Lab 1: Arduino Basics

Rodrigo Carbajales and Marco Zennaro
ICTP Trieste-Italy

Step Zero

Clean up your desks! :)

Goals of this Lab

- Learn how the programming takes place
- Excercises about:
-
  - installing the IDE
  - setting the clock
  - measuring the temperature
  - timestamping the temperature reading
  - saving the data on the SD card

Getting started

We will:

1) Download and install the Arduino IDE
2) Install the SODAQ Mbili files and libraries
3) Select the SODAQ Mbili hardware profile
4) Configure the serial port

Installing the IDE

- IDE= Integrated development environment
- Arduino IDE is Open Source

Installing the IDE

Windows Installation Process

Go to the web address below to access the instructions for installations on a Windows-based computer.

http://arduino.cc/en/Guide/Windows

Macintosh OS X Installation Process

Macs do not require you to install drivers. Enter the following URL if you have questions. Otherwise proceed to next page.

http://arduino.cc/en/Guide/MacOSX

Linux: 32 bit / 64 bit, Installation Process

Go to the web address below to access the instructions for installations on a Linux-based computer.

http://www.arduino.cc/playground/Learning/Linux

Installing the Arduino IDE

After downloading and installing the software, you need to run the Arduino IDE once for it to create a the sketchbook directory called Arduino inside your **documents** folder. You can then close the program.

Installing the SODAQ Mbili files

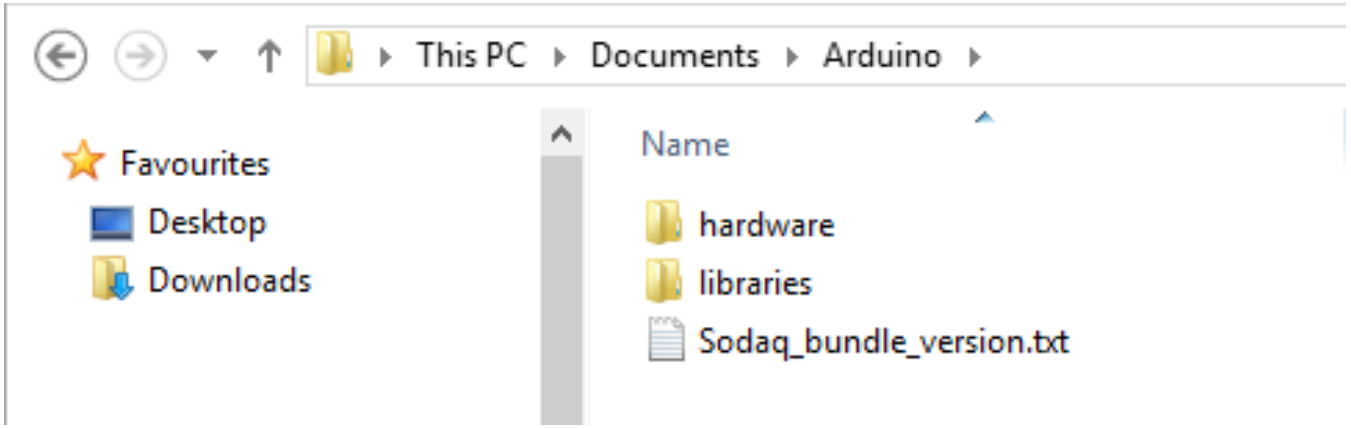
The next step is to install the SODAQ Mbili files (in the lab1.zip file)

You must unpack this zip file and place the contents in the Arduino sub-folder of your documents folder (the folder that was created by the Arduino IDE the first time it was run).

In Windows it is located in: C:\Users\yourusername\Documents\Arduino\

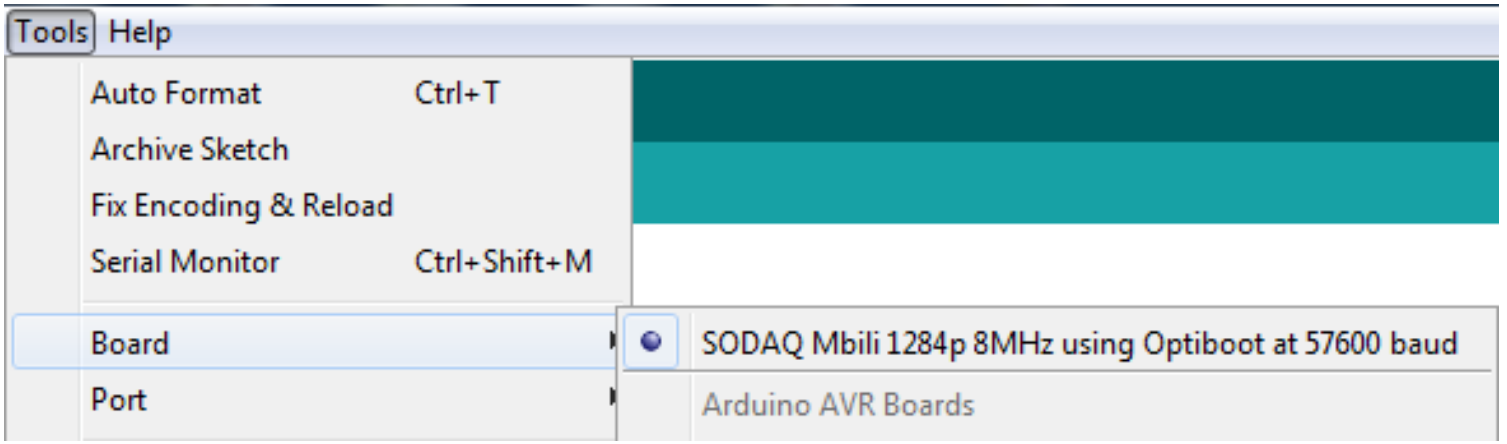
Installing the SODAQ Mbili files

The contents of the Arduino folder should now look like this:



