



# Arm<sup>®</sup> Cortex<sup>®</sup>-A76AE Core Cryptographic Extension

Revision: r1p1

## Technical Reference Manual

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# Arm® Cortex®-A76AE Core Cryptographic Extension

## Technical Reference Manual

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## Release Information

### Document history

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0000-00	29 October 2018	Non-Confidential	First development release for r0p0
0000-01	7 December 2018	Non-Confidential	First release for r0p0
0100-00	28 February 2020	Confidential	First release for r1p0
0100-01	28 February 2020	Confidential	Second release for r1p0
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## Product Status

The information in this document is Final, that is for a developed product.

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This document includes language that can be offensive. We will replace this language in a future issue of this document.

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# Contents

<b>1 Introduction.....</b>	<b>6</b>
1.1 Product revision status.....	6
1.2 Intended audience.....	6
1.3 Conventions.....	6
1.4 Additional reading.....	8
<b>2 Functional description.....</b>	<b>9</b>
2.1 About the Cryptographic Extension.....	9
2.2 Revisions.....	9
<b>3 Register descriptions.....</b>	<b>10</b>
3.1 Identifying the Cryptographic instructions implemented.....	10
3.2 Disabling the Cryptographic Extension.....	10
3.3 Register summary.....	10
3.4 ID_AA64ISAR0_EL1, AArch64 Instruction Set Attribute Register 0, EL1.....	11
3.5 ID_ISAR5_EL1, AArch32 Instruction Set Attribute Register 5, EL1.....	13
<b>A Document revisions.....</b>	<b>16</b>
A.1 Revisions.....	16

# 1 Introduction

## 1.1 Product revision status

The  $r_xp_y$  identifier indicates the revision status of the product described in this manual, for example,  $r1p2$ , where:

$r_x$  Identifies the major revision of the product, for example,  $r1$ .  
 $p_y$  Identifies the minor revision or modification status of the product, for example,  $p2$ .

## 1.2 Intended audience

This manual is for system designers, system integrators, and programmers who are designing or programming a *System-on-Chip* (SoC) that uses the Cortex®-A76AE core with the optional Cryptographic Extension.

## 1.3 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](https://developer.arm.com/glossary).

### Typographic conventions

Convention	Use
<i>italic</i>	Citations.
<b>bold</b>	Interface elements, such as menu names.  Signal names.  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.
<b>monospace bold</b>	Language keywords when used outside example 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.

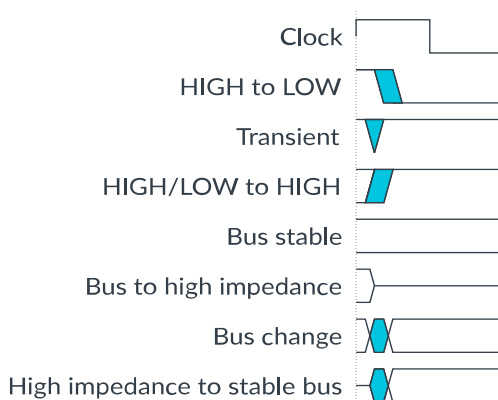
Convention	Use
<and>	Encloses replaceable terms for assembler syntax where they appear in code or code fragments.  For example:  <pre>MRC p15, 0, &lt;Rd&gt;, &lt;CRn&gt;, &lt;CRm&gt;, &lt;Opcode_2&gt;</pre>
<b>SMALL CAPITALS</b>	Terms that have specific technical meanings as defined in the <i>Arm® Glossary</i> . For example, <b>IMPLEMENTATION DEFINED</b> , <b>IMPLEMENTATION SPECIFIC</b> , <b>UNKNOWN</b> , and <b>UNPREDICTABLE</b> .
 Caution	Recommendations. Not following these recommendations might lead to system failure or damage.
 Warning	Requirements for the system. Not following these requirements might result in system failure or damage.
 Danger	Requirements for the system. Not following these requirements will result in system failure or damage.
 Note	An important piece of information that needs your attention.
 Tip	A useful tip that might make it easier, better or faster to perform a task.
 Remember	A reminder of something important that relates to the information you are reading.

