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M16C Family

High Carrier Frequency PWM

Introduction

The M16C family of devices provides PWM outputs using Timer A. These timers allow both 8 bit and 16 bit PWM resolution. However, this limits the maximum carrier frequency. This application note describes a method to create a higher frequency carrier PWM than can be achieved using Timer A standard PWM mode

Target Device

Applicable MCU: M16C and M32C Devices with Timer A

Contents

Program Description

This program uses Timer A0 in one-shot mode and Timer B2 in Timer mode. The frequency of the PWM carrier is determined by the count value loaded into Timer B0. Timer A0 is triggered by the underflow from Timer B0 and the time-out period of the one-shot timer sets the duty cycle. The analog pot is used to vary the duty cycle of the PWM waveform

PWM Timer Operation

The M16C Timer A peripheral has a PWM operating mode. In this mode the resolution of the PWM output can be selected to be either 16 bits or 8 bits. These are very common and valuable settings in most applications but this does limit the maximum carrier frequency. In any standard PWM output the maximum carrier frequency, resolution and timer clock setting are related by the formula:

Timer Clock Frequency = PWM carrier * PWM states (resolution)

Since a 16 bit PWM resolution means there are 65,536 states (2^{16}) the maximum carrier frequency is then limited to the timer clock setting divided by 65,536 (in M16C devices the actual division is 65,535 since 0xFFFF is not a valid state in the timer). For an M16C device with a 20 MHz peripheral clock this limits the PWM carrier to approximately 305 Hz. In 8 bit mode the resolution is only 256 steps but the carrier can now be as high as 78.431 kHz. This relationship between the timer clock frequency and maximum carrier is one reason that a high timer clock like the 40 MHz available on the R8C family devices is very desirable

High Carrier Frequency PWM

In some applications it may be desirable to have a higher PWM carrier frequency even though the resolution may be limited. The higher carrier frequency can allow using smaller inductors in switching circuits and is also easier to filter from the output. The limited resolution can also be improved by “dithering” the PWM output. This method effectively creates intermediate duty cycle values by alternating between two duty cycle values

In the sample program Timer A0 is configured in one-shot mode. This timer will create a pulse output that has a high timer determined by the value loaded into the timer register. The counter provides one pulse for every trigger signal. The value written to the timer reload register is automatically reloaded after the timer has counted down to 0 after a trigger event.

The period of the PWM carrier is determined by the count value loaded into Timer B2 . Timer A1 or Timer A4 could also have been used to set the carrier frequency since these timers can also be configured as trigger sources for Timer A0. Timer B2 does not provide any output pulse. The carrier frequency will be equal to the timer count source divided by n+1, where n is the number written to the timer register.

Result

The sample program sets the PWM frequency to 100 kHz by using the f1 clock source (20 MHz) and loading the B2 timer with the value 199. This results in a maximum resolution of 200 counts (20 MHz / 100k) or a little less than 8 bit resolution which would have 256 counts. Timer A0 also uses the f1 clock source and loads a value into the timer register based upon the setting of the analog potentiometer. A minimum potentiometer input results in 0% duty cycle. Notice that similar to a standard PWM timer mode, an update to the Timer A0 value is only required to change the duty cycle there is no overhead on the CPU core for a constant PWM duty cycle value. If a value is written to the reload register of Timer A0 during a count cycle the timer does not change the value in the count register until the next trigger cycle so there is no requirement to synchronize the update to the period of the waveform.

The sample program was run on an RSKM16C29; however, it should apply to any M16C or M32C device which has timer A available. .

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