Computer Technology I

Lab. 4 :Timer and UART

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Area: Computer Science
Course code: 1DT301

Contents

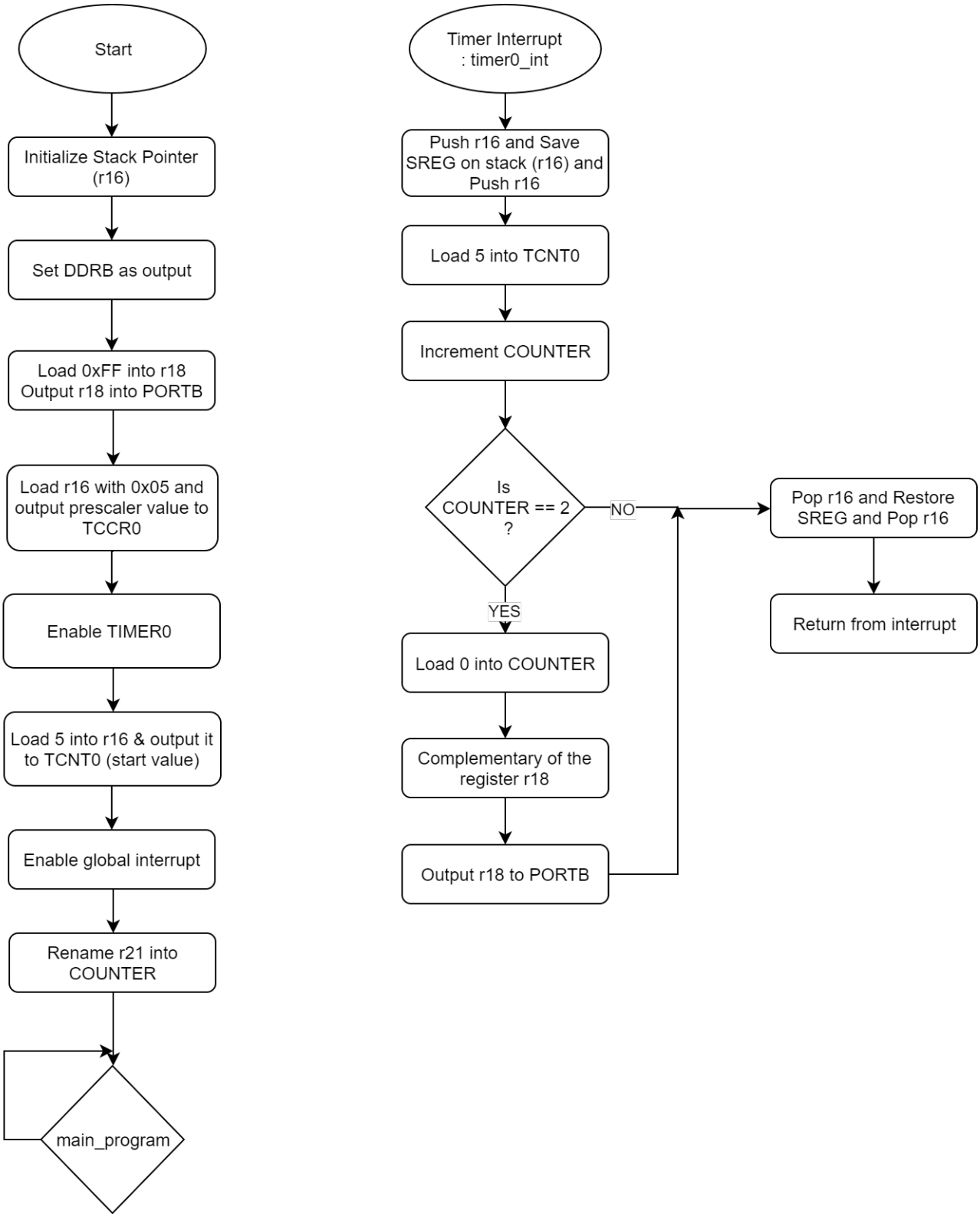
1 Task 1 - Square wave generator

Write a program in Assembly that creates a square wave. One LED should be connected and switch with the frequency 1 Hz. Duty cycle 50 percent. (On: 0.5 sec, Off: 0.5 sec.) Use the timer function to create an interrupt with 2 Hz, which change between On and Off in the interrupt subroutine.

```
;>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>
; 1DT301, Computer Technology I
; Date: 2019-10-04
; Author:
; Loic GALLAND
; Leonardo PEDRO
;
; Lab number: 4
; Title: Timer and UART
;
; Hardware: STK600, CPU ATmega2560
;
; Function: Program that creates a Square Wave Generator using a timer
    interrupt. It will make the light turn on for 0.5s and turn off for
     0.5s
;
; Input ports: No input ports
;
; Output ports: PORTB for the LEDs
;
; Subroutines: If applicable.
; Included files: m2560def.inc
;<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<
.include "m2560def.inc"

.org 0x00
rjmp restart

.org OVF0addr   ;Address of the Timer Interrupt 0
rjmp timer0_int

.org 0x72

restart:
ldi r16, LOW(RAMEND) ; initialize SP, Stackpointer
out SPL, r16
ldi r16, HIGH(RAMEND)
out SPH, r16

ldi r16, 0xFF   ;Set PORTB as output
out DDRB, r16

ldi r18, 0b11111111     ;Initialize LEDs (Turn OFF)
out portb,r18

ldi r16, 0x05 ; prescaler value to TCCR0
