlike with SB. SBe is a power hog, they said Bulldozer was a power hog, well they must not have foreseen Intel doing the same thing. SBe can pull 350-400 Watts at 4800mhz+ before power conversion of the VRM. That is a lot of watts. I used Corsair **AX1200**.

Optional Parts:

Those are the only parts very important to OCing. Personally I bought a few optional parts:

Digital Multi-Meter: A digital voltage meter, it has two probes, read and black and they can measure voltage. You can pick one up at any electronics store like Home Depot, even stores like microcenter carry them. They can be had for as little at $5-10 USD for cheap ones, and upwards of $100-200 for very nice ones. Really even a cheap one is better than software. Analog meters are cheaper, but they just have a needle that points to a voltage, don't buy one of these. Buy one with an LCD screen. Many boards have voltage read points, and these points are made to be used with a Digital Multi-Meter (DMM from here on out). Not only can you read your VCore in real time, as well as other motherboard voltages, but you can also test out your PSU and see how well it's voltage regulation is. A DMM is 10x better than any PSU tester, and cheaper usually too.

Small heatsinks: I bought some from my local Microcenter, pretty cheap, I put them on un-heatsinked components, like the MOSFETs around the board. You really don't need to put heatsinks on them, but I thought it looked cool. Plus aftermarket copper heatsinks always work better than stock ones.



Fan for the board: If you are using watercooling then you are disregarding the airflow required around the CPU socket, particularly for the memory and VRM. With SB heat wasn't really the enemy, but with SBe it is the #1 enemy. A fan over the VRM heatsink is recommended for all LGA2011 boards. You will even see Alienware computers come with directional fan over the VRM with LGA2011 boards.

Power Meter: You can go to Radio Shack, Home Depot, or Microcenter and buy a $30 wall power meter; it will tell you power consumption at the wall in watts. Reviewer's use these. You can also buy a DC power meter, Zalman just released one, and it has decent abilities, up to 250W of the 12v rail of your PSU on the 8-pin connector. This is as close as one can get to telling CPU power consumption, without worrying that too many other components are using the same rail. The CPU has its own connector to help reduce the noise and EMI between components, we a user can take advantage and get a nice power reading.

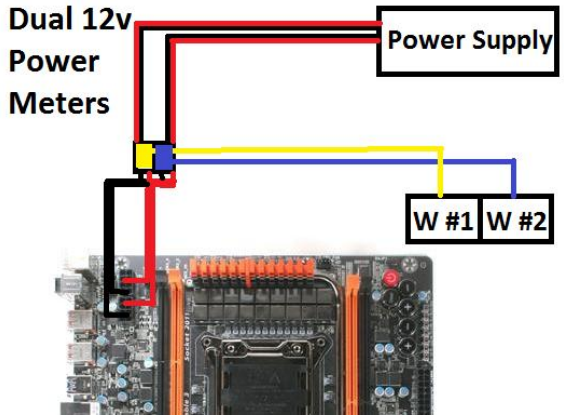
Anti-Static Stuff: A $3 wrist band can save you hundreds of dollars in dead hardware, and hours of frustration. There is no shame in being safe.

IR Thermometer: There are some really fancy Fluke IR thermometers and then there are some cheap ($15) laser ones with limited temperature ranges. You can buy one from an auto-parts store or Microcenter carries cheap ones in variety. It is nice to be able to read temperatures without a probe, and most work just fine. The more expensive ones can capture a thermal IR image, and they are very nice.

Jumper Buttons: These are sometimes included with tech benches, but now some computer hardware stores sell them separately, Microcenter carries them in a pack. They can replace your case's buttons and make it easier for you to power, restart, and clear CMOS on your board. Of course if your board already has built in buttons, like my UD7 does, then you don't really need these.

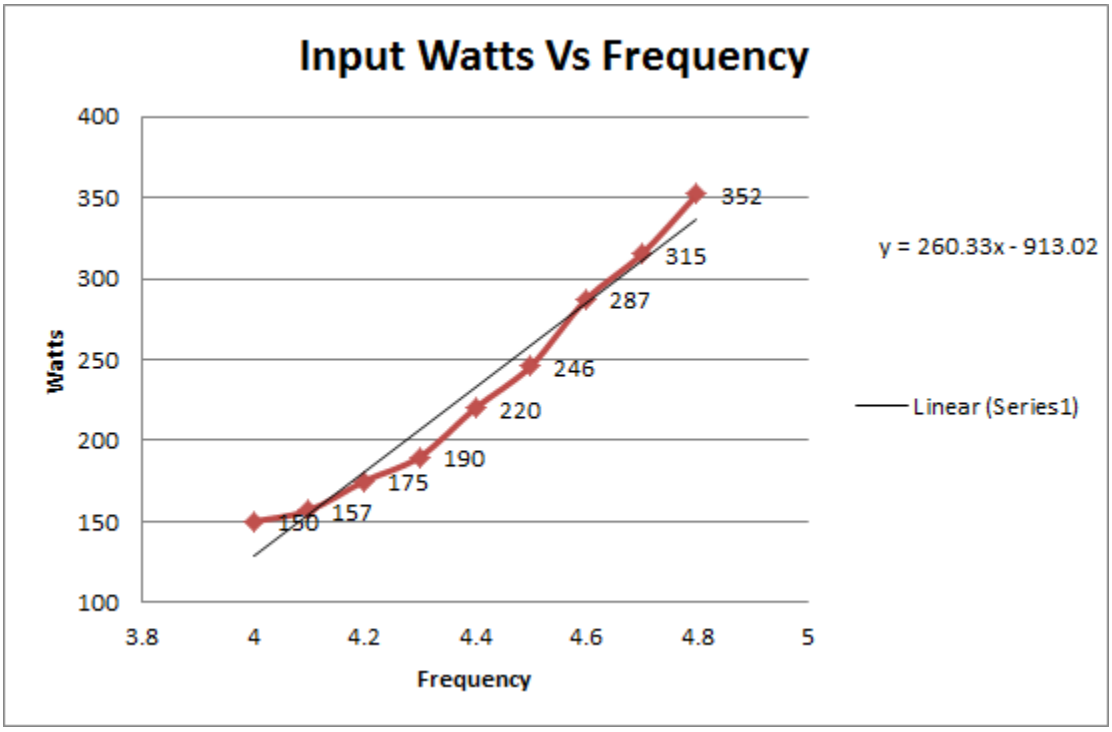
So how much power does SBe pull?

So have you read a SBe review? And they showed you power consumption tests, correct? Well that was of the entire system, how about just how much power the CPU pulls? No they probably didn't show you that. So let me show you that. The one reason we can do this is because of the 8-pin 12v connectors, as the CPU VRM pulls almost all of its power directly from there. It gives us a better estimate of how much power the CPU pulls, but it isn't perfect, since some other smaller VRs pull power from the 24-pin(DRAM), and supply it to parts of the CPU, but it's a very small amount.

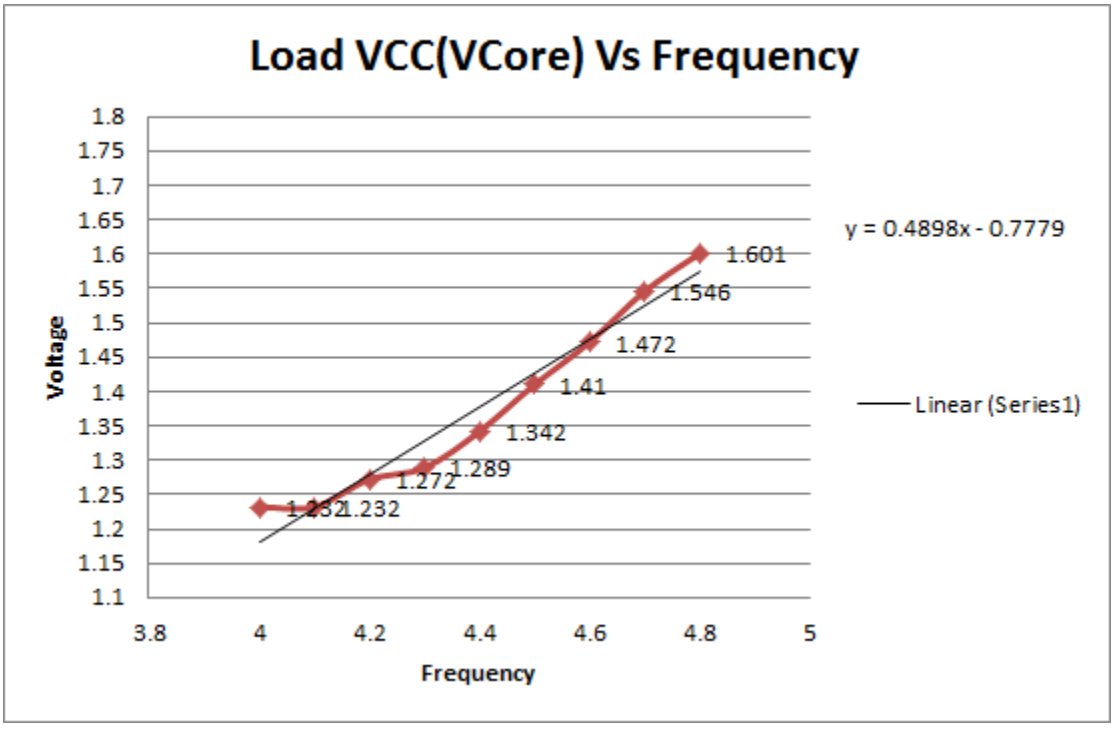


Here is how I measured the power; I used two 12v meters made by Zalman. Each can only measure up to 250Watts, so I modded two of them together, and I add the resulting numbers. Remember that to measure current you need to break the circuit.

