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RENESAS

Application Note

78K0S/Kx1+

Sample Program (Interrupt)

External Interrupt Generated by Switch Input

This document describes an operation overview of the sample program, as well as how to use the sample program and how to set and use the interrupt function. In the sample program, an interrupt is generated by detecting the falling edge of the switch input and an LED lighting pattern is displayed according to the number of switch inputs.

Target devices

78K0S/KA1+ microcontroller
78K0S/KB1+ microcontroller
78K0S/KU1+ microcontroller
78K0S/KY1+ microcontroller

CONTENTS

Document No. U18812EJ2V0AN00 (2nd edition)
Date Published September 2008 NS

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M8E 02. 11-1

CHAPTER 1 OVERVIEW

In this sample program, an example of using the interrupt function is presented. An LED lighting pattern is displayed according to the number of switch inputs, by detecting the falling edge of the switch input and performing interrupt servicing.

1.1 Main Contents of Initial Settings

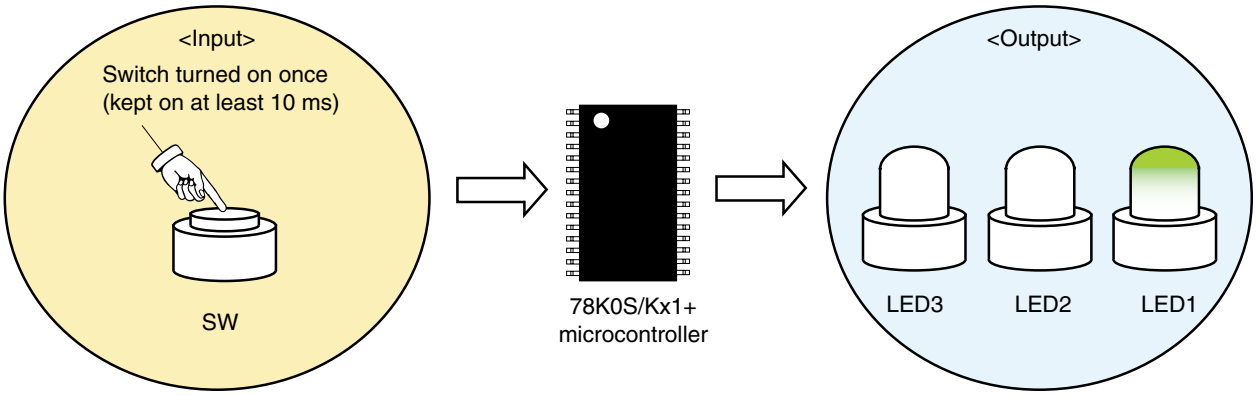
The contents of the initial settings are as follows.

- Selecting the high-speed internal oscillator as the system clock source[Note]
- Stopping watchdog timer operation
- Setting the CPU clock frequency and peripheral hardware clock frequency to 2 MHz
- Setting I/O ports
- Setting the valid edge of INTP1 (external interrupt) to the falling edge
- Enabling interrupt

Note This is set by using the option byte.

1.2 Contents Following the Main Loop

Interrupt servicing is performed by detecting the falling edge of the INTP1 pin, caused by switch input. In interrupt servicing, the LED lighting pattern is changed by confirming that the switch is on, after about 10 ms have elapsed after the falling edge of the INTP1 pin was detected. If the switch is off, after about 10 ms have elapsed, processing is identified as chattering and the LED lighting pattern is not changed.



Number of Switch Inputs[Note]	LED Output		
	LED3	LED2	LED1
0	OFF	OFF	OFF
1	OFF	OFF	ON
2	OFF	ON	OFF
3	OFF	ON	ON
4	ON	OFF	OFF
5	ON	OFF	ON
6	ON	ON	OFF
7	ON	ON	ON

Note The lighting patterns from the zeroth switch input are repeated after the eighth switch input.

Caution For cautions when using the device, refer to the user's manual of each product (78K0S/KU1+, 78K0S/KY1+, 78K0S/KA1+, 78K0S/KB1+).

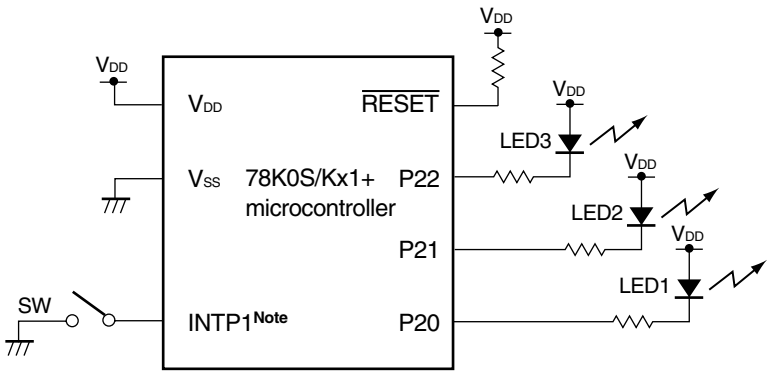
[Column] Chattering
Chattering is a phenomenon in which the electric signal repeats turning on and off due to a mechanical flip-flop of the contacts, immediately after the switch has been pressed.

CHAPTER 2 CIRCUIT DIAGRAM

This chapter describes a circuit diagram and the peripheral hardware to be used in this sample program.

2.1 Circuit Diagram

A circuit diagram is shown below.



Note INTP1/P43: 78K0S/KA1+ and 78K0S/KB1+ microcontrollers
INTP1/P32: 78K0S/KY1+ and 78K0S/KU1+ microcontrollers

Cautions 1. Connect the AV_{REF} pin directly to V_{DD} (only for the 78K0S/KA1+ and 78K0S/KB1+ microcontrollers).
2. Connect the AV_{SS} pin directly to GND (only for the 78K0S/KB1+ microcontroller).
3. Leave all unused pins open (unconnected), except for the pins shown in the circuit diagram and the AV_{REF} and AV_{SS} pins.

2.2 Peripheral Hardware

The peripheral hardware to be used is shown below.

(1) Switch (SW)

A switch is used as an input to control the lighting of an LED.

(2) LEDs (LED1, LED2, LED3)

The LEDs are used as outputs corresponding to switch inputs.

CHAPTER 3 SOFTWARE

This chapter describes the file configuration of the compressed file to be downloaded, internal peripheral functions of the microcontroller to be used, and initial settings and operation overview of the sample program, and shows a flow chart.

3.1 File Configuration

The following table shows the file configuration of the compressed file to be downloaded.

File Name	Description	Compressed (*.zip) File Included		
				
main.asm (Assembly language version) --- main.c (C language version)	Source file for hardware initialization processing and main processing of microcontroller	●Note 1	●Note 1	
op.asm	Assembler source file for setting the option byte (sets the system clock source)	●	●	
int.prw	Work space file for integrated development environment PM+		●	
int.prj	Project file for integrated development environment PM+		●	
int.pri int.prs int.prm	Project files for system simulator SM+ for 78K0S/Kx1+		●Note 2	
int0.pnl	I/O panel file for system simulator SM+ for 78K0S/Kx1+ (used for checking peripheral hardware operations)		●Note 2	●
int0.wvo	Timing chart file for system simulator SM+ for 78K0S/Kx1+ (used for checking waveforms)			●

Notes 1. “main.asm” is included with the assembly language version, and “main.c” with the C language version.

2. These files are not included among the files for the 78K0S/KU1+ microcontroller.

Remark  : Only the source file is included.

 : The files to be used with integrated development environment PM+ and 78K0S/Kx1+ system simulator SM+ are included.

 : The microcontroller operation simulation file to be used with system simulator SM+ for 78K0S/Kx1+ is included.

3.2 Internal Peripheral Functions to Be Used

The following internal peripheral functions of the microcontroller are used in this sample program.

- Switch input: INTP1[Note] (external interrupt)
- LED output: P20, P21, P22 (output ports)