out TCCR0B, r16 ; CS2 - CS2 = 101, osc.clock / 1024
ldi r16, 0b00000001; Timer 0 enable flag, TOIE0
sts TIMSK0, r16 ; to register TIMSK
ldi r16, 5 ; starting value for counter. Will count from 5 to 255 and
```

```
   therefore will take 250ms
out TCNT0, r16 ; counter register
sei ; enable global interrupt

.DEF COUNTER = r21      ;To count how many times the program goes into
   the timer interrupt
ldi COUNTER, 0

start:  ;Infinite loop that does nothing so that the timer interupt
   interupts something
nop
rjmp start

timer0_int:     ;TIMER INTERRUPT
        push r16 ;Push to Stack and input to SREG, so that no other
           interrupt interrupts the timer interrupt
        in r16, SREG ; save SREG on stack
        push r16

        ldi r16, 5 ; starting value for counter, (Reset the counter)
        out TCNT0, r16
        inc COUNTER     ;Increase by 1 the COUNTER(r21)

        cpi COUNTER, 2  ;Checks if COUNTER = 2, therefore 500ms has
           passed and the LEDs needs to be switched
        BRLT continue   ;If COUNTER is less than 2 then branches to "
           continue". otherwise it will switch the LEDs

        ldi COUNTER,0   ;Reset COUNTER
        COM r18 ;COM the LEDs so that they change state from turned on
           to turned off
        out PORTB, r18

        continue:
        pop r16 ; restore SREG
        out SREG, r16   ;Open the interrupts again.
        pop r16 ; restore register
reti
```

This is the flowchart of the task 1:



