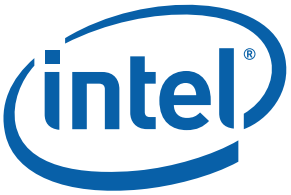

# Intel® Xeon® E3-1200 v5 Processor Family

## Specification Update

***December 2020***

Reference Number: 333133-036US

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# Content

# Revision History

| Revision | Description | Date |
|---|---|---|
| 036 | • Added erratum SKW186. | December 2020 |
| 035 | • Added erratum SKW185. | September 2020 |
| 034 | • Updated erratum SKW173.<br>• Added erratum SKW184. | June 2020 |
| 033 | • Added errata SKW182 and SKW 183. | April 2020 |
| 032 | • Added errata SKW180 and SKW181. | March 2020 |
| 031 | • Added errata SKW174,SKW175, SKW176, SKW 177, SKW 178, SKW179. | February 2020 |
| 030 | • Revised content and title of SKW36.<br>• Added errata SKW172 and SKW173. | August 2019 |
| 029 | • Added erratum SKW171. | July 2019 |
| 028 | • Added errata SKW168, SKW169, SKW170 | May 2019 |
| 027 | • Not available. | February 2019 |
| 026 | • Added erratum SKW167. | November 2018 |
| 025 | • Removed erratum SKW23.<br>• Updated errata SKW35, SKW50, SKW62, SKW160.<br>• Added errata SKW164 - SKW166. | October 2018 |
| 024 | • Added errata SKW162 - SKW163. | August 2018 |
| 023 | • Updated errata SKW26, SKW161. | July 2018 |
| 022 | • Added errata SKW160 - SKW161. | June 2018 |
| 021 | • Added errata SKW154 - SKW159. | March 2018 |
| 020 | • Updated erratum SKW147.<br>• Added errata SKW152 - SKW153. | February 2018 |
| 019 | • Added erratum SKW151. | November 2017 |
| 018 | • Added errata SKW149 - SKW150. | October 2017 |
| 017 | • Added erratum SKW148. | September 2017 |
| 016 | • Added erratum SKW146 - SKW147. | August 2017 |
| 015 | • Skipped, no updates. | NA |
| 014 | • Added erratum SKW145. | May 2017 |
| 013 | • Added errata SKW143 - SKW144. | April 2017 |
| 012 | • Removed erratum SKW2.<br>• Added errata SKW134 - SKW142.<br>• Updated Product Family SKUs Table. | March 2017 |
| 011 | • Updated erratum SKW124.<br>• Added errata SKW132 - SKW133. | January 2017 |
| 010 | • Removed erratum SKW115.<br>• Added errata SKW107- SKW131.<br>• Added Specification clarification SKW1. | October 2016 |
| 008-009 | • Skipped. | NA |
| 007 | • Added errata SKW102- SKW106. | June 2016 |
| 006 | • Added errata SKW98 - SKW101. | April 2016 |
| 005 | • Skipped. | NA |

| Revision | Description | Date |
|---|---|---|
| 004 | • Added errata SKW94 - SKW97. | March 2016 |
| 003 | • Updated SKW57.<br>• Added errata SKW83-SKW93. | February 2016 |
| 002.1 | • Added Erratum SKW81-82. | January 2016<br>(Out of cycle) |
| 002 | • Updated SKW12.<br>• Updated SKW67.<br>• Added errata SKW77-SKW80.<br>• Corrected Product family SKU table.<br>• Added Specification change SKW1. | December 2015 |
| 001 | • Initial Release. | November 2015 |

# Preface

This document is an update to the specifications contained in the next table "Affected Documents". It is a compilation of device and documentation errata, specification clarifications, and changes. It is intended for hardware system manufacturers and software developers of applications, operating systems, or tools.

Information types defined in "Nomenclature" are consolidated into the specification update and are no longer published in other documents.

This document may contain information that was not previously published.

## Affected Documents

| Document Title | Document Number |
|---|---|
| *Intel® Xeon® Processor E3-1200 v5 Product Family Datasheet, Volume 1 of 2* | 333131 |
| *Intel® Xeon® Processor E3-1200 v5 Product Family Datasheet, Volume 2 of 2* | 333132 |

## Related Documents

| Document Title | Document Number/ Location |
|---|---|
| *Intel® 64 and IA-32 Architectures Software Developer's Manual Volume 2A: Instruction Set Reference, A-L -- Refer to section "AP-485, Intel® Processor Identification and the CPUID Instruction"* | http://www.intel.com/design/processor/applnots/241618.htm |
| *Intel® 64 and IA-32 Architectures Software Developer's Manual, Volume 1: Basic Architecture*<br>*Intel® 64 and IA-32 Architectures Software Developer's Manual, Volume 2A: Instruction set reference, A-L*<br>*Intel® 64 and IA-32 Architectures Software Developer's Manual, Volume 2B: Instruction set reference, M-U*<br>*Intel® 64 and IA-32 Architectures Software Developer's Manual, Volume 2C: Instruction set reference, V-Z*<br>*Intel® 64 and IA-32 Architectures Software Developer's Manual, Volume 3A: System programming guide, part 1*<br>*Intel® 64 and IA-32 Architectures Software Developer's Manual, Volume 3B: System programming guide, part 2*<br>*Intel® 64 and IA-32 Intel Architecture Optimization Reference Manual* | http://www.intel.com/products/processor/manuals/index.htm |
| *Intel® 64 and IA-32 Architectures Software Developer's Manuals* | http://www.intel.com/content/www/us/en/processors/architectures-software-developer-manuals.html |
| *Advanced Configuration Power Interface (ACPI) Specifications* | www.acpi.info |

## Nomenclature

**Errata** are design defects or errors. These may cause the processor behavior to deviate from published specifications. Hardware and software designed to be used with any given stepping must assume that all errata documented for that stepping are present on all devices.

**S-Spec Number** is a five-digit code used to identify products. Products are differentiated by their unique characteristics such as, core speed, L2 cache size, package type, and so forth, as described in the processor identification information table. Read all notes associated with each S-Spec number.

**Qualification Detail Form (QDF) Number Specification Changes** are modifications to the current published specifications. These changes will be incorporated in any new release of the specification.

**Specification Clarifications** describe a specification in greater detail or further highlight a specification's impact to a complex design situation. These clarifications will be incorporated in any new release of the specification.

**Documentation Changes** include typos, errors, or omissions from the current published specifications. These will be incorporated in any new release of the specification.

***Note:*** Errata remain in the specification update throughout the product's lifecycle, or until a particular stepping is no longer commercially available. Under these circumstances, errata removed from the specification update are archived and available upon request. Specification changes, specification clarifications and documentation changes are removed from the specification update when the appropriate changes are made to the appropriate product specification or user documentation (datasheets, manuals, and so on).

# Summary Tables of Changes

The following tables indicate the errata, specification changes, specification clarifications, or documentation changes which apply to the processor. Intel may fix some of the errata in a future stepping of the component, and account for the other outstanding issues through documentation or specification changes as noted. These tables use the following notations.

## Codes Used in Summary Tables

### Stepping

| | |
|---|---|
| X: | Errata exists in the stepping indicated. Specification Change or Clarification that applies to this stepping. |
| (No mark) or (Blank box): | This erratum is fixed in listed stepping or specification change does not apply to listed stepping. |

### Page

| | |
|---|---|
| (Page): | Page location of item in this document. |

### Status

| | |
|---|---|
| Doc: | Document change or update will be implemented. |
| Plan Fix: | This erratum may be fixed in a future stepping of the product. |
| Fixed: | This erratum has been previously fixed. |
| No Fix: | There are no plans to fix this erratum. |

### Row

Change bar to left of a table row indicates this erratum is either new or modified from the previous version of the document.

## Errata (Sheet 1 of 7)

| Number | Steppings | Status | ERRATA |
|---|---|---|---|
| | R-0 | | |
| SKW1 | X | No Fix | Reported Memory Type May Not Be Used to Access the Virtual-Machine Control Structure (VMCS) and Referenced Data Structures |
| SKW2 | X | No Fix | Erratum has been Removed |
| SKW3 | X | No Fix | Execution of VAESIMC or VAESKEYGENASSIST with An Illegal Value for VEX.vvvv May Produce a Device-Not-Available (#NM) Exception |
| SKW4 | X | No Fix | The Corrected Error Count Overflow Bit in IA32_ MC0_STATUS Is Not Updated When The UC Bit Is Set |
| SKW5 | X | No Fix | VM Exit May Set IA32_EFER.NXE When IA32_MISC_ENABLE Bit 34 Is Set to 1 |
| SKW6 | X | No Fix | SMRAM State-Save Area Above the 4 GB Boundary May Cause Unpredictable System Behavior |

## Errata (Sheet 2 of 7)

| Number | Steppings | Status | ERRATA |
|---|---|---|---|
| | R-0 | | |
| SKW7 | X | No Fix | x87 FPU Exception (#MF) May Be Signaled Earlier Than Expected |
| SKW8 | X | No Fix | Incorrect FROM_IP Value For an Restricted Transactional Memory (RTM) Abort in BTM or BTS May Be Observed |
| SKW9 | X | No Fix | DR6 Register May Contain an Incorrect Value When a MOV to SS or POP SS Instruction Is Followed by an XBEGIN Instruction |
| SKW10 | X | No Fix | Opcode Bytes F3 0F BC May Execute As TZCNT Even When TZCNT Not Enumerated by CPUID |
| SKW11 | X | No Fix | PCIe* Root-port Initiated Compliance State Transmitter Equalization Settings May Be Incorrect |
| SKW12 | X | No Fix | The SMSW Instruction May Execute Within an Enclave |
| SKW13 | X | No Fix | PEBS Record After a WRMSR to IA32_BIOS_UPDT_TRIG May be Incorrect |
| SKW14 | X | No Fix | Intel® Processor Trace (Intel® PT) TIP.PGD May Not Have Target IP Payload |
| SKW15 | X | No Fix | Operand-Size Override Prefix Causes 64-bit Operand Form of MOVBE Instruction to Cause an #UD |
| SKW16 | X | No Fix | Execution of the FXSAVE or the FXRSTOR With the VEX Prefix May Produce an #NM Exception |
| SKW17 | X | No Fix | WRMSR May Not Clear The Sticky Count Overflow Bit in The IA32_MCi_STATUS MSRs' Corrected Error Count Field |
| SKW18 | X | No Fix | PEBS Eventing IP Field May Be Incorrect After Not-Taken Branch |
| SKW19 | X | No Fix | Debug Exceptions May Be Lost or Misreported Following WRMSR to IA32_BIOS_UPDT_TRIG |
| SKW20 | X | No Fix | Attempts to Retrain a PCIe* Link May Be Ignored |
| SKW21 | X | No Fix | Intel® PT Packet Stream Boundary (PSB)+ Packets May Contain Unexpected Packets |
| SKW22 | X | No Fix | An Advanced Programmable Interrupt Controller (APIC) Timer Interrupt During Core C6 Entry May Be Lost |
| SKW24 | X | No Fix | VM Entry That Clears TraceEn May Generate a FUP |
| SKW25 | X | No Fix | EDRAM Corrected Error Events May Not Be Properly Logged After a Warm Reset |
| SKW26 | X | No Fix | Performance Monitor Event For Outstanding Offcore Requests May Be Incorrect |
| SKW27 | X | No Fix | Processor Instability May Occur When Using the Platform Environmental Control Interface (PECI) RdIAMSR Command |
| SKW28 | X | No Fix | ENCLU[EGETKEY] Ignores KEYREQUEST.MISCMASK |
| SKW29 | X | No Fix | POPCNT Instruction May Take Longer to Execute Than Expected |
| SKW30 | X | No Fix | ENCLU[EREPORT] May Cause a General Protection Exception (#GP) When TARGETINFO.MISCSELECT Is Non-Zero |
| SKW31 | X | No Fix | A VMX Transition Attempting to Load a Non-Existent MSR May Result in a Shutdown |
| SKW32 | X | No Fix | Transitions Out of 64-Bit Mode May Corrupt the x87 FPU Instruction and Data Pointer Registers |
| SKW33 | X | No Fix | Intel® PT FUP May Be Dropped After the OVF |
| SKW34 | X | No Fix | ENCLS[ECREATE] Causes a #GP if Enclave Base Address Is Not Canonical |
| SKW35 | X | No Fix | Data Breakpoint May Not Be Detected on a REP MOVS |
| SKW36 | X | No Fix | Graphics Error: Intel® Virtualization Technology (Intel® VT) for Directed I/O (Intel® VT-d) Hardware May Cache Invalid Entries |
| SKW37 | X | No Fix | PCIe* and DMI Links With Lane Polarity Inversion May Result in Link Failure |
| SKW38 | X | No Fix | PCIe* Expansion ROM Base Address Register May Be Incorrect |
| SKW39 | X | No Fix | PCIe* Perform Equalization May Lead to Link Failure |

## Errata (Sheet 3 of 7)

| Number | Steppings | Status | ERRATA |
|---|---|---|---|
| | R-0 | | |
| SKW40 | X | No Fix | Two DIMMs Per Channel 2133 MHz DDR4 SODIMM Daisy-Chain Systems with Different Vendors May Hang |
| SKW41 | X | No Fix | ENCLS[EINIT] Instruction May Unexpectedly #GP |
| SKW42 | X | No Fix | Intel® Processor Trace (Intel® PT) OVF Packet May be Lost if Immediately Preceding a TraceStop |
| SKW43 | X | No Fix | Detecting an Intel® PT Stopped or Error Condition Within an Intel® TSX Region May Result in a System Hang |
| SKW44 | X | No Fix | WRMSR to IA32_BIOS_UPDT_TRIG May Be Counted as Multiple Instructions |
| SKW45 | X | No Fix | The x87 FIP May Be Incorrect |
| SKW46 | X | No Fix | Branch Instructions May Initialize Intel® Memory Protection Extensions (Intel® MPX) Bound Registers Incorrectly |
| SKW47 | X | No Fix | Writing a Non-Canonical Value to an Last Branch Record (LBR) MSR Does Not Signal a #GP When Intel® PT Is Enabled |
| SKW48 | X | No Fix | Processor May Run Intel® Advanced Vector Extensions (Intel® AVX) Code Much Slower Than Expected |
| SKW49 | X | No Fix | Intel® PT Buffer Overflow May Result in Incorrect Packets |
| SKW50 | X | No Fix | Intel® PT PSB+ Packets May Be Omitted on a C6 Transition |
| SKW51 | X | No Fix | IA32_PERF_GLOBAL_STATUS.TRACE_TOPA_PMI Bit Cannot Be Set by Software |
| SKW52 | X | No Fix | Enabling VMX-Preemption Timer Blocks Hardware Duty Cycling (HDC) Operation |
| SKW53 | X | No Fix | ENCLU[EGETKEY] Instruction Ignores MISCMASK Value |
| SKW54 | X | No Fix | Intel® TSX Abort May Result in Unpredictable System Behavior |
| SKW55 | X | No Fix | Use of Prefetch Instructions May Lead to a Violation of Memory Ordering |
| SKW56 | X | No Fix | CS Limit Violation May Not be Detected |
| SKW57 | X | No Fix | Last Level Cache Performance Monitoring Events May Be Inaccurate |
| SKW58 | X | No Fix | #GP Occurs Rather Than the Debug Exception (#DB) on Code Page Split Inside an Intel® SGX Enclave |
| SKW59 | X | No Fix | Execution of VAESENCLAST Instruction May Produce a #NM Exception Instead of a #UD Exception |
| SKW60 | X | No Fix | Intel® SGX Enclave Accesses to the APIC-Access Page May Cause APIC-Access VM Exits |
| SKW61 | X | No Fix | CR3 Filtering Does Not Compare Bits [11:5] of CR3 and IA32_RTIT_CR3_MATCH in PAE Paging Mode |
| SKW62 | X | No Fix | Intel® PT PacketEn Change on C-state Wake May Not Generate a TIP Packet |
| SKW63 | X | No Fix | Graphics Configuration May Not Be Correctly Restored After a Package C8 Exit |
| SKW64 | X | No Fix | x87 FDP Value May Be Saved Incorrectly |
| SKW65 | X | No Fix | PECI Frequency Limited to 1 MHz |
| SKW66 | X | No Fix | Processor Graphics IOMMU Unit May Not Mask DMA Remapping Faults |
| SKW67 | X | No Fix | Processor With Intel® SGX Support May Hang During S3 Wake or Power-On Reset |
| SKW68 | X | No Fix | Pending x87 FPU Exceptions (#MF) May Be Signaled Earlier Than Expected |
| SKW69 | X | No Fix | IA Core Ratio Change Coincident With Outstanding Read to the Display Engine (DE) May Cause a System Hang |
| SKW70 | X | No Fix | TSC Is Not Affected by Warm Reset |
| SKW71 | X | No Fix | Intel® PT Buffer Overflow Indication May be Lost if it Immediately Precedes a TraceStop |
| SKW72 | X | No Fix | Intel® PT CYCThresh Value of 13 Is Not Supported |
| SKW73 | X | No Fix | Intel® PT May Drop Some Timing Packets After Entering Thread C3 |

## Errata (Sheet 4 of 7)

| Number | Steppings | Status | ERRATA |
|---|---|---|---|
| | R-0 | | |
| SKW74 | X | No Fix | Underflow and Denormal Conditions During a Vector Dot Product of Packed Single Precision Floating-Point Values (VDPPS) Instruction With YMM Operands May Not Produce The Expected Results |
| SKW75 | X | No Fix | APIC Timer Interrupt May Be Delivered Early |
| SKW76 | X | No Fix | System May Hang When Using Intel® Trusted Execution Technology (Intel® TXT) And Memory That Supports Address Mirroring |
| SKW77 | X | No Fix | Display Flicker May Occur When Both Intel® VT-d And FBC Are Enabled |
| SKW78 | X | No Fix | Certain Processors May be Configured With an Incorrect Thermal Design Power (TDP) |
| SKW79 | X | No Fix | MOVNTDQA From Write Combining (WC) Memory May Pass Earlier MFENCE Instructions |
| SKW80 | X | No Fix | Integrated Audio Codec May Not Be Detected |
| SKW81 | X | No Fix | Processor May Hang or Cause Unpredictable System Behavior |
| SKW82 | X | No Fix | REP MOVS May Not Operate Correctly With Extended Page Table (EPT) Enabled |
| SKW83 | X | No Fix | Ring Frequency Changes May Cause a Machine Check And System Hang |
| SKW84 | X | No Fix | x87 FPU Data Pointer Updated Only For Instructions That Incur Unmasked Exceptions |
| SKW85 | X | No Fix | WRMSR to IA32_BIOS_UPDT_TRIG Concurrent With an Safer Mode Extensions (SMX) SENTER/SEXIT May Result in a System Hang |
| SKW86 | X | No Fix | Incorrect Branch Predicted Bit in BTS/BTM Branch Records |
| SKW87 | X | No Fix | MACHINE_CLEARS.MEMORY_ORDERING Performance Monitoring Event May Undercount |
| SKW88 | X | No Fix | CTR_FRZ May Not Freeze Some Counters |
| SKW89 | X | No Fix | Instructions And Branches Retired Performance Monitoring Events May Overcount |
| SKW90 | X | No Fix | Some OFFCORE_RESPONSE Performance Monitoring Events May Overcount |
| SKW91 | X | No Fix | Using the BIOS to Disable Cores May Lead to a System Hang |
| SKW92 | X | No Fix | #GP After RSM May Push Incorrect RFLAGS Value When Intel® PT is Enabled |
| SKW93 | X | No Fix | Display Flickering May be Observed with Specific eDP Panels |
| SKW94 | X | No Fix | PEBS Record May Be Generated After Being Disabled |
| SKW95 | X | No Fix | Monitor Trap Flag (MTF) VM Exit on XBEGIN Instruction May Save State Incorrectly |
| SKW96 | X | No Fix | Access to Intel® SGX EPC Page in BLOCKED State Is Not Reported as an Intel® SGX-Induced Page Fault |
| SKW97 | X | No Fix | Software Using Intel® TSX May Behave Unpredictably |
| SKW98 | X | No Fix | Digital Thermal Sensor, version 2.0 (DTS2.0) Fan Control Regulation Is Incorrect |
| SKW99 | X | No Fix | Package-C6 Exit Latency May be Higher Than Expected Leading to Display Flicker |
| SKW100 | X | No Fix | PCIe* Ports Do Not Support DLL Link Active Reporting |
| SKW101 | X | No Fix | MOVNTDQA From WC Memory May Pass Earlier Locked Instructions |
| SKW102 | X | No Fix | System May Hang When EDRAM is Enabled And Double Data Rate (DDR) is Operating at 1600 MHz |
| SKW103 | X | No Fix | DR6.B0-B3 May Not Report All Breakpoints Matched When a MOV/POP SS Is Followed by a Store or an MMX Instruction |
| SKW104 | X | No Fix | Package C3 Exit Latency May Be Longer Than Expected Leading to Display Flicker |
| SKW105 | X | No Fix | Processor DDR VREF Signals May Briefly Exceed JEDEC* Spec When Entering S3 State |
| SKW106 | X | No Fix | Uncore Performance Monitoring Counters May be Disabled or Cleared After Package C7 |
| SKW107 | X | No Fix | Complex Interactions With Internal Graphics May Impact Processor Responsiveness |
| SKW108 | X | No Fix | #GP on Segment Selector Descriptor that Straddles Canonical Boundary May Not Provide Correct Exception Error Code |

## Errata (Sheet 5 of 7)

| Number | Steppings | Status | ERRATA |
|---|---|---|---|
| | R-0 | | |
| SKW109 | X | No Fix | Management Component Transport Protocol (MCTP) Header Packets with TAG 0x5 May Be Dropped |
| SKW110 | X | No Fix | Intel® PT Table of Physical Addresses (ToPA) PerfMon Interrupt (PMI) Does Not Freeze Performance Monitoring Counters |
| SKW111 | X | No Fix | Use of VMASKMOV to Store When Using the EPT May Fail |
| SKW112 | X | No Fix | Hardware P-states (HWP)'s Maximum_Performance Value Is Reset to 0xFF |
| SKW113 | X | No Fix | HWP's Guaranteed_Performance Updated Only on Configurable TDP Changes |
| SKW114 | X | No Fix | HWP's Guaranteed_Performance and Relevant Status/Interrupt May be Updated More Than Once Per Second |
| SKW115 | X | No Fix | Removed |
| SKW116 | X | No Fix | Core and/or Ring Frequency May Be Briefly Lower Than Expected After BIOS Completes |
| SKW117 | X | No Fix | Resume Flag (RF) May be Incorrectly Set in The EFLAGS That Is Saved on a Fault in PEBS or BTS |
| SKW118 | X | No Fix | Some Memory Performance Monitoring Events May Produce Incorrect Results When Filtering on Either OS or USR Modes |
| SKW119 | X | No Fix | RING_PERF_LIMIT_REASONS May be Incorrect |
| SKW120 | X | No Fix | The HWP May Generate Thermal Interrupt While Not Enabled |
| SKW121 | X | No Fix | Camera Device Does Not Issue an Message Signaled Interrupts (MSI) When INTx is Enabled |
| SKW122 | X | No Fix | Violations of Intel® SGX Access-Control Requirements Produce #GP Instead of Page Fault (#PF) |
| SKW123 | X | No Fix | PCIe and PCIe* Express Graphics (PEG) Advanced Error Reporting (AER) is Not Enabled |
| SKW124 | X | No Fix | Performance Monitoring Counters May Undercount When Using CPL Filtering |
| SKW125 | X | No Fix | SMRAM State-Save Area Above the 4 GB Boundary May Cause Unpredictable System Behavior |
| SKW126 | X | No Fix | Certain Non-Canonical IA32_BNDCFGS Values Will Not Cause VM-Entry Failures |
| SKW127 | X | No Fix | PEBS EventingIP Field May Be Incorrect Under Certain Conditions |
| SKW128 | X | No Fix | Executing a 256 Bit Intel® AVX Instruction May Cause Unpredictable Behavior |
| SKW129 | X | No Fix | An x87 Store Instruction Which Pends Precision Exception (#PE) May Lead to Unexpected Behavior When EPT A/D Is Enabled. |
| SKW130 | X | No Fix | PECI May Not Be Functional After Power On or S3/S4/S5 Resume |
| SKW131 | X | No Fix | A System Hang or Machine Check May Occur When eDRAM Is Enabled |
| SKW132 | X | No Fix | Load Latency Performance Monitoring Facility May Stop Counting |
| SKW133 | X | No Fix | BNDLDX And BNDSTX May Not Signal #GP on Non-Canonical Bound Directory Access |
| SKW134 | X | No Fix | DTS Temperature Reading May be Inaccurate on DDR4 systems |
| SKW135 | X | No Fix | Performance Monitoring Load Latency Events May Be Inaccurate For Gather Instructions |
| SKW136 | X | No Fix | IA32_RTIT_CR3_MATCH MSR Bits[11:5] Are Treated As Reserved |
| SKW137 | X | No Fix | APIC Timer Interrupt May Not Be Generated at The Correct Time In TSC-Deadline Mode |
| SKW138 | X | No Fix | Some Bits in MSR_MISC_PWR_MGMT May Be Updated on Writing Illegal Values to This MSR |
| SKW139 | X | No Fix | Unpredictable System Behavior May Occur When System Agent Enhanced Intel SpeedStep® Technology Is Enabled |
| SKW140 | X | No Fix | Processor May Hang Under Complex Scenarios |
| SKW141 | X | No Fix | The Intel® PT CR3 Filter Is Not Re-evaluated on VM Entry |

## Errata (Sheet 6 of 7)

| Number | Steppings | Status | ERRATA |
|---|---|---|---|
| | R-0 | | |
| SKW142 | X | No Fix | Display Slowness May Be Observed Under Certain Display Commands Scenario |
| SKW143 | X | No Fix | CPUID TLB Associativity Information Is Inaccurate |
| SKW144 | X | No Fix | Short Loops Which Use AH/BH/CH/DH Registers May Cause Unpredictable System Behavior |
| SKW145 | X | No Fix | Processor Graphics May Render Incorrectly or May Hang Following Warm Reset With Package C8 Disabled |
| SKW146 | X | No Fix | Unpredictable System Behavior May Occur in DDR4 Multi-Rank System |
| SKW147 | X | No Fix | Processor May Hang on Complex Sequence of Conditions |
| SKW148 | X | No Fix | Display Artifacts May Be Seen With High Bandwidth, Multiple Display Configurations |
| SKW149 | X | No Fix | Spurious Corrected Errors May Be Reported |
| SKW150 | X | No Fix | Masked Bytes in a Vector Masked Store Instructions May Cause Write Back of a Cache Line |
| SKW151 | X | No Fix | Processor May Incorrectly Assert PROCHOT During PkgC10 |
| SKW152 | X | No Fix | Writing Non-Zero Values to Read Only Fields in IA32_THERM_STATUS MSR May #GP |
| SKW153 | X | No Fix | Precise Performance Monitoring May Generate Redundant PEBS Records |
| SKW154 | X | No Fix | SGX ENCLS[EINIT] May Not Signal an Error For an Incorrectly Formatted SIGSTRUCT Input |
| SKW155 | X | No Fix | Branch Instruction Address May Be Incorrectly Reported on Intel® TSX Abort When Using Intel® MPX |
| SKW156 | X | No Fix | Setting Performance Monitoring IA32_PERF_GLOBAL_STATUS_SET MSR Bit 63 May Not #GP |
| SKW157 | X | No Fix | Hitting a Code Breakpoint Inside a Intel® SGX Debug Enclave May Cause The Processor to Hang |
| SKW158 | X | No Fix | Performance Monitoring Anti Side-Channel Interference (ASCI) Status Bit May be Inaccurate |
| SKW159 | X | No Fix | Processor May Hang When Executing Code In an Hardware Lock Elision (HLE) Transaction Region |
| SKW160 | X | No Fix | Intel® PT CYC Packet Can Be Dropped When Immediately Preceding PSB |
| SKW161 | X | No Fix | Intel® PT VM-entry Indication Depends on The Incorrect VMCS Control Field |
| SKW162 | X | No Fix | VCVTPS2PH To Memory May Update MXCSR in The Case of a Fault on the Store |
| SKW163 | X | No Fix | Intel® PT May Drop All Packets After an Internal Buffer Overflow |
| SKW164 | X | No Fix | ZMM/YMM Registers May Contain Incorrect Values |
| SKW165 | X | No Fix | Intel® PT ToPA Tables Read From Non-Cacheable Memory During an Intel® TSX Transaction May Lead to Processor Hang |
| SKW166 | X | No Fix | Performing an XACQUIRE to an Intel® PT ToPA Table May Lead to Processor Hang |
| SKW167 | X | No Fix | When Virtualization Exceptions are Enabled, EPT Violations May Generate Erroneous Virtualization Exceptions |
| SKW168 | X | No Fix | Using Intel® TSX Instructions May Lead to Unpredictable System Behavior |
| SKW169 | X | No Fix | Performance Monitoring General Purpose Counter 3 May Contain Unexpected Values |
| SKW170 | X | No Fix | Intel® PT Trace May Silently Drop Second Byte of CYC Packet |
| SKW171 | X | No Fix | Unexpected Uncorrected Machine Check Errors May Be Reported |
| SKW172 | X | No Fix | Gen9 Graphics Intel® VT Hardware May Cache Invalid Entries |
| SKW173 | X | No Fix | A Pending Fixed Interrupt May Be Dispatched Before an Interrupt of The Same Priority Completes |
| SKW174 | X | No Fix | Executing Some Instructions May Cause Unpredictable Behavior |
| SKW175 | X | No Fix | Incorrect Execution of Internal Branch Instructions May Lead to Unpredictable System Behavior |

## Errata (Sheet 7 of 7)

| Number | Steppings | Status | ERRATA |
|---|---|---|---|
| | R-0 | | |
| SKW176 | X | No Fix | Unexpected Page Faults in Guest Virtualization Environment |
| SKW177 | X | No Fix | Intel® SGX Key Confidentiality May Be Compromised |
| SKW178 | X | No Fix | Instruction Fetch May Cause Machine Check if Page Size Was Changed Without Invalidation |
| SKW179 | X | No Fix | System May Hang Under Complex Conditions |
| SKW180 | X | No Fix | PEG PCIe* Link May Fail to Link When Resuming From PKG-C8 |
| SKW181 | X | No Fix | Incorrect Error Correcting Code (ECC) Reporting Following Entry to PKG-C7 |
| SKW182 | X | No Fix | PMU MSR_UNC_PERF_FIXED_CTR Is Cleared After Pkg C7 or Deeper |
| SKW183 | X | No Fix | Performance Monitoring General Counter 2 May Have Invalid Value Written When Intel® TSX Is Enabled |
| SKW184 | X | No Fix | Overflow Flag in IA32_MC0_STATUS MSR May Be Incorrectly Set |
| SKW185 | X | No Fix | VERR Instruction Inside VM-entry May Cause DR6 to Contain Incorrect Values |
| SKW186 | X | No Fix | Processor May Hang If Warm Reset Triggers While BIOS Is Initialization |

## Specification Changes

| Number | SPECIFICATION CHANGES |
|---|---|
| SKW1 | Intel® Xeon® E3-1235L v5 and E3-1240L v5 processor ICCmax specification to change from 40A to 55A. |

## Specification Clarifications

| Number | SPECIFICATION CLARIFICATIONS |
|---|---|
| SKW1 | Attempts to Simultaneously Perform Microcode Updates |

## Documentation Changes

| Number | DOCUMENTATION CHANGES |
|---|---|
| | None for this revision of this specification update. |

# Identification Information

## Component Identification Using Programming Interface

The processor stepping can be identified by the following register contents.

**Table 1. Component Identification**

| Reserved | Extended Family | Extended Model | Reserved | Processor Type | Family Code | Model Number | Stepping ID |
|---|---|---|---|---|---|---|---|
| 31:28 | 27:20 | 19:16 | 15:14 | 13:12 | 11:8 | 7:4 | 3:0 |
| | 00000000b | 0101b | | 00b | 0110b | 1110b | xxxxb |

***Notes:***

1. The Extended Family, Bits [27:20] are used in conjunction with the Family Code, specified in Bits[11:8], to indicate whether the processor belongs to the Intel386™, Intel486™, Pentium®, Pentium 4, or Intel® Core™ processor family.
2. The Extended Model, Bits [19:16] in conjunction with the Model Number, specified in Bits [7:4], are used to identify the model of the processor within the processor's family.
3. The Family Code corresponds to Bits [11:8] of the Extended Data Register (EDX) register after RESET, Bits [11:8] of the Extended Accumulator Register (EAX) register after the CPUID instruction is executed with a 1 in the EAX register, and the generation field of the Device ID register accessible through Boundary Scan.
4. The Model Number corresponds to Bits [7:4] of the EDX register after RESET, Bits [7:4] of the EAX register after the CPUID instruction is executed with a 1 in the EAX register, and the model field of the Device ID register accessible through Boundary Scan.
5. The Stepping ID in Bits [3:0] indicates the revision number of that model. See the processor Identification table for the processor stepping ID number in the CPUID information.

When EAX is initialized to a value of "1", the CPUID instruction returns the Extended Family, Extended Model, Processor Type, Family Code, Model Number and Stepping ID value in the EAX register. Note that the EDX processor signature value after reset is equivalent to the processor signature output value in the EAX register.

Cache and Translation Lookaside Buffer (TLB) descriptor parameters are provided in the EAX, Extended Base Register (EBX), Extended Count Register (ECX) and EDX registers after the CPUID instruction is executed with a 2 in the EAX register.

The processor can be identified by the following register contents.

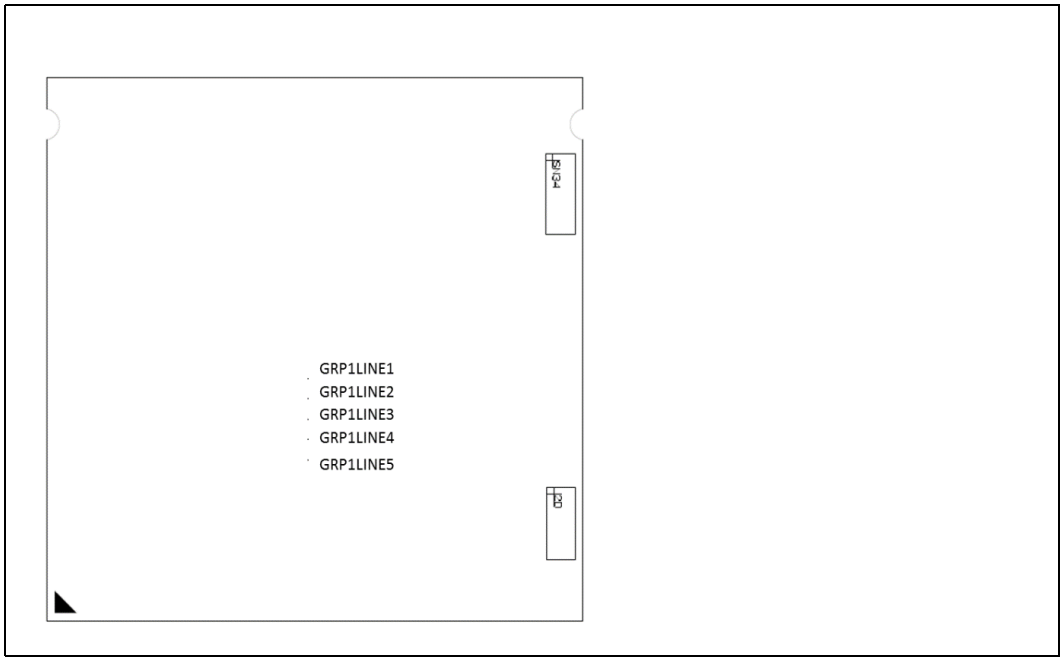
**Table 2. Processor Identification by Register Contents**

| Processor Line | Stepping | Vendor ID | Host Device ID | Processor Graphics Device ID | Host Revision ID | Compatibility Revision ID |
|---|---|---|---|---|---|---|
| Intel® Xeon® E3-1200 v5 | R-0 | 8086h | 1918h | 1912h | 07h | 07h |

## Component Marking Information

The processor stepping can be identified by the following component markings.

**Figure 1. Intel® Xeon® E3-1200 v5 Processor Family Land Grid Array (LGA) Top-Side Markings**




Pin Count: 1151 Package Size: 37.5 mm x 37.5 mm

**Sample (SSPEC):**

| | |
|---|---|
| GRP1LINE1: | Intel logo |
| GRP1LINE2: | BRAND |
| GRP1LINE3: | PROC# |
| GRP1LINE4: | SSPEC SPEED |
| GRP1LINE5: | {FPO} {eX} |

For Intel® Xeon® Processor E3-1200 v5 Product Family SKUs, see:

https://ark.intel.com/content/www/us/en/ark/products/series/88210/intel-xeon-processor-e3-v5-family.html#@nofilter

# Errata

## SKW1. Reported Memory Type May Not Be Used to Access the Virtual-Machine Control Structure (VMCS) and Referenced Data Structures

Problem: Bits [53:50] of the `IA32_VMX_BASIC` Model Specific Register (MSR) report the memory type that the processor uses to access the VMCS and data structures referenced by pointers in the VMCS. Due to this erratum, a Virtual Machine Extensions (VMX) access to the VMCS or referenced data structures will instead use the memory type that the Memory Type Range Registers (MTRR) specify for the physical address of the access.

Implication: Bits [53:50] of the `IA32_VMX_BASIC` MSR report that the Write-Back (WB) memory type will be used but the processor may use a different memory type.

Workaround: Software should ensure that the VMCS and referenced data structures are located at physical addresses that are mapped to WB memory type by the MTRRs.

Status: For the steppings affected, see the "Summary Tables of Changes".

## SKW2. Erratum has been Removed

## SKW3. Execution of VAESIMC or VAESKEYGENASSIST with An Illegal Value for VEX.vvvv May Produce a Device-Not-Available (#NM) Exception

Problem: The VAESIMC and VAESKEYGENASSIST instructions should produce an Invalid-Opcode (#UD) exception if the value of the vvvv field in the Vector Extensions (VEX) prefix is not 1111b. Due to this erratum, if CR0.TS is "1", the processor may instead produce an #NM exception.

Implication: Due to this erratum, some undefined instruction encodings may produce a #NM instead of a #UD exception.

Workaround: Software should always set the vvvv field of the VEX prefix to 1111b for instances of the VAESIMC and VAESKEYGENASSIST instructions.

