DKAN0005A

PWM Example Using Microchip's Capture/Compare/PWM Module

09 March 2010

Features

- Pulse Width Modulation (PWM) signal generation
- Capture/Compare/PWM (CCP) module configuration
- Example PWM power control circuit (LED light engine dimming) using the PIC12F683

Introduction

Microchip Technology's CCP module is included in a variety of PIC microcontrollers, such as the PIC12F683. This document familiarizes users with PWM generation using Microchip's CCP module. It also describes a dimming application using the OPA731W light engine from TT Electronics/Optek Technology. It includes a description of the circuit, register calculations, and source code. Microchip's MPLAB IDE, ICD2, and AC162058 header are used in this example circuit.

Application

The circuit shown in Figure 1 controls the intensity of an LED array by adjusting the duty-cycle of a 100Hz PWM waveform. The waveform produced by the PIC12F683 microcontroller is used to drive an N-channel logic level MOSFET in order to supply ground to the LED array. Current limiting to the array is accomplished on the high side utilizing a linear voltage regulator configured as a constant current source. The microcontroller monitors a pushbutton switch. The duty-cycle increases and decreases between limits while the button is pressed. As the duty-cycle changes, it is continuously stored in EEPROM, which allows the circuit to retain the light intensity while powered down.

Hardware Overview

The PIC12F683-I/P has a CCP module and software configurable internal oscillator, which make it suitable for this application. The CCP module is used to generate the free-running PWM waveform. Also, its internal 8MHz oscillator, which can be divided down via software to one of eight distinct clock frequencies, allows for flexibility in the waveform period.

The light array requires a minimum of 18V at about 1.4A to obtain full intensity. The PWM output controls an N-channel logic-level MOSFET (IRLZ24N) to provide ground to the light array. The high side of the light array is supplied using an adjustable voltage regulator (LM1084IT-ADJ), configured as a constant current source. The voltage regulator is set near the 1.4A maximum current requirement to produce approximately 960lm of light from the array. To prevent excessive power dissipation and overheating in the current limiting regulator, the supply voltage is relatively close to the forward voltage of the array.

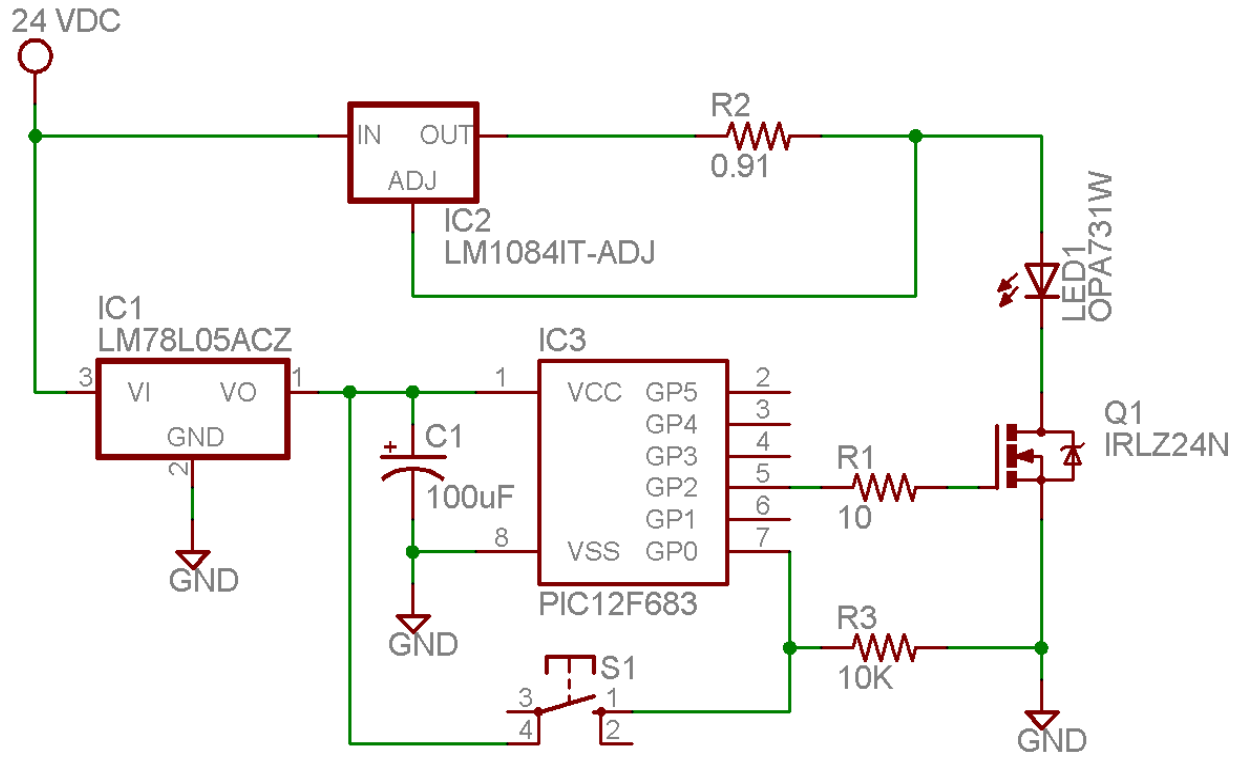

Figure 1. Example Circuit

Software Overview

Calculations

Depending upon the particular application, a suitable PWM frequency needs to be selected. In the case of driving an LED array with a pulse, it is necessary to take into account the persistence of vision of the human eye and generate a frequency above the 60Hz "bright light" flicker fusion threshold. For the purpose of this discussion, a 100Hz frequency is used. The PR2 register value determines the PWM period, while the value of register CCPR1L and bits 4 and 5 of the CCP1CON register determine the duty-cycle.

As shown in Equation 1, the PWM frequency is determined by the PR2 and TMR2 registers in conjunction with the internal oscillator frequency.

$$(1) \qquad f_{PWM} = \frac{f_{osc}}{(PR2+1)\times 4\times TMR2}$$

Where f_{PWM} is 100Hz, *TMR2* is a prescale value of 1, 4, or 16, and f_{osc} is one of the eight distinct clock frequencies. Table 1 shows the values of PR2 that yield a f_{PWM} of 100Hz given different combinations of TMR2 and f_{osc}. Since PR2 is an 8-bit register, it is limited to a maximum of 255.

Table 1. Possible Values for PR2

		TMR2		
		1	4	16
f_{osc} (MHz)	8.000	Invalid	Invalid	Invalid
	4.000	Invalid	Invalid	Invalid
	2.000	Invalid	Invalid	Invalid
	1.000	Invalid	Invalid	155.25
	0.500	Invalid	Invalid	77.13
	0.250	Invalid	155.25	38.06
	0.125	Invalid	77.13	18.53
	0.031	76.50	18.38	3.84

In choosing a PR2 value of 156 (0x9C), f_{osc} is set to 1MHz and TMR2 is 16. This is accomplished by setting the Internal Oscillator Frequency Select bits (IRFC<6:4>) of the OSCCON register to 0b100.

While the pulse width resolution is 10-bits, it is necessary to determine what resolution is available for a given PWM period using Equation 2.

$$(2) \qquad Pulse\ \ Width = \frac{(CCPR1L : CCP1CON < 5 : 4 >) \times TMR2}{f_{osc}}$$

When the pulse width is maximum ($1 / f_{PWM} = 0.01$s), CCPR1L:CCP1CON<5:4> = 625. Therefore, each step represents a time of 0.01s/625 = 16µs or a 0.16% modulation of the period. This is unnecessary for this LED dimming application. Dropping the two least significant bits and using only the 8-bit CCPR1L register achieves a more suitable 0.64% resolution and lower code overhead.

Program Flow

Once the program has properly initialized the microcontroller, it loads a duty-cycle value from EEPROM memory and enables the PWM output. The program then monitors the push-button switch for closure. Upon detecting a switch closure, the software determines whether to increment or decrement the existing duty-cycle, writes the value to EEPROM, loads the duty-cycle value, and enables the PWM output. The flowchart in Figure 2 illustrates the program execution.

