

Intel[®] Extreme Memory Profile (Intel[®] XMP) DDR3 Technology

White Paper

January 2009



INFORMATION IN THIS DOCUMENT IS PROVIDED IN CONNECTION WITH INTEL® PRODUCTS. NO LICENSE, EXPRESS OR IMPLIED, BY ESTOPPEL OR OTHERWISE, TO ANY INTELLECTUAL PROPERTY RIGHTS IS GRANTED BY THIS DOCUMENT. EXCEPT AS PROVIDED IN INTEL'S TERMS AND CONDITIONS OF SALE FOR SUCH PRODUCTS, INTEL ASSUMES NO LIABILITY WHATSOEVER, AND INTEL DISCLAIMS ANY EXPRESS OR IMPLIED WARRANTY, RELATING TO SALE AND/OR USE OF INTEL PRODUCTS INCLUDING LIABILITY OR WARRANTIES RELATING TO FITNESS FOR A PARTICULAR PURPOSE, MERCHANTABILITY, OR INFRINGEMENT OF ANY PATENT, COPYRIGHT OR OTHER INTELLECTUAL PROPERTY RIGHT. Intel products are not intended for use in medical, life saving, or life sustaining applications.

Intel may make changes to specifications and product descriptions at any time, without notice.

Designers must not rely on the absence or characteristics of any features or instructions marked "reserved" or "undefined." Intel reserves these for future definition and shall have no responsibility whatsoever for conflicts or incompatibilities arising from future changes to them.

The Intel® X48 Express Chipset MCH component may contain design defects or errors known as errata which may cause the product to deviate from published specifications. Current characterized errata are available on request.

Contact your local Intel sales office or your distributor to obtain the latest specifications and before placing your product order.

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.

Intel and the Intel logo are trademarks of Intel Corporation in the U.S. and other countries.

*Other names and brands may be claimed as the property of others.

Copyright © 2008 - 2009, Intel Corporation



Contents

| | | |
|---|--|----|
| 1 | Introduction | 5 |
| 2 | What is Intel® XMP and why is it needed?..... | 6 |
| | 2.1 What is Intel® XMP?..... | 6 |
| | 2.2 Summary of Features and Benefits | 7 |
| | 2.3 Intel® XMP and the Intel® X48 Express Chipset..... | 7 |
| 3 | How Does Intel® XMP Work?..... | 9 |
| | 3.1 Intel® XMP Boot Flow | 9 |
| | 3.2 Intel® XMP SPD Space Requirements..... | 10 |
| | 3.3 Intel® XMP Profiles | 10 |
| | 3.4 Tuning Utilities..... | 11 |
| 4 | Intel® XMP and Intel® X48 Express Chipset Certification Program..... | 12 |



Revision History

| Revision Number | Description | Revision Date |
|------------------------|--------------------------------------|----------------------|
| -001 | Initial release | March 2008 |
| -002 | Removed XMP Specification references | January 2009 |

§



1 *Introduction*

With the introduction of DDR3, PC gamers and enthusiasts alike have been able to increase the performance of their PC beyond what DDR2 platforms could provide. The lowering of memory voltages and the doubling of memory clock speeds are just a few of the benefits of DDR3 over DDR2.

Intel has taken the performance envelope even further by offering the Intel® Extreme Memory Profiles (Intel® XMP), which is an easy way to use an over-clocking solution to an existing DDR3 implementation.

This document details the Intel® Extreme Memory Profile (XMP) DDR3 memory technology and it is intended for the enthusiast interested in learning about the Intel® XMP background, purpose, and usage.

§



2 *What is Intel® XMP and why is it needed?*

The first couple of questions that are commonly asked is “What is Intel® XMP?” and “Why do I need this technology?”. The following sections are intended to help answer these questions in addition to provided additional details to the benefits and features on Intel® XMP.

