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R8C/11、 R8C/13群

应用商用频率的高速内部振荡器频率的调整

1. 概要

本资料说明了通过商用频率 （50Hz/60Hz）来调整高速内部振荡器频率的程序。

2. 前言

本资料中说明的应用例，适合以下单片机在下列条件下使用。

- 单片机 ：R8C/11、 R8C/13群
- RAM容量、 ROM容量 ：1K字节/16K字节

和R8C/11群有相同的SFR（外围设备控制寄存器）的其它的R8C/Tiny系列也可以使用本程序。但有时会因增加一部分功能等而有所改变,所以必须通过手册进行确认。在使用本应用说明时必须进行充分的评价。

目录

3. 应用例的说明

3.1 高速内部振荡器的概要

R8C/11 群搭载约 8MHz 的高速内部振荡器。内部振荡器由于工作温度、电源电压等外部因素，工作频率产生变化。可通过设定 HR1 寄存器调整频率。

HR1 寄存器的值和高速内部振荡器的周期的关系如下。但因各个位的延迟量不完全相同，所以必须进行调整以使各个位发生变化。另外，必须将 bit7 清 “0”。

$$\text{高速内部振荡器的周期} = td(HRoffset)+(b6+ \frac{b5}{2} + \frac{b4}{4} + \frac{b3}{8} + \frac{b2}{16} + \frac{b1}{32} + \frac{b0}{64}) \times td(HR)$$

在本应用说明中对使用商用频率 （50MHz/60MHz）的高速内部振荡器进行频率调整。

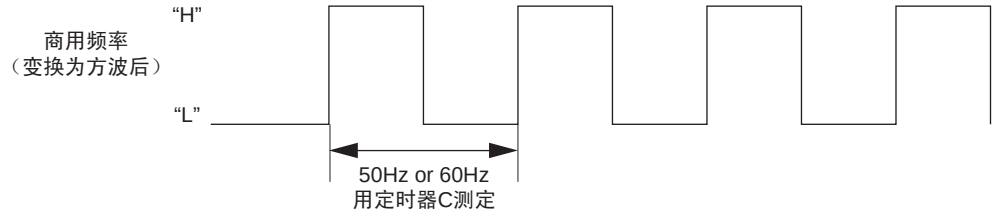
3.2 程序概要

使用商用频率调整高速内部振荡器频率的方法如下所示。

通过将高速内部振荡器作为计数源的定时器C来测定商用频率。为使测定值和理论值匹配，通过调整HR1寄存器，将高速内部振荡器的频率调至8MHz。

理论值可用如下公式求出。

$$\text{定时器C测定的理论值} = \frac{\text{高速内部振荡器的预期频率}}{\text{商用频率} \times \text{高速内部振荡器的分频比}}$$



将高速内部振荡器调整为8MHz时测定的理论值

商用频率	理论值	
	无分频	8分频
50Hz	160000	20000
60Hz	133333	16667

图1 商用频率测定

HR1寄存器的调整率 （向HR1寄存器写00h时和写01h时的周期的差）为1ns。 HR1寄存器设定为n时的频率可调整为8MHz的情况下，此时HR1的设定值和定时器C的测定值的关系如**表1**所示。

表1 HR1的设定值和定时器C的测定值

HR1的设定值	高速内部振荡器振荡		定时器C的测定值 （60Hz测定时）	
	周期	频率	无分频	8分频
n–2	123ns	8.13MHz	135501	16938
n–1	124ns	8.06MHz	134409	16801
n	125ns	8.00MHz	133333	16667
n+1	126ns	7.94MHz	132275	16534
n+2	127ns	7.87MHz	131234	16404

在本应用说明中，定时器C采用8分频，并将测定结果除以100后和理论值 （166）进行比较。当测定结果和理论值匹配时，频率为7.97MHz（定时器C的测定值为16600时）～8.02MHz（定时器C的测定值为16699时）。

