Application Note

HSI Frequency Adjustment

Introduction

This application note provides a frequency adjustment method for HSI, which is convenient for users to adjust the HSI frequency according to their specific requirements during regular operation.

This document is only applicable to Nsing MCU products. Currently, the supported product series include N32G43x series, N32L43x series, N32L40x series.

NSING Technologies Pte. Ltd.
Add: NSING, Teletech Park #02-28, 20 Science Park Road,
Singapore 117674
Tel: +65 69268090
Email: sales@nsing.com.sg

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NSING Technologies Pte. Ltd.
Add: NSING, Teletech Park #02-28, 20 Science Park Road,
Singapore 117674
Tel: +65 69268090
Email: sales@nsing.com.sg

1 Overview

The MCU provides a variety of clocks for users to choose, including an internal RC oscillator (HSI: high-speed internal oscillator of 16MHz). The HSI can be used as the system clock without any external components.

Voltage and temperature have an impact on the accuracy of RC oscillator in users' application scenario. The HSI frequency is adjusted by setting the afec_hsi_opt[24:16] bit in the TRIMR1 register. The HSI coarse trimming step is about 700kHz by setting afec_hsi_opt[24:21] bits, while the HSI fine trimming step is about 40kHz by setting afec_hsi_opt[20:16] bits.

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Add: NSING, Teletech Park #02-28, 20 Science Park Road, Singapore 117674
Tel: +65 69268090
Email: sales@nsing.com.sg

2 Operation Method

2.1 Parameter Definition

The following parameters are predefined:

```
/** hsi_opt_dec **/
#define     AFEC_HSI_OPT_NUM0       ((uint32_t)0x0<<21)
#define     AFEC_HSI_OPT_NUM1       ((uint32_t)0x1<<21)
#define     AFEC_HSI_OPT_NUM2       ((uint32_t)0x2<<21)
#define     AFEC_HSI_OPT_NUM3       ((uint32_t)0x3<<21)
#define     AFEC_HSI_OPT_NUM4       ((uint32_t)0x4<<21)
#define     AFEC_HSI_OPT_NUM5       ((uint32_t)0x5<<21)
#define     AFEC_HSI_OPT_NUM6       ((uint32_t)0x6<<21)
#define     AFEC_HSI_OPT_NUM7       ((uint32_t)0x7<<21)
#define     AFEC_HSI_OPT_NUM8       ((uint32_t)0x8<<21)     //default
#define     AFEC_HSI_OPT_NUM9       ((uint32_t)0x9<<21)
#define     AFEC_HSI_OPT_NUM10      ((uint32_t)0xA<<21)
#define     AFEC_HSI_OPT_NUM11      ((uint32_t)0xB<<21)
#define     AFEC_HSI_OPT_NUM12      ((uint32_t)0xC<<21)
#define     AFEC_HSI_OPT_NUM13      ((uint32_t)0xD<<21)
#define     AFEC_HSI_OPT_NUM14      ((uint32_t)0xE<<21)
#define     AFEC_HSI_OPT_NUM15      ((uint32_t)0xF<<21)

#define     IS_AFEC_HSI_OPT(NUM)                                                    \
          (((NUM) == AFEC_HSI_OPT_NUM0)   || ((NUM) == AFEC_HSI_OPT_NUM1)         \
          || ((NUM) == AFEC_HSI_OPT_NUM2)   || ((NUM) == AFEC_HSI_OPT_NUM3)       \
          || ((NUM) == AFEC_HSI_OPT_NUM4)   || ((NUM) == AFEC_HSI_OPT_NUM5)       \
          || ((NUM) == AFEC_HSI_OPT_NUM6)   || ((NUM) == AFEC_HSI_OPT_NUM7)       \
          || ((NUM) == AFEC_HSI_OPT_NUM8)   || ((NUM) == AFEC_HSI_OPT_NUM9)       \
          || ((NUM) == AFEC_HSI_OPT_NUM10)  || ((NUM) == AFEC_HSI_OPT_NUM11)      \
          || ((NUM) == AFEC_HSI_OPT_NUM12)  || ((NUM) == AFEC_HSI_OPT_NUM13)      \
          || ((NUM) == AFEC_HSI_OPT_NUM14)  || ((NUM) == AFEC_HSI_OPT_NUM15))
```

```
/** hsi_trim_dec **/
#define     AFEC_HSI_TRIM_NUM0      ((uint32_t)0x0<<16)
#define     AFEC_HSI_TRIM_NUM1      ((uint32_t)0x1<<16)
#define     AFEC_HSI_TRIM_NUM2      ((uint32_t)0x2<<16)
#define     AFEC_HSI_TRIM_NUM3      ((uint32_t)0x3<<16)
#define     AFEC_HSI_TRIM_NUM4      ((uint32_t)0x4<<16)
#define     AFEC_HSI_TRIM_NUM5      ((uint32_t)0x5<<16)     //default
#define     AFEC_HSI_TRIM_NUM6      ((uint32_t)0x6<<16)
#define     AFEC_HSI_TRIM_NUM7      ((uint32_t)0x7<<16)
#define     AFEC_HSI_TRIM_NUM8      ((uint32_t)0x8<<16)
```


