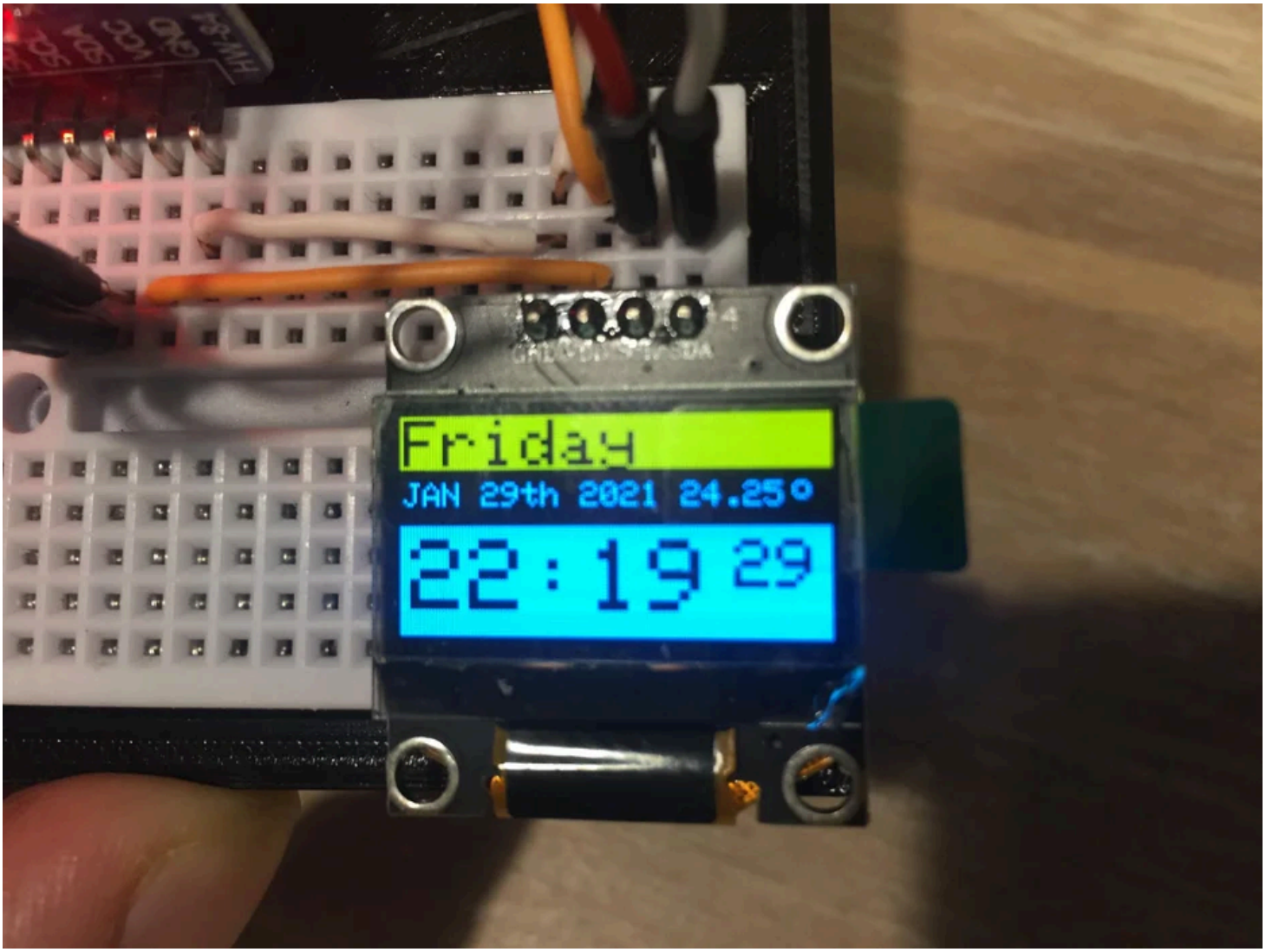
How to Create a Clock Using Arduino , DS3231 RTC Module and OLED Display

