Computer Technology I

Lab. 5 :Display JHD202

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Area: Computer Science
Course code: 1DT301

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1 Task 1 - Write a program that displays a character on the display

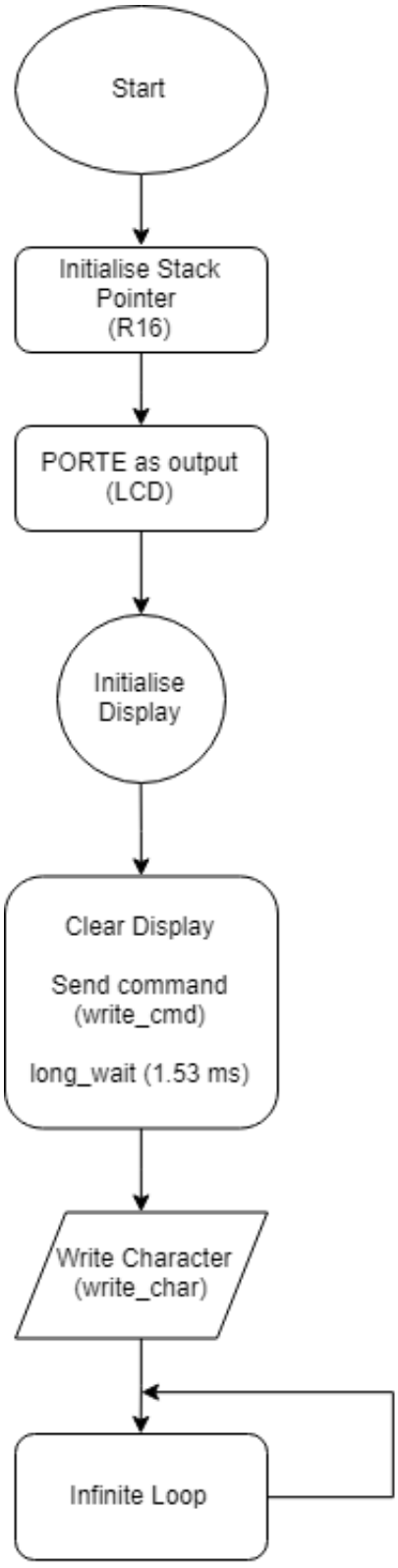
Write a program in Assembly that displays the character "percent". Look in the data sheet how to initiate the display. The data sheet you'll find on https://www.student.vxu.se/. The display will be connected as in the figure above. 4-bit-mode should be used, since only RS, E, D7, D6, D5 and D4 are connected to I/O-pins on the STK600.

