Final Exercise

Name: Wong Kah Quan

Matric ID.: HA18015 (UMP,MY)

E-Mail: nelsonwongisme@gmail.com

Subject: Mikrorechner/Microcomputer Technology (BHM 3313)

There is an apartment in a big house with a bell button aside the entrance door. The door has an electrical door lock and in the hallway of the apartment there is a light and the doorbell.

Bell button (Signal name Bb), doorbell (DoorBell), door lock (DL) and hallway light (HL) are connected to a controller with the following function: A bell button press rings the door bell and switch on the hallway light 10 seconds after release for 15 seconds.

- If you press again within 5 seconds after the light has switched off again for less than 3 seconds, the door lock opens for 2 seconds and the bell does not ring.

- If you fail the timing nothing happens, and the bell button is disabled for 20 seconds.

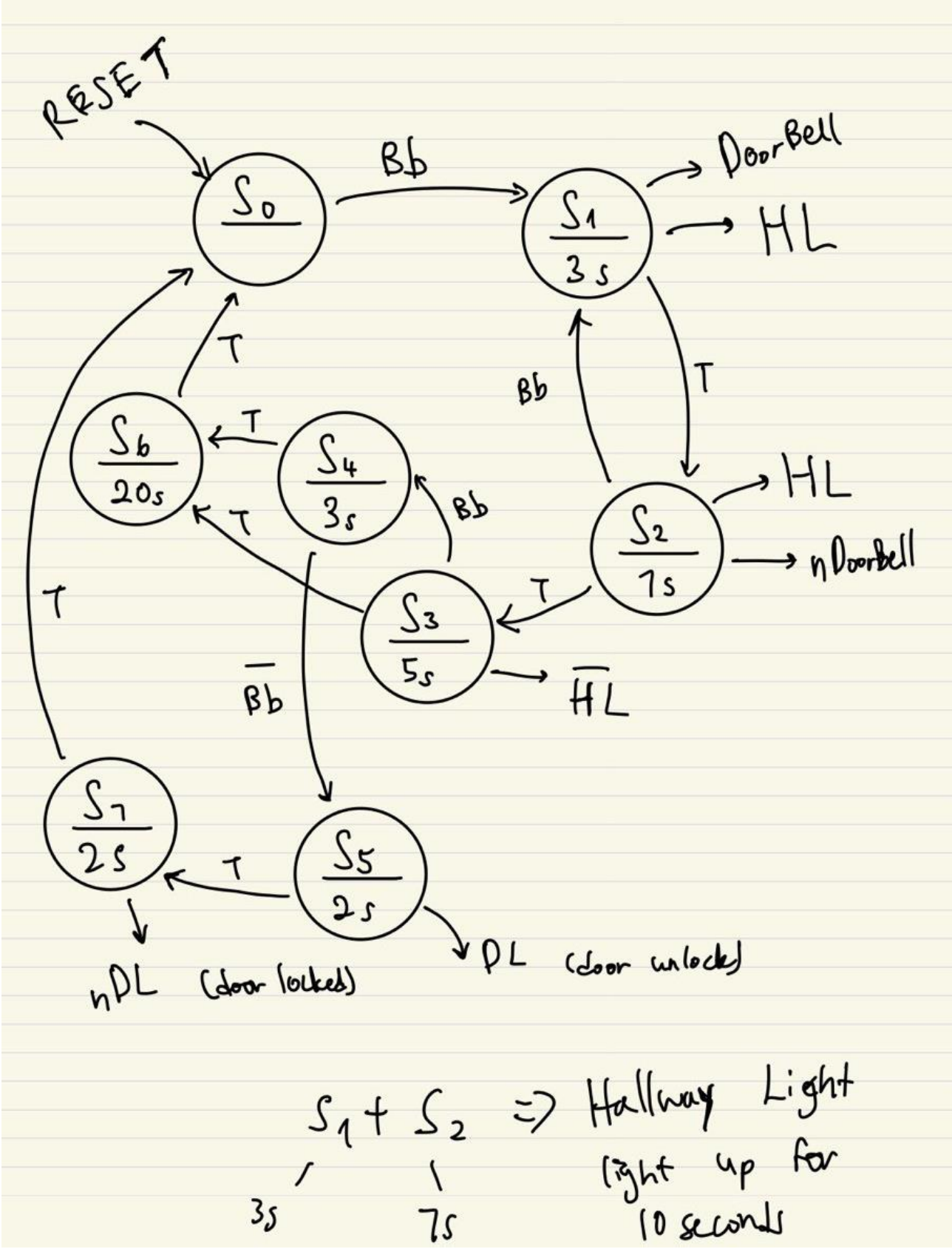
Sensors and Actuators:

Sensor	Actuator
Bell button pressed (Bb)	Doorbell (DoorBell)
Bell button unpressed (nBb)	Door Lock (DL)
	Hallway Light (HL)

String of “DoorBell” is used instead of DB or Db or db to avoid confusion in the IDE. As in the IDE DB or Db or db is a directive.

1. Sketch the bubble chart.

Finite State Machine Diagram for the system:



Bits in Outpattern declaration & explanation:

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
X	X	X	X	X	DL	HL	DoorBell

DL: DoorLock. When DL = 1, Door is unlocked, else, Door is locked.

HL: Hallway Lights. When HL = 1, Hallway Light is on, else, off.

DoorBell: When DoorBell = 1, Doorbell rings. else, no ring.

X : Don't care. As only the first 3 bits matter.

Outpattern:

State	Outpattern		
	Binary	HEX	Decimal
S0	00000000	0x00	0
S1	00000011	0x03	3
S2	00000010	0x02	2
S3	00000000	0x00	0
S4	00000000	0x00	0
S5	00000100	0x04	4
S6	00000000	0x00	0
S7	00000000	0x00	0

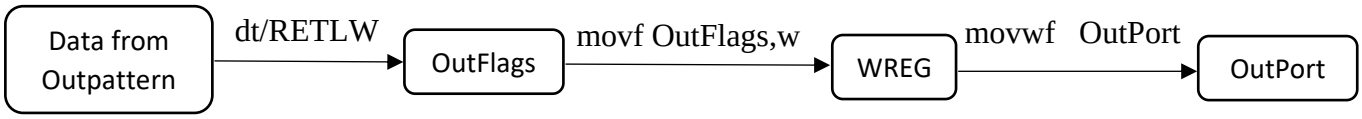
In MPLAB IDE:

```
;       States
;       S0    S1    S2    S3    S4    S5    S6    S7
Outpattern  addwf   PCL,f
   dt    0,    3,    2,    0,    0,    4,    0,    0
```

These Outpattern are return from the FSMTable to the Work Register (using Define Table/dt which done by RETLW) then copy to OutFlags then to OutPort, These are the outputs which then copied to PORTB with:

```
ShadowOut
   movf    OutPort,w
   movwf   PORTB
ShadowOut_e
```

Illustrated as below:



For example:

Outpattern of of State 1(S1) is B'00000011'. The Bit 0 and Bit 1 is HIGH, which means that DoorBell and HL are HIGH. In other words, rings the Doorbell and switch on the Hallway Light.

2. Modify 1st.asm from cloud and run the system in MPLAB Simulator.

Source code(.asm) with comments/explanation is attached along this email.

Besides, the List file(.lst), Stimulus (.sbs), Watch(.wtch) and so on are also in the file. These files can be easily open by opening the Workspace file(.mcw) or the Project file(.mcp).

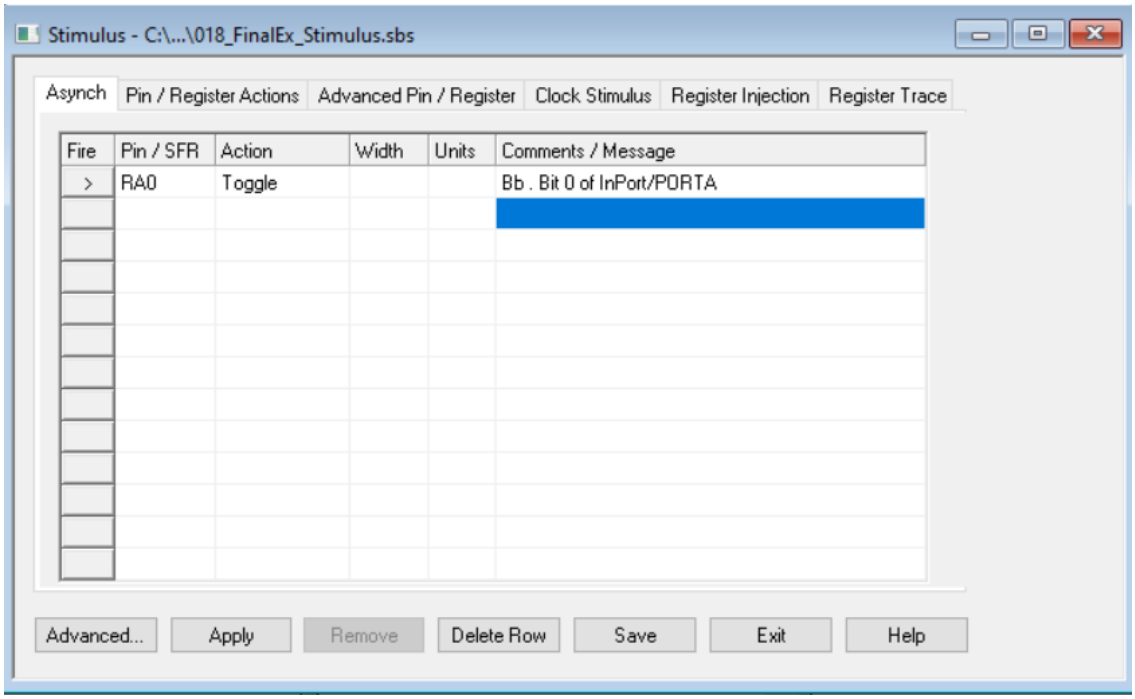
3. Include the lst File and a screenshot of MPLAB debug session (with watch and stimulus) in a pdf report.

For this debug session and simulation, there are 3 cases as follows:

Case	Event
1	Event: User presses the Bell button. The Hallway Light lights up for 10 seconds. No action within the 5 seconds after Hallway Light switched off, the bell button is disabled for 20 seconds, as timing failed.
2	User presses the Bell button. The Hallway Light lights up for 10 seconds. User press the bell button again within 5 seconds for LESS than 3 seconds after the light has switched off, the door lock opens for 2 seconds and the bell does not ring.
3	User presses the Bell button. The Hallway Light lights up for 10 seconds. User press the bell button again within 5 seconds for MORE than 3 seconds after the light has switched off, the bell button is disabled for 20 seconds, as timing failed.

