

**VIA Eden<sup>TM</sup>**

**Embedded System Platform  
Processor Datasheet**

*Preliminary Information*

November 2002

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## SECTION

## 1

## INTRODUCTION

The VIA Eden™ Embedded System Platform Processor (VIA Eden ESP for short) is based upon a unique internal architecture and is manufactured using advanced 0.15 $\mu$  CMOS technology. The VIA Eden ESP architecture and companion chips provide a highly compatible, high-performance, low-cost, and low-power solution for the embedded, min-notebook, embedded, and Internet Appliance markets. The VIA Eden ESP is available in several operating frequencies.

When considered individually, the compatibility, function, performance, cost, and power dissipation of the VIA Eden ESP family are all very competitive. Furthermore, the value added from the advanced EBGA packaging includes remarkable compactness, cost efficiency and excellent thermal characteristics. The VIA Eden ESP represents a breakthrough combination for enabling high-value, high-performance, low-power, fanless x86-based solutions. When considered as a whole, the VIA Eden ESP family offers a peerless level of *value*.

## 1.1 DATASHEET OUTLINE

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The intent of this datasheet is to make it easy for a direct user—a board designer, a system designer, or a BIOS developer—to use the VIA Eden ESP processor. The companion chipset is documented separately.

**Section 1** of the datasheet summarizes the key features of the VIA Eden ESP processor. **Section 2** provides a detailed description of the internal architecture of the VIA Eden ESP processor. **Section 3** specifies the primary programming interface. **Section 4** does the same for the bus interface. **Sections 5, 6, and 7** specify the classical datasheet topics of AC timings, ballouts, and mechanical specifications.

**Appendix A** documents the VIA Eden ESP processor machine specific registers (MSRs).

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## 1.2 BASIC FEATURES

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The VIA Eden ESP processor family currently consists of two basic models with several different MHz versions. Due to their low power dissipation, either model is ideally suited for both desktop and mobile applications. All versions share the following common features:

- Extremely low power dissipation for fanless operation
- A proprietary Enhanced Ball Grid Array (EBGA) package that shares with Socket 370 processors features such as bus protocol and electrical interface
- Seamlessly software compatible with the thousands of available x86 software applications
- MMX-compatible instructions for enhanced media performance
- AMD-compatible 3DNow! Instructions for turbocharging games, photo processing and media applications
- Two large (64-KB each, 4-way) on-chip Level 1 caches
- 64-KB Level 2 victim cache
- Two large TLBs (128 entries each, 8-way) with two page directory caches
- Unique and sophisticated branch prediction mechanisms
- Bus speeds up to 133 MHz
- Very small die (52 mm<sup>2</sup> in TSMC 0.13μ technology)
- Compact and economical EBGA packaging with excellent thermal dissipation characteristics

## 1.3 PROCESSOR VERSIONS

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Typically, there are five specification parameters that characterize different versions of a processor family: package, voltage, maximum case temperature, external bus speed, and internal MHz.

The VIA Eden ESP processor is differentiated from the VIA C3 family by its extreme low power consumption, high performance, and low-profile Enhance Ball Grid Array packaging. The EBGA package is not only compact and economical, but delivers excellent thermal properties for truly Cool Processing.

The internal operating frequency of a particular VIA Eden ESP processor chip is defined by two parameters: the specified external bus speed and the internal bus-clock multiplier. VIA Eden ESP chips come in two bus-speed versions: either 100MHz bus or 133 MHz bus. (Either version can also operate at 66MHz bus speeds.) Bus frequency select balls (BSEL 0 and BSEL 1) identify the appropriate bus speed (100 MHz or 133 MHz).

The bus-clock multiplier is hardwired into initial VIA Eden ESP processors. For these, the ratio of the internal processor clock speed to the externally supplied bus clock is frozen<sup>1</sup>. Several different clock-multiplier versions are currently offered.

Future VIA Eden ESP processors will not have the bus multiplier locked. They will carry the “S” designation. In these chips, the clock ratio is set using the external bus ratio balls, *BR[4:0]*.

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<sup>1</sup> Actually, it is semi-frozen. A VIA-unique machine specific register allows programming to temporarily change the hard-wired multiplier. This capability, documented in Appendix A, is intended for special BIOS situations and test and debug usage.

More information on these topics is included in Sections 4, 5, and 6 of this datasheet

- The VIA Eden ESP processor is initially available in a variety of models:
  - VIA Eden ESP 4000 (4.0 x 100-MHz bus) 1.05V
  - VIA Eden ESP 5000 (4.0 x 133-MHz bus) 1.20V
  - VIA Eden ESP 6000 (4.5 x 133-MHz bus) 1.20V
- Future versions of the VIA Eden ESP processor may provide other models with other speed grades and bus speed combinations.
- Future versions of the VIA Eden ESP processor may have different voltages

## 1.4 COMPETITIVE COMPARISONS

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Section 2 of this datasheet contains considerable detail about the unique internal design of the VIA Eden ESP processor.

Such an internal architecture comparison, however, does not directly address the most important considerations of users: compatibility, availability, price, MHz, application performance, and power dissipation. For that reason, we do not provide a detailed architecture comparison with other processors in this datasheet. Following instead is the high-level summary of an internal-architecture comparison:

- The VIA Eden ESP processor has better cache and TLB capabilities. These are critical to system performance for modern PC operating systems and applications.
- The VIA Eden ESP has a generally simpler internal architecture. However, the VIA Eden ESP implements many advanced features critical to performance (such as sophisticated branch prediction) and is highly tuned for good application performance, especially on “integer” or office applications.
- The VIA Eden ESP has a much smaller die size (52 mm<sup>2</sup>).
- The VIA Eden ESP has much lower power dissipation at the same operating frequency than its competitors.
- No competitive processor matches the VIA Eden ESP in terms of combined low-power, modest thermal demands, performance, flexible packaging and attractive pricing.

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## 1.5 COMPATIBILITY

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The VIA Eden ESP processor shares much with conventionally packaged x86 siblings. Knowledgeable board designers can leverage their existing designs with the VIA Eden ESP. In most cases, however, a special BIOS is needed. Currently, BIOS support for the VIA Eden ESP is available from Award, AMI, Phoenix, and Insyde.

The VIA Eden ESP processor requires external termination of bus signals. Physical and bus compatibility is covered in more detail in Section 4 of this datasheet.

The VIA Eden ESP supports 3DNow! instructions. The VIA Eden ESP does NOT support multiple processors. These functions are defined as optional by, and are identified to software via, the CUID instruction. The VIA Eden ESP processor carefully follows the protocol for defining the availability of these optional features. Both the additional and omitted optional features are covered in more detail in Section 3 of this datasheet.

To verify compatibility of the VIA Eden ESP with real PC applications and hardware, VIA has performed extensive testing of hundreds of PC boards and peripherals, thousands of software applications, and all known operating systems.

*Indicative of this high compatibility, the VIA Eden ESP has obtained both Windows 98 and Windows NT certification.*



## SECTION

## 2

## ARCHITECTURE

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## 2.1 INTRODUCTION

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The VIA Eden ESP processor architecture can be either that of the VIA Samuel 2 or the VIA Ezra. It is different from any other x86 processor architecture. This unique processor design provides a significantly smaller die size using less power than any other x86 CPU. The VIA Eden ESP processor features cores that lower power, improve performance (MHz and CPI) and further reduces die size and power. (The major differences between the VIA Eden ESP 4000/5000 processor and the VIA Eden ESP 6000 are highlighted in the descriptions below.)

The VIA Eden ESP processor architecture is based on, and directly exploits, basic “facts” about the current x86 market, applications, and bus environment. While seemingly straightforward, these concepts are not exploited in other processor architectures. The major concepts that shape the VIA Eden ESP architecture are:

- **Only a few instructions dominate x86 instruction execution time.** On typical applications, over 90% of instruction execution time is due to a handful of basic x86 instructions. Most x86 instructions have no significant impact on performance.

The VIA Eden ESP processor design optimizes performance of the most important x86 instructions while minimizing the hardware provided for the little-used x86 functions (infrequently used x86 instructions are primarily implemented in microcode). The resulting instruction execution speed of highly used instructions is as good or better than comparable processors. For example, **the VIA Eden ESP processor executes x86 load-ALU-store instructions in only one clock** as compared to several clocks on other processors. The execution time of little-used instructions is impacted to reduce die size, but this has no effect on real application performance.

- **Improving clock frequency has higher leverage than improving CPI.** The result of advanced computer design approaches over the last few years has been that the improvements in cycles-per-instruction (CPI) often impact MHz improvements, and certainly impact die size. Our belief is that the best way to improve total performance and keep a small low-power die is to improve MHz.

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Thus, the VIA Eden ESP family architecture provides improved performance by optimizing MHz via a 12-stage pipeline while maintaining a good CPI. Complex CPI-driven features such as out-of-order instruction execution are not implemented because they (1) impact MHz, (2) require a lot of die area and power, and (3) have little impact on real performance since... (the next point)

- **Memory performance is the limiting CPI performance factor.** In modern PCs, the processor bus is slow compared to the internal clock frequency. Thus, off-chip memory-accesses dominate processor CPI as opposed to internal instruction execution performance.

The VIA Eden ESP processor addresses this phenomenon by providing many specific features designed to reduce bus activity: large primary caches, large TLBs, aggressive prefetching, an efficient level-2 cache (new to the VIA Eden ESP 4000/5000 and 6000), and so forth.

- **Different market segments have different workload characteristics.** The hardware, operating systems, and applications used in fanless PC's, internet appliances, small form factor PC's have different technical characteristics than those in the high-end, workstation, or server market.

The VIA Eden ESP family exploits these differences by implementing very specific design trade-offs, providing high performance with low cost in the target environments. These optimizations are based on extensive analysis of actual behavior of target-market hardware and software.

- **Small is beautiful.** VIA Eden ESP processors are highly optimized for small die size. In addition to the obvious cost benefits, this small size reduces power consumption and improves reliability.

## 2.2 COMPONENT SUMMARY

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### 2.2.1 GENERAL ARCHITECTURE & FEATURES

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Figure 2-1 illustrates the basic 12-stage (integer) pipeline structure of the VIA Eden ESP family. At a high level, there are four major functional groups: *I*-fetch, decode and translate, execution, and data cache.

The *I*-fetch components deliver x86 instruction bytes from the large I-cache or the external bus. Large buffers allow fetching to proceed asynchronously to other operations. The *decode and translate* components convert x86 instruction bytes into internal execution forms. Branches are also identified, predicted, and the targets prefetched. Large buffers allow decoding and translating to proceed asynchronously to other operations. The *execution* components issue, execute, and retire internal instructions. The *data cache* components manage the efficient loading and storing of execution data to and from the caches, bus, and internal components.

At one level the VIA Eden ESP processor architecture seems simple: instructions are issued, executed, and retired in order, only one instruction can be issued per clock, and most data cache misses stall the pipeline. However, the design is actually highly optimized and highly tuned to achieve high performance in the targeted environment. Some of the significant features providing this performance are:

- **High internal clock frequency.** The 12-stage pipeline facilitates high MHz
- **Large on-chip caches and TLBs.** The VIA Eden ESP implements large caches and TLBs that significantly reduce stalls due to bus traffic. These primary caches and TLBs are larger than those on any other x86 processor:
  - Two 64-KB primary (L1) caches with 4-way associativity
  - A 4-way 64-KB unified level-2 (L2) cache
  - Two 128-entry TLBs with 8-way associativity

- Two 8-entry page directory caches that effectively eliminate loads of page directory entries upon TLB misses
  - A four-entry (8 bytes each) store queue that also forwards store data to subsequent loads
  - A four-entry write buffer that also performs write combining
- **Extensive features to further minimize bus stalls. These include:**
- Full memory type range registers (MTRRs)
  - A non-stalling write-allocate implementation
  - Implementation of the “cache lock” feature
  - Non-blocking out-of-order retirement of pipeline stores
  - Implementation of x86 prefetch instruction (3DNow!)
  - Implicit speculative *data* prefetch into D-cache
  - Aggressive implicit instruction prefetch into I-cache
  - Highly asynchronous execution with extensive queuing to allow fetching, decoding and translating, executing, and data movement to proceed in parallel
- **High-performance bus implementation.** The VIA Eden ESP socket 370 compatible bus implementation includes the following performance enhancements:
- No stalls on snoops
  - Up to 8 transactions can be initiated by the processor
  - Aggressive write pipelining
  - Smart bus allocation prioritization
  - 100MHz and 133MHz bus operation
- **Good performance for highly used instructions.** Heavily used instructions—including complex functions such as protect-mode segment-register loads and string instructions—are executed fast. In particular, the pipeline is arranged to provide one-clock execution of the heavily used register-memory and memory-register forms of x86 instructions. Many instructions require fewer pipeline clocks than on comparable processors.

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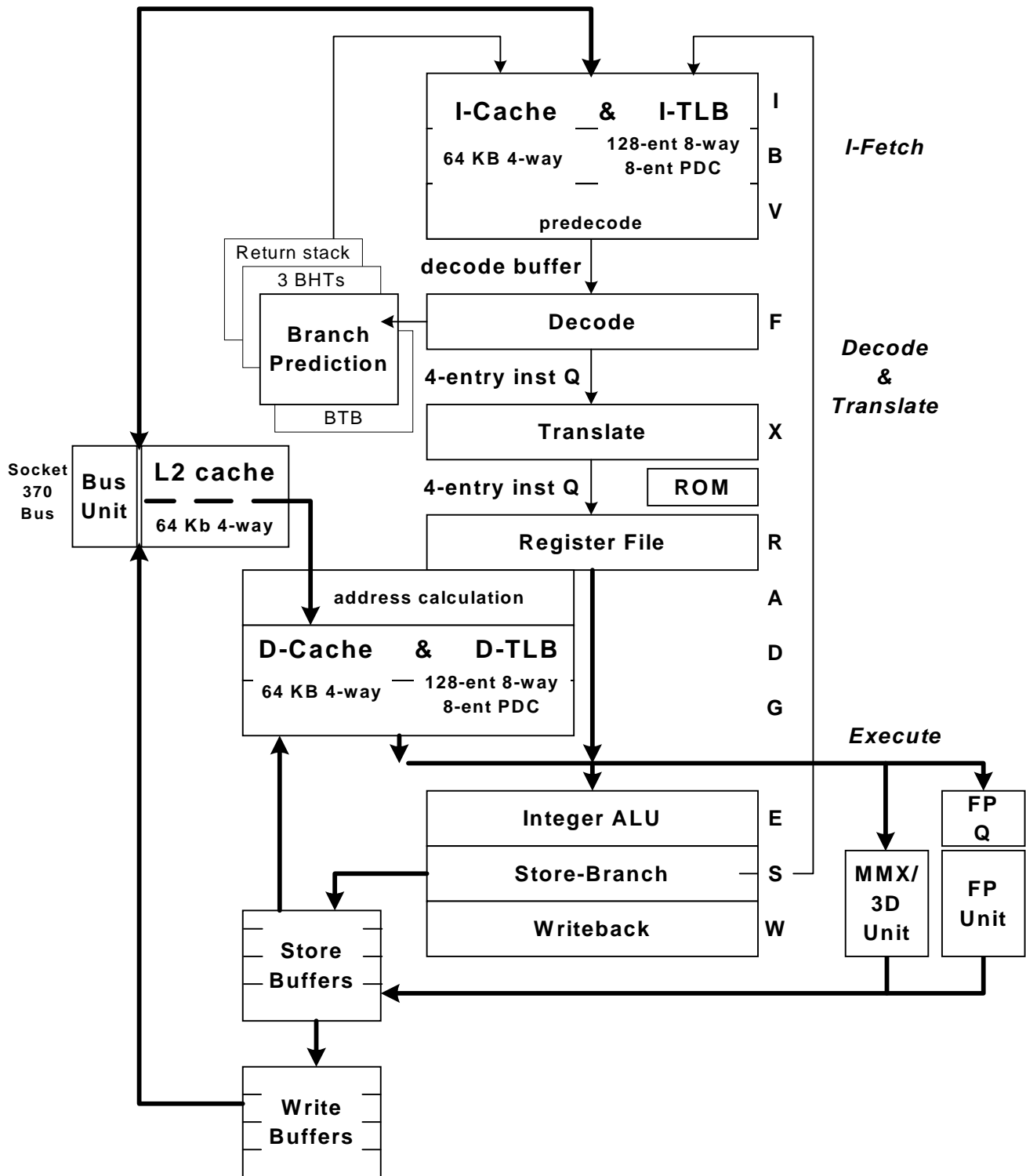


Figure 2-1. The VIA Eden ESP Processor Pipeline Structure

### 2.2.2 INSTRUCTION FETCH

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The first three pipeline stages (I, B, V) deliver aligned instruction data from the I-cache or external bus into the instruction decode buffers. These stages are fully pipelined such that on each clock cycle a new instruction fetch address is fetched from the I-cache and either 16 bytes (I-cache) or 8-bytes (bus) of instruction data is delivered for decode.

The primary I-cache contains 64 KB organized as four-way set associative with 32-byte lines. The associated large I-TLB contains 128 entries organized as 8-way set associative. In addition, the I-TLB includes an eight-entry page directory cache that significantly reduces the TLB miss penalty. The cache, TLB, and page directory cache all use a pseudo-LRU replacement algorithm.

As opposed to many other contemporary x86 processors, the data in the I-cache is exactly what came from the bus; that is, there are no “hidden” predecode bits. This allows a large cache capacity in a small physical size. The instruction data is predecoded as it comes out of the cache; this predecode is overlapped with other required operations and, thus, effectively takes no time.

The fetched instruction data is placed sequentially into multiple buffers. Starting with a branch, the first branch-target byte is left adjusted into the instruction decode buffer (the *XIB*). As instructions are decoded, they are removed from the *XIB*. Each clock, new incoming fetch data is concatenated with the remaining data in the *XIB*. Once the *XIB* is filled, fetching continues to fill three 16-byte buffers that feed the *XIB*.

If an I-cache miss occurs during the filling of the fetch buffers, up to four 32-byte lines are speculatively prefetched from the external bus into the cache. These prefetches are pipelined on the bus for optimal bus efficiency. This aggressive prefetch algorithm exploits the large size and four-way structure of the I-cache, as well as the high-bandwidth bus implementation.

### 2.2.3 INSTRUCTION DECODE

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Instruction bytes in the *XIB* are decoded and translated into the internal format by two pipeline stages (F, X). These units are fully pipelined such that, in general, an x86 instruction is decoded and translated every clock cycle.

The F stage decodes and “formats” an x86 instruction (completely contained in the *XIB*) into an intermediate x86 format. This process requires only one clock cycle for every x86 instruction. However, instruction prefixes other than 0F require an additional cycle for each prefix. The internal-format instructions are placed into a five-deep FIFO queue: the *FIQ*. The *FIQ* facilitates the asynchronous fetch and “lookahead” capability of the formatter such that the extra cycles for prefixes rarely result in a bubble in the execution pipeline. The *FIQ* also allows for branch prediction to proceed even if the pipeline ahead of the branch is stalled.

The X-stage “translates” an intermediate-form x86 instruction from the *FIQ* into the internal micro-instruction format. The output of the translator contains: (1) the internal micro-instruction stream to perform the x86 instruction function, (2) the immediate data fields from the x86 instruction, and (3) various x86 state information used to control execution (for example, operand size). The internal micro-instruction stream consists of micro-instructions directly generated by the translator plus, in some cases, an on-chip ROM address. The translator can generate up to three micro-instructions per clock plus a ROM address. Most x86 instructions except for repetitive string operations are translated in one clock.