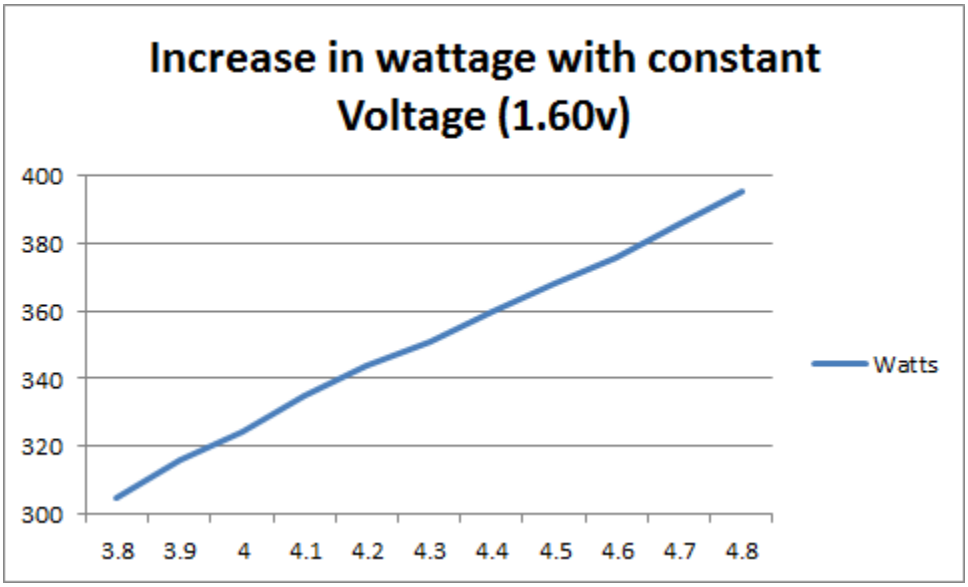
The results are a bit shocking:



Here are the voltages used, mind you they were required for our CPU to be stable (100%) at those frequencies (they are a bit higher than most will need, no LLC was used and that is why)



Now what if we set a constant voltage, and just increased the frequency, would the watts increase? (1.6v set with LLC 30% (5mv increase under load).



Yes they would. An increase in frequency requires an increase in work, work demands power to do the work, and thus current increases. Watt=Power=Current X Voltage in simplified terms. Power conversion rate (change from 12v to 1.6v) is about 80-90%, so the figures shown can be multiplied by .85 for more realistic power input. That is about 300 Watts at 4.8 GHz. That is how much power would go in, so power coming out would be less as well.

Overclocking Sandy Bridge-E, CPU Overclock Section:

Frequency of CPU is always Multiplier times Base Clock. Now with SBe we can further enhance the Base Clock (BLCK). It isn't required to get superb overclocks; I personally tend not to use it. Unlike previous Intel platforms SBe's BLCK straps are very virtual, and if you skip down to the BLCK strap section I will explain their affect in full. This section was done with a GIGABYTE UEFI BIOS, but the settings in this section are universal, so it can be used for other motherboards.

Step #1: Determine what type of OC you want: do you want a 24/7 OC? Or do you want something to pass a benchmark or just max CPU Clock? What type of memory frequency do you want? What type of cooling do you have? Once you determine those you should determine whether or not you want to use BLCK. **You should also determine whether or not you want to use Power Saving states like (EIST, C1E, and C3/C6 states) to down clock your processor during less intensive loading scenarios like being idle.** You should also determine if you want to just have a small OC without any voltage changes.

Step #2 Increasing BLCK and/or Frequency: You have to use Turbo Mode to OC SBe with every board. You need to leave Turbo Mode enabled, and set each multiplier, or just set one for all cores. On some boards EIST or C1E needs to be left enabled to use Turbo multipliers. On the UD7 it isn't necessary to leave either one on. If you want to use BLCK straps or change BLCK**,** please do that first. Set the strap and BLCK you want and restart, if that doesn't work go down to the **BLCK Strap Section** for more help. Next after you find BLCK, whether stock or not, then start increasing the multiplier. Increase it two at a time. Please realize that you won't be doing over 4.8 GHz 24/7, at least not many will because of heat restraints. If you fail to POST, or fail stability tests in Windows, then you need to increase your VCore. At this point you should disable power saving settings, which are EIST (Speed step), C1E, and C3/C6 states. On some boards you need to leave EIST or C1E on to maintain the OC at all.

Step #3 Pick a good VCore: Warning! At or above 1.7v the CPU will DIE. From 1.5-1.69v the CPU will DEGRADE more quickly than below 1.5v**.** When a CPU degrades it is very easy to tell, as it will require more voltage than before for the same frequency. Once you reach your max OC your VCore might be higher than you want. For every 100 MHz I use 30mv higher. So is my VID is 1.25v with a 3960X start with the maximum stock turbo ratio of 39x. Below is a list of

Recommended Voltage ranges. The “Set to Get” column is a rough estimation of a voltage you can set and a multiplier you can set and get into Windows with. If that is stable, then you should move to reduce the voltage by 10mv-20mv steps until it is unstable and then increase it until you find the lowest voltage at which your processor is stable at for your task at hand.

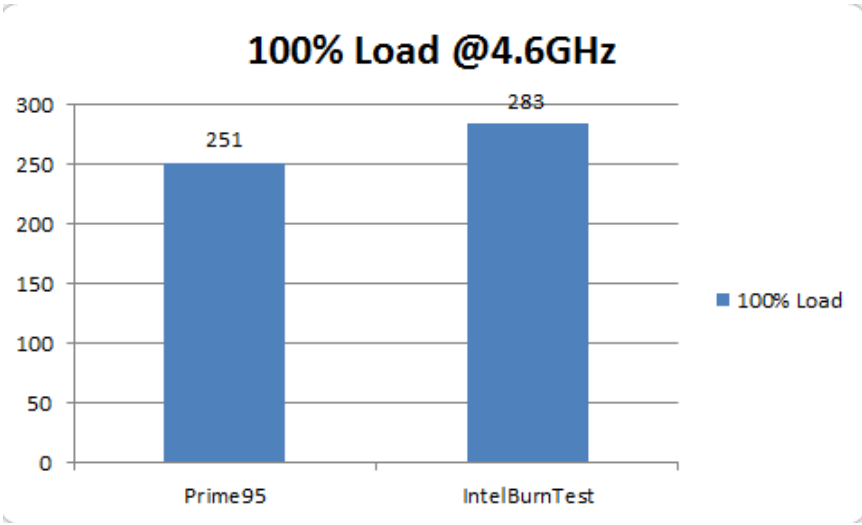
Recommended Voltage Range		
Frequency	Set to Get +30mv	Reduce/Increase
3.9	1.25	-
4	1.28	1.25-1.33
4.1	1.31	1.25-1.37
4.2	1.34	1.3-1.37
4.3	1.37	1.3-1.37
4.4	1.4	1.35-1.45
4.5	1.43	1.35-1.45
4.6	1.46	1.37-1.48
4.7	1.49	1.42-1.55
4.8	1.52	1.44-1.57
4.9	1.55	1.45-1.6
5	1.58	1.45-1.6

Of course your processor could also be unstable at the voltages under “Set to Get”. If that is the case then you might want to get back into the BIOS, and look at some other settings.

DVID Offset: With SB and SBe we have SVID, and SVID will change the VCore unless the VCore is explicitly set. At 4 GHz my VID will be 1.30v, at 4.1 it will then be 1.315v, at 4.3 it will be 1.335v. Setting DVID is setting a positive or negative offset onto that VID. The issue is that VID changes with frequency, so if you set a +0.100v offset, at 4GHz it would be 1.4v, at 4.1 GHz it would be 1.415v, and at 4.3 GHz it would be 1.435v. You can’t control the final VID on these CPUs, so I do not recommend using DVID offset, but if you want the voltage to drop when the frequency drops then you need to use it. Please set the maximum frequency you wish to achieve, and disable all power saving features (EIST, C1E, C3/C6 states). Then boot into Windows and then restart and go into BIOS. Your max SVID bin for that frequency should now be your VID. Set the offset off this voltage, and then save, that will be your max VCore. If you increase the frequency more, then do that again, SVID might or might not change the VCore.

If you want the voltage and frequency to drop when the CPU is idle, you have to enable C1E and/or C3/C6 and EIST and you have to use DVID. Using DVID will allow the voltage to drop to 0.9v at idle when the CPU is only at 1200 MHz.

Step #4 Test Stability: For this step you need to monitor conditions, with a program such as **CPU-Z**(http://www.cpuid.com/downloads/cpu-z/1.59-setup-en.exe) for frequency, and then something like **HWMonitor**(http://www.cpuid.com/downloads/hwmonitor/1.18-setup.exe), **RealTemp**(http://www.techpowerup.com/downloads/1872/Real_Temp_3.60.html), or even motherboard software like **EasyTune6-GIGABYTE**(http://download.gigabyte.asia/FileList/Utility/motherboard_utility_et6_intel-x79.exe**)** and **TurboV/AI Suite II-ASUS**(http://www.xtremesystems.org/forums/showthread.php?276839-ASUS-Official-X79-Motherboards-Support-Thread). Then you need a stress testing program, now there are two: **Prime95**(http://download.cnet.com/Prime95/3000-2053_4-192895.html) and **IntelBurnTest**(http://www.softpedia.com/dyn-postdownload.php?p=115298&t=0&i=1)/LinX. So which is better? Well with Sandy Bridge is it apparent that Prime95 was the better one, even though in the past IntelBurnTest was just as good, it seems that something in the SB uArch is more heavily stressed with Prime95. SB also didn't have huge issues with heat, one could reach maximum CPU clock without subzero cooling. SBe is not like this, there is no way you can reach your maximum clock on all cores without subzero. So my hunch was that IBT was better, since the heat was going to be more of a killer. So I did a power consumption comparison:

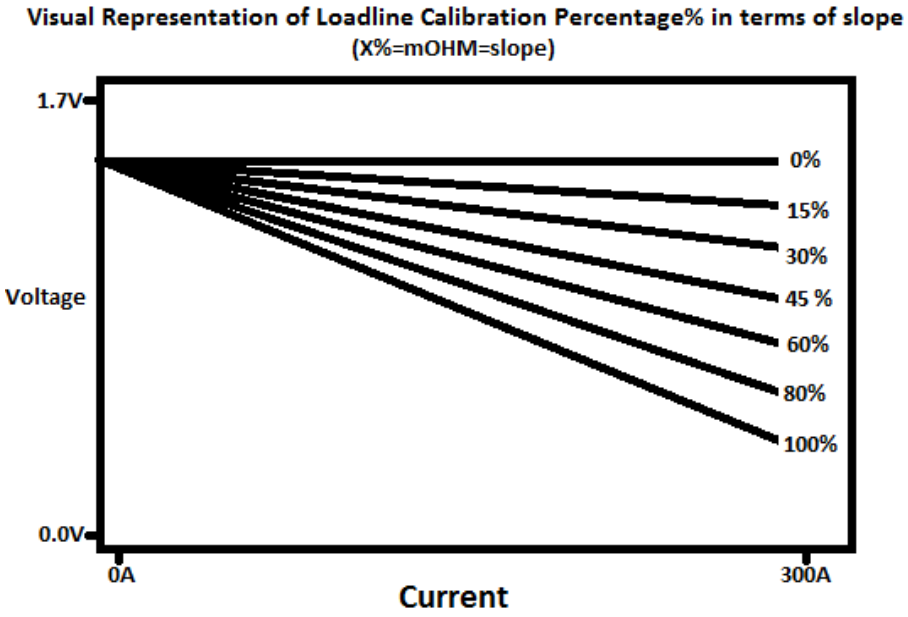


So IBT really does pull more power. But then I tried seeing which would fail first. Prime95 failed first every time, and it failed when IBT would pass. So same as Sandy Bridge, **Prime95 is a better stability tester for Sandy Bridge-E than IBT/LinX.** Stability is subjective, some might call stability enough to run their game other like folders might need something that is just as stable as it was at stock, and then they would need to run Prime95 for at least 12 hours to a day or two to deem that stable. There are stability clubs and they require 12 hours or so of Prime95. There are benchers who really don't care for stability like that and will just say if it can bench a benchmark it is stable enough. No one is wrong and no one is right. Stability is subjective. 24/7 Stability is not subjective.

