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H8/300H Tiny Series

Entering Low Power Consumption Mode (H8/3687)

Introduction

The switching function for low power consumption modes of the H8/3687 Group products allows the user to choose from among five different modes: active, sub-active, sleep, sub-sleep, and standby.

Target Device

H8/3687

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2. Configuration 2
3. Sample Program 3
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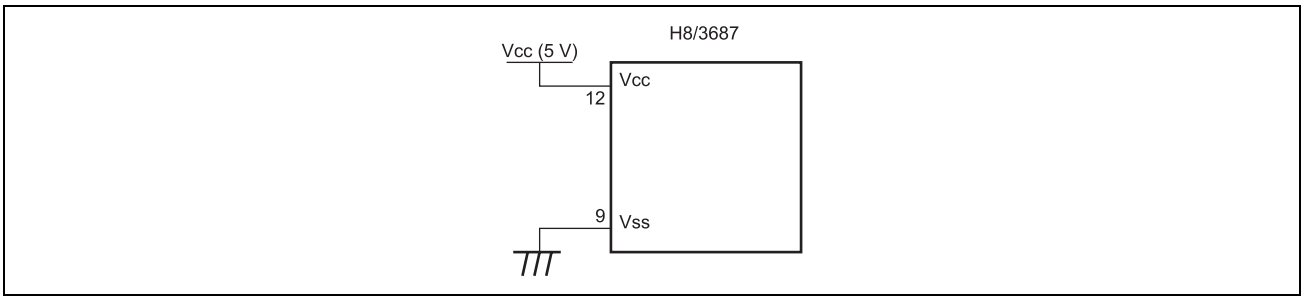
1. Overview

By means of a function for switching between H8/3687 low power consumption modes, switching between active, sub-active, sleep, sub-sleep, and standby modes is performed.

2. Configuration



Specifications

H8/3687 operating frequency: 16 MHz

3. Sample Program

3.1 Functions

- Direct transitions are made into active and sub-active modes.
- Transitions are made into sleep, sub-sleep, and standby modes. Interrupts are used to return to active and sub-active modes at the specified operating frequency.

3.2 Program incorporation

- Sample program 2-A
  Incorporate #define directives.
- Sample program 2-B
  Incorporate prototype declarations.
- Sample program 2-C
  Add the sample program 2-C as the common routine.

3.3 Modifications to sample programs

Without modifications to the sample program, the system may not run. Modifications must be made according to the customer's program and system environment.

- By using a file with definitions of IO register structures which can be obtained free of charge from the Renesas web site, the sample program can be used without further changes. When creating definitions independently, the customer should modify the IO register structures used in the sample program as appropriate.

3.4 Method of use

- The operating frequency is changed.

```
com_frequency_change (int return_mode, int frequency)
```

Argument	Description
return_mode	Specifies the operating mode after the frequency is changed. ACTIVE_MODE(0): Active mode SUB_ACTIVE_MODE(1): Sub-active mode
frequency	Indicates the operating frequency after the change. OSC_PER_1 (0x00): ϕ (In this sample program, setting is 16 MHz) OSC_PER_8 (0x10): ϕ/8 (In this sample program, setting is 2 MHz)* OSC_PER_16 (0x14): ϕ/16 (In this sample program, setting is 1 MHz)* OSC_PER_32 (0x18): ϕ/32 (In this sample program, setting is 0.5 MHz)* OSC_PER_64 (0x1C): ϕ/64 (In this sample program, setting is 0.25 MHz)* OSC_PER_W8 (0x00): ϕw/8 (4.096 kHz) OSC_PER_W4 (0x01): ϕw/4 (8.192 kHz) OSC_PER_W2 (0x02): ϕw/2 (16.384 kHz) Note: * Settings resulting in a frequency of less than 78.125 kHz (the minimum operating frequency) are not possible. Example: When ϕ=4 MHz, ϕ/64=62.5 kHz, and so OSC_PER_64 (0x1C) cannot be specified.

