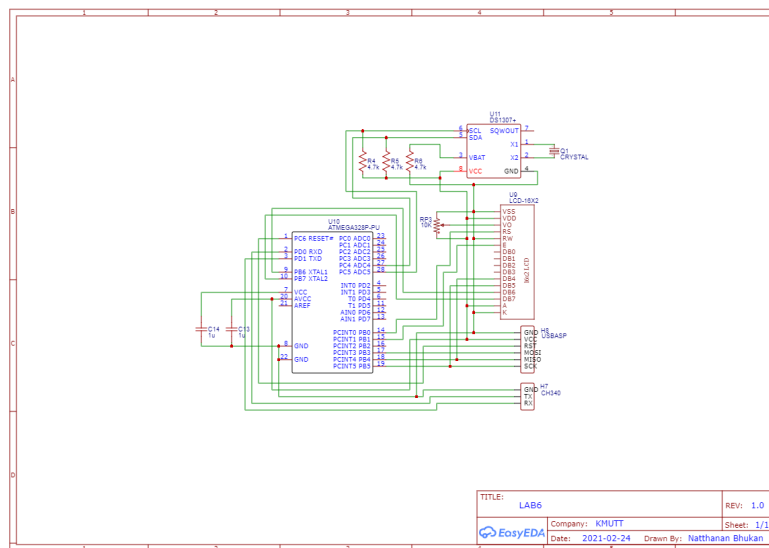




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 Faculty of Engineering, Department of Computer Engineering
CPE 328 Embedded System, 2/2020
 LAB Lecture 6: AVR Inter-Integrated Circuit (I²C) Protocol

Assign Date: 24 Feb 2021 Due Date: 2 Mar 2021

Schematic Diagram



Code

```
#define F_CPU 8000000L

#include <avr/io.h>
#include <util/delay.h>
#include <stdio.h>
#include <string.h>
#include <stdlib.h>

#define LCD_Dir DDRB /* Define LCD data port direction */
#define LCD_Port PORTB /* Define LCD data port */
#define RS PB0 /* Define Register Select pin */
#define EN PB1 /* Define Enable signal pin */
#define DS1307_ADDR 0xD0 /* Define DS1307 Address */

void LCD_Command( unsigned char cmd )
{
    LCD_Port = (LCD_Port & 0x0F) | (cmd & 0xF0); /* sending upper nibble */
    LCD_Port &= ~(1<<RS); /* RS=0, command reg. */
    LCD_Port |= (1<<EN); /* Enable pulse */
    _delay_us(1);
    LCD_Port &= ~(1<<EN);

    _delay_us(200);

    LCD_Port = (LCD_Port & 0x0F) | (cmd << 4); /* sending lower nibble */
    LCD_Port |= (1<<EN);
    _delay_us(1);
    LCD_Port &= ~(1<<EN);
    _delay_ms(2);
}
```



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```
void LCD_Char( unsigned char data )
{
    LCD_Port = (LCD_Port & 0x0F) | (data & 0xF0); /* sending upper */
    LCD_Port |= (1<<RS); /* RS=1, data reg. */
    LCD_Port|= (1<<EN);
    _delay_us(1);
    LCD_Port &= ~(1<<EN);

    _delay_us(200);

    LCD_Port = (LCD_Port & 0x0F) | (data << 4); /* sending lower */
    LCD_Port |= (1<<EN);
    _delay_us(1);
    LCD_Port &= ~(1<<EN);
    _delay_ms(2);
}

void LCD_Init (void) /* LCD Initialize function */
{
    LCD_Dir = 0xFF; /* Make LCD port direction as o/p */
    _delay_ms(20); /* LCD Power ON delay always >15ms */

    LCD_Command(0x02); /* send for 4 bit initialization of LCD */
    LCD_Command(0x28); /* 2 line, 5*7 matrix in 4-bit mode */
    LCD_Command(0x0c); /* Display on cursor off*/
    LCD_Command(0x06); /* Increment cursor (shift cursor to right)*/
    LCD_Command(0x01); /* Clear display screen*/
    _delay_ms(2);
}

void LCD_String (char *str) /* Send string to LCD function */
{
    int i;
    for(i=0; str[i]!=0 && str[i]!=0x000a; i++) /* Send each char of string to LCD */
    {
        LCD_Char(str[i]);
    }
}
```

