# Intel® Desktop Board DP55KG and Intel® Desktop Board DP55SB
## Extreme Series

Performance Tuning Guide

*Revision 1.4*

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*Part Number: E78969-002*

Intel® Turbo Boost Technology requires a PC with a processor with Intel Turbo Boost Technology capability. Intel Turbo Boost Technology performance varies depending on hardware, software and overall system configuration. Check with your PC manufacturer on whether your system delivers Intel Turbo Boost Technology. For more information, see http://www.intel.com/technology/turboboost.

**Warning: Altering PC memory frequency and/or voltage may (i) reduce system stability and use life of the system, memory and processor; (ii) cause the processor and other system components to fail; (iii) cause reductions in system performance; (iv) cause additional heat or other damage; and (v) affect system data integrity. Intel assumes no responsibility that the memory, included if used with altered clock frequencies and/or voltages, will be fit for any particular purpose. Check with memory manufacturer for warranty and additional details.**

**Warning: Altering clock frequency and/or voltage may (i) reduce system stability and useful life of the system and processor; (ii) cause the processor and other system components to fail; (iii) cause reductions in system performance; (iv) cause additional heat or other damage; and (v) affect system data integrity. Intel has not tested, and does not warranty, the operation of the processor beyond its specifications.**

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# 1. Introduction

Performance tuning on Intel® Desktop Board DP55KG and Intel® Desktop Board DP55SB can be a simple and straightforward process, providing useful gains in overall system performance. This guide describes ways to increase system performance by tuning the various subsystems of the desktop board. The main focus areas include the Intel® Core™ i7-800 and Intel® Core™ i5-700 processor series, the memory subsystem, and the data interlinks connecting the various desktop board components. The procedures and examples in this document are for reference only and are not guaranteed to work in all situations and system configurations.

Please note that operating desktop board components beyond their nominal values adds additional thermal stress to the overall system and additional cooling may be required to ensure stable system operation.

It is also important to note that over-clocking any desktop board can create additional electrical and thermal stress on the components and can reduce the system's overall useful lifespan. Consequently, over-clocking on an Intel® Desktop Board Extreme Series is not covered under the standard warranty.

Performance tuning is not an exact science; system stability is highly dependent upon overall system construction and will vary with each system configuration.

During the lifetime of the board the BIOS may be updated with additional features and improvements like the look and feel.

## 1.1. Intel® Desktop Control Center

The Intel® Desktop Control Center is a great tool for monitoring most Intel Desktop Board Extreme Series-based systems and is available for download at http://www.intel.com/go/dcc. New to Intel Desktop Board DP55KG/DP55SB is the easy auto tune capability. Beyond the scope of this guide, the Intel Desktop Control Center (Figure 1) is another resource for performance tuning.


**Figure 1. Intel Desktop Control Center**

# 2. Intel® Core™ i7 and Intel® Core i5™ Processors and Intel® P55 Express Chipset General Concepts

## 2.1. Architecture

The Intel Desktop Board DP55KG/DP55SB platform consists of an Intel Core i7-800 or Intel Core i5-700 processor series and the Intel® P55 Express Chipset component—the Intel® P55 Platform Controller Hub (PCH). For a detailed description of the complete platform, refer to the *Intel Desktop Board DP55KG Technical Product Specification* or the *Intel Desktop Board DP55SB Technical Product Specification* available at http://www.intel.com/products/desktop/motherboard.

The processor now integrates the system memory controller and accesses DDR3 memory through two independent memory channels. The processor also provides support for one full PCI Express* 2.0 x16 graphics slot or switches to two PCI Express 2.0 x8 slots. The processor connects to the PCH via the Direct Media Interface (DMI) interconnect bus. The PCH provides support for SATA (3.0 Gb/s), USB 2.0, and other system interfaces. Figure 2 shows a block diagram of the Intel Desktop Board DP55KG/DP55SB platform.

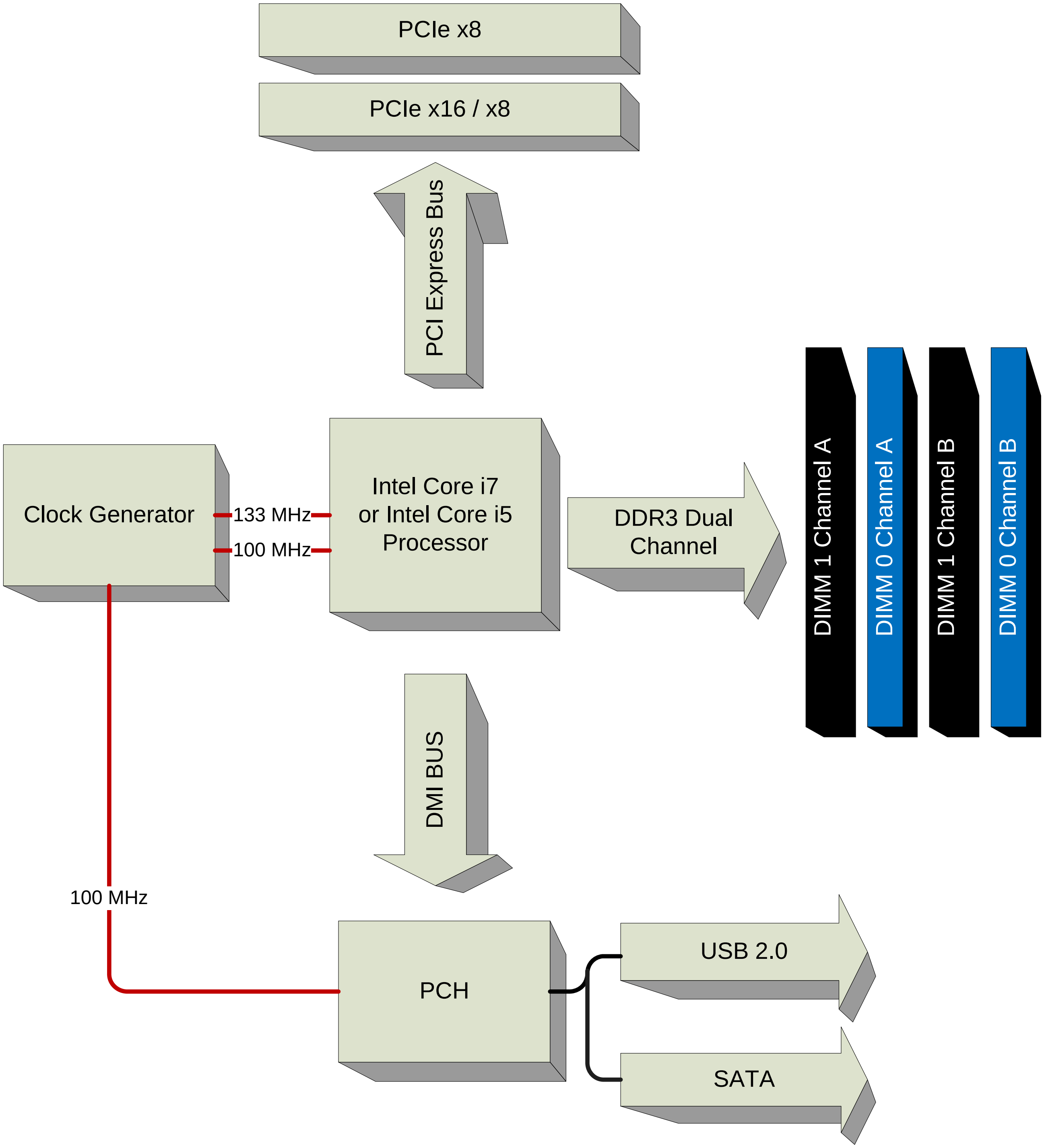


**Figure 2. Intel Desktop Board DP55KG/DP55SB Block Diagram**

All desktop board components are driven from a single 133 MHz host clock (BCLK). The resulting processor frequency is generated by applying a multiplier value to the host clock (BCLK).

There are three frequency multipliers on these desktop boards. All frequencies are tied to the host clock (BCLK) which is used to develop the overall system speed. The multipliers are as follows:

1. Processor: The processor frequency is developed when the system host clock frequency (default 133 MHz) is multiplied by the Processor Multiplier. The Processor Multiplier automatically adjusts higher with Turbo Mode or lower with EIST.
2. Memory: The memory frequency is developed when the Memory Multiplier is multiplied by the system host clock frequency. For example, a Memory Multiplier of 10 × 133 MHz host clock results in a memory frequency of 1333 MHz.
3. Uncore: Applies to the non-core related items in the processor, such as the cache controller, memory controller, and the data and address buffers. The Uncore Multiplier is locked by the processor at 18 for an Intel Core i7-870 processor for example. The Uncore Multiplier is unlocked on Intel Core i7-900 series Extreme Edition processors for example.

# 3. Intel Desktop Board DP55KG/DP55SB BIOS Setup

This section describes examples of modifying system controls and the performance tuning options that are available to enhance desktop board performance.

## 3.1. Accessing BIOS Setup

The BIOS setup screen can be accessed at system startup by pressing the F2 key at the setup screen prompt. It is advised to run the latest BIOS version to ensure that performance features are at the highest level of optimization. The latest version BIOS can be obtained from http://downloadcenter.intel.com.

Before starting any performance tuning, be sure that the BIOS setup defaults have been applied by pressing the F9 key while in BIOS setup mode. Press the F10 key to save the settings once the BIOS changes have been made.

## 3.2. Recovering from an Unstable System

Should performance values be set beyond the point of stable system operation, there are three options for recovery:

1. Third-Generation Watchdog Timer
2. Back-to-BIOS button
3. BIOS configuration jumper

A third-generation hardware Watchdog Timer has been included as part of the desktop board circuitry. This timer is enabled by default in the BIOS and will automatically boot to BIOS with a safe set of performance values whenever it detects unstable system operation or if the board hangs during start up.

If the Watchdog Timer fails to automatically reboot the board, the Back-to-BIOS button located on the back panel can be depressed to cause the board to boot into the Back-to-BIOS screen with default BIOS settings invoked while maintaining all of the user's BIOS settings shown to allow for easy recovery.

In addition, the BIOS configuration jumper is provided on the board to force the board to boot in a safe mode making it possible to reset the BIOS to default settings and restore the board to functionality. Refer to the desktop board product guide for instructions on using the jumper for resetting purposes.