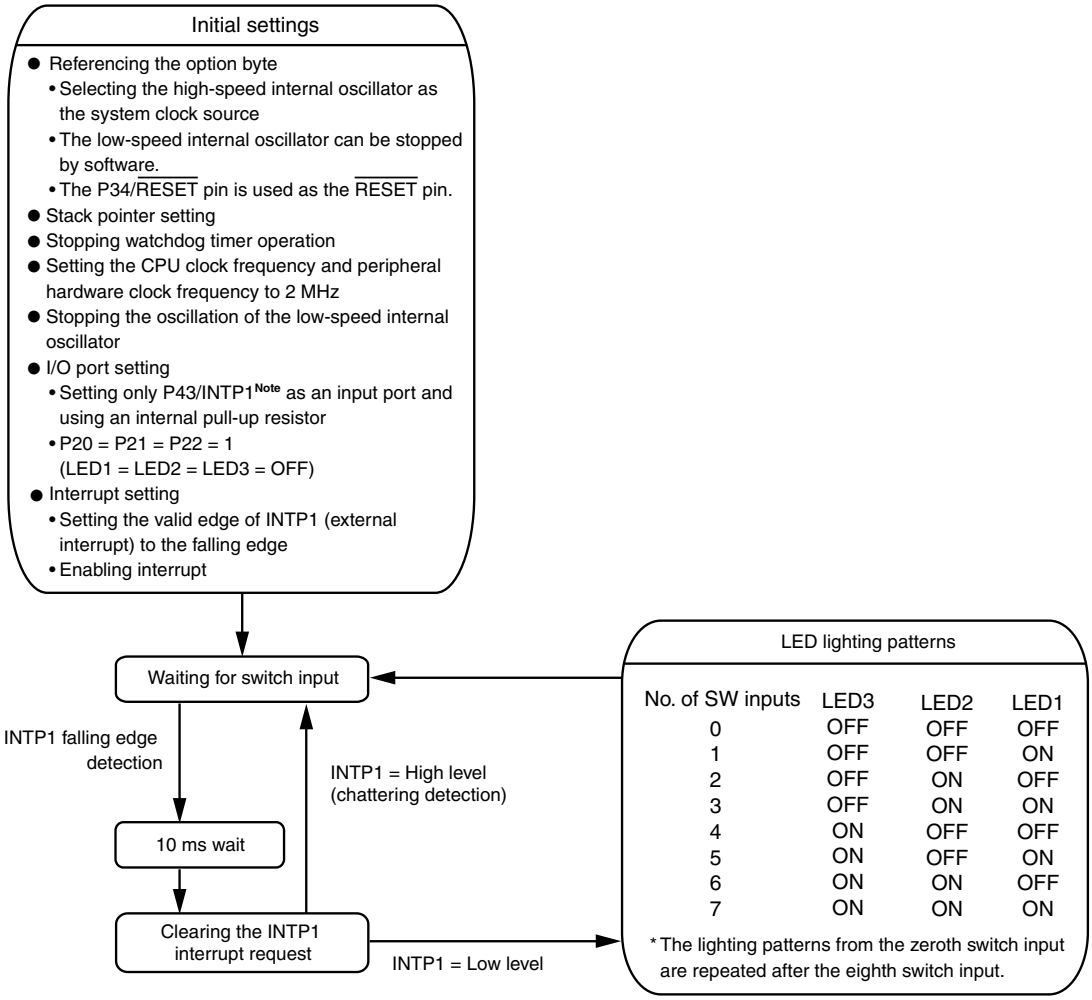
Note INTP1/P43: 78K0S/KA1+ and 78K0S/KB1+ microcontrollers
INTP1/P32: 78K0S/KY1+ and 78K0S/KU1+ microcontrollers

3.3 Initial Settings and Operation Overview

In this sample program, the selection of the clock frequency, setting of the I/O ports, setting of interrupts, and the like are performed in the initial settings.

After completion of the initial settings, interrupt servicing is performed by detecting the falling edge of the switch input (SW) and the lighting of the three LEDs (LED1, LED2, and LED3) is controlled according to the number of switch inputs.

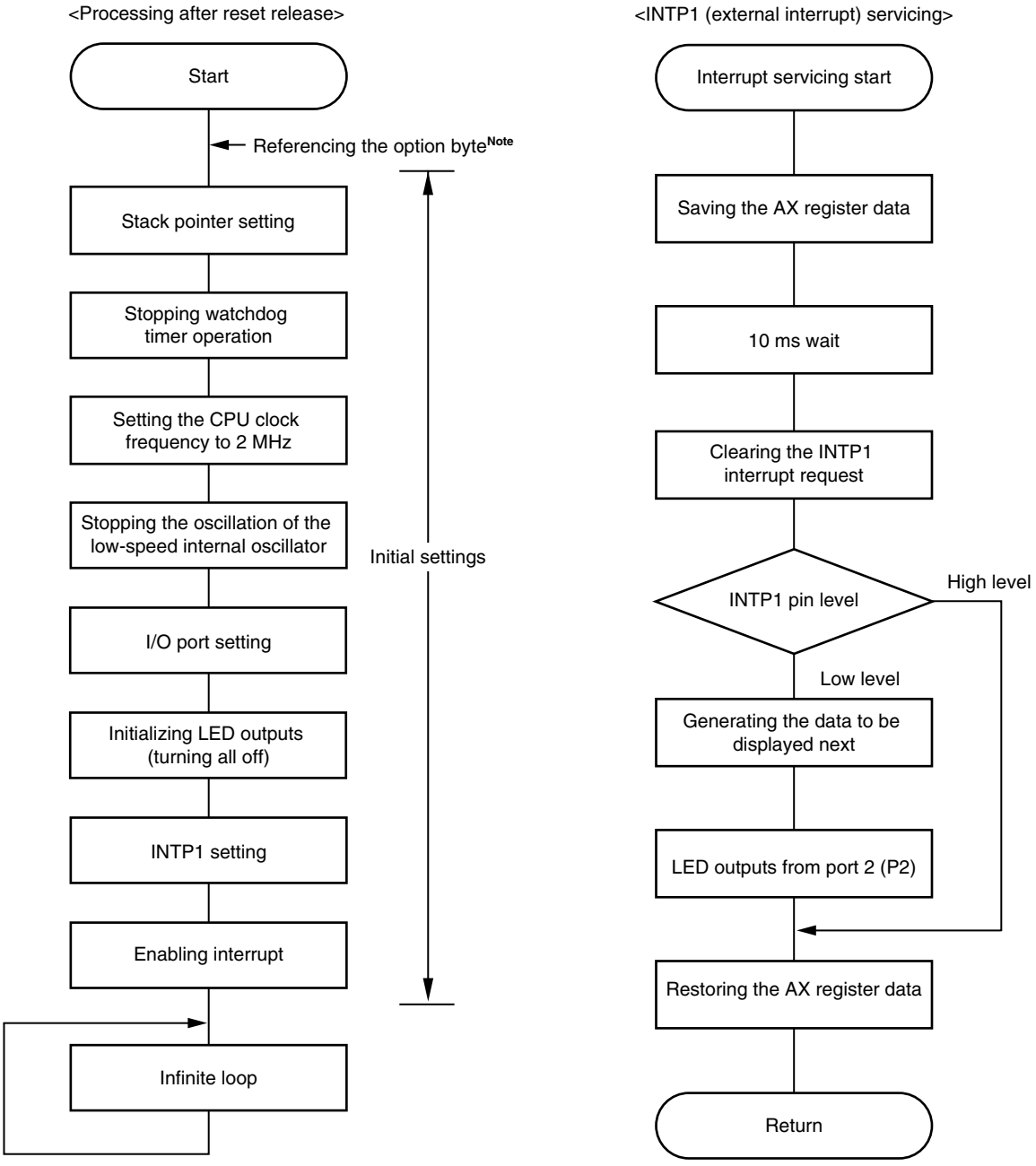
The details are described in the state transition diagram shown below.



Note INTP1/P43: 78K0S/KA1+ and 78K0S/KB1+ microcontrollers
INTP1/P32: 78K0S/KY1+ and 78K0S/KU1+ microcontrollers

3.4 Flow Chart

A flow chart for the sample program is shown below.



Note Referencing the option byte is automatically performed by the microcontroller after reset release. In this sample program, the following contents are set by referencing the option byte.

- Using the high-speed internal oscillation clock (8 MHz (TYP.)) as the system clock source
- The low-speed internal oscillator can be stopped by using software
- Using the P34/$\overline{\text{RESET}}$ pin as the $\overline{\text{RESET}}$ pin

CHAPTER 4 SETTING METHODS

This chapter describes how to set interrupts, as well as interrupt servicing.

For other initial settings, refer to the **78K0S/Kx1+ Sample Program (Initial Settings) LED Lighting Switch Control Application Note**.

For how to set registers, refer to the user's manual of each product (**78K0S/KU1+**, **78K0S/KY1+**, **78K0S/KA1+**, **78K0S/KB1+**).

For assembler instructions, refer to the **78K/0S Series Instructions User's Manual**.

4.1 Interrupt Setting

The interrupt functions are controlled by using the following four types of registers.

- Interrupt request flag registers 0, 1[Note] (IF0, IF1[Note])
- Interrupt mask flag registers 0, 1[Note] (MK0, MK1[Note])
- External interrupt mode registers 0, 1[Note] (INTM0, INTM1[Note])
- Program status word (PSW)

The names of interrupt request flags and interrupt mask flags for various interrupt requests are shown below.

Interrupt Request Signal Name	Interrupt Request Flag	Interrupt Mask Flag
INTLVI	LVIIF	LVIMK
INTP0	PIF0	PMK0
INTP1	PIF1	PMK1
INTTMH1	TMIFH1	TMMKH1
INTTM000	TMIF000	TMMK000
INTTM010	TMIF010	TMMK010
INTAD	ADIF	ADMK
INTP2[Note]	PIF2[Note]	PMK2[Note]
INTP3[Note]	PIF3[Note]	PMK3[Note]
INTTM80[Note]	TMIF80[Note]	TMMK80[Note]
INTSRE6[Note]	SREIF6[Note]	SREMK6[Note]
INTSR6[Note]	SRIF6[Note]	SRMK6[Note]
INTST6[Note]	STIF6[Note]	STMK6[Note]

Note Only 78K0S/KA1+ and 78K0S/KB1+ microcontrollers

(1) Interrupt request flag setting

An interrupt request flag is set to 1 when the corresponding interrupt request is generated, or when an instruction is executed. It is cleared to 0 when an interrupt request is acknowledged, a reset is executed, or an instruction is executed.

To use the interrupt function, clear to 0 the interrupt request flag to be used before the interrupt request is generated.

Figure 4-1. Format of Interrupt Request Flag Registers 0, 1[Note] (IF0, IF1[Note])

IF0

ADIF	TMIF 010	TMIF 000	TMIFH 1	PIF1	PIF0	LVIIF	0

IF1[Note]

0	STIF6 [Note]	SRIF6 [Note]	SREIF6 [Note]	TMIF 80[Note]	PIF3[Note]	PIF2[Note]	0

Interrupt request flag

0	No interrupt request signal has been generated.
1	An interrupt request signal has been generated and an interrupt is being requested.

(2) Interrupt servicing enable/disable setting

An interrupt mask flag is used to enable (0) or disable (1) the corresponding interrupt servicing.

To use the interrupt function, clear to 0 the interrupt mask flag to be used before the interrupt request is generated.

