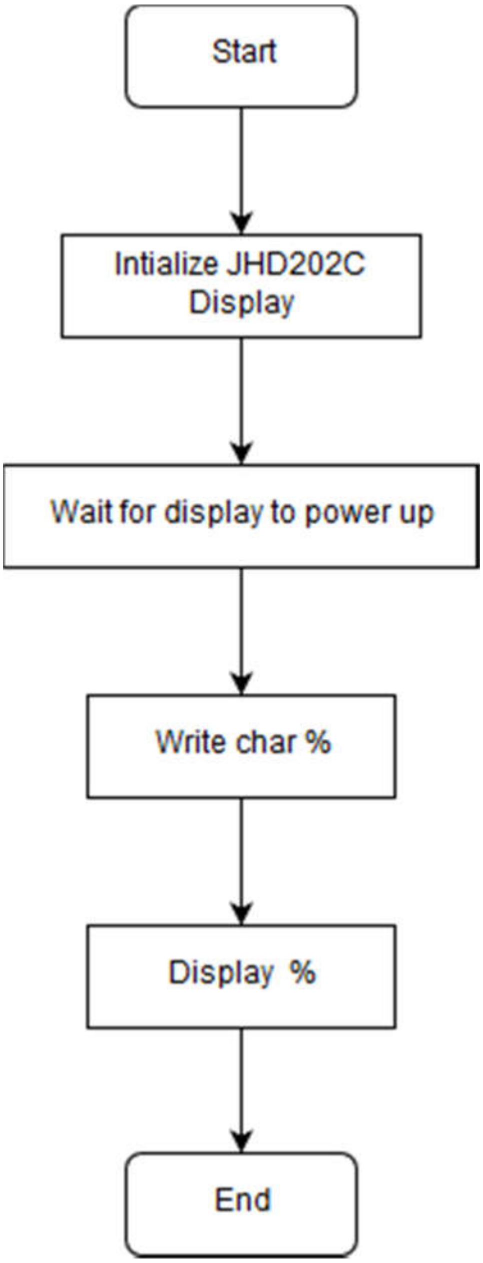
Task 1

```
;>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>
; 1DT301, Computer Technology I
; Date: 2017-10-09
; Author:
; Student name 1 Ruth Dirnfeld
; Student name 2 Alexandra Bjäremo
;
; Lab number: 5
; Title: Display JHD202
;
; Hardware: STK600, CPU ATmega2560
;
; Function: A program that displays a character on the LCD display.
;
; Input ports: None.
;
; Output ports: LCD display connected to DDRE.
;
; Subroutines: Display initialization.
; Included files: m2560def.inc
;
; Other information: Clock set at 1MHz.
;
; Changes in program:
;
;<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<
.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_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, 0b00100101
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

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

; source: lecture slides 9
/*Description
*The program displays the character % on the LCD display, that is connected to PORTE.
*/
```



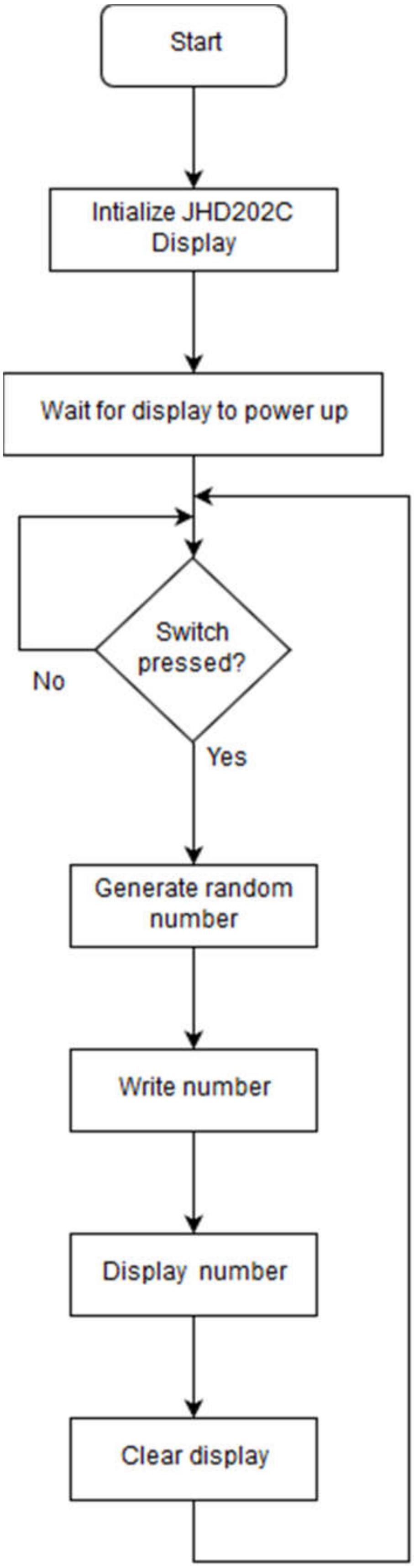
Task 2

```
;>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>
; 1DT301, Computer Technology I
; Date: 2017-10-09
; Author:
; Student name 1 Ruth Dirnfeld
; Student name 2 Alexandra Bjäremo
;
; Lab number: 5
; Title: Display JHD202
;
; Hardware: STK600, CPU ATmega2560
;
; Function: Electronic bingo machine
;
; Input ports: None.