## 3.3. Preparing Setup Options (Optional)

It is recommended to disable non-essential interfaces (such as, onboard audio, USB, LAN, external SATA, etc.) when tuning to get a clean and basic system as a starting point for performance tuning. Once the performance variables have been optimized, the other onboard features can then be re-enabled as needed.

Scroll to "Configuration" and use the submenu to disable these features (Figure 3).

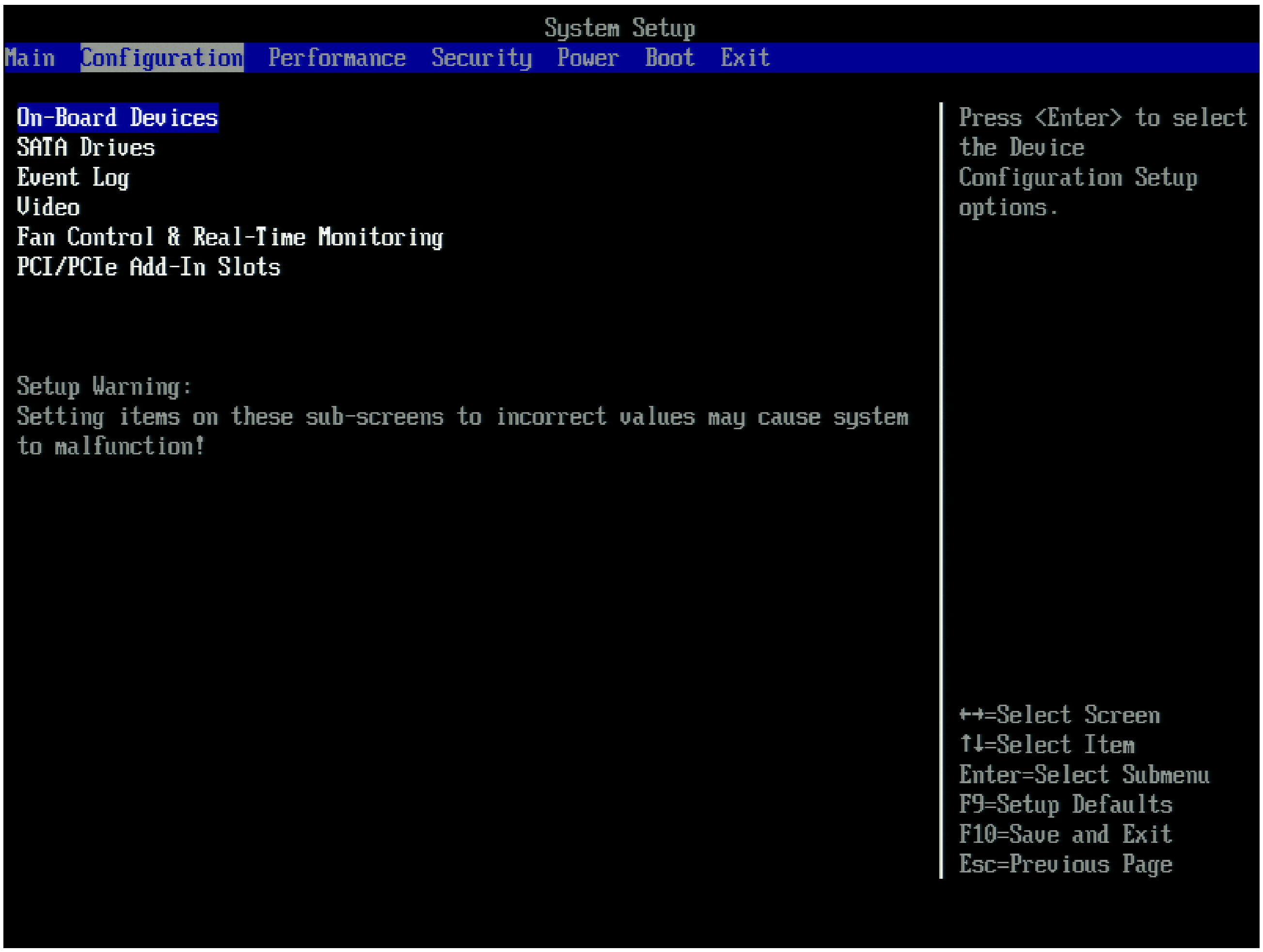


**Figure 3. System Setup with Features Disabled (Optional)**

Figure 4 shows the System Power submenu with the CPU C states disabled for example.

*Note: 1-, 2-, and 3-Core Turbo modes require CPU C-states. Disabling C-states will limit Core Turbo to only the 4-Core ratio. For example, an Intel Core i7-870 processor with a 4-Core Turbo ratio results in a maximum frequency of only 3.2 GHz.*

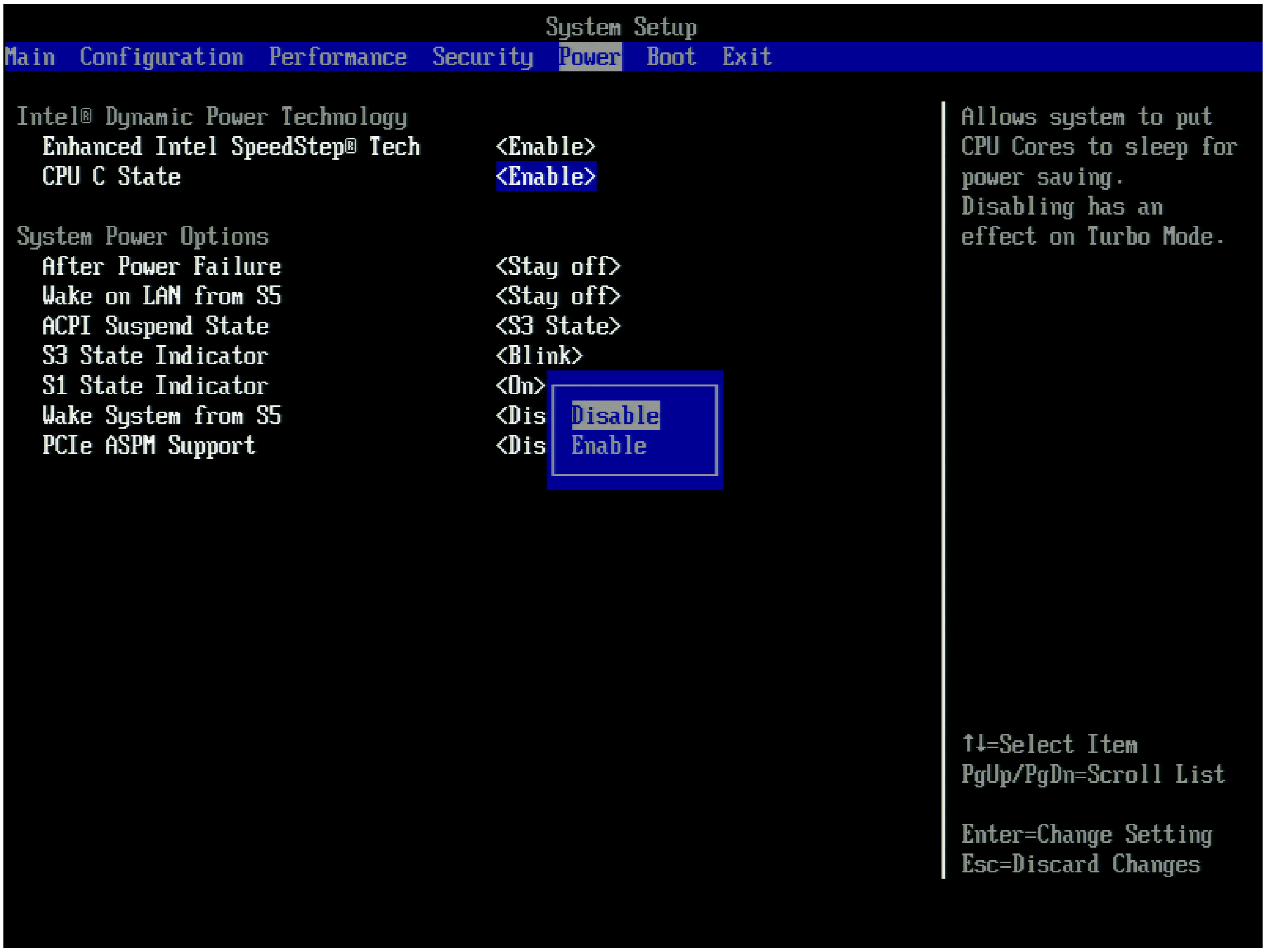


**Figure 4. System Power with CPU C States Disabled (Optional)**

# 4. Optimizing Processor Performance

Performance tuning options are located in a menu section labeled "Performance." Read and agree to the disclaimer (Figure 5). Please note that any performance increase achieved is dependent on the Processor, memory and motherboard used. All of these parts of the system have inherent variability and one or more will limit the overall systems ultimate top performance.