By dziubym in CircuitsArduino

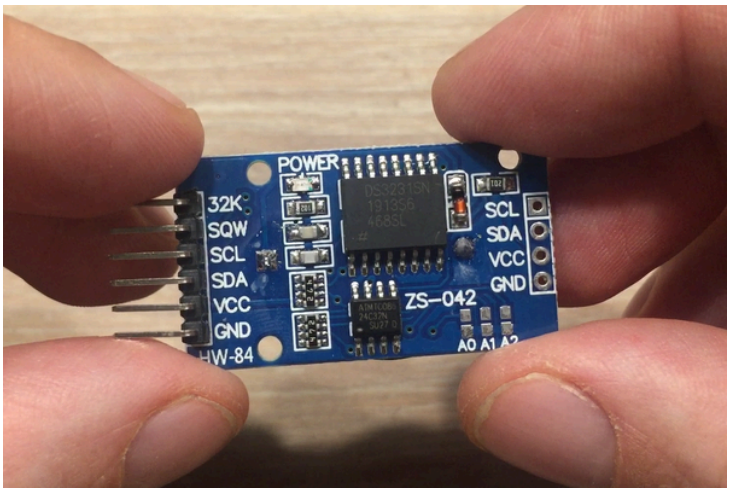
Introduction: How to Create a Clock Using Arduino , DS3231 RTC Module and OLED Display

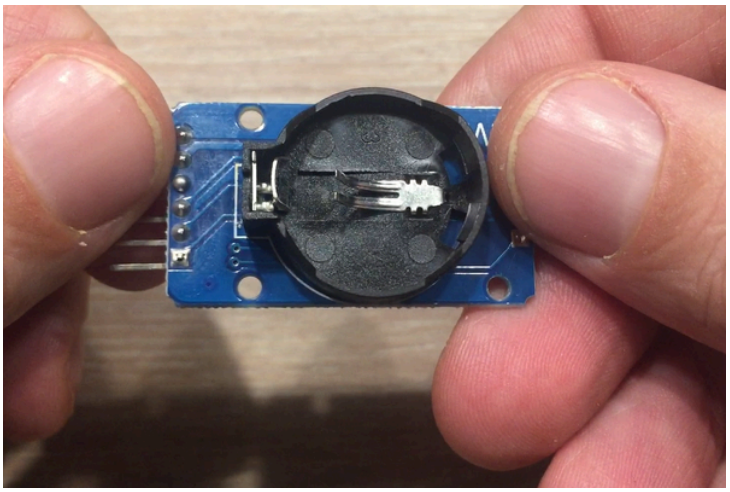


I have made a couple of clock project in the past. I have always used DS1306 module to do it. I received the backl ash from my viewers. They questioned why I would use that particuler RTC module labeling it as not relaible. Now that I think of it I had issues with those RTC modules being off by a minute or two after operating for a week. Ever yone pointed to DS3231 as a much more precise module. I thought to myself : "I have to give it a try".

So here is a tutorial how to build cool looking clock using Arduino, DS3231 and OLED display.

