Lab 2: Sending Data and Connecting Sensors

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Step Zero

Clean up your desks! :)

Goals of this Lab

- Learn how to send sensor data via SMS
- Excercises about:
-

  sending SMS
  connecting external sensors
  sending data from external sensors via SMS

Lab Examples

From the Workshop's webpage, download the zip file with all the examples for the Lab 2 Session.

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 */
```

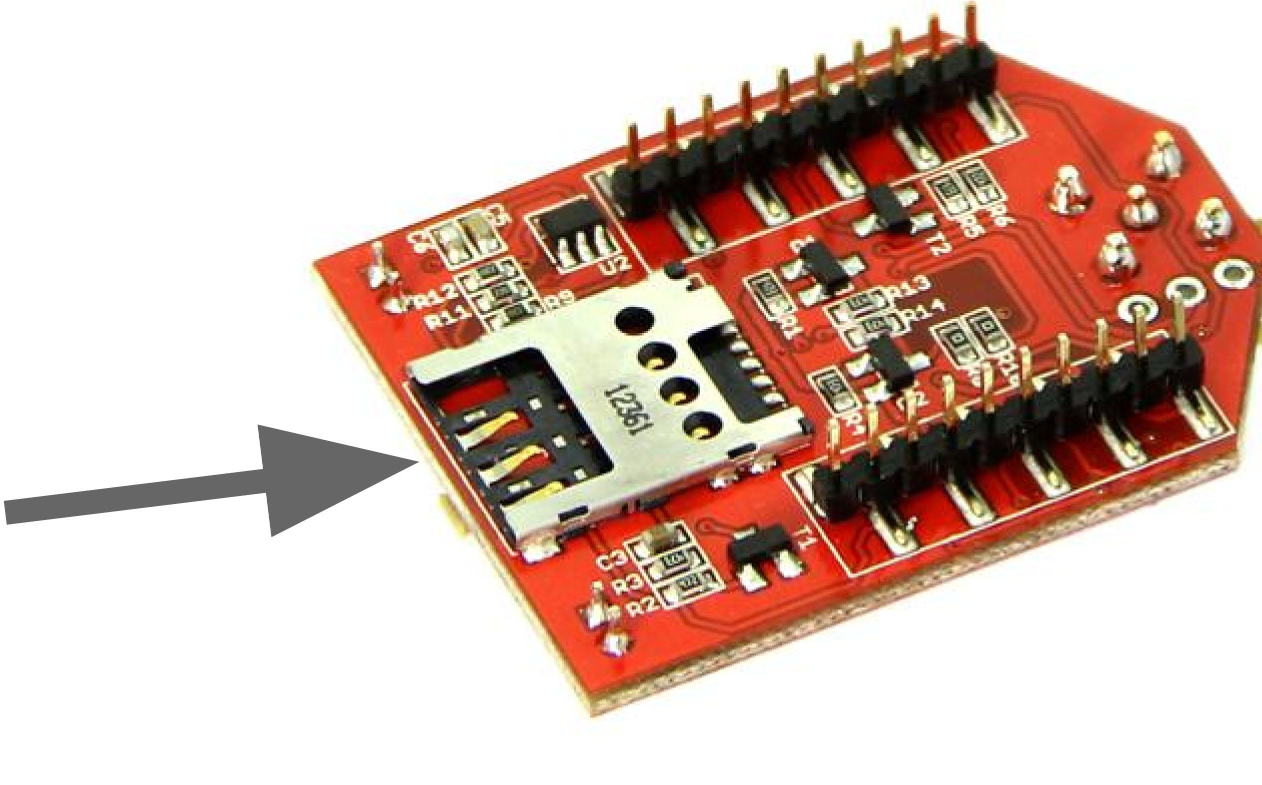
Start!

Example 1

Send_SMS.ino will send an SMS message using the GPRSbee module.

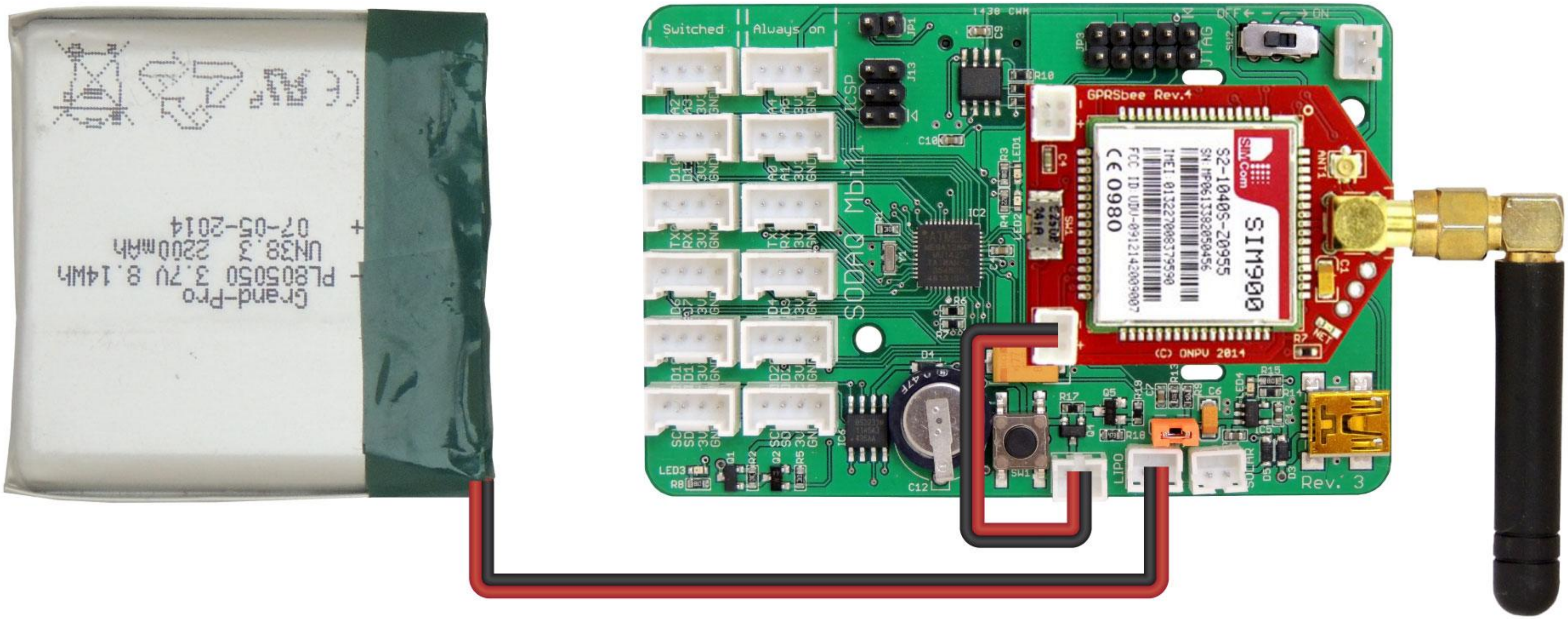
It has an operating voltage of 3.5 - 4.5 volt and can draw up to 2A power during broadcasts bursts.

Example 1



µSIM

Example 1


Grand-Pro
PL805050 3.7V 8.14Wh
UN38.3 2200mAh
07-05-2014
Switched
Always on
SODAQ Mbili
GPRSbee Rev.4
SIM900
LIPO
SOLAR
Rev. 3

Example 1

Send_SMS.ino will send an SMS message using the GPRSbee module.

```
//SODAQ Mbili libraries
#include <GPRSbee.h>

// Fill in your mobile number here. Start with + and country code
#define TELNO      "+393898896252"

void setup ()
{
    Serial.begin(9600);      // Serial1 is connected to SIM900 GPRSbee
    Serial.println("sending a SMS text: Hello world");
    setupComms();
}

void loop ()
{
   bool smsSent = gprsbee.sendSMS(TELNO,"Hello World");
   delay(10000);
}
```

Example 1 - extended

Try to write something else.

Change the delay - but keep an eye on the airtime.

Send two different messages to two different users.

Example 2

Send_SMS_DateTemp.ino will send an SMS with Date, Time, RTC Temperature and Battery Voltage.

You can imagine an application where you want to remotely monitor the temperature of a room.

Example 2

Send_SMS_DateTemp.ino

```
//Create the data
String dataRec = createData();
Serial.println("Sending SMS with value: "+ dataRec);
bool smsSent = gprsbee.sendSMS(TELNO,dataRec.
c_str());
```

￼￼￼

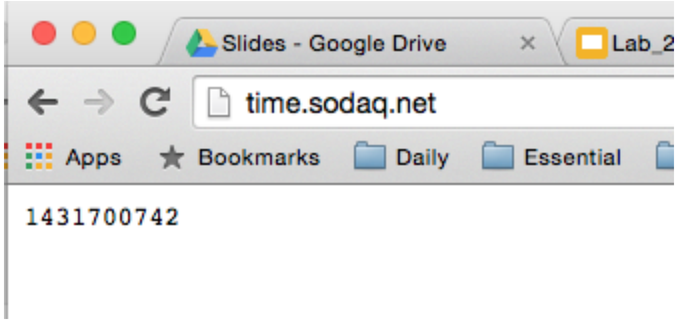
Example 2 - extended

How long does it take to receive the SMS? (blink an LED when you sent the message)

Send the SMS only if temperature is above a certain threshold value.

Example 3

RTC_update.ino will set the time of the SODAQ RTC using the server at http://time.sodaq.net.