```
void LCD_Clear()
{
    LCD_Command(0x01); /* Clear display */
    _delay_ms(2);
    LCD_Command(0x80); /* Cursor at home position */
}

/* Terms
 * S = Start
 * SR = Repeated Start
 * P = Stop
 * SLA+W = Slave Address Write mode
 * SLA+R = Slave Address Read mode
 * ACK = Acknowledge
 * NACK = Not ACK
 */

void I2C_Init()
{
    // SCL, SDA as output
    DDRC |= (1 << DDC4) | (1 << DDC5);

    // Init I2C
    // 100kHz @ prescaler /4
    TWBR = 8;
    TWCR |= (1 << TWPS0);

    // Enable I2C
    TWCR |= (1 << TWEN);
}

void I2C_Start(){
    // Send S
    TWCR = (1 << TWEN) | (1 << TWINT) | (1 << TWSTA);
    // Wait complete
    while(!(TWCR & (1 << TWINT)));
}
```



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```
void I2C_Stop(){
    // Send P
    TWCR = (1 << TWEN) | (1 << TWINT) | (1 << TWSTO);
}

void I2C_Write(uint8_t data){
    // Write data
    TWDR = data;
    TWCR = (1 << TWEN) | (1 << TWINT);
    // Wait complete
    while(!(TWCR & (1 << TWINT)));
}

uint8_t I2C_ReadAck() {
    // Read and Send Ack
    TWCR = (1<<TWINT)|(1<<TWEN)|(1<<TWEA);
    // Wait complete
    while (!(TWCR & (1<<TWINT)));
    return TWDR;
}

uint8_t I2C_ReadNAck() {
    // Read and not send Ack
    TWCR = (1<<TWINT)|(1<<TWEN);
    // Wait complete
    while (!(TWCR & (1<<TWINT)));
    return TWDR;
}

uint8_t I2C_GetStatusCode() {
    uint8_t status;
    // Get Status
    status = TWSR & 0xF8;
    return status;
}
```

```
void dateFormat(char *dateBuffer, uint8_t day, uint8_t date, uint8_t month, uint8_t year){
    char dict_day[7][5] = {"Mon", "Tue", "Wed", "Thr", "Fri", "Sat", "Sun"};
    char dict_month[12][5] = {"Jan", "Feb", "Mar", "Apr", "May", "Jun",
                             "Jul", "Aug", "Sep", "Oct", "Nov", "Dec"};

    char temp[10];

    // Format date from DS1307
    strcat(dateBuffer, dict_day[day]);
    strcat(dateBuffer, " ");
    sprintf(temp, "%u", date);
    strcat(dateBuffer, temp);
    strcat(dateBuffer, " ");
    strcat(dateBuffer, dict_month[month]);
    strcat(dateBuffer, " ");
    sprintf(temp, "20%u\n", year);
    strcat(dateBuffer, temp);
}
```



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```
void readTimeDS1307() {
    // Send S
    I2C_Start();
    if(I2C_GetStatusCode() != 0x08) I2C_Stop();

    // Send SLA + W
    I2C_Write((uint8_t)(DS1307_ADDR));
    if (I2C_GetStatusCode() != 0x18) I2C_Stop();

    // Send address that want to read
    I2C_Write((uint8_t) 0x00);
    if (I2C_GetStatusCode() != 0x28) I2C_Stop();

    // SR
    I2C_Start();
    if(I2C_GetStatusCode() != 0x10) I2C_Stop();

    // Send SLA + R
    I2C_Write((uint8_t)(DS1307_ADDR + 1));
    if (I2C_GetStatusCode() != 0x40) I2C_Stop();

    uint8_t temp[7];
    for(int i=0; i < 8; i++){
        // Get data and send Ack
        temp[i] = I2C_ReadAck();
        if (I2C_GetStatusCode() != 0x50) I2C_Stop();

        // Get data and not send Ack
        if(i == 7){
            temp[i] = I2C_ReadNAck();
            if (I2C_GetStatusCode() != 0x58) I2C_Stop();
        }
    }
}
```

```
    // Send P
    I2C_Stop();