Example of use:

```
/* disable SCI3 reception interrupts */
SCI3.SCR3.BYTE = 0x10;
/* invalidate TimerZ interrupts */
TZ0.TIER.BIT.IMIEA = 0;
/* change the frequency */
com_frequency_change (ACTIVE_MODE, OSC_PER_8);
// return using a direct transition interrupt
// make transition to active mode, operating frequency ϕ/8
```

- Make a transition to sleep/sub-sleep/standby mode. When an interrupt occurs, return to active/sub-active mode at the specified operating frequency.

```
com_mode_change (int stop_mode, int return_mode, int freuqncy)
```

Argument	Description
stop_mode	Specifies a stop mode. SLEEP_MODE(0): Sleep mode SUB_SLEEP_MODE(1): Sub-sleep mode STANDBY_MODE(2): Standby mode
return_mode	Specifies the operating mode after the frequency is changed. ACTIVE_MODE(0): Active mode SUB_ACTIVE_MODE(1): Sub-active mode
frequency	Indicates the operating frequency after the change. OSC_PER_1 (0x00): ϕ (In this sample program, setting is 16 MHz) OSC_PER_8 (0x10): ϕ/8 (In this sample program, setting is 2 MHz)* OSC_PER_16 (0x14): ϕ/16 (In this sample program, setting is 1 MHz)* OSC_PER_32 (0x18): ϕ/32 (In this sample program, setting is 0.5 MHz)* OSC_PER_64 (0x1C): ϕ/64 (In this sample program, setting is 0.25 MHz)* OSC_PER_W8 (0x00): ϕw/8 (4.096 kHz) OSC_PER_W4 (0x01): ϕw/4 (8.192 kHz) OSC_PER_W2 (0x02): ϕw/2 (16.384 kHz) Note: * Settings resulting in a frequency of less than 78.125 kHz (the minimum operating frequency) are not possible. Example: When ϕ = 4 MHz, ϕ/64 = 62.5 kHz, and so OSC_PER_64 (0x1C) cannot be specified.

Example of use:

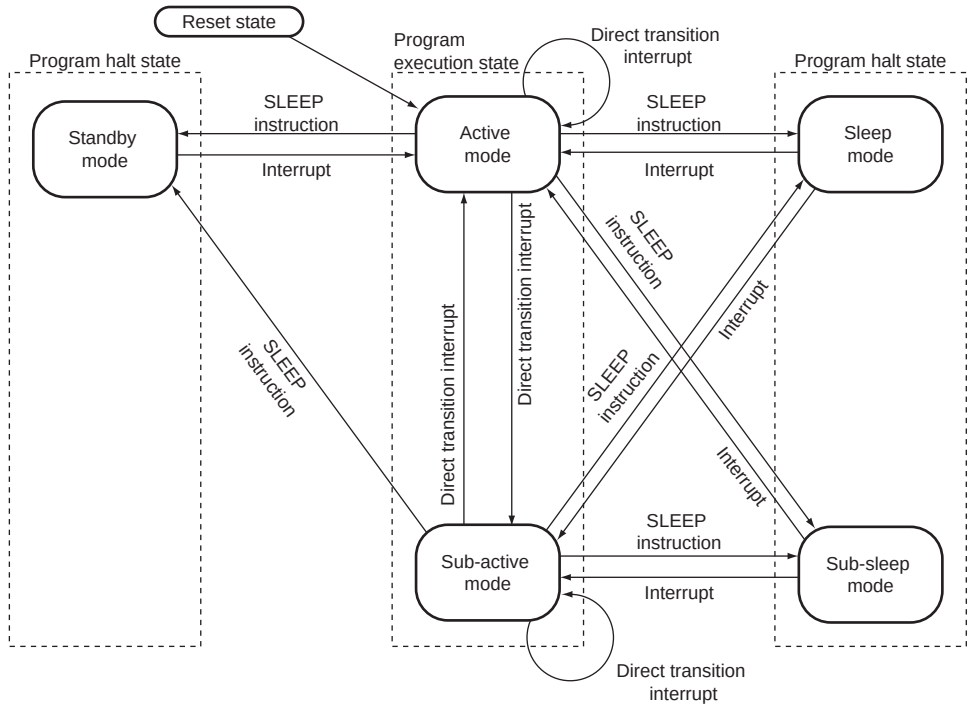
```
/* disable SCI3 reception interrupts */
SCI3.SCR3.BYTE = 0x10;
/* invalidate TimerZ interrupts */
TZ0.TIER.BIT.IMIEA = 0;
/* enable int 0*/
IENR1.BIT.IEN0 = 1;
com_mode_change (SLEEP_MODE, ACTIVE_MODE, OSC_PER_1);
// enter sleep mode; return on int0 interrupt
// active mode, return at frequency ϕ
```