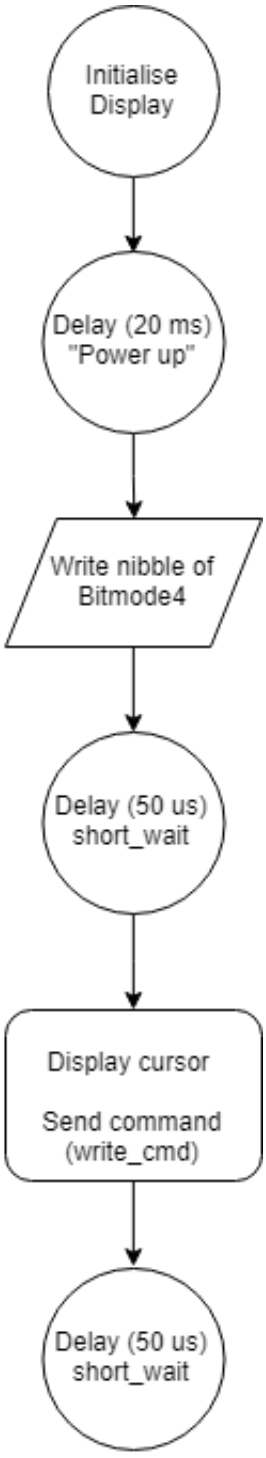
```
;>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>
; 1DT301, Computer Technology I
; Date: 2019-10-11
; Author:
; Loic GALLAND
; Leonardo PEDRO
;
; Lab number: 5
; Title: Display JHD202
;
; Hardware: STK600, CPU ATmega2560
;
; Function: Program that shows a percentage sign on the display
;
; Input ports: No input ports
;
; Output ports: PORTE for the display
;
; Subroutines: If applicable.
; Included files: m2560def.inc
;<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<
.include        "m2560def.inc"
.def    Temp    = r16
.def    Data    = r17
.def    RS      = r18

.equ    BITMODE4        = 0b00000010            ; 4-bit operation
.equ    CLEAR   = 0b00000001                    ; Clear display
.equ    DISPCTRL        = 0b00001111            ; Display on, cursor on
    , blink on.

.cseg
.org    0x0000                          ; Reset vector
        jmp reset

.org    0x0072

reset:

        ldi Temp, HIGH(RAMEND)  ; Temp = high byte of ramend address
        out SPH, Temp                   ; sph = Temp
        ldi Temp, LOW(RAMEND)   ; Temp = low byte of ramend address
        out SPL, Temp                   ; spl = Temp

        ser Temp                                ; r16 = 0b11111111
        out DDRE, Temp                  ; port E = outputs ( Display
            JHD202A)
        clr Temp                                ; r16 = 0
        out PORTE, Temp
```

```
; **
; ** init_display
; **
init_disp:
        rcall power_up_wait             ; wait for display to power up
        ldi Data, BITMODE4              ; 4-bit operation
        rcall write_nibble              ; (in 8-bit mode)
        rcall short_wait                ; wait min. 39 us
        ldi Data, DISPCTRL              ; disp. on, blink on, curs. On
        rcall write_cmd                 ; send command
        rcall short_wait                ; wait min. 39 us

rcall clr_disp
ldi Data, 0x25
rcall write_char
loop:   nop
        rjmp loop                       ; loop forever


clr_disp:
        ldi Data, CLEAR                 ; clr display
        rcall write_cmd                 ; send command
        rcall long_wait                 ; wait min. 1.53 ms
        ret

; **
; ** write char/command
; **

write_char:
        ldi RS, 0b00100000              ; RS = high
        rjmp write
write_cmd:
        clr RS                                  ; RS = low
write:
        mov Temp, Data                  ; copy Data
        andi Data, 0b11110000   ; mask out high nibble
        swap Data                               ; swap nibbles
        or Data, RS                             ; add register select
        rcall write_nibble              ; send high nibble
        mov Data, Temp                  ; restore Data
        andi Data, 0b00001111   ; mask out low nibble
        or Data, RS                             ; add register select

write_nibble:
        rcall switch_output             ; Modify for display JHD202A,
           port E
        nop                                             ; wait 542nS
        sbi PORTE, 5                    ; enable high, JHD202A
        nop
        nop                                             ; wait 542nS
        cbi PORTE, 5                    ; enable low, JHD202A
        nop
        nop                                             ; wait 542nS
        ret


; **
; ** busy_wait loop
; **
```

```
short_wait:
        clr zh                                  ; approx 50 us
        ldi zl, 30
        rjmp wait_loop
long_wait:
        ldi zh, HIGH(1000)              ; approx 2 ms
        ldi zl, LOW(1000)
        rjmp wait_loop
dbnc_wait:
        ldi zh, HIGH(4600)              ; approx 10 ms
        ldi zl, LOW(4600)
        rjmp wait_loop
power_up_wait:
        ldi zh, HIGH(9000)              ; approx 20 ms
        ldi zl, LOW(9000)

wait_loop:
        sbiw z, 1                               ; 2 cycles
        brne wait_loop                  ; 2 cycles
        ret

; **
; ** modify output signal to fit LCD JHD202A, connected to port E
; **

switch_output:
        push Temp
        clr Temp
        sbrc Data, 0                            ; D4 = 1?
        ori Temp, 0b00000100            ; Set pin 2
        sbrc Data, 1                            ; D5 = 1?
        ori Temp, 0b00001000            ; Set pin 3
        sbrc Data, 2                            ; D6 = 1?
        ori Temp, 0b00000001            ; Set pin 0
        sbrc Data, 3                            ; D7 = 1?
        ori Temp, 0b00000010            ; Set pin 1
        sbrc Data, 4                            ; E = 1?
        ori Temp, 0b00100000            ; Set pin 5
        sbrc Data, 5                            ; RS = 1?
        ori Temp, 0b10000000            ; Set pin 7 (wrong in previous
            version)
        out porte, Temp
        pop Temp
        ret
```

This is the flowchart of the task 1:





2 Task 2 - Electronic bingo machine

You should create an electronic bingo generator. The generator should create random numbers between 1 and 75. The numbers should be displayed on the display. Clear the display before a new value is displayed. Use interrupt and a pushbutton for the input.

```
;>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>
; 1DT301, Computer Technology I
; Date: 2019-10-11
; Author:
; Loic GALLAND
; Leonardo PEDRO
;
; Lab number: 5
; Title: Display JHD202
;
; Hardware: STK600, CPU ATmega2560
;
; Function: Program that creates a bingo machine.
;
; Input ports: PORTD for the switches
;
; Output ports: PORTE for the display
;
; Subroutines: If applicable.
; Included files: m2560def.inc
;<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<
.include        "m2560def.inc"
.def    Temp     = r16
.def    Data     = r17
.def    RS       = r18
.def    RandomNumber= r20
.def    RandomNumber2 = r21
.def    NumberBetween05= r22

.equ    BITMODE4        = 0b00000010            ; 4-bit operation
.equ    CLEAR    = 0b00000001                   ; Clear display
.equ    DISPCTRL        = 0b00001111            ; Display on, cursor on
   , blink on.


.cseg
.org    0x0000                          ; Reset vector
        jmp reset
.org Int0addr
rjmp interrupt

.org    0x0072

reset:

        ldi Temp, HIGH(RAMEND)   ; Temp = high byte of ramend address
        out SPH, Temp                   ; sph = Temp
        ldi Temp, LOW(RAMEND)    ; Temp = low byte of ramend address
        out SPL, Temp                   ; spl = Temp
```

