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| Sekolah: SEKOLAH KEJURUTERAAN ELEKTRIK | |
| Nama Matapelajaran: Kod Matapelajaran : SKEE 3732 | Semakan : 1 Tarikh Keluaran : November 2020 Pindaan Terakhir : November 2020 No. Prosedur : PK-UTM-SKE-(0)-10 |



UTM
UNIVERSITI TEKNOLOGI MALAYSIA

**SEKOLAH KEJURUTERAAN ELEKTRIK
FAKULTI KEJURUTERAAN
UNIVERSITI TEKNOLOGI MALAYSIA
KAMPUS SKUDAI
JOHOR
SKEE 3732**

MICROPROCESSOR LABORATORY

Laboratory 3: Interrupt and Timer Programming on ATmega32.

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| Prepared by: Mohd Afzan Othman Signature & Stamp:  <small>DR. MOHD AFZAN BIN OTHMAN Pensyarah Kanan Jabatan Elektronik dan Kejuruteraan Komputer Fakulti Kejuruteraan Elektrik Universiti Teknologi Malaysia 81310 Johor Bahru Johor, Malaysia</small> Date: 25/12/2020 | Approved by : Head of Department Name: Signature & Stamp:  <small>ASSOC PROF IR DR RUBITA SUDIRMAN Director Electronic & Computer Engineering School of Electrical Engineering, Faculty of Engineering Universiti Teknologi Malaysia 81310 UTM Johor Bahru, Johor (+60) 07-5557075 rubita@utm.my</small> Date: 26/12/2020 |
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I. PRELIMINARY PREPARATION (15 marks)

Important Note: You are required to do following BEFORE the lab session.

1. Referring to the program “Lab3Exp1.c” in Figure A.2(a) of “Appendix A For SKEE3732 Laboratory 3 Sheet.pdf”, create the GCC C executable project named “Lab3Exp1” for device “ATmega32” and write the program.
2. Compile the program to see if the program is free from errors. It can be done by clicking **Build > Build Solution** to compile the program. Take a screenshot of successfully compiled program.
3. List down directive or file that are required in interrupt programming.

4. Determine the code in program “Lab3Exp1.c” that is use to enable interrupt program.

5. Given program A below, answer the following questions:

```
DDRD=0b11110011;  
PORTD=0b00001100;  
GICR=0b11000000;  
MCUCR = MCUCR|0b00001110;
```

Program A

- (a) Types of External Interrupt hardware that were enabled in Program A.
- (b) What is the use of MCUCR?
- (c) Identify the trigger options enabled in Program A.

II. LABORATORY SHEET

1 Title: Interrupts and Timer on ATmega32A Target Board.

2 Objective:

1. To initialize the interrupt programming setting.
2. To investigate the level triggered function.
3. To simulate the outputs of firmware using AVR IDE Simulator.
4. To add additional code that upgrade the operation of firmware

3 Equipment/Software/Reference:

1. A computer system running Windows XP, Window Vista, Window 7 or Window 8.
2. AVR Studio 6 installed on the system
3. AVR IDE Simulator.
4. Reference 1 - Appendix C For SKEE3732 Laboratory 1 Sheet.pdf
5. Reference 2- Appendix A For SKEE3732 Laboratory 2 Sheet.pdf
6. Reference 3- Appendix A For SKEE3732 Laboratory 3 Sheet.pdf
7. Reference 4– Atmega32 Reference manual .pdf
8. Reference 5– Embedded C Programming and the Atmel AVR, Second Edition.pdf
9. Reference 6– AVR libc function reference.pdf

All softcopy of the references can be sourced in the “Reference For Laboratory 3” sub-folder of the folder site where this Laboratory 3 Sheet is located.

4 Procedures

I. To Open Project (create during pre-lab session)

Open Project named “Lab3Exp1” which you have created as instructed in section 1 of “Preliminary Report” by double clicking “Lab3Exp1.atstn” in the “Lab3Exp1” directory.

II. To Wire up peripherals on AVR Simulator IDE.

Connect the AVR Simulator IDE as shown in the Figure 1.1 below. Make sure to select 8 x LED Board (to connect to PORTC), Microcontroller view, 7-Segment LED Displays Panel (to connect to PORTA) and INT1 switch to PD3 (PORTD) from **Tools**. Set the clock frequency to 4 MHz.