Status: For the steppings affected, see the "Summary Tables of Changes".

## SKW4. The Corrected Error Count Overflow Bit in IA32_ MC0_STATUS Is Not Updated When The UC Bit Is Set

Problem: After an Uncorrected (UC) error is logged in the `IA32_MC0_STATUS` MSR (401H), corrected errors will continue to be counted in the lower 14 bits [bits 51:38] of the Corrected Error Count. Due to this erratum, the sticky count overflow bit [bit 52] of the Corrected Error Count will not get updated when the UC bit [bit 61] is set to 1.

Implication: The corrected error count overflow indication will be lost if the overflow occurs after an uncorrectable error has been logged.

Workaround: None identified.

Status: For the steppings affected, see the "Summary Tables of Changes".

### SKW5. VM Exit May Set IA32_EFER.NXE When IA32_MISC_ENABLE Bit 34 Is Set to 1

Problem: When "XD Bit Disable" in the IA32_MISC_ENABLE MSR (1A0H) bit 34 is set to 1, it should not be possible to enable the "execute disable" feature by setting IA32_EFER.NXE. Due to this erratum, a VM exit that occurs with the 1-setting of the "load IA32_EFER" VM-exit control may set IA32_EFER.NXE even if IA32_MISC_ENABLE bit 34 is set to 1. This erratum can occur only if IA32_MISC_ENABLE bit 34 was set by guest software in VMX non-root operation.

Implication: Software in VMX root operation may execute with the "execute disable" feature enabled despite the fact that the feature should be disabled by the IA32_MISC_ENABLE MSR. Intel has not observed this erratum with any commercially available software.

Workaround: A virtual-machine monitor should not allow guest software to write to the IA32_MISC_ENABLE MSR

Status: For the steppings affected, see the "Summary Tables of Changes".

### SKW6. SMRAM State-Save Area Above the 4 GB Boundary May Cause Unpredictable System Behavior

Problem: If the BIOS uses the Resume System Management Mode (RSM) instruction to load the SMBASE register with a value that would cause any part of the SMRAM state-save area to have an address above 4 GBytes, subsequent transitions into and out of System Management Mode (SMM) might save and restore processor state from incorrect addresses.

Implication: This erratum may cause unpredictable system behavior. Intel has not observed this erratum with any commercially available system.

Workaround: Ensure that the SMRAM state-save area is located entirely below the 4 GB address boundary.

Status: For the steppings affected, see the "Summary Tables of Changes".

### SKW7. x87 FPU Exception (#MF) May Be Signaled Earlier Than Expected

Problem: x87 instructions that trigger #MF normally service interrupts before the #MF. Due to this erratum, if an instruction that triggers #MF is executing when an Enhanced Intel SpeedStep® Technology transitions, an Intel® Turbo Boost Technology transitions, or a Thermal Monitor events occurs, the #MF may be taken before pending interrupts are serviced.

Implication: Software may observe #MF being signaled before pending interrupts are serviced.

Workaround: None identified.

Status: For the steppings affected, see the "Summary Tables of Changes".

### SKW8. Incorrect FROM_IP Value For an Restricted Transactional Memory (RTM) Abort in BTM or BTS May Be Observed

Problem: During the RTM operation when branch tracing is enabled using the Branch Trace Message (BTM) or the Branch Trace Store (BTS), the incorrect EIP value (From_IP pointer) may be observed for an RTM abort.

Implication: Due to this erratum, the From_IP pointer may be the same as that of the immediately preceding taken branch.

Workaround: None identified.

Status: For the steppings affected, see the "Summary Tables of Changes".

### SKW9. DR6 Register May Contain an Incorrect Value When a MOV to SS or POP SS Instruction Is Followed by an XBEGIN Instruction

Problem: If the XBEGIN is executed immediately after an execution of MOV to SS or POP SS, a transactional abort occurs and the logical processor restarts execution from the fallback instruction address. If execution of the instruction at that address causes a debug exception, bits [3:0] of the DR6 register may contain an incorrect value.

Implication: When the instruction at the fallback instruction address causes a debug exception, DR6 may report a breakpoint that was not triggered by that instruction, or it may fail to report a breakpoint that was triggered by the instruction.

Workaround: Avoid following a MOV SS or POP SS instruction immediately with an XBEGIN instruction.

Status: For the steppings affected, see the "Summary Tables of Changes".

### SKW10. Opcode Bytes F3 0F BC May Execute As TZCNT Even When TZCNT Not Enumerated by CPUID

Problem: If the CPUID.(EAX=07H, ECX=0):EBX.BMI1 [bit 3] is 1 then opcode bytes F3 0F BC should be interpreted as TZCNT otherwise they will be interpreted as REP BSF. Due to this erratum, opcode bytes F3 0F BC may execute as TZCNT even if CPUID.(EAX=07H, ECX=0):EBX.BMI1 [bit 3] is 0.

Implication: Software that expects REP prefix before a Bit Scan Forward (BSF) instruction to be ignored may not operate correctly since there are cases in which BSF and TZCNT differ with regard to the flags that are set and how the destination operand is established.

Workaround: Software should use the opcode bytes F3 0F BC only if CPUID.(EAX=07H, ECX=0):EBX.BMI1 [bit 3] is 1 and only if the functionality of TZCNT (and not BSF) is desired.

Status: For the steppings affected, see the "Summary Tables of Changes".

### SKW11. PCIe* Root-port Initiated Compliance State Transmitter Equalization Settings May Be Incorrect

Problem: If the processor is directed to enter Peripheral Component Interconnect Express* (PCIe*) Polling.Compliance at 5.0 GT/s or 8.0 GT/s transfer rates, it should use the Link Control 2 Compliance Preset/De-emphasis field (bits [15:12]) to determine the correct de-emphasis level. Due to this erratum, when the processor is directed to enter Polling.Compliance from 2.5 GT/s transfer rate, it retains 2.5 GT/s de-emphasis values.

Implication: The processor may operate in Polling.Compliance mode with an incorrect transmitter de-emphasis level.

Workaround: None identified.

Status: For the steppings affected, see the "Summary Tables of Changes".



### SKW12. The SMSW Instruction May Execute Within an Enclave

Problem: The SMSW instruction is illegal within an Intel® Software Guard Extensions (Intel® SGX) enclave, and an attempt to execute it within an enclave should result in a #UD. Due to this erratum, the instruction executes normally within an enclave and does not cause a #UD.

Implication: The SMSW instruction provides access to CR0 bits 15:0 and will provide that information inside an enclave. These bits include NE, ET, TS, EM, MP and PE.

Workaround: None identified. If the SMSW execution inside an enclave is unacceptable, system software should not enable Intel® SGX.

Status: For the steppings affected, see the "Summary Tables of Changes".

### SKW13. Precise Event Based Sampling (PEBS) Record After a WRMSR to IA32_BIOS_UPDT_TRIG May Be Incorrect

Problem: A PEBS record generated by a WRMSR to `IA32_BIOS_UPDT_TRIG` MSR (79H) may have an incorrect value in the Eventing EIP field if an instruction prefix was used on the WRMSR.

Implication: The Eventing EIP field of the generated PEBS record may be incorrect. Intel has not observed this erratum with any commercially available software.

Workaround: Instruction prefixes have no architecturally-defined function for the WRMSR instruction; instruction prefixes should not be used with the WRMSR instruction.

Status: For the steppings affected, see the "Summary Tables of Changes".

### SKW14. Intel® Processor Trace (Intel® PT) TIP.PGD May Not Have Target IP Payload

Problem: When Intel® Processor Trace (Intel® PT) is enabled and a direct unconditional branch clears `IA32_RTIT_STATUS.FilterEn` (MSR 571H, bit 0), due to this erratum, the resulting Target IP Packet, Packet Generation Disable (TIP.PGD) may not have an IP payload with the target IP.

Implication: It may not be possible to tell which instruction in the flow caused the TIP.PGD using only the information in trace packets when this erratum occurs.

Workaround: The Intel® PT trace decoder can compare direct unconditional branch targets in the source with the FilterEn address ranges to determine which branch cleared FilterEn.

Status: For the steppings affected, see the "Summary Tables of Changes".

### SKW15. Operand-Size Override Prefix Causes 64-bit Operand Form of MOVBE Instruction to Cause an #UD

Problem: Execution of a 64 bit operand MOVBE instruction with an operand-size override instruction prefix (66H) may incorrectly cause an #UD.

Implication: A MOVBE instruction with both REX.W=1 and a 66H prefix will unexpectedly cause an #UD. Intel has not observed this erratum with any commercially available software.

Workaround: Do not use a 66H instruction prefix with a 64-bit operand MOVBE instruction.

Status: For the steppings affected, see the "Summary Tables of Changes".

### SKW16. Execution of the FXSAVE or the FXRSTOR With the VEX Prefix May Produce an #NM Exception

Problem: Attempt to use the FXSAVE or the FXRSTOR with a VEX prefix should produce an #UD exception. If either the TS or the EM flag bits in CR0 are set, an #NM exception will be raised instead of the #UD exception.

Implication: Due to this erratum an #NM exception may be signaled instead of an #UD exception on an FXSAVE or an FXRSTOR with a VEX prefix.

Workaround: Software should not use FXSAVE or FXRSTOR with the VEX prefix.

Status: For the steppings affected, see the "Summary Tables of Changes".

### SKW17. WRMSR May Not Clear The Sticky Count Overflow Bit in The IA32_MCi_STATUS MSRs' Corrected Error Count Field

Problem: The sticky count overflow bit is the most significant bit [bit 52] of the corrected error count field (bits [52:38]) in `IA32_MCi_STATUS` MSRs. Once set, the sticky count overflow bit may not be cleared by a WRMSR instruction. When this occurs, that bit can only be cleared by power-on reset.

Implication: Software that uses the corrected error count field and expects to be able to clear the sticky count overflow bit may misinterpret the number of corrected errors when the sticky count overflow bit is set. This erratum does not affect threshold-based Corrected Machine Check Error Interrupt (CMCI) signaling.

Workaround: None identified.

Status: For the steppings affected, see the "Summary Tables of Changes".

### SKW18. PEBS Eventing IP Field May Be Incorrect After Not-Taken Branch

Problem: When a PEBS record is logged immediately after a not-taken conditional branch (Jcc instruction), the Eventing IP field should contain the address of the first byte of the Jcc instruction. Due to this erratum, it may instead contain the address of the instruction preceding the Jcc instruction.

Implication: Performance monitoring software using PEBS may incorrectly attribute PEBS events that occur on a Jcc to the preceding instruction.

Workaround: None identified.

Status: For the steppings affected, see the "Summary Tables of Changes".

### SKW19. Debug Exceptions May Be Lost or Misreported Following WRMSR to IA32_BIOS_UPDT_TRIG

Problem: If the WRMSR instruction writes to the `IA32_BIOS_UPDT_TRIG` MSR (79H) immediately after an execution of MOV SS or POP SS that generated a debug exception, the processor may fail to deliver the debug exception or, if it does, the DR6 register contents may not correctly reflect the causes of the debug exception.

Implication: Debugging software may fail to operate properly if a debug exception is lost or does not report complete information.

Workaround: Software should avoid using WRMSR instruction immediately after executing MOV SS or POP SS.

Status: For the steppings affected, see the "Summary Tables of Changes".

### SKW20. Attempts to Retrain a PCIe* Link May Be Ignored

Problem: A PCIe* link should retrain when retrain link [bit 5] in the link control register (Bus 0; Device 1; Functions 0,1,2; Offset 0xB0) is set. Due to this erratum, if the link is in the L1 state, it may ignore the retrain request.

Implication: The PCIe* link may not behave as expected.

Workaround: It is possible for the BIOS to contain a workaround for this erratum.

Status: For the steppings affected, see the "Summary Tables of Changes".

### SKW21. Intel® PT Packet Stream Boundary (PSB)+ Packets May Contain Unexpected Packets

Problem: Some Intel® PT packets should be issued only between Target IP Packet.Packet Generation Enable (TIP.PGE) and TIP.PGD packets. Due to this erratum, when a TIP.PGE packet is generated it may be preceded by a PSB+ that incorrectly includes Flow Update Packet (FUP) and MODE.Exec packets.

Implication: Due to this erratum, the FUP and the MODE.Exec may be generated unexpectedly.

Workaround: Decoders should ignore the FUP and the MODE.Exec packets that are not between TIP.PGE and TIP.PGD packets.

Status: For the steppings affected, see the "Summary Tables of Changes".

### SKW22. An Advanced Programmable Interrupt Controller (APIC) Timer Interrupt During Core C6 Entry May Be Lost

Problem: Due to this erratum, an APIC timer interrupt coincident with the core entering C6 state may be lost rather than held for servicing later.

Implication: A lost APIC timer interrupt may lead to missed deadlines or a system hang.

Workaround: It is possible for the BIOS to contain a workaround for this erratum.

Status: For the steppings affected, see the "Summary Tables of Changes".

### SKW24. VM Entry That Clears TraceEn May Generate a FUP

Problem: If the VM entry clears the Intel® PT `IA32_RTIT_CTL.TraceEn` (MSR 570H, bit 0) while PacketEn is 1 then a FUP will precede the TIP.PGD. The VM entry can clear TraceEn if the VM-entry MSR-load area includes an entry for the `IA32_RTIT_CTL` MSR.

Implication: When this erratum occurs, an unexpected FUP may be generated that creates the appearance of an asynchronous event taking place immediately before or during the VM entry.

Workaround: The Intel® PT trace decoder may opt to ignore any FUP whose IP matches that of a VM entry instruction.

Status: For the steppings affected, see the "Summary Tables of Changes".

### SKW25. EDRAM Corrected Error Events May Not Be Properly Logged After a Warm Reset

Problem: After a warm reset, an Embedded Dynamic Random Access Memory (DRAM) (EDRAM) corrected error may not be logged correctly until the associated machine check register is initialized. This erratum may affect `IA32_MC8_STATUS` or `IA32_MC10_STATUS`.

Implication: The EDRAM corrected error information may be lost when this erratum occurs.

Workaround: Data from the affected machine check registers should be read and the registers initialized as soon as practical after a warm reset.

Status: For the steppings affected, see the "Summary Tables of Changes".

### SKW26. Performance Monitor Event For Outstanding Offcore Requests May Be Incorrect

Problem: The performance monitor event `OFFCORE_REQUESTS_OUTSTANDING` (Event 60H, any Umask Value) should count the number of offcore outstanding transactions each cycle. Due to this erratum, the counts may be higher or lower than expected.

Implication: The performance monitor event `OFFCORE_REQUESTS_OUTSTANDING` may reflect an incorrect count.

Workaround: None identified.

Status: For the steppings affected, see the "Summary Tables of Changes".

### SKW27. Processor Instability May Occur When Using the Platform Environmental Control Interface (PECI) RdIAMSR Command

Problem: Under certain circumstances, reading a machine check register using the PECI RdIAMSR command may result in a machine check, processor hang or shutdown.

Implication: Machine check, hang or shutdown may be observed when using the PECI RdIAMSR command.

Workaround: It is possible for the BIOS to contain a workaround for this erratum.

Status: For the steppings affected, see the "Summary Tables of Changes".

### SKW28. ENCLU[EGETKEY] Ignores KEYREQUEST.MISCMASK

Problem: The Intel® SGX ENCLU[EGETKEY] instruction ignores the MISCMASK field in KEYREQUEST structure when computing a provisioning key, a provisioning seal key, or a seal key.

Implication: ENCLU[EGETKEY] will return the same key in response to two requests that differ only in the value of KEYREQUEST.MISCMASK. Intel has not observed this erratum with any commercially available software.

Workaround: When executing the ENCLU[EGETKEY] instruction, software should ensure the bits set in KEYREQUEST.MISCMASK are a subset of the bits set in the current SECS' MISCSELECT field.

Status: For the steppings affected, see the "Summary Tables of Changes".

### SKW29. POPCNT Instruction May Take Longer to Execute Than Expected

Problem: POPCNT instruction execution with a 32 or 64 bit operand may be delayed until previous non-dependent instructions have executed.

Implication: Software using the POPCNT instruction may experience lower performance than expected.

Workaround: None identified.

Status: For the steppings affected, see the "Summary Tables of Changes".

### SKW30. ENCLU[EREPORT] May Cause a General Protection Exception (#GP) When TARGETINFO.MISCSELECT Is Non-Zero

Problem: The Intel® SGX ENCLU[EREPORT] instruction may cause a #GP if any bit is set in TARGETINFO structure's MISCSELECT field.

Implication: This erratum may cause unexpected general-protection exceptions inside enclaves.

Workaround: When executing the ENCLU[EREPORT] instruction, software should ensure the bits set in TARGETINFO.MISCSELECT are a subset of the bits set in the current SECS' MISCSELECT field.

Status: For the steppings affected, see the "Summary Tables of Changes".

### SKW31. A VMX Transition Attempting to Load a Non-Existent MSR May Result in a Shutdown

Problem: A VMX transition may result in a shutdown (without generating a machine-check event) if a non-existent MSR is included in the associated MSR-load area. When such a shutdown occurs, a machine check error will be logged with `IA32_MCi_STATUS.MCACOD` (bits [15:0]) of 406H, but the processor does not issue the special shutdown cycle. A hardware reset must be used to restart the processor.

Implication: Due to this erratum, the hyper-visor may experience an unexpected shutdown.

Workaround: Software should not configure VMX transitions to load non-existent MSRs.

Status: For the steppings affected, see the "Summary Tables of Changes".

### SKW32. Transitions Out of 64-Bit Mode May Corrupt the x87 FPU Instruction and Data Pointer Registers

Problem: A transition from 64-bit mode to compatibility mode may zero bits [63:32] of the x87 FPU Instruction Pointer Offset (FIP) and the x87 FPU Data Pointer Offset (FDP).

Implication: A later instruction that saves x87 FPU state will not save bits [63:32] of the instruction and data pointers of the last non-control instruction executed.

Workaround: 64-bit software should save x87 FPU state before leaving 64-bit mode.

Status: For the steppings affected, see the "Summary Tables of Changes".

### SKW33. Intel® PT FUP May Be Dropped After the OVF

Problem: Some Intel® PT Overflow (OVF) packets may not be followed by a FUP or TIP.PGE.

Implication: When this erratum occurs, an unexpected packet sequence is generated.

Workaround: When it encounters an OVF without a following FUP or TIP.PGE, the Intel® PT trace decoder should scan for the next TIP, TIP.PGE, or PSB+ to resume operation.

Status: For the steppings affected, see the "Summary Tables of Changes".

### SKW34. ENCLS[ECREATE] Causes a #GP if Enclave Base Address Is Not Canonical

Problem: The ENCLS[ECREATE] instruction uses an SECS (Intel® SGX enclave control structure) referenced by the SRCPAGE pointer in the PAGEINFO structure, which is referenced by the RBX register. Due to this erratum, the instruction causes a #GP if the SECS attributes indicate that the enclave should operate in 64-bit mode and the enclave base linear address in the SECS is not canonical.

Implication: System software will incur a general-protection fault if it mistakenly programs the SECS with a non-canonical address. Intel has not observed this erratum with any commercially available software.

Workaround: System software should always specify a canonical address as the base address of the 64-bit mode enclave.

Status: For the steppings affected, see the "Summary Tables of Changes".

### SKW35. Data Breakpoint May Not Be Detected on a REP MOVS

Problem: A REP MOVS instruction that causes an exception or a VM exit may not detect a data breakpoint that occurred on an earlier memory access of that REP MOVS instruction.

