Lab 3 Report

Authors: Andrei Neagu
Konstantinos Tatsis
Course code: 1DT301

Contents

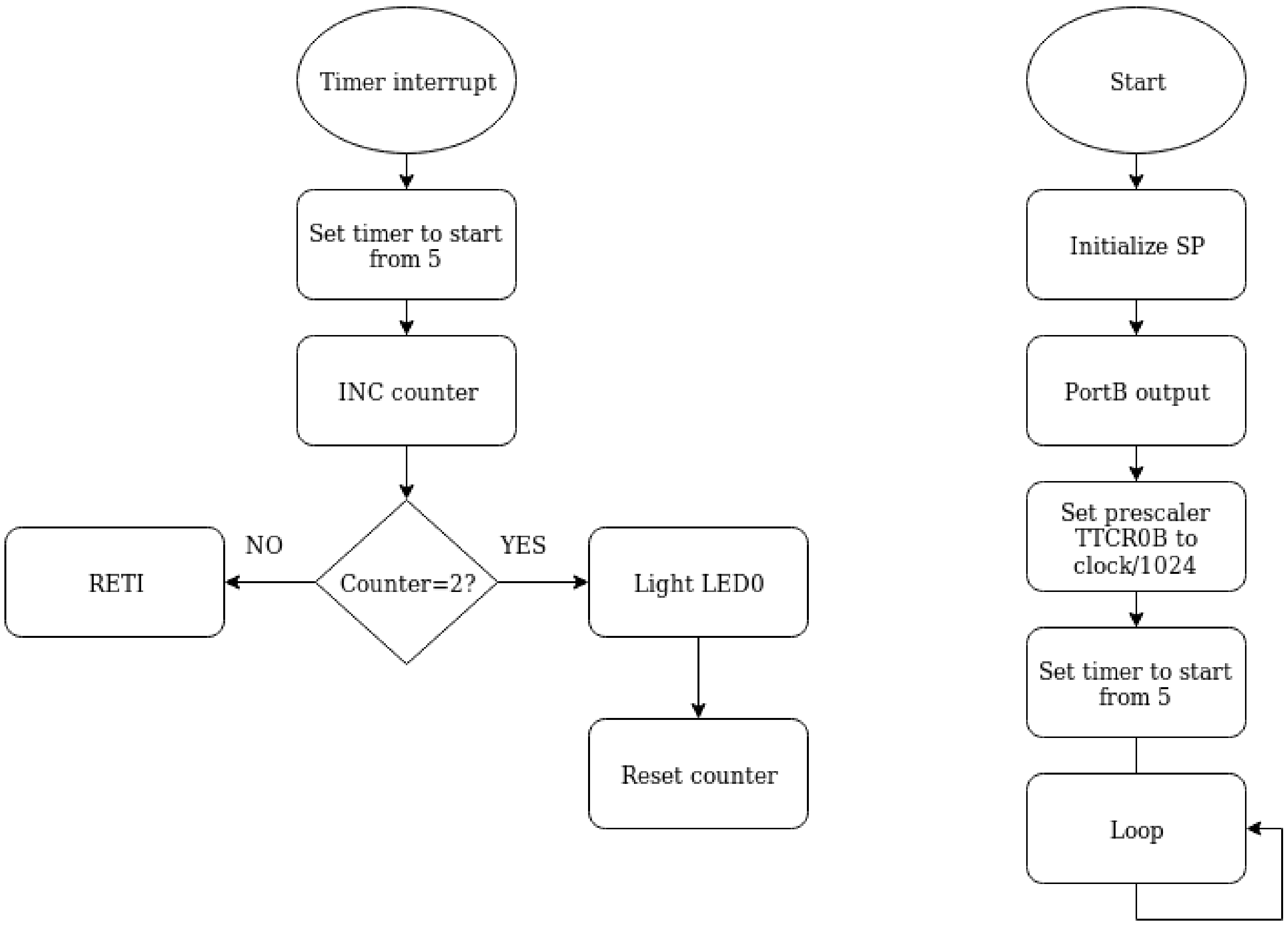
1 Task 1

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. (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: 2019-10-10
; Author:
; Andrei Neagu
; Konstantinos Tatsis
;
; Lab number: 3
; Title: Timer and UART
;
; Hardware: STK600, CPU ATmega2560
;
; Function: Square wave generator
;
; Input ports:
;
; Output ports: PORTB
;
; Subroutines: reset, loop, again, led, timer0_int
; Included files: m2560def.inc
;
; Other information:
;
; Changes in program: (Description and date)
;<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<
.include "m2560def.inc"

.def temp = r16
.def ledState = r17
.def counter = r18

.org 0x00
rjmp reset

.org OVF0addr
rjmp timer0_int

.org 0x72
reset:

ldi temp, LOW(RAMEND)    ;initialize stack pointer
out SPL, temp
ldi temp, HIGH(RAMEND)
out SPH, temp

ldi temp, 0x01                  ; set DDRB as output
out DDRB, temp

ldi temp, 0x05                  ; prescaler value to TCCR0B
out TCCR0B, temp                ;0b101 means clock/1025

ldi temp, (1<<TOIE0)     ;enable overflow flag
sts TIMSK0, temp                ; to TIMSK

ldi temp, 5                             ; starts from 5 to 255 meaning 250 times
out TCNT0, temp                 ; until overflow

sei
clr ledState                    ; clear ledstate used for outputting to leds

loop:
        out PORTB, ledState
        rjmp loop

timer0_int:
        in temp, SREG    ; save sreg in SP
        push temp

        ;set start value for timer so next interrupt occurs after 250 ms
        ldi temp, 5
```

```
out TCNT0, temp
inc counter
cpi counter, 2                  ; if counter is 2 then 0,5 sec have passed
breq led                                ; then branch to change_led_state

rjmp again

led:
        com ledState            ; toggle LED0
        clr counter                     ; reset counter to 0

again:
        pop temp                        ; save sreg in SP
        out SREG, temp
        reti
```

1.1 Flowchart 1



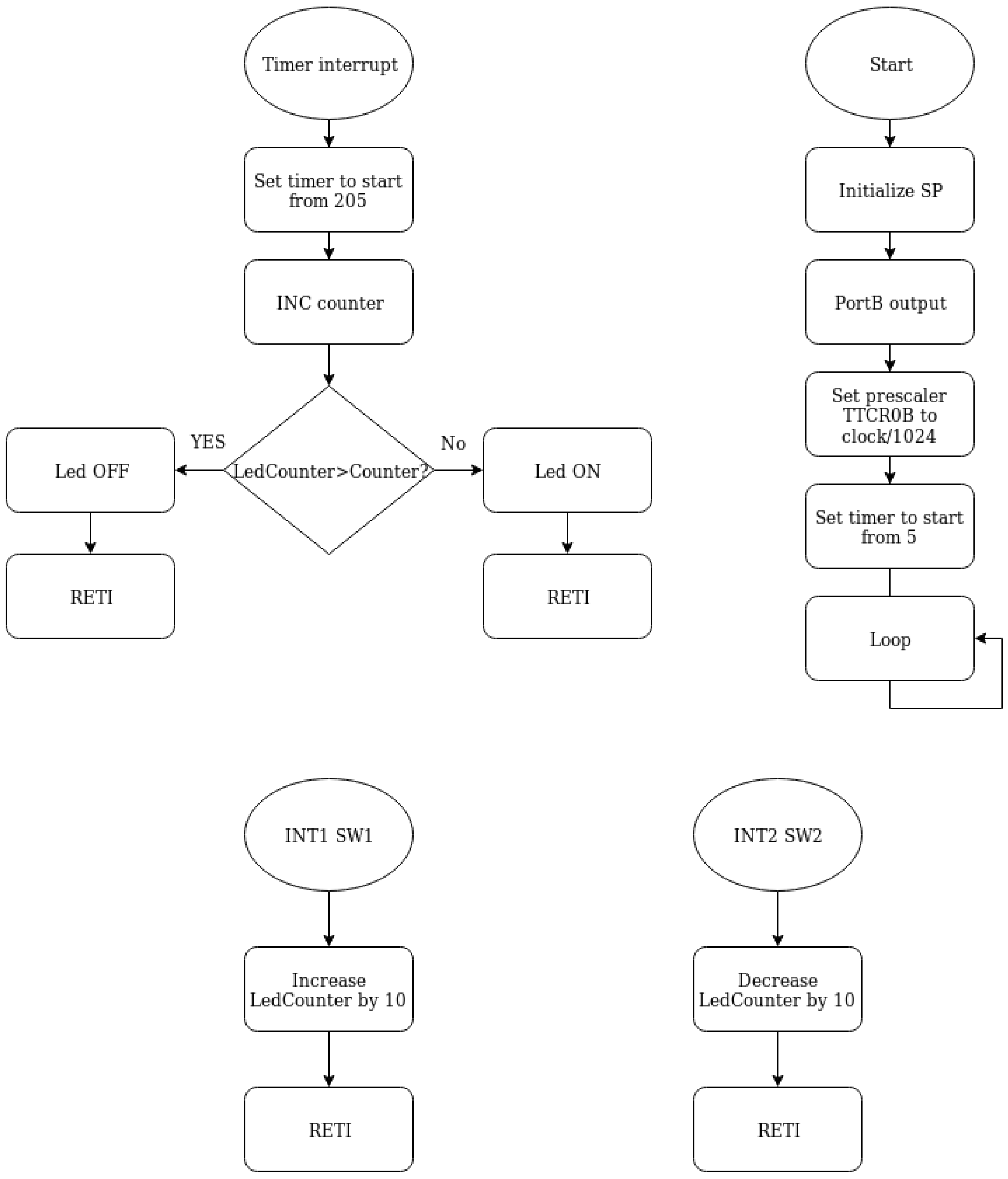
2 Task 2

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 up to 100 in steps of 5 . Connect the output to an oscilloscope, to visualize the change in duty cycle

```
;>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>
; 1DT301, Computer Technology I
; Date: 2019-10-10
; Author:
; Andrei Neagu
; Konstantinos Tatsis
;
; Lab number: 3
; Title: Timer and UART
;
; Hardware: STK600, CPU ATmega2560
;
; Function: Square wave generator
;
; Input ports:
;
; Output ports: PORTB
;
; Subroutines: reset, loop, again, led, timer0_int
; Included files: m2560def.inc
;
; Other information:
;
; Changes in program: (Description and date)
;<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<
.include "m2560def.inc"

.def temp = r16
.def ledState = r17
.def counter = r18

.org 0x00
rjmp reset

.org OVF0addr
rjmp timer0_int

.org 0x72
reset:

ldi temp, LOW(RAMEND)    ;initialize stack pointer
out SPL, temp
ldi temp, HIGH(RAMEND)
out SPH, temp

ldi temp, 0x01                ; set DDRB as output
out DDRB, temp

ldi temp, 0x05                ; prescaler value to TCCR0B
out TCCR0B, temp              ;0b101 means clock/1025

ldi temp, (1<<TOIE0)     ;enable overflow flag
sts TIMSK0, temp              ; to TIMSK

ldi temp, 5                           ; starts from 5 to 255 meaning 250 times
out TCNT0, temp               ; until overflow

sei
clr ledState                  ; clear ledstate used for outputting to leds

loop:
        out PORTB, ledState
        rjmp loop

timer0_int:
        in temp, SREG    ; save sreg in SP
        push temp
```

```
;set start value for timer so next interrupt occurs after 250 ms
ldi temp, 5
out TCNT0, temp
inc counter
cpi counter, 2                  ; if counter is 2 then 0,5 sec have passed
breq led                                ; then branch to change_led_state

rjmp again

led:
        com ledState            ; toggle LED0
        clr counter                     ; reset counter to 0

again:
        pop temp                        ; save sreg in SP
        out SREG, temp
        reti
```

2.1 Flowchart 2

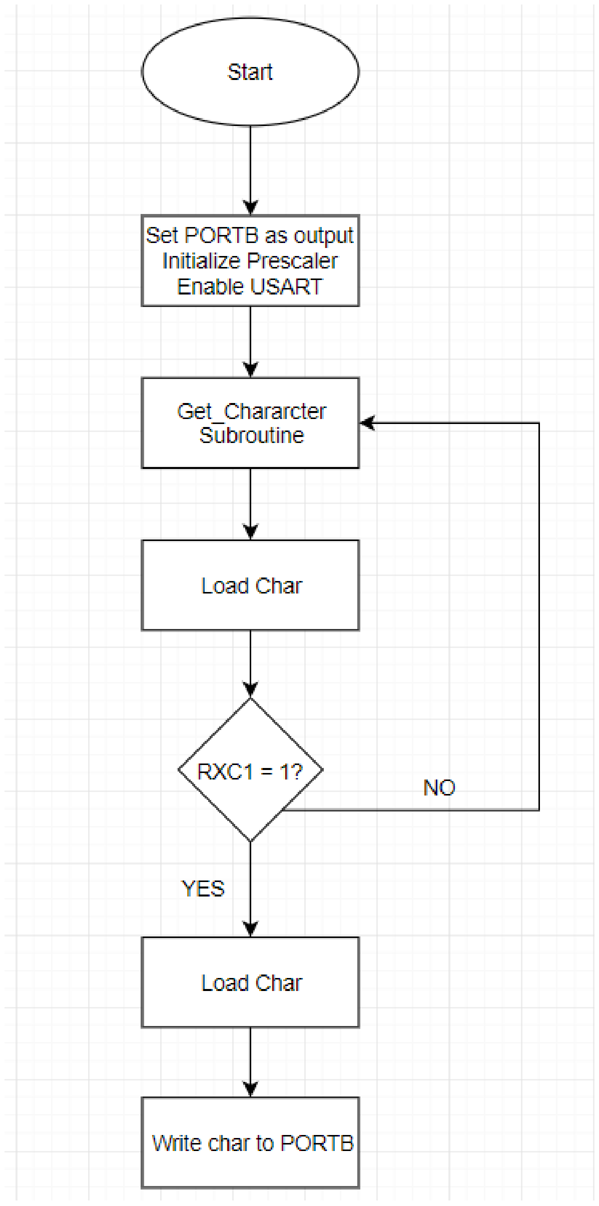

Timer interrupt
Set timer to start from 205
INC counter
LedCounter>Counter?
YES
No
Led OFF
Led ON
RETI
RETI
Start
Initialize SP
PortB output
Set prescaler TTCR0B to clock/1024
Set timer to start from 5
Loop
INT1 SW1
Increase LedCounter by 10
RETI
INT2 SW2
Decrease LedCounter by 10
RETI

3 Task 3

Write a programin 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 shouldreceive characters that are sent from the computer, and show the code on the LEDs. For example, if you send character A, it has the hex code 65, the bit pattern is 0110 0101 and should be displayed with LEDs On for each ‘one’. Use polled UART, which means that the UART should be checked regularly by the program. Serial communication.