2 Task 2 - Pulse Width Modulation (PWM)

Modify the program in Task 1 to obtain Pulse Width Modulation (PWM). The frequency should be fixed, but the duty cycle should be possible to change. Use two push buttons to change the duty cycle up and down. Use interrupt for each pushbutton. The duty cycle should be possible to change from 0 percent up to 100 percent in steps of 5 percent. Connect the output to an oscilloscope, to visualize the change in duty cycle.

```
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; Date: 2019-10-04
; Author:
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;
; Lab number: 4
; Title: Timer and UART
;
; Hardware: STK600, CPU ATmega2560
;
; Function: Program that creates a Pulse Width Modulation using a timer
     interrupt. When clicking on buttons it will increase or decrease
    the amount of time in 1s that the LEDs will be on.
;                         When the Duty cycle is 50 percent then the LEDs
     are 0.5s ON and 0.5s OFF. If the Duty cycle is 20 percent, then
    the LEDs will be ON for 0.2s and OFF 0.8s.
;
; Input ports: PORTD to control the switches
;
; Output ports: PORTB for the LEDs
;
; Subroutines: If applicable.
; Included files: m2560def.inc
;<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<
.include "m2560def.inc"

.org 0x00
rjmp restart

.org OVF0addr   ;Address of the Timer Interrupt number 0
rjmp timer0_int

.org INT0addr   ;Address of the Interrupt number 0
rjmp PLUS

.org INT1addr ;Address of the Interrupt number 1
rjmp MINUS

.org 0x72

restart:;To initialize everything
ldi r16, LOW(RAMEND) ; initialize SP, Stackpointer
out SPL, r16
ldi r16, HIGH(RAMEND)
out SPH, r16

ldi r16, 0xFF   ;Set PORTB as output
```
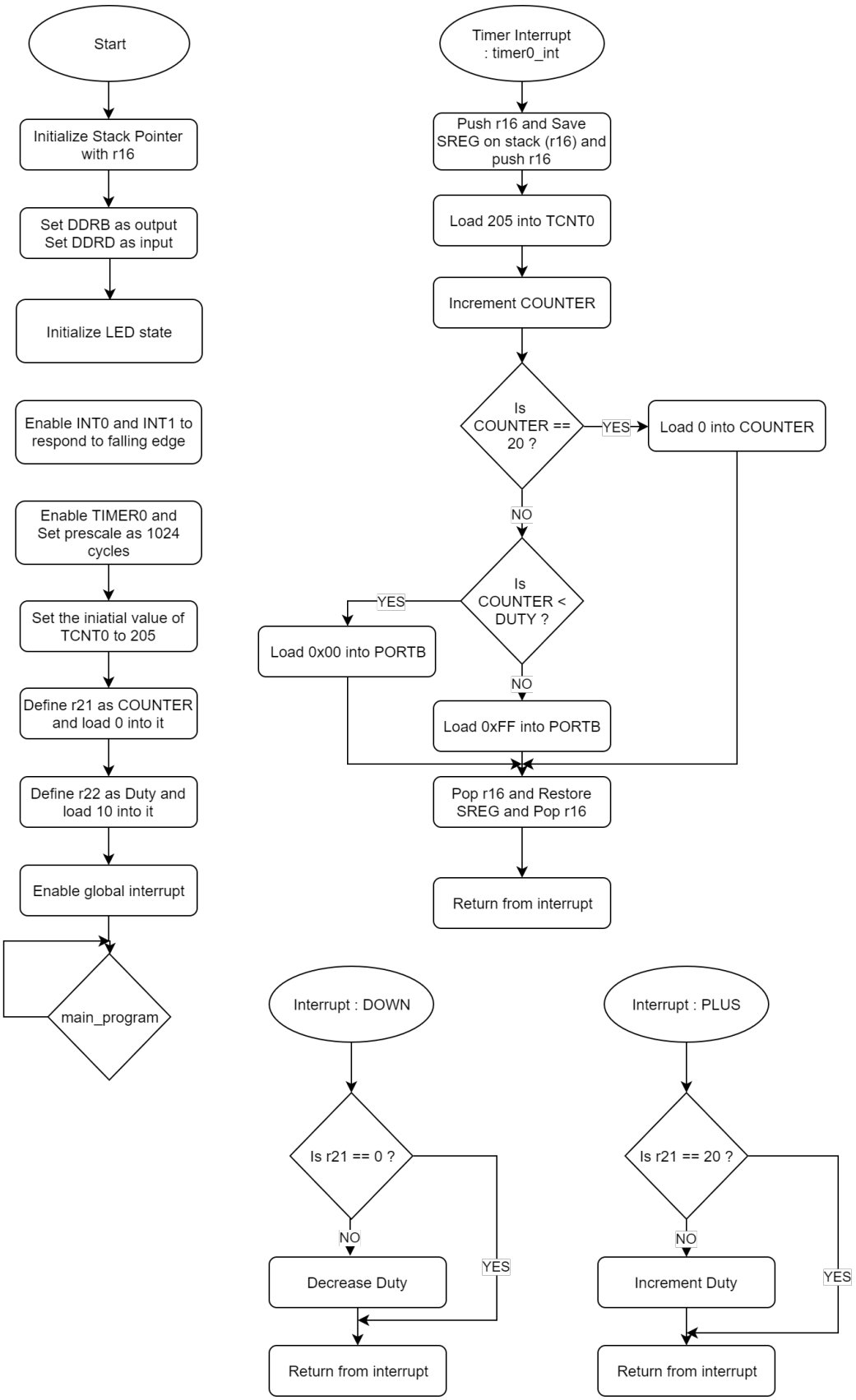

```
out DDRB, r16

ldi r16, 0x00   ;Set PORTD as input
out DDRD, r16

ldi r18, 0b11111111     ;Initialize LED state
out portb,r18

ldi r20,0b00001010 ;Setting INT0-INT1 into falling edge
sts EICRA,r20
ldi r20,0b0000011 ;Enable INT0-INT1
out EIMSK,r20

ldi r16, 0x05 ; prescaler value to TCCR0
out TCCR0B, r16 ; CS2 - CS2 = 101, osc.clock / 1024
ldi r16, 0b00000001; Timer 0 enable flag, TOIE0
sts TIMSK0, r16 ; to register TIMSK
ldi r16, 205 ; starting value for counter. Will count from 205 to 255