初始运行时，进行高速内部振荡器的调整，并将设定值保存到闪存ROM。要避免保存的地址和程序配置块的匹配。样本程序的存储器映像图如**图2**所示。

在下一次之后 （保存HR1的调整值后）的运行时，从数据闪存读出HR1寄存器的初始值，并进行设定。此后，每检测到一次商用频率的上升沿就进行一次微调。

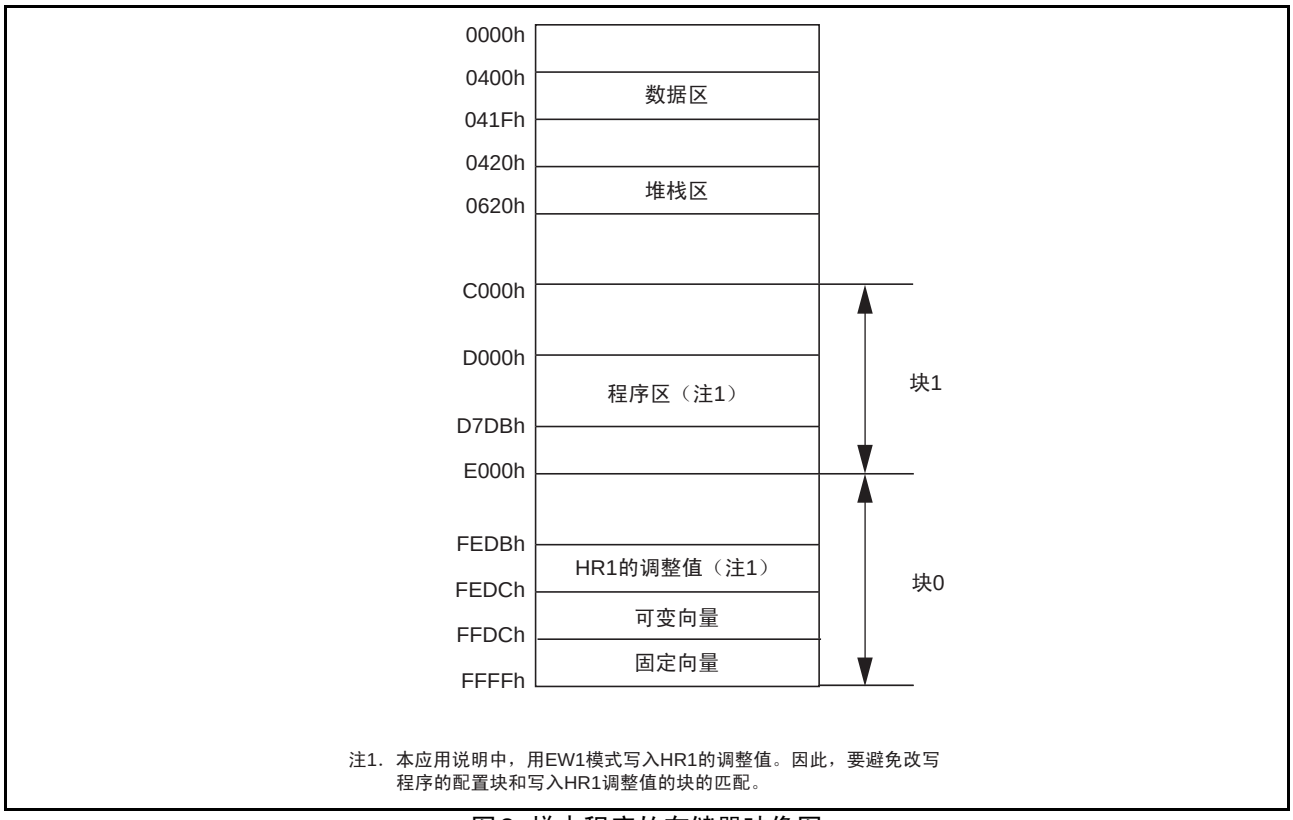


图2 样本程序的存储器映像图

3.3 使用引脚

表2 使用引脚和功能

引脚名	输入/输出	功能
P3$_3$/$\overline{\text{INT3}}$/TC$_{IN}$	输入	商用频率 （方波）的输入

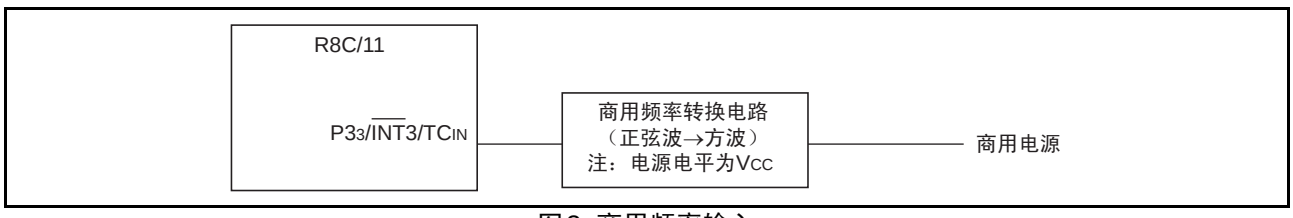


图3 商用频率输入

4. 函数表和流程图

4.1 函数表

声明	void main(void)		
概要	主函数		
参数	参数名		意义
	无		
返回值	类型	值	意义
	无		
功能说明	进行SFR的初始设定和LOOP处理		

声明	void sfr_init(void)		
概要	SFR初始化函数		
参数	参数名		意义
	无		
返回值	类型	值	意义
	无		
功能说明	进行SFR的初始设定		

声明	void first_hz_adjut(void)		
概要	初始频率调整函数		
参数	参数名		意义
	无		
返回值	类型	值	意义
	无		
功能说明	初始启动时，进行高速内部振荡器的调整		

声明	void write_ringadjust_data(unsigned char data)		
概要	频率调整值写入函数		
参数	参数名		意义
	unsigned char data		调整值
返回值	类型	值	意义
	无		
功能说明	将HR1寄存器的调整值写入闪存ROM		

声明	void flash_open_ew1_mode(void)		
概要	EW1 模式转移函数		
参数	参数名		意义
	无		
返回值	类型	值	意义
	无		
功能说明	使CPU改写模式 （EW1模式）变为有效。		

声明	void flash_close_ew1_mode(void)		
概要	EW1 模式解除函数		
参数	参数名		意义
	无		
返回值	类型	值	意义
	无		
功能说明	使CPU改写模式无效		

