Vector Table的重新映射

NuMicro® 32 位系列微控制器範例代碼介紹

文件資訊

代碼簡述	透過 Vector table 的重新映射，實現兩套程式相互切換執行
BSP 版本	NUC123 Series BSP CMSIS V3.01.001
開發平台	NuTiny-EVB-123-LQFP64_V1.0

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1 功能介紹

1.1 簡介

Nuvoton NUC123系列微控制器提供重新映射Vector table的功能，開發者可以將兩套程式分別下載到APROM不同的位置。透過重新映射Vector table與函式指標的方式，達到兩套程式可以相互切換執行。

1.2 原理

由於Cortex-M0規範Vector table必須放置於位址0的位置，若有兩套程式需要在APROM切換執行，將會有位址覆蓋的問題發生。此時，可以將兩套程式的位址適當的安排於APROM中，再透過重新映射Vector table位址，避免位址覆蓋造成程式錯誤。

本範例分為APP1與APP2，APP1的位址為0x0，APP2的位址為0x3000，如圖 1-1所示。當APP1執行完畢，首先重置周邊IPs，接著使用ISP指令將0x3000的位址映射至0x0的位置，並且將堆疊指標設為0x3000位址的值。完成上述步驟後，可切換至APP2執行，即使用指標函式跳至APP2的Reset函式(0x3000+0x4)。當APP2執行完畢，切換至APP1的步驟與上述相同，但必需將映射0x3000至0x0的設定復原，且堆疊指標設為0x0位址的值。

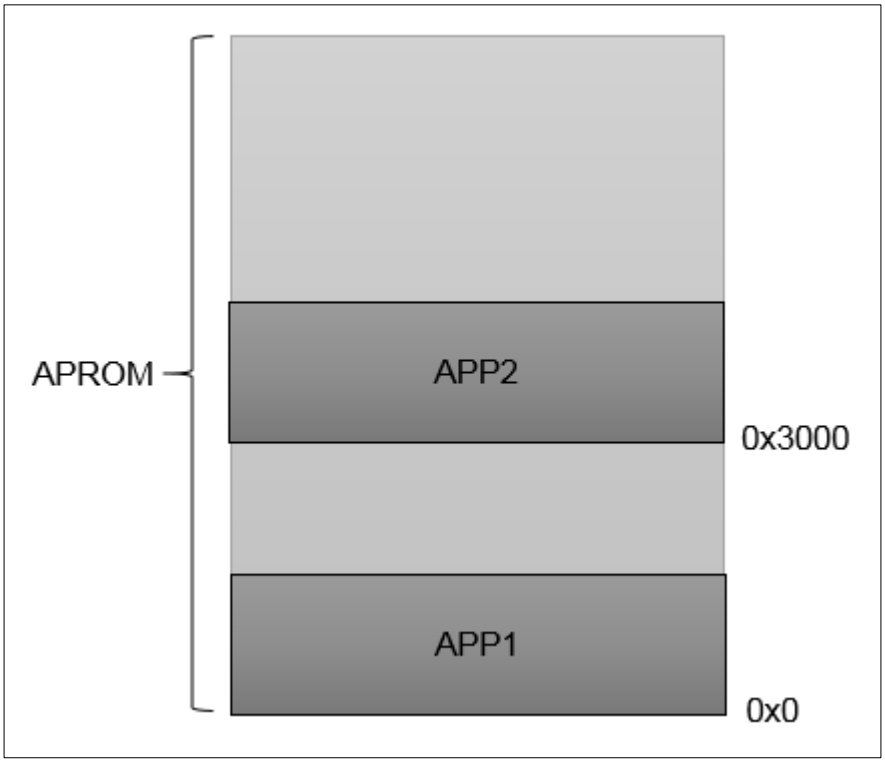

圖 1-1 Memory map

1.3 執行結果

APP1與APP2分別印出不同的字串，並且toggle PB4腳位使LED燈閃爍，APP1 toggle頻率較快，APP2較慢，如圖 1-2所示。經由打印的字串以及LED燈閃爍的頻率，可以觀察到APP1與APP2不斷的切換執行。

```
/*****************************************************************/
/***   NUC123 Change Vector Table Address Sample Code(App1)  ***/
/*****************************************************************/
/*****************************************************************/
/***   NUC123 Change Vector Table Address Sample Code(App2)  ***/
/*****************************************************************/
/*****************************************************************/
/***   NUC123 Change Vector Table Address Sample Code(App1)  ***/
/*****************************************************************/
/*****************************************************************/
/***   NUC123 Change Vector Table Address Sample Code(App2)  ***/
/*****************************************************************/
```

