Electrical and Computer Engineering

EE3613 Processor Systems Laboratory

LAB 7

Hardware Programming using Assembly Language –

Atmel 324PB Board IO PORT Operation using 8 LEDs and 7 segment display

Fall 2019

In the lab 7, we will use assembly language to operate the IO ports of the Atmel 324PB Board. We will program the microprocessor to perform bitwise operation and control output signal of the pins. LEDs and 7-segment display are going to be used to show the result of these operations. Each activity requires that you develop your own code based on your own flowchart.

OBJECTIVES:

- To program AVR microprocessor using assembly language
- To control IO and learn bit operation of the available ports on the Atmel 324PB board
- To learn the use of *sbi* and *cbi* assembly instructions
- To learn the basic concept of using *Pulse Width Modulation* (PWM)
- To apply PWM to operate the IO pins and the LEDs
- To learn programming a 7-sigment display and connection method

REFERENCES:

Mazidi and Naimi, "The AVR Microcontroller and Embedded Systems," 2nd Ed. Chapters 4.

MATERIALS:

Atmel Studio 7, Atmel 324PB XPlained PRO Board (PORTA: 7 Segment display and LEDs are built-in on the board). The detailed board information is available in the lab6.

BACKGROUND INFORMATION:

(1) I/O PORT commands you might find useful for this lab:

Instruction	Syntax	Function
SBI	ioReg, bit	Set Bit in I/O register (set bit: bit = 1)
CBI	ioReg, bit	Clear Bit in I/O register (clear bit: bit = 0)
SBIC	ioReg, bit	Skip if Bit in I/O register is Cleared. (Skip next instruction if bit = 0)
SBIS	ioReg, bit	Skip if Bit in I/O register is Set. (Skip next instruction if bit = 1)
SBRC	Reg, bit	Skip if a single Bit in a register is Cleared. (Skip next instruction if bit = 0)
SBRS	Reg, bit	Skip if a single Bit in a register is Set. (Skip next instruction if bit = 1)

Each bit can be operated using direct value assigned, '1' for set and '0' for clear pin as shown in this example:

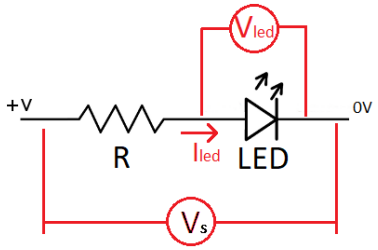
Example:

```
LDI    R16,0x55     ;R16 = 0x55
OUT    PORTA,R16    ;put 0x55 on Port A pins
LDI    R16,0xAA     ;R16 = 0xAA
OUT    PORTA,R16    ;put 0xAA on Port A pins
```

01010101

10101010

(2) Calculating Resistor value for LEDs or Seven Segments:



$$R = \frac{(V_s - V_{led})}{I_{led}}$$

Figure 1. Basic structure of the circuit for LED

Typically, V_s = 3.3V, V_{led} = 1.8V, I_{led} = 10mA. So, **R = (3.3V-1.8V) / 10mA = 150 Ohms** [Check datasheet for exact figures]. In professional design, instead of using a single resistor in the common anode or common cathode display, you should use individual resistors for each segment to achieve maximum and uniform brightness from the display, also it will prevent led burnout.

(3) Board settings: Make sure to turn on only PORTA_SW1_0 for 8 LEDS or only PORTA_SW1_1 for 7 segment display. Check Lab 5 manual for connection reference.

(4) Seven Segment Display: There are two types of 7-segment displays, Common Anode and Common Cathode. Following figure shows the generic internal diagram for both types.