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Singapore 117674
Tel: +65 69268090
Email: sales@nsing.com.sg

```
#define     AFEC_HSI_TRIM_NUM9      ((uint32_t)0x9<<16)
#define     AFEC_HSI_TRIM_NUM10     ((uint32_t)0xA<<16)
#define     AFEC_HSI_TRIM_NUM11     ((uint32_t)0xB<<16)
#define     AFEC_HSI_TRIM_NUM12     ((uint32_t)0xC<<16)
#define     AFEC_HSI_TRIM_NUM13     ((uint32_t)0xD<<16)
#define     AFEC_HSI_TRIM_NUM14     ((uint32_t)0xE<<16)
#define     AFEC_HSI_TRIM_NUM15     ((uint32_t)0xF<<16)
#define     AFEC_HSI_TRIM_NUM16     ((uint32_t)0x10<<16)
#define     AFEC_HSI_TRIM_NUM17     ((uint32_t)0x11<<16)
#define     AFEC_HSI_TRIM_NUM18     ((uint32_t)0x12<<16)
#define     AFEC_HSI_TRIM_NUM19     ((uint32_t)0x13<<16)
#define     AFEC_HSI_TRIM_NUM20     ((uint32_t)0x14<<16)
#define     AFEC_HSI_TRIM_NUM21     ((uint32_t)0x15<<16)
#define     AFEC_HSI_TRIM_NUM22     ((uint32_t)0x16<<16)
#define     AFEC_HSI_TRIM_NUM23     ((uint32_t)0x17<<16)
#define     AFEC_HSI_TRIM_NUM24     ((uint32_t)0x18<<16)
#define     AFEC_HSI_TRIM_NUM25     ((uint32_t)0x19<<16)
#define     AFEC_HSI_TRIM_NUM26     ((uint32_t)0x1A<<16)
#define     AFEC_HSI_TRIM_NUM27     ((uint32_t)0x1B<<16)
#define     AFEC_HSI_TRIM_NUM28     ((uint32_t)0x1C<<16)
#define     AFEC_HSI_TRIM_NUM29     ((uint32_t)0x1D<<16)
#define     AFEC_HSI_TRIM_NUM30     ((uint32_t)0x1E<<16)
#define     AFEC_HSI_TRIM_NUM31     ((uint32_t)0x1F<<16)

#define     IS_AFEC_HSI_TRIM(NUM)                                                   \
          (((NUM) == AFEC_HSI_TRIM_NUM0)    || ((NUM) == AFEC_HSI_TRIM_NUM1)    \
        || ((NUM) == AFEC_HSI_TRIM_NUM2)    || ((NUM) == AFEC_HSI_TRIM_NUM3)    \
        || ((NUM) == AFEC_HSI_TRIM_NUM4)    || ((NUM) == AFEC_HSI_TRIM_NUM5)    \
        || ((NUM) == AFEC_HSI_TRIM_NUM6)    || ((NUM) == AFEC_HSI_TRIM_NUM7)    \
        || ((NUM) == AFEC_HSI_TRIM_NUM8)    || ((NUM) == AFEC_HSI_TRIM_NUM9)    \
        || ((NUM) == AFEC_HSI_TRIM_NUM10)   || ((NUM) == AFEC_HSI_TRIM_NUM11)   \
        || ((NUM) == AFEC_HSI_TRIM_NUM12)   || ((NUM) == AFEC_HSI_TRIM_NUM13)   \
        || ((NUM) == AFEC_HSI_TRIM_NUM14)   || ((NUM) == AFEC_HSI_TRIM_NUM15)   \
        || ((NUM) == AFEC_HSI_TRIM_NUM16)   || ((NUM) == AFEC_HSI_TRIM_NUM17)   \
        || ((NUM) == AFEC_HSI_TRIM_NUM18)   || ((NUM) == AFEC_HSI_TRIM_NUM19)   \
        || ((NUM) == AFEC_HSI_TRIM_NUM20)   || ((NUM) == AFEC_HSI_TRIM_NUM21)   \
        || ((NUM) == AFEC_HSI_TRIM_NUM22)   || ((NUM) == AFEC_HSI_TRIM_NUM23)   \
        || ((NUM) == AFEC_HSI_TRIM_NUM24)   || ((NUM) == AFEC_HSI_TRIM_NUM25)   \
        || ((NUM) == AFEC_HSI_TRIM_NUM26)   || ((NUM) == AFEC_HSI_TRIM_NUM27)   \
        || ((NUM) == AFEC_HSI_TRIM_NUM28)   || ((NUM) == AFEC_HSI_TRIM_NUM29)   \
        || ((NUM) == AFEC_HSI_TRIM_NUM30)   || ((NUM) == AFEC_HSI_TRIM_NUM31))
```


NSING Technologies Pte. Ltd.
Add: NSING, Teletech Park #02-28, 20 Science Park Road, Singapore 117674
Tel: +65 69268090
Email: sales@nsing.com.sg

