# Computer Technology I

# Lab. 2 : Subroutines

*Author:* Anas Kwefati
*Supervisor:* Anders Haggren
*Semester:* Autumn 2019
*Area:* Computer Science
*Course code:* 1DT301

## Contents

# 1 Task 1

```
;>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>
; 1DT301, Computer Technology I
; Date: 2016-09-15
; Author:
;       Anas Kwefati
;
; Lab number: 2
; Title: Subroutines
;
; Hardware: STK600, CPU ATmega2560
;
; Function: Program that switches between Ring counter and Johnson
    counter.
;       No delay between the button is pressed and the change between
    Ring/Johnson.
;       Each time I press the button, the program should change
    counter.

; Input ports: PORTA checks if we pressed the switch 0 (SW0; PA0).
;
; Output ports: PORTB turns on/off the light (LEDs)
;
; Subroutines: If applicable.
; Included files: m2560def.inc
;
; Other information:
;
; Changes in program: (Description and date)
;<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<

.include "m2560def.inc"

; Initialize SP, Stack Pointer
ldi r21, HIGH(RAMEND) ; R20 = high part of RAMEND address
out SPH,R21 ; SPH = high part of RAMEND address
ldi R21, low(RAMEND) ; R20 = low part of RAMEND address
out SPL,R21 ; SPL = low part of RAMEND address

;we initialize
ldi r16, 0xFF ;
out DDRB, r16 ; we set the DDRB as output

ldi r17, 0x00
out DDRA, r17 ; we set DDRA as input

ldi r16, 0xFF ; we load 0b1111 1111 to the register r16
out PORTB,r16 ; we set the PORTB to r16 SO it means that we put each
    light off

ldi r20, 0b11111110 ;This register will be used to check if we pressed
    SW0
ldi r19, 0b10111111 ;Turn on light at 0
ldi r22,0x00

loop:
        in r18, PINA ;we put the incoming data from PINA(input) to r18
        cp r20,r18 ; we compare if r20 and r18
```

```
        breq ring_counter ;if r18==r20 then go to ring_counter
        brne johnson_counter ;otherwise johnson_counter

;LED -> 0 == on and 1 == off
ring_counter:
        ldi r18, 0b11111110 ;We load 1111 1110 to r18
        call ring_loop

ring_loop:
        out PORTB, r18 ;We output r18 to PORTB, like that LED0 turns on
        call Delay ;We call the Delay
        com r18 ;we take the complement of r18. So here it would be
           0000 0001
        LSL r18 ;We do a Logical Shift Left, it shifts all bits to the
           left.
        ;So here we would get for the first r18 : 0000 0010
        com r18 ;we take the complement of r18, so we will get r18 =
           1111 1101

        ;Check if everything is off if true then go to ring counter to
           make infinite loop
        ldi r24,0xFF
        cp r24, r18 ;compare r24 with r18
        breq ring_counter ;if r24 == r18 go to ring_counter

;We check if we pressed SW0, if yes we go to Johnson_counter
        in r19, PINA
        cp r20,r19
        breq johnson_counter

        rjmp ring_loop ;we repeat the ring_loop


rjmp loop ; we go back at the beginning of the infinite loop

johnson_counter :
        ldi r19, 0b11111110 ;We load 1111 1110 to r19
        ldi r22, 0x00

johnson_loop:
        out PORTB, r19 ;We output r19 to PORTB, we turn the light LED0
        LSL r19 ; we do a logical shift left, so for the first one we
           will get
        ; r19 = 1111 1100
        call Delay
        cp r19, r22 ;we compare r19 with r22 to check if all LEDs are
           turned ON
        breq johnson ;if r19==r22 then go to johnson

;Check if PINA SW0 has been pressed if yes then it goes to ring counter
        in r18, PINA
        cp r20,r18
        breq ring_counter

        rjmp johnson_loop

rjmp loop ; we go back at the beginning of the infinite loop

;We do the reverse
```

```
johnson :
        out PORTB, r22 ;Output r22 to PORTB, so all LEDs are turned ON
        ldi r22, 0b11111111 ;Load 1111 1111 to r22
        call Delay
        ldi r19,0b10000000 ; Load 1000 0000 to r19

        more_john :
                out PORTB, r19 ;Ouput r19 to PORTB, so LED7 is OFF and
                   everything else is ON
                ASR r19 ;We do an Arithmetic Shift Right, it shifts all
                    bits to the Right
                ;So for the first one it will be r19 = 1100 0000
                call Delay
                cp r19, r22 ;compare r19 and r22
                breq johnson_counter ; if r19 == r22 go to
                   johnson_counter to repeat the process

;Check if PINA SW0 has been pressed if yes then it goes to ring counter
                in r18, PINA
                cp r20,r18
                breq ring_counter

        rjmp more_john



Delay :
; Generated by delay loop calculator
; at http://www.bretmulvey.com/avrdelay.html

        ldi  r21, 5
    ldi  r23, 20
    ldi  r24, 175
L1: dec  r24
    brne L1
    dec  r23
    brne L1
    dec  r21
    brne L1
        ret
```