    // Format to time system
    uint8_t second = ((temp[0] & 0x70) >> 4) * 10 + (temp[0] & 0x0F);
    uint8_t minute = ((temp[1] & 0x70) >> 4) * 10 + (temp[1] & 0x0F);
    uint8_t hour = ((temp[2] & 0x70) >> 4) * 10 + (temp[2] & 0x0F);
    uint8_t day = (temp[3] & 0x0F);
    uint8_t date = ((temp[4] & 0x70) >> 4) * 10 + (temp[4] & 0x0F);
    uint8_t month = ((temp[5] & 0x70) >> 4) * 10 + (temp[5] & 0x0F);
    uint8_t year = ((temp[6] & 0x70) >> 4) * 10 + (temp[6] & 0x0F);

    // Format the term to show
    char timeBuffer[10];
    char dateBuffer[20] = "";
    sprintf(timeBuffer, "%.2u:%.2u:%.2u\n", hour, minute, second);
    dateFormat(dateBuffer, day, date, month, year);

    // Show to lcd
    LCD_Clear();
    LCD_String(dateBuffer);
    LCD_Command(0xC0);
    LCD_String(timeBuffer);
    _delay_ms(1000);
}
```



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```
uint8_t setTimeDS1307(uint8_t *data){
    // Send S
    I2C_Start();
    if(I2C_GetStatusCode() != 0x08) I2C_Stop();

    // Send SLA + W
    I2C_Write((uint8_t)(DS1307_ADDR));
    if (I2C_GetStatusCode() != 0x18) I2C_Stop();

    // Send address to write
    I2C_Write((uint8_t)(0x00));
    if (I2C_GetStatusCode() != 0x28) I2C_Stop();

    for(int i=0; i < 8; i++){
        // Write each data to slave
        I2C_Write((uint8_t)(data[i]));
        if (I2C_GetStatusCode() != 0x28) I2C_Stop();
    }

    // Send P
    I2C_Stop();
}
```

```
int main(void) {
    I2C_Init();           /* Initialization of I2C*/
    LCD_Init();           /* Initialization of LCD*/
    LCD_Clear();
    _delay_ms(1000);

    /* Second, Minute, Hour, Day, Date, Month, Year*/
    uint8_t timeInit[] = {0x00, 0x36, 0x19, 0x02, 0x24, 0x01, 0x21};

    // Set time for DS1307
    setTimeDS1307(timeInit);

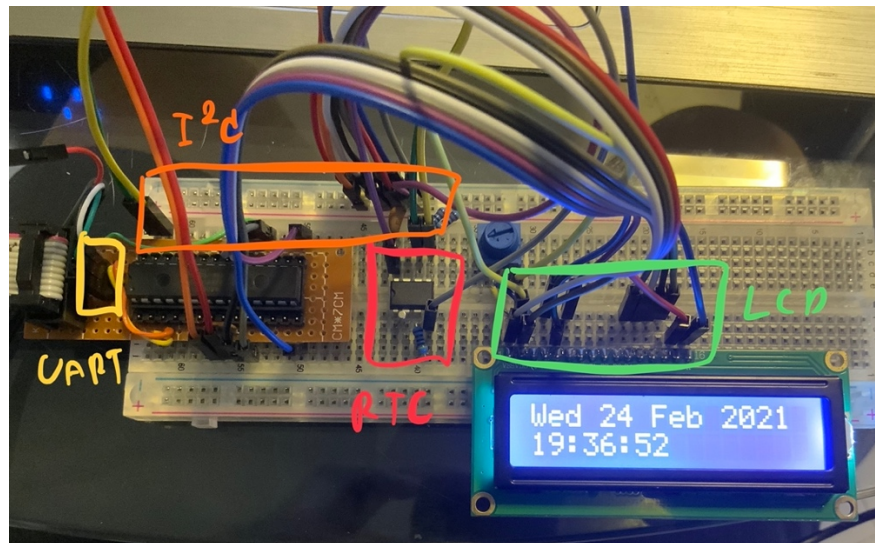
    while (1) {
        // Read the current time from DS1307
        readTimeDS1307();
    }
}
```



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On board



- 1) Connect a circuit with an ATmega328P and DS1307 (realtime clock IC) and write a program to display the current date and time on the 16x2 alphanumeric LCD screen

Result