Selecting the SODAQ hw profile

Select the SODAQ board in Tools→ Board



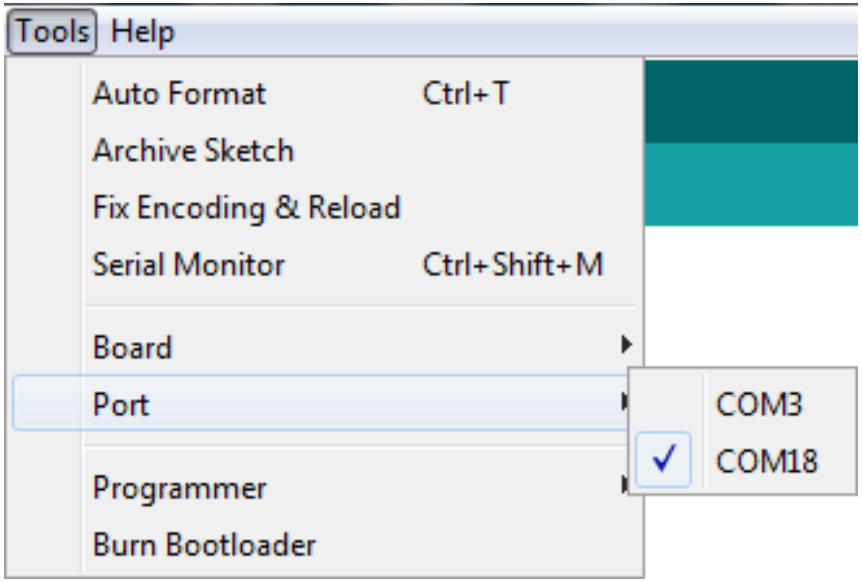
Configuring the serial port

Windows versions 7 and 8 will normally find the right USB driver when you plug in the SODAQ Mbili for the first time. The same is also true for Mac and Linux. If your system doesn't find the driver you will have to download the FTDI drivers.

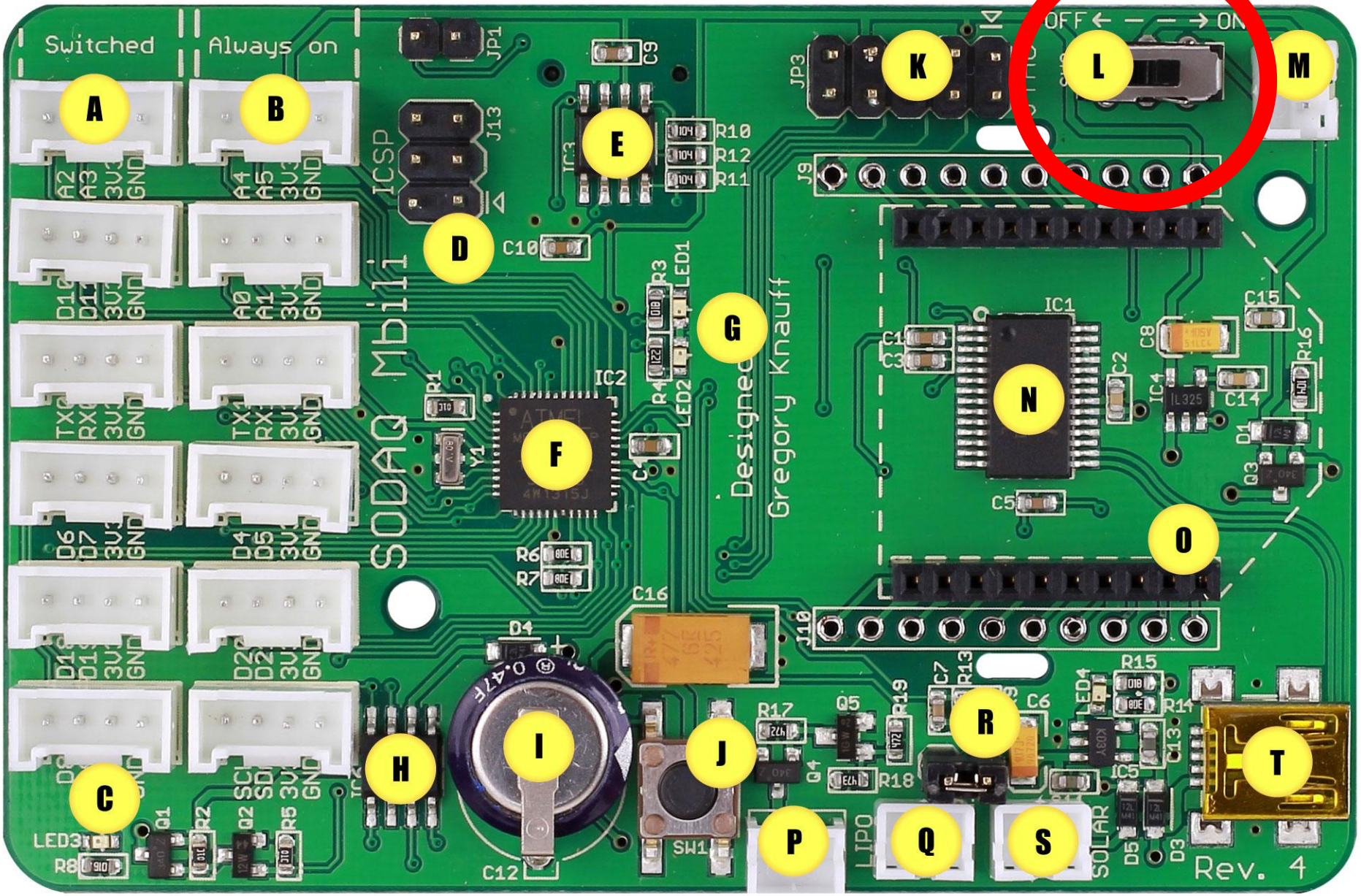
The FTDI driver adds a virtual serial port. In Windows this is _COMx_ (so _COM1, COM8,_ etc.).