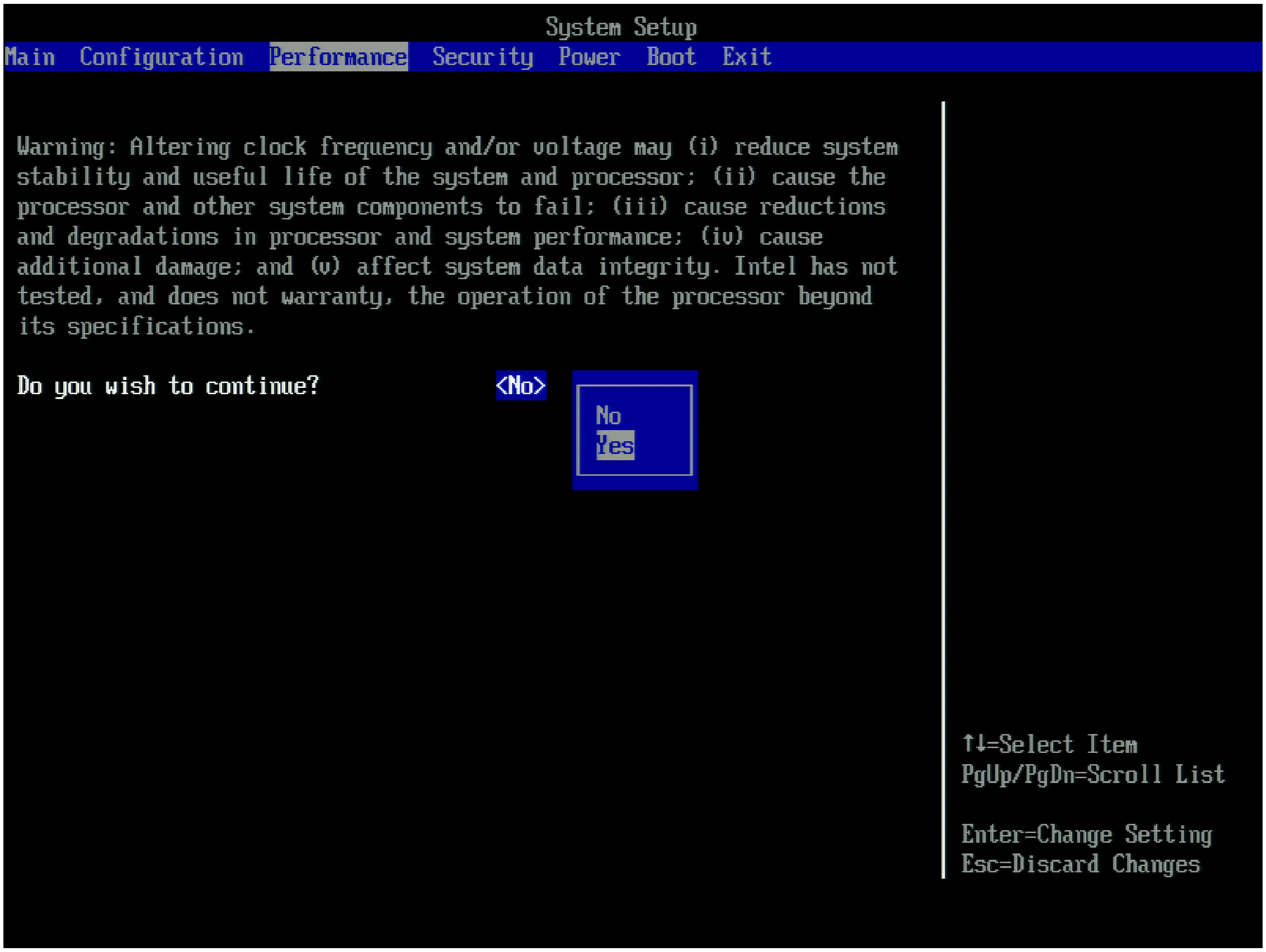


**Figure 5. Performance Tuning Disclaimer**

## 4.1. Processor Performance Tuning Options

The main Performance Tuning page is shown in Figure 6 with an Intel Core i7-870 processor installed.

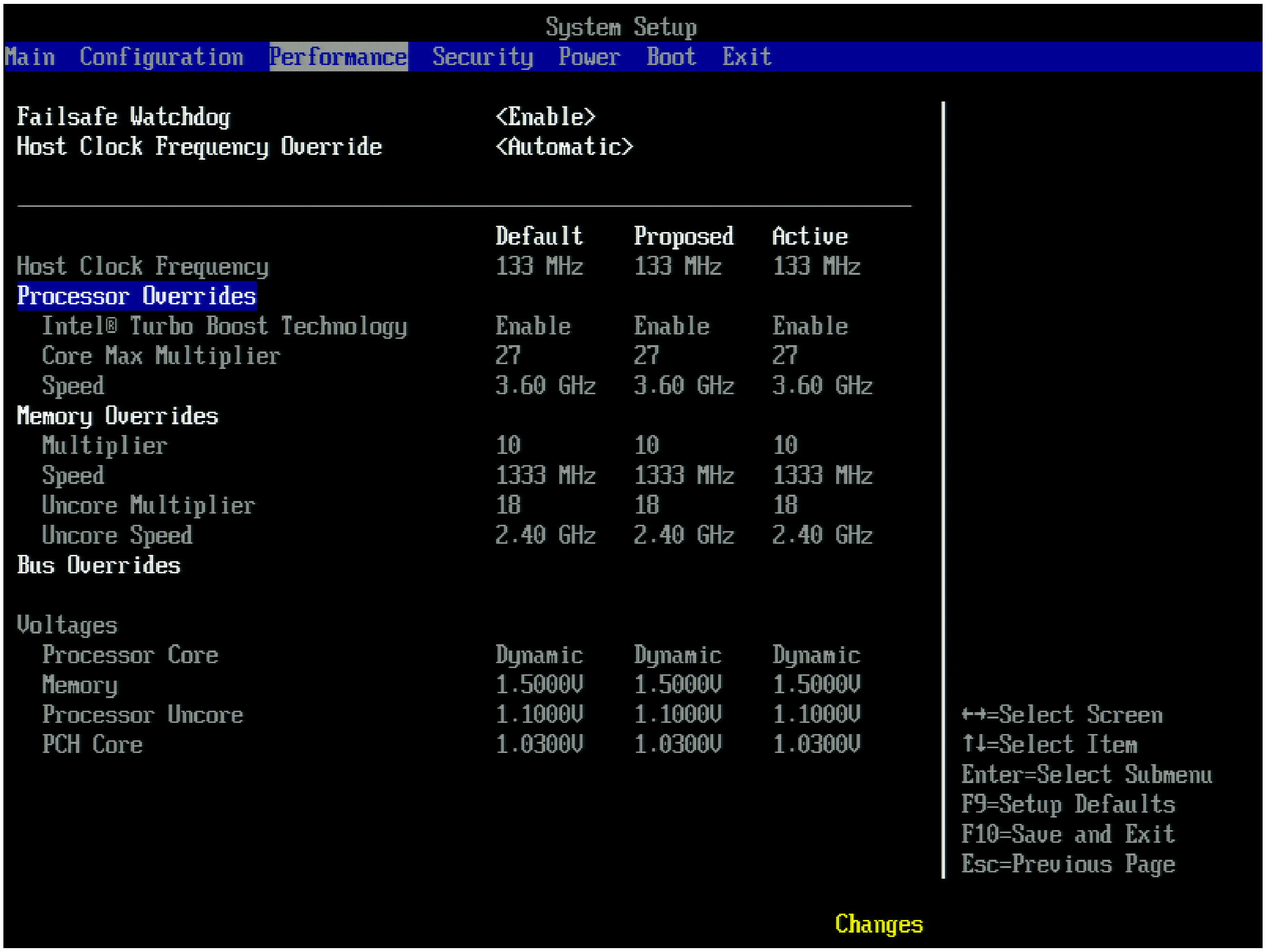


**Figure 6. Performance Tuning Main Page**

CPU tuning options are listed under "Processor Overrides" as shown in Figure 7. Refer to Table 1 for descriptions of the Processor Overrides.