Figure 4-2. Format of Interrupt Mask Flag Registers 0, 1[Note] (MK0, MK1[Note])

MK0

ADMK	TMMK 010	TMMK 000	TMMK H1	PMK1	PMK0	LVIMK	1

MK1[Note]

1	STMK6 [Note]	SRMK6 [Note]	SRE MK6[Note]	TMMK 80[Note]	PMK3 [Note]	PMK2 [Note]	1

Interrupt servicing control

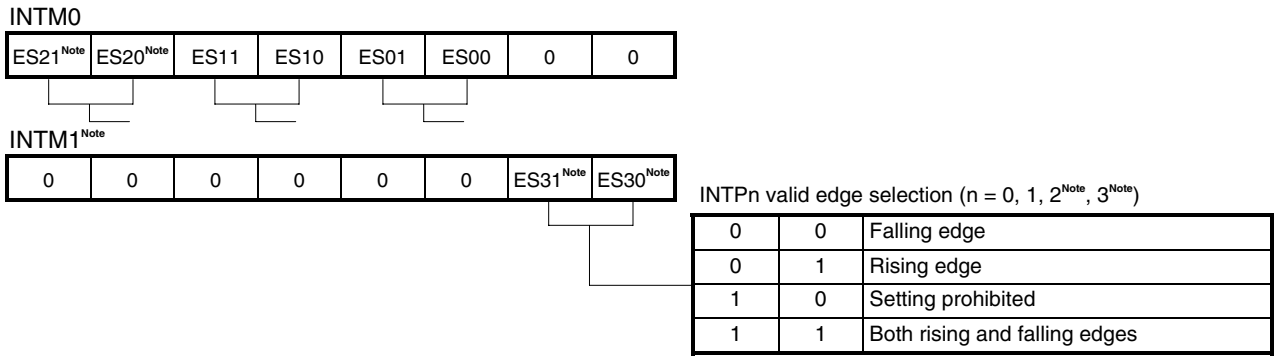
0	Enables interrupt servicing.
1	Disables interrupt servicing.

Note Only 78K0S/KA1+ and 78K0S/KB1+ microcontrollers

(3) External interrupt valid edge setting

INTM0 and INTM1[Note] are used to set the valid edges of INTP0, INTP1, INTP2[Note], and INTP3[Note] (external interrupts).

Figure 4-3. Format of External Interrupt Mode Registers 0 and 1[Note] (INTM0, INTM1[Note])



The combinations of external interrupts and valid edge setting flags are shown below.

Setting Flag		External Interrupt
ES31[Note]	ES30[Note]	INTP3[Note]
ES21[Note]	ES20[Note]	INTP2[Note]
ES11	ES10	INTP1
ES01	ES00	INTP0

Note Only 78K0S/KA1+ and 78K0S/KB1+ microcontrollers

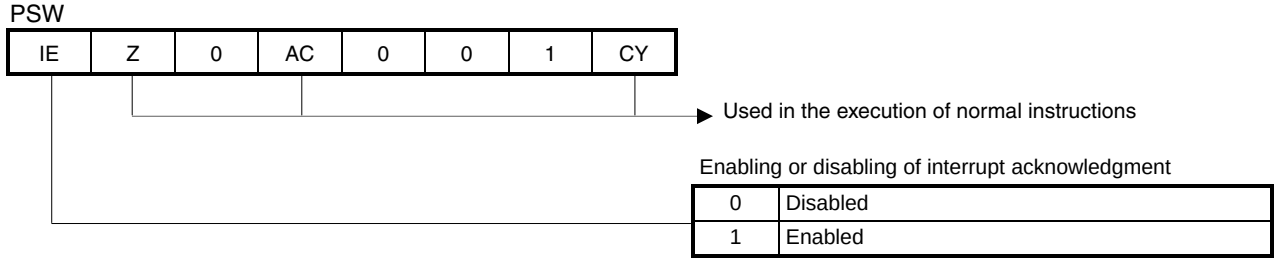
(4) Interrupt enable/disable setting

The IE flag of the program status word (PSW) is used to enable (1) or disable (0) interrupt. The IE flag can be manipulated by using a dedicated instruction (EI: enable interrupt, DI: disable interrupt).

When the interrupt mask flag is cleared to 0 and the IE flag is set to 1, an interrupt request is generated and an interrupt is acknowledged when the interrupt request flag is set to 1.

When the interrupt is acknowledged, the PSW is automatically saved to the stack and the IE flag is cleared to 0.

Figure 4-4. Format of Program Status Word (PSW)



[Example] Performing interrupt servicing by detecting the falling edge of INTP1 (same content as the sample program setting)

● Register settings

- Clearing to 0 the interrupt request flag (PIF1) corresponding to INTP1
- Clearing to 0 the interrupt mask flag (PMK1) corresponding to INTP1
- Setting the valid edge of INTP1 to “Falling edge”
- Enabling interrupt by executing the EI instruction

IF0

0	0	0	0	0	0	0	0

Interrupt request flag

0	No interrupt request signal has been generated.

MK0

1	1	1	1	0	1	1	1

Interrupt servicing control

0	Enables interrupt servicing.

INTM0

0	0	0	0	0	0	0	0

INTP1 valid edge selection

0	0	Falling edge

PSW

1	0	0	0	0	0	1	0

Enabling or disabling of interrupt acknowledgment

1	Enabled

Remark Set the port shared with INTP1 (P43: 78K0S/KA1+ and 78K0S/KB1+ microcontrollers, P32: 78K0S/KY1+ and 78K0S/KU1+ microcontrollers) to “Input port”. Furthermore, set to “Use internal pull-up resistors” because the circuit configuration in this sample program is set not to connect pull-up resistors outside the microcontroller. The use of the internal pull-up resistors is not a setting required when using external interrupts.

For the port settings, refer to **78K0S/Kx1+ Sample Program (Initial Settings) LED Lighting Switch Control Application Note**.

● Assembly language program example

(Same content as the 78K0S/KB1+ microcontroller sample program setting)

```
XVCT   CSEG   AT     0000H
       DW     RESET_START          ;(00)  RESET
       DW     RESET_START          ;(02)  --
       DW     RESET_START          ;(04)  --
       DW     RESET_START          ;(06)  INTLVI
       DW     RESET_START          ;(08)  INTP0
       DW     INTERRUPT_P1         ;(0A)  INTP1
       DW     RESET_START          ;(0C)  INTTMH1
       DW     RESET_START          ;(0E)  INTTM000
       DW     RESET_START          ;(10)  INTTM010
       DW     RESET_START          ;(12)  INTAD
       DW     RESET_START          ;(14)  --
       DW     RESET_START          ;(16)  INTP2
       DW     RESET_START          ;(18)  INTP3
       DW     RESET_START          ;(1A)  INTTM80
       DW     RESET_START          ;(1C)  INTSRE6
       DW     RESET_START          ;(1E)  INTSR6
       DW     RESET_START          ;(20)  INTST6
                •
                •
                •
XMAIN  CSEG   UNIT
RESET_START:
                •
                •
                •
       MOV    P4,    #00000000B    ;Set output latches of P40-P47 as low
       MOV    PU4,   #00001000B    ;Connect on-chip pull-up resistor to P43
       MOV    PM4,   #00001000B    ;Set P43 as input mode, P40-P42 and
                                   ;P44-P47 as output mode
                •
                •
                •
       MOV    INTM0, #00000000B    ;Set the valid edge of INTP1 to falling edge
       CLR1   PIF1                 ;Clear invalid interrupt requests in advance
       CLR1   PMK1                 ;Release the INTP1 interrupt mask
       EI                          ;Enable vector interrupt

MAIN_LOOP:
       NOP
       BR     $MAIN_LOOP           ;Go to the MAIN_LOOP

INTERRUPT_P1:
       PUSH   AX
                •
                •
                •
       RETI
```

Interrupt servicing is started from the “INTERRUPT_P1” symbol when an interrupt is generated, by describing the initial value (“INTERRUPT_P1”) using the DW pseudo instruction.

Setting P43 shared with the INTP1 pin as an input port

INTP1 settings

Enabling of interrupt

Interrupt servicing is started from “INTERRUPT_P1” by detecting the valid edge (falling edge) of INTP1.

● C language program example

(Same content as the 78K0S/KB1+ microcontroller sample program setting)

```
#pragma interrupt INTP1 fn_intp1  /* Interrupt function declaration: INTP1 */

                •
                •
                •
void hdwinit(void){
                •
                •
                •
        P4    = 0b00000000;   /* Set output latches of P40-P47 as low */
        PU4   = 0b00001000;   /* Connect on-chip pull-up resistor to P43 */
        PM4   = 0b00001000;   /* Set P43 as input mode, P40-P42 and */
                              /* P44-P47 as output mode */
                •
                •
                •
        INTM0 = 0b00000000;   /* Set the valid edge of INTP1 to falling edge */
        PIF1  = 0;            /* Clear invalid interrupt requests in advance */
        PMK1  = 0;            /* Release the INTP1 interrupt mask */

        return;
}

void main(void){

        EI();                 /* Enable vector interrupt */

        while (1){
              NOP();
              NOP();
        }
}

__interrupt void fn_intp1(){
        unsigned int unChat;  /* 16-bit variable for the chattering removal timer */
                •
                •
                •
         return;
}
```

Interrupt servicing is started from the interrupt function declared with the _interrupt modifier when an interrupt is generated, by declaring the INTP1 interrupt function (“fn_intp1” in this case) in the preprocessing directive (#pragma directive) and declaring that interrupt function using the _interrupt modifier.

Setting P43 shared with the INTP1 pin as an input port

INTP1 settings

Enabling of interrupt

Interrupt servicing is started from “fn_intp1” by detecting the valid edge (falling edge) of INTP1.