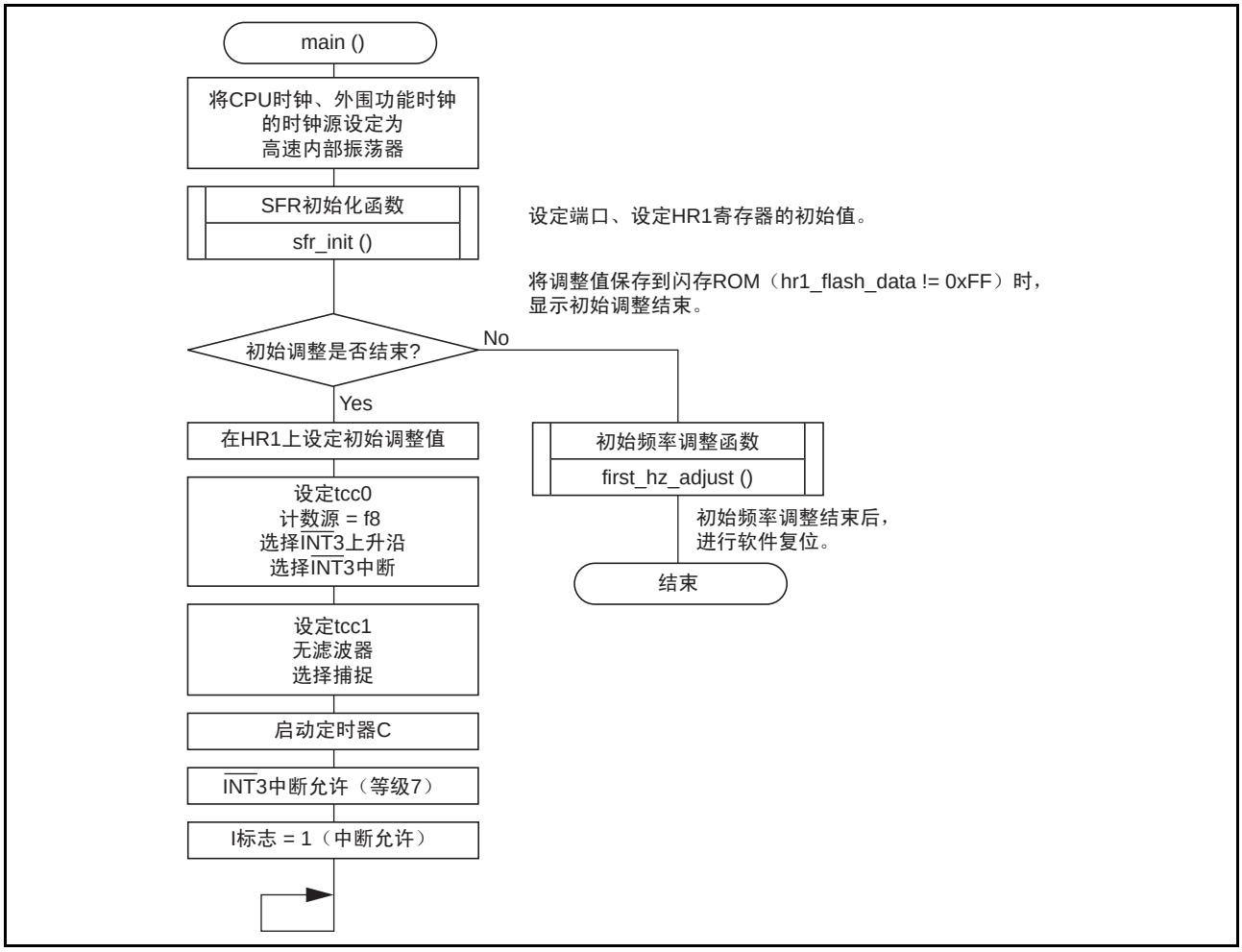
声明	int flash_byte_write(unsigned char *address , unsigned char data)		
概要	闪存写入函数		
参数	参数名		意义
	unsigned char *address		写入地址
	unsigned char data		写入数据
返回值	类型	值	意义
	int	chk_flash_status( )	闪存写入状态
功能说明	向写入地址 （*address）写入1字节的数据 （data）。		

声明	int chk_flash_status(void)		
概要	全状态检查函数		
参数	参数名		意义
	无		
返回值	类型	值	意义
	int	chk_flash_status( )	闪存改写状态
功能说明	进行全状态检查，返回闪存改写状态 （正常退出、命令顺序错误、擦除错误、编程错误）。		

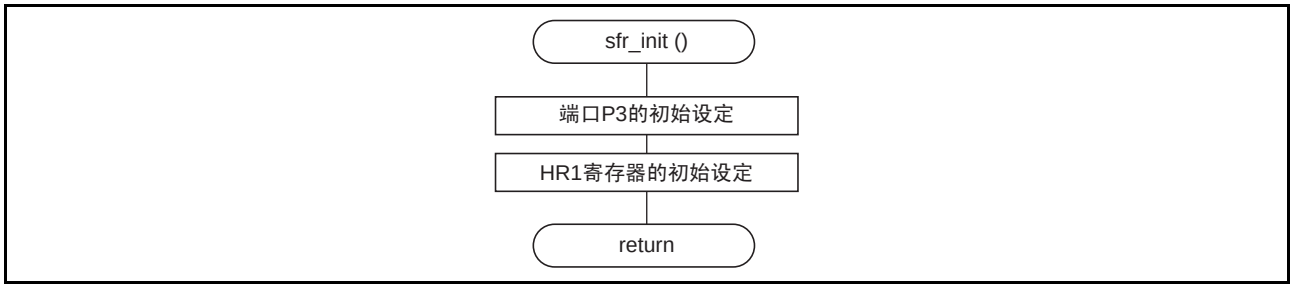
声明	void int3_hz_in(void)		
概要	高速内部振荡器调整函数 （INT3中断函数）		
参数	参数名		意义
	无		
返回值	类型	值	意义
	无		
功能说明	当检测到$\overline{\text{INT3}}$/TCIN引脚的下降沿时进行中断处理。 通过定时器C的测定值进行高速内部振荡器的调整。		