;
; Output ports: LCD display connected to DDRE.
;
; Subroutines: Display initialization.
; Included files: m2560def.inc
;
; Other information: Clock set at 1MHz.
;
; Changes in program:
;
;<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<
.include "m2560def.inc"

.def Temp = r16
.def Data = r17
.def RS = r18
.def small_num = r19
.def tens_num = r20

.equ BITMODE4 = 0b00000010          ; 4-bit operation
.equ CLEAR = 0b00000001             ; Clear display
.equ DISPCTRL = 0b00001111          ; Display on, cursor on, blink on.  //DISP_CTRL
.equ VAL_MAX = 75
.equ VAL_MIN = 1

.equ LCD = 0b0011_0000              ; Prefix for outputting number on LCD


.cseg
.org 0x00
jmp reset
```

```
.org int0addr
jmp int_generateRandom

.org 0x72

reset:

; Init stack pointer
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

; set LCD output port
ser Temp                            ; r16 = 0b11111111
out DDRE, Temp                      ; port E = outputs ( Display JHD202A)
clr Temp                            ; r16 = 0
out DDRD, Temp

; Initialize display
rcall init_disp

ldi Temp, (1<<int0)
out EIMSK, Temp

ldi Temp, (3<<ISC00)
sts EICRA, Temp

sei

rjmp reset_value

value_loop:
cpi small_num, VAL_MAX
brge reset_value
inc small_num
rjmp value_loop

reset_value:
ldi small_num, VAL_MIN
rjmp value_loop

; Display subroutines
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

clr_display:
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 zh, 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

int_generateRandom:
lds Temp, PORTD

delay:
   ldi  r31, 130
   ldi  r30, 222
L1: dec  r30
```

```
   brne L1
   dec  r31
   brne L1
   nop

   lds r29, PORTD
   cp Temp, r29
   brne delay

   ldi tens_num, 0

increase_loop:
cpi small_num, 10
brge increase

rcall clr_display

ldi Data, LCD
or Data, tens_num
rcall write_char

ldi Data, LCD
or Data, small_num
rcall write_char

reti

increase:
subi small_num, 10
inc tens_num
rjmp increase_loop

/*Description
*A program that simulates a bingo machine,
* as in each time the switch is pressed a random
*number *between 0-75 will be generate and
* shown on the LCD display.