Executable micro-instructions can come from either the *XIQ* or the on-chip ROM. For performance-sensitive instructions, there is no delay due to access of micro-code from ROM. The microcode ROM capacity is larger than most x86 microcode ROMs to allow unimportant (relative to performance) func-

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tions to be performed in microcode (versus in hardware). The large size also allows the inclusion of extensive self-test microcode and extensive built-in debugging aids (for processor design debug).

Instruction fetch, decode, and translation are made asynchronous from execution via a five-entry FIFO queue (the *XIQ*) between the translator and the execution unit. This queue allows the formatter and translator to “look-ahead” and continue translating x86 instructions even though the execution unit is stalled.

## 2.2.4 BRANCH PREDICTION

The VIA Eden ESP processor implements a very unique and sophisticated, yet relatively small, branch prediction mechanism. Several different mechanisms predict all basic types of branches: jumps and calls using a displacement, returns, indirect jumps and calls, and “far” (inter-segment) branches (new to the VIA Ezra core). These types of jumps represent almost 25% of all instructions executed.

The prediction starts when the branch is decoded in the F stage. If a branch is predicted taken, the target is fetched such that a four-clock “bubble” appears to occur. In practice however, this bubble averages less than two clocks due to the extensive instruction queuing below the F stage; the delay in fetching the predicted branch target is absorbed by execution of these queued instructions. There is also a special case: short forward branches that “hit” in the XIB require only one clock delay.

For displacement-from branches, the target address is directly calculated. This direct calculation of the target address eliminates the need for a large branch-target buffer (a *BTB* or *BTAC*). The direct calculation always produces the correct address whereas a BTB often mispredicts the address, or fails to predict at all.

Two different prediction algorithms are used to predict the direction of conditional branches. The underlying theory behind this approach is that, in practice, branches tend to fall into two categories. Most branches can be accurately predicted by a classic mechanism using a counter associated with the branch location. The associated VIA Eden ESP processor mechanism is a simple array of predictors 4K in the Samuel 2 core.

However, about 20% of branches are hard to predict, because whether they branch or not depends on dynamic execution state. The VIA Eden ESP processor mechanism for predicting these pattern-based branches uses a 13-bit global branch history XOR'd with the branch instruction address to index a branch history table with 8K entries in the Ezra core versus 4K in the Samuel 2 core. This branch-history mechanism is called *g-share* in the technical literature. A third 4K-entry table selects which predictor (simple or history-based) to use for a particular branch based on the previous behavior of the branch.

All three predictor tables actually use a one-bit “agree/disagree” predictor rather than the conventional two-bit counter. This unique approach uses a static predictor that considers the type of conditional branch and what type of instruction previously set the condition flag being tested. Rather than indicate taken or not, the one-bit entry in the predictor tables predicts whether the conditional branch direction agrees with the static prediction. The static predictor is accurate about 70% of the time, and the dynamic predictor is accurate about 95% of the time.

In addition, x86 return instructions are predicted by a 16-entry return-address stack. This prediction is about 90% accurate.

Finally, indirect jump and call instructions are predicted using a conventional 64-entry (4-way) in the Samuel 2 core. This small array predicts about 75% of indirect branches correctly. The BTB is also used to predict inter-segment (“far”) branches.

## 2.2.5 INTEGER UNIT

Internal micro-instructions are executed in a tightly coupled seven-stage (integer) pipeline that is similar in structure to a basic four-stage RISC pipeline with extra stages for memory loads and stores inserted. These extra stages allow instructions that perform a load and ALU operation, or a load, ALU, and store operation to execute in one clock.

The micro-instructions and associated execution units are highly tuned for the x86 architecture. The micro-instructions closely resemble highly used x86 instructions. Examples of specialized hardware features supporting the x86 architecture are: hardware handling of the x86 condition codes, segment descriptor manipulation instructions, and hardware to automatically save the x86 floating-point environment.

The integer execution stages are:

- **Decode stage (R):** Micro-instructions are decoded, integer register files are accessed and resource dependencies are evaluated.
- **Addressing stage (A):** Memory addresses are calculated and sent to the D-cache. The VIA Eden ESP processor is capable of calculating most x86 instruction address forms in one clock; a few forms containing two registers or a shifted index register require two clocks. Addresses can be automatically incremented or decremented for implementing stack and string operations.

Some ALU operations are duplicated in this stage to reduce AGI (address generation interlock) stalls. For example, the sequence of adding to the stack pointer register followed by using it in a return does not cause an AGI. In general, register adds and moves are performed in the A-stage.

- **Cache Access stages (D, G):** The D-cache and D-TLB are accessed and aligned load data returned at the end of the G-stage. The cache is fully pipelined such that a new load or store can be started and data returned each clock.
- **Execute stage (E):** Integer ALU operations are performed. All basic ALU functions take one clock except multiply and divide. Load-ALU and Load-ALU-store instructions require only one clock (the data is loaded before the ALU stage). Results from the ALU can be forwarded to any instruction following the ALU instruction using a unique result-forwarding cache.

Branch instructions are evaluated in this stage and, if incorrectly predicted, the corrected branch address is sent to the I-cache during the next clock. No additional action is required for correctly predicted branches.

During this stage the floating-point, MMX, and 3DNow! execution units access their registers or consume the load data just delivered. These execution units “hang off” the end of the main execution unit so that load-ALU operations for these units can be pipelined in one clock.

- **Store stage (S):** Integer store data is grabbed in this stage and placed in a store buffer. Positioning stores in this stage allows a one-clock load-ALU-store instruction. MMX and floating-point stores, however, are placed in the store buffer in a subsequent cycle due to their deep pipelines.
- **Write-back stage (W):** The results of operations are committed to the register file.

## 2.2.6 D-CACHE & DATAPATH

The D-cache contains 64 KB organized as four-way set associative with 32-byte lines. The associated large D-TLB contains 128 entries organized as 8-way set associative. In addition, the D-TLB includes an eight-entry page directory cache that significantly reduces the TLB miss penalty. The cache, TLB, and page directory cache all use a pseudo-LRU replacement algorithm.

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Associated with the D-cache are store and write buffers. All stores that pass the W-stage are placed in a four-entry store buffer (8 bytes each). Stores from the store buffer are drained to the D-cache or bus in actual program order, regardless of when the data appeared in the store buffers. Stores that miss the D-cache percolate to the write buffers where they wait for the bus. If the memory region is defined as write-combining, the stores can combine in the write buffers.

## 2.2.7 L2 CACHE

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The VIA Eden ESP processor contains an efficient level-2 cache. This L2 cache is *exclusive* (this approach is sometimes called a “victim” cache). This means that the contents of the L2 cache at any point in time are not contained in the two 64-KB L1 caches. As lines are displaced from the L1 caches (due to bringing in new lines from memory), the displaced lines are placed in the L2 cache. Thus, a future L1-cache miss on this displaced line can be satisfied by returning the line from the L2 cache instead of having to access the external memory.

Thus, the total effective cache size on the VIA Eden ESP processor is 192 KB (two 64-KB L1 caches and the 64-KB L2). Processors, such as the Intel Celeron processor, that have an *inclusive* L2 cache have a total effective cache size equal to the L2 size (128 KB in the case of the current Intel Celeron processor). This is because the contents of the L1 caches are duplicated within an inclusive L2 cache.

The L2 cache is also “unified;” that is, it contains lines displaced from both the L1 I-cache and the L1 D-cache. Thus the L2 cache provides a significant assist for the cases where an I-fetch hits in the L1 data cache, or a data reference hits in the L1 I-cache. To provide correct execution semantics, these cases require the hit line to be ejected from the L1 cache.

The VIA Eden ESP processor L2 cache is 64 KB organized as four-way set associative with 32-byte lines and uses a pseudo-LRU replacement algorithm.

## 2.2.8 FP UNIT

---

In addition to the integer execution unit, the VIA Eden ESP processor has a separate 80-bit floating-point execution unit that can execute x86 floating-point instructions in parallel with integer instructions. Since the VIA Eden ESP processor is designed for mainstream applications that stress integer performance, floating-point throughput is not a priority. The FP unit is clocked at  $\frac{1}{2}$  the processor clock speed; that is, in an 800-MHz VIA Eden ESP, the FP-unit runs at 400 MHz.

Floating-point instructions proceed through the integer R, A, D, and G stages. Thus, load-ALU x86 floating-point instructions do not require an extra clock for the load. Floating-point instructions are then passed from the integer pipeline to the FP-unit through an 8-instruction FIFO queue (new to the VIA Eden ESP). This queue, which runs at the processor clock speed, decouples the slower running FP unit from the integer pipeline so that the integer pipeline can continue to process instructions overlapped with up to eight FP instructions.

Basic arithmetic floating-point instructions (add, multiply, divide, square root, compare, etc.) are represented by a single internal floating-point instruction. Certain little-used and complex floating point instructions (sin, tan, etc.), however, are implemented in microcode and are represented by a long stream of instructions coming from the ROM. These instructions “tie up” the integer instruction pipeline such that integer execution cannot proceed until they complete.

One floating-point instruction can issue from the FP queue to the FP unit every two clocks. The FP pipeline is six-stages deep following the E stage. It is partially pipelined: a non-dependent add or multiply can start every two clocks.



---

### 2.2.9 MMX UNIT

---

The VIA Eden ESP processor contains a separate execution unit for the MMX-compatible instructions. MMX instructions proceed through the integer R, A, D, and G stages. Thus, load-ALU x86 MMX instructions do not require an extra clock for the load. One MMX instruction can issue into the MMX unit every clock.

The MMX multiplier is fully pipelined and can start one non-dependent MMX multiply[-add] instruction (which consists of up to four separate multiplies) every clock. Other MMX instructions execute in one clock. Multiplies followed by a dependent MMX instruction require two clocks.

Architecturally, the MMX registers are the same as the floating-point registers. However, there are actually two different register files (one in the FP-unit and one in the MMX units) that are kept synchronized by hardware.

---

### 2.2.10 3DNow! UNIT

---

The VIA Eden ESP processor contains a separate execution unit for the 3DNow! instructions. These instructions are compatible with the AMD K6-II™ processor 3DNow! instructions and provide performance assists for graphics transformations via new SIMD single-precision floating-point capabilities. 3DNow! instructions proceed through the integer R, A, D, and G stages. Thus, load-ALU x86 3DNow! instructions do not require an extra clock for the load. One 3DNow! instruction can issue into the 3DNow! unit every clock.

The 3DNow! unit has two single-precision floating-point multipliers and two single-precision floating-point adders. Other functions such as conversions, reciprocal, and reciprocal square root are provided.

The multiplier and adder are fully pipelined and can start any non-dependent 3DNow! instruction every clock.

---

### 2.2.11 BUS UNIT

---

The VIA Eden ESP bus unit provides an external bus interface, supporting bus speeds of 100 MHz and 133 MHz.

The VIA Eden ESP processor bus implementation has no stalls on snoops, up to eight transactions can be generated (versus four), and stores are more heavily pipelined on the bus.

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### 2.2.12 POWER MANAGEMENT

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Power management is not a component but rather a pervasive feature in all components. There are two major modes: powering down components based on bus signals such as stop clock and sleep, and dynamically powering off components during execution when they are not needed.

The VIA Eden ESP processor implements the bus-controlled power management modes including: auto-HALT power down state, stop grant state, sleep state, and deep sleep, or stop clock, state.

While in normal running state, all major functional components are powered off when not in use. All caches, tags and TLBs are turned on and off on a clock-by-clock basis based on their usage. Other major components such as the MMX unit, the 3DNow! unit, the FP unit, and the ROM are turned on and off as used. In addition, even in blocks that are powered up, internal buses and latches hold their values when not needed to reduce dynamic power consumption.



## SECTION

## 3

# PROGRAMMING INTERFACE

## 3.1 GENERAL

---

The VIA Eden ESP processor's functions include:

- All basic x86 instructions, registers, and functions
- All floating-point (numeric processor) instructions, registers and functions
- All basic operating modes: real mode, protect mode, virtual-8086 mode
- System Management Interrupt (SMI) and the associated System Management Mode (SMM)
- All interrupt and exception functions
- All debug functions (including the new I/O breakpoint function)
- All input/output functions
- All tasking functions (TSS, task switch, etc.)
- Processor initialization behavior
- Page Global Enable feature

*The VIA Eden ESP processor, in addition to the MMX instructions, also includes instructions to boost the performance of 3D graphics compatible with the AMD 3DNow! Technology.*

However, there are some differences between the VIA Eden ESP and the Celeron processor. These differences fall into three groups:

- **Implementation-specific differences.** Examples are cache and TLB testing features, and performance monitoring features that expose the internal implementation features. These types of functions are incompatible among *all* different x86 implementations.

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- **Omitted functions.** Some Intel Celeron processor functions are not provided on the VIA Eden ESP processor because they are not used or are not needed in the targeted PC systems. Examples are some specific bus functions such as functional redundancy checking and performance monitoring. Other examples are architectural extensions such as support for 4-MByte pages, Page Attribute Tables, etc.

These types of differences are similar to those among various versions of the processors. The CPUID instruction is used by system software to determine whether these features are supported.

- **Low-level behavioral differences.** A few low-level VIA Eden ESP processor functions are different from Intel Celeron because the results are (1) documented in the documentation as *undefined*, and (2) known to be different for different x86 implementations. That is, compatibility with the Intel Celeron processor for these functions is clearly not needed for software compatibility (or they would not be different across different implementations).
- **EBGA package.** The VIA Eden ESP processor is exclusively produced in its advanced, inexpensive, compact and thermally efficient EBGA package.

This chapter summarizes the first three types of differences: additional functions, implementation-specific functions, and omitted functions. *Appendix A* contains more details on machine-specific functions.

## 3.2 ADDITIONAL FUNCTIONS

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The VIA Eden ESP processor includes AMD-compatible 3DNow! instructions to boost the performance of 3D applications. These instructions are not defined in this datasheet but are defined in the appropriate AMD documentation.

## 3.3 MACHINE-SPECIFIC FUNCTIONS

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### 3.3.1 GENERAL

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All x86 processor implementations provide a variety of *machine-specific functions*. Examples are cache and TLB testing features and performance monitoring features that expose the internal implementation features.

This section describes the VIA Eden ESP processor machine-specific functions that are most likely used by software, and compares them to related processors where applicable. *Appendix A* describes the VIA Eden ESP machine-specific registers (*MSRs*).

This section covers those features of Intel Pentium-compatible processors that are used to commonly identify and control processor features. All Pentium-compatible processors have the same mechanisms, but the bit-specific data values often differ.

### 3.3.2 STANDARD CPUID INSTRUCTION FUNCTIONS

---

The CPUID instruction is available on all contemporary x86 processors. The CPUID instruction has two standard functions requested via the EAX register. The first function returns a vendor identification string in registers EBX, ECX, and EDX. The second CPUID function returns an assortment of bits in EAX and EDX that identify the chip version and describe the specific features available.

The EAX:EBX:ECX:EDX return values of the CPUID instruction executed with EAX == 0 are:

**Table 3-1. CPUID Return Values (EAX = 0)**

| <b>REGISTER[BITS] – MEANING</b>                      | <b>VIA EDEN ESP</b> |
|------------------------------------------------------|---------------------|
| EAX<br>(highest EAX input value understood by CPUID) | 1                   |
| EBX:EDX:ECX<br>(vendor ID string)                    | “Centaur Hauls”     |

The EAX return values of the CPUID instruction executed with EAX == 1 are:

**Table 3-2. CPUID EAX Return Values (EAX = 1)**

| <b>EAX BITS - MEANING</b> | <b>VIA EDEN ESP</b>                                            |
|---------------------------|----------------------------------------------------------------|
| 3:0 - Stepping ID         |                                                                |
| 7:4 - Model ID            | Same as the return value in EDX after Reset (see next section) |
| 11:8 - Family ID          |                                                                |
| 13:12 – Type ID           |                                                                |

The EDX return values of the CPUID instruction with EAX == 1 are:

**Table 3-3 CPUID EDX Return Values (EAX = 1)**

| <b>EDX BITS – MEANING</b>                | <b>VIA EDEN</b> | <b>NOTES</b> |
|------------------------------------------|-----------------|--------------|
| 0 - FPU present                          | 1               |              |
| 1 - Virtual Mode Extension               | 0               |              |
| 2 - Debugging Extensions                 | 1               |              |
| 3 - Page Size Extensions (4MB)           | 0               |              |
| 4 - Time Stamp Counter (TSC) supported   | 1               |              |
| 5 - Model Specific Registers present     | 1               |              |
| 6 - Physical Address Extension           | 0               |              |
| 7 - Machine Check Exception              | 0/1             |              |
| 8 - CMPXCHG8B instruction                | 0/1             | 1            |
| 9 - APIC supported                       | 0               | 2            |
| 10- Reserved                             |                 |              |
| 11- Fast System Call                     | 0               |              |
| 12- Memory Range Registers               | 1               |              |
| 13 - PTE Global Bit supported            | 1/0             | 3            |
| 14- Machine Check Architecture supported | 0               |              |
| 15- Conditional Move supported           | 0               |              |

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| <i>EDX BITS – MEANING</i>              | <i>VIA EDEN</i> | <i>NOTES</i> |
|----------------------------------------|-----------------|--------------|
| 16- Page Attribute Table               | 0               |              |
| 17- 36-bit Page Size Extension         | 0               |              |
| 18- Processor serial number            | 0               |              |
| 19:22 – Reserved                       |                 |              |
| 23- MMX supported                      | 1               |              |
| 24- FXSR                               | 0               |              |
| 25- Streaming SIMD Extension supported | 0               |              |
| 26:31 – Reserved                       |                 |              |

**Notes On CPUID Feature Flags:**

General: an “x/y” entry means that the default setting of this bit is x but the bit (and the underlying function) can be set to y using the FCR MSR.

1. The CMPXCHG8B instruction is provided and always enabled, however, it appears disabled in the corresponding CPUID function bit 0 to avoid a bug in an early version of Windows NT. However, this default can be changed via a bit in the FCR MSR.
2. SMP is not supported, it has no utility in the target system environment.
3. The VIA Eden ESP processor’s support for Page Global Enable can be enabled or disabled by a bit in the FCR. The CPUID bit reports the current setting of this enable control.

### 3.3.3 EXTENDED CPUID INSTRUCTION FUNCTIONS

The VIA Eden ESP supports extended CPUID functions. These functions provide additional information about the VIA Eden ESP. Extended CPUID functions are requested by executing CPUID with EAX set to any value in the range 0x80000000 through 0x80000005.

The following table summarizes the extended CPUID functions.

**Table 3-4. Extended CPUID Functions**

| <i>EAX</i> | <i>TITLE</i>                          | <i>OUTPUT</i>                                                                                                        |
|------------|---------------------------------------|----------------------------------------------------------------------------------------------------------------------|
| 80000000   | Largest Extended Function Input Value | EAX=80000006<br>EBX,ECX,EDX=Reserved                                                                                 |
| 80000001   | Processor Signature and Feature Flags | EAX=Processor Signature<br>EBX,ECX=Reserved<br>EDX=Extended Feature Flags                                            |
| 80000002   | Processor Name String                 | EAX,EBX,ECX,EDX                                                                                                      |
| 80000003   | Processor Name String                 | EAX,EBX,ECX,EDX                                                                                                      |
| 80000004   | Processor Name String                 | EAX,EBX,ECX,EDX                                                                                                      |
| 80000005   | TLB and L1 Cache Information          | EAX = Reserved<br>EBX = TLB Information<br>ECX = L1 Data Cache Information<br>EDX = L1 Instruction Cache Information |
| 80000006   | L2 Cache Information                  | EAX, EBX, EDX = Reserved<br>ECX = L2 Cache Information                                                               |

#### **Largest Extended Function Input Value (EAX==0x80000000)**

Returns 0x80000006 in EAX, the largest extended function input value.

#### **Processor Signature and Feature Flags (EAX==0x80000001)**

Returns processor version information in EAX, this value is identical to the value of EDX after RESET.

