UNIVERSITY OF CALIFORNIA SAN DIEGO

Course # WES 237A

Course Title: Intro to Embed Sys Des

Final Project Report

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Project Title: Intelligent Lighting System

Student 1 :Ajlan, Abdullah, A69028719

Project Objective

The objective of the project is to develop an Intelligent Lighting System that offers customizable illumination based on user preferences and environmental conditions. By leveraging the capabilities of the PYNQ-Z2 board, including FPGA-based hardware acceleration and software control, the project aims to provide dynamic lighting effects while promoting energy efficiency and user comfort. This project demonstrates the integration of hardware and software intelligence to create a sophisticated lighting solution suitable for various real-world applications such as smart homes, offices, and public spaces.

Apparatus

1. PYNQ-Z2 Board: *The PYNQ-Z2 board serves as the core component of the system, combining FPGA fabric and an ARM processor for hardware acceleration and software control. Link to specifications*

2. RGB LED (KY-016): *This LED provides a spectrum of colors for customizable illumination, controlled by the PYNQ-Z2 board. Link to specifications*

3. Photoresistor (KY-018): *The photoresistor detects ambient light levels, allowing for adaptive lighting control. It interfaces with the PYNQ-Z2 board to adjust brightness accordingly. Link to specifications*

4. Joystick: *The joystick provides manual control input for adjusting lighting parameters such as color and brightness. It interfaces with the PYNQ-Z2 board to enable user interaction with the system. Link to specifications*

5. Resistors and Wiring: *Used for connecting the RGB LED, photoresistor, joystick, and other components. These components facilitate the physical connections required for the system to function.*

Software:

- *Developed an app using **MIT App Inventor** to control the light on/off and change LED colors.*
- *Integrated with the **Thingspeak platform** to monitor system status remotely.*
- *Utilized external libraries for FPGA programming and sensor interfacing.*
- *GitHub repository: https://github.com/ajlan-UCSD/Final-Project*

Procedure

1. ***Hardware Setup:*** *Assembled the PYNQ-Z2 board, RGB LED, photoresistor, joystick, resistors, and wiring according to the circuit diagram. Connected the components to the appropriate pins on the PYNQ-Z2 board.*

2. *Software Development:*
   - *Developed FPGA code to control the RGB LED and interface with the photoresistor and joystick for light sensing and manual control input, respectively.*
   - *Implemented software algorithms to interpret joystick inputs and adjust lighting parameters such as color and brightness accordingly.*
   - *Created a mobile app using MIT App Inventor to provide remote control functionality and interface with the PYNQ-Z2 board.*

3. ***Integration:*** *Integrated the hardware and software components to ensure seamless communication between the PYNQ-Z2 board, sensors, joystick, actuators, and the mobile app. Tested the system for functionality and stability, ensuring that joystick inputs were accurately reflected in the lighting control.*

4. ***Testing and Optimization:*** *Conducted thorough testing to validate the performance of the system under different scenarios, including manual control via the joystick and remote control via the mobile app. Optimized algorithms for responsive and intuitive user interaction, fine-tuning parameters for optimal lighting effects.*

5. ***Calibration:*** *Calibrated the photoresistor to accurately detect ambient light levels and adjust the lighting brightness accordingly. Ensured that the system responded appropriately to changes in environmental lighting conditions.*

6. ***User Interface Design:*** *Designed an intuitive user interface for the mobile app, allowing users to easily control lighting parameters such as color. Incorporated feedback mechanisms to provide users with real-time status updates and visual feedback on their actions.*

Results

The intelligent lighting system functioned effectively, providing customizable illumination based on user preferences and environmental conditions. The system successfully demonstrated dynamic lighting effects, adaptive brightness control, and remote accessibility via the mobile app. However, there were some challenges encountered during the development process, including initial calibration issues with the photoresistor and minor software bugs.

Conclusion

In conclusion, the project achieved its objective of developing an intelligent lighting system that combines hardware acceleration with software intelligence. The system demonstrated successful integration of FPGA-based hardware control with software algorithms for dynamic lighting effects. While the system functioned well overall, there is room for further optimization and refinement, particularly in calibration algorithms and user interface design. Future work could focus on expanding the functionality of the system, integrating additional sensors for enhanced environmental sensing, and improving the user experience. Overall, Lumos represents a significant advancement in smart lighting technology with potential applications in various real-world settings.


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Final Project
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Light ON
Light OFF
Color 1
Color 2
Graphs

In [1]:
```
# Make sure the base overlay is loaded
from pynq.overlays.base import BaseOverlay
from pynq.lib import Pmod_IO
base = BaseOverlay("base.bit")
```

In [2]:
```
from pynq.lib.arduino import Arduino_Analog
from pynq.lib.arduino import ARDUINO_GROVE_A1
from pynq.lib.arduino import ARDUINO_GROVE_A2
from pynq.lib.arduino import ARDUINO_GROVE_A3
pmod_pin2 = Pmod_IO(base.PMODA, 2, 'out')
pmod_pin3 = Pmod_IO(base.PMODA, 3, 'out')
analog1 = Arduino_Analog(base.ARDUINO,ARDUINO_GROVE_A1)
analog2 = Arduino_Analog(base.ARDUINO,ARDUINO_GROVE_A2)
analog3 = Arduino_Analog(base.ARDUINO,ARDUINO_GROVE_A3)
```

In [3]:
```
import requests
import random
import time

# Define the API URL for RTD sensor and joystick
url = "https://api.thingspeak.com/update"

# Define the API key
api_key = "ZWDDD7SRLM2MQYX3"
# Define the API URL for reading data
read_url = "https://api.thingspeak.com/channels/2453222/feeds/last.json?pi_key=ZWDDD7SRLM2MQYX3"
```

In [ ]:

In [ ]:
```
import requests
import time

# Define the API URLs for reading data and sending results
read_url = "https://api.thingspeak.com/channels/2453222/feeds.json?results="  # Fetch only the latest record
write_url = "https://api.thingspeak.com/update"  # Replace with your actual API endpoint

# Define the API key
api_key = "ZWDDD7SRLM2MQYX3"

def process_data():
    try:
        # Make the API request to read data
        response = requests.get(read_url)

        # Check if the request was successful
        if response.status_code == 200:
            # Extract the JSON data from the response
            data = response.json()

            # Extract the latest feed from the response
            feeds = data["feeds"]

            # Initialize variables to store the latest values of field3 and field4
            latest_field3 = None
            latest_field4 = None

            # Iterate through the feeds in reverse order to find the latest values of field3 and field4
            for feed in reversed(feeds):
                if "field3" in feed and feed["field3"] is not None:
                    latest_field3 = feed["field3"]
                    break

            for feed in reversed(feeds):
                if "field4" in feed and feed["field4"] is not None:
                    latest_field4 = feed["field4"]
                    break

            # Check if both field3 and field4 have valid values
            if latest_field3 is not None and latest_field4 is not None:
                print(f"Latest values - field3: {latest_field3}, field4: {latest_field4}")

                # Check the conditions and print messages accordingly
                if latest_field3 == "1" and latest_field4 == "1":
                    print("Field3 is 1 and Field4 is 1")
                    pmod_pin2.write(1)
                    pmod_pin3.write(1)
                elif latest_field3 == "1" and latest_field4 == "0":
                    print("Field3 is 1 and Field4 is 0")
                    pmod_pin2.write(1)
                    pmod_pin3.write(0)
                else:
                    print("Field3 is 0")
                    pmod_pin2.write(0)
                    pmod_pin3.write(0)

                # Define the payloads for each field
                payload1 = {"api_key": api_key, "field5": latest_field3}
                payload2 = {"api_key": api_key, "field6": latest_field4}

                # Send data for field5
                response1 = requests.post(write_url, data=payload1)
                time.sleep(20)
                if response1.status_code == 200:
                    print(f"Value {latest_field3} was successfully written to field5.")
                else:
                    print(f"Error writing value to field5. Status code: {response1.status_code}")

                # Send data for field6
                response2 = requests.post(write_url, data=payload2)
                time.sleep(20)
                if response2.status_code == 200:
                    print(f"Value {latest_field4} was successfully written to field6.")
                else:
                    print(f"Error writing value to field6. Status code: {response2.status_code}")

            else:
                print("No valid values found for field3 and field4 in the latest feeds.")

        else:
            print(f"Failed to fetch data from ThingSpeak. Status code: {response.status_code}")

    except Exception as e:
        print(f"An error occurred: {e}")

# Main loop
while True:
    process_data()
    time.sleep(60)  # Adjust the time interval as needed
```

```
Latest values - field3: 1, field4: 1
Field3 is 1 and Field4 is 1
Value 1 was successfully written to field5.
Value 1 was successfully written to field6.
Latest values - field3: 1, field4: 1
```

```
Field3 is 1 and Field4 is 1
Value 1 was successfully written to field5.
Value 1 was successfully written to field6.
Latest values - field3: 1, field4: 1
Field3 is 1 and Field4 is 1
Value 1 was successfully written to field5.
Value 1 was successfully written to field6.
Latest values - field3: 1, field4: 1
Field3 is 1 and Field4 is 1
Value 1 was successfully written to field5.
Value 1 was successfully written to field6.
Latest values - field3: 1, field4: 1
Field3 is 1 and Field4 is 1
Value 1 was successfully written to field5.
Value 1 was successfully written to field6.
```

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```

In [ ]:
```
while True:
    # Generate a random value between 0 and 3.3
    field1_value = analog1.read() [0]
    field2_value = analog2.read() [0]
    field3_value = analog3.read() [0]
    if field2_value > 1:
     pmod_pin3.write(1)
     pmod_pin2.write(0)
    else:
     pmod_pin2.write(1)
     pmod_pin3.write(0)
    # Create the payload
    payload1 = {"api_key": api_key, "field1": field1_value}
    payload2 = {"api_key": api_key, "field2": field2_value}
    # Make the API request
    response1 = requests.get(url, params=payload1)
    time.sleep(1)
    response2 = requests.get(url, params=payload2)

    # Check if the request was successful
    if response1.status_code == 200:
        print(f"Value {field1_value} was successfully written to field1.")
    else:
        print(f"Error writing value to field1. Status code: {response1.status_code}")

    if response2.status_code == 200:
        print(f"Value {field2_value} was successfully written to field2.")
    else:
        print(f"Error writing value to field1. Status code: {response2.status_code}")


    # Wait for 1 second
    time.sleep(1)
```

```
Value 0.008231506347656250 was successfully written to field1.
Value 1.4269976806640625 was successfully written to field2.
Value 0.008638000488281250 was successfully written to field1.
Value 1.4306053161621095 was successfully written to field2.
Value 0.008892059326171875 was successfully written to field1.
Value 1.4312150573730469 was successfully written to field2.
Value 0.008688812255859376 was successfully written to field1.
Value 1.4316215515136719 was successfully written to field2.
Value 0.008841247558593750 was successfully written to field1.
Value 1.4305036926269532 was successfully written to field2.
Value 0.008790435791015625 was successfully written to field1.
Value 1.4309609985351563 was successfully written to field2.
Value 0.008536376953125 was successfully written to field1.
Value 1.4298431396484375 was successfully written to field2.
Value 0.008536376953125 was successfully written to field1.
Value 1.430402069091797 was successfully written to field2.
Value 0.009146118164062500 was successfully written to field1.
Value 1.4301988220214843 was successfully written to field2.
Value 0.008892059326171875 was successfully written to field1.
Value 1.4280647277832033 was successfully written to field2.
Value 0.008536376953125 was successfully written to field1.
Value 1.4285220336914062 was successfully written to field2.
Value 0.009298553466796875 was successfully written to field1.
Value 1.4275057983398438 was successfully written to field2.
Value 0.008841247558593750 was successfully written to field1.
Value 1.4303004455566406 was successfully written to field2.
Value 0.008587188720703125 was successfully written to field1.
Value 1.4277090454101562 was successfully written to field2.
Value 0.008942871093750000 was successfully written to field1.
Value 1.4309101867675782 was successfully written to field2.
Value 0.008688812255859376 was successfully written to field1.
Value 1.430808563232422 was successfully written to field2.
Value 0.008942871093750000 was successfully written to field1.
Value 1.431265869140625 was successfully written to field2.
Value 0.008638000488281250 was successfully written to field1.
Value 1.430808563232422 was successfully written to field2.
Value 0.008485565185546875 was successfully written to field1.
Value 1.4309101867675782 was successfully written to field2.
Value 0.008587188720703125 was successfully written to field1.
Value 1.4306561279296874 was successfully written to field2.