Configuring the serial port

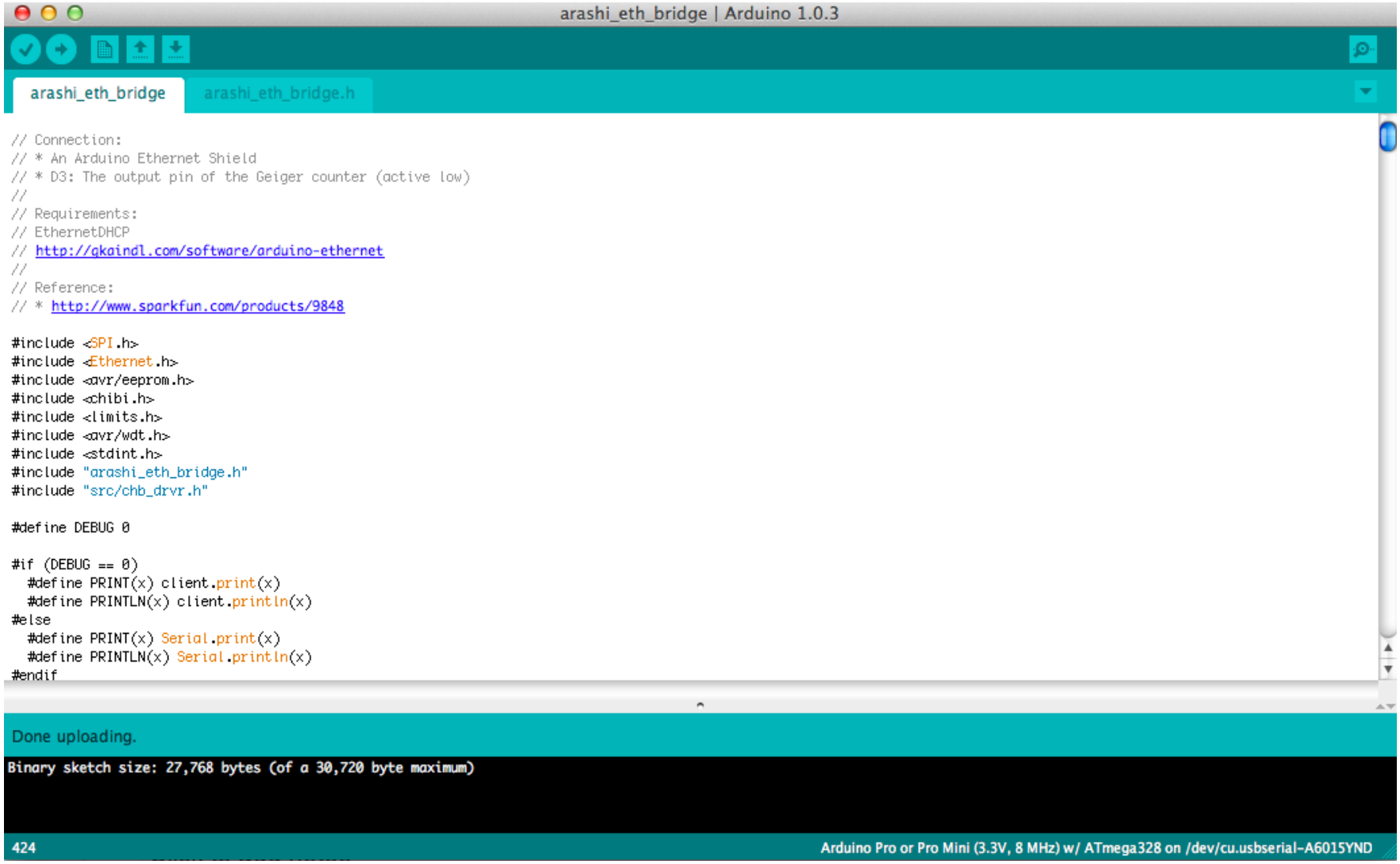
Select the serial port in Tools→ Port



The associated serial port is only visible in that list when the SODAQ Mbili board is **connected** and **switched on**.


Switched
Always on
A
B
C
D
E
F
G
H
I
J
K
L
M
N
O
P
Q
R
S
T
OFF
ON
SODAQ Mbili
Designed by
Gregory Knauff
ICSP
LIPO
SOLAR
Rev. 4

The Arduino IDE



Programming an Arduino

From the File menu, choose Open and select the code you want to open.

The source code will appear in the IDE window.

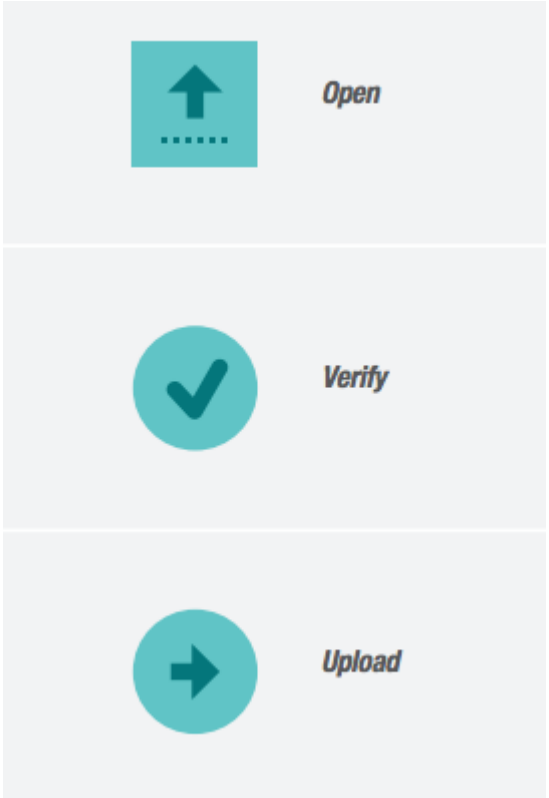
Lab Examples

From the Workshop's webpage,
download the zip file with all the examples
for this Lab 1 Session.

Open the folder called Lab1.1
and open the **Hello_world.ino** file

Programming workflow

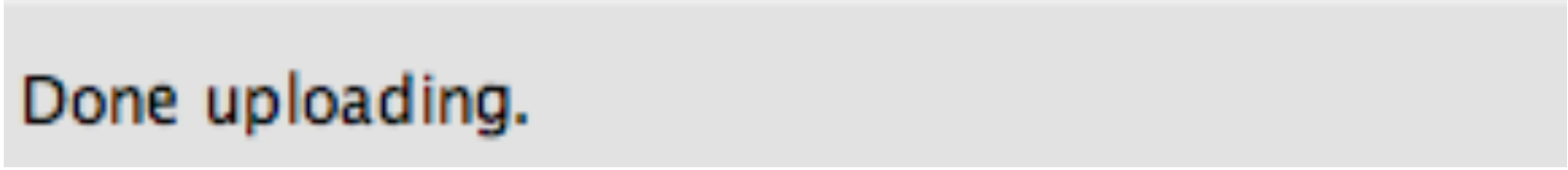
1. Opening
2. Verifying
3. Uploading



Programming an Arduino

Click on the upload button and wait until the code has been compiled and uploaded.