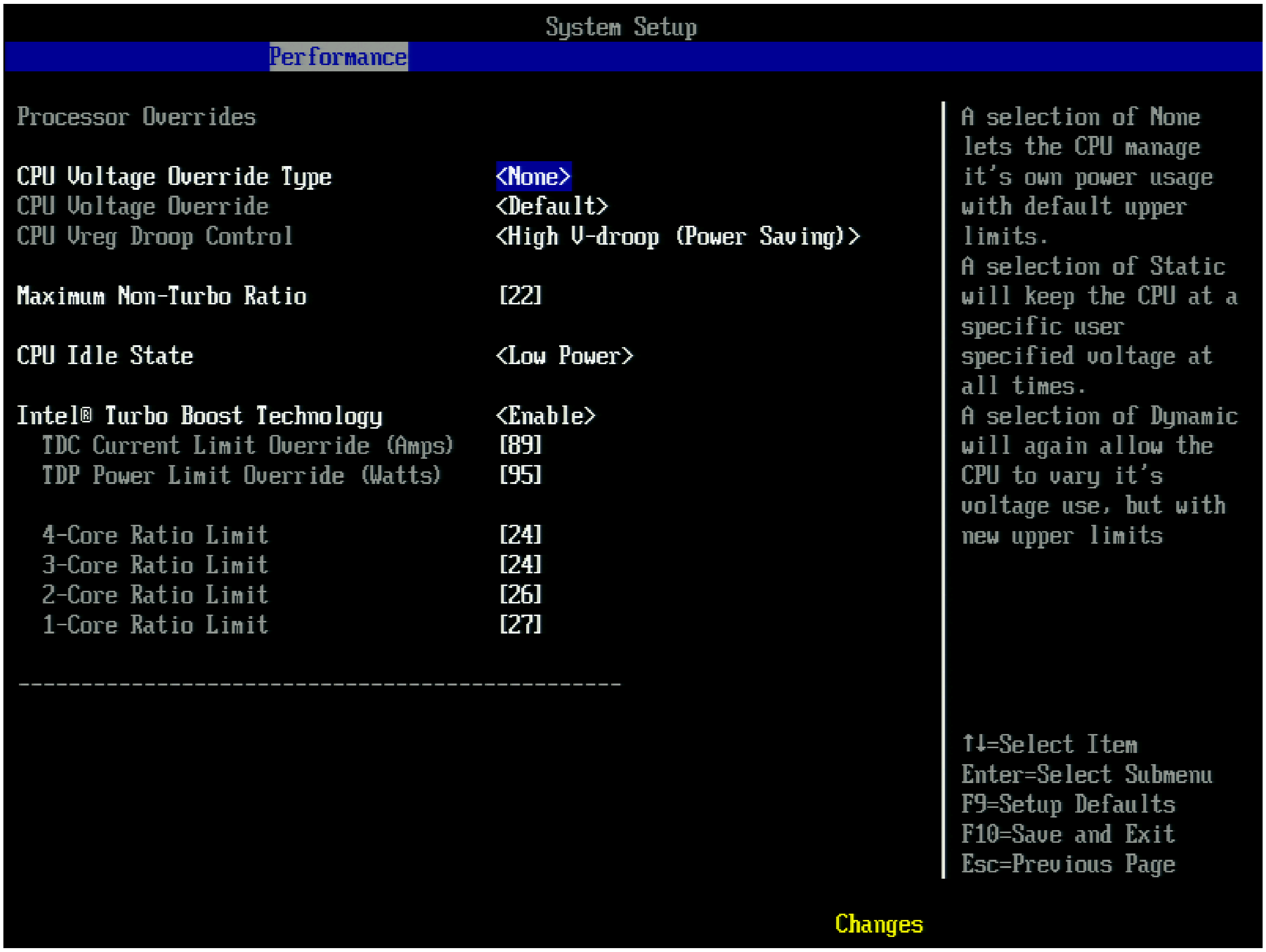


**Figure 7. Processor Overrides Page**

**Table 1. Processor Overrides**

| Setup Option | Description |
|---|---|
| **CPU Voltage Override Options** | |
| Static CPU Voltage Override | Overrides the voltage requested by the processor and applies a static voltage. This option disables the dynamic voltage control of the processor. |
| Dynamic CPU Voltage Offset (mV) | Maintains the dynamic VID control of the processor which scales the output voltage around the selected base voltage automatically. |
| CPU Vreg Droop Control | Changes the amount of voltage drop applied when the processor draws maximum current. Choosing the “Low V-droop” option causes the desktop board to supply voltage with no drop even at maximum processor current draw. |
| **Processor Performance Options** | |
| *Note: All multiplier values listed below are applied to the single 133 MHz Host clock.* | |
| Maximum Non-Turbo Ratio | Sets the default multiplier that the processor will use. Useful when increasing the host clock frequency above 133 MHz. The maximum multiplier is dependent on the processor installed. |
| CPU Idle State | Enables CPU low power states. High performance mode will always run the CPU at the chosen multiplier. Low power mode allows EIST to function. |
| **Turbo Mode Override Options** | |
| TDC Current Limit Overrride (Amps)<br>TDP Power Limit Override (Watts) | Displays the default current limit and the processor rated TDP. |
| Turbo Mode Multipliers<br>4-Core Ratio Limit<br>3-Core Ratio Limit<br>2-Core Ratio Limit<br>1-Core Ratio Limit | Display’s Maximum CPU performance given adequate thermal margin, voltage, and current applied while not in C3 or C6 power states. |

## 4.2. Processor Tuning Process: The Host Clock Method

The frequency of the CPU can be set by increasing the host clock and leaving the multipliers unchanged.

From the Performance page set the “Host Clock Frequency Override” setting to “Manual”.

Next, increase the Host Clock Frequency (MHz) to a desired level.

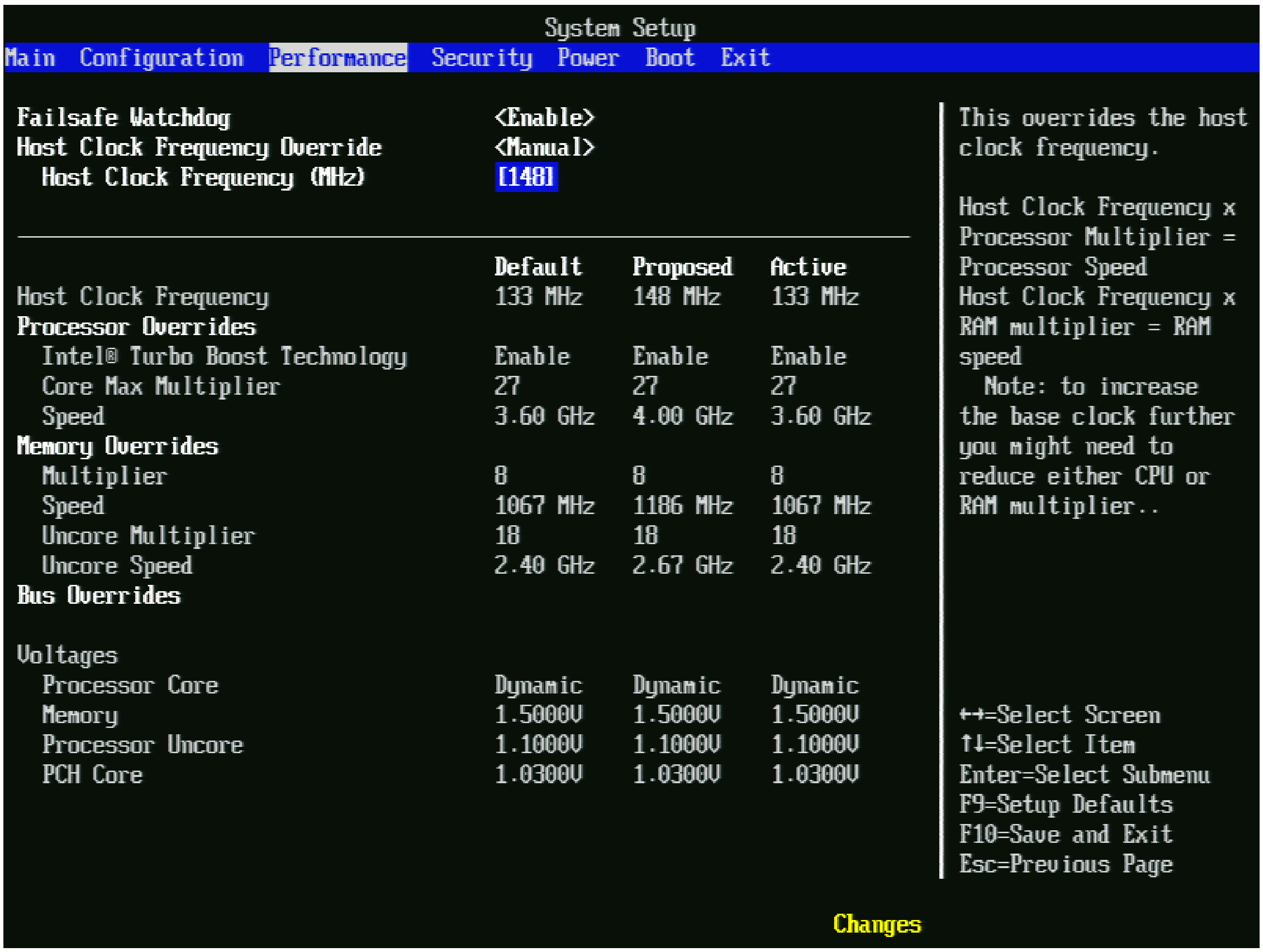


**Figure 8. Increasing the Host Clock Frequency**

In Figure 8, the column labeled “Proposed” shows the results of setting the host clock to 148 MHz which will result in a processor speed of 4.00 GHz with Turbo mode set to default 27 multiplier with Turbo Boost enabled. Additional voltage may need to be applied to the processor to ensure stable performance at 4.00 GHz.

*Note: The multipliers for the processor were left unchanged and only the host clock frequency (BCLK) was increased. Since the frequency of the other board subsystems is derived from the base clock, the memory speed will be increased as well, this can be seen in Figure 8 as 1186 MHz memory frequency.*

This increase may affect system stability, and, therefore, memory timings and voltage adjustments in the BIOS memory section might be necessary for system stability.

Refer to Section 5 for more information on memory settings.

## 4.3. Confirming System Stability

Once the selections are made, it is time to confirm the selected frequency and gauge system stability:

1. Save changes using the F10 key and boot into the operating system.
2. Next force the operating system to request that the processor operate in P0. P0 is the highest performance state. To do so, in Windows* XP, select the "Always On" profile. In Windows Vista* or Windows* 7 use the "Performance" profile, in the Power Settings Control Panel applet.
3. When processor cores are idle, the Intel Core i7-800 and Intel Core i5-700 processor series will operate at a reduced multiplier value. By applying a heavy load to the processor in the operating system all processor cores will be out of the idle state and run at the multiplier values chosen in the BIOS setup. Heavy loads can be applied by using any common processor benchmarking software.

*Note: If the settings have been set too aggressively and the board becomes unstable, refer to Section 3.2 for recovery options.*

Other software tools to test stability are:

Orthos (http://sp2004.fre3.com/beta/beta2.htm)

3DMark* Vantage (http://www.futuremark.com/benchmarks/3dmarkvantage/introduction/)

Loading the processor will also serve to test the stability of the system. Prime95*, Super PI*, or similar software can be used to load the processor.

## 4.4. How to Measure Processor Core Frequency

Use a processor frequency display tool to verify the final speed. The Intel Desktop Control Center will have details on processor frequency and system speeds as shown in Figure 9.


**Figure 9. Confirming System Levels with Intel Desktop Control Center**

Third party tools are also available like CPUID CPU-Z* or CPUID TMonitor* to monitor processor speed.

Once the desired frequency and system stability have been confirmed, the other subsystems can be optimized.

# 5. Memory Optimization

## 5.1. Optimizing Memory Performance

A wide variety of memory timing parameters can be adjusted in the BIOS setup.

Although each memory parameter can be modified individually, the easiest method of optimizing memory performance is to use memory that supports XMP profiles. These profiles are pre-programmed by the memory module manufacturer in the memory module itself and can be selected through the BIOS Memory Configuration. These profiles are validated by the manufacturer and are optimized for both performance and system stability.

The BIOS is designed to use the XMP memory profiles as a starting point for extending memory performance by more sophisticated system tweakers by then taking manual control after selecting an XMP profile.

In addition, memory population will also affect system performance. The Intel Core i7-800 and Intel Core i5-700 processor series have two independent memory channels. On Intel Desktop Board DP55KG/DP55SB, these are indicated by the two blue memory sockets. For best performance, populate the DIMM 0 of each channel, signified by the color blue with memory matched by manufacturer, size, speed, and type first. This matching allows the processor to access data across each of the memory channels by interleaving. Interleaving greatly reduces the latencies of waiting for memory to return data.

The two black memory connectors allow the end user to double the board's system memory capacity. Higher total memory capacity can have a positive benefit in very data-intensive applications. Always populate the blue memory sockets first for best system performance.

## 5.2. Memory Performance Options

The Memory Configuration page (Figure 10) contains all the memory timing options that can be adjusted and Table 2 describes the Performance Memory Profiles.

