To our customers,

Old Company Name in Catalogs and Other Documents

On April 1st, 2010, NEC Electronics Corporation merged with Renesas Technology Corporation, and Renesas Electronics Corporation took over all the business of both companies. Therefore, although the old company name remains in this document, it is a valid Renesas Electronics document. We appreciate your understanding.

Renesas Electronics website: http://www.renesas.com

April 1st, 2010
Renesas Electronics Corporation

Issued by: Renesas Electronics Corporation (http://www.renesas.com)

Send any inquiries to http://www.renesas.com/inquiry.

RENESAS

Notice

1. All information included in this document is current as of the date this document is issued. Such information, however, is subject to change without any prior notice. Before purchasing or using any Renesas Electronics products listed herein, please confirm the latest product information with a Renesas Electronics sales office. Also, please pay regular and careful attention to additional and different information to be disclosed by Renesas Electronics such as that disclosed through our website.
2. Renesas Electronics does not assume any liability for infringement of patents, copyrights, or other intellectual property rights of third parties by or arising from the use of Renesas Electronics products or technical information described in this document. No license, express, implied or otherwise, is granted hereby under any patents, copyrights or other intellectual property rights of Renesas Electronics or others.
3. You should not alter, modify, copy, or otherwise misappropriate any Renesas Electronics product, whether in whole or in part.
4. Descriptions of circuits, software and other related information in this document are provided only to illustrate the operation of semiconductor products and application examples. You are fully responsible for the incorporation of these circuits, software, and information in the design of your equipment. Renesas Electronics assumes no responsibility for any losses incurred by you or third parties arising from the use of these circuits, software, or information.
5. When exporting the products or technology described in this document, you should comply with the applicable export control laws and regulations and follow the procedures required by such laws and regulations. You should not use Renesas Electronics products or the technology described in this document for any purpose relating to military applications or use by the military, including but not limited to the development of weapons of mass destruction. Renesas Electronics products and technology may not be used for or incorporated into any products or systems whose manufacture, use, or sale is prohibited under any applicable domestic or foreign laws or regulations.
6. Renesas Electronics has used reasonable care in preparing the information included in this document, but Renesas Electronics does not warrant that such information is error free. Renesas Electronics assumes no liability whatsoever for any damages incurred by you resulting from errors in or omissions from the information included herein.
7. Renesas Electronics products are classified according to the following three quality grades: “Standard”, “High Quality”, and “Specific”. The recommended applications for each Renesas Electronics product depends on the product’s quality grade, as indicated below. You must check the quality grade of each Renesas Electronics product before using it in a particular application. You may not use any Renesas Electronics product for any application categorized as “Specific” without the prior written consent of Renesas Electronics. Further, you may not use any Renesas Electronics product for any application for which it is not intended without the prior written consent of Renesas Electronics. Renesas Electronics shall not be in any way liable for any damages or losses incurred by you or third parties arising from the use of any Renesas Electronics product for an application categorized as “Specific” or for which the product is not intended where you have failed to obtain the prior written consent of Renesas Electronics. The quality grade of each Renesas Electronics product is “Standard” unless otherwise expressly specified in a Renesas Electronics data sheets or data books, etc.

   “Standard”: Computers; office equipment; communications equipment; test and measurement equipment; audio and visual equipment; home electronic appliances; machine tools; personal electronic equipment; and industrial robots.

   “High Quality”: Transportation equipment (automobiles, trains, ships, etc.); traffic control systems; anti-disaster systems; anti-crime systems; safety equipment; and medical equipment not specifically designed for life support.

   “Specific”: Aircraft; aerospace equipment; submersible repeaters; nuclear reactor control systems; medical equipment or systems for life support (e.g. artificial life support devices or systems), surgical implantations, or healthcare intervention (e.g. excision, etc.), and any other applications or purposes that pose a direct threat to human life.
8. You should use the Renesas Electronics products described in this document within the range specified by Renesas Electronics, especially with respect to the maximum rating, operating supply voltage range, movement power voltage range, heat radiation characteristics, installation and other product characteristics. Renesas Electronics shall have no liability for malfunctions or damages arising out of the use of Renesas Electronics products beyond such specified ranges.
9. Although Renesas Electronics endeavors to improve the quality and reliability of its products, semiconductor products have specific characteristics such as the occurrence of failure at a certain rate and malfunctions under certain use conditions. Further, Renesas Electronics products are not subject to radiation resistance design. Please be sure to implement safety measures to guard them against the possibility of physical injury, and injury or damage caused by fire in the event of the failure of a Renesas Electronics product, such as safety design for hardware and software including but not limited to redundancy, fire control and malfunction prevention, appropriate treatment for aging degradation or any other appropriate measures. Because the evaluation of microcomputer software alone is very difficult, please evaluate the safety of the final products or system manufactured by you.
10. Please contact a Renesas Electronics sales office for details as to environmental matters such as the environmental compatibility of each Renesas Electronics product. Please use Renesas Electronics products in compliance with all applicable laws and regulations that regulate the inclusion or use of controlled substances, including without limitation, the EU RoHS Directive. Renesas Electronics assumes no liability for damages or losses occurring as a result of your noncompliance with applicable laws and regulations.
11. This document may not be reproduced or duplicated, in any form, in whole or in part, without prior written consent of Renesas Electronics.
12. Please contact a Renesas Electronics sales office if you have any questions regarding the information contained in this document or Renesas Electronics products, or if you have any other inquiries.