Step #5 Finer tuning Intel Power Settings and PLL OV: Go under the Turbo Mode menu, you want to increase the processor watts to 500W and the processor amps to 300A. Those are the maximum that I could do in my GIGABYTE board, and they are way more than enough. Next you want to Enable CPU PLL Overvoltage, this setting really doesn't do much at frequencies under 4.8ghz, but at and above 4.9ghz it helps. With some boards this setting has an odd affect; please look here for more info: http://hwbot.org/forum/showpost.php?p=138563&postcount=17

Step #6 Finer Tuning LLC: This step deals with fine-tuning LLC. LLC is Load Line Calibration, it helps reduce voltage droop under load. There was a scary article on Anandatech a while ago talking about overshoot, and explaining that VDroop is implemented so that overshoot doesn't exceed VAbsolute. With modern boards and high-tech PWM technology, voltage output is more stable, and you shouldn't be scared to use LLC with high quality board. MOSFETs are higher quality now on high-end boards, inductors are better, and so are VRD specs. Sure VDroop is still a good idea, but it isn't as bad as it was in the LGA775 days. Do not be afraid, **you can use LLC with great results**. After all you are OCing, so your processor life will be hurt anyways.

Here is what LLC levels really look like (Remember: 80% or 0.8mOHM is standard Intel VDroop):



Go to your menu where you can mess with Load Line Calibration, or Vdroop Control. On many boards you have 3-5 settings, either names or values. On GIGABYTE LGA2011 boards it is a number, and the lower the number the stronger the LLC =less vdroop. On ASUS boards it is named, and you have something like 5 settings. On no board should you use the highest setting for everyday normal overclocks, the highest setting increases the voltage under load, and that can be harmful. If you are using a very low voltage, then that might help.

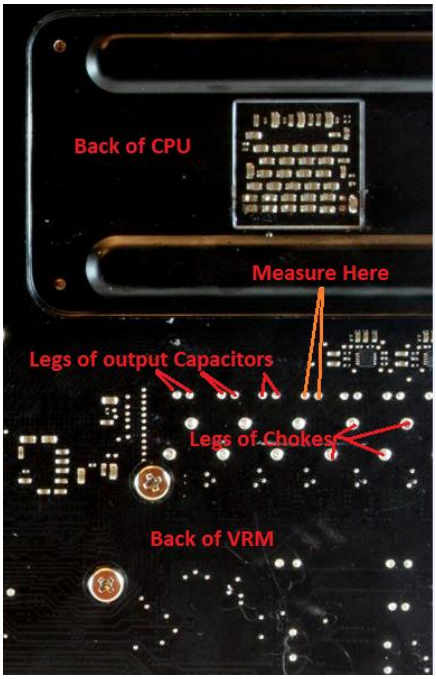
Here is an example, the LLC on my UD7. You will see how effective 30% and 45% are, as well as how 80% (stock) acts. I recommend the 30% or 45% or 3rd or 4th setting strongest setting on other boards.

BIOS F4 LLC Levels Test CPU(3960X)@4.4GHz IBT 12 Threads@ 1.5v Set 100% VS 0% Load						
DMM=Digital Multimeter (Real)			SW=Software (Virtual/CPUz)		Watt=VRM Input Power	
LLC %	DMM Idle	DMM Load	SW Idle	SW Load	Watts Idle	Watts Load
15%	1.526	1.59	1.512	1.524	102	320
30%	1.506	1.508	1.488	1.452	95	280
45%	1.501	1.494	1.476	1.44	93	273
60%	1.496	1.48	1.464	1.428	91	265
65%	1.495	1.476	1.476	1.416	90	260
70%	1.493	1.47	1.464	1.416	90	258
75%	1.49	1.465	1.464	1.404	90	255
80%	1.487	1.46	1.464	1.404	90	253
85%	1.485	1.455	1.464	1.404	90	250
90%	1.485	1.451	1.464	1.392	90	245
95%	1.484	1.447	1.452	1.392	90	243
100%	1.482	1.443	1.452	1.392	90	241

For this test LLC levels were chosen, Vcore was set at 1.5v throughout the entire test, with only LLC levels changed. Intel Burn Test was used for loading, 12 threads. A watts meter connected to both 8-pin 12v inputs for the CPU VRM measured input watts, during IBT load spikes peak watts were recorded as well as vcore during the peak load. To guarantees consistent results idle Vcore was measured at lowest Watts, and load vvcore was measured at peak watts (highest).DMM is real voltage, software is just well software.

Measuring Vcore, the best way:

So currently 99% of users use software to measure VCore, but that is not a good way to do so. Software always under reports or over reports the VCore. This isn't the program's fault, but rather that software is almost always wrong when dealing with real voltage measurements. Just like no one should use software to measure their PSU's voltage outputs, one shouldn't use software to correctly measure VCore, especially when you are dealing with high voltages. Luckily there is a very easy method to measure VCore on all motherboards. Since VRM design is pretty much the same on all boards, with the output capacitors nearest the CPU socket being one of the last steps before the voltage is inputted into the CPU, we can measure VCore from the legs of these capacitors. It is best to use both legs, one for ground and the other for VCC (Power/VCore).



Method #1: Voltage read points. If you have a X79-UD7 or a Rampage 4 Extreme, then you are in luck, as your motherboard has voltage read points, in convenient places so that you can hook your digital multimeter up to it.

Method #2: Measure VCore off of the legs of one of the output capacitors. These capacitors are closest to the CPU socket, and underneath the board have their legs. One of the legs can be used for VCC/power (red probe) and the other for Ground (black probe). If you are not sure which one is ground and which is power, then try it anyways, if the reading is negative voltage, and reverse the probes and it will be positive.

Step #7 Fine Tuning VCore PWM Settings: Next you need to work with CPU VCore settings from the PWM. If you want a detailed description of these settings, which correspond to a Digital PWM, like those on GIGABYTE and ASUS board's please go down to the **PWM Settings Optimization section**. Since most board use Digital PWMs now, including GIGABYTE, you need to increase current capability, and possibly some other things. Go under the menu where you have the ability to change VCore switching frequency, phase control, ect. Increase the CPU Current capability to something like 128% for GIGABYTE boards, and more for other boards. Even board has a different current rating to the percentage of increase, for instances GIGABYTE's 128% corresponds to 300A. Next if you have an option for VCore Thermal Protection, you want to increase that threshold as well. Then on some board's you can/should increase the switching frequency as well, on the UD7 it makes no difference.

Now once you have optimized the VCore settings, please go back into windows, and test again.

Step #8 Taking Care of CPU OC issues:

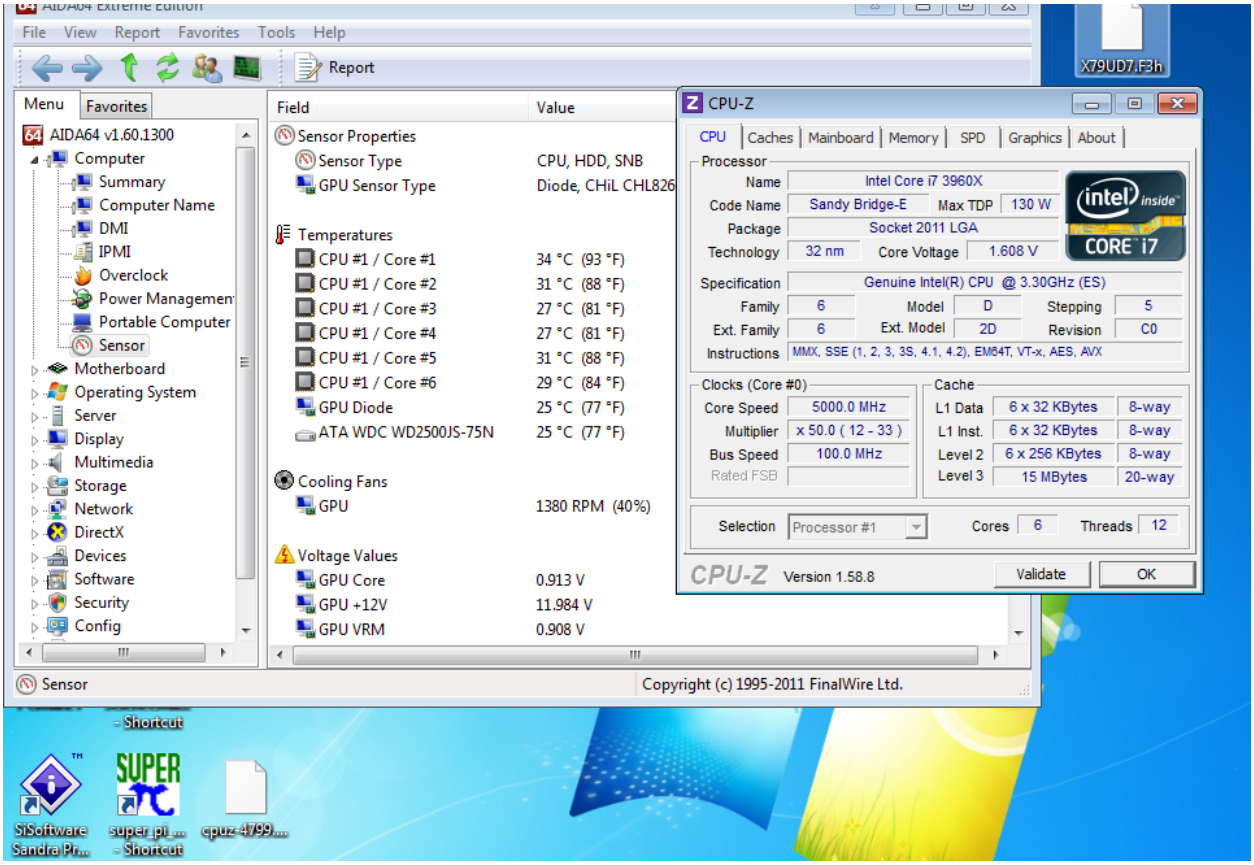
At some point you are going to hit a wall, no matter what you do you cannot get past it. That is how it is with SB and that is how it is with SBe. With SBe, going subzero will let you gain a few hundred MHz, which wasn't the case with SB.