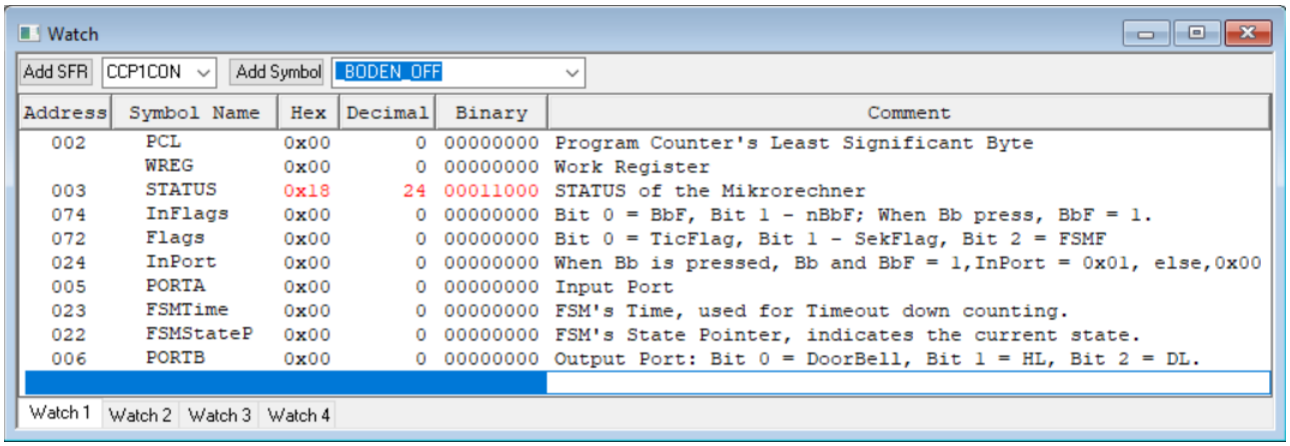
Each of the cases will be illustrated with the simulation result with the help of Watch and Stimulus (as Bb, Bell Button).

Stimulus



When tap on the " > " sign on the left side(column "fire"), it will Toggle the Pin R0A, which is the Bb, i.e., the bit 0 in InPort/PORTA.

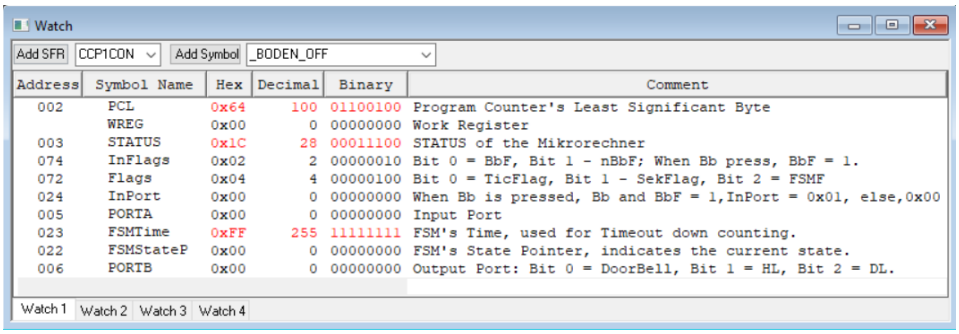
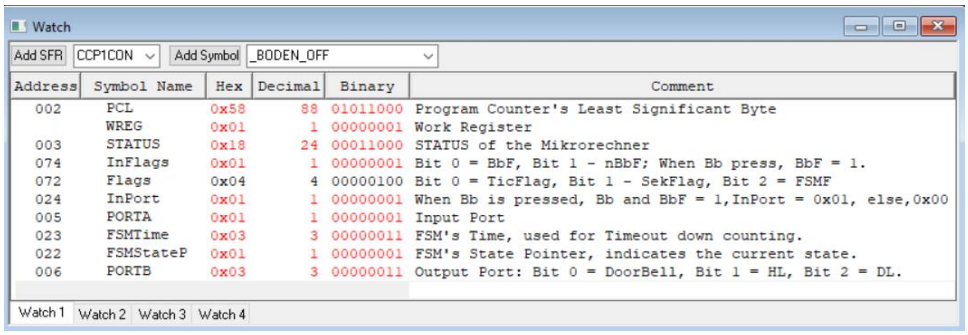
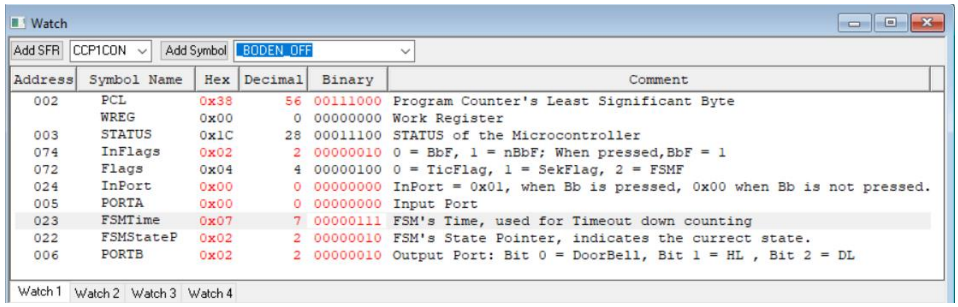
Watch

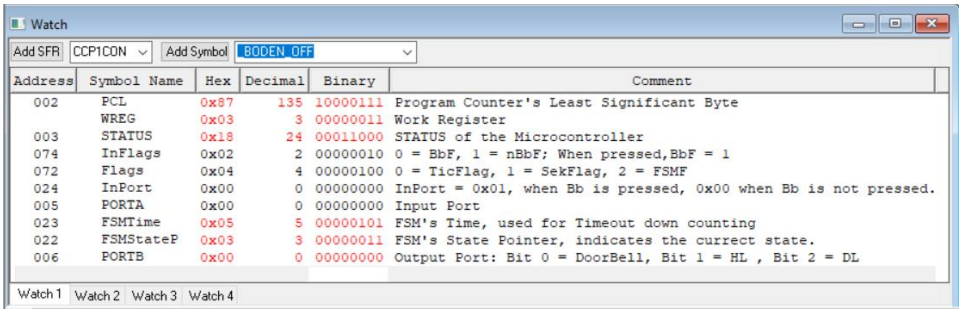
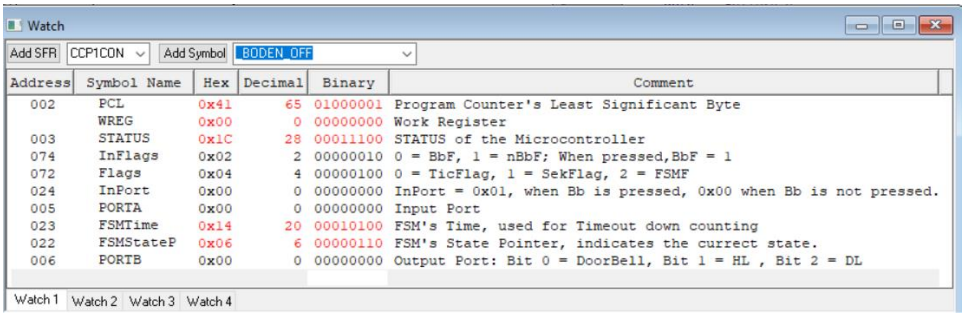
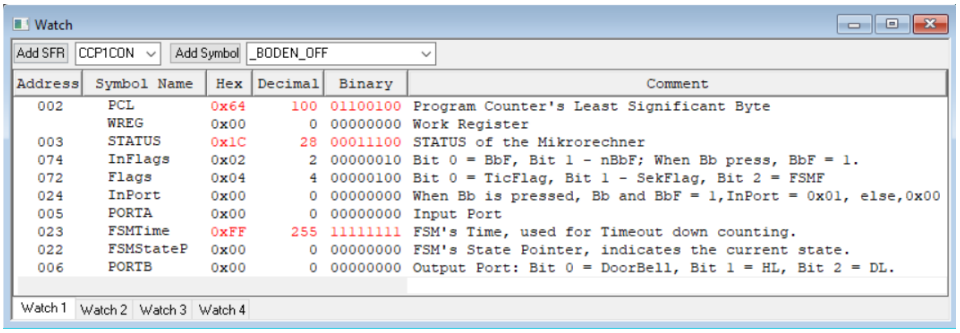


Above are registers that should be considered to check the results of simulation.

Case 1

Event: User presses the Bell button. The Hallway Light lights up for 10 seconds. No action within the 5 seconds after Hallway Light switched off, the bell button is disabled for 20 seconds, as timing failed.

State	Event	Watch's result in Simulation
S0	Waiting for Stimulus	
S1	Bb pressed, Doorbell rings and Hallway Light switches on for 3 seconds. DoorBell = 1, HL = 1. FSMTime: 3 (seconds) PORTB: 00000011	
S2	S1 delay timeout. Doorbell stop ringing. Hallway light is on for another 7 seconds. Total light on for 10 seconds. DoorBell = 0, HL = 1. FSMTime: 7 (seconds) PORTB: 00000010	

S3	Down count 5 seconds and no stimulus. Turn off Hallway Light as it lights up for 10 seconds already. HL = 0 PORTB: 00000000	
S6	No stimulus. The bell button is disabled for 20 seconds, as timing failed. FSMTime: 20	
S0	Back to S0, waiting for stimulus.	

