

# **Intel<sup>®</sup> HD Graphics with Dynamic Frequency Technology**

**White Paper**

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***March 2012***



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## *Revision History*

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<b>Document Number</b>	<b>Revision Number</b>	<b>Description</b>	<b>Revision Date</b>
323324	-001	<ul style="list-style-type: none"><li>• Initial release.</li></ul>	February 2010
	-002	<ul style="list-style-type: none"><li>• Revised document title and Intel trademarks.</li><li>• Misc. editing.</li></ul>	March 2012

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# 1 Introduction

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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 enthusiasts.

## 1.1 Terminology

Term	Description
CUI	Common User Interface

## 1.2 Reference Documents

Document	Document Location
<i>Intel® Turbo Boost Technology Frequently Asked Questions</i>	<a href="http://www.intel.com/support/processors/sb/CS-029908.htm">http://www.intel.com/support/processors/sb/CS-029908.htm</a>





## 2 Intel® HD Graphics Dynamic Frequency Technology

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Since 2010, all Intel® Core™ processors include Intel® HD Graphics as part of the processor architecture. This integration of Central Processor Unit (CPU), memory controller and the graphics processing capability provides some exciting new features that improve system performance and reduce 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 newest family of Intel® Core™ i5 and Intel® Core™ i3 processors continue to combine both Intel Turbo Boost Technology and 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 Technology 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 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 of Intel® Turbo Boost Technology to increase both frequency and voltage, to help speed up the application. In essence, the processor is borrowing the 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.



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 Dynamic Frequency Technology while also utilizing Intel Turbo Boost Technology by increasing processor frequency, which translates into increased performance.

Starting with Sandy Bridge, the graphics core(s) are included on the same die as the processor cores. This enables greater efficiencies when managing power and thermal budgets. The integration also removes the need for additional software support, since the capabilities are now managed by hardware engines. Integration also makes it possible for the die to actually exceed TDP for short periods of time that are not thermally relevant.

Intel's latest processor generation has further enhanced Intel Turbo Boost Technology and Intel HD Graphics Dynamic Frequency Technology with increased efficiencies in power-sharing algorithms and further increasing the time in which TDP may be exceeded, thereby providing an improved end-user experience.

Figure 1. Power Load Line

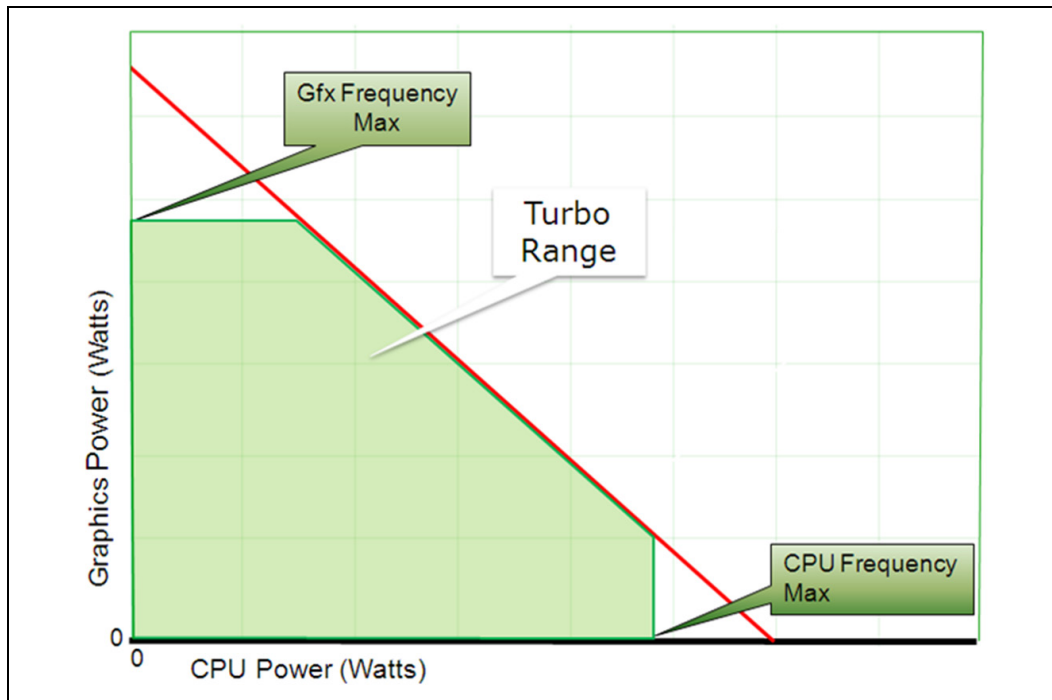




Figure 2. Core Limits without Intel® Turbo Boost Technology and Intel® HD Graphics Dynamic Frequency Technology