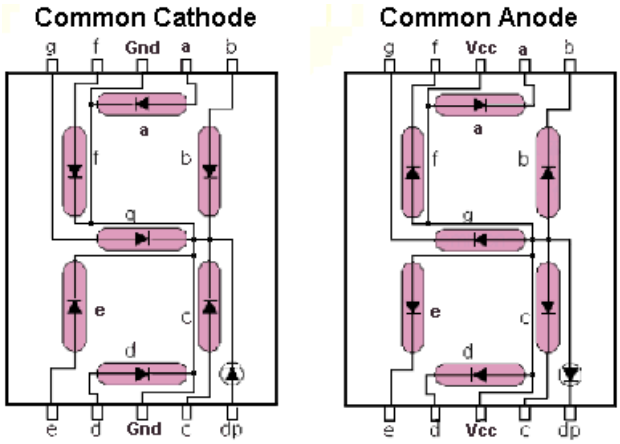
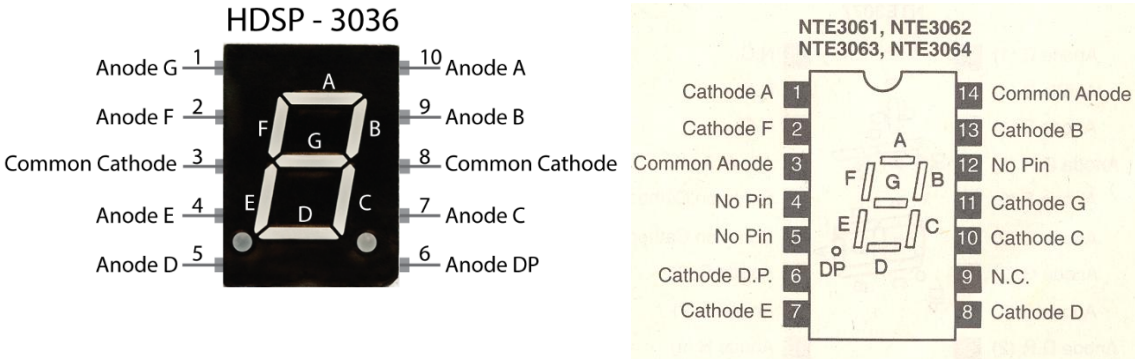


Figure 2. Inside structure of 7-Segment Display

The schematics shown below are of two real world models of 7-segment displays. First one is **Common Anode (CA)** type and the second one is **Common Cathode (CC)** type. Notice their pin mapping. When you need to connect them to your circuit, you should always find the pin mapping in their corresponding datasheets (usually available in manufacturer's website).



Common Cathode Type
(Active HIGH)

Common Anode Type
(Active LOW)

Figure 3. Types of 7-Segment Display and their pins, HDSP – 3036

Active low device requires 'LOW' signal to activate the LEDs while the common anode is connected to the Vcc. In contrast, active high device requires 'HIGH' signal to active the LEDs and the common cathode should be connected to the Ground. Models such as NTE3061-64 are active low and models such as HDSP 3036 is one of the active high display devices. For most

models of 7-segment displays, the datasheets are easily available from manufacturer's website. Figure 4 shows numbers and letters that can be presented on 7-Segment display and the corresponding pins.

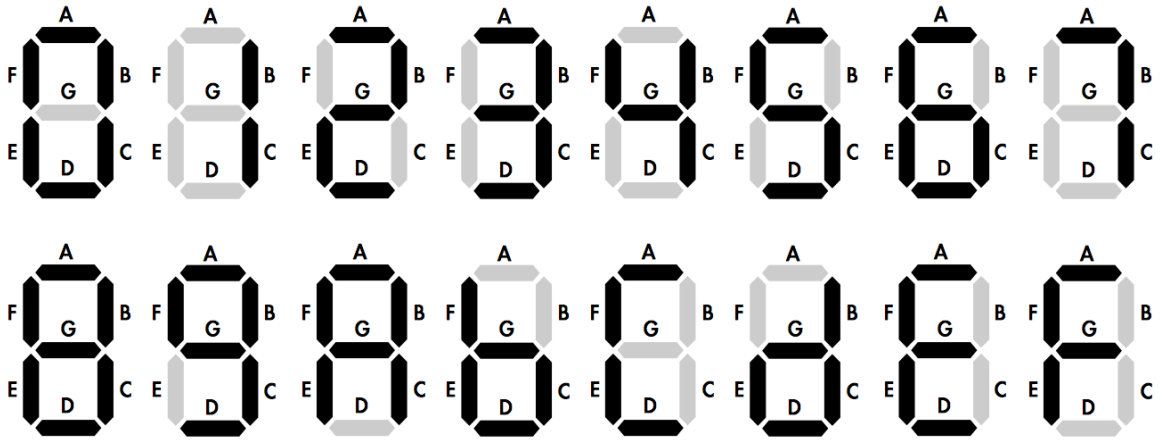


Figure 4: Driving the segments of a seven-segment display

Table 1. Example of displaying 'E' depending on the types of 7-Segment Display (Common Cathode (CC) – active high, Common Anode (CA) – active low)