Watch

Add SFR CCP1CON Add Symbol _BODEN_OFF

Address	Symbol Name	Hex	Decimal	Binary	Comment
002	PCL	0x87	135	10000111	Program Counter's Least Significant Byte
	WREG	0x03	3	00000011	Work Register
003	STATUS	0x18	24	00011000	STATUS of the Microcontroller
074	InFlags	0x02	2	00000010	0 = BbF, 1 = nBbF; When pressed,BbF = 1
072	Flags	0x04	4	00000100	0 = TicFlag, 1 = SekFlag, 2 = FSMF
024	InPort	0x00	0	00000000	InPort = 0x01, when Bb is pressed, 0x00 when Bb is not pressed.
005	PORTA	0x00	0	00000000	Input Port
023	FSMTime	0x05	5	00000101	FSM's Time, used for Timeout down counting
022	FSMStateP	0x03	3	00000011	FSM's State Pointer, indicates the currect state.
006	PORTB	0x00	0	00000000	Output Port: Bit 0 = DoorBell, Bit 1 = HL , Bit 2 = DL

Watch 1 Watch 2 Watch 3 Watch 4

Watch

Add SFR CCP1CON Add Symbol _BODEN_OFF

Address	Symbol Name	Hex	Decimal	Binary	Comment
002	PCL	0x41	65	01000001	Program Counter's Least Significant Byte
	WREG	0x00	0	00000000	Work Register
003	STATUS	0x1C	28	00011100	STATUS of the Microcontroller
074	InFlags	0x02	2	00000010	0 = BbF, 1 = nBbF; When pressed,BbF = 1
072	Flags	0x04	4	00000100	0 = TicFlag, 1 = SekFlag, 2 = FSMF
024	InPort	0x00	0	00000000	InPort = 0x01, when Bb is pressed, 0x00 when Bb is not pressed.
005	PORTA	0x00	0	00000000	Input Port
023	FSMTime	0x14	20	00010100	FSM's Time, used for Timeout down counting
022	FSMStateP	0x06	6	00000110	FSM's State Pointer, indicates the currect state.
006	PORTB	0x00	0	00000000	Output Port: Bit 0 = DoorBell, Bit 1 = HL , Bit 2 = DL

Watch 1 Watch 2 Watch 3 Watch 4

Watch

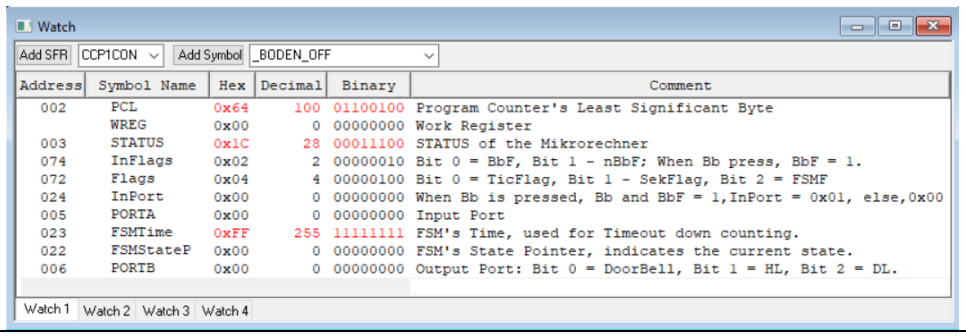
Add SFR CCP1CON Add Symbol _BODEN_OFF

Address	Symbol Name	Hex	Decimal	Binary	Comment
002	PCL	0x64	100	01100100	Program Counter's Least Significant Byte
	WREG	0x00	0	00000000	Work Register
003	STATUS	0x1C	28	00011100	STATUS of the Mikrorechner
074	InFlags	0x02	2	00000010	Bit 0 = BbF, Bit 1 - nBbF; When Bb press, BbF = 1.
072	Flags	0x04	4	00000100	Bit 0 = TicFlag, Bit 1 - SekFlag, Bit 2 = FSMF
024	InPort	0x00	0	00000000	When Bb is pressed, Bb and BbF = 1,InPort = 0x01, else,0x00
005	PORTA	0x00	0	00000000	Input Port
023	FSMTime	0xFF	255	11111111	FSM's Time, used for Timeout down counting.
022	FSMStateP	0x00	0	00000000	FSM's State Pointer, indicates the current state.
006	PORTB	0x00	0	00000000	Output Port: Bit 0 = DoorBell, Bit 1 = HL, Bit 2 = DL.

Watch 1 Watch 2 Watch 3 Watch 4

Case 2

Event: User presses the Bell button. The Hallway Light lights up for 10 seconds. User press the bell button again within 5 seconds for LESS than 3 seconds after the light has switched off, the door lock opens for 2 seconds and the bell does not ring.

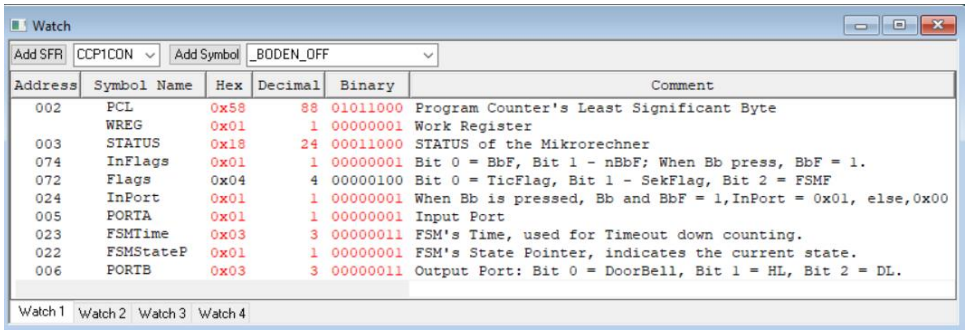
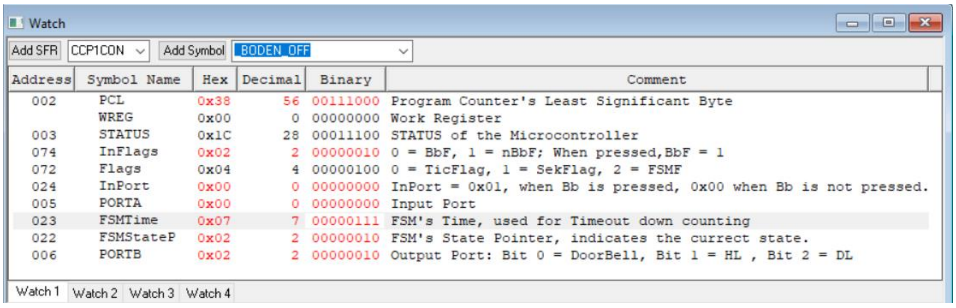
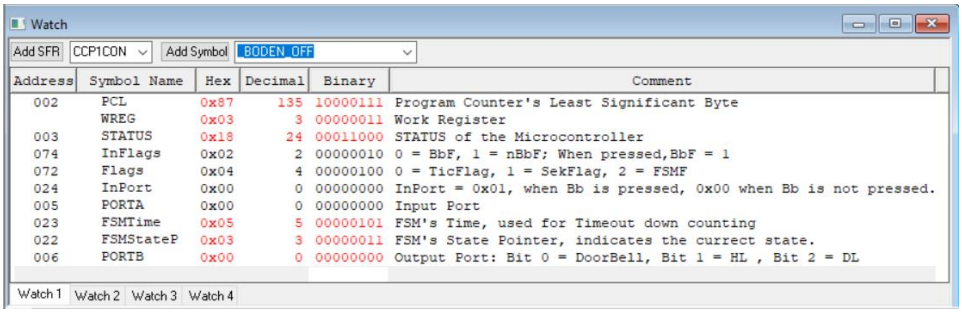
State	Event	Watch's result in Simulation
S0	Waiting for Stimulus	

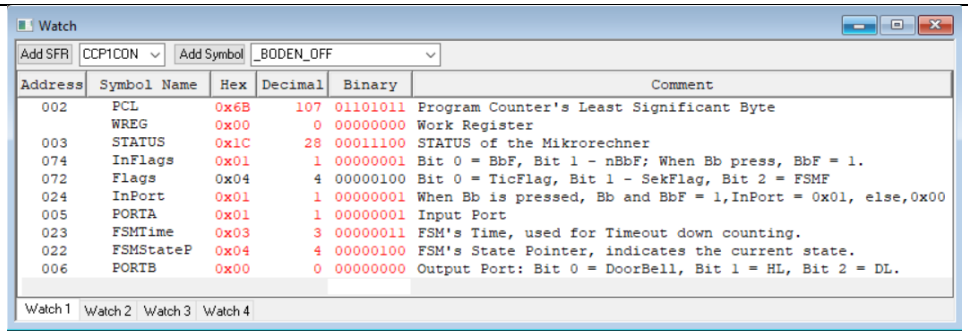
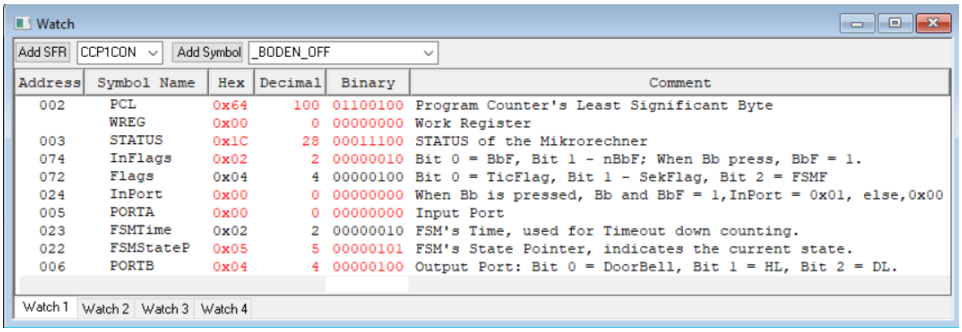
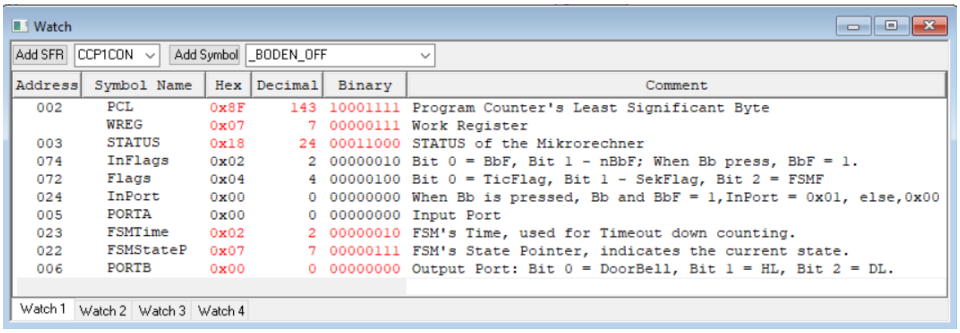
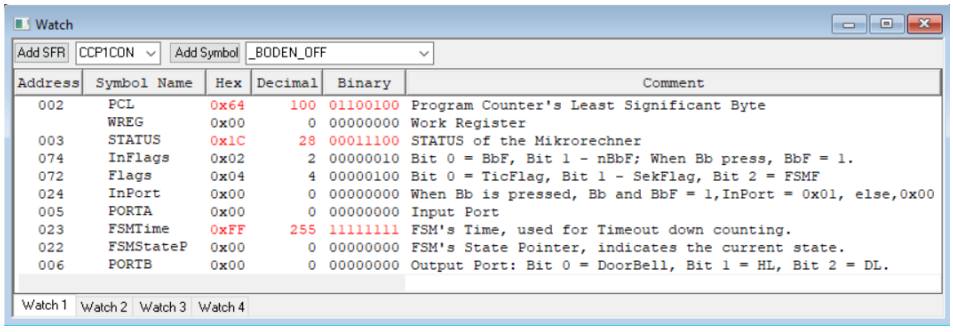
Watch

Add SFR CCP1CON Add Symbol _BODEN_OFF

Address	Symbol Name	Hex	Decimal	Binary	Comment
002	PCL	0x64	100	01100100	Program Counter's Least Significant Byte
	WREG	0x00	0	00000000	Work Register
003	STATUS	0x1C	28	00011100	STATUS of the Mikrorechner
074	InFlags	0x02	2	00000010	Bit 0 = BbF, Bit 1 - nBbF; When Bb press, BbF = 1.
072	Flags	0x04	4	00000100	Bit 0 = TicFlag, Bit 1 - SekFlag, Bit 2 = FSMF
024	InPort	0x00	0	00000000	When Bb is pressed, Bb and BbF = 1,InPort = 0x01, else,0x00
005	PORTA	0x00	0	00000000	Input Port
023	FSMTime	0xFF	255	11111111	FSM's Time, used for Timeout down counting.
022	FSMStateP	0x00	0	00000000	FSM's State Pointer, indicates the current state.
006	PORTB	0x00	0	00000000	Output Port: Bit 0 = DoorBell, Bit 1 = HL, Bit 2 = DL.

