

Intel[®] HD Graphics Dynamic Frequency Technology

White Paper

February 2010



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"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>

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Revision History

Document Number	Revision Number	Description	Revision Date
323324	-001	Initial release.	February 2010

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1 Introduction

The purpose of this document is to explain what Intel® HD Graphics Dynamic Frequency Technology is and how it complements Intel® Turbo Boost Technology. The document will also explain how the user can interact with the technology to further enhance the computing experience. This document has been written for OEMs, ODMs, Technical press, and technical enthusiast.

1.1 Terminology

Term	Description
CUI	Common User Interface

1.2 Reference Documents

Document	Document Location
Intel® Turbo Boost Technology frequently asked questions	http://www.intel.com/support/processors/sb/CS-029908.htm





2 Intel® HD Graphics Dynamic Frequency Technology

The new 2010 Intel® Core™ processor family now includes Intel® HD Graphics as part of the processor. This integration of Central Processor Unit (CPU), memory controller and the graphics processing capability provides some exciting new features that improve system performance and reduces power usage, especially in mobile systems. Two of these new features are Intel® Turbo Boost Technology and Intel® HD Graphics Dynamic Frequency Technology. Intel Turbo Boost Technology takes advantage of unused power budget to increase single or multi-core processor frequency. Intel Turbo Boost Technology was first introduced with the Penryn family of processors and later enhanced with Intel® Core™ i7 processor family to provide more frequency bins of performance and also included multi-core turbo technology which made it possible to also get more frequency for each active core. The upcoming Intel® Core™ i5 and Intel® Core™ i3 processor family of processors are now the first mainstream processor package to marry both Intel® Turbo Boost Technology with the new Intel® HD Graphics dynamic frequency technology. Intel mobile platforms are designed to maximize performance and minimize power usage for a given power budget based upon form factor. With the combination of Intel Turbo Boost Technology on the CPU and dynamic frequency as part of the Intel® HD Graphics the system may be able to increase the processor or graphics frequency and voltage in order to speed up the application processing.

2.1 Power Sharing Theory of Operation

The theory of operation starts with the power load line or turbo triangle - see Figure 1. On the x-axis is the maximum CPU power, and on the Y-Axis is the maximum graphics power. The majority of time both the CPU and graphics are at idle or near idle power. Figure 2 shows the power limits when turbo is not available. The maximum processor and graphics core power is based upon maximum package power that can be delivered and cooled. In essence, this is the guaranteed frequency and power for the individual cores, should applications require both cores to be fully active concurrently. However, in most cases, an application will only make the processor core or graphics core active at a time. Upon the launch of an application, that application may be very processor intensive. If there is additional thermal and power budget, the processor can make use Intel® Turbo Boost technology to increase both frequency and voltage to help speed up the application. In essence, the processor is borrowing unused graphics power and thermal budget - see Figure 3. This also works for applications that are graphics intensive. The graphics engine makes use of dynamic frequency technology to increased both frequency and voltage - see Figure 4. Finally, some applications will be balanced or require increased processor or graphics processing capability. Figure 5 is an example of an application utilizing Intel® HD Graphics with dynamic frequency technology while also utilizing Intel® Turbo Boost Technology by increasing processor frequency that translates to increased performance.