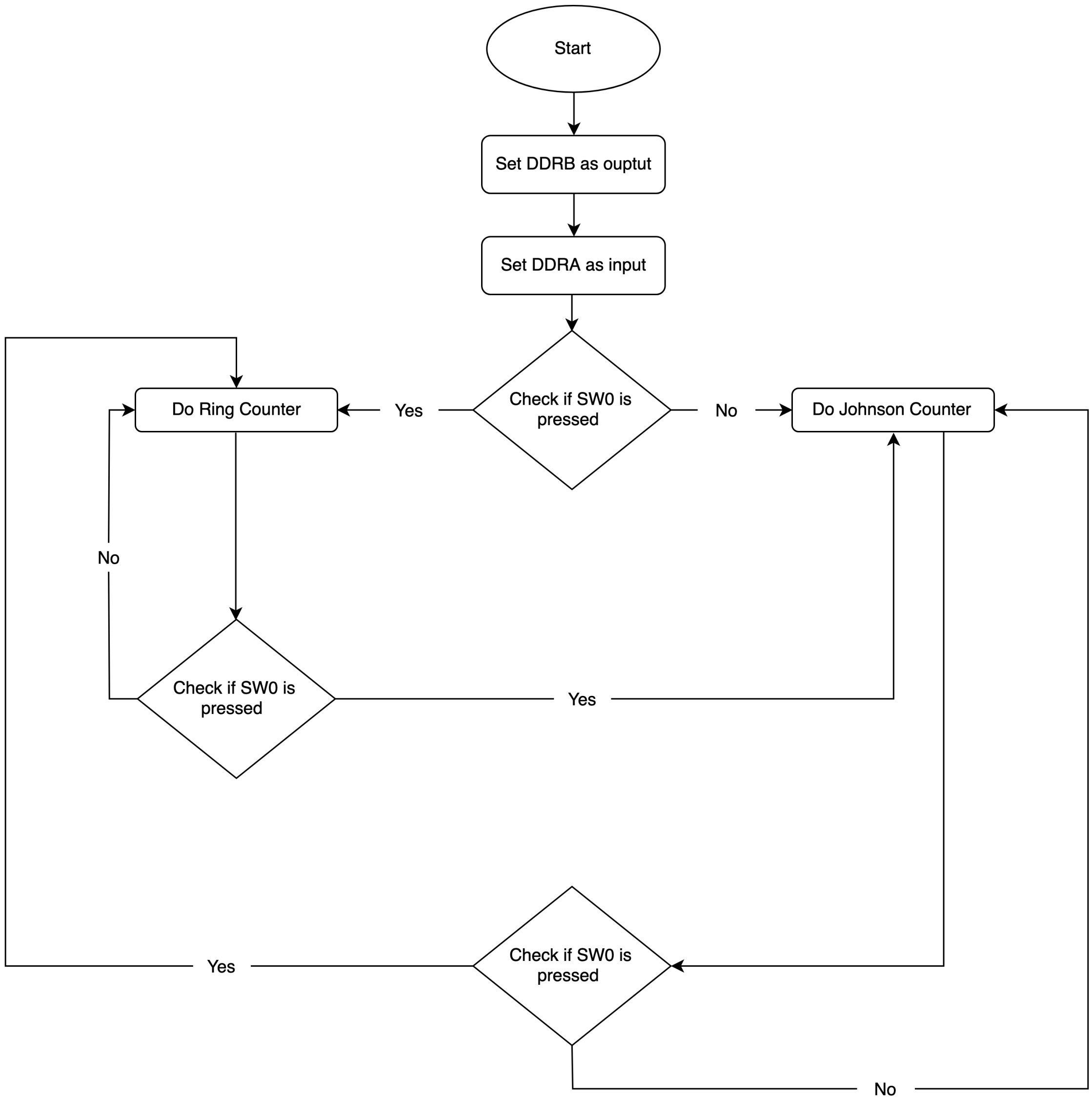


Figure 1: Task 1 flowchart

## 2 Task 2

For the second task the aim is to read switches and light to corresponding LED. This was done by using a data direction register

```
;>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>
; 1DT301, Computer Technology I
; Date: 2016-09-15
; Author:
;       Anas Kwefati
;
; Lab number: 2
; Title: Subroutines
;
; Hardware: STK600, CPU ATmega2560
;
; Function: Create an electronic dice. The number 1 to 6 should be
   generated randomly. The result should be displayed through the LEDs
;
; Input ports: PORTA checks if we pressed the switch 0 (SW0).
;
; Output ports: PORTB turns on/off the light (LEDs)
;
; Subroutines: If applicable.
; Included files: m2560def.inc
;
; Other information:
;
; Changes in program: (Description and date)
;<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<

.include "m2560def.inc"

; Initialize SP, Stack Pointer
ldi r21, HIGH(RAMEND) ; R20 = high part of RAMEND address
out SPH,R21 ; SPH = high part of RAMEND address
ldi R21, low(RAMEND) ; R20 = low part of RAMEND address
out SPL,R21 ; SPL = low part of RAMEND address

;we initialize
ldi r16, 0xFF ; we load 0b1111 1111 to r16
out DDRB, r16 ; we set the DDRB as output

ldi r17, 0x00 ; we load 0b0000 0000 to r17
out DDRA, r17 ; we set DDRA as input


out PORTB, r16 ;we output r16 to PORTB

ldi r18, 0b11111110 ; we load 0b1111 1110 to r18
;it will allow us to make sure that SW0 is pressed

ldi r20, 1 ; we load 0b0000 0001 to r20

ldi r16, 0b11111111 ;we load 0b1111 1111 to r16

loop :
        ;We check if SW0 is pressed or not
        in r19,PINA ;we put PINA data into r19
```

```
        cp r19, r18 ;we compare r19 to r18 (0b1111 1110)
        breq listening_loop ; if r19 == r18 then go to listening_loop

rjmp loop ;otherwise jump back to loop and repeat it until it is true (
    SW0 pressed)


listening_loop :
        inc r20 ;we increment r20 by 1