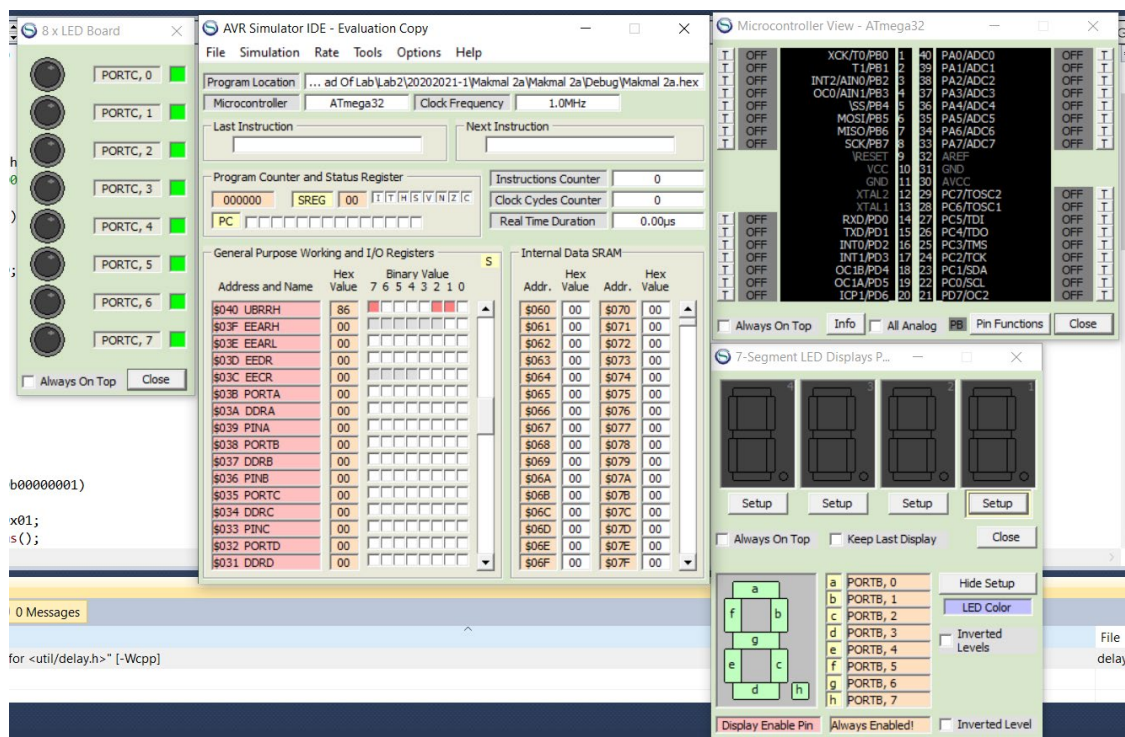


Figure 1.1

III. Inspecting the operation of program Lab3Exp1.c

Simulate Lab3Exp1 on the AVR Simulator IDE and fill Table 1, the display is observed on the seven segments Display and LEDs. Write your observation.

IV. Write a program to generate delay.

By using Timer 1, CTC mode and with optimum prescaler; calculate the OCR value to generate 500ms delay. Shows the calculation clearly and write the “Delay500ms” function. Use XTAL frequency of 4 MHz. Fill in Figure 2.

V. Implementing the Complete Function of “Lab3Exp1.c” as required in Table 2.

Modify the program such that the program will executes the pattern sequence as specified in Table 2 for command if INT0 and INT1 is pressed. Use falling edge triggered to invoke the ISR. Run the program after modification and get an endorsement in **Figure 3** from the supervising lecturer after showing the working program.

Hint: You will need an additional Function and Case conditions.

