追朔硬體錯誤原因

NuMicro® 32 位系列微控制器範例代碼介紹

文件資訊

代碼簡述	找出 CPU 讀取非法位置造成硬體錯誤原因的範例代碼
BSP 版本	Nano100B Series BSP CMSIS v3.03.000
開發平台	NuTiny–EVB–NANO130_LQFP128 V1.2

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1 功能介紹

1.1 簡介

微控制器透過16位元指標讀取記憶體時，若此16位元指標位置未符合2位元組的對齊限制，硬體將產生異常中斷，並讓處理器跳到異常處理程序，此範例將演示如何在發生硬體錯誤且跳至異常程序後，追朔導致硬體異常的原因。

1.2 原理

微處理器為了提供較佳的存取效率，會加上資料對齊的設計。開發工具的鏈結器在排列變數時，通常也是使用自然對齊(Natural Alignment)的方式。自然對齊的方式是對齊資料型態本身的大小，請參考圖1-1，uint16_t 對齊2byte aligned，uint32_t 對齊4 byte aligned，uint8_t 對齊byte aligned。

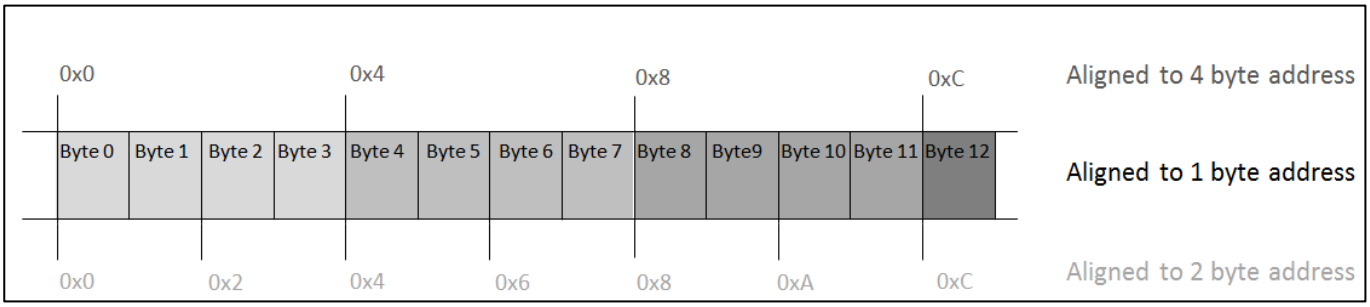

圖1-1 資料自然對齊

Nuvoton NANO100 series 是Arm® Cortex®–M0 核心，請參考下圖1-2，Arm® 所提供的Cortex®–M0 generic user guide對於address alignment 有特別說明，Cortex®–M0不支援非對齊的訪問方式，非對齊的訪問方式會導致硬體異常中斷。

Cortex-M0 Devices Generic User Guide

Home > The Cortex-M0 Instruction Set > About the instruction descriptions > Address alignment

3.3.4. Address alignment

An aligned access is an operation where a word-aligned address is used for a word, or multiple word access, or where a halfword-aligned address is used for a halfword access. Byte accesses are always aligned.

There is no support for unaligned accesses on the Cortex-M0 processor. Any attempt to perform an unaligned memory access operation results in a HardFault exception.

圖1-2 Arm® Cortex®-M0 位置對齊說明 (截自 http://infocenter.arm.com)

當硬體異常中斷發生，暫存器將會被存在堆疊裡，並前往異常處理程序。此時可觀察堆疊指標的位置，透過堆疊指標的位置找出硬體異常中斷時的暫存器值，參考圖1-3可得知PC，即可得知硬體異常的位置為何，並查詢Disassembly PC的位置是執行什麼指令。

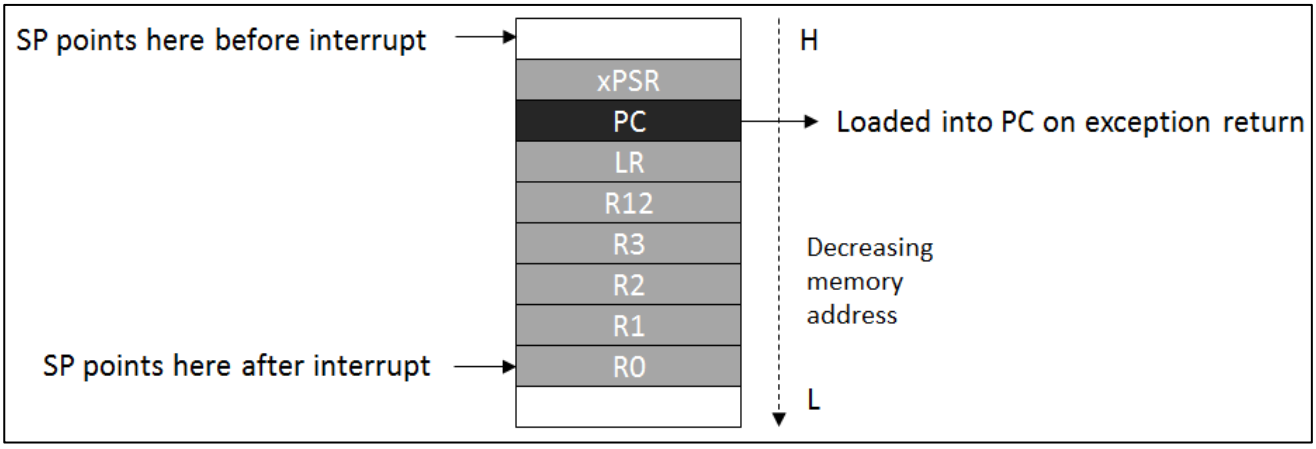

圖1-3 Cortex®-M0 堆疊框架內容

1.3 執行結果

發生硬體異常後，將會顯示進入異常中斷前所存放在堆疊的資料，如圖1-4。接下來將簡易說明如何從偵錯模式下找出原因。

```
In Hard Fault Handler
r0  = 0x20000001
r1  = 0x40050000
r2  = 0x400000
r3  = 0x791
r12 = 0x0
lr  = 0x775
pc  = 0x792
psr = 0x61000000
```