4.2 流程图

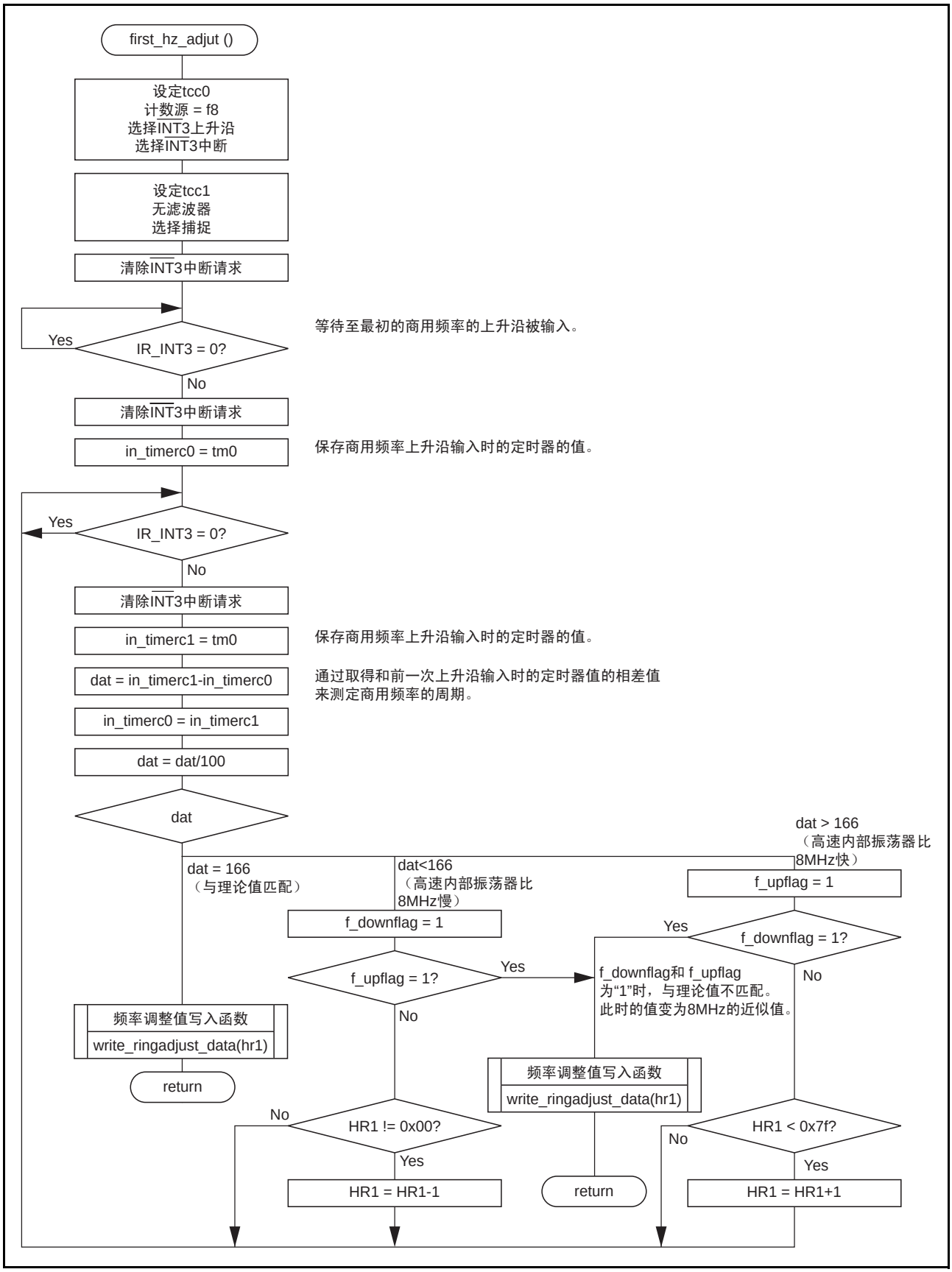
4.2.1 主函数



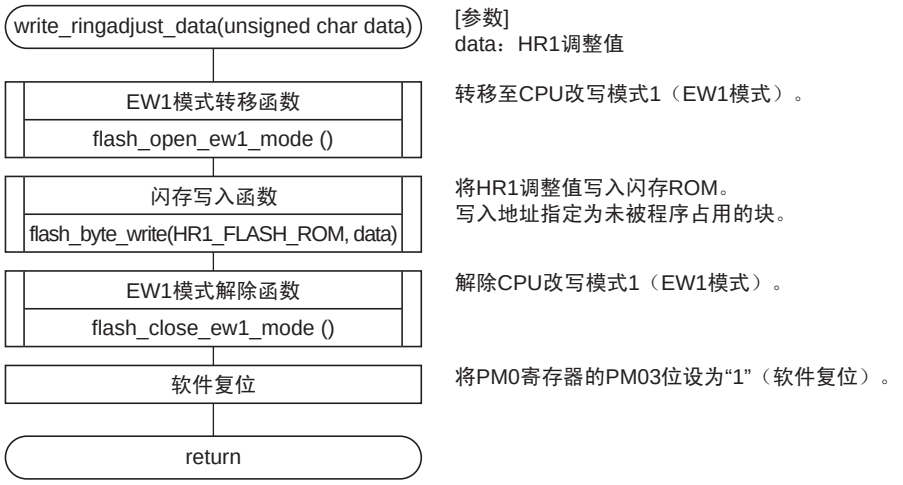
4.2.2 SFR初始化函数



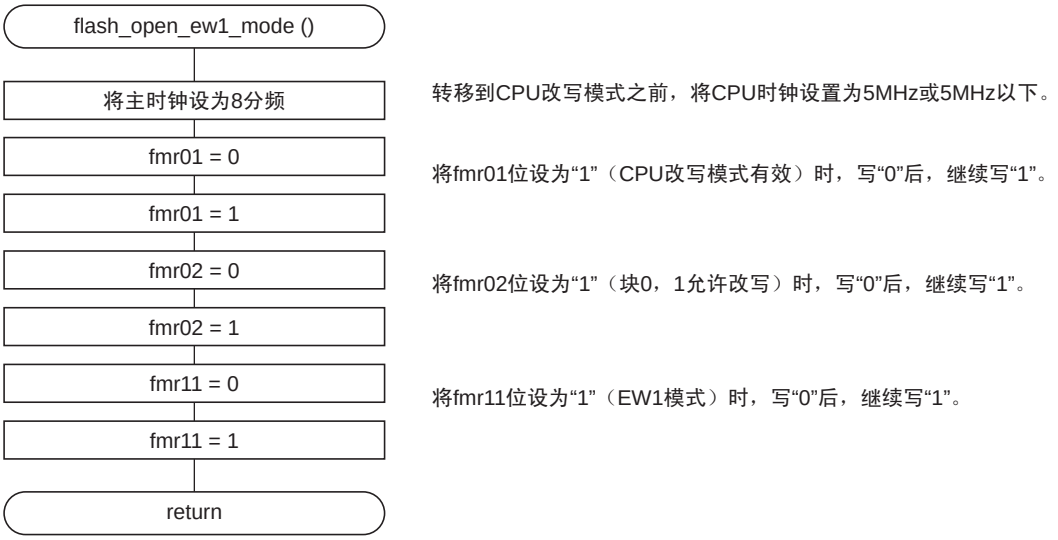
4.2.3 初始频率调整函数



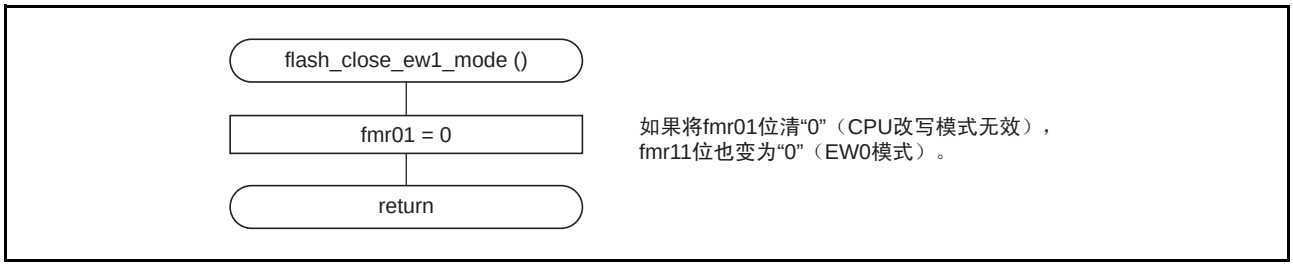
