



Arm[®] Server Base System Architecture Compliance

Revision: r7p1

User Guide

Non-Confidential

Issue 02

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Arm® Server Base System Architecture Compliance User Guide

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Release Information

Document history

| Issue | Date | Confidentiality | Change |
|---------|-------------------|------------------|---|
| A | 30 November 2016 | Non-Confidential | Alpha release |
| B | 31 March 2017 | Non-Confidential | Beta release |
| C | 13 July 2017 | Non-Confidential | REL 1.0 |
| D | 11 May 2018 | Non-Confidential | REL 2.0 |
| 0200-01 | 27 December 2018 | Non-Confidential | REL 2.1. The document now follows a new numbering format. |
| 0200-02 | 26 April 2019 | Non-Confidential | REL 2.2 |
| 0200-03 | 18 September 2019 | Non-Confidential | REL 2.3 |
| 0200-04 | 20 March 2020 | Non-Confidential | REL 2.4 |
| 0300-01 | 30 September 2020 | Non-Confidential | REL 3.0 |
| 0301-01 | 27 September 2021 | Non-Confidential | REL 3.1 |
| 0302-01 | 26 July 2022 | Non-Confidential | REL 3.2 |
| 0601-01 | 28 October 2022 | Non-Confidential | REL 6.1 |
| 0700-01 | 15 June 2022 | Non-Confidential | REL 7.0 ALPHA release |

| Issue | Date | Confidentiality | Change |
|---------|-----------------|------------------|--------------------------|
| 0701-01 | 16 January 2023 | Non-Confidential | REL 7.1 BETA-0 release |
| 0701-02 | 28 March 2023 | Non-Confidential | REL 7.1.1 BETA-1 release |

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(LES-PRE-20349|version 21.0)

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Contents

| | |
|---|-----------|
| 1. Introduction..... | 7 |
| 1.1 Conventions..... | 7 |
| 1.2 Useful resources..... | 8 |
| 1.3 Other information..... | 9 |
| 2. Overview of the SBSA tests..... | 10 |
| 2.1 Abbreviations..... | 10 |
| 2.2 Overview of tests..... | 11 |
| 2.3 Test IDs..... | 11 |
| 3. UEFI shell application..... | 13 |
| 3.1 UEFI application arguments..... | 13 |
| 3.2 UEFI implementation of PAL APIs..... | 15 |
| 4. Linux application..... | 18 |
| 4.1 Linux application arguments..... | 18 |
| 4.2 Environment setup..... | 18 |
| 4.2.1 Test requirements..... | 19 |
| 4.2.2 Runtime environment..... | 19 |
| 5. PMU Linux application..... | 21 |
| 5.1 Running the PMU application..... | 21 |
| A. Revisions..... | 22 |
| A.1 Revisions..... | 22 |

1. Introduction

1.1 Conventions

The following subsections describe conventions used in Arm documents.

Glossary

The Arm® Glossary is a list of terms used in Arm documentation, together with definitions for those terms. The Arm Glossary does not contain terms that are industry standard unless the Arm meaning differs from the generally accepted meaning.

See the Arm Glossary for more information: developer.arm.com/glossary.

| Convention | Use |
|----------------------------|--|
| <i>italic</i> | Citations. |
| bold | Terms in descriptive lists, where appropriate. |
| monospace | Text that you can enter at the keyboard, such as commands, file and program names, and source code. |
| monospace <u>underline</u> | A permitted abbreviation for a command or option. You can enter the underlined text instead of the full command or option name. |
| <and> | Encloses replaceable terms for assembler syntax where they appear in code or code fragments. For example: <pre>MRC p15, 0, <Rd>, <CRn>, <CRm>, <Opcode_2></pre> |
| SMALL CAPITALS | Terms that have specific technical meanings as defined in the Arm® Glossary. For example, IMPLEMENTATION DEFINED , IMPLEMENTATION SPECIFIC , UNKNOWN , and UNPREDICTABLE . |



Recommendations. Not following these recommendations might lead to system failure or damage.



Requirements for the system. Not following these requirements might result in system failure or damage.



Requirements for the system. Not following these requirements will result in system failure or damage.



An important piece of information that needs your attention.