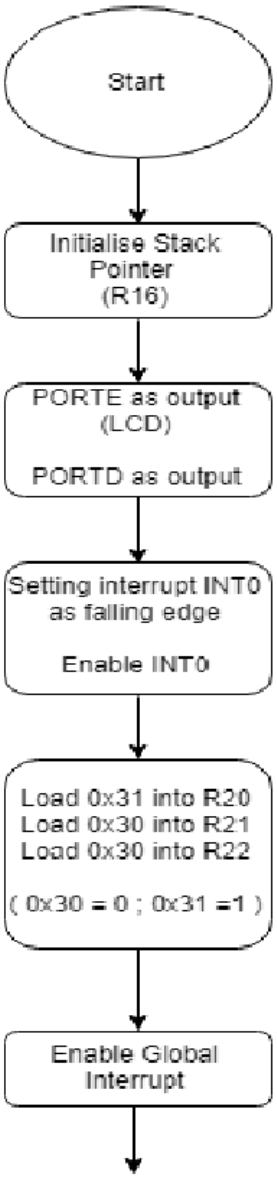
```
        ser Temp                                    ; r16 = 0b11111111
        out DDRE, Temp                      ; port E = outputs ( Display
            JHD202A)
        clr Temp                                    ; r16 = 0
        out PORTE, Temp

        ldi Temp,0x00
        out DDRD,Temp


        ldi Temp,0b00000010 ;Setting INT0 into falling edge
        sts EICRA,Temp
        ldi Temp,0b0000001 ;Enable INT0
        out EIMSK,Temp
        ldi RandomNumber,0x31
        ldi RandomNumber2,0x30
        ldi NumberBetween05,0x30

        sei


; **
; ** init_display
; **
init_disp:
        rcall power_up_wait             ; wait for display to power up

        ldi Data, BITMODE4              ; 4-bit operation
        rcall write_nibble              ; (in 8-bit mode)
        rcall short_wait                ; wait min. 39 us
        ldi Data, DISPCTRL              ; disp. on, blink on, curs. On
        rcall write_cmd                 ; send command
        rcall short_wait                ; wait min. 39 us




loop:
        rcall increaseNumber
        rcall increaseNumber2
        rcall increaseNumber3
rjmp loop                       ; loop forever


clr_disp:
        ldi Data, CLEAR                 ; clr display
        rcall write_cmd                 ; send command
        rcall long_wait                 ; wait min. 1.53 ms
        ret

; **
; ** write char/command
; **

increaseNumber: ;To get the first digit

        cpi RandomNumber,0x37 ;
        breq ResetDisplay
```

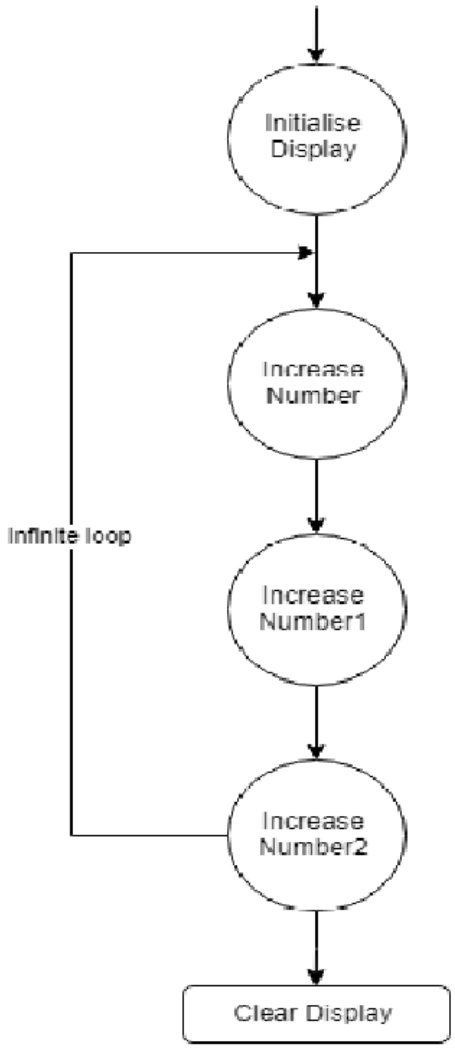
```
        inc RandomNumber
        jmp END

        ResetDisplay:
                ldi RandomNumber,0x31
        END:
ret

increaseNumber2:        ;Second digit if the first is not 7
        cpi RandomNumber2,0x39 ;
        breq ResetDisplay2

        inc RandomNumber2
        jmp END2

        ResetDisplay2:
                ldi RandomNumber2,0x30
        END2:
ret

increaseNumber3: ;Second digit if the first is  7
        cpi NumberBetween05,0x35 ;
        breq ResetDisplay3

        inc NumberBetween05
        jmp END3

        ResetDisplay3:
                ldi NumberBetween05,0x30
        END3:
ret

write_char:
        ldi RS, 0b00100000              ; RS = high
        rjmp write
write_cmd:
        clr RS                                  ; RS = low
write:
        mov Temp, Data                  ; copy Data
        andi Data, 0b11110000   ; mask out high nibble
        swap Data                               ; swap nibbles
        or Data, RS                             ; add register select
        rcall write_nibble              ; send high nibble
        mov Data, Temp                  ; restore Data
        andi Data, 0b00001111   ; mask out low nibble
        or Data, RS                             ; add register select

write_nibble:
        rcall switch_output             ; Modify for display JHD202A,
           port E
        nop                                                     ; wait 542nS
        sbi PORTE, 5                    ; enable high, JHD202A
        nop
        nop                                                     ; wait 542nS
        cbi PORTE, 5                    ; enable low, JHD202A
        nop
        nop                                                     ; wait 542nS
        ret
```