Returns feature flags in EDX, this value is identical to the value in EDX after CPUID standard function 1, with the exception of bit 31:

EDX[31]=0 3DNow! instructions not supported.

EDX[31]=1 3DNow! instructions supported.

Note that if FCR[20]=0 then 3DNow! instructions are not supported and EDX[31] will be 0.

#### **Processor Name String (EAX==0x80000002–0x80000004)**

Returns the name of the processor, suitable for BIOS to display on the screen (ASCII). The string can be up to 48 characters in length. If the string is shorter, the rightmost characters are padded with zero. The leftmost characters go in EAX, then EBX, ECX, and EDX. The leftmost character goes in least significant byte (little endian).

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For example, the string “VIA Ezra” would be returned by extended function EAX=0x80000002 as follows:

EAX = 0x20414956

EBX = 0x61727A45

ECX = 0x00000000

EDX = 0x00000000

Since the string is less than 17 bytes, the extended functions EAX=0x80000003 and EAX=0x80000004 return zero in EAX, EBX, ECX, and EDX.

### L1 Cache Information (EAX == 0x80000005)

Returns information about the implementation of the TLBs and caches:

**Table 3-5. L1 Cache & TLB Configuration Encoding**

| REGISTER   | DESCRIPTION                      | VALUE |
|------------|----------------------------------|-------|
| EAX        | Reserved                         |       |
| EBX        | TLB Information                  |       |
| EBX[31:24] | D-TLB associativity              | 8     |
| EBX[23:16] | D-TLB # entries                  | 128   |
| EBX[15: 8] | I-TLB associativity              | 8     |
| EBX[ 7: 0] | I-TLB # entries                  | 128   |
| ECX        | L1 Data Cache Information        |       |
| ECX[31:24] | Size (Kbytes)                    | 64    |
| ECX[23:16] | Associativity                    | 4     |
| ECX[15: 8] | Lines per Tag                    | 1     |
| ECX[ 7: 0] | Line Size (bytes)                | 32    |
| EDX        | L1 Instruction Cache Information |       |
| EDX[31:24] | Size (Kbytes)                    | 64    |
| EDX[23:16] | Associativity                    | 4     |
| EDX[15: 8] | Lines per Tag                    | 1     |
| EDX[ 7: 0] | Line Size (bytes)                | 32    |

### L2 Cache Information (EAX == 0x80000006)

Returns information about the implementation of the L2 cache:

**Table 3-6. L2 Cache Configuration Encoding**

| REGISTER      | DESCRIPTION | VALUE |
|---------------|-------------|-------|
| EAX, EBX, EDX | Reserved    |       |



| ECX        | L2 Data Cache Information |    |
|------------|---------------------------|----|
| ECX[31:24] | Size (Kbytes)             | 64 |
| ECX[23:16] | Associativity             | 4  |
| ECX[15: 8] | Lines per Tag             | 1  |
| ECX[ 7: 0] | Line Size (bytes)         | 32 |

### 3.3.4 PROCESSOR IDENTIFICATION

The VIA Eden ESP processor provides several machine-specific features. These features are identified by the standard CPUID function EAX=1.

Other machine-specific features are controlled by VIA Eden ESP processor MSRs. Some of these features are not backward-compatible with the predecessors in the IDT WinChip family.

System software must not assume that all future processors in the VIA processor family will implement all of the same machine-specific features, or even that these features will be implemented in a backward-compatible manner. In order to determine if the processor supports particular machine-specific features, system software should follow the following procedure.

Identify the processor as a member of the VIA processor family by checking for a Vendor Identification String of "CentaurHauls" using CPUID with EAX=0. Once this has been verified, system software must determine the processor version in order to properly configure the machine-specific registers.

In general system software can determine the processor version by comparing the Family and Model Identification fields returned by the CPUID standard function EAX=1.

If the processor version is not recognized then system software must not attempt to activate any machine-specific feature.

### 3.3.5 EDX VALUE AFTER RESET.

After reset the EDX register holds a component identification number as follows:

|            | 31:14    | 13:12   | 11:8      | 7:4      | 3:0         |
|------------|----------|---------|-----------|----------|-------------|
| <b>EDX</b> | Reserved | Type ID | Family ID | Model ID | Stepping ID |
|            | 18       | 2       | 4         | 4        | 4           |

The specific values for the VIA Eden ESP 4000/5000/6000 are:

| PROCESSOR                          | TYPE ID | FAMILY ID | MODEL ID | STEPPING ID |
|------------------------------------|---------|-----------|----------|-------------|
| VIA Eden ESP<br>4000 / 5000 / 6000 | 0       | 6         | 7        | Begins at 0 |

The specific values for the VIA Eden ESP 8000 are:

| PROCESSOR            | TYPE ID | FAMILY ID | MODEL ID | STEPPING ID |
|----------------------|---------|-----------|----------|-------------|
| VIA Eden ESP<br>8000 | 0       | 6         | 9        | Begins at 0 |

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### 3.3.6 CONTROL REGISTER 4 (CR4)

Control register 4 (CR4) controls some of the advanced features of the Celeron processor. The VIA Eden ESP provides a CR4 with the following specifics:

**Table 3-7. CR4 Bits**

| CR4 BITS – MEANING                             | VIA EDEN | CELERON MODEL 6 | CELERON MODEL 8 | NOTES |
|------------------------------------------------|----------|-----------------|-----------------|-------|
| 0: VME: Enables VME feature                    | 0        | 0/1             | 0/1             | 1     |
| 1: PVI: Enables PVI feature                    | 0        | 0/1             | 0/1             | 1     |
| 2: TSD: Makes RDTSC inst privileged            | 0/1      | 0/1             | 0/1             |       |
| 3: DE: Enables I/O breakpoints                 | 0/1      | 0/1             | 0/1             |       |
| 4: PSE: Enables 4-MB pages                     | 0        | 0/1             | 0/1             | 1     |
| 5: PAE: Enables address extensions             | r        | r               | r               |       |
| 6: MCE: Enables machine check exception        | 0/1      | 0/1             | 0/1             | 2     |
| 7: PGE: Enables global page feature            | 0/1      | 0/1             | 0/1             |       |
| 8: PCE: Enables RDPMC for all levels           | 0/1      | 0/1             | 0/1             |       |
| 9: OSFXSR: Enables FXSAVE//FXRSTOR Support     | r        | r               | 0/1             |       |
| 10: OSXMMEXCPT: O/S Unmasked Exception Support | r        | r               | 0/1             |       |
| 31:11 – reserved                               | r        | r               | r               |       |

#### Notes On CR4

General: a “0/1” means that the default setting of this bit is 0 but the bit can be set to (1). A “0” means that the bit is always 0; it cannot be set. An “r” means that this bit is reserved. It appears as a 0 when read, and a GP exception is signaled if an attempt is made to write a 1 to this bit.

1. The VIA Eden ESP processor does not provide this “Appendix H” function and this CR4 bit cannot be set. However, no GP exception occurs if an attempt is made to set this bit. The Cyrix 6x86MX processor also does not provide this function.
2. The VIA Eden ESP processor Machine Check has different specifics than the Machine Check function of compatible processors.

### 3.3.7 MACHINE-SPECIFIC REGISTERS

The VIA Eden ESP processor implements the concept of Machine Specific Registers (MSRs). RDMSR and WRMSR instructions are provided and the CPUID instruction identifies that the VIA Eden ESP processor supports MSRs.

In general, the MSRs have no usefulness to application or operating system software and are not used. (This is to be expected since the MSRs are different on each processor.) *Appendix A* contains a detailed description of the VIA Eden ESP’s MSRs.

---

### 3.4 OMITTED FUNCTIONS

---

This section summarizes those functions that are not in the VIA Eden ESP processor.

#### **Symmetric Multiprocessing Support: APIC**

This bus function is omitted since the target market for the VIA Eden ESP processor is small form factor PC's, internet appliances, and fanless PC's.

A bit in the feature identification returned from the CPUID instruction indicates whether this feature is present or not. This enhancement is not provided on the VIA Eden ESP processor.

#### **Other Functions**

There are other functions that are not implemented in the VIA Eden ESP processor. These are identified accordingly in the CPUID feature flags, Conditional Move instructions, Page Attribute Tables, 4-Mbyte pages, 36-bit Page Size Extension, and FXSAVE/FXRSTOR instructions.

The VIA Eden ESP processor contains a 64KB L2 cache. Model specific registers pertaining to the L2 cache are detailed in Appendix A. Model specific registers pertaining to APIC, Machine Check, and Debug and Trace features are not supported.



## SECTION

## 4

# HARDWARE INTERFACE

## 4.1 BUS INTERFACE

---

The VIA Eden ESP bus interface is functionally similar to the Socket 370 interface.

The majority of the balls within the bus interface are involved with the physical memory and I/O interface. The remaining balls are for power and ground, test and debug support, and various ancillary control functions. The balls and associated functions are listed and described in this section.

### 4.1.1 DIFFERENCES

---

The areas where the VIA Eden ESP processor differs from compatible processors should not cause operational compatibility issues. These differences are:

- Bus-to-core Ratio Control
- Bus Frequency Control
- Probe Mode / JTAG / TAP Port (see *Test and Debug Section*)

#### **Bus-to-Core Frequency Ratio Control**

The VIA Eden ESP processor supports both fused and software control of the bus-to-core frequency ratio. At reset, the factory-set, fused ratio is used. This ratio can then be adjusted via software. This adjustment lasts until the next reset.

Software can adjust the bus-to-core ratio using the VIA Eden ESP processor's LongHaul extensions. These are documented separately in the VIA LongHaul Specification.

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### Bus Frequency Selection

The VIA Eden ESP processor supports automated bus frequency selection through the BSEL balls. The BSEL balls are used as a mechanism whereby the processor and the system board can negotiate to support high frequency bus frequencies. The standard BSEL decoding is shown in Table 4-1.

While the VIA Eden ESP processor is designed to operate at bus frequencies of 66, 100, or 133 MHz, performance is improved by running at higher bus frequencies. Various speed bins preclude 133 MHz operation because the available bus-to-core ratios do not permit operation at the desired core MHz.

Processors from these speed bins indicate this by shorting the BSEL[1] ball to ground internal to the package. For these processors the BSEL[0] ball is left floating. Processors from speed bins which permit 133 MHz bus operation indicate this by allowing both BSEL[1] and BSEL[0] to float.

It is anticipated that motherboards will pull up both BSEL balls. The resulting BSEL-indicated bus frequency will then be either 100 MHz or 133 MHz according to speed bin. Bus operation at 66MHz is not desirable.

**Table 4-1. BSEL Frequency Mapping**

| <i>BSEL[1]</i> | <i>BSEL[0]</i> | <i>BUS FREQUENCY</i> |
|----------------|----------------|----------------------|
| 0              | 0              | 66 MHz               |
| 0              | 1              | 100 MHz              |
| 1              | 0              | Reserved             |
| 1              | 1              | 133 MHz              |

## 4.1.2 CLARIFICATIONS

### Power Supply Voltage

The VIA Eden ESP automatically controls its core processor power supply voltage with the VID balls.

The VID mapping for the VIA Eden ESP is in Table 4-2. This mapping corresponds to the VRM8.5 specification.

Table 4-2. Core Voltage Settings

| VID4 | VID3 | VID2 | VID1 | VID0 | VCORE  |
|------|------|------|------|------|--------|
| 0    | 0    | 1    | 0    | 0    | 1.050V |
| 1    | 0    | 1    | 0    | 0    | 1.075V |
| 0    | 0    | 0    | 1    | 1    | 1.100V |
| 1    | 0    | 0    | 1    | 1    | 1.125  |
| 0    | 0    | 0    | 1    | 0    | 1.150V |
| 1    | 0    | 0    | 1    | 0    | 1.175V |
| 0    | 0    | 0    | 0    | 1    | 1.200V |
| 1    | 0    | 0    | 0    | 1    | 1.225V |
| 0    | 0    | 0    | 0    | 0    | 1.250V |
| 1    | 0    | 0    | 0    | 0    | 1.275V |
| 0    | 1    | 1    | 1    | 1    | 1.300V |
| 1    | 1    | 1    | 1    | 1    | 1.325V |
| 0    | 1    | 1    | 1    | 0    | 1.350V |
| 1    | 1    | 1    | 1    | 0    | 1.375V |
| 0    | 1    | 1    | 0    | 1    | 1.400V |
| 1    | 1    | 1    | 0    | 1    | 1.425V |
| 0    | 1    | 1    | 0    | 0    | 1.450V |
| 1    | 1    | 1    | 0    | 0    | 1.475V |
| 0    | 1    | 0    | 1    | 1    | 1.500V |
| 1    | 1    | 0    | 1    | 1    | 1.525V |
| 0    | 1    | 0    | 1    | 0    | 1.550V |
| 1    | 1    | 0    | 1    | 0    | 1.575V |
| 0    | 1    | 0    | 0    | 1    | 1.600V |
| 1    | 1    | 0    | 0    | 1    | 1.625V |
| 0    | 1    | 0    | 0    | 0    | 1.650V |
| 1    | 1    | 0    | 0    | 0    | 1.675V |
| 0    | 0    | 1    | 1    | 1    | 1.700V |
| 1    | 0    | 1    | 1    | 1    | 1.725V |
| 0    | 0    | 1    | 1    | 0    | 1.750V |
| 1    | 0    | 1    | 1    | 0    | 1.775V |
| 0    | 0    | 1    | 0    | 1    | 1.800V |
| 1    | 0    | 1    | 0    | 1    | 1.825V |

**VCCCMOS**

The VIA Eden ESP renames VCC<sub>1.5</sub> and VCC<sub>CMOS</sub> as VTT power pins. This signal is not used by the processor, but is intended to be used by the system as the power supply for CMOS level signals. VCC<sub>CMOS</sub> should not be expected to source more than 250mA.

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**RESET#**

The VIA Eden ESP processor is reset by the assertion of the RESET# ball, T-3.

**Thermal Monitoring**

The VIA Eden ESP processor supports thermal monitoring via the THERMDN and THERMDP balls.

**4.1.3 OMISSIONS****Driver Termination**

Current VIA Eden ESP processors require external termination. Future Eden cores support on-die termination.

System boards must terminate signals to ensure correct operation.

**Advanced Peripheral Interrupt Controller (APIC)**

The APIC is not supported by the VIA Eden ESP processor. The APIC balls (PICCLK, PICD0, and PICD1) are specified as reserved.

**Breakpoint and Performance Monitoring Signals**

The VIA Eden ESP processor internally supports instruction and data breakpoints. However, the VIA Eden ESP processor does not support the external indication of breakpoint matches. Similarly, the VIA Eden ESP processor contains performance monitoring hooks internally, but it does not support the indication of performance monitoring events.

**Error Checking**

The VIA Eden ESP processor does not support error checking. The BERR#, BINIT#, AERR#, AP#[1:0], DEP#[7:0], IERR#, RP#, and RSP# signals do not exist.

**RTTCTRL**

Current VIA Eden ESP processors do not connect to the RTTCTRL ball. Future Eden cores use the RTTCTRL ball to control integrated I/O pull-ups.

**NCHCTRL**

Current VIA Eden ESP processors do not connect to the NCHCTRL ball. Future Eden cores use the NCHCTRL ball to control the output impedance.

**4.2 BALL DESCRIPTION****Table 4-3. Ball Descriptions**

| <i>Ball Name</i> | <i>Description</i>                                                                                                                                                                                                                                                     | <i>I/O</i> | <i>Clock</i> |
|------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------|--------------|
| A[31:3]#         | The address Bus provides addresses for physical memory and external I/O devices. During cache inquiry cycles, A31#-A3# are used as inputs to perform snoop cycles.                                                                                                     | I/O        | BCLK         |
| A20M#            | A20 Mask causes the CPU to make (force to 0) the A20 address bit when driving the external address bus or performing an internal cache access. A20M# is provided to emulate the 1 MByte address wrap-around that occurs on the 8086. Snoop addressing is not affected. | I (VTT)    | ASYNC        |
| ADS#             | Address Strobe begins a memory/I/O cycle and indicates the address bus (A31#-A3#) and transaction request signals (REQ#) are valid.                                                                                                                                    | I/O        | BCLK         |



| Ball Name | Description                                                                                                                                                                                                                                                                                                                                                                              | I/O      | Clock |
|-----------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------|-------|
| BCLK      | Bus Clock provides the fundamental timing for the VIA Eden ESP Ezra CPU. The frequency of the VIA Eden ESP Ezra CPU input clock determines the operating frequency of the CPU's bus. External timing is defined referenced to the rising edge of CLK.                                                                                                                                    | I (2.5V) | -     |
| BNR#      | Block Next Request signals a bus stall by a bus agent unable to accept new transactions.                                                                                                                                                                                                                                                                                                 | I/O      | BCLK  |
| BPRI#     | Priority Agent Bus Request arbitrates for ownership of the system bus.                                                                                                                                                                                                                                                                                                                   | I        | BCLK  |
| BR[4:0]   | Hardware strapping options for setting the processors internal clock multiplier. Future VIA Eden ESP processors do not have their clock multiplier set to a factory default value. Use jumpers or populate 0Ω resistors to select the rated multiplier. The BR[4:0] balls should be wired to VSS for a value of "0" or wired to OPEN for setting of "1." See Table 4-4 for ratio values. | I        | BCLK  |
| BSEL[1:0] | Bus Selection Bus provides system bus frequency data to the CPU.                                                                                                                                                                                                                                                                                                                         | O (3.3V) | BCLK  |
| BREQ#     | BREQ# drives the BREQ[0]# signal in the system to request access to the system bus.                                                                                                                                                                                                                                                                                                      | I/O      | None  |
| D[63:0]#  | Data Bus signals are bi-directional signals which provide the data path between the VIA Eden ESP Ezra CPU and external memory and I/O devices. The data bus must assert DRDY# to indicate valid data transfer.                                                                                                                                                                           | I/O      | BCLK  |
| DBSY#     | Data Bus Busy is asserted by the data bus driver to indicate data bus is in use.                                                                                                                                                                                                                                                                                                         | I/O      | BCLK  |
| DEFER#    | Defer is asserted by target agent (e.g., north bridge) and indicates the transaction cannot be guaranteed as an in-order completion.                                                                                                                                                                                                                                                     | I        | BCLK  |
| DRDY#     | Data Ready is asserted by data driver to indicate that a valid signal is on the data bus.                                                                                                                                                                                                                                                                                                | I/O      | BCLK  |
| FERR#     | FPU Error Status indicates an unmasked floating-point error has occurred. FERR# is asserted during execution of the FPU instruction that caused the error.                                                                                                                                                                                                                               | O (VTT)  | ASYNC |
| FLUSH#    | Flush Internal Caches writing back all data in the modified state.                                                                                                                                                                                                                                                                                                                       | I (VTT)  | ASYNC |
| HIT#      | Snoop Hit indicates that the current cache inquiry address has been found in the cache (exclusive or shared states).                                                                                                                                                                                                                                                                     | I/O      | BCLK  |
| HITM#     | Snoop Hit Modified indicates that the current cache inquiry address has been found in the cache and dirty data exists in the cache line (modified state).                                                                                                                                                                                                                                | I/O      | BCLK  |
| INIT#     | Initialization resets integer registers and does not affect internal cache or floating point registers.                                                                                                                                                                                                                                                                                  | I (VTT)  | ASYNC |
| INTR      | Maskable Interrupt                                                                                                                                                                                                                                                                                                                                                                       | I (VTT)  | ASYNC |
| NMI       | Non-Maskable Interrupt                                                                                                                                                                                                                                                                                                                                                                   | I (VTT)  | ASYNC |
| LOCK#     | Lock Status is used by the CPU to signal to the target that the operation is atomic.                                                                                                                                                                                                                                                                                                     | I/O      | BCLK  |
| NCHCTRL   | Future VIA Eden processors use the NCHCTRL ball to control integrated I/O pull-ups. Connect this signal to VTT with a 14Ω resistor.                                                                                                                                                                                                                                                      | I        | ASYNC |
| PWRGD     | Indicates that the processor's VCC is stable.                                                                                                                                                                                                                                                                                                                                            | I        | ASYNC |
| REQ[4:0]# | Request Command is asserted by bus driver to define current transaction type.                                                                                                                                                                                                                                                                                                            | I/O      | BCLK  |
| RESET#    | Resets the processor and invalidates internal cache without writing back.                                                                                                                                                                                                                                                                                                                | I        | BCLK  |
| RTTCTRL   | Future VIA Eden processors use the RTTCTRL ball to control the output impedance. Connect this signal to VSS with a 56Ω resistor if relying upon on-die termination. Connect this signal to VSS with a 110Ω resistor if relying upon board termination.                                                                                                                                   | I        | ASYNC |
| RS[2:0]#  | Response Status signals the completion status of the current transaction when the CPU is the response agent.                                                                                                                                                                                                                                                                             | I        | BCLK  |
| SLP#      | Sleep, when asserted in the stop grant state, causes the CPU to enter the sleep state.                                                                                                                                                                                                                                                                                                   | I (VTT)  | ASYNC |
| SMI#      | System Management (SMM) Interrupt forces the processor to save the CPU state to the top of SMM memory and to begin execution of the SMI services routine at the beginning of the defined SMM memory space. An SMI is a high-priority interrupt than NMI.                                                                                                                                 | I (VTT)  | ASYNC |
| STPCLK#   | Stop Clock causes the CPU to enter the stop grant state.                                                                                                                                                                                                                                                                                                                                 | I (VTT)  | ASYNC |