圖 1-2 Massage on the terminal

2 代碼介紹

2.1 APP1

打印訊息與閃爍 LED

```
    printf("/*****************************************************************/\n");
    printf("/***   NUC123 Change Vector Table Address Sample Code(App1)  ***/\n");
    printf("/*****************************************************************/\n");

    /* Set GPIO to output mode */
    GPIO_SetMode(PB, BIT4, GPIO_PMD_OUTPUT);

    /* Flashing LED */
    while(u8LEDFlashNum--)
    {
        PB4 = 0;
        for(i = 0; i < LED_TIME_LENGTH; i++);
        PB4 = 1;
        for(i = 0; i < LED_TIME_LENGTH; i++);
    }
```

初始化周邊 IPs 與重新映射位址

```
    /* Reset IPs */
    SYS->IPRSTC1 = SYS_IPRSTC1_PDMA_RST_Msk;
    SYS->IPRSTC2 = (SYS_IPRSTC2_I2S_RST_Msk|SYS_IPRSTC2_ADC_RST_Msk
                   |SYS_IPRSTC2_USBD_RST_Msk|SYS_IPRSTC2_PS2_RST_Msk
                   |SYS_IPRSTC2_PWM03_RST_Msk|SYS_IPRSTC2_UART1_RST_Msk
                   |SYS_IPRSTC2_UART0_RST_Msk|SYS_IPRSTC2_SPI2_RST_Msk
                   |SYS_IPRSTC2_SPI1_RST_Msk|SYS_IPRSTC2_SPI0_RST_Msk
                   |SYS_IPRSTC2_I2C1_RST_Msk|SYS_IPRSTC2_I2C0_RST_Msk
                   |SYS_IPRSTC2_TMR3_RST_Msk|SYS_IPRSTC2_TMR2_RST_Msk
                   |SYS_IPRSTC2_TMR1_RST_Msk|SYS_IPRSTC2_TMR0_RST_Msk
                   |SYS_IPRSTC2_GPIO_RST_Msk);
    SYS->IPRSTC1 &= ~SYS_IPRSTC1_PDMA_RST_Msk;
    SYS->IPRSTC2 &= ~(SYS_IPRSTC2_I2S_RST_Msk|SYS_IPRSTC2_ADC_RST_Msk
                   |SYS_IPRSTC2_USBD_RST_Msk|SYS_IPRSTC2_PS2_RST_Msk
                   |SYS_IPRSTC2_PWM03_RST_Msk|SYS_IPRSTC2_UART1_RST_Msk
                   |SYS_IPRSTC2_UART0_RST_Msk|SYS_IPRSTC2_SPI2_RST_Msk
                   |SYS_IPRSTC2_SPI1_RST_Msk|SYS_IPRSTC2_SPI0_RST_Msk
                   |SYS_IPRSTC2_I2C1_RST_Msk|SYS_IPRSTC2_I2C0_RST_Msk
                   |SYS_IPRSTC2_TMR3_RST_Msk|SYS_IPRSTC2_TMR2_RST_Msk
                   |SYS_IPRSTC2_TMR1_RST_Msk|SYS_IPRSTC2_TMR0_RST_Msk
                   |SYS_IPRSTC2_GPIO_RST_Msk);
```

```
    /* Remap vector table address to APP2 address */
    CLK->APBCLK |= CLK_AHBCLK_ISP_EN_Msk;
    FMC->ISPCON |= FMC_ISPCON_ISPEN_Msk;
    FMC->ISPCMD = FMC_ISPCMD_VECMAP;
    FMC->ISPADR = APP2_ADDR;
    FMC->ISPTRG |= FMC_ISPTRG_ISPGO_Msk;
```

重設堆疊指標與執行 APP2

```
    /* Set stack pointer to the value stored in APP2 address */
    pu32SP = (uint32_t *)APP2_ADDR;
    spChange(pu32SP);

    /* Execute another application */
    func = (FUNC_PTR *)(*(uint32_t *)(APP2_ADDR + 4));
    func();
```