- If you are still stuck, and it is unstable and you are using BLCK Straps, try not using BLCK Straps. If you are using only Multi, then try BLCK Straps!
- With SBe high memory speed will limit your CPU OC, so try lowering your memory speed if you have already OCed your memory. If you are having memory issues, please try to go down to the **Memory OC section**.
- You can also Increase VCore and/or CPU PLL Voltage for stability
- If you have a GIGABYTE board, and your OC is not sticking, please disable Easytune6, either uninstall it or make sure it doesn't start on startup.
- You can always try a higher VCore, as that is really all you need for CPU frequency OC.
- If your OC is throttling, recheck your turbo power limits, recheck your PWM power limits, and then put a fan over the VRM area.

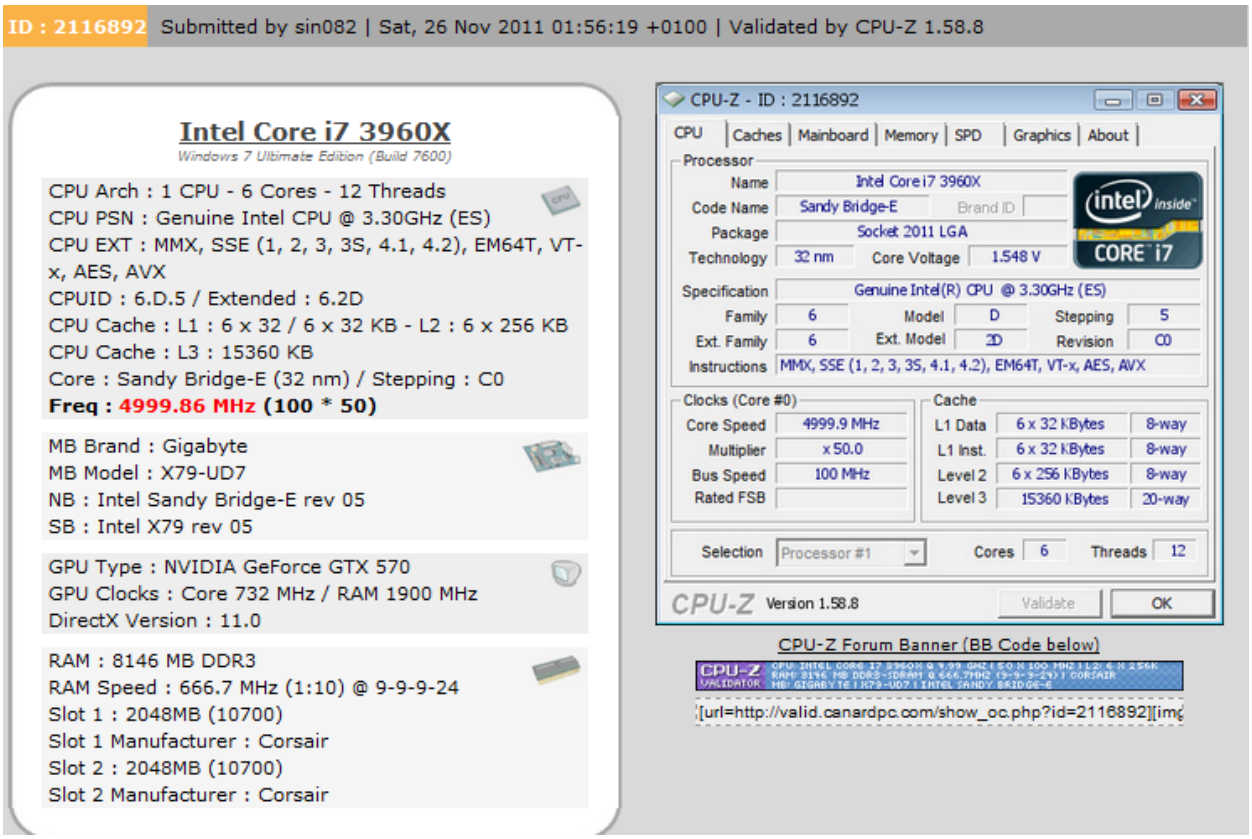
My results:

I used that Antec Khuler 920 and my results were generally decent. I was able to finally pull off 5.0 GHz after some fine tuning and BIOS release. My trick was the cool down my VRM heatsink with a fan. I had to open the window as it was getting hot, and stability was better in general.

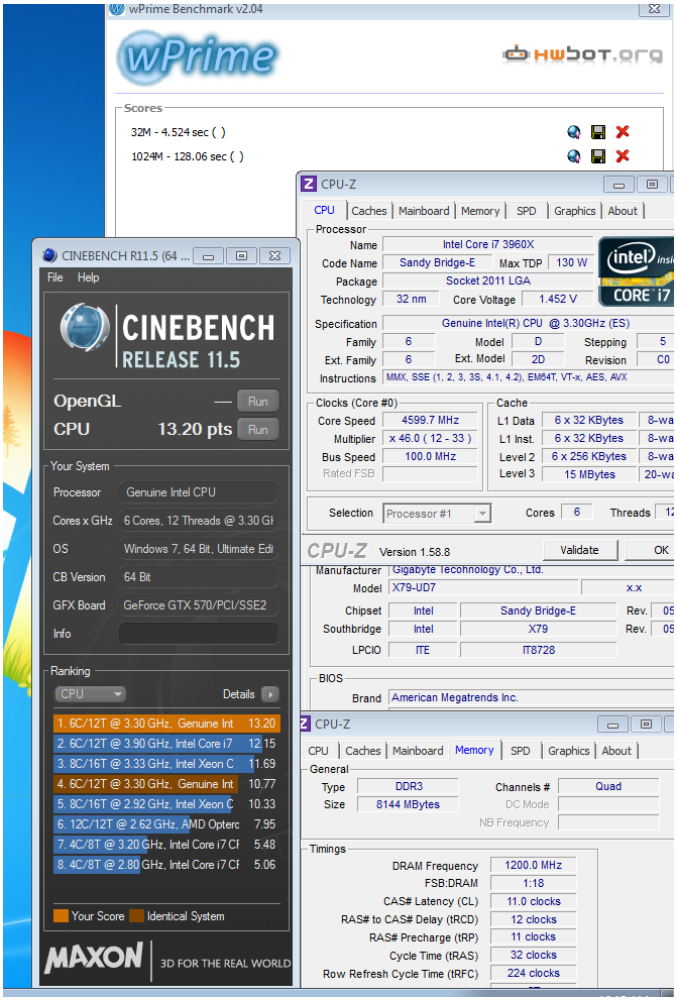
My temps are shown below, it isn't that cold outside.



1.608v is not required, in fact I can do it on 60mv less:



For 24/7 OC I found that 4.6ghz worked very well for this particular CPU in terms of heat and power consumption. You have to keep in mind that every single CPU is different and that clocks will vary. Just because someone can do 4.8ghz 24/7 and your CPU wont do 4.7ghz 24/7 doesn't mean you suck at OCIng, it just means they have a better CPU or better cooling.



You can see I used 4.6ghz, and it 2400mhz memory. Well I will talk about tuning memory in the **Memory Tuning Section**. But next we have the BLCK Straps section to better explain them.

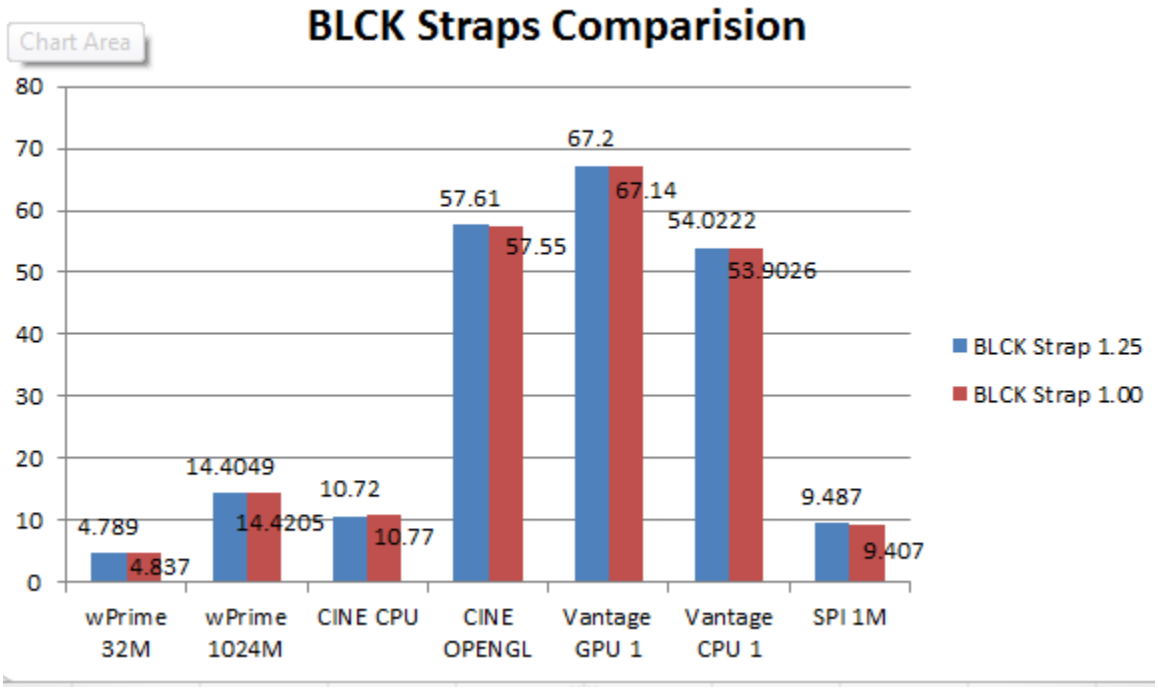
BLCK Straps:

First we have to realize that SBe also has BLCK overclocking. SB also had slight BLCK overclocking; the base frequency of 100 MHz could be OCed 5-7%. The same thing is possible with SBe, so you could look at 106-107 MHz BLCK on average. The issue with going higher is that the BLCK is now tied to the PCI-E bus and DMI. You can corrupt your OS and your GPUs by increasing the BLCK too much. Otherwise the CPU also won't want to do it either. So Intel introduced BLCK straps, multipliers really, at 1.00(stock), 1.25, 1.67, and 2.5.