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| Ball Name | Description                                                                                                       | I/O      | Clock |
|-----------|-------------------------------------------------------------------------------------------------------------------|----------|-------|
| TRDY#     | Target Ready indicates that the target is ready to receive a write or write-back transfer from the CPU.           | I        | BCLK  |
| VID[4:0]  | Voltage Identification Bus informs the regulatory system on the motherboard of the CPU Core voltage requirements. | O (1.5V) | ASYN  |

Table 4-4. Clock Ratio

| BR[4] | BR[3] | BR[2] | BR[1] | BR[0] | Bus Ratio |
|-------|-------|-------|-------|-------|-----------|
| 0     | 0     | 0     | 0     | 0     | 9.0X      |
| 0     | 0     | 0     | 0     | 1     | 3.0X      |
| 0     | 0     | 0     | 1     | 0     | 4.0X      |
| 0     | 0     | 0     | 1     | 1     | 10.0X     |
| 0     | 0     | 1     | 0     | 0     | 5.5X      |
| 0     | 0     | 1     | 0     | 1     | 3.5X      |
| 0     | 0     | 1     | 1     | 0     | 4.5X      |
| 0     | 0     | 1     | 1     | 1     | 9.5X      |
| 0     | 1     | 0     | 0     | 0     | 5.0X      |
| 0     | 1     | 0     | 0     | 1     | 7.0X      |
| 0     | 1     | 0     | 1     | 0     | 8.0X      |
| 0     | 1     | 0     | 1     | 1     | 6.0X      |
| 0     | 1     | 1     | 0     | 0     | 12.0X     |
| 0     | 1     | 1     | 0     | 1     | 7.5X      |
| 0     | 1     | 1     | 1     | 0     | 8.5X      |
| 0     | 1     | 1     | 1     | 1     | 6.5X      |
| 1     | 0     | 0     | 0     | 0     | Reserved  |
| 1     | 0     | 0     | 0     | 1     | 11.0X     |
| 1     | 0     | 0     | 1     | 0     | 12.0X     |
| 1     | 0     | 0     | 1     | 1     | Reserved  |
| 1     | 0     | 1     | 0     | 0     | 13.5X     |
| 1     | 0     | 1     | 0     | 1     | 11.5X     |
| 1     | 0     | 1     | 1     | 0     | 12.5X     |
| 1     | 0     | 1     | 1     | 1     | 10.5X     |
| 1     | 1     | 0     | 0     | 0     | 13.0X     |
| 1     | 1     | 0     | 0     | 1     | 15.0X     |
| 1     | 1     | 0     | 1     | 0     | 16.0X     |
| 1     | 1     | 0     | 1     | 1     | 14.0X     |
| 1     | 1     | 1     | 0     | 0     | Reserved  |
| 1     | 1     | 1     | 0     | 1     | 15.5X     |
| 1     | 1     | 1     | 1     | 0     | Reserved  |
| 1     | 1     | 1     | 1     | 1     | 14.5X     |

## 4.3 POWER MANAGEMENT

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The VIA Eden ESP processor provides both static and dynamic power management.

The VIA Eden ESP processor supports five power management modes: NORMAL state, STOP GRANT state, AUTOHALT state, SLEEP state, and DEEPSLEEP state.

The VIA Eden ESP processor uses dynamic power management techniques to reduce power consumption in the NORMAL state. In NORMAL state, the on-chip arrays, selected datapaths, and the associated control logic are powered down when not in use. In addition, units which are in use attempt to minimize switching of inactive nodes.

- NORMAL state is the normal operating state for the processor.
- STOP GRANT state is the low power state where most of the processor clocks do not toggle. It is entered when the STPCLK# signal is asserted. Snoop cycles are supported in this state.
- AUTO HALT state is the low power state where most of the processor clocks do not toggle. It is entered when the processor executes the HALT instruction. Snoop cycles are supported in this state.
- SLEEP state is the very low power state where only the processor's PLL (phase lock loop) toggles. It is entered from STOP GRANT state when the processor samples the SLP# signal asserted. Snoop cycles that occur while in SLEEP state or during a transition into or out of SLEEP state will cause unpredictable behavior.
- DEEP SLEEP state is the lowest power state. It is entered when the BCLK signal is stopped while the processor is in the SLEEP state. Snoop cycles will be completely ignored in this state.

## 4.4 TEST & DEBUG

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### 4.4.1 BIST

---

A Built-in Self-Test (BIST) can be requested as part of the VIA Eden ESP reset sequence by holding INIT# asserted as RESET# is de-asserted.

The VIA Eden ESP processor BIST performs the following general functions:

- A hardware-implemented exhaustive test of (1) all internal microcode ROM, and (2) the X86 instruction decode, instruction generation, and entry point generation logic.
- An extensive microcode test of all internal registers and datapaths.
- An extensive microcode test of data and instruction caches, their tags, and associated TLBs.

BIST requires about four million internal clocks.

#### **EAX Value After Reset**

The result of a BIST is indicated by a code in EAX. Normally EAX is zero after reset. If a BIST is requested as part of the Reset sequence, EAX contains the BIST results. A 0 in EAX after BIST Reset means that no failures were detected. Any value other than zero indicates an error has occurred during BIST.

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#### **4.4.2 JTAG**

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The VIA Eden ESP processor has a JTAG scan interface that is used for test functions and the proprietary Debug Port. However, the VIA Eden ESP does not provide a fully compatible IEEE 1149.1 JTAG function.

From a practical user viewpoint, JTAG does not exist and the associated balls (TCLK, and so forth) should not be used.

#### **4.4.3 DEBUG PORT**

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Certain processors have a proprietary Debug Port which uses the JTAG scan mechanism to control internal debug features (“probe mode”). These interfaces are not documented and are available (if at all) only under a non-disclosure agreement.

The VIA Eden ESP processor does not have a debug interface.

## SECTION

## 5

## ELECTRICAL SPECIFICATIONS

## 5.1 AC TIMING TABLES

Table 5-1: System Bus Clock AC Specifications (133 MHz)<sup>1</sup>

| SYMBOL             | PARAMETER                           | MIN  | MAX  | UNIT | FIGURE | NOTES       |
|--------------------|-------------------------------------|------|------|------|--------|-------------|
|                    | System Bus Frequency                |      | 133  |      | MHz    |             |
| T <sub>1S</sub>    | BCLK Period                         | 7.5  | 7.65 | ns   | 6      | (2)         |
| T <sub>1Sabs</sub> | BCLK Period – Instantaneous Minimum | 7.25 |      |      |        | (2)         |
| T <sub>2S</sub>    | BCLK Period Stability               |      | ±250 | ps   |        | (2),(3),(4) |
| T <sub>3S</sub>    | BCLK High Time                      | 1.4  |      | ns   | 6      | at>2.0V     |
| T <sub>4S</sub>    | BCLK Fall Time                      | 1.4  |      | ns   | 6      | at<0.5V     |
| T <sub>5S</sub>    | BCLK Rise Time                      | 0.4  | 1.6  | ns   | 6      | (5)         |
| T <sub>6S</sub>    | BCLK Fall Time                      | 0.4  | 1.6  | ns   | 6      | (5)         |

**Notes:**

1. All AC timings for bus and CMOS signals are referenced to the BCLK rising edge at 1.25V.
2. Period, jitter, skew and offset measured at 1.25V.
3. Not 100% tested. Specified by design/characterization
4. Measured on the rising edge of adjacent BCLKs at 1.25V. The jitter present must be accounted for as a component of BCLK skew between devices.
5. Measured between 0.5V and 2.0V.

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**Table 5-2. System Bus Clock AC Specifications (100 MHz)<sup>1</sup>**

| <b>SYMBOL</b>       | <b>PARAMETER</b>                    | <b>MIN</b> | <b>MAX</b> | <b>UNIT</b> | <b>FIGURE</b> | <b>NOTES</b> |
|---------------------|-------------------------------------|------------|------------|-------------|---------------|--------------|
|                     | System Bus Frequency                |            | 100        | MHz         |               |              |
| T <sub>1S1</sub>    | BCLK Period                         |            | 10         | ns          | 5-1           | (2)          |
| T <sub>1S1abs</sub> | BCLK Period – Instantaneous Minimum | 9.75       |            | ns          |               | (2)          |
| T <sub>2S1</sub>    | BCLK Period Stability               |            |            | ps          |               | (2),(3),(4)  |
| T <sub>3S1</sub>    | BCLK High Time                      | 2.70       |            | ns          | 5-1           | at>2.0V      |
| T <sub>4S1</sub>    | BCLK Fall Time                      | 2.45       |            | ns          | 5-1           | at<0.5V      |
| T <sub>5S1</sub>    | BCLK Rise Time                      | 0.4        |            | ns          | 5-1           | (5)          |
| T <sub>6S1</sub>    | BCLK Fall Time                      | 0.4        |            | ns          | 5-1           | (5)          |

**Notes:**

1. All AC timings for bus and CMOS signals are referenced to the BCLK rising edge at 1.25V.
2. Period, jitter, skew and offset measured at 1.25V.
3. Not 100% tested. Specified by design/characterization
4. Measured on the rising edge of adjacent BCLKs at 1.25V. The jitter present must be accounted for as a component of BCLK skew between devices.
5. Measured between 0.5V and 2.0V.

**Table 5-3. Bus Signal Groups AC Specifications<sup>1</sup>**

| <b>SYMBOL</b>   | <b>PARAMETER</b>       | <b>MIN</b>   | <b>MAX</b> | <b>UNIT</b> | <b>FIGURE</b> | <b>NOTES</b>       |
|-----------------|------------------------|--------------|------------|-------------|---------------|--------------------|
| T <sub>7</sub>  | Bus Output Valid Delay | 0.40         | 3.25       | ns          | 5-2           |                    |
| T <sub>8</sub>  | Bus Input Setup Time   | 0.95<br>1.30 |            | ns          | 5-3           | (2),(3),(6)<br>(7) |
| T <sub>9</sub>  | Bus Input Hold Time    | 1            |            | ns          | 5-3           | (4)                |
| T <sub>10</sub> | RESET# Pulse Width     | 1            |            | ms          | 5-4           | (5)                |

**Notes:**

1. All AC timings for Bus and CMOS signals are referenced to the BCLK rising edge at 1.25V. All bus signals are referenced at VREF. Unless specified, all timings apply to both 100 MHz and 133 MHz bus frequencies.
2. RESET# can be asserted (active) asynchronously, but must be deasserted synchronously.
3. Specification is for a minimum 0.4V swing from VREF-200 mV to VREF+200 mV.
4. Specification is for a maximum 0.8V swing from VTT-0.8V to VTT.
5. After VCC, VTT and BCLK become stable and PWRGOOD is asserted.
6. Applies to processors supporting 133 MHz bus clock frequency.
7. Applies to processors supporting 100 MHz bus clock frequency.

**Table 5-4. CMOS and Open-drain Signal GROUPS AC Specifications<sup>1,2</sup>**

| SYMBOL          | PARAMETER                              | MIN | MAX | UNIT  | FIGURE | NOTES                      |
|-----------------|----------------------------------------|-----|-----|-------|--------|----------------------------|
| T <sub>14</sub> | 1.5V Input Pulse Width, except PWRGOOD | 2   |     | BCLKs | 5-2    | Active and inactive states |
| T <sub>15</sub> | PWRGOOD Inactive Pulse Width           | 2   |     | μs    | 5-5    | (3)                        |

**Notes:**

1. All AC timings for CMOS and Open-drain signals are referenced to the rising edge of BCLK at 1.25V. All CMOS and Open-drain signals are referenced at 1.0V.
2. Minimum output pulse width on CMOS outputs is 2 BCLKs.
3. When driven inactive, or after VCC, VTT and BCLK become stable. PWRGOOD must remain below V<sub>IL18,MAX</sub> until all the voltage planes meet the voltage tolerance specifications in Table 5-7 through Table 5-8 and BCLK have met the BCLK AC specifications in Table 5-1 and Table 5-2 for a least 2 μs.

**Table 5-5. Reset Configuration AC Specifications and Power On/Power Down Timings**

| SYMBOL           | PARAMETER                                                                | MIN | TYP | MAX | UNIT  | FIGURE | NOTES                                     |
|------------------|--------------------------------------------------------------------------|-----|-----|-----|-------|--------|-------------------------------------------|
| T <sub>16</sub>  | Reset Configuration Signals (A[15:5]#, BREQ0#, FLUSH#, INIT#) Setup Time | 4   |     |     | BCLKs | 5-4    | Before deassertion of RESET#              |
| T <sub>17</sub>  | Reset Configuration Signals (A[15:5]#, BREQ0#, FLUSH#, INIT) Hold Time   | 2   |     | 20  | BCLKs | 5-4    | After clock that deasserts RESET#         |
| T <sub>18</sub>  | RESET#/PWRGOOD Setup Time                                                | 1   |     |     | ms    | 5-5    | Before deassertion of RESET# <sup>1</sup> |
| T <sub>18B</sub> | VCC to PWRGOOD Setup Time                                                |     | 10  |     | ms    | 5-5    |                                           |
| T <sub>18D</sub> | RESET# inactive to Valid Outputs                                         | 1   |     |     | BCLK  | 5-4    |                                           |
| T <sub>18E</sub> | RESET# inactive to Drive Signals                                         | 4   |     |     | BCLKs | 5-4    |                                           |
| T <sub>19A</sub> | Time from VCC(nominal)-12% to PWRGOOD low                                |     |     | 0   | ns    | 5-6    | VCC(nominal) is the VID voltage setting   |
| T <sub>19B</sub> | All outputs valid after PWRGOOD low                                      | 0   |     |     | ns    | 5-6    |                                           |
| T <sub>19C</sub> | All inputs required valid after PWRGOOD low                              | 0   |     |     | ns    | 5-6    |                                           |
| T <sub>20B</sub> | All outputs valid after VTT-12%                                          | 0   |     |     | ns    | 5-7    |                                           |
| T <sub>20C</sub> | All inputs required valid after VTT-12%                                  | 0   |     |     | ns    | 5-7    |                                           |
| T <sub>20D</sub> | VID, BSEL signals valid after VTT-12%                                    | 0   |     |     | ns    | 5-7    |                                           |

**Notes:** At least 1 ms must pass after PWRGOOD rises above V<sub>IH18min</sub> and BCLK meet their AC timing specification until RESET# may be deasserted.

**Table 5-6. StopGrant/Deep Sleep AC Specifications**

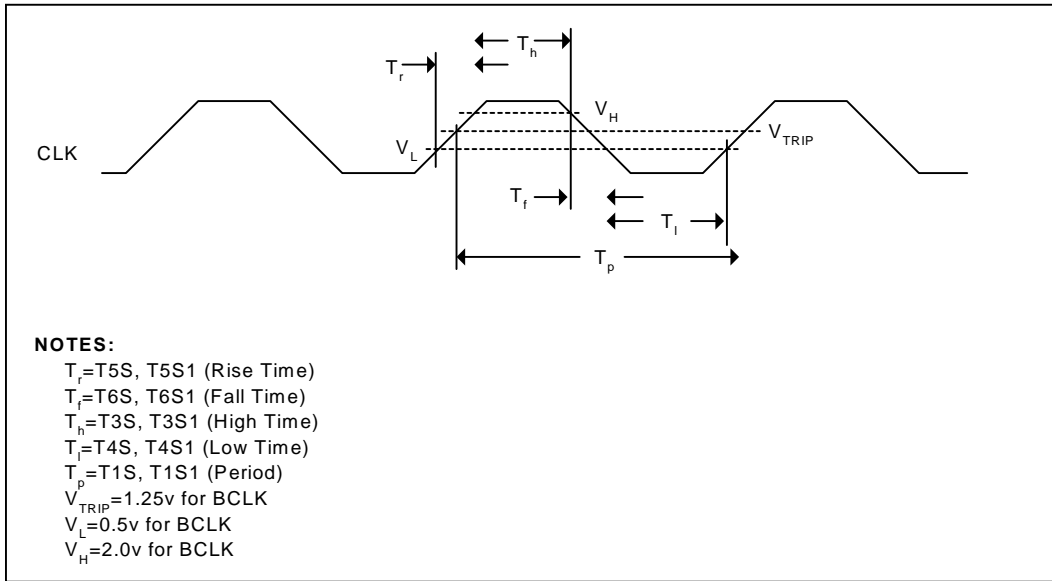
| SYMBOL          | PARAMETER                                                   | MIN | MAX | UNIT  | FIGURE | NOTES |
|-----------------|-------------------------------------------------------------|-----|-----|-------|--------|-------|
| T <sub>45</sub> | Stop Grant Cycle Completion to Clock Stop or SLP# assertion | 100 |     | BCLKs | 17, 18 |       |
| T <sub>46</sub> | Stop Grant Cycle Completion to Input Signals Stable         |     | 0   | μs    | 17, 18 |       |
| T <sub>47</sub> | Sleep PLL Lock Latency                                      | 0   | 30  | μs    | 17, 18 | (2)   |
| T <sub>48</sub> | STPCLK# Hold Time from PLL Lock                             | 0   |     | μs    | 17, 18 |       |
| T <sub>49</sub> | Input Signal Hold Time from STPCLK# Deassertion             | 8   |     | BCLKs | 17, 18 |       |

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**Notes:**

1. Input Signals other than RESET# and BPRI# must be held constant in the Stop Grant state.
2. The BCLK Settling Time specification ( $T_{60}$ ) applies to Deep Sleep state exit under all conditions.

