Adriann Liceralde
Dr. Brian McPherson
Carbon Science Research at the University of Utah
Wireless Sensor Network Project
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Evaluating the Power Usage of the Sensor Nodes

I. Introduction

The *Wireless Sensor Network Project* (*WSN*) aims to develop a low-cost monitoring system for detecting carbon sources within an area. The project uses prototype instruments called *Sensor Nodes*, or *Nodes* for short, containing sensors and electronic modules to measure and collect data. Powering the *Sensor Nodes* requires either continuous on-grid electric or off-grid solar power. *Nodes* placed in fields with no access to on-grid outlets require a solar panel and battery kit. This evaluation seeks to determine the power requirements of the *Nodes* to know how much solar power is needed to maintain reliable operation.

II. Equipment

a. Arduino Version

There are two variants of the *Node*. The *Arduino Version* is controlled by an Arduino board, as shown in Figure 1. The circuitry is built over a solderless breadboard, and the major components of this variant are the following:

- Arduino microcontroller
- CO_2 sensor
- Anemometer
- Real-time clock
- MicroSD card module

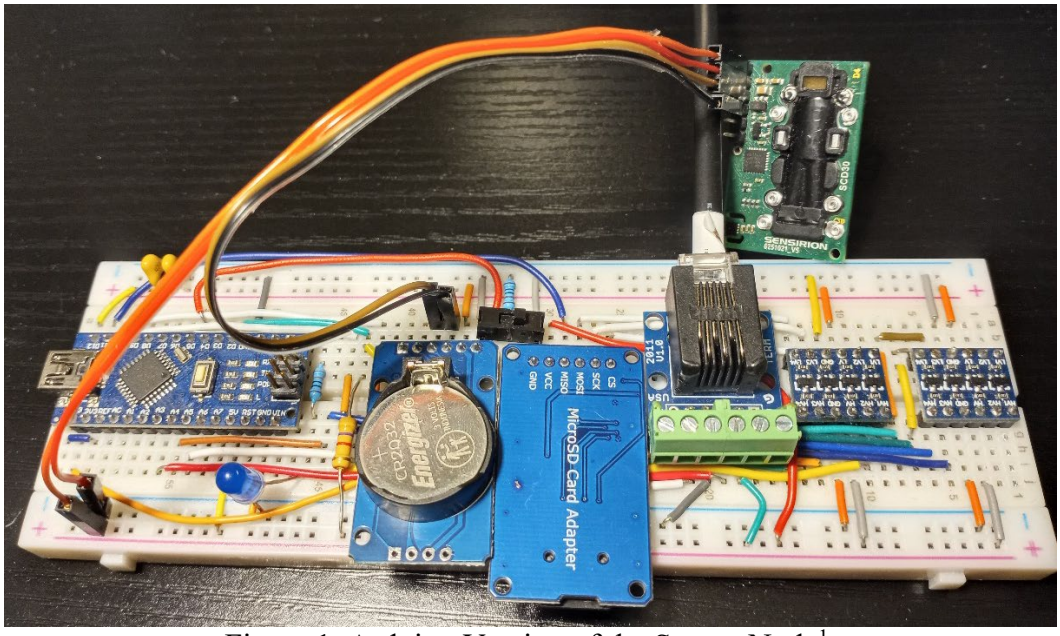

Figure 1. Arduino Version of the Sensor Node[1].

b. XBee Version

The second variant of the *Node* is the *XBee Version*. Instead of an Arduino microcontroller and a solderless breadboard, this version uses an *XBee RF Module* and a custom printed circuit board (PCB), as shown in Figure 2. The major components for this version are the following:

- XBee RF module
- CO_2 sensor
- Anemometer
- Real-time clock

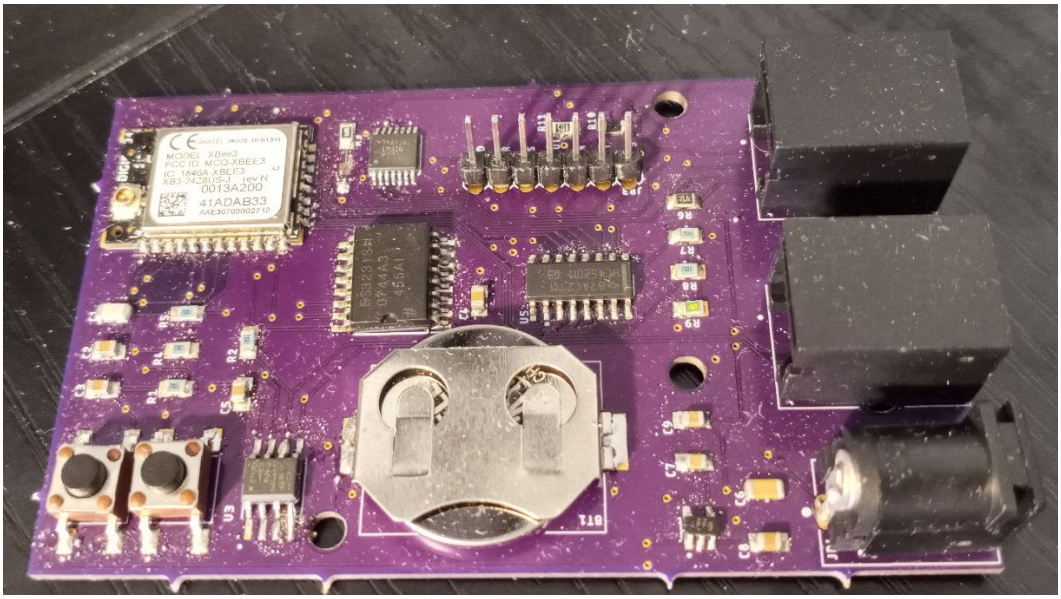

Figure 2. XBee Version of the Sensor Node[2].