(Note 1) “Renesas Electronics” as used in this document means Renesas Electronics Corporation and also includes its majority-owned subsidiaries.

(Note 2) “Renesas Electronics product(s)” means any product developed or manufactured by or for Renesas Electronics.

H8/38602

Low Power Mode Demonstration

Introduction

This application note demonstrates the H8/38602 in all possible power modes using all the types of transitions possible. The code was developed using HEW4, the Renesas toolchain version 6.1.0.0 and an E8.

Contents

Development Environment

Figure 1 shows the development environment used to produce the H8/38602 low power code.

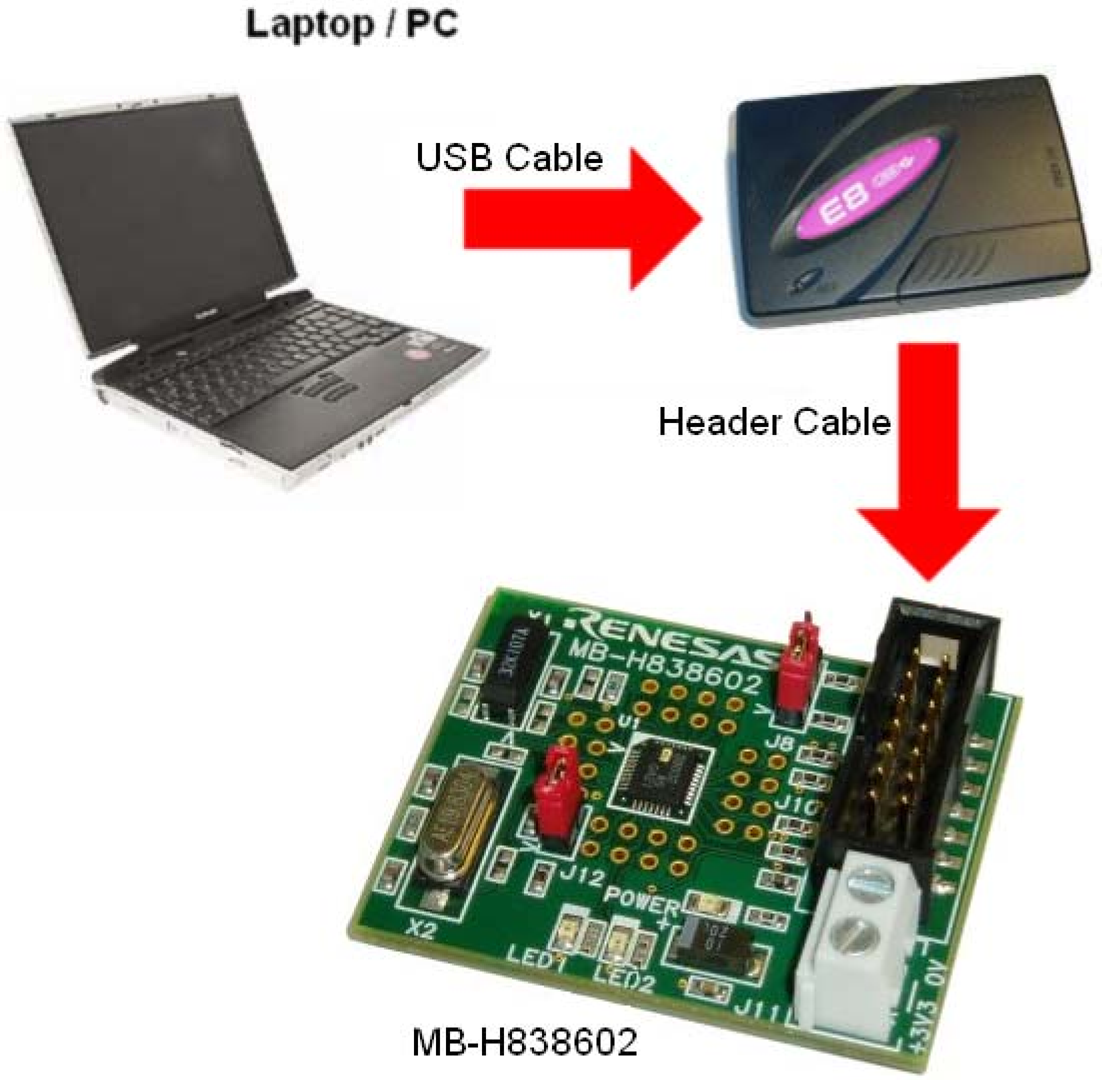

Figure 1: Development Environment