## Timing diagrams

The following figure explains the components used in timing diagrams. Variations, when they occur, have clear labels. You must not assume any timing information that is not explicit in the diagrams.

Shaded bus and signal areas are undefined, so the bus or signal can assume any value within the shaded area at that time. The actual level is unimportant and does not affect normal operation.

**Figure 1-1: Key to timing diagram conventions**



## Signals

The signal conventions are:

### Signal level

The level of an asserted signal depends on whether the signal is active-HIGH or active-LOW. Asserted means:

- HIGH for active-HIGH signals.
- LOW for active-LOW signals.

### Lowercase n

At the start or end of a signal name, n denotes an active-LOW signal.

## 1.4 Additional reading

This document contains information that is specific to this product. See the following documents for other relevant information:

**Table 1-2: Arm publications**

Document name	Document ID	Licensee only
Arm® Cortex®-A76AE Core Technical Reference Manual	101392	No
Arm® Cortex®-A76AE Core Configuration and Sign-off Guide	101393	Yes
Arm® Cortex®-A76AE Core Integration Manual	101394	Yes
Arm® Architecture Reference Manual Armv8, for A-profile architecture	DDI 0487	No

**Table 1-3: Other publications**

Document ID	Organization	Document name
FIPS 197	-	Advanced Encryption Standard
FIPS 180-4	-	Secure Hash Standard (SHS)



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## 2 Functional description

This chapter describes the Cortex®-A76AE core Cryptographic Extension.

### 2.1 About the Cryptographic Extension

The Cortex®-A76AE core Cryptographic Extension supports the Arm®v8-A Cryptographic Extension. Some parts of the Arm®v8-A Cryptographic Extension are optional.

For more information on the optional parts of the Arm®v8-A Cryptographic Extension, see the *AArch64 Instruction Set Attribute Register 0, EL1* register (ID\_AA64ISAR0\_EL1) in the *Arm® Cortex®-A76AE Core Technical Reference Manual*.

The Cryptographic Extension adds new A64, A32, and T32 instructions to Advanced SIMD that accelerate *Advanced Encryption Standard* (AES) encryption and decryption. It also adds instructions to implement the *Secure Hash Algorithm* (SHA) functions SHA-1, SHA-224, and SHA-256.



The optional Cryptographic Extension is not included in the base product. Arm supplies the Cryptographic Extension only under an additional license to the Cortex®-A76AE core.

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### 2.2 Revisions

This section describes the differences in functionality between product revisions.

r0p0	First release.
r1p0	Added support for <i>Page-Based Hardware Attributes</i> (PBHA).
r1p1	No functional changes to core for this revision.

## 3 Register descriptions

This chapter describes the Cryptographic Extension registers.

### 3.1 Identifying the Cryptographic instructions implemented

Software can identify the Cryptographic instructions that are implemented by reading two registers.

#### About this task

The two registers are:

- ID\_AA64ISAR0\_EL1 in the AArch64 Execution state
- ID\_ISAR5\_EL1 in the AArch64 Execution state

### 3.2 Disabling the Cryptographic Extension

To disable the Cryptographic Extension, assert the **CRYPTODISABLE** input signal, which applies to all the Cortex®-A76AE cores present in a cluster. This signal is sampled only during reset of the cores.

#### About this task

When **CRYPTODISABLE** is asserted:

- Executing a Cryptographic instruction results in an **UNDEFINED** exception.
- The ID registers described in [Cryptographic Extension register summary](#) on page 10 indicate that the Cryptographic Extension is not implemented.

### 3.3 Register summary

The core has two instruction identification registers. Each register has a specific purpose, usage constraints, configurations, and attributes.

The following table lists the instruction identification registers for the Cortex®-A76AE core Cryptographic Extension.

