Session 6

-

Display devices, LCD display

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Lab assignment

1. **Preparation tasks**

- Table with LCD signals

LCD signal (s)	AVR pin(s)	Description
RS	PB0	Register selection signal. Selection between Instruction register (RS=0) and Data register (RS=1)
R/W	GND	Pin writing/reading to/from - LCD
E	PB1	Enabling pin. When this pin is set to logical low, the LCD does not care what is happening with R/W, RS, and the data bus lines. When this pin is set to logical high, the LCD is processing the incoming data
D[3:0]	-	We won't use them. They would only be used if we worked in 8 bits mode
D[7:4]	PD4, PD5, PD6, PD7	Four high order bidiriectional tristate data bus pins. Used for data transfer and receive between the MPU and the LCD

- ASCII values

Representation	Binary	Decimal	Hexadecimal
A	0100 0001	65	41
B	0100 0010	66	42
C	0100 0011	67	43
D	0100 0100	68	44
E	0100 0101	69	45
F	0100 0110	70	46
G	0100 0111	71	47
H	0100 1000	72	48
I	0100 1001	73	49
J	0100 1010	74	4A
K	0100 1011	75	4B
L	0100 1100	76	4C
M	0100 1101	77	4D
N	0100 1110	78	4E
O	0100 1111	79	4F
P	0101 0000	80	50
Q	0101 0001	81	51
R	0101 0010	82	52
S	0101 0011	83	53
T	0101 0100	84	54
U	0101 0101	85	55
V	0101 0110	86	56
W	0101 0111	87	57
X	0101 1000	88	58
Y	0101 1001	89	59
Z	0101 1010	90	5A

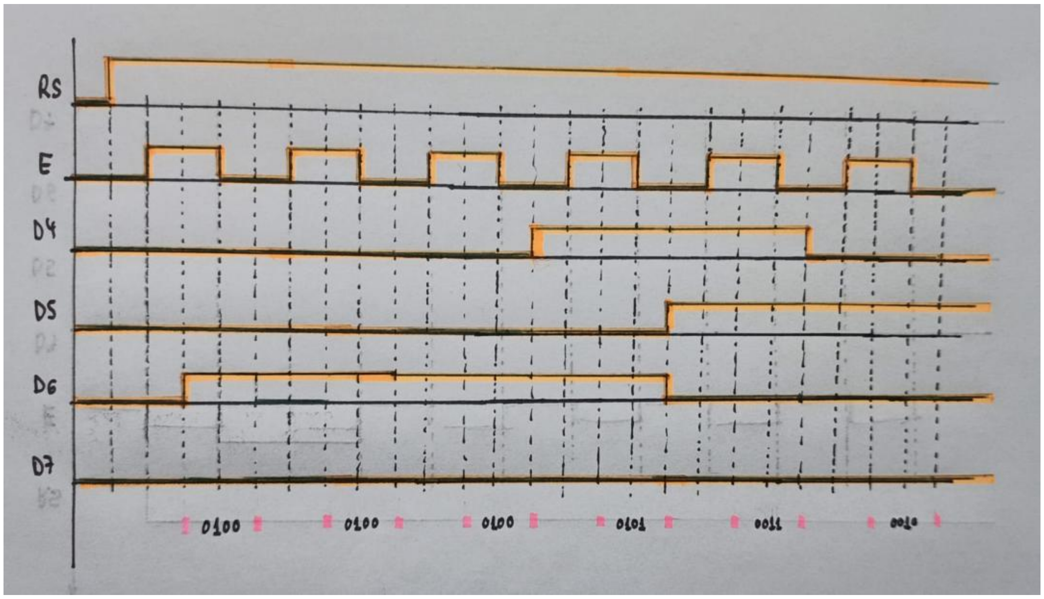
Representation	Binary	Decimal	Hexadecimal
a	0110 0001	97	61
b	0110 0010	98	62
c	0110 0011	99	63
d	0110 0100	10	64
e	0110 0101	101	65
f	0110 0110	102	66
g	0110 0111	103	67
h	0110 1000	104	68
i	0110 1001	105	69
j	0110 1010	106	6A
k	0110 1011	107	6B
l	0110 1100	108	6C
m	0110 1101	109	6D
n	0110 1110	110	6E
o	0110 1111	111	6F
p	0111 0000	112	70
q	0111 0001	113	71
E	0111 0010	114	72
s	0111 0011	115	73
t	0111 0100	116	74
u	0111 0101	117	75
v	0111 0110	118	76
w	0111 0111	119	77
x	0111 1000	120	78
y	0111 1001	121	79
z	0111 1010	122	7A

