Project 4: Real-time clock

Use the DS1307 real-time-clock (RTC) chip to make a clock to show the hour, minute, second, month and day.

Components needed:

- Arduino
- DS1307 real-time clock (RTC) chip
- 4-digit 7-segment LED display
- Two push buttons

System detail:

1. Connect the DS1307 RTC chip to the Arduino using 4 wires (SCL, SDA, VCC and GND). To understand the operation of the DS1307, you need to read the following sections in the DS1307 data sheet:

    - General Description (page 1)
    - Features
    - Pin Configurations
    - Timing Diagram (page 4)
    - Pin Description (page 6)
    - Detailed Description (page 6)
    - RTC and RAM Address Map (page 7)
    - Clock and Calendar (page 8)
    - I^{2}C Data Bus (page 10)

    The RTC uses the I^{2}C serial interface and protocol to communicate with the Arduino. The hardest part of this project is to understand the I^{2}C bus operation and timing. You **cannot** use the wire.h library, but instead you must write your own code for the I^{2}C communications. Refer to the I^{2}C Data Bus section (page 10) in the DS1307 data sheet, the I^{2}C bus operation document and the I^{2}C bus communication code template.

2. On power up or reset the RTC is automatically set by your program to April 18, 2025, 3:15:00 PM. The system is in the clock display mode, and the current date and time obtained from the RTC chip is shown on the LED display. The display alternates between showing the time (**hour** and **second**) for 7 seconds and the date (**month** and **day**) for 3 seconds. When the time is showing the colon will blink every second (1 Hz). When the date is showing the decimal point on digit 2 is turned on. The time is shown as a **12-hour clock**. When it is PM the decimal point on digit 0 is turned on. When it is AM the decimal point on digit 0 is turned off.

    Hint: use bitRead() and bitWrite() to manipulate the individual bits of a byte when working with the hour register.

3. A long press (more than 1 second) of button A will switch the system between the clock display mode and the register change mode.

4. To change the date and time, first do a long press (more than 1 second) of button A to switch to the register change mode. Once it is in the register change mode, then each short press (less than 1 second) of button A will cycle through and display the following characters for year, month, day, day of the week, hour, minute and second together with the corresponding register value for each. Each of the characters as shown next

| year | month | day | week | hour | minute | second |
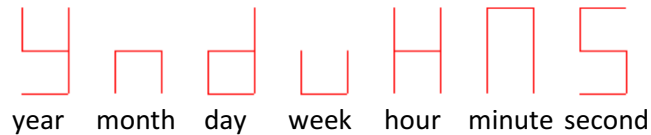
is displayed on the leftmost digit, and the corresponding register value is displayed on the two rightmost digits.

When in the register change mode, each short press of button B will increment the current value being displayed. Holding down button B will continuously increment the value at a faster speed. The value will count up to the maximum and roll around. For example the day of the week value will count from 1 to 7 and roll back to 1. Refer to the DS1307 data sheet for valid ranges. The hour value will count from 1 to 12 AM and then to 1 to 12 PM.
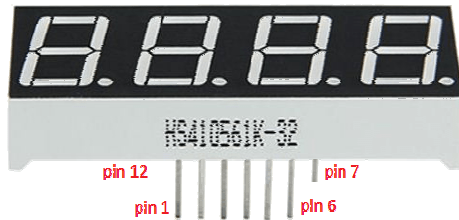
A long press on button A will switch back to the clock display mode.

5. Bonus: A short press of button A when in the clock display mode will show other register values.

DS1307 RTC connections:

DS1307 RTC	Arduino
pin 5 (SDA)	A4
pin 6 (SCL)	A5
pin 4	GND
pin 8	5V

4-digit 7-segment LED display pins:

The colon is turned on when digit 2 is on, i.e. pin 9 connected to GND.

The decimal point for digit 2 is turned on when digit 3 is on.

The decimal point for digit 3 is not connected and therefore cannot be turned on.

LED pins	Description
6 (Common Cathode)	Digit 0 (rightmost digit)
8 (Common Cathode)	Digit 1
9 (Common Cathode)	Digit 2
12 (Common Cathode)	Digit 3
11	Segment A
10	Segment F
7	Segment B
5	Segment G
4	Segment C
1	Segment E
3	Segment DP/Colon
2	Segment D