```
1431700742
```

This is the current UTC time, specified in seconds since the start of Epoch time (00:00:00 01/01/1970).

Example 3

RTC_update.ino

```
#define APN "internet.mtn"
#define APN_USERNAME ""
#define APN_PASSWORD ""

#define TIME_URL "time.sodaq.net"
#define TIME_ZONE 0.0
#define TIME_ZONE_SEC (TIME_ZONE * 3600)
```

Example 3

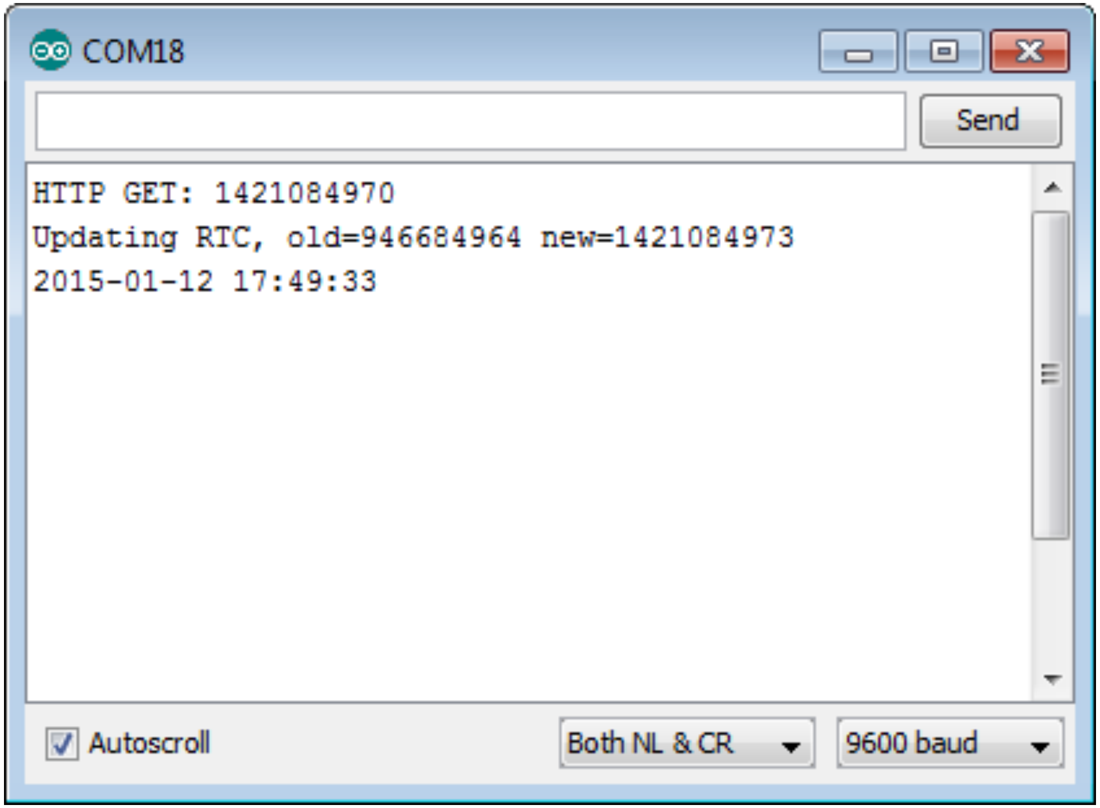
RTC_update.ino

```
//This is required for the Switched Power method
gprsbee.setPowerSwitchedOnOff(true);

//Sync time
syncRTCwithServer();

//Print out new date/time
Serial.println(getDateTime());
```

Example 3



```
HTTP GET: 1421084970
Updating RTC, old=946684964 new=1421084973
2015-01-12 17:49:33
```

☑ Autoscroll

Both NL & CR

9600 baud

Example 3

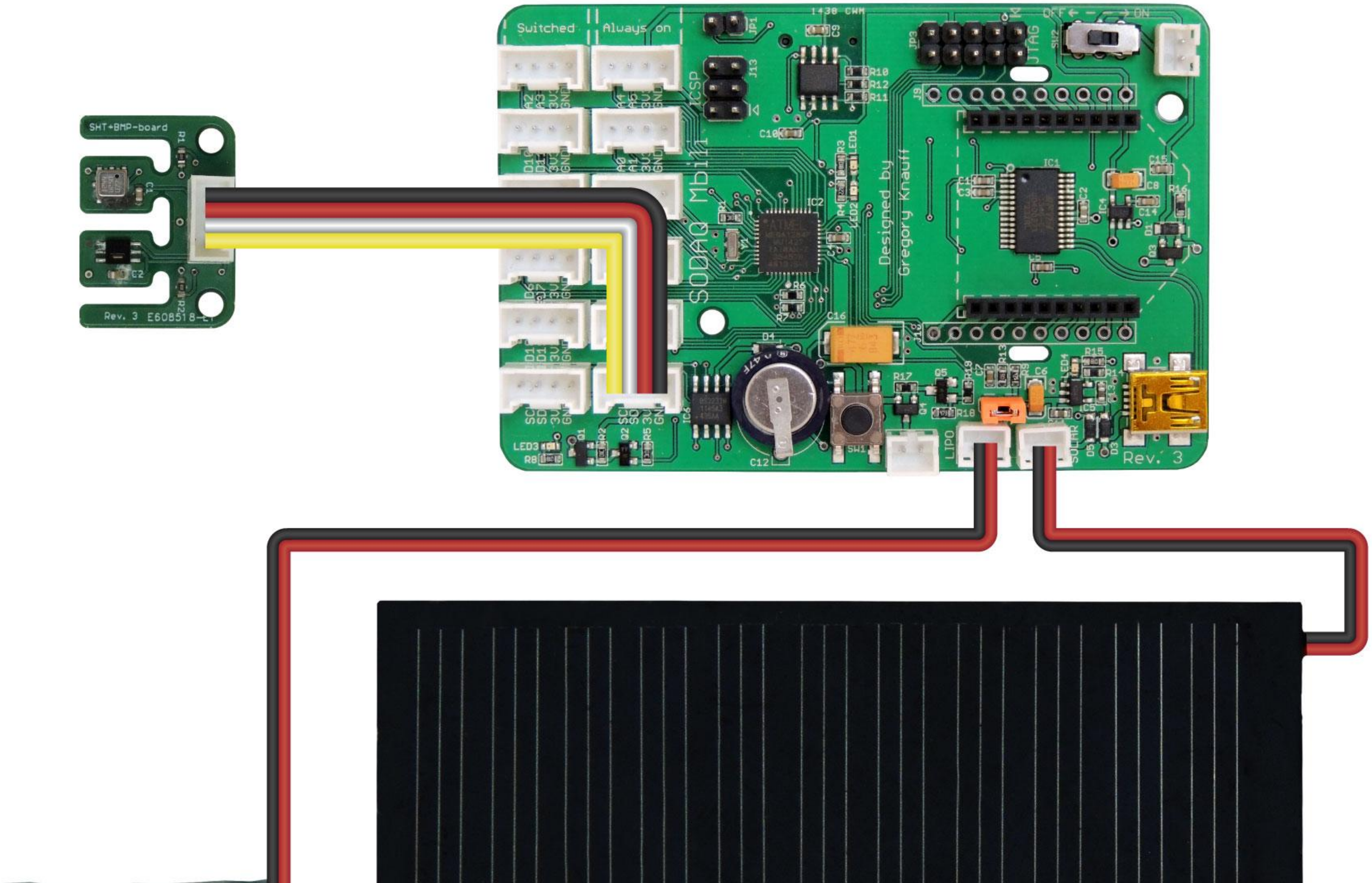
Important:

If the current time stamp of the RTC is within about 30 seconds of the retrieved time stamp, the RTC will not be updated and you will not see the second line of output.

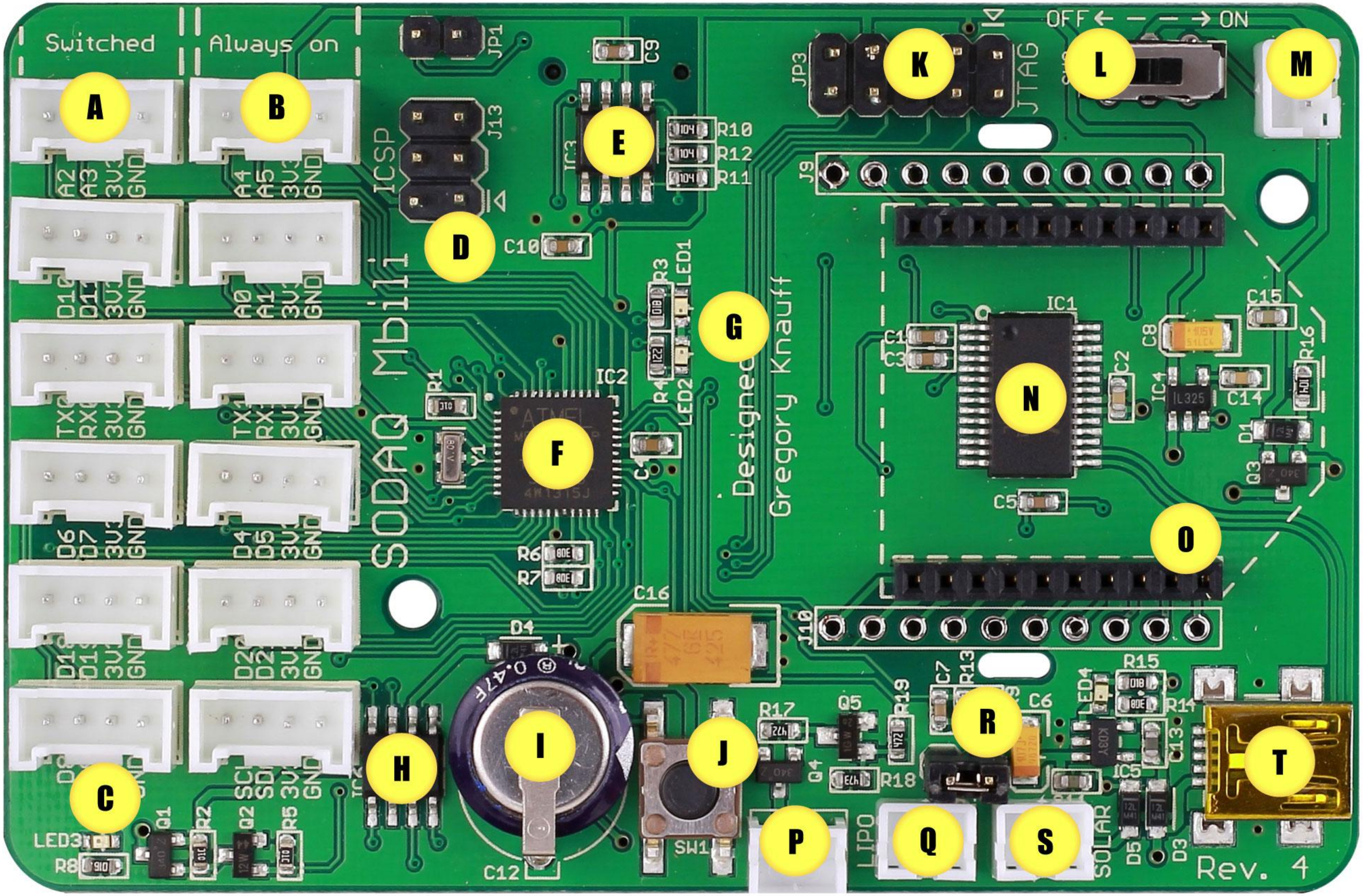
Example 4

Digital_TPH.ino will read values from the Grove TPH sensor. Grove TPH Sensor board is a I^{2}C component which comprises of two separate sensor devices. The first is the **SHT21 Sensor** which provides temperature and humidity readings. The other is a **BMP180 Sensor** which provides a second temperature reading as well as a pressure reading.

Example 4


SHT+BMP-board
Rev. 3 E608518-E1
Switched
Always on
SODAQ Mbili
Designed by
Gregory Knauff
ICSP
JTAG
OFF ON
LIPO
SOLAR
Rev. 3

Example 4


A
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Switched
Always on
ICSP
JTAG
OFF ← — — → ON
SODAQ Mbili
Designed Gregory Knauff
LIPO
SOLAR
Rev. 4

Example 4

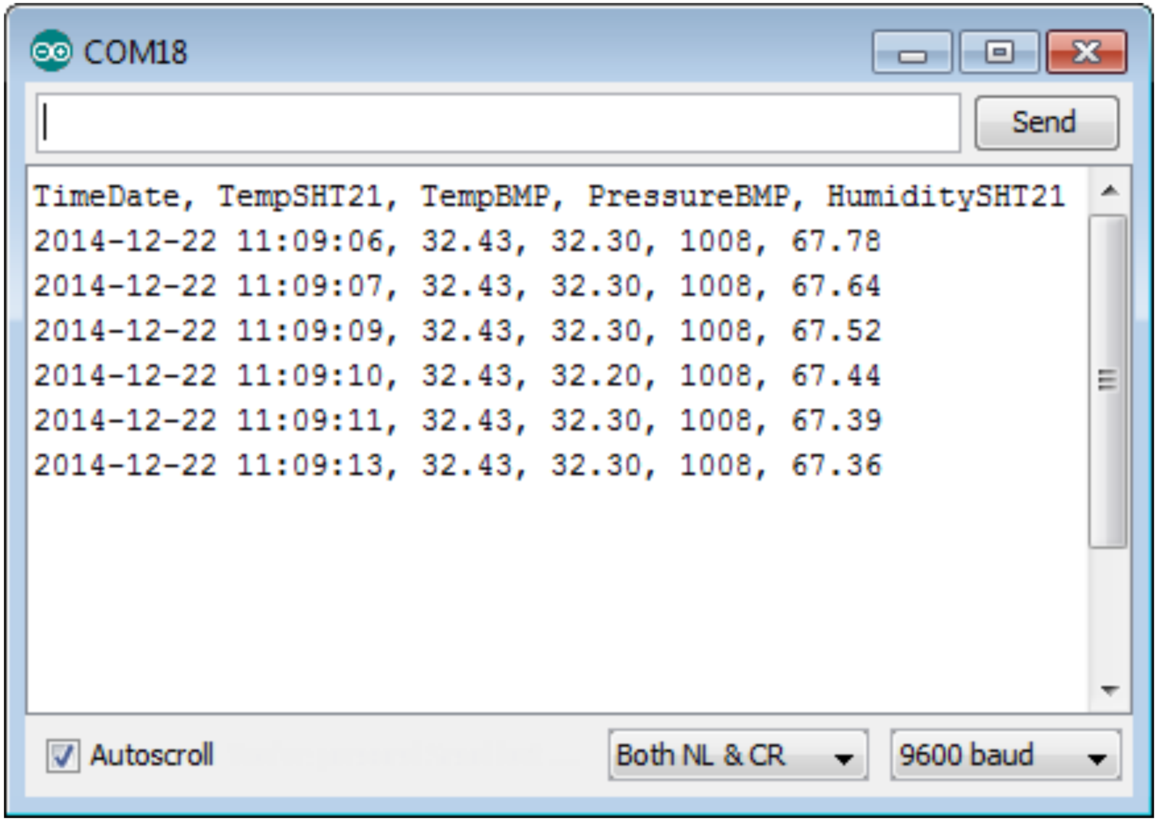
```
#include <Wire.h>