4.2 Processing During Interrupt

The processing during interrupt is described below.

(1) Assembly language

The following operations are performed in the assembly language processing during interrupt.

<1> An interrupt request is generated by switch input and interrupt servicing is started.
<2> AX register data is saved to the stack.
<3> Processing waits for 10 ms.
<4> PIF1 (INTP1 interrupt request flag) is cleared to 0.
<5> The pin status of INTP1/P43[Note] is checked.
- INTP1/P43[Note] = Low level → <5>
- INTP1/P43[Note] = High level (chattering detection) → <9>

<6> The P2 data currently output is read.
<7> The read data is decremented by 1.
<8> The values of bits other than bits 0 to 2, among the data in <7>, are set to 0.
<9> The data in <8> is output to P2.
<10> The data saved to the stack is restored to the AX register.
<11> Processing is returned from interrupt servicing.

Note INTP1/P43: 78K0S/KA1+ and 78K0S/KB1+ microcontrollers
INTP1/P32: 78K0S/KY1+ and 78K0S/KU1+ microcontrollers

Remarks 1. <1> to <11> mentioned above correspond to <1> to <11> on the next page.
2. The content of the program example on the next page is the same as that of the 78K0S/KB1+ microcontroller sample program.

RAM area setting

```
XRAM   DSEG   SADDR
CNT_1: DS     1          ; For major loop
CNT_2: DS     1          ; For minor loop
```

Saves the work area (1 byte × 2) of RAM to be used for interrupt servicing.

Interrupt servicing

```
<1>  INTERRUPT_P1:
<2>          PUSH   AX              ; Save the AX register data to the stack

             ;-----  10 ms wait to handle chattering  -----
             MOV    CNT_1,  #28     ; Assign the count value for the major loop   (a) 6 clocks
             NOP                                                                  (b) 2 clocks
     LOOP_1:
<3>          MOV    CNT_2,  #70     ; Assign the count value for the minor loop   (c) 6 clocks
     LOOP_2:
             NOP                                                                  (d) 2 clocks
             DBNZ   CNT_2,  $LOOP_2     ; Minor loop                              (e) 8 clocks
             DBNZ   CNT_1,  $LOOP_1     ; Major loop                              (f) 8 clocks
<4>          CLR1   PIF1                ; Clear the INTP1 interrupt request

             ;-----  Identification of chattering detection  -----
<5>          BT     P4.3,   $END_INTP1  ; Branch if there is no switch input

             ;-----  LED lighting processing  -----
<6>          MOV    A,      P2          ; Read the current output value
<7>          DEC    A                   ; Decrement the A register value by 1
<8>          AND    A,      #00000111B  ; Mask bits other than bits 0 to 2
<9>          MOV    P2,     A           ; Output the LED light

     END_INTP1:
<10>         POP    AX                  ; Restore the AX register data
<11>         RETI                       ; Return from interrupt servicing
```

Number of clocks of the instruction

INTP1/P43 = Low level

INTP1/P43 = High level (chattering detection)

Correspondences between the input data and output data are shown below.

Number of Switch Inputs[Note]	P22, P21, P20 Output Data		LED Lighting
0	P22 = P21 = P20 = 1	7	Turns off all LEDs.
1	P22 = P21 = 1, P20 = 0	6	LED3, LED2: off, LED1: on
2	P22 = 1, P21 = 0, P20 = 1	5	LED3: off, LED2: on, LED1: off
3	P22 = 1, P21 = P20 = 0	4	LED3: off, LED2, LED1: on
4	P22 = 0, P21 = P20 = 1	3	LED3: on, LED2, LED1: off
5	P22 = 0, P21 = 1, P20 = 0	2	LED3: on, LED2: off, LED1: on
6	P22 = P21 = 0, P20 = 1	1	LED3, LED2: on, LED1: off
7	P22 = P21 = P20 = 0	0	Lights all LEDs.

Note The lighting patterns from the zeroth switch input are repeated after the eighth switch input.

Remarks 1. The wait time (10 ms) at <3> indicated above can be calculated by the following expressions.

- 1 clock = 1/2 MHz = 0.5 μs
- Number of clocks at <3> = (a) + (b) + { (c) + ((d) + (e)) × 70 + (f) } × 28

Repeats (d) + (e) 70 times

Repeats (c) to (f) 28 times

- Wait time at <3> = [(a) + (b) + { (c) + ((d) + (e)) × 70 + (f) } × 28] × 0.5 μs

  = [6 + 2 + {6 + (2 + 8) × 70 + 8} × 28] × 0.5 μs

  = 20,000 × 0.5 μs = 10,000 μs = 10 ms

2. <1> to <11> mentioned above correspond to <1> to <11> on the previous page.

(2) C language

Similar operation as with the assembly language is performed with C language interrupt servicing.

Remark The content of the following program example is the same as that of the 78K0S/KB1+ microcontroller sample program.

Interrupt servicing

```
__interrupt void fn_intp1(){
       unsigned int unChat;                  /* 16-bit variable for the chattering
removal timer */
       for (unChat = 0; unChat < 278; unChat++){
                                             /* Wait for about 10 ms (for chattering
removal) */
              NOP();
       }
       PIF1  = 0;                            /* Clear the INTP1 interrupt request */
       if (!P4.3){                           /* Processing performed if SW is on for
10 ms or more */
              P2 = (P2 - 1) & 0b00000111;    /* LED output according to the number of
SW inputs */
       }

       return;
}
```

Correspondences between the input data and output data are shown below.

Number of Switch Inputs[Note]	P22, P21, P20 Output Data		LED Lighting
0	P22 = P21 = P20 = 1	7	Turns off all LEDs.
1	P22 = P21 = 1, P20 = 0	6	LED3, LED2: off, LED1: on
2	P22 = 1, P21 = 0, P20 = 1	5	LED3: off, LED2: on, LED1: off
3	P22 = 1, P21 = P20 = 0	4	LED3: off, LED2, LED1: on
4	P22 = 0, P21 = P20 = 1	3	LED3: on, LED2, LED1: off
5	P22 = 0, P21 = 1, P20 = 0	2	LED3: on, LED2: off, LED1: on
6	P22 = P21 = 0, P20 = 1	1	LED3, LED2: on, LED1: off
7	P22 = P21 = P20 = 0	0	Lights all LEDs.

Note The lighting patterns from the zeroth switch input are repeated after the eighth switch input.

CHAPTER 5 OPERATION CHECK USING SYSTEM SIMULATOR SM+

This chapter describes how the sample program operates with system simulator SM+ for 78K0S/Kx1+, by using the assembly language file that has been downloaded by selecting the  icon.

<R> **Caution System simulator SM+ for 78K0S/Kx1+ is not supported with the 78K0S/KU1+ microcontroller (as of July 2008). The operation of the 78K0S/KU1+ microcontroller can therefore not be checked by using system simulator SM+ for 78K0S/Kx1+.**

<R> 5.1 Building the Sample Program

To check the operation of the sample program by using system simulator SM+ for 78K0S/Kx1+ (hereinafter referred to as “SM+”), SM+ must be started after building the sample program. This section describes how to build a sample program by using the assembly language sample program (source program + project file) downloaded by clicking the  icon. See the **78K0S/Kx1+ Sample Program Startup Guide Application Note** for how to build other downloaded programs.

For the details of how to operate PM+, refer to the **PM+ Project Manager User’s Manual**.

[Column] Build errors

Change the compiler option setting according to the following procedure when the error message “A006 File not found ‘C:\NECTOOLS32\LIB78K0S\s0sl.rel’” or “*** ERROR F206 Segment ‘@@DATA’ can’t allocate to memory - ignored.” is displayed, when building with PM+.

<1> Select [Compiler Options] from the [Tool] menu.
<2> The [Compiler Options] dialog box will be displayed. Select the [Startup Routine] tab.
<3> Uncheck the [Using Fixed Area of Standard Library] check box. (Leave the other check boxes as they are.)

A RAM area of 118 bytes that has been secured as a fixed standard library area will be enabled for use when the [Using Fixed Area of Standard Library] check box is unchecked; however, the standard libraries (such as the getchar function and malloc function) will be disabled for use.