Representation	Binary	Decimal	Hexadecimal
0	0011 0000	48	30
1	0011 0001	49	31
2	0011 0010	50	32
3	0011 0011	51	33
4	0011 0100	52	34
5	0011 0101	53	35
6	0011 0110	54	36
7	0011 0111	55	37
8	0011 1000	56	38
9	0011 1001	57	39

2. HD44780 communication

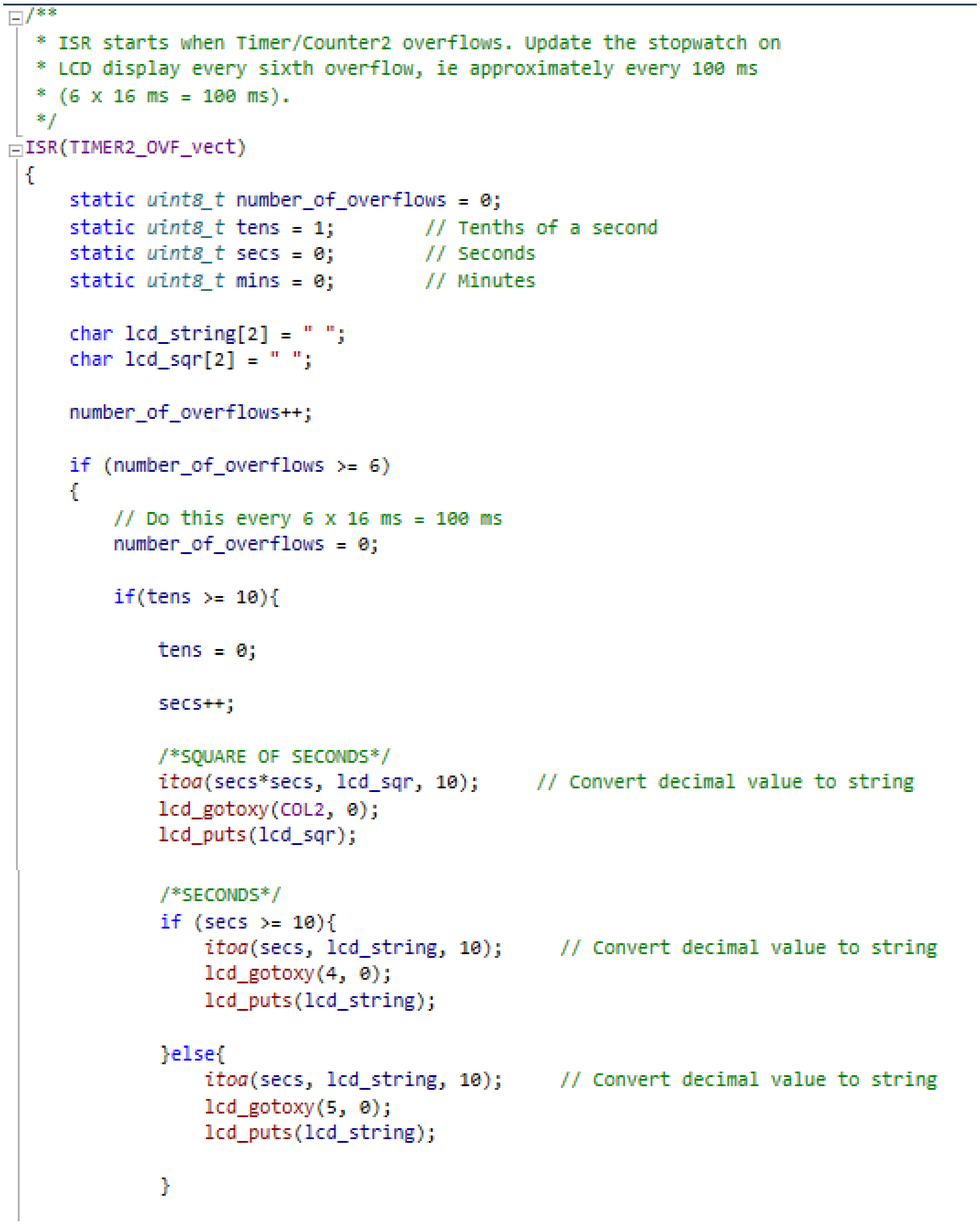
- Picture of time signals between ATmega328P and HD44780 (LCD keypad shield) when transmitting data **DE2**