Figure 1. Power Load Line

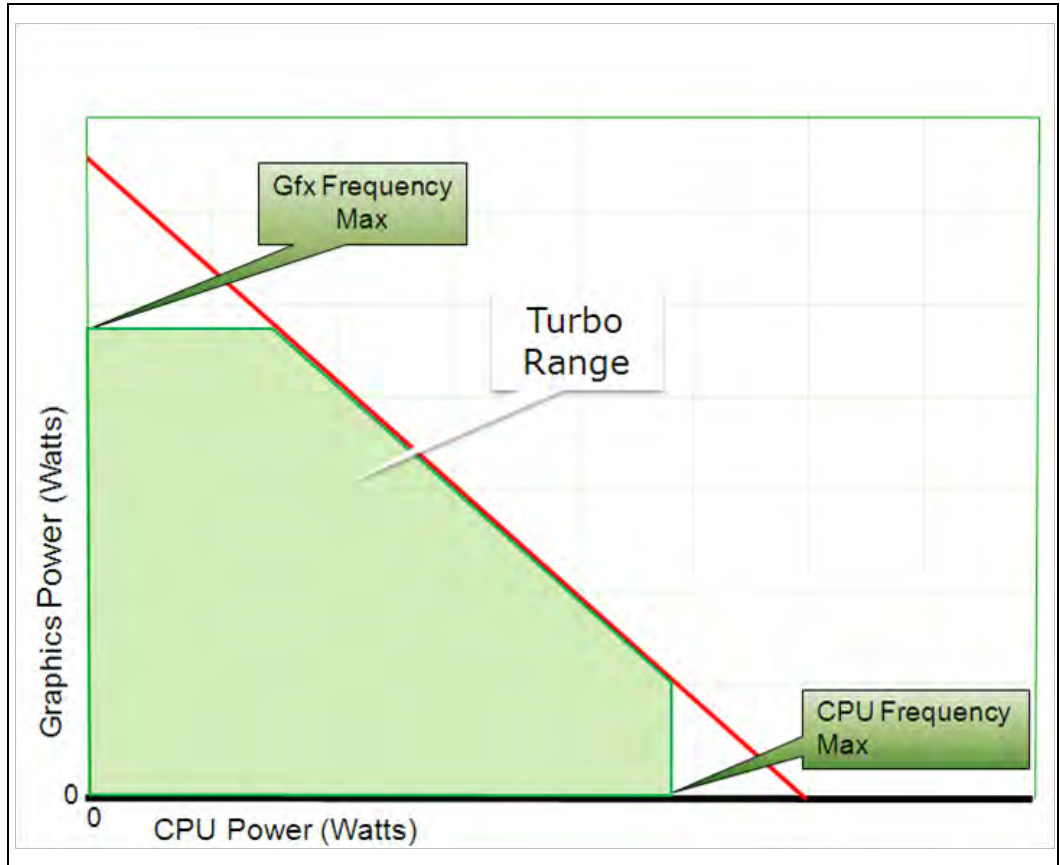




Figure 2. Core limits without Intel® Turbo Boost Technology and Dynamic Frequency