The PC is used to run HEW4, utilise the toolchain and to drive the E8. It is connected to one side of the E8 via a USB cable, another side of the E8 is connected to the MB-H838602 board via a header cable. The E8 provides a 3v3 supply to the MCU board, so whilst debugging with the E8 there is no external power requirement for the H8/38602 board.

Code purpose and flow

The purpose of the code is to demonstrate each power mode transition at least once. The power mode transition diagram is shown in figure 2.

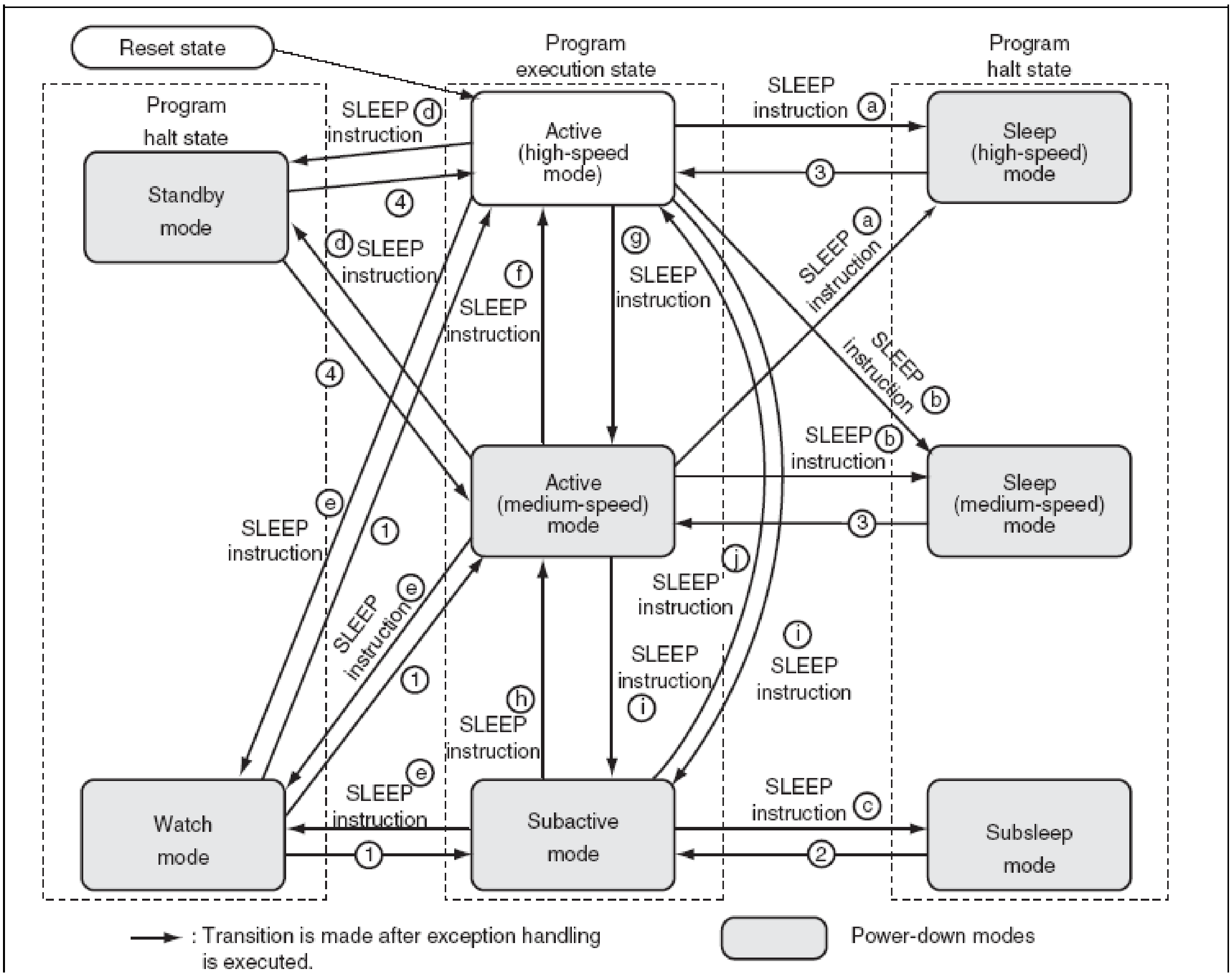

Figure 2: Power mode transition

The transitions marked a to j are software transitions i.e. some bits must be set in specific registers and a specific instruction executed for these transitions to occur. In the sleep modes the CPU is switched off, so typically most interrupts will initiate a transition out of sleep mode.

The active modes are modes in which the CPU is active so transitions between and out of these modes are software controlled.

Standby and watch modes are also modes in which the CPU is off. In these modes specific peripherals are also inactive.

For the purposes of this demo code, the transitions are controlled by timer B. Timer B is configured to produce an interrupt every 8 seconds. This interrupt is used either to automatically change power mode (for transitions which only require the timer B interrupt) or for controlling software transitions.

A diagram of the transition made in the code is shown in figure 3.

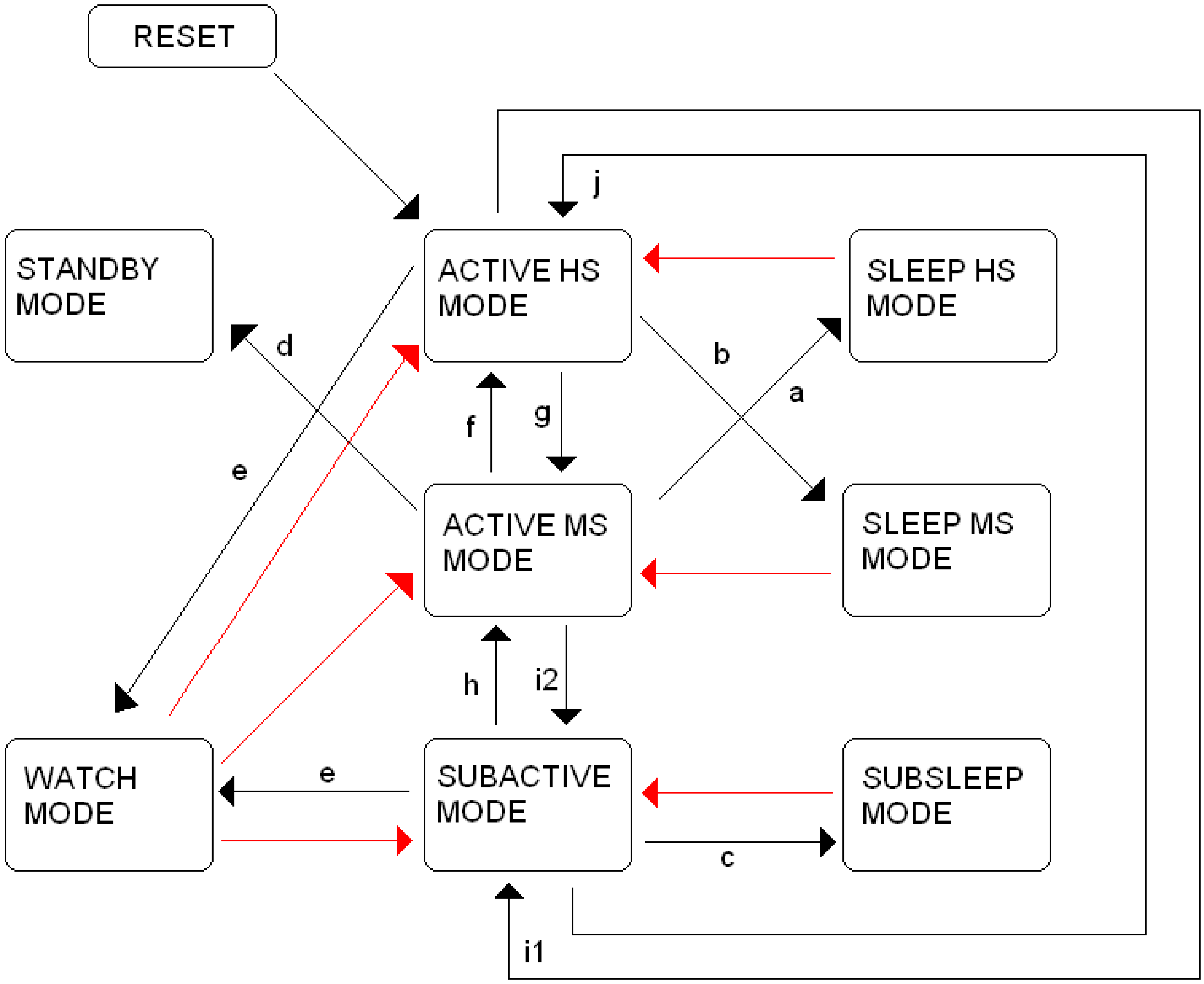

Figure 3: Power mode transitions used in the code

Figure 3 shows software controlled transitions in black and interrupt driven transitions in red. The demo code utilises as many of the transitions as possible, at least once. Transitions from active high speed mode to and from standby mode are not performed in the code, neither are transitions from standby to active medium speed mode or active medium to watch.

The order in which the transitions are performed is listed in table 1

Power Mode	Transition type to next power mode
Reset	None required: automatically goes to active high speed mode.
Active HS	Software Transition b
Sleep MS	By timer B interrupt
Active MS	Software Transition a
Sleep HS	By timer B interrupt
Active HS	Software Transition g
Active MS	Software Transition i2
Subactive	Software Transition c
Subsleep	By timer B interrupt
Subactive	Software Transition j
Active HS	Software Transition e
Watch	By timer B interrupt
Active HS	Software Transition i1
Subactive	Software Transition e
Watch	By timer B interrupt
Subactive	Software Transition h
Active MS	Software Transition f
Active HS	Software Transition e
Watch	By timer B interrupt
Active MS	Software Transition d
Standby	Device stays in this mode until the device is reset

Table 1: Power Mode transition table

The code will make the transitions in the order given in table 1 above. Some modes are entered more than once. Once the code reaches the last power mode (standby mode), the device will stay in standby mode until the device is reset again or disconnected from the power supply.

The timer B is set up to produce an interrupt every 8 seconds. This should provide sufficient time to perform a current consumption reading if desired.

Power Mode Code and Workspace

Workspace View

Figures 4 and 5 show the workspace view when the H8/38602 low power demo workspace code is opened. There are two build configurations and two sessions in the workspace. The build configurations are "Release" and "Debug". For debugging using the E8, use the ".abs" file produced by the Debug build, for standalone code use the ".mot" file under the Release build. The Debug session file automatically points to the Debug abs file, the Release session file points to the ".mot" file produced by the Release build.

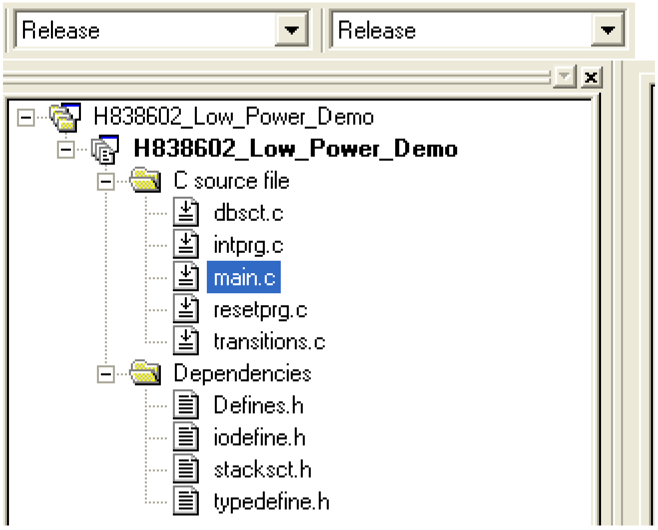

Figure 4: Release session and build configuration

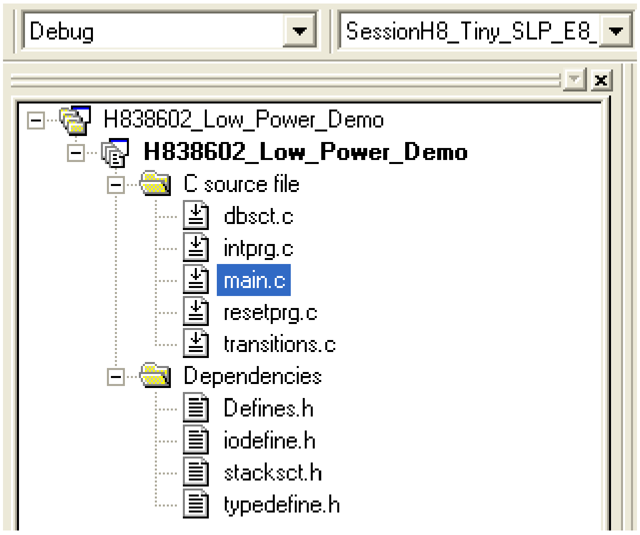

Figure 5: H838602 Low Power Demo Workspace

To download the ".abs" file using the debug configuration, click on the "connect" icon and select the first option.

To download the ".mot" file using the Release configuration, click on the "connect" icon and select the third option in the window that appears.

Workspace Files

There are five C source files in the workspace. These are:

"**dbsct.c**": sets up the memory sections

"**intprg.c**": contains the interrupt vector table

"**resetprg.c**": holds code which is run after a reset

"**Transitions.c**": provides a function for performing the software transitions

"**main.c**": Contains the main function, and majority of code.

resetprg.c

The code for the resetprg.c file is shown below

```
// include low level machine functions
#include     <machine.h>
#include     <_h_c_lib.h>
// include typedefine to define _UBYTE
#include     "typedefine.h"
// inlcude stack size
#include     "stacksct.h"

// declare function main as external
extern void main(void);
// Declare reset function
void PowerON_Reset(void);

// Define a section called ResetPRG
#pragma section ResetPRG

// Set this function as first function
// to be run after a reset
__entry(vect=0) void PowerON_Reset(void)
{
  // Set the interrupt mask bit
     set_imask_ccr((_UBYTE)1);
  // Initialise the data sections
    _INITSCT();
  // Clear the I mask bit
    set_imask_ccr((_UBYTE)0);
  // Set entry to function main
    main();
  // Code should never get here!
    sleep();
}
```

Some header files are included which allow the code to access the CCR, and to define _UBYTE.

main.c

The code for the main function is shown in the next code section. Firstly two variables are declared; one to hold the current power mode and the other to specify whether or not a power transition is required. Following a reset the device is set for the watchdog timer to be on. This must be switched off after a short time otherwise the device will continuously reset without running much user code. Since the code requires timer B to perform the power mode transitions, the timer B module is switched on, and the timer B interrupt enabled. Some set up of timer B is then required and so the start bit is cleared, the timer is set as a reload timer, and the slowest clock is selected as the clock input. The timer B load register is cleared to 0 to give the longest possible period between timer B interrupts. This is because the reload value in the register is placed in the counter register when the counter register overflows. An infinite while loop is then set up, within this loop the INCREMENT_PMODE variable is tested as to whether the power mode should be changed or not. If its value is 0, no power mode change is required and the code goes round the loop continuously testing the value of INCREMENT_PMODE. If the value is 1, the current power mode value is tested, and the appropriate software settings are made to enable a transition to the next desired power mode. For those power modes which do not require a software transition (such as the sleep modes, where a timer B interrupt is sufficient to cause the transition) the code exits the loop and continues to test the value of INCREMENT_PMODE for when a software change in power mode transition is required.

```
void main(void)
{
  // The following lines of code
    WDT.TCSRWD1.BYTE = 0x9e;     /* Watchdog timer OFF */
    WDT.TCSRWD1.BYTE = 0xa2;
    WDT.TCSRWD1.BYTE = 0x8e;
 // Switch on the timer B module
    CKSTPR1.BIT.TB1CKSTP = 1;
    CKSTPR2.BIT.WDCKSTP = 0;
 // Enable the timer B interrupt
    IENR2.BIT.IENTB1 = 1;
 // Ensure timer B is turned off
    TB1.TMB1.BIT.STR = 0;
 // Set timer B as reload timer
    TB1.TMB1.BIT.RLD = 1;
 // Set the clock input to thiw/1024 (slowest clock)
    TB1.TMB1.BIT.CKS = 6;
 // Timer load register set to 0 for maximum count time
    TB1.TLB1 = 0x00;
 // All the setup is done so start the timer
    TB1.TMB1.BIT.STR = 1;
        // All outputs ON
    IO.PCR1 = 0xff;
    IO.PDR1.BYTE = 0xff;
    IO.PCR3 = 0xff;
    IO.PDR3.BYTE = 0xff;
    IO.PCR8 = 0xff;
    IO.PDR8.BYTE = 0xff;
    IO.PCR9 = 0xff;
    IO.PDR9.BYTE = 0xff;
    while(1) // Enter while loop
    {
     // Global var to determine whether it is time
     // to change power mode. If it is time...
     if(INCREMENT_PMODE == 1)
     {  // Reset the variable
        INCREMENT_PMODE = 0;
      // Determine the current power mode
      if(  // If in any of these modes, timer B interrupt will be enough to
           // make the transition automatically
          (PMODE == SLEEP_MS) || (PMODE == SLEEP_HS) || (PMODE == SUBSLEEP) ||
          (PMODE == WATCH_1) || (PMODE == WATCH_2) || (PMODE == WATCH_3))
         {//return
         ;}
      // For all other power modes, determine the appropriate transition
      else if (PMODE == ACTIVE_HS_1)
      {
        TRANSITIONS(b);
        //return;
      }
```

```
else if (PMODE == ACTIVE_MS_1)
{
  TRANSITIONS(a);
  //return;
}
else if (PMODE == ACTIVE_HS_2)
{
  TRANSITIONS(g);
  //return;
}
else if (PMODE == ACTIVE_MS_2)
{
  TRANSITIONS(i2);
  //return;
}
else if (PMODE == SUBACTIVE_1)
{
  TRANSITIONS(c);
  //return;
}
else if (PMODE == SUBACTIVE_2)
{
  TRANSITIONS(j);
  //return;
}
else if (PMODE == ACTIVE_HS_3)
{ // Determine power mode to be entered
  // on coming out of the next power mode
  SYSCR2.BIT.MSON = 0;
  SYSCR1.BIT.LSON = 0;
  TRANSITIONS(e);
  //return;
}
else if (PMODE == ACTIVE_HS_4)
{
  TRANSITIONS(i1);
  //return;
}
else if (PMODE == SUBACTIVE_3)
{ // Determine power mode to be entered
  // on coming out of the next power mode
  SYSCR2.BIT.MSON = 0;
  SYSCR1.BIT.LSON = 1;
  TRANSITIONS(e);
  //return;
}
else if (PMODE == SUBACTIVE_4)
{
  TRANSITIONS(h);
  //return;
}
else if (PMODE == ACTIVE_MS_3)
{
  TRANSITIONS(f);
  //return;
}
```

```
      else if (PMODE == ACTIVE_HS_5)
      { // Determine power mode to be entered
        // on coming out of the next power mode
        SYSCR2.BIT.MSON = 1;
        SYSCR1.BIT.LSON = 0;
        TRANSITIONS(e);
        //return;
      }

       else if (PMODE == ACTIVE_MS_4)
       {
         TRANSITIONS(d);
         //return;
       }
       // Increment the power mode variable to indicate
       // the next power mode
       PMODE++;
      }
     }

while(1);

}
// Interrupt B overflow
__interrupt(vect=33) void INT_TIMERB1(void)
{    // Clear the flag
     IRR2.BIT.IRRTB1 = 0;
     // Set the change power mode variable
     INCREMENT_PMODE = 1;
}

__interrupt(vect=13) void INT_DIRECT_TRANS(void)
{

}
```

The interrupt service routine for timer B is also shown here. Once the ISR is entered, the timer B flag is cleared. The INCREMENT_PMODE variable is then set to indicate to the main code that the current power mode is to change. No code is required for the direct transition interrupt for this specific device (H8/38602).

Current Measurement Technique

The current consumed by the H8/38602 device in the various power modes was measured via the jumper, J12. This jumper was removed, and a current meter connected between the jumper terminals. Figure shows the section of circuitry on the MB-H838602 board which contains jumper J12.

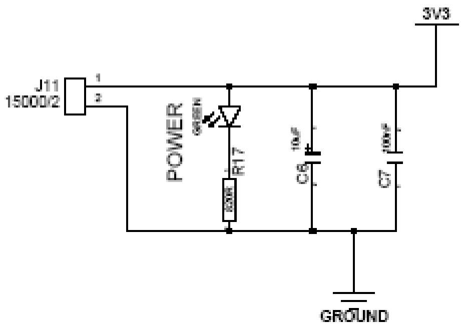

Figure: Circuitry section for MB-H838602 Board

The equipment used to measure the MB-H838602 power consumption were a Fluke 87 true RMS multimeter and a Thurlby PL320 power supply set to 2.7V. The results of the current consumption values are shown in the "Current Results Section".

The E8 connector was disconnected during the power measurement.

The resistors R9 and R10 (which connect LED1 and LED2 to 3V3) were also removed.

Current Results

Table 2 shows the current consumption of the device in the various power modes.

Power Mode	Expected Power Consumption (MAX)	Actual Power Consumption
Active HS	10 mA	6.22 mA
Sleep MS	6.4 mA	1.021 mA
Active MS	1.3 mA	1.022 mA
Sleep HS	6.4 mA	4.04 mA
Active HS	10 mA	6.225 mA
Active MS	1.3 mA	1.022 mA
Subactive	75 uA	9.29 uA
Subsleep	16 uA	3.21 uA
Subactive	75 uA	9.05uA
Active HS	10 mA	6.226 mA
Watch	5 uA	2.75 uA
Active HS	10 mA	6.226 mA
Subactive	75 uA	9.33 uA
Watch	5 uA	2.81 uA
Subactive	75 uA	9.56 uA
Active MS	1.3 mA	1.023 mA
Active HS	10 mA	6.226 mA
Watch	5 uA	2.75 uA
Active MS	1.3 mA	1.025 mA
Standby	5 uA	2.56 uA

Table 2: Current values

All current measurement values were within the expected maximum values. The lowest power consumption recorded was 2.56 uA in standby mode. In some cases there is a large difference between the actual and expected current consumption. This is because the device was running from 2.7 V and the expected values are maximum values.

Conclusion

All the possible software transition types were implemented in the software. All power modes were entered and the current consumption in each mode measured. The power consumption measured in each mode was within the maximum values given in the hardware manual.

Website and Support

Renesas Technology Website
http://www.renesas.com/

Inquiries
http://www.renesas.com/inquiry

Notes regarding these materials

1. This document is provided for reference purposes only so that Renesas customers may select the appropriate Renesas products for their use. Renesas neither makes warranties or representations with respect to the accuracy or completeness of the information contained in this document nor grants any license to any intellectual property rights or any other rights of Renesas or any third party with respect to the information in this document.
2. Renesas shall have no liability for damages or infringement of any intellectual property or other rights arising out of the use of any information in this document, including, but not limited to, product data, diagrams, charts, programs, algorithms, and application circuit examples.
3. You should not use the products or the technology described in this document for the purpose of military applications such as the development of weapons of mass destruction or for the purpose of any other military use. When exporting the products or technology described herein, you should follow the applicable export control laws and regulations, and procedures required by such laws and regulations.
4. All information included in this document such as product data, diagrams, charts, programs, algorithms, and application circuit examples, is current as of the date this document is issued. Such information, however, is subject to change without any prior notice. Before purchasing or using any Renesas products listed in this document, please confirm the latest product information with a Renesas sales office. Also, please pay regular and careful attention to additional and different information to be disclosed by Renesas such as that disclosed through our website. (http://www.renesas.com)
5. Renesas has used reasonable care in compiling the information included in this document, but Renesas assumes no liability whatsoever for any damages incurred as a result of errors or omissions in the information included in this document.
6. When using or otherwise relying on the information in this document, you should evaluate the information in light of the total system before deciding about the applicability of such information to the intended application. Renesas makes no representations, warranties or guaranties regarding the suitability of its products for any particular application and specifically disclaims any liability arising out of the application and use of the information in this document or Renesas products.
7. With the exception of products specified by Renesas as suitable for automobile applications, Renesas products are not designed, manufactured or tested for applications or otherwise in systems the failure or malfunction of which may cause a direct threat to human life or create a risk of human injury or which require especially high quality and reliability such as safety systems, or equipment or systems for transportation and traffic, healthcare, combustion control, aerospace and aeronautics, nuclear power, or undersea communication transmission. If you are considering the use of our products for such purposes, please contact a Renesas sales office beforehand. Renesas shall have no liability for damages arising out of the uses set forth above.
8. Notwithstanding the preceding paragraph, you should not use Renesas products for the purposes listed below:
   (1) artificial life support devices or systems
   (2) surgical implantations
   (3) healthcare intervention (e.g., excision, administration of medication, etc.)
   (4) any other purposes that pose a direct threat to human life

   Renesas shall have no liability for damages arising out of the uses set forth in the above and purchasers who elect to use Renesas products in any of the foregoing applications shall indemnify and hold harmless Renesas Technology Corp., its affiliated companies and their officers, directors, and employees against any and all damages arising out of such applications.
9. You should use the products described herein within the range specified by Renesas, especially with respect to the maximum rating, operating supply voltage range, movement power voltage range, heat radiation characteristics, installation and other product characteristics. Renesas shall have no liability for malfunctions or damages arising out of the use of Renesas products beyond such specified ranges.
10. Although Renesas endeavors to improve the quality and reliability of its products, IC products have specific characteristics such as the occurrence of failure at a certain rate and malfunctions under certain use conditions. Please be sure to implement safety measures to guard against the possibility of physical injury, and injury or damage caused by fire in the event of the failure of a Renesas product, such as safety design for hardware and software including but not limited to redundancy, fire control and malfunction prevention, appropriate treatment for aging degradation or any other applicable measures. Among others, since the evaluation of microcomputer software alone is very difficult, please evaluate the safety of the final products or system manufactured by you.
11. In case Renesas products listed in this document are detached from the products to which the Renesas products are attached or affixed, the risk of accident such as swallowing by infants and small children is very high. You should implement safety measures so that Renesas products may not be easily detached from your products. Renesas shall have no liability for damages arising out of such detachment.
12. This document may not be reproduced or duplicated, in any form, in whole or in part, without prior written approval from Renesas.
13. Please contact a Renesas sales office if you have any questions regarding the information contained in this document, Renesas semiconductor products, or if you have any other inquiries.