So final CPU frequency = CPU Multiplier X BLCK X BLCK Strap.

Memory Frequency= Memory Multiplier X BLCK X BLCK Strap

Since the memory frequency is also tied to the BLCK Strap you need to pay attention to it. Most users will just OC with 1.00 BLCK Multiplier, as it is easier. BLCK straps of course let you use frequencies like 2000 MHz memory speed that previously were very hard/impossible to produce. Also the BLCK multipliers don't really increase performance, how do I know? Well I tested it. I asked myself the question, "at what frequency can I use the 1.00 and 1.25 multipliers, but also have the same memory and CPU frequency?" Answer: 4.00 GHz CPU and 1333 MHz Memory, here were my results:



It seems that the BLCK straps are virtual. They do however offer the benefit of hitting frequencies that cannot be done with stock multipliers. For instance if you want to get 2000 MHz memory, you have to use a strap.

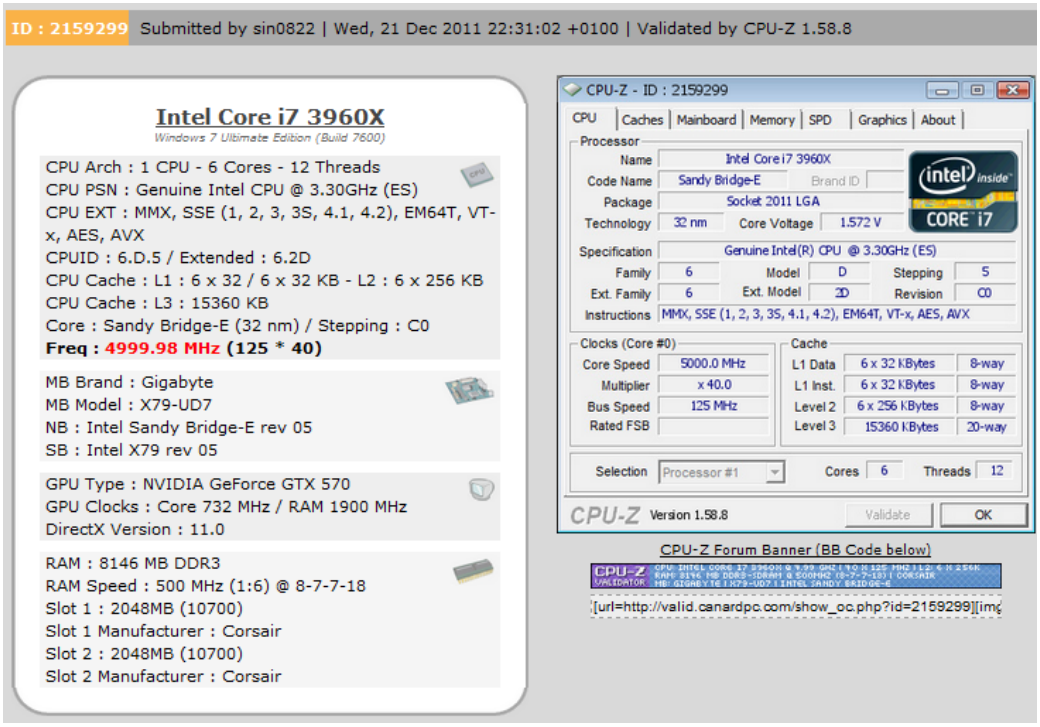
Here are some Tips:

- **Remember to LOWER CPU and MEMORY Multipliers after changing BLCK Straps!!!!!!**
- Set the Straps/multiplier for the BLCK BEFORE changing other settings.
- VCore Helps with higher BLCK, you can also try VTT.
- 1.67 multiplier is very hard to use with 100.00mhz BLCK, to use this multiplier you should try 90.00mhz BLCK and then change the multiplier to 1.67, that will give you 150mhz BLCK. Then work your way up. A very small percentage of CPUs can do 100x1.67.
- CPU Switching Frequency can slightly help BLCK, I saw no affect though.

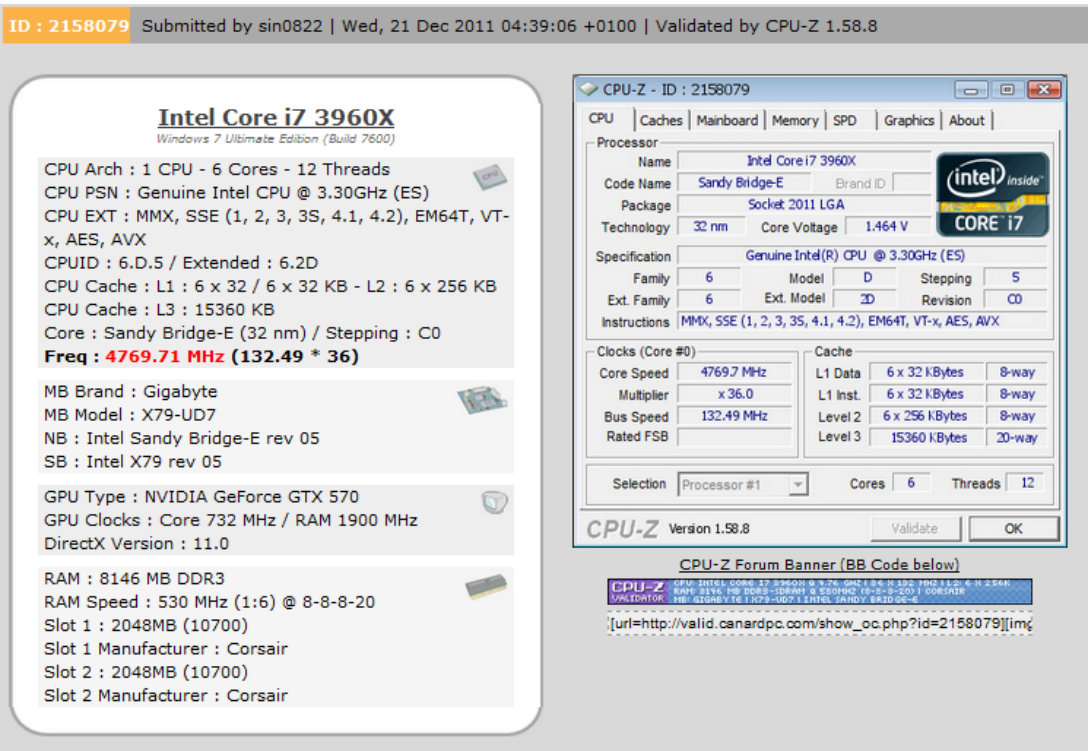
- Changing the BLCK or Straps in BIOS WILL require a reboot of the system, so keep that in-mind when OCing.
- It might be easier to hit higher memory frequencies with the 1.25 strap than 1.00, but I saw no difference in ease.
- If you are having trouble hitting 1.67, first try 1.00x90.00, than try 1.25x90.00, then try 1.67x90.00
- Disabling C States might help
- Increasing memory frequency slightly might help

My Examples:

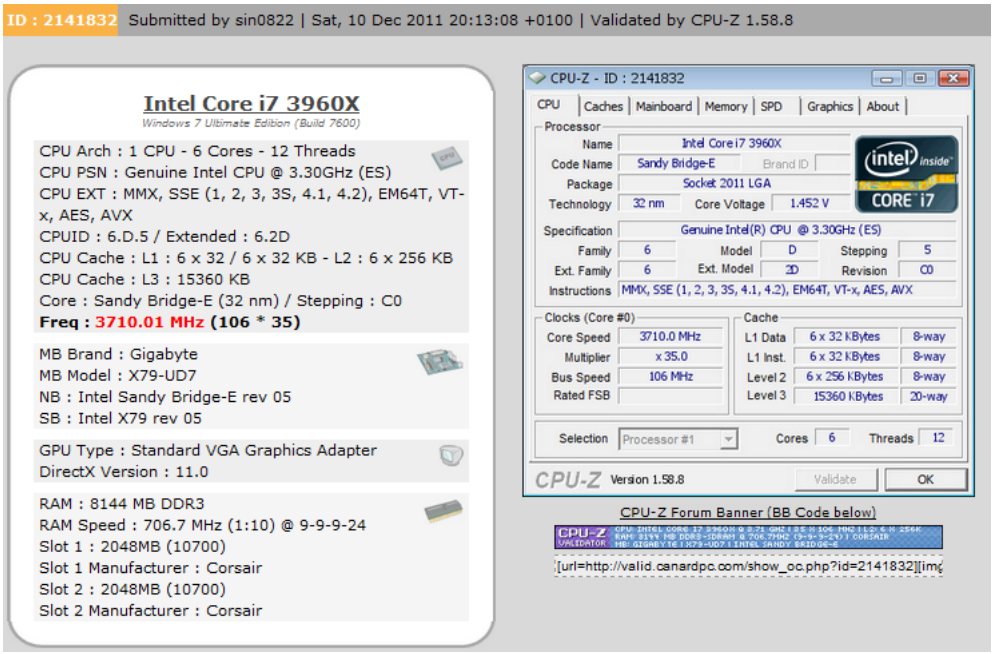
5GHz WITH 1.25 Strap. So with straps you use lower CPU Multiplier and Memory Multiplier.



How about 132.5mhz BLCK?