//SODAQ Mbili libraries
#include <Sodaq_BMP085.h>
#include <Sodaq_SHT2x.h>
#include <Sodaq_DS3231.h>

//The delay between the sensor readings
#define READ_DELAY 1000

//Data header
#define DATA_HEADER "TimeDate, TempSHT21, TempBMP, PressureBMP, HumiditySHT21"

//TPH BMP sensor
Sodaq_BMP085 bmp;
```

Example 4

```
String createDataRecord()
{
//Create a String type data record in csv format
//TimeDate, TempSHT21, TempBMP, PressureBMP, HumiditySHT21

String data = getDateTime() + ", ";
data += String(SHT2x.GetTemperature()) + ", ";
data += String(bmp.readTemperature()) + ", ";
data += String(bmp.readPressure() / 100) + ", ";
data += String(SHT2x.GetHumidity());
return data;
}
```

Example 4

The output will look like this:



```
TimeDate, TempSHT21, TempBMP, PressureBMP, HumiditySHT21
2014-12-22 11:09:06, 32.43, 32.30, 1008, 67.78
2014-12-22 11:09:07, 32.43, 32.30, 1008, 67.64
2014-12-22 11:09:09, 32.43, 32.30, 1008, 67.52
2014-12-22 11:09:10, 32.43, 32.20, 1008, 67.44
2014-12-22 11:09:11, 32.43, 32.30, 1008, 67.39
2014-12-22 11:09:13, 32.43, 32.30, 1008, 67.36
```

☑ Autoscroll   Both NL & CR   9600 baud

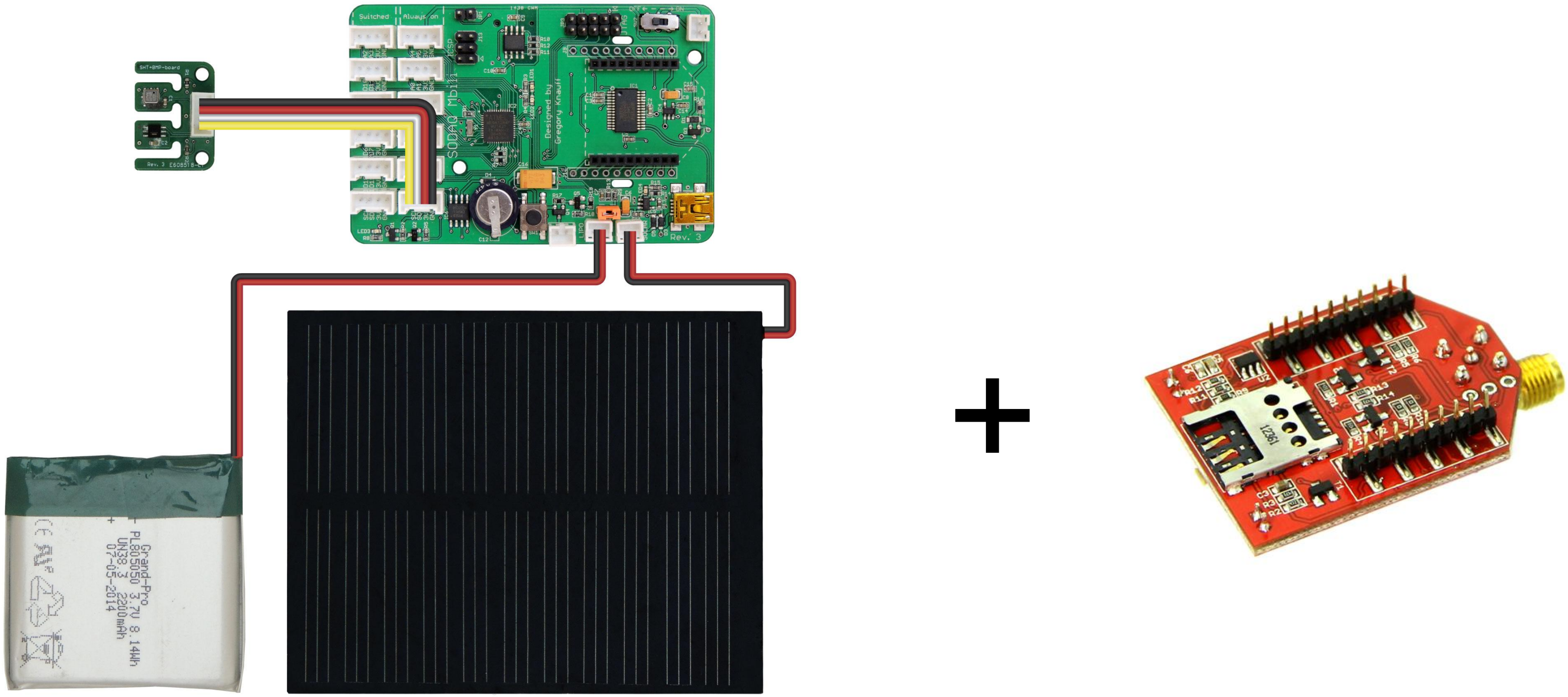
Example 4 - extended

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

Which one gives higher values? TPH or RTC?

Example 5

SMS_TPH.ino will read values from the Grove TPH sensor and send them via SMS using the GPRSbee module.



Example 5