        cpi r20, 7 ;cpi allows us to compare constant numbers.
        ;so here compare r20 to 7
        breq reset ;if r20 == 7 we go to reset
        ;this part allow us to check if SW0 is still pressed or not.
        ;if PINA is still pressed, we stay in this loop and r20 gets +1
        ;if it is not pressed anymore, so we released the button we go
            to random
        in r19, PINA ;we put PINA data into r19
        cp r16,r19 ;we compare r16 (0b1111 1111) and r19
        breq random ; if r16 == r19 we go to random
rjmp listening_loop ;jump back to listening_loop if button SW0 not
    released

reset :
        ldi r20, 1 ;we set back r10 to 1 when r20 reaches 7
        rjmp loop ;and we jump back to the beginning loop

random :
;this part allows us to do the random process. Meaning, we check the
    constant
;If the Constant r20 is equal to the corresponding number
; it will go to another section of the program

        cpi r20, 1 ;we compare the constant r19 to check if r20 == 1
        breq number_one ;if yes we go to number_one
        cpi r20, 2
        breq number_two
        cpi r20, 3
        breq number_three
        cpi r20, 4
        breq number_four
        cpi r20, 5
        breq number_five
        cpi r20, 6
        breq number_six


number_one:
        ldi r22, 0b11111101 ;we load 0b1111 1101 to r22
        out PORTB, r22 ;we turn on the light LED 2
        rjmp loop ;we turn on the light and we go back to the loop and
            wait
        ;we wait for another SW0 pressed

number_two:
        ldi r22, 0b10111101
        out PORTB, r22
rjmp loop
number_three:
        ldi r22, 0b10101011
```

```
        out PORTB, r22
rjmp loop
number_four:
        ldi r22, 0b00111001
        out PORTB, r22
rjmp loop
number_five:
        ldi r22, 0b00101001
        out PORTB, r22
rjmp loop
number_six:
        ldi r22, 0b00010001
        out PORTB, r22
rjmp loop
```