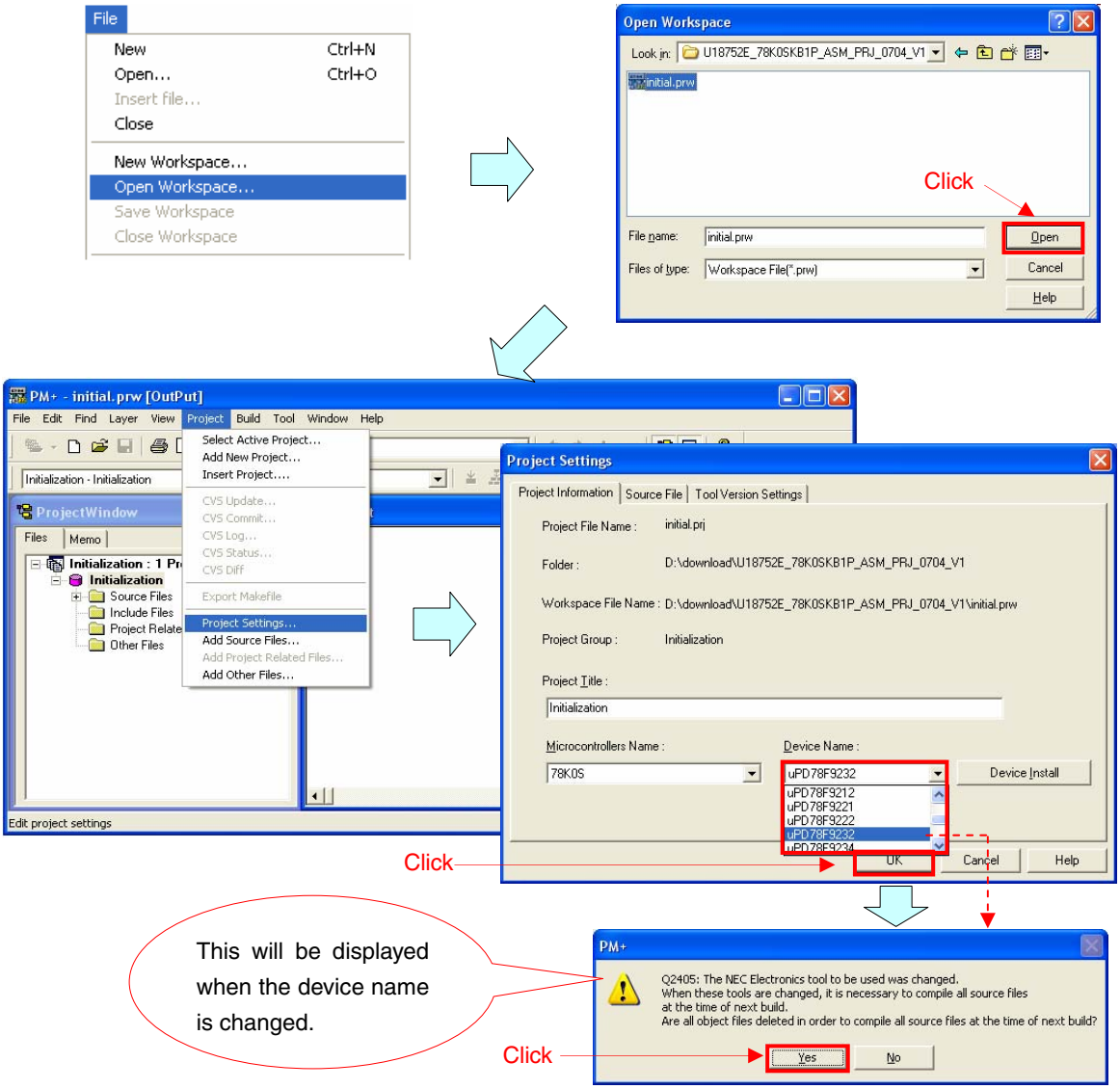
The [Using Fixed Area of Standard Library] check box is unchecked by default when the file that has been downloaded by clicking the  icon is used in this sample program.

(1) Start PM+.

(2) Select “int.prw” by clicking [Open Workspace] from the [File] menu and click [Open]. A workspace into which the source file will be automatically read will be created.

(3) Select [Project Settings] from the [Project] menu. When the [Project Settings] window opens, select the name of the device to be used (the device with the largest ROM or RAM size will be selected by default), and click [OK].

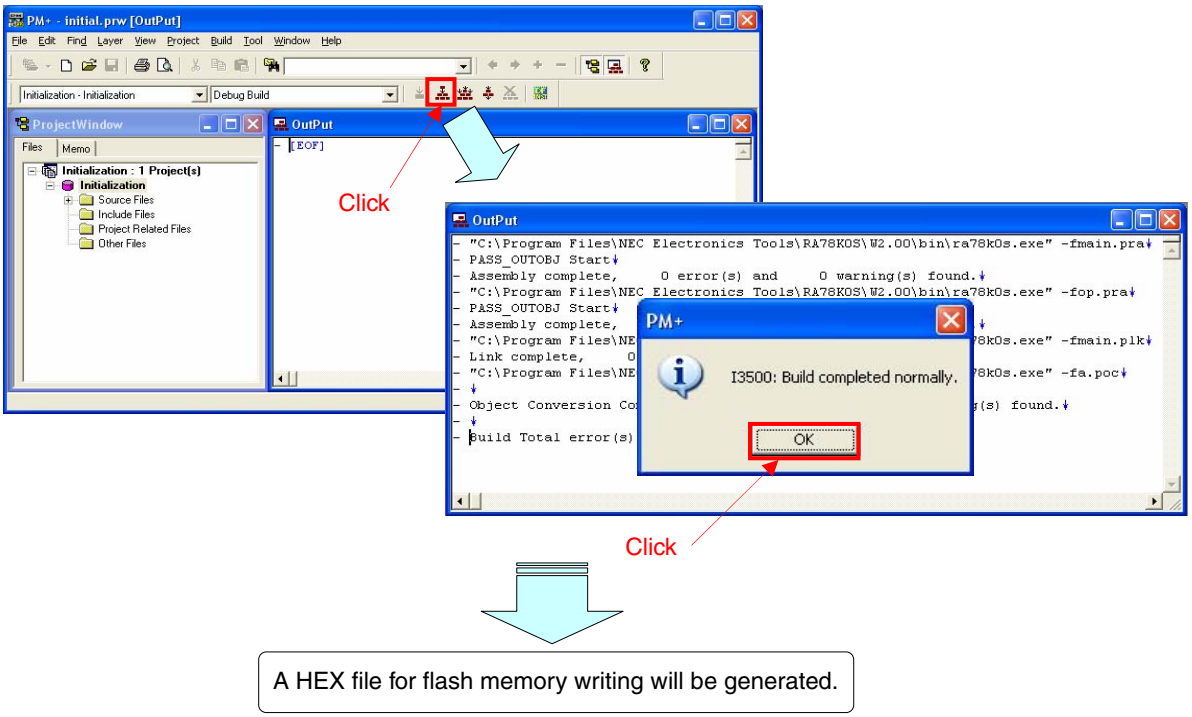
Remark Screenshots of the Sample Program (Initial Settings) LED Lighting Switch Control are shown below.



(4) Click  ([Build] button). When the source files are built normally, the message “I3500: Build completed normally.” will be displayed.

(5) Click the [OK] button in the message dialog box. A HEX file for flash memory writing will be created.

Remark Screenshots of the Sample Program (Initial Settings) LED Lighting Switch Control are shown below.



5.2 Operation with SM+

This section describes examples of checking the operation on the I/O panel window or timing chart window of SM+. For the details of how to operate SM+, refer to the **SM+ System Simulator Operation User’s Manual**.

<R> (1) When SM+ for 78K0S/Kx1+ W1.02 (“SM+” hereafter) is used in the environment of PM+ Ver. 6.30, SM+ cannot be selected as the debugger. In this case, start SM+ via method (a) or (b) described below, while keeping PM+ running after completing building a project.

(a) When starting SM+ in PM+

<1> Select [Register Ex-tool] from the [Tool] menu and register “SM+ for 78K0S/Kx1+”.

<2> Select [Ex-tool Bar] from the [View] menu and add the SM+ icon to the PM+ toolbar.

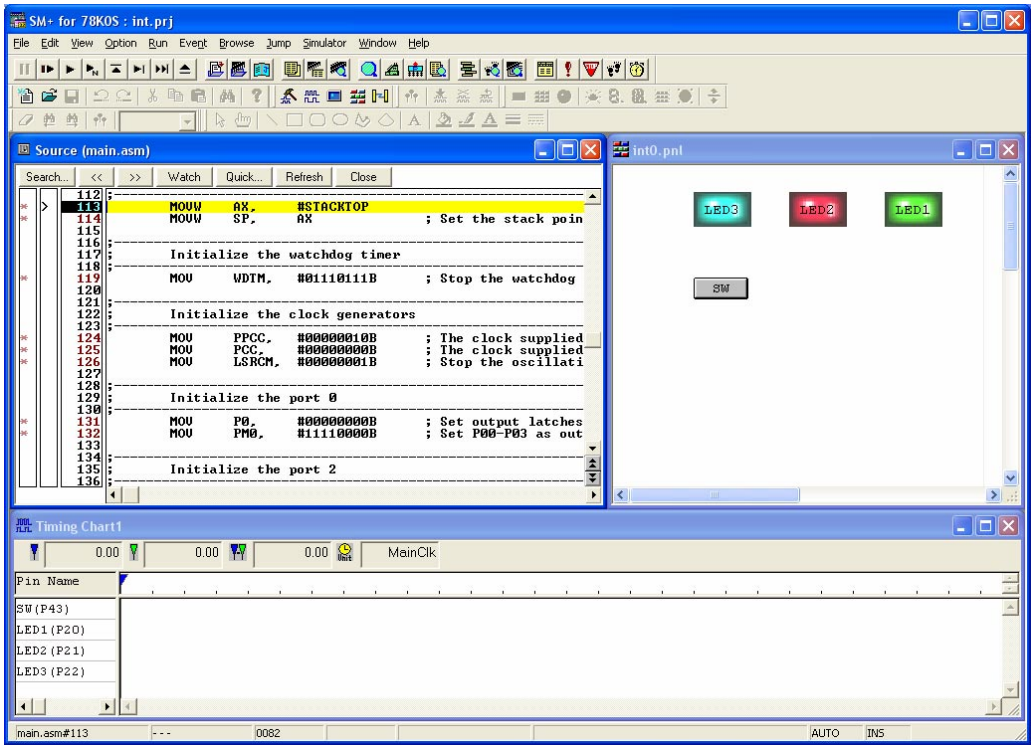
<3> Click the SM+ icon and start SM+.

(See the PM+ help for details on how to register external tools.)