```
void loop ()
{
   //Create the data
   String dataRec = createData();
   Serial.println("Sending SMS with value: "+ dataRec);
   bool smsSent = gprsbee.sendSMS(TELNO,dataRec.
c_str()); //String.c_str() send Char array of String
   delay(SEND_DELAY);
}
```

Example 5 - extended

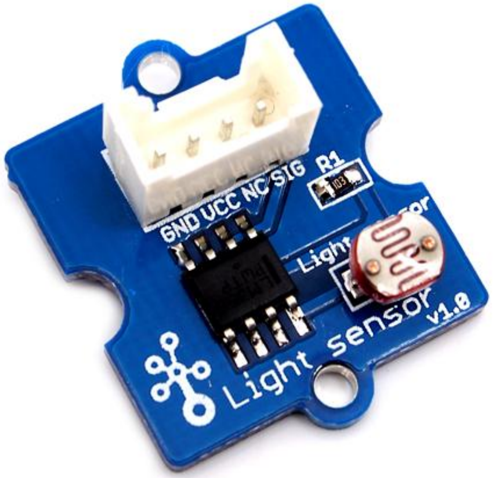
Add some intelligence to the software: send a message via SMS if the temperature is above a certain value, another if the humidity is above a certian value, etc.

Example 6

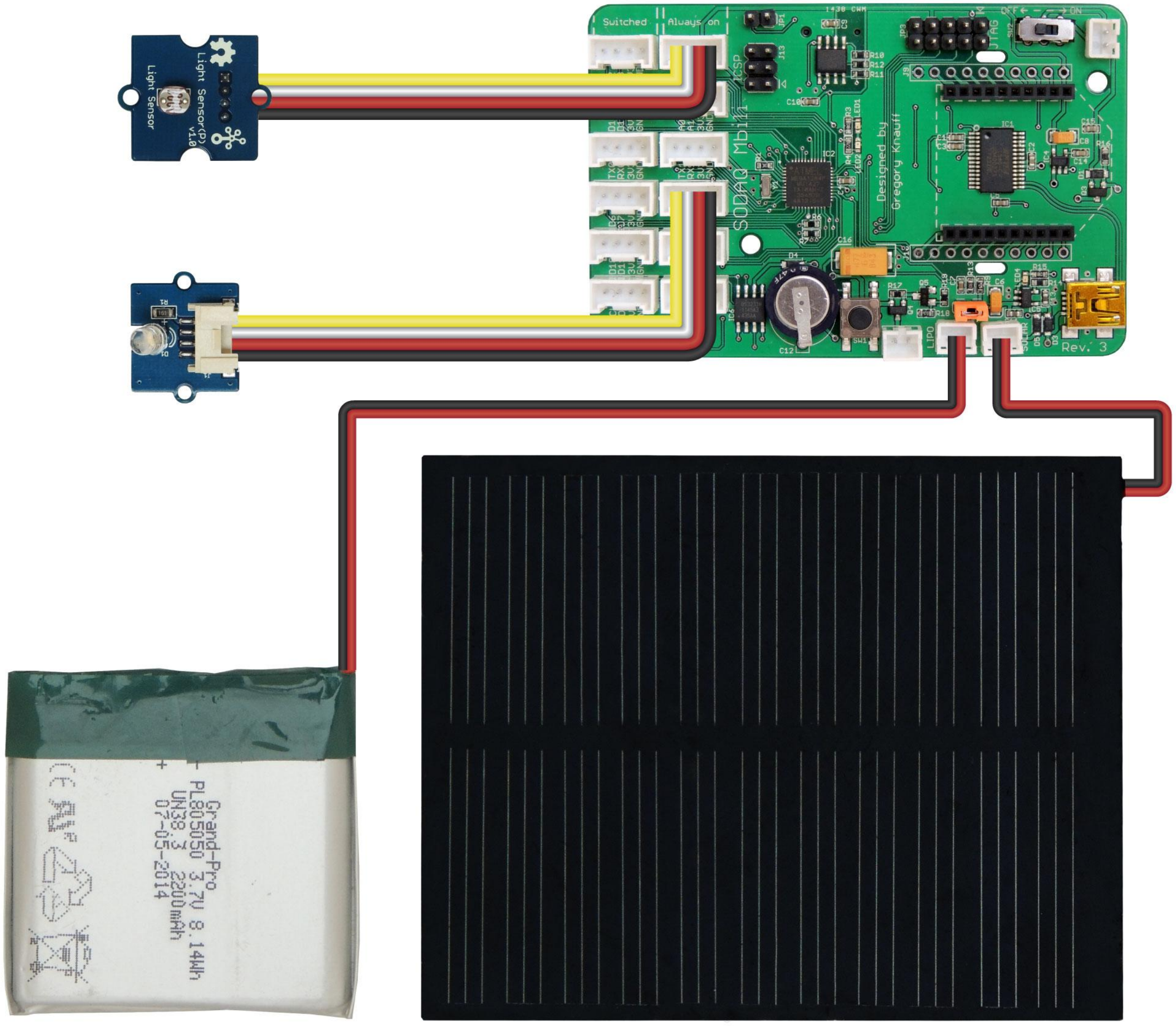
In the Light_LED.ino example we will demonstrate how to use a **Grove Light Sensor to control an LED**. The LED will be automatically switched on or off depending on the level of light hitting the sensor. This is a good example of how to use analog input (the light sensor) to control a digital output (the LED). In this case an analog signal is processed and converted to a digital signal based on a threshold value.

Example 6

The Grove - Light Sensor module incorporates a **Light Dependent Resistor (LDR)**. Typically, the resistance of the LDR or Photoresistor will decrease when the ambient light intensity increases. **This means that the output signal from this module will be HIGH in bright light, and LOW in the dark.**



Example 6


Light Sensor(P) v1.0
Light Sensor
Switched
Always on
SODAQ Mbili
Designed by Gregory Knauff
LIPO
Rev. 3
Grand-Pro
PL805050 3.7V 8.14Wh
UN38.3 2200mAh
07-05-2014

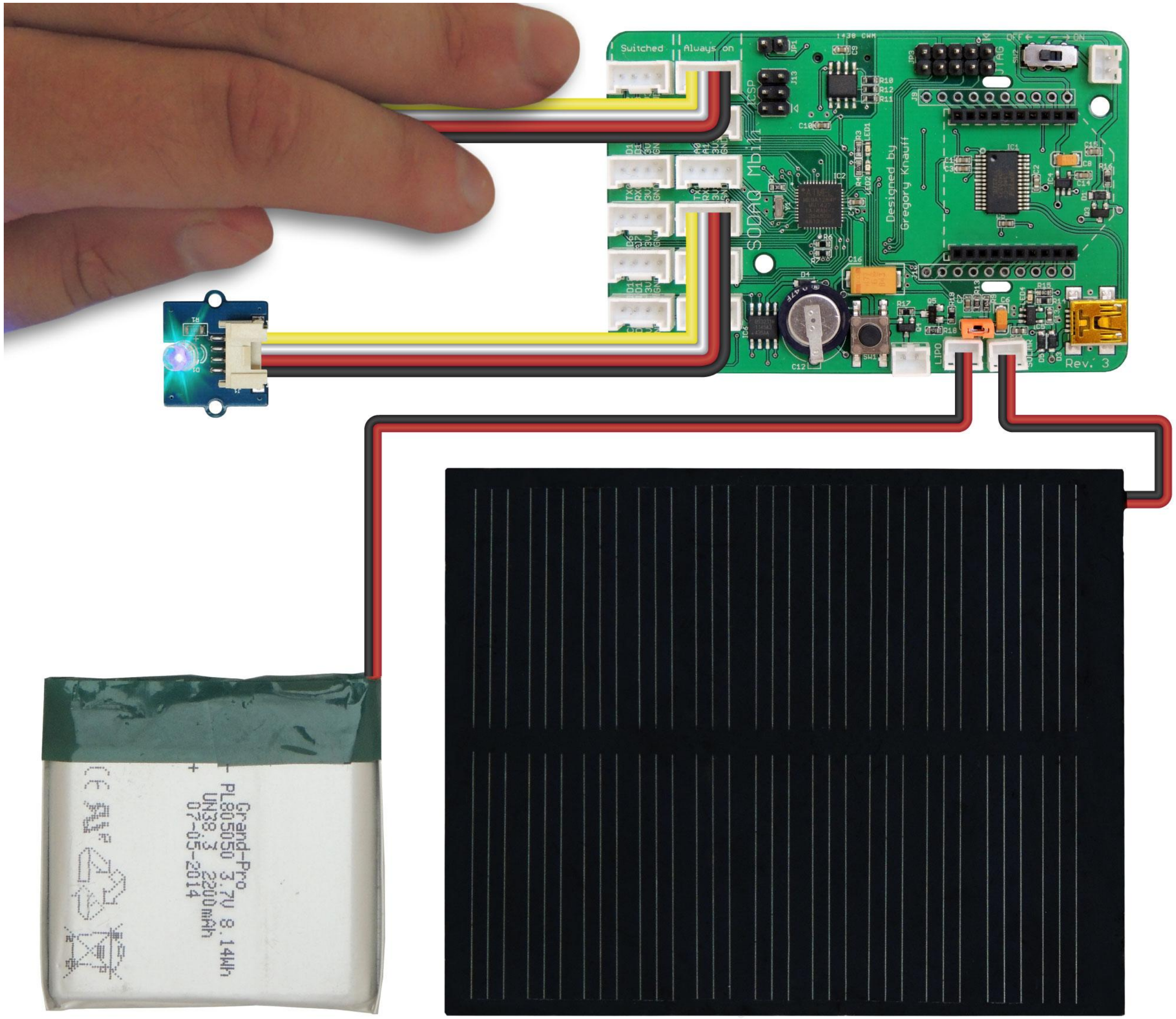
Example 6

```
#define LED_PIN 4 //Use digital pin 4 for the LED
#define SENSOR_PIN A4 //Use analog pin A4 for the sensor
#define THRESHOLD_VALUE 50 //Activation threshold

void setup()
{
  //Set the LED digital pin to OUTPUT mode
  pinMode(LED_PIN, OUTPUT);
}