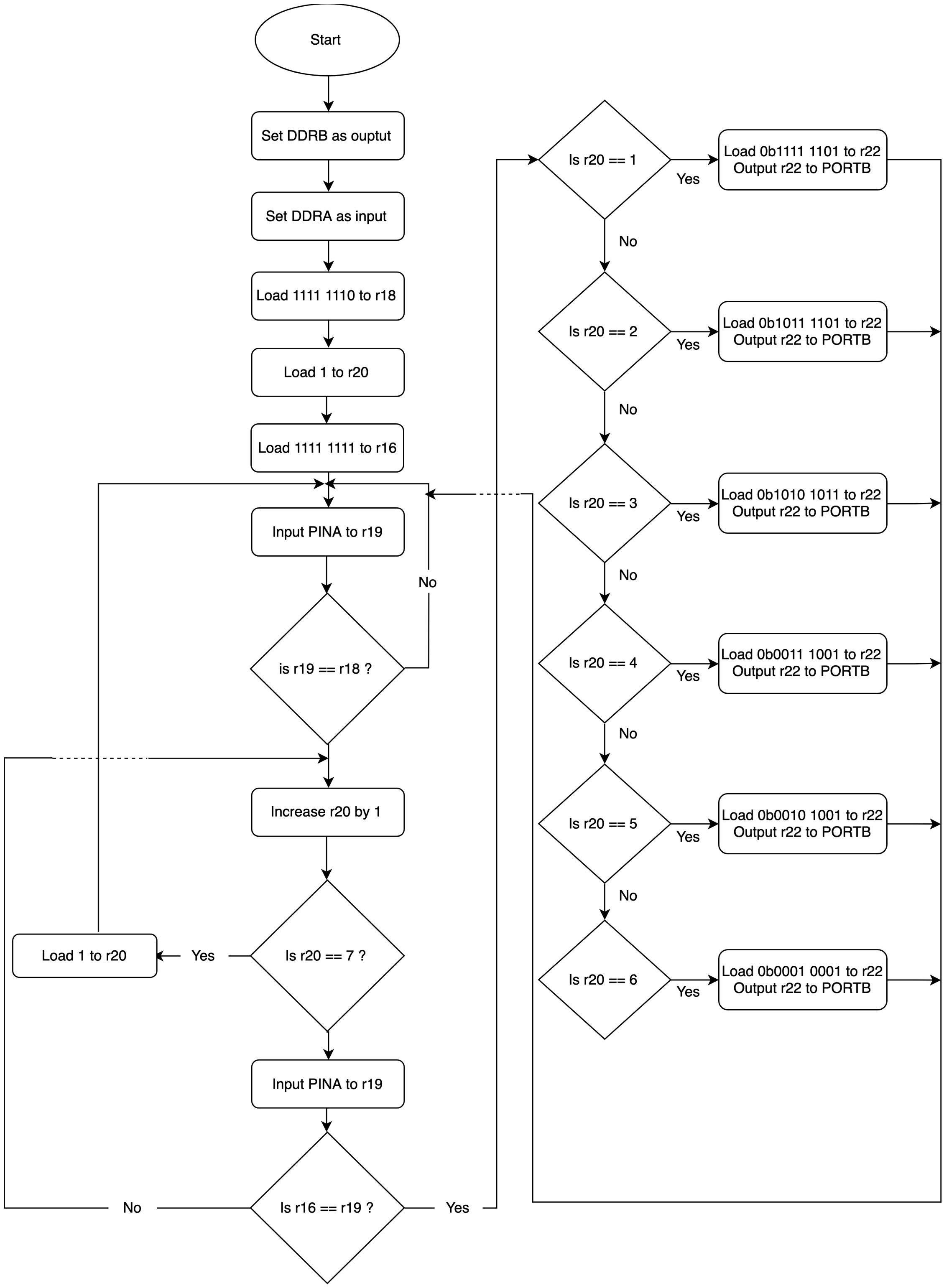


Figure 2: Task 2 flowchart

## 3 Task 3

```
;>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>
; 1DT301, Computer Technology I
; Date: 2016-09-15
; Author:
;       Anas Kwefati
;
; Lab number: 2
; Title: Subroutines
;
; Hardware: STK600, CPU ATmega2560
;
; Function: The program counts the number of time we press and release
   SW0
;
; Input ports: PORTA checks if we pressed the switch 0 (SW0).
;
; Output ports: PORTB turns on/off the light (LEDs)
;
; Subroutines: If applicable.
; Included files: m2560def.inc
;
; Other information:
;
; Changes in program: (Description and date)
;<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<
.include "m2560def.inc"

; Initialize SP, Stack Pointer
ldi r21, HIGH(RAMEND) ; R20 = high part of RAMEND address
out SPH,R21 ; SPH = high part of RAMEND address
ldi R21, low(RAMEND) ; R20 = low part of RAMEND address
out SPL,R21 ; SPL = low part of RAMEND address

;we initialize
ldi r16, 0xFF ;
out DDRB, r16 ; we set the DDRB as output

ldi r17, 0x00
out DDRA, r17 ; we set DDRA as input

out PORTB, r16

ldi r18, 0b00000000 ; counter

ldi r19, 0b11111101 ; to check if button is pressed
ldi r23, 0xFF

loop :
        in r20, PINA
        cp r20,r19 ;compare r20 and r19
        breq counting ;if equal then go to counting
rjmp loop


counting :
        inc r18 ; we add +1 to the counter
        ;so when we press the first time r18 will become : 0b0000 0001
```

```
        mov r21, r18 ; we copy r18 to r21
        com r21 ; we put the reverse of what was in r21.

        ;0 becomes 1 and 1 becomes 0. We put the complement of r21
        ;So here, r21 will become 0b1111 1110
        ;we display the binary value. When LEDs are turned on it means
            1
        ;When LED is not turned on it means 0.
        ;For example when we press, we count 1 and its binary value is
            : 0000 0001
        ;We reverse it and we get 1111 1110. Which means we turn on the
             light at LED1
        ;In LED logic, 0 means light on and 1 means light off.
        ;When light is on (0 for LED logic) for us it will mean 1.
        ;When light is off (1 for LED logic) for us it will mean 0.

        out PORTB, r21 ;we output r21 in PORTB to turn the correct LED
            position

        counting_loop :

                in r20, PINA ; we take the data of PINA and put it in
                    r20
                cp r20, r23 ; we compare r20 with r23

                breq whatever ;if r20 == r23 we go to whatever

                rjmp counting_loop ;else we go back to the beginning of
                     that loop

whatever :
        inc r18 ;we increment r18 by 1
        mov r21, r18 ;we copy r18 to r21
        com r21 ;  we put the reverse of what was in r21.

        out PORTB, r21 ;we output it in PORTB

        rjmp loop ;we start over, from the beginning
```

