

# Computer Technology I

## Lab. 2: Subroutines



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HAGGREN

Semester: Autumn 2019 Area: Computer Science Course code: 1DT301

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```
; 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. 0 \times 00
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
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 \rightarrow 0 == on and 1 == off
ring_counter:
        ldi r18, Ob111111110 ; We load 1111 1110 to r18
        call ring_loop
ring_loop:
        out PORTB, r18 ; We output r18 to PORTB, like that LEDO 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 SWO, 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, Ob111111110 ;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 SWO 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, 0b111111111 ;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 SWO 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
```

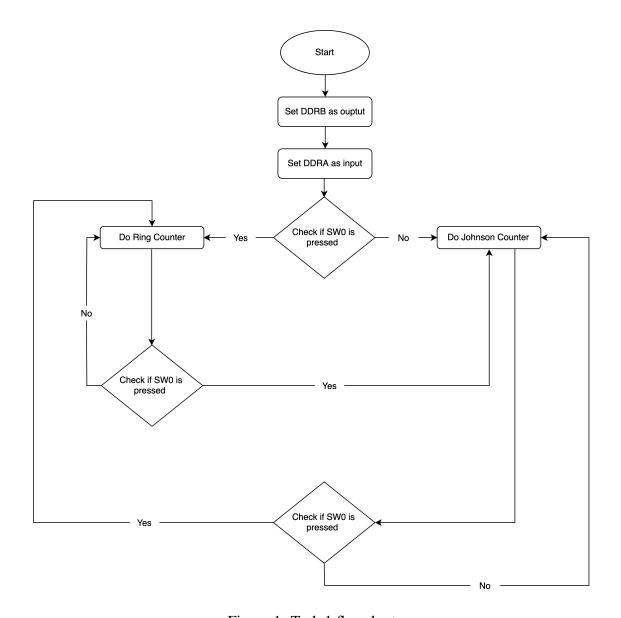


Figure 1: Task 1 flowchart

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 (SWO).
; 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, Ob111111110 ; we load Ob1111 1110 to r18
;it will allow us to make sure that SWO is pressed
ldi r20, 1 ; we load 0b0000 0001 to r20
ldi r16, 0b111111111 ; we load 0b1111 1111 to r16
loop :
       ; We check if SWO 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 (
   SWO 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 SWO 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 SWO 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, 0b111111101 ;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 SWO 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
number_six:
        ldi r22, 0b00010001
        out PORTB, r22
rjmp loop
```

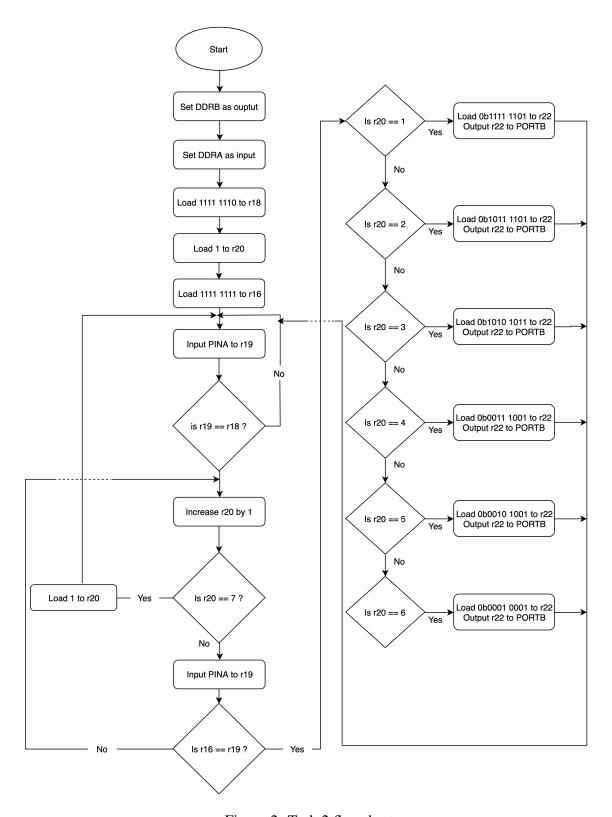


Figure 2: Task 2 flowchart

```
; 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 (SWO).
; 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, Ob111111101; 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 Ob1111 1110
        ; we display the binary value. When LEDs are turned on it means
        ; 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
```

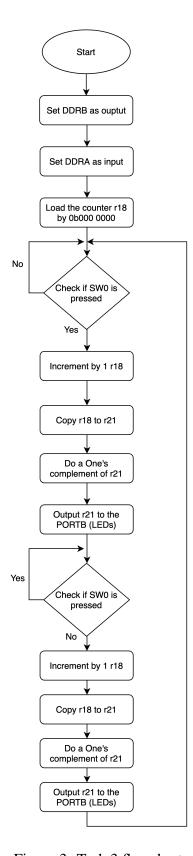


Figure 3: Task 3 flowchart

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
```

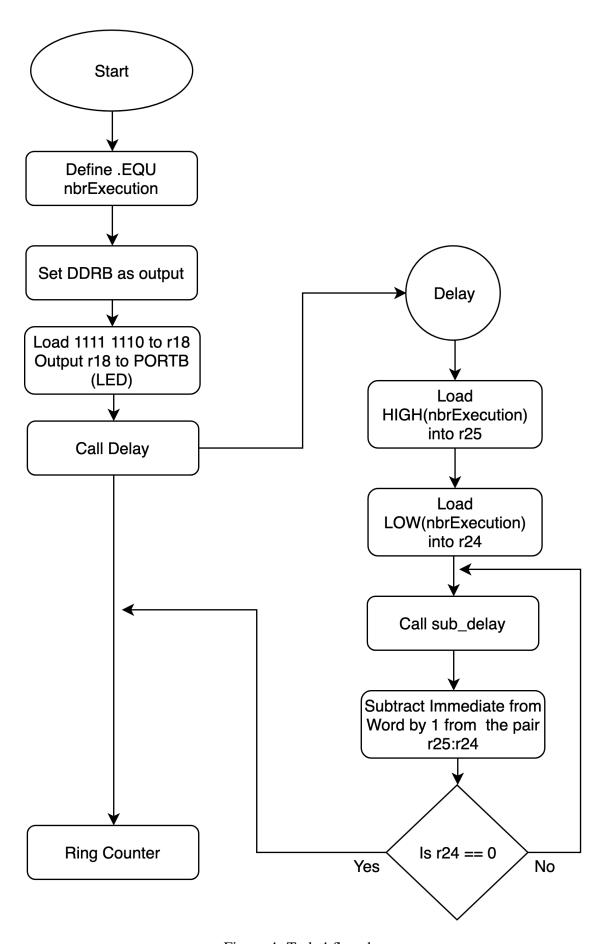


Figure 4: Task 4 flowchart