4.2.4 周期频率调整值写入函数



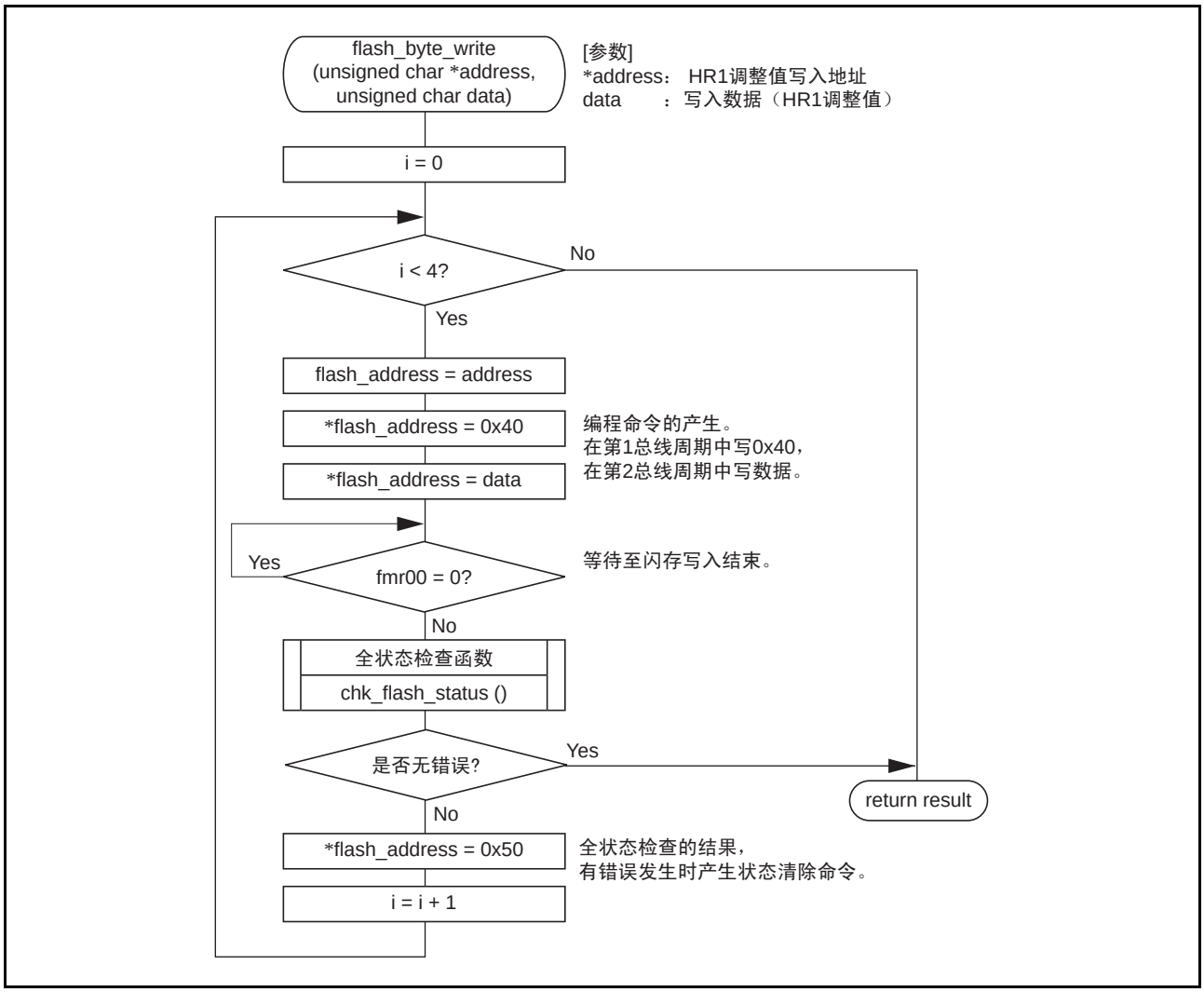
4.2.5 EW1 模式转移函数



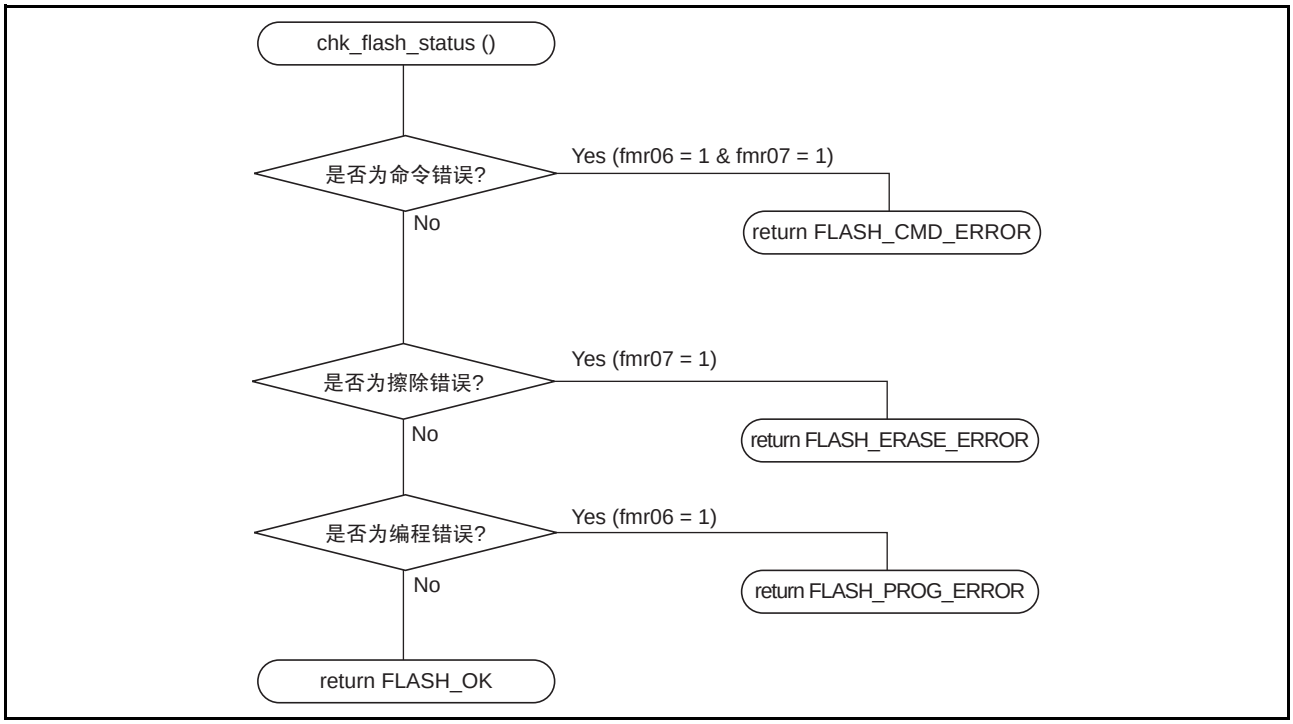
4.2.6 EW1 模式解除函数



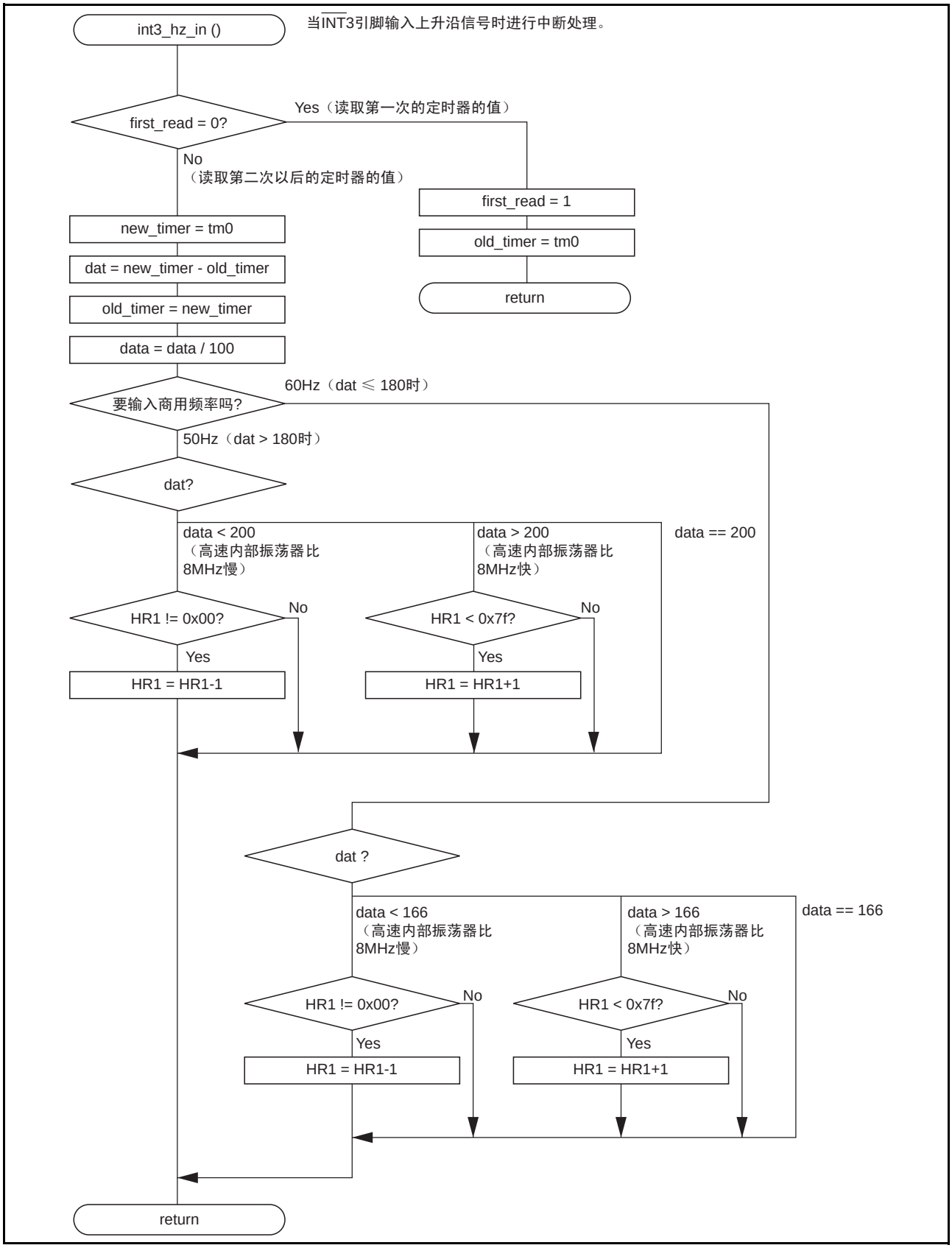
4.2.7 闪存写入函数



4.2.8 全状态检查函数


chk_flash_status ()
是否为命令错误?
Yes (fmr06 = 1 & fmr07 = 1)
return FLASH_CMD_ERROR
No
是否为擦除错误?
Yes (fmr07 = 1)
return FLASH_ERASE_ERROR
No
是否为编程错误?
Yes (fmr06 = 1)
return FLASH_PROG_ERROR
No
return FLASH_OK