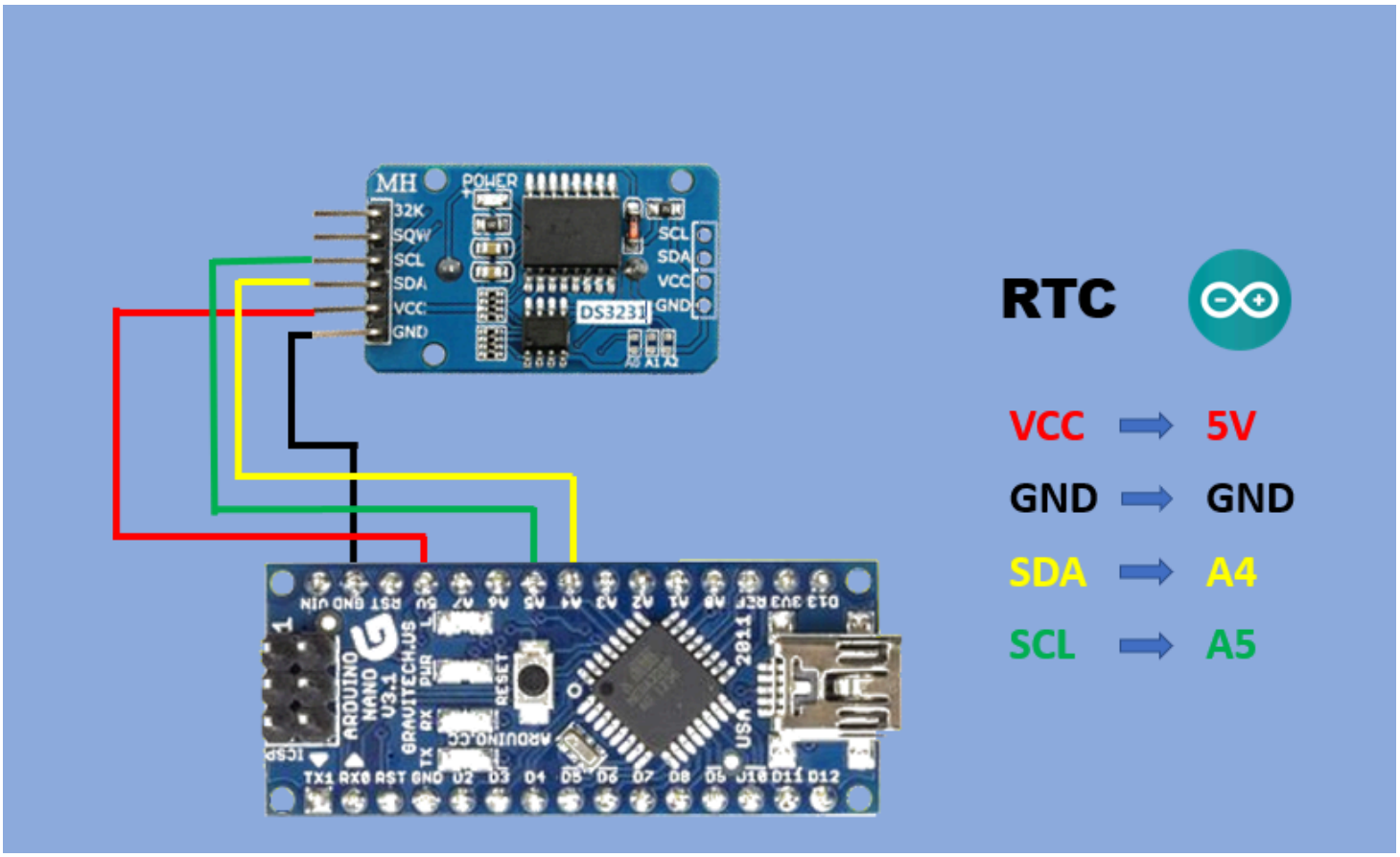
Step 1: DS3231 RTC Module





The DS3231 is a low-cost, extremely accurate I2C real- time clock (RTC) with an integrated temperature sensor. T he device has a battery input, and maintains accurate timekeeping when main power to the device is interupted

