– ECE 09.321: Final Project–

Occupancy Sensor

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1 Design Overview

This project incorporates 3 types of sensors to detect the occupancy of a room. The sensors collect information on the light, temperature, and motion within the room and sends the information over UART on Wifi to a server that displays the occupancy of the room in a website GUI. The purpose of this project is to allow users to check to see if a collab room is occupied before physically scoping out the room.

1.1 Design Features

These are the design features:

- Temperature Sensor
- PIR Sensor
- Photocell
- UART

1.2 Featured Applications

- Detect occupancy in spaces
- Detect movement in spaces
- Detect temperature in spaces
- Alert when there is unexpected movement in a space
- Alert when there is lack of movement in a space

1.3 Design Resources

Github Link
Code

1.4 Block Diagram

As it sounds, this is just a block diagram of how the system is connected. The block diagram should be designed in such a way that other than the Figure Caption saying something like “System Block Diagram”, it should be able to be understood what is going on.

1.5 Board Image

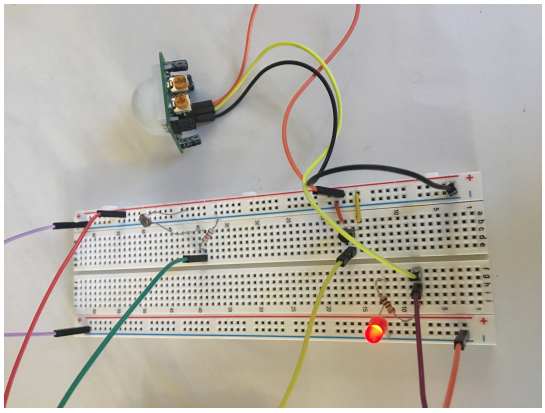

Figure 1: Breadboard Configuration

2 Key System Specifications

PARAMETER	SPECIFICATIONS	DETAILS
Measure Brightness	Detect if a room is bright or dark	The photoresistor is capable of measuring the brightness of a room whether it is dark or light
Measure Temperature	From 20 to 120 degrees Celsius	Measuring the temperature of a room.
Detect Motion	Detect motion in a room	Detect if someone enters and exits the room.

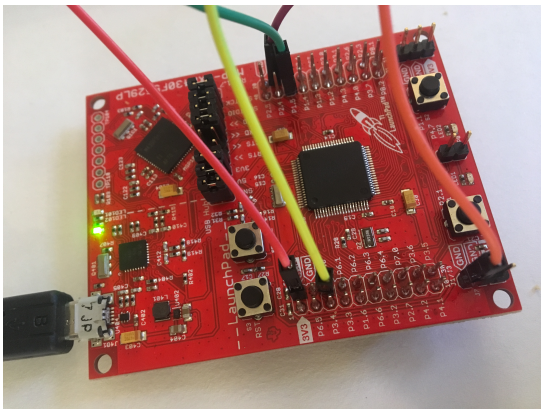

Figure 2: MSP430 Configuration

3 System Description

Currently, there is high demand among students in the Engineering building to find collaboration rooms in between classes to meet up with study groups to work. The high demand results in collab rooms being frequently occupied and no rooms being open. If one wants to work in a collab room during the day, they must physically check to see if there are any rooms open. In order to notify students if a room is open without having to physically check, we made a sensor to be implemented in each room that can send information over WiFi and notify a user in a user interface if any rooms are unoccupied. In addition to notifying users in a user interface, the sensor will sound an alarm (as per Dr. Schmalzel's request of a COB) if a room is empty.

3.1 Detailed Block Diagram

3.2 Highlighted Devices

- MSP430F5529
- DS7505 Temperature Sensor
- ESP8226 Arduino WiFi Module
- CDS Photocell Photoresistor
- Passive Infrared Motion Sensor

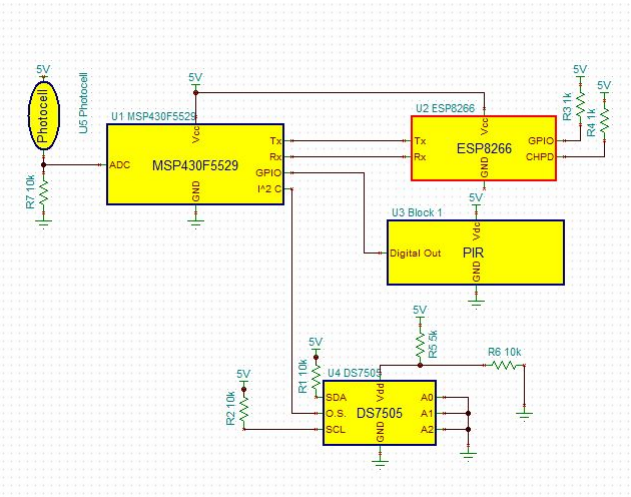

Figure 3: Detailed Block Diagram of Occupancy Sensor

3.3 MSP430F5529

The MSP430F5529 is used in this circuit to decide whether the light is turned on inside of the room, the temperature of the room, and send out a value if someone walks past the motion sensor. The brightness of the room is determined by measuring the voltage drop across the photocell which is then placed in an analog to digital converter. The bits are then converted to a voltage value and a comparison is done using the average voltage value of the brightness of the room. If the voltage value measured is greater, then the room is considered bright. If not, the room is considered dark. This interrupt then enables the GPIO interrupt.

The passive infrared motion sensor is connected to a general purpose input pin. The interrupt is activated by a low to high transition. If someone passes the infrared LED of the motion sensor, a value of 1 will be sent through UART and an LED will turn on. When there someone doesn't pass by the sensor, a value of 0 will be sent over UART and the LED will be turned off. This interrupt then sends enables the I2C interrupt.

The temperature sensor is connected to the I2C input of the MSP430F5529. The interrupt is called when through the general purpose interrupt. The I2C interrupt sends the temperature value over UART after it is measured from the DS7505 temperature sensor. It then returns back to the analog to digital converter interrupt.

3.4 DS7505 Temperature Sensor

The purpose of the DS7505 Temperature Sensor is to accurately measure the temperature of the room it is placed in. Since the temperature sensor has a max voltage capacity of 3.7 volts, a voltage divider connected to a voltage supply of 5 volts and a 5000 and a 10000 ohm resistor are placed in parallel to the VDD input. This is done

to supply the temperature sensor with nearly 3.3 volts. All three of the address bits are connected to the ground pin because there was no need for an address bit in this circuit. Also, the SCL and SDA inputs are connected in parallel with a 10000 ohm resistor to the 5 volt source. This is done because these inputs are unused as well. The output of the temperature sensor is connected to the I2C input of the MSP430F5529. The output of the DS7505 Temperature Sensor is a temperature value in Celsius, so no calculations are needed and the value can be directly transmitted over UART.

3.5 CDS Photocell Photoresistor

The purpose of the CDS Photocell Photoresistor is to detect how intense the light is in the room. If the light in the room is bright, we assume that the room is occupied. If the light in the room is dark, we assume that the room is not occupied. This is done by placing the photocell photoresistor in series with a 3000000 ohm resistor. The value of the resistor is so high because of the values of the max and minimum resistance for the photoresistor. The voltage drop of the resistor is measured and converted to a digital bit value by the analog to digital converter of the MSP430F5529. That value is then converted into a voltage value by dividing by the the amount of bits (4096 bits) and multiplying answer with the supply voltage (5 volts).

3.6 Passive Infrared Motion Sensor

The purpose of the Passive Infrared Motion Sensor is to detect if someone is in the room in use. The motion sensor is supplied with 5 volts and its input is connected to a GPIO pin of the MSP430F5529. How the motion sensor works is that it consists of an infrared LED. This LED is placed behind a Fresnel lens. When a warm body passes by the lens, it first intercepts half of the infrared sensor which then triggers a positive voltage change. When the sensing area is left, a negative voltage change occurs, which results in a pulse. When someone walks past the motion sensor, it will detect both halves of the infrared sensor. While measuring an entrance with a positive change followed by a negative change, detecting whether someone has entered or exited the room is easier. To detect an exit, the motion sensor looks for a low to high transition, then a high to low transition. To measure an entrance, it measures a high to low transition, then a low to high transition. If an entrance is detected, a value of 1 is sent over UART, while if an exit is detected a value of 0 is sent over UART.

4 SYSTEM DESIGN THEORY

This project is required to make something useless into something useful. We utilized skills learned from milestone and lab assignments in this project to display knowledge of the content.

4.1 Design Requirement 1

The first requirement of this project was to utilize sensors and collect information for the microcontroller to interpret. This requirement is fulfilled by using a temperature sensor to measure temperature, a photoresistor to measure light, and a PIR motion sensor to detect motion.

4.2 Design Requirement 2

The second design requirement of this project is to implement a COB, a convert-o-box. This requirement is fulfilled by using a low-side switch to power a speaker that outputs a signal whenever a room is not occupied.

5 Getting Started/How to use the device

The end goal of this project is to create a device that can be battery powered so that it doesn't need a wall outlet and can be hung on a wall in a collaboration room. The product is to be made exclusively for the Engineering Hall collaboration rooms. This is because the software needs to be specifically configured for the Rowan IOT WiFi. Ideally, all the user will need to do is put the device in a room, turn it on, and information should be sent to the website that will display information about the collab rooms.

6 Getting Started Software/Firmware

Let this section specifically deal with the firmware and software for your project and how to interface with it. Again, look at other documents to get a sense for what is contained here. Below are some example sections you could consider using.

7 Test Setup

To set up the device, connect the USB to your computer and open up RealTerm. In real term set the display as Ascii, check off half duplex, select your USB port, and set the baud rate to 115200. You should be able to see the data being sent from the MSP.

7.1 Test Data

We tested the following conditions: lights on/off and movement vs. no movement. We attained the following output:

Light	Movement	Output
ON	Detected	Room is occupied
OFF	Detected	Room is occupied
ON	Not Detected	Room is occupied
OFF	Not Detected	Room not occupied

8 Design Files

PIR Motion Sensor
Photoresistor
PTAT

8.1 Bill of Materials

Item	Price
MSP430F5529	$10.37
TMP360z	$1.50
Adafruit PIR Sensor	$9.95
Photocell	$0.95
ESP8226	$6.95
TOTAL:	**$29.72**