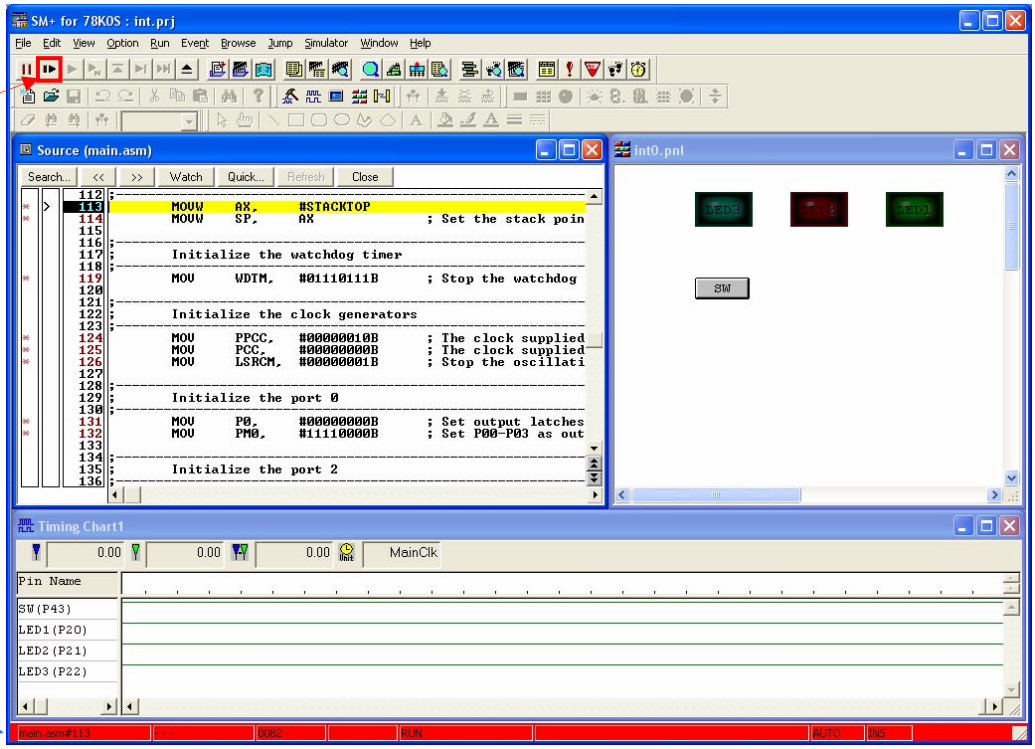
(b) When not starting SM+ in PM+

•Start SM+ from the Windows start menu.

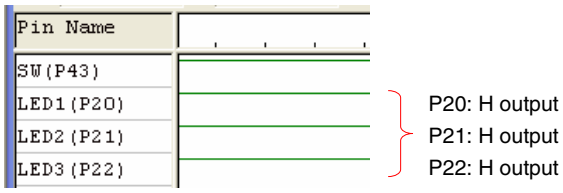
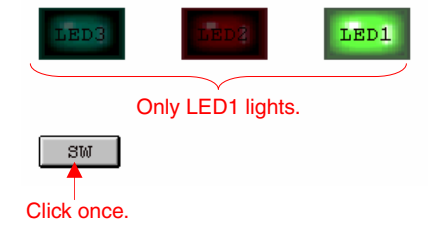
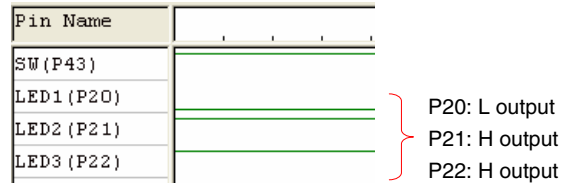
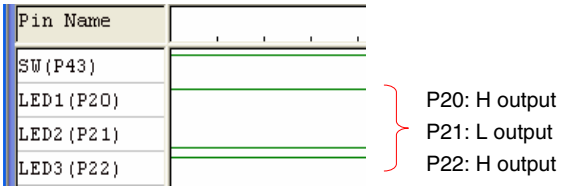
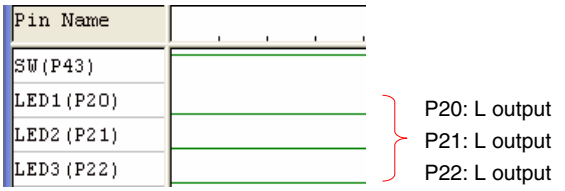
(2) The following screen will be displayed when SM+ is started. (This is a sample screenshot of when an assembly language source file downloaded by clicking the  icon was used.)



(3) Click  ([Restart] button). The program will be executed after the CPU is reset and the following screen will be displayed.



(4) Click the [SW] button in the I/O panel window, during program execution.
Check that the lighting of [LED1] to [LED3] in the I/O panel window, as well as the waveforms in the timing chart window change, depending on the number of [SW] button inputs.

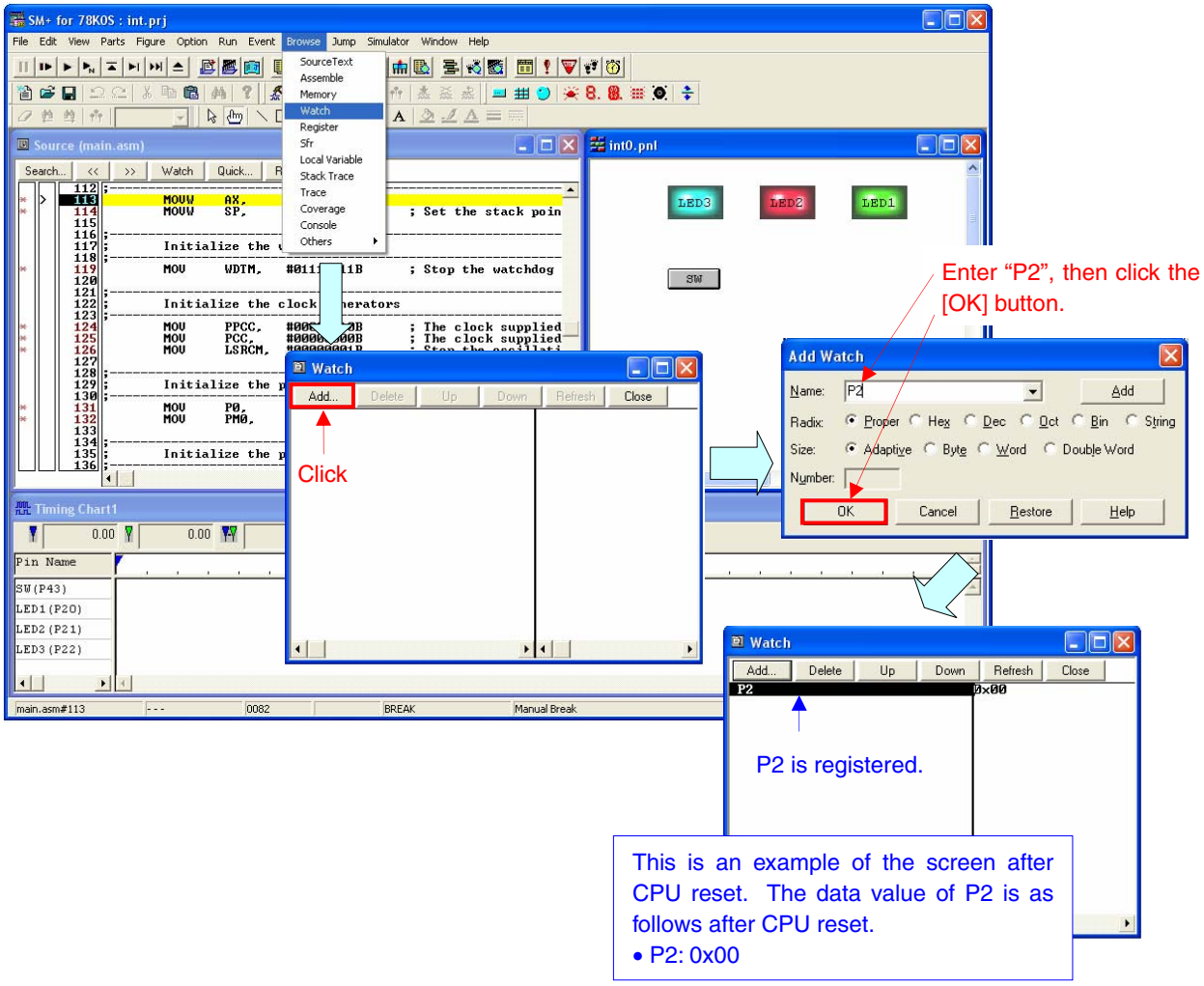
I/O panel window	Timing chart window
	
	
	
• • •	• • •
	

Note The lighting patterns from the zeroth switch input are repeated after the eighth switch input.

Remark H: High level, L: Low level

[Supplement 1] The changes in the data value of port 2 can be checked by using the SM+ watch function.

<1> Select [Watch] from the [Browse] menu to open the [Watch] window.
<2> Click [Add] to open the [Add Watch] window. (At this time, the [Watch] window is kept opened.)
<3> Enter “P2” in the [Name] field and click the [OK] button to register “P2” in the [Watch] window and close the [Add Watch] window.



<4> Execute the program and click the [SW] button in the I/O panel window. Check that the data value of P2 in the [Watch] window changes, depending on the number of [SW] button inputs.