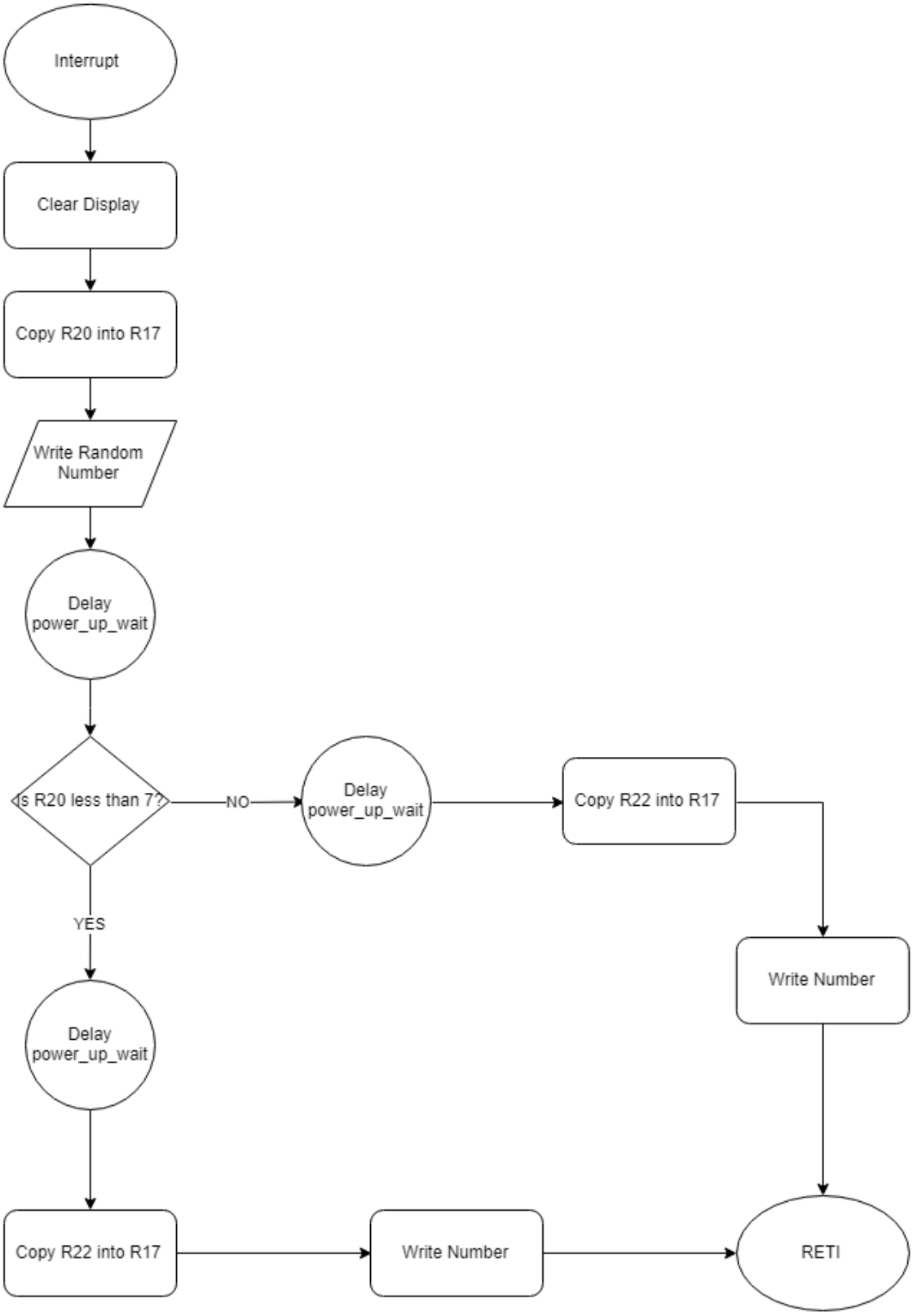
```
; **
; ** busy_wait loop
; **
short_wait:
        clr zh                                  ; approx 50 us
        ldi zl, 30
        rjmp wait_loop
long_wait:
        ldi zh, HIGH(1000)              ; approx 2 ms
        ldi zl, LOW(1000)
        rjmp wait_loop
dbnc_wait:
        ldi zh, HIGH(4600)              ; approx 10 ms
        ldi zl, LOW(4600)
        rjmp wait_loop
power_up_wait:
        ldi zh, HIGH(9000)              ; approx 20 ms
        ldi zl, LOW(9000)

wait_loop:
        sbiw z, 1                               ; 2 cycles
        brne wait_loop                  ; 2 cycles
        ret

; **
; ** modify output signal to fit LCD JHD202A, connected to port E
; **

switch_output:
        push Temp
        clr Temp
        sbrc Data, 0                            ; D4 = 1?
        ori Temp, 0b00000100            ; Set pin 2
        sbrc Data, 1                            ; D5 = 1?
        ori Temp, 0b00001000            ; Set pin 3
        sbrc Data, 2                            ; D6 = 1?
        ori Temp, 0b00000001            ; Set pin 0
        sbrc Data, 3                            ; D7 = 1?
        ori Temp, 0b00000010            ; Set pin 1
        sbrc Data, 4                            ; E = 1?
        ori Temp, 0b00100000            ; Set pin 5
        sbrc Data, 5                            ; RS = 1?
        ori Temp, 0b10000000            ; Set pin 7 (wrong in previous
           version)
        out porte, Temp
        pop Temp
        ret

interrupt:      ;USART Interrupt
        rcall clr_disp
        mov Data, RandomNumber
        rcall write_char
        call power_up_wait
        cpi RandomNumber,0x37
        brlt IfLessSeven

        call power_up_wait
        mov Data, NumberBetween05
        rcall write_char
```