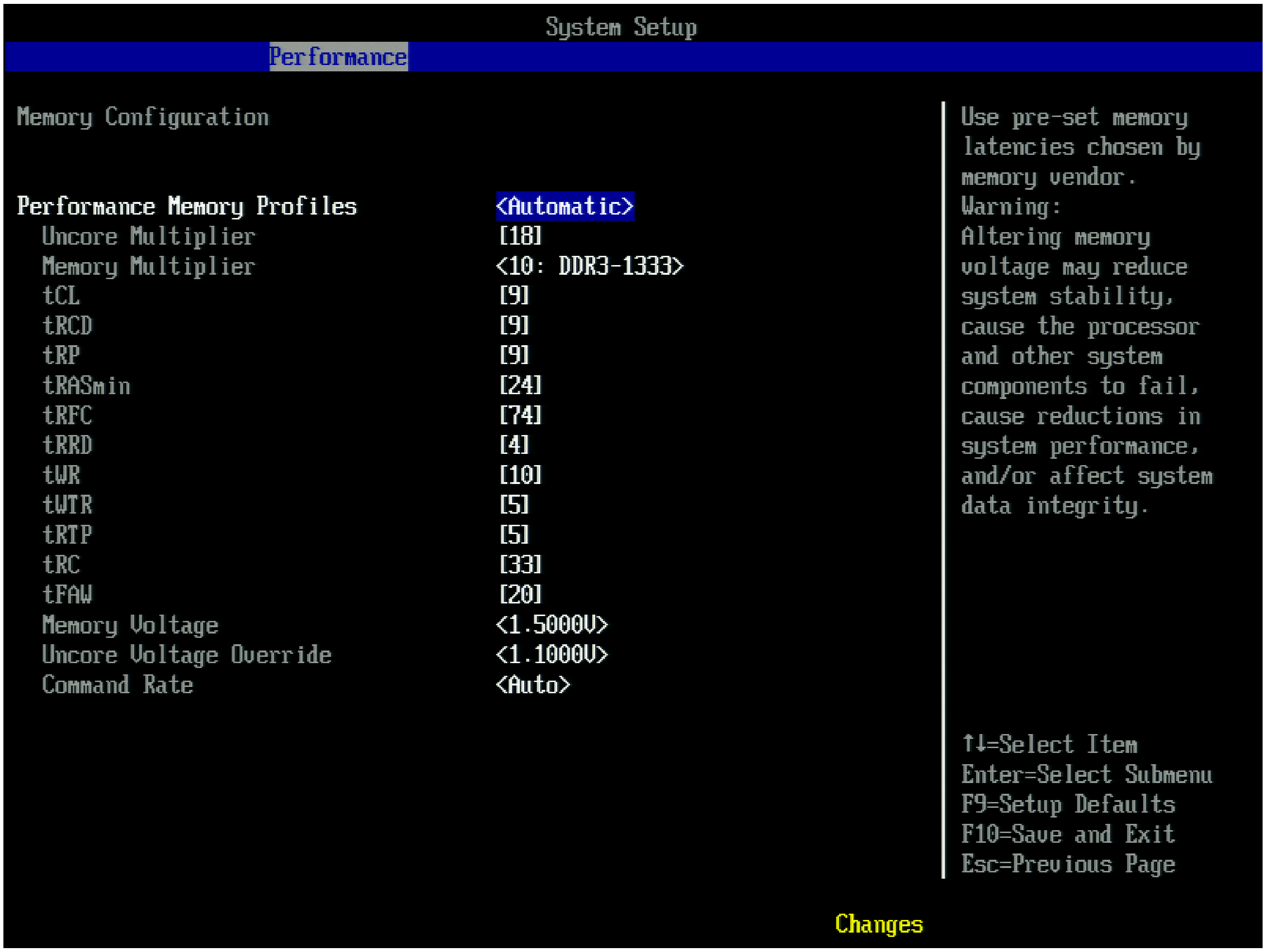


**Figure 10. Memory Configuration**

**Table 2. Performance Memory Profiles**

| Setup Option | Description |
|---|---|
| **Memory Performance Options** | |
| *Note: All multiplier values listed below are applied to the single 133 MHz (default) host clock.* | |
| Performance Memory Profiles | **Automatic** setting uses default values provided by the memory module.<br>**Manual** mode allows the user to change each of the settings.<br>If the installed memory module supports **XMP**, there will be additional selections for each profile stored in the module. Selecting a profile will populate all the settings with those recommended by the manufacturer. |
| Uncore Multiplier | Sets the Uncore CPU multiplier. This is non-adjustable for Intel Core i7 and Intel Core i5 processors. It is shown for information purposes. |
| Memory Multiplier | Sets the memory multiplier provided by the on die memory controller of the installed processor. |
| tCL | **CAS Latency**: The amount of time in cycles between sending a read command and the time to act on it. |
| tRCD | **RAS to CAS Delay**: The amount of time in cycles for issuing an active command and the read/write commands. |
| tRP | **RAS Precharge Time**: This is the minimum time between active commands and the read/writes of the next bank on the memory module. |
| tRASmin | **Minimum RAS Active Time**: The amount of time between a row being activated by precharge and deactivated. |
| tRFC | **RAS Refresh Cycle Timing**: This determines the amount of cycles to refresh a row on a memory bank. |
| tRRD | **RAS to RAS Delay**: The amount of cycles that it takes to activate the next bank of memory. |
| tWR | **Write Recover Time**: The amount of cycles that are required after a valid write operation and precharge. |
| tWTR | **Write to Read Delay**: The amount of cycles required between a valid write command and the next read command. |
| tRTP | **Read to Precharge Delay**: The minimum delay prior to when a Read can occur. |

| Setup Option | Description |
|---|---|
| **Memory Performance Options** | |
| *Note: All multiplier values listed below are applied to the single 133 MHz (default) host clock.* | |
| tRC | **Row Cycle Time**: The minimum time interval between successive ACTIVE commands to the same bank. |
| tFAW | Four Active Window – Period of time before the fifth successive ACTIVE command to a new memory Bank can be issued. |
| Memory Voltage | Changes the memory voltage. |
| Uncore Voltage Override | Allows the CPU Uncore voltage to be adjusted. (A good starting Voltage for high frequency operation is setting the Uncore Voltage to 1.30 V). |
| Command Rate | The amount of time that commands can be issued. |

*Note: For each of the timings, except the multipliers, the lower the number, the higher the performance and the less stable the system may become.*

## 5.3. Determining Memory Frequency

Over all, memory frequency can easily be determined by multiplying the host clock frequency (default is 133 MHz) by the Memory Multipliers shown in Table 3.

**Table 3. Memory Multipliers**

| Multiplier | BCLK (MHz) | Resulting Memory Frequency (MHz) |
|---|---|---|
| 6 | 133 | 800 |
| 8 | 133 | 1066 |
| 10 | 133 | 1333 |
| 12 | 133 | 1600 |

Increasing the host clock will increase the memory speed as well.

*Note: The Intel Core i7-800 and Intel Core i5-700 processor series support only even multipliers.*

## 5.4. Using XMP Profiles

XMP memory profiles can be invoked by selecting them from the Memory Configuration page (Figure 11).

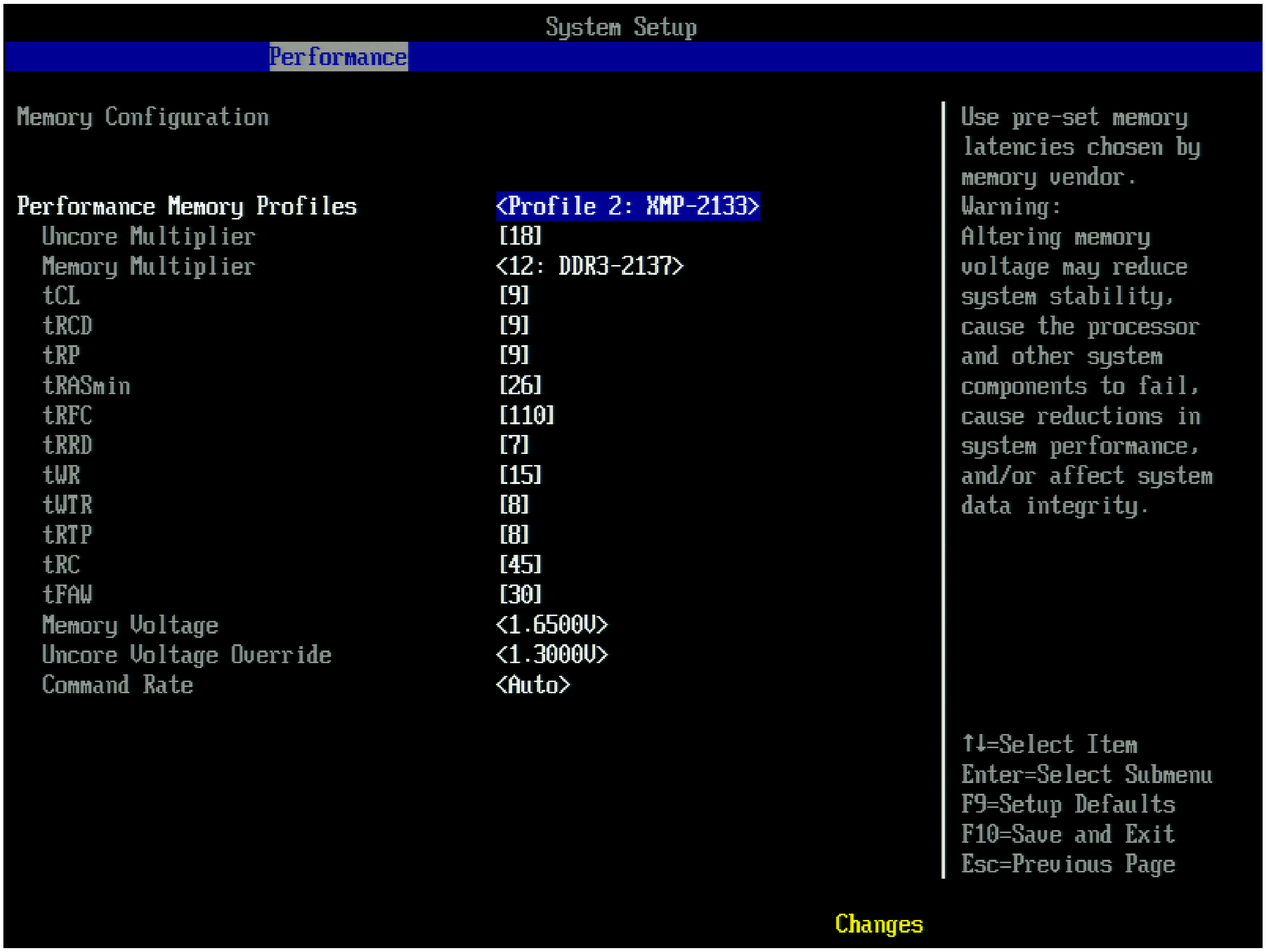


**Figure 11. Selecting XMP Profiles**

*Note: It has been found during testing that earlier XMP memory modules that work correctly with the socket 1366 Intel Core i7-900 processor series have a higher (Uncore Voltage Override) voltage and do not perform as well at the higher voltage when used with the socket 1156 Intel Core i7-800 and Intel Core i5-700 processor series. It is recommended to manually adjust the Uncore voltage to a starting value of 1.35 V or lower if these memory modules are used (see Figure 12).*

