



Arm Processor  
Cortex™-M4 (AT520) and Cortex-M4 with FPU (AT521)

**Product Revision r0**

## **Software Developers Errata Notice**

**Non-Confidential - Released**

## Non-Confidential Proprietary notice

This document is protected by copyright and other related rights and the practice or implementation of the information contained in this document may be protected by one or more patents or pending patent applications. No part of this document may be reproduced in any form by any means without the express prior written permission of Arm. **No license, express or implied, by estoppel or otherwise to any intellectual property rights is granted by this document unless specifically stated.**

Your access to the information in this document is conditional upon your acceptance that you will not use or permit others to use the information for the purposes of determining whether implementations infringe any third party patents.

THIS DOCUMENT IS PROVIDED "AS IS". ARM PROVIDES NO REPRESENTATIONS AND NO WARRANTIES, EXPRESS, IMPLIED OR STATUTORY, INCLUDING, WITHOUT LIMITATION, THE IMPLIED WARRANTIES OF MERCHANTABILITY, SATISFACTORY QUALITY, NON-INFRINGEMENT OR FITNESS FOR A PARTICULAR PURPOSE WITH RESPECT TO THE DOCUMENT. For the avoidance of doubt, Arm makes no representation with respect to, and has undertaken no analysis to identify or understand the scope and content of, third party patents, copyrights, trade secrets, or other rights.

This document may include technical inaccuracies or typographical errors.

TO THE EXTENT NOT PROHIBITED BY LAW, IN NO EVENT WILL ARM BE LIABLE FOR ANY DAMAGES, INCLUDING WITHOUT LIMITATION ANY DIRECT, INDIRECT, SPECIAL, INCIDENTAL, PUNITIVE, OR CONSEQUENTIAL DAMAGES, HOWEVER CAUSED AND REGARDLESS OF THE THEORY OF LIABILITY, ARISING OUT OF ANY USE OF THIS DOCUMENT, EVEN IF ARM HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES.

This document consists solely of commercial items. You shall be responsible for ensuring that any use, duplication or disclosure of this document complies fully with any relevant export laws and regulations to assure that this document or any portion thereof is not exported, directly or indirectly, in violation of such export laws. Use of the word "partner" in reference to Arm's customers is not intended to create or refer to any partnership relationship with any other company. Arm may make changes to this document at any time and without notice.

If any of the provisions contained in these terms conflict with any of the provisions of any click through or signed written agreement covering this document with Arm, then the click through or signed written agreement prevails over and supersedes the conflicting provisions of these terms. This document may be translated into other languages for convenience, and you agree that if there is any conflict between the English version of this document and any translation, the terms of the English version of the Agreement shall prevail.

The Arm corporate logo and words marked with ® or ™ are registered trademarks or trademarks of Arm Limited (or its subsidiaries) in the US and/or elsewhere. All rights reserved. Other brands and names mentioned in this document may be the trademarks of their respective owners. Please follow Arm's trademark usage guidelines at <http://www.arm.com/company/policies/trademarks>.

Copyright © 2010-2019 Arm Limited (or its affiliates). All rights reserved.

Arm Limited. Company 02557590 registered in England.

110 Fulbourn Road, Cambridge, England CB1 9NJ.

LES-PRE-20349

## Document confidentiality status

This document is Non-Confidential. The right to use, copy and disclose this document may be subject to license restrictions in accordance with the terms of the agreement entered into by Arm and the party that Arm delivered this document to.

## Web address

<http://www.arm.com/>

## Feedback on the product

If you have any comments or suggestions about this product, contact your supplier giving:

- The product name
- The product revision or version.
- An explanation with as much information as you can provide. Include symptoms and diagnostic procedures if appropriate.

## Feedback on this document

If you have any comments about this document, please send an email to [errata@arm.com](mailto:errata@arm.com) giving:

- The document title
- The document number, ARM-ECM-0426805
- If applicable, the page number(s) to which your comments refer.
- A concise explanation of your comments

Arm also welcomes general suggestions for additions and improvements.

**Release Information**

Errata are listed in this section if they are new to the document, or marked as “updated” if there has been any change to the erratum text in Chapter 2. Fixed errata are not shown as updated unless the erratum text has changed. The summary table in section 2.2 identifies errata that have been fixed in each product revision.

