Computer Technology I

Lab. 3 : Interrupts

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Course code: 1DT301

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1 Task 1 -

Write a program that turns ON and OFF a LED with a push button. The LED will be extinguished when pressing the button. The program will use Interrupt. Connect the push buttons to PORT D. The program should have a main program that runs in a loop and wait for the interrupts. An interrupt routine is called when the push button is pressed. Each time the button is pressed, the lamp should switch from 'OFF' to 'ON', or from 'ON' to 'OFF'.

```
;>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>
; 1DT301, Computer Technology I
; Date: 2019-09-29
; Author:
; Loic GALLAND
; Leonardo PEDRO
;
; Lab number: 3
; Title: How to use interrupts
;
; Hardware: STK600, CPU ATmega2560
;
; Function: Program that when clicking on a switch the LEDs switch from
    ON to OFF and vice versa. It is using interupts to do it.
;
; Input ports: PORTD
;
; Output ports: PORTB
;
; Subroutines: If applicable.
; Included files: m2560def.inc
;<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<
.include "m2560def.inc"

.org 0x00       ;Location where the program will start
rjmp start

.org INT0addr   ;INT0 interrupt address
rjmp interrupt_0

.org 0x72

start:
.def LIGHT = r21        ;Give a name to r21
; Initialize SP, Stack Pointer
ldi r20, HIGH(RAMEND) ; R20 = high part of RAMEND address
out SPH,R20 ; SPH = high part of RAMEND address
ldi R20, low(RAMEND) ; R20 = low part of RAMEND address
out SPL,R20 ; SPL = low part of RAMEND address

ldi r16,0xFF    ;Load 0xFF into r16 to initialize PORTB
out DDRB,r16
ldi r16,0x00    ;Load 0x00 into r16 and initialize PORTD
out DDRD,r16

ldi r18, 0xFF   ;initiliaze the LEDs (turn them off)
out PORTB, r18
```