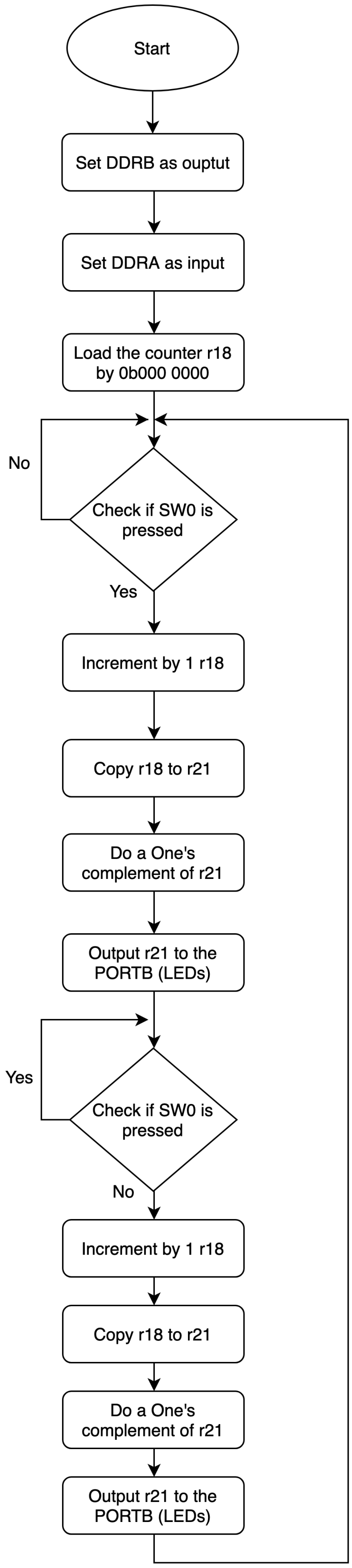


Figure 3: Task 3 flowchart

# 4 Task 4

For task 5 we needed to create a ring counter. This was done by creating a loop which constantly shifts the PORTB register one sideways with a delay.

```
;>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>
; 1DT301, Computer Technology I
; Date: 2016-09-15
; Author:
; Anas Kwefati
;
; Lab number: 2
; Title: Subroutines
;
; Hardware: STK600, CPU ATmega2560
;
; Function: Ring Counter program with a different delay, with a number
    of ms transferred to
;register pair r25:24
;
; Input ports: None
;
; Output ports: PORTB turns on/off the light (LEDs)
;
; Subroutines: If applicable.
; Included files: m2560def.inc
;
; Other information:
;
; Changes in program: (Description and date)
;<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<

.include "m2560def.inc"

; Initialize SP, Stack Pointer
ldi r21, HIGH(RAMEND) ; R20 = high part of RAMEND address
out SPH,R21 ; SPH = high part of RAMEND address
ldi R21, low(RAMEND) ; R20 = low part of RAMEND address
out SPL,R21 ; SPL = low part of RAMEND address

.equ nbrExecution = 2000 ; equ assigns a constant value to a label
    therefore this value cannot be changed later
; we define the number of loop executions as constant

;we initialize
ldi r16, 0xFF ;
out DDRB, r16 ; we set the DDRB as output

ring_counter:
        ldi r18, 0b11111110

ring_loop:
        out PORTB, r18 ;we put the value of r18 to PORTB which should
            turn on the light
        call Delay
        com r18
        LSL r18
        com r18
```

```
        ;Check if everything is off if true then go to ring counter to
           make infinite loop
        ldi r21,0xFF
        cp r21, r18
        breq ring_counter
        rjmp ring_loop

Delay :

        ; r25:r24 is a 16 bit register and so can have 65,536 different
            numbers, it can count 256 times longer than with an 8 bit
           register only.

        ;The lower byte of the 16-bit-adress is located in the lower
           register, the higher byte in the upper register. Both parts
            have their own names, e.g. the higher byte of Z is named
           ZH (=R31), the lower Byte is ZL (=R30).
        ;These names are defined in the standard header file for the
           chips. Dividing these 16-bit-pointer-names into two
           different bytes is done like follows:
        ldi r25, HIGH(nbrExecution) ; We load the Most Significant Bit
           register with the upper byte from the address nbrExecution
        ldi r24, LOW(nbrExecution) ; We set the Least Significant Bit
           register with the lower byte from the address nbrExecution

        wait_milliseconds :
                rcall sub_delay ;we call the sub_delay that contains 1
                   ms that is going to be repeated 1000 times to do 1s
                sbiw r24, 1 ; By doing that we substract 1 from the
                   register pair r25:r24
                ;We decrease the double register value by 1
                ;The instruction "SBIW R24,1" decreases the register
                   pair word-wise. That means that whenever the LSB (
                   Least Significant Bit r24) underflows, the MSB(Most
                    Significant Bit r25) is also automatically reduced
                    by 1.
                brne wait_milliseconds ; if not zero start loop again,
                   if zero continue

sub_delay :
        ; Generated by delay loop calculator
        ; at http://www.bretmulvey.com/avrdelay.html
        ;
        ; Delay 2 000 cycles
        ; 500us at 4.0 MHz

                ldi  r17, 3
                ldi  r19, 152
        L1: dec  r19
                brne L1
                dec  r17
                brne L1
                nop
                ret
```