Watch 1 Watch 2 Watch 3 Watch 4

S1	Bb pressed, Doorbell rings and Hallway Light switches on for 3 seconds. DoorBell = 1, HL = 1. FSMTime: 3 (seconds) PORTB: 00000011	
S2	S1 delay timeout. Doorbell stop ringing. Hallway light is on for another 7 seconds. Total light on for 10 seconds. DoorBell = 0, HL = 1. FSMTime: 7 (seconds) PORTB: 00000010	
S3	Turn off Hallway Light as it lights up for 10 seconds already. Then, down count 5 seconds, waiting for stimulus HL = 0 PORTB: 00000000	

S4	Bb is pressed within the 5 seconds timeframe. But the Bb pressed is less than 3 seconds, hence timing is correct, the door lock opens for 2 seconds and the bell does not ring.	
S5	The door lock opens for 2 seconds and the bell does not ring. DL = 1, DoorBell = 0. FSMTime = 2 (seconds) Let DoorBell rings for 2 seconds. PORTB: 00000100	
S7	After the Door is unlocked for 2 seconds, it will be locked. For this, 2 seconds for the door to lock again is suffice, hence, timeout delay is 2 seconds. DL = 0, FSMTime: 2 (seconds) PORTB: 00000000	
S0	Back to S0, waiting for stimulus.	

Watch

Add SFR CCP1CON Add Symbol _BODEN_OFF

Address	Symbol Name	Hex	Decimal	Binary	Comment
002	PCL	0x6B	107	01101011	Program Counter's Least Significant Byte
	WREG	0x00	0	00000000	Work Register
003	STATUS	0x1C	28	00011100	STATUS of the Mikrorechner
074	InFlags	0x01	1	00000001	Bit 0 = BbF, Bit 1 - nBbF; When Bb press, BbF = 1.
072	Flags	0x04	4	00000100	Bit 0 = TicFlag, Bit 1 - SekFlag, Bit 2 = FSMF
024	InPort	0x01	1	00000001	When Bb is pressed, Bb and BbF = 1,InPort = 0x01, else,0x00
005	PORTA	0x01	1	00000001	Input Port
023	FSMTime	0x03	3	00000011	FSM's Time, used for Timeout down counting.
022	FSMStateP	0x04	4	00000100	FSM's State Pointer, indicates the current state.
006	PORTB	0x00	0	00000000	Output Port: Bit 0 = DoorBell, Bit 1 = HL, Bit 2 = DL.

Watch 1 Watch 2 Watch 3 Watch 4

Watch

Add SFR CCP1CON Add Symbol _BODEN_OFF

Address	Symbol Name	Hex	Decimal	Binary	Comment
002	PCL	0x64	100	01100100	Program Counter's Least Significant Byte
	WREG	0x00	0	00000000	Work Register
003	STATUS	0x1C	28	00011100	STATUS of the Mikrorechner
074	InFlags	0x02	2	00000010	Bit 0 = BbF, Bit 1 - nBbF; When Bb press, BbF = 1.
072	Flags	0x04	4	00000100	Bit 0 = TicFlag, Bit 1 - SekFlag, Bit 2 = FSMF
024	InPort	0x00	0	00000000	When Bb is pressed, Bb and BbF = 1,InPort = 0x01, else,0x00
005	PORTA	0x00	0	00000000	Input Port
023	FSMTime	0x02	2	00000010	FSM's Time, used for Timeout down counting.
022	FSMStateP	0x05	5	00000101	FSM's State Pointer, indicates the current state.
006	PORTB	0x04	4	00000100	Output Port: Bit 0 = DoorBell, Bit 1 = HL, Bit 2 = DL.

Watch 1 Watch 2 Watch 3 Watch 4

Watch

Add SFR CCP1CON Add Symbol _BODEN_OFF

Address	Symbol Name	Hex	Decimal	Binary	Comment
002	PCL	0x8F	143	10001111	Program Counter's Least Significant Byte
	WREG	0x07	7	00000111	Work Register
003	STATUS	0x18	24	00011000	STATUS of the Mikrorechner
074	InFlags	0x02	2	00000010	Bit 0 = BbF, Bit 1 - nBbF; When Bb press, BbF = 1.
072	Flags	0x04	4	00000100	Bit 0 = TicFlag, Bit 1 - SekFlag, Bit 2 = FSMF
024	InPort	0x00	0	00000000	When Bb is pressed, Bb and BbF = 1,InPort = 0x01, else,0x00
005	PORTA	0x00	0	00000000	Input Port
023	FSMTime	0x02	2	00000010	FSM's Time, used for Timeout down counting.
022	FSMStateP	0x07	7	00000111	FSM's State Pointer, indicates the current state.
006	PORTB	0x00	0	00000000	Output Port: Bit 0 = DoorBell, Bit 1 = HL, Bit 2 = DL.

Watch 1 Watch 2 Watch 3 Watch 4

Watch

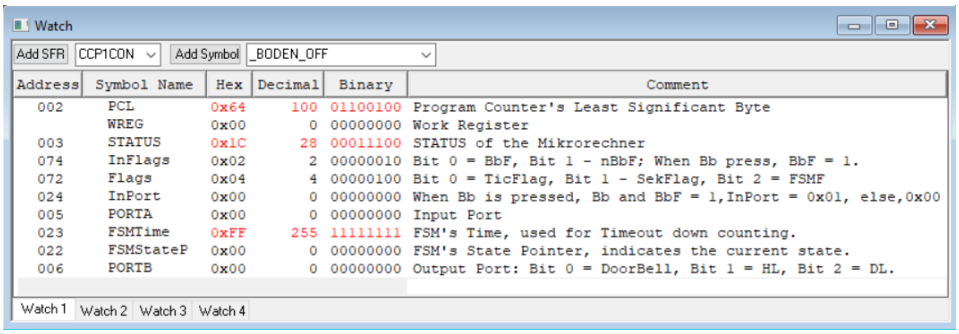
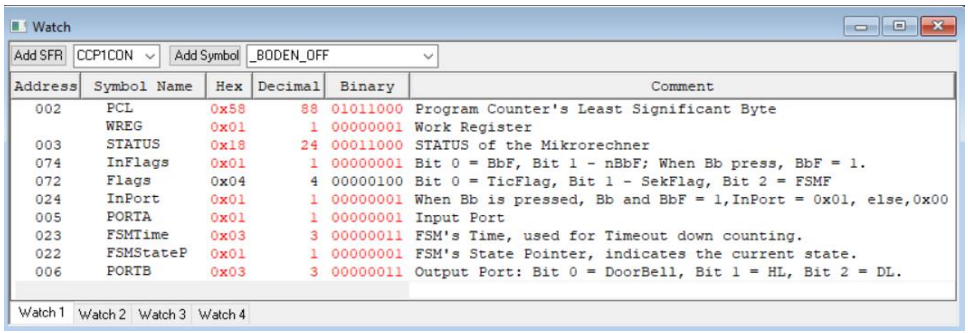
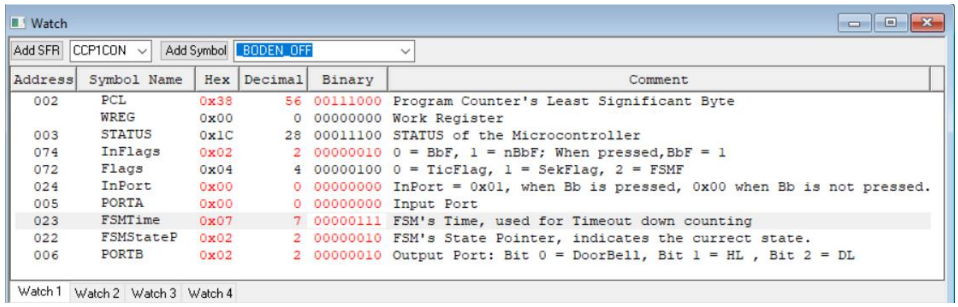
Add SFR CCP1CON Add Symbol _BODEN_OFF