Important information: When making a transition to sub-active mode, operation is limited as follows.

- The RTC interval timer cannot be used.
- The watchdog timer, I^2C, timer B1, and timer Z cannot be used.
- The timer V, SCI3, and A/D converter are reset, and so the various registers should be rewritten as necessary.

3.5 Description of operation

Figure 1 shows the possible transitions between modes. A transition from a program execution state to a program halt state is made by executing a SLEEP instruction. An interrupt is used to return from the program halt state to the program execution state. Direct transitions can also be made between active mode and sub-active mode, which are program execution states, without stopping program execution. And, by making direct transitions from active mode to active mode, and from sub-active mode to sub-active mode, the operating frequency can be changed in the same mode. A transition from all modes to the reset state is made through RES input. Table 1 indicates transition conditions to various modes when the SLEEP instruction is executed, as well as return destinations resulting from an interrupt; Table 2 describes the internal states of the LSI device in each of the operating modes.



Notes: 1. In transitions between modes using interrupts, the interrupt request must be accepted, and interrupt processing performed.
2. For details of conditions for transitions between modes, refer to Table 1.

Figure 1 Mode transition diagram

Table 1 States upon SLEEP instruction execution and return destinations on interrupt

SYSCR1	SYSCR2			States upon SLEEP Instruction Execution	Return Destination on Interrupt
DTON	SSBY	SMSEL	LSON		
0	0	0	0	Sleep mode	Active mode
0	0	0	1	Sleep mode	Sub-active mode
0	0	1	0	Sub-sleep mode	Active mode
0	0	1	1	Sub-sleep mode	Sub-active mode
0	1	×	×	Standby mode	Active mode
1	×	0*	0	Active mode (direct transition)	
1	×	×	1	Sub-active mode (direct transition)	

[Legend] ×: Don't care

Note: * When making a state transition with SMSEL=1, the timer V, SCI3, and A/D converter are set, and the values in registers are returned to the initial values. After a transition to active mode, when using these functions the register values must be rewritten.

Table 2 LSI states in different operating modes

Function		Active	Sleep	Sub-active	Sub-sleep	Standby
System clock oscillator		Operates	Operates	Stop	Stop	Stop
Sub-clock oscillator		Operates	Operates	Operates	Operates	Operates
CPU	Instruction execution	Operates	Stop	Operates	Stop	Stop
	Register	Operates	Held	Operates	Held	Held
RAM		Operates	Held	Operates	Held	Held
I/O port		Operates	Held	Operates	Held	Registers held; output at high impedance
External interrupt	IRQ3 to IRQ0	Operates	Operates	Operates	Operates	Operates
	WKP5 to WKP0	Operates	Operates	Operates	Operates	Operates
Peripheral module	RTC	Operates	Operates	Operates when clock time base function selected; held when interval timer selected		
	Timer V	Operates	Operates	Reset	Reset	Reset
	Watchdog timer	Operates	Operates	Held (however, operates when internal oscillator selected for counter clock*)		
	SCI3, SCI3_2	Operates	Operates	Reset	Reset	Reset
	IIC2	Operates	Operates	Held*	Held	Held
	Timer B1	Operates	Operates	Held*	Held	Held
	Timer Z	Operates	Operates	Held*	Held	Held
	A/D converter	Operates	Operates	Reset	Reset	Reset

Note: * In sub-active mode, register read/write is possible.