Table 2

| Switch Pressed | LEDs panel display requirement when respective button is selected | Remarks | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
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| No switches pressed | Seven Segment LED display will continuously count from 0 to 9. | Time delay for each blinking is 500ms | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| INT0 | <p style="text-align: center;">Pattern1</p> <table border="1" style="margin-left: auto; margin-right: auto;"> <thead> <tr> <th>State #</th> <th>Led7</th> <th>Led6</th> <th>Led5</th> <th>Led4</th> <th>Led3</th> <th>Led2</th> <th>Led1</th> <th>Led0</th> </tr> </thead> <tbody> <tr> <td>0</td> <td>●</td> <td>●</td> <td>●</td> <td>●</td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>1</td> <td></td> <td></td> <td></td> <td></td> <td>●</td> <td>●</td> <td>●</td> <td>●</td> </tr> <tr> <td>2</td> <td>●</td> <td>●</td> <td>●</td> <td>●</td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>3</td> <td></td> <td></td> <td></td> <td></td> <td>●</td> <td>●</td> <td>●</td> <td>●</td> </tr> <tr> <td>4</td> <td>●</td> <td>●</td> <td>●</td> <td>●</td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>5</td> <td></td> <td></td> <td></td> <td></td> <td>●</td> <td>●</td> <td>●</td> <td>●</td> </tr> <tr> <td>6</td> <td>●</td> <td>●</td> <td>●</td> <td>●</td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>7</td> <td></td> <td></td> <td></td> <td></td> <td>●</td> <td>●</td> <td>●</td> <td>●</td> </tr> </tbody> </table> <p style="text-align: center;">Bold indicate LED ON</p> | State # | Led7 | Led6 | Led5 | Led4 | Led3 | Led2 | Led1 | Led0 | 0 | ● | ● | ● | ● | | | | | 1 | | | | | ● | ● | ● | ● | 2 | ● | ● | ● | ● | | | | | 3 | | | | | ● | ● | ● | ● | 4 | ● | ● | ● | ● | | | | | 5 | | | | | ● | ● | ● | ● | 6 | ● | ● | ● | ● | | | | | 7 | | | | | ● | ● | ● | ● | Time delay for each blinking is 500ms | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| State # | Led7 | Led6 | Led5 | Led4 | Led3 | Led2 | Led1 | Led0 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
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| INT1 | <p style="text-align: center;">Pattern2</p> <table border="1" style="margin-left: auto; margin-right: auto;"> <thead> <tr> <th>State #</th> <th>Led7</th> <th>Led6</th> <th>Led5</th> <th>Led4</th> <th>Led3</th> <th>Led2</th> <th>Led1</th> <th>Led0</th> </tr> </thead> <tbody> <tr> <td>0</td> <td>●</td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>1</td> <td></td> <td>●</td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>2</td> <td></td> <td></td> <td>●</td> <td></td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>3</td> <td></td> <td></td> <td></td> <td>●</td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>4</td> <td></td> <td></td> <td></td> <td></td> <td>●</td> <td></td> <td></td> <td></td> </tr> <tr> <td>5</td> <td></td> <td></td> <td></td> <td></td> <td></td> <td>●</td> <td></td> <td></td> </tr> <tr> <td>6</td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td>●</td> <td></td> </tr> <tr> <td>7</td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td>●</td> </tr> <tr> <td>8</td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td>●</td> <td></td> </tr> <tr> <td>9</td> <td></td> <td></td> <td></td> <td></td> <td></td> <td>●</td> <td></td> <td></td> </tr> <tr> <td>10</td> <td></td> <td></td> <td></td> <td></td> <td>●</td> <td></td> <td></td> <td></td> </tr> <tr> <td>11</td> <td></td> <td></td> <td></td> <td>●</td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>12</td> <td></td> <td></td> <td>●</td> <td></td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>13</td> <td></td> <td>●</td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>14</td> <td>●</td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>15</td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> </tr> </tbody> </table> <p style="text-align: center;">Bold indicate LED ON</p> | State # | Led7 | Led6 | Led5 | Led4 | Led3 | Led2 | Led1 | Led0 | 0 | ● | | | | | | | | 1 | | ● | | | | | | | 2 | | | ● | | | | | | 3 | | | | ● | | | | | 4 | | | | | ● | | | | 5 | | | | | | ● | | | 6 | | | | | | | ● | | 7 | | | | | | | | ● | 8 | | | | | | | ● | | 9 | | | | | | ● | | | 10 | | | | | ● | | | | 11 | | | | ● | | | | | 12 | | | ● | | | | | | 13 | | ● | | | | | | | 14 | ● | | | | | | | | 15 | | | | | | | | | Time delay for each blinking is 500ms |
| State # | Led7 | Led6 | Led5 | Led4 | Led3 | Led2 | Led1 | Led0 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
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| 11 | | | | ● | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 12 | | | ● | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 13 | | ● | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 14 | ● | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 15 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

Table 1: Result to be taken in Procedure III

| Input | Change Register value. | Describe Display at Seven Segment Display | Describe Pattern generated at LED Panel | Observation (based on MCUCR) |
|--|-------------------------------|--|--|-------------------------------------|
| INT1 not pressed | No change | | | |
| INT1 pressed & hold | MCUCR = 0x08; | | | |
| INT1 pressed then released (after 5sec) | MCUCR = 0x0C; | | | |
| INT1 pressed & hold | GICR = 0; | | | |

**Discuss what happens every time the interrupt triggered and after interrupt finished at Seven Segment Display.

500ms Delay calculations using Timer 1:

“Delay500ms” Function coding:

Figure 2

Write the additional code and its location in the program "Lab3Exp1.c" that need to be made to implement Procedure V.

You may Cut and Paste from modified program:

Execution of Command when INT0 pressed: Working/Not working

Execution of Command when INT1 pressed: Working/Not working

Name and Signature of Lecturer:

Figure 3

5 Report Writing

Title:

Objective:

Equipment/Software Used:

Procedure:

Written in third person (reporting) speech:

Result:

Fill Table and Figures for Result and attach with result. I/O views, Watch etc. will require snapshot as evidence.

Discussion:

Discuss based on Objective and Result and Table 1. There shouldn't be any alien Objective and Result.

Conclusion:

Conclude based on Objective, Result and Discussion of the programs.