**Figure 5-1: BCLK Generic Clock Timing Waveform**



**Figure 5-2: Valid Delay Timings**

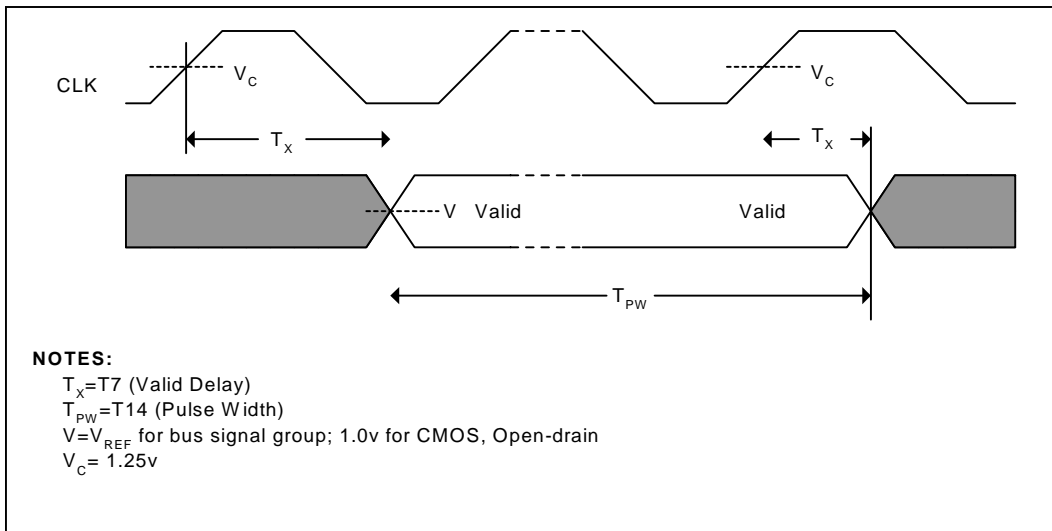




Figure 5-3: Setup and Hold Timings

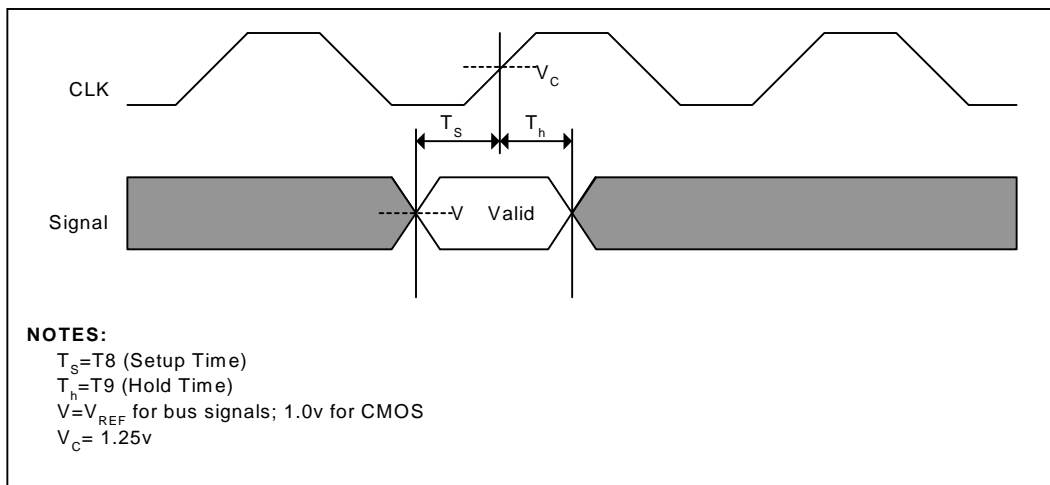
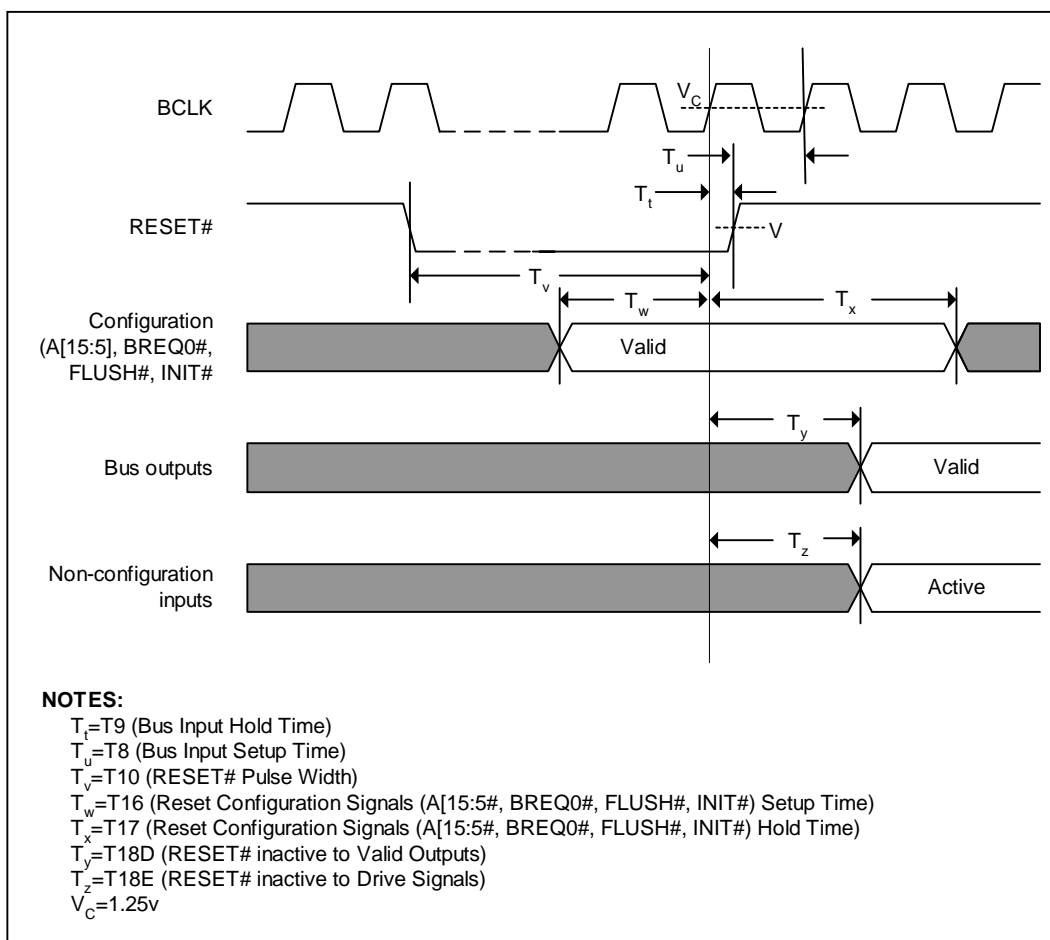


Figure 5-4: Cold/Warm Reset and Configuration Timings



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Figure 5-5: Power-on Sequence and Reset Timings

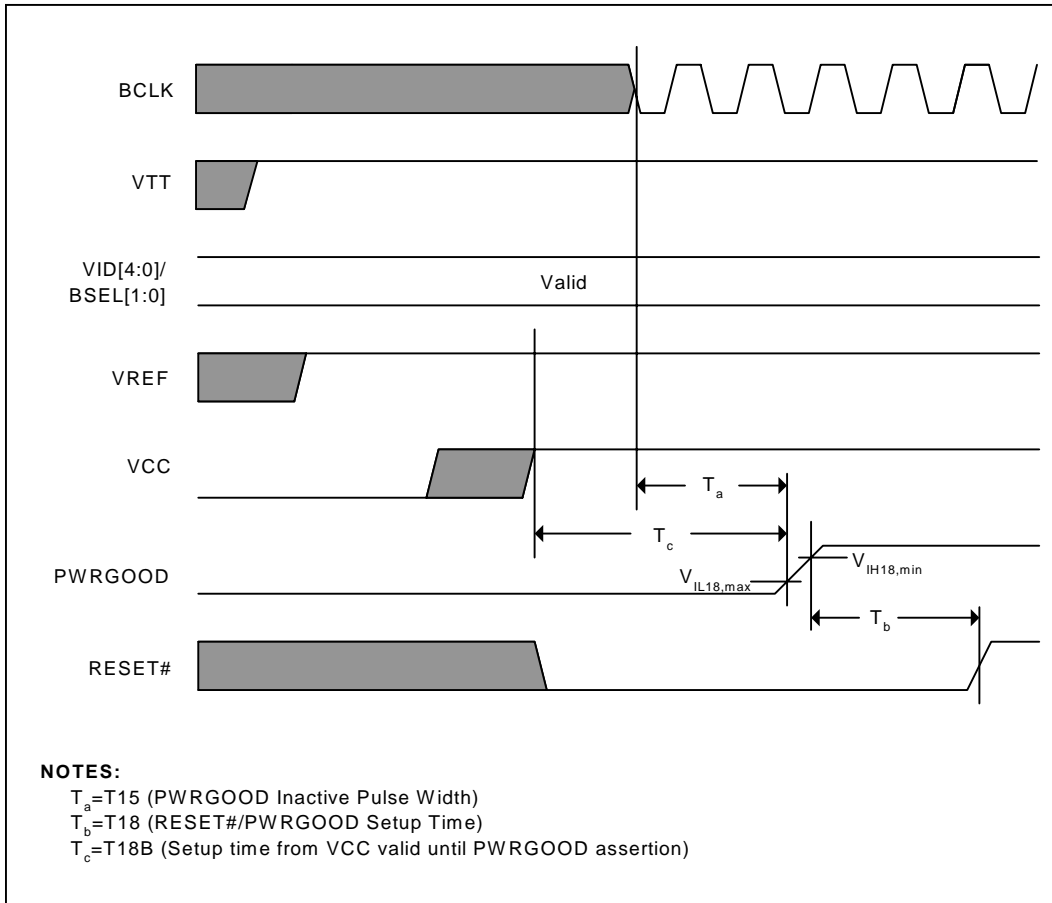
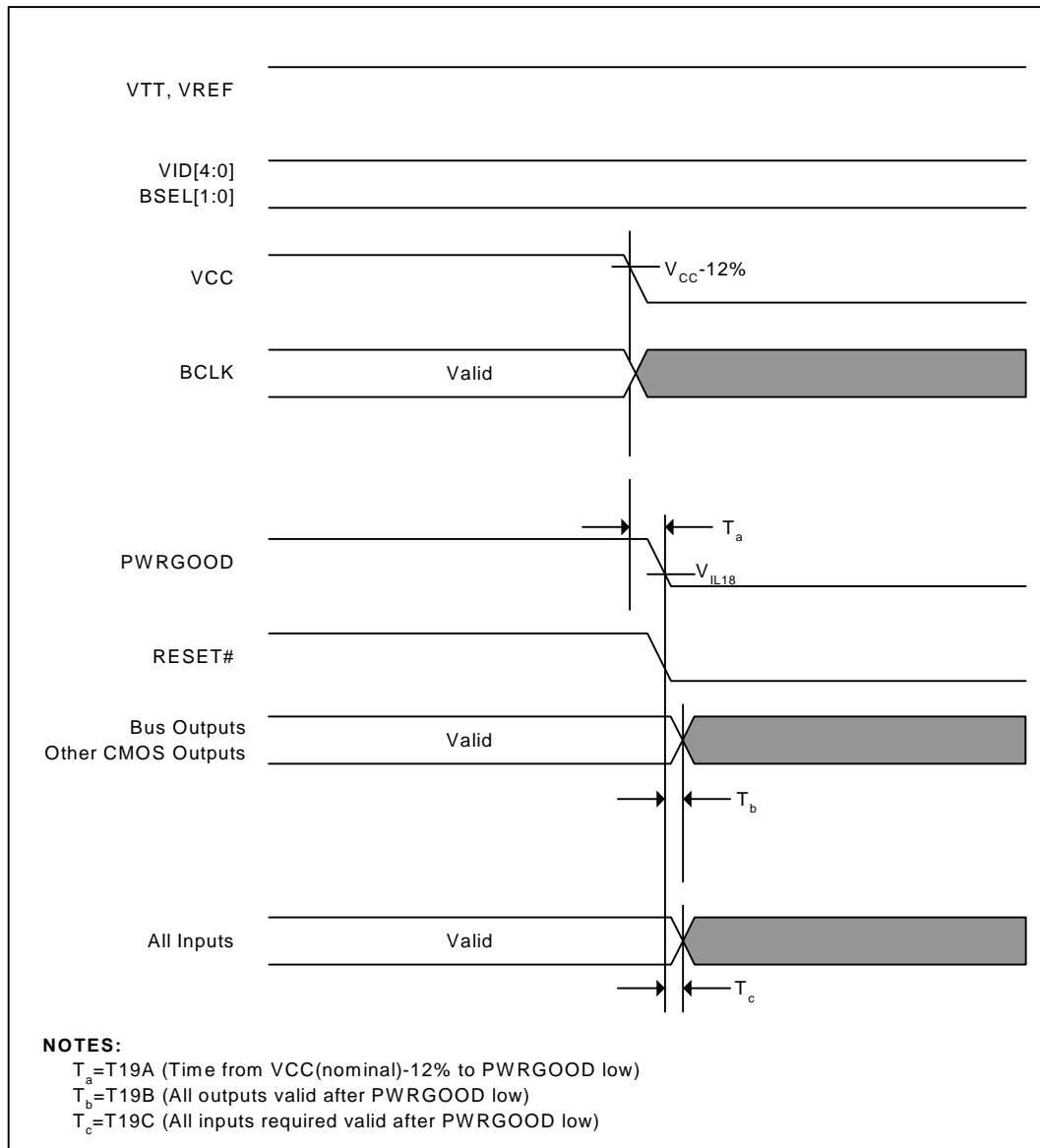


Figure 5-6: Power Down Sequencing and Timings (VCC Leading)



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Figure 5-7: Power Down Sequencing and Timings (VTT Leading)

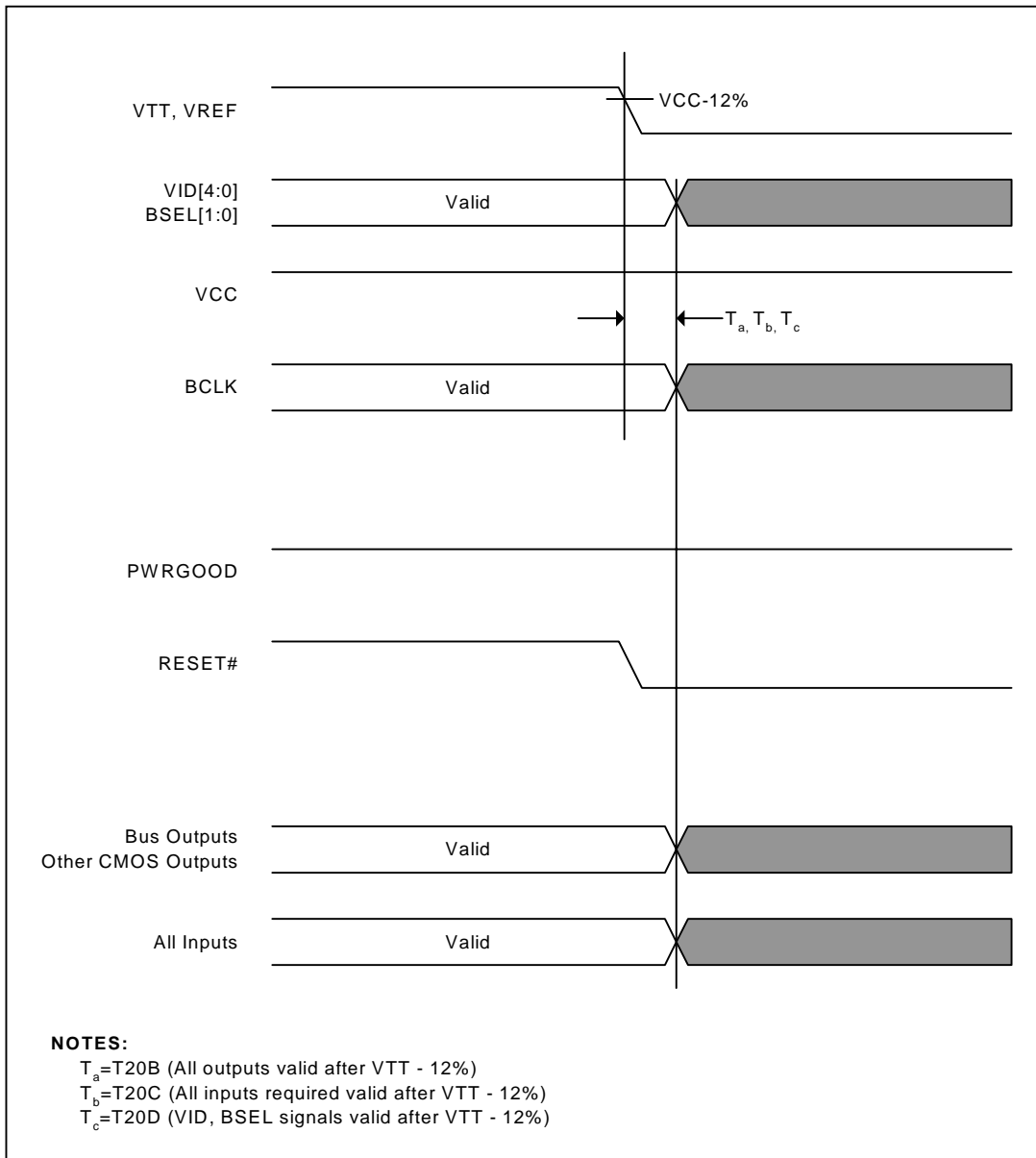
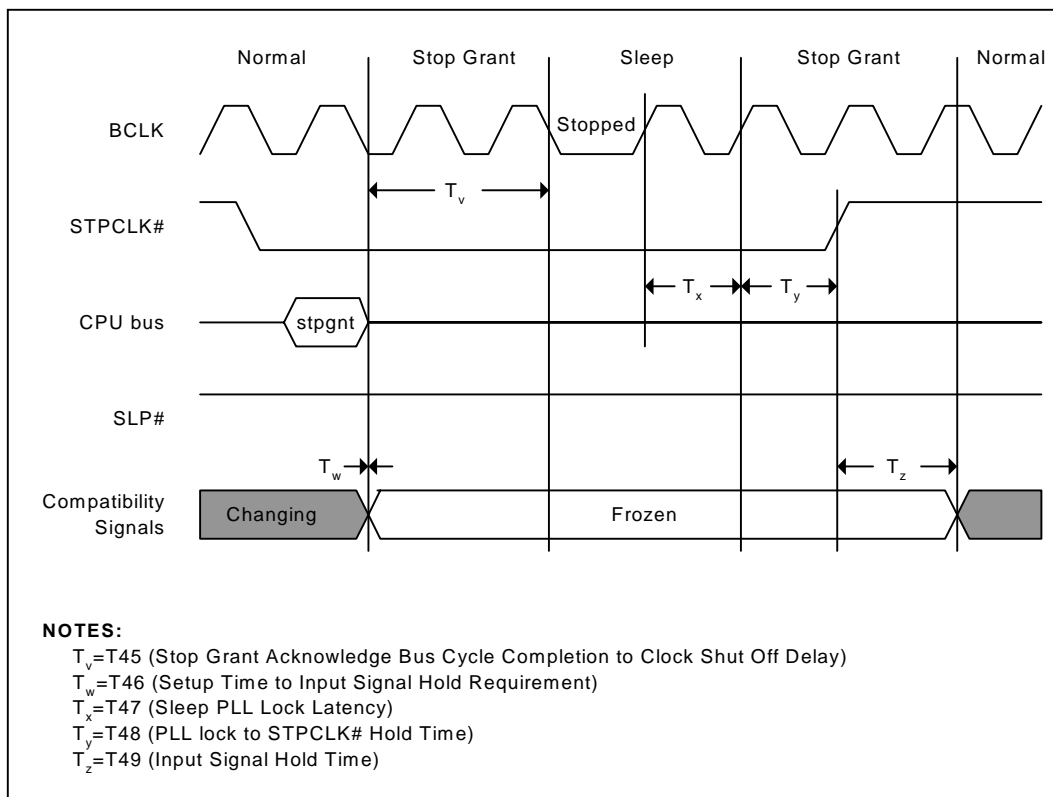
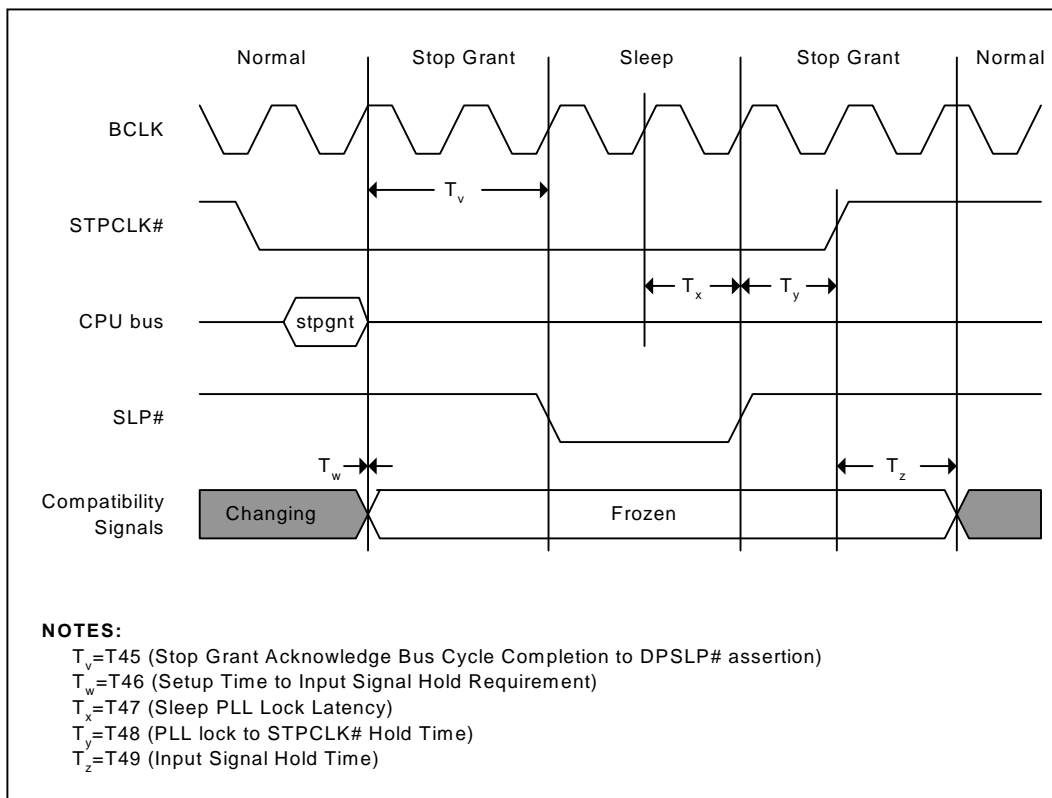