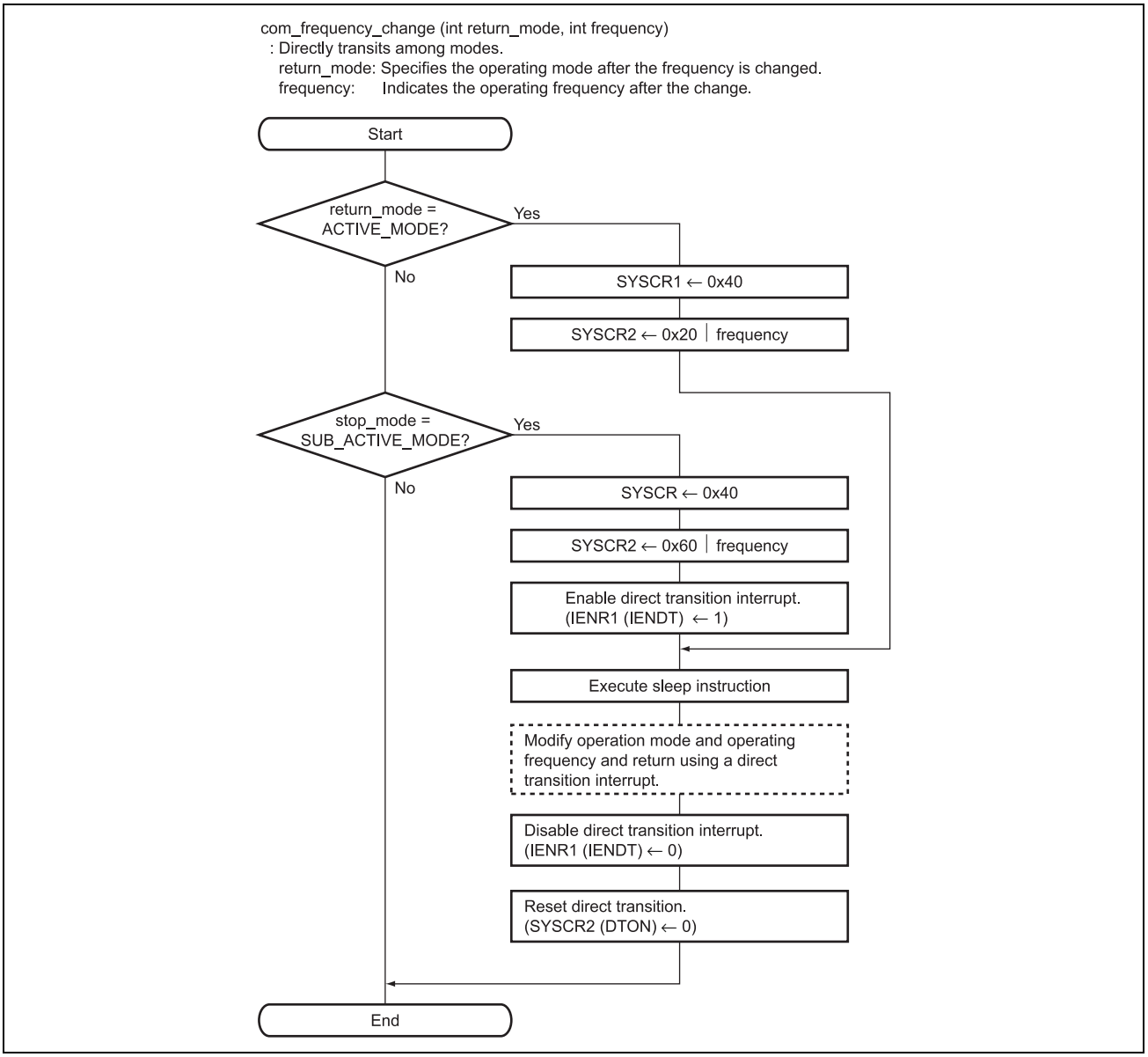
3.6 List of registers used

The H8 microcomputer internal registers used in this sample program are listed. For details, refer to the H8/3687 Group Hardware Manual.

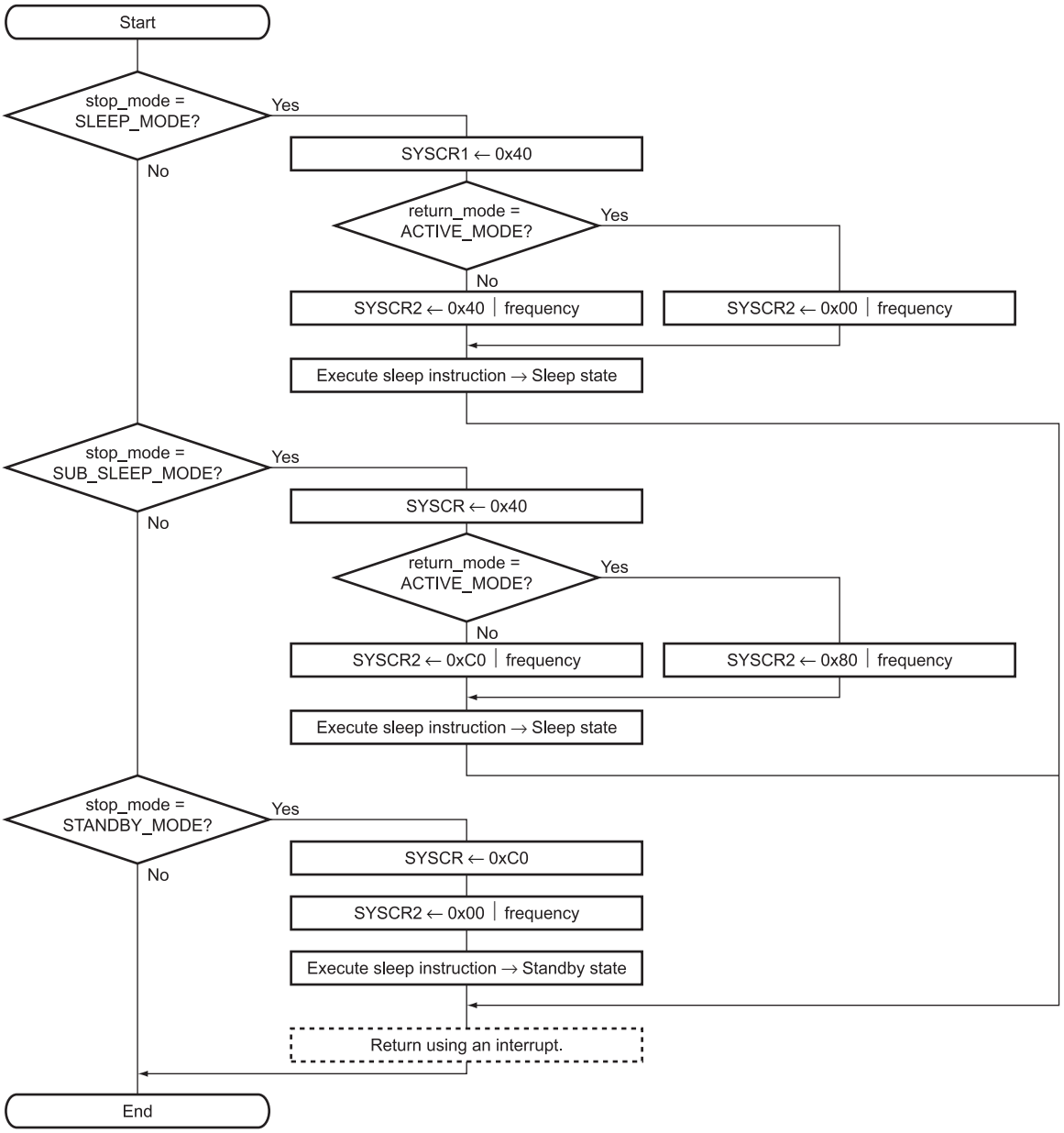
Name	Description
System control register 1 (SYSCR1)	Controls low power consumption modes
System control register 2 (SYSCR2)	Controls low power consumption modes

3.7 Flowcharts

The flow of program execution is indicated below.



com_mode_change (int stop_mode, int return_mode, int frequency)
: Makes transition among modes.
stop_mode: Specifies a stop mode.
return_mode: Specifies the operating mode after the frequency is changed.
frequency: Indicates the operating frequency after the change.



3.8 Program Listing

```
/* ------------------------------------------------------------------------------------------------------------------------ */
/* ------------------------------------------------------------------------------------------------------------------------ */
/* 1. Sample Program 11-A #define directives ------------------------------------------------------------------------------  */
/* ------------------------------------------------------------------------------------------------------------------------ */
/* ------------------------------------------------------------------------------------------------------------------------ */

/************************************************************************************************************************/
/*   For frequency and mode modification                                                                                    */
/************************************************************************************************************************/
#define   OSC_PER_1           0x00
#define   OSC_PER_8           0x10
#define   OSC_PER_16          0x14
#define   OSC_PER_32          0x18
#define   OSC_PER_64          0x1C
#define   OSC_PER_W8          0x00
#define   OSC_PER_W4          0x01
#define   OSC_PER_W2          0x02

#define   ACTIVE_MODE         0
#define   SUB_ACTIVE_MODE     1

#define   SLEEP_MODE          0
#define   SUB_SLEEP_MODE      1
#define   STANDBY_MODE        2



/* ------------------------------------------------------------------------------------------------------------------------ */
/* ------------------------------------------------------------------------------------------------------------------------ */
/* 2. Sample program 11-B  Prototype declaration ------------------------------------------------------------------------- */
/* ------------------------------------------------------------------------------------------------------------------------ */
/* ------------------------------------------------------------------------------------------------------------------------ */

/* Mode modification processing                                                                                             */
void com_mode_change (int stop_mode , int return_mode , int frequency) ;
void com_frequency_change (int return_mode , int frequency ) ;
```

```
/* ------------------------------------------------------------------------------------------------------------------------ */
/* ------------------------------------------------------------------------------------------------------------------------ */
/* 4. Sample program 11-C  Common source codes ---------------------------------------------------------------------------- */
/* ------------------------------------------------------------------------------------------------------------------------ */
/* ------------------------------------------------------------------------------------------------------------------------ */

/************************************************************************************************************************/
/************************************************************************************************************************/
/************************************************************************************************************************/
/*                                                                                                                      */
/*                           Low power consumption mode                                                                 */
/*                                                                                                                      */
/************************************************************************************************************************/
/************************************************************************************************************************/
/************************************************************************************************************************/

/************************************************************************************************************************/
/*   1. Module name: com_mode_change                                                                                    */
/*   2. Function overview:' Performs a mode transition                                                                  */
/*     Parameter combination                                                                                            */
/*     stop_mode         return_mode        frequency                                                                   */
/*     SLEEP_MODE   →    ACTIVE_MODE        OSC_PER_1/8/16/32/64                                                        */
/*     SLEEP_MODE   →    SUB_ACTIVE_MODE    OSC_PER_W8/4/2                                                              */
/*     SUB_SLEEP_MODE    →ACTIVE_MODE       OSC_PER_1/8/16/32/64                                                        */
/*     SUB_SLEEP_MODE    →SUB_ACTIVE_MODE   OSC_PER_W8/4/2                                                              */
/*     STANDBY_MODE      →ACTIVE_MODE       OSC_PER_1/8/16/32/64                                                        */
/*                                                                                                                      */
/************************************************************************************************************************/
void com_mode_change (int stop_mode , int return_mode , int frequency    )
{

     switch (stop_mode){
          case SLEEP_MODE :
               /************************************************************************************************************/
               /*   Sets SYSCR1 :                                                                                          */
               /*        SSBSY     = 0 Enters sleep mode during sleep instruction execution                                */
               /*        STS2:0    = 100 specifies the wait time for clock stabilization from standby to sleep as 8.2 ms.  */
               /*        NESEL     = 0 specifies the noise elimination sampling frequency as 8 MHzk/16.                    */
               /************************************************************************************************************/
               SYSCR1.BYTE    = 0x40 ;

               /************************************************************************************************************/
               /*   Sets SYSCR2 :                                                                                          */
               /*        SMSEL     = 0 Enters sleep mode                                                                   */
               /*        LSON      = 0/1                                                                                   */
               /*        DTON      = 0 Disables direct transition during sleep instruction execution                       */
               /*        MA2:0     = 000 Selects the main clock operating frequency (Specified by argument frequency)      */
               /*        SA1:0     = 00 Selects the sub-clock operating frequency (Specified by argument frequency)        */
               /************************************************************************************************************/
               if (return_mode == ACTIVE_MODE){
                    SYSCR2.BYTE    = 0x00 |  frequency ;
               }
               else{
                    SYSCR2.BYTE    = 0x40 |  frequency ;
               }
```

```
        /*****************************************************************************************************************/
        /*   Makes the device sleep and enters sleep mode.                                                               */
        /*****************************************************************************************************************/
        sleep() ;

        /* ============================================================================================================= */
        /* === Returns here by an interrupt                                                                          === */
        /* ============================================================================================================= */

        break ;

    case SUB_SLEEP_MODE :
        /*****************************************************************************************************************/
        /*   Sets SYSCR1 :                                                                                               */
        /*        SSBSY     = 0 Enters sleep mode during sleep instruction execution                                     */
        /*        STS2:0    = 100 specifies the wait time for clock stabilization from standby to sleep as 8.2 ms.       */
        /*        NESEL     = 0 specifies the noise elimination sampling frequency as 8 MHzk/16.                         */
        /*****************************************************************************************************************/
        SYSCR1.BYTE    = 0x40 ;

        /*****************************************************************************************************************/
        /*   Sets SYSCR2 :                                                                                               */
        /*        SMSEL     = 1 Enters sub-sleep mode                                                                    */
        /*        LSON      = 1/0                                                                                        */
        /*        DTON      = 0 Disables direct transition during sleep instruction execution                            */
        /*        MA2:0     = 000 Selects the main clock operating frequency (Specified by argument frequency)           */
        /*        SA1:0     = 00 Selects the sub-clock operating frequency (Specified by argument frequency)             */
        /*****************************************************************************************************************/
        if (return_mode == ACTIVE_MODE){
            SYSCR2.BYTE    = 0x80 |  frequency ;
        }
        else{
            SYSCR2.BYTE    = 0xC0 |  frequency ;
        }

        /*****************************************************************************************************************/
        /*   Makes the device sleep and enters sleep mode.                                                               */
        /*****************************************************************************************************************/
        sleep() ;
        /* ============================================================================================================= */
        /* === Returns here by an interrupt                                                                          === */
        /* ============================================================================================================= */

        break ;

    case STANDBY_MODE :
        /*****************************************************************************************************************/
        /*   Sets SYSCR1 :                                                                                               */
        /*        SSBSY     = 1 Makes a transition from sleep mode to standby mode                                       */
        /*        STS2:0    = 100 specifies the wait time for clock stabilization from standby to sleep as 8.2 ms.       */
        /*        NESEL     = 0 specifies the noise elimination sampling frequency as 8 MHzk/16.                         */
        /*****************************************************************************************************************/
        SYSCR1.BYTE    = 0xC0 ;
```

```
                /*****************************************************************************************************************/
                /*   Sets SYSCR2 :                                                                                               */
                /*        SMSEL     = x                                                                                          */
                /*        LSON      = x                                                                                          */
                /*        DTON      = 0 Disables direct transition during sleep instruction execution                            */
                /*        MA2:0     = 000 Selects the main clock operating frequency (Specified by argument frequency)           */
                /*        SA1:0     = 00 Selects the sub-clock operating frequency (Specified by argument frequency)             */
                /*****************************************************************************************************************/
                SYSCR2.BYTE    = 0x00 |  frequency ;

                /*****************************************************************************************************************/
                /*   Makes the device sleep and enters sleep mode.                                                               */
                /*****************************************************************************************************************/
                sleep() ;
                /* ============================================================================================================= */
                /* === Returns here by an interrupt                                                                          === */
                /* ============================================================================================================= */

                break ;


        }
}

/*****************************************************************************************************************************/
/*   1. Module name: com_frequency_change                                                                                        */
/*   2. Function overview: Performs a mode transition                                                                            */
/*   Parameter combination                                                                                                       */
/*   return_mode              frequency                                                                                          */
/*   ACTIVE_MODE              OSC_PER_1/8/16/32/64                                                                               */
/*   SUB_ACTIVE_MODE          OSC_PER_W8/4/2                                                                                     */
/*                                                                                                                               */
/*****************************************************************************************************************************/
void com_frequency_change (int return_mode , int frequency    )
{
     int i , j ;
     unsigned int    h8_addr;

     switch (return_mode){
          case ACTIVE_MODE :

                /*****************************************************************************************************************/
                /*   Sets SYSCR1 :                                                                                               */
                /*        SSBSY     = 0                                                                                          */
                /*        STS2:0    = 100 specifies the wait time for clock stabilization from standby to sleep as 8.2 ms.       */
                /*        NESEL     = 0 specifies the noise elimination sampling frequency as 8 MHzk/16.                         */
                /*****************************************************************************************************************/
                SYSCR1.BYTE    = 0x40 ;
```

```
            /*****************************************************************************************************************/
            /*   Sets SYSCR2 :                                                                                               */
            /*        SMSEL     = 0                                                                                          */
            /*        LSON      = 0                                                                                          */
            /*        DTON      = 1 Specifies a direct transition during sleep instruction execution                         */
            /*        MA2:0     = 000 Selects the main clock operating frequency (Specified by argument frequency)           */
            /*        SA1:0     = 00 Selects the sub-clock operating frequency (Specified by argument frequency)             */
            /*****************************************************************************************************************/
            SYSCR2.BYTE    = 0x20 |  frequency ;

            break ;

        case SUB_ACTIVE_MODE :

            /*****************************************************************************************************************/
            /*   Sets SYSCR1 :                                                                                               */
            /*        SSBSY     = 0                                                                                          */
            /*        STS2:0    = 100 specifies the wait time for clock stabilization from standby to sleep as 8.2 ms.       */
            /*        NESEL     = 0 specifies the noise elimination sampling frequency as 8 MHzk/16.                         */
            /*****************************************************************************************************************/
            SYSCR1.BYTE    = 0x40 ;

            /*****************************************************************************************************************/
            /*   Sets SYSCR2 :                                                                                               */
            /*        SMSEL     = 0 Not used                                                                                 */
            /*        LSON      = 1 Low-speed flag                                                                           */
            /*        DTON      = 1 Specifies a direct transition during sleep instruction execution                         */
            /*        MA2:0     = 000 Selects the main clock operating frequency (Specified by argument frequency)           */
            /*        SA1:0     = 00 Selects the sub-clock operating frequency (Specified by argument frequency)             */
            /*****************************************************************************************************************/
            SYSCR2.BYTE    = 0x60 |  frequency ;

            break ;

    }

    /* Enables direct transition interrupts                                                                                  */
    IENR1.BIT.IENDT     = 1 ;

    /*****************************************************************************************************************/
    /*   Makes the device sleep and generates a direct transition interrupt.                                         */
    /*   Prepare the interrupt vector routine for direct transition .                                                */
    /*****************************************************************************************************************/
    sleep() ;

    /* ============================================================================================================= */
    /* === A direct transition interrupt occurs and the frequency switches to the specified frequency.          === */
    /* ============================================================================================================= */

    /*****************************************************************************************************************/
    /*   Cancels interrupt disable                                                                                   */
    /*****************************************************************************************************************/

    /* Disables direct transition interrupts                                                                                 */
    IENR1.BIT.IENDT     = 0 ;

    /* Resets direct transitions                                                                                             */
    SYSCR2.BIT.DTON     = 0 ;

}
```

4. Reference Documents

- H8/3687 Group Hardware Manual (published by Renesas Technology Corp.)

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