DE2 = 0100 0100 – 0100 0101 – 0011 0010

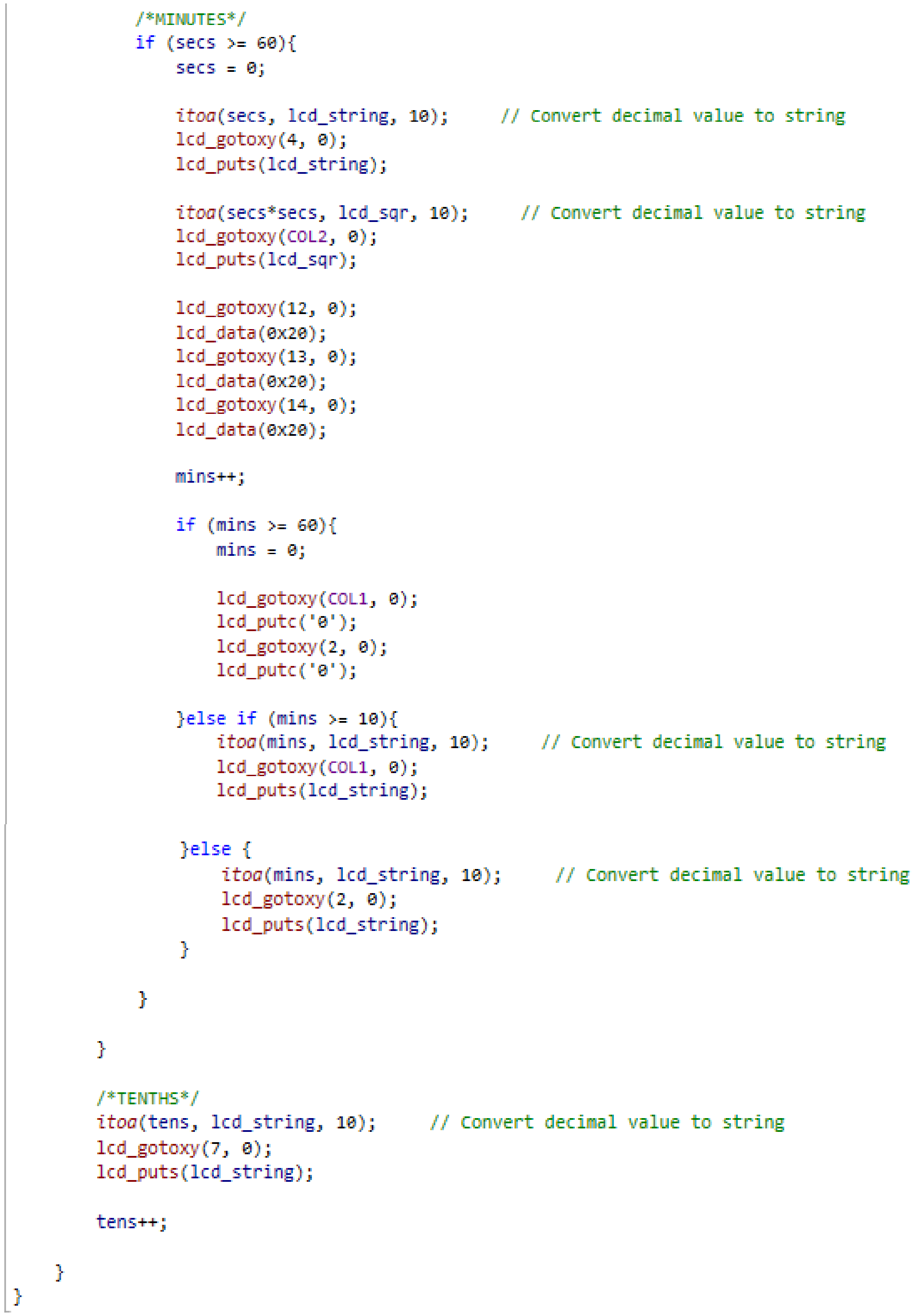


3. **Stopwatch**

- Listing of **TIMER2_OVF_vect** interrupt routine with complete stopwatch code (minutes:seconds.tenths) and square value computation



```
/**
 * ISR starts when Timer/Counter2 overflows. Update the stopwatch on
 * LCD display every sixth overflow, ie approximately every 100 ms
 * (6 x 16 ms = 100 ms).
 */
ISR(TIMER2_OVF_vect)
{
    static uint8_t number_of_overflows = 0;
    static uint8_t tens = 1;        // Tenths of a second
    static uint8_t secs = 0;        // Seconds
    static uint8_t mins = 0;        // Minutes

    char lcd_string[2] = " ";
    char lcd_sqr[2] = " ";

    number_of_overflows++;

    if (number_of_overflows >= 6)
    {
        // Do this every 6 x 16 ms = 100 ms
        number_of_overflows = 0;

        if(tens >= 10){

            tens = 0;

            secs++;

            /*SQUARE OF SECONDS*/
            itoa(secs*secs, lcd_sqr, 10);     // Convert decimal value to string
            lcd_gotoxy(COL2, 0);
            lcd_puts(lcd_sqr);

            /*SECONDS*/
            if (secs >= 10){
                itoa(secs, lcd_string, 10);     // Convert decimal value to string
                lcd_gotoxy(4, 0);
                lcd_puts(lcd_string);

            }else{
                itoa(secs, lcd_string, 10);     // Convert decimal value to string
                lcd_gotoxy(5, 0);
                lcd_puts(lcd_string);

            }
```