2.2 APP2

打印訊息與閃爍 LED

```
    printf("/*****************************************************************/\n");
    printf("/***   NUC123 Change Vector Table Address Sample Code(App2)  ***/\n");
    printf("/*****************************************************************/\n");

    /* Set GPIO to output mode */
    GPIO_SetMode(PB, BIT4, GPIO_PMD_OUTPUT);

    /* Flashing LED */
    while(u8LEDFlashNum--)
    {
        PB4 = 0;
        for(i = 0; i < LED_TIME_LENGTH; i++);
        PB4 = 1;
        for(i = 0; i < LED_TIME_LENGTH; i++);
    }
```

初始化周邊 IPs 與重新映射位址

```
    /* Reset IPs */
    SYS->IPRSTC1 = SYS_IPRSTC1_PDMA_RST_Msk;
    SYS->IPRSTC2 = (SYS_IPRSTC2_I2S_RST_Msk|SYS_IPRSTC2_ADC_RST_Msk
                   |SYS_IPRSTC2_USBD_RST_Msk|SYS_IPRSTC2_PS2_RST_Msk
                   |SYS_IPRSTC2_PWM03_RST_Msk|SYS_IPRSTC2_UART1_RST_Msk
                   |SYS_IPRSTC2_UART0_RST_Msk|SYS_IPRSTC2_SPI2_RST_Msk
                   |SYS_IPRSTC2_SPI1_RST_Msk|SYS_IPRSTC2_SPI0_RST_Msk
                   |SYS_IPRSTC2_I2C1_RST_Msk|SYS_IPRSTC2_I2C0_RST_Msk
                   |SYS_IPRSTC2_TMR3_RST_Msk|SYS_IPRSTC2_TMR2_RST_Msk
                   |SYS_IPRSTC2_TMR1_RST_Msk|SYS_IPRSTC2_TMR0_RST_Msk
                   |SYS_IPRSTC2_GPIO_RST_Msk);
    SYS->IPRSTC1 &= ~SYS_IPRSTC1_PDMA_RST_Msk;
    SYS->IPRSTC2 &= ~(SYS_IPRSTC2_I2S_RST_Msk|SYS_IPRSTC2_ADC_RST_Msk
                   |SYS_IPRSTC2_USBD_RST_Msk|SYS_IPRSTC2_PS2_RST_Msk
                   |SYS_IPRSTC2_PWM03_RST_Msk|SYS_IPRSTC2_UART1_RST_Msk
                   |SYS_IPRSTC2_UART0_RST_Msk|SYS_IPRSTC2_SPI2_RST_Msk
                   |SYS_IPRSTC2_SPI1_RST_Msk|SYS_IPRSTC2_SPI0_RST_Msk
                   |SYS_IPRSTC2_I2C1_RST_Msk|SYS_IPRSTC2_I2C0_RST_Msk
                   |SYS_IPRSTC2_TMR3_RST_Msk|SYS_IPRSTC2_TMR2_RST_Msk
                   |SYS_IPRSTC2_TMR1_RST_Msk|SYS_IPRSTC2_TMR0_RST_Msk
                   |SYS_IPRSTC2_GPIO_RST_Msk);

    /* Remap vector table address to 0x0 */
    CLK->APBCLK |= CLK_AHBCLK_ISP_EN_Msk;
    FMC->ISPCON |= FMC_ISPCON_ISPEN_Msk;
    FMC->ISPCMD = FMC_ISPCMD_VECMAP;
    FMC->ISPADR = APP1_ADDR;
    FMC->ISPTRG |= FMC_ISPTRG_ISPGO_Msk;
```

重設堆疊指標與執行 APP1

```
    /* Set stack pointer to the value stored in APP1 address */
    pu32SP = (uint32_t *)APP1_ADDR;
    spChange(pu32SP);

    /* Execute another application */
    func = (FUNC_PTR *)(*(uint32_t *)(APP1_ADDR+ 4));
    func();
```

3 軟體與硬體環境

● 軟體環境

- ■ BSP 版本
  - ◆ NUC123 Series BSP CMSIS V3.01.001
- ■ IDE 版本
  - ◆ Keil uVersion 5.26
- ■ IDE 環境設定
  - ◆ APP1 linker (R/O Base: 0x00000000, R/W Base: 0x20000000)，如圖 3-1 所示