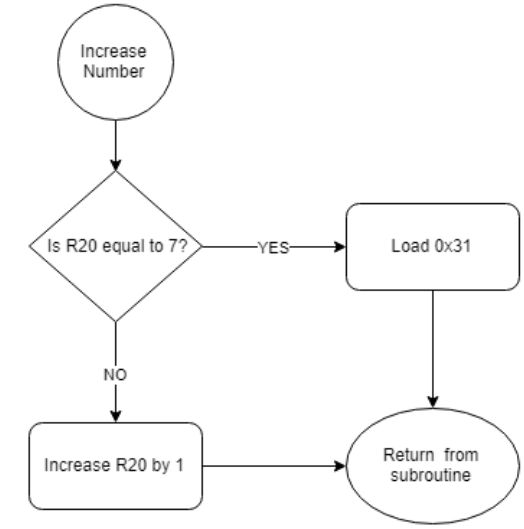
```
        rjmp endInt

        IfLessSeven:
                call power_up_wait
                mov Data, RandomNumber2
                rcall write_char

endInt:

RETI
```

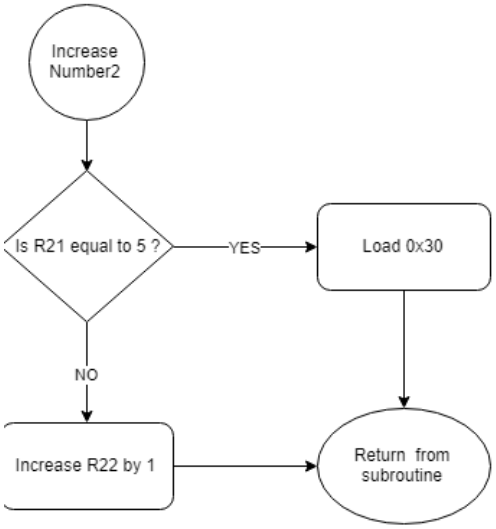
This is the flowcharts of the task 2:

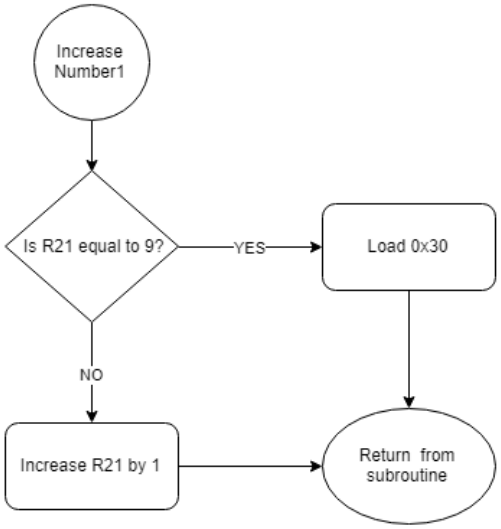





Interrupt
Clear Display
Copy R20 into R17
Write Random Number
Delay power_up_wait
Is R20 less than 7?
NO
Delay power_up_wait
Copy R22 into R17
Write Number
YES
Delay power_up_wait
Copy R22 into R17
Write Number
RETI


Increase Number
Is R20 equal to 7?
YES
Load 0x31
NO
Increase R20 by 1
Return from subroutine


Increase Number2
Is R21 equal to 5 ?
YES
Load 0x30
NO
Increase R22 by 1
Return from subroutine


Increase Number1
Is R21 equal to 9?
YES
Load 0x30
NO
Increase R21 by 1
Return from subroutine

3 Task 3 -Serial communication and display

Use program modules from lab 4 and write a program that receives a character on the serial port and displays each character on the display.