*/
```

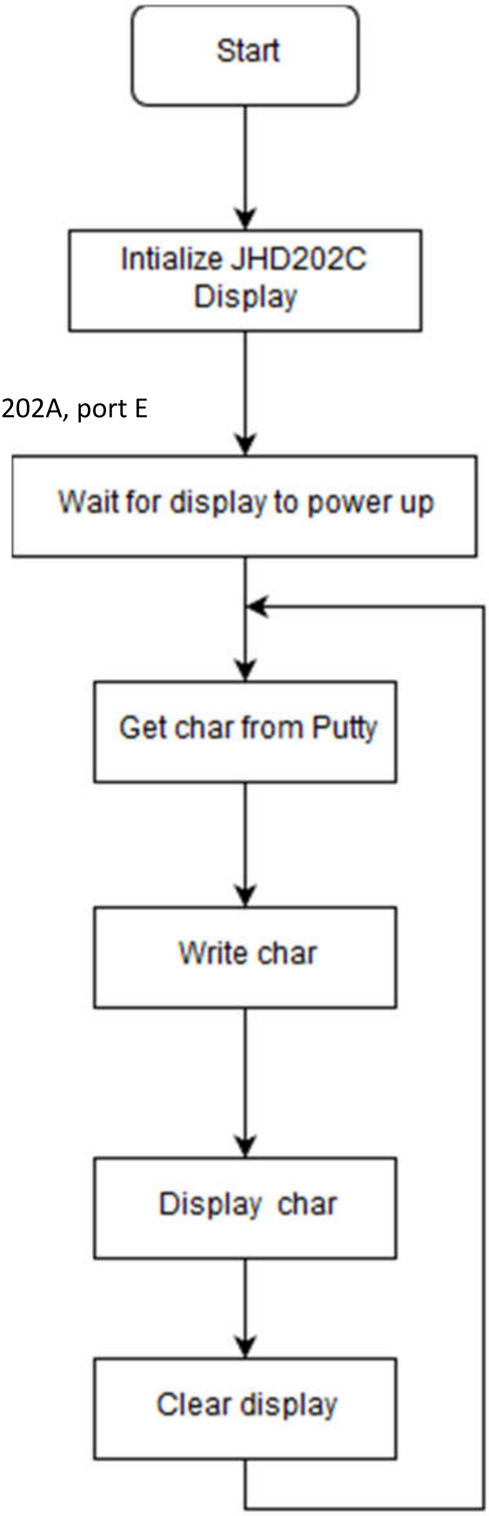


Task 3

```
;>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>
; 1DT301, Computer Technology I
; Date: 2017-10-09
; Author:
; Student name 1 Ruth Dirnfeld
; Student name 2 Alexandra Bjäremo
;
; Lab number: 5
; Title: Display JHD202
;
; Hardware: STK600, CPU ATmega2560
;
; Function: Serial communication and display
;
; Input ports: TX, RX on PIND2, respective PIND3.
;
; Output ports: LCD display connected to DDRE.
;
; Subroutines: Display and serial communication initialization.
; Included files: m2560def.inc
;
; Other information: Clock set at 1MHz.
;
; Changes in program:
;
;<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<
.include "m2560def.inc"
.def Temp = r16
.def Data = r17
.def RS = r18
.def char = r23


.equ BITMODE4 = 0b00000010                     ; 4-bit operation
.equ CLEAR = 0b00000001                       ; Clear display
.equ DISPCTRL = 0b00001111                    ; Display on, cursor on, blink on.
.equ ubrr_value = 12                          ; use 4800 speed, set to 1 MHz


.cseg
.org 0x0000                                   ; Reset vector
jmp reset

.org URXC1addr                                ; interrupt address for USART
rjmp get_char
```

```
.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, ubrr_value
sts UBRR1L, Temp

ldi Temp, (1<<TXEN1) | (1<<RXEN1) | (1<<RXCIE1) ; enable interrupt in USART
sts UCSR1B, 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

sei
rcall clr_disp

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

get_char:
lds char, UCSR1A
lds Data, UDR1
rcall outLCD
reti

outLCD :
rcall write_char
ret

/*Description
*A program that uses serial communication to retrieve characters that have been inputted from the
keyboard into the Putty terminal so that they can then be sent and displayed on the JHD202C LED
display.
*/
```

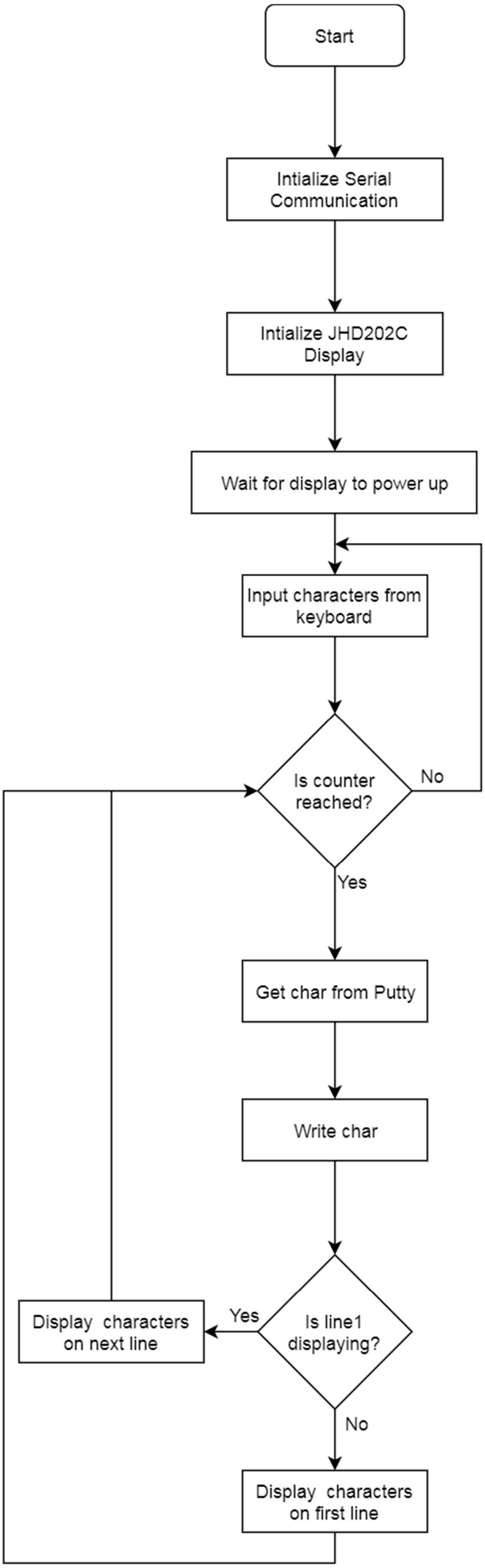
Task 4

```
;>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>
; 1DT301, Computer Technology I
; Date: 2017-10-09
; Author:
; Student name 1 Ruth Dirnfeld
; Student name 2 Alexandra Bjäremo
;
; Lab number: 5
; Title: Display JHD202
;
; Hardware: STK600, CPU ATmega2560
;
; Function: Serial communication while displaying with delay on different lines.
;
; Input ports: TX, RX on PIND2, PIND3.
;
; Output ports: LCD display connected to DDRE.
;
; Subroutines: If applicable.
; Included files: m2560def.inc
;
; Other information: Clock set at 1MHz.
;
; Changes in program:  2017-10-15, 2017-10-17, 2017-10-24, 2017-10-31

;
;<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<


.include "m2560def.inc"