*Note: It is very important to check the memory voltage (see Figure 12) after applying the profile to ensure that the DIMM has not selected a memory voltage above the recommended processor memory controller voltage limit. If it has, switch the profile setting to "Manual – User Defined" and reduce the voltage to avoid damage to the processor.*

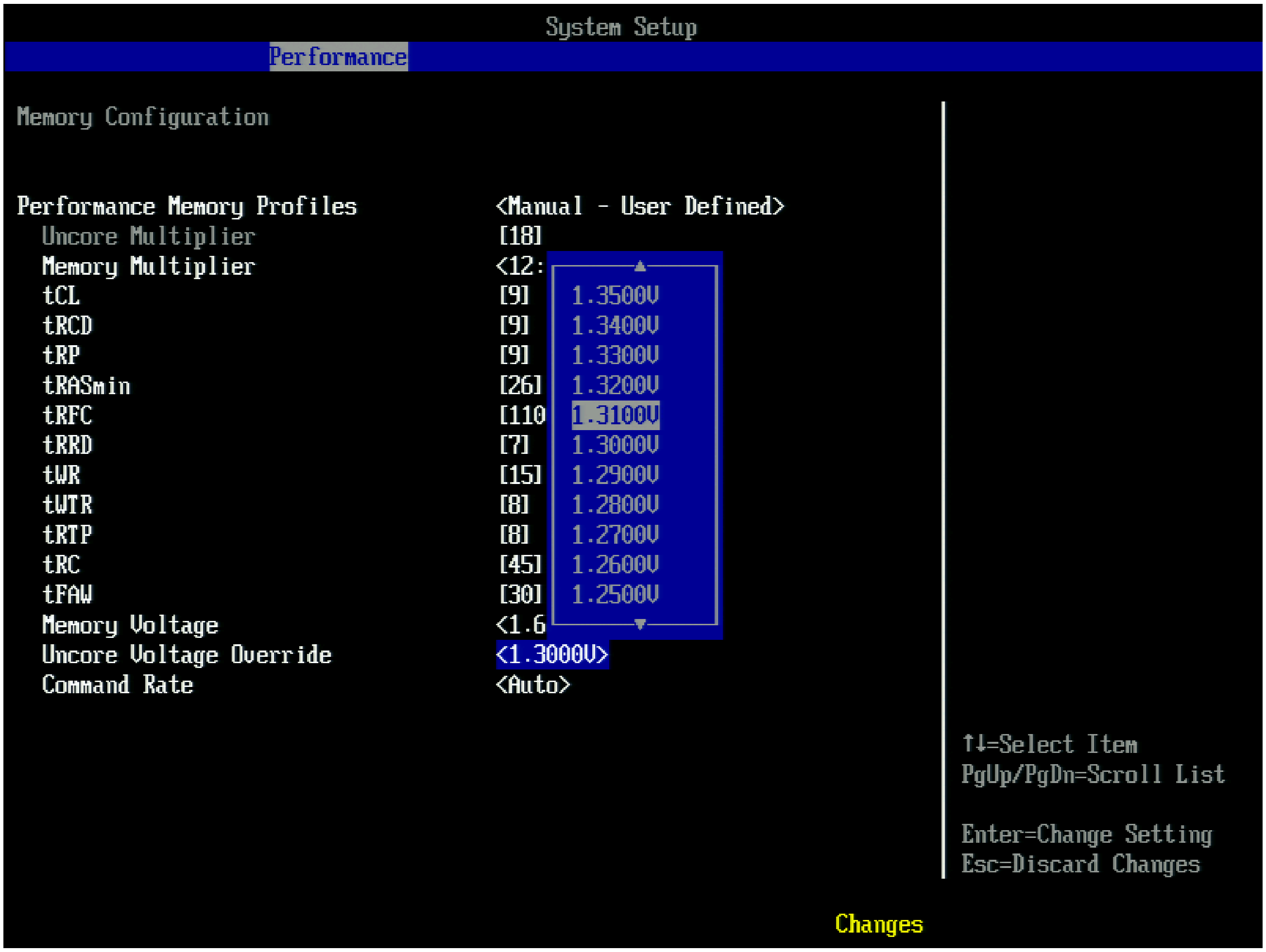


**Figure 12. Checking the Uncore Voltage Override**

Once the profile has been applied, save the settings and boot into the operating system to verify system stability using the same methods described in Section 4.3.

## 5.5. XMP Manual Mode

XMP profiles can provide a starting point for stretching memory performance even further. To begin, choose the XMP profile first, presetting all profile values. At this point choose “Manual – User Defined” to set values further.

From here, increase the performance further by setting the tCL, tRCD, tRP, and tRAS values to their maximum settings and increase the host clock in small increments while checking system stability between each clock increase until the system becomes unstable.

Once the point of instability has been reached, back down the clock frequency and start reducing the tCL, tRCD, tRP, and tRAS settings until the system once again becomes unstable, then reduce them by one increment.

For XMP profiles above DDR3 1600, the BIOS will automatically raise the system BCLK to reach those memory speeds. This means that when using an Intel Core i7-870 processor running at a base speed of 2.93 GHz, the processor will run at a maximum frequency of 4.51 GHz. If this type of fast memory is used, be sure to look at the other processor parameters in the BIOS and ensure they are set to support the faster processor frequency.

# 6. Examples of Over-Clocked Settings

## 6.1. Using the Host Clock for Performance Boost

The example shown in Figure 13 uses host clock (BCLK) adjustments to reach higher system performance.

*Note: That the higher processor frequency will only be reached as long as there is sufficient thermal margin to support the higher speeds and the installed processor can handle this frequency.*

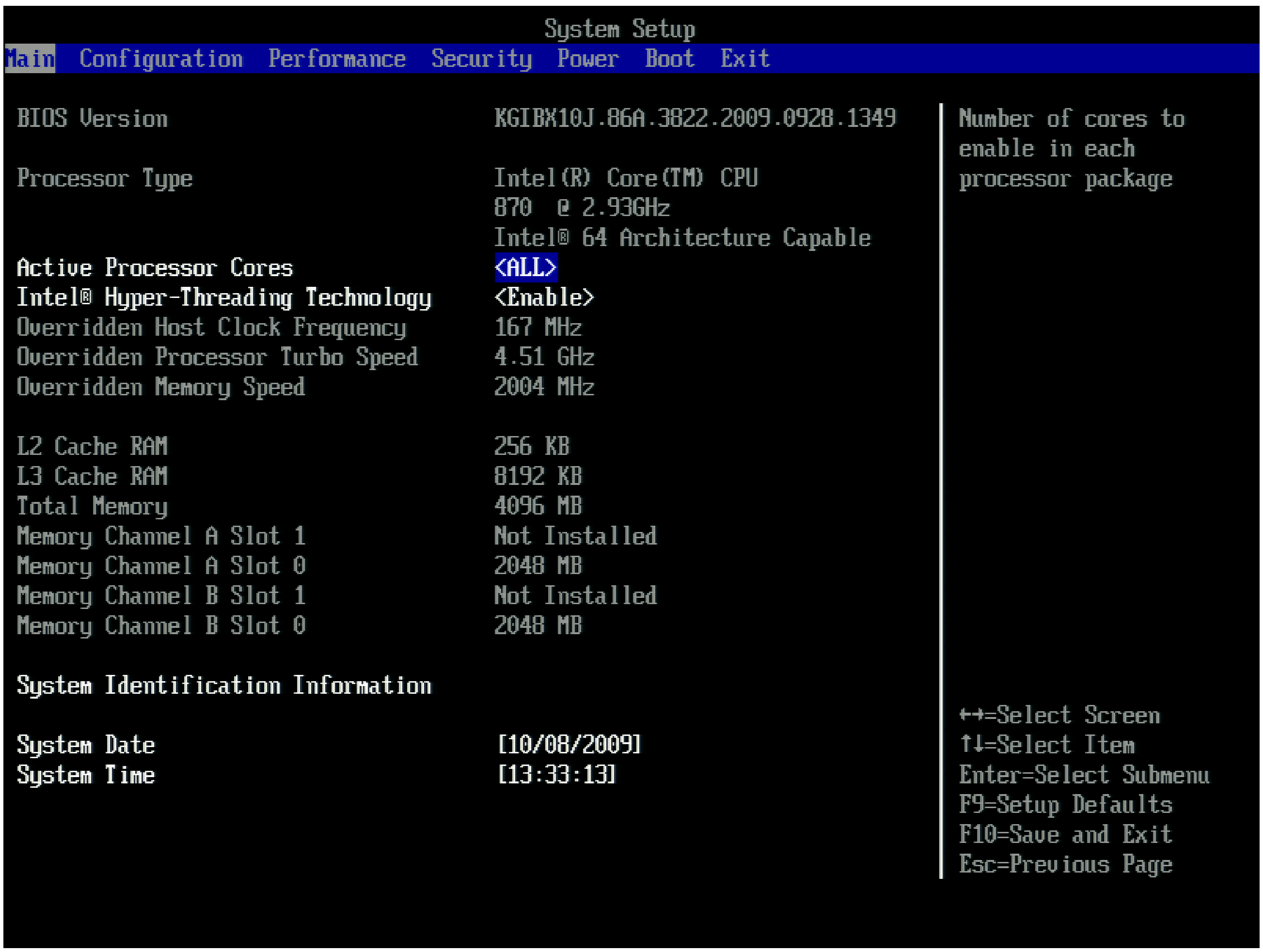


**Figure 13. System Overclocked to 3.67 GHz from 2.93 GHz with Turbo Disabled**

Figure 14 is a display of the Performance Tab showing Default (with Turbo enabled), Proposed, and Active adjustments.