   and therefore will take 50ms
out TCNT0, r16 ; counter register
sei ; enable global interrupt

.DEF COUNTER = r21      ;Counter to counts how many times the program
   went into the timer interrupt
ldi COUNTER, 0
.DEF Duty = r22 ;Register to change the duty cycle
ldi Duty,10
sei     ;Global interrupt enable

start:
nop     ;Infinite loop that does nothing so that the timer interrupt
   can interruot something
rjmp start

timer0_int:     ;Timer interrupt
        push r16        ;Push to Stack and input to SREG, so that no
           other interrupt interrupts the timer interrupt
        in r16, SREG ;
        push r16        ;


        ldi r16, 205 ; starting value for counter.
        out TCNT0, r16
        inc COUNTER     ;Increase by 1 the COUNTER

        cpi COUNTER, 20 ;Checks if the COUNTER = 20
        Breq reset      ;If it is, then reset

        cp COUNTER, Duty        ;As long as the COUNTER is less than
           the Duty then turn ON the LEDS.
        BRLT ON                         ;Otherwise turn OFF the LEDs

        OFF:    ;Routine for turning off the LEDs
                ldi r18,0xFF
                out PortB,r18
        rjmp END        ;Jumps to END routine so that does not go into
           the ON and reset routine.

        ON:             ;Rountine for turning ON the LEDs
```

```
                ldi r18,0x00
                out PORTB,r18
        rjmp END        ;Jumps to END routine so that does not go into
            the reset routine.

        reset:
                ldi COUNTER,0   ;Reset the COUNTER
        END:
                pop r16 ; restore SREG
                out SREG, r16   ;Enables the interrupts again.
                pop r16 ; restore register
reti    ;Return from timer interrupt

PLUS:   ;Interrupt to increase the Duty cycle
cpi Duty,20     ;Checks if duty =20. Do nothing if it is because 20
    should be the maximum.
breq DONE2
inc Duty        ;Otherwise increase the Duty by 1

DONE2: nop      ;Do nothing

RETI    ;return from interrupt

MINUS:  ;Interrupt to decrease the Duty Cycle
cpi Duty,0      ;Checks if duty =0. Do nothing if it is because 0
    should be the minimum.
breq DONE

dec Duty        ;Decrease Duty by 1

DONE: nop       ;Do nothing
RETI    ;return from interrupt
```

