František Konečný – ID: 211313 – BPC-DE2

Link to my repository in GitHub

https://github.com/Konecny343/Digital-electronics-2

1) Preparation tasks

Table with segments values for display 0 to 9 on a common anode 7-segment display

Digit	A	B	C	D	E	F	G	DP
0	0	0	0	0	0	0	1	1
1	1	0	0	1	1	1	1	1
2	0	0	1	0	0	1	0	1
3	0	0	0	0	1	1	0	1
4	1	0	0	1	1	0	0	1
5	0	1	0	0	1	0	0	1
6	0	1	0	0	0	0	0	1
7	0	0	0	1	1	1	1	1
8	0	0	0	0	0	0	0	1
9	0	0	0	0	1	0	0	1

- The Common Cathode (CC) – In the common cathode display, all the cathode connections of the LED segments are joined together to logic "0" or ground.
  The individual segments are illuminated by application of a "HIGH", or logic "1".

- The Common Anode (CA) – In the common anode display, all the anode connections of the LED segments are joined together to logic "1".
  The individual segments are illuminated by applying a ground, logic "LOW" or "0".

2) 7-segment library

File (`segment.c`)

```
/***********************************************************************
 *
 * Seven-segment display library for AVR-GCC.
 * ATmega328P (Arduino Uno), 16 MHz, AVR 8-bit Toolchain 3.6.2
 *
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 * Dept. of Radio Electronics, Brno University of Technology, Czechia
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 *
 **********************************************************************/

#define F_CPU 16000000

/* Includes ----------------------------------------------------------*/
#include <util/delay.h>
#include "gpio.h"
#include "segment.h"

/* Variables ---------------------------------------------------------*/
// Active-low digits 0 to 9
uint8_t segment_value[] = {
       // abcdefgDP
       0b00000011,          // Digit 0
       0b10011111,          // Digit 1
       0b00100101,          // Digit 2
       0b00001101,          // Digit 3
       0b10011001,          // Digit 4
       0b01001001,          // Digit 5
```

```
        0b01000001,         // Digit 6
        0b00011111,         // Digit 7
        0b00000001,         // Digit 8
        0b00001001};        // Digit 9

// Active-high position 0 to 3
uint8_t segment_position[] = {
        // p3p2p1p0....
        0b00010000,         // Position 0
        0b00100000,         // Position 1
        0b01000000,         // Position 2
        0b10000000};        // Position 3

/* Function definitions ----------------------------------------------*/
void SEG_init(void)
{
    /* Configuration of SSD signals */
    GPIO_config_output(&DDRD, SEGMENT_LATCH);
    GPIO_config_output(&DDRD, SEGMENT_CLK);
    GPIO_config_output(&DDRB, SEGMENT_DATA);
}

/*-------------------------------------------------------------------------*/
void SEG_update_shift_regs(uint8_t segments, uint8_t position)
{
        uint8_t bit_number;
        segments = segment_value[segments];     // 0, 1, ..., 9
        position = segment_position[position];  // 0, 1, 2, 3

        // Pull LATCH, CLK, and DATA low
        GPIO_write_low(&PORTD, SEGMENT_LATCH);
        GPIO_write_low(&PORTD, SEGMENT_CLK);
        GPIO_write_low(&PORTD, SEGMENT_DATA);

        // Wait 1 us
        _delay_us(1);


        // Loop through the 1st byte (segments)
        // a b c d e f g DP (active low values)
        for (bit_number = 0; bit_number < 8; bit_number++)
        {
                // Output DATA value (bit 0 of "segments")
                if (segments % 2 == 0)
                {
                        GPIO_write_low(&PORTB, SEGMENT_DATA);
                }
                else
                {
                        GPIO_write_high(&PORTB, SEGMENT_DATA);
                }

                // Wait 1 us
                _delay_us(1);

                // Pull CLK high
                GPIO_write_high(&PORTD, SEGMENT_CLK);

                // Wait 1 us
                _delay_us(1);

                // Pull CLK low
                GPIO_write_low(&PORTD, SEGMENT_CLK);

                // Shift "segments"
```

```
                segments = segments >> 1;
        }

        // Loop through the 2nd byte (position)
        // p3 p2 p1 p0 . . . . (active high values)
        for (bit_number = 0; bit_number < 8; bit_number++)
        {
                // Output DATA value (bit 0 of "position")
                if ((position & 1) == 0)
                {

                        GPIO_write_low(&PORTB, SEGMENT_DATA);
                }
                else
                {
                        GPIO_write_high(&PORTB, SEGMENT_DATA);
                }

                // Wait 1 us
                _delay_us(1);

                // Pull CLK high
                GPIO_write_high(&PORTD, SEGMENT_CLK);

                // Wait 1 us
                _delay_us(1);

                // Pull CLK low
                GPIO_write_low(&PORTD, SEGMENT_CLK);

                // Shift "position"
                position = position >> 1;
    }

    // Pull LATCH high
    GPIO_write_high(&PORTD, SEGMENT_LATCH);

    // Wait 1 us
    _delay_us(1);

}
```

File (`main.c`)

```
/*******************************************************************************
 *
 * Decimal counter with 7-segment output.
 * ATmega328P (Arduino Uno), 16 MHz, AVR 8-bit Toolchain 3.6.2
 *
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 *
 *******************************************************************************/

/* Includes ------------------------------------------------------------*/
#include <avr/io.h>         // AVR device-specific IO definitions
#include <avr/interrupt.h>  // Interrupts standard C library for AVR-GCC
#include "timer.h"          // Timer library for AVR-GCC
#include "segment.h"        // Seven-segment display library for AVR-GCC

uint8_t singles = 0, decimals = 0;

/* Function definitions ----------------------------------------------*/
/**
 * Main function where the program execution begins. Display decimal
 * counter values on SSD (Seven-segment display) when 16-bit
 * Timer/Counter1 overflows.
 */
int main(void)
{
    // Configure SSD signals
    SEG_init();

    /* Configure 8-bit Timer/Counter0
     * Set prescaler and enable overflow interrupt */
    TIM0_overflow_4ms();
    TIM0_overflow_interrupt_enable();

    /* Configure 16-bit Timer/Counter1
     * Set prescaler and enable overflow interrupt */
    TIM1_overflow_1s();
    TIM1_overflow_interrupt_enable();

    // Enables interrupts by setting the global interrupt mask
    sei();

    // Infinite loop
    while (1)
    {
        /* Empty loop. All subsequent operations are performed exclusively
         * inside interrupt service routines ISRs */
    }

    // Will never reach this
    return 0;
}
```
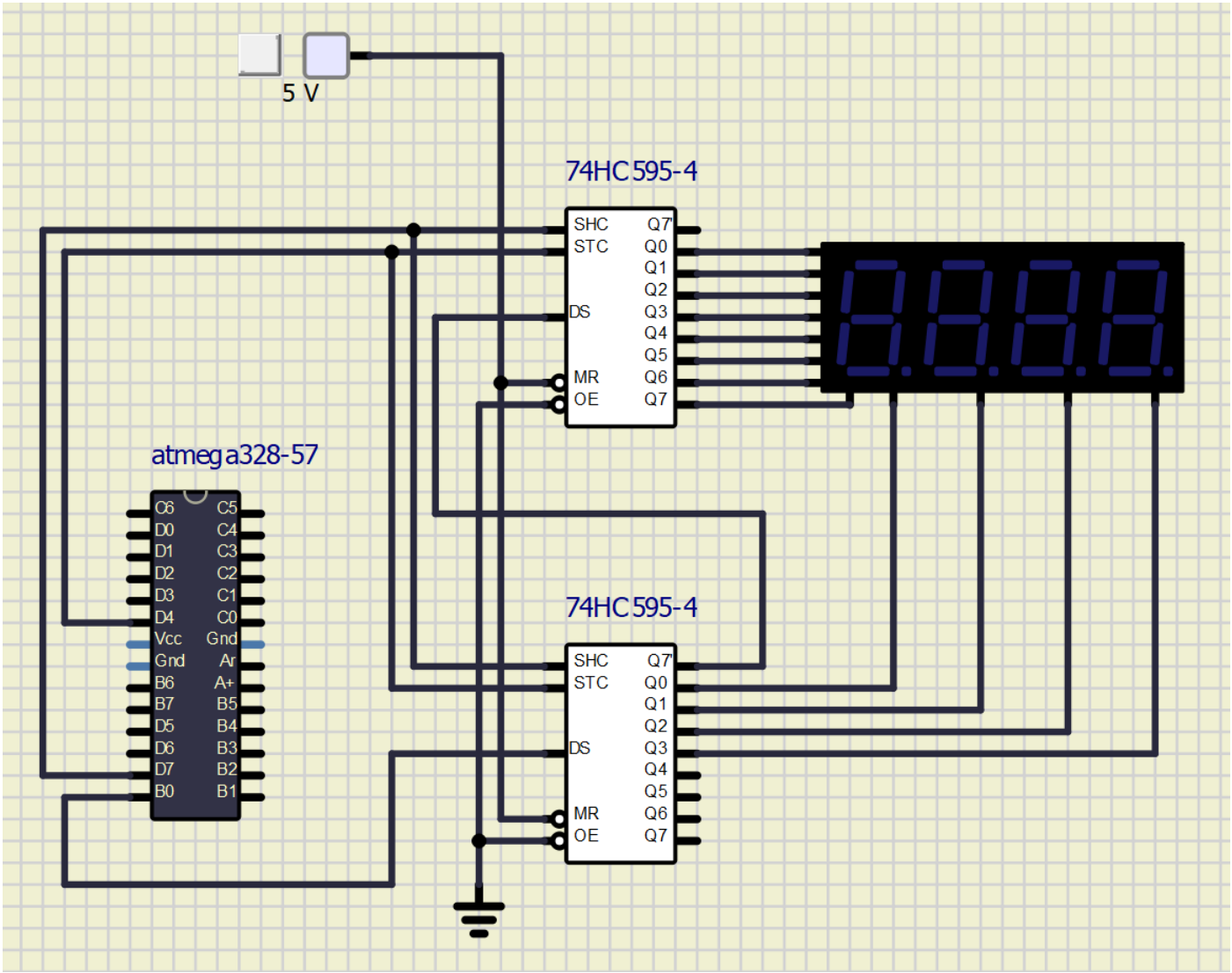

```
/* Interrupt service routines ---------------------------------------*/
/**
 * ISR starts when Timer/Counter0 overflows.
 * Display values on SSD.
 */
ISR(TIMER0_OVF_vect)
{
	static uint8_t pos = 0;

	if (pos == 0)
	{
		SEG_update_shift_regs(singles, pos);
		pos = 1;
	}
	else
	{
		SEG_update_shift_regs(decimals, pos);
		pos = 0;
	}
}

/**
 * ISR starts when Timer/Counter1 overflows. Increment decimal counter value.
 */
ISR(TIMER1_OVF_vect)
{
	singles++;
	if (singles > 9)
	{
		singles = 0;
		decimals++;
		if (decimals > 5)
		{
			decimals = 0;
		}
	}
}
```

Screenshot of SimulIDE circuit



3) Snake

Look-up table with snake definition

Digit	A	B	C	D	E	F	G	DP
0	0	1	1	1	1	1	1	1
1	1	0	1	1	1	1	1	1
2	1	1	0	1	1	1	1	1
3	1	1	1	0	1	1	1	1
4	1	1	1	1	0	1	1	1
5	1	1	1	1	1	0	1	1

File (`main.c`)

```
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 *
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 *
 **********************************************************************/

/* Includes ----------------------------------------------------------*/
#include <avr/io.h>         // AVR device-specific IO definitions
#include <avr/interrupt.h>  // Interrupts standard C library for AVR-GCC
#include "timer.h"          // Timer library for AVR-GCC
#include "segment.h"        // Seven-segment display library for AVR-GCC

uint8_t value = 0;

/* Function definitions ----------------------------------------------*/
/**
 * Main function where the program execution begins. Display decimal
 * counter values on SSD (Seven-segment display) when 16-bit
 * Timer/Counter1 overflows.
 */
int main(void)
{
    // Configure SSD signals
    SEG_init();

    /* Configure 16-bit Timer/Counter1
     * Set prescaler and enable overflow interrupt */
    TIM1_overflow_262ms();
    TIM1_overflow_interrupt_enable();

    // Enables interrupts by setting the global interrupt mask
    sei();

    // Infinite loop
    while (1)
    {
        /* Empty loop. All subsequent operations are performed exclusively
         * inside interrupt service routines ISRs */
    }
```

```
// Will never reach this
    return 0;
}

/* Interrupt service routines ---------------------------------------*/
/**
 * ISR starts when Timer/Counter1 overflows. Increment decimal counter value.
 */
ISR(TIMER1_OVF_vect)
{
       SEG_update_shift_regs(value++, 0);
       if (value > 5) value = 0;
}
```