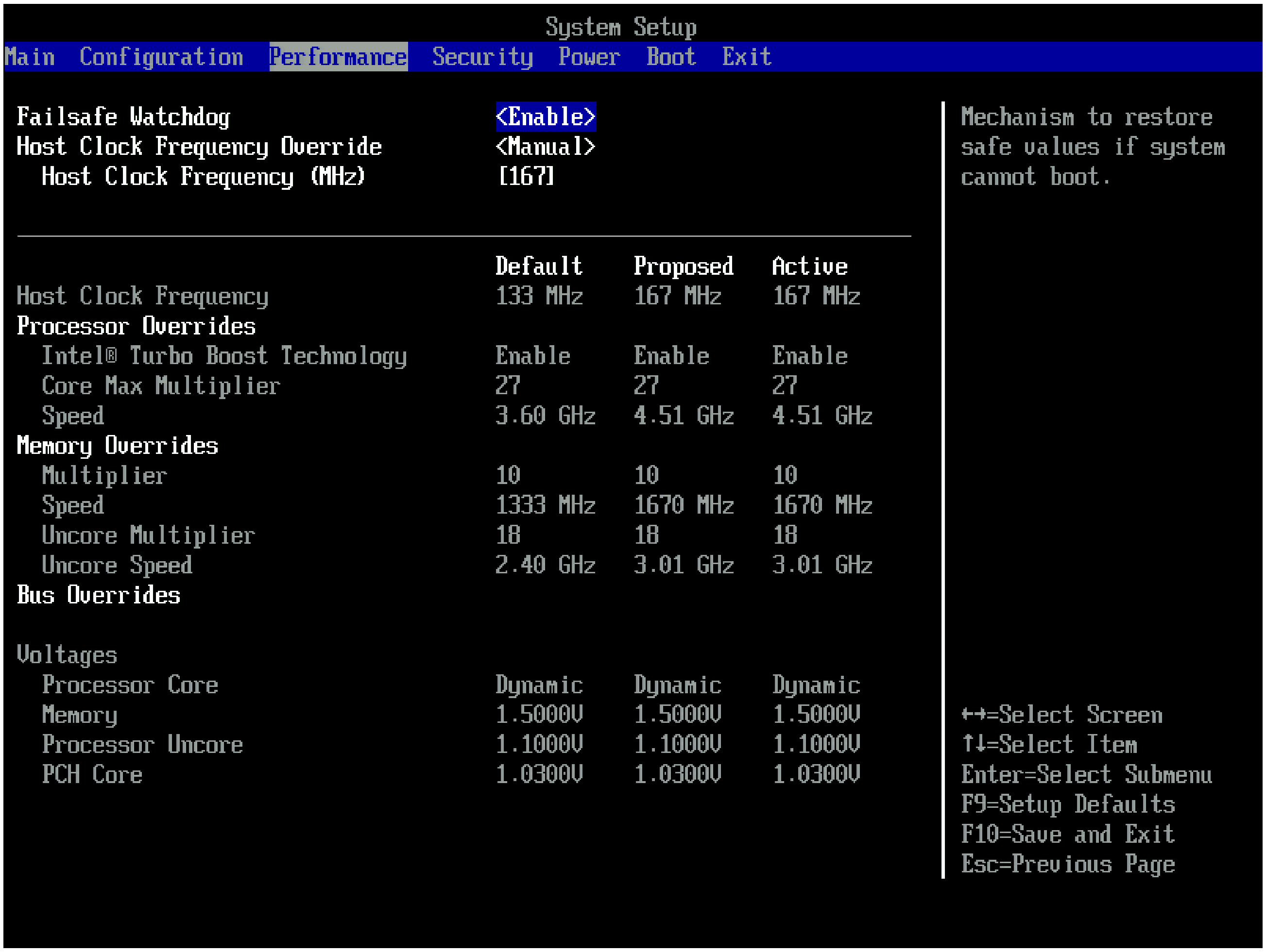


**Figure 14. System Overclocked with Default Processor Overrides**

Figure 15 is a display of the Performance Tab with Bus Overrides showing other board voltages at default. PCH Core Voltage might need to be adjusted when raising Uncore Voltage under the configuration page to achieve stable operation.

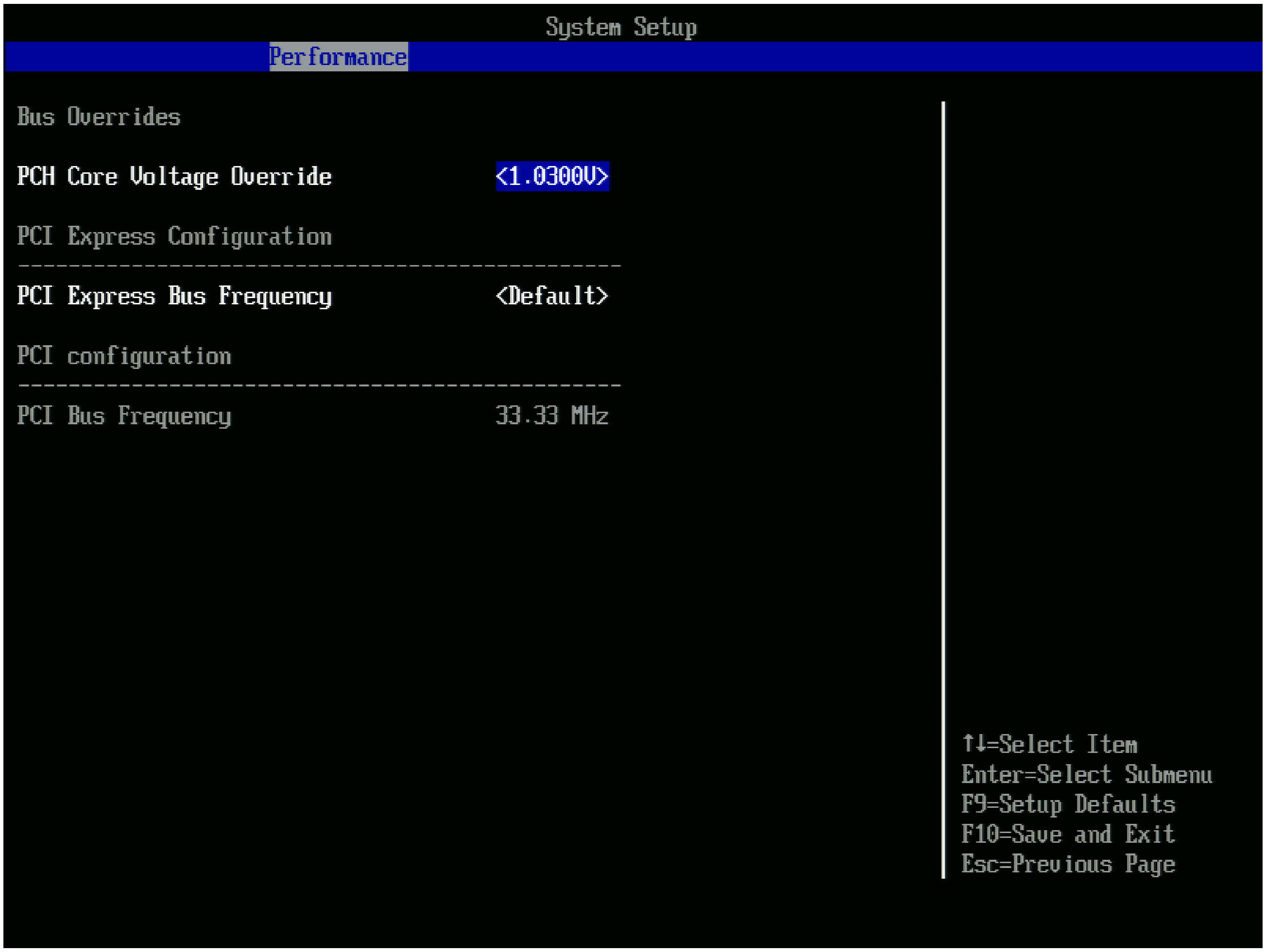


**Figure 15. Bus Overrides at Default**

Figure 16 shows the Memory Configuration with Uncore and Memory Voltages adjusted.