Value 0.009146118164062500 was successfully written to field1.
Value 1.4312150573730469 was successfully written to field2.
Value 0.008485565185546875 was successfully written to field1.
Value 1.431265869140625 was successfully written to field2.
Value 0.008638000488281250 was successfully written to field1.
Value 1.4309609985351563 was successfully written to field2.
Value 0.008993682861328125 was successfully written to field1.
Value 1.4306561279296874 was successfully written to field2.
Value 0.008942871093750000 was successfully written to field1.
Value 1.4311642456054687 was successfully written to field2.
Value 0.008942871093750000 was successfully written to field1.
Value 1.4309101867675782 was successfully written to field2.
Value 0.008892059326171875 was successfully written to field1.
Value 1.4313166809082032 was successfully written to field2.
Value 0.009044494628906250 was successfully written to field1.
Value 1.4313166809082032 was successfully written to field2.
Value 0.008892059326171875 was successfully written to field1.
Value 1.4273025512695312 was successfully written to field2.
Value 0.008587188720703125 was successfully written to field1.
Value 1.4264387512207031 was successfully written to field2.
Value 0.009095306396484376 was successfully written to field1.
Value 1.4279631042480469 was successfully written to field2.
Value 0.0 was successfully written to field1.
Value 1.4292333984375 was successfully written to field2.
Value 0.008333129882812500 was successfully written to field1.
Value 1.4305036926269532 was successfully written to field2.
Value 0.007621765136718750 was successfully written to field1.
Value 1.4300463867187500 was successfully written to field2.
Value 0.008333129882812500 was successfully written to field1.
Value 1.4297923278808593 was successfully written to field2.
```

