Sri Lanka Institute of Information Technology

B.Sc. Honours Degree in Information Technology
Specialized in Computer Systems & Network Engineering

Final Examination
Year 2, Semester 1 (2018)

IE2070 – Embedded Systems

Duration: 3 Hours

October 2018

Instructions to Candidates:

- ◆ This paper has 5 questions.
- ◆ Answer all questions in the booklet given.
- ◆ The total marks for the paper is 100.
- ◆ This paper contains 5 pages, including the cover page.
- ◆ Electronic devices capable of storing and retrieving text, including calculators and mobile phones are not allowed.
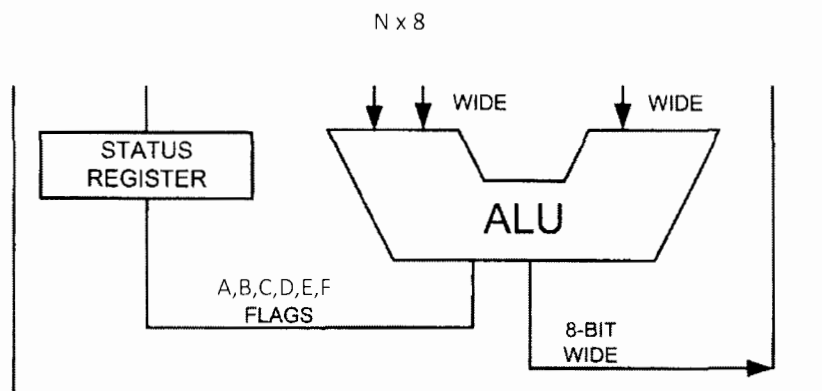
N x 8

Figure 1: AVR General Purpose Registers and ALU

1. Identify the 6 flags A,B,C,D,E and F   [3 marks]

2. Atmel AVR contains a significant number of General Purpose Registers. Identify the value of N.   [1 mark]

3. Atmel AVR contains an 8-bit ALU and 8-bit wide Data Memory, however, it has much better performance than an 8-bit microcontroller. Suggest the reason for the added performance?

                                                                    [2 marks]

4. Explain the difference between SRAM and EEPROM in terms of data retention.
                                                                    [2 marks]

5. The LDS instruction is used load data to a register from an address in data memory, what is the range of that address?

                                                                    [2 marks]

6. Consider the following program written for ATMega328p and fill in the table given below with contents after execution of each line.

```
Line Code
---------------
1    LDI  R20, 6
2    LDI  R21, 2
3    ADD  R20, R21
4    ADD  R20, R21
5    STS  0x122, R20
```

Location	After Line1	After Line2	After Line3	After Line4	After Line5
R20					
R21					
0x122					

[5 marks]

7. You are expected to load 0x55 (0b01010101) to R16 and output the contents of R1 to PORTB. Then you are supposed to output 0b10101010 to PORTB. You are supposed to write an assembly code that will perform this in 4 lines or less. [longer programs will earn less marks]

[5 marks]

Question 2 - Programming/Stack/Subroutines (20 Marks)

1. What is the difference between CISC and RISC instruction set architectures.

[2 marks]

2. Describe 4 features of RISC as implemented by the AVR microcontroller.

[4 marks]

3. What special hardware arrangement allows execution of instructions one after another without a gap? [1 marks]

4. What is the reason for branch penalty? Provide an example instruction.

[2 marks]

5. Draw a flow chart for an assembly program to (a) clear R22, then (b) add 3 to R22 eight times (c) send the sum to PORT B. [hint: use the zero flag and BRNE].

[4 marks]

6. Assume that the stack pointer is initialized to 0x085F. If the following code is executed, indicate the stack pointer location and respective stack memory contents after executing each of the following lines of assembly code.

```
LDI     R31,0
LDI     R20,0x21
LDI     R22,0x66

PUSH    R20
PUSH    R22

LDI     R20,0
LDI     R22,0

POP     R22
POP     R31
```

[5 marks]

7. What's the relationship between the subroutines and stack pointer?

[2 marks]

Question 3 – Interrupts   (20 Marks)

1. Provide one advantage and one disadvantage of having an interrupt subsystem in a microcontroller.   [2 marks]

2. List one similarity and one dis-similarity between subroutines and interrupt service routines   [2 marks]

3. Explain the 4 steps the ATMEL AVR microcontroller goes through upon activation of an interrupt.   [4 marks]

4. What are the two methods to disable an interrupt?   [2 marks]

5. Assume that on an ATMega328p, the INT0 pin is connected to a switch that is normally high. Write an assembly language program that toggles PORTB.4 whenever the INT0 goes low.

[10 marks]

Question 4 – TIMER   (20 Marks)

1. What are the timers and their sizes in ATmega328p?

[3 marks]

2. List the steps to program Timer0 in Normal mode?

[5 marks]

3. Calculate the delay generated by Timer0 in the following code. Do not include overhead due to instructions.

```
.INCLUDE "M32DEF.INC"
        INITSTACK           ;add its definition from Example 9-3
        LDI   R16,0x20
        SBI   DDRB,5        ;PB5 as an output
        LDI   R17,0
        OUT   PORTB,R17
BEGIN:RCALL DELAY
        EOR   R17,R16       ;toggle D5 of R17
        OUT   PORTB,R17     ;toggle PB5
        RJMP  BEGIN
DELAY:LDI   R20,0x3E
        OUT   TCNT0,R20     ;load timer0
        LDI   R20,0x01
        OUT   TCCR0,R20     ;Timer0, Normal mode, int clk, no prescaler
AGAIN:IN    R20,TIFR        ;read TIFR
        SBRS  R20,TOV0      ;if TOV0 is set skip next instruction
        RJMP  AGAIN
        LDI   R20,0x00
        OUT   TCCR0,R20         ;stop Timer0
        LDI   R20,(1<<TOV0)     ;R20 = 0x01
        OUT   TIFR,R20          ;clear TOV0 flag
        RET
```

[5 marks]

4. Illustrate using a diagram what you understand by CTC Mode in Timer/Counter 0.

[2 marks]

5. Assuming XTAL=16MHz, write a program to generate a delay of 6.4 ms. Use Timer0, CTC mode, with pre-scaler = 1024.

[5 marks]

Question 5 – Serial   (20 Marks)

1. Provide an advantage and a disadvantage of each: serial communications and parallel communications.

[2 marks]

2. Describe the role of MAX232 in RS232 communications.

[2 marks]

3. Draw a simplified block diagram of UART in ATMega328p clearly indicating the receive unit, transmit unit, clock divider and control & status unit.

[4 marks]

4. With F_{OSC}=16MHz, find the UBRR value needed to have a baud rate of 9600.

[2 marks]

5. What are the values of UCSR0B and UCSR0C needed to configure USART for asynchronous operating mode, 8 data bits, no parity and 2 stop bits keeping receive and transmit enabled.

[4 marks]

6. Write a program in Assembly for the ATMega328p to set values of UCSR0B and UCSR0C for this configuration

[6 marks]