A useful tip that might make it easier, better or faster to perform a task.



A reminder of something important that relates to the information you are reading.

1.2 Useful resources

This document contains information that is specific to this product. See the following resources for other useful information.

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- Non-Confidential documents are available at developer.arm.com/documentation. Each document link in the following tables goes to the online version of the document.
- Confidential documents are available to licensees only through the product package.

| Arm product resources | Document ID | Confidentiality |
|--|-------------|------------------|
| Arm® Server Base System Architecture 7.1 | DEN0029H | Non-Confidential |
| GICv3 and GICv4 Software Overview | DAI0492 | Non-Confidential |

| Arm architecture and specifications | Document ID | Confidentiality |
|---|-------------|------------------|
| Arm® Architecture Reference Manual for A-profile architecture | DDI0487I.a | Non-Confidential |
| Arm® Generic Interrupt Controller Architecture Specification for GIC architecture version 3.0 and version 4.0 | IHI0069H | Non-Confidential |



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- [Arm® Documentation](#).
- [Technical Support](#).
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2. Overview of the SBSA tests

This chapter provides an overview of the SBSA tests and the test IDs.

2.1 Abbreviations

The following table lists the abbreviations used in this document.

Table 2-1: Abbreviations and expansions

| Abbreviation | Expansion |
|--------------|--|
| ACPI | Advanced Configuration and Power Interface |
| ACS | Architecture Compliance Suite |
| AEST | Arm Error Source Table |
| BDF | Bus, Device, and Function |
| CATU | CoreSight Address Translation Unit |
| ELx | Exception Level x (where x can be 0 to 3) |
| ETR | Embedded Trace Router |
| GIC | Generic Interrupt Controller |
| GCD | Grand Central Dispatch |
| HMAT | Heterogeneous Memory Attribute Table |
| HVC | HyperVisor Call |
| IOMMU | Input-Output Memory Management Unit |
| ITS | Interrupt Translation Service |
| LPI | Locality-specific Peripheral Interrupt |
| MPAM | Memory System Resource Partitioning and Monitoring |
| MSI | Message-Signaled Interrupt |
| MTE | Memory Tagging Extension |
| NUMA | Non-Uniform Memory Access |
| PAL | Platform Abstraction Layer |
| PCIe | Peripheral Component Interconnect express |
| PCCT | Platform Communications Channel Table |
| APMT | Performance Monitoring Unit Table |
| PE | Processing Element |
| PMU | Performance Monitor Unit |
| PPTT | Processor Properties Topology Table |
| PSCI | Power State Coordination Interface |
| RAS | Reliability, Availability, and Serviceability |
| RAS2 | Reliability, Availability, and Serviceability 2 |
| RCiEP | Root Complex integrated End Point |

| Abbreviation | Expansion |
|--------------|---|
| SATA | Serial Advanced Technology Attachment |
| SBSA | Server Base System Architecture |
| SMC | Secure Monitor Call |
| SMMU | System Memory Management Unit |
| SRAT | System Resource Affinity Table |
| STS | Statistical Test Suite |
| SoC | System on Chip |
| UEFI | Unified Extensible Firmware Interface |
| UART | Universal Asynchronous Receiver and Transmitter |
| VAL | Validation Abstraction Layer |

2.2 Overview of tests

The following table describes the general divisions of Server Base System Architecture (SBSA) tests between Unified Extensible Firmware Interface (UEFI) shell application, Linux application, and Bare-metal.

Table 2-2: Test environment and modules

| Test environment | Modules |
|--------------------|--|
| UEFI Shell | PE, GIC, Timers, Watchdog, Wakeup, PCIe, NIST, Peripherals, SMMU, PMU, MPAM, RAS, Memory |
| Linux command line | PCIe, SMMU, PMU |
| Bare-metal | Exerciser |

2.3 Test IDs

Each test ID is generated as an addition of module ID and unit test ID. For a given module, unit test ID begins from 1.

The following table lists the module names and their IDs.