2.1 **What is Intel® XMP?**

Due to the growing need for memory performance in high end gaming and performance computing, Intel engineers decided to develop a solution named the Intel Extreme Memory Profile (Intel XMP). Intel co-developed the Extreme Memory Profile (XMP) specification with its memory partners to enable performance tuning of DDR3 memory to beyond standard JEDEC SPD specifications. Simply put, the XMP profiles defined by the XMP specification are stored in the SPD of XMP DIMM and are extracted by BIOS to “tune” the memory controller for optimal memory performance.

For the user, this technology is designed to give a new or experienced over-clocker confidence to over-clock their computers with compatible hardware that will ensure a certain level of performance with DDR3 modules that are XMP compatible.

So in a nutshell, Intel XMP is a performance-packed expansion of the standard DDR3 specification enabling a robust, over-clocking solution designed to take advantage of the performance features built into Intel chipsets such as the Intel® X48 Express Chipset.



2.2 Summary of Features and Benefits

Intel® XMP features and benefits can be summarized in the following table:

| Features | Benefits |
|---|--|
| Multiple SPD profiles | Enables preset or user defined memory profiles that can be selected depending on usage model. For example, an aggressive low latency profile could be used during intense gaming while the default memory setting can be used for everyday home computing, such as home office or web browsing. |
| Memory vendor specific SPD fields | Enables Memory Module suppliers to program their own capabilities and provide unique value to end users. |
| Easy Over-clocking (Novice) | Enables end users to easily over-clock their platforms by selecting the appropriate profile, instead of adjusting individual parameters in BIOS. Reselecting the default profile resets the platform to default setting. |
| Advanced Overclocking (Intermediate/Expert Users) | Expert users can manually change specific SPD parameters in the bios and save the profiles (Platform/BIOS specific). |
| Fail-safe default boot | "First boot" with default JEDEC setting on a platform that supports DDR3 standard JEDEC specification (your standard DDR3 memory frequencies), ensuring base functionality. Then, the user can enter BIOS and manually change settings, or use a system specific tuning utility that may be available through your motherboard or system vendor. |

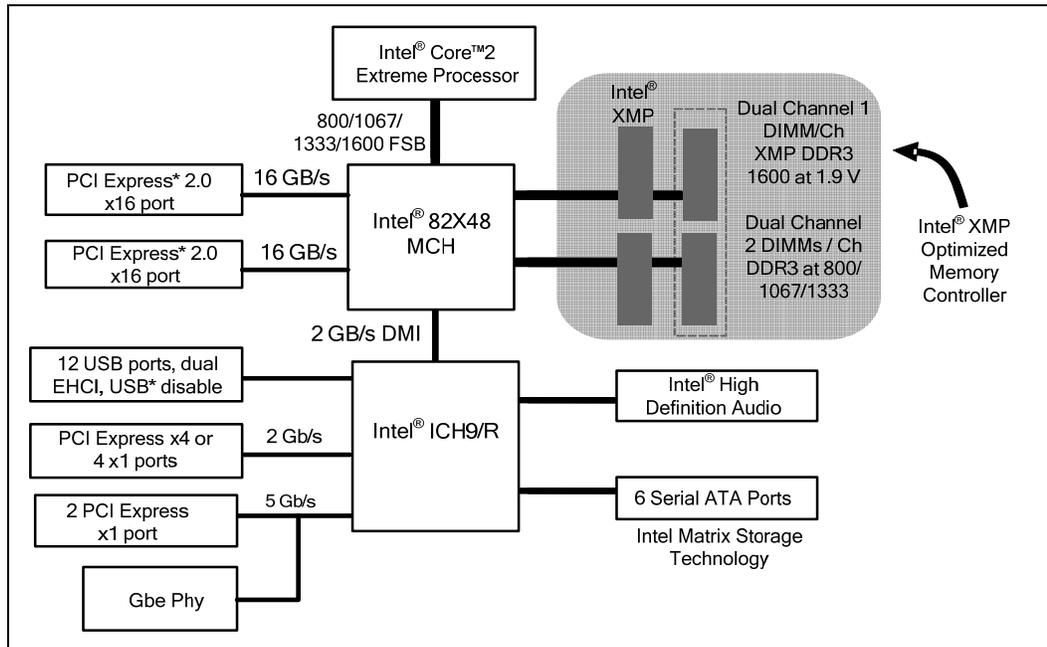
2.3 Intel® XMP and the Intel® X48 Express Chipset