Port Bits	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Segments	H(dot)	G	F	E	D	C	B	A
Letter 'E'	off	on	on	on	on	Off	off	On
Binary (CC)	0	1	1	1	1	0	0	1
Binary (CA)	1	0	0	0	0	1	1	0
Hex	*CC: 0b01110011 = 0x73* or *CA: 0b10000110 = 0x86*							

ACTIVITIES:

ACTIVITY 1

Write an assembly code to operate the specific LED outputs (PORTA) based on the PORTB switch inputs

Required operation in the code:

1. Read 2 switch inputs from PORTB – PB0 and PB1
2. Compare the input combination to the four cases given in Table 2.
3. Make the specified outputs (see Table 2) through PORTB using 8 LEDs. (You can use bitwise operation or port-based operation in this code to make the outputs). The LED

outputs must show the specified duty cycles (see Table 2) for each case. Use the time delay subroutine.

4. All outputs must follow the 4 seconds time period.
5. Each operation will remain in infinite loop until the input changes.

Table 2. Operating Conditions

PORT B Input		**PORT A Output**	
SW1	**SW0**	**PWM**	**LED Value**
0	0	25% duty cycle Period: **4 seconds**	0x25 or 0b00100101
0	1	50% duty cycle Period: **4 seconds**	0x51 or 0b01010001
1	0	75% duty cycle Period: **4 seconds**	0x75 or 0b01110101
1	1	50% duty cycle Period: **1 seconds**	0x51 or 0b01010001

NOTE: To activate the LEDs,

PORTA_SW1's switch 0 = 1
PORTA_SW1's switch 1 = 0
PORTA_SW1's switch 2 = 0
PORTA_SW1's switch 3 = 0

Required Procedure for the lab:

1. Draw a flowchart for your code. (Hand drawing is not acceptable.)
2. Write your code to complete the operation.
3. Upload the code to your board and observe the LED operations. Connect the PORTA pin0 (PA0) to the oscilloscope to see the PWM result.
4. Take the PWM results' screenshot with the switch inputs pictures (all four cases). Then, include them in the result section of your report.
5. Take a video and include the link in the report that your TA can review your result.
6. The video must show the complete operation of the task.
7. Make a code file separately in txt file and upload with your report.

ACTIVITY 2

Write a code to operate the Seven Segment Display on the Atmel breakout board.

Required operation in the code:

1. Make the outputs on the 7-segment Display (PORTA) – 'F','A','L','L','2','0','1','9' each letter and each number at a time .
2. Fill out Table 3 to show each letter and number with the corresponding binary value and segment light on and off. Include this table to your report. Label the result table as "Activity 2 Result Table 1 – 7-Segment Display Operation"

   The 7-Segment display on the Atmel breakout board is a common cathode (CC – active high) device. SO, to enable the 7-Segment device, set the switch for the PORTA as followings,

PORTA_SW1's switch 0 = 0 PORTA_SW1's switch 1 = 1 PORTA_SW1's switch 2 = 0 PORTA_SW1's switch 3 = 0

   then, connect the common cathode pin to GND and send '1' signal to turn on each segment.

Table 3: Activity 2 Result Table 1 – 7-Segment Display Operation

Port Bits	**Bit 7**	**Bit 6**	**Bit 5**	**Bit 4**	**Bit 3**	**Bit 2**	**Bit 1**	**Bit 0**
Segments	DP	G	F	E	D	C	B	A
Letter 'F'	off	on	on	on	off	off	off	On
Binary (CC)	0	1	1	1	0	0	0	1
Letter 'A'								
Binary (CC)								
Letter 'L'								
Binary (CC)								
Letter 'L'								
Binary (CC)								
Letter '2'								
Binary (CC)								
Letter '0'								
Binary (CC)								
Letter '1'								
Binary (CC)								
Letter '9'								
Binary (CC)								

3. Each letter must be shown for 1 second on(1sec) and off(1sec), and each number must be shown in 0.5 second on(0.5sec) and off(0.5sec). The result must be measured and shown in the stopwatch (Studio 7) for your report and in the result video.
4. The operation must be in infinite loop.

