

Wireless Sensors Utilizing Zigbee Mesh Networks

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Abstract—Conservation of energy involves the ability to identify where energy is being lost. The project focuses on a network of sensors that can be used to determine the status of lights in multiple rooms simultaneously. Digi XBee devices obtain light status in a room through a circuit containing a phototransistor, and convey the information to a receiver connected to a C-Stamp microcontroller. The information is displayed on a computer, which can be used to record activity throughout the day.

Index Terms—Detectors, Energy conservation, Light triggered switches, Networks

I. INTRODUCTION

GREEN technology comes in many forms, ranging from solar panels to electric cars. However, conservation of energy is as important as finding cleaner ways to generate and use energy. According to the American Almanac, although Americans only represent 5% of the world population, they consume more than 26% of the world's energy. [1] Of all of the energy used in America, nearly 9% is lighting. [2] Much of the time, lights are left on even when there is no one in the room using them. This happens very often on school grounds. The objective of this project is to design a device that will monitor when lights are turned on or off, and keep a record for whoever may be responsible for managing the classrooms.

II. SPECIFICATIONS

The design of the sensors is dependent on the environment in which it is located. During the development of the sensors, the environment used was Armstrong Hall, the Engineering building at the College of New Jersey. A total of 6 rooms needed to have the lights monitored and recorded for the local administrator. To do this, the sensors had to communicate wirelessly, and successfully transmit information regarding the status of the lights in the room. The devices used to transmit the wireless signal were the Digi XBee OEM radio frequency (RF) Modules.

The XBee modules were ideal for transmitting information wirelessly. XBee devices feature low-power, point-to-

multipoint/peer-to-peer networking. [3] Additionally, the firmware is modifiable via host computer, which allows for additional functionality to be added to the device. The devices also feature a fast 250 kbps data rate, and 128-bit AES encryption. A very important trait of the XBee device was the ability to set up a mesh network (Fig. 1). The devices could use each other to retransmit the signal to reach larger distances. Also, as a fail-safe, if any of the devices stopped functioning, the network would continue to work by resending the signal across a different path. The XBee devices were ideal for the design, as they were low cost, and very configurable.

All signals had to be sent to a central receiver that could interpret the data and transmit information to a host computer. In order to accomplish this, a XBee device was set up as a receiver and the incoming signal was sent to a A-WIT C-Stamp microcontroller. [4] Through the C-Stamp, the incoming signal was interpreted and displayed on a Windows machine. Once interfaced, the data can be displayed concisely using visual or textual queues.

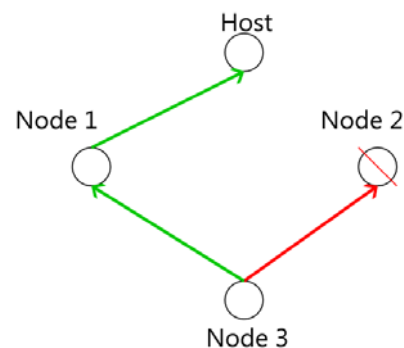


Fig. 1. Mesh Networking. If one of the nodes in the system fails to perform, the information is redirected to another node in order to transmit the data

III. TRANSMITTING THE SIGNAL

For the needs of this project, a digital signal needed to be transmitted wireless and efficiently to a host controller. The light status was obtained via a phototransistor. A MOSFET was used to switch the signal from high to low, depending on

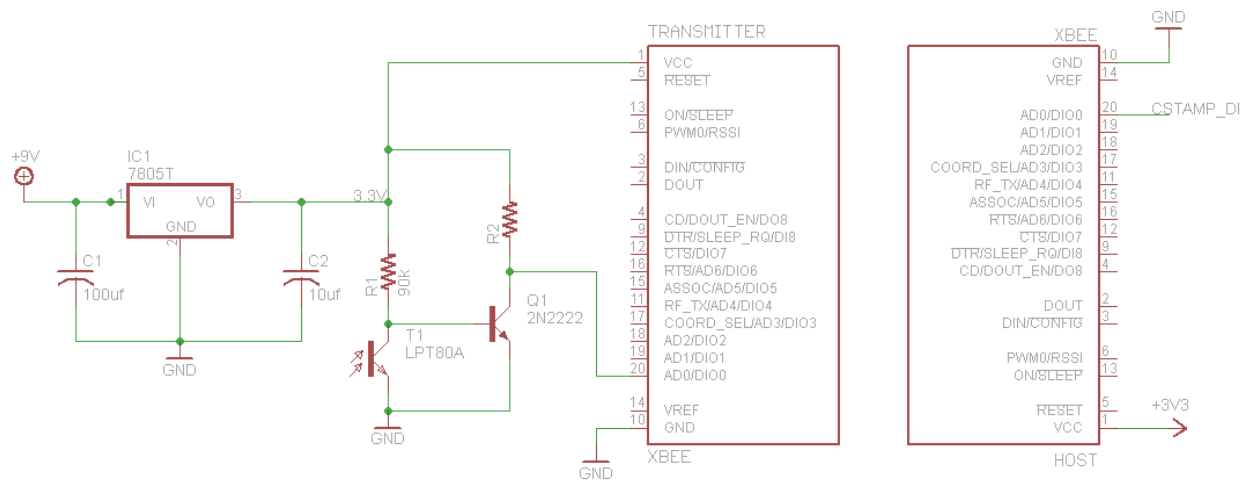


Fig. 2. System Schematic. A voltage regulator drops the voltage to 3.3V, which allows the phototransistor and MOSFET to send the appropriate signal to the XBee Transmitter. The XBee host receives the data wirelessly, and sends the signal to the C-Stamp.

which value was sent to the gate. This ensured that the signal on the incoming line to the XBee device was never in an undefined range. The full schematic for the design is shown in Figure 2. In order to ensure maximum power efficiency, only data that was vital to the objective of this project needed to be transmitted. In order to accomplish this, line passing was configured on the XBee firmware. Line passing is the idea of making a “virtual wire” of sorts in which a digital signal sent to one input on the XBee was transmitted and outputted to a specified pin on the receiver XBee. Configuring the firmware in this manner allowed a minimal amount of data to be transferred that designated the state of the light in a given room (Table 1). A digital low meant that the light in a room was on while a digital high meant the light in the room was off. Further configuration of the XBee module firmware allowed the modules to sleep (low power mode) and awake only on “change detect”. This allows the modules to use minimal idle power, wake when needed to transmit that signal, and sleep immediately after, allowing for maximum power efficiency. This results in a device that could last weeks on a single battery, rather than hours.

IV. C-STAMP MICROCONTROLLER

An A-WIT C-Stamp was used as a host controller that accepted data from the XBee host device. This data was interpreted and processed by embedded software on the C-Stamp and then transmitted to a PC through an RS-232 port. An application program on the host PC then accepted this data and displayed it to the user. This application program was written in C# due to the ease and flexibility of the language. This allows the possibility of expansion, providing easy channels to transmit or manipulate this data as needed. A potential example for expansion would be the idea of emailing a supervisor at a specific time with the state of all lights in a given building. Other options include logging and graphing the data for further examination, providing a quick visual way

state of the light in a room over time. This provides many opportunities to monitor the energy consumption in the building, potentially saving an organization a large amount of money in energy costs.

V. CONCLUSION

Although this project focused on using the XBee modules to transmit information pertaining to the light status, the design can be easily modified to transmit other important information, such as room temperature and pressure, or any other pertinent information

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