4.2.9 高速内部振荡器调整函数 （INT3中断函数）



5. 参考程序例

样本程序如下所示。

```
/***********************************************************************************************
*                                                                                              *
*   File Name      : main.c                                                                    *
*   Contents       : Main program of High frequency judgement R8C/11 Group                     *
*   Copyright, 2004 RENESAS TECHNOLOGY CORPORATION                                             *
*                     AND RENESAS SOLUTIONS CORPORATION                                        *
*                           All rights reserved                                                *
*   Version        : 1.00                                                                      *
***********************************************************************************************/
/***********************************
*   include file              *
***********************************/
#include "sfr_r811.h"                /* Definition of the R8C/11 SFR */
#include "sfr_r811_flash.h"          /* Definition of the R8C/11 flash SFR  */

/***********************************
*    prototype definition    *
***********************************/
void sfr_init(void);
void first_hz_adjut(void);
void write_ringadjust_data(unsigned char);
void flash_open_ew1_mode(void);
void flash_close_ew1_mode(void);
int flash_byte_write(unsigned char * , unsigned char);
int chk_flash_status(void);

/***********************************
*   global label              *
***********************************/
unsigned int in_timerc0;                        /* input_timerc loading0 */
unsigned int in_timerc1;                        /* input_timerc loading1 */
unsigned int dat;                               /* frequency */
unsigned int old_timer;                         /* input_timerc old loading */
unsigned int new_timer;                         /* input_timerc new loading */

union byte_def cnt_flag;
#define f_downflag cnt_flag.bit.b0              /* Hz under flag */
#define f_upflag cnt_flag.bit.b1                /* Hz over flag */
#define HR1_FLASH_ROM ((unsigned char *)0xfedb)  /* hr1 adjust data store rom address */
/***********************************
*   macro definition          *
***********************************/
enum{
    FLASH_OK,
    FLASH_CMD_ERROR,
    FLASH_ERASE_ERROR,
    FLASH_PROG_ERROR
};
/***********************************************************************************************
Name:           main
Parameters:     None
Returns:        None
Description:    High frequency judgement
***********************************************************************************************/
main() {
    /* Setting system clock */
    prc0 = 1;                                   /* Protect off */
    cm06 = 1;
    cm16 = 0;
    cm17 = 0;                                   /* 1/1 */
    hr00 = 1;                                   /* On-chip oscillator on */
    asm("nop");                                 /* waiting */
    asm("nop");
    asm("nop");
    hr01 = 1;
    cm06 = 0;                                   /* 1/8 */
    prc0 = 0;                                   /* Protect on */
```

```
    asm("FCLR I");                              /* Interrupt disable */

    sfr_init();                                 /* Initial setting of SFR registers */

    /* Confirm Adjusting */
    if (*HR1_FLASH_ROM == 0xff){
        first_hz_adjut();

    }else{
    /*  Setting high-speed on-chip oscillator control register1 */
        prc0 = 1;                               /* Protect off */
        hr1 = *HR1_FLASH_ROM;                   /* Loading adjust data for flash rom */
        prc0 = 0;                               /* Protect on */

    /* Setting timer C inputcapture */
        tcc0 = 0x02;                            /* Setting timer C control register0 */
        tcc1 = 0x00;                            /* Setting timer C control register1 */
        tcc00 = 1;                          /* Timer C start */
        int3ic = 0x07;                          /* interrupt level 7 */
        asm("FSET I");                      /* Interrupt enable */

        while(1){
            /* main loop */
        }
    }
}

/************************************************************************************************
Name:           sfr_init
Parameters:     None
Returns:        None
Description:    Initial setting of SFR registers
************************************************************************************************/
void sfr_init(void){

    /* Setting port registers */
    p3_3 = 0;
    /* Setting port direction registers */
    pd3_3 = 0;                                  /* INT3 pin input */

    /* High-speed on-chip oscillator control register1 */
    prc0 = 1;                                   /* Protect off */
    hr1 = 0x40;
    prc0 = 0;                                   /* Protect on */

}
/************************************************************************************************
Name:           first_hz_adjut
Parameters:     None
Returns:        None
Description:    The first high frequency judgement
************************************************************************************************/
void first_hz_adjut(void){

/* Setting timer C inputcapture */
    tcc0 = 0x02;                                /* Setting timer C control register0 */
    tcc1 = 0x00;                                /* Setting timer C control register1 */
    tcc00 = 1;                                  /* Timer C start */

    ir_int3ic = 0;                              /* INT3 interrupt request clear */

    /* First frequency measure */
    while (ir_int3ic == 0);                     /* Int3 upedge */

    ir_int3ic = 0;
    in_timerc0 = tm0;                           /* Loading timerC */
```

```
    while(1){
        /* Second frequency measure */
        while (ir_int3ic == 0);                 /* int3 upedge */
            ir_int3ic = 0;
            in_timerc1 = tm0;                   /* loading timerC */

            dat = in_timerc1 - in_timerc0;      /* Calculate palse width */
            in_timerc0 = in_timerc1;
            dat = dat / 100;

    /* 60Hz judgement */
        /* Equal to 60Hz */
        if (dat == 166){
            /* flash write & software reset */
            write_ringadjust_data(hr1);
            return;

    /* More than 60Hz */
    }else if (dat < 166){
        f_downflag = 1;
        if (f_upflag == 1){
            /* flash write & software reset */
            write_ringadjust_data(hr1);
            return;
        }
        if (hr1 != 0x00){               /* Minimum of high-speed on-chip oscillator register1 */