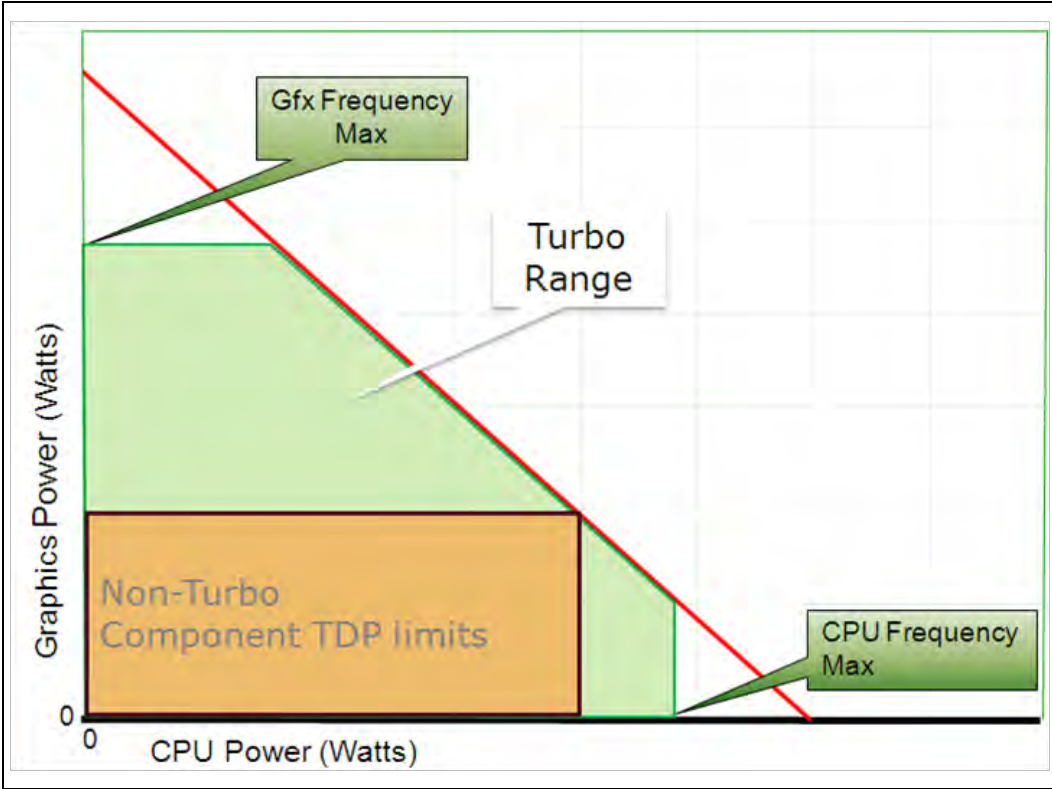




Figure 3. Intel® Turbo Boost Technology

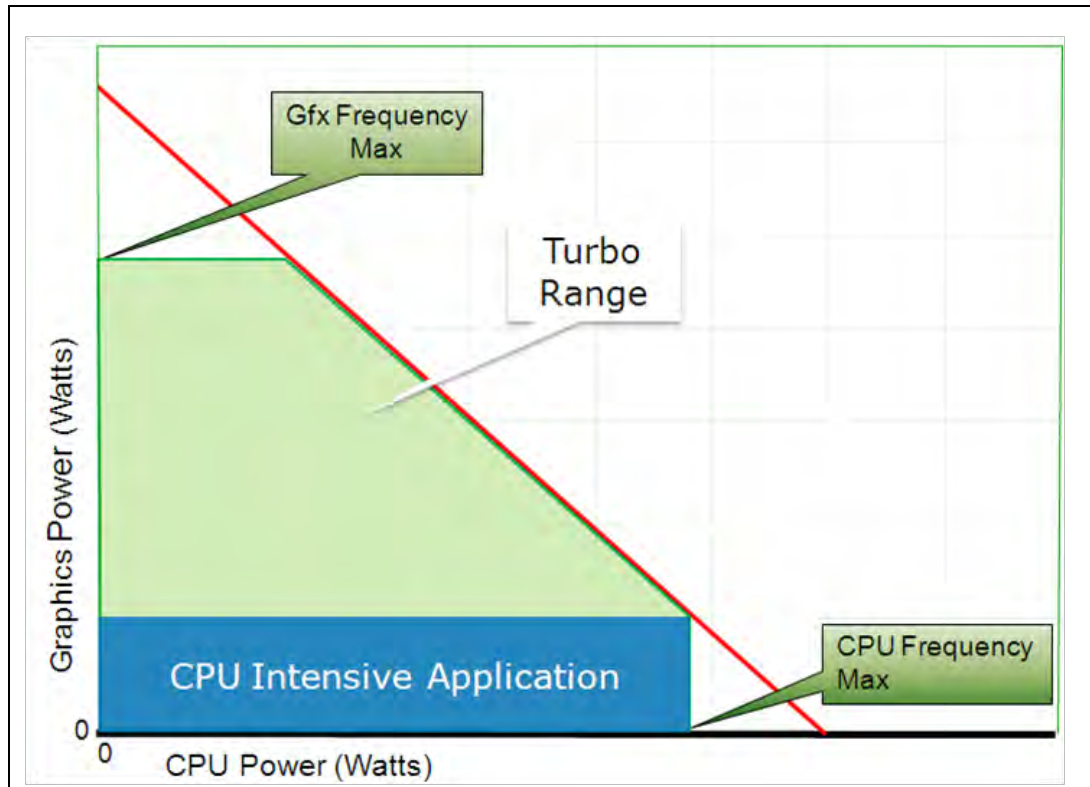