**11 Jan 2019: Changes in Document v3**

| Page | Status | ID      | Cat  | Rare | Summary of Erratum  |
|------|--------|---------|------|------|---|
| 12   | New    | 839676  | CatB | Rare | Fused MAC instructions give incorrect results for rare data combinations                                  |
| 13   | New    | 1299509 | CatC |      | Processor reset asserted asynchronously could corrupt FPB comparator registers and remap to wrong address |

**02 Dec 2014: Changes in Document v2**

| Page | Status | ID     | Cat  | Rare | Summary of Erratum   |
|------|--------|--------|------|------|--|
| 10   | New    | 806422 | CatB |      | ITM can deadlock when global timestamping enabled  |
| 10   | New    | 838869 | CatB | Rare | Store immediate overlapping exception return operation might vector to incorrect interrupt |

**01 Apr 2013: Changes in Document v1**

| Page | Status | ID     | Cat  | Rare | Summary of Erratum  |
|------|--------|--------|------|------|---|
| 9    | New    | 776924 | CatB |      | VDIV or VSQRT instructions might not complete correctly when very short ISRs are used |

## Contents

|  |          |
|--|----------|
| <b>CHAPTER 1.</b>  | <b>6</b> |
| <b>INTRODUCTION</b>  | <b>6</b> |
| 1.1. Scope of this document  | 6        |
| 1.2. Categorization of errata  | 6        |
| <b>CHAPTER 2.</b>  | <b>7</b> |
| <b>ERRATA DESCRIPTIONS</b>   | <b>7</b> |
| 2.1. Product Revision Status   | 7        |
| 2.2. Revisions Affected  | 7        |
| 2.3. Category A  | 8        |
| 2.4. Category A (Rare)   | 8        |
| 2.5. Category B  | 8        |
| 752770: Interrupted loads to SP can cause erroneous behaviour .....  | 8        |
| 776924: VDIV or VSQRT instructions might not complete correctly when very short ISRs are used.....                       | 9        |
| 806422: ITM can deadlock when global timestamping enabled.....   | 10       |
| 2.6. Category B (Rare)   | 10       |
| 838869: Store immediate overlapping exception return operation might vector to incorrect interrupt.....                  | 10       |
| 839676: Fused MAC instructions give incorrect results for rare data combinations .....                                   | 12       |
| 2.7. Category C  | 13       |
| 1299509: Processor reset asserted asynchronously could corrupt FPB comparator registers and remap to wrong address ..... | 13       |

# Chapter 1.

## Introduction

This chapter introduces the errata notice for the Arm processors Cortex-M4 and Cortex-M4 with Floating Point Unit.

### 1.1. Scope of this document

This document describes errata categorized by level of severity. Each description includes:

- the current status of the defect
- where the implementation deviates from the specification and the conditions under which erroneous behavior occurs
- the implications of the erratum with respect to typical applications
- the application and limitations of a ‘work-around’ where possible

This document describes errata that may impact anyone who is developing software that will run on implementations of this Arm product.

### 1.2. Categorization of errata

Errata recorded in this document are split into the following levels of severity:

**Table 1**      **Categorization of errata**

| Errata Type      | Definition   |
|------------------|--|
| Category A       | A critical error. No workaround is available or workarounds are impactful. The error is likely to be common for many systems and applications.   |
| Category A(rare) | A critical error. No workaround is available or workarounds are impactful. The error is likely to be rare for most systems and applications. Rare is determined by analysis, verification and usage. |
| Category B       | A significant error or a critical error with an acceptable workaround. The error is likely to be common for many systems and applications.   |
| Category B(rare) | A significant error or a critical error with an acceptable workaround. The error is likely to be rare for most systems and applications. Rare is determined by analysis, verification and usage.     |
| Category C       | A minor error.   |

## Chapter 2.

# Errata Descriptions

### 2.1. Product Revision Status

The *mpn* identifier indicates the revision status of the product described in this book, where:

- mn*** Identifies the major revision of the product.
- pn*** Identifies the minor revision or modification status of the product.

### 2.2. Revisions Affected

Table 2 below lists the product revisions affected by each erratum. A cell marked with **X** indicates that the erratum affects the revision shown at the top of that column.

This document includes errata that affect revision r0 only.

Refer to the reference material supplied with your product to identify the revision of the IP.