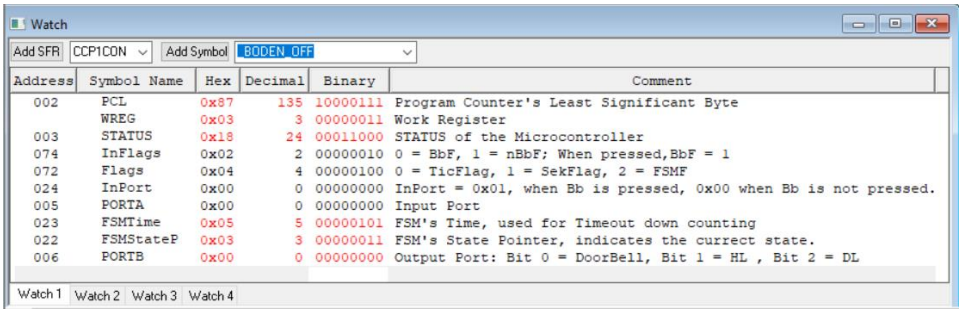
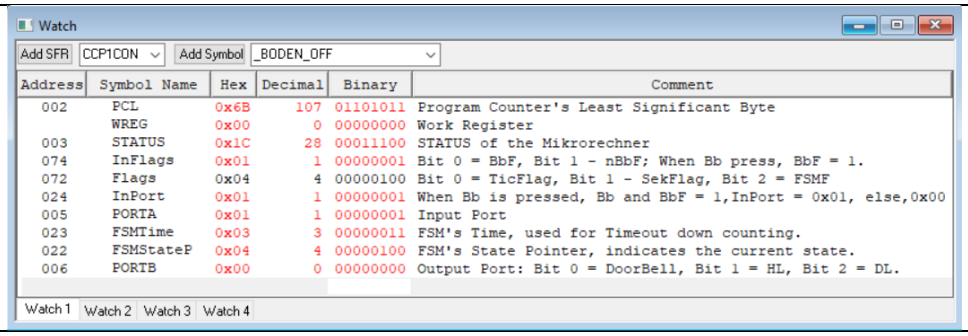
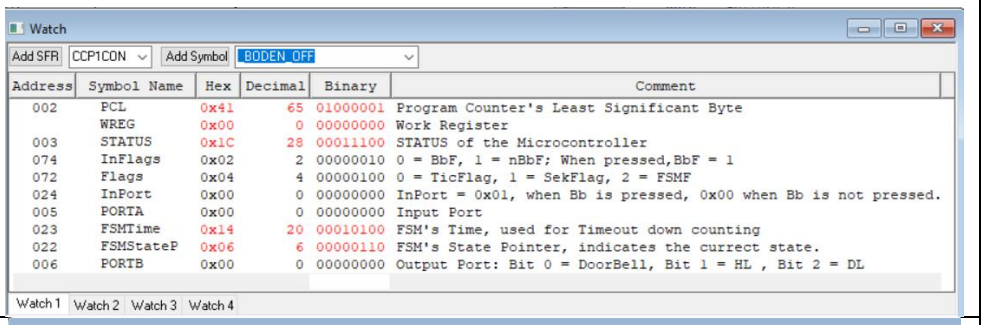
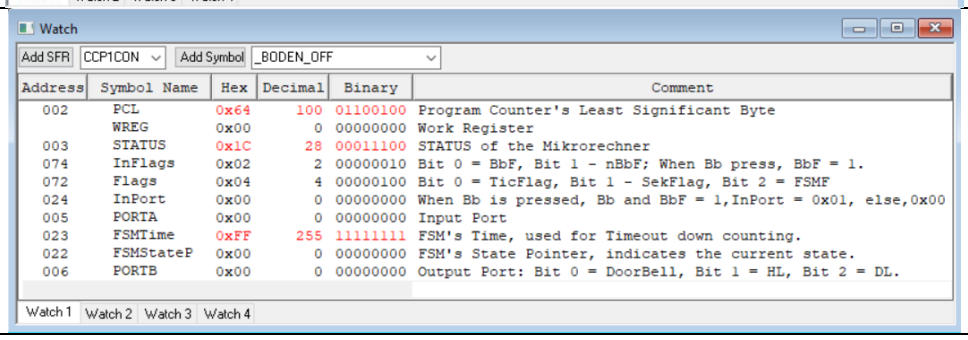
Address	Symbol Name	Hex	Decimal	Binary	Comment
002	PCL	0x64	100	01100100	Program Counter's Least Significant Byte
	WREG	0x00	0	00000000	Work Register
003	STATUS	0x1C	28	00011100	STATUS of the Mikrorechner
074	InFlags	0x02	2	00000010	Bit 0 = BbF, Bit 1 - nBbF; When Bb press, BbF = 1.
072	Flags	0x04	4	00000100	Bit 0 = TicFlag, Bit 1 - SekFlag, Bit 2 = FSMF
024	InPort	0x00	0	00000000	When Bb is pressed, Bb and BbF = 1,InPort = 0x01, else,0x00
005	PORTA	0x00	0	00000000	Input Port
023	FSMTime	0xFF	255	11111111	FSM's Time, used for Timeout down counting.
022	FSMStateP	0x00	0	00000000	FSM's State Pointer, indicates the current state.
006	PORTB	0x00	0	00000000	Output Port: Bit 0 = DoorBell, Bit 1 = HL, Bit 2 = DL.

Watch 1 Watch 2 Watch 3 Watch 4

Case 3

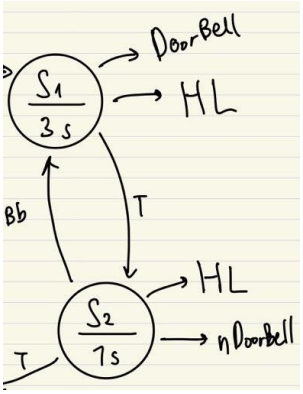
Event: User presses the Bell button. The Hallway Light lights up for 10 seconds. User press the bell button again within 5 seconds for MORE than 3 seconds after the light has switched off, the bell button is disabled for 20 seconds, as timing failed.

State	Event	Watch's result in Simulation
S0	Waiting for Stimulus	
S1	Bb pressed, Doorbell rings and Hallway Light switches on for 3 seconds. DoorBell = 1, HL = 1. FSMTime: 3 (seconds) PORTB: 00000011	
S2	S1 delay timeout. Doorbell stop ringing. Hallway light is on for another 7 seconds. Total light on for 10 seconds. DoorBell = 0, HL = 1. FSMTime: 7 (seconds) PORTB: 00000010	

S3	Turn off Hallway Light as it lights up for 10 seconds already. Then, down count 5 seconds, waiting for stimulus. HL = 0 PORTB: 00000000	
S4	Bb is pressed within the 5 seconds timeframe. But the Bb pressed is more than 3 seconds, hence timing failed, and bell button is disabled for 20 seconds.	
S6	The bell button is disabled for 20 seconds, as timing failed. FSMTime: 20	
S0	Back to S0, waiting for stimulus.	

Side note for the system's design

For the State transition's condition of Bell Button (Bb) from State 2(S2) to State 1 (S1) is for user to ring the bell anytime even the Hallway Light is switched on. However, when the Hallway Light is switched on (within the 10 seconds), the pressed Bb by the user will rings the Doorbell for 3 second (as per State 1) and **Refresh** the timing for Hallway Light. So, if the user press and hold the Bell button, the Bell button will keep on ringing. It will be more appropriate for a Doorbell.



4. Answer questions:

a. At which line do you set a breakpoint to verify that interrupt is working?

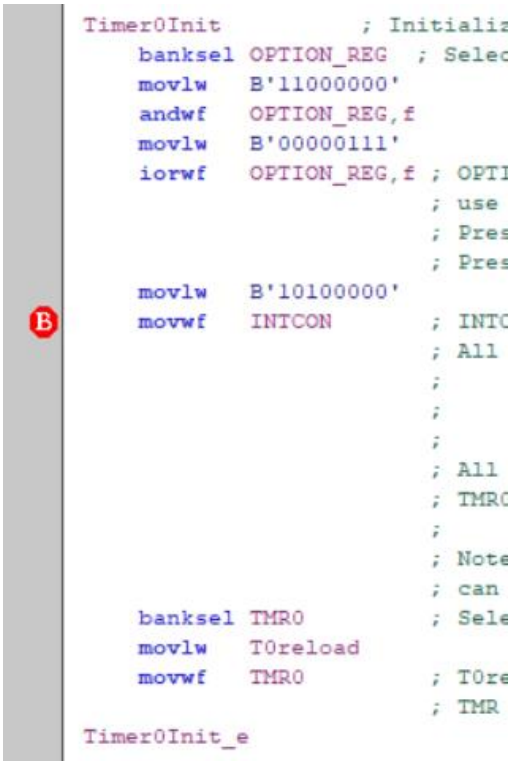
Line:

```
   movwf   INTCON
```

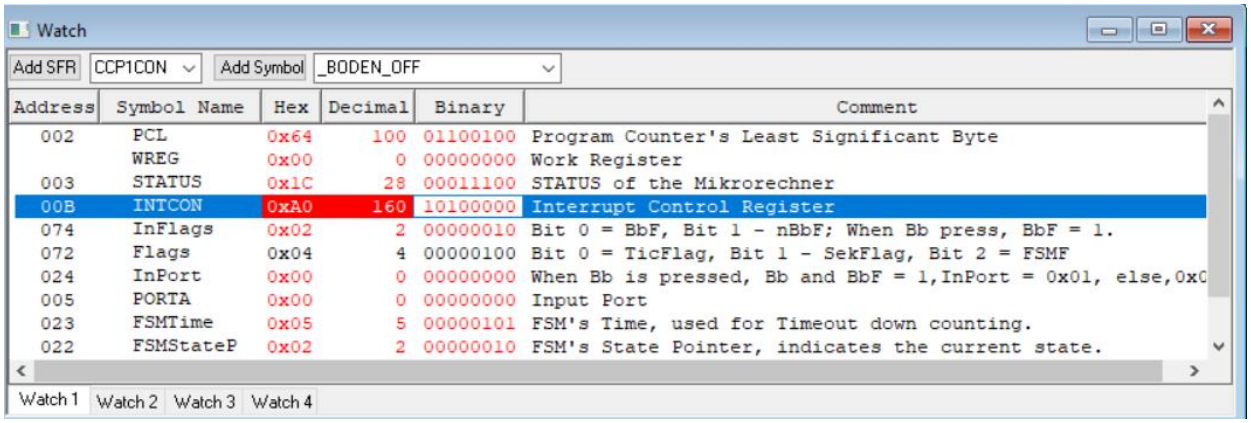
This line can be found in the following block:

```
Timer0Init        ; Initialize TMR0
   banksel OPTION_REG  ; Select bank of register of OPTION_REG
   movlw   B'11000000'
   andwf   OPTION_REG,f
   movlw   B'00000111'
   iorwf   OPTION_REG,f ; OPTION_REG's current bits: 11000111
                  ; use Internal instruction cycle clock (CLKOUT)
                  ; Prescaler is assigned to the Timer0 module
                  ; Prescaler Rate for TMR0 --> 1:256
   movlw   B'10100000'
      movwf   INTCON      ; INTCON's current bits: 10100000
   banksel TMR0
   movlw   T0reload
   movwf   TMR0
Timer0Init_e
```

In MPLAB IDE:



Simulation will be paused at that break point and here's the watch results.



By copying B '10100000' to INTCON with the help of WREG:

- All un-masked interrupts are ENABLED. Un-masked interrupt is a hardware interrupt, in our case, Bell Button (Bb)). Now the system able to listen to hardware interrupt.
- TMR0 Interrupt is ENABLED. Now the system able to listen to timing interrupt.

Interrupt requests are asynchronous events which means that an interrupt request can occur at any time during the execution of a program.

In other words, with that B '10100000' in INTCON configuration, the program can be interrupted asynchronously any time during the execution of program for both Hardware and Timing.

b. At which line do you set a breakpoint to verify that down counting of lifetime is working well?

Line:

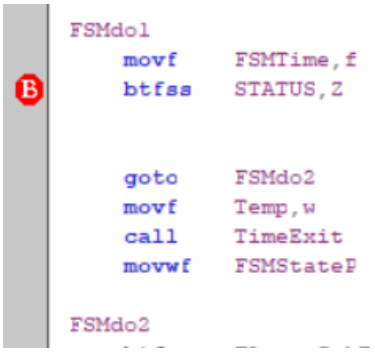
```
  btfss   STATUS,Z
```

This line shows that the down counting of the lifetime is working well as it goes to the next appropriate state after it finishes its down counting. Else, if this down counting code is not working well, it will not go to the next state.

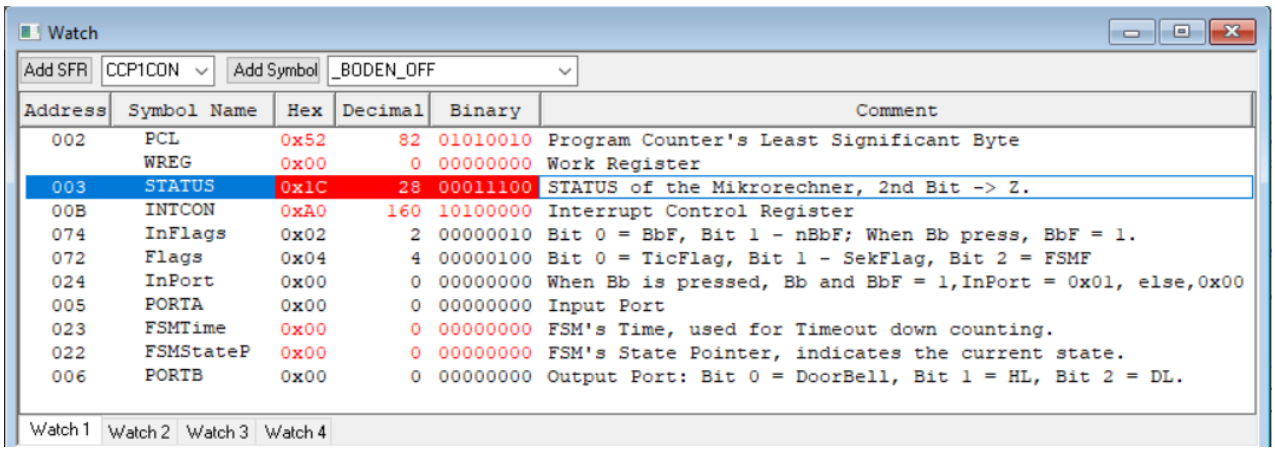
This line can be found in the following block:

```
FSMdo1              ;test timeout
  movf    FSMTime,f
  btfss   STATUS,Z
  goto    FSMdo2
  movf    Temp,w
  call    TimeExit
  movwf   FSMStateP
```

In MPLAB IDE:

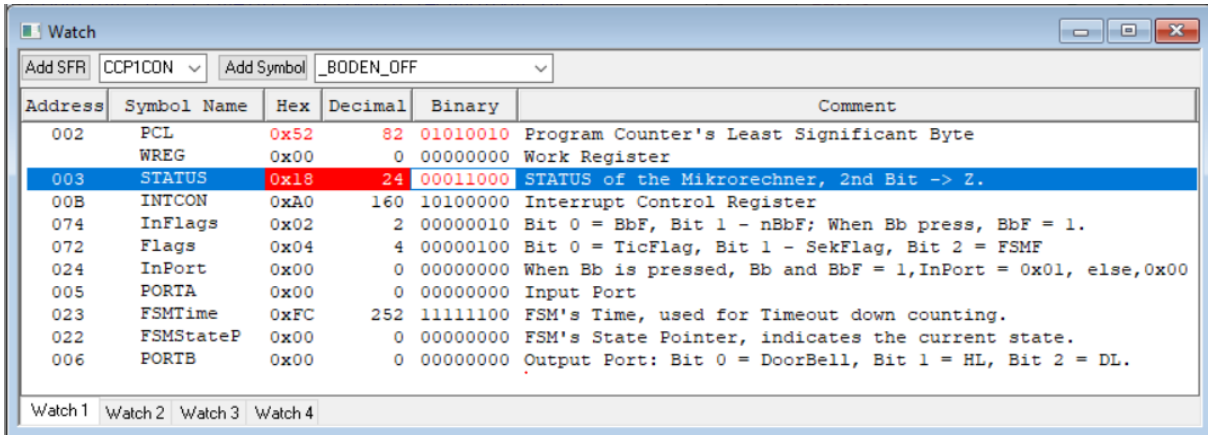


Simulation's Watch Results:



Z of STATUS is set, Z = 1: Shows that FSM Down Counting Lifetime is now zero.

On the other hand,



Z of STATUS is cleared, Z = 0: Shows that FSM Down Counting Lifetime is not zero.

By checking these two results, observing Z is either set or cleared and its corresponding FSM Lifetime (down counted). We can check whether the down counting of lifetime is working well or not. In my case, I can deduce that down counting of lifetime is working well.

Explanations

This line checks the bit of Z in STATUS register(03h).

Z is 2nd bit in the register:

Zero bit 1 = The result of an arithmetic or logic operation is zero, where if zero bit 0 = The result of an arithmetic or logic operation is not zero.

We check the result of the operation of

```
movf    FSMTime,f
```

If FSMTime is 0, which also means that FSM's delay of that state is timeout, the data will be copied to Work Register (WREG).

The Z = 1 in STATUS. Hence, it will skip the next line:

```
goto    FSMdo2
```

and execute the following:

```
    call    TimeExit
movwf   FSMStateP
```

This will invoke the TimeExit table and Return the literal of corresponding Next State(with RETLW) after timeout to the WREG. The literal returned is the Next State's literal. Then the WREG will copy its data to FSMStateP. Now, the machine is in the next state after the timeout delay.

c. At which line do you set a breakpoint to verify that bell button is detected by a state?

Line:

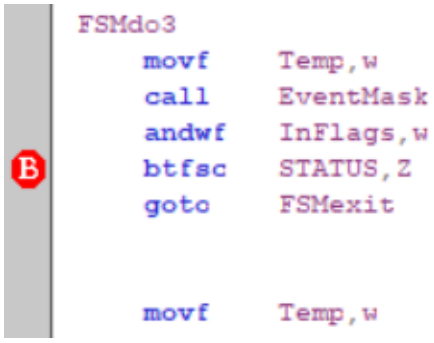
```
    btfsc   STATUS,Z
```

This line shows that the interrupt that goes to the next appropriate state after Stimulus is stimulated, or when the Bell Button (Bb) is fired/pressed. Else, if interrupt is not working, no state change when Bb is fired (for state that listens to Bb), i.e., not detected by a state.

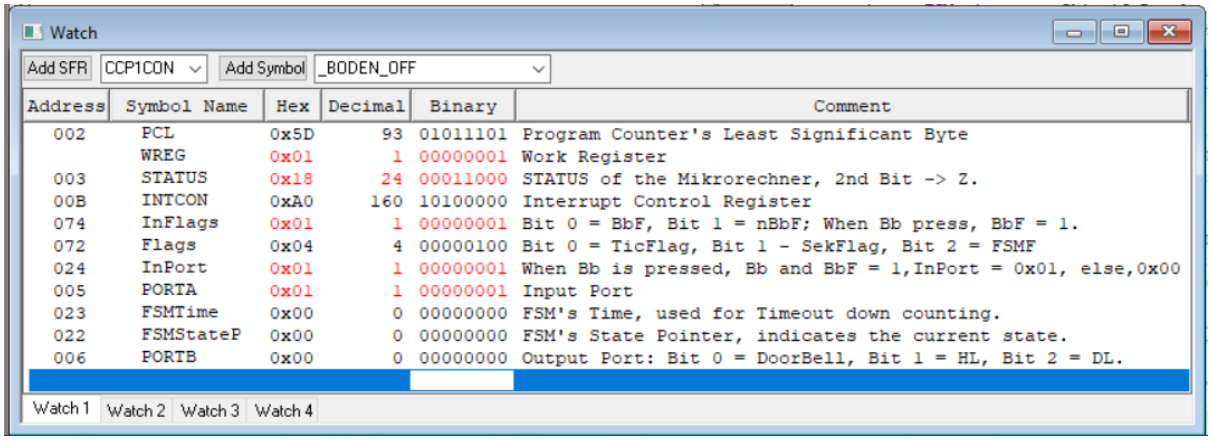
This line can be found in the following block:

```
FSMdo3
   movf    Temp,w
   call    EventMask
   andwf   InFlags,w
   btfsc   STATUS,Z
   goto    FSMexit
   movf    Temp,w
   call    EventExit
   movwf   FSMStateP
```

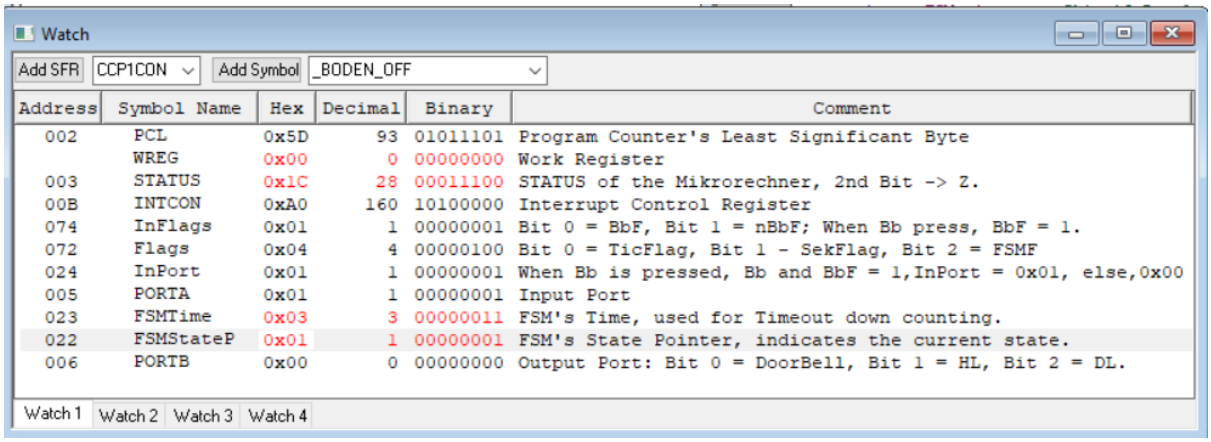
In MPLAB IDE:



In the Watch of simulated results:



Here, current state is S0. Then Bell Button (Bb) is fired, hence InPort = 1. Z in STATUS is CLEARED then the next cycle at that breakpoint is as shown:



Note that now FSMStateP = 1, shows that current state is S1.