Table 2-3: Module names and module IDs

| Module name | Module ID |
|------------------|-----------|
| PE | 0 |
| Memory | 100 |
| GIC | 200 |
| SMMU | 300 |
| Timer | 400 |
| Power and Wakeup | 500 |
| Peripheral | 600 |

| Module name | Module ID |
|-------------|-----------|
| Watchdog | 700 |
| PCIe | 800 |
| Exerciser | 900 |
| MPAM | 1000 |
| PMU | 1100 |
| RAS | 1200 |
| NIST | 1300 |

3. UEFI shell application

This chapter provides information on executing tests from the UEFI Shell application and its PAL API implementation.

3.1 UEFI application arguments

Run the UEFI Shell application with the following set of arguments:

```
uefi shell> sbsa.efi [-v <n>] [-l <n>] [-skip <x,y,z, ..>] [-f <file name>] [-p <n>]
[-nist] [-mmio] [-p2p] [-cache] [-t <test id>] [-m <module id>] [-timeout <wakeuptimeout multiple>]
```

The following table provides descriptions to the arguments.

Table 3-1: Descriptions of UEFI application arguments

| Argument | Description |
|----------|---|
| -v | Print level 1 INFO and above. 2 DEBUG and above. 3 TEST and above. 4 WARN and ERROR. 5 ERROR. |
| -l | Level of compliance to be tested for (0-7). The default value is 4. |
| -skip | Overrides the suite to skip the execution of a particular test(s) and/or module(s). For example, 301 skips test case with ID = 301. 500 skips all tests in module with ID = 500. For more information on module IDs, see 2.3 Test IDs on page 11. |
| -f | File name to which the output log is written. |
| -p | Enables or disables the execution of SBSA v7.1 PCIe compliance tests (RCiEP rules). Allowed values for <n> are 0 and 1, where 1 enables the PCIe tests and 0 disables it. Note: <ul style="list-style-type: none"> If this option is not provided, SBSA v7.1 PCIe (RCiEP rules) tests are not run. If -l has a value of 4 and above, these tests are always run. |
| -nist | Runs the SBSA ACS with NIST STS. |

| Argument | Description |
|----------|---|
| -mmio | Enables all the mmio read/write prints. Note: <ul style="list-style-type: none"> To enable pal_mmio_read or write prints, use with -v 1. Enables prints from specific module by using module id. <p>For example, -mmio 100, enables for GIC module, and -mmio 0, enables for PE module.</p> |
| -p2p | Enables p2p feature support. |
| -cache | Enables cache support. |
| -t | To run only single selected test. Note: -m will override -t if used on the same module. |
| -m | To run only single selected module |
| -timeout | Timeout value for wakeup test. |



- The UEFI session becomes unusable after the SBSA tests are run and the test results are printed on the UEFI console.
- The UEFI Shell application is enhanced to accept an additional argument [-p <n>] for PCIe. This is to enable optionally running SBSA v7.0 PCIe tests even when the other tests run at older levels. For example, you can optionally run SBSA v7.0 PCIe tests even when running other SBSA tests at level 3.

Example 1

```
shell> sbsa.efi -v 2 -l 3 -skip 100,36 -f acs.txt -p 1
```

The set of parameters shown in the code block:

- Prints messages with verbosity of 2 and above.
- Tests for compliance against SBSA level 3 for other tests and runs SBSA v7.1 PCIe (RCiEP rules) tests.
- Skips execution of all tests belonging to Memory module and test number 36.
- Stores the log messages to the file `acs.txt`.

Example 2

```
shell > sbsa.efi -m 100 -skip 102
```

The set of parameters shown in the code block:

- Runs only the Memory module.
- Skips the Memory test 102.

3.2 UEFI implementation of PAL APIs

This section provides information on infrastructure APIs and module-specific APIs.

Infrastructure APIs

The following table describes the Platform Abstraction Layer (PAL) APIs and UEFI interfaces.