This is the flowchart of the task 2:



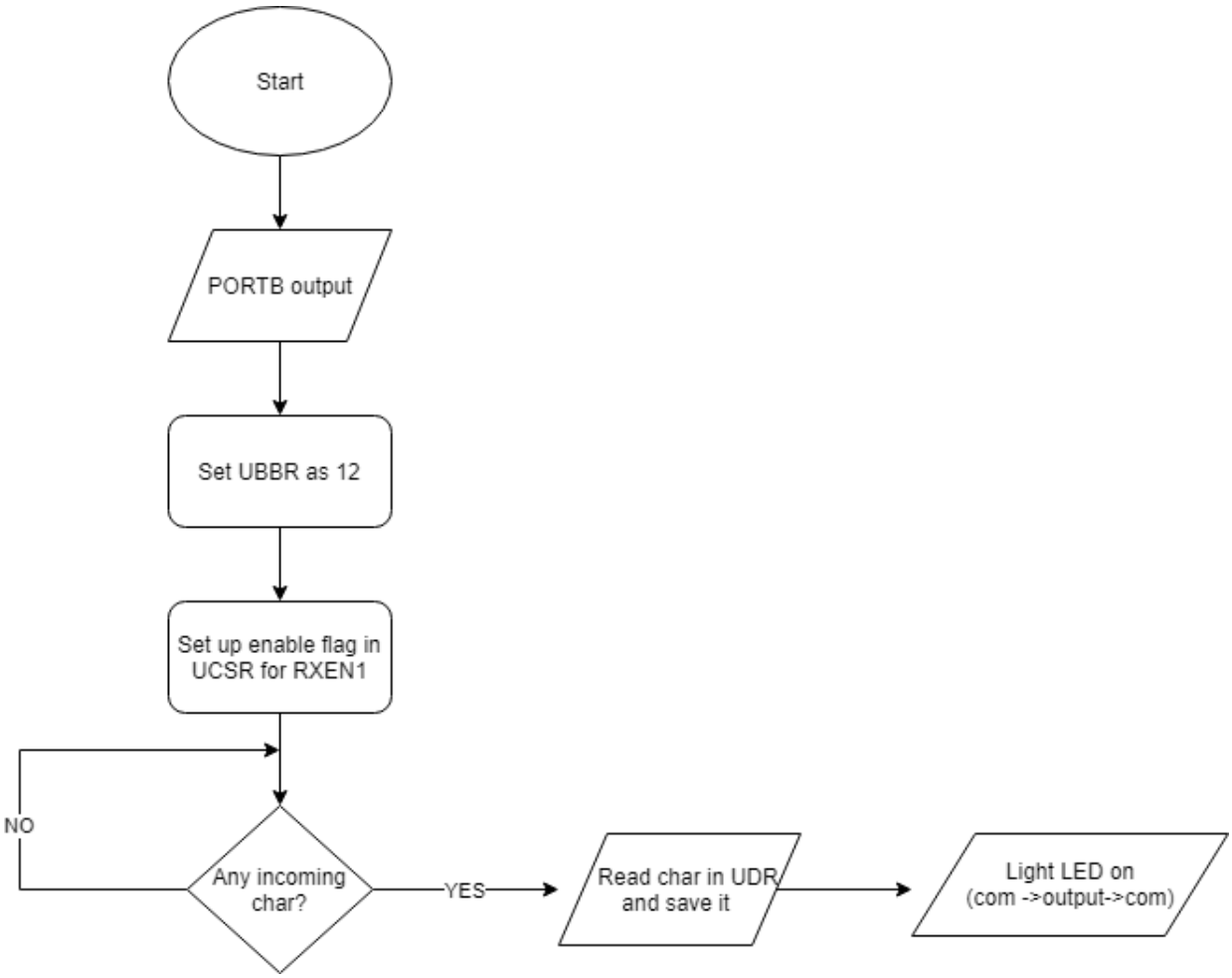
3 Task 3 -Serial communication

Write a program in Assembly that uses the serial communication port0 (RS232). Connect a computer to the serial port and use a terminal emulation program. (Ex. Hyper Terminal) The program should receive characters that are sent from the computer, and show the code on the LEDs.

```
;>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>
; 1DT301, Computer Technology I
; Date: 2019-10-04
; Author:
; Loic GALLAND
; Leonardo PEDRO
;
; Lab number: 4
; Title: Timer and UART
;
; Hardware: STK600, CPU ATmega2560
;
; Function: Program that when we type a letter to the terminal it will
   show the ascii binary code of that letter to the LEDs. Using UART.
;
; Input ports: Port0 (RS232) VGA
;
; Output ports: PORTB for the LEDs
;
; Subroutines: If applicable.
; Included files: m2560def.inc
; The code for this exercise was taken from the lecture.
;<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<
.include "m2560def.inc"

.org 0x00
rjmp start

.org 0x72

start:  ;To initialize everything
        ldi r16,0xFF    ;PORTB outputs
        out DDRB, r16

        out PORTB,r16   ;Iniatial value to outputs

        ldi r16, 12     ;osc = 1MHz, 4800 bps => UBBRR = 12
        sts UBRR1L , r16        ;Store Prescaler value in UBRR1L

        ldi r16, (1<<RXEN1)     ;Set RX enable flags
        sts UCSR1B, r16

GetChar:        ;Receive data
        lds r16, UCSR1A ;read UCSR1A I/O register to r16
        sbrs r16,RXC1   ;RXC1=1 -> new Character
        rjmp GetChar    ;RXC1=0 -> no character received
        lds r18,UDR1    ;Read character in UDR

Port_output:    ;Show data on the LEDs
        com r18 ;COM to have the 1s become 0s as asked for the exercice
```

```
        out PORTB,r18    ;Write character to PORTB
        com r18 ;COM again to make it normal
```