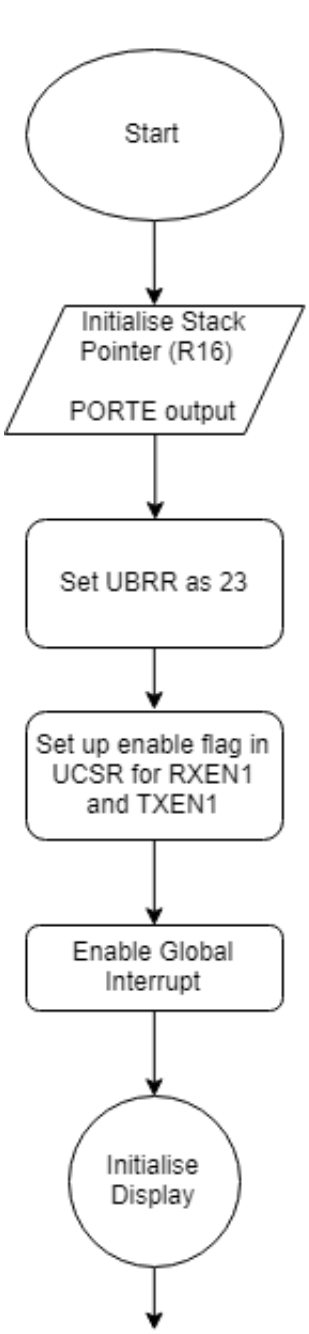
```
;>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>
; 1DT301, Computer Technology I
; Date: 2019-10-11
; Author:
; Loic GALLAND
; Leonardo PEDRO
;
; Lab number: 5
; Title: Display JHD202
;
; Hardware: STK600, CPU ATmega2560
;
; Function: program that receives a character on the serial port and
   displays each character on the display.
;
; Input ports: No input ports
;
; Output ports: PORTE for the display
;
; Subroutines: If applicable.
; Included files: m2560def.inc
;<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<
.include        "m2560def.inc"
.def    Temp    = r16
.def    Data    = r17
.def    RS      = r18


.equ    BITMODE4        = 0b00000010            ; 4-bit operation
.equ    CLEAR   = 0b00000001                    ; Clear display
.equ    DISPCTRL        = 0b00001111            ; Display on, cursor on
   , blink on.

.cseg
.org    0x0000                          ; Reset vector
        jmp reset

.org URXC1addr  ;USART Interrupt
rjmp GetChar

.org    0x0072

reset:

        ldi Temp, HIGH(RAMEND)  ; Temp = high byte of ramend address
        out SPH, Temp                   ; sph = Temp
        ldi Temp, LOW(RAMEND)   ; Temp = low byte of ramend address
        out SPL, Temp                   ; spl = Temp

        ser Temp                                ; r16 = 0b11111111
        out DDRE, Temp                  ; port E = outputs ( Display
           JHD202A)
        clr Temp                                ; r16 = 0
```

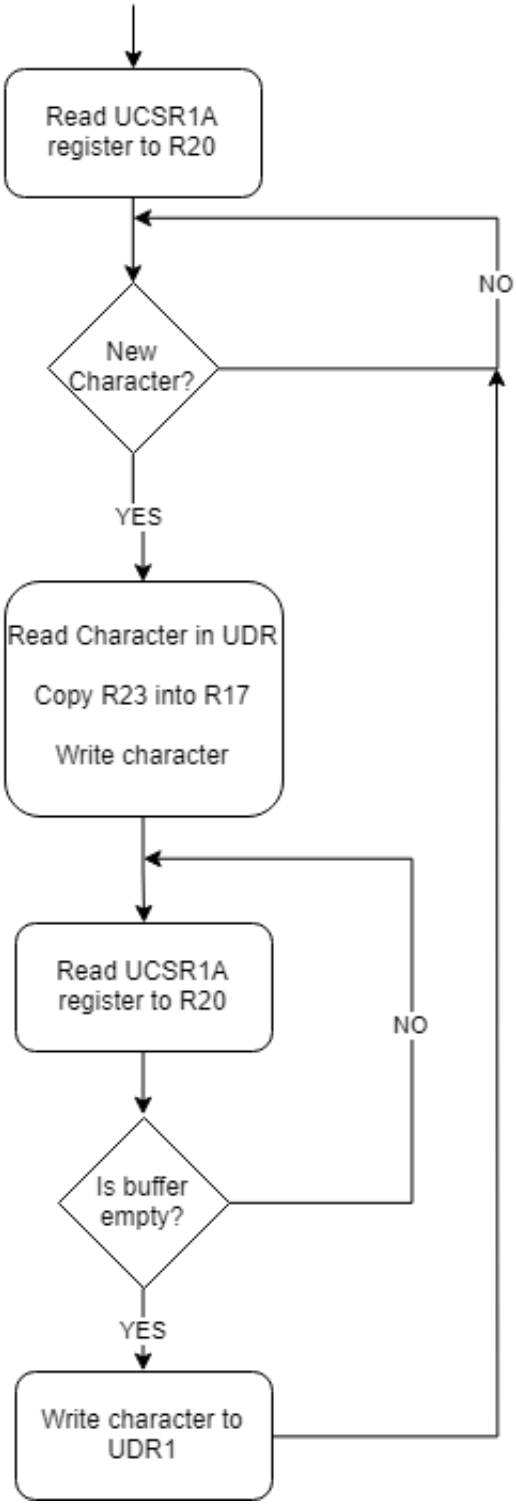
```
        out PORTE, Temp

        ldi r16, 23             ;osc = 1.843MHz, 4800 bps => UBBRR = 23
        sts UBRR1L , r16        ;Store Prescaler value in UBRR1L

        ldi r16, (1<<RXEN1 | 1<<TXEN1);Set RX, TX enable flags and
           RXCIE = 1
        sts UCSR1B, r16
        sei     ;Set global interrupt flag

; **
; ** init_display
; **
init_disp:
        rcall power_up_wait             ; wait for display to power up
        ldi Data, BITMODE4              ; 4-bit operation
        rcall write_nibble              ; (in 8-bit mode)
        rcall short_wait                ; wait min. 39 us
        ldi Data, DISPCTRL              ; disp. on, blink on, curs. On
        rcall write_cmd                 ; send command
        rcall short_wait                ; wait min. 39 us

call clr_disp

GetChar:        ;Receive data
        lds r20, UCSR1A ;read UCSR1A I/0 register to r20
        sbrs r20,RXC1   ;RXC1=1 -> new Character
        rjmp GetChar    ;RXC1=0 -> no character received
        lds r23,UDR1    ;Read character in UDR

        Port_output:
                mov Data,r23
                call write_char
        PutChar:
        lds r20, UCSR1A ;Read UCSR1A i/O register to r20
        sbrs r20, UDRE1 ;UDRE1 =1 => buffer is empty
        rjmp PutChar    ;UDRE1 = 0 => buffer is not empty
        sts UDR1,r23    ;write character to UDR1
rjmp GetChar    ;Return to loop

clr_disp:
        ldi Data, CLEAR                 ; clr display
        rcall write_cmd                 ; send command
        rcall long_wait                 ; wait min. 1.53 ms
        ret

; **
; ** write char/command
; **
write_char:
        ldi RS, 0b00100000              ; RS = high
        rjmp write
write_cmd:
        clr RS                                  ; RS = low
write:
        mov Temp, Data                  ; copy Data
        andi Data, 0b11110000   ; mask out high nibble
        swap Data                               ; swap nibbles
        or Data, RS                             ; add register select
```

```
        rcall write_nibble              ; send high nibble
        mov Data, Temp                  ; restore Data
        andi Data, 0b00001111   ; mask out low nibble
        or Data, RS                             ; add register select

write_nibble:
        rcall switch_output             ; Modify for display JHD202A,
           port E
        nop                                             ; wait 542nS
        sbi PORTE, 5                    ; enable high, JHD202A
        nop
        nop                                             ; wait 542nS
        cbi PORTE, 5                    ; enable low, JHD202A
        nop
        nop                                             ; wait 542nS
        ret

; **
; ** busy_wait loop
; **
short_wait:
        clr zh                                  ; approx 50 us
        ldi zl, 30
        rjmp wait_loop
long_wait:
        ldi zh, HIGH(1000)              ; approx 2 ms
        ldi zl, LOW(1000)
        rjmp wait_loop
dbnc_wait:
        ldi zh, HIGH(4600)              ; approx 10 ms
        ldi zl, LOW(4600)
        rjmp wait_loop
power_up_wait:
        ldi zh, HIGH(9000)              ; approx 20 ms
        ldi zl, LOW(9000)

wait_loop:
        sbiw z, 1                               ; 2 cycles
        brne wait_loop                  ; 2 cycles
        ret

; **
; ** modify output signal to fit LCD JHD202A, connected to port E
; **
switch_output:
        push Temp
        clr Temp
        sbrc Data, 0                            ; D4 = 1?
        ori Temp, 0b00000100            ; Set pin 2
        sbrc Data, 1                            ; D5 = 1?
        ori Temp, 0b00001000            ; Set pin 3
        sbrc Data, 2                            ; D6 = 1?
        ori Temp, 0b00000001            ; Set pin 0
        sbrc Data, 3                            ; D7 = 1?
        ori Temp, 0b00000010            ; Set pin 1
        sbrc Data, 4                            ; E = 1?
        ori Temp, 0b00100000            ; Set pin 5
        sbrc Data, 5                            ; RS = 1?
        ori Temp, 0b10000000            ; Set pin 7 (wrong in previous
```

```
        version)
    out porte, Temp
    pop Temp
    ret
```