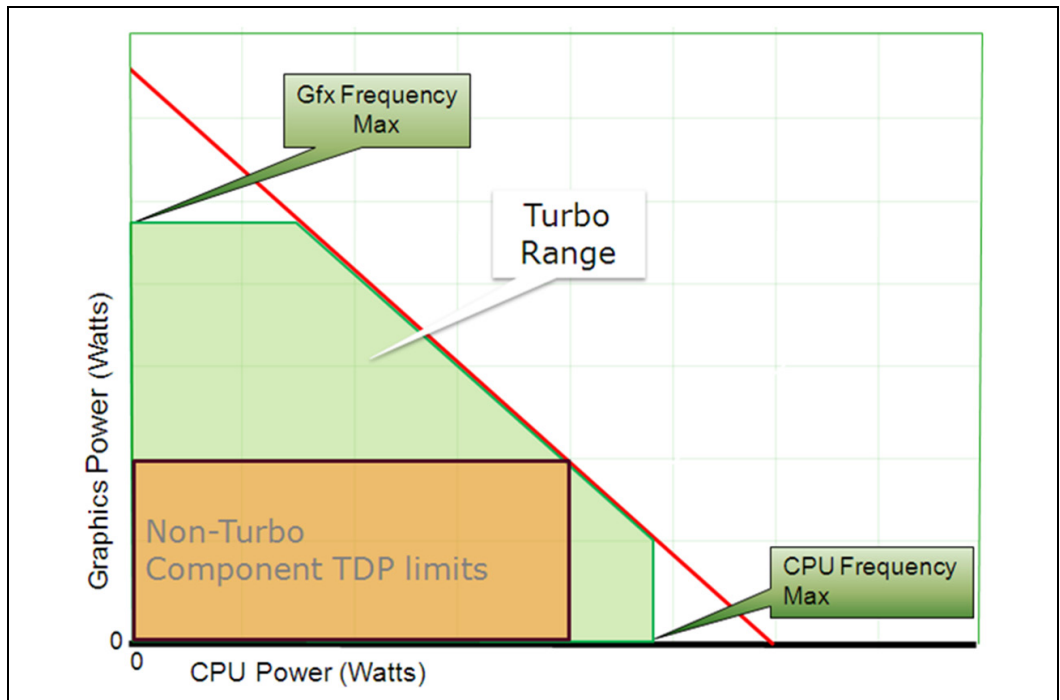


Figure 3. Intel® Turbo Boost Technology

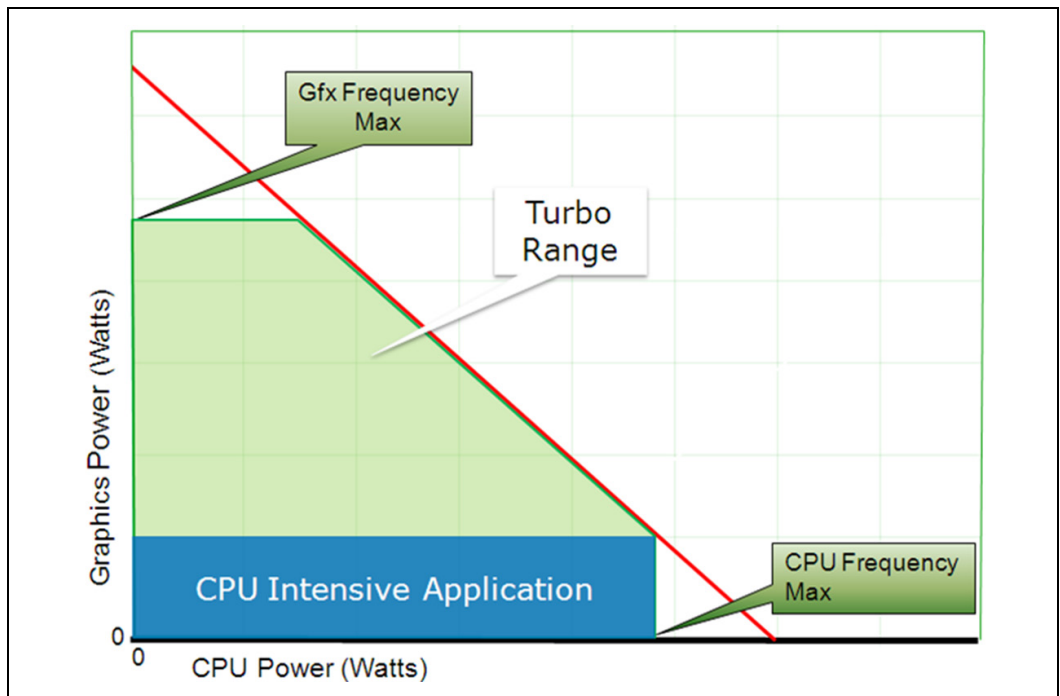




Figure 4. Intel® HD Graphics with Dynamic Frequency Technology

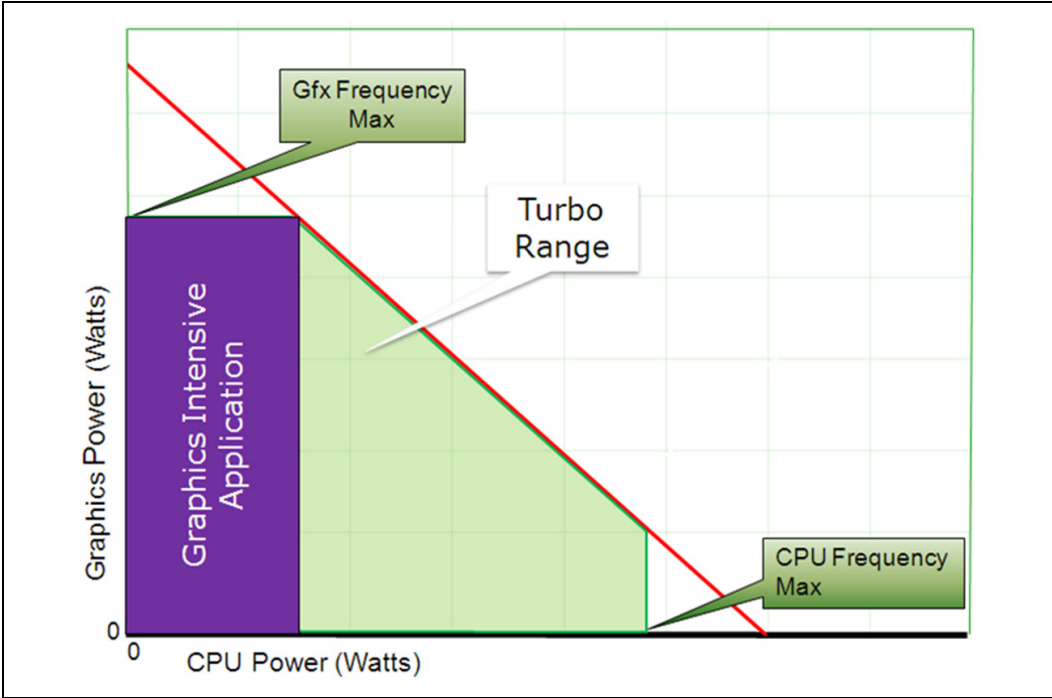
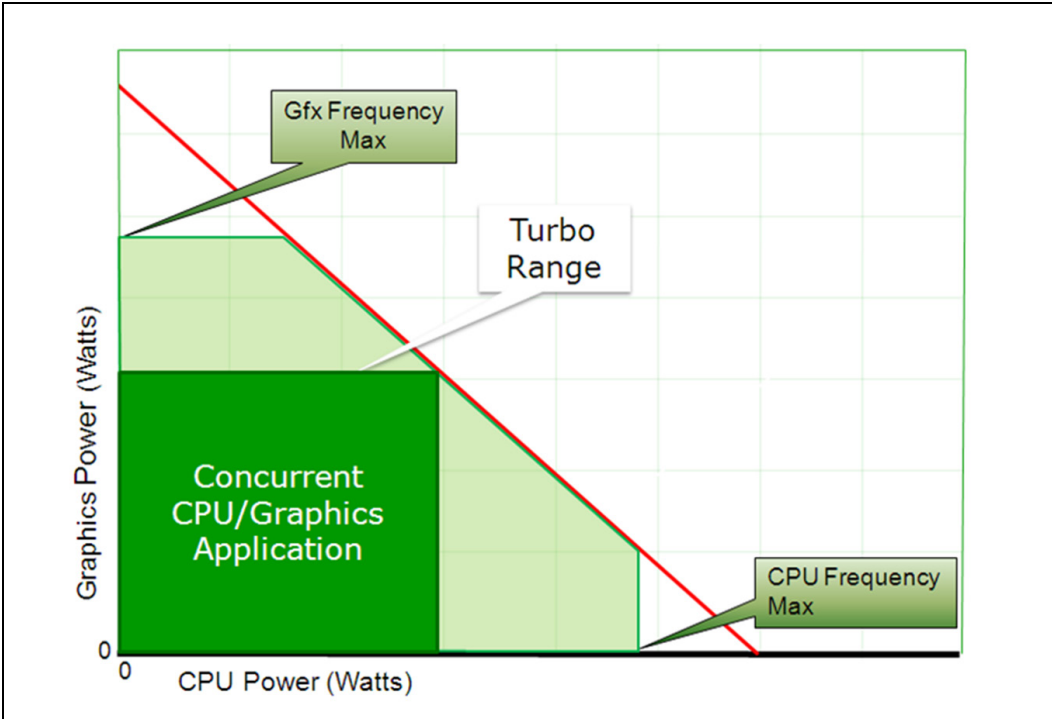


Figure 5. Both Processor and Graphics Active with Graphics Utilizing Dynamic Frequency Technology





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

Platforms based upon Intel® Core™ i5 and i3 processors receive Intel Turbo Boost Technology and Intel HD Graphics with Dynamic Frequency Technology, provided that proper power, thermal design, and ambient temperature are maintained. One major advantage that Intel Turbo Boost Technology provides is increased performance on the most commonly-used applications, such as when a user converts 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. 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 use on a mobile device while travelling on an airplane 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 Technology.

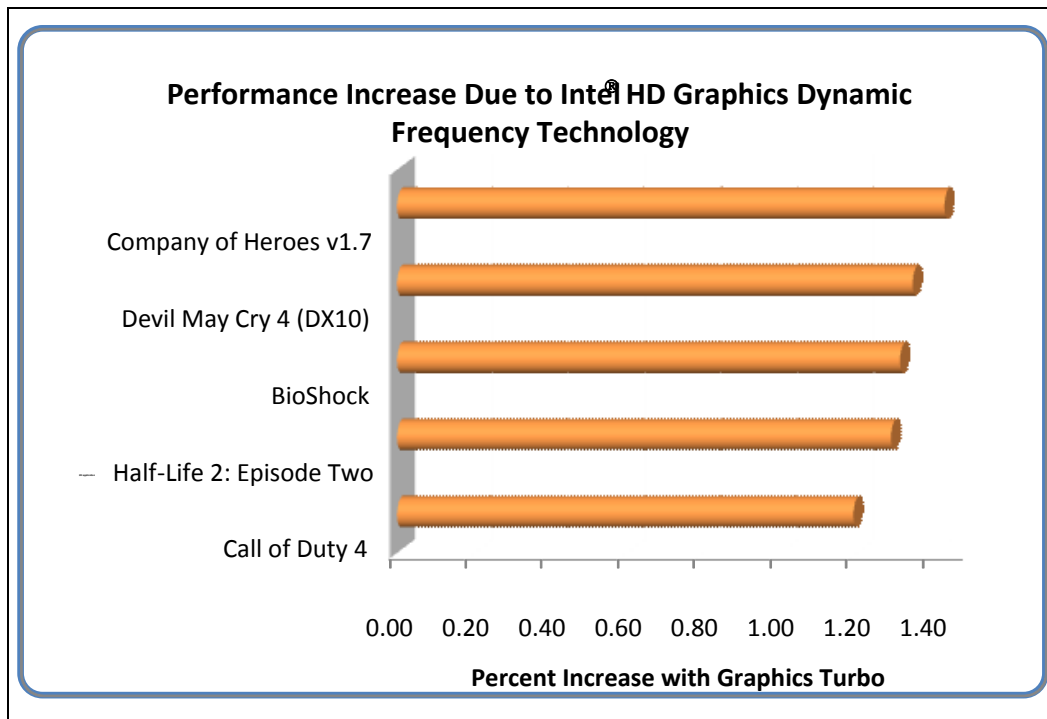
Many mobile users enjoy having a highly-portable and light laptop. With portability, users have previously had to sacrifice some media performance. This is no longer the case with Intel HD Graphics with Dynamic Frequency Technology. Users are now able to watch their favorite Blu-ray\* movies while travelling without having to lug around a heavy laptop that was previously required to get this feature.

Intel® HD Graphics with Dynamic Frequency Technology also provides additional 3D performance. During game play, the graphics core, along with the graphics driver, have the intelligence to sense when additional performance is required. Increased demand causes the graphics core to make use of Dynamic Frequency Technology to ensure increased frame rate and a better user experience.

Figure 6 shows several games that experience increased performance due to Intel® HD Graphics with Dynamic Frequency Technology.



Figure 6. Benefits of Intel® HD Graphics with Dynamic Frequency Technology



### 2.3 End User Controls

Intel is also enabling end-user controls. The controls are part of the Microsoft Operating System Power Plan settings (see Figure 7) and Intel® Graphics and Media Control Panel CUI controls (see Figure 8). Intel chose to follow the three industry-established power settings: Maximum Performance, Balanced, or Maximum Battery.

The OS attempts to maintain the highest performance state on the processor core when the Power Plan options in the OS are set to Maximum Performance. 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 the processor core unless the graphics CUI is set to Maximum Performance. The final option, Maximum Battery, will essentially disable Intel® Turbo Boost Technology by preventing the OS from allowing the processor to enter its highest performance state.

Intel Graphics and Media Control Panel CUI settings work similarly to the Power Plan in the OS. Selecting Maximum Battery limits the graphics frequency to the guaranteed frequency for the part. Maximum Performance and Balanced settings work similarly to the Power Plan as well, except when there is a request from both the processor and the graphics cores for power budget. In this circumstance, the Intel® Turbo Boost Driver will make a determination regarding which core will receive the budget (based upon the Power Plan setting). In most cases, the power budget is given to the processor core unless it is set to Balanced or Maximum Battery, and the graphics is set to Maximum Performance.



Figure 7. Operating System Power Plans

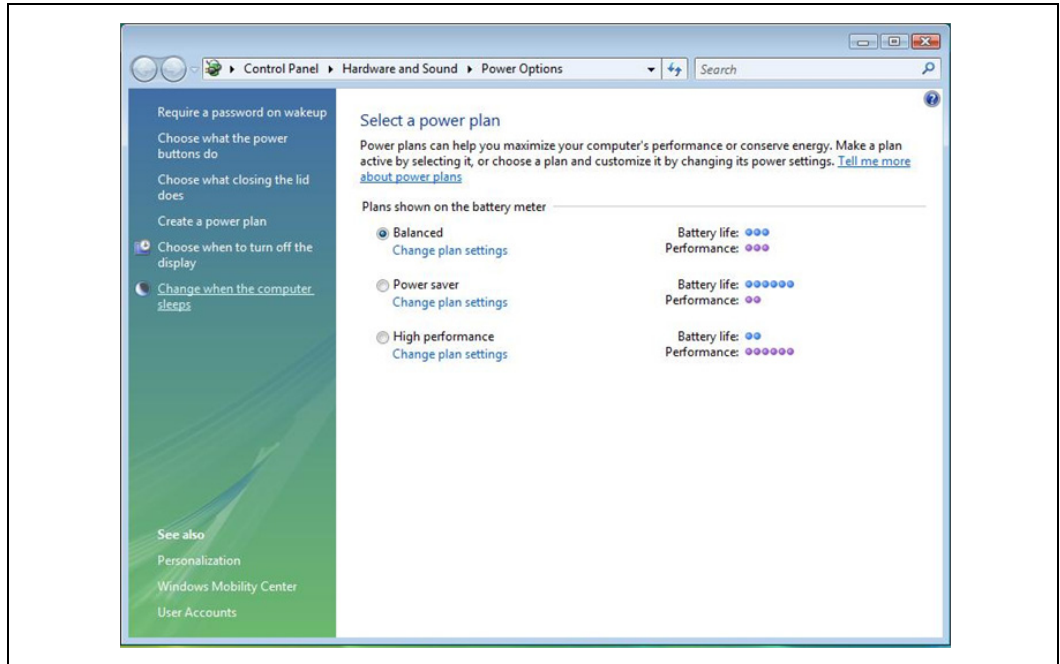


Figure 8. Graphics CUI Power Plans





## **2.4 Summary**

Since the launch of the Intel® Core™ i5 and Intel® Core™ i3 processor family of products, Intel includes both Intel® Turbo Boost Technology and Intel® HD Graphics with Dynamic Frequency Technology. This combination of technologies takes 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 that applications require full utilization of all processor and graphics cores, the part will run at the guaranteed frequency, thereby preserving system performance.

The benefits range from everyday applications such as Apple\* iTunes\* to further enhance one's music library; to video encoding to share videos with friends and family. Smooth and vibrant Blu-ray\* video playback delivered by Intel® HD Graphics will also utilize Dynamic Frequency Technology to minimize power use and maximize portability. Finally, 3D applications take further advantage of Intel® HD Graphics with Dynamic Frequency Technology to enhance the user's visual experience in increased frame rates and better 3D quality.