圖1-4 由UART輸出範例執行結果

如下圖1-5，

1. 發生硬體異常中斷後，SP = 0x200004F0

2. 在 Memory window 輸入 0x200004F0

3. 根據堆疊框架內容可得知 PC 為 0x792

4. 在 Disassembly 可找到 0x792 的指令為對於 0x2000001D 位置做 16 位元的讀取

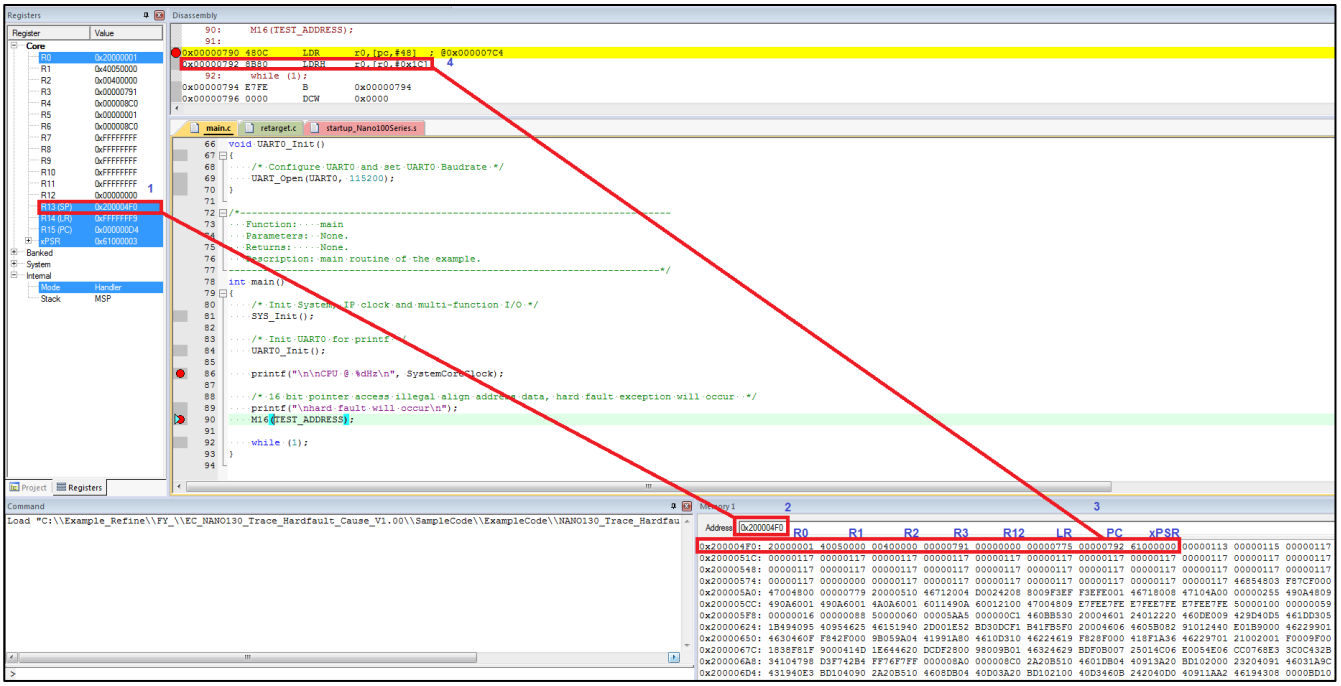

圖1-5 偵錯模式下的範例執行結果

2 代碼介紹

定義測試讀取的記憶體位置

```
/* define pointer address - not follow data alignment */
#define TEST_ADDRESS                                0x2000001D
```

使用 16bit 指標讀取測試位置，執行後將會觸發硬體異常中斷。

```
/* 16 bit pointer access illegal align address data */
    M16(TEST_ADDRESS);
```

3 軟體與硬體環境

- **軟體環境**
  - BSP 版本
    - Nano100B Series BSP CMSIS v3.03.000
  - IDE 版本
    - Keil uVersion 5.24
- **硬體環境**
  - 電路元件
    - NuTiny–EVB–NANO130_LQFP128 V1.2

4 目錄資訊

- EC_NANO130_Trace_Hardfault_Cause_V1.00
  - Library — Sample code header and source files
    - CMSIS — Cortex® Microcontroller Software Interface Standard (CMSIS) by Arm® Corp.
    - Device — CMSIS compliant device header file
    - StdDriver — All peripheral driver header and source files
  - SampleCode
    - ExampleCode — Source file of example code

5 如何執行範例程式

1. 根據目錄資訊章節進入 ExampleCode 路徑中的 KEIL 資料夾，雙擊 Trace_Hardfault_Cause.uvproj.。
2. 進入編譯模式介面
   a. 編譯
   b. 下載代碼至記憶體
   c. 進入 / 離開除錯模式
3. 進入除錯模式介面
   a. 執行代碼

6 修訂紀錄

Date	Revision	Description
Jul. 9, 2019	1.00	1. 初始發佈.

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