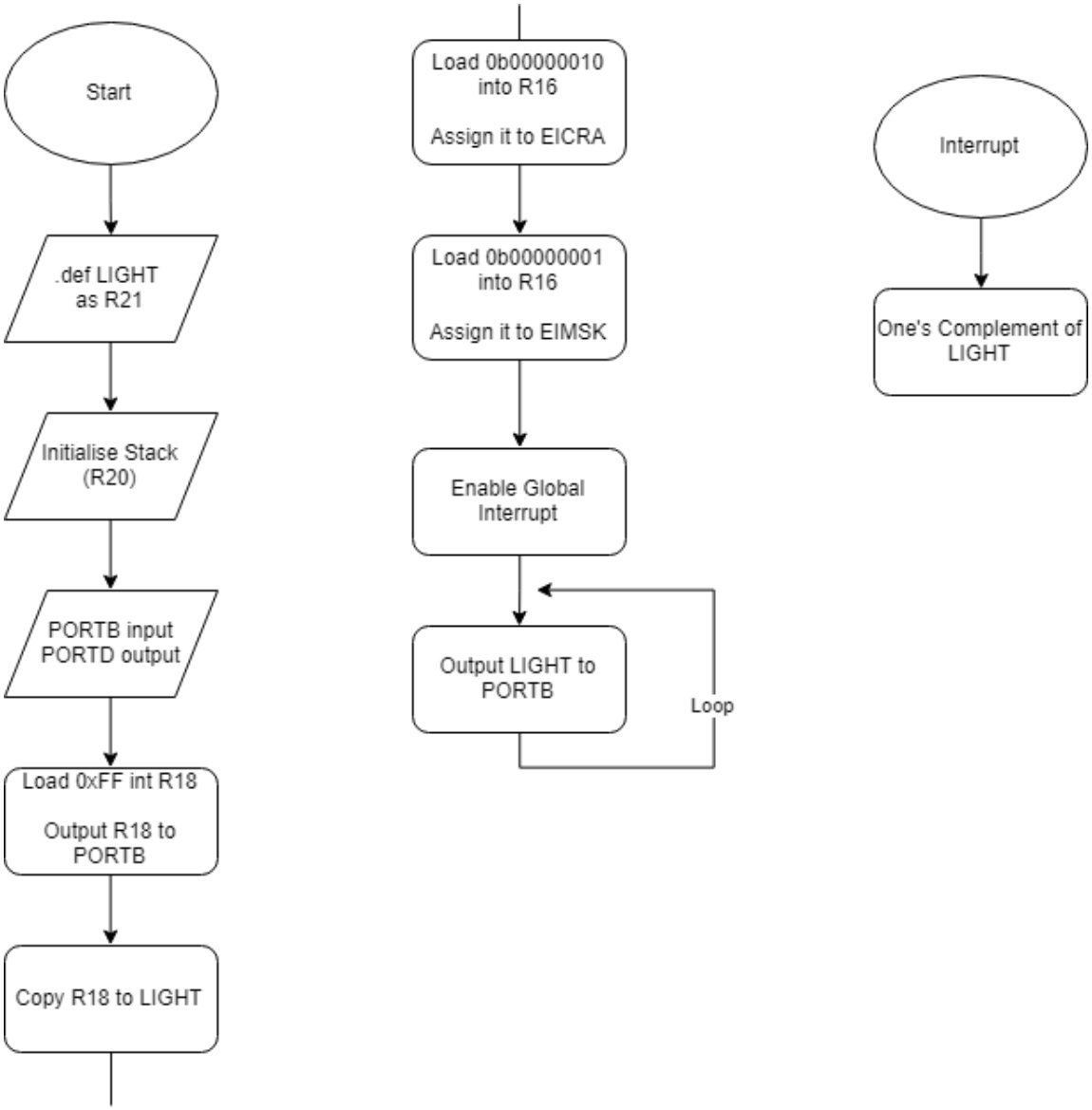
```
mov LIGHT,r18   ;Copy the r18 into "LIGHT"
;Initialised the Interrupts
ldi r16, 0b00000010     ;INT0 falling edge
sts EICRA, r16  ;Setup internal

ldi r16, 0b00000001     ;INT0 enable, pin 0 of PORT D
out EIMSK, r16
sei     ;Global interrupt enable

main:
        out PORTB, LIGHT        ;Turn on the LEDs
rjmp main

interrupt_0:
        com LIGHT       ;Change the 0s into 1s, to show the lights on
RETI
```

This is the flowchart of the task 1:



2 Task 2 - Switch – Ringcounter / Johnsoncounter, with interrupt

Write a program that by means of a switch can choose to flash 8 LEDs either in the form of a ring counter or in the form of a Johnson counter. Use the switch SW0 connected to PORTD to switch between the two counters. Each time the button is pressed, a shift between the two counters should take place. By using interrupts you'll swap directly with no delay.

```
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;
; Lab number: 3
; Title: How to use interrupts
;
; Hardware: STK600, CPU ATmega2560
;
; Function: Program that when clicking on a switch switches between
    Ring Counter and Johnson Counter
;
; Input ports: PORTD
;
; Output ports: PORTB
;
; Subroutines: If applicable.
; Included files: m2560def.inc
;<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<
.include "m2560def.inc"

.org 0x00
rjmp start

.org INT0addr   ;Address of the Interrupt 0
rjmp interrupt

.org 0x72

start:
; Initialize SP, Stack Pointer
ldi r20, HIGH(RAMEND) ; R20 = high part of RAMEND address
out SPH,R20 ; SPH = high part of RAMEND address
ldi R20, low(RAMEND) ; R20 = low part of RAMEND address
out SPL,R20 ; SPL = low part of RAMEND address

ldi r20,0b00000010 ;Setting INT0 into falling edge
sts EICRA,r20
ldi r20,0b00000001 ;INT0 enable, pin 0 of Port D
out EIMSK,r20

ldi r17,0xFF    ;Set PORTB as output
out DDRB, r17

ldi r17,0x00    ;Set PORTD as input
out DDRD,r17
```
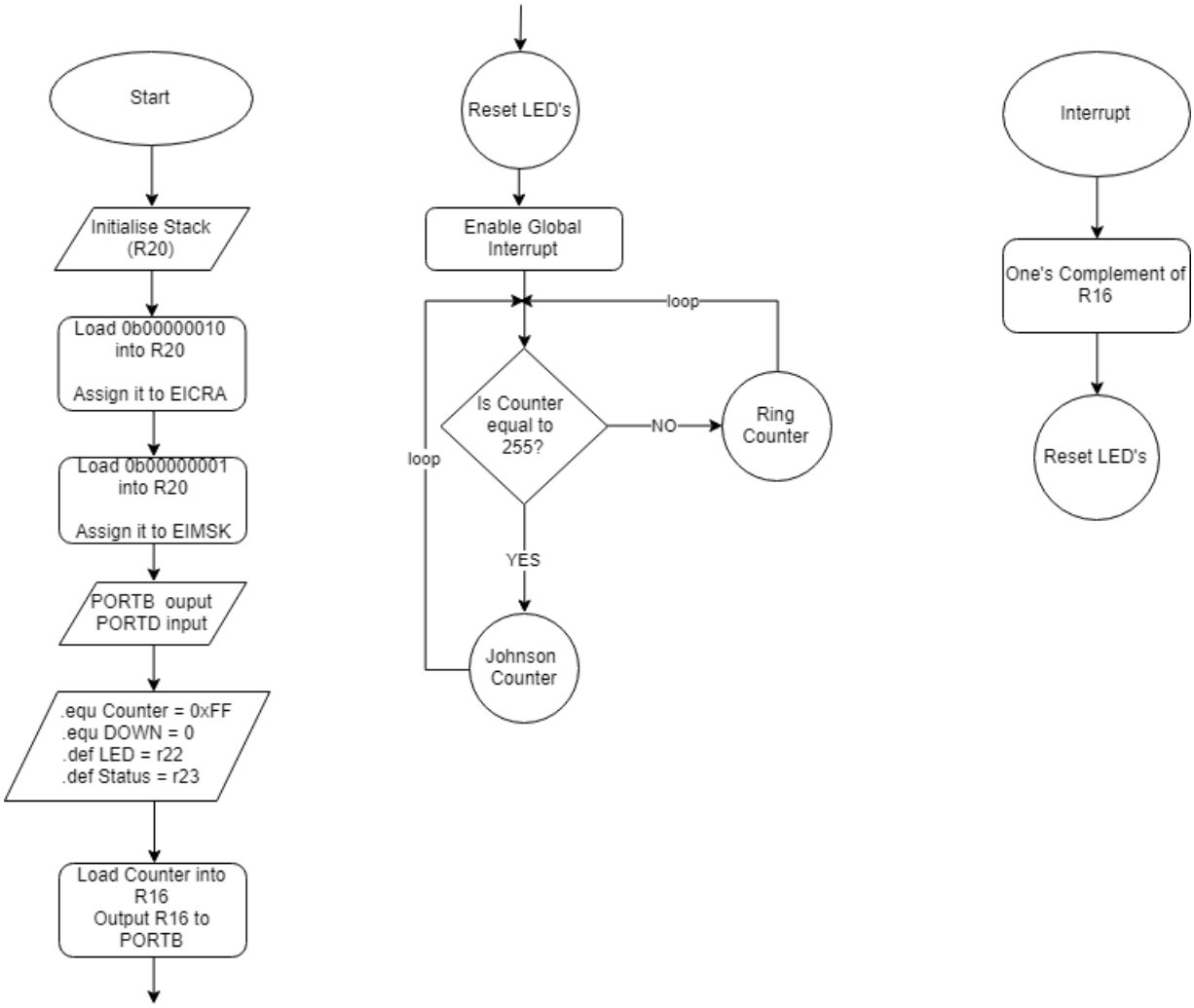

```
.equ Counter = 0xFF     ;This variable will help us to know in which
   counter the program is to switch to the other one
.equ DOWN = 0   ;Variable to check if the Johnson counter is going left
    or right
.def LED = r22  ;Giving a name to r22 like if it a variable
.def Status = r23       ;Same here
ldi Status,DOWN ;Loading 0 (DOWN) into R23(Status)

ldi r16, Counter        ;iniatialize LEDs (Turn them off)
out PORTB,r16

call reset ;To reset the LEDs
sei     ;Global interrupt enable

main:
        cpi r16, Counter        ;Check in which program it is
                breq Ring_Johnson       ;Send to Johnson counter if r16
                    = 0xFF

        Johnson_Ring:   ;Else goes here ans send to Ring counter

                call RC ;Call the Ring Counter routine
        rjmp main

        Ring_Johnson:
                call JC ;Call the Johnson Counter routine

rjmp main

reset:  ;To reset the LEDS
ldi LED,0b11111110      ;Load 254 into LED.
out PORTB,LED   ;Show the result on the LEDs.
RET     ;Return to where the reset was called.

RC:     ;RING COUNTER
        SBIS PORTB,PINB7 ;If the LED7 is ON then reset the LEDs
           otherwise skip the next line.
                ldi LED,0b11111110
        SBIC PORTB,PINB7        ;If the LED7 is OFF then Rotate
           otherwise skip the next line
                rol LED ;Rotate to the left
        out PORTB,LED   ;output to PORTB to show the LEDs
        call Delay      ;Delay of 0.5 sec
rjmp main

JC:     ;JOHNSON COUNTER
        cpi Status,DOWN ;Check if the LEDs needs to go left
                breq JCLEFT     ;IF Status =0x00 go to JCLEFT
        rjmp JCRIGHT    ;Otherwise go to JCRIGHT

        shift_left_right:
        ldi LED, 0b10000000     ;Reset the LEDs to make go right
        out PORTB,LED
        call Delay
        com Status      ;Change the status to 0xFF
        rjmp JCRIGHT

        shift_right_left:
```

```
        com Status      ;Change the status to 0x00
        rjmp JCLEFT     ;Jump back to JCLEFT

        JCLEFT:
                sbis PORTB,PINB7        ;Checks if LED7 is on
                        rjmp shift_left_right   ;if it is on then jump
                           to shift_left_right
                LSL LED ;Otherwise Logical shift to the left for the
                   LEDs
                out PORTB, LED  ;output to PORTB
                CALL Delay      ;Delay of 0.5 sec
        rjmp finish

        JCRIGHT:
                sbic PORTB,PINB0        ;If LED7 is off then jump to
                   shift_right_left
                        rjmp shift_right_left
                ASR LED ;Otherwise skip the jump and Arithmetic shift
                   right
                out PORTB,LED
                CALL Delay

finish:
RET     ;Return to where to it was called

interrupt:
com r16 ;To change between
call reset
RETI

Delay:
; Generated by delay loop calculator
; at http://www.bretmulvey.com/avrdelay.html
; Delay 500 000 cycles
; 500ms at 1 MHz
    ldi  r18, 3
    ldi  r19, 138
    ldi  r20, 86
L1: dec  r20
    brne L1
    dec  r19
    brne L1
    dec  r18
    brne L1
    rjmp PC+1
RET
```