**Table 3-1: Cryptographic Extension register summary**

Name	Execution state	Description
ID_AA64ISAR0_EL1	AArch64	See <a href="#">3.4 ID_AA64ISAR0_EL1, AArch64 Instruction Set Attribute Register 0, EL1</a> on page 11.
ID_ISAR5_EL1	AArch64	See <a href="#">3.5 ID_ISAR5_EL1, AArch32 Instruction Set Attribute Register 5, EL1</a> on page 13.

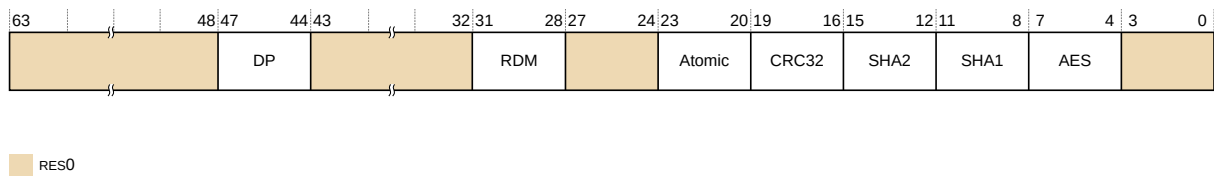
## 3.4 ID\_AA64ISAR0\_EL1, AArch64 Instruction Set Attribute Register 0, EL1

The ID\_AA64ISAR0\_EL1 provides information about the instructions that are implemented in AArch64 state, including the instructions provided by the Cryptographic Extension.

### Bit field descriptions

ID\_AA64ISAR0\_EL1 is a 64-bit register.

**Figure 3-1: ID\_AA64ISAR0\_EL1 bit assignments**



#### RES0, [63:48]

RES0 Reserved

#### DP, [47:44]

Indicates whether Dot Product support instructions are implemented.

0x1 UDOT, SDOT instructions are implemented.

#### RES0, [43:32]

RES0 Reserved

#### RDM, [31:28]

Indicates whether *Rounding Double Multiply* (RDM) instructions are implemented. The value is:

0x1 SQRDMLAH and SQRDMLSH instructions are implemented.

#### RES0, [27:24]

RES0 Reserved

#### Atomic, [23:20]

Indicates whether atomic instructions are implemented. The value is:

0x2 LDADD, LDCLR, LDEOR, LDSET, LDSMAX, LDSMIN, LDUMAX, LDUMIN, CAS, CASP, and SWP instructions are implemented.

### CRC32, [19:16]

Indicates whether CRC32 instructions are implemented. The value is:

0x1 CRC32 instructions are implemented.

### SHA2, [15:12]

Indicates whether SHA2 instructions are implemented. The possible values are:

0x0 No SHA2 instructions are implemented. This is the value if the core implementation does not include the Cryptographic Extension.  
0x1 SHA256H, SHA256H2, SHA256U0, and SHA256U1 are implemented. This is the value if the core implementation includes the Cryptographic Extension.

### SHA1, [11:8]

Indicates whether SHA1 instructions are implemented. The possible values are:

0x0 No SHA1 instructions are implemented. This is the value if the core implementation does not include the Cryptographic Extension.  
0x1 SHA1C, SHA1P, SHA1M, SHA1SU0, and SHA1SU1 are implemented. This is the value if the core implementation includes the Cryptographic Extension.

### AES, [7:4]

Indicates whether AES instructions are implemented. The possible values are:

0x0 No AES instructions implemented. This is the value if the core implementation does not include the Cryptographic Extension.  
0x2 AESE, AESD, AESMC, and AESIMC are implemented, plus PMULL and PMULL2 instructions operating on 64-bit data. This is the value if the core implementation includes the Cryptographic Extension.

### RES0, [3:0]

RES0 Reserved

## Configurations

ID\_AA64ISAR0\_EL1 is architecturally mapped to external register ID\_AA64ISAR0.