            prc0 = 1;                       /* Protect off */
            --hr1;                         /* Sub high-speed on-chip oscillator register1 */
            prc0 = 0;                      /* Protect on */
        }

        /* Less than 60Hz */
        }else if (dat > 166){
            f_upflag = 1;
            if (f_downflag == 1){
                /* flash write & software reset */
                write_ringadjust_data(hr1);
                return;
            }
            if (hr1 < 0x7f){            /* Maximum of high-speed on-chip oscillator register1 */
                prc0 = 1;               /* Protect off */
                ++hr1;                  /* Add high-speed on-chip oscillator register1 */
                prc0 = 0;               /* Protect on */
            }
        }
    }
}

/***********************************************************************************************
Name:           write_ringadjust_data
Parameters:     Adjust data
Returns:        None
Description:    Software reset after flash writing
***********************************************************************************************/
void write_ringadjust_data(unsigned char data){

    /* Starting of flash write mode */
    flash_open_ew1_mode();

    /* Write a high-speed on-chip oscillator register1 adjusted data ( Retry is  4 times ) */
    flash_byte_write(HR1_FLASH_ROM,  data);
    /* Finishing of flash write mode */
    flash_close_ew1_mode();

    /* Software reset */
    prc1 = 1;
    pm03 = 1;
    prc1 = 0;
}
```

```
/***********************************************************************************************
Name:           flash_open_ew1_mode
Parameters:     None
Returns:        None
Description:    Open Flash write mode
***********************************************************************************************/
void flash_open_ew1_mode(void){

    /* Slow down cpu clock */
    prc0 = 1;
    cm06 = 1;
    prc0 = 0;

    /* Set flash write enable */
    fmr01 = 0;
    fmr01 = 1;                              /* CPU writing mode */

    fmr02 = 0;
    fmr02 = 1;                              /* writing permission */

    fmr11 = 0;                              /* EW1 mode */
    fmr11 = 1;
}

/***********************************************************************************************
Name:           flash_close_mode
Parameters:     None
Returns:        None
Description:    End of flash write mode
***********************************************************************************************/
void flash_close_ew1_mode(void){

    /* Reset flash write enable */
    fmr01 = 0;
}

/***********************************************************************************************
Name:           flash_byte_write
Parameters:     Write Address, Write Data
Returns:        flash status
Description:    Write byte data to Flash
***********************************************************************************************/
int flash_byte_write(unsigned char *address , unsigned char data){

unsigned char *flash_address;
unsigned char i;
unsigned int result;

    /* Retry 4 times */
    for ( i = 0 ; i < 4 ; ++i ){

        /* Set write address */
        flash_address = address;

        /* Set program mode */
        *flash_address = 0x40;

        /* Write data */
        *flash_address = data;

        /* Finishing data */
        while(fmr00 == 0);

        /* Full status check */
        result = chk_flash_status();
        if( result == FLASH_OK)  break;

        /* Clear status */
        *flash_address = 0x50;
    }
    return result;
}
```

```
/***********************************************************************************************
Name:           chk_flash_status
Parameters:     None
Returns:        flash status
Description:    Check a flash full status
***********************************************************************************************/
int chk_flash_status(void){
    /* Check of Command error */
    if (fmr06 == 1 && fmr07 == 1) return(FLASH_CMD_ERROR);

    /* Check erase error */
    if (fmr07 == 1)          return(FLASH_ERASE_ERROR);

    /* Check of program error */
    if (fmr06 == 1)          return(FLASH_PROG_ERROR);

    return(FLASH_OK);
}

/***********************************************************************************************
Name:           int3_hz_in
Parameters:     None
Returns:        None
Description:    measurement of Int3
***********************************************************************************************/
#pragma INTERRUPT int3_hz_in
void int3_hz_in(void){
    static char first_read = 0;

    if(first_read == 0){
        /* First capture */
        first_read = 1;
        old_timer = tm0;
        return;
    }
    /* First frequency measure */
    new_timer = tm0;                        /* loading timerC */

    dat = new_timer - old_timer;            /* Calculate palse width */
    old_timer = new_timer;
    dat = dat / 100;

    /* 55Hz judgement */
    if (dat > 180){
        /* 50Hz judgement */
        /* Equal to 50Hz */
        if (dat == 200){

        /* More than 50Hz */
        }else if (dat < 200){
            if (hr1 != 0x00){           /* Minimum of high-speed on-chip oscillator register1 */
                prc0 = 1;               /* Protect off */
                --hr1;                  /* Sub high-speed on-chip oscillator register1 */
                prc0 = 0;               /* Protect on */
            }
        /* Less than 50Hz */
        }else if (dat > 200){
            if (hr1 < 0x7f){            /* Maximum of high-speed on-chip oscillator register1 */
                prc0 = 1;               /* Protect off */
                ++hr1;                  /* Add high-speed on-chip oscillator register1 */
                prc0 = 0;               /* Protect on */
            }
        }
    }else{
```

```
        /* 60Hz judgement */
        /* Equal to 60Hz */
        if (dat == 166){

        /* More than 60Hz */
        }else if (dat < 166){
            if (hr1 != 0x00){
                prc0 = 1;                   /* Protect off */
                ++hr1;                      /* Add high-speed on-chip oscillator register1 */
                prc0 = 0;                   /* Protect on */
            }

        /* Less than 60Hz */
        }else if (dat > 166){
            if (hr1 < 0x7f){
                prc0 = 1;                   /* Protect off */
                ++hr1;                      /* Add high-speed on-chip oscillator register1 */
                prc0 = 0;                   /* Protect on */
            }
        }
    }
}
```

6. 参考文档

硬件手册

R8C/11 群硬件手册

（最新版请从瑞萨科技公司主页获取。）

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