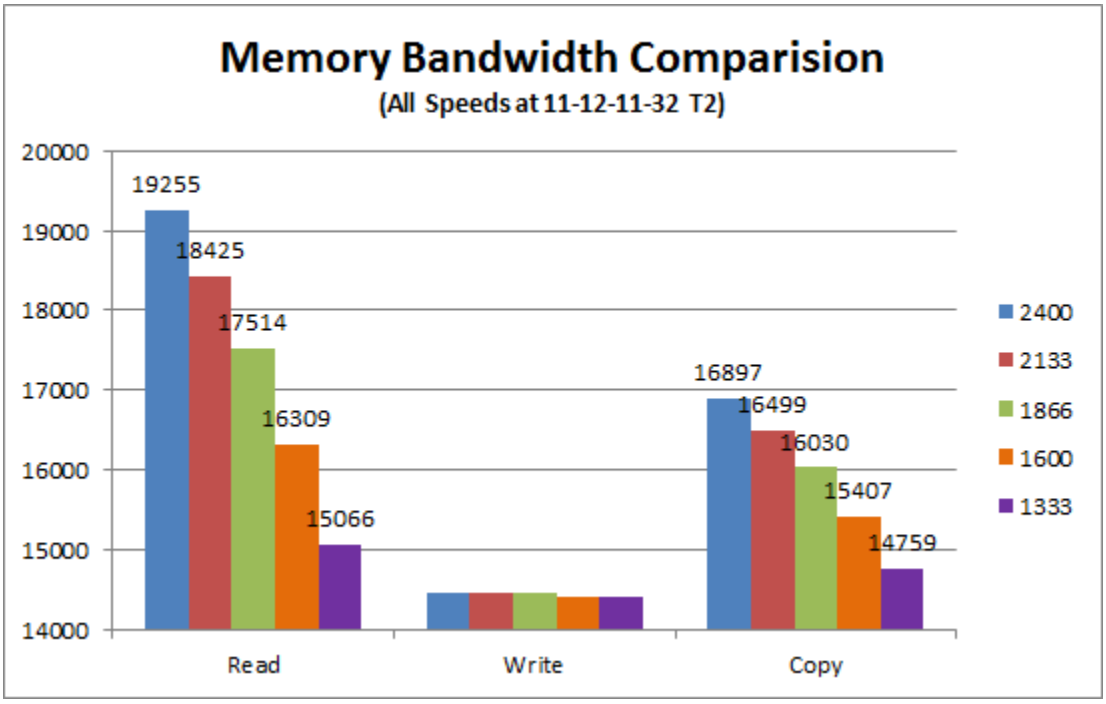
Here is my max BLCK with 1.00, that is stable (it required increased VCore):



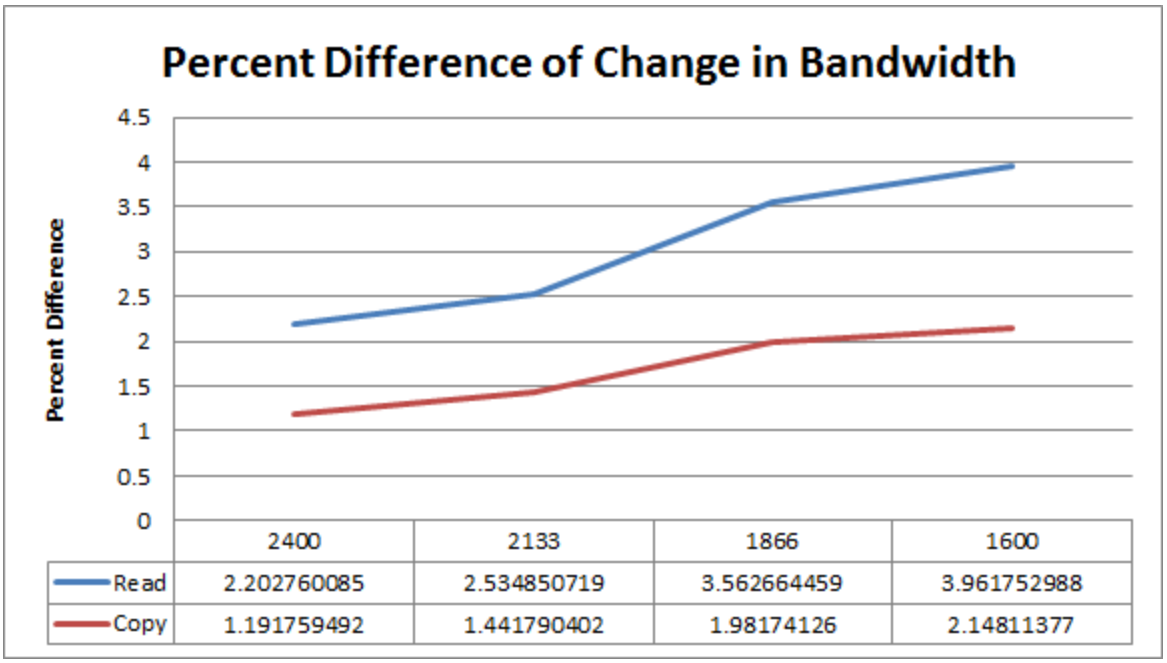
Memory Overclocking with Sandy Bridge-E:

As a pretense to this section I would like to state, I am by no means a professional memory overclocker. This section will just be about memory performance scaling and some other aspects for beginners. But, using what I have said here I was able to hit 2400 MHz, on a CPU that really didn't want to do it at first, with memory that is cheap (I used two sets of mainstream corsair XMS memory) and rated 400 MHz lower.

Step #1: Find out your rated timings and speed. Determine how you want to OC, if at all. Here is what I found in terms of scaling:



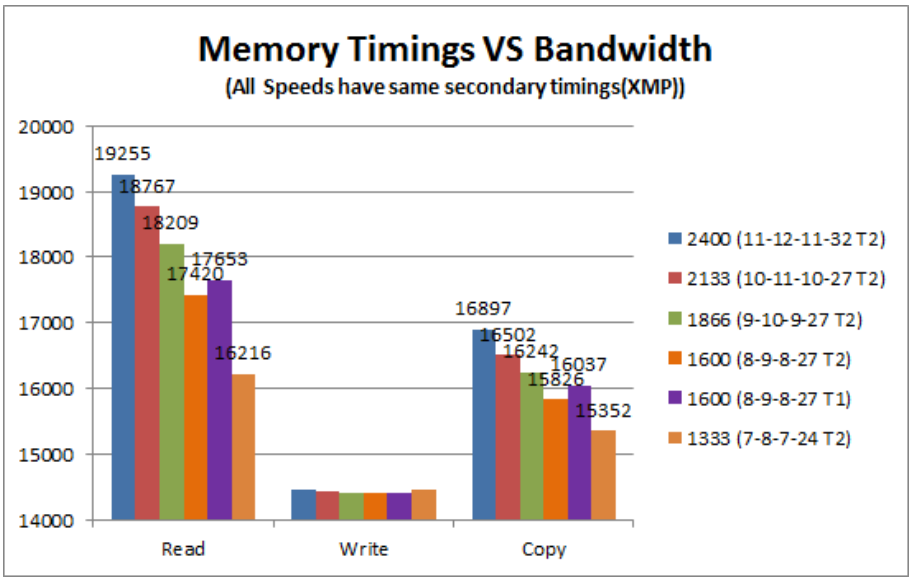
In the graph above I used the same exact timings, and I just changed the divider. XMP was loaded so all timings are exactly the same. You can see that the difference is big in the graph, but here is the percent change of the frequency:



	2400	2133	1866	1600
Read	2.202760085	2.534850719	3.562664459	3.961752988
Copy	1.191759492	1.441790402	1.98174126	2.14811377

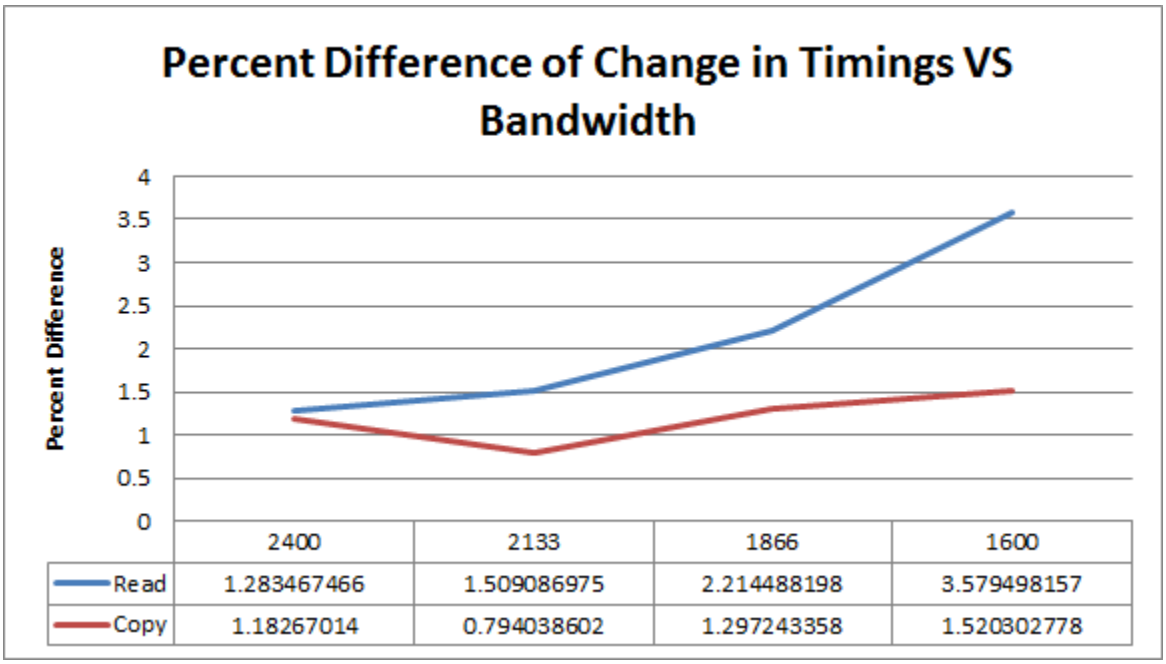
You can see that from 1333 to 1600 to 1866 we see larger changes than from 1866 to 2133 and from 2133 to 2400. If the timings are kept the same then the change is smaller as we get to higher speeds. So it might not be worth it to increase the speed from 1866 to 2400 as much as it is to change from 1333 to 1866. I should also say that it is hard to get maximum CPU OC with maximum memory OC at the same time, one of those OC needs to be toned down to max out the other. You should also note that it is harder 2400 to work well and stable for most CPUs. Most CPUs won't do 2400 with ease, only some will.