**Table 2**      **Revisions Affected**

| ID      | Cat  | Rare | Summary of Erratum  | r0p0 | r0p1 |
|---------|------|------|---|------|------|
| 806422  | CatB |      | ITM can deadlock when global timestamping enabled   | X    | X    |
| 776924  | CatB |      | VDIV or VSQRT instructions might not complete correctly when very short ISRs are used                     | X    | X    |
| 752770  | CatB |      | Interrupted loads to SP can cause erroneous behaviour   | X    | X    |
| 838869  | CatB | Rare | Store immediate overlapping exception return operation might vector to incorrect interrupt                | X    | X    |
| 839676  | CatB | Rare | Fused MAC instructions give incorrect results for rare data combinations                                  | X    | X    |
| 1299509 | CatC |      | Processor reset asserted asynchronously could corrupt FPB comparator registers and remap to wrong address | X    | X    |

## 2.3. Category A

There are no errata in this category

## 2.4. Category A (Rare)

There are no errata in this category

## 2.5. Category B

### 752770: Interrupted loads to SP can cause erroneous behaviour

#### Category B

**Products Affected:** Cortex-M4, Cortex-M4F.

**Present in:** r0p0, r0p1

#### Description

If an interrupt occurs during the data-phase of a single word load to the stack-pointer (SP/R13), erroneous behaviour can occur. In all cases, returning from the interrupt will result in the load instruction being executed an additional time. For all instructions performing an update to the base register, the base register will be erroneously updated on each execution, resulting in the stack-pointer being loaded from an incorrect memory location.

The affected instructions that can result in the load transaction being repeated are:

- 1) LDR SP,[Rn],#imm
- 2) LDR SP,[Rn,#imm]!
- 3) LDR SP,[Rn,#imm]
- 4) LDR SP,[Rn]
- 5) LDR SP,[Rn,Rm]

The affected instructions that can result in the stack-pointer being loaded from an incorrect memory address are:

- 1) LDR SP,[Rn],#imm
- 2) LDR SP,[Rn,#imm]!

#### Conditions

- 1) An LDR is executed, with SP/R13 as the destination
- 2) The address for the LDR is successfully issued to the memory system
- 3) An interrupt is taken before the data has been returned and written to the stack-pointer.

#### Implications

Unless the load is being performed to Device or Strongly-Ordered memory, there should be no implications from the repetition of the load. In the unlikely event that the load is being performed to Device or Strongly-Ordered memory, the repeated read can result in the final stack-pointer value being different than had only a single load been performed.

Interruption of the two write-back forms of the instruction can result in both the base register value and final stack-pointer value being incorrect. This can result in apparent stack corruption and subsequent unintended modification of memory.

#### Workaround

Both issues may be worked around by replacing the direct load to the stack-pointer, with an intermediate load to a general-purpose register followed by a move to the stack-pointer.

If repeated reads are acceptable, then the base-update issue may be worked around by performing the stack-pointer load without the base increment followed by a subsequent ADD or SUB instruction to perform the appropriate update to the base register.



**776924: VDIV or VSQRT instructions might not complete correctly when very short ISRs are used****Category B****Products Affected: Cortex-M4F.****Present in: r0p0, r0p1****Description**

On Cortex-M4 with FPU, the VDIV and VSQRT instructions take 14 cycles to execute. When an interrupt is taken a VDIV or VSQRT instruction is not terminated, and completes its execution while the interrupt stacking occurs. If lazy context save of floating point state is enabled then the automatic stacking of the floating point context does not occur until a floating point instruction is executed inside the interrupt service routine.

Lazy context save is enabled by default. When it is enabled, the minimum time for the first instruction in the interrupt service routine to start executing is 12 cycles. In certain timing conditions, and if there is only one or two instructions inside the interrupt service routine, then the VDIV or VSQRT instruction might not write its result to the register bank or to the FPSCR.

**Conditions**

- 1) The floating point unit is present and enabled
- 2) Lazy context saving is not disabled
- 3) A VDIV or VSQRT is executed
- 4) The destination register for the VDIV or VSQRT is one of s0 - s15
- 5) An interrupt occurs and is taken
- 6) The interrupt service routine being executed does not contain a floating point instruction
- 7) 14 cycles after the VDIV or VSQRT is executed, an interrupt return is executed

A minimum of 12 of these 14 cycles are utilised for the context state stacking, which leaves 2 cycles for instructions inside the interrupt service routine, or 2 wait states applied to the entire stacking sequence (which means that it is not a constant wait state for every access).