Required Procedure for the lab:

1. Draw a flowchart for your code. (Hand drawing is not acceptable.)
2. Write your code to complete the operation.
3. Simulate the operation in the simulator (Studio 7) and capture the screenshot of the stopwatch for each letter. Then, upload the code to your board and observe the 7-Segment Display operation.
4. Use the given table that is labelled as "Activity 2 Result Table 2 – 7-Segment Display Result and Time Delay". This table must include all result of displaying letter and number on the 7-segment display. This table must be included in your report. Take the picture of the output for each letter and include in the table .

Table 4: Activity 2 Result Table 2 – 7-Segment Display Result and Time Delay

Output	**Output PORTA**	**7-Segment Display view**	**Stopwatch view** (only show one delay execution for letter and one delay execution for number)
F	**01110001**		**For Letter,** **Stopwatch reading initial:** Put your screenshot **Stopwatch reading final:** Put your screenshot Use **one of the letters simulation** time delay 1 second
A			
L			
L			
2			**For Number:** **Stopwatch reading initial:** Put your screenshot **Stopwatch reading final:** Put your screenshot Use **one of the numbers simulation** time delay 0.5 second
0			
1			
9			

5. Take a video and include the link in the report that your TA can review your result.
6. Make a code file separately in txt file and upload with your report.

REPORT

The **lab 7** requires the formal full-length report. The report must include following sections:

- Cover page (5pts)
- Introduction (10pts)
- Procedure (30pts –10pts for two flowcharts, 20pts for two activities' method description)
- Result (40pts – 30 points for the result of two activities, 10pts for two videos)
- Discussion (10pts)
- Conclusion (5pts)
- Code (0pts, but 10pts deduction if you do not include it)

You must include the following details in your report and grading will be done using the rubric attached.

<< DO NOT COPY FROM LAB MANUAL OR ANY OTHER SOURCES >>

1. Cover page (5pts): your information must be shown
2. Introduction
    - Objectives
    - Any related knowledge – what is PWM, duty cycle, how to adjust length of the pulse, how to differentiate various duty cycles, and how to use PWM to control pins, 7 segments etc.
3. Procedure
    - Flowchart: activity 1 and activity 2
    - Method: description of the given tasks based on your understanding and your approaches to make the solutions / Explanation of the required procedure and the expected result after you follow the procedure
4. Results
    - Tables, screenshots, and pictures: you must explain the result with your own words
        - Activity 2 – Operation result (Pictures or screenshots of Port outputs / inputs of switches during each condition)
        - Activity 3 – Tables:
            1. Activity 2 Result Table 1 – 7-Segment Display Operation
            2. Activity 2 Result Table 2 – 7-Segment Display Result and Time Delay
    - Physical result –video links for each activity
5. Discussion
    - Verification of the answers and discuss the results by comparing with the expected result.
6. Conclusion
    - Summary of key concepts of this lab
7. Appendix
        - Code for Activity 1
        - Code for Activity 2

Your codes must be saved in .txt file, too. Then, submit the .txt file to the LAB 7 Code submission part separately. This submission will be your extra 5 points.

ECE3613 Processor System Laboratory Rubric
Lab #: 7
Section: 001 / 002
Name: _____

Report Section	Activity	Task	Full Points	Earned Points	Comment
Cover Page			**5**		**Comment**
Introduction			**10**		
Procedure	1	Flowchart	5		
		Method	10		Understanding of the activity (5pts), Code sectional description for the corresponding task (5pts)
	2	Flowchart	5		
		Method	10		Understanding of the activity (5pts), Code sectional description for the corresponding task (5pts)
	Subtotal		**30**		
Result	1	Result	15		Resulted pictures of input switches and output reading of oscilloscope, 2.5 pts for each case and 5pts for the description of the result
		Video	5		Video link
	2	Result	15		Resulted screenshots and tables with pictures of the 7-Segment display, Tables (5pts ea.) and 5pts for the description of the result
		Video	5		Video link
	Subtotal		**40**		
Discussion			**10**		
Conclusion			**5**		
Total			**100**		