This is the flowchart of the task 3:



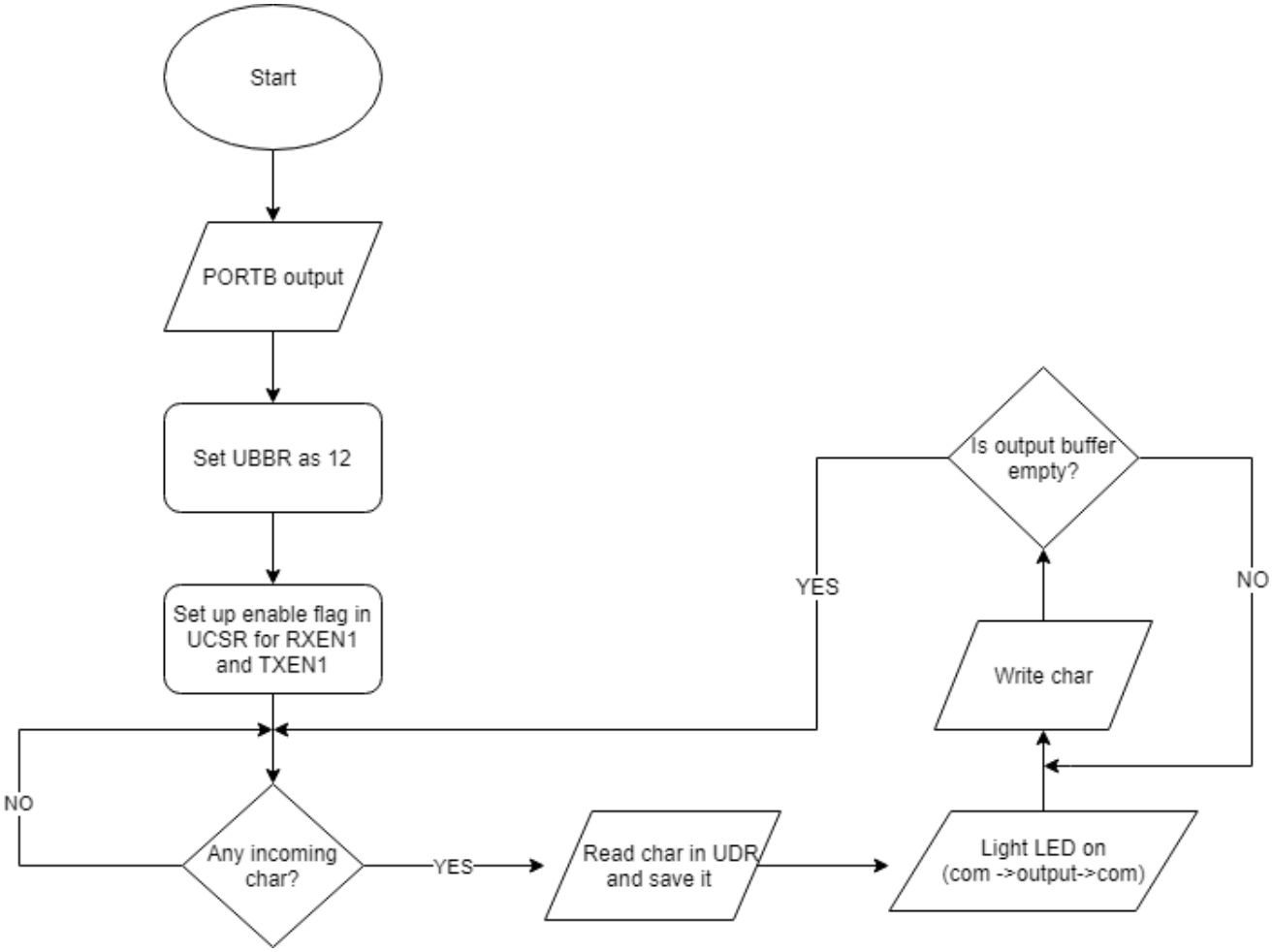
4 Task 4 - Serial communication with echo