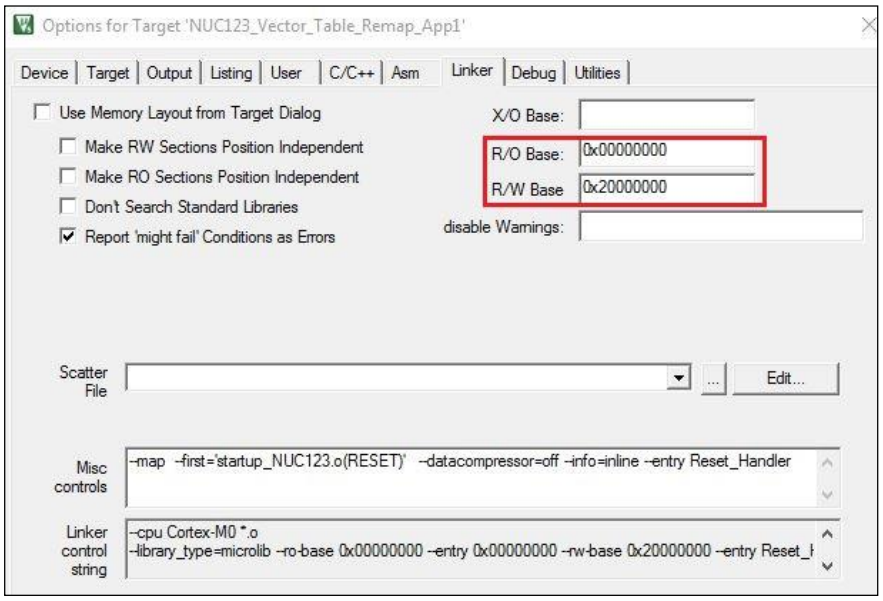

圖 3-1 APP1 linker setting

- APP2 linker (R/O Base: 0x00003000, R/W Base: 0x20000000)，如圖 3-2 所示

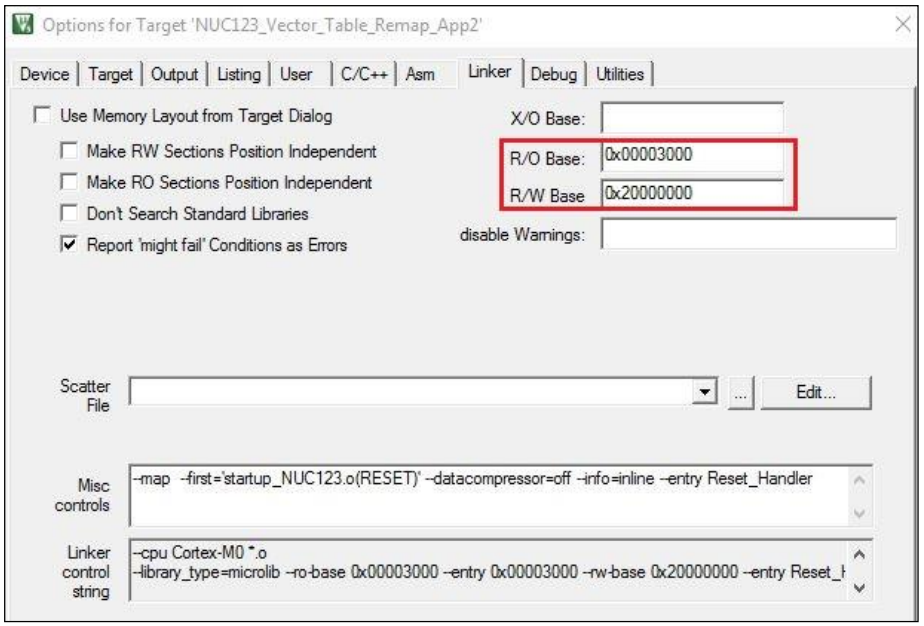

圖 3-2 APP2 linker setting

● 硬體環境

■ 電路元件

- NuTiny-EVB-123-LQFP64_V1.0

4 目錄資訊

- EC_NUC123_Vector_Table_Remap_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 NUC123_Vector_Table_Remap_App1.uvprojx
2. 進入編譯模式介面
   a. 編譯
   b. 下載代碼至記憶體
3. 雙擊 NUC123_Vector_Table_Remap_App2.uvprojx
4. 進入編譯模式介面
   c. 編譯
   d. 下載代碼至記憶體

6 修訂紀錄

Date	Revision	Description
Aug. 7, 2019	1.00	初始發布.

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