Figure 4. Intel® HD Graphics with Dynamic Frequency

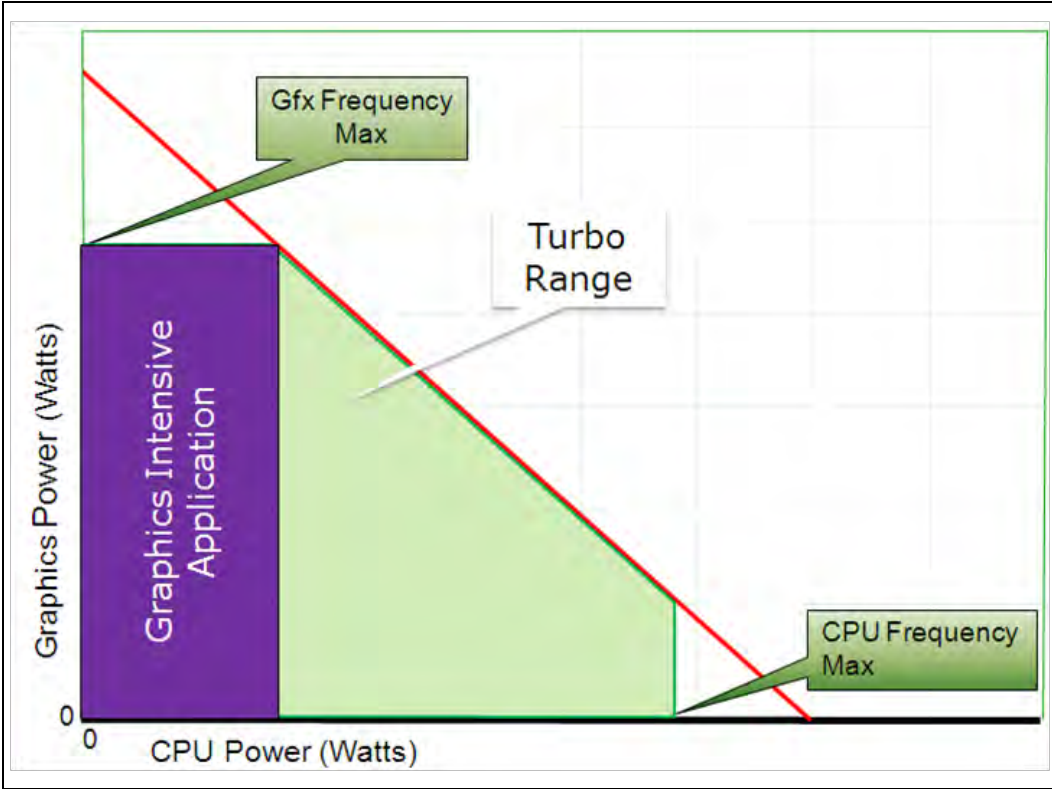
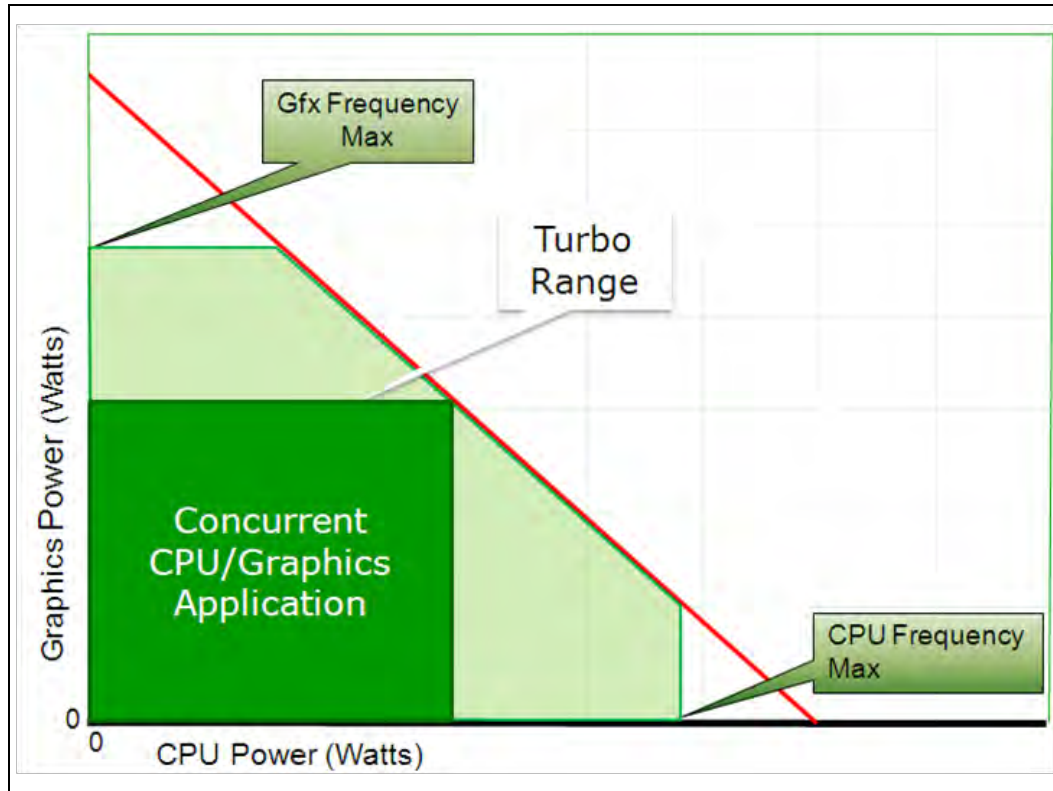