Implication: A debugger may miss a data read/write access if it is done by a REP MOVS instruction.

Workaround: Software that relies on data breakpoint for correct execution should disable fast-strings (bit 0 in `IA32_MISC_ENABLE` MSR).

Status: For the steppings affected, see the "Summary Tables of Changes".

### SKW36. Graphics Error: Intel® Virtualization Technology (Intel® VT) for Directed I/O (Intel® VT-d) Hardware May Cache Invalid Entries

Problem: The processor's graphics I/O Memory Management Unit (IOMMU) may cache invalid Intel® VT-d context entries. This violates the Intel® VT-d specification for HW Caching Mode where hardware implementations of this architecture must not cache invalid entries.

Implication: Due to this erratum, unpredictable system behavior and/or a system hang may occur.

Workaround: Software should flush the Gfx Intel® VT-d context cache after any update of context table entries.

Status: For the steppings affected, see the "Summary Tables of Changes".

### SKW37. PCIe* and DMI Links With Lane Polarity Inversion May Result in Link Failure

Problem: The processor's PCIe* and DMI links may fail after exiting Package C7 or deeper if the platform requires the link to utilize lane polarity inversion.

Implication: Due to this erratum, the processor cannot support lane polarity inversion on the PCIe* or DMI links when Package C7 or deeper is enabled.

Workaround: None identified.

Status: For the steppings affected, see the "Summary Tables of Changes".

### SKW38. PCIe* Expansion ROM Base Address Register May Be Incorrect

Problem: After PCIe* 8.0 GT/s Link Equalization on a root port (Bus 0; Device 1; Function 0, 1, 2) has completed, the Expansion ROM Base Address Register (Offset 38H) may be incorrect.

Implication: Software that uses this Base Address Register (BAR) may behave unexpectedly. Intel has not observed this erratum with any commercially available software.

Workaround: It is possible for the BIOS to contain a partial workaround for this erratum. Software should wait at least 5 ms following link equalization before accessing these Expansion ROM Base Address Register.

Status: For the steppings affected, see the "Summary Tables of Changes".

### SKW39. PCIe* Perform Equalization May Lead to Link Failure

Problem: Due to this erratum, when a processor PCIe* port operating at 8.0 GT/s is directed to redo equalization, either via software or from the link partner, incorrect coefficients may be conveyed during Equalization Phase 3.

Implication: If the link partner accepts the incorrect coefficients, the link may become unstable. Note this affects 8.0 GT/s only.

Workaround: It is possible for the BIOS to contain a workaround for this erratum.

Status: For the steppings affected, see the "Summary Tables of Changes".

### SKW40. Two DIMMs Per Channel 2133 MHz DDR4 SODIMM Daisy-Chain Systems with Different Vendors May Hang

Problem: When, on a single memory channel with 2133 MHz DDR4 SODIMMs, mixing different vendors or mixing single rank and dual rank DIMMs, may lead to a higher rate of correctable errors or system hangs.

Implication: Due to this erratum, reported correctable error counts may increase or system may hang.

Workaround: Use a single vendor for and do not mix single rank and dual rank 2133 MHz DDR4 SODIMM.

Status: For the steppings affected, see the "Summary Tables of Changes".

### SKW41. ENCLS[EINIT] Instruction May Unexpectedly #GP

Problem: When using Intel® SGX, the ENCLS[EINIT] instruction will incorrectly cause a #GP if the MISCSELECT field of the SIGSTRUCT structure is not zero.

Implication: This erratum may cause an unexpected #GP, but only if software has set bits in the MISCSELECT field in SIGSTRUCT structure that do not correspond to extended features that can be written to the MISC region of the State Save Area (SSA). Intel has not observed this erratum with any commercially available software.

Workaround: When executing the ENCLS[EINIT] instruction, software should only set bits in the MISCSELECT field in the SIGSTRUCT structure that are enumerated as 1 by CPUID.(EAX=12H,ECX=0):EBX (the bit vector of extended features that can be written to the MISC region of the SSA).

Status: For the steppings affected, see the "Summary Tables of Changes".

### SKW42. Intel® PT OVF Packet May Be Lost if Immediately Preceding a TraceStop

Problem: If an Intel® PT internal buffer overflow occurs immediately before software executes a taken branch or event that enters an Intel® PT Trace Stop region, the OVF packet may be lost.

Implication: The trace decoder will not see the OVF packet, nor any subsequent packets (for example, TraceStop) that were lost due to overflow.

Workaround: None identified.

Status: For the steppings affected, see the "Summary Tables of Changes".

### SKW43. Detecting an Intel® PT Stopped or Error Condition Within an Intel® TSX Region May Result in a System Hang

Problem: While executing within an Intel® TSX transactional region with Intel® PT enabled and an event occurs that causes either the Error bit [bit 4] or Stopped bit [bit 5] in the `IA32_RTIT_STATUS` MSR (0571H) to be set then, due to this erratum, the system may hang.

Implication: A system hang may occur when Intel® PT and Intel® TSX are used together.

Workaround: It is possible for the BIOS to contain a workaround for this erratum.

Status: For the steppings affected, see the "Summary Tables of Changes".

### SKW44. WRMSR to IA32_BIOS_UPDT_TRIG May Be Counted as Multiple Instructions

Problem: When software loads a microcode update by writing to MSR `IA32_BIOS_UPDT_TRIG` (79H) on multiple logical processors in parallel, a logical processor may, due to this erratum, count the WRMSR instruction as multiple instruction-retired events.

Implication: Performance monitoring with the instruction-retired event may over count by up to four extra events per instance of WRMSR which targets the `IA32_BIOS_UPDT_TRIG` register.

Workaround: None identified.

Status: For the steppings affected, see the "Summary Tables of Changes".

### SKW45. The x87 FIP May Be Incorrect

Problem: The x87 FPU should update the x87 FIP for every non-control x87 instruction executed. Due to this erratum, the FIP is valid only if the last non-control FP instruction had an unmasked exception.

Implication: When this erratum occurs, an instruction that saves FIP (for example, FSTENV) may save an incorrect value. Software that depends on the FIP value for x87 non-control instructions without unmasked exceptions may not operate as expected.

Workaround: It is possible for the BIOS to contain a workaround for this erratum.

Status: For the steppings affected, see the "Summary Tables of Changes".



### SKW46. Branch Instructions May Initialize Intel® Memory Protection Extensions (Intel® MPX) Bound Registers Incorrectly

Problem: Depending on the current Intel® MPX configuration, execution of certain branch instructions (near CALL, near RET, near JMP, and Jcc instructions) without a BND prefix (F2H) initialize the Intel® MPX bound registers. Due to this erratum, execution of such a branch instruction on a user-mode page may not use the Intel® MPX configuration register appropriate to the current privilege level (BNDCFGU for CPL 3 or BNDCFGS otherwise) for determining whether to initialize the bound registers; it may thus initialize the bound registers when it should not, or fail to initialize them when it should.

Implication: After a branch instruction on a user-mode page has executed, a Bound-Range (#BR) exception may occur when it should not have or a #BR may not occur when one should have.

Workaround: If supervisor software is not expected to execute instructions on user-mode pages, software can avoid this erratum by setting CR4.SMEP[bit 20] to enable Supervisor-Mode Execution Prevention (SMEP). If the SMEP is not available or if supervisor software is expected to execute instructions on user-mode pages, no workaround is identified.

Status: For the steppings affected, see the "Summary Tables of Changes".

### SKW47. Writing a Non-Canonical Value to an Last Branch Record (LBR) MSR Does Not Signal a #GP When Intel® PT Is Enabled

Problem: If Intel® PT is enabled, WRMSR will not cause a general-protection exception (#GP) on an attempt to write a non-canonical value to any of the following MSRs:

- MSR_LASTBRANCH_{0 - 31}_FROM_IP (680H – 69FH)
- MSR_LASTBRANCH__{0 - 31}_TO_IP (6C0H – 6DFH)
- MSR_LASTBRANCH_FROM_IP (1DBH)
- MSR_LASTBRANCH_TO_IP (1DCH)
- MSR_LASTINT_FROM_IP (1DDH)
- MSR_LASTINT_TO_IP (1DEH)

Instead the same behavior will occur as if a canonical value had been written. Specifically, the WRMSR will be dropped and the MSR value will not be changed.

Implication: Due to this erratum, an expected #GP may not be signaled.

Workaround: None identified.

Status: For the steppings affected, see the "Summary Tables of Changes".

### SKW48. Processor May Run Intel® Advanced Vector Extensions (Intel® AVX) Code Much Slower Than Expected

Problem: After a C6 state exit, the execution rate of Intel® AVX instructions may be reduced.

Implication: Applications using Intel® AVX instructions may run slower than expected.

Workaround: It is possible for the BIOS to contain a workaround for this erratum.

Status: For the steppings affected, see the "Summary Tables of Changes".

### SKW49. Intel® PT Buffer Overflow May Result in Incorrect Packets

Problem: Under complex microarchitectural conditions, an Intel® PT OVF packet may be issued after the first byte of a multi-byte Cycle Count (CYC) packet, instead of any remaining bytes of the CYC.

Implication: When this erratum occurs, the splicing of the CYC and the OVF packets may prevent the Intel® PT decoder from recognizing the overflow. The Intel® PT decoder may then encounter subsequent packets that are not consistent with expected behavior.

Workaround: None Identified. The decoder may be able to recognize that this erratum has occurred when a two-byte CYC packet is followed by a single byte CYC, where the latter 2 bytes are 0xf302, and where the CYC packets are followed by a FUP and a PSB+. It should then treat the two CYC packets as indicating an overflow.

Status: For the steppings affected, see the "Summary Tables of Changes".

### SKW50. Intel® PT PSB+ Packets May Be Omitted on a C6 Transition

Problem: An Intel® PT PSB+ set of packets may not be generated as expected when `IA32_RTIT_STATUS.PacketByteCnt` [48:32] (MSR 0x571) reaches the PSB threshold and a logical processor C6 entry occurs within the following one KByte of trace output.

Implication: After a logical processor enters C6, Intel® PT output may be missing PSB+ sets of packets.

Workaround: None identified.

Status: For the steppings affected, see the "Summary Tables of Changes".

### SKW51. IA32_PERF_GLOBAL_STATUS.TRACE_TOPA_PMI Bit Cannot Be Set by Software

Problem: A WRMSR that attempts to set `Trace_ToPA_PMI` (bit 55) in the `IA32_PERF_GLOBAL_STATUS` MSR (38EH) by writing a "1" to bit 55 in the `IA32_PERF_GLOBAL_STATUS_SET` (MSR (391H) will cause a #GP fault.

Implication: Software cannot set the `Trace_ToPA_PMI` bit.

Workaround: It is possible for the BIOS to contain a workaround for this erratum.

Status: For the steppings affected, see the "Summary Tables of Changes".

### SKW52. Enabling VMX-Preemption Timer Blocks Hardware Duty Cycling (HDC) Operation

Problem: The HDC will not put the physical package into the forced idle state while any logical processor is in VMX non-root operation and the "activate VMX-preemption timer" VM-execution control is 1.

Implication: HDC will not provide the desired power reduction when the VMX-preemption timer is active in VMX non-root operation.

Workaround: None identified.

Status: For the steppings affected, see the "Summary Tables of Changes".

### SKW53. ENCLU[EGETKEY] Instruction Ignores MISCMASK Value

Problem: The ENCLU[EGETKEY] instruction always generates SEAL, PROVISION, and PROVISION_SEAL keys as if the MISCMASK field in the KEYREQUEST structure is 0.

Implication: The ENCLU[EGETKEY] instruction will generate the same keys for different MISCMASK values.

Workaround: Software should not rely on ENCLU[EGETKEY] to produce different keys by supplying different MISCMASK values. Software should use other KEYREQUEST fields to produce separation of the keys.

Status: For the steppings affected, see the "Summary Tables of Changes".

### SKW54. Intel® TSX Abort May Result in Unpredictable System Behavior

Problem: Certain micro-architectural conditions during an Intel® TSX abort may result in unpredictable system behavior.

Implication: Software using Intel® TSX may be unreliable.

Workaround: It is possible for the BIOS to contain a workaround for this erratum.

Status: For the steppings affected, see the "Summary Tables of Changes".

### SKW55. Use of Prefetch Instructions May Lead to a Violation of Memory Ordering

Problem: Under certain micro architectural conditions, execution of a PREFETCHh instruction or a PREFETCHW instruction may cause a load from the prefetched cache line to appear to execute before an earlier load from another cache line.

Implication: Software that relies on loads executing in program order may not operate correctly.

Workaround: It is possible for the BIOS to contain a workaround for this erratum.

Status: For the steppings affected, see the "Summary Tables of Changes".

### SKW56. Code Segment (CS) Limit Violation May Not Be Detected

Problem: A CS limit reduction may not be properly applied.

Implication: Instructions may be executed beyond the CS limit. Intel has not observed this erratum to impact the operation of any commercially available software.

Workaround: It is possible for the BIOS to contain a workaround for this erratum.

Status: For the steppings affected, see the "Summary Tables of Changes".

### SKW57. Last Level Cache Performance Monitoring Events May Be Inaccurate

Problem: The performance monitoring events LONGEST_LAT_CACHE.REFERENCE (Event 2EH; Umask 4FH) and LONGEST_LAT_CACHE.MISS (Event 2EH; Umask 41H) count requests that reference or miss in the last level cache. However, due to this erratum, the count may be incorrect.

Implication: LONGEST_LAT_CACHE events may be incorrect.

Workaround: None identified. Software may use the following OFFCORE_REQUESTS model-specific sub events that provide related performance monitoring data: DEMAND_DATA_RD, DEMAND_CODE_RD, DEMAND_RFO, ALL_DATA_RD, L3_MISS_DEMAND_DATA_RD, ALL_REQUESTS.

Status: For the steppings affected, see the "Summary Tables of Changes".

### SKW58. #GP Occurs Rather Than the Debug Exception (#DB) on Code Page Split Inside an Intel® SGX Enclave

Problem: When executing within an Intel® SGX enclave, a #GP may be delivered instead of a #DB when an instruction breakpoint is detected. This occurs when the instruction to be executed spans two pages, the second of which has an entry in the Enclave Page Cache Map (EPCM) that is not valid.

Implication: Debugging software may not be invoked when an instruction breakpoint is detected.

Workaround: Software should ensure that all pages containing enclave instructions have valid EPCM entries.

Status: For the steppings affected, see the "Summary Tables of Changes".

### SKW59. Execution of VAESENCLAST Instruction May Produce a #NM Exception Instead of a #UD Exception

Problem: Execution of VAESENCLAST with VEX.L= 1 should signal a #UD exception, however, due to the erratum, a Device Not Available (#NM) exception may be signaled.

Implication: As a result of this erratum, an operating system may restore Intel® AVX and other state unnecessarily.

Workaround: None identified.

Status: For the steppings affected, see the "Summary Tables of Changes".

### SKW60. Intel® SGX Enclave Accesses to the APIC-Access Page May Cause APIC-Access VM Exits

Problem: In VMX non-root operation, Intel® SGX enclave accesses to the APIC-access page may cause APIC-access VM exits instead of page faults.

Implication: A VMM may receive a VM exit due to an access that should have caused a page fault, which would be handled by the guest OS.

Workaround: A VMM avoids this erratum if it does not map any part of the Enclave Page Cache (EPC) to the guest's APIC-access address; an operating system avoids this erratum if it does not attempt indirect enclave accesses to the APIC.

Status: For the steppings affected, see the "Summary Tables of Changes".

### SKW61. CR3 Filtering Does Not Compare Bits [11:5] of CR3 and IA32_RTIT_CR3_MATCH in PAE Paging Mode

Problem: In PAE paging mode, the CR3[11:5] are used to locate the page-directory-pointer table. Due to this erratum, those bits of CR3 are not compared to `IA32_RTIT_CR3_MATCH` (MSR 572H) when `IA32_RTIT_CTL.CR3Filter` (MSR 570H, bit 7) is set.

Implication: If multiple page-directory-pointer tables are co-located within a 4 KB region, CR3 filtering will not be able to distinguish between them so additional processes may be traced.

Workaround: None identified.

Status: For the steppings affected, see the "Summary Tables of Changes".

### SKW62. Intel® PT PacketEn Change on C-state Wake May Not Generate a TIP Packet

Problem: A TIP.PGE or TIP.PGD packet may not be generated if Intel® PT PacketEn changes after `IA32_RTIT_STATUS.FilterEn` (MSR 571H, bit 0) is re-evaluated on wakeup from C6 or deeper sleep state.

Implication: When code enters or exits an IP filter region without a taken branch, tracing may begin or cease without proper indication in the trace output. This may affect trace decoder behavior.

Workaround: None identified. A trace decoder will need to skip ahead to the next TIP or FUP packet to determine the current IP.

Status: For the steppings affected, see the "Summary Tables of Changes".

### SKW63. Graphics Configuration May Not Be Correctly Restored After a Package C8 Exit

Problem: The processor should ensure internal graphics configuration is restored during a Package C8 or deeper exit event. Due to this erratum, some internal graphics configurations may not be correctly restored.

Implication: When this erratum occurs, a graphics driver restart may lead to system instability. Such a restart may occur when upgrading the graphics driver.

Workaround: It is possible for the BIOS to contain a workaround for this erratum.

Status: For the steppings affected, see the "Summary Tables of Changes".

### SKW64. x87 FDP Value May Be Saved Incorrectly

Problem: Execution of the FSAVE, FNSAVE, FSTENV, or FNSTENV instructions in real-address mode or virtual-8086 mode may save an incorrect value for the x87 FDP (FPU data pointer). This erratum does not apply if the last non-control x87 instruction had an unmasked exception.

Implication: Software operating in real-address mode or virtual-8086 mode that depends on the FDP value for non-control x87 instructions without unmasked exceptions may not operate properly.

Workaround: None identified. Software should use the FDP value saved by the listed instructions only when the most recent non-control x87 instruction incurred an unmasked exception.

Status: For the steppings affected, see the "Summary Tables of Changes".

### SKW65. PECI Frequency Limited to 1 MHz

Problem: The PECI 3.1 specification's operating frequency range is 0.2 MHz to 2 MHz. Due to this erratum, PECI may be unreliable when operated above 1 MHz.

Implication: Platforms attempting to run PECI above 1 MHz may not behave as expected.

Workaround: None identified. Platforms should limit PECI operating frequency to 1 MHz.

Status: For the steppings affected, see the "Summary Tables of Changes".

### SKW66. Processor Graphics IOMMU Unit May Not Mask DMA Remapping Faults

Problem: Intel® VT-d specification specifies setting the FPD field in the context (or extended-context) entry of IOMMU to mask recording of qualified DMA remapping faults for DMA requests processed through that context entry. Due to this erratum, the IOMMU unit for Processor Graphics device may record DMA remapping faults from Processor Graphics device (Bus: 0; Device: 2; Function: 0) even when the FPD field is set to 1.

Implication: Software may continue to observe DMA remapping faults recorded in the IOMMU Fault Recording Register even after setting the FPD field.

Workaround: None identified. Software may mask the fault reporting event by setting the Interrupt Mask (IM) field in the IOMMU Fault Event Control register (Offset 038H in GFXVTBAR).

Status: For the steppings affected, see the "Summary Tables of Changes".

### SKW67. Processor With Intel® SGX Support May Hang During S3 Wake or Power-On Reset

Problem: Processors that support Intel® SGX may experience hangs when waking from S3 (Standby) system sleep state or during a power-on reset. This erratum may occur even if the Intel® SGX feature is not enabled.

Implication: Due to this erratum, the system may not wake after entering standby sleep state or may not start up after a power-on reset.

Workaround: It is possible for the BIOS to contain a workaround for this erratum. For systems that do not power gate Vcc Sustain, if the workaround detects this erratum, support for Intel® SGX will be removed until platform power is disconnected and reapplied.

Status: For the steppings affected, see the "Summary Tables of Changes".

### SKW68. Pending x87 FPU Exceptions (#MF) May Be Signaled Earlier Than Expected

Problem: x87 instructions that trigger #MF normally service interrupts before the #MF. Due to this erratum, if an instruction that triggers #MF is executed while Enhanced Intel SpeedStep® Technology transitions, Intel® Turbo Boost Technology transitions, or Thermal Monitor events occur, the pending #MF may be signaled before pending interrupts are serviced.

Implication: Software may observe #MF being signaled before pending interrupts are serviced.

Workaround: None identified.

Status: For the steppings affected, see the "Summary Tables of Changes".

### SKW69. IA Core Ratio Change Coincident With Outstanding Read to the Display Engine (DE) May Cause a System Hang

Problem: An outstanding read from an IA core to the DE that is coincident with an IA core ratio change may result in a system hang.

Implication: Due to this erratum, the system may hang.

Workaround: It is possible for the BIOS to contain a workaround for this erratum.

Status: For the steppings affected, see the "Summary Tables of Changes".

### SKW70. TSC Is Not Affected by Warm Reset

Problem: The TSC (IA32_TIME_STAMP_COUNTER MSR 10H) should be cleared on reset. Due to this erratum the TSC is not affected by warm reset.

Implication: The TSC is not cleared by a warm reset. The TSC is cleared by power-on reset as expected.

Workaround: None identified.

Status: For the steppings affected, see the "Summary Tables of Changes".

### SKW71. Intel® PT Buffer Overflow Indication May be Lost if it Immediately Precedes a TraceStop

Problem: If an Intel® PT internal buffer overflow occurs just before software executes a taken branch or event that enters an Intel® PT TraceStop region, the OVF packet may be lost.

Implication: When this erratum occurs, the decoder will not see the OVF packet or any TIP.PGD and may not see the TraceStop packet at the end of the trace.

Workaround: None identified.

Status: For the steppings affected, see the "Summary Tables of Changes".

### SKW72. Intel® PT CYCThresh Value of 13 Is Not Supported

Problem: Intel® PT CYC threshold is configured through CYCThresh field in bits [22:19] of IA32_RTIT_CTL MSR (570H). A value of 13 is advertised as supported by CPUID (leaf 14H, sub-lead 1H). Due to this erratum, if CYCThresh is set to 13 then the CYC threshold will be 0 cycles instead of 4096 (213-1) cycles.

Implication: CYC packets may be issued in higher rate than expected if threshold value of 13 is used.

Workaround: None identified. Software should not use value of 13 for CYC threshold.

Status: For the steppings affected, see the "Summary Tables of Changes".

### SKW73. Intel® PT May Drop Some Timing Packets After Entering Thread C3

Problem: Intel® PT may temporarily stop sending Mini Time Counter (MTC) and CYC packets after entering thread C3 state. MTC and CYC packets may be missing in up to 1KB of trace output after entering thread C3.

Implication: Some Intel® PT timing packets may temporarily not be sent after thread C3 is entered.

Workaround: It is possible for the BIOS to contain a workaround for this erratum.

Status: For the steppings affected, see the "Summary Tables of Changes".

### SKW74. Underflow and Denormal Conditions During a Vector Dot Product of Packed Single Precision Floating-Point Values (VDPPS) Instruction With YMM Operands May Not Produce The Expected Results

Problem: A VDPPS instruction operating on YMM registers with denormal operands or experiencing an underflow may not produce the expected result if the exception is masked in the MXCSR. This may also happen when intermediate multiply results have underflow conditions.

Implication: VDPPS with YMM registers may not produce the expected result.

Workaround: It is possible for the BIOS to contain a workaround for this erratum.

Status: For the steppings affected, see the "Summary Tables of Changes".

### SKW75. APIC Timer Interrupt May Be Delivered Early

Problem: When the APIC timer is configured to TSC Deadline Mode, a timer interrupt may occur before the expected deadline if any of `IA32_TSC_DEADLINE` MSR (6E0H) bits [63:56] are set.

Implication: A timer interrupt may be delivered earlier than specified by the `IA32_TSC_DEADLINE` MSR.

Workaround: It is possible for the BIOS to contain a workaround for this erratum.

Status: For the steppings affected, see the "Summary Tables of Changes".

### SKW76. System May Hang When Using Intel® Trusted Execution Technology (Intel® TXT) And Memory That Supports Address Mirroring

Problem: Within platforms that utilize memory that supports address mirroring, processors that utilize Intel® TXT measured launch environment may fail to boot and hang.

Implication: Due to this erratum, system may hang.

Workaround: A BIOS code change has been identified and may be implemented as a workaround for this erratum.

Status: For the steppings affected, see the "Summary Tables of Changes".

### SKW77. Display Flicker May Occur When Both Intel® VT-d And FBC Are Enabled

Problem: Display flickering may occur when both Frame Buffer Compression (FBC) and Intel® VT-d are enabled and in use by the display controller.

Implication: Due to this erratum, display flickering may be observed.

Workaround: It is possible for the Intel® Graphics Driver to contain a workaround for this erratum. This workaround will disable FBC.

Status: For the steppings affected, see the "Summary Tables of Changes".

### SKW78. Certain Processors May be Configured With an Incorrect Thermal Design Power (TDP)

Problem: Certain processors should be configured with a TDP limit of 54 or 51 watts. Due to this erratum, these processors may be incorrectly configured at 65 W TDP. The following processors are affected by this erratum: Intel® Core™ i3 Processor Series, Celeron® and Pentium® (Dual-Core With GT1/GT2). A processor that reports a value of 0x208 in `TDP_POWER_OF_SKU` field in MSR `PACKAGE_POWER_SKU` (MSR 614H [14:0]) are affected by this erratum.

Implication: Processors affected by this erratum may spend more time in turbo and thus may experience unexpected thermal throttling events.

Workaround: It is possible for the BIOS to contain a workaround for this erratum.

Status: For the steppings affected, see the "Summary Tables of Changes".

### SKW79. MOVNTDQA From Write Combining (WC) Memory May Pass Earlier MFENCE Instructions

Problem: An execution of MOVNTDQA or VMOVNTDQA that loads from WC memory may appear to pass an earlier execution of the MFENCE instruction.

Implication: When this erratum occurs, an execution of MOVNTDQA or VMOVNTDQA may appear to execute before memory operations that precede the earlier MFENCE instruction. Software that uses MFENCE to order subsequent executions of the MOVNTDQA instructions may not operate properly.

Workaround: It is possible for the BIOS to contain a workaround for this erratum.

Status: For the steppings affected, see the "Summary Tables of Changes".

### SKW80. Integrated Audio Codec May Not Be Detected

Problem: Integrated Audio Codec may lose power when Low-Power Single Pipe (LPSP) mode is enabled for an or HDMI ports. Platforms with Intel® Smart Sound Technology (Intel® SST) enabled are not affected.

Implication: The Audio Bus driver may attempt to do enumeration of Codecs when embedded Display Port* (eDP*) or HDMI port enters LPSP mode, due to this erratum, the Integrated Audio Codec will not be detected and audio may be be lost.

Workaround: Intel® Graphics Driver 15.40.11.4308 or later will prevent the Integrated Audio Codec from losing power when LPSP mode is enabled.

Status: For the steppings affected, see the "Summary Tables of Changes".

### SKW81. Processor May Hang or Cause Unpredictable System Behavior

Problem: Under complex micro-architecture conditions, processor may hang with an internal timeout error (MCACOD 0400H) logged into `IA32_MCi_STATUS` or cause unpredictable system behavior.

Implication: When this issue occurs, the system may cause unpredictable system behavior.

Workaround: It is possible for the BIOS to contain a workaround for this erratum.

Status: For the steppings affected, see the "Summary Tables of Changes".

### SKW82. REP MOVS May Not Operate Correctly With Extended Page Table (EPT) Enabled

Problem: Execution of REP MOVS may incorrectly change [R/E]CX, [R/E]SI, and/or [R/E]DI register values during instruction execution. This erratum occurs only if the execution would set an accessed or dirty flag in a paging structure to which EPT does not allow writes.

Implication: Incorrect changes to RCX, RSI, and/or RDI may lead to a block-copy operation with an unexpected length, an unexpected source location, and/or an unexpected destination location.

Workaround: It is possible for the BIOS to contain a workaround for this erratum.

Status: For the steppings affected, see the "Summary Tables of Changes".

### SKW83. Ring Frequency Changes May Cause a Machine Check And System Hang

Problem: Ring frequency changes may lead to a system hang with the processor logging a machine check in `IA32_MCi_STATUS` where the MCACOD (bits [15:0]) value is 0x0402 and the MSCOD (bits [31:16]) value is 0x77yy (yy is any 8-bit value).

Implication: When this erratum occurs, the system will log a machine check and hang. Power management activity, including system power state changes, can result in ring frequency changes that may trigger this erratum.

Workaround: It is possible for the BIOS to contain a workaround for this erratum.

Status: For the steppings affected, see the "Summary Tables of Changes".

### SKW84. x87 FPU Data Pointer Updated Only For Instructions That Incur Unmasked Exceptions

Problem: The x87 FPU data pointer points to the data (operand) for the last x87 non-control instruction executed, unless `CPUID.(EAX=07H,ECX=0H):EBX.FDP_EXCPTN_ONLY` [bit 6] is 1, in which case it points to the operand for the last x87 non-control instruction that incurred an unmasked x87 exception. Due to this erratum, x87 FPU data pointer behaves as if the `FDP_EXCPTN_ONLY` flag is 1 even when that bit is 0.

Implication: If the most recent x87 non-control instruction did not incur an unmasked x87 exception, software that then examines the x87 FPU data pointer will see an incorrect value. Intel has not observed this erratum with any commercially available software.

Workaround: It is possible for the BIOS to contain a workaround for this erratum.

Status: For the steppings affected, see the "Summary Tables of Changes".

### SKW85. WRMSR to IA32_BIOS_UPDT_TRIG Concurrent With an Safer Mode Extensions (SMX) SENTER/SEXIT May Result in a System Hang

Problem: Performing WRMSR to `IA32_BIOS_UPDT_TRIG` (MSR 79H) on a logical processor while another logical processor is executing an SMX SENTER/SEXIT operation (GETSEC[SENTER] or GETSEC[SEXIT] instruction) may cause the processor to hang.

Implication: When this erratum occurs, the system will hang. Intel has not observed this erratum with any commercially available system.

Workaround: None identified.

Status: For the steppings affected, see the "Summary Tables of Changes".

### SKW86. Incorrect Branch Predicted Bit in BTS/BTM Branch Records

Problem: The BTS and the BTM send branch records to the Debug Store management area and system bus respectively. The Branch Predicted bit (bit 4 of eighth byte in BTS/BTM records) should report whether the most recent branch was predicted correctly. Due to this erratum, the branch predicted bit may be incorrect.

Implication: The BTS and the BTM cannot be used to determine the accuracy of branch prediction.

Workaround: None identified.

Status: For the steppings affected, see the "Summary Tables of Changes".

### SKW87. MACHINE_CLEARS.MEMORY_ORDERING Performance Monitoring Event May Undercount

Problem: The performance monitoring event MACHINE_CLEARS.MEMORY_ORDERING (Event C3H; Umask 02H) counts the number of machine clears caused by memory ordering conflicts. However due to this erratum, this event may undercount for VGATHER*/ VPGATHER* instructions with four or more elements.

Implication: MACHINE_CLEARS.MEMORY_ORDERING performance monitoring event may undercount.

Workaround: None identified.

Status: For the steppings affected, see the "Summary Tables of Changes".

### SKW88. CTR_FRZ May Not Freeze Some Counters

Problem: IA32_PERF_GLOBAL_STATUS.CTR_FRZ (MSR 38EH, bit 59) is set when either (1) IA32_DEBUGCTL.FREEZE_PERFMON_ON_PMI (MSR 1D9H, bit 12) is set and a PMI is triggered, or (2) software sets bit 59 of IA32_PERF_GLOBAL_STATUS_SET (MSR 391H). When set, CTR_FRZ should stop all core performance monitoring counters from counting. However, due to this erratum, IA32_PMC4-7 (MSR C5-C8H) may not stop counting. IA32_PMC4-7 are only available when a processor core is not shared by two logical processors.

Implication: General performance monitoring counters 4-7 may not freeze when IA32_PERF_GLOBAL_STATUS.CTR_FRZ is set.

Workaround: None identified.

Status: For the steppings affected, see the "Summary Tables of Changes".

### SKW89. Instructions And Branches Retired Performance Monitoring Events May Overcount

Problem: The performance monitoring events INST_RETIRED (Event C0H; any Umask value) and BR_INST_RETIRED (Event C4H; any Umask value) count instructions retired and branches retired, respectively. However, due to this erratum, these events may overcount in certain conditions when:

- Executing VMASKMOV* instructions with at least one masked vector element.
- Executing REP MOVS or REP STOS with Fast Strings enabled (IA32_MISC_ENABLES MSR (1A0H), bit 0 set).
- An Intel® MPX #BR exception occurs on BNDLDX/BNDSTX instructions and the BR_INST_RETIRED (Event C4H; Umask is 00H or 04H) is used.

Implication: INST_RETIRED and BR_INST_RETIRED performance monitoring events may overcount.

Workaround: None identified.

Status: For the steppings affected, see the "Summary Tables of Changes".

### SKW90. Some OFFCORE_RESPONSE Performance Monitoring Events May Overcount

Problem: The performance monitoring events `OFFCORE_RESPONSE` (Events B7H and BBH) should count off-core responses matching the request-response configuration specified in `MSR_OFFCORE_RSP_0` and `MSR_OFFCORE_RSP_1` (1A6H and 1A7H, respectively) for core-originated requests. However, due to this erratum, `DMND_RFO` (bit 1), `DMND_IFETCH` (bit 2) and OTHER (bit 15) request types may overcount.

Implication: Some `OFFCORE_RESPONSE` events may overcount.

Workaround: None identified. Software may use the following model-specific events that provide related performance monitoring data: `OFFCORE_REQUESTS` (all sub-events), `L2_TRANS.L2_WB` and `L2_RQSTS.PF_MISS`.

Status: For the steppings affected, see the "Summary Tables of Changes".

### SKW91. Using the BIOS to Disable Cores May Lead to a System Hang

Problem: Using the BIOS hardware core disable facility may cause the processor to hang when it attempts to enter or exit Package C6.

Implication: When this erratum occurs, attempting to enter or exit Package C6 state will hang the system.

Workaround: It is possible for the BIOS to contain a workaround for this erratum.

Status: For the steppings affected, see the "Summary Tables of Changes".

### SKW92. #GP After RSM May Push Incorrect RFLAGS Value When Intel® PT is Enabled

Problem: If Intel® PT is enabled, a #GP caused by the instruction fetch immediately following execution of an RSM instruction may push an incorrect value for RFLAGS onto the stack.

Implication: Software that relies on the RFLAGS value pushed on the stack under the conditions described may not work properly.

Workaround: None identified.

Status: For the steppings affected, see the "Summary Tables of Changes".

### SKW93. Display Flickering May be Observed with Specific eDP* Panels

Problem: The processor may incorrectly configure transmitter buffer characteristics if the associated eDP* panel requests VESA equalization preset three, five, six, or eight.

Implication: Display flickering or display loss maybe observed.

Workaround: Intel® Graphics Driver version 15.40.12.4326 or later contains a workaround for this erratum.

Status: For the steppings affected, see the "Summary Tables of Changes".

### SKW94. PEBS Record May Be Generated After Being Disabled

Problem: A performance monitoring counter may generate a PEBS record after disabling the PEBS or the performance monitoring counter by clearing the corresponding enable bit in IA32_PEBS_ENABLE MSR (3F1H) or IA32_PERF_GLOBAL_CTRL MSR (38FH).

Implication: A PEBS record generated after a VMX transition will store into memory according to the post-transition DS configuration. These stores may be unexpected if the PEBS is not enabled following the transition.

Workaround: It is possible for the BIOS to contain a workaround for this erratum. A software workaround is possible through disallowing PEBS during VMX non-root operation and disabling PEBS prior to VM entry.

Status: For the steppings affected, see the "Summary Tables of Changes".

### SKW95. Monitor Trap Flag (MTF) VM Exit on XBEGIN Instruction May Save State Incorrectly

Problem: Execution of an XBEGIN instruction while the "monitor trap flag" VM-execution control is 1 will be immediately followed by an MTF VM exit. If advanced debugging of RTM transactional regions has been enabled, the VM exit will erroneously save the address of the XBEGIN instruction as the instruction pointer (instead of the fallback instruction address specified by the XBEGIN instruction). In addition, it will erroneously set bit 16 of the pending-debug-exceptions field in the VMCS indicating that a debug exception or a breakpoint exception occurred.

Implication: Software using the monitor trap flag to debug or trace transactional regions may not operate properly. Intel has not observed this erratum with any commercially available software.

Workaround: None identified.

Status: For the steppings affected, see the "Summary Tables of Changes".

### SKW96. Access to Intel® SGX EPC Page in BLOCKED State Is Not Reported as an Intel® SGX-Induced Page Fault

Problem: If a page fault results from an attempt to access a page in the Intel® SGX EPC that is in the BLOCKED state, the processor does not indicate that the page fault was Intel® SGX-induced by setting bit 15 of the error code pushed on the stack.

Implication: Due to this erratum, software may not recognize these page faults as being Intel® SGX-induced.

Workaround: Before using the EBLOCK instruction to marking a page as BLOCKED, software should mark the page not present.

Status: For the steppings affected, see the "Summary Tables of Changes".

### SKW97. Software Using Intel® TSX May Behave Unpredictably

Problem: Under a complex set of internal timing conditions and system events, software using the Intel® TSX instructions may behave unpredictably.

Implication: This erratum may result in unpredictable behavior of the software using Intel® TSX.

Workaround: It is possible for the BIOS to contain a workaround for this erratum.

Status: For the steppings affected, see the "Summary Tables of Changes".

### SKW98. Digital Thermal Sensor, version 2.0 (DTS2.0) Fan Control Regulation Is Incorrect

Problem: The DTS2.0 fan control temperature is incorrect.

Implication: Due to this erratum, the incorrect fan control temperature may lead to the processor running hot enough to reach its thermal throttling point, unnecessarily reducing processor performance. Other thermal control methods are not impacted by this erratum.

Workaround: It is possible for the BIOS to contain a workaround for this erratum.

Status: For the steppings affected, see the "Summary Tables of Changes".

### SKW99. Package-C6 Exit Latency May be Higher Than Expected Leading to Display Flicker

Problem: Package-C6 exit latency may be higher than expected.

Implication: Due to this erratum, the display may flicker or other Isochronous devices may be affected.

Workaround: It is possible for the BIOS to contain a workaround for this erratum.

Status: For the steppings affected, see the "Summary Tables of Changes".

### SKW100. PCIe* Ports Do Not Support DLL Link Active Reporting

Problem: The PCIe* Base Specification requires every "Downstream Port that supports Link speeds greater than 5.0 GT/s" to support Data Link Layer (DLL) Link Active Reporting, However, the PCIe* ports do not support DLL Link Active Reporting.

Implication: Due to this erratum, the PCIe* ports do not support DLL Link Active Reporting. This may be reported by a PCIe* compliance test.

Workaround: None identified.

Status: For the steppings affected, see the "Summary Tables of Changes".

### SKW101. MOVNTDQA From WC Memory May Pass Earlier Locked Instructions

Problem: An execution of (V)MOVNTDQA (streaming load instruction) that loads from the WC memory may appear to pass an earlier locked instruction that accesses a different cache line.

Implication: Software that expects a lock to fence subsequent (V)MOVNTDQA instructions may not operate properly.

Workaround: None identified. Software that relies on a locked instruction to fence subsequent executions of (V)MOVNTDQA should insert an MFENCE instruction between the locked instruction and subsequent (V)MOVNTDQA instruction.

Status: For the steppings affected, see the "Summary Tables of Changes".

### SKW102. System May Hang When EDRAM is Enabled And Double Data Rate (DDR) is Operating at 1600 MHz

Problem: When EDRAM is enabled and the DDR operating frequency is 1600 MHz, a system hang may occur.

Implication: When this erratum occurs, the system may hang.

Workaround: It is possible for the BIOS to contain a workaround for this erratum.

Status: For the steppings affected, see the "Summary Tables of Changes".

### SKW103. DR6.B0-B3 May Not Report All Breakpoints Matched When a MOV/POP SS Is Followed by a Store or an MMX Instruction

Problem: Normally, data breakpoints matches that occur on a MOV SS, r/m or POP SS will not cause a debug exception immediately after MOV/POP SS but will be delayed until the instruction boundary following the next instruction is reached. After the debug exception occurs, DR6.B0-B3 bits will contain information about data breakpoints matched during the MOV/POP SS as well as breakpoints detected by the following instruction. Due to this erratum, DR6.B0-B3 bits may not contain information about data breakpoints matched during the MOV/POP SS when the following instruction is either an MMX instruction that uses a memory addressing mode with an index or a store instruction.

Implication: When this erratum occurs, DR6 may not contain information about all breakpoints matched. This erratum will not be observed under the recommended usage of the MOV SS,r/m or POP SS instructions (that is, following them only with an instruction that writes [E/R]SP).

Workaround: None identified.

Status: For the steppings affected, see the "Summary Tables of Changes".

### SKW104. Package C3 Exit Latency May Be Longer Than Expected Leading to Display Flicker

Problem: Package C3 exit latency may be longer than expected.

Implication: When this erratum occurs on a system with multiple high resolution displays, the displays may flicker.

Workaround: It is possible for the BIOS to contain a workaround for this erratum.

Status: For the steppings affected, see the "Summary Tables of Changes".

### SKW105. Processor DDR VREF Signals May Briefly Exceed JEDEC Spec When Entering S3 State

Problem: Voltage glitch of up to 200 mV on the VREF signal lasting for about 1 mS may be observed when entering System S3 state. This violates the JEDEC Double Data Rate (DDR) specifications.

Implication: Intel has not observed this erratum to impact the operation of any commercially available system.

Workaround: None identified.

Status: For the steppings affected, see the "Summary Tables of Changes".

### SKW106. Uncore Performance Monitoring Counters May be Disabled or Cleared After Package C7

Problem: After entering into Package C7, the following Uncore performance monitoring MSRs may be cleared to zero: `MSR_ UNC _PERF_GLOBAL_CTRL (E01H), MSR_ UNC _PERF_GLOBAL_STATUS (E02H), MSR_ UNC _PERF_FIXED_CTRL (394H), MSR_ UNC _PERF_FIXED_CTR (395H).`

Implication: Uncore performance monitoring counters may be disabled and some counter state may be cleared after Package C7.

Workaround: It is possible for the BIOS to contain a workaround for this erratum.

Status: For the steppings affected, see the "Summary Tables of Changes".

### SKW107. Complex Interactions With Internal Graphics May Impact Processor Responsiveness

Problem: Under complex conditions associated with the use of internal graphics, the processor may exceed the `MAX_LAT` CSR values (PCI configuration space, offset 03FH, bits[7:0]).

Implication: When this erratum occurs, the processor responsiveness is affected. Intel has not observed this erratum with any commercially available software.

Workaround: None identified.

Status: For the steppings affected, see the "Summary Tables of Changes".

### SKW108. #GP on Segment Selector Descriptor that Straddles Canonical Boundary May Not Provide Correct Exception Error Code

Problem: During a #GP, the processor pushes an error code on to the exception handler's stack. If the segment selector descriptor straddles the canonical boundary, the error code pushed onto the stack may be incorrect.

Implication: An incorrect error code may be pushed onto the stack. Intel has not observed this erratum with any commercially available software.

Workaround: None identified.

Status: For the steppings affected, see the "Summary Tables of Changes".

### SKW109. Management Component Transport Protocol (MCTP) Header Packets with TAG 0x5 May Be Dropped

Problem: Downstream MCTP packets from the processor to the PCH will be incorrectly routed during MCTP device enumeration if the TAG field of the MCTP message header has a value of 0x5 and the routing type is Route to Root Complex (Type=0).

Implication: The device will function but cannot be MCTP managed. **Note:** This issue has only been observed with a synthetic test device where the MCTP header field was set to 0x5.

Workaround: MCTP devices should not use a TAG of 0x5 when performing MCTP enumeration.

Status: For the steppings affected, see the "Summary Tables of Changes".

### SKW110. Intel® PT Table of Physical Addresses (ToPA) PerfMon Interrupt (PMI) Does Not Freeze Performance Monitoring Counters

Problem: Due to this erratum, if IA32_DEBUGCTL.FREEZE_PERFMON_ON_PMI (MSR 1D9H, bit 12) is set to 1 when Intel® PT triggers a ToPA PMI, performance monitoring counters are not frozen as expected.

Implication: Performance monitoring counters will continue to count for events that occur during PMI handler execution.

Workaround: PMI handler software can programmatically stop performance monitoring counters upon entry.

Status: For the steppings affected, see the "Summary Tables of Changes".

### SKW111. Use of VMASKMOV to Store When Using the EPT May Fail

Problem: Use of VMASKMOV instructions to store data that splits over two pages, when the instruction resides on the first page may cause a hang if the EPT is in use, and the store to the second page requires setting the A/D bits in the EPT entry.

Implication: Due to this erratum, the CPU may hang on the execution of VMASKMOV.

Workaround: It is possible for the BIOS to contain a workaround for this erratum.

Status: For the steppings affected, see the "Summary Tables of Changes".

### SKW112. Hardware P-states (HWP)'s Maximum_Performance Value Is Reset to 0xFF

Problem: According to HWP specification, the reset value of the Maximum_Performance field (bits [15:8]) in IA32_HWP_REQUEST MSR (774h) should be set to the value of IA32_HWP_CAPABILITIES MSR (771H) Highest_Performance field (bits [7:0]) after reset. Due to this erratum, the reset value of Maximum_Performance is always set to 0xFF.

Implication: Software may see an unexpected value in Maximum Performance field. Hardware clipping will prevent invalid performance states.

Workaround: None identified.

Status: For the steppings affected, see the "Summary Tables of Changes".

### SKW113. HWP's Guaranteed_Performance Updated Only on Configurable TDP Changes

Problem: According to HWP specification, the Guaranteed_Performance field (bits [15:8]) in the IA32_HWP_CAPABILITIES MSR (771H) should be updated as a result of changes in the configuration of TDP, Running Average Power Limit (RAPL), RATL and other platform tuning options that may have dynamic effects on the actual guaranteed performance support level. Due to this erratum, the processor will update the Guaranteed_Performance field only as a result of configurable TDP dynamic changes.

Implication: Software may read a stale value of the Guaranteed _Performance field.

Workaround: None identified.

Status: For the steppings affected, see the "Summary Tables of Changes".

### SKW114. HWP's Guaranteed_Performance and Relevant Status/Interrupt May be Updated More Than Once Per Second

Problem: According to HWP specification, the Guaranteed_Performance field (bits [15:8]) in the IA32_HWP_CAPABILITIES MSR (771H) and the Guaranteed_Performance_Change (bit 0) bit in IA32_HWP_STATUS MSR (777H) should not be changed more than once per

second nor should the thermal interrupt associated with the change to these fields be signaled more than once per second. Due to this erratum, the processor may change these fields and generate the associated interrupt more than once per second.

Implication: HWP interrupt rate due to `Guaranteed_Performance` field change can be higher than specified.

Workaround: Clearing the `Guaranteed_Performance_Change` status bit no more than once per second will ensure that interrupts are not generated at too fast a rate.

Status: For the steppings affected, see the "Summary Tables of Changes".

### SKW115. Removed

### SKW116. Core and/or Ring Frequency May Be Briefly Lower Than Expected After BIOS Completes

Problem: Due to this erratum, the core and ring frequencies may be lower than expected for up to several seconds after BIOS completes.

Implication: Processing immediately after BIOS completes may take longer than expected. The erratum does not cause any functional failures.

Workaround: It is possible for the BIOS to contain a workaround for this erratum.

Status: For the steppings affected, see the "Summary Tables of Changes".

### SKW117. Resume Flag (RF) May be Incorrectly Set in The EFLAGS That Is Saved on a Fault in PEBS or BTS

Problem: After a fault due to a failed PEBS or BTS address translation, the RF may be incorrectly set in the EFLAGS image that is saved.

Implication: When this erratum occurs, a code breakpoint on the instruction following the return from handling the fault will not be detected. This erratum only happens when the user does not prevent faults on the PEBS or the BTS.

Workaround: Software should always prevent faults on the PEBS or the BTS.

Status: For the steppings affected, see the "Summary Tables of Changes".

### SKW118. Some Memory Performance Monitoring Events May Produce Incorrect Results When Filtering on Either OS or USR Modes

Problem: The memory at-retirement performance monitoring events (next listed) may produce incorrect results when a performance counter is configured in OS-only or USR-only modes (bits 17 or 16 in IA32_PERFEVTSELx MSR). Counters with both OS and USR bits set are not affected by this erratum.
The list of affected memory at-retirement events is as follows:

```
MEM_INST_RETIRED.STLB_MISS_LOADS event D0H, umask 11H
MEM_INST_RETIRED.STLB_MISS_STORES event D0H, umask 12H
MEM_INST_RETIRED.LOCK_LOADS event D0H, umask 21H
MEM_INST_RETIRED.SPLIT_LOADS event D0H, umask 41H
MEM_INST_RETIRED.SPLIT_STORES event D0H, umask 42H
MEM_LOAD_RETIRED.L2_HIT event D1H, umask 02H
MEM_LOAD_RETIRED.L3_HIT event D1H, umask 04H
MEM_LOAD_RETIRED.L4_HIT event D1H, umask 80H
MEM_LOAD_RETIRED.L1_MISS event D1H, umask 08H
MEM_LOAD_RETIRED.L2_MISS event D1H, umask 10H
MEM_LOAD_RETIRED.L3_MISS event D1H, umask 20H
MEM_LOAD_RETIRED.FB_HIT event D1H, umask 40H
MEM_LOAD_L3_HIT_RETIRED.XSNP_MISS event D2H, umask 01H
MEM_LOAD_L3_HIT_RETIRED.XSNP_HIT event D2H, umask 02H
MEM_LOAD_L3_HIT_RETIRED.XSNP_HITM event D2H, umask 04H
MEM_LOAD_L3_HIT_RETIRED.XSNP_NONE event D2H, umask 08H
```

Implication: The listed performance monitoring events may produce incorrect results including PEBS records generated at an incorrect point.

Workaround: None identified.

Status: For the steppings affected, see the "Summary Tables of Changes".

### SKW119. RING_PERF_LIMIT_REASONS May be Incorrect

Problem: Under certain conditions, RING_PERF_LIMIT_REASONS (MSR 6B1H) may incorrectly assert the OTHER status bit (bit 8) as well as the OTHER log bit [bit 24].

Implication: When this erratum occurs, software using this register will incorrectly report clipping because of the OTHER reason.

Workaround: It is possible for the BIOS to contain a workaround for this erratum.

Status: For the steppings affected, see the "Summary Tables of Changes".

### SKW120. The HWP May Generate Thermal Interrupt While Not Enabled

Problem: Due to this erratum, the conditions for HWP to generate a thermal interrupt on a logical processor may generate thermal interrupts on both logical processors of that core.

Implication: If two logical processors of a core have different configurations of the HWP (for example, only enabled on one), an unexpected thermal interrupt may occur on one logical processor due to the HWP settings of the other logical processor.

Workaround: Software should configure the HWP consistently on all logical processors of a core.

Status: For the steppings affected, see the "Summary Tables of Changes".

### SKW121. Camera Device Does Not Issue an Message Signaled Interrupts (MSI) When INTx is Enabled

Problem: When both MSI and legacy INTx are enabled by the camera device, INTx is asserted rather than issuing the MSI, in violation of the PCI Local Bus Specification.

Implication: Due to this erratum, camera device interrupts can be lost leading to device failure.

Workaround: The camera device must disable legacy INTx by setting bit 10 of PCICMD (Bus 0; Device 5; Function 0; Offset 04H) before MSI is enabled.

Status: For the steppings affected, see the "Summary Tables of Changes".

### SKW122. Violations of Intel® SGX Access-Control Requirements Produce #GP Instead of Page Fault (#PF)

Problem: Intel® SGX define new access-control requirements on memory accesses. A violation of any of these requirements causes a #PF that sets bit 15 (Intel® SGX) in the page-fault error code. Due to this erratum, these violations instead cause general-protection exceptions (#GP).

Implication: Software resuming from system sleep states S3 or S4 and relying on receiving a page fault from the previous enclave accesses may not operate properly.

Workaround: Software can monitor #GP faults to detect that an enclave has been destroyed and needs to be rebuilt after resuming from S3 or S4.

Status: For the steppings affected, see the "Summary Tables of Changes".

### SKW123. PCIe* Graphics (PEG) Advanced Error Reporting (AER) is Not Enabled

Problem: The PCIe* and PEG AER capability is not enabled for Server/Workstation SKUs.

Implication: Software cannot use AER capabilities.

Workaround: It is possible for the BIOS to contain a workaround for this erratum.

Status: For the steppings affected, see the "Summary Tables of Changes".

### SKW124. Performance Monitoring Counters May Undercount When Using CPL Filtering

Problem: Performance Monitoring counters configured to count only OS or only USR events by setting exactly one of bits 16 or 17 in `IA32_PERFEVTSELx` MSRs (186H-18DH) may not count for a brief period during the transition to a new CPL.

Implication: A measurement of ring transitions (using the edge-detect bit 18 in `IA32_PERFEVTSELx`) may undercount, such as `CPL_CYCLES.RING0_TRANS` (Event 5CH, Umask 01H). Additionally, the sum of an OS-only event and a USR-only event may not exactly equal an event counting both OS and USR. Intel has not observed any other software-visible impact.

Workaround: None identified.

Status: For the steppings affected, see the "Summary Tables of Changes".

### SKW125. SMRAM State-Save Area Above the 4 GB Boundary May Cause Unpredictable System Behavior

Problem: If the BIOS uses the RSM instruction to load the SMBASE register with a value that would cause any part of the SMRAM state-save area to have an address above 4 GBytes, subsequent transitions into and out of SMM might save and restore processor state from incorrect addresses.

Implication: This erratum may cause unpredictable system behavior. Intel has not observed this erratum with any commercially available system.

Workaround: Ensure that the SMRAM state-save area is located entirely below the 4 GB address boundary.

Status: For the steppings affected, see the "Summary Tables of Changes".

### SKW126. Certain Non-Canonical IA32_BNDCFGS Values Will Not Cause VM-Entry Failures

Problem: If the VM-entry controls Load `IA32_BNDCFGS` field (bit 16) is 1, VM-entry should fail when the value of the guest `IA32_BNDCFGS` field in the VMCS is not canonical (that is, when bits 63:47 are not identical). Due to this erratum, VM-entry does not fail if bits 63:48 are identical but differ from bit 47. In this case, VM-entry loads the `IA32_BNDCFGS` MSR with a value in which bits 63:48 are identical to the value of bit 47 in the VMCS field.

Implication: If the value of the guest `IA32_BNDCFGS` field in the VMCS is not canonical, VM-entry may load the `IA32_BNDCFGS` MSR with a value different from that of the VMCS field.

Workaround: None identified.

Status: For the steppings affected, see the "Summary Tables of Changes".

### SKW127. PEBS EventingIP Field May Be Incorrect Under Certain Conditions

Problem: The EventingIP field in the PEBS record reports the address of the instruction that triggered the PEBS event. Under certain complex micro-architectural conditions, the EventingIP field may be incorrect.

Implication: When this erratum occurs, performance monitoring software may not attribute the PEBS events to the correct instruction.

Workaround: None identified.

Status: For the steppings affected, see the "Summary Tables of Changes".

### SKW128. Executing a 256 Bit Intel® AVX Instruction May Cause Unpredictable Behavior

Problem: Under complex micro-architectural conditions, executing a 256 Intel® AVX bit instruction may result in unpredictable system behavior.

Implication: When this erratum occurs, the system may behave unpredictably.

Workaround: It is possible for the BIOS to contain a workaround for this erratum.

Status: For the steppings affected, see the "Summary Tables of Changes".

### SKW129. An x87 Store Instruction Which Pends Precision Exception (#PE) May Lead to Unexpected Behavior When EPT A/D Is Enabled.

Problem: An x87 store instruction which causes a #PE to be pended and updates an EPT A/D bit and causes a VM exit (such as EPT violation or #PF VM exit) may lead to unexpected behavior.

Implication: The VMM may experience unexpected x87 fault or a machine check exception with the value of 0x150 in `IA32_MC0_STATUS.MCACOD` (bits [15:0] in MSR 401H).

Workaround: It is possible for the BIOS to contain a workaround for this erratum.

Status: For the steppings affected, see the "Summary Tables of Changes".

### SKW130. PECI May Not Be Functional After Power On or S3/S4/S5 Resume

Problem: When resuming from S3/S4/S5 or following a power on, PECI may fail to function properly.

Implication: When this erratum occurs, the PECI does not respond to any command.

Workaround: It is possible for the BIOS to contain a workaround for this erratum.

Status: For the steppings affected, see the "Summary Tables of Changes".

### SKW131. A System Hang or Machine Check May Occur When eDRAM Is Enabled

Problem: When eDRAM is enabled, the processor may experience a hang or a machine check exception with an error reported in `IA32_MC10_STATUS`.

Implication: When this erratum occurs, the system will generate a machine check error or hang.

Workaround: It is possible for the BIOS to contain a workaround for this erratum.

Status: For the steppings affected, see the "Summary Tables of Changes".

### SKW132. Load Latency Performance Monitoring Facility May Stop Counting

Problem: The performance monitoring events `MEM_TRANS_RETIRED.LOAD_LATENCY_*` (Event CDH; UMask 01H; any latency) count load instructions whose latency exceed a predefined threshold, where the loads are randomly selected using the Load Latency facility (PEBS extension). However, due to this erratum, load latency facility may stop counting load instructions when Intel® Hyper-Threading Technology (Intel® HT Technology) is enabled.

Implication: Counters programmed with the affected events stop incrementing and do not generate PEBS records.

Workaround: None identified.

Status: For the steppings affected, see the "Summary Tables of Changes".

### SKW133. BNDLDX And BNDSTX May Not Signal #GP on Non-Canonical Bound Directory Access

Problem: BNDLDX and BNDSTX instructions access the bound's directory and table to load or store bounds. These accesses should signal #GP when the address is not canonical (for example, bits 48 to 63 are not the sign extension of bit 47). Due to this erratum, #GP may not be generated by the processor when a non-canonical address is used by BNDLDX or BNDSTX for their bound directory memory access.

Implication: Intel has not observed this erratum with any commercially available software.

Workaround: Software should use canonical addresses for bound directory accesses.

Status: For the steppings affected, see the "Summary Tables of Changes".

### SKW134. Digital Thermal Sensor (DTS) Temperature Reading May Be Inaccurate on DDR4 systems

Problem: The temperature reported by the DTS on DDR4 systems may vary from the actual temperature by +5°C to -15°C rather than the specified ±5°C.

Implication: When this erratum occurs, CPU throttling may occur later than expected. Intel has not observed this erratum to have any impact on system.

Workaround: None identified.

Status: For the steppings affected, see the "Summary Tables of Changes".

### SKW135. Performance Monitoring Load Latency Events May Be Inaccurate For Gather Instructions

Problem: The performance monitoring events `MEM_TRANS_RETIRED.LOAD_LATENCY_*` (Event CDH; UMask 01H; any latency) count load instructions whose latency exceed a predefined threshold, where the loads are randomly selected using the load latency facility (an extension of PEBS). However due to this erratum, these events may count incorrectly for VGATHER*/VPGATHER* instructions.

Implication: The Load Latency Performance Monitoring events may be Inaccurate for Gather instructions.

Workaround: None identified.

Status: For the steppings affected, see the "Summary Tables of Changes".

### SKW136. IA32_RTIT_CR3_MATCH MSR Bits[11:5] Are Treated As Reserved

Problem: Due to this erratum, bits [11:5] in `IA32_RTIT_CR3_MATCH` (MSR 572H) are reserved; an MSR write that attempts to set that field to a non-zero value will result in a #GP fault.

Implication: The inability to write the identified bit field does not affect the functioning of Intel® PT operation because, as described in erratum SKL061, the bit field that is the subject of this erratum is not used during Intel® PT CR3 filtering.

Workaround: Ensure that bits 11:5 of the value written to `IA32_RTIT_CR3_MATCH` are zero, including cases where the selected page-directory-pointer-table base address has non-zero bits in this range.

Status: For the steppings affected, see the "Summary Tables of Changes".

### SKW137. APIC Timer Interrupt May Not Be Generated at The Correct Time In TSC-Deadline Mode

Problem: After writing to the `IA32_TSC_ADJUST` MSR (3BH), any subsequent write to the `IA32_TSC_DEADLINE` MSR (6E0H) may incorrectly process the desired deadline. When this erratum occurs, the resulting timer interrupt may be generated at the incorrect time.

Implication: When the local APIC timer is configured for TSC-Deadline mode, a timer interrupt may be generated much earlier than expected or much later than expected. Intel has not observed this erratum with most commercially available software.

Workaround: It is possible for the BIOS to contain a workaround for this erratum.

Status: For the steppings affected, see the "Summary Tables of Changes".

### SKW138. Some Bits in MSR_MISC_PWR_MGMT May Be Updated on Writing Illegal Values to This MSR

Problem: Attempts to write illegal values to `MSR_MISC_PWR_MGMT` (MSR 0x1AA) result in #GP and should not change the MSR value. Due to this erratum, some bits in the MSR may be updated on writing an illegal value.

Implication: Certain fields may be updated with allowed values when writing illegal values to `MSR_MISC_PWR_MGMT`. Such writes will always result in #GP as expected.

Workaround: None identified. Software should not attempt to write illegal values to this MSR.

Status: For the steppings affected, see the "Summary Tables of Changes".

### SKW139. Unpredictable System Behavior May Occur When System Agent Enhanced Intel SpeedStep® Technology Is Enabled

Problem: Under complex system conditions, system agent Enhanced Intel SpeedStep® Technology may result in unpredictable system behavior.

Implication: When this erratum occurs, the system may behave unpredictably.

Workaround: It is possible for the BIOS to contain a workaround for this erratum.

Status: For the steppings affected, see the "Summary Tables of Changes".

### SKW140. Processor May Hang Under Complex Scenarios

Problem: Under complex micro-architectural conditions, the processor may hang with an internal timeout error (MCACOD 0400H) logged into `IA32_MCi_STATUS`.

Implication: This erratum results in a processor hang.

Workaround: It is possible for the BIOS to contain a workaround for this erratum.

Status: For the steppings affected, see the "Summary Tables of Changes".

### SKW141. The Intel® PT CR3 Filter Is Not Re-evaluated on VM Entry

Problem: On a VMRESUME or VMLAUNCH with both TraceEn[0] and CR3Filter[7] in `IA32_RTIT_CTL` (MSR 0570H) set to 1 both before the VM Entry and after, the new value of CR3 is not compared with `IA32_RTIT_CR3_MATCH` (MSR 0572H).

Implication: The Intel® PT CR3 filtering mechanism may continue to generate packets despite a mismatching CR3 value, or may fail to generate packets despite a matching CR3, as a result of an incorrect value of `IA32_RTIT_STATUS`.ContextEn[1] (MSR 0571H) that results from the failure to re-evaluate the CR3 match on VM entry.

Workaround: None identified.

Status: For the steppings affected, see the "Summary Tables of Changes".

### SKW142. Display Slowness May Be Observed Under Certain Display Commands Scenario

Problem: Back-to-back accesses to the VGA register ports (I/O addresses 0x3C2, 0x3CE, 0x3CF) will experience higher than expected latency.

Implication: Due to this erratum, the processor may redraw the screen slowly when in VGA mode.

Workaround: None identified.

Status: For the steppings affected, see the "Summary Tables of Changes".

### SKW143. CPUID TLB Associativity Information Is Inaccurate

Problem: CPUID leaf 2 (EAX=02H) TLB information inaccurately reports that the shared Second-Level TLB is six-way set associative (value C3H), although it is 12-way set associative. Other information reported by CPUID leaf 2 is accurate.

Implication: Software that uses CPUID shared Second-Level TLB associativity information for value C3H may operate incorrectly. Intel has not observed this erratum to impact the operation of any commercially available software.

Workaround: None identified. Software should ignore the shared Second-Level TLB associativity information reported by CPUID for the affected processors.

Status: For the steppings affected, see the "Summary Tables of Changes".

### SKW144. Short Loops Which Use AH/BH/CH/DH Registers May Cause Unpredictable System Behavior

Problem: Under complex microarchitectural conditions, short loops of less than 64 instructions that use AH, BH, CH or DH registers as well as their corresponding wider register (for example, RAX, EAX or AX for AH) may cause unpredictable system behavior. This can only happen when both logical processors on the same physical processor are active.

Implication: Due to this erratum, the system may experience unpredictable system behavior.

Workaround: It is possible for the BIOS to contain a workaround for this erratum.

Status: For the steppings affected, see the "Summary Tables of Changes".

### SKW145. Processor Graphics May Render Incorrectly or May Hang Following Warm Reset With Package C8 Disabled

Problem: Processor Graphics may not properly restore internal configuration after warm reset when package C8 is disabled.

Implication: Due to this erratum Processor Graphics may render incorrectly or hang on warm reset.

Workaround: It is possible for the BIOS to contain a workaround for this erratum.

Status: For the steppings affected, see the "Summary Tables of Changes".

### SKW146. Unpredictable System Behavior May Occur in DDR4 Multi-Rank System

Problem: Due to incorrect configuration of DDR4 ODT by BIOS, it is possible for a multi-rank system to violate section 4.27 of the DDR4 JEDEC spec revision JESED79-4A.

Implication: Due to this erratum, complex microarchitectural conditions may result in unpredictable system behavior.

Workaround: A BIOS code change has been identified and may be implemented as a workaround for this erratum.

Status: For the steppings affected, see the "Summary Tables of Changes".

### SKW147. Processor May Hang on Complex Sequence of Conditions

Problem: A complex set of architectural and micro-architectural conditions may lead to a processor hang with an internal timeout error (MCACOD 0400H) logged into `IA32_MC3_STATUS` (MSR 040DH, bits [15:0]). When both logical processors in a core are active, this erratum will not occur in one logical processor unless there is no interrupt for more than 10 seconds to the other logical processor.

Implication: This erratum may result in a processor hang. Intel has not observed this erratum with any commercially available software.

Workaround: None Identified.

Status: For the steppings affected, see the "Summary Tables of Changes".

### SKW148. Display Artifacts May Be Seen With High Bandwidth, Multiple Display Configurations

Problem: With high bandwidth, multiple display configurations, display engine underruns may occur.

Implication: Due to this erratum, the display engine may generate display artifacts.

Workaround: This erratum can be worked around by Intel® Graphics Driver revisions of 15.46.4.64.4749 or later.

Status: For the steppings affected, see the "Summary Tables of Changes".

### SKW149. Spurious Corrected Errors May Be Reported

Problem: Due to this erratum, spurious corrected errors may be logged in the `IA32_MC0_STATUS` MSR (401H) register with the valid field [bit 63] set, the uncorrected error field bit ]bit 61] not set, a model specific error code (bits [31:16]) of 0x0001, and an MCA error code (bits [15:0]) of 0x0005. If CMCI is enabled, these spurious corrected errors also signal interrupts.

Implication: When this erratum occurs, software may see an unusually high rate of reported corrected errors. As it is not possible to distinguish between spurious and non-spurious errors, this erratum may interfere with reporting non-spurious corrected errors.

Workaround: None identified.

Status: For the steppings affected, see the "Summary Tables of Changes".

### SKW150. Masked Bytes in a Vector Masked Store Instructions May Cause Write Back of a Cache Line

Problem: Vector masked store instructions to the WB memory-type that cross cache lines may lead to a CPU writing back cached data even for cache lines where all of the bytes are masked.

Implication: The processor may generate writes of un-modified data. This can affect Memory Mapped IO (MMIO) or non-coherent agents in the following ways:

1. For MMIO range that is mapped as WB memory type, this erratum may lead to Machine Check Exception (MCE) due to writing back data into the MMIO space. This applies only to cross page vector masked stores where one of the pages is in MMIO range.

2. If the CPU cached data is stale, for example in the case of memory written directly by a non-coherent agent (agent that uses non-coherent writes), this erratum may lead to writing back stale cached data even if these bytes are masked.

Workaround: Platforms should not map MMIO memory space or non-coherent device memory space as a WB memory. If a WB is used for MMIO range, software or VMM should not map such MMIO page adjacent to a regular WB page (adjacent on the linear address space, before or after the IO page). Memory that may be written by non-coherent agents should be separated by at least 64 bytes from regular memory used for other purposes (on the linear address space).

Status: For the steppings affected, see the "Summary Tables of Changes".

### SKW151. Processor May Incorrectly Assert PROCHOT During PkgC10

Problem: If the PROCHOT# pin is configured as an output-only signal, PROCHOT# may incorrectly be asserted during PkgC10.

Implication: When this erratum occurs, PROCHOT# may be incorrectly asserted. This can lead to the system fan unnecessarily turning on during PkgC10 or other unexpected platform behaviors.

Workaround: None identified.

Status: For the steppings affected, see the "Summary Tables of Changes".

### SKW152. Writing Non-Zero Values to Read Only Fields in IA32_THERM_STATUS MSR May #GP

Problem: `IA32_THERM_STATUS` MSR (19CH) includes Read-Only (RO) fields as well as writable fields. Writing a non-zero value to any of the read-only fields may cause a #GP.

Implication: Due to this erratum, software that reads the `IA32_THERM_STATUS` MSR, modifies some of the writable fields, and attempts to write the MSR back may #GP.

Workaround: Software should clear all read-only fields before writing to this MSR.

Status: For the steppings affected, see the "Summary Tables of Changes".

### SKW153. Precise Performance Monitoring May Generate Redundant PEBS Records

Problem: PEBS may generate redundant records for a counter overflow when used to profile cycles. This may occur when a precise performance monitoring event is configured on a general counter while setting the Invert and Counter Mask fields in `IA32_PERFEVTSELx` MSRs (186H - 18DH), and the counter is reloaded with a value smaller than 1000 (through the PEBS-counter-reset field of the DS Buffer Management Area).

Implication: PEBS may generate multiple redundant records, when used to profile cycles in certain conditions.

Workaround: It is recommended for software to forbid the use of the Invert bit in `IA32_PERFEVTSELx` MSRs or restrict PEBS-counter-reset value to a value of at least 1000.

Status: For the steppings affected, see the "Summary Tables of Changes".

### SKW154. Intel® SGX ENCLS[EINIT] May Not Signal an Error For an Incorrectly Formatted SIGSTRUCT Input

Problem: The ENCLS[EINIT] instruction leaf may not signal an error on a specific combination of SIGSTRUCT values even though the signature does not fully comply with RSA signature specifications.

Implication: When this erratum occurs, ENCLS[EINIT] instruction leaf may pass the checks although the SIGSTUCT signature does not fully comply with RSA signature specifications. This erratum does not compromise the security of Intel® SGX and does not impact normal usage of Intel® SGX.

Workaround: None identified. Software is not expected to be impacted by this erratum.

Status: For the steppings affected, see the "Summary Tables of Changes".

### SKW155. Branch Instruction Address May Be Incorrectly Reported on Intel® TSX Abort When Using Intel® MPX

Problem: When using Intel® MPX, an Intel® TSX transaction abort will occur in case of legacy branch (that causes bounds registers INIT) when at least one Intel® MPX bounds register was in a NON-INIT state. On such an abort, the branch Instruction address should be reported in the `FROM_IP` field in the LBR, the BTS and BTM as well as in the FUP source IP address for Intel® PT. Due to this erratum, the `FROM_IP` field in LBR/BTS/BTM, as well as the FUP source IP address that correspond to the Intel® TSX abort, may point to the preceding instruction.

Implication: Software that relies on the accuracy of the FROM_IP field/FUP source IP address and uses Intel® TSX may operate incorrectly when Intel® MPX is used.

Workaround: None identified.

Status: For the steppings affected, see the "Summary Tables of Changes".

### SKW156. Setting Performance Monitoring IA32_PERF_GLOBAL_STATUS_SET MSR Bit 63 May Not #GP

Problem: Bit 63 of `IA32_PERF_GLOBAL_STATUS_SET` MSR (391H) is reserved. Due to this erratum, setting the bit will not result in a #GP.

Implication: Software that attempts to set bit 63 of `IA32_PERF_GLOBAL_STATUS_SET` MSR does not generate #GP. There are no other system implications to this behavior.

Workaround: None identified.

Status: For the steppings affected, see the "Summary Tables of Changes".

### SKW157. Hitting a Code Breakpoint Inside a Intel® SGX Debug Enclave May Cause The Processor to Hang

Problem: Under complex micro-architecture conditions, the processor may hang when hitting code breakpoint inside a Intel® SGX debug enclave. This may happen only after opt-out entry into a Intel® SGX debug enclave and when the execution would set the accessed bit (A-bit) in any level of the paging or EPT structures used to map the code page, and when both logical processors on the same physical core are active.

Implication: Due to this erratum, the processor may hang while debugging an Intel® SGX debug enclave.

Workaround: None identified.

Status: For the steppings affected, see the "Summary Tables of Changes".

### SKW158. Performance Monitoring Anti Side-Channel Interference (ASCI) Status Bit May be Inaccurate

Problem: The ASCI field in `IA32_PERF_GLOBAL_STATUS` (MSR 38EH, bit 60) should be set when the count in any of the configured performance counters (for example, IA32_PMCx or `IA32_FIXED_CTRx`) was altered due to direct or indirect operation of Intel® SGX. Due to this erratum, the ASCI bit may not be set properly when `IA32_FIXED_CTR0` is used.

Implication: Software that relies on the value of the ASCI bit in `IA32_PERF_GLOBAL_STATUS` for its operation may not operate correctly when `IA32_FIXED_CTR0` is used.

Workaround: None identified.

Status: For the steppings affected, see the "Summary Tables of Changes".

### SKW159. Processor May Hang When Executing Code In an Hardware Lock Elision (HLE) Transaction Region

Problem: Under certain conditions, if the processor acquires an HLE lock via the XACQUIRE instruction in the Host Physical Address range between 40000000H and 403FFFFFH, it may hang with an internal timeout error (MCACOD 0400H) logged into `IA32_MCi_STATUS`.

Implication: Due to this erratum, the processor may hang after acquiring a lock via XACQUIRE.

Workaround: The BIOS can reserve the host physical address ranges of 40000000H and 403FFFFFH (for example, map it as UC/MMIO). Alternatively, VMM can reserve that address range so no guest can use it. In non-virtualized systems, the OS can reserve that memory space.

Status: For the steppings affected, see the "Summary Tables of Changes".

### SKW160. Intel® PT CYC Packet Can Be Dropped When Immediately Preceding PSB

Problem: Due to a rare microarchitectural condition, generation of an Intel® PT PSB packet can cause a single CYC packet, possibly along with an associated MTC packet, to be dropped.

Implication: An Intel® PT decoder that is using CYCs to track time or frequency will get an improper value due to the lost CYC packet.

Workaround: If an Intel® PT decoder is using CYCs and MTCs to track frequency, and either the first MTC following a PSB shows that an MTC was dropped, or the CYC value appears to be 4095 cycles short of what is expected, the CYC value associated with that MTC should not be used. The decoder should wait for the next MTC before measuring frequency again.

Status: For the steppings affected, see the "Summary Tables of Changes".

### SKW161. Intel® PT VM-entry Indication Depends on The Incorrect VMCS Control Field

Problem: An Intel® PT Paging Information Packet (PIP), which includes indication of entry into non-root operation, will be generated on VM-entry as long as the "Conceal VMX in Intel® PT" field [Bit 19] in Secondary Execution Control register (`IA32_VMX_PROCBASED_CTLS2`, MSR 048BH) is clear. This diverges from expected behavior, since this PIP should instead be generated only with a zero value of the "Conceal VMX entries from Intel® PT" field [Bit 17] in the Entry Control register (`IA32_VMX_ENTRY_CTLS` MSR 0484H).

Implication: An Intel® PT trace may incorrectly expose entry to non-root operation.

Workaround: A VMM should always set both the "Conceal VMX entries from Intel® PT" field in the Entry Control register and the "Conceal VMX in Intel® PT" in the Secondary Execution Control register to the same value.

Status: For the steppings affected, see the "Summary Tables of Changes".

### SKW162. VCVTPS2PH To Memory May Update MXCSR in The Case of a Fault on the Store

Problem: Execution of the VCVTPS2PH instruction with a memory destination may update the MXCSR exceptions flags (bits [5:0]) if the store to memory causes a fault (for example, #PF) or VM exit. The value written to the MXCSR exceptions flags is what would have been written if there were no fault.

Implication: Software may see exceptions flags set in MXCSR, although the instruction has not successfully completed due to a fault on the memory operation. Intel has not observed this erratum to affect any commercially available software.

Workaround: None identified.

Status: For the steppings affected, see the "Summary Tables of Changes".

### SKW163. Intel® PT May Drop All Packets After an Internal Buffer Overflow

Problem: Due to a rare micro-architectural condition, an Intel® PT ToPA entry transition can cause an internal buffer overflow that may result in all trace packets, including the OVF packet, being dropped.

Implication: When this erratum occurs, all trace data will be lost until either Intel® PT is disabled and re-enabled via `IA32_RTIT_CTL`.TraceEn [bit 0] (MSR 0570H) or the processor enters and exits a C6 or deeper C state.

Workaround: None identified.

Status: For the steppings affected, see the "Summary Tables of Changes".

### SKW164. ZMM/YMM Registers May Contain Incorrect Values

Problem: Under complex microarchitectural conditions values stored in ZMM and YMM registers may be incorrect.

Implication: Due to this erratum, YMM and ZMM registers may contain an incorrect value. Intel has not observed this erratum with any commercially available software.

Workaround: It is possible for the BIOS to contain a workaround for this erratum.

Status: For the steppings affected, see the "Summary Tables of Changes".

### SKW165. Intel® PT ToPA Tables Read From Non-Cacheable Memory During an Intel® TSX Transaction May Lead to Processor Hang

Problem: If an Intel® PT ToPA table is placed in Uncacheable (UC) or Uncacheable Speculative Write Combining (USWC) memory, and a ToPA output region is filled during an Intel TSX transaction, the resulting ToPA table read may cause a processor hang.

Implication: Placing Intel® PT ToPA tables in non-cacheable memory when Intel® TSX is in use may lead to a processor hang.

Workaround: None identified. Intel® PT ToPA tables should be located in WB memory if Intel® TSX is in use.

Status: For the steppings affected, see the "Summary Tables of Changes".

### SKW166. Performing an XACQUIRE to an Intel® PT ToPA Table May Lead to Processor Hang

Problem: If an XACQUIRE lock is performed to the address of an Intel® PT ToPA table, and that table is later read by the CPU during the HLE transaction, the processor may hang.

Implication: Accessing ToPA tables with XACQUIRE may result in a processor hang.

Workaround: None identified. Software should not access ToPA tables using XACQUIRE. An OS or hypervisor may wish to ensure all application or guest writes to ToPA tables to take page faults or EPT violations.

Status: For the steppings affected, see the "Summary Tables of Changes".

### SKW167. When Virtualization Exceptions are Enabled, EPT Violations May Generate Erroneous Virtualization Exceptions

Problem: An access to a Guest-Physical Address (GPA) may cause an EPT-violation VM exit. When the "EPT-violation Virtualization Exception (#VE)" VM-execution control is 1, an EPT violation may cause a #VE instead of a VM exit. Due to this erratum, an EPT violation may erroneously cause a #VE when the "suppress #VE" bit is set in the EPT paging-structure entry used to map the GPA being accessed. This erratum does not apply when the "EPT-violation #VE" VM-execution control is 0 or when delivering an event through the IDT. This erratum applies only when the GPA in CR3 is used to access the root of the guest paging-structure hierarchy (or, with PAE paging, when the GPA in a PDPTE is used to access a page directory).

Implication: When using PAE paging mode, an EPT violation that should cause an VMexit in the VMM may instead cause a VE# in the guest. In other paging modes, in addition to delivery of the erroneous #VE, the #VE may itself cause an EPT violation, but this EPT violation will be correctly delivered to the VMM.

Workaround: A VMM may support an interface that guest software can invoke with the VMCALL instruction when it detects an erroneous #VE.

Status: For the steppings affected, see the "Summary Tables of Changes".

### SKW168. Using Intel® TSX Instructions May Lead to Unpredictable System Behavior

Problem: Under complex micro-architectural conditions, software using Intel® TSX may result in unpredictable system behavior. Intel has only seen this under synthetic testing conditions. Intel is not aware of any commercially available software exhibiting this behavior.

Implication: Due to this erratum, unpredictable system behavior may occur.

Workaround: It is possible for BIOS to contain a workaround for this erratum.

Status: For the steppings affected, see the "Summary Tables of Changes".

### SKW169. Performance Monitoring General Purpose Counter 3 May Contain Unexpected Values

Problem: When the RTM is supported (CPUID.07H.EBX.RTM [bit 11] = 1) and when `TSX_FORCE_ABORT=0`, Performance Monitor Unit (PMU) general purpose counter 3 (`IA32_PMC3`, MSR C4H and `IA32_A_PMC3`, MSR 4C4H) may contain unexpected values. Further, `IA32_PREFEVTSEL3` (MSR 189H) may also contain unexpected configuration values.

Implication: Due to this erratum, software that uses PMU general purposes counter 3 may read an unexpected count and configuration.

Workaround: Software can avoid this erratum by writing 1 to bit 0 of `TSX_FORCE_ABORT` (MSR 10FH) which will cause all Restricted Transactional Memory (RTM) transactions to abort with EAX code 0. `TSX_FORCE_ABORT` MSR is available when CPUID.07H.EDX[bit 13]=1.

Status: For the steppings affected, see the "Summary Tables of Changes".

### SKW170. Intel® PT Trace May Silently Drop Second Byte of CYC Packet

Problem: Due to a rare microarchitectural condition, the second byte of a 2-byte CYC packet may be dropped without an OVF packet.

Implication: A trace decoder may signal a decode error due to the lost trace byte.

Workaround: None identified. A mitigation is available for this erratum. If a decoder encounters a multi-byte CYC packet where the second byte has bit 0 (Ext) set to 1, it should assume that 4095 cycles have passed since the prior CYC packet, and it should ignore the first byte of the CYC and treat the second byte as the start of a new packet.

Status: For the steppings affected, see the "Summary Tables of Changes".

### SKW171. Unexpected Uncorrected Machine Check Errors May Be Reported

Problem: In rare micro-architectural conditions, the processor may report unexpected machine check errors. When this erratum occurs, `IA32_MC0_STATUS` (MSR 401H) will have the valid bit set [bit 63], the uncorrected error bit set [bit 61], a model specific error code of 03H (bits [31:16]) and an MCA error code of 05H (bits [15:0]).

Implication: Due to this erratum, software may observe unexpected machine check exceptions.

Workaround: None identified.

Status: For the steppings affected, see the "Summary Tables of Changes".

### SKW172. Gen9 Graphics Intel® VT Hardware May Cache Invalid Entries

Problem: The Gen9 graphics subsystem may cache invalid Intel® VT context entries.

Implication: Due to this erratum, unpredictable system behavior and/or a system hang may occur.

Workaround: Software should flush the Gfx Intel® VT context cache after any update of context table entries.

Status: For the steppings affected, see the "Summary Tables of Changes".

### SKW173. A Pending Fixed Interrupt May Be Dispatched Before an Interrupt of The Same Priority Completes

Problem: Resuming from C6 Sleep-State, with Fixed Interrupts of the same priority queued (in the corresponding bits of the Intel Reuse Repository [IRR] and Intel Strategic Research [ISR] APIC registers), the processor may dispatch the second interrupt (from the IRR bit) before the first interrupt has completed and written to the End-of-Interrupt (EOI) register, causing the first interrupt to never complete.

Implication: Due to this erratum, Software may behave unexpectedly when an earlier call to an Interrupt Handler routine is overridden with another call (to the same Interrupt Handler) instead of completing its execution.

Workaround: None identified.

Status: For the steppings affected, see the "Summary Tables of Changes".

### SKW174. Executing Some Instructions May Cause Unpredictable Behavior

Problem: Under complex micro-architectural conditions, executing an X87, Intel® AVX, or integer divide instruction may result in unpredictable system behavior.

Implication: When this erratum occurs, the system may behave unpredictably. Intel has not observed this erratum with any commercially available software.

Workaround: It is possible for the BIOS to contain a workaround for this erratum.

Status: For the steppings affected, see the "Summary Tables of Changes".

### SKW175. Incorrect Execution of Internal Branch Instructions May Lead to Unpredictable System Behavior

Problem: Under complex micro-architecture conditions, incorrect execution of internal branch instructions that span multiple 64 byte boundaries (cross cache line), may result in unpredictable system behavior including unexpected #PF or #UD faults due to incorrect execution of internal branch operations.

Implication: When this erratum occurs, the system may exhibit unpredictable system behavior including unexpected #PF or #UD faults.

Workaround: It is possible for the BIOS to contain a workaround for this erratum.

Status: For the steppings affected, see the "Summary Tables of Changes".

### SKW176. Unexpected Page Faults in Guest Virtualization Environment

Problem: Under complex microarchitectural conditions, a virtualized guest could observe unpredictable system behavior.

Implication: When this erratum occurs, systems operating in a virtualization environment may exhibit unexpected page faults (double faults) leading to guest OS shutdown.

Workaround: It is possible for the BIOS to contain a workaround for this erratum.

Status: For the steppings affected, see the "Summary Tables of Changes".

### SKW177. Intel® SGX Key Confidentiality May Be Compromised

Problem: Under complex micro-architectural conditions, it may be possible for the value of Intel® SGX keys to be inferred using speculative execution side channel methods.

Implication: If exposed, such keys could allow an attacker to access Intel® SGX enclave data. Processors that do not support Intel® HT Technology are not affected by this issue.

Workaround: It is possible for the BIOS to contain a workaround for this erratum.

Status: For the steppings affected, see the "Summary Tables of Changes".

### SKW178. Instruction Fetch May Cause Machine Check if Page Size Was Changed Without Invalidation

Problem: This erratum may cause a machine-check error (IA32_MCi_STATUS.MCACOD=005H with IA32_MCi_STATUS.MSCOD=00FH or IA32_MCi_STATUS.MCACOD=0150H with IA32_MCi_STATUS.MSCOD=00FH) on the fetch of an instruction. It applies only if (1) instruction bytes are fetched from a linear address translated using a 4-Kbyte page and cached in the processor; (2) the paging structures are later modified so that these bytes are translated using a large page (2 Mbyte, 4 Mbyte or 1 GB) with a different Physical Address (PA), memory type (PWT, PCD and PAT bits), or User/Supervisor (U/S) bit; and (3) the same instruction is fetched after the paging structure modification but before software invalidates any TLB entries for the linear region.

Problem: Implication: Due to this erratum an unexpected machine check with error code 0150H with MSCOD 00FH may occur, possibly resulting in a shutdown. This erratum could also lead to unexpected correctable machine check (IA32_MCi_STATUS.UC=0) with error code 005H with MSCOD 00FH.

Implication: Due to this erratum an unexpected machine check with error code 0150H with MSCOD 00FH may occur, possibly resulting in a shutdown. This erratum could also lead to unexpected correctable machine check (IA32_MCi_STATUS.UC=0) with error code 005H with MSCOD 00FH.

Workaround: Software should not write to a paging-structure entry in a way that would change the page size and either the physical address, memory type or User/Supervisor bit. It can instead use one of the following algorithms: first clear the P flag in the relevant paging-structure entry (for example, PDE); then invalidate any translations for the affected linear addresses; and then modify the relevant paging-structure entry to set the P flag and establish the new page size. An alternative algorithm: first change the physical page attributes (combination of physical address, memory type and User/Supervisor bit) in all 4K pages in the affected linear addresses; then invalidate any translations for the affected linear addresses; and then modify the relevant paging-structure entry to establish the new page size.

Status: For the steppings affected, see the "Summary Tables of Changes".

### SKW179. System May Hang Under Complex Conditions

Problem: Under complex conditions, insufficient access control in graphics subsystem may lead to a system hang or crash upon a register read.

Implication: When this erratum occurs a system hang or crash may occur.

Workaround: It is possible for a combination of BIOS and a graphics driver to contain a workaround for this erratum.

Status: For the steppings affected, see the "Summary Tables of Changes".

### SKW180. PEG PCIe* Link May Fail to Link When Resuming From PKG-C8

Problem: PEG IO registers may not be restored after resuming from PKG-C8.

Implication: PEG PCIe* may fail to link resuming from PKG-C8.

Workaround: None identified.

Status: For the steppings affected, see the "Summary Tables of Changes".

### SKW181. Incorrect Error Correcting Code (ECC) Reporting Following Entry to PKG-C7

Problem: Correctable and Uncorrectable ECC errors reported in ECCERRLOG0/1 (MCHBAR Offset 4048h/404Ch) may be overwritten after entry to PKG-C7.

Implication: DDR4 Correctable and Uncorrectable ECC errors reported in ECCERRLOG0/1 (MCHBAR Offset 4048h/404Ch) may be unreported resuming from PKG-C7. Intel has only observed this erratum in a synthetic test environment.

Workaround: None identified.

Status: For the steppings affected, see the "Summary Tables of Changes".

### SKW182. PMU MSR_UNC_PERF_FIXED_CTR Is Cleared After Pkg C7 or Deeper

Problem: The Performance Monitoring Unit Uncore Performance Fixed Counter (`MSR_UNC_PERF_FIXED_CTR` (MSR 395h)) is cleared after pkg C7 or deeper.

Implication: Due to this erratum, once the system enters pkg C7 or deeper the uncore fixed counter does not reflect the actual count.

Workaround: None identified.

Status: For the steppings affected, see the "Summary Tables of Changes".

### SKW183. Performance Monitoring General Counter 2 May Have Invalid Value Written When Intel® TSX Is Enabled

Problem: When Intel® TSX is enabled, and there are aborts (HLE or RTM) overlapping with access or manipulation of the `IA32_PMC2` general-purpose performance counter (Offset: C3h) it may return invalid value.

Implication: Software may read invalid value from IA32_PMC2.

Workaround: None identified.

Status: For the steppings affected, see the "Summary Tables of Changes".

### SKW184. Overflow Flag in IA32_MC0_STATUS MSR May Be Incorrectly Set

Problem: Under complex micro-architectural conditions, a single internal parity error seen in `IA32_MC0_STATUS` MSR (401h) with MCACOD (bits 15:0) value of 5h and MSCOD (bits 31:16) value of 7h, may set the overflow flag (bit 62) in the same MSR.

Implication: Due to this erratum, the `IA32_MC0_STATUS` overflow flag may be set after a single parity error. Intel has not observed this erratum with any commercially available software.

Workaround: None identified.

Status: For the steppings affected, see the "Summary Tables of Changes".

### SKW185. VERR Instruction Inside VM-entry May Cause DR6 to Contain Incorrect Values

Problem: Under complex micro-architectural conditions, a VERR instruction that follows a VM-entry with a guest state indicating MOV SS blocking (bit 1 in the Interruptibility state) and at least one of B3-B0 bits set (bits 3:0 in the pending debug exception), may lead to incorrect values in DR6.

Implication: Due to this erratum, DR6 may contain incorrect values. Intel has not observed this erratum with any commercially available software.

Workaround: None identified.

Status: For the steppings affected, see the "Summary Tables of Changes".

### SKW186. Processor May Hang if Warm Reset Triggers While BIOS is Initialization

Problem: Under complex micro-architectural conditions, when the processor receives a warm reset during BIOS initialization, the processor may hang with a machine check error reported in `IA32_MCi_STATUS`, with MCACOD (bits [15:0]) value of 0400H, and MSCOD (bits [31:16]) value of 0080H.

Implication: Due to this erratum, the processor may hang. Intel has only observed this erratum in a synthetic test environment.

Workaround: None identified.

Status: For the steppings affected, see the "Summary Tables of Changes".

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# Specification Changes

The Specification Changes listed in this section apply to the following documents:

- *Intel® 64 and IA-32 Architectures Software Developer's Manual, Volume 1: Basic Architecture*
- *Intel® 64 and IA-32 Architectures Software Developer's Manual, Volume 2A: Instruction set reference, A-L*
- *Intel® 64 and IA-32 Architectures Software Developer's Manual, Volume 2B: Instruction set reference, M-U*
- *Intel® 64 and IA-32 Architectures Software Developer's Manual, Volume 2C: Instruction set reference, V-Z*
- *Intel® 64 and IA-32 Architectures Software Developer's Manual, Volume 3A: System programming guide, part 1*
- *Intel® 64 and IA-32 Architectures Software Developer's Manual, Volume 3B: System programming guide, part 2*
- *6th Generation Intel® Core™ Processor, Intel® Xeon® Processor, and Intel® Pentium® Product Families External Design Specification (EDS) - Volume 1 of 2*
- *6th Generation Intel® Core™ Processor Family and Intel® Xeon® Processor E3-1200 v5 Product Family External Design Specification (EDS) - Volume 2 of 2*

## SKW1. Intel® Xeon® E3-1235L v5 and E3-1240L v5 processor ICCmax specification to change from 40A to 55A.

Intel will update the Intel® Xeon® E3-1235L v5 and E3-1240L v5 processors ICCmax to 55A from the current value of 40A. Recent evaluation of these products have shown, that the increased ICCmax may improve turbo residency. Current processors have been tested above this value so this change will have no negative impact.

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# Specification Clarifications

The Specification Clarifications listed in this section may apply to the following documents:

- *Intel® 64 and IA-32 Architectures Software Developer's Manual, Volume 1: Basic Architecture*
- *Intel® 64 and IA-32 Architectures Software Developer's Manual, Volume 2A: Instruction set reference, A-L*
- *Intel® 64 and IA-32 Architectures Software Developer's Manual, Volume 2B: Instruction set reference, M-U*
- *Intel® 64 and IA-32 Architectures Software Developer's Manual, Volume 2C: Instruction set reference, V-Z*
- *Intel® 64 and IA-32 Architectures Software Developer's Manual, Volume 3A: System programming guide, part 1*
- *Intel® 64 and IA-32 Architectures Software Developer's Manual, Volume 3B: System programming guide, part 2*

There are no new Specification Changes in this Specification Update revision.

## SKW1. Attempts to Simultaneously Perform Microcode Updates

Section 8.7.11 Microcode Update Resources of the *Intel® 64 and IA-32 Architectures Software Developer's Manual*, Volume 3, will be modified to state the following:

(a) All of the microcode update steps during processor initialization should use the same update data on all threads.

(b) Any subsequent microcode update (general by an OS) must apply the same microcode update to all threads.

(c) If the processor detects an attempt to load an older microcode update in place of a newer microcode update, it may reject the older update to stay with the newer update.

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# Documentation Changes

The Documentation Changes listed in this section apply to the following documents:

- *Intel® 64 and IA-32 Architectures Software Developer's Manual, Volume 1: Basic Architecture*
- *Intel® 64 and IA-32 Architectures Software Developer's Manual, Volume 2A: Instruction set reference, A-L*
- *Intel® 64 and IA-32 Architectures Software Developer's Manual, Volume 2B: Instruction set reference, M-U*
- *Intel® 64 and IA-32 Architectures Software Developer's Manual, Volume 2C: Instruction set reference, V-Z*
- *Intel® 64 and IA-32 Architectures Software Developer's Manual, Volume 3A: System programming guide, part 1*
- *Intel® 64 and IA-32 Architectures Software Developer's Manual, Volume 3B: System programming guide, part 2*

All Documentation Changes will be incorporated into a future version of the appropriate Processor documentation.

***Note:*** Documentation changes for *Intel® 64 and IA-32 Architecture Software Developer's Manual* volumes 1, 2A, 2B, 2C, 3A, and 3B will be posted in a separate document, Intel® 64 and IA-32 Architecture Software Developer's Manual Documentation Changes. Use the following link to access this file: http://www.intel.com/content/www/us/en/processors/architectures-software-developer-manuals.html.

There are no new Documentation Changes in this Specification Update revision.

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