At the end you will see in the bottom right corner:



Programming an Arduino

This is the template of a basic Arduino program:

```
void setup()
{
  Initialize variables, open USB, open WiFi, etc
}
```

SETUP (once)

```
void loop()
{
   Perform some action

   Wait for a certain number of msecs or wait for an alarm
}
```

LOOP (forever)

Lab session

This lab session will be like this:

```
For (i=1;i<=3;i++) {
    Simple example (me)  /* 2 min */
    Extended example (you) /* 20 min */
}

Real-world exercise /* 1 hour */
```

Start!

Example 1

Hello_world.ino will write Hello World on the serial port.

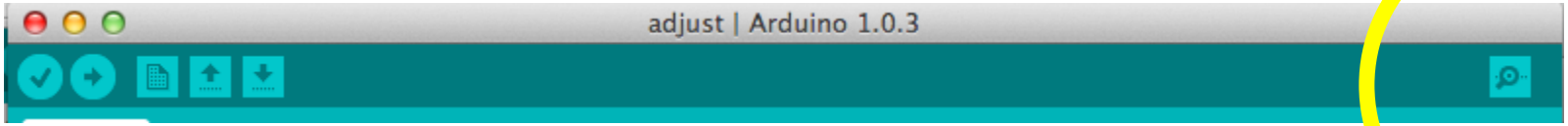
```
void setup()
{
  // put your setup code here, to run once:
  Serial.begin(9600);
  Serial.println("Starting...");
}

void loop()
{
  // put your main code here, to run repeatedly:
  Serial.println("Hello World");
  delay(1000);
}
```

Example 1

How do you see the output of your code?

Select Serial Monitor (via Tools → Serial):

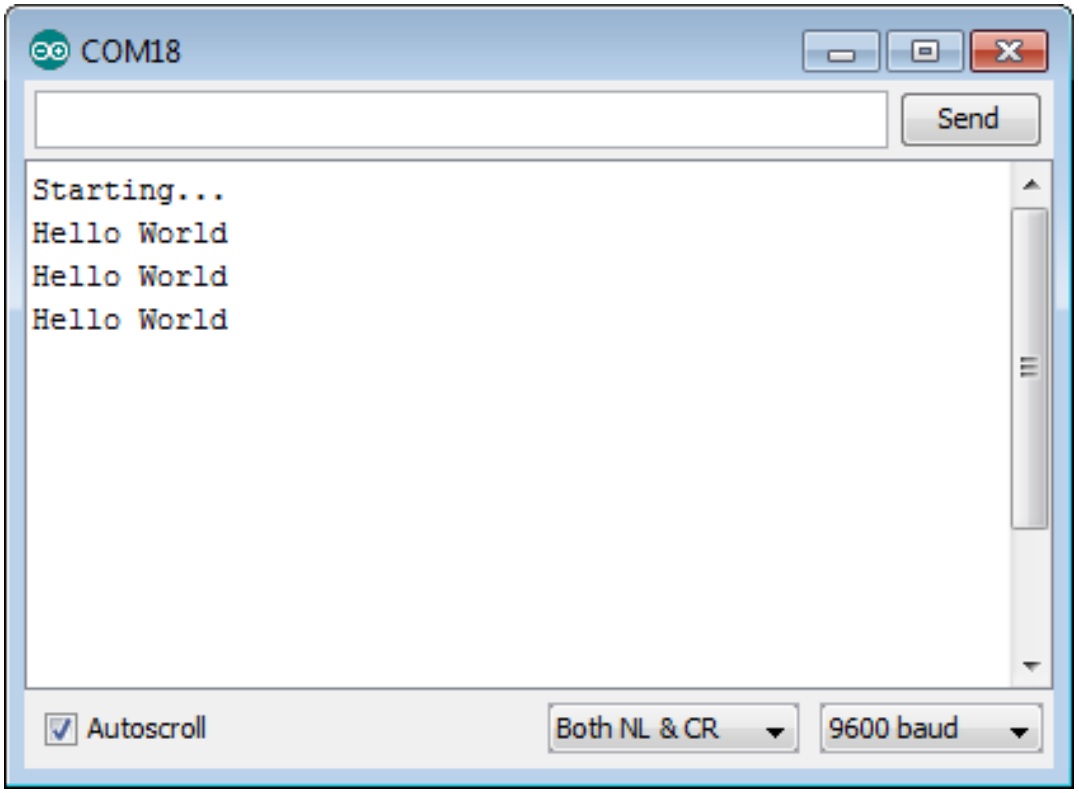


Note the Serial Baud Rate that is set in the code!

Your Serial Monitor needs to match that!

Example 1

You will see the following:



Example 1 - extended

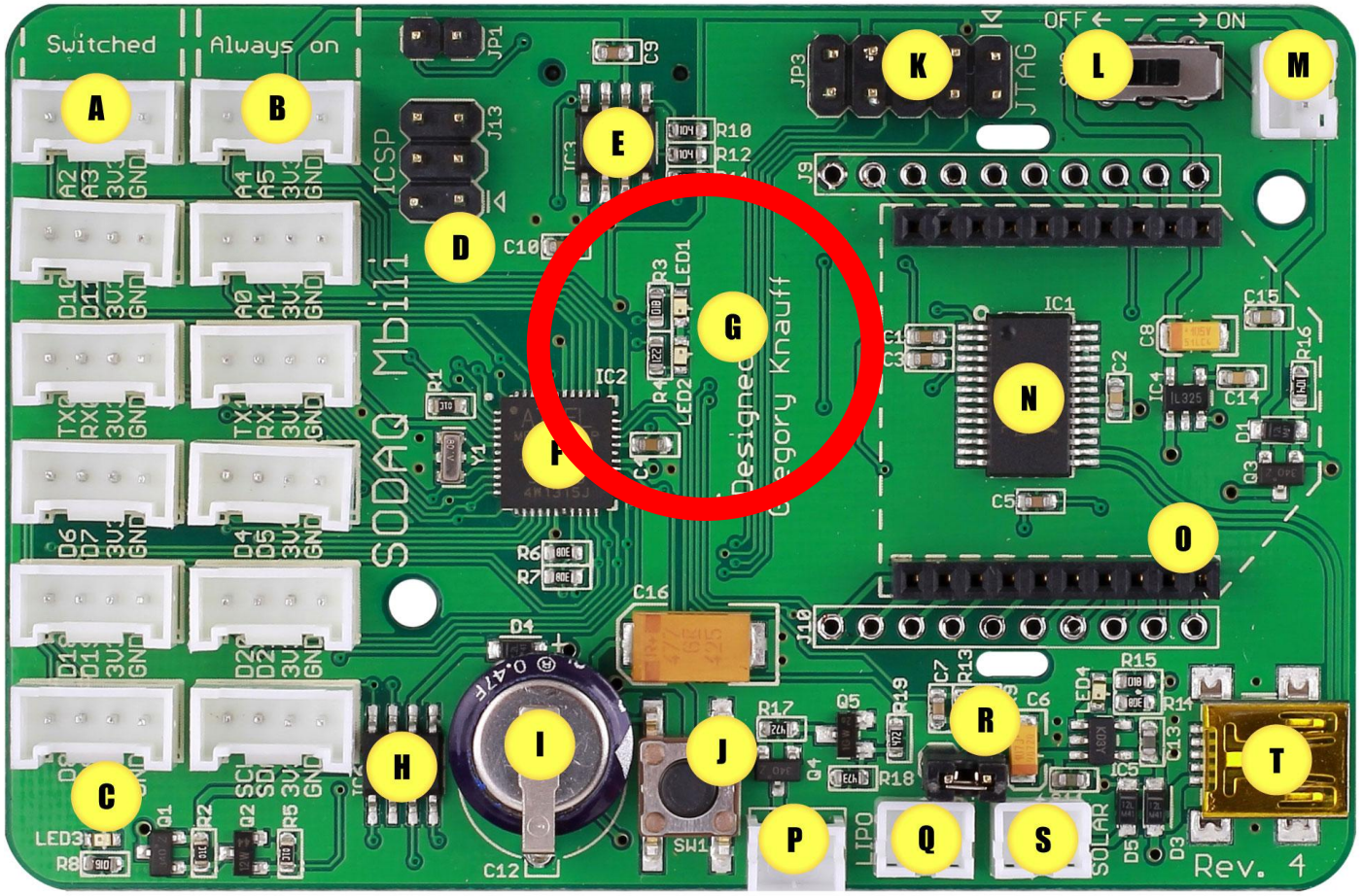
Get acquainted with the IDE.

Try to write something else.

Change the delay.

Example 2

Leds1_2.ino will blink LED1(green) and LED2(red).



Example 2

Leds1_2.ino will blink LED1(green) and LED2(red).

```
//How long to activate each LED
#define DELAY_TIME 1000

void setup()
{
  //LED1
  pinMode(LED1, OUTPUT);
  digitalWrite(LED1, LOW);

  //LED2
  pinMode(LED2, OUTPUT);
  digitalWrite(LED2, LOW);
}
```

Example 2

Leds1_2.ino will blink LED1(green) and LED2(red).

```
void loop()
{
  //Switch LED1 on then off again after DELAY_TIME (ms)
  digitalWrite(LED1, HIGH);
  delay(DELAY_TIME);
  digitalWrite(LED1, LOW);

  //Repeat for LED2
  digitalWrite(LED2, HIGH);
  delay(DELAY_TIME);
  digitalWrite(LED2, LOW);
}
```

Example 2 - extended

Make the LEDs blink as fast as possible.

Make the LEDs blink at the same time.

Write SOS in Morse Code (...---...).

Real Time Clock (RTC)

Having a RTC is useful for two reasons:

1. to time stamp the collected data (for example: temperature is 27.4C at 10:02:30 of 6/7/2020)
2. to be able to set alarms to wake up the mote from sleeping mode (for example: wake up on Tuesday 15th of August at 10:30:00).

SODAQ has a RTC!

Example 3

RTC_date_time_update.ino will set the time of the SODAQ using the RTC.

To program the RTC you need to download some libraries first. In the zip file you will find the DS3231 and Wire libraries.

Make sure the files in folder labelled “Sodaq_DS3231” and “Wire” are into your Arduino libraries folder.

Restart the IDE!

Example 3

RTC_date_time_update.ino will set the time of the Seeduino using the RTC.

Change the line:

DateTime dt(2011, 11, 10, 15, 18, 0, 5);

to adjust to today's date and time.

Format is: year, month, date, hour, min, sec and week-day (starts from 0 (Sunday) and goes to 6 (Saturday))

Example 3

RTC_date_time_update.ino will set the RTC and then show it.

```
/Include the necessary libraries
#include <Wire.h>
#include <Sodaq_DS3231.h>

Sodaq_DS3231 RTC; //Create RTC object for DS3231
DateTime dt(2014, 06, 05, 11, 5, 00, 4);
```

Example 3

```
void setup()
{
  //Start serial
  Serial.begin(9600);
  Serial.println("Date,     Time");

  //Start the I2C protocol
  Wire.begin();

  //initialize the DS3231
  RTC.begin();
  RTC.setDateTime(dt); //Adjust date-time as defined 'dt' above
}
```

Example 3

```
void loop()
{

  String data = getDateTime();
  Serial.println(data);
}

String getDateTime()
{
  String dateTimeStr;

  //Create a DateTime object from the current time
  DateTime dt(RTC.makeDateTime(RTC.now().getEpoch()));

  //Convert it to a String
  dt.addToString(dateTimeStr);

  return dateTimeStr;
}
```

Example 3

Important:

Once the RTC has been set, line

```
RTC.setDateTime(dt);
```

has to be commented in order not to update every reboot of the board.