This is the flowchart of the task 2:



3 Task 3 - Rear lights on a car

Program that simulates the rear lights on a car The 8 LEDs should behave like the rear lights.

```
;>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>
; 1DT301, Computer Technology I
; Date: 2019-09-29
; Author:
; Loic GALLAND
; Leonardo PEDRO
;
; Lab number: 3
; Title: How to use interrupts
;
; Hardware: STK600, CPU ATmega2560
;
; Function: Program that acts like the rear lights of a car. Either
   blinking right, left or just normal
;
; Input ports: PORTD
;
; Output ports: PORTB
;
; Subroutines: If applicable.
; Included files: m2560def.inc
;<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<
.include "m2560def.inc"

.org 0x00
rjmp start

.org INT0addr   ;Address of Interrupt 0
rjmp BlinkRight

.org INT1addr  ;Address of Interrupt 1
rjmp normal

.org INT2addr   ;Address of Interrupt 2
rjmp BlinkLeft

.org 0x72

start:
; Initialize SP, Stack Pointer
ldi r20, HIGH(RAMEND) ; R20 = high part of RAMEND address
out SPH,R20 ; SPH = high part of RAMEND address
ldi R20, low(RAMEND) ; R20 = low part of RAMEND address
out SPL,R20 ; SPL = low part of RAMEND address

ldi r20,0b00101010 ;Setting INT0-INT1-INT2 into falling edge
sts EICRA,r20
ldi r20,0b00000111 ;Enable INT0-INT1-INT2
out EIMSK,r20

ldi r17,0xFF    ;Set PORTB as output
out DDRB, r17
```

```
ldi r17,0x00    ;Set PORTD as input
out DDRD,r17

ldi r16, 0xFF   ;Initialized LED state
out PORTB, r16

.def LED = r16  ;Give the name "LED" to the register number 16
.def Normal_Right = r22 ;Give the name "Normal_Right" to the register
   number 22, will be used to simulate the left rear light
ldi Normal_Right, 0b11000000
.def Normal_Left = r21  ;Give the name "Normal_Left" to the register
   number 21 will be used to simulate the right rear light
ldi Normal_Left,0b00000011
sei     ;Global interrupt enable


ldi r23, 1      ;Variable to know in which configuration we are in.


Main:
        cpi r23, 1      ;If r23 = 1 then branch to NLED which is the
           normal LEDs:
        breq NLED

        cpi r23, 2      ;If r23 = 2 then branch to BLeft which is the
           blinking to left.
        breq BLeft

        cpi r23, 3 ;If r23 = 3 then branch to BLeft which is the
           blinking to left.
        breq BRight


rjmp Main

NLED:   ;Routine for turning on the both rear lights, for the "normal"
   configuration
ldi LED, 0b00111100
out PORTB, LED
rjmp Main       ;Jumps back to "Main" loop

BLeft: ;RING COUNTER

        SBIS PORTB,PINB7 ;If the LED7 is on then reset the LEDs
           otherwise skip the next line
                ldi LED,0b00010000
        SBIC PORTB,PINB7        ;If the LED7 is not on then Rotate
           otherwise skip the next line
                rol LED ;Rotate to the left
        mov r17,LED     ;Copy the info of "LED" and load it into r17
        add r17,Normal_Left     ;Add the 0b00000011 to r17 to make it
           become like that: 00010011 for the first round
        COM r17 ;One's Complement of r17 to switch the 0s into 1s to
           output the correct binary code for the LEDs
        out PORTB,r17   ;output to PORTB to show the LEDs
        call Delay      ;Delay of 0.5 sec
rjmp main
```

```
BRight:
        SBIS PORTB,PINB0 ;If the LED0 is on then reset the LEDs
           otherwise skip the next line
                ldi LED,0b00001000
        SBIC PORTB,PINB0        ;If the LED0 is not on then Rotate
           otherwise skip the next line
                ror LED ;Rotate to the left
        mov r17,LED     ;Copy the info of "LED" and load it into r17
        add r17,Normal_Right    ;Add the 0b00000011 to r17 to make it
           become like that: 00010011 for the first round
        COM r17 ;One's Complement of r17 to switch the 0s into 1s to
           output the correct binary code for the LEDs
        out PORTB,R17   ;output to PORTB to show the LEDs
        call Delay      ;Delay of 0.5 sec
rjmp main


normal: ;Interupt for the normal lights
ldi r23, 1      ;Load 1 into r23 to know later on which program we are
    in
RETI    ;Return to where the interrupt interrupted the code

BlinkLeft:      ;Interrupt for when we need to blink left
ldi r23, 2      ;Load 2 into r23 to know later on which program we are
    in
ldi LED,0b00010000      ;Initial state of the LEDs
RETI    ;Return to where the interrupt interrupted the code

BlinkRight:     ;Interrupt for when we need to blink left
ldi r23, 3      ;Load 3 into r23 to know later on which program we are
    in
ldi LED,0b00001000      ;Initial state of the LEDs
RETI    ;Return to where the interrupt interrupted the code

Delay:
; Generated by delay loop calculator
; at http://www.bretmulvey.com/avrdelay.html
; Delay 500 000 cycles
; 500ms at 1 MHz
    ldi  r18, 3
    ldi  r19, 138
    ldi  r20, 86
L1: dec  r20
    brne L1
    dec  r19
    brne L1
    dec  r18
    brne L1
    rjmp PC+1
RET
```

This is the flowchart of the task 3:

4 Task 4 - Rear lights on a car, with light for brakes

```
;>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>
; 1DT301, Computer Technology I
; Date: 2019-09-29
; Author:
; Loic GALLAND
; Leonardo PEDRO
;
; Lab number: 3
; Title: How to use interrupts
;
; Hardware: STK600, CPU ATmega2560
;
; Function: Same program as Task 3, but now there is another Interrupt
   to simulate the brakes. When breaking all the lights needs to be
   turned on.
;                     When blinking right LED7-4 light up and LED3-0
   do Ring Counter to the right.
;                     When blinking left LED3-0 light up & LED7-4 do
   Ring Counter to the left.
; Input ports: PORTD
;
; Output ports: PORTB
;
; Subroutines: If applicable.
; Included files: m2560def.inc
;<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<
.include "m2560def.inc"

.org 0x00
rjmp start

.org INT0addr   ;Address of Interrupt 0, used for blinking right.
rjmp BlinkRight

.org INT1addr   ;Address of Interrupt 1, used for normal lights.
rjmp Normal_Interrupt

.org INT2addr   ;Address of Interrupt 2, used for the break lights.
rjmp Press_Break

.org INT3addr   ;Address of Interrupt 3, used for blinking left.
rjmp BlinkLeft

.org 0x72

start:
; Initialize SP, Stack Pointer
ldi r20, HIGH(RAMEND) ; R20 = high part of RAMEND address
out SPH,R20 ; SPH = high part of RAMEND address
ldi R20, low(RAMEND) ; R20 = low part of RAMEND address
out SPL,R20 ; SPL = low part of RAMEND address

ldi r20,0b10101010 ;Setting INT0-INT1-INT2-INT3 into falling edge
sts EICRA,r20
ldi r20,0b00001111 ;Enable INT0-INT1-INT2-INT3
out EIMSK,r20
```

```
ldi r17,0xFF    ;Set PORTB as output
out DDRB, r17

ldi r17,0x00    ;Set PORTD as input
out DDRD,r17

ldi r16, 0xFF   ;Iniatialize the LEDs
out PORTB, r16

.def LED = r16  ;Give the name "LED" to the register number 16
.def Normal_Right = r22 ;Give the name "Normal_Right" to the register
   number 22, will be used to simulate the left rear light
ldi Normal_Right, 0b11000000
.def Normal_Left = r21  ;Give the name "Normal_Left" to the register
   number 21 will be used to simulate the right rear light
ldi Normal_Left,0b00000011

sei     ;Global interrupt enable


ldi r23, 1      ;Variable to know in which configuration we are in.


Main:
        cpi r23,1       ;If r23 = 1 then branch to NLED which is the
           normal LEDs:
        breq NLED

        cpi r23, 2      ;If r23 = 2 then branch to BLeft which is the
           blinking to right.
        breq BRight

        cpi r23, 3      ;If r23 = 3 then branch to BLeft which is the
           blinking to left.
        breq BLeft
rjmp Main

NLED:
        ldi LED, 0b00000000     ;Load 0x00 into "LED", to "reset" it
        ADD LED,Normal_Right    ;Add both side of the rear lights with
           binary code
        add LED,Normal_Left             ; 0b11000011
        mov r17,LED     ;Copy the info from LED
        COM r17 ;One's complement of r17
        out PORTB, r17