Table 3-2: PAL APIs and UEFI interfaces

| PAL API | UEFI interfaces |
|---------------------|--------------------|
| pal_print | AsciiPrint |
| mem_alloc | gBS->AllocatePool |
| mem_free | gBS->FreePool |
| mem_alloc_shared | gBS->AllocatePool |
| mem_free_shared | gBS->FreePool |
| mem_get_shared_addr | None |
| mem_alloc_cacheable | gBS->AllocatePages |
| mem_free_cacheable | gBS->FreePages |
| time_delay_ms | gBS->Stall |
| mem_alloc_pages | gBS->AllocatePages |
| mem_free_pages | gBS->FreePages |
| mmio_read | None |
| mmio_write | None |
| aligned_alloc | gBS->AllocatePool |
| mem_free_aligned | gBS->FreePool |

Module-specific APIs

The following table represents the mapping of PAL API to Advanced Configuration and Power Interface (ACPI), if the system firmware presents platform configuration through ACPI tables.

Table 3-3: PAL APIs, UEFI interfaces, and ACPI tables consumed

| PAL API | UEFI interfaces consumed | ACPI table consumed |
|-----------------------|--|---------------------|
| pe_create_info_table | <ul style="list-style-type: none"> gST->ConfigurationTable CompareGuid IndustryStandard/Acpi.h | MADT Table |
| pe_execute_payload | - | - |
| pe_install_esr | <ul style="list-style-type: none"> gEfiCpuArchProtocolGuid Cpu->RegisterInterruptHandler | - |
| gic_create_info_table | <ul style="list-style-type: none"> gST->ConfigurationTable CompareGuid IndustryStandard/Acpi.h | MADT table |

| PAL API | UEFI interfaces consumed | ACPI table consumed |
|---|--|---------------------|
| <code>gic_install_isr</code> | <ul style="list-style-type: none"> gHardwareInterruptProtocolGuid RegisterInterruptSource EnableInterruptSource | - |
| <code>timer_create_info_table</code> | <ul style="list-style-type: none"> gST->ConfigurationTable CompareGuid IndustryStandard/Acpi.h | GTDT table |
| <code>wd_create_info_table</code> | <ul style="list-style-type: none"> gST->ConfigurationTable CompareGuid IndustryStandard/Acpi.h | GTDT table |
| <code>pcie_create_info_table</code> | <ul style="list-style-type: none"> gST->ConfigurationTable CompareGuid IndustryStandard/Acpi.h | MCFG table |
| <code>pcie_get_mcfg_ecam</code> | <ul style="list-style-type: none"> gST->ConfigurationTable CompareGuid, IndustryStandard/Acpi.h IndustryStandard/MemoryMappedConfigurationSpaceAccessTable.h | MCFG table |
| <code>iovirt_create_info_table</code> | <ul style="list-style-type: none"> gST->ConfigurationTable CompareGuid IndustryStandard/Acpi.h | IORT table |
| <code>peripheral_create_info_table</code> | <ul style="list-style-type: none"> gEfiPciIoProtocolGuid Pci->GetLocation Pci->Pci.Read | - |
| <code>memory_create_info_table</code> | gBS->GetMemoryMap | - |
| <code>cache_create_info_table</code> | <ul style="list-style-type: none"> IndustryStandard/Acpi.h gST->ConfigurationTable CompareGuid | PPTT table |
| <code>hmat_create_info_table</code> | <ul style="list-style-type: none"> IndustryStandard/Acpi.h gST->ConfigurationTable CompareGuid | HMAT table |
| <code>ras_create_info_table</code> | <ul style="list-style-type: none"> gST->ConfigurationTable CompareGuid IndustryStandard/ArmErrorSourceTable.h | AEST table |
| <code>mpam_create_info_table</code> | <ul style="list-style-type: none"> gST->ConfigurationTable CompareGuid IndustryStandard/Acpi.h | MPAM table |
| <code>pmu_create_info_table</code> | <ul style="list-style-type: none"> gST->ConfigurationTable CompareGuid IndustryStandard/Acpi.h | APMT table |
| <code>ras2_create_info_table</code> | <ul style="list-style-type: none"> gST->ConfigurationTable CompareGuid IndustryStandard/Acpi.h | RAS2 and PCCT table |

| PAL API | UEFI interfaces consumed | ACPI table consumed |
|------------------------|--|---------------------|
| srat_create_info_table | <ul style="list-style-type: none">gST->ConfigurationTableCompareGuidIndustryStandard/Acpi.h | SRAT table |

4. Linux application

This chapter provides information on executing tests from the Linux application.