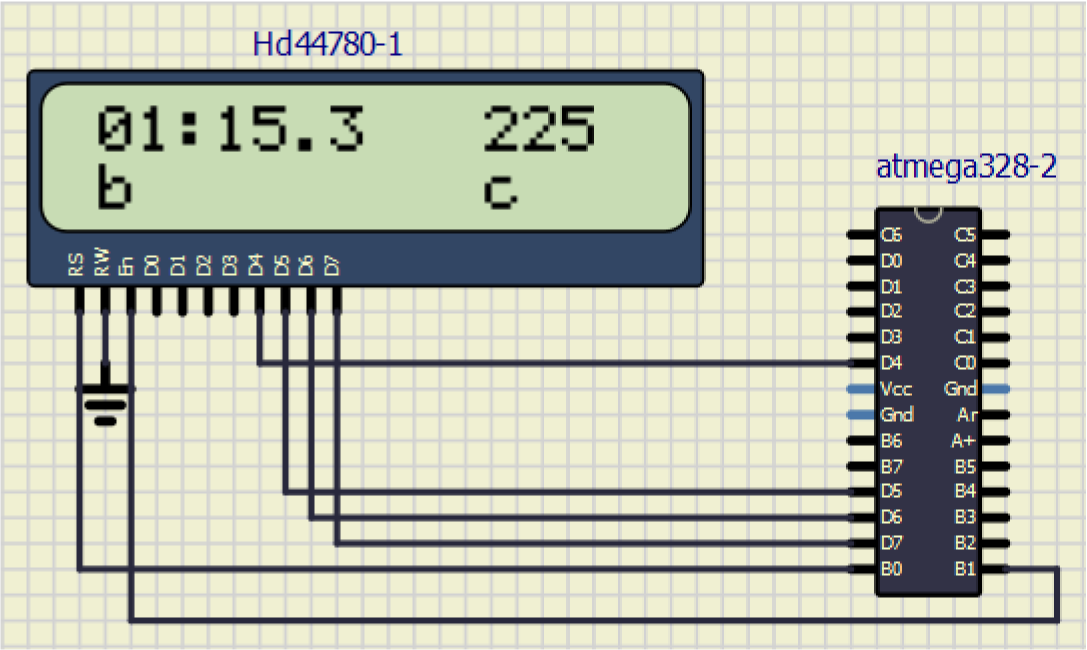


```
            /*MINUTES*/
            if (secs >= 60){
                secs = 0;

                itoa(secs, lcd_string, 10);     // Convert decimal value to string
                lcd_gotoxy(4, 0);
                lcd_puts(lcd_string);

                itoa(secs*secs, lcd_sqr, 10);     // Convert decimal value to string
                lcd_gotoxy(COL2, 0);
                lcd_puts(lcd_sqr);

                lcd_gotoxy(12, 0);
                lcd_data(0x20);
                lcd_gotoxy(13, 0);
                lcd_data(0x20);
                lcd_gotoxy(14, 0);
                lcd_data(0x20);

                mins++;

                if (mins >= 60){
                    mins = 0;

                    lcd_gotoxy(COL1, 0);
                    lcd_putc('0');
                    lcd_gotoxy(2, 0);
                    lcd_putc('0');

                }else if (mins >= 10){
                    itoa(mins, lcd_string, 10);     // Convert decimal value to string
                    lcd_gotoxy(COL1, 0);
                    lcd_puts(lcd_string);

                }else {
                    itoa(mins, lcd_string, 10);     // Convert decimal value to string
                    lcd_gotoxy(2, 0);
                    lcd_puts(lcd_string);
                }

            }

        }

        /*TENTHS*/
        itoa(tens, lcd_string, 10);     // Convert decimal value to string
        lcd_gotoxy(7, 0);
        lcd_puts(lcd_string);

        tens++;

    }
}
```