Step 2: Connecting DS3231 to Arduino

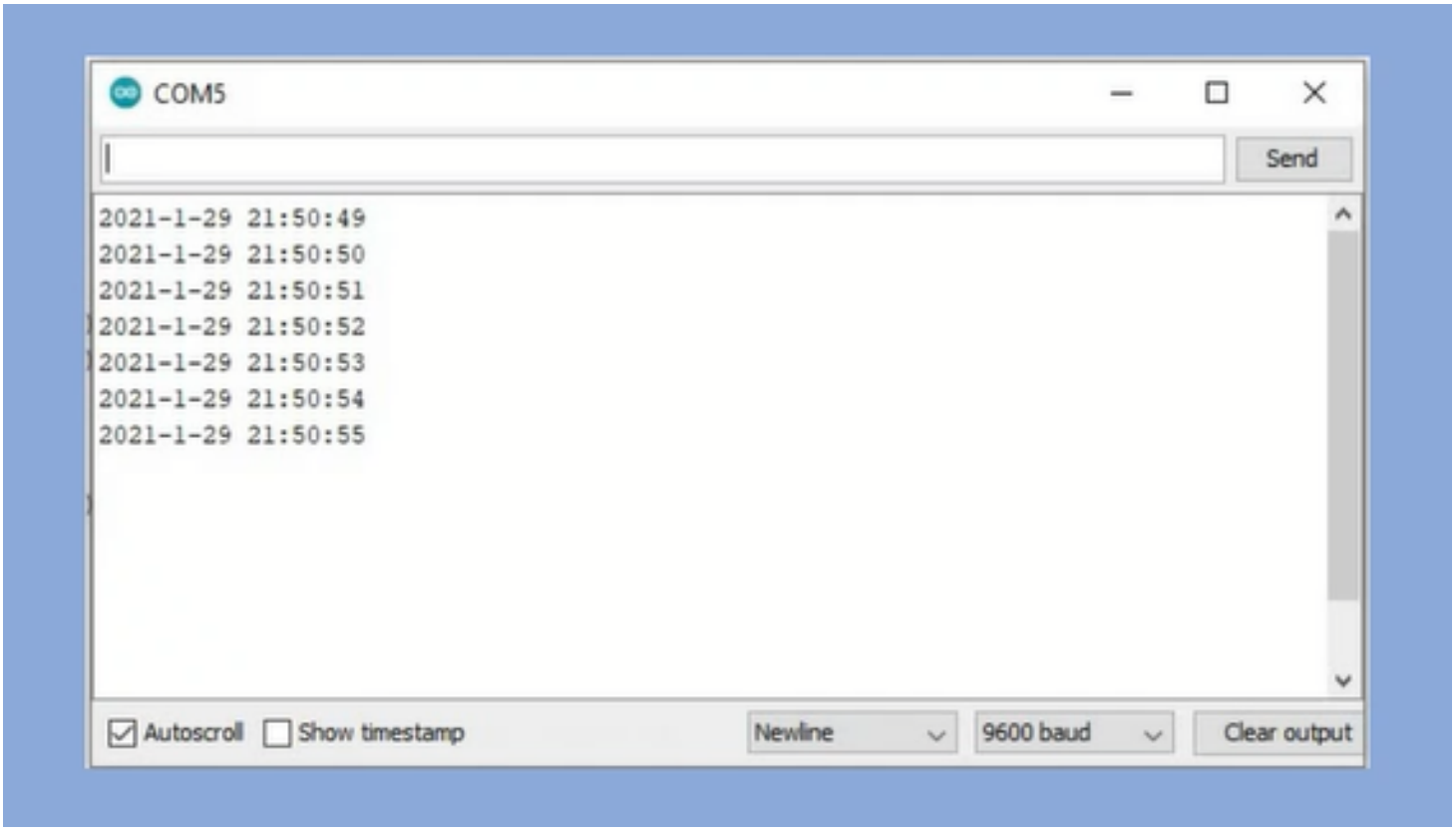


Finally the project where the connectivity is super simple. To connect this RTC module to Arduino we need to:

- Connect VCC pin to arduino 5v pin.
- Ground to ground.
- SDA pin to arduino analog pin A4
- SCL pin to Arduino Analog pin A5.

We have to use exactly those pins as they are meant for I2C comunication.

Step 3: Writing Simple Code to Display Time



Before we look at the code we need to import DS3231 library. There are a few of them available on Github. Here is the link to the library I am going to use.

DS3231 Library

To get it in you need to download the zip file. Then open this zip file in Arduino IDE. With each library come some example sketches and this one is no different. As you can see there are few of them.

Now to the code . Lets create the simplest scetch to display date and time in the most basic format.

We start with declaring the libraries.

```
#include <Wire.h><br>#include <DS3231.h>
```

First one enables us to use I2C comunication and the second one is the one we just installed which will help us wi th controlling RTC module.
The we declare the RTC module and also we declare the of RTCDateTime object .

```
DS3231 clock;<br>RTCDateTime dt;
```

RTCDateTime type consists of following components .

- uint16_t year,
- uint8_t month,
- uint8_t dayOfWeek,
- uint8_t hour,
- uint8_t minute,
- uint8_t second

In setup function we open serial monitor to be able to see the scetch results and then we initiate the RTC module. And finally we set the time to the time the scetch was compiled at. That is very handy functionality which makes s etting up current time on the RTC very easy

```
void setup() {

Serial.begin(9600);

clock.begin();

// Set sketch compiling time

clock.setDateTime( __DATE__ , __TIME__ );
```

In the main loop we run **clock.getDateTime()** time method to read current date and time to the **dt** object we have previously defined. And then with print function we output the time serial monitor. As you can see the format is ver y basic. You do not see the leading zeros where they should be so if you wanted to output date in time in the other way there would still be some string operations required.

```
void loop(){
  dt = clock.getDateTime();
  Serial.print(dt.year);   Serial.print("-");
  Serial.print(dt.month);  Serial.print("-");
  Serial.print(dt.day);    Serial.print(" ");
  Serial.print(dt.hour);   Serial.print(":");
  Serial.print(dt.minute); Serial.print(":");
  Serial.print(dt.second); Serial.println("");
  delay(1000);
}
```

Step 4: Reading Temperature With DS3231

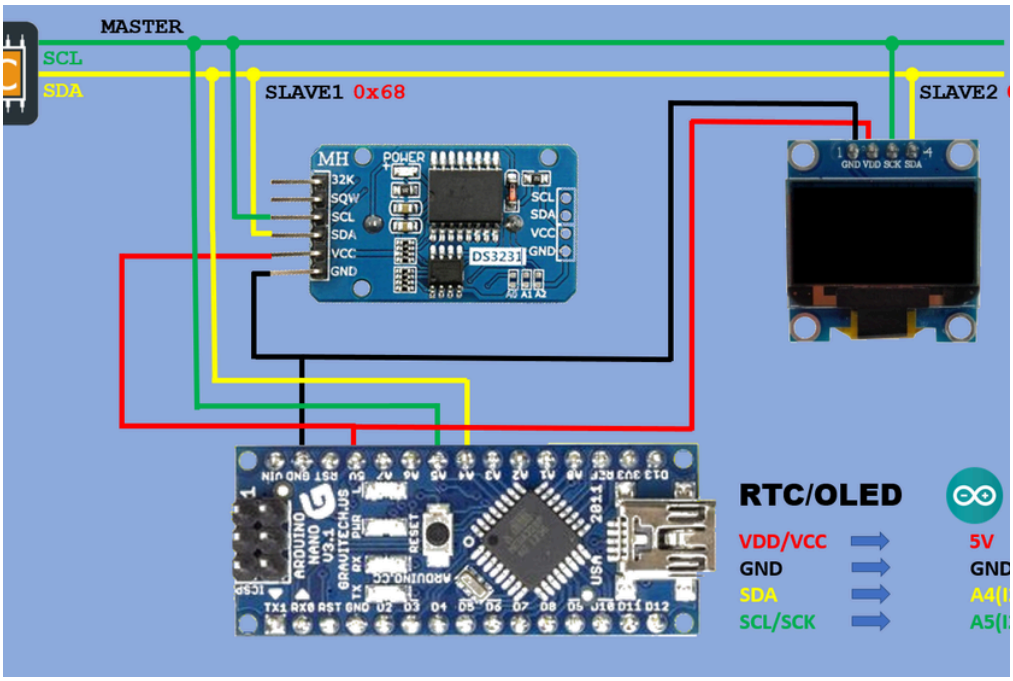
The DS3231 RTC has a built-in temperature sensor with a resolution of 0.25 and an accuracy of ±3°C .

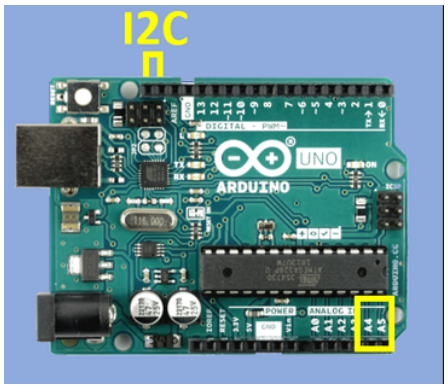
The temperature registers are updated after every 64-second conversion.
If you want force temperature conversion use **forceConversion()**

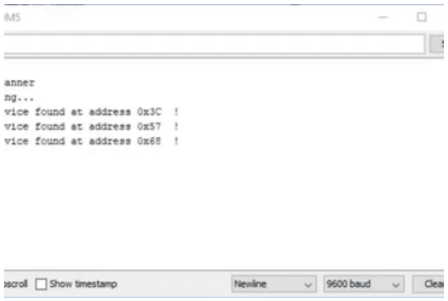
So if you want to display temperature in the main loop you have to add following lines of code

```
clock.forceConversion();

Serial.print("Temperature: ");

<br>Serial.println(clock.readTemperature());
```

Step 5: Adding OLED Display Into the Project







Now that we know how to controle this type or rtc module lets move away from serial monitor and try to display ti me on the small OLED display. When I wanted to connect it to arduino I realised that it also needs to be connecte d via pins A4 and A5 as this OLED display is also an I2C device. So what now. Those pins are already taken. You have to realise that those pins are not dedicated to any particular device. They can be shared accross many devic es as they connect those devices to I2c bus. So for starters lets connect VCC and ground of the oled display to ar duino

Then lets envisage the I2C bus with the Serial Data line called SDA in short and Serial Clock line called SCL. Ardu ino is connected to that bus via analog pin a4 to SDA and via analog pin A5 to SCL. Microcontroller is a master de vice.

The way of Connecting to I2C bus may differ depending on which arduino board you use. e.g in Uno A4 And A5 pi ns would work but there are also dedicated I2C ports. In Arduino Mega on the other hand A4 and A5 cannot be us ed for that purpose. So check the documentation of the board you are planning to use.

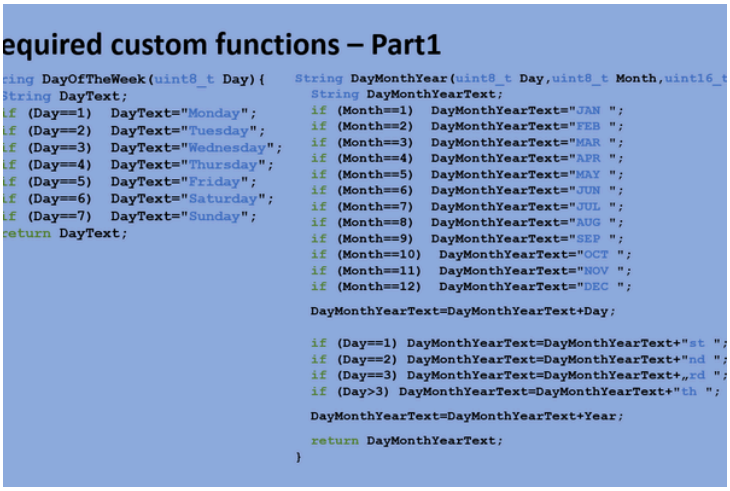
Now we can connect the rtc module to that bus as a slave and OLED display in the same way as a second slave device. Ok. But how would Arduino recognise which device is which to communicate with it. Each device have its unique address. So DS3231 RTC module should be avaiable at 68hex address while OLED display should be at 3C hex. If however you come accross issues while connecting any of the commponents you can use I2c scanner sketch to detect all avaialble devices connected to the bus and their addresses.

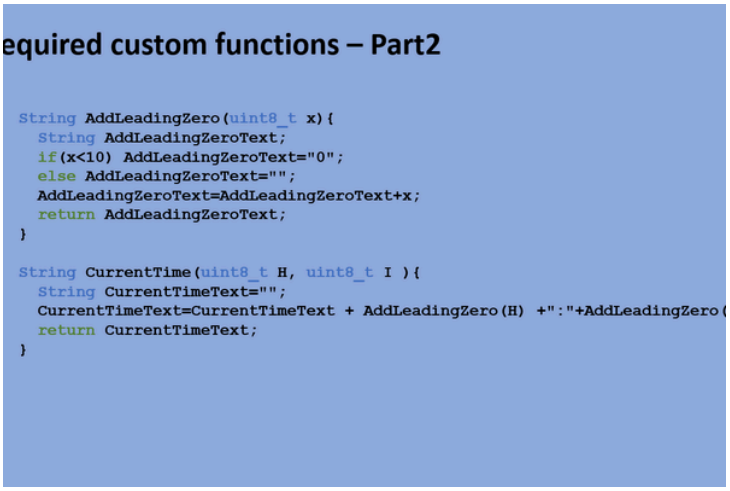
Here is the url you can find a I2C scanner sketch.

https://playground.arduino.cc/Main/I2cScanner/

Paste it to the arduino IDE and execute it. For my little set up the I2c scanner detects following devices (see attac hed screenshot)

Step 6: Custom Functions Needed to Display Time in a Proper Format.

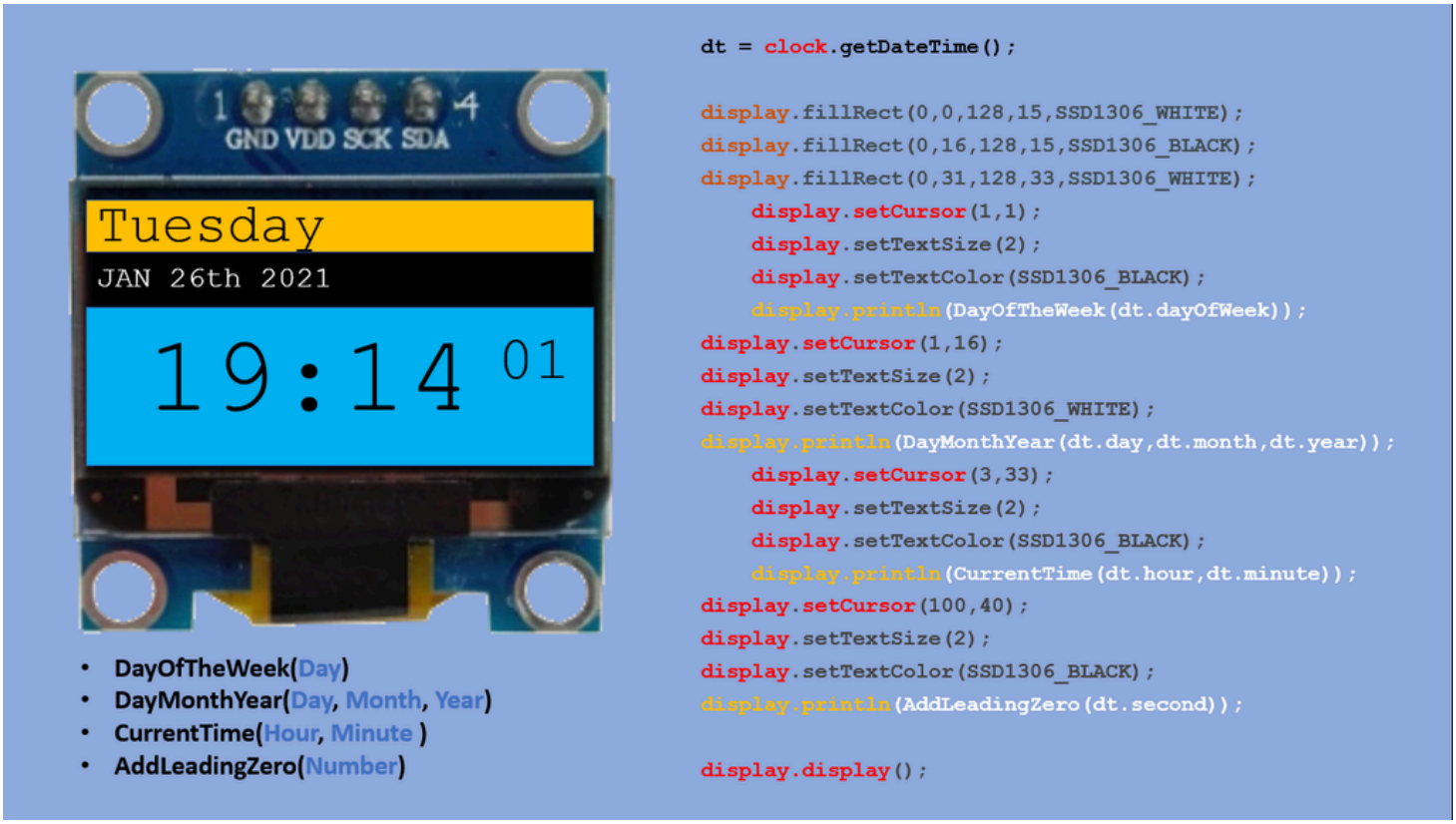




We need to write following function to be able to format the output the values read from RTC module into desired date and time format:

- **DayOfTheWeek** - It convert the day of the week reading into full name of the day (1-7->Mon-Sun)
  DayMonthYear - converts day month and year into single stringl. It bilds it from short name of the month, or dinal representation of the day of the month and then full year.
- **AddLeadingZero** - used to add leading zero to single digit readings for hour , minutes, and seconds
- **CurrentTime** - takes hours and minutes reading. Makes sure that the necessary leading zeros are provided and builds the string from hour and minutes separated by a colon

Step 7: Code to Display Time on the OLED Display



Having custom functions in place we can write a code that will display date and time in desired format on the oled display.

We require two more libraries for controling the display

```
#include <Adafruit_GFX.h>

#include <Adafruit_SSD1306.h>
```

Then we define its dimentions.
And decalre the display itself

```
#define SCREEN_WIDTH 128 // OLED display width, in pixels
#define SCREEN_HEIGHT 64 // OLED display height, in pixels
#define OLED_RESET     -1 // Reset pin # (or -1 if sharing Arduino reset pin)
Adafruit_SSD1306 display(SCREEN_WIDTH, SCREEN_HEIGHT, &Wire, OLED_RESET);
```

In setup function we add a section which checks if display properly initialised. It halts sketch execution if display is not detected.

```
if(!display.begin(SSD1306_SWITCHCAPVCC, 0x3C)) { // Address 0x3D for 128x64
    Serial.println(F("SSD1306 allocation failed"));
    for(;;); // Don't proceed, loop forever
 }
display.display(); //display initial Adafruit logo
delay(2000);
// Clear the display
display.clearDisplay();
display.display();
```

Now lets look at the code of the main loop to transform reading from the RTC module to graphical representation of date and time

First we save the reading from the RTC to the dt object

```
dt = clock.getDateTime();
```

Then we draw three rectanglers/panels. First in white and since this particular display is dual color one where first 15 lines are yellow it shows in yellow. Then we draw another one in black and then another one in white which will show in blue as that part of the display is blue. (as shown on the photo)

```
display.fillRect(0,0,128,16,SSD1306_WHITE);
display.fillRect(0,17,128,16,SSD1306_BLACK);
display.fillRect(0,31,128,33,SSD1306_WHITE);
```

Then after selecting cursor position and font color and size we output full day of the week in top panel using

DayOfTheWeek function.

```
display.setCursor(1,1);
display.setTextSize(2);
display.setTextColor(SSD1306_BLACK);
display.println(DayOfTheWeek(dt.dayOfWeek));
```

We continue with displaying Short name of the month day of the month and a full year in middle panel using Day MonthYear function

```
display.setCursor(1,18);
display.setTextSize(1);
display.setTextColor(SSD1306_WHITE);
display.println(DayMonthYear(dt.day,dt.month,dt.year));
```

We can also add temperature into top panel as well.

```
clock.forceConversion();
display.setCursor(85,18);
display.setTextSize(1);
display.setTextColor(SSD1306_WHITE);
display.print(clock.readTemperature());
display.setCursor(117,16);
display.print("o");
```

In main panel we display hours and minutes using CurrentTime function and then with the smaller font we are also displaying seconds.

```
display.setCursor(3,35);
display.setTextSize(3);
display.setTextColor(SSD1306_BLACK);
display.println(CurrentTime(dt.hour,dt.minute));

display.setCursor(100,35);
display.setTextSize(2);
display.setTextColor(SSD1306_BLACK);
display.println(AddLeadingZero(dt.second));
```

We ended up with fairly nice looking design of the clock.

Step 8: Problematic DateFormat Function

The library I am using in this tutorial provide one extra function called DateFormat. This is a powerful function whic h helps us to format the time/date read of the RTC module anyway we want easy and without the need of writing additional functions like we did in our code.

I am providing syntax of this function here with examples.

There is a problem with that function though. It requires a lot of memory and if you coose to use it with OLED displ ay your sketch would run out of memory. This problem was reported to library creator, but it seems he has stoppe d working on this library, and this problem may never be fixed.

You can still use this function with arduino compatible microcontrollers thathave more than 2k of Sram (Arduino M ega, Bluepill etc).

I will provide in the closing chapter a link to the code that is using this DateFormat format to achieve the same res ult as our code here, and you will see that this greatly simplifies the code.

Step 9: Conclusion

Thank you for spending time reading through this tutorial.

I stronglt encourage you to watch the Youtube video at the beginnig of this tutorial which shows the code creation and you can see the final result.

If you find this tutorial useful please give this youtube video a like. It helps me to create similar content.

Here you will find link to the code:

Link to the code

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