Figure 5. Both Processor and Graphics Active with Graphics Utilizing Dynamic Frequency



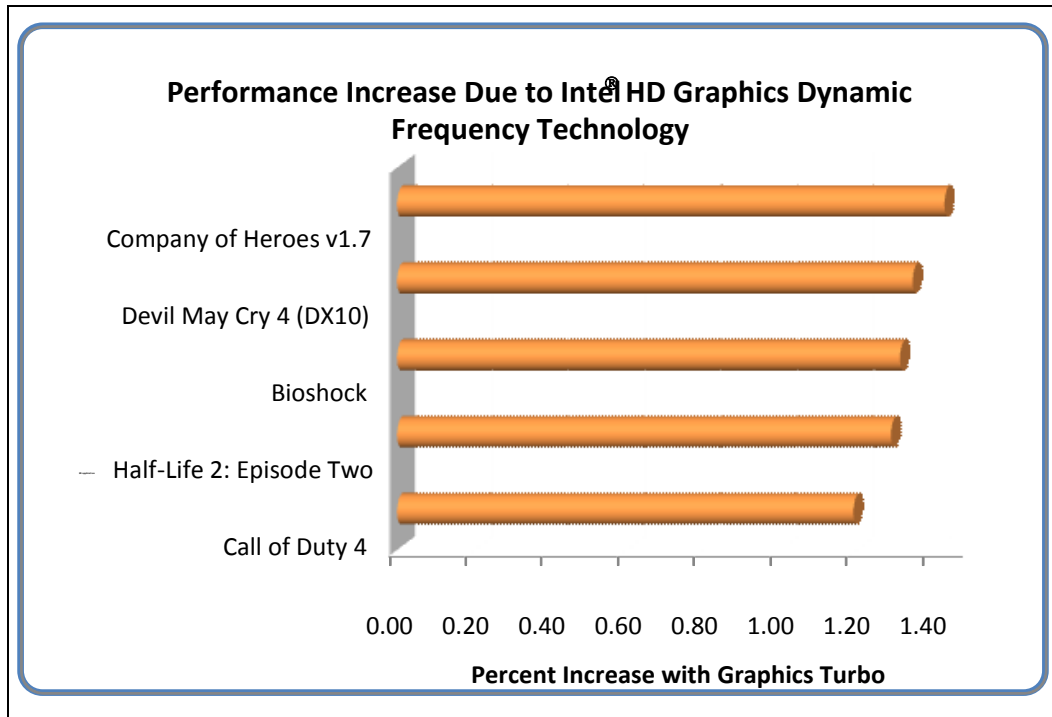
2.2 Benefits of Intel® Turbo Boost Technology and Intel® HD Graphics with Dynamic Frequency

