**Tutorial 2**

Note: We use AVR ATmega32 microprocessor in this homework.  
**Q1.** (30 pts) Find the time delay for the delay subroutine shown below if the system has an AVR with a frequency of 10 MHz:

LDI R20, 200  
BACK: LDI R25, 100  
 NOP  
 NOP  
 NOP  
HERE: DEC R25  
 BRNE HERE  
 DEC R20  
 BRNE BACK

***Ans.***

|  |  |
| --- | --- |
| **Instruction** | MCs |
| LDI R20, 200  BACK: LDI R25, 100  HERE: NOP   NOP   NOP   DEC R25   BRNE HERE   DEC R20   BRNE BACK | **1**  **1**  **1**  **1**  **1**  **1**  **1/2**  **1**  **1/2** |

1 MC = **1/(10 MHz) = 0.1** μ**s**  
Total MCs = Time delay = **1+(1+(3+1+2)x100–1+1+2)x200–1= 120600 MCs**  
**= 120600 x 0.1** μ**s = 12060** μ**s = 12.06 ms**  
If we include RET instruction (4 MCs) ⇒ Time delay **= 12060.4** μ**s**

**Q2.** (15 pts) Write a program to get 8-bit data from PORTC and send it to PORTB and PORTD.

***Ans.***

**.include “M32DEF.INC”**  
 **.org 0**  
 **LDI R16, 0**  
 **OUT DDRC, R16; PORTC: Input port**  
 **LDI R16, 0xFF**  
 **OUT DDRB, R16; PORTB: Output port**  
 **OUT DDRD, R16; PORTD: Output port**  
**LOOP: IN R16, PINC**  
 **OUT PORTB, R16**  
 **OUT PORTD, R16**  
 **RJMP LOOP**

**Q3.** (25 pts) Write a program to monitor the PA0 bit. When it is HIGH, send $99 to PORTB. If it is LOW, send $66 to PORTB.  
***Ans.***

**.include “M32DEF.INC”**  
 **.rg 0**  
 **LDI R16, $FF**  
 **OUT DDRB, R16 ; PORTB: Output Port**  
 **CBI DDRA, 0 ; PA0 is input pin**  
**AGAIN: SBIC PINA,0 ; Skip next if PA0 is clear**  
 **RJMP OVER ; Jump to OVER if PA0 is high**  
 **LDI R16,0x66**  
 **OUT PORTB, R16 ; Send 0x66 to PORTD when PA0 = 0**  
 **RJMP AGAIN**  
**OVER: LDI R16,0x99**  
 **OUT PORTB, R16 ; Send 0x99 to PORTD when PA0 = 1**  
 **RJMP AGAIN**

**Q4.** (30 pts) Write a program to monitor the PB5 and PB6 bits. When both of them are HIGH, send $AA to PORTC; otherwise, send $55 to PORTC.  
***Ans.***

**.include “M32DEF.INC”**  
 **.org 0**  
 **LDI R16, $FF**  
 **OUT DDRC, R16 ; PORTC: Output Port**  
 **CBI DDRB, 5 ; PB5 is input pin**  
 **CBI DDRB, 6 ; PB6 is input pin**  
**AGAIN: SBIC PINB,5 ; Skip next if PB5 is clear**  
 **RJMP OVER ; Jump to OVER if PB5 is high**  
 **RJMP OTHER**  
**OVER: SBIS PINB,6 ; Skip next if PB6 is set**  
 **RJMP OTHER ; Jump to OVER if otherwise**  
 **LDI R16,$AA**  
 **OUT PORTC,R16 ; Send $AA to PORTC if PB5=PB6=1**  
 **RJMP AGAIN**  
**OTHER: LDI R16,$55**  
 **OUT PORTC,R16 ; Send $55 to PORTC if otherwise**  
 **RJMP AGAIN**