Number of [SW] Button Inputs[Note]	Data Value in [Watch] Window
0	P2: 0x07
1	P2: 0x06
2	P2: 0x05
3	P2: 0x04
4	P2: 0x03
5	P2: 0x02
6	P2: 0x01
7	P2: 0x00

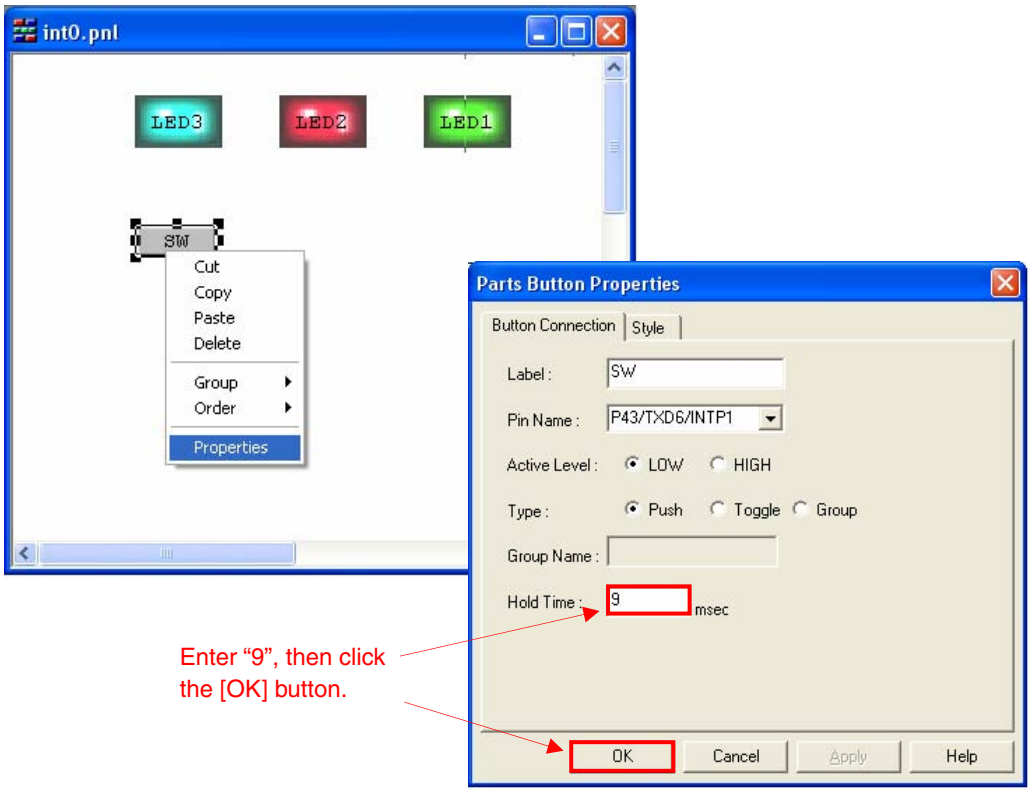
Note The lighting patterns from the zeroth switch input are repeated after the eighth switch input.

[Supplement 2] The [SW] button hold time can be set to less than 10 ms to check whether chattering is being detected.

<1> Select  on the toolbar.

<2> Right-click the [SW] button in the I/O panel window and select [Properties].

<3> Enter “9” for the Hold Time and click the [OK] button.



<4> Select  on the toolbar.

<5> Execute the program and click the [SW] button. Even if the [SW] button is clicked, chattering will be identified and the LED lighting pattern will not change, because the button hold time is 9 ms.

CHAPTER 6 RELATED DOCUMENTS

	Document Name			Japanese/English
	78K0S/KU1+ User's Manual			PDF
	78K0S/KY1+ User's Manual			PDF
	78K0S/KA1+ User's Manual			PDF
	78K0S/KB1+ User's Manual			PDF
	78K/0S Series Instructions User's Manual			PDF
	RA78K0S Assembler Package User's Manual		Language	PDF
			Operation	PDF
	CC78K0S C Compiler User's Manual		Language	PDF
			Operation	PDF
	PM+ Project Manager User's Manual			PDF
	SM+ System Simulator Operation User's Manual			PDF
<R>	Flash Programming Manual (Basic) MINICUBE2 version		78K0S/KU1+	PDF
			78K0S/KY1+	PDF
			78K0S/KA1+	PDF
			78K0S/KB1+	PDF
<R>	78K0S/Kx1+ Application Note	Sample Program Startup Guide		PDF
		Sample Program (Initial Settings) LED Lighting Switch Control		PDF

APPENDIX A PROGRAM LIST

As a program list example, the 78K0S/KB1+ microcontroller source program is shown below.

● main.asm (Assembly language version)

```
;*******************************************************************************
;
;     NEC Electronics     78K0S/KB1+
;
;*******************************************************************************
;     78K0S/KB1+  Sample program
;*******************************************************************************
;     Interrupt
;*******************************************************************************
;<<History>>
;     2007.6.--   Release
;*******************************************************************************
;
;<<Overview>>
;
;This sample program presents an example of using the interrupt function.
;An LED lighting pattern according to the number of switch inputs is displayed
;by detecting the falling edge of the switch input and generating an interrupt.
;Here, chattering within 10 ms will not be counted as a switch input, because
;a chattering removal time of 10 ms is set immediately after the interrupt.
;
;
;  <Principal setting contents>
;
;  - Set the vector table
;  - Set the stack pointer
;  - Stop the watchdog timer operation
;  - Set the CPU clock frequency to 2 MHz
;  - Set the valid edge of external interrupt INTP1 to falling edge
;  - Set the chattering detection time during switch input to 10 ms;
;
;
;  <Number of switch inputs and LED lighting patterns>
;
;    +-----------------------------------+
;    |  SW Inputs |  LED3 |  LED2 |  LED1 |
;    |    (P43)   | (P22) | (P21) | (P20) |
;    |------------|-----------------------|
;    |   0 times  |  OFF  |  OFF  |  OFF  |
;    |   1 time   |  OFF  |  OFF  |  ON   |
;    |   2 times  |  OFF  |  ON   |  OFF  |
;    |   3 times  |  OFF  |  ON   |  ON   |
;    |   4 times  |  ON   |  OFF  |  OFF  |
;    |   5 times  |  ON   |  OFF  |  ON   |
;    |   6 times  |  ON   |  ON   |  OFF  |
;    |   7 times  |  ON   |  ON   |  ON   |
;    +-----------------------------------+
;    # The lighting patterns from the zeroth switch input are repeated after
the eighth switch input.
;
;
```

```
;<<I/O port settings>>
;
;  Input: P43
;  Output: P00-P03, P20-P23, P30-P33, P40-P42, P44-P47, P120-P123, P130
;  # All unused ports are set as the output mode.
;
;************************************************************************


;========================================================================
;
;     Vector table
;
;========================================================================
XVCT  CSEG  AT    0000H
      DW    RESET_START       ;(00) RESET
      DW    RESET_START       ;(02) --
      DW    RESET_START       ;(04) --
      DW    RESET_START       ;(06) INTLVI
      DW    RESET_START       ;(08) INTP0
      DW    INTERRUPT_P1      ;(0A) INTP1
      DW    RESET_START       ;(0C) INTTMH1
      DW    RESET_START       ;(0E) INTTM000
      DW    RESET_START       ;(10) INTTM010
      DW    RESET_START       ;(12) INTAD
      DW    RESET_START       ;(14) --
      DW    RESET_START       ;(16) INTP2
      DW    RESET_START       ;(18) INTP3
      DW    RESET_START       ;(1A) INTTM80
      DW    RESET_START       ;(1C) INTSRE6
      DW    RESET_START       ;(1E) INTSR6
      DW    RESET_START       ;(20) INTST6

;========================================================================
;
;     Define the RAM
;
;========================================================================
XRAM  DSEG  SADDR
CNT_1:      DS    1           ; For major loop
CNT_2:      DS    1           ; For minor loop

;========================================================================
;
;     Define the memory stack area
;
;========================================================================
XSTK  DSEG  AT    0FEE0H
STACKEND:
      DS    20H               ; Memory stack area = 32 bytes
STACKTOP:                     ; Start address of the memory stack area = FF00H

;************************************************************************
;
;     Initialization after RESET
;
;************************************************************************
XMAIN CSEG  UNIT
RESET_START:
```

```
;--------------------------------------------------------------------------
;     Initialize the stack pointer
;--------------------------------------------------------------------------
      MOVW  AX,    #STACKTOP
      MOVW  SP,    AX               ; Set the stack pointer

;--------------------------------------------------------------------------
;     Initialize the watchdog timer
;--------------------------------------------------------------------------
      MOV   WDTM,  #01110111B   ; Stop the watchdog timer operation

;--------------------------------------------------------------------------
;     Initialize the clock generators
;--------------------------------------------------------------------------
      MOV   PPCC,  #00000010B   ; The clock supplied to the peripheral
hardware (fxp) = fx/4 (= 2 MHz)
      MOV   PCC,   #00000000B   ; The clock supplied to the CPU (fcpu) = fxp
(= 2 MHz)
      MOV   LSRCM, #00000001B   ; Stop the oscillation of the low-speed
internal oscillator

;--------------------------------------------------------------------------
;     Initialize the port 0
;--------------------------------------------------------------------------
      MOV   P0,    #00000000B   ; Set output latches of P00-P03 as low
      MOV   PM0,   #11110000B   ; Set P00-P03 as output mode

;--------------------------------------------------------------------------
;     Initialize the port 2
;--------------------------------------------------------------------------
      MOV   P2,    #00000111B   ; Set output latches of P20-P22 as high (turn
off LED1-LED3), P23 as low
      MOV   PM2,   #11110000B   ; Set P20-P23 as output mode

;--------------------------------------------------------------------------
;     Initialize the port 3
;--------------------------------------------------------------------------
      MOV   P3,    #00000000B   ; Set output latches of P30-P33 as low
      MOV   PM3,   #11110000B   ; Set P30-P33 as output mode

;--------------------------------------------------------------------------
;     Initialize the port 4
;--------------------------------------------------------------------------
      MOV   P4,    #00000000B   ; Set output latches of P40-P47 as low
      MOV   PU4,   #00001000B   ; Connect on-chip pull-up resistor to P43
      MOV   PM4,   #00001000B   ; Set P43 as input mode, P40-P42 and P44-P47
as output mode

;--------------------------------------------------------------------------
;     Initialize the port 12
;--------------------------------------------------------------------------
      MOV   P12,   #00000000B   ; Set output latches of P120-P123 as low
      MOV   PM12,  #11110000B   ; Set P120-P123 as output mode

;--------------------------------------------------------------------------
;     Initialize the port 13
;--------------------------------------------------------------------------
      MOV   P13,   #00000001B   ; Set output latch of P130 as high
```

```
;-------------------------------------------------------------------------
;     Set the interrupt
;-------------------------------------------------------------------------
      MOV   INTM0, #00000000B   ; Set the valid edge of INTP1 to falling edge
      CLR1  PIF1                ; Clear invalid interrupt requests in advance
      CLR1  PMK1                ; Release the INTP1 interrupt mask

      EI                        ; Enable vector interrupt

;*************************************************************************
;
;     Main loop
;
;*************************************************************************
MAIN_LOOP:
      NOP
      BR    $MAIN_LOOP          ; Go to the MAIN_LOOP

;*************************************************************************
;
;     External interrupt INTP1
;
;*************************************************************************
INTERRUPT_P1:
      PUSH  AX                  ; Save the AX register data to the stack

;-----  10 ms wait to handle chattering  -----
      MOV   CNT_1, #28          ; Assign the count value for the major loop
      NOP
LOOP_1:
      MOV   CNT_2, #70          ; Assign the count value for the minor loop
LOOP_2:
      NOP
      DBNZ  CNT_2, $LOOP_2      ; Minor loop
      DBNZ  CNT_1, $LOOP_1      ; Major loop

      CLR1  PIF1                ; Clear the INTP1 interrupt request

;-----  Identification of chattering detection  -----
      BT    P4.3,  $END_INTP1   ; Branch if there is no switch input

;-----  LED lighting processing  -----
      MOV   A,     P2           ; Read the current output value
      DEC   A                   ; Decrement the A register value by 1
      AND   A,     #00000111B   ; Mask bits other than bits 0 to 2
      MOV   P2,    A            ; Output the LED light

END_INTP1:
      POP   AX                  ; Restore the AX register data
      RETI                      ; Return from interrupt servicing

end
```