4.1 Linux application arguments

Run the Linux application with the following set of arguments:

```
shell> sbsa [-v <n>] [-l <n>] [-skip <x,y,z>]
```

Table 4-1: Description of Linux application arguments

| Argument | Description |
|----------|--|
| -v | Print level 1 INFO and above 2 DEBUG and above 3 TEST and above 4 WARN and ERROR 5 ERROR |
| -l | Level of compliance to be tested for. (0 to 7) |
| skip | Overrides the suite to skip the execution of a particular test. For example, 53 skips test case with ID 53. |

Example

```
shell> sbsa -v 3 -l 3 -skip 57
```

This set of parameters tests for compliance against SBSA level 3 with print verbosity set to 3, and skips test number 57.

Loading the kernel module

Before the SBSA ACS Linux application is run, load the SBSA ACS kernel module using the `insmod` command.

```
shell> insmod sbsa_acs.ko
```

4.2 Environment setup

This section details the target and runtime environment setup.

4.2.1 Test requirements

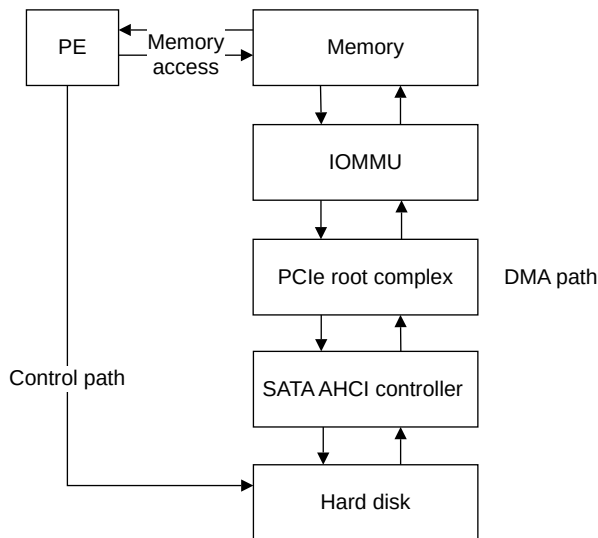
The set of tests assumes that at least one Serial Advanced Technology Attachment (SATA) controller is behind a PCIe root complex. The SATA controller may or may not be behind an Input-Output Memory Management Unit (IOMMU).

Before running these tests, at least one SATA hard disk must be connected to the SATA controller. The test performs read and write operations to the SATA hard disk. Therefore, the data on the HDD is overwritten. The SATA drive must not be the boot device for the OS.

4.2.2 Runtime environment

The following figure describes the hardware functional blocks.

Figure 4-1: Hardware functional blocks



The PCIe-DMA tests initiate data transfers from a DMA requester. By default, the test searches for a SATA controller which is part of the PCIe subsystem.

1. The test programs the known data from the PE to main memory.
2. The test programs the DMA requester to transfer this known data to its end-point device.
3. The test programs the DMA requester to transfer the data back to a different location in the main memory.
4. The test compares the data at both the locations.

If the SATA controller is not placed before an IOMMU, then during this data transfer, the address that is used by the SATA controller is retrieved and compared with the DMA address that is seen by the PE.

If the DMA requester is placed before an IOMMU, then the address that is used by the SATA AHCI controller is compared with the address that is seen by the IOMMU. Both these addresses must match.

To enable the export of the addresses that are seen by the SATA AHCI controller and IOMMU, the kernel drivers for these two modules must be patched.

5. PMU Linux application

This chapter describes on how to run the PMU Linux application.

5.1 Running the PMU application

The following steps describe on how to run the PMU application.

Steps to run the application

1. Export the path from which the Python modules are present.

```
export PYTHONPATH=/lib/python3.10/site-packages/
```

2. Navigate to the directory where the scripts are present.

```
cd /bin/pmuval
```

3. Run script

```
python sbsa_acs_pmu.py -a
```

Options -: -a -- All PEs

Appendix A Revisions

This appendix describes the technical changes between released issues of this book.

A.1 Revisions

The following tables describe the changes between different issues of this document.