```
Value 0.007774200439453125 was successfully written to field1.
Value 1.4299447631835938 was successfully written to field2.
Value 0.007977447509765626 was successfully written to field1.
Value 1.4298939514160156 was successfully written to field2.
Value 0.008180694580078125 was successfully written to field1.
Value 1.4305545043945314 was successfully written to field2.
Value 0.007977447509765626 was successfully written to field1.
Value 1.4296907043457032 was successfully written to field2.
Value 0.007672576904296875 was successfully written to field1.
Value 1.4292842102050782 was successfully written to field2.
Value 0.007774200439453125 was successfully written to field1.
Value 1.4245079040527344 was successfully written to field2.
Value 0.00782501220703125 was successfully written to field1.
Value 1.428776092529297 was successfully written to field2.
Value 0.008282318115234374 was successfully written to field1.
Value 1.4296907043457032 was successfully written to field2.
Value 0.007977447509765626 was successfully written to field1.
Value 1.4301480102539064 was successfully written to field2.
Value 0.00762176513671875 was successfully written to field1.
Value 1.4299447631835938 was successfully written to field2.
Value 0.0081298828125 was successfully written to field1.
Value 1.4294366455078125 was successfully written to field2.
Value 0.00823150634765625 was successfully written to field1.
Value 1.430402069091797 was successfully written to field2.
Value 0.008079071044921875 was successfully written to field1.
Value 1.430452880859375 was successfully written to field2.
Value 0.007875823974609375 was successfully written to field1.
Value 1.4294874572753906 was successfully written to field2.
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Value 0.007977447509765626 was successfully written to field1.
Value 1.4232884216308594 was successfully written to field2.
Value 0.008079071044921875 was successfully written to field1.
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Value 0.007977447509765626 was successfully written to field1.
Value 1.4281155395507812 was successfully written to field2.
Value 0.007774200439453125 was successfully written to field1.
Value 0.009298553466796875 was successfully written to field2.
Value 0.0083331298828125 was successfully written to field1.
Value 1.4259814453125 was successfully written to field2.
Value 0.00823150634765625 was successfully written to field1.
Value 0.009298553466796875 was successfully written to field2.
Value 0.0083331298828125 was successfully written to field1.
Value 1.4264895629882812 was successfully written to field2.
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Value 1.428776092529297 was successfully written to field2.
Value 0.008180694580078125 was successfully written to field1.
Value 1.428776092529297 was successfully written to field2.
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Value 1.4294366455078125 was successfully written to field2.
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Value 0.0081298828125 was successfully written to field1.
Value 1.429589080810547 was successfully written to field2.
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Value 1.4293350219726564 was successfully written to field2.
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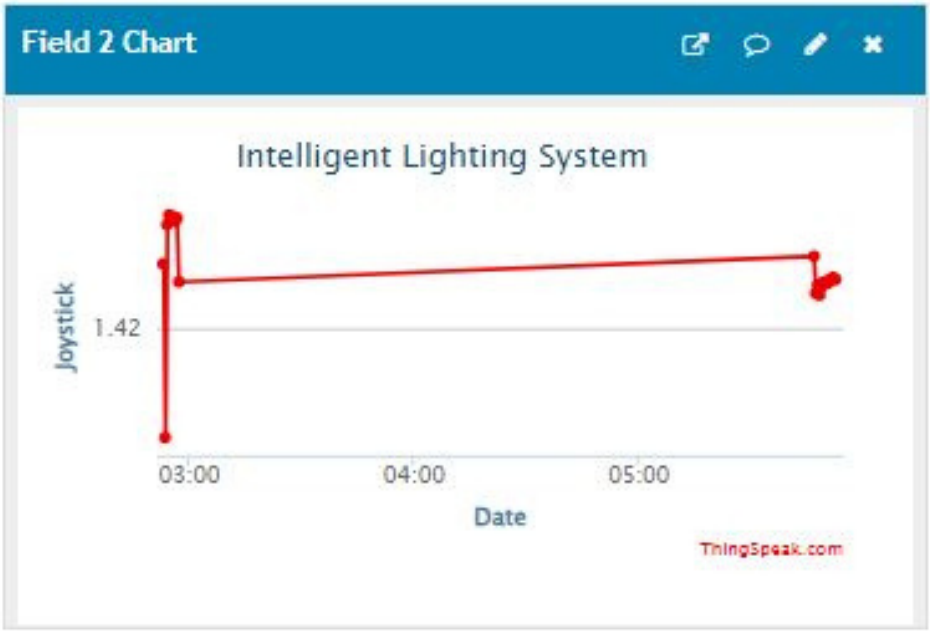
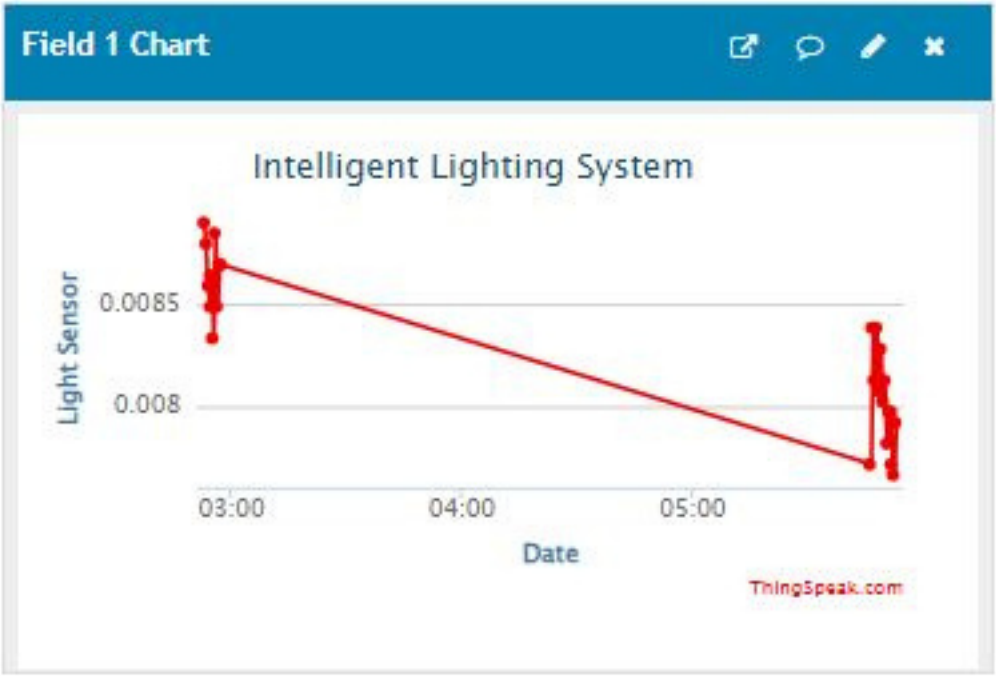
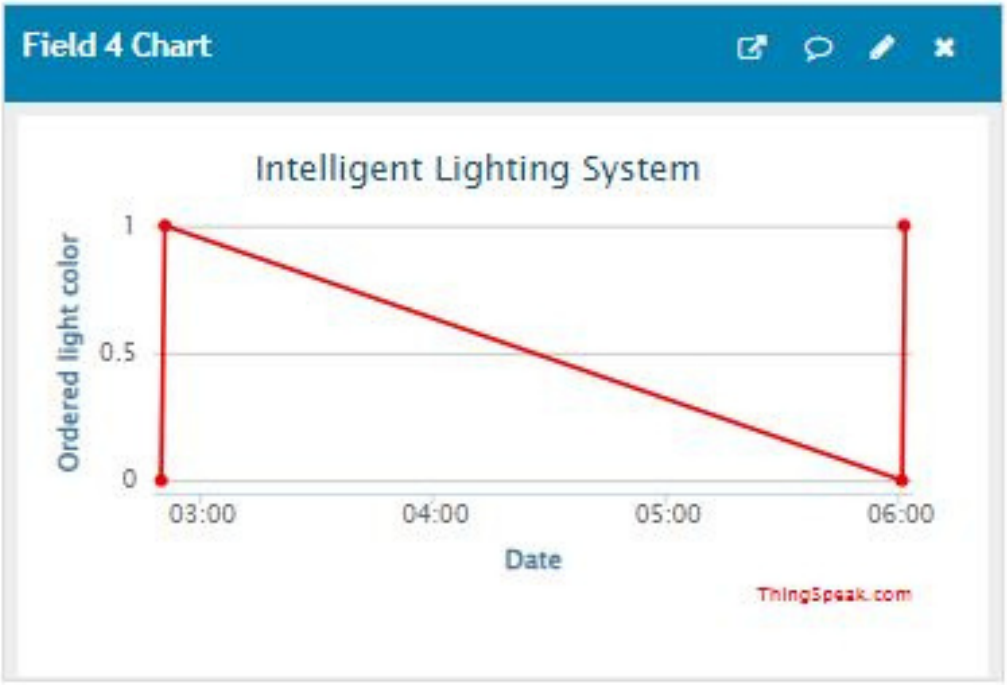
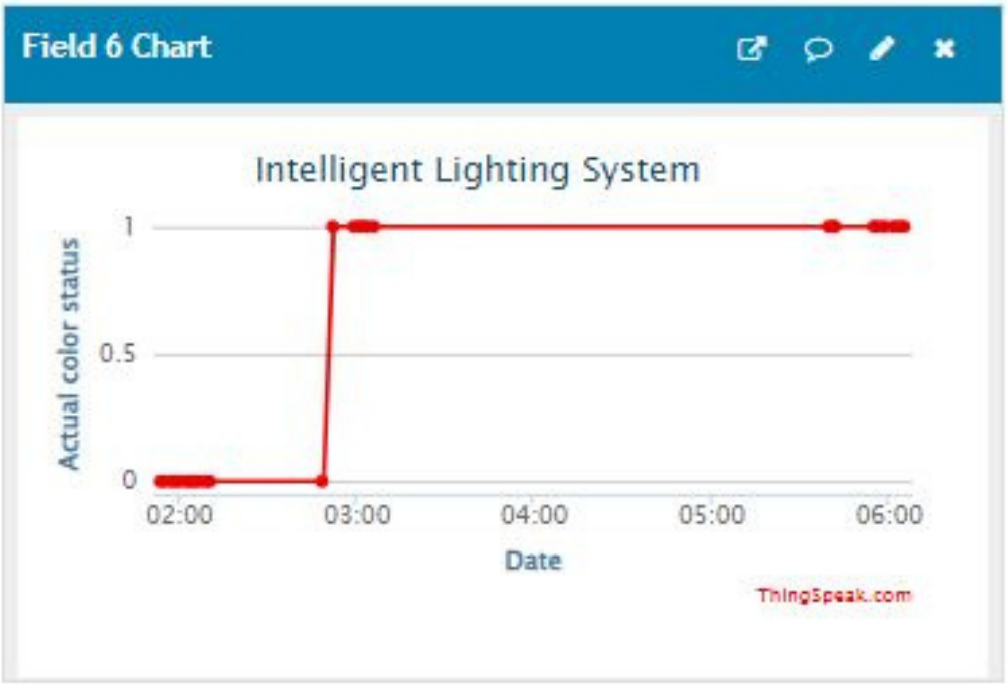
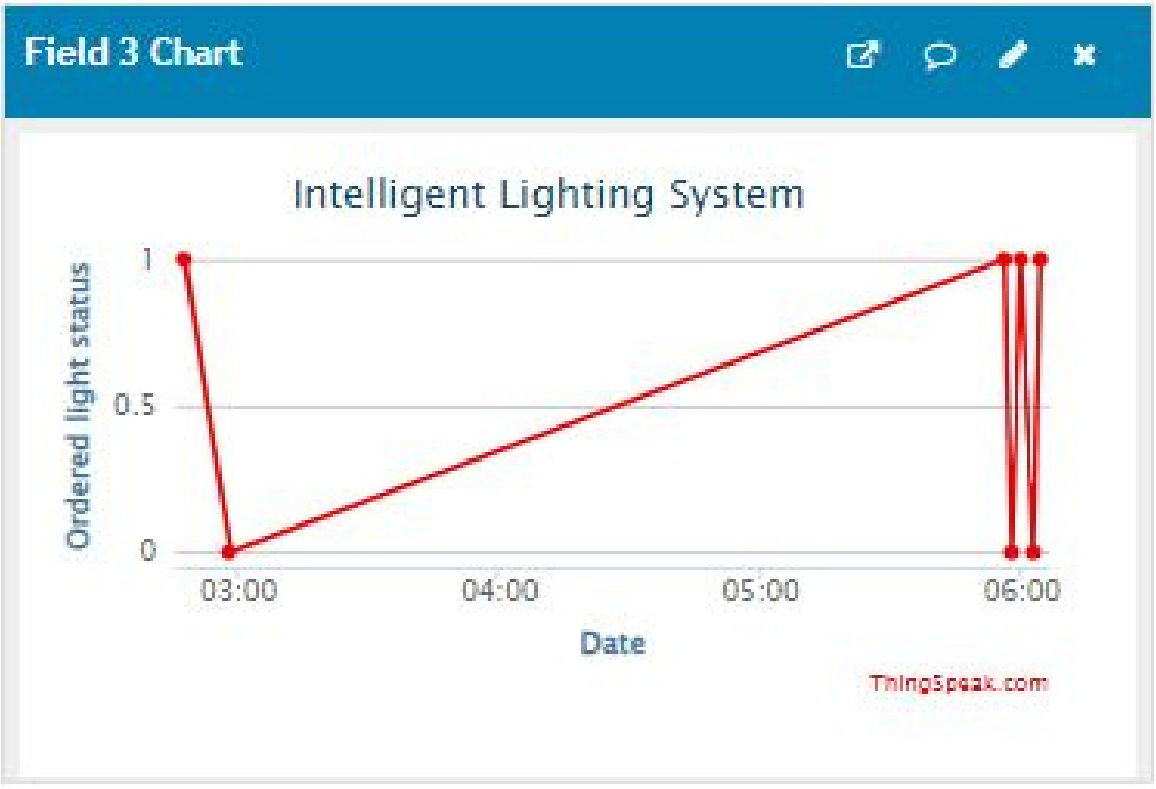
Value 0.008485565185546875 was successfully written to field1.
Value 1.430452880859375 was successfully written to field2.
```

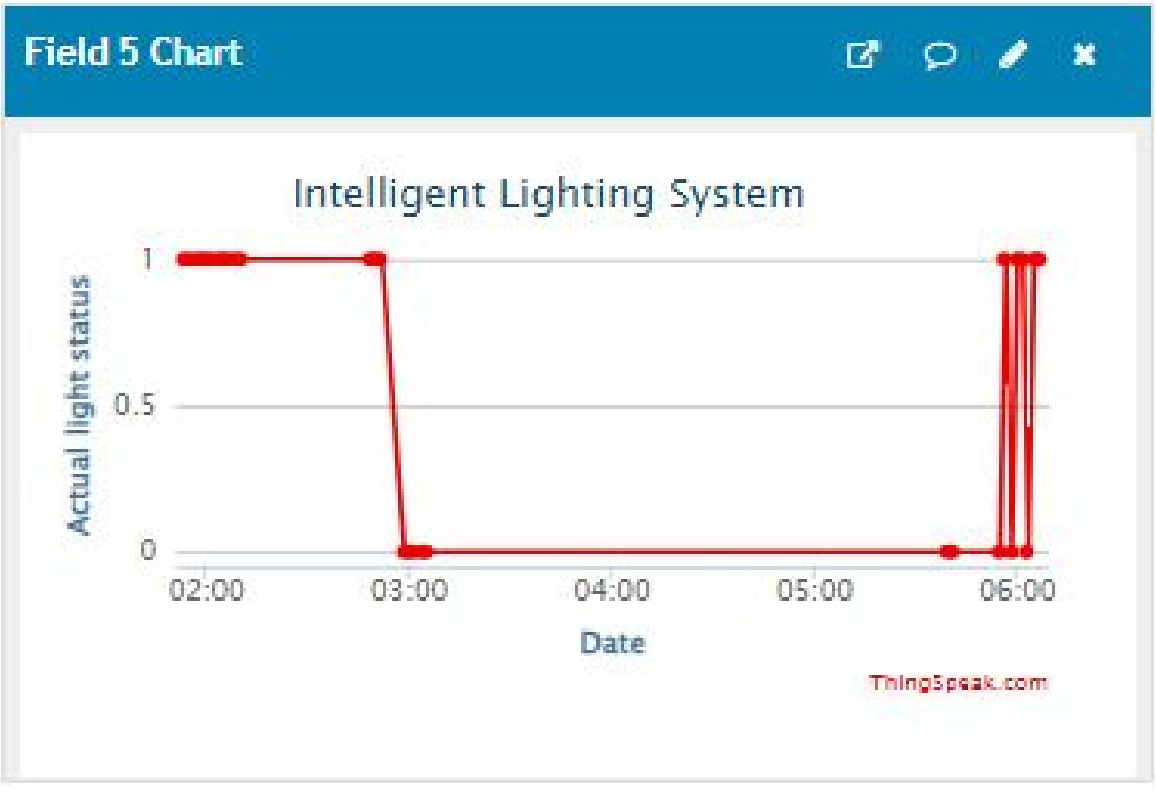

Field 2 Chart
Intelligent Lighting System
Joystick
1.42
03:00
04:00
05:00
Date
ThingSpeak.com


Field 1 Chart
Intelligent Lighting System
Light Sensor
0.0085
0.008
03:00
04:00
05:00
Date
ThingSpeak.com


Field 4 Chart
Intelligent Lighting System
Ordered light color
1
0.5
0
03:00
04:00
05:00
06:00
Date
ThingSpeak.com


Field 6 Chart
Intelligent Lighting System
Actual color status
1
0.5
0
02:00
03:00
04:00
05:00
06:00
Date
ThingSpeak.com


Field 3 Chart
Intelligent Lighting System
Ordered light status
1
0.5
0
03:00
04:00
05:00
06:00
Date
ThingSpeak.com


Field 5 Chart
Intelligent Lighting System
Actual light status
1
0.5
0
02:00
03:00
04:00
05:00
06:00
Date
ThingSpeak.com