Figure 5-8: Stop Grant /Sleep Timing (BCLK Stopping Method)



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Figure 5-9: Stop Grant/Sleep Timing (SLP# assertion method)



## 5.2 DC SPECIFICATIONS

### 5.2.1 RECOMMENDED OPERATING CONDITIONS

Functional operation of the VIA Eden ESP processor is guaranteed if the conditions in Table 5-3 are met. Sustained operation outside of the recommended operating conditions may damage the device.

Table 5-7. Recommended Operating Conditions

| PARAMETER                           | MIN           | NOM                  | MAX           | UNITS | NOTES                          |
|-------------------------------------|---------------|----------------------|---------------|-------|--------------------------------|
| Operating Junction Temperature      | 5             |                      | 90            | °C    |                                |
| V <sub>CORE</sub> Voltage           | See Table 5-8 | 1.05<br>1.20<br>1.20 | See Table 5-8 | V     | VIA Eden ESP<br>4000/5000/6000 |
| V <sub>CORE</sub> Voltage           | See Table 5-8 | 1.10                 | See Table 5-8 | V     | VIA Eden ESP<br>8000           |
| V <sub>CORE</sub> Static Tolerance  | See Table 5-4 |                      |               | V     | (1)                            |
| V <sub>CORE</sub> Dynamic Tolerance |               |                      |               | V     | (2)                            |

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|                  |        |              |       |          |                                |
|------------------|--------|--------------|-------|----------|--------------------------------|
| $V_{TT}$ Voltage | 1.365  | 1.5          | 1.635 | V        | VIA Eden ESP<br>4000/5000/6000 |
| $V_{TT}$ Voltage | 1.1375 | 1.25         | 1.635 | V        | VIA Eden ESP<br>8000           |
| $R_{TT}$         | 50     | 56           | 115   | $\Omega$ | (3)                            |
| $V_{REF}$        | -2%    | $2/3 V_{TT}$ | +2%   | V        |                                |

**Notes:**

1. DC measurement
2. AC noise measured with bandwidth limited to 20MHz
3. Necessary for future VIA Eden processors.  $R_{TT}$  is controlled by RTTCTRL ball. RTTCTRL should be  $56\Omega$  when relying upon on-die bus termination. RTTCTRL should be  $110\Omega$  when relying upon board termination.

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**Table 5-8.  $V_{CC}$  Static and Transient Tolerance**

| I <sub>CC</sub> (A) | Voltage Deviation from VID Setting (mV) |     |     |                     |     |
|---------------------|-----------------------------------------|-----|-----|---------------------|-----|
|                     | Static Tolerance                        |     |     | Transient Tolerance |     |
|                     | Min                                     | Nom | Max | Min                 | Max |
| 0                   | 15                                      | 40  | 65  | 5                   | 85  |
| 2                   | 5                                       | 30  | 55  | -5                  | 74  |
| 4                   | -5                                      | 20  | 45  | -15                 | 62  |
| 6                   | -15                                     | 10  | 35  | -25                 | 51  |
| 8                   | -25                                     | 0   | 25  | -35                 | 40  |
| 10                  | -35                                     | -10 | 15  | -45                 | 28  |
| 12                  | -45                                     | -20 | 5   | -55                 | 17  |
| 14                  | -55                                     | -30 | -5  | -65                 | 6   |
| 16                  | -65                                     | -40 | -15 | -76                 | -5  |

## 5.2.2 MAXIMUM RATINGS

While functional operation is not guaranteed beyond the operating ranges listed in Table 5-4, the device may be subjected to the limits specified in Table 5-5 without causing long-term damage.

These conditions must not be imposed on the device for a sustained period—any such sustained imposition may damage the device. Likewise exposure to conditions in excess of the maximum ratings may damage the device.

**Table 5-9. Maximum Ratings**

| PARAMETER                   | MIN  | MAX            | UNITS | NOTES |
|-----------------------------|------|----------------|-------|-------|
| Operating Case Temperature  | 5    | 85             | °C    |       |
| Storage Temperature         | -65  | 150            | °C    |       |
| Supply Voltage ( $V_{CC}$ ) | -0.5 | 4.0            | V     |       |
| CMOS I/O Voltage            | -0.5 | 2.0            | V     |       |
| I/O Voltage                 | -0.5 | $V_{TT} + 0.5$ | V     |       |



## 5.2.3 DC CHARACTERISTICS

**Table 5-10. DC Characteristics**

| PARAMETER                                                          | MIN  | MAX             | UNITS | NOTES                      |
|--------------------------------------------------------------------|------|-----------------|-------|----------------------------|
| I <sub>OL</sub> – Low level output current                         | -9.0 |                 | mA    | @ V = V <sub>OL(max)</sub> |
| V <sub>OH</sub> – High Level Output Voltage                        |      | V <sub>TT</sub> | V     |                            |
| V <sub>OL</sub> – Low Level Output Voltage                         | 0    | 0.4             | V     | @ I <sub>ol</sub> = -8mA   |
| I <sub>L</sub> – Input Leakage Current                             |      | ± 100           | μA    |                            |
| I <sub>LU</sub> – Input Leakage Current for inputs with pull-ups   |      | 200             | μA    |                            |
| I <sub>LD</sub> – Input Leakage Current for inputs with pull-downs |      | -400            | μA    |                            |

**Table 5-11. CMOS DC Characteristics**

| PARAMETER                                   | MIN                    | MAX             | UNITS | NOTES             |
|---------------------------------------------|------------------------|-----------------|-------|-------------------|
| V <sub>IL</sub> -- Input Low Voltage        | -0.58                  | 0.700           | V     |                   |
| V <sub>IH1.5</sub> – Input High Voltage     | V <sub>REF</sub> + 0.2 | V <sub>TT</sub> | V     | (2)               |
| V <sub>IH2.5</sub> – Input High Voltage     | 2.0                    | 3.18            | V     | (3)               |
| V <sub>OL</sub> – Low Level Output Voltage  |                        | 0.40            | V     | @ I <sub>OL</sub> |
| V <sub>OH</sub> – High Level Output Voltage |                        | 1.50            | V     | (1)               |
| I <sub>OL</sub> – Low Level Output Current  | 9                      |                 | mA    | @ V <sub>OL</sub> |
| I <sub>LI</sub> – Input Leakage Current     |                        | ±100            | μA    |                   |
| I <sub>LO</sub> – Output Leakage Current    |                        | ±100            | μA    |                   |

**Notes:**

1. All CMOS signals are open drain.
2. Applies to all CMOS signals except **BCLK**.
3. Applies only to **BCLK**.

## 5.2.4 POWER DISSIPATION

Table 5-8 through Table 5-15 give the core power consumption for the VIA Eden ESP processor models. Note that this does not include the power consumed by the I/O pads.

**Table 5-12. Normal Mode V<sub>CC</sub> Power Consumption**

| PARAMETER                                                 | TYPICAL <sup>3,4</sup> | MAX <sup>1,2</sup> | UNITS | NOTES         |
|-----------------------------------------------------------|------------------------|--------------------|-------|---------------|
| P <sub>CC</sub> - Normal Mode Operating Power Consumption |                        |                    |       |               |
| VIA Eden ESP 4000 (4.0 X 100 MHz) 1.05V                   | 1.7                    | 3.0                | W     | 0.15u process |
| VIA Eden ESP 5000 (4.0 X 133 MHz) 1.20V                   | 2.8                    | 5.0                | W     | 0.15u process |
| VIA Eden ESP 6000 (4.5 X 133 MHz) 1.20V                   | 3.2                    | 6.0                | W     | 0.15u process |

**Notes:**

1. 100% tested. Consider these power numbers as the factory maximum. The factory will reject processors that exceed these values.

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- The above power consumption is preliminary and based on 90°C junction and 1.20 (VIA Eden ESP 6000) or 1.20/1.05 (VIA Eden ESP 4000/5000) Volts.
- Typical power is defined as the average power dissipated while running WinStone99 on Win98. Contact your VIA Sales Representative for further information.
- Thermal solutions must be designed to account for worst-case core and I/O power consumption.

**Table 5-13. StopGrant V<sub>CC</sub> Power Consumption**

| PARAMETER                                                               | MAX <sup>1,2</sup> | UNITS | NOTES                |
|-------------------------------------------------------------------------|--------------------|-------|----------------------|
| P <sub>CC</sub> – StopGrant / AutoHalt Mode Operating Power Consumption |                    |       | No snooping activity |
| VIA Eden ESP 4000 (4.0 X 100 MHz) 1.05V                                 | 1.00               | W     | 0.15u process        |
| VIA Eden ESP 5000 (4.0 X 133 MHz) 1.20V                                 | 1.00               | W     | 0.15u process        |
| VIA Eden ESP 6000 (4.5 X 133 MHz) 1.20V                                 | 1.30               | W     | 0.15u process        |

**Notes:**

- 100% tested. Consider these power numbers as the factory maximum. The factory will reject processors that exceed these values.
- The above power consumption is preliminary and based on 90°C junction and 1.20 (VIA Eden ESP 6000) or 1.20/1.05 (VIA Eden ESP 4000/5000) Volts.

**Table 5-14. Sleep V<sub>CC</sub> Power Consumption**

| PARAMETER                                                | MAX <sup>1</sup> | UNITS | NOTES         |
|----------------------------------------------------------|------------------|-------|---------------|
| P <sub>CC</sub> – Sleep Mode Operating Power Consumption |                  |       |               |
| VIA Eden ESP 4000 (4.0 X 100 MHz) 1.05V                  | 1.00             | W     | 0.15u process |
| VIA Eden ESP 5000 (4.0 X 133 MHz) 1.20V                  | 1.00             | W     | 0.15u process |
| VIA Eden ESP 6000 (4.5 X 133 MHz) 1.20V                  | 1.3              | W     | 0.15u process |

**Notes:**

- 100% tested. Consider these power numbers as the factory maximum. The factory will reject processors that exceed these values.
- The above power consumption is preliminary and based on 90°C junction and 1.20 (VIA Eden ESP 6000) or 1.20/1.05 (VIA Eden ESP 4000/5000) Volts.

**Table 5-15. Deep Sleep V<sub>CC</sub> Power Consumption**

| PARAMETER                                                     | MAX <sup>1</sup> | UNITS | NOTES         |
|---------------------------------------------------------------|------------------|-------|---------------|
| P <sub>CC</sub> – Deep Sleep Mode Operating Power Consumption |                  |       |               |
| VIA Eden ESP 4000 (4.0 X 100 MHz) 1.05V                       | 0.87             | W     | 0.15u process |
| VIA Eden ESP 5000 (4.0 X 133 MHz) 1.20V                       | 0.87             | W     | 0.15u process |
| VIA Eden ESP 6000 (4.5 X 133 MHz) 1.20V                       | 1.00             | W     | 0.15u process |

**Notes:**

- 100% tested. Consider these power numbers as the factory maximum. The factory will reject processors that exceed these values.
- The above power consumption is preliminary and based on 90°C junction and 1.20 (VIA Eden ESP 6000) or 1.20/1.05 (VIA Eden ESP 4000/5000) Volts.

**Table 5-16. Vss-I/O Power Consumption**

| <i>PARAMETER</i>                          | <i>TYPICAL</i> | <i>MAX</i> | <i>UNITS</i> | <i>NOTES</i> |
|-------------------------------------------|----------------|------------|--------------|--------------|
| Pss-I/O – I/O Operating Power Consumption | 300            | 820        | mW           |              |



SECTION

6

# MECHANICAL SPECIFICATIONS

## 6.1 EPGA PACKAGE

---

The VIA Eden ESP processor is packaged in a unique enhanced ball grid array that facilitates compact and economical surface mounting. The VIA Eden ESP processor bus is functionally similar to Socket 370 used by conventional x86 processors but is not mechanically compatible. Allowable Pressure on the top of the package is 800kPa (116Psi).

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Figure 6-1: VIA Eden ESP processor EPGA Ball Diagram (Bottom View)