Motherboards with BIOS and chipset optimized to support Intel XMP are needed in addition to XMP DIMMs for this technology to work. Figure 1 shows a block diagram of the X48 Express Chipset using the Intel® XMP optimized memory controller. The X48 Express Chipset is the first chipset validated by Intel to support XMP 1600 DDR3 DIMMs.

The X48 Express Chipset has been validated to support Intel® XMP DDR3 DIMMs at 1600 MHz @ 1.9 V. The Intel X48 chipset supports a single XMP DDR3 DIMM per channel at 1600 MHz or 2 standard DDR3 DIMMs per channel at up to 1333 MHz.



Figure 1. Intel® X48 Express Chipset using the Intel® XMP Optimized Memory Controller



§



3 How Does Intel® XMP Work?

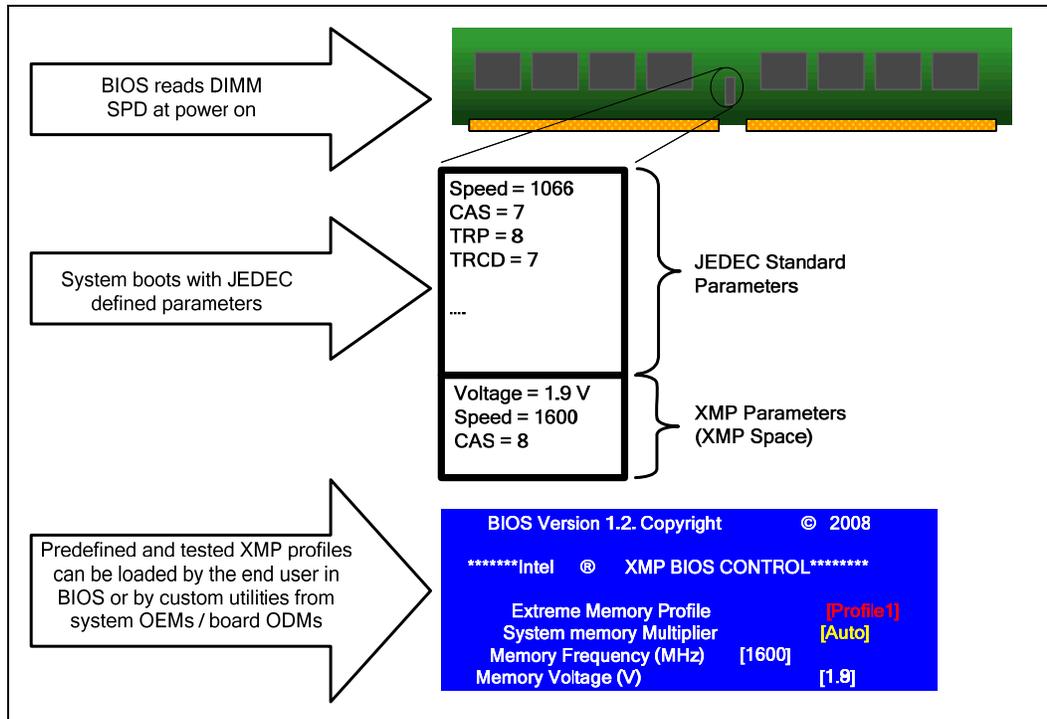
In the previous section we covered the purpose of XMP and what it is all about. Now we will take a closer look at how it works. The following sections show the outline of how XMP enabling fits into the normal JEDEC DDR3 boot flow and details on the actual XMP profiles that are programmed into the SPD.