```
 ;
; Task 3.asm
;
; Created: 2019-10-12 14:35:33
; Author : kt222iq
;
; Replace with your application code
.include "m2560def.inc"

.org 0x00


rjmp start

.org 0x72

start:
ldi r20, 0xFF                ; Load immediately value "0xFF" to r20
out DDRB, r20                ; Set PORTB as output with the value of r20
out PORTB, r20               ; Output value of r20 to PORTB

ldi r20, 12                          ; Store Prescaler value in UBRR1L
sts UBRR1L, r20

ldi r20, (1<<TXEN1) | (1<<RXEN1)                ; Enable receiver and Transmitter
sts UCSR1B, r20                                                 ; Set TXEN1 and RXC1 enable flags

main:

get_Character:
lds r20, UCSR1A              ; read UCSR1A I/O register to r20
sbrs r20, RXC1               ; RXC1 = 1 new Char received
rjmp get_Character           ; RXC1 = 0 then no Char was received
lds r15, UDR1                ; Read char in UDR1

com r15
out PORTB, r15               ; Write chars to PORTB
com r15
```

3.1 Flowchart 3

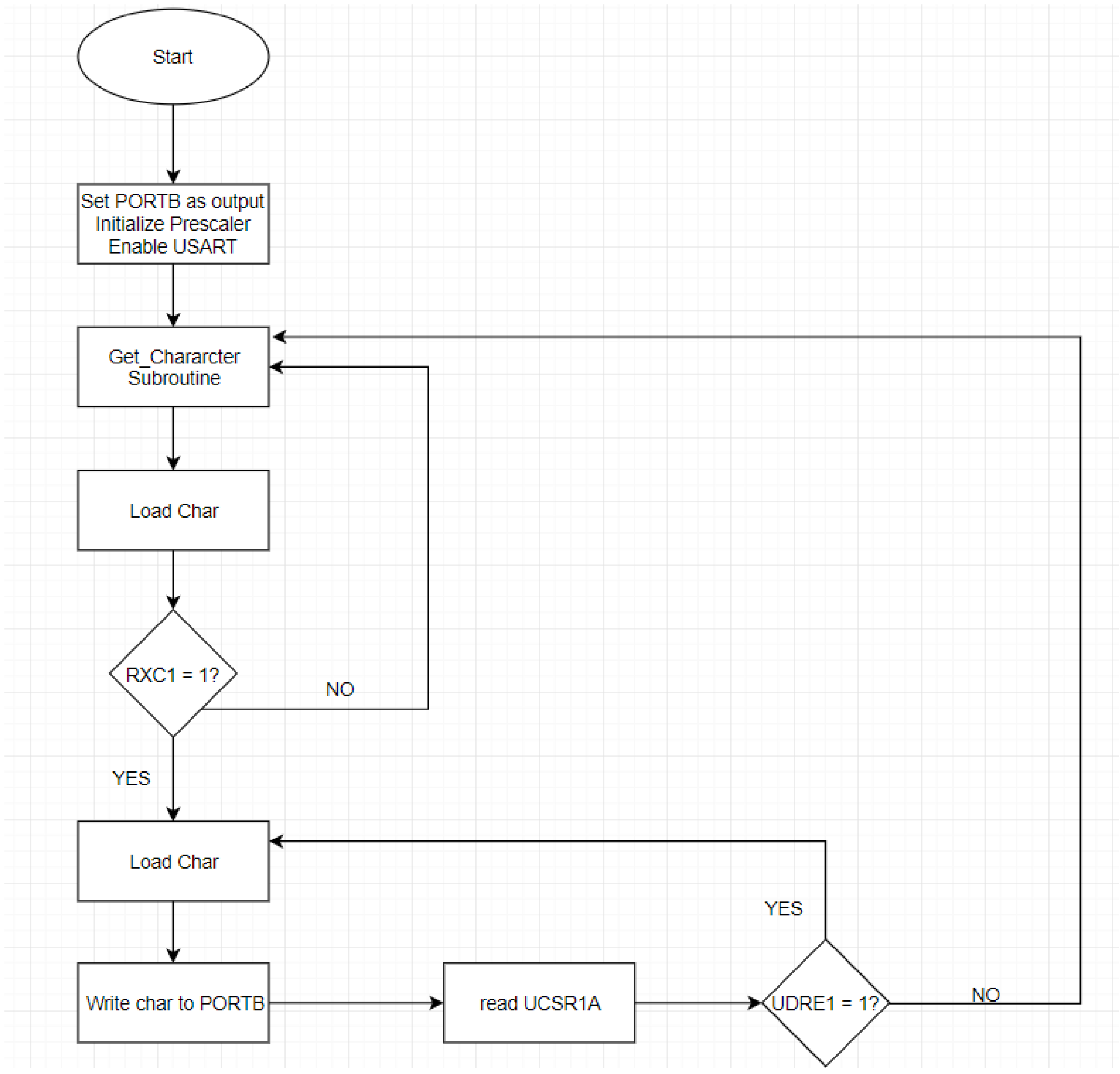


4 Task 4

Modify the program in task 3 toobtain 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.