//TPH BMP sensor
Sodaq_BMP085 bmp;
```

Example 6

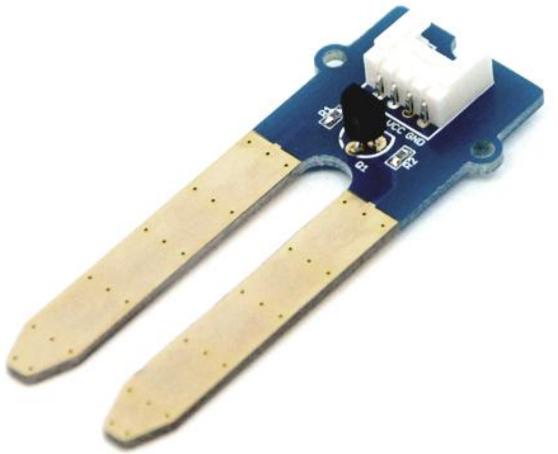
```
void loop()
{
  //Read the analog value from the sensor
  int sensorValue = analogRead(SENSOR_PIN);

  //Calculate the resistance from the sensor
  float rSensor=(float)(1023-sensorValue)*10 / sensorValue;

  //Compare the calculated resistance against the threshold
  if (rSensor > THRESHOLD_VALUE)
  {
    //If the result is above the threshold, turn the LED on
    digitalWrite(LED_PIN, HIGH);
  }
  else
  {
    //If not, turn the LED off
    digitalWrite(LED_PIN, LOW);
  }
}
```

Example 6

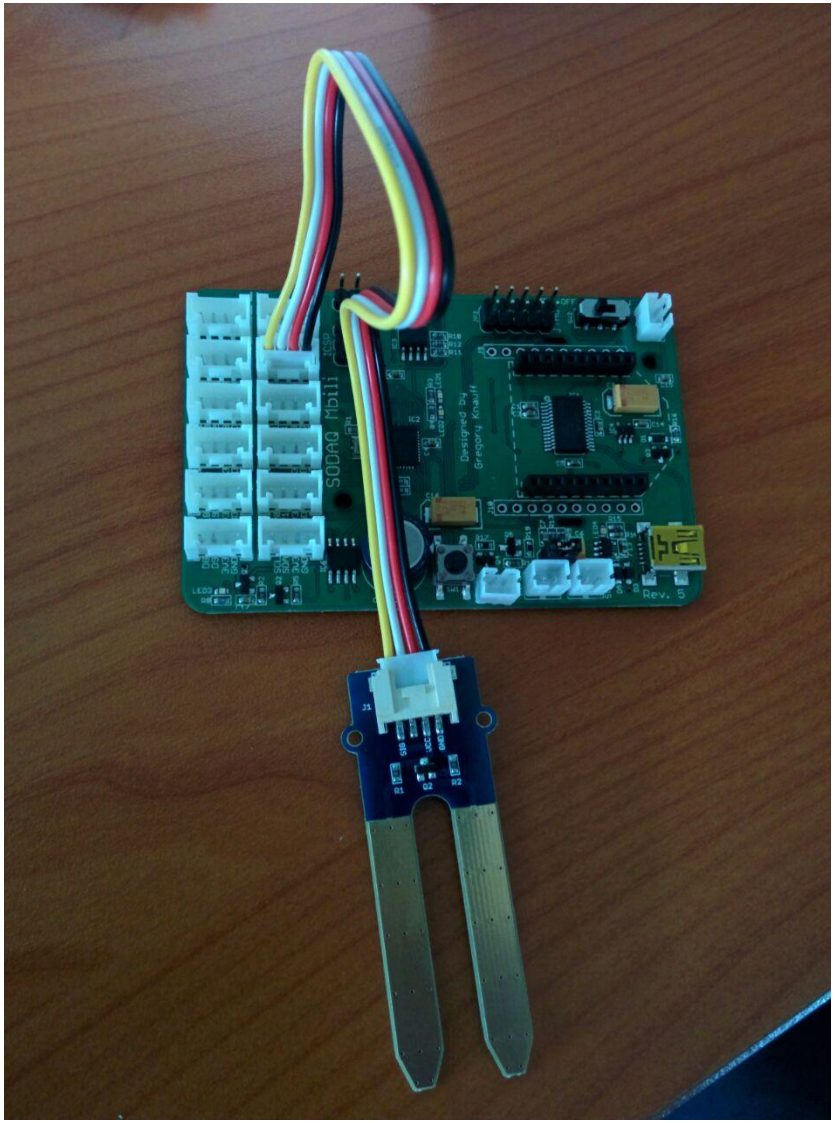

Switched
Always on
SODAQ Mbili
Designed by Gregory Knauff
Rev. 3
LIPO
SOLAR
Grand-Pro
PL805050 3.7V 8.14Wh
UN38.3 2200mAh
07-05-2014

Example 7

The analog **Grove Moisture Sensor** can be used to measure soil moisture or detect if there is water around the sensor. You can for example let the plants in your garden reach out for human help when they need irrigation. Check the moisture.ino code.



Example 7


SODAQ Mbili
Designed by
Gregory Knauff
Rev. 5
J1
SIG
VCC
GND
R1
Q2
R2

Example 7

Sensor in air= 0

Sensor in dry soil = 5-50

Sensor in humid soil = around 500

Sensor in water = 900-1000

Example 7

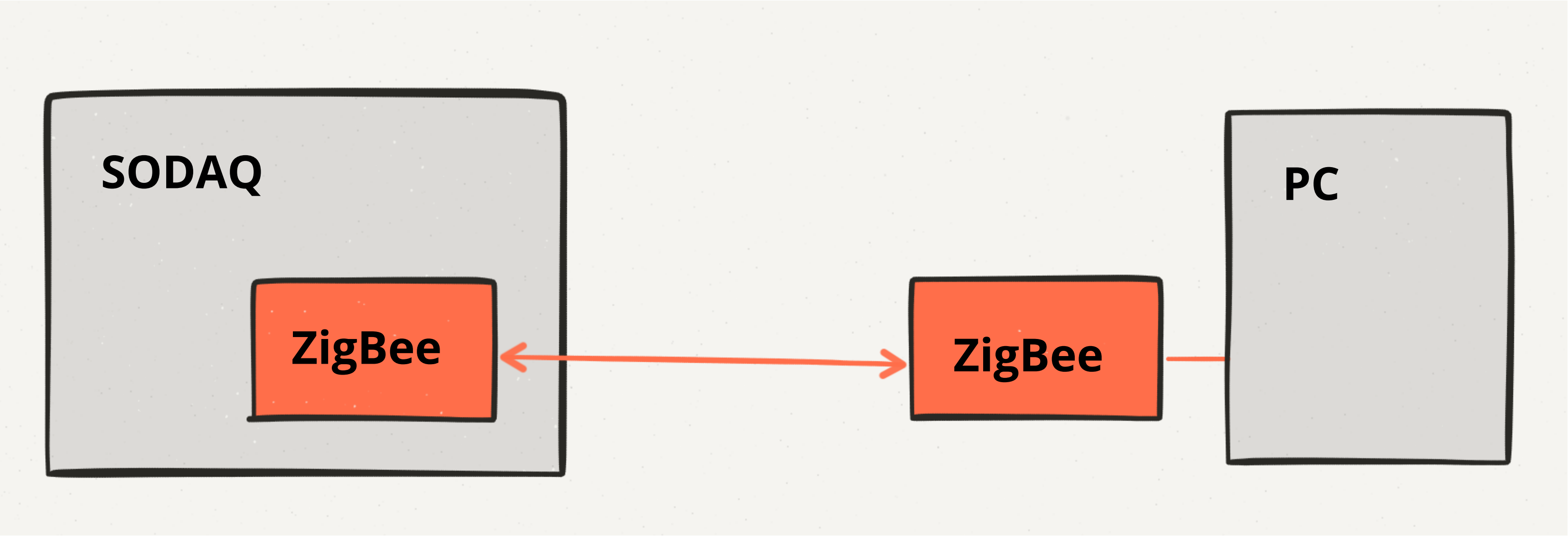
```
void loop() {
  // read the value from the sensor:
  sensorValue = analogRead(sensorPin);
  delay(1000);
  Serial.print("sensor = " );
  Serial.println(sensorValue);
}
```

Real-world excercise

Read Temperature, Pressure and Humidity from the TPH sensor, light from the light sensor and moisture from the moisture sensor. Send the values via SMS and blink the external LED when the message has been sent.

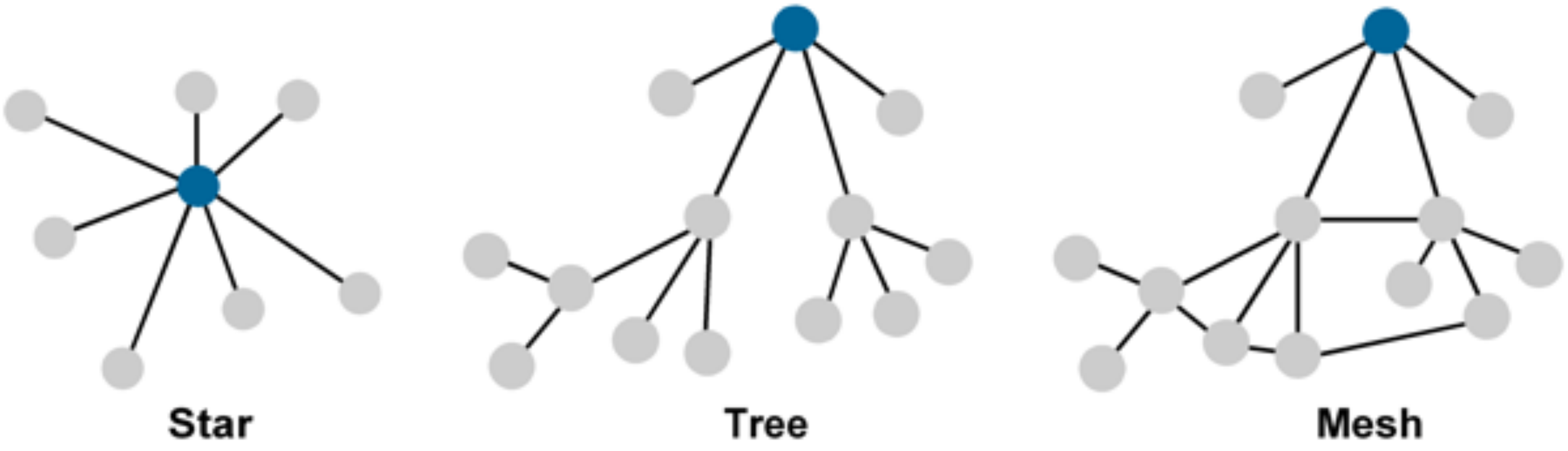
Example 8

RTC_date_Volt_Temp_Zigbee.ino will send Date, Time, Temperature from RTC and Battery voltage via Zigbee to a PC.



Zigbee - node types

Co-ordinator: all ZigBee networks must have one (and only one) Co-ordinator



Zigbee - node types

The tasks of the **Co-ordinator** at the network layer are:

- Selects the frequency channel to be used by the network (usually the one with the least detected activity)
- Starts the network
- Allows other devices to connect to it (that is, to join the network)

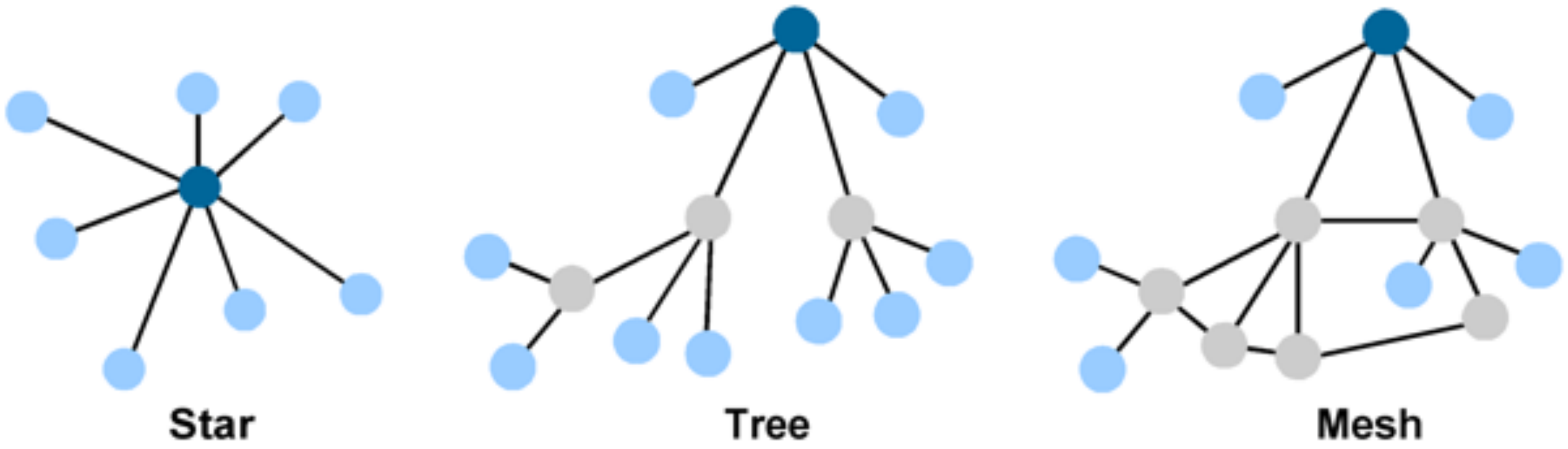
The Co-ordinator can also provide message routing (for example, in a Star network), security management and other services.

Zigbee - node types

End Devices are always located at the extremities of a network:

In the Star topology, they are perimeter nodes

In the Tree and Mesh topologies, they are leaf nodes



Zigbee - node types

The main tasks of an **End Device** at the network level are sending and receiving messages. Note that End Devices cannot relay messages and cannot allow other nodes to connect to the network through them.

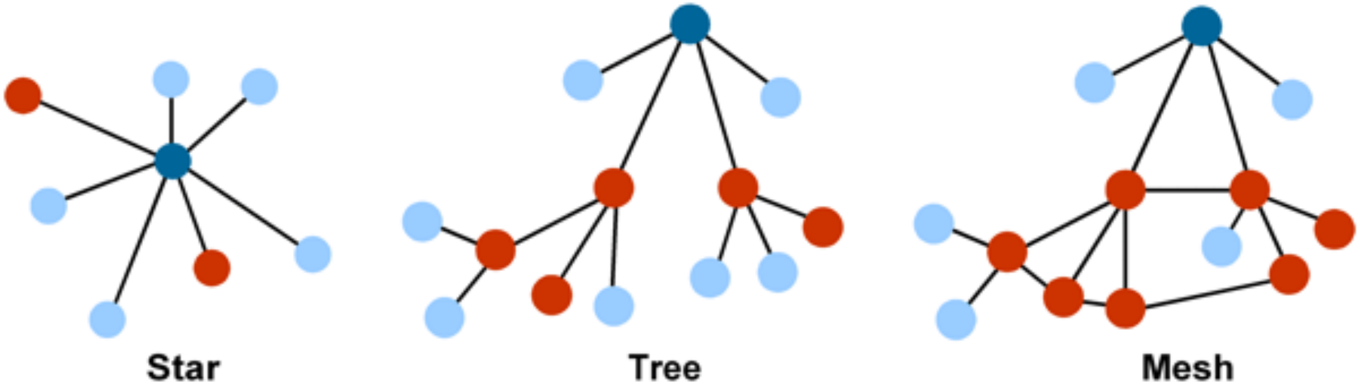
An End Device can often be battery-powered and, when not transmitting or receiving, **can sleep in order to conserve power.**

Zigbee - node types

Networks with Tree or Mesh topologies need at least one **Router**. The main tasks of a Router are:

Relays messages from one node to another. Allows child nodes to connect to it.

In a Star topology, these functions are handled by the Co-ordinator and, therefore, a Star network does not need Routers.



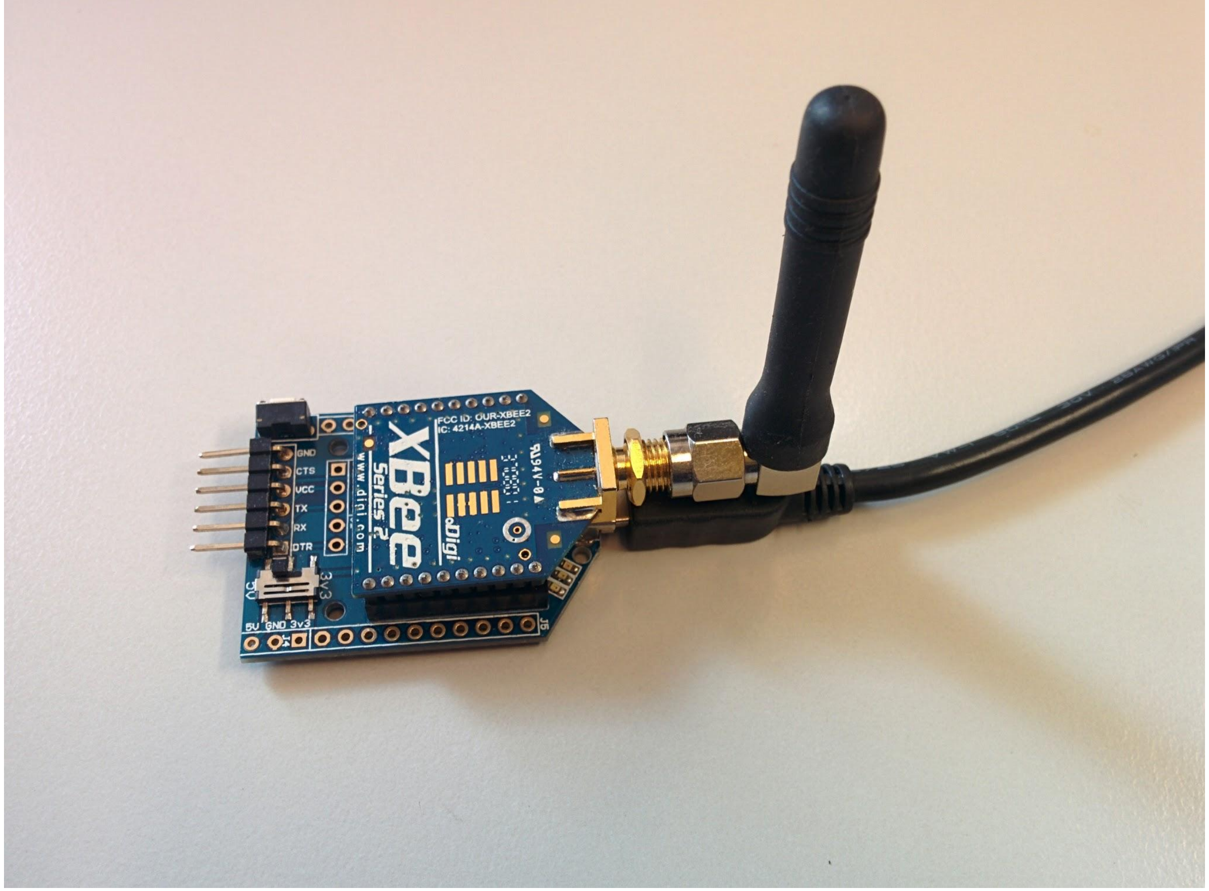
Zigbee - node types

In Tree and Mesh topologies, Routers are located as follows:

- In a Tree topology, Routers are normally located in network positions that allow messages to be passed up and down the tree.
- In a Mesh topology, a Router can be located anywhere that a message passing node is required.

Note that a Router cannot sleep.

Example 8


FCC ID: OUR-XBEE2
IC: 4214A-XBEE2
XBee
Series 2
www.digi.com
Digi
GND
CTS
VCC
TX
RX
DTR
5V
3v3
5V GND 3v3
J4
J5

Example 8

```
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;

  String data= DEVICE_NUM +",";
  data += getDateTime()+ ", ";
  data += String(temperatureS)+ "C, ";
  data += String(mv)+ "mV";
  Serial.println(data);
  Serial1.println(data);
}
```

Example 8 - extended

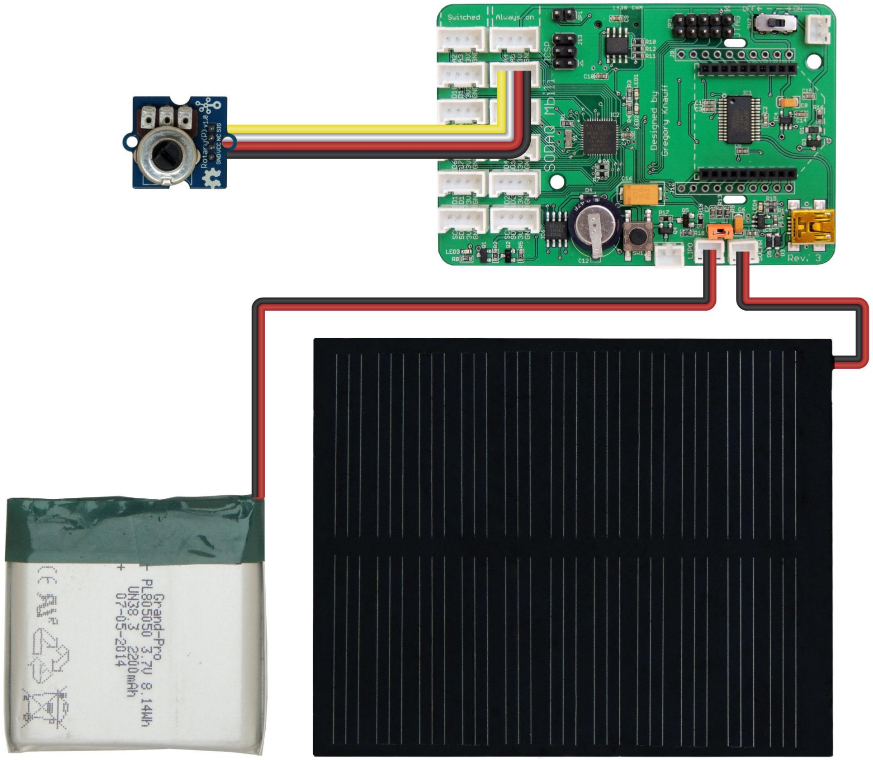
You can now move the node and measure the temperature outside!

What is the maximum distance you can reach?

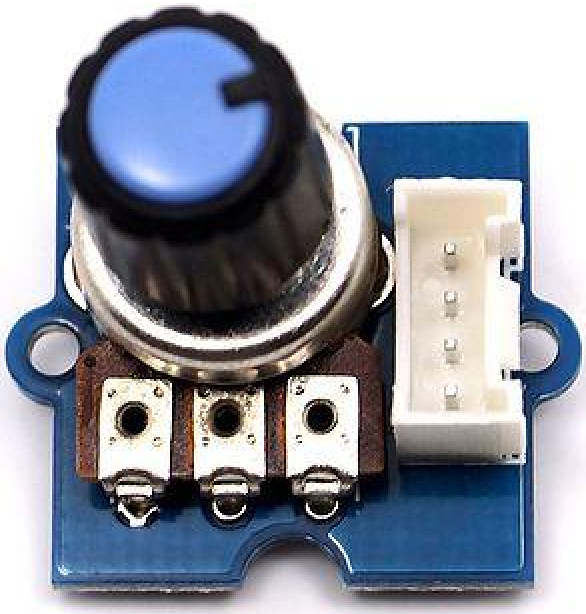
Try to change the height of the node: can you go farther?

Example 9

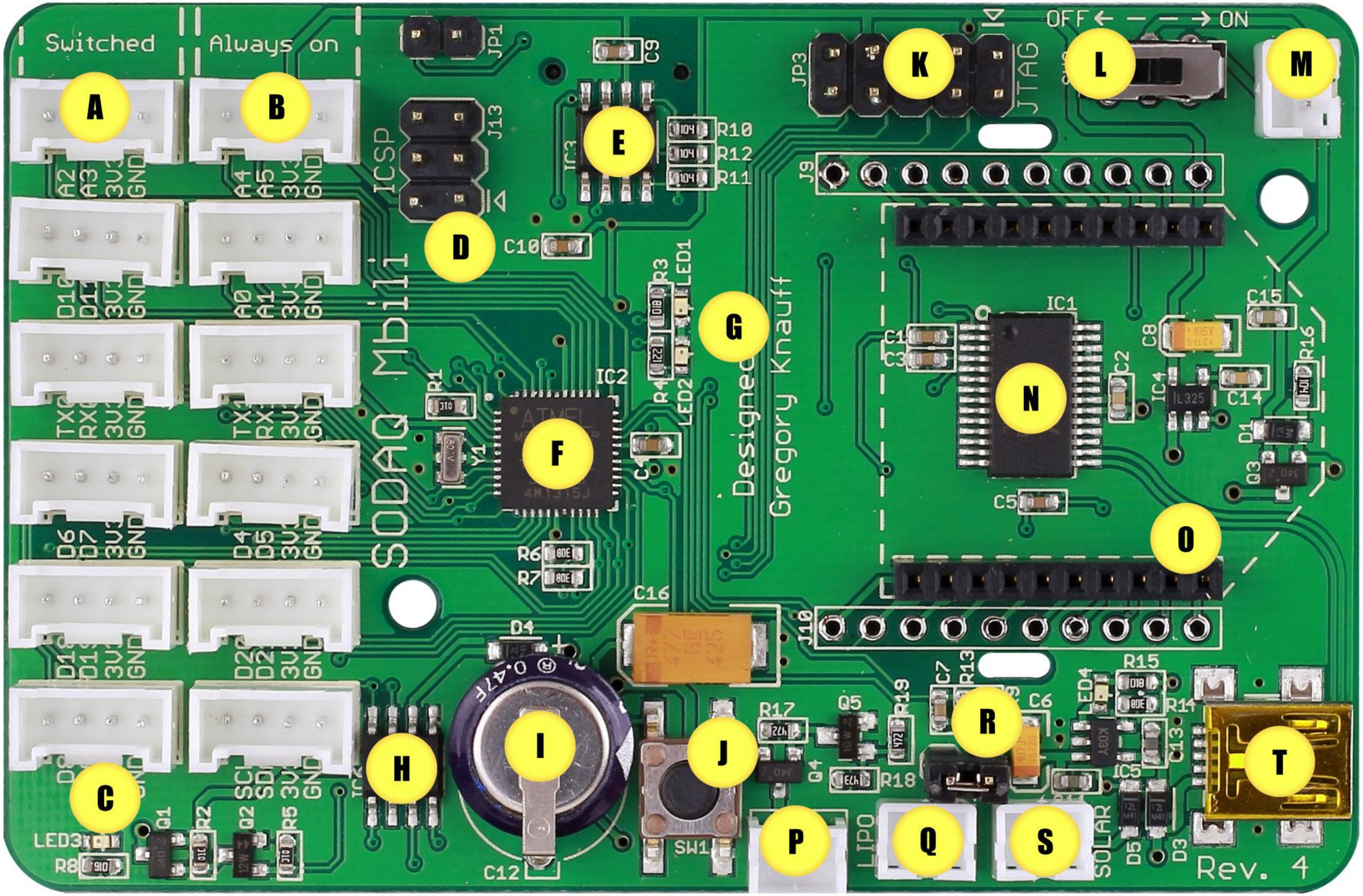
Pote_angle.ino will read the angle of a potentiometer.
We will use a Grove analog potentiometer.



Example 9



Example 9


Switched
Always on
A
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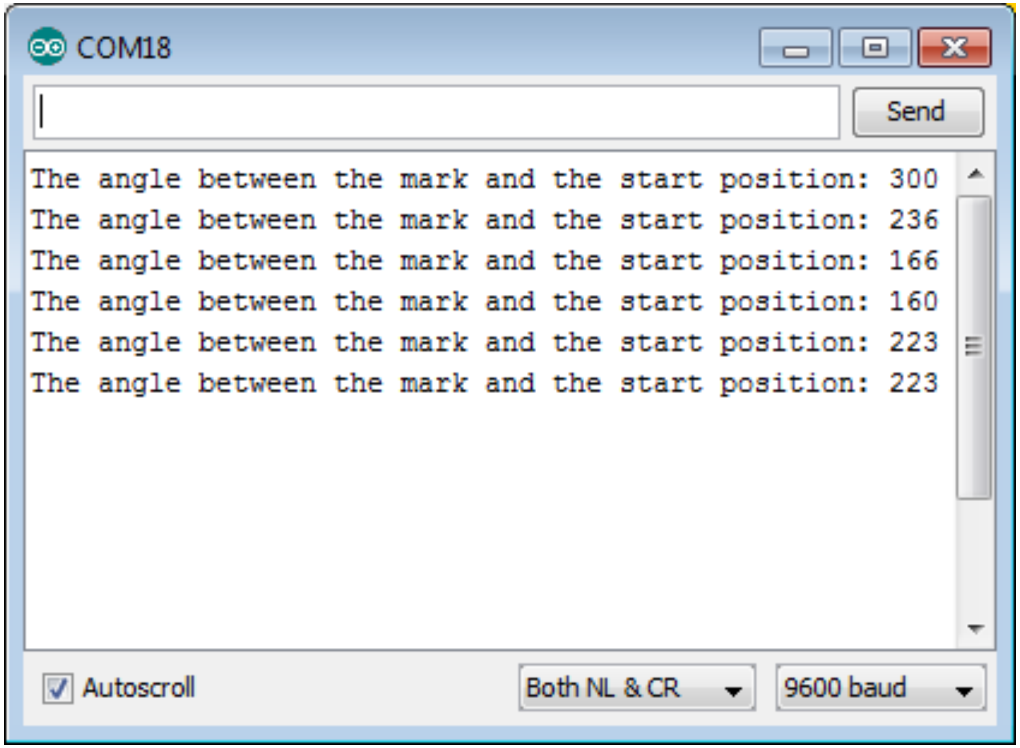
ICSP
SODAQ Mbili
Designed by Gregory Knauff
JTAG
OFF ← — — → ON
LIPO
SOLAR
Rev. 4

Example 9

Pote_angle.ino will read the angle of a potentiometer.