● main.c (C language version)

```
/************************************************************************

    NEC Electronics     78K0S/KB1+

************************************************************************
    78K0S/KB1+  Sample program
************************************************************************
    Interrupt
************************************************************************
<<History>>
    2007.6.--   Release
************************************************************************

<<Overview>>

This sample program presents an example of using the interrupt function.
An LED lighting pattern according to the number of switch inputs is
displayed by detecting the falling edge of the switch input and generating
an interrupt.
Here, chattering within 10 ms will not be counted as a switch input, because
a chattering removal time of 10 ms is set immediately after the interrupt.


  <Principal setting contents>

  - Declare a function run by an interrupt: INTP1 -> fn_intp1()
  - Stop the watchdog timer operation
  - Set the CPU clock frequency to 2 MHz
  - Set the valid edge of external interrupt INTP1 to falling edge
  - Set the chattering detection time during switch input to 10 ms


  <Number of switch inputs and LED lighting patterns>


    +-----------------------------------+
    |  SW Inputs |  LED3 |  LED2 |  LED1 |
    |   (P43)    | (P22) | (P21) | (P20) |
    |------------|-----------------------|
    |   0 times  |  OFF  |  OFF  |  OFF  |
    |   1 time   |  OFF  |  OFF  |  ON   |
    |   2 times  |  OFF  |  ON   |  OFF  |
    |   3 times  |  OFF  |  ON   |  ON   |
    |   4 times  |  ON   |  OFF  |  OFF  |
    |   5 times  |  ON   |  OFF  |  ON   |
    |   6 times  |  ON   |  ON   |  OFF  |
    |   7 times  |  ON   |  ON   |  ON   |
    +-----------------------------------+
    # The lighting patterns from the zeroth switch input are repeated after
the eighth switch input.


<<I/O port settings>>

  Input: P43
  Output: P00-P03, P20-P23, P30-P33, P40-P42, P44-P47, P120-P123, P130
  # All unused ports are set as the output mode.
```

```
************************************************************************/


/*=======================================================================

    Preprocessing directive (#pragma)

=======================================================================*/
#pragma   SFR                     /* SFR names can be described at the C
source level */
#pragma   EI                      /* EI instructions can be described at the
C source level */
#pragma   NOP                     /* NOP instructions can be described at
the C source level */
#pragma interrupt INTP1 fn_intp1  /* Interrupt function declaration:INTP1 */

/************************************************************************

    Initialization after RESET

************************************************************************/
void hdwinit(void){

/*-----------------------------------------------------------------------
    Initialize the watchdog timer
-----------------------------------------------------------------------*/
    WDTM  = 0b01110111;           /* Stop the watchdog timer operation */

/*-----------------------------------------------------------------------
    Initialize the clock generators
-----------------------------------------------------------------------*/
    PPCC  = 0b00000010;           /* The clock supplied to the peripheral
hardware (fxp) = fx/4 (= 2 MHz) */
    PCC   = 0b00000000;           /* The clock supplied to the CPU (fcpu) =
fxp (= 2 MHz) */
    LSRCM = 0b00000001;           /* Stop the oscillation of the low-speed
internal oscillator */

/*-----------------------------------------------------------------------
    Initialize the port 0
-----------------------------------------------------------------------*/
    P0    = 0b00000000;           /* Set output latches of P00-P03 as low */
    PM0   = 0b11110000;           /* Set P00-P03 as output mode */

/*-----------------------------------------------------------------------
    Initialize the port 2
-----------------------------------------------------------------------*/
    P2    = 0b00000111;           /* Set output latches of P20-P22 as high
(turn off LED1-LED3), P23 as low */
    PM2   = 0b11110000;           /* Set P20-P23 as output mode */

/*-----------------------------------------------------------------------
    Initialize the port 3
-----------------------------------------------------------------------*/
    P3    = 0b00000000;           /* Set output latches of P30-P33 as low */
    PM3   = 0b11110000;           /* Set P30-P33 as output mode */

/*-----------------------------------------------------------------------
    Initialize the port 4
```

```
  ------------------------------------------------------------------------*/
      P4    = 0b00000000;     /* Set output latches of P40-P47 as low */
      PU4   = 0b00001000;     /* Connect on-chip pull-up resistor to P43 */
      PM4   = 0b00001000;     /* Set P43 as input mode, P40-P42 and P44-P47 as
  output mode */

  /*------------------------------------------------------------------------
      Initialize the port 12
  ------------------------------------------------------------------------*/
      P12   = 0b00000000;     /* Set output latches of P120-P123 as low */
      PM12  = 0b11110000;     /* Set P120-P123 as output mode */

  /*------------------------------------------------------------------------
      Initialize the port 13
  ------------------------------------------------------------------------*/
      P13   = 0b00000001;        /* Set output latch of P130 as high */

  /*------------------------------------------------------------------------
      Set the interrupt
  ------------------------------------------------------------------------*/
      INTM0 = 0b00000000;        /* Set the valid edge of INTP1 to falling
edge */
      PIF1  = 0;                 /*  Clear invalid interrupt requests in
advance */
      PMK1  = 0;                 /* Release the INTP1 interrupt mask */

      return;
  }

  /************************************************************************

      Main loop

  ************************************************************************/
  void main(void){

      EI();                      /* Enable vector interrupt */

      while (1){
            NOP();
            NOP();
      }
  }

  /************************************************************************

      External interrupt INTP1

  ************************************************************************/
  __interrupt void fn_intp1(){
      unsigned int unChat;    /* 16-bit variable for the chattering removal
timer */

      for (unChat = 0; unChat < 278; unChat++){ /* Wait for about 10 ms (for
  chattering removal) */
            NOP();
      }

      PIF1  = 0;              /* Clear the INTP1 interrupt request */
```

```
    if (!P4.3){             /* Processing performed if SW is on for 10 ms or
more */
           P2 = (P2 - 1) & 0b00000111;  /* LED output according to the
number of SW inputs */
    }


    return;
}
```

● op.asm (Common to assembly language and C language versions)

```
  ;=============================================================================
  ;
  ;   Option byte
  ;
  ;=============================================================================
  OPBTCSEG  AT    0080H
          DB      10011100B      ; Option byte area
  ;                   ||||
  ;                   |||+--------- Low-speed  internal  oscillator  can  be
stopped by software
  ;                   |++---------- High-speed internal oscillation clock (8
MHz) is selected for system clock source
  ;                   +------------ P34/RESET pin is used as RESET pin

          DB      11111111B      ; Protect byte area (for the self programming
mode)
  ;                 ||||||||
  ;                 ++++++++--------- All blocks can be written or erased

  end
```

APPENDIX B REVISION HISTORY

The mark “<R>” shows major revised points. The revised points can be easily searched by copying an “<R>” in the PDF file and specifying it in the “Find what.” field.

Edition	Date Published	Page	Revision
1st edition	October 2007	–	–
2nd edition	September 2008	p.18	CHAPTER 5 OPERATION CHECK USING SYSTEM SIMULATOR SM+ • Modification of description in Caution ((as of June 2007) → (as of July 2008))
		pp.18 to 20	Modification of 5.1 Building the Sample Program
		p.20	5.2 Operation with SM+ • Addition of (1)
		p.25	CHAPTER 6 RELATED DOCUMENTS • Addition of Flash Programming Manual (Basic) MINICUBE2 version • Addition of the link to 78K0S/Kx1+ Sample Program Startup Guide

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