c. USB Meter

The MakerHawk USB Meter measures the voltage, current, and power going into a device at a frequency of 1 second. The USB Meter automatically considers the power that it uses for itself. Therefore, the values it displays reflect only what the connected device consumes, in this case, the *Sensor Node*. In addition, the product comes with software that allows a PC to collect the data from the device if the PC powers it[3].

Figure 3. MakerHawk USB Meter[4].

III. Power Requirements

The power consumption of both *Sensor Node* versions is measured using the USB Meter.

a. Procedure

1. Connect the USB Meter to a PC and open the USB Meter Software.
2. Connect the *Arduino Version* to the USB Meter.
3. When the *Node* starts consuming power, the USB Meter automatically measures the voltage, current, and power draw. The software also automatically records this information.
4. Allow the *Node* to operate for any duration.
5. After an adequate amount of data is collected, save the data from the software.
6. Shut down the *Node* and disconnect it from the USB Meter.
7. Repeat steps 2 to 6 using the *XBee Version* instead.

b. Results

The minimum, maximum, and average for voltage, current, and power were determined from the collected dataset spanning 6 hours. The results for both *Node* variants are presented in Table 1.

Table 1. Voltage, Current, and Power Measurements of the Sensor Nodes

Sensor Node	Arduino Version	XBee Version
Min Voltage	4.97 V	4.97 V
Max Voltage	4.99 V	4.99 V
Avg Voltage	4.98 V	4.98 V
Min Current	29.2 mA	9.0 mA
Max Current	92.9 mA	80.9 mA
Avg Current	41.0 mA	33.8 mA
Min Power	145 mW	45 mW
Max Power	463 mW	404 mW
Avg Power	204 mW	169 mW

c. Analysis

The equation below calculates the total power consumed in a given time interval[5]:

$$P\ (Wh) = v\ (V) * i\ (A) * t\ (h)$$

Where:

P is the total power consumed in the duration
v is the average voltage
i is the average current
t is the total duration

The following equation calculates the theoretical daily power consumption:

$$Daily\ P\ \left(\frac{W}{day}\right) = P\ (Wh)\ /\ t\ (h) * 24\ (\frac{hours}{day})$$

Using the two equations allows the daily power consumption of each *Sensor Node* to be determined. The results are shown in Table 2.

Table 2. Results of the Power Consumption Calculations

Sensor Node	Arduino Version	XBee Version
Power consumed	1.23 Wh	1.01 Wh
Daily requirement	4.90 W/day	4.04 W/day

IV. Conclusion

This evaluation aimed to determine the theoretical daily power requirement of the *Sensor Nodes*. The USB Meter and the calculations estimate that the *Arduino Version* and the *XBee Version* require 4.90 W/day and 4.04 W/day, respectively. The *Sensor Nodes* can be powered with solar panels and an associated battery pack. A solar kit must at least produce roughly 5 W of usable energy per day to ensure that the *Sensor Nodes* operate continuously.

Additional resources are contained in the Wireless Sensor Network repository[6] and the CSR Arduino Collection repository[7].

References and Useful Links

[1] Overview of the Arduino Version of the Sensor Node
https://github.com/jkub6/WirelessSensorNetwork/tree/master/Section1-Prototyping/SensorNode-ArduinoVersion

[2] Overview of the XBee Version of the Sensor Node
https://github.com/jkub6/WirelessSensorNetwork/tree/master/Section1-Prototyping/SensorNode-XBeeVersion

[3] Software Link for MakerHawk USB Meter
https://www.mediafire.com/folder/q2b8h079hpywq/UM25C.%20Guide%20Video:%20www.youtube.com/watch?v=pNtRmlR9Z9w

[4] Product Link for MakerHawk USB Meter
https://www.makerhawk.com/products/makerhawk-um25c-usb-tester-bluetooth-usb-meter-type-c-current-meter-usb-power-meter-dc-24-000v-5-0000a-usb-cable-tester-1-44-inch-color-lcd-multimeter-voltage-tester-usb-load-qc-2-0-qc-3-0

[5] Power Calculations
https://convert-formula.com/a-h-mAh#:~:text=Convert%20amps%20(A)%20and%20hours,to%20mAh%20(milliampere%2Dhours)&text=The%20formula%20is%20(A)*(,*5h*1000%20%3D%2015000mAh.

[6] Wireless Sensor Network Repository
https://github.com/jkub6/WirelessSensorNetwork

[7] CSR Arduino Collection Repository
https://github.com/RiceAllDay22/CSR_Arduino_Collection

Contact

For any questions or assistance, email Adriann Liceralde at adriann8399@gmail.com