Modify the program in task 3 to obtain an echo, which means that the received character should also be sent back to the terminal. This could be used as a confirmation in the terminal, to ensure that the character has been transferred correctly.

```
;>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>
; 1DT301, Computer Technology I
; Date: 2019-10-04
; Author:
; Loic GALLAND
; Leonardo PEDRO
;
; Lab number: 4
; Title: Timer and UART
;
; Hardware: STK600, CPU ATmega2560
;
; Function: Program that when we type a letter to the terminal it will
   show the ascii binary code of that letter to the LEDs.
;                        And then sends the letter back to the terminal.
    Using UART
; Input ports: Port0 (RS232) VGA
;
; Output ports: PORTB for the LEDs
;
; Subroutines: If applicable.
; Included files: m2560def.inc
; The code for this exercice was taken from the lecture.
;<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<
.include "m2560def.inc"

.org 0x00
rjmp start

.org 0x72

start:
        ldi r16,0xFF    ;Set PORTB as output
        out DDRB, r16

        out PORTB,r16   ;Iniatialize LEDs state

        ldi r16, 12             ;osc = 1MHz, 4800 bps => UBBRR = 12
        sts UBRR1L , r16        ;Store Prescaler value in UBRR1L

        ldi r16, (1<<RXEN1 | 1<<TXEN1);Set RX and TX enable flags
        sts UCSR1B, r16

GetChar:        ;Receive data
        lds r16, UCSR1A ;read UCSR1A I/0 register to r16
        sbrs r16,RXC1   ;RXC1=1 -> new Character
        rjmp GetChar    ;RXC1=0 -> no character received
        lds r18,UDR1    ;Read character in UDR

Port_output:    ;Show Data on LEDs
        com r18
```

```
        out PORTB,r18   ;Write character to PORTB
        com r18

PutChar:        ;Show data back to the terminal
        lds r16, UCSR1A ;Read UCSR1A i/O register to r16
        sbrs r16, UDRE1 ;UDRE1 =1 => buffer is empty
        rjmp PutChar    ;UDRE1 = 0 => buffer is not empty
        sts UDR1,r18    ;write character to UDR1
        rjmp GetChar    ;Return to loop
```

This is the flowchart of the task 4:



5 Task 5 - Serial communication using Interrupt

Do task 3 and 4, but use Interrupt instead of polled UART. (USART, Rx Complete, USART Data Register Empty and USART, Tx Complete)

```
;>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>
; 1DT301, Computer Technology I
; Date: 2019-10-04
; Author:
; Loic GALLAND
; Leonardo PEDRO
;
; Lab number: 4
; Title: Timer and UART
;
; Hardware: STK600, CPU ATmega2560
;
; Function: Program that when we type a letter to the terminal it will
   show the ascii binary code of that letter to the LEDs.
;                     And then sends the letter back to the terminal.
    Using USART Interrupt
;
; Input ports: Port0 (RS232) VGA
;
; Output ports: PORTB for the LEDs
;
; Subroutines: If applicable.
; Included files: m2560def.inc
; The code for this exercice was taken from the lecture.
;<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<
.include "m2560def.inc"

.org 0x00
rjmp start

.org URXC1addr  ;USART Interrupt
rjmp GetChar

.org 0x72

start:
        ldi r16,LOW(RAMEND)     ;iniatilize SP
        out SPL,r16
        ldi r16,HIGH(RAMEND)
        out SPH,r16

        ldi r16,0xFF    ;Set PORTB as output
        out DDRB, r16
        out PORTB,r16   ;Initialize LEDs

        ldi r16, 12             ;osc = 1MHz, 4800 bps => UBBRR = 12
        sts UBRR1L , r16        ;Store Prescaler value in UBRR1L

        ldi r16, 0b10011000;Set RX, TX enable flags and RXCIE = 1
        sts UCSR1B, r16
        sei     ;Set global interrupt flag

Main_loop:
```

```
nop             ;Infinite loop that does nothing
rjmp Main_loop

GetChar:        ;Receive data
        lds r16, UCSR1A ;read UCSR1A I/O register to r16
        lds r18,UDR1    ;Read character in UDR

Port_output:    ;Show data on the LEDs
        com r18
        out PORTB,r18   ;Write character to PORTB
        com r18

PutChar:        ;Sends back the character to the Terminal
        lds r16, UCSR1A ;Read UCSR1A i/O register to r16
        sts UDR1,r18    ;write character to UDR1
RETI    ;Return from interrupt
```

This is the flowchart of the task 5: