Milestone 1 Application Note

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1 Design Overview

For this Milestone the goal was to build an addressable RGB LED which could be connected in series with one boards and can have patterns generated from them. With the boards connected one board will be sent bits and the first board will take those bits and execute the code on how the LED should light up and then pass on the next command to the next board and should continue for the amount of board that are connected and the length of the initial command.

1.1 Design Features

These are the design features:

- Utilizing the UART capabilities of the processor
  - Receiving bits and executing code
  - Altering the received bits and sending the new bits to a different processor
- Communication between nodes

1.2 Featured Applications

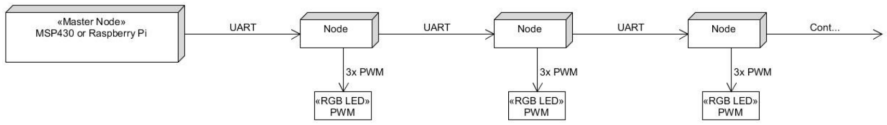
These are the featured applications

- Altering Duty Cycle of RGB LED
- Receiving bit and executing code with received bits
- Altering received bits
- Sending new bits to another board

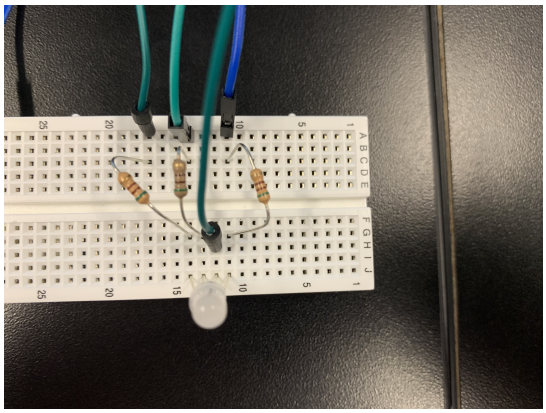
1.3 Design Resources

GitHub repository link: https: `//github.com/Intro-To-Embedded-Systems-RU09342/milestone-1-rigginsn7/tree/master/Milestone_StrangerThings`

1.4 Block Diagram



1.5 Board Image



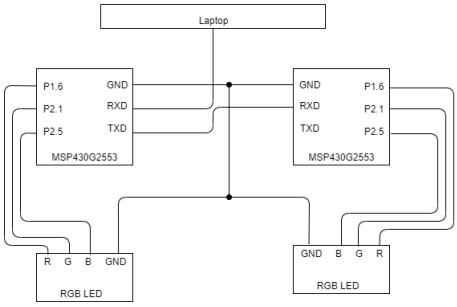
2 Key System Specifications

Parameters	Specifications	Details
RGB LED	Control the color and brightness of the RGB LED	Utilize hardware PWM to change the duty cycle of the red, green, and blue pins of the LED based on the received transmission
UART transmissions	Send and receive UART transmissions across processors	Sending and receiving a number of bytes between two or more processors that can be used to execute specific functions within the code

3 System Description

The problem given was to create code for the MSP430G2553 that would be able to send and receive bytes of information between processors that would be used to alter the color and brightness of an RGB LED. Once this was done, a circuit must be created that would connect the send and receive pins of the processors together, as well as connect the output and ground pins on the processor to their respective positions on the LEDs.

3.1 Detailed Block Diagram



3.2 Highlighted Devices

These are the highlighted devices

- MSP430G2553
- RGB LED

The MSP430G2553 is the processor used to execute the code and control the RGB LED. The code was written in C language and is executed on the MSP430G2553. The processor took the received bit that was send from a computer and used that the light up the LED to what ever the bits corresponded too. The bits represented the duty cycle of red, green and blue parts of the led.

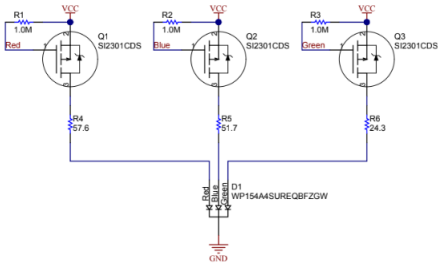
3.3 Device 1: MSP430G2553

The MSP430G2553 is the processor used for this milestone. The code that was put on the processor was written in C. The pins on the processor had to be switch to enable send and receive and use the UART capabilities. Realterm was used to send the initial bits to the first board. The way the bits must be sent is that the first bit tells the processor the length of the transmission, the second bit is the duty cycle of the red LED, the third bit is the duty cycle of the green LED, and the fourth bit is the duty cycle of the blue LED. After the processor executes those the first bit's value is lowered by 3 and every thing after the first bit is shifted left 3 times and that new transmission is

now the initial transmission length minus 3 and that new transmission is sent. The last bit is just to signal that the transmission is done and it 0X0D every time.

3.4 Device 2: RGB LED

An RGB LED is a combination of 3 LEDS. The three LEDS are red, green, and blue. This makes it possible to produce almost any color by adjusting the duty cycle of each color which would change the intensity of the color. The duty cycle just determines for the amount time the LED is on. The duty cycle of each color was changed using a PWM signal. The PWM signal was determined by the input bits received from the processor.



4 SYSTEM DESIGN THEORY

The design of this project as a whole can be split into two main components, the UART transmission and the PWM signal. In order to perform the task at hand, the micro controller must first receive several bytes of information through UART. It would then utilize this information to change three different PWM signals corresponding to the red, green, and blue colors of the RGB LED, enabling it to alter the brightness of each of the three colors. Once the PWM signals are set, the micro controller must alter and send the received bytes to the next micro controller so that the full transmission can be executed.

4.1 Design Requirement 1

The first requirement of the project was to be able to send and receive bytes of information through UART that could be used throughout the other parts of the code. The received transmission would be split into 5 parts. The first byte would indicate how many total bytes are in the transmission, the second, third, and fourth bytes would indicate the brightness of the red, green, and blue colors respectively, and the final part would indicate the end of the transmission. These parts where split within the code by using a switch case statement to separate which code to execute based on which byte number was being read. If the transmission was more than 5 bytes, the system would alter the transmission and send it to the next micro controller. In order for the next micro controller to be able to use the sent information effectively, the transmission

would have to be altered by removing the first four bytes corresponding to the length of the transmission, and the red, green, and blue colors that were used by the first micro controller, and replace them with the length of the new transmission followed by the bytes that were not removed from the original transmission. To do this, the length of the original transmission was stored upon receiving it, and the new transmission would be the original length reduced by the three bytes that were used (For example, if the original transmission was 8, the new transmission would be 5). After the new length was sent, all that had to be done was to send the any bytes after the fourth byte in the original transmission straight to the transmit pin for the next micro controller.

4.2 Design Requirement 2

The second main part of the project was the PWM signals for each color of the RGB LED. In order to do this, two different timers within the MSP430G2553 were used to set up different duty cycles for each of the colors. Each timer was set to count up to a maximum of 255, the maximum value possible from one byte, and then trigger an interrupt for the rest of the code. In addition to this, the timers were also set to a new output mode that would set a value upon reaching the first interrupt, and then reset the value upon reaching the next interrupt. Once this was done, the interrupts that would control the duty cycle of each of the colors were to be set up with the red duty cycle being on the first timer, and the green and blue duty cycles being on the second timer. The values for each of these duty cycles would come from their respective transmission bytes. The received values would be set to the new interrupt so that the timers would set and reset the output of each color's pin at the desired duty cycle. This would allow the brightness of each color to be changed to whatever value is desired in the received transmission.

5 Getting Started/How to use the device

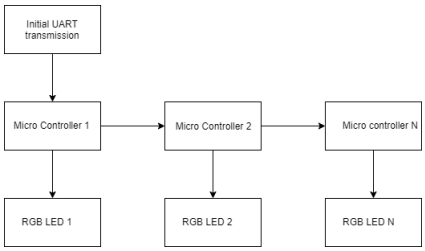
These are the steps you should take for using the device

- Connect device to PC
- Make sure MSP430G2253 send and receive pins are turned on
- Connect P1.6 on the MSP430G2553 to the red portion of the RGB LED
- Connect P2.1 on the MSP430G2553 to the green portion of the RGB LED
- Connect P2.5 on the MSP430G2553 to the blue portion of the RGB LED
- Make sure the processor and RGB LED are both grounded
- Connect the sent pin of the first processor to the receive of the next processor

6 Getting Started Software/Firmware

The code for the MSP430G2553 was written in C code on a compiler. After the code was loaded on to the processor chip then realterm is used to send the initial bits to the board and then the boards start to interact with each other.

6.1 Hierarchy Chart



6.2 Communicating with the Device

In order to communicate successfully with the device and send it a transmission the software Realterm is used. Several things must be changed in Realterm for the software to communicate with the micro controller. First in the display tab, the display as setting must be changed to Hex[space] and half duplex must be checked off. In addition to this, under the port tab the baud must be changed to 9600, the open button must be pressed down, and the port must be changed to the port that the micro controller is connected to. Once these are done, a hexadecimal signal can successfully be sent to the micro controller. The order of the bytes that are sent must be the total number of bytes first, followed by the red duty cycle, green duty cycle, blue duty cycle, then either end transmission or the color duty cycles for the other micro controllers.

6.3 Device Specific Information

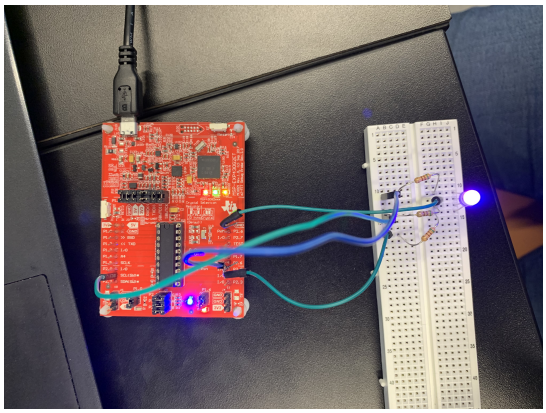
Some devices can have a faulty baud rate, and because of this they can send incorrect transmissions even if they receive the correct transmission initially. To fix this, baud rate trimming can be added to the code to correct the faulty baud rate.

7 Test Setup

To test the device, the circuit must be set up first. the red, green, and blue pins of the led must be connected to a resistor which is the connected to the correct pin for each color. The corresponding pins for red, green, and blue are P1.6, P2.1, and P2.5 respectively. After this is done the on board ground must be connected to the ground pin on the LED as well. These steps must also be repeated for both boards. Next, the TXD pin of the micro controller that is receiving the initial transmission must

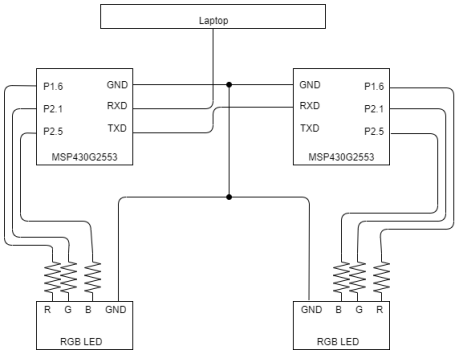
be connected to the second micro controllers RXD pin. Once all of this is done, the code can be flashed onto each board and Realterm can be set up to send the initial transmission. Specific values that are easy to see should be used at first to be able to see if each of the three LED colors are working probably.

7.1 Test Data



8 Design Files

8.1 Schematics



8.2 Bill of Materials

Item #	Description	Quantity
1	MSP430G2553	1
2	RGB LED	1
3	510 ohm, 1/4 watt, 5% tolerance resistor	3