UART configured LEDs

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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
- Addressable LED arrays for displays or decoration

- Personal electronics

1.3 Design Resources

Link to code to program MSP430FR2311: UART-Code.

1.4 Block Diagram

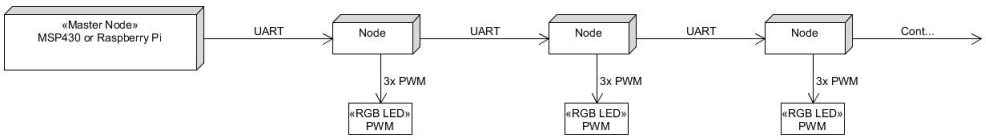

Figure 1: Serial connection of RGB nodes, communicating with UART

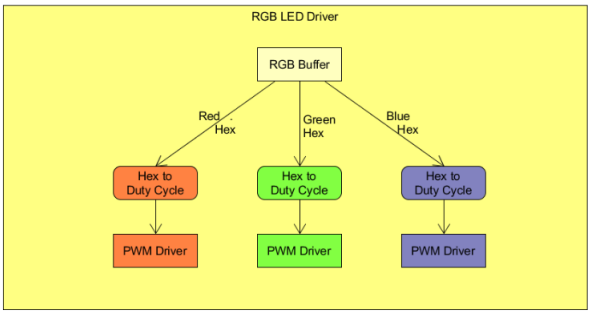

Figure 2: Buffer converts bytes received into a PWM signal for the LEDs

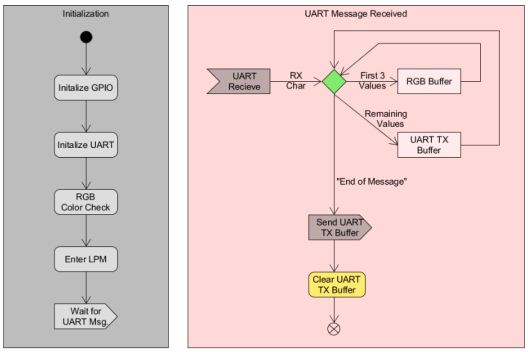

Figure 3: Shows initialization process and execution process for circuit

1.5 Board Image

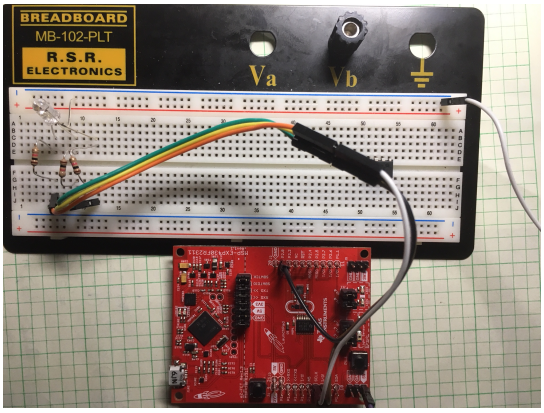

Figure 4: Breadboard Setup for RGB node

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

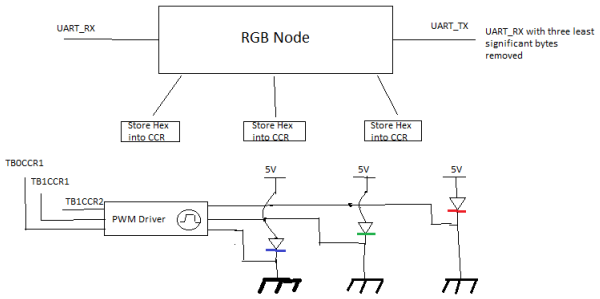

Figure 5: Buffer converts bytes received into a PWM signal for the LEDs

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 of the LEDs. The PWM for the LEDs is controlled using a timer module. The Timer peripheral counts up to the number 255. As a result, the bytes received can be directly used to set the PWM signal because they can only take on 255 possible value. The byte received 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, the 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 PWM

Three different PWM signals are required to drive the RGB LEDs. The MSP430FR2311 only has two PWM modules implemented in hardware. In order to generate the third PWM signal, interrupts have to be used to create the signal at the pin. One interrupt is to set the duty cycle and the other is to reinitialize the signal.

5 Getting Started/How to use the device

5.0.1 Pin Assignments

In order to use this device, first make sure all of the pins are connected correctly. The LED will have to be connected to the MSP430FR2311 by using a breadboard or PCB. The RGB should be common anode. The anode of the RGB being used should be connected to the 5 volt supply coming from the microcontroller. Then connect the cathodes of the Red to P2.3(Port 2, Pin 3), the Green LED to P2.1, and the Blue LED

to P2.2 on the MSP430FR2311. The UART receiver will be connected to P1.6 and the UART transmitter will be connected to P1.7.

5.0.2 Testing

Connect the MSP430 to power through a computer. Once the computer is on, run a Serial terminal to transmit and receive messages through UART. The terminal should be configured for a 9600 baud rate, and sets of bytes should be sent to the device. A good Serial terminal is Real-Term. Make sure that for each message sent, that the total byte size is accurate. The results should be clearly seen on the RGB and through serial terminal.

5.0.3 Test Data

6 Getting Started Software/Firmware

6.1 Software

Milestone1FR2311.c: See code in Design Resources

6.2 Development Tools

Code Composer Studio Use to download or adjust the MilestoneFR2311.c file for the MSP430FR2311.

Real-Term Use terminal to send bytes over UART

7 Design Files

7.1 Schematics

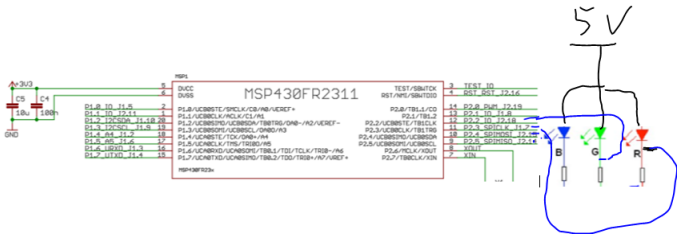

Figure 6: Schematic for addressable LEDs

7.2 Bill of Materials

1.) MSP430FR2311
2.) Common anode RGB LED
3.) Three 1000 ohm resistors
4.) Breadboard
5.) Jumper cables