You can find the code on my GitHub:

https://github.com/GuicoRM/Digital-Electronics-2

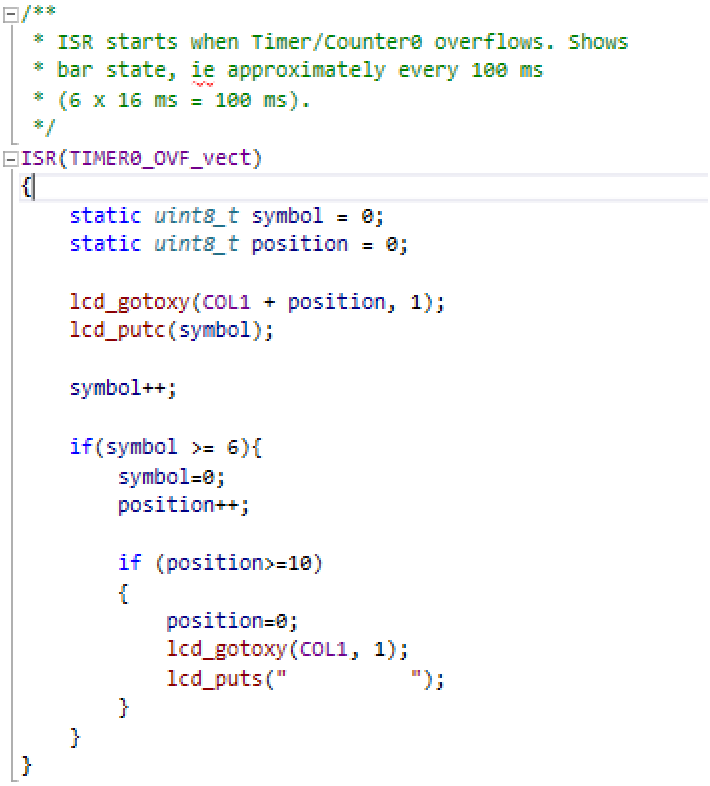
- Screenshot of SimulIDE circuit when “Power Circuit” is applied



```
01:15.3    225
b          c
```

4. Progress bar

- Listing of **TIMER0_OVF_vect** interrupt routine with a progress bar



```
/**
 * ISR starts when Timer/Counter0 overflows. Shows
 * bar state, ie approximately every 100 ms
 * (6 x 16 ms = 100 ms).
 */
ISR(TIMER0_OVF_vect)
{
    static uint8_t symbol = 0;
    static uint8_t position = 0;

    lcd_gotoxy(COL1 + position, 1);
    lcd_putc(symbol);

    symbol++;

    if(symbol >= 6){
        symbol=0;
        position++;

        if (position>=10)
        {
            position=0;
            lcd_gotoxy(COL1, 1);
            lcd_puts("          ");
        }
    }
}
```

