Use of Microcontroller Technology to Drive LEDs

Introduction

This document is a review of using microcontroller (MCU) based technology to drive LEDs. The document covers existing MCUs in industry for LED control and outlines the methods used to drive and control multiple LEDs using a microcontroller.

Microcontrollers in Industry

Microcontrollers, also known as embedded controllers are solitary VLSI chips [1]. Microcontrollers have many applications in industry including mobile devices, automobiles, security systems and general consumer electronics [2]. The use of MCUs specifically for controlling LEDs has been favorable because a microcontroller can provide efficient energy source, optimal performance and maintain long lives of LEDs, while adding features that can make a lighting solution more attractive [3]. Some simple 8-bit MCUs currently in market for LED control can be summarized below.

Name	Features	Cost
PIC10F200 (6-pin, 8-bit)	4 I/O pins, high current sink/source for LED drive, 8-bit timer [4]	$0.36 per 3000 units [4]
PIC16F1503 (14 pin, 8-bit)	12 I/O pins, 4 PWM peripherals, SPI, two 8-bit timers, one16-bit timer [5]	$0.67 per 5000 units [5]

Types of Microcontrollers

Microcontrollers can range from being very complex to being very simple systems and usually include memory, peripherals and most importantly a processor [6]. Microcontrollers can be divided into different categories based on their word length:

- 8 bit microcontrollers execute simple logic and arithmetic operations and are apt for simple processes such as controlling an LED [7].
- 16 bit microcontrollers execute with greater accuracy and performance than 8 bit systems.
- 32 bit microcontrollers are chiefly used in automatically controlled appliances such as office machines and medical appliances [1].

Use of Microcontrollers to Control LEDs

LEDs may be driven using the GPIO pins of a microcontroller. However, depending on the current capabilities of the GPIO, the MCU can either act as a source or sink. If used as a source, the anode of the LED is connected to the GPIO pin of the MCU. If used as a sink, the cathode is connected to the GPIO pin of the MCU, with an external current source driving the LED. Turning the LED on/off would depend on outputting a high or low through the GPIO pin. In both cases, the current through the LED is limited by the sinking/sourcing capabilities of the microcontroller. This can be overcome using an MCU controlled transistor to drive the LED [8].

LED Brightness Control

The brightness of an LED can be controlled using a Pulse Width Modulation (PWM) signal. Hence, an MCU with the ability to produce PWM signals is vital for better lighting solutions. A PWM is defined by a period and a duty cycle and the duty cycle can be interpreted as the percentage of the period that the LED is on. If the period is set to a large value (several seconds) the LED will blink. If the period is set to a low value (in the range of micro or milliseconds) then a lower duty cycle will make the LED appear dimmer and a higher duty cycle will make it appear brighter [8].

Controlling Multiple LEDs from limited I/O pins

One of the challenges involved in controlling multiple LEDs from a small microcontroller is having insufficient GPIO pins. The following methods include ways of circumventing this problem.

Row-Column Scanning

Row column scanning allows a microcontroller to control more than one LED per output pin. This involves connecting a row of LEDs to one pin and a column to another pin. To turn on an LED, the microcontroller can be configured to drive its corresponding row low and column high. Turning the LED off would involve driving the column low or the row high [9].

Shift Registers

Microcontrollers can also be programmed to use synchronous serial communication to shift data onto a shift register to control LEDs. This would involve using three pins for data, clock and latch between the MCU and the shift register [4]. Many LED drivers make use of shift registers. An example is the TLC6C5912-Q1 power logic 12 channel shift register LED driver. The TLC6C5912 contains a serial-in, parallel out shift register that feeds a 12-bit D-type storage register [10].

References

[1] "Advantages and Applications of Microcontroller in Our Daily Life", *Wikiforu.com*, 2012. [Online]. Available: http://www.wikiforu.com/2012/10/applications-of-microcontroller.html. [Accessed: 05- Mar- 2017]

[2] "Microcontroller Basics, Types and Applications", *Electronics Hub*, 2015. [Online]. Available: http://www.electronicshub.org/microcontrollers/. [Accessed: 05- Mar- 2017]

[3] M. Pallones, "More Than Efficient Lighting: An Effective LED Driver Using an 8-Bit MCU", *designnews.com*, 2017. [Online]. Available: https://www.designnews.com/electronics-test/more-efficient-lighting-effective-led-driver-using-8-bit-mcu/126476129147250/page/0/2. [Accessed: 05- Mar- 2017]

[4] *PIC10F200/202/204/206 6-Pin, 8-Bit Flash Microcontrollers*, 4th ed. Microchip Technology Inc., 2014, p. 1 [Online]. Available: http://ww1.microchip.com/downloads/en/DeviceDoc/40001239F.pdf. [Accessed: 05- Mar- 2017]

[5] *PIC16(L)F1503 14-Pin Flash, 8-Bit Microcontrollers*, 4th ed. Microchip Technology Inc., 2015, pp. 1-2 [Online]. Available: http://ww1.microchip.com/downloads/en/DeviceDoc/40001607D.pdf. [Accessed: 05- Mar- 2017]

[6] "Basics of Microcontrollers", *circuitstoday.com*, 2011. [Online]. Available: http://www.circuitstoday.com/basics-of-microcontrollers. [Accessed: 05- Mar- 2017]

[7] G. Pitcher, "Rumours of the death of the 8bit microcontroller have been greatly exaggerated", *Newelectronics.co.uk*, 2016. [Online]. Available: http://www.newelectronics.co.uk/electronics-technology/rumours-of-the-death-of-the-8bit-microcontroller-have-been-greatly-exaggerated/114051/. [Accessed: 05- Mar- 2017]

[8] "Using LEDs in Embedded Designs", *Stratifylabs.co*, 2013. [Online]. Available: https://stratifylabs.co/embedded%20design%20tips/2013/10/24/Tips-Using-LEDs-in-Embedded-Designs/. [Accessed: 05- Mar- 2017]

[9] T. Igoe, "Controlling Lots of Outputs from a Microcontroller", *Tigoe.com*, 2009. [Online]. Available: https://www.tigoe.com/pcomp/code/arduinowiring/486/. [Accessed: 06- Mar- 2017]

[10] *TLC6C5912-Q1 Power Logic 12 Channel Shift Register LED Driver*, 4th ed. Texas Instruments, 2012, pp. 1-2 [Online]. Available: http://www.ti.com/lit/ds/symlink/tlc6c5912-q1.pdf. [Accessed: 06- Mar- 2017]