Platforms based upon Intel® Core™ i5 and i3 processors will receive Intel® Turbo Boost Technology and Intel® HD Graphics with dynamic frequency provided the proper power, thermal design, and ambient temperature are maintained. One major advantage that Intel® Turbo Boost Technology provides is increased performance on the applications we all use today. For example, a user is converting an audio file to sync with their favorite MP3 player. With iTunes8*, Intel® has seen approximately 10% or greater improvement over the same processor without Intel® Turbo Boost Technology turned off. This is accomplished by the processor making use of Intel® Turbo Boost Technology to increase processor frequency to decrease the amount of time it takes to convert the file(s). The user may also want to convert a video file for usage on a mobile device while travelling on a plane or sending an E-mail to family in another State or Country. The performance boost with Intel® Turbo Boost Technology for video encode can be anywhere from 2% to 22% depending on the application and the video source files. One of the major benefits of the Intel® Core™ i5 and Intel® Core™ i3 family of processors is Intel® HD Graphics with dynamic frequency. Many mobile users enjoy having a highly portable and light laptop. With the portability users have had to sacrifice on media performance. That is no longer the case with Intel® HD Graphics with dynamic frequency. Users are now able to watch their



favorite Blu-Ray* movies while travelling without having to lug around a heavy laptop that was previously required to get this feature. Intel® HD Graphics with dynamic frequency also provides additional 3D performance. During game play the graphics core along with the graphics driver has the intelligence to sense when additional performance is required. The increased demand will cause the graphics core to make use of dynamic frequency to ensure increased frame rate and a better user experience. Figure 6 shows several games that were able to increase in performance with Intel® HD Graphics with dynamic frequency.

Figure 6 Benefits of Intel® HD Graphics with Dynamic Frequency



2.3 End User Controls

Intel is also enabling end user controls. The controls are part of the Microsoft Operating System power settings Figure 7 and Intel® Graphics CUI controls Figure 8. Intel chose to follow industry established power settings in that there are three choices: Maximum Performance, Balanced, or Maximum Battery. The OS attempts to maintain the highest performance state on the processor core when the power options in the OS are set to maximum performance. The Intel® Turbo Boost Technology Driver will place a bias on power budget requests to the processor core in this configuration regardless of graphics CUI setting. When the OS power option is set to balanced, the driver will bias to processor core unless the graphics CUI is set to maximum performance. The final option, maximum battery, will essentially disable Intel® Turbo Boost Technology in that the OS never allows the processor to enter the highest performance state. The graphics CUI settings work much the same as the power plan in the OS. Setting maximum battery limits the graphics frequency to the guaranteed



frequency for the part. Maximum performance and balanced work much the same way, except when there is a request from both the processor and graphics cores for power budget. In this case, the Intel® Turbo Boost Driver will make a determination on which core gets the budget based upon the power plans. In most cases, the power budget is given to the processor core unless it is set to balanced budget plan, or maximum battery, and the graphics is set to maximum performance.