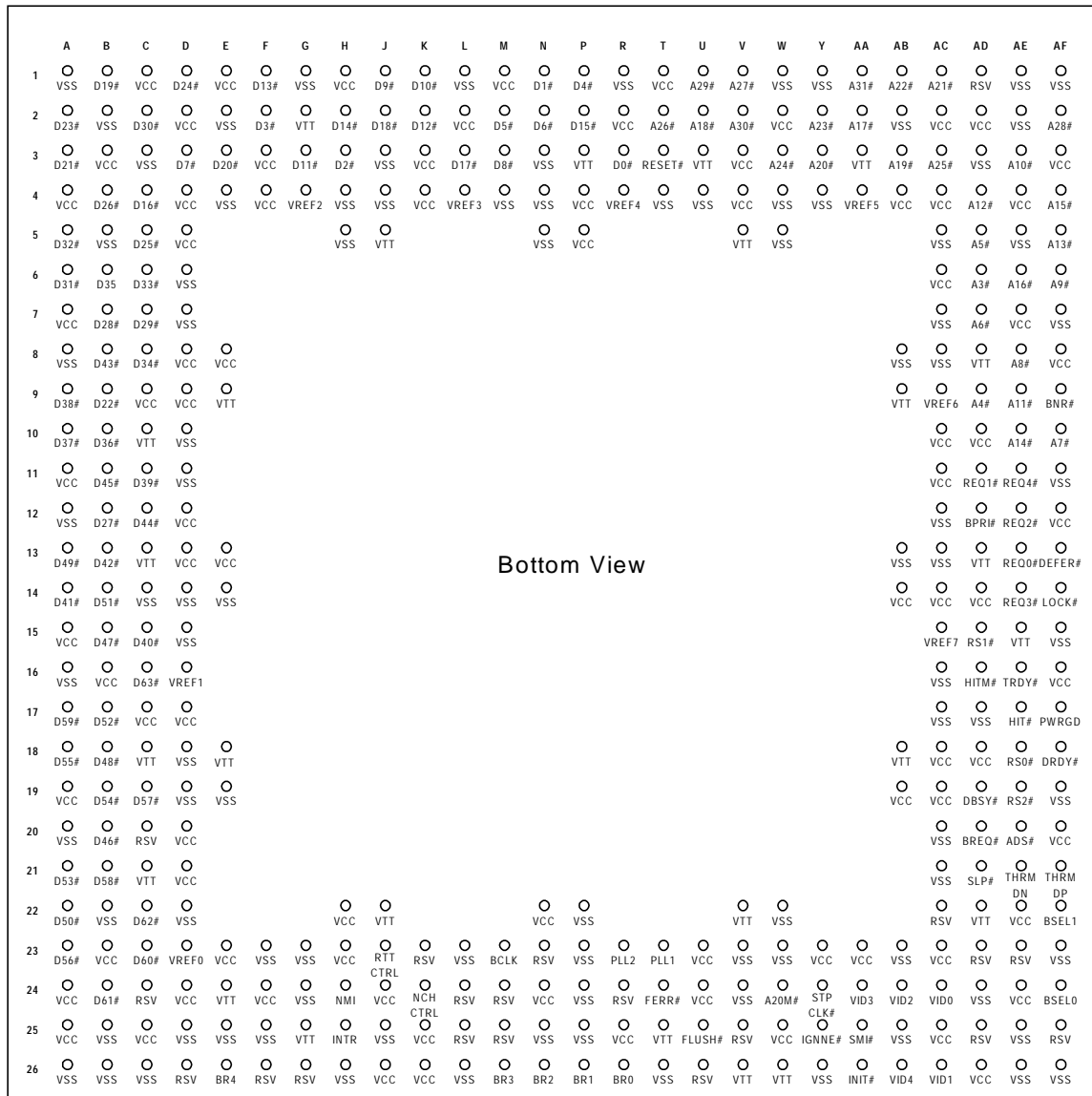


Table 6-1. EPGA Ball Cross Reference

| Address |       | Data |      | Control |       | Power/other |       | VCC   | VTT                | VSS   | Reserved |
|---------|-------|------|------|---------|-------|-------------|-------|-------|--------------------|-------|----------|
| Name    | Ball  | Name | Ball | Name    | Ball  | Name        | Ball  | Ball  | Ball               | Ball  | Ball     |
| A3#     | AD-6  | D0#  | R-3  | A20M#   | W-24  | PLL1        | T-23  | A-11  | AA-3 <sup>1</sup>  | A-1   | M-24     |
| A4#     | AD-9  | D1#  | N-1  | ADS#    | AE-20 | PLL2        | R-23  | A-15  | AD-13 <sup>1</sup> | A-12  | R-24     |
| A5#     | AD-5  | D2#  | H-3  | BCLK    | M-23  | THERMDN     | AE-21 | A-19  | AD-22 <sup>1</sup> | A-16  | AC-22    |
| A6#     | AD-7  | D3#  | F-2  | BNR#    | AF-9  | THERMDP     | AF-21 | A-24  | AD-8 <sup>1</sup>  | A-20  | AE-23    |
| A7#     | AF-10 | D4#  | P-1  | BPRI#   | AD-12 | VID0        | AC-24 | A-25  | AE-15 <sup>1</sup> | A-26  | AD-1     |
| A8#     | AE-8  | D5#  | M-2  | BREQ#   | AD-20 | VID1        | AC-26 | A-4   | C-10 <sup>1</sup>  | A-8   | AD-25    |
| A9#     | AF-6  | D6#  | N-2  | BSEL0   | AF-24 | VID2        | AB-24 | A-7   | C-13 <sup>1</sup>  | AB-13 | AD-23    |
| A10#    | AE-3  | D7#  | D-3  | BSEL1   | AF-22 | VID3        | AA-24 | AA-23 | C-18 <sup>1</sup>  | AB-2  | AF-25    |
| A11#    | AE-9  | D8#  | M-3  | DBSY#   | AD-19 | VID4        | AB-26 | AB-19 | C-21 <sup>1</sup>  | AB-23 | G-26     |
| A12#    | AD-4  | D9#  | J-1  | DEFER#  | AF-13 | VREF0       | D-23  | AB-4  | E-24 <sup>1</sup>  | AB-25 | D-26     |
| A13#    | AF-5  | D10# | K-1  | DRDY#   | AF-18 | VREF1       | D-16  | AB-14 | G-2 <sup>1</sup>   | AB-8  | F-26     |
| A14#    | AE-10 | D11# | G-3  | FERR#   | T-24  | VREF2       | G-4   | AC-10 | G-25 <sup>1</sup>  | AC-12 | K-23     |
| A15#    | AF-4  | D12# | K-2  | FLUSH#  | U-25  | VREF3       | L-4   | AC-11 | P-3 <sup>1</sup>   | AC-13 | L-25     |
| A16#    | AE-6  | D13# | F-1  | HIT#    | AE-17 | VREF4       | R-4   | AC-14 | T-25 <sup>1</sup>  | AC-16 | M-25     |
| A17#    | AA-2  | D14# | H-2  | HITM#   | AD-16 | VREF5       | AA-4  | AC-18 | U-3 <sup>1</sup>   | AC-17 | V-25     |
| A18#    | U-2   | D15# | P-2  | IGNNE#  | Y-25  | VREF6       | AC-9  | AC-19 | W-26 <sup>1</sup>  | AC-20 | C-20     |
| A19#    | AB-3  | D16# | C-4  | INIT#   | AA-26 | VREF7       | AC-15 | AC-2  | V-26 <sup>1</sup>  | AC-21 | U-26     |
| A20#    | Y-3   | D17# | L-3  | INTR    | H-25  |             |       | AC-23 | E-9 <sup>1</sup>   | AC-5  | C-24     |
| A21#    | AC-1  | D18# | J-2  | LOCK#   | AF-14 |             |       | AC-25 | E-18 <sup>1</sup>  | AC-7  | L-24     |
| A22#    | AB-1  | D19# | B-1  | NMI     | H-24  |             |       | AC-4  | J-5 <sup>1</sup>   | AC-8  | N-23     |
| A23#    | Y-2   | D20# | E-3  | PWRGD   | AF-17 |             |       | AC-6  | J-22 <sup>1</sup>  | AD-17 |          |
| A24#    | W-3   | D21# | A-3  | REQ0#   | AE-13 |             |       | AD-10 | V-5 <sup>1</sup>   | AD-24 |          |
| A25#    | AC-3  | D22# | B-9  | REQ1#   | AD-11 |             |       | AD-14 | V-22 <sup>1</sup>  | AD-3  |          |
| A26#    | T-2   | D23# | A-2  | REQ2#   | AE-12 |             |       | AD-18 | AB-9 <sup>1</sup>  | AE-1  |          |
| A27#    | V-1   | D24# | D-1  | REQ3#   | AE-14 |             |       | AD-26 | AB-18 <sup>1</sup> | AE-2  |          |
| A28#    | AF-2  | D25# | C-5  | REQ4#   | AE-11 |             |       | AD-2  |                    | AE-25 |          |
| A29#    | U-1   | D26# | B-4  | RESET#  | T-3   |             |       | AE-22 |                    | AE-26 |          |
| A30#    | V-2   | D27# | B-12 | RS0#    | AE-18 |             |       | AE-24 |                    | AE-5  |          |
| A31#    | AA-1  | D28# | B-7  | RS1#    | AD-15 |             |       | AE-4  |                    | AF-1  |          |
|         |       | D29# | C-7  | RS2#    | AE-19 |             |       | AE-7  |                    | AF-11 |          |
|         |       | D30# | C-2  | RTTCTRL | J-23  |             |       | AF-12 |                    | AF-15 |          |
|         |       | D31# | A-6  | SLP#    | AD-21 |             |       | AF-16 |                    | AF-19 |          |

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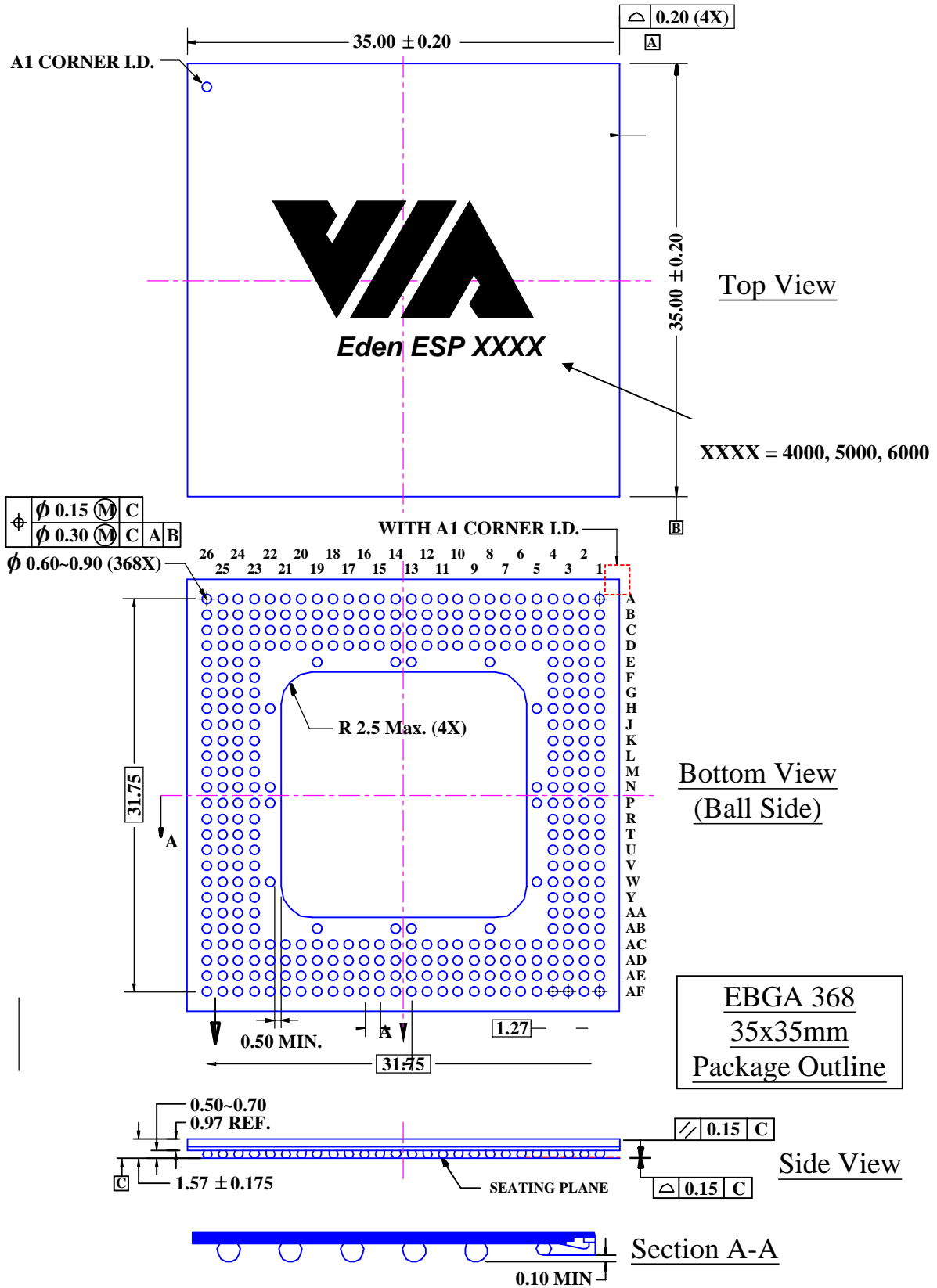
| Address |  | Data |      | Control          |       | Power/other |  | V <sub>CC</sub> | V <sub>TT</sub> | V <sub>SS</sub> | Reserved |
|---------|--|------|------|------------------|-------|-------------|--|-----------------|-----------------|-----------------|----------|
|         |  | D32# | A-5  | SMI#             | AA-25 |             |  | AF-20           |                 | AF-23           |          |
|         |  | D33# | C-6  | STPCLK#          | Y-24  |             |  | AF-3            |                 | AF-26           |          |
|         |  | D34# | C-8  | TRDY#            | AE-16 |             |  | AF-8            |                 | AF-7            |          |
|         |  | D35# | B-6  | BR0              | R-26  |             |  | B-16            |                 | B-2             |          |
|         |  | D36# | B-10 | BR1              | P-26  |             |  | B-23            |                 | B-22            |          |
|         |  | D37# | A-10 | BR2              | N-26  |             |  | B-3             |                 | B-25            |          |
|         |  | D38# | A-9  | BR3              | M-26  |             |  | C-1             |                 | B-26            |          |
|         |  | D39# | C-11 | BR4 <sup>1</sup> | E-26  |             |  | C-17            |                 | B-5             |          |
|         |  | D40# | C-15 | NCHCTRL          | K-24  |             |  | C-25            |                 | C-14            |          |
|         |  | D41# | A-14 |                  |       |             |  | C-9             |                 | C-3             |          |
|         |  | D42# | B-13 |                  |       |             |  | D-12            |                 | C-26            |          |
|         |  | D43# | B-8  |                  |       |             |  | D-13            |                 | D-10            |          |
|         |  | D44# | C-12 |                  |       |             |  | D-17            |                 | D-11            |          |
|         |  | D45# | B-11 |                  |       |             |  | D-2             |                 | D-14            |          |
|         |  | D46# | B-20 |                  |       |             |  | D-20            |                 | D-15            |          |
|         |  | D47# | B-15 |                  |       |             |  | D-21            |                 | D-18            |          |
|         |  | D48# | B-18 |                  |       |             |  | D-24            |                 | D-19            |          |
|         |  | D49# | A-13 |                  |       |             |  | D-4             |                 | D-22            |          |
|         |  | D50# | A-22 |                  |       |             |  | D-5             |                 | D25             |          |
|         |  | D51# | B-14 |                  |       |             |  | D-8             |                 | D-6             |          |
|         |  | D52# | B-17 |                  |       |             |  | D-9             |                 | D-7             |          |
|         |  | D53# | A-21 |                  |       |             |  | E-1             |                 | E-14            |          |
|         |  | D54# | B-19 |                  |       |             |  | E-13            |                 | E-19            |          |
|         |  | D55# | A-18 |                  |       |             |  | E-23            |                 | E-2             |          |
|         |  | D56# | A-23 |                  |       |             |  | E-8             |                 | E-25            |          |
|         |  | D57# | C-19 |                  |       |             |  | F-24            |                 | E-4             |          |
|         |  | D58# | B-21 |                  |       |             |  | F-3             |                 | F-23            |          |
|         |  | D59# | A-17 |                  |       |             |  | F-4             |                 | F-25            |          |
|         |  | D60# | C-23 |                  |       |             |  | H-1             |                 | G-1             |          |
|         |  | D61# | B-24 |                  |       |             |  | H-22            |                 | G-23            |          |
|         |  | D62# | C-22 |                  |       |             |  | H-23            |                 | G-24            |          |
|         |  | D63# | C-16 |                  |       |             |  | J-24            |                 | H-26            |          |
|         |  |      |      |                  |       |             |  | J-26            |                 | H-4             |          |
|         |  |      |      |                  |       |             |  | K-25            |                 | H-5             |          |
|         |  |      |      |                  |       |             |  | K-26            |                 | J-25            |          |



| Address |  | Data |  | Control |  | Power/other |  | V <sub>CC</sub> | V <sub>TT</sub> | V <sub>SS</sub> | Reserved |
|---------|--|------|--|---------|--|-------------|--|-----------------|-----------------|-----------------|----------|
|         |  |      |  |         |  |             |  | K-3             |                 | J-3             |          |
|         |  |      |  |         |  |             |  | K-4             |                 | J-4             |          |
|         |  |      |  |         |  |             |  | L-2             |                 | L-1             |          |
|         |  |      |  |         |  |             |  | M-1             |                 | L-23            |          |
|         |  |      |  |         |  |             |  | N-22            |                 | L-26            |          |
|         |  |      |  |         |  |             |  | N-24            |                 | M-4             |          |
|         |  |      |  |         |  |             |  | P-4             |                 | N-25            |          |
|         |  |      |  |         |  |             |  | P-5             |                 | N-3             |          |
|         |  |      |  |         |  |             |  | R-2             |                 | N-4             |          |
|         |  |      |  |         |  |             |  | R-25            |                 | N-5             |          |
|         |  |      |  |         |  |             |  | T-1             |                 | P-22            |          |
|         |  |      |  |         |  |             |  | U-23            |                 | P-23            |          |
|         |  |      |  |         |  |             |  | U-24            |                 | P-24            |          |
|         |  |      |  |         |  |             |  | V-3             |                 | P-25            |          |
|         |  |      |  |         |  |             |  | V-4             |                 | R-1             |          |
|         |  |      |  |         |  |             |  | W-2             |                 | T-26            |          |
|         |  |      |  |         |  |             |  | W-25            |                 | T-4             |          |
|         |  |      |  |         |  |             |  | Y-23            |                 | U-4             |          |
|         |  |      |  |         |  |             |  |                 |                 | V-23            |          |
|         |  |      |  |         |  |             |  |                 |                 | V-24            |          |
|         |  |      |  |         |  |             |  |                 |                 | W-1             |          |
|         |  |      |  |         |  |             |  |                 |                 | W-4             |          |
|         |  |      |  |         |  |             |  |                 |                 | W-5             |          |
|         |  |      |  |         |  |             |  |                 |                 | W-22            |          |
|         |  |      |  |         |  |             |  |                 |                 | W-23            |          |
|         |  |      |  |         |  |             |  |                 |                 | Y-1             |          |
|         |  |      |  |         |  |             |  |                 |                 | Y-4             |          |
|         |  |      |  |         |  |             |  |                 |                 | Y-26            |          |

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Figure 6-2: Mechanical Specification – 368 Enhanced Ball Grid Array Package



## SECTION

## 7

# THERMAL SPECIFICATIONS

## 7.1 INTRODUCTION

---

The VIA Eden ESP processor is specified for operation with device **junction** temperatures in the range of 0°C to 85°C. Operation outside of this range will result in functional failures and may potentially damage the device.

Care must be taken to ensure that the case temperature remains within the specified range at all times during operation. An effective heat sink with adequate airflow is therefore a requirement during operation.

## 7.2 TYPICAL ENVIRONMENTS

---

Typical thermal solutions involve three components: a heat sink, an interface material between the heat sink and the package, and a source of airflow. The best thermal solutions rely on the use of all three components. To the extent that any of these components are not used, the other components must be improved to compensate for such omission. In particular, the use of interface material such as thermal grease, silicone paste, or graphite paper can make a 40°C difference in the case temperature. Likewise, the imposition of airflow is realistically a requirement.

## 7.3 MEASURING $T_C$ AND $T_J$

---

The case temperature ( $T_C$ ) should be measured by attaching a thermocouple to the center of the VIA Eden ESP processor package. The heat produced by the processor is very localized so measuring the case temperature anywhere else will underestimate the case temperature.

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The presence of a thermocouple is inherently invasive; effort must be taken to minimize the effect of the measurement. The thermocouple should be attached to the processor through a small hole drilled in the heat sink. Thermal grease should be used to ensure that the thermocouple makes good contact with the package, but the thermocouple should not come in direct contact with the heat sink.

The junction temperature ( $T_J$ ) should be measured with the processors on-die thermal diode.

### Physical Test Conditions

Case temperature measurements should be made in the worst case operating environments. Ideally, systems should be maximally configured, and tested at the worst-case ambient temperature.

### Test Patterns

During normal operation the processor attempts to minimize power consumption. Consequently, normal power consumption is much lower than the maximum power consumption. Thermal testing should be done while running software which causes the processor to operate at its thermal limits.

## 7.4 MEASURING $T_J$

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The junction temperature of the die can be measured by using the processor's on-chip diode.

## 7.5 ESTIMATING $T_C$

---

The VIA Eden ESP processor's case temperature can be estimated based on the general characteristics of the thermal environment. This estimate is not intended as a replacement for actual measurement.

Case temperature can be estimated from Table 7-1 below, where,

$T_A$   $\equiv$  Ambient Temperature

$T_C$   $\equiv$  Case Temperature

$\theta_{CA}$   $\equiv$  case-to-ambient thermal resistance

$\theta_{JA}$   $\equiv$  junction-to-ambient thermal resistance

$\theta_{JC}$   $\equiv$  junction-to-case thermal resistance

$P$   $\equiv$  power consumption (Watts)

and,

$$T_J = T_C + (P * \theta_{JC})$$

$$T_A = T_J - (P * \theta_{JA})$$

$$T_A = T_C - (P * \theta_{CA})$$

$$\theta_{CA} = \theta_{JA} - \theta_{JC}$$

Table 7-1. EBGA  $\theta_{JC}$  and  $\theta_{JA}$

| Heat Sink in Inches (height) | $\theta_{JC}$ ( $^{\circ}\text{C}/\text{Watt}$ ) | $\theta_{JA}$ ( $^{\circ}\text{C}/\text{WATT}$ ) VS. LAMINAR AIRFLOW (LINEAR FT/MIN) |      |      |     |     |     |
|------------------------------|--------------------------------------------------|--------------------------------------------------------------------------------------|------|------|-----|-----|-----|
|                              |                                                  | 0                                                                                    | 100  | 200  | 400 | 600 | 800 |
| 0.25                         | 0.9                                              | 9.5                                                                                  | 8.4  | 7.0  | 4.9 | 4.0 | 3.4 |
| 0.35                         | 0.9                                              | 9.2                                                                                  | 7.9  | 6.4  | 4.4 | 3.7 | 3.2 |
| 0.45                         | 0.9                                              | 8.8                                                                                  | 7.4  | 5.7  | 4.0 | 3.3 | 2.9 |
| 0.55                         | 0.9                                              | 8.5                                                                                  | 6.9  | 5.1  | 3.6 | 3.0 | 2.7 |
| 0.65                         | 0.9                                              | 8.1                                                                                  | 6.4  | 4.7  | 3.4 | 2.8 | 2.5 |
| 0.80                         | 0.9                                              | 7.4                                                                                  | 5.7  | 4.3  | 3.2 | 2.6 | 2.4 |
| 1.00                         | 0.9                                              | 6.7                                                                                  | 5.1  | 4.0  | 3.0 | 2.5 | 2.2 |
| 1.20                         | 0.9                                              | 6.3                                                                                  | 4.7  | 3.7  | 2.8 | 2.4 | 2.2 |
| 1.40                         | 0.9                                              | 5.8                                                                                  | 4.3  | 3.4  | 2.6 | 2.3 | 2.1 |
| No Heat Sink                 | 1.6                                              | 14.7                                                                                 | 13.4 | 12.0 | 9.1 | 7.7 | 6.8 |

Environment: these estimates assume the use of thermal grease between the processor and the heat sink. Heat sinks are 1.95" square.



## APPENDIX



# MACHINE SPECIFIC REGISTERS

## A.1 GENERAL

---

Tables A-1 and A-2 summarize the VIA Eden ESP processor machine-specific registers (MSRs). Further description of each MSR follows the table. MSRs are read using the RDMSR instruction and written using the WRMSR instruction.