## Usage constraints

### Accessing the ID\_AA64ISAR0\_EL1

To access the ID\_AA64ISAR0\_EL1:

```
MRS <Xt>, ID_AA64ISAR0_EL1 ; Read ID_AA64ISAR0_EL1 into Xt
```

Register access is encoded as follows:

**Table 3-2: ID\_AA64ISAR0\_EL1 access encoding**

op0	op1	CRn	CRm	op2
11	000	0000	0110	000

### Accessibility

This register is accessible as follows:

EL0	EL1 (NS)	EL1 (S)	EL2	EL3 (SCR.NS = 1)	EL3 (SCR.NS = 0)
-	RO	RO	RO	RO	RO

## 3.5 ID\_ISAR5\_EL1, AArch32 Instruction Set Attribute Register 5, EL1

The AArch64 register ID\_ISAR5\_EL1 provides information about the instructions that are implemented in AArch32 state, including the instructions provided by the optional Cryptographic Extension.

### Bit-field descriptions

ID\_ISAR5\_EL1 is a 32-bit register.

**Figure 3-2: ID\_ISAR5\_EL1 bit assignments**

31	28	27	24	23	20	19	16	15	12	11	8	7	4	3	0
				RDM				CRC32	SHA2		SHA1		AES		SEVL

 RES0

### RES0, [31:28]

 Reserved

### RDM, [27:24]

Indicates whether RDM instructions are implemented. The value is:

0x1 SQRDMLAH and SQRDMLSH instructions are implemented.

### RES0, [23:20]

 Reserved

### CRC32, [19:16]

Indicates whether CRC32 instructions are implemented in AArch32 state. The value is:

0x1 CRC32 instructions are implemented.

### SHA2, [15:12]

Indicates whether SHA2 instructions are implemented in AArch32 state. The possible values are:

0x0 Cryptographic Extension is not implemented or is disabled.  
0x1 SHA256H, SHA256H2, SHA256SU0, and SHA256SU1 instructions are implemented.

### SHA1, [11:8]

Indicates whether SHA1 instructions are implemented in AArch32 state. The possible values are:

0x0 Cryptographic Extension is not implemented or is disabled.  
0x1 SHA1C, SHA1P, SHA1M, SHA1H, SHA1SU0, and SHA1SU1 instructions are implemented.

### AES, [7:4]

Indicates whether AES instructions are implemented in AArch32 state. The possible values are:

0x0 Cryptographic Extension is not implemented or is disabled.  
0x2 AESE, AESD, AESMC, and AESIMC are implemented, plus PMULL and PMULL2 instructions operating on 64-bit data.

### SEVL, [3:0]

Indicates whether the SEVL instruction is implemented. The value is:

0x1 SEVL implemented to send event local.

## Configurations

This register has no configuration options.

## Usage constraints

### Accessing the ID\_ISAR5\_EL1

To access the ID\_ISAR5\_EL1:

```
MRS <Xt>, ID_ISAR5_EL1 ; Read ID_ISAR5_EL1 into Xt
```

Register access is encoded as follows:

**Table 3-4: ID\_ISAR5\_EL1 access encoding**

op0	op1	CRn	CRm	op2
11	000	0000	0010	101

### Accessibility

This register is accessible as follows:

EL0	EL1 (NS)	EL1 (S)	EL2	EL3 (SCR.NS = 1)	EL3 (SCR.NS = 0)
-	RO	RO	RO	RO	RO

# Appendix A Document revisions

Changes between released issues of this book are summarized in tables.

## A.1 Revisions

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

**Table A-1: Issue 0000-01**

Change	Location
First Non-Confidential development release for r0p0	-

**Table A-2: Differences between Issue 0000-01 and Issue 0100-00**

Change	Location
First Confidential release for r1p0	-
Updated the section.	<a href="#">2.1 About the Cryptographic Extension</a> on page 9

**Table A-3: Differences between Issue 0100-00 and Issue 0101-00**

Change	Location
First Non-Confidential release for r1p1	-
No technical changes.	-