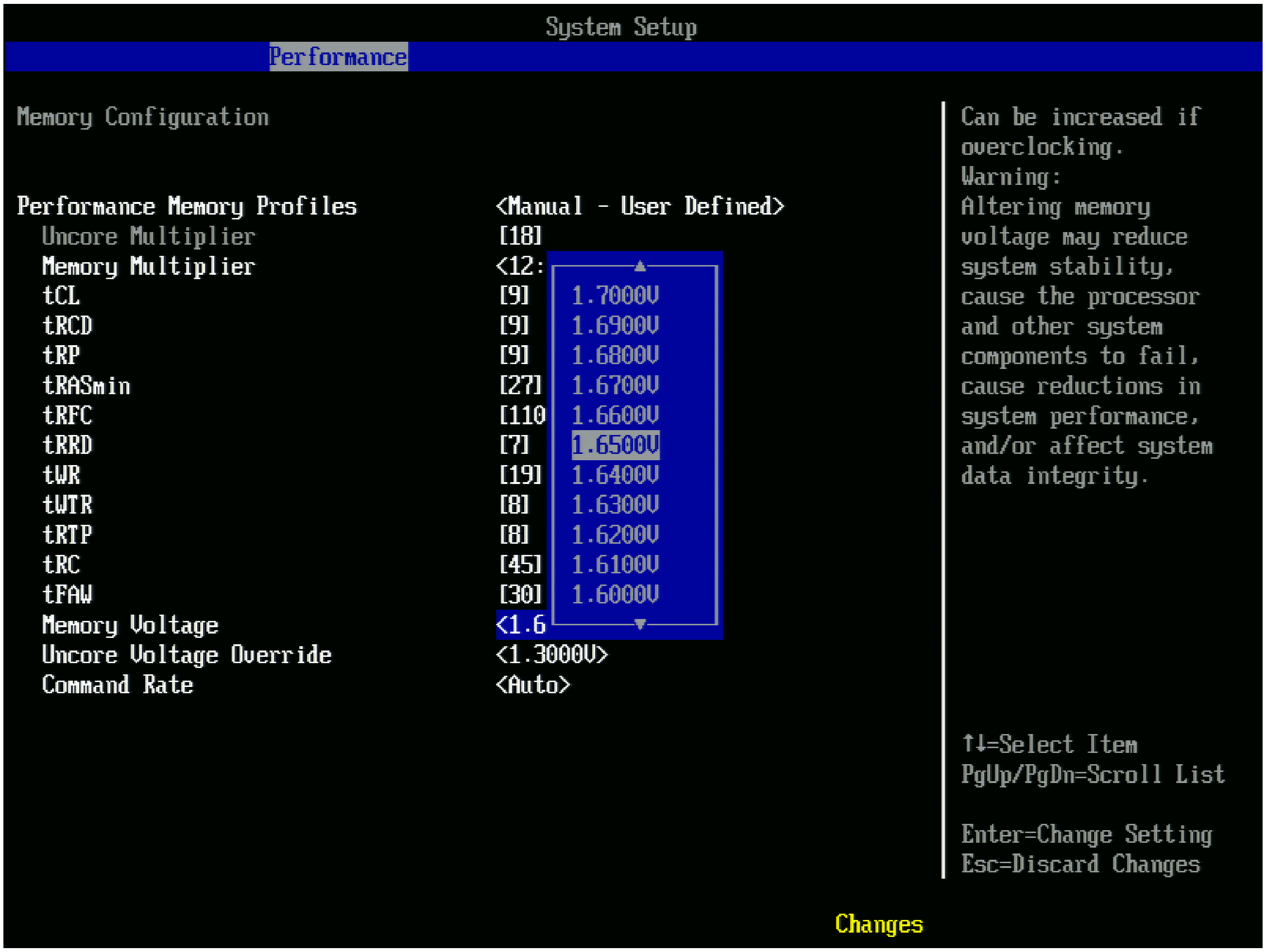


**Figure 16. Memory Configuration with Uncore Voltage Adjusted in Manual Mode**

Figure 17 shows the Memory Performance increased with the BCLK using the maximum Memory Multiplier.

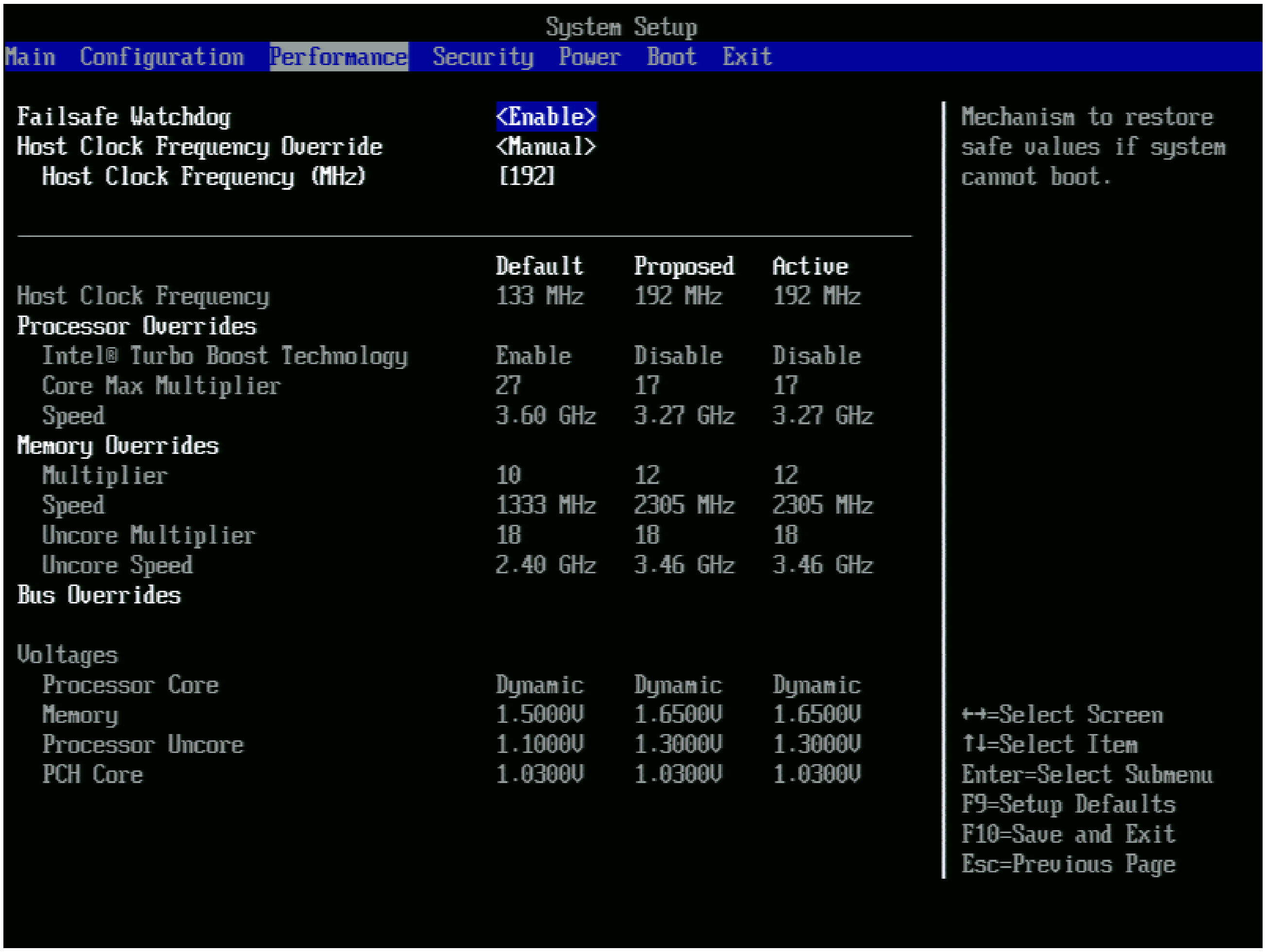


**Figure 17. Memory Performance Increased to 2305 MHz**

Figure 18 shows what happens when you push the system too far either in Memory Performance or Processor Performance.

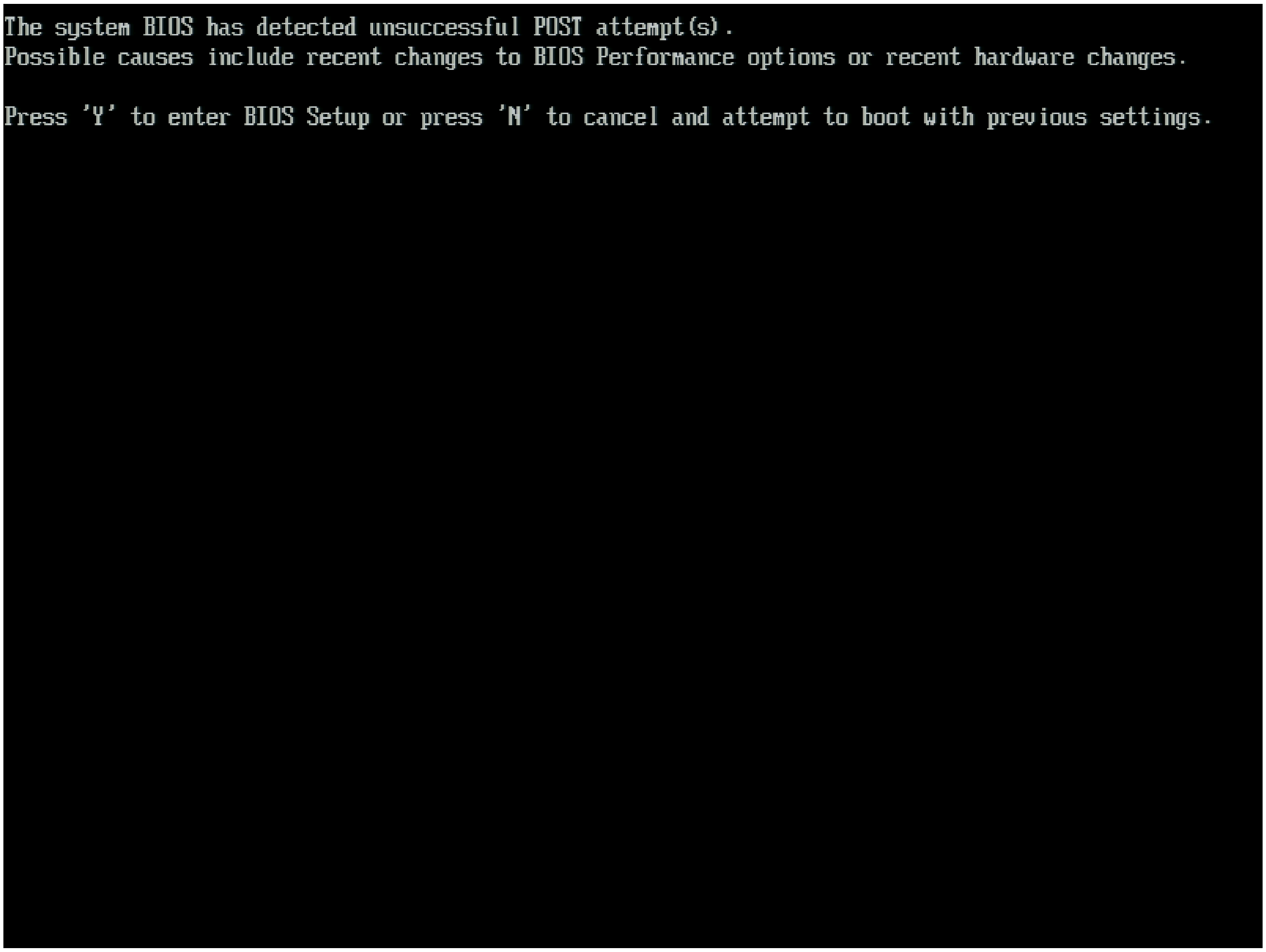


**Figure 18. Watchdog Timer Tripped**