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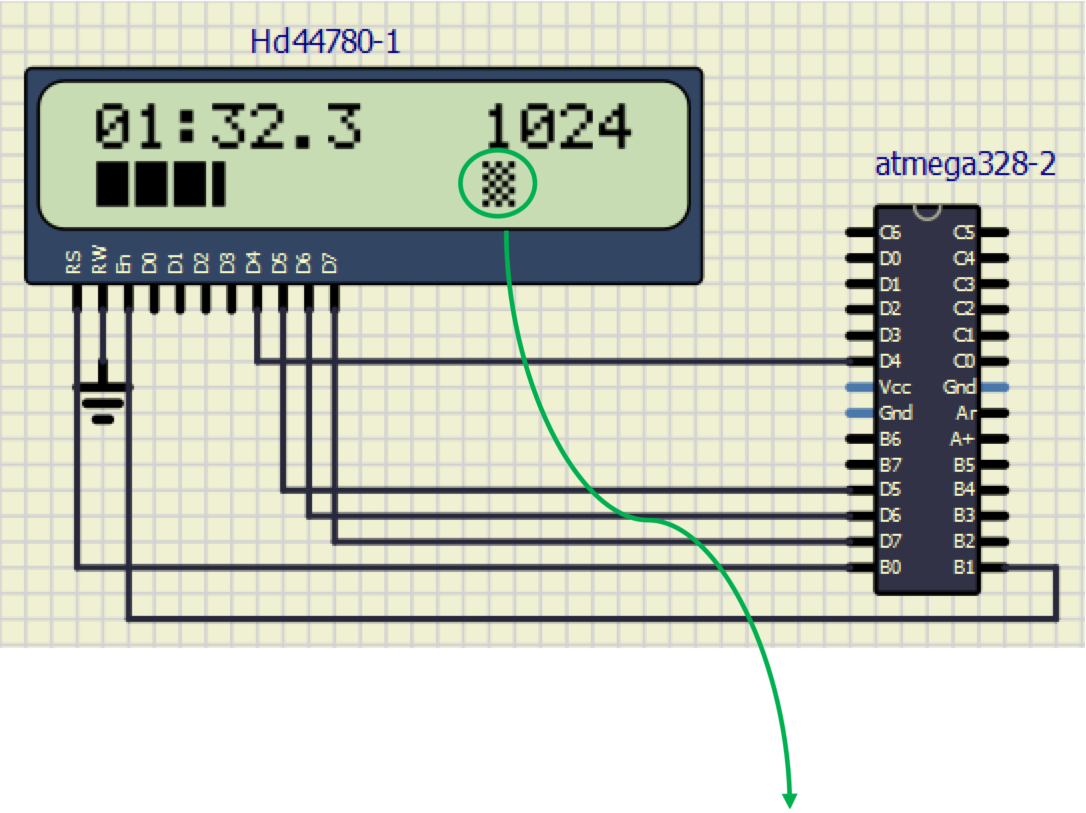
- Screenshot of SimulIDE circuit when ”Power Circuit” is applied

  <u>Note</u>: I also added one custome character (‘chessboard’) in position ‘c’ in order to test it



```
01:32.3    1024
████▌      ▩
```

Position ‘c’

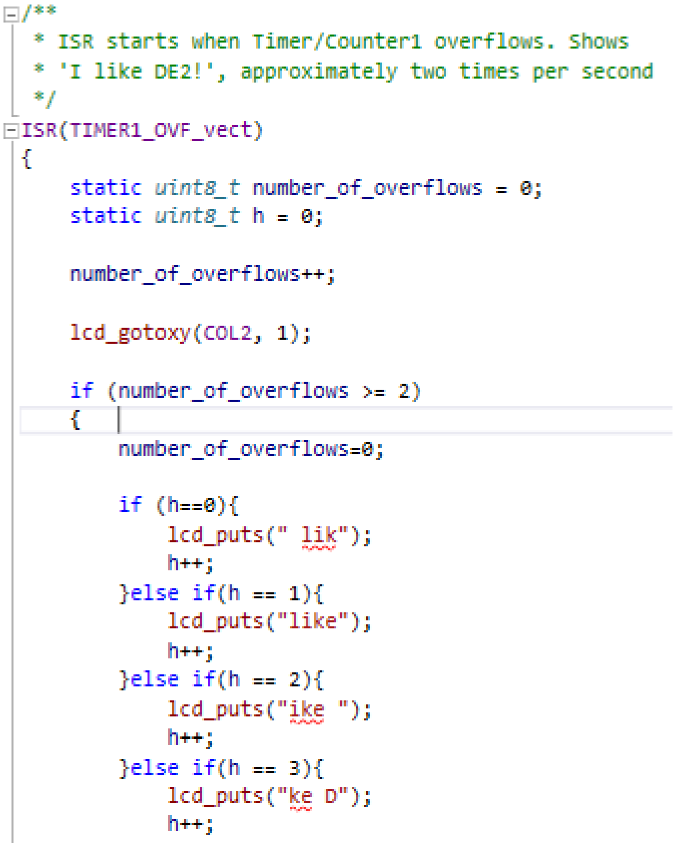
You can find the code of **custome character** on my GitHub:

https://github.com/GuicoRM/Digital-Electronics-2

5. EXTRA

- From the LCD position "c", displays running text, ie text that moves characters to the left twice per second

Note: I achieved to show moving text ‘I like DE2!’ in rudimentary way. It probably won’t be the best way to get moving text, but it works.



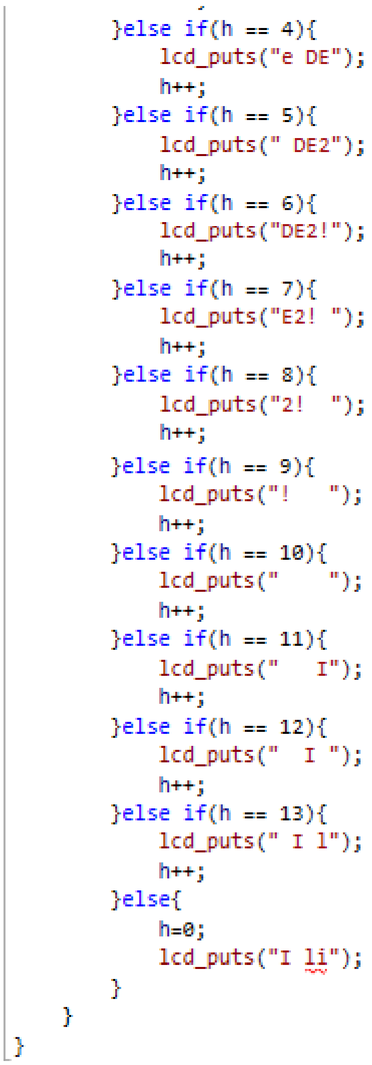
```
/**
 * ISR starts when Timer/Counter1 overflows. Shows
 * 'I like DE2!', approximately two times per second
 */
ISR(TIMER1_OVF_vect)
{
    static uint8_t number_of_overflows = 0;
    static uint8_t h = 0;

    number_of_overflows++;

    lcd_gotoxy(COL2, 1);

    if (number_of_overflows >= 2)
    {
        number_of_overflows=0;

        if (h==0){
            lcd_puts(" lik");
            h++;
        }else if(h == 1){
            lcd_puts("like");
            h++;
        }else if(h == 2){
            lcd_puts("ike ");
            h++;
        }else if(h == 3){
            lcd_puts("ke D");
            h++;
```

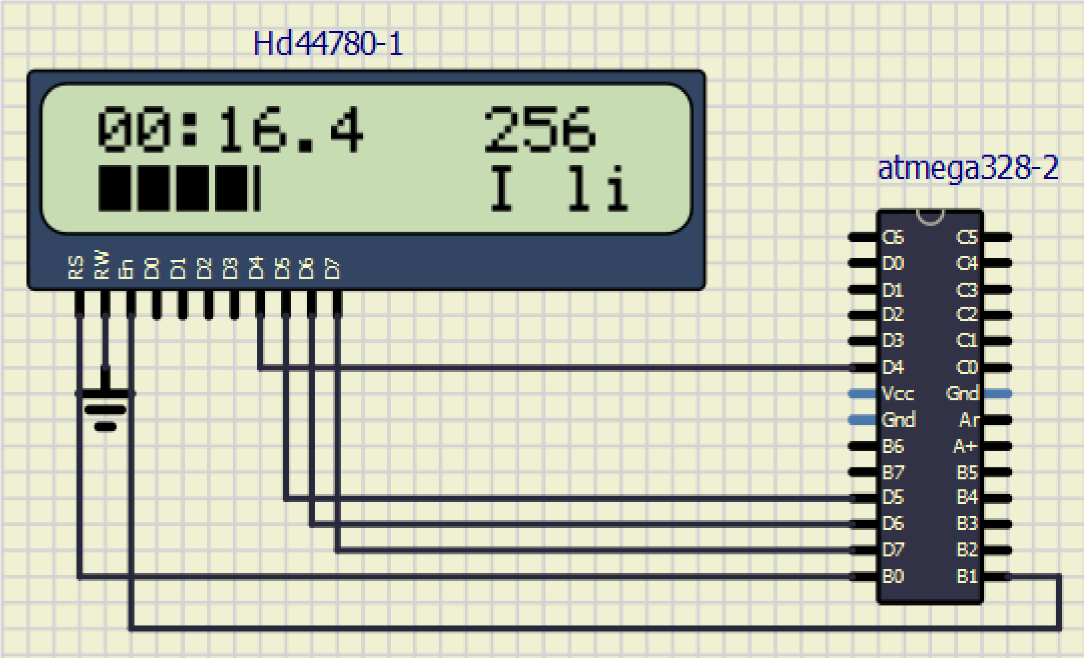


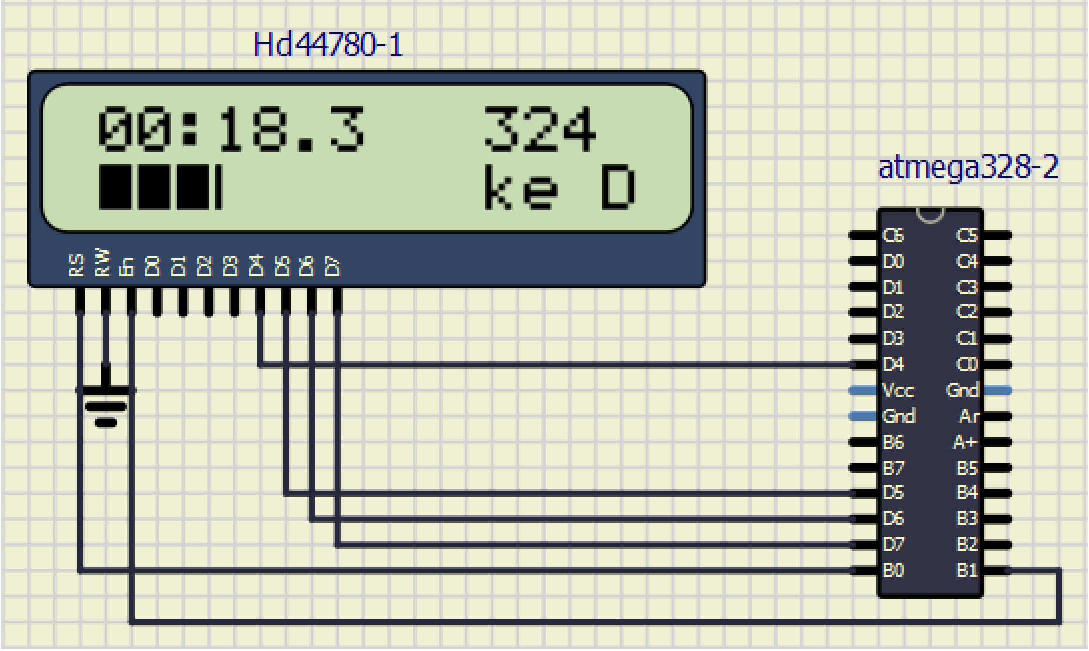
```
        }else if(h == 4){
            lcd_puts("e DE");
            h++;
        }else if(h == 5){
            lcd_puts(" DE2");
            h++;
        }else if(h == 6){
            lcd_puts("DE2!");
            h++;
        }else if(h == 7){
            lcd_puts("E2! ");
            h++;
        }else if(h == 8){
            lcd_puts("2!  ");
            h++;
        }else if(h == 9){
            lcd_puts("!   ");
            h++;
        }else if(h == 10){
            lcd_puts("    ");
            h++;
        }else if(h == 11){
            lcd_puts("   I");
            h++;
        }else if(h == 12){
            lcd_puts("  I ");
            h++;
        }else if(h == 13){
            lcd_puts(" I l");
            h++;
        }else{
            h=0;
            lcd_puts("I li");
        }
    }
}
```

You can find the code of **custome character** on my GitHub:

https://github.com/GuicoRM/Digital-Electronics-2

- Screenshots of SimulIDE circuit when ”Power Circuit” is applied


Hd44780-1
00:16.4 256
▮▮▮▮▏ I li
RS RW En D0 D1 D2 D3 D4 D5 D6 D7
atmega328-2
C6 D0 D1 D2 D3 D4 Vcc Gnd B6 B7 D5 D6 D7 B0
C5 C4 C3 C2 C1 C0 Gnd Ar A+ B5 B4 B3 B2 B1


Hd44780-1
00:18.3 324
▮▮▮▏ ke D
RS RW En D0 D1 D2 D3 D4 D5 D6 D7
atmega328-2
C6 D0 D1 D2 D3 D4 Vcc Gnd B6 B7 D5 D6 D7 B0
C5 C4 C3 C2 C1 C0 Gnd Ar A+ B5 B4 B3 B2 B1

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