# Hitachi America, Ltd.

## Application Note

## H8/300

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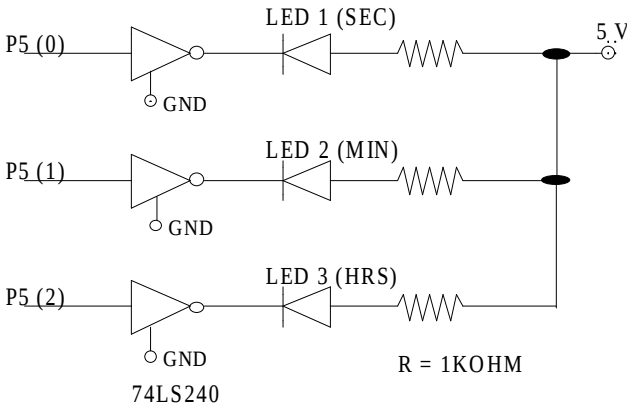
# Using the H8/300 to Generate a Time-of-Day Clock

### INTRODUCTION

The H8/300 series microcontrollers are highly integrated devices incorporating not only a CPU core but also a number of system peripheral devices such as on-chip ROM and RAM, a UART channel, a 16-bit Free Running Timer (FRT) module, a dual-channel 8-bit timer, several I/O Ports, and an 8-channel A/D converter as well. Such a chip diversification certainly allows for a multitude of applications. This application note will illustrate how to implement a time-of-day digital clock using the 16-bit FRT module, utilizing I/O ports and interrupt control.

### DESCRIPTION OF OPERATION

The time-of-day clock is simulated by repeatedly pulsing 3 LEDs every second, minute, and hour, for 1/2 second. In this endeavour, the H8/330 evaluation board is utilized in order to produce the 3 time signals via port bits 0-2 of the I/O Port 5 through the corresponding output pins of jumper connector J2. Please refer to the H8/330 Evaluation Board User's Manual for details. The chip is set into operation mode 3 (single chip mode), and the controlling software is downloaded into the on-chip ROM via the RS-232 channel. An additional board is used to drive and invert the 3 time signals via a 74LS240 tri-statable inverter to the 3 pulsing LEDs, and a 1KOhm SIP resistor pack is employed to pull high the LED inputs. This configuration is illustrated in the figure below:




A 1 MHz external crystal oscillator connected across the XTAL and EXTAL pins of the controller is used, thus providing a 0.5MHz CPU clock. Bits 1 and 0 (CKS1 and 0) of the Timer Control Register (TCR) are set as to provide a 15.625KHz timer clock (0.5MHz/32). Enabling bit 1 (OVIE) of the Timer Interrupt Enable Register (TIER) and loading the Free Running Counter (FRC) with FFFF initiates the interrupt service routine that controls the clock operation. The FRC contents are incremented on each consecutive falling edge of the timer clock. Since a compare-match value of 15,625 (or 3D09 hex) was loaded into the Output Compare Register A (OCRA), and bit 0 (CCLRA) of the Timer Control/Status Register (TCSR) was set to 1, the FRC will reset its contents to 0 and resume counting after each second has elapsed. Bit 3 (OCFA) of TCSR indicates a match between OCRA and FRC has occured, and is continously monitored by the user software. When it is set, a high pulse is transmitted through output port bit P5(0), and LED 0 will turn on each second. A loop counter in the program is used to hold this signal high for 1/2 second, and then turn it low. After 60 compare-matches between OCRA and FRC have occurred, output port bit P5(1) is set high, turning on LED 1 for 1/2 second, indicating that a minute has elapsed. Similarly, after 3600 compare-matches between OCRA and FRC, LED 3 will be turned on for 1/2 second via P5(3) indicating an hour has passed. Figure 1 on the next page illustrates the timing of the output port bits P5(2-0). The program flowcharts are shown in figures 2-5.