```
 ; Task 4.asm
; Created: 2019-10-12 14:38:08
; Author : kt222iq
; Replace with your application code
.include "m2560def.inc"

.org 0x00

rjmp start

.org 0x72

start:

ldi r20, 0xFF                   ; Load immediately value "0xFF" to r20
out DDRB, r20                   ; Set PORTB as output with the value of r20
out PORTB, r20                  ; Output value of r20 to PORTB

ldi r20, 12                             ; Store Prescaler value in UBRR1L
sts UBRR1L, r20

ldi r20, (1<<TXEN1) | (1<<RXEN1)        ; Enable receiver and Transmitter
sts UCSR1B, r20                                         ; Set TXEN1 and RXC1 enable flags

main:

get_Character:
lds r20, UCSR1A                 ; read UCSR1A I/O register to r20
sbrs r20, RXC1                  ; RXC1 = 1 new Char received
rjmp get_Character              ; RXC1 = 0 then no Char was received
lds r15, UDR1                   ; Read char in UDR1

com r15
out PORTB, r15                  ; Write chars to PORTB
com r15

put_Character:
lds r20, UCSR1A                 ; read UCSR1A I/O register to r20
sbrs r20, UDRE1                 ; UDRE1 = 1 buffer is empty
rjmp put_Character              ; UDRE1 = 0 buffer is not empty
sts UDR1, r15                   ; Write char to UDR1
rjmp get_Character              ; Jump back to loop
```

4.1 Flowchart 4

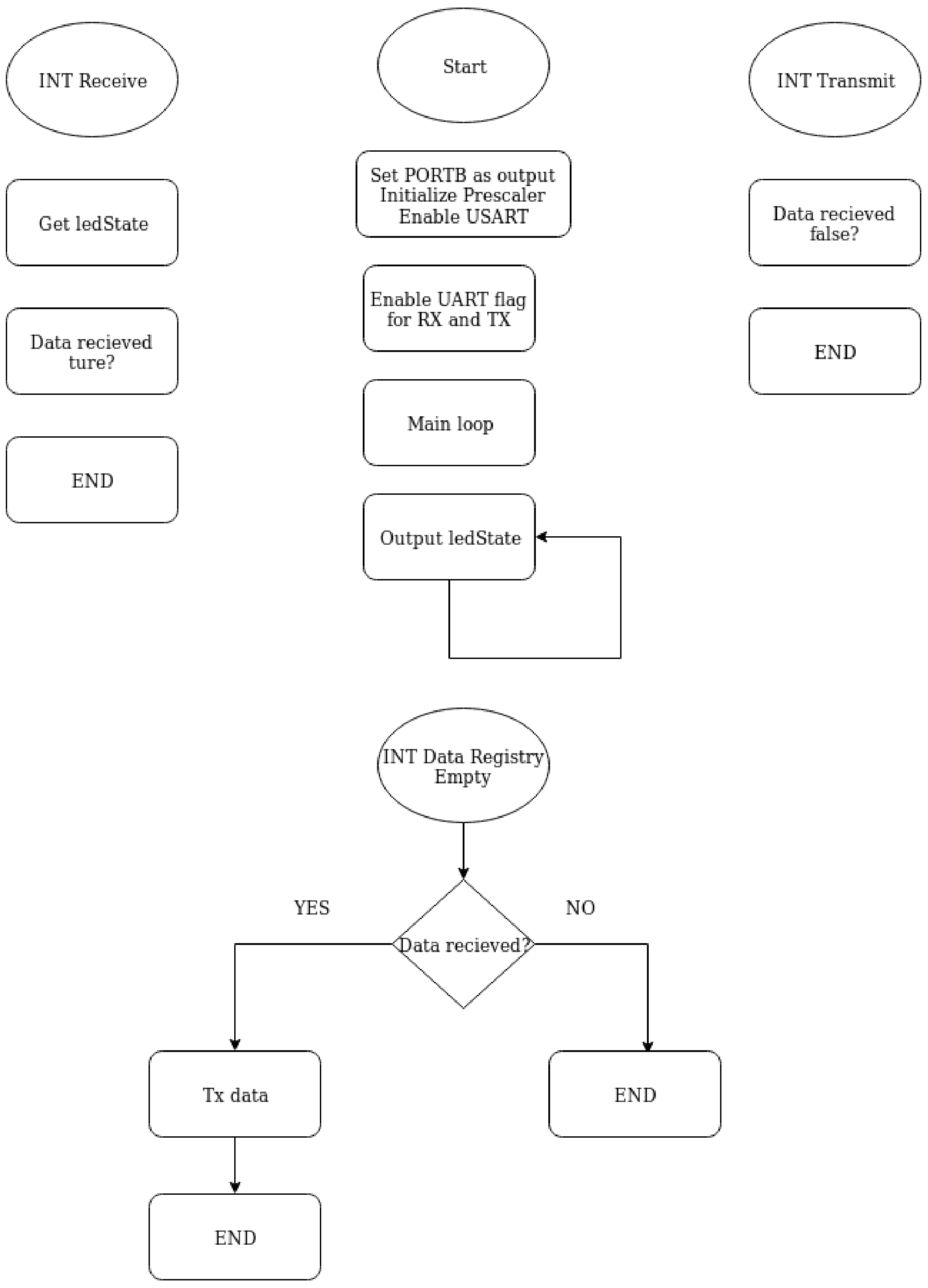


5 Task 5