```
#define ROTARY_ANGLE_SENSOR A0 //Use analog pin A0 for the Rotary Angle Sensor
#define ADC_REF 3.3 //Rreference voltage of ADC is 3.3v
#define FULL_ANGLE 300.0 //Full value of the rotary angle is 300 degrees

…
//Read the raw sensor value
int sensor_value = analogRead(ROTARY_ANGLE_SENSOR);

float voltage = (float)sensor_value * ADC_REF / 1023;
float degrees = (voltage * FULL_ANGLE) / ADC_REF;
```

Example 9



```
The angle between the mark and the start position: 300
The angle between the mark and the start position: 236
The angle between the mark and the start position: 166
The angle between the mark and the start position: 160
The angle between the mark and the start position: 223
The angle between the mark and the start position: 223
```

☑ Autoscroll

Example 9

You can map analog measurements to other values:

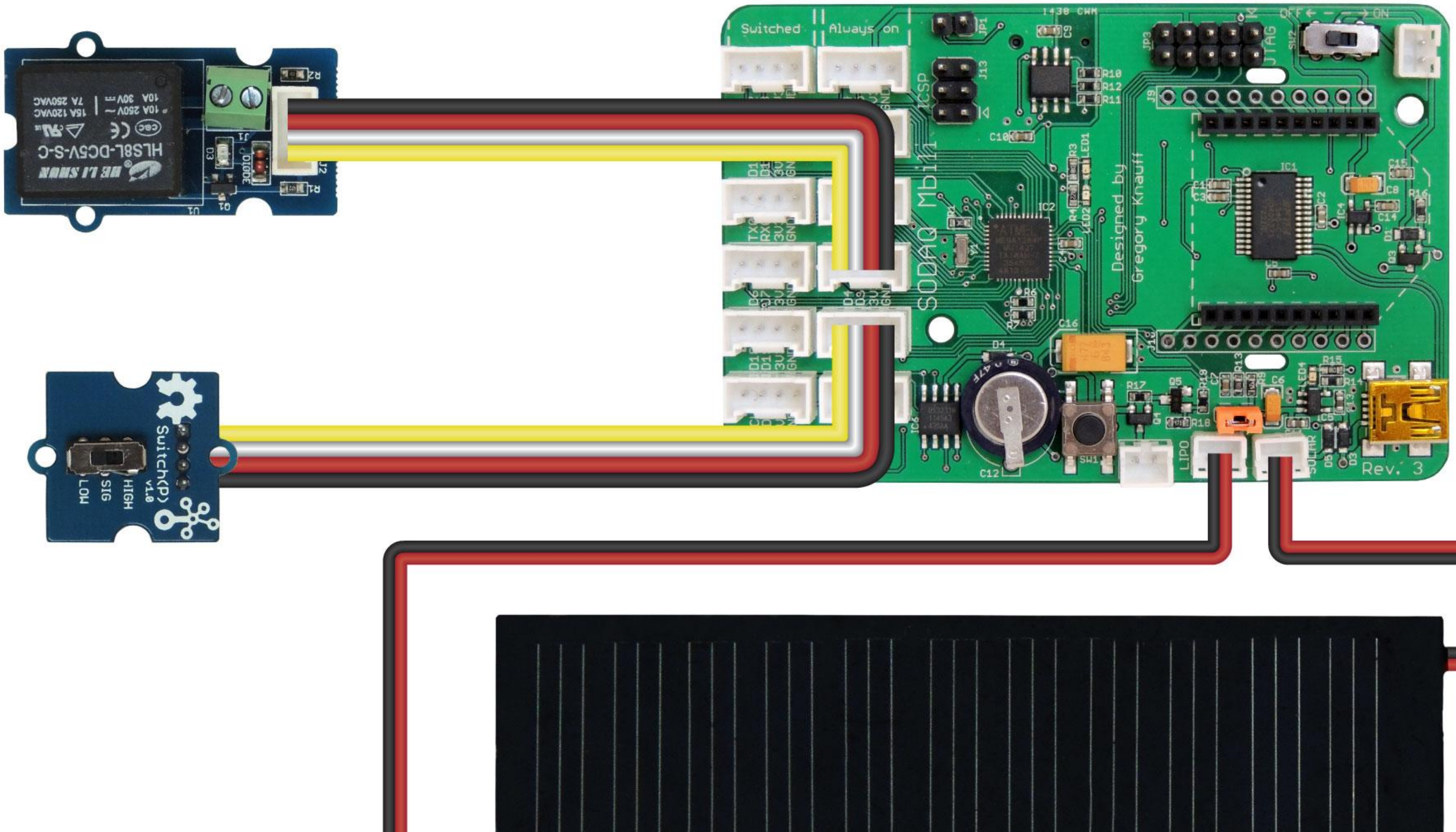
```
sensorVal = map(analogRead(A0),0,1023,0,100);

sensorVal = map(analogRead(A0),0,1023,100,0);

sensorVal = map(analogRead(A0),0,1023,0,1000);

sensorVal = map(analogRead(A0),200,800,0,100);

sensorVal = constrain(map(analogRead(A0),200,800,0,100),0,100);
```

Example 9 - extended

Change the LED blinking rate according to the value of the potentiometer.

Example 10

Switch_relay.ino will read the value of a Grove Switch and act on a Grove relay.



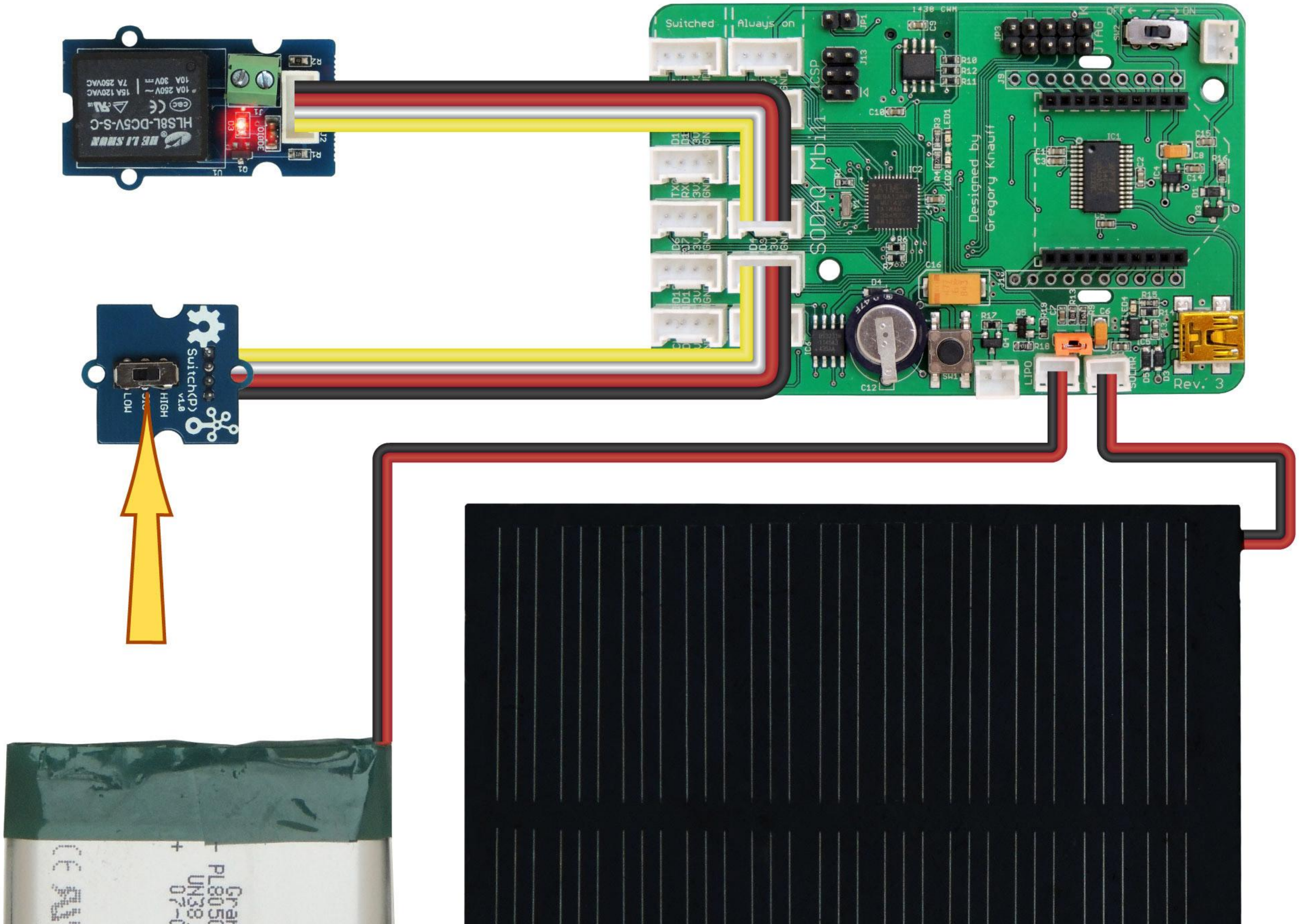
Example 10

```
#define SWITCH_PIN 20 //Use digital pin 20 for the switch
#define RELAY_PIN 4 //Use digital pin 4 for the relay
int switchState = 0;

void setup()
{ //Set the digital pin modes
  pinMode(SWITCH_PIN, INPUT);
  pinMode(RELAY_PIN, OUTPUT);
}
```

Example 10

```
void loop()
{ //Read the current state of the switch
switchState = digitalRead(SWITCH_PIN);

if (switchState == HIGH)
{
//If the switch is set to HIGH, turn the relay on
    digitalWrite(RELAY_PIN, HIGH);
    delay(100);
}
else
{
//If not, turn the relay off
    digitalWrite(RELAY_PIN, LOW);
  }
}
```

Example 10


HLS8L-DC5V-S-C
Switch(P)
v1.0
LOW
HIGH
Switched
Always on
SODAQ Mbili
Designed by
Gregory Knauff
LIPO
SOLAR
Rev. 3

Real-world excercise

Read Temperature, Pressure and Humidity from the TPH sensor and send it via Zigbee together with Date and Time.

If the Grove switch is ON, read TPH. If the switch is OFF, read RTC temperature.

Thanks

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http://wireless.ictp.it