Figure 7. Operating System Power Plans

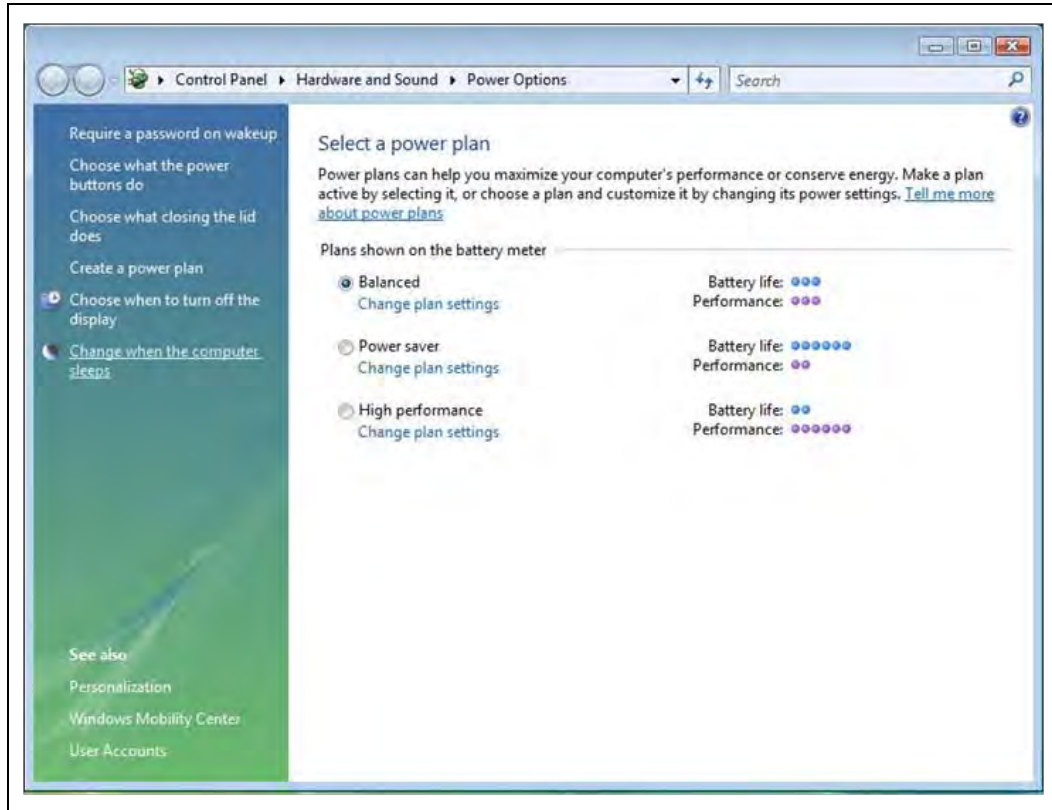




Figure 8. Graphics CUI Power Plans



2.4 Summary

With the upcoming launch of Intel® Core™ i5 and Intel® Core™ i3 processor family of products, Intel will include both Intel® Turbo Boost Technology and Intel® HD Graphics with dynamic frequency. This combination of technologies take advantage of unused power by either processor or graphics cores and allows that power budget to be given to the other core to work above the guaranteed frequency and power. In the event an application or applications require full utilization of all processor and graphics cores the part will run at the guaranteed frequency thereby not robbing the system of performance. The benefits range from everyday applications like Apple* iTunes* to further enhance ones music library; to video encode to share videos with friends and family. Smooth and vibrant Blu-ray* video playback delivered by Intel® HD Graphics will also utilize dynamic frequency to minimize power use and maximize portability. Finally, 3D applications take further advantage of Intel® HD Graphics with dynamic frequency to enhance the user's visual experience in increased frame rates and better 3D quality.



Intel® HD Graphics Dynamic Frequency Technology