2.2 Method of Use

2.2.1 API Functions

Call the following API function, and the MCU sets the TRIM1[24:16] bits to calibrate the frequency of the internal RC oscillator HSI.

```
void AFEC_ConfigHSITrim(uint32_t HSI_OPT, uint32_t HSI_TRIM)
{
    uint32_t tmpregister = 0;

    /* Check the parameters */
    assert_param(IS_AFEC_HSI_OPT(HSI_OPT));
    assert_param(IS_AFEC_HSI_TRIM(HSI_TRIM));

    tmpregister = AFEC->TRIMR1;

    /* Clear OPT and TRIM[24:16] bits */
    tmpregister &= ((uint32_t)0xFE00FFFF);

    /* Set OPT[24:21] bits according to AFEC_HSI_OPT value */
    tmpregister |= HSI_OPT;

    /* Set OPT[20:16] bits according to AFEC_HSI_TRIM value */
    tmpregister |= HSI_TRIM;

    /* Store the new value */
    AFEC->TRIMR1 = tmpregister;
}
```

2.2.2 System Clock Setting

Refer to the following function, you can set the system clock to 16MHz with using HSI as system clock source.

```
void SetSysClockToHSI(void)
{
    uint32_t msi_ready_flag = RESET;

    RCC_EnableHsi(ENABLE);

    /* Wait till HSI is ready */
    HSIStartUpStatus = RCC_WaitHsiStable();

    if (HSIStartUpStatus == SUCCESS)
    {
```


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Singapore 117674
Tel: +65 69268090
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```
    /* Enable Prefetch Buffer */
    FLASH_PrefetchBufSet(FLASH_PrefetchBuf_EN);

    if(((*(__IO uint8_t*)((UCID_BASE + 0x2))) == 0x01)
    || ((*(__IO uint8_t*)((UCID_BASE + 0x2))) == 0x11)
    || ((*(__IO uint8_t*)((UCID_BASE + 0x2))) == 0xFF))
    {
        /* Cheak if MSI is Ready */
        if(RESET == RCC_GetFlagStatus(RCC_CTRLSTS_FLAG_MSIRD))
        {
            /* Enable MSI and Config Clock */
            RCC_ConfigMsi(RCC_MSI_ENABLE, RCC_MSI_RANGE_4M);
            /* Waits for MSI start-up */
            while(SUCCESS != RCC_WaitMsiStable());

            msi_ready_flag = SET;
        }
        /* Select MSI as system clock source */
        RCC_ConfigSysclk(RCC_SYSCLK_SRC_MSI);

        /* Disable PLL */
        RCC_EnablePll(DISABLE);

        RCC_ConfigPll(RCC_PLL_HSI_PRE_DIV2, RCC_PLL_MUL_2, RCC_PLLDIVCLK_DISABLE);

        /* Enable PLL */
        RCC_EnablePll(ENABLE);

        /* Wait till PLL is ready */
        while (RCC_GetFlagStatus(RCC_CTRL_FLAG_PLLRDF) == RESET);

        /* Select PLL as system clock source */
        RCC_ConfigSysclk(RCC_SYSCLK_SRC_PLLCLK);

        /* Wait till PLL is used as system clock source */
        while (RCC_GetSysclkSrc() != 0x0C);

        if(msi_ready_flag == SET)
        {
            /* MSI oscillator OFF */
            RCC_ConfigMsi(RCC_MSI_DISABLE, RCC_MSI_RANGE_4M);
        }
    }
    else
```


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Singapore 117674
Tel: +65 69268090
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```
        {
            /* Select HSI as system clock source */
            RCC_ConfigSysclk(RCC_SYSCLK_SRC_HSI);

            /* Wait till HSI is used as system clock source */
            while (RCC_GetSysclkSrc() != 0x04)
            {
            }
        }

        /* Flash 0 wait state */
        FLASH_SetLatency(FLASH_LATENCY_0);

        /* HCLK = SYSCLK */
        RCC_ConfigHclk(RCC_SYSCLK_DIV1);

        /* PCLK2 = HCLK */
        RCC_ConfigPclk2(RCC_HCLK_DIV1);

        /* PCLK1 = HCLK */
        RCC_ConfigPclk1(RCC_HCLK_DIV1);
    }
    else
    {
        /* If HSI fails to start-up, the application will have wrong clock configuration.
            User can add here some code to deal with this error */

        /* Go to infinite loop */
        while (1)
        {
        }
    }
}
```

2.3 Application Example

Please refer to the application note example RCC_HSIClockTrim, which demonstrates how to adjust the HSI frequency. You can visualize the frequency changes on oscilloscope while HSI frequency is being measured.

NSING Technologies Pte. Ltd.
Add: NSING, Teletech Park #02-28, 20 Science Park Road,
Singapore 117674
Tel: +65 69268090
Email: sales@nsing.com.sg

3 Version History

Version	Date	Changes
V1.0	2021.06.10	Initial version

NSING Technologies Pte. Ltd.
Add: NSING, Teletech Park #02-28, 20 Science Park Road,
Singapore 117674
Tel: +65 69268090
Email: sales@nsing.com.sg

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Tel: +65 69268090
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