Which means that from S0, when Bell Button (Bb) is fired, the state(S0) detects it and goes to next state which is state 1(S1).

Explanations

Register of InFlags:

Bit 0	Bit 1	Bit 2	Bit 3	Bit 4	Bit 5	Bit 6	Bit 7
X	X	X	X	X	X	nBbF	BbF

When Bb is pressed, or when Bb = 1, BbF = 1 and nBbF = 0.

In line:

```
andwf   InFlags,w
btfsc   STATUS,Z
goto    FSMexit
```

WREG is the EventMask which returned from the EventMask Table.

AND Logical operation of InFlags and WREG is executed. Below is the event for the results:

Event	Event's Explanation	Actions Flow		
		1	2	3
InFlags AND WREG = 0	Bb is not fired	Z = 1	Bit Test Z	Detected Bb = 0 and execute "goto FSMexit".
InFlags AND WREG = 1	Bb is fired and EventMask = 1	Z = 0	Bit Test Z	Detected Bb= 1 and Skip "goto FSMexit". This state listen to Bb and Bb is fired. Will go to next state denoted by FSMStateP.

Where Z (Zero Bit is Bit 2 in STATUS register) and EventMask = 1 means that the state can go to next state with the right stimulus.

In the loop, it always test/check for bit Bb (Bit 0) of file register of InPort. If Bb is pressed, it will set BbF = 1 and clear nBbF = 0 in the InFlags file register, where BbF is the Bell Button Flag. This is an asynchronous interrupt.

d. At which line do you set a breakpoint to stop if the state will be changed?

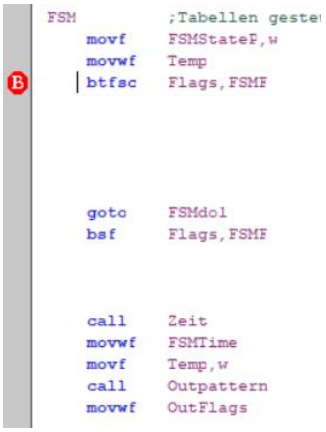
Line

```
   btfsc   Flags,FSMF
```

This line can be found in the following block:

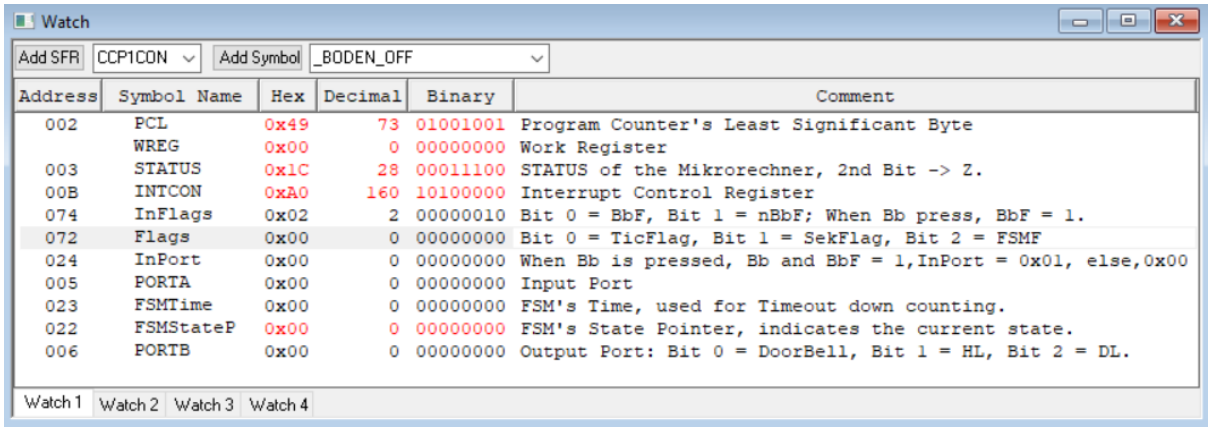
```
FSM         ;Tabellen gesteuerter Zustandsautomat/Finite State Machine
   movf    FSMStateP,w
   movwf   Temp
   btfsc   Flags,FSMF
   goto    FSMdo1
   bsf     Flags,FSMF
   call    Zeit
   movwf   FSMTime
   movf    Temp,w
   call    Outpattern
   movwf   OutFlags
```

In MPLAB IDE:

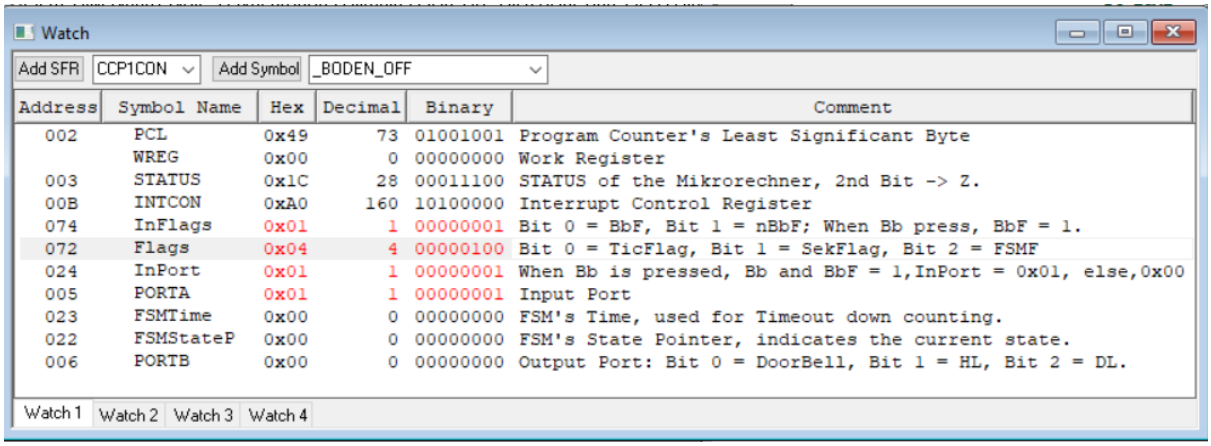


Explanations

Initially from S0,



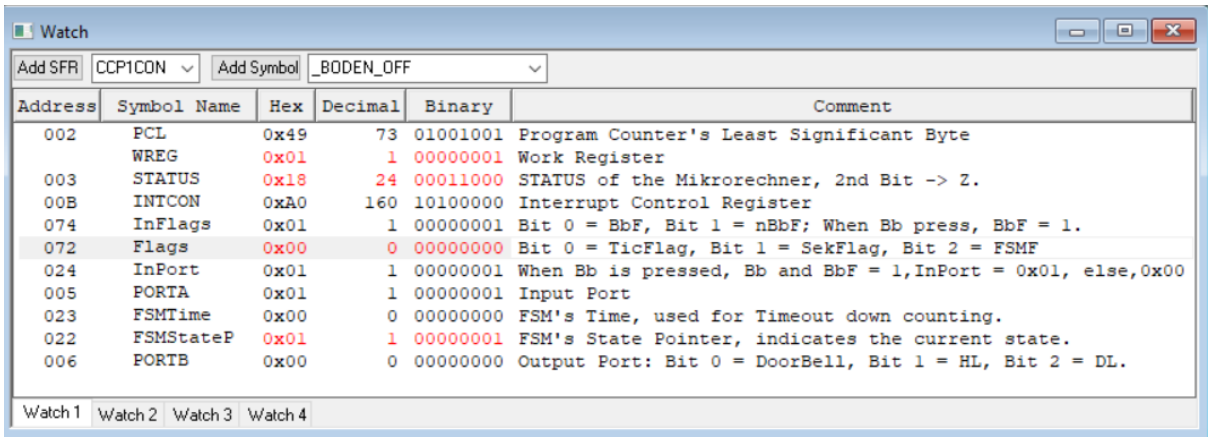
Bell Button (Bb) is fired, Bb = 1.



Transition of state from S0 to S1.

Here we can see that Flags file register's data is B '00000100' , where the 2nd bit is FSMF.

FSMF = 1, means that FSM Flag is flagged up and state transition occur will occur in next cycle (next screenshot).



FSMF is then flagged down or cleared, ready to check if there's any incoming state transition. Current state is S1.

Here, we can deduce that FSMF listen to the state transition.