rjmp Main

BLeft: ;RING COUNTER
        SBIS PORTB,PINB7 ;If the LED7 is on then reset the LEDs
           otherwise skip the next line
                ldi LED,0b00010000
        SBIC PORTB,PINB7        ;If the LED7 is not on then Rotate
           otherwise skip the next line
                rol LED;Rotate to the left
        call Out_LED_Left       ;call the method that will ouput to the
            LEDs
        call Delay      ;Delay of 0.5 sec
rjmp main
```

```
BRight:
        SBIS PORTB,PINB0 ;If the LED0 is on then reset the LEDs
           otherwise skip the next line
                ldi LED,0b00001000
        SBIC PORTB,PINB0        ;If the LED0 is not on then Rotate
           otherwise skip the next line
                ror LED ;Rotate to the left
        call Out_LED_Right      ;call the method that will ouput to the
            LEDs
        call Delay      ;Delay of 0.5 sec
rjmp main

Out_LED_Right:  ;To output to PORTB the LEDs when it is going to the
    right
        mov r17,LED     ;Copy the info from "LED" to r17
        add r17,Normal_Right    ;Add "Normal_Right" to r17
        com r17 ;One's Complement of r17. to switch the 0s into 1s
        out PORTB,r17
RET     ;Return to where the routine was called
Out_LED_Left:   ;To output to PORTB the LEDs when it is going to the
    left
        mov r17,LED     ;Copy the info from "LED" to r17
        add r17,Normal_Left     ;Add "Normal_Left" to r17
        com r17 ;One's Complement of r17. to switch the 0s into 1s
        out PORTB,r17
RET     ;Return to where the routine was called

Normal_Interrupt:       ;Interrupt for the normal lights
ldi r23,1       ;Load 1 into r23 to know later on in which program we
    are.
ldi Normal_Right, 0b11000000    ;Load the correct binary code to Normal
     Right
ldi Normal_Left,0b00000011      ;Load the correct binary code to Normal
     Left
RETI    ;Return to where the interrupt "interrupted"

BlinkRight:     ;Interrupt to when it's blinking right
ldi r23, 2      ;Load 2 into r23 to know later on in which program we
    are.
ldi LED,0b00001000      ;Initialise the LEDs
ldi Normal_Right, 0b11000000
ldi Normal_Left,0b00000011
RETI    ;Return to where the interrupt "interrupted"

BlinkLeft:      ;Interrupt to when it's blinking left
ldi r23, 3      ;Load 3 into r23 to know later on in which program we
    are.
ldi LED,0b00010000
ldi Normal_Right, 0b11000000
ldi Normal_Left,0b00000011
RETI    ;Return to where the interrupt "interrupted"

Press_Break:    ;Interrupt for when we are breaking
        ldi Normal_Left,0b00001111
        ldi Normal_Right,0b11110000
RETI    ;Return to where the interrupt "interrupted"
```

```
Delay:
; Generated by delay loop calculator
; at http://www.bretmulvey.com/avrdelay.html
; Delay 500 000 cycles
; 500ms at 1 MHz
    ldi  r18, 3
    ldi  r19, 138
    ldi  r20, 86
L1: dec  r20
    brne L1
    dec  r19
    brne L1
    dec  r18
    brne L1
    rjmp PC+1
RET
```

This is the flowchart of the task 4: