UART configured LEDs

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October 22, 2018

1   Design Overview

By sending a PWM or pulse-width modulated signal to an LED, the brightness and the color can be configured to whatever is desired by the user. In order to adjust the setting of multiple LEDs in an array, every LED has to have a unique address. This milestone uses UART (Universal Asynchronous Receiver/Transmitter) to receive and transfer color codes for different RGB nodes. The message received sets the corresponding RGB LED, and then the node takes the remainder of the message and sends it to another RGB node until the message ends. The LED will still lit a specific color until another message is detected.

1.1   Design Features

These are the design features:

- Design is optimized to be implemented on the MSP430FR2311 microcontroller

- Baud Rate for UART controller is 9600

- The first byte receive by the UART controller is the total number of bytes to expect in the message. The three least significant bytes set the individual LEDs in the RGB node.

- PWM for LEDs is a hybrid of both hardware and software techniques

- PWM allows for 2^8 steps of LED brightness

1.2   Featured Applications

- Lighting effects for events or personal use

- Addressable LED arrays for displays or decoration

1.3   Design Resources

Link to code to program MSP430FR2311: UART-Code.
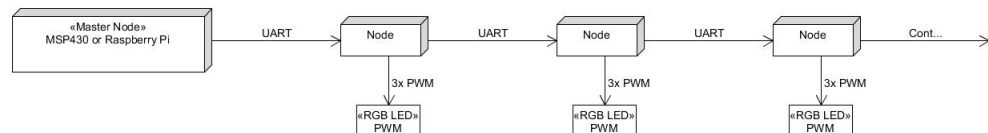
1.4   Block Diagram

Figure 1: Serial connection of RGB nodes, communicating with UART

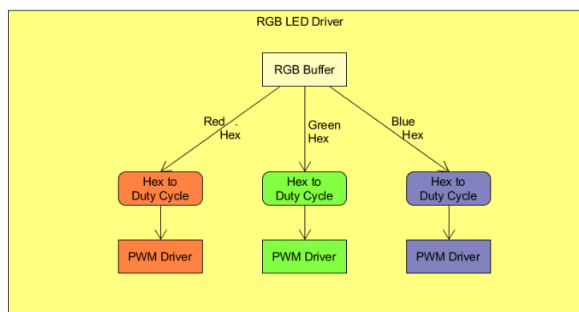
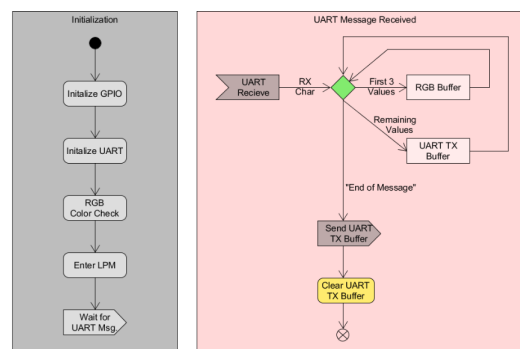Figure 2: Buffer converts bytes received into a PWM signal for the LEDs

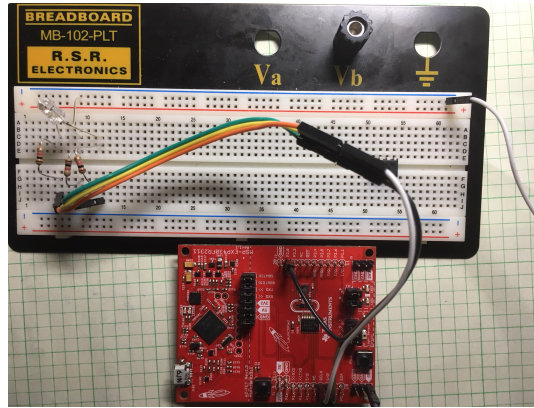Figure 3: Shows initialization process and execution process for circuit

1.5 Board Image

Figure 4: Breadboard Setup for RGB node

2 Key System Specifications

PARAMETER	SPECIFICATIONS	DETAILS
Total RGB nodes	Up to 84	Programmed to receive a total of 255 bytes which is only enough for 84 nodes
Color range	Standard RGB (0 to 255)	Only 255 steps of brightness for RGB node

3 System Description

At each individual RGB node there are three parts. First an input or message is received through UART. Part of that message is converted to a duty cycle to drive each LED. The remainder of the message is then transmitted to another RGB node to repeat the process until the message ends. The collection of all the RGB nodes comprises the entire system.

3.1 Detailed Block Diagram

Figure 5: Buffer converts bytes received into a PWM signal for the LEDs

3.2 Highlighted Devices

- MSP430FR2311
  Programmed as a UART controller and also generates PWM signals to load LEDs on the board.

3.3 MSP430FR2311

MSP430FR2311 comes equipped with a variety of tools and peripherals. In this milestone however, the focus is on using UART. UART takes in bytes one at a time. The rate at which it receives and transmits is known as its Baud rate. Upon receiving one byte, the receive buffer is filled and triggers an interrupt (if enabled). Depending on the interrupt different things can occur, but likely it will transmit a new byte based on what was received. The MSP430FR2311 also comes equipped with Timers that can used for PWM. This elaborated on in the next section.

3.4 RGB LEDs and Driver

Timers are the basis for the PWM, generating a certain frequency based on the clock in use. To generate the PWM signals for the three LEDs both hardware and software are used. The MSP430FR2311 comes equipped with the hardware necessary to generate a PWM. To configure it, only the output mode and the trigger or register value at which the output shift occurs has to be set. Software on the other mimics this effect by changing the output values through interrupts instead of circuitry.

4   SYSTEM DESIGN THEORY

The system for the addressable RGB LEDs depends solely upon the microcontroller. The MSP430FR2311 provides the UART module, and the PWM to drive the LEDs. In order to set up the UART controller, a baud rate must be selected. Depending on the baud rate and the clock frequency used, the USCI (Universal Serial Connection Interface) has to be configured to receive the incoming bytes at the right pace through modulation. Bits are sent to the UART module and enter a receive buffer. When the buffer is filled or when a full byte is received, an interrupt is triggered. The first time the interrupt triggers, is sets a variable which holds the total number of bytes in the incoming message. This is used to reset the UART routine when the message ends. The next three bytes received are used to set the PWM for each LEDs. The PWM for the LEDs is controlled using a timer module. The Timer counts up to the number 255. As a result, the byte received can be directly used to set the PWM signal because it takes on 255 possible value. The byte receive is assigned to a CCR register that sets the PWM for the specific LED. Since the RGB used in experiment is common anode, the pulse is first set and then reset. After the PWM for each LED in the RGB is set, remainder of the message is sent to the transmit buffer in UART module one byte at a time. When this buffer is full it will send the byte contained to the next RGB node in cascade. The only difference is that total byte size sent to the next node is reduced by 3.

4.1   Design Requirement 1

For these design requirements, really dig into the technical grit. This is where you have to explain what you did as the engineer to meet the system requirements.

4.2   Design Requirement 2

5   Getting Started/How to use the device

This section is all about actually using and interfacing with your device. Write this as if you were to hand your system to someone and they needed to get the thing working.
NOTE: You will be choosing what subsections to include in here. I highly recommend looking at other examples from TI and other companies to see how they break up there documents.

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.

6.1 Hierarchy Chart

6.2 Communicating with the Device

6.3 Device Specific Information

7 Test Setup

How to setup the device for testing.

7.1 Test Data

8 Design Files

8.1 Schematics

8.1.1 MSP430FR2311

8.1.2 RGB LEDs

8.2 Bill of Materials

1.) MSP430FR2311

2.) Common anode RGB LED

3.) 1000 ohm resistors

4.) Breadboard

5.) Jumpers