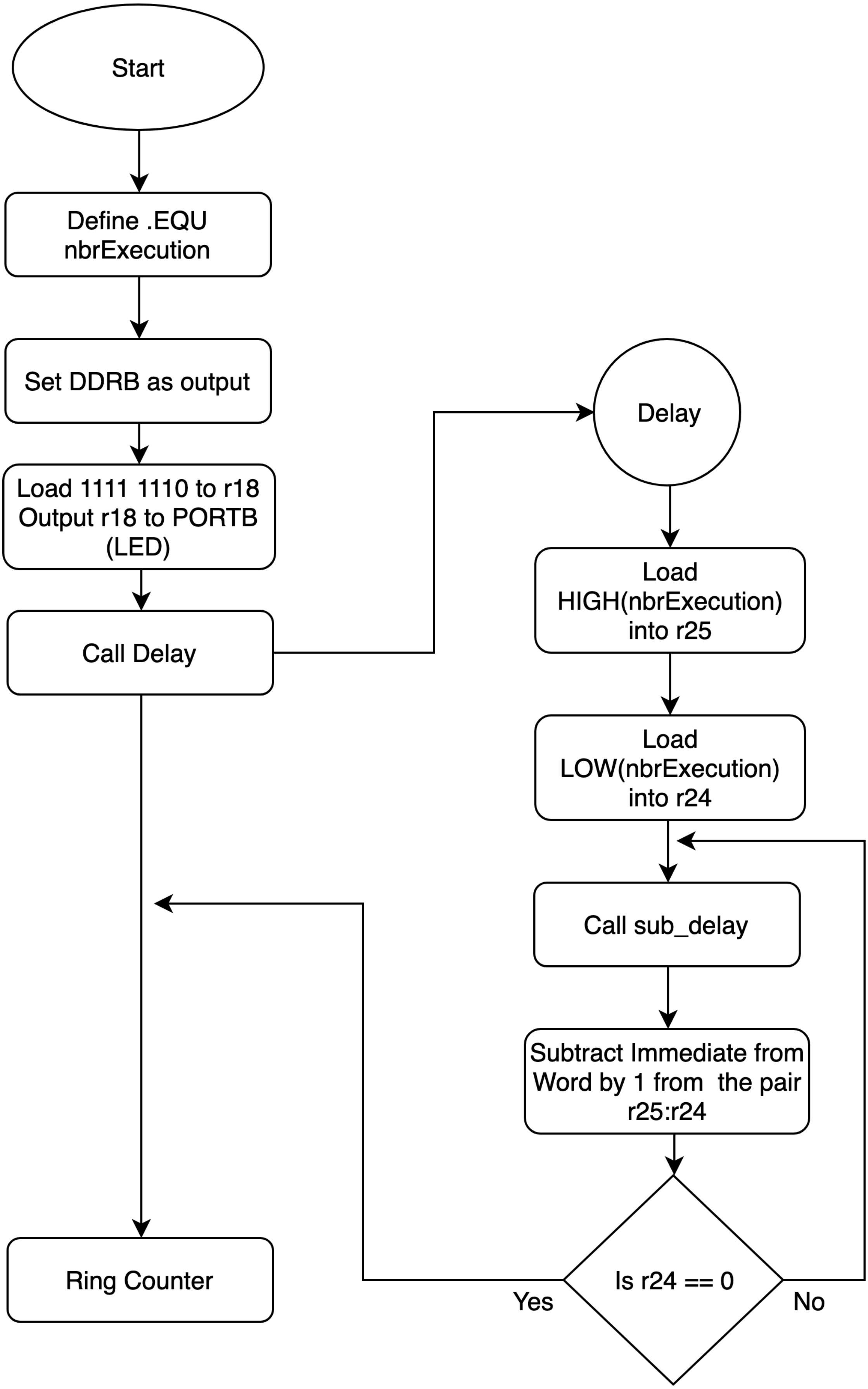


Figure 4: Task 4 flowchart