Table A-1: Issue 0200-01

| Change | Location |
|---|---|
| Information about exerciser is added. | See 2.3 Test IDs on page 11. |
| A new parameter <code>--e</code> is added to Linux application arguments. | See 4.1 Linux application arguments on page 18. |

Table A-2: Differences between Issue 0200-01 and Issue 0200-02

| Change | Location |
|---|---|
| Bare-metal test environment is added to the table. | See 2.2 Overview of tests on page 11. |
| A note about additional porting for the exerciser is added. | See 4.1 Linux application arguments on page 18. |

Table A-3: Differences between Issue 0200-02 and Issue 0200-03

| Change | Location |
|-----------------------|----------|
| No technical changes. | - |

Table A-4: Differences between Issue 0200-03 and Issue 0200-04

| Change | Location |
|--|---|
| <ul style="list-style-type: none">Arguments for NIST and PCIe tests are added.A note about UEFI session is added. | See 3.1 UEFI application arguments on page 13. |
| NIST module ID is updated. | See 2.3 Test IDs on page 11. |
| Linux application arguments are updated. | See 4.1 Linux application arguments on page 18. |

Table A-5: Differences between Issue 0200-04 and Issue 0300-01

| Change | Location |
|---|--|
| Additional level of compliance to be tested is added. | See table in 3.1 UEFI application arguments on page 13 and 4.1 Linux application arguments on page 18. |

Table A-6: Differences between Issue 0300-01 and Issue 0301-01

| Change | Location |
|--|---|
| Removed Secure module. | See 2.3 Test IDs on page 11. |
| Updated the link to linux-acs. | See 4.2 Environment setup on page 18. |
| Updated the build steps and environment setup. | See 4.2 Environment setup on page 18. |

Table A-7: Differences between Issue 0301-01 and Issue 0302-01

| Change | Location |
|--|--|
| Arguments for p2p and cache are added. | See 3.1 UEFI application arguments on page 13. |

Table A-8: Differences between Issue 0302-01 and Issue 0601-01

| Change | Location |
|--|--|
| Added an abbreviation for HVC. | See 2.1 Abbreviations on page 10. |
| Removed Exerciser module from the Linux command line. | See 2.2 Overview of tests on page 11. |
| Added new argument options for test id, module id, and timeout with more examples. | See 3.1 UEFI application arguments on page 13. |
| Section on Build steps and environment setup is moved to the README file. | - |

Table A-9: Differences between Issue 0300-01 and Issue 0700-01

| Change | Location |
|---|---|
| Added information on PMU Linux application | See 5. PMU Linux application on page 21. |
| Added new terms in Abbreviations and new APIs in UEFI implementation of PAL APIs. | See 2.1 Abbreviations on page 10, 3.2 UEFI implementation of PAL APIs on page 15. |
| Added details for PMU, MPAM, and RAS; removed Exerciser module. | See 2.2 Overview of tests on page 11. |
| Updated the arguments and description for UEFI application. | See 3.1 UEFI application arguments on page 13. |
| Added new module names and IDs. | See 2.3 Test IDs on page 11. |
| Added new PAL APIs. | See 3.2 UEFI implementation of PAL APIs on page 15. |
| Updated the commands and versions. | See 4.2 Environment setup on page 18. |

Table A-10: Differences between Issue 0700-01 and Issue 0701-01

| Change | Location |
|---|---|
| Added details for Memory module. | See 2.2 Overview of tests on page 11. |
| Updated the arguments and description for UEFI application. | See 3.1 UEFI application arguments on page 13. |
| Added a new module Memory. | See 2.3 Test IDs on page 11. |
| Added RAS and SRAT APIs. | See 3.2 UEFI implementation of PAL APIs on page 15. |
| Added new terms in Abbreviations. | See 2.1 Abbreviations on page 10. |
| Updated the steps to run the PMU application. | See 5.1 Running the PMU application on page 21. |

Table A-11: Differences between Issue 0700-01 and Issue 0701-02

| Change | Location |
|--|--|
| Changed the order of modules executed in the Table 2-3: Test environment and modules | See 2.2 Overview of tests on page 11 |
| Updated the UEFI application arguments | See 3.1 UEFI application arguments on page 13 |
| Added new PAL APIs in Table 3-2: PAL APIs and UEFI interfaces | See 3.2 UEFI implementation of PAL APIs on page 15 |