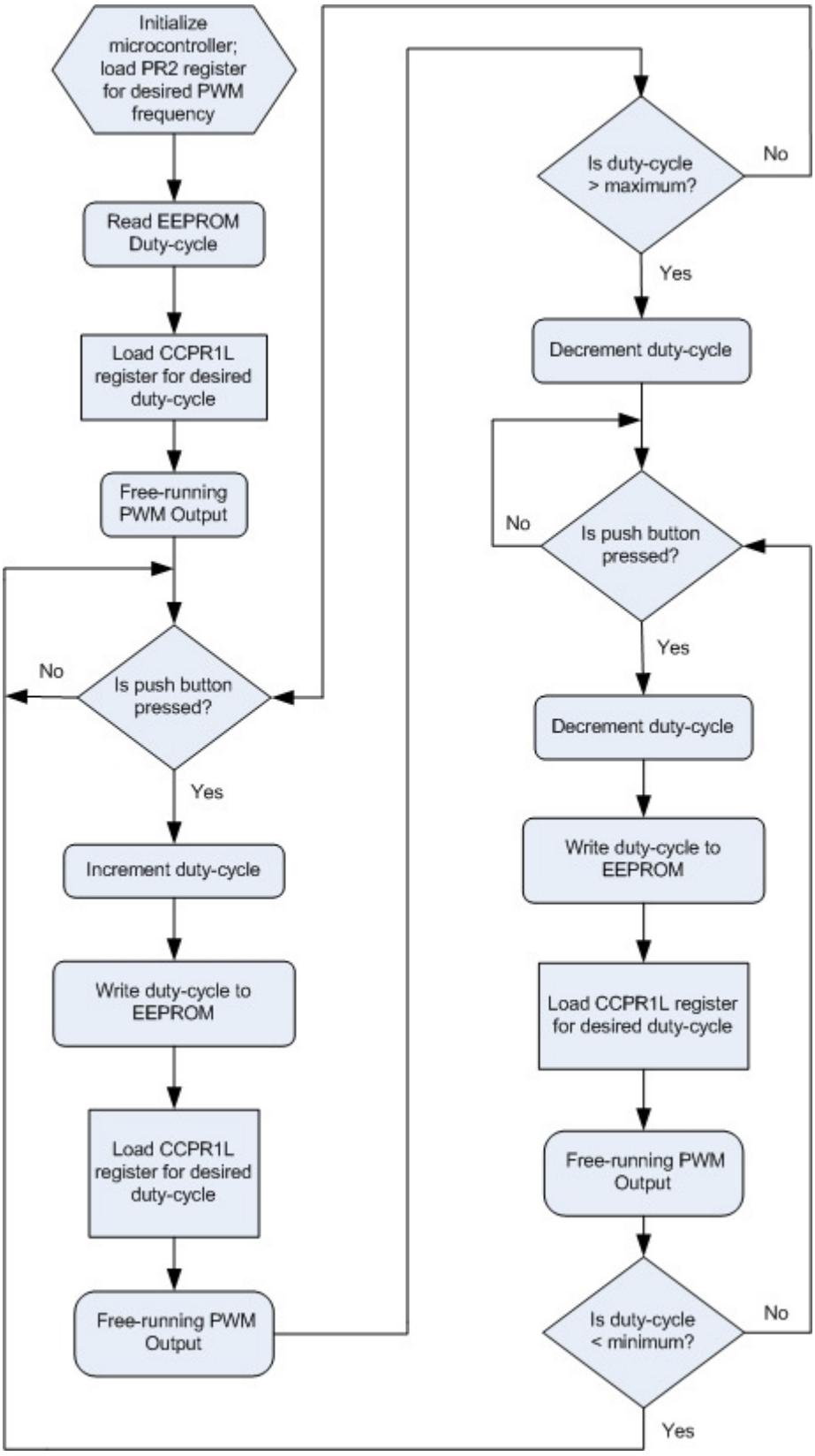

Figure 2. Software Flowchart

Conclusion

While this application controls the intensity of an LED array, the general circuit lends itself to many low voltage applications requiring PWM power control. The circuit can be adapted to other applications by setting the required current with the LM1084IT-ADJ and changing the software to produce a desired PWM frequency and duty-cycle.

Appendix: Parts List

Part	Digi-Key P/N	Description	Manufacturer P/N
IC1	LM78L05ACZFS-ND	5V voltage regulator	LM78L05ACZ
IC2	LM1084IT-ADJ-ND	5A adj voltage regulator	LM1084IT-ADJ/NOPB
IC3	PIC12F683-I/P-ND	microcontroller	PIC12F683-I/P
R1	10QBK-ND	10Ω resistor, ¼W	CFR-25JB-10R
R2	P0.91W-3BK-ND	0.91Ω resistor, 3W	ERX-3SJR91
R3	10KQBK-ND	10KΩ resistor, ¼W	CFR-25JB-10K
Q1	IRLZ24NPBF-ND	N-channel logic level MOSFET	IRLZ24NPBF
S1	SW401-ND	mom pushbutton tact switch	B3F-1002
C1	P5165-ND	cap 100uF 35V alum lytic radial	ECA-1VM101
LED1	365-1369-ND	LED Array	OPA731W

Disclaimer

This document is for informational use only and is subject to change without prior notice. Digi-Key makes no commitment to update or keep current the information contained herein. Digi-Key does not guarantee or warrant that any information provided is accurate, complete, or correct and disclaims any and all liability associated with the use of the information contained herein. The use of this information and Digi-Key's liability is subject to Digi-Key's standard Terms & Conditions which can be found at www.digi-key.com by clicking on the Terms & Conditions link at the bottom of the web page.

No license, whether express, implied, arising by estoppel or otherwise is granted under any intellectual property or other rights of Digi-Key or others.

Trademarks

DIGI-KEY® is a registered trademark of Digi-Key Corporation. All other trademarks, service marks and product names contained herein are the sole property of their respective owner and their use is for informational purposes only and does not imply any endorsement, recommendation, sponsorship or approval by the trademark owner of the contents.

Copyright