In general this means that if the memory system inserts wait states for stack transactions then this erratum cannot be observed.

**Implications**

The VDIV or VSQRT instruction does not complete correctly and the register bank and FPSCR are not updated, meaning that these registers hold incorrect, out of date, data.

**Workaround**

A workaround is only required if the floating point unit is present and enabled. A workaround is not required if the memory system inserts one or more wait states to every stack transaction.

There are two workarounds:

- 1) Disable lazy context save of floating point state by clearing LSPEN to 0 (bit 30 of the FPCCR at address 0xE000EF34).
- 2) Ensure that every interrupt service routine contains more than 2 instructions in addition to the exception return instruction.

**806422: ITM can deadlock when global timestamping enabled****Category B****Products Affected: Cortex-M4, Cortex-M4F.****Present in: r0p0, r0p1****Description**

The Cortex-M4 processor contains an optional Instrumentation Trace Macrocell (ITM). This can be used to generate trace data under software control, and is also used with the Data Watchpoint and Trace (DWT) module which generates event driven trace. The processor supports global timestamping. This allows count values from a system-wide counter to be included in the trace stream.

When connected directly to a CoreSight funnel (or other component which holds ATREADY low in the idle state), the ITM will stop presenting trace data to the ATB bus after generating a timestamp packet. In this condition, the ITM\_TCR.BUSY register will indicate BUSY.

Once this condition occurs, a reset of the Cortex-M4 is necessary before new trace data can be generated by the ITM.

Timestamp packets which require a 5 byte GTS1 packet, or a GTS2 packet do not trigger this erratum. This generally only applies to the first timestamp which is generated.

Devices which use the Cortex-M optimized TPIU (CoreSight ID register values 0x923 and 0x9A1) are not affected by this erratum.

**Conditions**

- Cortex-M4 is configured with DWT present
- The ATB is connected directly to a CoreSight Funnel or similar component
- Global timestamping is enabled (ITM\_TCR.GTSFREQ != b00)
- The ITM is enabled (ITM\_TCR.ITMENA == 1)
- An event which causes a timestamp to be generated occurs.
- A 2nd event which causes a timestamp to be generated occurs with only bits [20:0] of the timestamp changing.

**Implications**

If the system is susceptible to this erratum, global timestamps can not be used reliably.

**Workaround**

There is no software workaround for this erratum. If the device being used is susceptible to this erratum, you must not enable global timestamping.

A system implementer can add an ATB synchronous bridge slice component between the Cortex-M4 and the downstream ATB system.

**2.6. Category B (Rare)****838869: Store immediate overlapping exception return operation might vector to incorrect interrupt****Category B Rare****Products Affected: Cortex-M4, Cortex-M4F.****Present in: r0p0, r0p1****Description**

The Cortex-M4 includes a write buffer that permits execution to continue while a store is waiting on the bus. Under specific timing conditions, during an exception return while this buffer is still in use by a store instruction, a late change in selection of the next interrupt to be taken might result in there being a mismatch between the interrupt acknowledged by the interrupt controller and the vector fetched by the processor.

## Configurations Affected

This erratum only affects systems where writeable memory locations can exhibit more than one wait state.

## Conditions

- 1) The handler for interrupt A is being executed.
- 2) Interrupt B, of the same or lower priority than interrupt A, is pending.
- 3) A store with immediate offset instruction is executed to a bufferable location.
  - STR/STRH/STRB <Rt>, [<Rn>,#imm]
  - STR/STRH/STRB <Rt>, [<Rn>,#imm]!
  - STR/STRH/STRB <Rt>, [<Rn>],#imm
- 4) Any number of additional data-processing instructions can be executed.
- 5) A BX instruction is executed that causes an exception return.
- 6) The store data has wait states applied to it such that the data is accepted at least two cycles after the BX is executed.
  - Minimally this is two cycles if the store and the BX instruction have no additional instructions between them.
  - The number of wait states required to observe this erratum needs to be increased by the number of cycles between the store and the interrupt service routine exit instruction.
- 7) Before the bus accepts the buffered store data, another interrupt C is asserted which has the same or lower priority as A, but a greater priority than B.

## Implications

The processor should execute interrupt handler C, and on completion of handler C should execute the handler for B. If the conditions above are met, then this erratum results in the processor erroneously clearing the pending state of interrupt C, and then executing the handler for B twice. The first time the handler for B is executed it will be at interrupt C's priority level. If interrupt C is pending by a level-based interrupt which is cleared by C's handler then interrupt C will be pending again once the handler for B has completed and the handler for C will be executed.