This is the flowchart of the task 3:





4 Task 4 - Modify the program in task 3

Modify the program in task 3 so that 4 lines of text can be displayed. Each textline should be displayed during 5 seconds, after that the text on line 1 should be moved to line 2 and so on. The text should be entered from the terminal program, PUTTY, via the serial port.

```
;>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>
; 1DT301, Computer Technology I
; Date: 2019-10-11
; Author:
; Loic GALLAND
; Leonardo PEDRO
;
; Lab number: 5
; Title: Display JHD202
;
; Hardware: STK600, CPU ATmega2560
;
; Function: program that receives a character on the serial port and
   displays each character on the display.
;
; Input ports: No input ports
;
; Output ports: PORTE for the display
;
; Subroutines: If applicable.
; Included files: m2560def.inc
;<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<
.include        "m2560def.inc"
.def    Temp    = r16
.def    Data    = r17
.def    RS      = r25
.def    COUNTER = r24


.equ    BITMODE4        = 0b00000010            ; 4-bit operation
.equ    CLEAR   = 0b00000001                    ; Clear display
.equ    DISPCTRL        = 0b00001111            ; Display on, cursor on
   , blink on.

.cseg
.org    0x0000                          ; Reset vector
        jmp reset

.org URXC1addr  ;USART Interrupt
rjmp GetChar

.org    0x0072

reset:
        ldi COUNTER,0
        ldi Temp, HIGH(RAMEND)  ; Temp = high byte of ramend address
        out SPH, Temp                   ; sph = Temp
        ldi Temp, LOW(RAMEND)   ; Temp = low byte of ramend address
        out SPL, Temp                   ; spl = Temp
```

```
        ser Temp                                    ; r16 = 0b11111111
        out DDRE, Temp                      ; port E = outputs ( Display
           JHD202A)
        clr Temp                                    ; r16 = 0
        out PORTE, Temp

        ldi r16, 23             ;osc = 1.843MHz, 4800 bps => UBBRR = 23
        sts UBRR1L , r16        ;Store Prescaler value in UBRR1L

        ldi r16, (1<<RXEN1 | 1<<TXEN1);Set RX, TX enable flags and
           RXCIE = 1
        sts UCSR1B, r16
        sei     ;Set global interrupt flag
        ;Inialiaze Y and X pointer to memory address 0x200
        ldi YH , HIGH (0x200)
        ldi YL , LOW(0x200)
        ldi XH , HIGH (0x200)
        ldi XL , LOW(0x200)

; **
; ** init_display
; **
init_disp:
        rcall power_up_wait             ; wait for display to power up
        ldi Data, BITMODE4              ; 4-bit operation
        rcall write_nibble              ; (in 8-bit mode)
        rcall short_wait                ; wait min. 39 us
        ldi Data, DISPCTRL              ; disp. on, blink on, curs. On
        rcall write_cmd                 ; send command
        rcall short_wait                ; wait min. 39 us

call clr_disp

GetChar:        ;Receive data
        lds r21, UCSR1A ;read UCSR1A I/O register to r20
        sbrs r21,RXC1   ;RXC1=1 -> new Character
        rjmp GetChar    ;RXC1=0 -> no character received
        lds r23,UDR1    ;Read character in UDR
        cpi r23,0x0D
        breq next_line
        st Y+,r23

        Port_output:
                ;call clr_disp
                mov Data,r23
                call write_char
        PutChar:
        lds r21, UCSR1A ;Read UCSR1A i/O register to r20
        sbrs r21, UDRE1 ;UDRE1 =1 => buffer is empty
        rjmp PutChar    ;UDRE1 = 0 => buffer is not empty
        sts UDR1,r23    ;write character to UDR1
        rjmp END

        next_line:
                rcall FiveSec_delay
                ldi Data, CLEAR
                rcall write_cmd
                rcall long_wait
                ldi Data, 0x40
```

```
                rcall write_cmd
                ;clr Data

                        loop:
                        ;COMPARARE BEFORE IT GETS MEMORY OUT OF
                            BOUNDARY
                                cp YH , XH
                                brne continue_printing
                                cp YL , XL
                                breq Stop

                                continue_printing:
                                        ld Data,X+      ;load from X
                                            pointer to Data
                                        rcall write_char
                                        rcall long_wait
                                rjmp loop

                        Stop:           ;Reinialize the pointers
                                ldi YH , HIGH (0x200)
                                ldi YL , LOW(0x200)
                                ldi XH , HIGH (0x200)
                                ldi XL , LOW(0x200)
                                ldi Data, 0b00000010
                                rcall write_cmd

                        rjmp End
END:nop
rjmp GetChar    ;Return to loop


clr_disp:
        ldi Data, CLEAR                 ; clr display
        rcall write_cmd                 ; send command
        rcall long_wait                 ; wait min. 1.53 ms
        ret

; **
; ** write char/command
; **

write_char:
        ldi RS, 0b00100000              ; RS = high
        rjmp write
write_cmd:
        clr RS                                  ; RS = low
write:
        mov Temp, Data                  ; copy Data
        andi Data, 0b11110000   ; mask out high nibble
        swap Data                               ; swap nibbles
        or Data, RS                             ; add register select
        rcall write_nibble              ; send high nibble
        mov Data, Temp                  ; restore Data
        andi Data, 0b00001111   ; mask out low nibble
        or Data, RS                             ; add register select

write_nibble:
        rcall switch_output             ; Modify for display JHD202A,
            port E
```

```
        nop                                             ; wait 542nS
        sbi PORTE, 5                    ; enable high, JHD202A
        nop
        nop                                             ; wait 542nS
        cbi PORTE, 5                    ; enable low, JHD202A
        nop
        nop                                             ; wait 542nS
        ret

; **
; ** busy_wait loop
; **
short_wait:
        clr zh                                  ; approx 50 us
        ldi zl, 30
        rjmp wait_loop
long_wait:
        ldi zh, HIGH(1000)              ; approx 2 ms
        ldi zl, LOW(1000)
        rjmp wait_loop
dbnc_wait:
        ldi zh, HIGH(4600)              ; approx 10 ms
        ldi zl, LOW(4600)
        rjmp wait_loop
power_up_wait:
        ldi zh, HIGH(9000)              ; approx 20 ms
        ldi zl, LOW(9000)

wait_loop:
        sbiw z, 1                               ; 2 cycles
        brne wait_loop                  ; 2 cycles
        ret

FiveSec_delay:
; Generated by delay loop calculator
; at http://www.bretmulvey.com/avrdelay.html
; Delay 9 215 000 cycles
; 5s at 1.843 MHz
    ldi  r18, 47
    ldi  r19, 192
    ldi  r20, 104
L1: dec  r20
    brne L1
    dec  r19
    brne L1
    dec  r18
    brne L1
RET

; **
; ** modify output signal to fit LCD JHD202A, connected to port E
; **
switch_output:
        push Temp
        clr Temp
        sbrc Data, 0                            ; D4 = 1?
        ori Temp, 0b00000100            ; Set pin 2
        sbrc Data, 1                            ; D5 = 1?
        ori Temp, 0b00001000            ; Set pin 3
```

```
        sbrc Data, 2                        ; D6 = 1?
        ori Temp, 0b00000001            ; Set pin 0
        sbrc Data, 3                        ; D7 = 1?
        ori Temp, 0b00000010            ; Set pin 1
        sbrc Data, 4                        ; E = 1?
        ori Temp, 0b00100000            ; Set pin 5
        sbrc Data, 5                        ; RS = 1?
        ori Temp, 0b10000000            ; Set pin 7 (wrong in previous
            version)
        out porte, Temp
        pop Temp
        ret
```

This is the flowchart of the task 4: