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CpE 403 Section 1001
Date Submitted: 10/30/2018

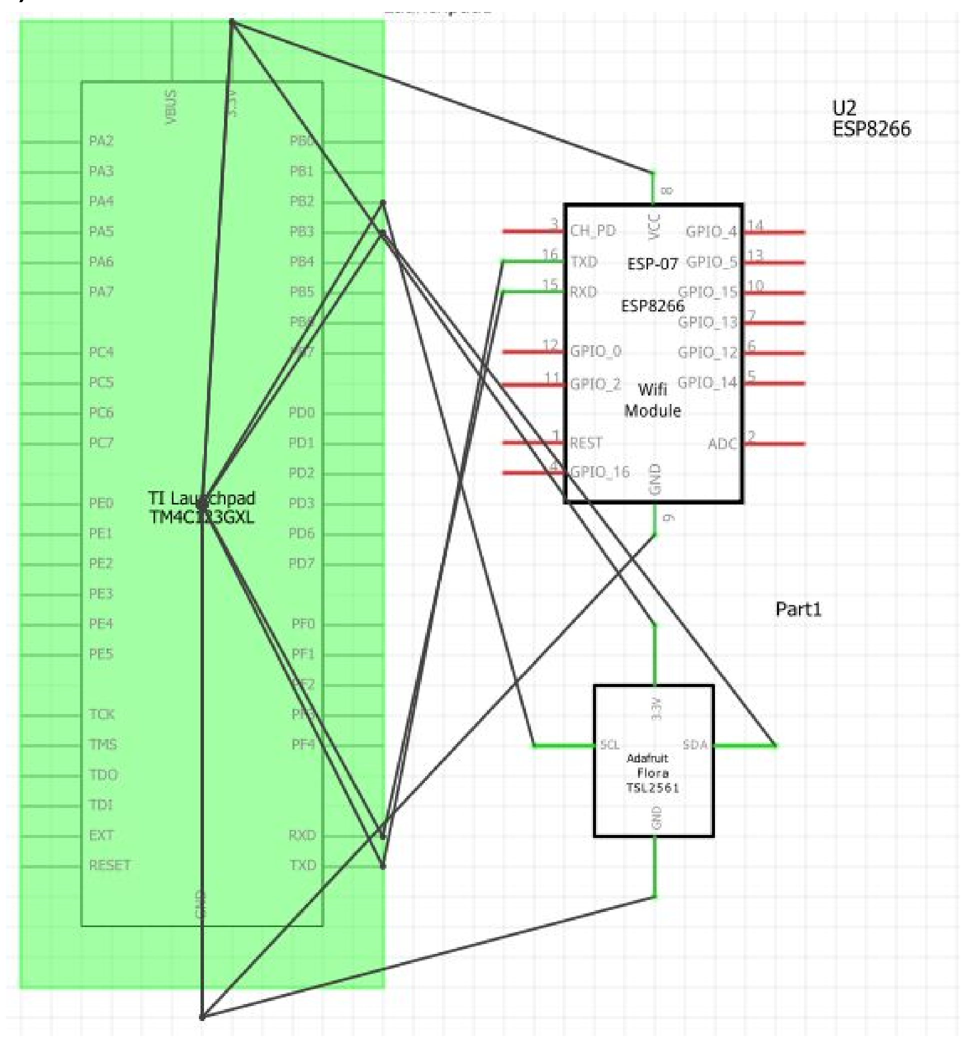
1) Goal

The goal of this project was to have the Tiva C TM4C123G read lux values from the TSL2561 chip through I2C connection then send them to Thingspeak using the ESP8266 chip through UART.

2) Detailed Implementation

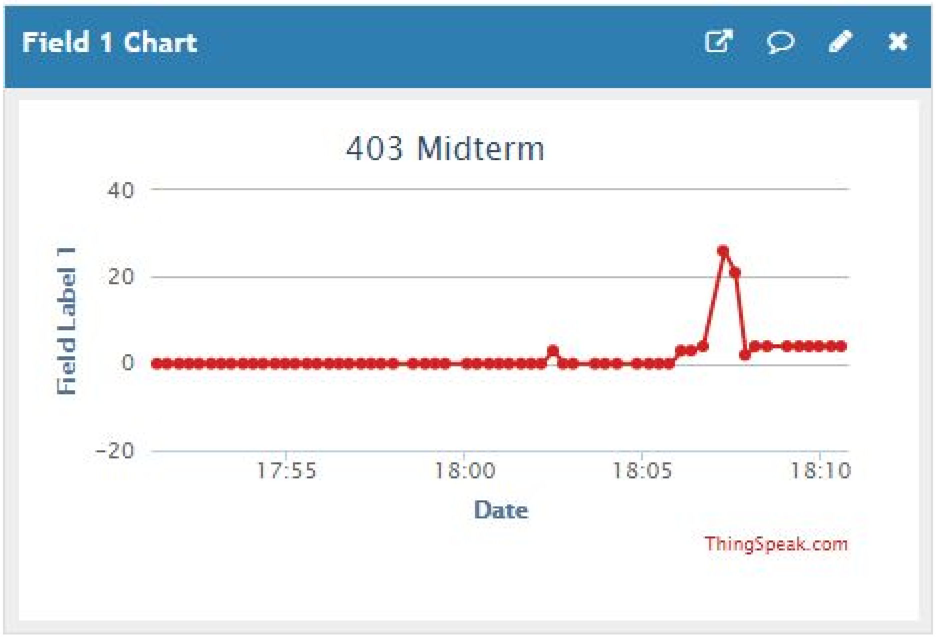
The implementation has the SDA pin on the TSL2561 is connected to pin PB3 on the board. The SCL pin on the TSL2561 is connect to pin PB2 on the board. The TX pin on the ESP8266 is connected to PB0 on the board. The RX pin on the ESP8266 is connect to PB1 on the board.

3) Schematics



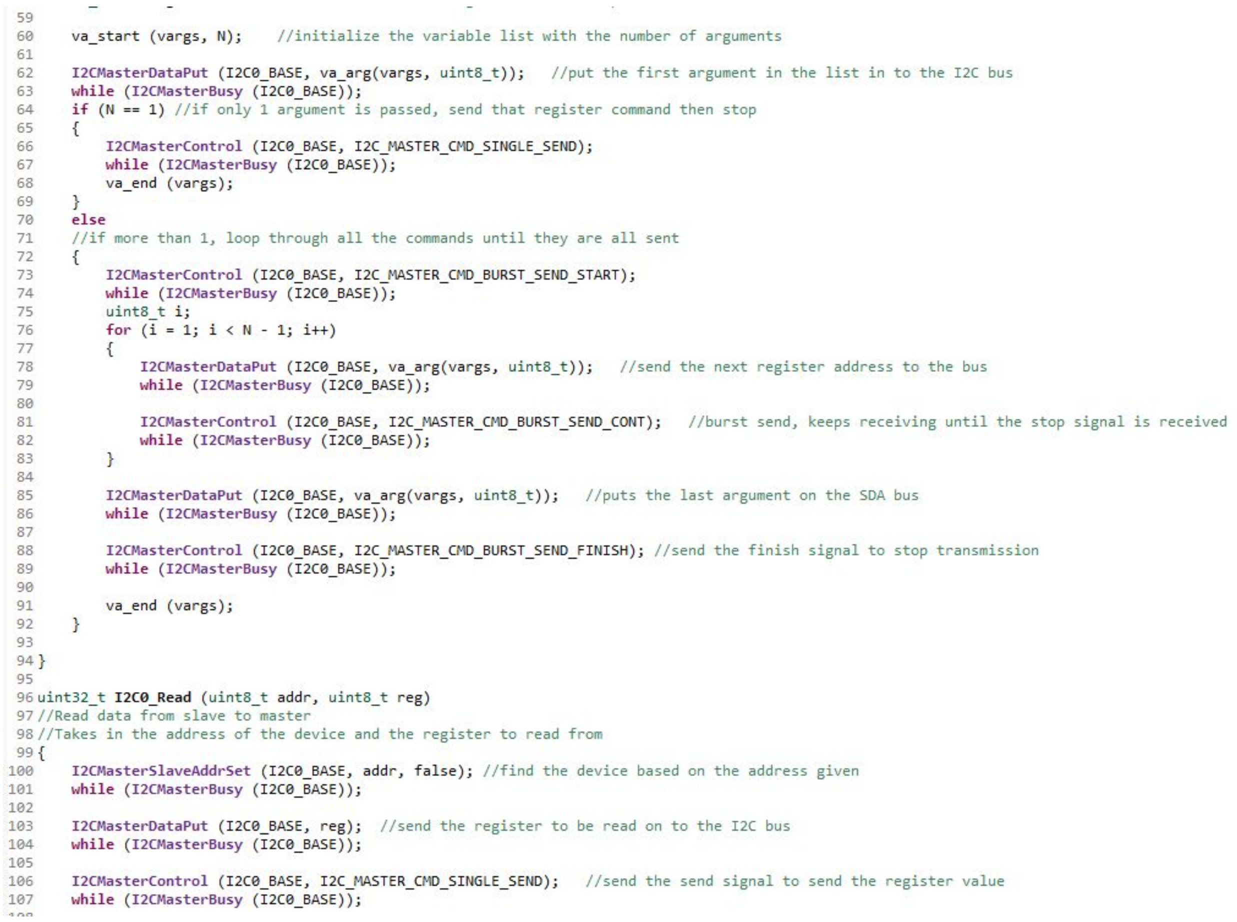
4) Links:
Video Link: https://youtu.be/lFTyy5-65y0
Thingspeak Link: https://thingspeak.com/channels/614878

5) Screenshots
Thingspeak:

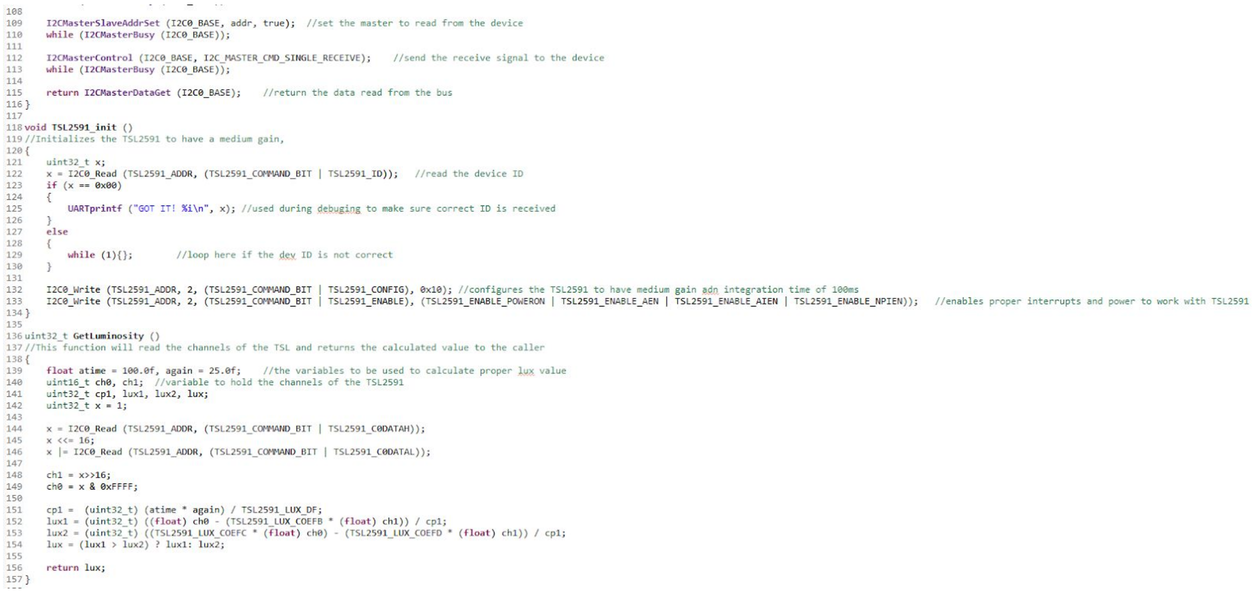


Code:

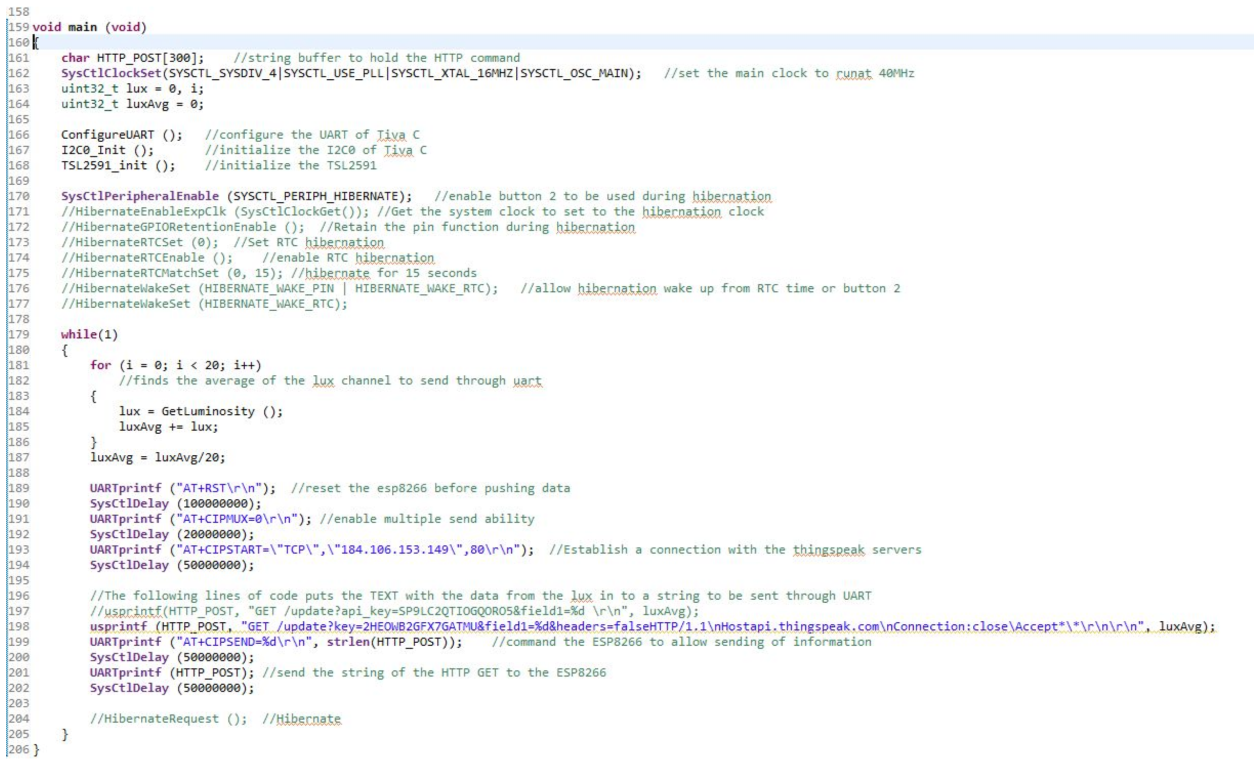
```c
#include <stdarg.h>
#include <stdbool.h>
#include <stdint.h>
#include <string.h>
#include "inc/tm4c123gh6pm.h"
#include "inc/hw_i2c.h"
#include "inc/hw_memmap.h"
#include "inc/hw_types.h"
#include "inc/hw_gpio.h"
#include "driverlib/i2c.h"
#include "driverlib/sysctl.h"
#include "driverlib/gpio.h"
#include "driverlib/pin_map.h"
#include "driverlib/uart.h"
#include "utils/uartstdio.h"
#include "driverlib/interrupt.h"
#include "driverlib/hibernate.h"
#include "driverlib/TSL2591_def.h"
#include "utils/ustdlib.h"

void ConfigureUART(void)
//Configures the UART to run at 19200 baud rate
{
    SysCtlPeripheralEnable(SYSCTL_PERIPH_UART1);    //enables UART module 1
    SysCtlPeripheralEnable(SYSCTL_PERIPH_GPIOB);    //enables GPIO port b

    GPIOPinConfigure(GPIO_PB1_U1TX);    //configures PB1 as TX pin
    GPIOPinConfigure(GPIO_PB0_U1RX);    //configures PB0 as RX pin
    GPIOPinTypeUART(GPIO_PORTB_BASE, GPIO_PIN_0 | GPIO_PIN_1);  //sets the UART pin type

    UARTClockSourceSet(UART1_BASE, UART_CLOCK_PIOSC);   //sets the clock source
    UARTStdioConfig(1, 115200, 16000000);   //enables UARTstdio baud rate, clock, and which UART to use
}


void I2C0_Init ()
//Configure/initialize the I2C0
{
    SysCtlPeripheralEnable (SYSCTL_PERIPH_I2C0);    //enables I2C0
    SysCtlPeripheralEnable (SYSCTL_PERIPH_GPIOB);   //enable PORTB as peripheral
    GPIOPinTypeI2C (GPIO_PORTB_BASE, GPIO_PIN_3);   //set I2C PB3 as SDA
    GPIOPinConfigure (GPIO_PB3_I2C0SDA);

    GPIOPinTypeI2CSCL (GPIO_PORTB_BASE, GPIO_PIN_2);    //set I2C PB2 as SCLK
    GPIOPinConfigure (GPIO_PB2_I2C0SCL);

    I2CMasterInitExpClk (I2C0_BASE, SysCtlClockGet(), false);   //Set the clock of the I2C to ensure proper connection
    while (I2CMasterBusy (I2C0_BASE));  //wait while the master SDA is busy
}

void I2C0_Write (uint8_t addr, uint8_t N, ...)
//Writes data from master to slave
//Takes the address of the device, the number of arguments, and a variable amount of register addresses to write to
{
    I2CMasterSlaveAddrSet (I2C0_BASE, addr, false); //Find the device based on the address given
    while (I2CMasterBusy (I2C0_BASE));

    va_list vargs;  //variable list to hold the register addresses passed

```



```c
    va_start (vargs, N);    //initialize the variable list with the number of arguments

    I2CMasterDataPut (I2C0_BASE, va_arg(vargs, uint8_t));   //put the first argument in the list in to the I2C bus
    while (I2CMasterBusy (I2C0_BASE));
    if (N == 1) //if only 1 argument is passed, send that register command then stop
    {
        I2CMasterControl (I2C0_BASE, I2C_MASTER_CMD_SINGLE_SEND);
        while (I2CMasterBusy (I2C0_BASE));
        va_end (vargs);
    }
    else
    //if more than 1, loop through all the commands until they are all sent
    {
        I2CMasterControl (I2C0_BASE, I2C_MASTER_CMD_BURST_SEND_START);
        while (I2CMasterBusy (I2C0_BASE));
        uint8_t i;
        for (i = 1; i < N - 1; i++)
        {
            I2CMasterDataPut (I2C0_BASE, va_arg(vargs, uint8_t));   //send the next register address to the bus
            while (I2CMasterBusy (I2C0_BASE));

            I2CMasterControl (I2C0_BASE, I2C_MASTER_CMD_BURST_SEND_CONT);   //burst send, keeps receiving until the stop signal is received
            while (I2CMasterBusy (I2C0_BASE));
        }

        I2CMasterDataPut (I2C0_BASE, va_arg(vargs, uint8_t));   //puts the last argument on the SDA bus
        while (I2CMasterBusy (I2C0_BASE));

        I2CMasterControl (I2C0_BASE, I2C_MASTER_CMD_BURST_SEND_FINISH); //send the finish signal to stop transmission
        while (I2CMasterBusy (I2C0_BASE));

        va_end (vargs);
    }

}

uint32_t I2C0_Read (uint8_t addr, uint8_t reg)
//Read data from slave to master
//Takes in the address of the device and the register to read from
{
    I2CMasterSlaveAddrSet (I2C0_BASE, addr, false); //find the device based on the address given
    while (I2CMasterBusy (I2C0_BASE));

    I2CMasterDataPut (I2C0_BASE, reg);  //send the register to be read on to the I2C bus
    while (I2CMasterBusy (I2C0_BASE));

    I2CMasterControl (I2C0_BASE, I2C_MASTER_CMD_SINGLE_SEND);   //send the send signal to send the register value
    while (I2CMasterBusy (I2C0_BASE));
```



```c

    I2CMasterSlaveAddrSet (I2C0_BASE, addr, true);  //set the master to read from the device
    while (I2CMasterBusy (I2C0_BASE));

    I2CMasterControl (I2C0_BASE, I2C_MASTER_CMD_SINGLE_RECEIVE);    //send the receive signal to the device
    while (I2CMasterBusy (I2C0_BASE));

    return I2CMasterDataGet (I2C0_BASE);    //return the data read from the bus
}

void TSL2591_init ()
//Initializes the TSL2591 to have a medium gain,
{
    uint32_t x;
    x = I2C0_Read (TSL2591_ADDR, (TSL2591_COMMAND_BIT | TSL2591_ID));   //read the device ID
    if (x == 0x00)
    {
        UARTprintf ("GOT IT! %i\n", x); //used during debuging to make sure correct ID is received
    }
    else
    {
        while (1){};        //loop here if the dev ID is not correct
    }

    I2C0_Write (TSL2591_ADDR, 2, (TSL2591_COMMAND_BIT | TSL2591_CONFIG), 0x10); //configures the TSL2591 to have medium gain adn integration time of 100ms
    I2C0_Write (TSL2591_ADDR, 2, (TSL2591_COMMAND_BIT | TSL2591_ENABLE), (TSL2591_ENABLE_POWERON | TSL2591_ENABLE_AEN | TSL2591_ENABLE_AIEN | TSL2591_ENABLE_NPIEN));   //enables proper interrupts and power to work with TSL2591
}

uint32_t GetLuminosity ()
//This function will read the channels of the TSL and returns the calculated value to the caller
{
    float atime = 100.0f, again = 25.0f;    //the variables to be used to calculate proper lux value
    uint16_t ch0, ch1;  //variable to hold the channels of the TSL2591
    uint32_t cp1, lux1, lux2, lux;
    uint32_t x = 1;

    x = I2C0_Read (TSL2591_ADDR, (TSL2591_COMMAND_BIT | TSL2591_C0DATAH));
    x <<= 16;
    x |= I2C0_Read (TSL2591_ADDR, (TSL2591_COMMAND_BIT | TSL2591_C0DATAL));

    ch1 = x>>16;
    ch0 = x & 0xFFFF;

    cp1 =  (uint32_t) (atime * again) / TSL2591_LUX_DF;
    lux1 = (uint32_t) ((float) ch0 - (TSL2591_LUX_COEFB * (float) ch1)) / cp1;
    lux2 = (uint32_t) ((TSL2591_LUX_COEFC * (float) ch0) - (TSL2591_LUX_COEFD * (float) ch1)) / cp1;
    lux = (lux1 > lux2) ? lux1: lux2;

    return lux;
}
```



```
void main (void)
{
    char HTTP_POST[300];    //string buffer to hold the HTTP command
    SysCtlClockSet(SYSCTL_SYSDIV_4|SYSCTL_USE_PLL|SYSCTL_XTAL_16MHZ|SYSCTL_OSC_MAIN);   //set the main clock to runat 40MHz
    uint32_t lux = 0, i;
    uint32_t luxAvg = 0;

    ConfigureUART ();   //configure the UART of Tiva C
    I2C0_Init ();       //initialize the I2C0 of Tiva C
    TSL2591_init ();    //initialize the TSL2591

    SysCtlPeripheralEnable (SYSCTL_PERIPH_HIBERNATE);   //enable button 2 to be used during hibernation
    //HibernateEnableExpClk (SysCtlClockGet()); //Get the system clock to set to the hibernation clock
    //HibernateGPIORetentionEnable ();  //Retain the pin function during hibernation
    //HibernateRTCSet (0);  //Set RTC hibernation
    //HibernateRTCEnable ();    //enable RTC hibernation
    //HibernateRTCMatchSet (0, 15); //hibernate for 15 seconds
    //HibernateWakeSet (HIBERNATE_WAKE_PIN | HIBERNATE_WAKE_RTC);   //allow hibernation wake up from RTC time or button 2
    //HibernateWakeSet (HIBERNATE_WAKE_RTC);

    while(1)
    {
        for (i = 0; i < 20; i++)
            //finds the average of the lux channel to send through uart
        {
            lux = GetLuminosity ();
            luxAvg += lux;
        }
        luxAvg = luxAvg/20;

        UARTprintf ("AT+RST\r\n");  //reset the esp8266 before pushing data
        SysCtlDelay (100000000);
        UARTprintf ("AT+CIPMUX=0\r\n"); //enable multiple send ability
        SysCtlDelay (20000000);
        UARTprintf ("AT+CIPSTART=\"TCP\",\"184.106.153.149\",80\r\n");  //Establish a connection with the thingspeak servers
        SysCtlDelay (50000000);

        //The following lines of code puts the TEXT with the data from the lux in to a string to be sent through UART
        //usprintf(HTTP_POST, "GET /update?api_key=SP9LC2QTIOGQORO5&field1=%d \r\n", luxAvg);
        usprintf (HTTP_POST, "GET /update?key=2HEOWB2GFX7GATMU&field1=%d&headers=falseHTTP/1.1\nHostapi.thingspeak.com\nConnection:close\Accept*\*\r\n\r\n", luxAvg);
        UARTprintf ("AT+CIPSEND=%d\r\n", strlen(HTTP_POST));    //command the ESP8266 to allow sending of information
        SysCtlDelay (50000000);
        UARTprintf (HTTP_POST); //send the string of the HTTP GET to the ESP8266
        SysCtlDelay (50000000);

        //HibernateRequest ();  //Hibernate
    }
}
```

6) Conclusions

The tasks completed include: successfully connecting the ESP8266 chip and TSL2561 chip to the board, getting the lux sensor to read values, and getting the ESP8266 to send data to Thingspeak.

7) Circuit Photo