If interrupt C is level based, then this interrupt will eventually become re-pending and subsequently be handled. If interrupt C is a single pulse interrupt, then there is a possibility that this interrupt will be lost.

## Workaround

For software not using the memory protection unit, this erratum can be worked around by setting DISDEFWBUF in the Auxiliary Control Register.

In all other cases, the erratum can be avoided by ensuring a DSB occurs between the store and the BX instruction. For exception handlers written in C, this can be achieved by inserting the appropriate set of intrinsics or inline assembly just before the end of the interrupt function, for example:

ARMCC:

```
...
__schedule_barrier();
__asm{DSB};
__schedule_barrier();
}
```

GCC:

```
...
__asm volatile ("dsb 0xf":::"memory");
}
```

**839676: Fused MAC instructions give incorrect results for rare data combinations****Category B Rare****Products Affected: Cortex-M4F.****Present in: r0p0, r0p1****Description**

The Cortex-M4 processor includes optional floating-point logic which supports the fused MAC instructions (VFNMA, VFNMS, VFMA, VFMS). This erratum causes fused MAC operations on certain combinations of operands to result in either or both of the following:

- A result being generated which is one Unit of Least Precision (ULP) greater than the correct result.
- Inexact or underflow flags written to the Floating-point Status Control Register, FPSCR, incorrectly.

**Configurations Affected**

Cortex-M4F configured with floating-point.

**Conditions**

The conditions for this erratum are all of the following:

1. Cortex-M4 is configured with floating-point and it is enabled in the Coprocessor Access Control Register, CPACR.
2. Flush-to-Zero (FZ) mode is not enabled, that is, FPSCR.FZ is clear.
3. A fused MAC instruction (VFNMA, VFNMS, VFMA, or VFMS) is executed with all of the following properties:
  - The addition part of the operation is Unlike Signed Addition (USA). This implies that the combination of the instruction used and the signs of the operands means that a subtraction is being performed.
  - The result of the instruction, before rounding, is subnormal. This implies that the result is smaller in magnitude than  $2^{-126}$ .
  - The significance of the product and the addend operand are the same or differ by one.

**Implications**

If this erratum occurs, then the processor either produces an incorrect result to a computation or fails to run a floating-point exception routine when it should.

**Note:**

It is expected that most algorithms only use normalised numbers because:

- Subnormal results have low precision.
- It is easier to avoid underflow.

This erratum does not affect algorithms which only use normalized numbers.

**Workaround**

Enable FZ mode in the FPSCR.

## 2.7. Category C

### **1299509: Processor reset asserted asynchronously could corrupt FPB comparator registers and remap to wrong address**

#### **Category C**

**Products Affected:** Cortex-M4, Cortex-M4F

**Present in:** r0p0, r0p1. Open.

#### **Description**

Normally, the debugger uses the Flash Patch and Breakpoint (FPB) unit for breakpoints or for patching ROM code during debugging. However, you can also use the FPB functionality as a method of in-the-field ROM code patching. On the Cortex-M4 processor, the processor reset can be asynchronously asserted and this could potentially cause problems if the processor is in the middle of writing to debug components (which are not reset by the processor reset) such as the FPB unit.

#### **Configurations Affected**

A Cortex-M4 processor that is configured with debug.

#### **Conditions**

- 1) The processor is programming the FPB to remap an address in ROM to fetch a replacement opcode or vector from an area in RAM.
- 2) The processor is asynchronously reset during the programming of the FPB.
- 3) The data is incorrectly written to the FPB register due to metastability.

#### **Implications**

In the unlikely event of this occurring it may cause incorrect functional operation of the processor to occur. If the FPB is programmed with incorrect data it may cause the processor to unintentionally patch instructions.

#### **Workaround**

The problem does not arise if the FPB is not used to patch instructions.

If the FPB is used to patch instructions, a software workaround is to ensure that the FPB is globally disabled before programming any comparators. If code exists which programs the FPB other than at reset, the software workaround should include:

1. Disable the FPB.
2. Program the individual comparators required.
3. Explicitly disable the individual comparators not required.
4. Re-enable the FPB.

This sequence prevents any corruptly programmed FPB comparators from being activated.