There are four basic groups of MSRs (not necessarily with contiguous addresses). Other than as defined below, a reference to an undefined MSR causes a General Protection exception.

1. Generally these registers can have some utility to low-level programs (like BIOS).

Note that some of the MSRs (address 0 to 0x4FF) have no function in the VIA Eden ESP processor. These MSRs do not cause a GP when used on the VIA Eden ESP; instead, reads to these MSRs return zero, and writes are ignored. Some of these undocumented MSRs may have ill side effects when written to indiscriminately. Do not write to undocumented MSRs.

2. There are some undocumented internal-use MSRs used for low-level hardware testing purposes. Attempts to read or write these undocumented MSRs cause unpredictable and disastrous results; so don't use MSRs that are not documented in this datasheet!
3. MSRs used for cache and TLB testing. These use MSR addresses that are not used on compatible processor. These test functions are very low-level and complicated to use. They are not documented in this datasheet but the information will be provided to customers given an appropriate justification

*MSRs are not reinitialized by the bus INIT interrupt; the setting of MSRs is preserved across INIT.*

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Table A-1. Category 1 MSRs

| MSR            | MSR NAME               | ECX  | EDX          | EAX          | TYPE | NOTES |
|----------------|------------------------|------|--------------|--------------|------|-------|
| TSC            | Time Stamp Counter     | 10h  | TSC[63:32]   | TSC[31:0]    | RW   |       |
| EBL_CR_POWERON | EBL_CR_POWERON         | 2Ah  | n/a          | Control bits | RW   |       |
| PERFCTR0       | Performance counter 0  | C1h  | TSC[39:32]   | TSC[31:0]    | RW   | 1     |
| PERFCTR1       | Performance counter 1  | C2h  | 0            | Count[31:0]  | RW   |       |
| BBL_CR_CTL3    | L2 Hardware Disabled   | 11Eh | n/a          | 00800000h    | RO   |       |
| EVNTSEL0       | Event counter 0 select | 186h | n/a          | 00470079h    | RO   | 1     |
| EVNTSEL1       | Event counter 1 select | 187h | n/a          | Control bits | RW   |       |
| MTRR           | MTRRphysBase0          | 200h | Control bits | Control bits | RW   |       |
| MTRR           | MTRRphysMask0          | 201h | Control bits | Control bits | RW   |       |
| MTRR           | MTRRphysBase1          | 202h | Control bits | Control bits | RW   |       |
| MTRR           | MTRRphysMask1          | 203h | Control bits | Control bits | RW   |       |
| MTRR           | MTRRphysBase2          | 204h | Control bits | Control bits | RW   |       |
| MTRR           | MTRRphysMask2          | 205h | Control bits | Control bits | RW   |       |
| MTRR           | MTRRphysBase3          | 206h | Control bits | Control bits | RW   |       |
| MTRR           | MTRRphysMask3          | 207h | Control bits | Control bits | RW   |       |
| MTRR           | MTRRphysBase4          | 208h | Control bits | Control bits | RW   |       |
| MTRR           | MTRRphysMask4          | 209h | Control bits | Control bits | RW   |       |
| MTRR           | MTRRphysBase5          | 20Ah | Control bits | Control bits | RW   |       |
| MTRR           | MTRRphysMask5          | 20Bh | Control bits | Control bits | RW   |       |
| MTRR           | MTRRphysBase6          | 20Ch | Control bits | Control bits | RW   |       |
| MTRR           | MTRRphysMask6          | 20Dh | Control bits | Control bits | RW   |       |
| MTRR           | MTRRphysBase7          | 20Eh | Control bits | Control bits | RW   |       |
| MTRR           | MTRRphysMask7          | 20Fh | Control bits | Control bits | RW   |       |
| MTRR           | MTRRfix64K_00000       | 250h | Control bits | Control bits | RW   |       |
| MTRR           | MTRRfix16K_80000       | 258h | Control bits | Control bits | RW   |       |
| MTRR           | MTRRfix16K_A0000       | 259h | Control bits | Control bits | RW   |       |
| MTRR           | MTRRfix4K_C0000        | 268h | Control bits | Control bits | RW   |       |
| MTRR           | MTRRfix4K_C8000        | 269h | Control bits | Control bits | RW   |       |
| MTRR           | MTRRfix4K_D0000        | 26Ah | Control bits | Control bits | RW   |       |
| MTRR           | MTRRfix4K_D8000        | 26Bh | Control bits | Control bits | RW   |       |
| MTRR           | MTRRfix4K_E0000        | 26Ch | Control bits | Control bits | RW   |       |
| MTRR           | MTRRfix4K_E8000        | 26Dh | Control bits | Control bits | RW   |       |
| MTRR           | MTRRfix4K_F0000        | 26Eh | Control bits | Control bits | RW   |       |
| MTRR           | MTRRfix4K_F8000        | 26Fh | Control bits | Control bits | RW   |       |
| MTRR           | MTRRdefType            | 2FFh | Control bits | Control bits | RW   |       |



**Notes:**

1. PERFCTR0 is an alias for the lower 40 bits of the Time Stamp Counter. EVNTSEL0 is a read only MSR that reflects this limitation.

**Table A-2. Category 2 MSRs**

| MSR  | MSR NAME              | ECX   | EDX     | EAX        | TYPE | NOTES |
|------|-----------------------|-------|---------|------------|------|-------|
| FCR  | Feature Control Reg   | 1107h | n/a     | FCR value  | RW   |       |
| FCR2 | Feature Control Reg 2 | 1108h | FCR2_Hi | FCR2 value | RW   | 1     |
| FCR3 | Feature Control Reg 3 | 1109h | FCR3_Hi | FCR3 value | WO   | 1     |

**Notes:**

1. FCR2 and FCR3 provide system software with the ability to specify the Vendor ID string returned by the CPUID instruction.

**A.2 CATEGORY 1 MSRS****10H: TSC (TIME STAMP COUNTER)**

VIA Eden ESP processor has a 64-bit MSR that materializes the Time Stamp Counter (TSC). System increments the TSC once per processor clock. The TSC is incremented even during AutoHalt or StopClock. A WRMSR to the TSC will clear the upper 32 bits of the TSC.

**2AH: EBL\_CR\_POWERON**

| 31:28         | 27         | 26                     | 25:22 | 21:20 | 19:18 | 17:15 | 14    | 13       | 12:0                                                 |
|---------------|------------|------------------------|-------|-------|-------|-------|-------|----------|------------------------------------------------------|
| Res<br>'1100' | BF<br>High | LowPow-<br>erEn<br>'1' | BF    | Res   | BSEL  | Res   | 1MPOV | IOQDepth | Reserved<br>(Ignored on write;<br>returns 0 on read) |
| 4             | 1          | 1                      | 4     | 2     | 2     | 3     | 1     | 1        | 13                                                   |

**IOQDepth:** 0 = In Order Queue Depth with up to 8 transactions

1 = 1 transaction

**1MPOV:** 0 = Power on Reset Vector at 0xFFFFFFFF0 (4Gbytes)

1 = Power on Reset Vector at 0x000FFFF0 (1 Mbyte)

**BSEL:** 01 = 133 MHz Bus

10 = 100 MHz Bus

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**BF\_High & BF: Bus Clock Frequency Ratio**

| BF_High<br>(27) | BF<br>(25:22) | Clock Multiplier |
|-----------------|---------------|------------------|
| 0               | 0000          | 5.0              |
| 0               | 0001          | 3.0              |
| 0               | 0010          | 4.0              |
| 0               | 0011          | 10.0             |
| 0               | 0100          | 5.5              |
| 0               | 0101          | 3.5              |
| 0               | 0110          | 4.5              |
| 0               | 0111          | 9.5              |
| 0               | 1000          | 9.0              |
| 0               | 1001          | 7.0              |
| 0               | 1010          | 8.0              |
| 0               | 1011          | 6.0              |
| 0               | 1100          | 12.0             |
| 0               | 1101          | 7.5              |
| 0               | 1110          | 8.5              |
| 0               | 1111          | 6.5              |
| 1               | 0000          | Reserved         |
| 1               | 0001          | 11.0             |
| 1               | 0010          | 12.0             |
| 1               | 0011          | Reserved         |
| 1               | 0100          | 13.5             |
| 1               | 0101          | 11.5             |
| 1               | 0110          | 12.5             |
| 1               | 0111          | 10.5             |
| 1               | 1000          | 13.0             |
| 1               | 1001          | 15.0             |
| 1               | 1010          | 16.0             |
| 1               | 1011          | 14.0             |
| 1               | 1100          | Reserved         |
| 1               | 1101          | 15.5             |
| 1               | 1110          | Reserved         |
| 1               | 1111          | 14.5             |

**LowPowerEn:** This bit always set to '1'

**C1H-C2H: PERFCTR0 & PERFCTR1**

These are events counters 0 and 1. VIA Eden ESP processors PERFCTR0 is an alias for the lower 40 bits of the TSC.

**11EH: BBL\_CR\_CTL3**

| 31:24           | 23                    | 22:0                                                        |
|-----------------|-----------------------|-------------------------------------------------------------|
| <i>Reserved</i> | L2_Hdw_Disable<br>'1' | <i>Reserved</i><br>(Ignored on write;<br>returns 0 on read) |
| 8               | 1                     | 23                                                          |

The VIA Eden ESP processor does contain an L2 cache. For compatibility, this read-only MSR indicates to the BIOS or system software that the L2 is disabled even if the L2 is enabled.

**L2\_Hdw\_Disable:** This bit always set to '1'

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**186H: EVNTSEL0 (EVENT COUNTER 0 SELECT)**

|                 |                 |                 |                            |
|-----------------|-----------------|-----------------|----------------------------|
| 31:24           | 23:16           | 15:9            | 8:0                        |
| <i>Reserved</i> | <i>Reserved</i> | <i>Reserved</i> | CTR0 Event<br>Select = 79h |
| 8               | 8               | 7               | 9                          |

PERFCTR0 is an alias for the lower 40 bits of the Time Stamp Counter. EVNTSEL0 is a read only MSR which reflects this limitation. The CTR0\_Event Select field always returns 0x0079, which corresponds to counting of processor clocks.

**187H: EVNTSEL1 (EVENT COUNTER 1 SELECT)**

|                 |                 |                 |                      |
|-----------------|-----------------|-----------------|----------------------|
| 31:24           | 23:16           | 15:9            | 8:0                  |
| <i>Reserved</i> | <i>Reserved</i> | <i>Reserved</i> | CTR1 Event<br>Select |
| 8               | 8               | 7               | 9                    |

VIA Eden ESP processor have two MSRs that contain bits defining the behavior of the two hardware event counters: PERFCTR0 and PERFCTR1.

The CTR1\_Event\_Select control field defines which of several possible events is counted. The possible Event Select values for PERFCTR1 are listed in the table below. Note that CTR1\_Event\_Select is a 9-bit field.

The EVNTSEL1 register should be written before PERFCTR1 is written to initialize the counter. The counts are not necessarily perfectly exact; the counters are intended for use over a large number of events and may differ by one or two counts from what might be expected.

Most counter events are internal implementation-dependent debug functions, having no meaning to software. The counters that can have end-user utility are:

| <i>EVENT</i> | <i>DESCRIPTION</i>                          |
|--------------|---------------------------------------------|
| C0h          | Instructions executed                       |
| 1C0h         | Instructions executed and string iterations |
| 79h          | Internal clocks (default event for CTR0)    |

**A.3 CATEGORY 2 MSRS****1107H: FCR (FEATURE CONTROL REGISTER)**

The FCR controls the major optional feature capabilities of the VIA Eden ESP processor. Table A-3 contains the bit values for the FCR. The default settings shown for the FCR bits are not necessarily exact. The actual settings can be changed as part of the manufacturing process and thus a particular VIA Eden ESP processor version can have slightly different default settings than shown here. All reserved bit values of the FCR must be preserved by using a read-modify-write sequence to update the FCR.

Table A-3. FCR Bit Assignments

| <b>BIT</b> | <b>NAME</b> | <b>DESCRIPTION</b>                                 | <b>DEFAULT</b> |
|------------|-------------|----------------------------------------------------|----------------|
| 0          | ALTINST     | <i>Reserved for test &amp; special uses</i>        | 0              |
| 1          | ECX8        | Enables CPUID reporting CX8                        | 0              |
| 2          |             | <i>Reserved</i>                                    | 0              |
| 3          |             | <i>Reserved</i>                                    | 0              |
| 4          |             | <i>Reserved</i>                                    | 0              |
| 5          | DSTPCLK     | Disables supporting STPCLK                         | 0              |
| 6          |             | <i>Reserved</i>                                    | 0              |
| 7          | EPGE        | Enables CR4.PGE and CPUID.PGE (Page Global Enable) | 1              |
| 8          | DL2         | Disables L2 Cache                                  | 0              |
| 9          |             | <i>Reserved</i>                                    | 1              |
| 10         |             | <i>Reserved</i>                                    | 0              |
| 11         | DPDC        | Disables Page Directory cache                      | 0              |
| 12         | EBRPRED     | Enables Branch Prediction                          | 1              |
| 13         | DIC         | Disables I-Cache                                   | 0              |
| 14         | DDC         | Disables D-Cache                                   | 0              |
| 15         |             | <i>Reserved</i>                                    | 1              |
| 16         |             | <i>Reserved</i>                                    | 1              |
| 17         |             | <i>Reserved</i>                                    | 1              |
| 18         |             | <i>Reserved</i>                                    | 0              |
| 19         |             | <i>Reserved</i>                                    | 1              |
| 20         |             | <i>Reserved</i>                                    | 1              |
| 21         |             | <i>Reserved</i>                                    | 1              |
| 22:25      | SID         | Stepping ID                                        | 0              |
| 26         |             | <i>Reserved</i>                                    | 0              |
| 27         |             | <i>Reserved</i>                                    | 0              |
| 28         |             | <i>Reserved</i>                                    | 1              |
| 29         |             | <i>Reserved</i>                                    | 0              |
| 30         |             | <i>Reserved</i>                                    | 0              |
| 31         |             | <i>Reserved</i>                                    | 1              |

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- ALTINST:** 0 = Normal x86 instruction execution.  
1 = Alternate instruction set execution is enabled (see details below)
- ECX8:** 0 = The CPUID instruction does not report the presence of the CMPXCHG8B instruction (CX8 = 0). The instruction actually exists and operates correctly, however.  
1 = The CPUID instruction reports that the CMPXCHG8B instruction is supported (CX8 = 1).
- DSTPCLK:** 0 = STPCLK interrupt properly supported.  
1 = Ignores SPCLK interrupt.
- EPGE:** 0 = The processor does not support Page Global Enable and therefore CPUID Feature Flags reports EDX[13]=0; attempts to set CR4.PGE are ignored.  
1 = The processor supports Page Global Enable and therefore CPUID Feature Flags reports EDX[13]=1; CR4.PGE can be set to 1.
- DL2:** 0 = L2 Cache enabled.  
1 = L2 Cache disabled.
- DPDC:** 0 = Enables use of internal Page Directory Cache.  
1 = Disables use of internal Page Directory Cache.
- EBRPRED:** 0 = Disables branch prediction function.  
1 = Enables branch prediction function.
- DIC:** 0 = Enables use of I-Cache.  
1 = Disables use of I-Cache: cache misses are performed as single transfer bus cycles, PCD is de-asserted. This overrides any setting of CR0.CD and CR0.NW.
- DDC:** 0 = Enables use of D-Cache.  
1 = Disables use of D-Cache: same semantics as for DIC except for D-Cache.

## ALTERNATE INSTRUCTION EXECUTION

---

When set to 1, the ALTINST bit in the FCR enables execution of an alternate (not x86) instruction set. While setting this FCR bit is a privileged operation, executing the alternate instructions can be done from any protection level.

This alternate instruction set includes an extended set of integer, MMX, floating-point, and 3DNow! instructions along with additional registers and some more powerful instruction forms over the x86 instruction architecture. For example, in the alternate instruction set, privileged functions can be used from any protection level, memory descriptor checking can be bypassed, and many x86 exceptions such as alignment check can be bypassed.

This alternate instruction set is intended for testing, debug, and special application usage. Accordingly, it is not documented for general usage. If you have a justified need for access to these instructions, contact your VIA representative.

The mechanism for initiating execution of this alternate set of instructions is as follows:

1. Set the FCR ALTINST bit to 1 using WRMSR instruction (this is a privileged instruction). This should be done using a read-modify-write sequence to preserve the values of other FCR bits.
2. The ALTINST bit enables execution of a new x86 jump instruction that starts execution of alternate instructions. This new jump instruction can be executed from any privilege level at any time that ALTINST is 1. The new jump instruction is a two-byte instruction: 0x0F3F. If ALTINST is 0, the execution of 0x0F3F causes an Invalid Instruction exception.
3. When executed, the new 0x0F3F x86 instruction causes a near branch to CS:EAX. That is, the branch function is the same as the existing x86 instruction
  - `jmp [eax]`
  - In addition to the branch, the 0x0F3F instruction sets the processor into an internal mode where the target bytes are not interpreted as x86 instructions but rather as alternate instruction set instructions.
4. The alternate instructions fetched following the 0x0F3F branch should be of the form
  - `0x8D8400XXXXXXXX` where `0XXXXXXXX` is the 32-bit alternate instruction
  - That is, the alternate instructions are presented as the 32-bit displacement of a
    - `LEA [EAX+EAX+disp]`
    - instruction. This example assumes that the current code segment size is 32-bits, if it is 16-bits, then an address size prefix (0x67) must be placed in front of the LEA opcode.
5. Upon fetching, the LEA “wrapper” is stripped off and the 32-bit alternate instruction contained in the displacement field is executed.
6. The alternate instruction set contains a special branch instruction that returns control to x86 fetch and execute mode. The x86 state upon return is not necessarily what it was when alternate instruction execution is entered since the alternate instructions can completely modify the x86 state.

While all VIA C3 processor processors contain this alternate instruction feature, the invocation details (e.g., the 0x8D8400 “prefix”) may be different between processors. Check the appropriate processor datasheet for details.

## 1108H: FCR2 (FEATURE CONTROL REGISTER 2)

This MSR contains more feature control bits — many of which are undefined. It is important that all reserved bits are preserved by using a read-modify-write sequence to update the MSR.

63:32

|                                                 |
|-------------------------------------------------|
| Last 4 characters of Alternate Vendor ID string |
|-------------------------------------------------|

|                 |     |            |           |          |            |
|-----------------|-----|------------|-----------|----------|------------|
| 31:15           | 14  | 13:12      | 11:8      | 7:4      | 3:0        |
| <i>Reserved</i> | AVS | <i>Res</i> | Family ID | Model ID | <i>Res</i> |
| 17              | 1   | 2          | 4         | 4        | 4          |

**AVS:** 0 = The CPUID instruction vendor ID is “CentaurHauls”  
 1 = The CPUID instruction returns the alternate Vendor ID. The first 8 characters of the alternate Vendor ID are stored in FCR3 and the last 4 characters in FCR2[63:32]. These

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12 characters are undefined after RESET and may be loaded by system software using WRMSR.

**Family ID:** This field will be returned as the family ID field by subsequent uses of the CPUID instruction

**Model ID:** This field will be returned as the model ID field by subsequent uses of the CPUID instruction

### 1109H: FCR (FEATURE CONTROL REGISTER 3)

---

This MSR contains the first 8 characters of the alternate Vendor ID. The alternate Vendor ID is returned by the CPUID instruction when FCR2[AVS] is set to '1'. FCR3 is a write-only MSR.

63:32

First 4 characters of Alternate Vendor ID string

31:0

Middle 4 characters of Alternate Vendor ID string