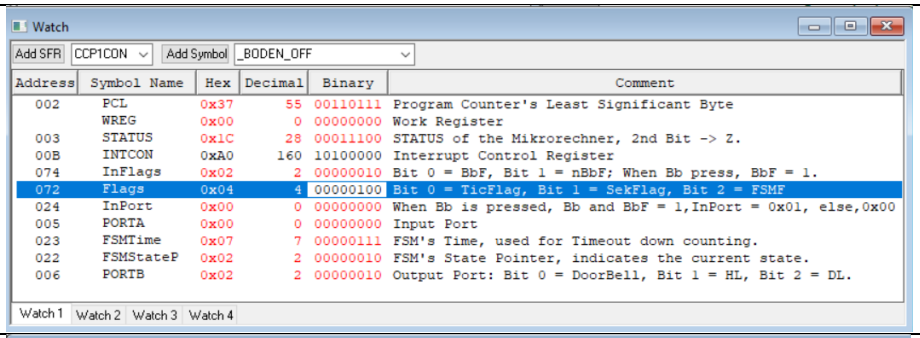
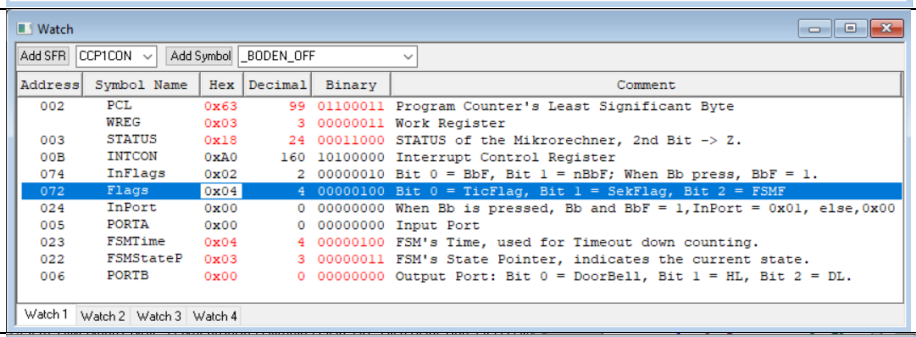
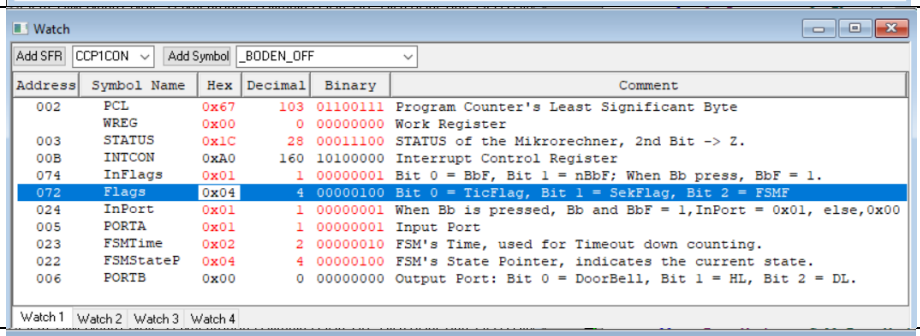
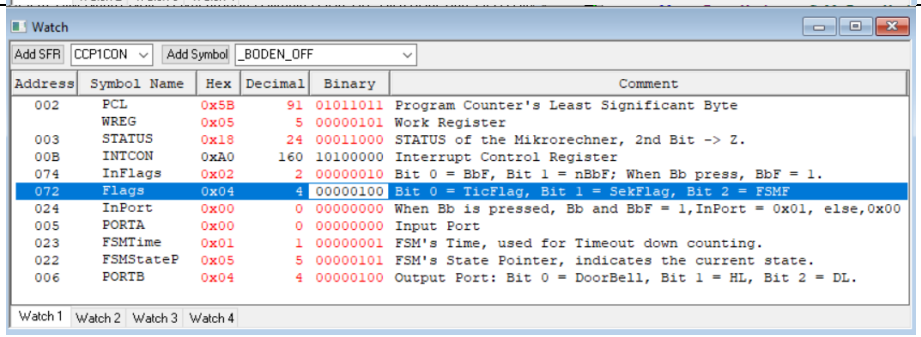
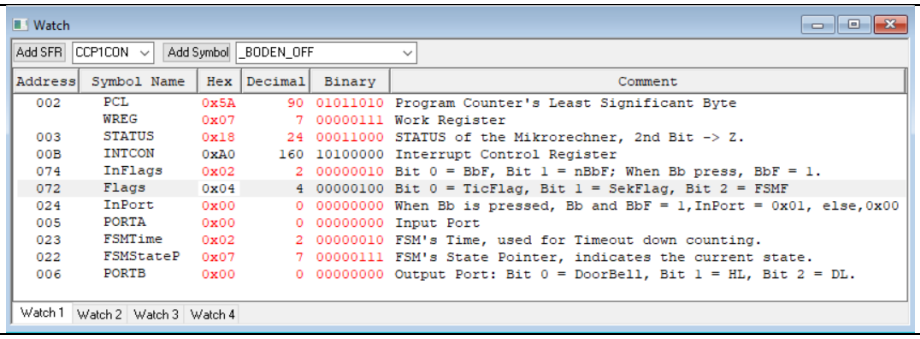
When there's state transition, FSMF = 1 or is set.

Moving forward from S1(above), then S2 and so on (illustrated below).

Below are some additional examples to illustrate that when Flags file register's data is

B '00000100' , where the 2nd bit of FSMF = 1. The current state is different form the previous one.

Looking at 2nd bit of file register of Flags(00000‘X’00) and the FSMStateP:

Previous State	Current State	FSMF	Watch result
S1	S2	1	
S2	S3	1	
S3	S4	1	
S4	S5	1	
S7	S7	1	

Watch

Add SFR CCP1CON Add Symbol _BODEN_OFF

Address	Symbol Name	Hex	Decimal	Binary	Comment
002	PCL	0x37	55	00110111	Program Counter's Least Significant Byte
	WREG	0x00	0	00000000	Work Register
003	STATUS	0x1C	28	00011100	STATUS of the Mikrorechner, 2nd Bit -> Z.
00B	INTCON	0xA0	160	10100000	Interrupt Control Register
074	InFlags	0x02	2	00000010	Bit 0 = BbF, Bit 1 = nBbF; When Bb press, BbF = 1.
072	Flags	0x04	4	00000100	Bit 0 = TicFlag, Bit 1 = SekFlag, Bit 2 = FSMF
024	InPort	0x00	0	00000000	When Bb is pressed, Bb and BbF = 1,InPort = 0x01, else,0x00
005	PORTA	0x00	0	00000000	Input Port
023	FSMTime	0x07	7	00000111	FSM's Time, used for Timeout down counting.
022	FSMStateP	0x02	2	00000010	FSM's State Pointer, indicates the current state.
006	PORTB	0x02	2	00000010	Output Port: Bit 0 = DoorBell, Bit 1 = HL, Bit 2 = DL.

Watch 1 Watch 2 Watch 3 Watch 4

Watch

Add SFR CCP1CON Add Symbol _BODEN_OFF

Address	Symbol Name	Hex	Decimal	Binary	Comment
002	PCL	0x63	99	01100011	Program Counter's Least Significant Byte
	WREG	0x03	3	00000011	Work Register
003	STATUS	0x18	24	00011000	STATUS of the Mikrorechner, 2nd Bit -> Z.
00B	INTCON	0xA0	160	10100000	Interrupt Control Register
074	InFlags	0x02	2	00000010	Bit 0 = BbF, Bit 1 = nBbF; When Bb press, BbF = 1.
072	Flags	0x04	4	00000100	Bit 0 = TicFlag, Bit 1 = SekFlag, Bit 2 = FSMF
024	InPort	0x00	0	00000000	When Bb is pressed, Bb and BbF = 1,InPort = 0x01, else,0x00
005	PORTA	0x00	0	00000000	Input Port
023	FSMTime	0x04	4	00000100	FSM's Time, used for Timeout down counting.
022	FSMStateP	0x03	3	00000011	FSM's State Pointer, indicates the current state.
006	PORTB	0x00	0	00000000	Output Port: Bit 0 = DoorBell, Bit 1 = HL, Bit 2 = DL.

Watch 1 Watch 2 Watch 3 Watch 4

Watch

Add SFR CCP1CON Add Symbol _BODEN_OFF

Address	Symbol Name	Hex	Decimal	Binary	Comment
002	PCL	0x67	103	01100111	Program Counter's Least Significant Byte
	WREG	0x00	0	00000000	Work Register
003	STATUS	0x1C	28	00011100	STATUS of the Mikrorechner, 2nd Bit -> Z.
00B	INTCON	0xA0	160	10100000	Interrupt Control Register
074	InFlags	0x01	1	00000001	Bit 0 = BbF, Bit 1 = nBbF; When Bb press, BbF = 1.
072	Flags	0x04	4	00000100	Bit 0 = TicFlag, Bit 1 = SekFlag, Bit 2 = FSMF
024	InPort	0x01	1	00000001	When Bb is pressed, Bb and BbF = 1,InPort = 0x01, else,0x00
005	PORTA	0x01	1	00000001	Input Port
023	FSMTime	0x02	2	00000010	FSM's Time, used for Timeout down counting.
022	FSMStateP	0x04	4	00000100	FSM's State Pointer, indicates the current state.
006	PORTB	0x00	0	00000000	Output Port: Bit 0 = DoorBell, Bit 1 = HL, Bit 2 = DL.

Watch 1 Watch 2 Watch 3 Watch 4

Watch

Add SFR CCP1CON Add Symbol _BODEN_OFF

Address	Symbol Name	Hex	Decimal	Binary	Comment
002	PCL	0x5B	91	01011011	Program Counter's Least Significant Byte
	WREG	0x05	5	00000101	Work Register
003	STATUS	0x18	24	00011000	STATUS of the Mikrorechner, 2nd Bit -> Z.
00B	INTCON	0xA0	160	10100000	Interrupt Control Register
074	InFlags	0x02	2	00000010	Bit 0 = BbF, Bit 1 = nBbF; When Bb press, BbF = 1.
072	Flags	0x04	4	00000100	Bit 0 = TicFlag, Bit 1 = SekFlag, Bit 2 = FSMF
024	InPort	0x00	0	00000000	When Bb is pressed, Bb and BbF = 1,InPort = 0x01, else,0x00
005	PORTA	0x00	0	00000000	Input Port
023	FSMTime	0x01	1	00000001	FSM's Time, used for Timeout down counting.
022	FSMStateP	0x05	5	00000101	FSM's State Pointer, indicates the current state.
006	PORTB	0x04	4	00000100	Output Port: Bit 0 = DoorBell, Bit 1 = HL, Bit 2 = DL.

Watch 1 Watch 2 Watch 3 Watch 4

Watch

Add SFR CCP1CON Add Symbol _BODEN_OFF

Address	Symbol Name	Hex	Decimal	Binary	Comment
002	PCL	0x5A	90	01011010	Program Counter's Least Significant Byte
	WREG	0x07	7	00000111	Work Register
003	STATUS	0x18	24	00011000	STATUS of the Mikrorechner, 2nd Bit -> Z.
00B	INTCON	0xA0	160	10100000	Interrupt Control Register
074	InFlags	0x02	2	00000010	Bit 0 = BbF, Bit 1 = nBbF; When Bb press, BbF = 1.
072	Flags	0x04	4	00000100	Bit 0 = TicFlag, Bit 1 = SekFlag, Bit 2 = FSMF
024	InPort	0x00	0	00000000	When Bb is pressed, Bb and BbF = 1,InPort = 0x01, else,0x00
005	PORTA	0x00	0	00000000	Input Port
023	FSMTime	0x02	2	00000010	FSM's Time, used for Timeout down counting.
022	FSMStateP	0x07	7	00000111	FSM's State Pointer, indicates the current state.
006	PORTB	0x00	0	00000000	Output Port: Bit 0 = DoorBell, Bit 1 = HL, Bit 2 = DL.

Watch 1 Watch 2 Watch 3 Watch 4