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

```
    .include "m2560def.inc"

.def temp = r16
.def ledState = r17
.def complement = r18
.def dataReceived = r19

.equ TRANSFER_RATE = 12          ;1MHz, 4800 bps
.equ TRUE = 0x01
.equ FALSE = 0x00

.cseg

.org 0x00
rjmp reset

.org URXC1addr
rjmp data_received_interrupt

.org UDRE1addr
rjmp buffer_empty_interrupt

.org 0x72

reset:

ldi temp, LOW(RAMEND)
out SPL, temp
ldi temp, HIGH(RAMEND)
out SPH, temp

ser temp
out DDRB, temp

ldi temp, TRANSFER_RATE
sts UBRR1L, temp

ldi temp, (1<<RXEN1) | (1<<TXEN1) | (1<<RXCIE1) | (1<<UDRIE1)
sts UCSR1B, temp

sei
clr ledState


main_loop:
        rcall led_output
        rjmp main_loop

led_output:
        mov complement, ledState
        com complement
        out PORTB, complement

        ret

data_received_interrupt:
        lds ledState, UDR1              ;load received data to ledState
    ldi dataReceived, TRUE

    reti

buffer_empty_interrupt:
    cpi dataReceived, FALSE
    breq buffer_empty_end

        sts UDR1, ledState      ;send data
        ldi dataReceived, FALSE

    buffer_empty_end:
        reti
```

5.1 Flowchart 5


INT Receive
Get ledState
Data recieved ture?
END
Start
Set PORTB as output Initialize Prescaler Enable USART
Enable UART flag for RX and TX
Main loop
Output ledState
INT Transmit
Data recieved false?
END
INT Data Registry Empty
YES
Data recieved?
NO
Tx data
END
END