It is important to note that, in order to keep the software less complex, the timer clock has to be less than 65.536KHz (FFFF hex), which corresponds to a maximum CPU clock of 65.536 x 32 = 2.097MHz, or a maximum external oscillator frequency of 4.194MHz. This is because the OCRA and FRC are 16-bit registers and therefore cannot be loaded with a hex value greater than FFFF.



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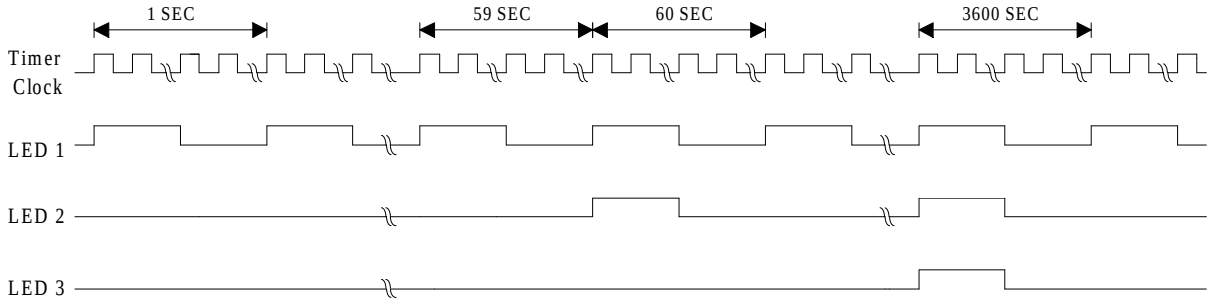


Figure 1: LED Timing

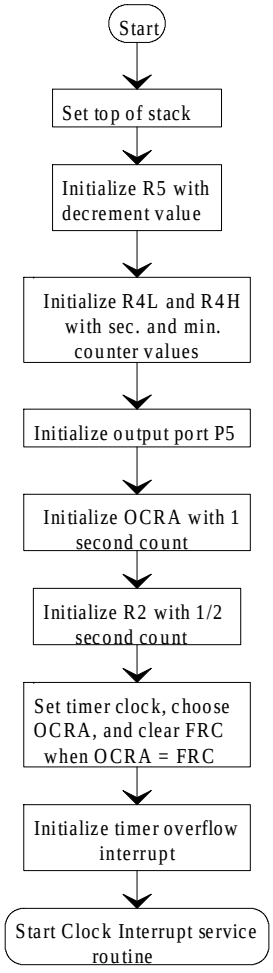


**Figure 2. Main Routine**.

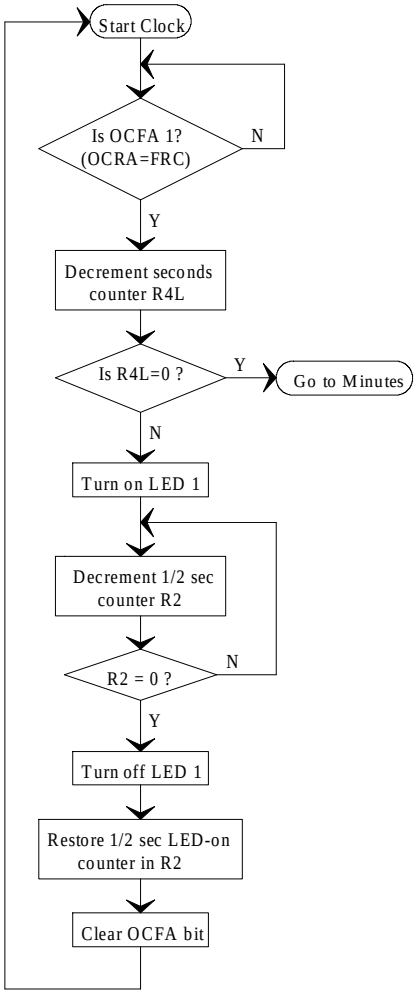


**Figure 3. Start Clock Service Routine.**



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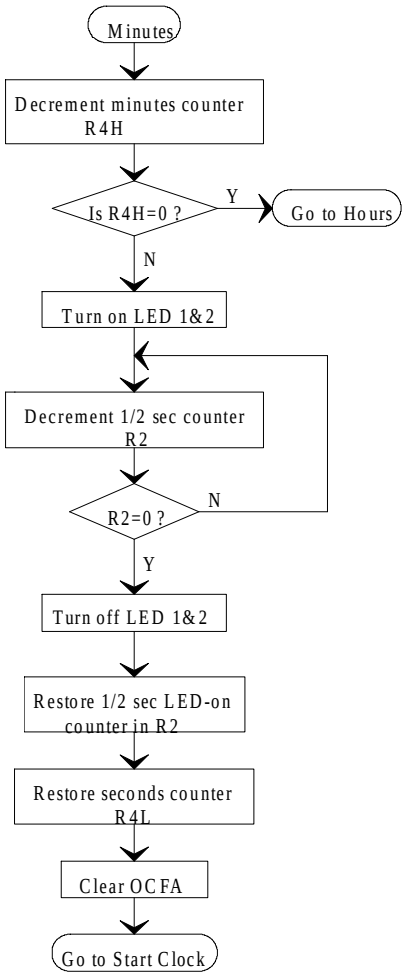


**Figure 4. Start Clock Service Routine (continuation)**

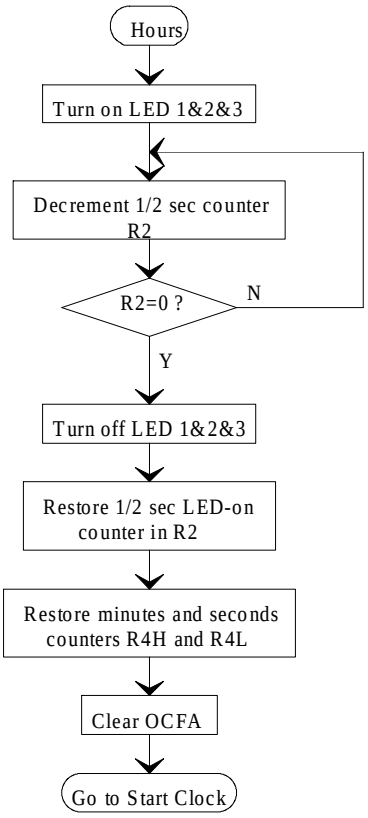


**Figure 5. Start Clock Service Routine (continuation)**



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Command line:  C:\MRI\ASMH83\ASMH83.EXE -l clock.src
Line        Addr
1                                   ;       FRT register definitions
2
3           FF90                    FRT_TIER        .equ    H'FF90
4           FF91                    FRT_TCSR        .equ    H'FF91
5           FF92                    FRT_FRC         .equ    H'FF92
6           FF94                    FRT_OCR         .equ    H'FF94
7           FF96                    FRT_TCR         .equ    H'FF96
8           FF97                    FRT_TOCR        .equ    H'FF97
9
10                                  ;       I/O Port definitions
11
12          FFB8                    P5_DDR          .equ    H'FFB8
13          FFBA                    P5_DR           .equ    H'FFBA
14
15                                  ;       Specify interrupt vector address and program start
16
17                                          .org    H'24
18          0024 053E                       .data.w START_CLK
19                                          .org    H'500
20
21                                  ;       Perform all initializations
22
23          0500 7907 FF80                  mov.w   #H'FF80,R7              ;initialize stackpointer
24          0504 0700                       ldc     #0,CCR                  ;unmask all interrupts
25          0506 7905 0001                  mov.w   #1,R5                   ;initialize decrement value for LED-on time counter
26          050A FC3C                       mov.b   #60,R4L                 ;set R4L with seconds counter value
27          050C F43C                       mov.b   #60,R4H                 ;set R4H with minutes counter value
28          050E F8FF                       mov.b   #H'FF,R0L               ;configure P5 as output port
29          0510 38B8                       mov.b   R0L,@P5_DDR
30          0512 7901 3D09                  mov.w   #H'3D09,R1              ;load OCRA with 1 sec. count
31          0516 6B81 FF94                  mov.w   R1,@FRT_OCR
32          051A 7902 1E84                  mov.w   #H'1E84,R2              ;set LED-on time
33          051E F802                       mov.b   #H'02,R0L               ;timer clock is 0.5MHz/32 = 15.625KHz
34          0520 3896                       mov.b   R0L,@FRT_TCR
35          0522 7F97 7240                  bclr    #4,@FRT_TOCR            ;CPU will access OCRA
36          0526 7F91 7000                  bset    #0,@FRT_TCSR            ;FRC will be cleared when OCRA=FRC
37          052A 7F90 7010                  bset    #1,@FRT_TIER            ;enable timer overflow interrupt request
38          052E 7900 FFFF                  mov.w   #H'FFFF,R0              ;start clock
39          0532 6B80 FF92                  mov.w   R0,@FRT_FRC
40          0536 0000                       nop
41          0538 0000                       nop
42          053A 0000                       nop
43          053C 0000                       nop
44
45                                  ;       Time-of-day clock interrupt service routine
46
47                                  START_CLK:
48          053E 7E91 7330                  btst    #3,@FRT_TCSR            ;is OCFA set to 1?
49          0542 47FA                       beq     START_CLK               ;if not, test again
50          0544 1A0C                       dec     R4L                     ;decrement seconds counter value
51          0546 4716                       beq     MINUTES                 ;if 60 sec. have passed, go to MINUTES
52          0548 7FBA 7000                  bset    #0,@P5_DR               ;turn on LED 1 (indicating seconds)
53                                  LED1_ON:
54          054C 1952                       sub     R5,R2                   ;LED 1 will be on for 1/2 sec.
55          054E 46FC                       bne     LED1_ON
56          0550 7FBA 7200                  bclr    #0,@P5_DR               ;turn off LED1
57          0554 7902 1E84                  mov     #H'1E84,R2              ;restore LED-on time counter value
58          0558 7F91 7230                  bclr    #3,@FRT_TCSR            ;clear OCFA
59          055C 40E0                       bra     START_CLK
60                                  MINUTES:
61          055E 1A04                       dec     R4H                     ;decrement minutes counter value
62          0560 4718                       beq     HOURS                   ;if 60 min. have passed, go to HOURS
63          0562 F8FB                       mov.b   #H'FB,R0L               ;turn on LED 1 and 2 (indicating sec and minutes)
64          0564 38BA                       mov.b   R0L,@P5_DR
65                                  LED12_ON:
66          0566 1952                       sub     R5,R2                   ;LED 1 and 2 will be on for 1/2 sec
67          0568 46FC                       bne     LED12_ON
68          056A F8F8                       mov.b   #H'F8,R0L               ;turn off LED 1 and 2
69          056C 38BA                       mov.b   R0L,@P5_DR
70          056E 7902 1E84                  mov.w   #H'1E84,R2              ;restore LED-on time counter value
71          0572 FC3C                       mov.b   #60,R4L                 ;restore seconds counter value
72          0574 7F91 7230                  bclr    #3,@FRT_TCSR            ;clear OCFA
73          0578 40C4                       bra     START_CLK
74          057A F8FF                   HOURS:  mov.b   #H'FF,R0L               ;turn on LED 1,2, and 3
75          057C 38BA                       mov.b   R0L,@P5_DR
76                                  LED123_ON:
77          057E 1952                       sub     R5,R2                   ;LED 1,2, and 3 will be on for 1/2 sec
78          0580 46FC                       bne     LED123_ON
79          0582 F8F8                       mov.b   #H'F8,R0L               ;turn off all LEDs
80          0584 38BA                       mov.b   R0L,@P5_DR
81          0586 7902 1E84                  mov.w   #H'1E84,R2              ;restore LED-on time counter value
82          058A F43C                       mov.b   #60,R4H                 ;restore minutes counter value
83          058C FC3C                       mov.b   #60,R4L                 ;restore seconds counter value
84          058E 7F91 7230                  bclr    #3,@FRT_TCSR            ;clear OCFA
85          0592 40AA                       bra     START_CLK
86                                          .end
```