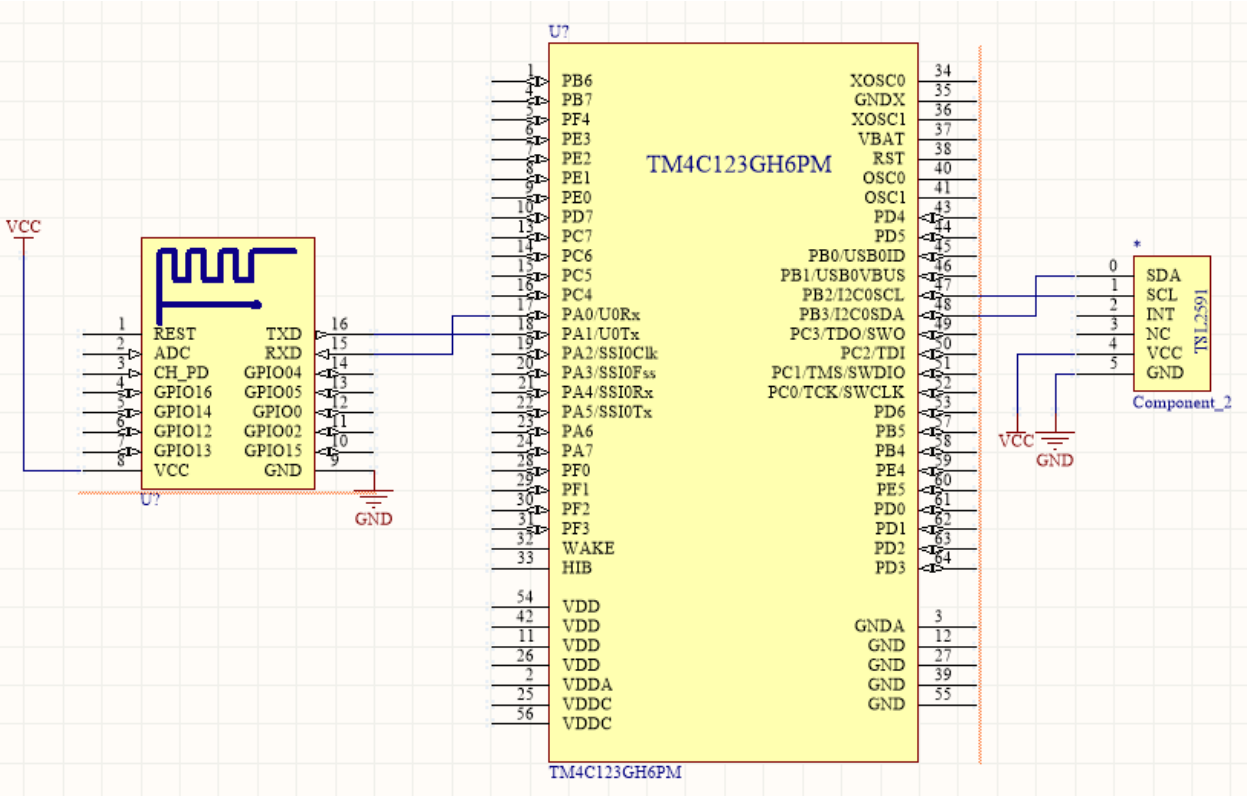
CPE 403 Midterm

Goal: The goal of this application is to measure light intensity and send it to the Tiva C interfaced by I2C. The data will be logged in a cloud service such as ThingSpeak which is send via the ESP8266 WiFi module.

Implementation: The TSL2591 is implemented using the build in I2C module on the Tiva C board. The I2C module works by sending a clock signal to the TSL2591 and bringing the clock bit to low to read from the TSL2591. The data is transmitted back by the SDA line, which will receive 9 bits: eight bits for data and one bit for stop sending or acknowledge bit. The ESP8266 is implemented using UART, which is also included on the Tiva C board. The UART need to agree on a baud rate or the rate of transmission to receive and send proper readings.

The Tiva C reads the TSL2591 data, sends to a cloud service, then goes to sleep for 30 minutes before the task is repeated. The hibernation can be interrupted anytime with switch 2. This allows data to be sent anytime.

Schematics:



Code:

```
#include <stdarg.h>
#include <stdbool.h>
#include <stdint.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 "uartstdio.h"
#include "driverlib/interrupt.h"
#include "driverlib/hibernate.h"
#include "TSL2591_def.h"
#include "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, 19200, 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

	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));

	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 == 0x50)
	{
		//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_5|SYSCTL_USE_PLL|SYSCTL_XTAL_16MHZ|SYSCTL_OSC_MAI
N);	//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, 1800);  //hibernate for 30 minutes
	HibernateWakeSet (HIBERNATE_WAKE_PIN | HIBERNATE_WAKE_RTC);	//allow
hibernation wake up from RTC time or button 2

	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=1\r\n");  //enable multiple send ability
	SysCtlDelay (20000000);
```

```
	UARTprintf ("AT+CIPSTART=4,\"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?key=R6Z98C0S5E3TWUSU&field1=%d&headers=falseHTTP/1.1\nHostapi.thingspeak.com\
nConnection:close\Accept*\*\r\n\r\n", luxAvg);
	UARTprintf ("AT+CIPSEND=4,%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
	while (1)
	{};
}
```

Screenshots:

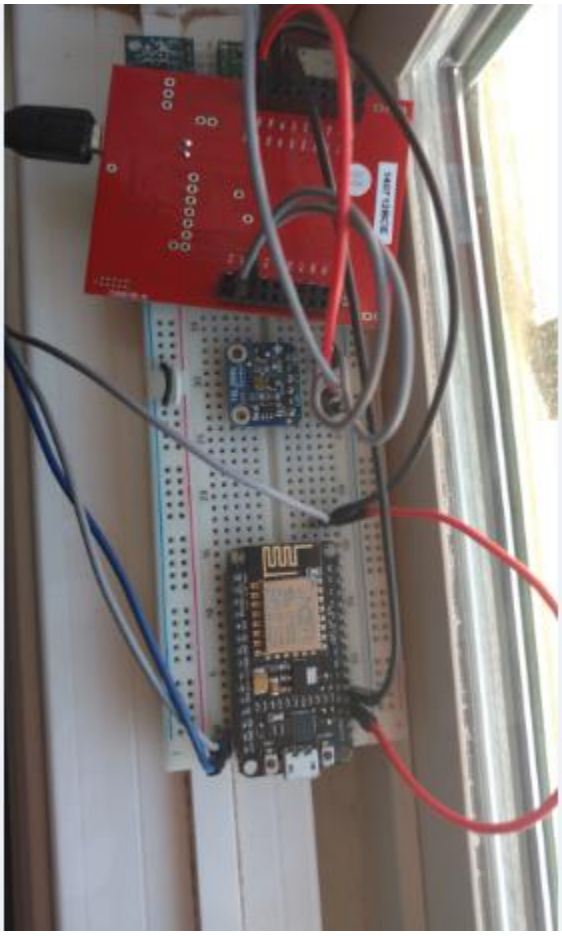


Figure 1: The TIva C connected to the TSL2591 and ESP8266; light is measured by the window throughout the day

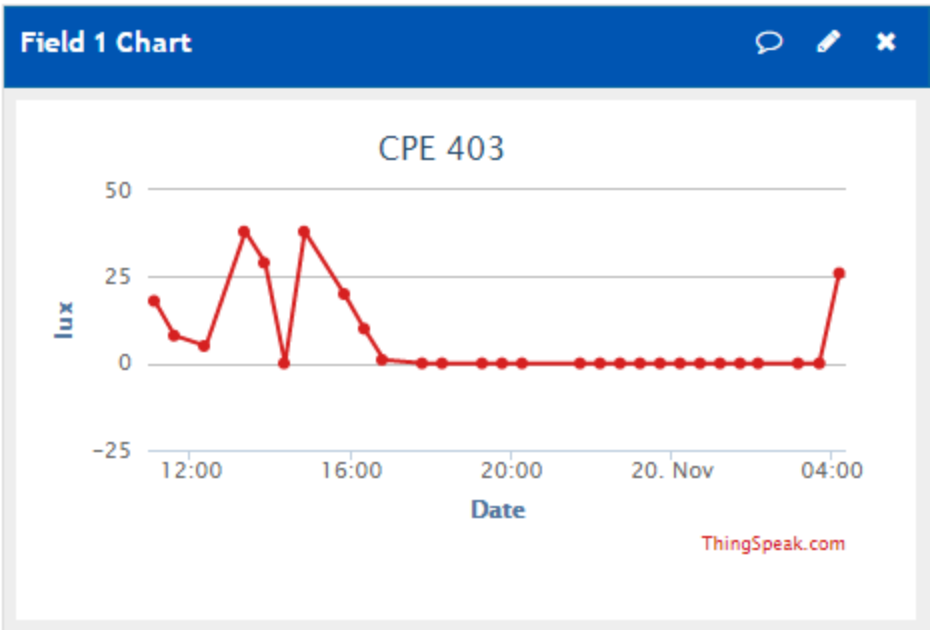


*Figure 2: Data logged in a day; * the spike at the end is due to a light being turned on**

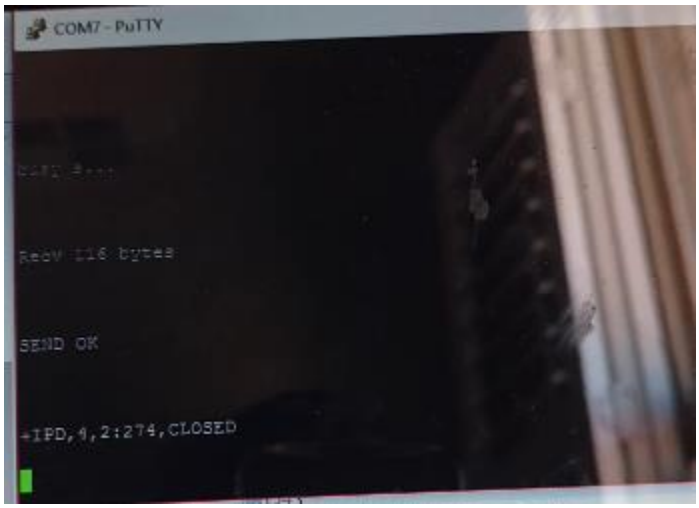


Figure 3: PuTTY used to debug the application to make sure data is sent through UART properly

Conclusion: The created application of the device will light intensity data to a cloud service, which will log the data. An application of this device can be used for home automation. When the threshold decreases to a certain value, the microcontroller can trigger a pin to turn on and off a light. This can lead to more efficient energy consumption or just overall convenience. Data is logged to a cloud service by means of the ESP8266, which is interfaced with UART communication. The TSL2591, on the other hand, is interfaced through I2C communication.

Video links: https://youtu.be/34gkcDMfI7A

Source code: https://github.com/nhand2/CPE403F16/tree/master/Midterm