So what if we change the timings along with the speed?



In the graph above I changed the timings, each of the 4 first four timings down one notch for each divider. However please note I did not change the 3rd timings, I just used XMP and changed the first 4, and I changed the command rate for one of the 1600 MHz runs. I did 1600 MHz twice, once with command rate of 2(CR2 or T2) and once with T1 or command rate of 1. Changing the command rate wasn't enough alone to make it as good as the speed above it, but there is a significant increase. Please also note that the 3rd and 4th sub timings are all the same, as defined by the XMP profile I used.

Here are the percent of change:



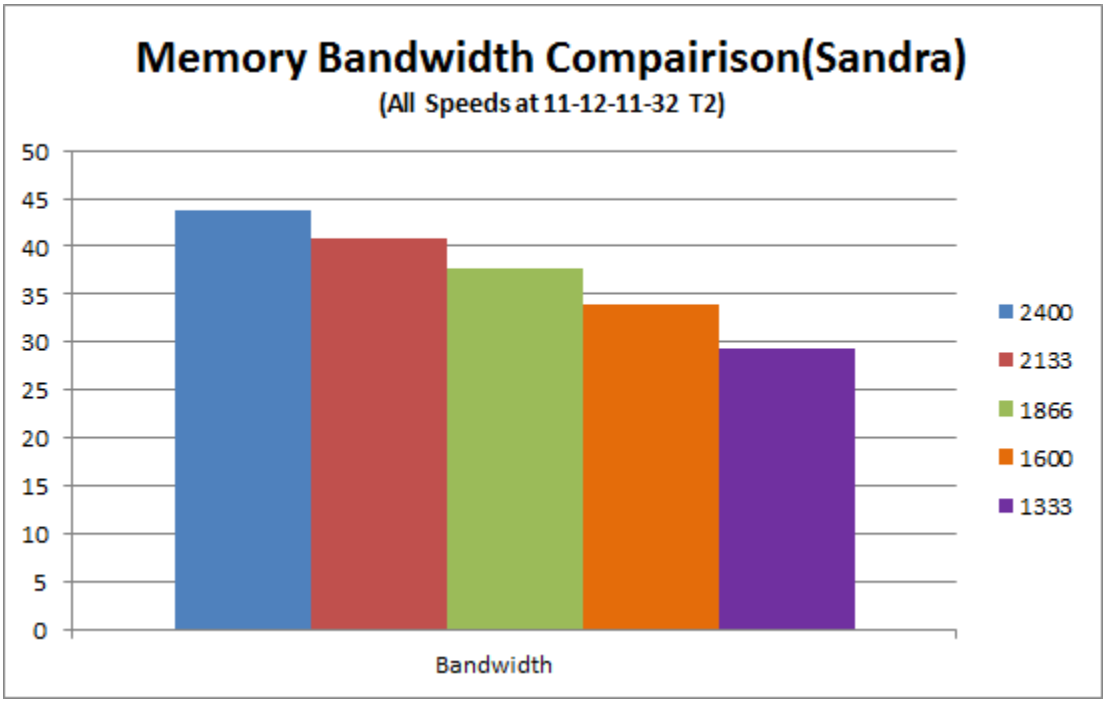
	2400	2133	1866	1600
Read	1.283467466	1.509086975	2.214488198	3.579498157
Copy	1.18267014	0.794038602	1.297243358	1.520302778

The write portion of the AIDA64 test didn't change much at all, so it wasn't included. You can draw your own conclusions, but the same trend as before applies, going from 1333 to 1600 you gain more than from going from 2133 to 2400, this time with timings change.

Overall the percent of change is very small only 2-4 percent maximum. Just like with Sandy Bridge memory bandwidth and timings aren't as important as density. More memory will give you more performance than less memory. Of course most programs in Windows will operate best at 4 GB-8GB; 16GB+ only really helps those that do things like edit large videos. 16GB+ is also beneficial if you want to make a RAM Disk, something that X79 is great for.

Nevertheless this should give you an idea of how important memory overclocking is, 4% is a lot to many people especially those who bench. Please note that AIDA64 isn't so optimized for SBe either, I just wanted to show scaling. Of course this is just a memory benchmark; some benchmarks will benefit more from timings and/or bandwidth than other benchmarks.

I also did Sandra:



Below are the timings used for these benchmarks with the same timings.

Step #2: Do you have XMP?

If you have XMP it might be a good idea to use it, if you bought a newer quad channel kit, your XMP will work fine, but if you use an older kit it might not. Some motherboards do a good job of setting the sub timings, but most of the timings written on the sticks themselves are important and easy to set. The ASUS R4E has specific memory profiles as well if you know what type of memory you have. Higher values for timings allow for higher speed, lower timings and lower speed. Lower timings will give you better performance.


GIGABYTE - UEFI DualBIOS
M.I.T.
System
BIOS Features
Peripherals
Power Management
Save & Exit
Back
M.I.T.\Advanced Memory Settings
3D BIOS
English
Q-Flash
Extreme Memory Profile(X.M.P.)
Disabled
System Memory Multiplier
10.66
32.00
Memory Frequency(MHz)
1066MHz
8000MHz
Performance Enhance
Turbo
DRAM Timing Selectable
Auto
Profile DDR Voltage
1.50V
1.50V
Profile VTT Voltage
1.05V
1.05V
Channel Interleaving
Auto
Rank Interleaveing
Auto
Channel A Timing Settings
Channel B Timing Settings
Channel C Timing Settings
Channel D Timing Settings
Set Channel B Timing
Select Memory Multiplier
Auto-Board Picks Timings
Quick-You set Timings once for all DIMMs
Expert-Set timings for individual DIMMs
Disable For Better Performance
↔: Select Screen ↑↓/Click: Select Item
Enter/Dbl Click: Select
+/-/PU/PD: Change Opt.
F1 : 3D Mode
F5 : Previous Values
F7 : Optimized Defaults
F8 : Q-Flash
F9 : System Information
F10 : Save & Exit
F12 : Print Screen
ESC/Right Click: Exit
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Step #3: Setting Voltages.

You should set your DRAM Voltage to what is suggested by the sticker on the memory module. You can increase this as needed, I don't go above 1.8v without adequate cooling, and most memory won't take much more than 1.7-1.75. Be careful, and do research on acceptable voltage for your sticks.

You should also increase QPI/VTT Voltage (VCCIO on some boards) along with System Agent/IMC (VCCSA on some boards) voltage. Max acceptable is 1.4v, but you only need like 1.2v for 2400 on some CPUs but 1.35v on others. Please have these voltages be the same if you can. If you raise DRAM voltage, you should raise these as well, try to have the difference between the DRAM voltage and the other two as close as you can. Don't unnecessarily increase your VTT and System Agent/IMC voltage to close the difference.

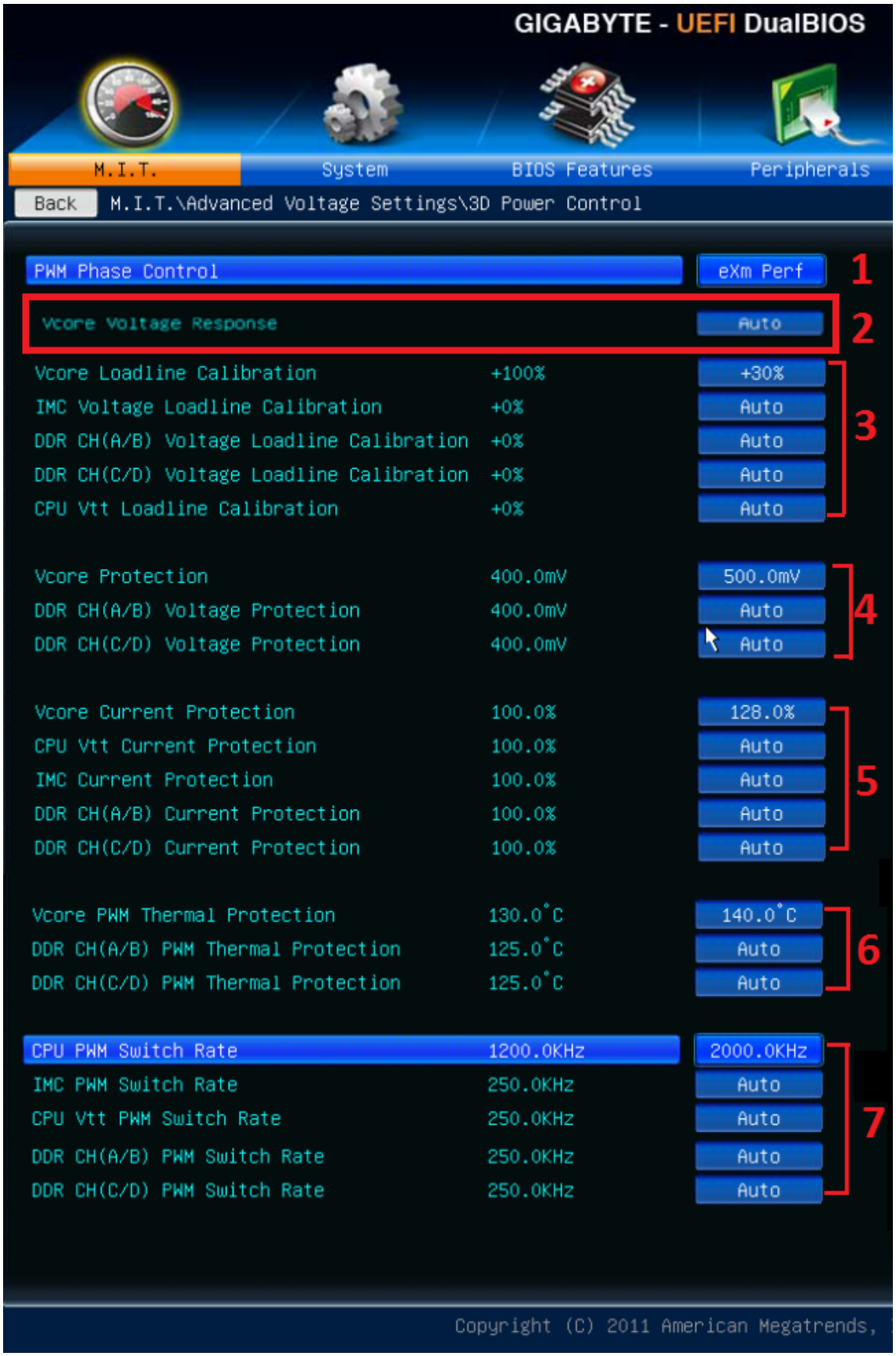
Unlike Sandy Bridge, Sandy Bridge-E's System Agent voltage is VERY important for memory OC. On GIGABYTE board's it is now called IMC (integrated memory controller) voltage, on other boards it's called VCCSA or System Agent.