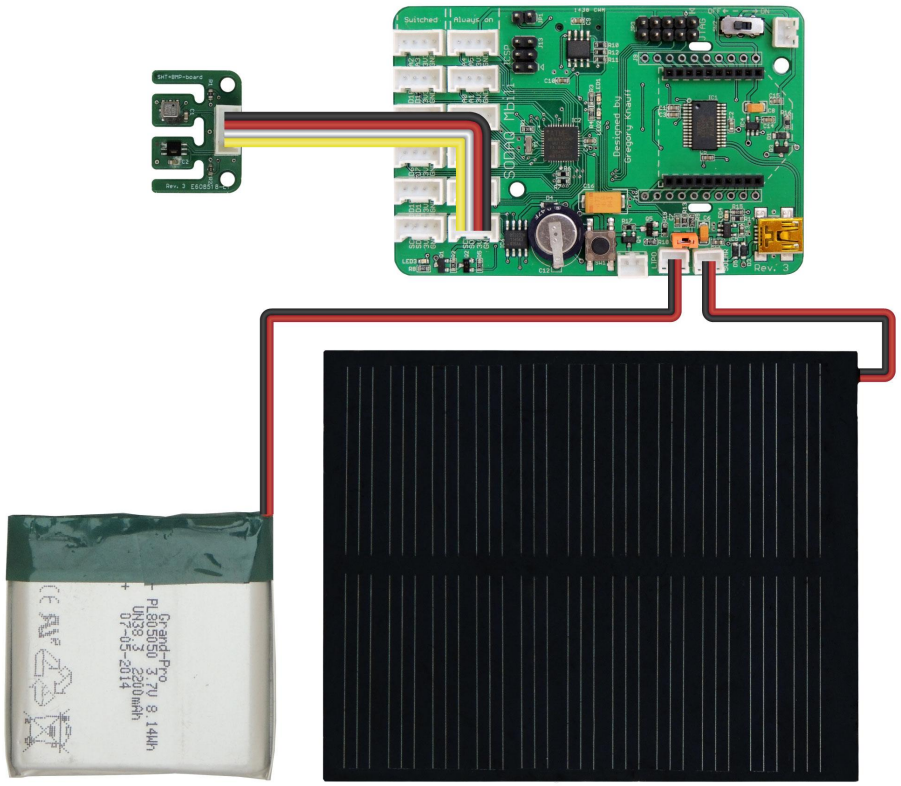
Example 3 - extended

Comment the line where you set the time. Is the time OK?

Disconnect the SSODAQ from the USB. Wait some minutes. Connect it again. Are the date and time OK?

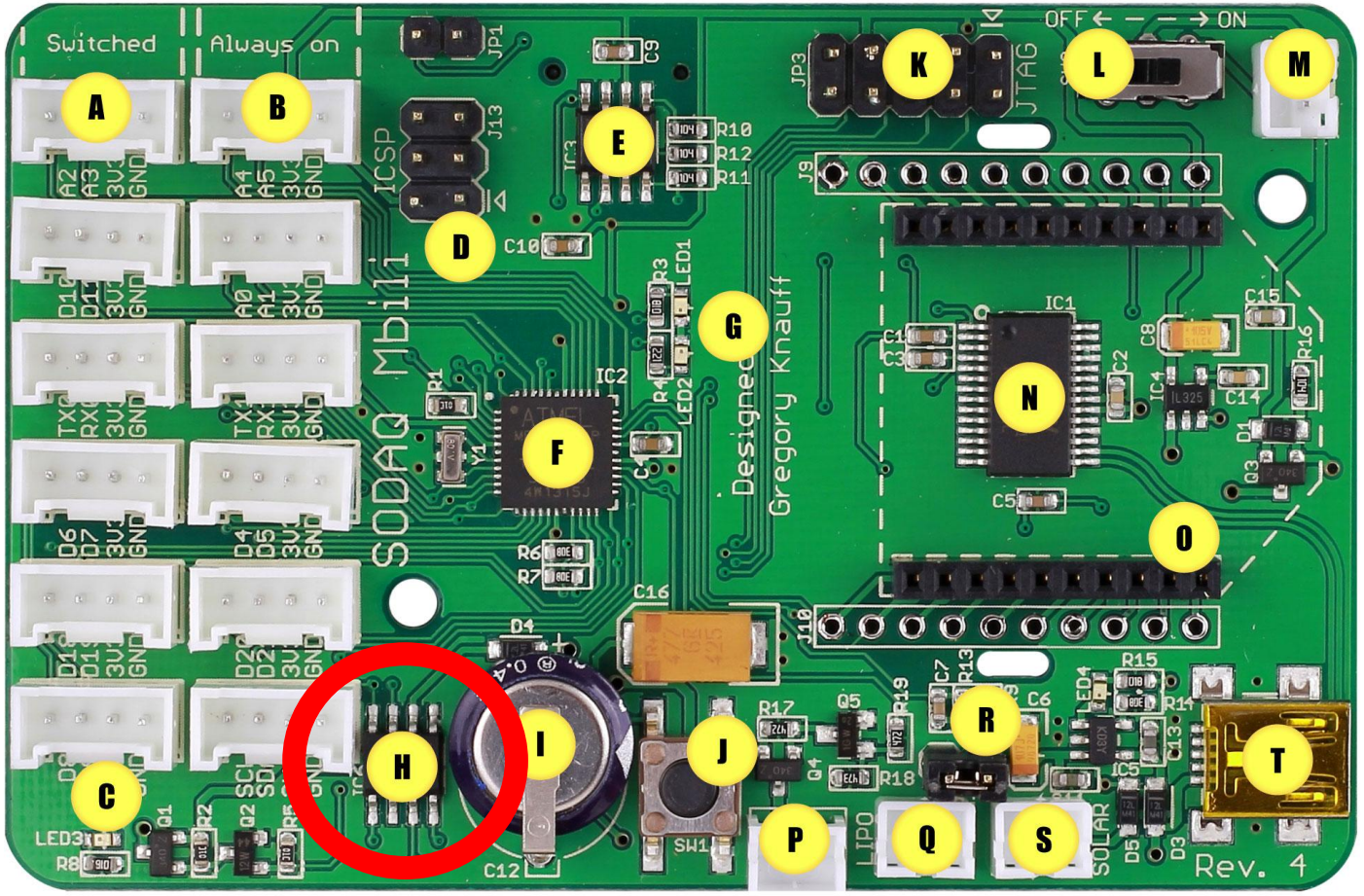
Example 4

RTC_date_Volt_Temp.ino will read the temperature of the RTC. It will also read the voltage level of the external battery. You don't need the TPH sensor yet.



Example 4

The RTC is shown here:



Example 4

RTC_date_Volt_Temp.ino will read the RTC temperature and the battery voltage.

```
void loop()
{
  ///Read the temperature
  RTC.convertTemperature();
  float temp = RTC.getTemperature();

  // Convert temperature voltage to string
  char buffer[14]; //make buffer large enough for 7 digits
  String temperatureS = dtostrf(temp, 7,2,buffer);
  temperatureS.trim();

 //Read the voltage
  int mv = getRealBatteryVoltage() * 1000.0;
```

Example 4 - extended

Touch the RTC and check if the temperature goes up or down.

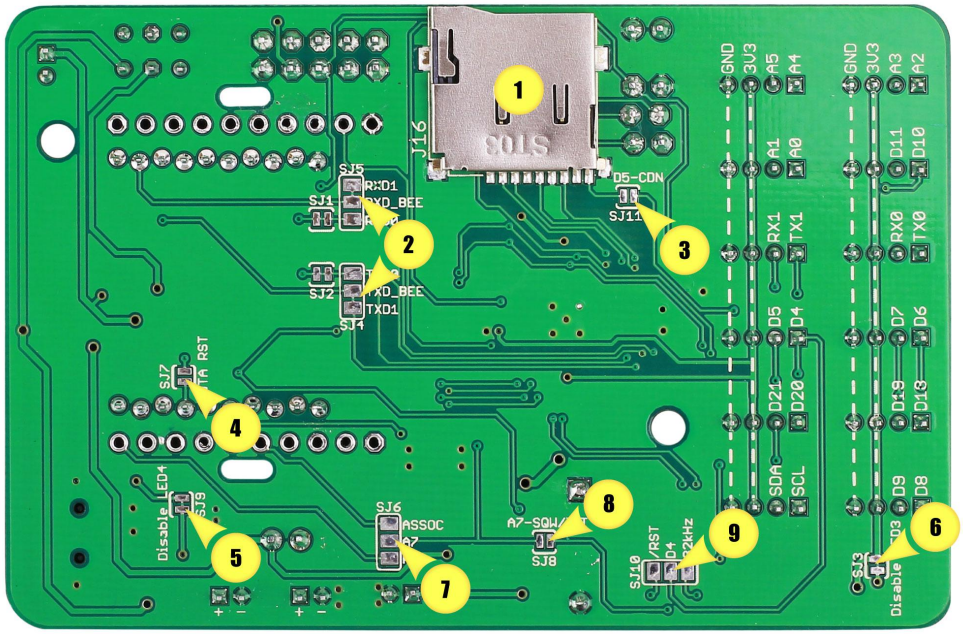
Convert the temperature to Fahrenheit and show values in both C and F.

Example 5

SD_write.ino will write a string to the µSD card.

The SPI and SD Libraries come pre-installed with the Arduino IDE, so there is no need to install them.

Insert a µSD card in the slot 1.



Example 5

SD_write.ino will write a string to the µSD card.

```
//Digital pin 11 is the MicroSD slave select pin on the Mbili
#define SD_SS_PIN 11

//The data log file
#define FILE_NAME "DataLog.txt"

//Data header
#define DATA_HEADER "Hello world"
```

Example 5

SD_write.ino will write a string to the µSD card.

```
void loop()
{
   //Create the data record
  String dataRec = createDataRecord();

  //Save the data record to the log file
  logData(dataRec);

  //Echo the data to the serial connection
  Serial.println(dataRec);

  //Wait before taking the next reading
  delay(READ_DELAY);
}
```

Example 5

SD_write.ino will write a string to the µSD card.

```
String createDataRecord()
{
  //Create a String type data record in csv format

  String data = "1st East-African Workshop on the Internet Of Things";
  return data;
}
```

Example 5 - extended

Try to write something else.

Remove the µSD card and read it with a card reader. Are the data formatted OK?

Example 6

RTC_date_Volt_Temp_SD.ino will write a string to the µSD card with date, temperature and voltage readings.

The log file will consist of Comma Separated Values (CSV) in ASCII format.

This type of application is called **data logger**.

Example 6

```
String createDataRecord()
{
  //Create a String type data record in csv format
  ///Read the temperature
  RTC.convertTemperature();
  float temp = RTC.getTemperature();
  // Convert temperature voltage to string
  char buffer[14]; //make buffer large enough for 7 digits
  String temperatureS = dtostrf(temp, 7,2,buffer);
  temperatureS.trim();
  //Read the voltage
  int mv = getRealBatteryVoltage() * 1000.0;

  String data = getDateTime()+ ", ";
  data += String(temperatureS)+ "C, ";
  data += String(mv)+ "mV";
  return data;
}
```

Example 7

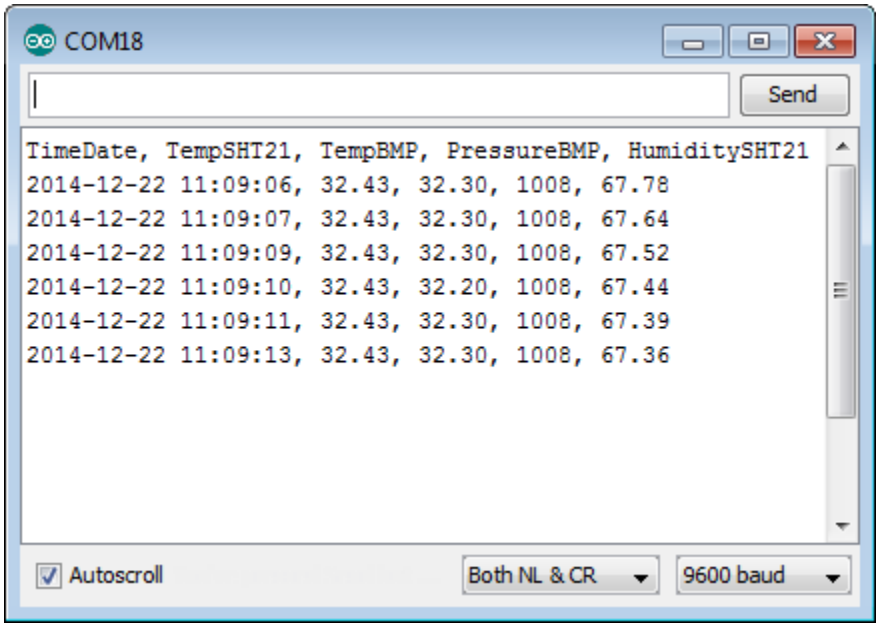
RTC_TPH_SD_Tiner.ino will demonstrate the use of a **RTCTimer** to schedule regular events.

This example builds on the previous example, but instead of using the delay() method, it uses a scheduling timer to control the frequency of the readings.

The required RTCTimer library is included with the SODAQ Mbili files that you have already installed.

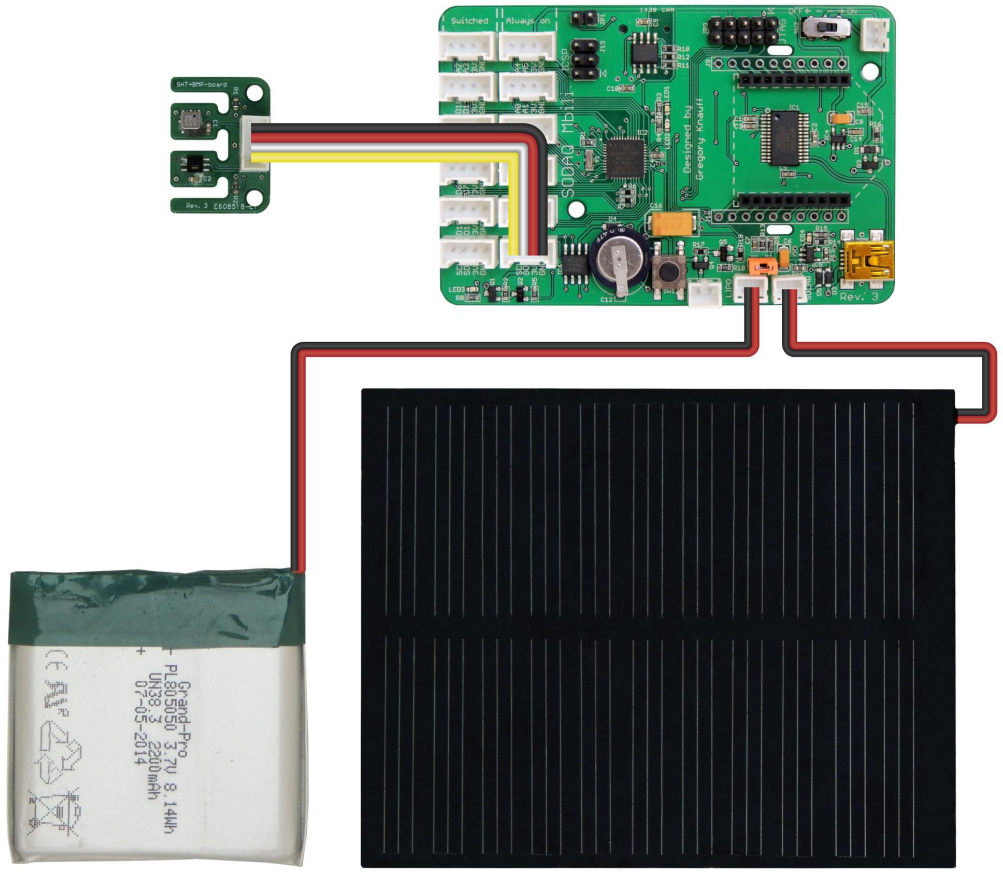
Example 7

The delay() method pauses the execution for a specified number of msecs → delays due to sum of execution time and delay.



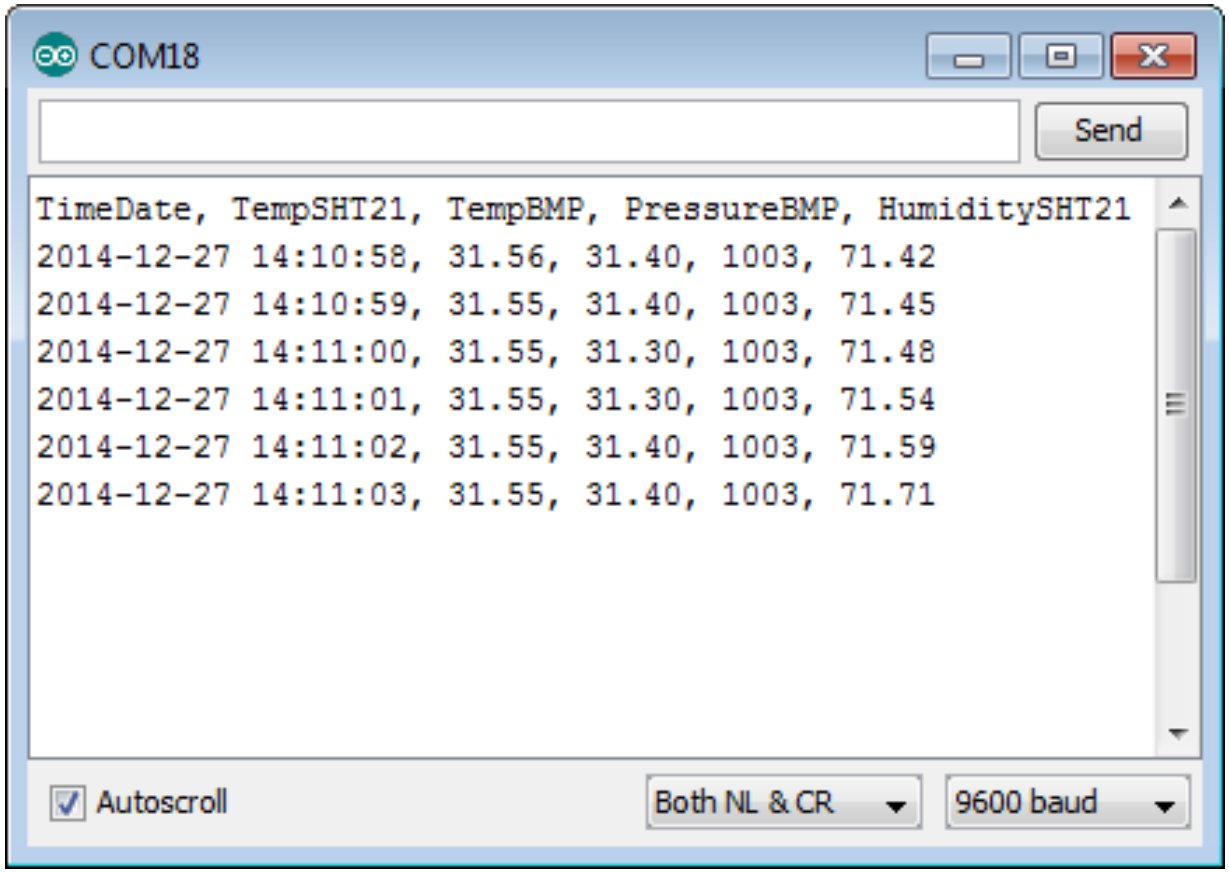
Example 7

We will read data from the TPH sensor, which is more precise than the internal RTC temperature sensor.



Example 7

Readings are now every second! (no delays)



Example 7 - extended

Compare the RTC temperature readings and the ones given by the TPH sensor.

Convert the temperature to Fahrenheit and save values in both C and F.

Thanks

Marco Zennaro and Rodrigo Carbajales

mzennaro@ictp.it

http://wireless.ictp.it