3.1 Intel® XMP Boot Flow

During the general boot process, BIOS starts executing code to initialize the processor, chipset, and additional supporting components in the system. During the memory initialization process BIOS reads the DIMM specific parameters from the Serial Presence Detect (SPD) EEPROM located on the DIMM to properly program the memory controller in the chipsets Memory Controller Hub (MCH).

The Intel Extreme Memory Profile specification adds to this process by providing special profiles in the SPD that are used to 'overclock' the DIMMs to achieve their maximum potential. These profiles are loaded into BIOS after the general JEDEC parameters are used to boot the system for stable operation. Figure 2 shows a summarized flow of the XMP boot process.

Figure 2. Intel® XMP Boot Process Summary





3.2 Intel® XMP SPD Space Requirements

DDR3 DIMMs currently have at least a 256 byte SPD flash device which stores all of the memory device parameters and configuration details for that specific DIMM. SPD programming, as defined by the standard DDR3 JEDEC specifications, currently use bytes 0-175 for all of the required memory device parameters with bytes 176–255 as open space for customer specific use.

XMP DDR3 DIMMs use bytes 176–255 to program specific profiles.

3.3 Intel® XMP Profiles

Intel® Extreme Memory Profiles are traditionally designed with two distinct performance profiles:

- **Profile 1** is used for the Enthusiast / Certified settings and is the profile that is tested under the Intel® Extreme Memory Certification program.
- **Profile 2** is designed to host the Extreme or Fastest possible settings that have no guard band and may or may not work on every system.

It should also be noted that Extreme Memory Profiles are not always defined as over-frequency / over-voltaged parts. In some cases, Extreme Memory Profiles can be used to define extremely power savvy settings or extremely fast latencies.

As Mentioned in Section 3.2, XMP DIMMs use bytes 176–255 to program XMP specific details. The following is the breakdown of the XMP SPD space.

- **Bytes 176 - 185:** Global Parameters for Intel Extreme Memory used across all profiles
- **Bytes 186 – 218:** Profile 1 programming
- **Bytes 219 – 254:** Profile 2 programming



3.4 Tuning Utilities

It was mentioned in Section 3.2 that after initial boot to JEDEC defined parameters, XMP profiles can be loaded by BIOS or a system OEM/ Board ODM specific tuning application.

Loading the XMP profiled via BIOS requires the users to enter into BIOS setup to make changes or the Motherboard BIOS automatically entering a “performance tuning” user interface prior to OS loading. This process is specific to the board vendor in which board documentation will detail the parameters and process in making changes.

Another way to load XMP profiles is through a tuning utility within the OS environment. Intel has enabled board/system vendors to generate tuning utilities for their specific products, which can be used in the OS environment to tune various aspects of system performance.

The advantages of the using the tuning utility in the OS environment are numerous:

- Utility can provide a simple-to-use wizard based tool enabling manual, auto tune, and stress testing capability for the user.
- Tuning ability of a wide range of platform parameters such as voltage, timing, and frequency.
- Ability to save custom profiles.
- Native support for Intel® Extreme Memory
- System Monitoring Screen

If additional details on a tuning utility for your specific board/system are desired, contact the product manufacturer.

§



4 Intel® XMP and Intel® X48 Express Chipset Certification Program

Intel is continuously working with memory vendors in enabling the Intel® XMP support in their DIMM lineup and to check for operation with platforms containing the X48 Express Chipset. Intel has developed a certification program for memory vendors to test their Intel XMP compatible DIMMs.

Memory vendors participating in this certification are required to test their memory for compliancy on known good platforms containing the X48 Express Chipset to a specific test plan and are to submit their results to Intel. A website has been developed which Intel provides to external customers showing the Memory Vendors DIMMs, tested frequencies/voltage, timings, and platforms that they were validated on. Visit <http://www.intel.com/personal/gaming/extremememory.htm?iid=search> for the latest list.

§