Step #4 Fine Tuning Other Settings/Tips:

- You can try disabling C1E and C3/C6 states which might help.
- Disabling Channel Interleaving and Rank Interleaving on GIGABYTE LGA2011 boards can help performance.
- If you have trouble hitting 2400MHz try using BLCK dividers
- Try lowering your CPU OC to OC memory higher
- Increase current limits to the QPI/VTT and System Agent/IMC
- Increase the switching frequency of the QPI/VTT, the System Agent/IMC, the DRAM Voltages
- Remember you need to change both setting for DRAM Voltages if you have all DIMMs populated
- Denser the memory or even more sticks, the harder it is to OC.
- If your memory is rated 2400mhz and you cannot get 2400mhz to work, it could be your CPU.

Digital PWM Power Options Explained In Full:

You see a lot of these newer power options in the BIOS which are customary with Digital PWM technology. Digital PWMs give the user total control of different aspects of the PWM/VRM. The PWM is the chip that controls the VRM, so it talks to the CPU with newer platforms. With Digital PWMs, the PWM has on-board NVM (nonvolatile memory) that can store profiles and be updated. It gives the user and the motherboard manufacturer total control over the PWM and thus the VRM as a whole. Let's take a look, and finally give you thorough explanations of what the settings do. I see some websites try and do explanations of these setting, but then just rehash the manual and give what they use. I will try to explain more in depth.


GIGABYTE - UEFI DualBIOS
M.I.T.
System
BIOS Features
Peripherals
Back
M.I.T.\Advanced Voltage Settings\3D Power Control
PWM Phase Control
eXm Perf
1
Vcore Voltage Response
Auto
2
Vcore Loadline Calibration
+100%
+30%
IMC Voltage Loadline Calibration
+0%
Auto
DDR CH(A/B) Voltage Loadline Calibration
+0%
Auto
DDR CH(C/D) Voltage Loadline Calibration
+0%
Auto
CPU Vtt Loadline Calibration
+0%
Auto
3
Vcore Protection
400.0mV
500.0mV
DDR CH(A/B) Voltage Protection
400.0mV
Auto
DDR CH(C/D) Voltage Protection
400.0mV
Auto
4
Vcore Current Protection
100.0%
128.0%
CPU Vtt Current Protection
100.0%
Auto
IMC Current Protection
100.0%
Auto
DDR CH(A/B) Current Protection
100.0%
Auto
DDR CH(C/D) Current Protection
100.0%
Auto
5
Vcore PWM Thermal Protection
130.0°C
140.0°C
DDR CH(A/B) PWM Thermal Protection
125.0°C
Auto
DDR CH(C/D) PWM Thermal Protection
125.0°C
Auto
6
CPU PWM Switch Rate
1200.0KHz
2000.0KHz
IMC PWM Switch Rate
250.0KHz
Auto
CPU Vtt PWM Switch Rate
250.0KHz
Auto
DDR CH(A/B) PWM Switch Rate
250.0KHz
Auto
DDR CH(C/D) PWM Switch Rate
250.0KHz
Auto
7
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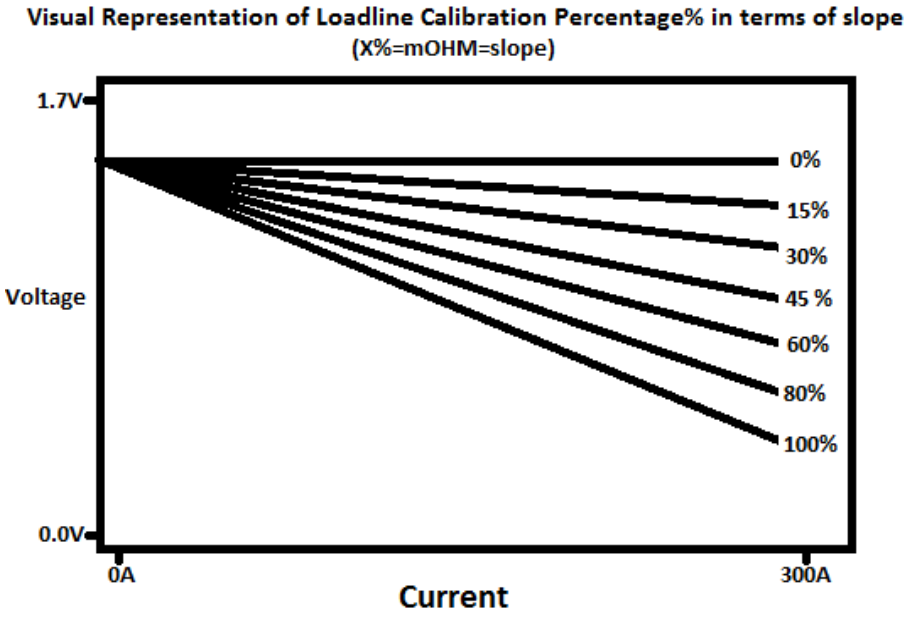
#1 PWM Phase Control: On this board this setting has a few options: eXm Perf (Extreme Performance), High Performance, Balanced Performance, Mid Power, and Lite Power. Modern PWMs can turn off phases not used; they can also reduce transient performance to benefit temperatures and efficiency. Extreme performance will sacrifice lower temperature and higher efficiency for higher performance and faster response, setting extreme will guarantee that no phases are turned off to save power. If you pick Extreme Performance you should use active VRM cooling as the VRM will get hot, if you use air cooling on the CPU that should be enough, but a fan pointed in the direction of the VRM heatsink is also a good idea. If you pick Lite Power then your VRM will probably only use as many phases as needed, and will sacrifice performance for higher efficiency and lower temperature. For overclocking high frequencies I recommend eXm Perf (Extreme Performance). If you don't want to use VRM cooling, you should pick something like balanced. If you want this board to be on 24/7 and have a light like 4.2 GHz and below OC, you might want to pick Balance Performance or Mid Power for better performance and longevity of parts.

#2 VCore Voltage Response: Or better known as Turbo Voltage Response. This setting might or might not be available in some of the GIGABYTE BIOSes. It has 4 settings: Extreme, Fast, Turbo, Standard. When the frequency is changed and thus load is changed the voltage also needs to change. This setting determines how fast that voltage changes. This is important if you are going to use SVID, but can just be left on Auto. If you are going for 4.5 GHz+ you might want to pick Fast. I believe Extreme was removed as it was redundant.

#3 Load Line Calibration: This setting has already been explained. On GIGABYTE board's it is a percentage which is equivalent to a mOHM rating. 80% or 0.8mOHM is the standard, 0% would be the least amount of droop. Corresponding the % or the mOHM to the slope of a line will help visualize the setting:



I tend to pick the second or third strongest setting when it comes to LLC. Remember 0% is least droop under load, 100% is most.

#4 Voltage Protection: This setting controls the maximum one can set the Voltage above standard ranges. You really do not need to touch this setting unless you are going subzero. If you are going to use more than 1.65v, you might want to increase the VCore limit.

#5 Current Protection: This setting controls how much current can pass to the components. You only need to change the VCore one. I was able to do 2400MHz memory with no change to the others. You can always just max out these settings, which is what I do. On GIGABYTE boards 128% is almost 300A, on other boards 128% might only be 200A or something. It is just a number tossed out there, maxing this setting out on any board will provide you a no limit scenario. 100% on one board may be different than 100% on another.

#6 Thermal Protection: This is a bit tricky. This is the measured temperature of the MOSFETs providing power to the components. The settings seem to be pretty high, 140C is the max for the CPU VCore, but it only seems that way. I max it out to 140C, as it has been tested, and if the temperature goes above 140C the system will shut down and there shouldn't be any damage to the board. If the temperature gets too high, the PWM will reduce the clock speed or shut down. A fan over the VRM area is a good idea if you are going to max out this setting or if your CPU frequency is throttling during heavy load during high OC.

#7 PWM Switch Rates: Switching Frequency as it should be called is measured in Hz. The maximum for PWMs made by Chil and IR are 1.2 MHz. With this board the VCore Switching frequency is 1/5 of what is displayed on the screen. 2 MHz setting is 500 kHz in real. 1.2 MHz is

the stock setting which corresponds to 300 kHz. For the VTT/IMC/DRAM the listed speed is the real frequency. Switching frequency is the amount of time per cycle the component is switched on. For the VRM each phase is on at once, and then they switch off, that rate at which they switch is the switching frequency. Increasing this will increase the performance; it will improve voltage response and overall transient performance. Increasing the SF will also allow for faster transient response as the rate as which power is stored is increased. It can help very high overclocks were every little bit counts. Turning this setting up will increase heat, and of course decrease efficiency. I found that this setting has little to no affect for the CPU OC on the UD7, but it might on other boards. Increasing this setting is like overclocking your VRM. I just leave it on auto, or even lower it for better VRM temps.

Extra OC Tips:

OC Profiles:

Most board have a way for you to save the profiles, on GIGABYTE board's you go to the last menu and save and load profiles:

VRM Cooling: Some users reported that when they had OCed to 4.5ghz with something like 1.45v and they were stressing, after an hour or so their CPU frequency would start to throttle. To fix this one can raise the PWM thermal limits and at the same time place a fan over the VRM area. With this new platform, since the DIMMs are on both sides of the CPu socket, board makers are left with much smaller room for the VRM for the CPU. At the same time Intel reduced VRM board real-estate, they released an extremely power hungry CPU. Power density has increased, and thus heat has also increased. It is recommended by many manufacturers for the majority of SBe boards that the user have some sort of active airflow around the CPU VRM area.

BIOS Flashing: The best way to flash any BIOS is through your BIOS's built in flash utility. It is best not to do it in Windows. Also please note that if everything is going fine, then you don't need to update your BIOS. BIOS updates can be a bit scary as your board can die. Most high-end boards and all GIGABYTE boards have Dual BIOS which can help users in cases of BIOS flash failures.