.def Temp = r16
.def Data = r17
.def RS = r18
.def counter = r19
.def spaces = r20

.equ BITMODE4 = 0b00000010              ; 4-bit operation
.equ CLEAR = 0b00000001                 ; Clear display
.equ DISPCTRL = 0b00001111              ; Display on, cursor on
                                        ; blink on.  //DISP_CTRL
.equ TIMER_VAL = 6

.cseg
.org 0x00
jmp reset
```

```
.org URXC1addr
jmp int_interrupt

.org ovf0addr
jmp count_interrupt

.org 0x72

reset:

; Init stack pointer
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

; set LCD output port
ser Temp                                ; r16 = 0b11111111
out DDRE, Temp                  ; port E = outputs (Display JHD202A)

; Init display
rcall init_disp

; Init Serial Communication
ldi Temp, 12                    ; = 4800 bps (1MHz)
sts UBRR1L, Temp                ;set transfer rate

ldi Temp, (1<<RXEN1) | (1<<RXCIE1)
sts UCSR1B, Temp                ;enable UART flag for receiving

; Init Timer
ldi Temp, 0x05                  ;set prescale to 1024
out TCCR0B, Temp

ldi Temp, (1<<TOIE0)            ;enable overflow flag
sts TIMSK0, Temp

ldi Temp, TIMER_VAL             ;set default val for timer
out TCNT0, Temp

sei

main:
nop
rjmp main

; Display subroutines
```

```
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

clr_display:
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 zh, 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
out PORTE, Temp
pop Temp
ret

int_interrupt:
```

```
lds Data, UDR1
rcall write_char
reti

count_interrupt:
push Temp
ldi Temp, TIMER_VAL
out TCNT0, Temp
inc counter

cpi counter, 20                 ; five seconds
brlo timer_end
ldi spaces, 0
ldi Data, 0b0000_0101           ;move
rcall write_cmd

move_row:
ldi Data, 0b0010_0000           ;space cmd
rcall write_char
inc spaces
cpi spaces, 20
brlo move_row
ldi data, 0b0000_0100                   ;default
rcall write_cmd

clr counter

timer_end:
pop Temp
reti

/*Description
* A program that uses serial communication to retrieve
* characters that have been inputted from the
* keyboard into the Putty terminal until the counter
*has been reached. After that the characters will be
*sent and displayed on the JHD202C LED display
*depending on which line is available. The lines
*change every five seconds, pushing the text from the
*previous line onto the next one.
*/
```


Start
Intialize Serial Communication
Intialize JHD202C Display
Wait for display to power up
Input characters from keyboard
Is counter reached?
No
Yes
Get char from Putty
Write char
Is line1 displaying?
Yes
Display characters on next line
No
Display characters on first line