PWM正弦波

NuMicro® 32 位系列微控制器范例代码介绍

文件信息

代码简述	使用 M031 的 PWM0 通道和 RC 滤波器，产生 60 Hz 的正弦波。
BSP 版本	M031_Series_BSP_CMSIS_V3.02.000
开发平台	NuMaker-M032SE V1.3

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1 功能介绍

1.1 简介

范例程序使用M031的PWM0通道0，产生60 Hz的正弦波。为了产生高解析的正弦波，将单一正弦波分成360点。并基于正弦数值以及PWM周期值，各点有不同的PWM占空比数值。然后PWM会依照正弦波的频率，根据各点的数值改变占空比的数值。藉由使用外部RC滤波器，PWM输出将形成平滑的正弦波。

1.2 原理

为了获得360点的PWM占空比数值，范例程序使用各点的正弦数值和PWM周期值相乘。这些数值会形成查找表数组，供PWM要改变占空比时使用。由于正弦数值的范围在-1到1之间，因此需要加上偏移植1，将正弦值移到0和2之间。接着除以2，让正弦值最后压缩在0到1之间。
范例程序同时使用Timer0，并且使能Timer0中断，用来改变PWM的占空比数值。Timer0使用周期模式，使Timer0能够自动重载Timer数值，达到周期中断。
Timer0的超时周期计算公式，如下所示：

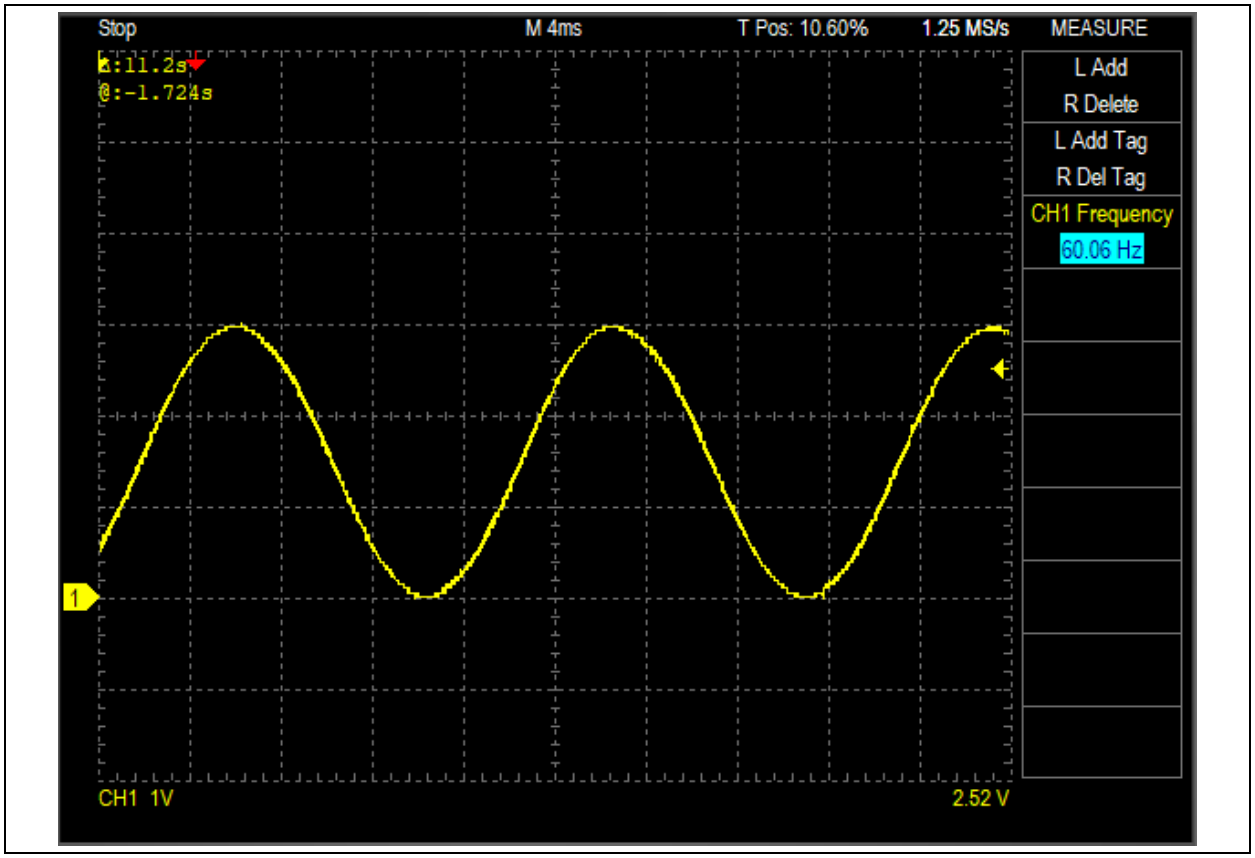
$$\text{超時週期} = \frac{1}{\text{TMR0_FREQ}} = \frac{1}{\text{正弦波频率} * \text{正弦波分辨率}}$$

由于正弦波频率为60 Hz，且正弦波分辨率为360时，TMR0_FREQ经由公式可以得到21600。另外若藉由于使用高频率PWM以及外部RC滤波器，可使输出的正弦波会更平滑。
PWM频率的计算公式，如下所示：

$$\text{PWM频率} = \frac{\text{Fsys}}{\text{PWM_PERIOD}}$$

根据计算公式，当Fsys为48 MHz，并且PWM频率为20 kHz时，PWM_PERIOD的值将会是2400。用户需要对PWM通道输出，使用100 Ω电阻以及4.7 μF电容，作为外部RC滤波器。

1.3 执行结果


Stop
M 4ms
T Pos: 10.60%
1.25 MS/s
MEASURE
L Add
R Delete
L Add Tag
R Del Tag
CH1 Frequency
60.06 Hz
CH1 1V
2.52 V

2 代码介绍

基于正弦数值以及PWM周期值，计算PWM占空比数值的查找表。

```
    /* Create sine table for lookup */
    for (i = 0; i < 360; i++)
        /* Add 1.0 to offset sine result from [-1, 1] to [0, 2],
        and divide with 2.0 to compress to [0, 1] */
        g_au16Sine[i] = ((sin((i * Pi_Value) / 180.0) + 1.0) / 2.0) * PWM_PERIOD;
```

设定Timer0以及始能中断，以改变PWM占空比数值。

```
    /* Set timer frequency to 21600Hz */
    TIMER_Open(TIMER0, TIMER_PERIODIC_MODE, TMR0_FREQ);
    /* Enable timer interrupt */
    TIMER_EnableInt(TIMER0);
    NVIC_EnableIRQ(TMR0_IRQn);
```

设定PA.5为PWM0信道0，并且设定PWM频率为20 kHz。

```
    /* Set PA5 multi-function pin for PWM0 Channel 5 */
    SYS->GPA_MFPL = (SYS->GPA_MFPL & ~(SYS_GPA_MFPL_PA5MFP_Msk)) |
                    (SYS_GPA_MFPL_PA5MFP_PWM0_CH0);
    …
    …
    …
    /* PWM0 channel 0 frequency and duty configuration are as follows */
       PWM_ConfigOutputChannel(PWM0, 0, PWM_FREQ, 50);
    /* Enable output of PWM0 channel 0 */
       PWM_EnableOutput(PWM0, 0x01);
```

开始Timer0和PWM。

```
    /* Start Timer0 counter */
    TIMER_Start(TIMER0);
    /* Start PWM counter */
    PWM_Start(PWM0, 0x01);
```

在Timer0中断处理中，改变PWM的占空比数值，以及将指标移往下一个数值。如果指标等于360，则重新归零。然后再次开始PWM。

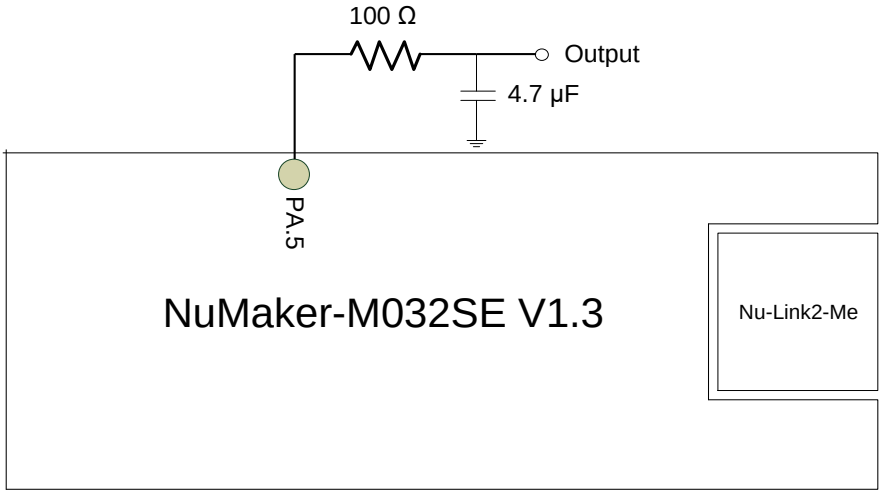
```
void TMR0_IRQHandler(void)
{
    if(TIMER_GetIntFlag(TIMER0) == 1)
    {
        /* Clear Timer0 time-out interrupt flag */
        TIMER_ClearIntFlag(TIMER0);
         /* Set PWM new setting according to sine phase from lookup table */
```

```
            PWM_SET_CMR(PWM0, 0, g_au16Sine[g_u16Sine_Count]);

            /* Add sine array pointer */
            g_u16Sine_Count++;

            /* Reset sine array pointer */
            if (g_u16Sine_Count == 360)
            {
                g_u16Sine_Count = 0;
            }
        }
}
```

3 软件与硬件环境

- 软件环境
  - BSP 版本
    - M031_Series_BSP_CMSIS_V3.02.000
  - IDE 版本
    - Keil uVersion 5.28
- 硬件环境
  - 电路组件
    - NuMaker-M032SE V1.3
  - 示意图

M031使用PWM0通道0来产生60 Hz的正弦波，还有PWM通道的输出需要使用100 Ω电阻以及4.7 μF电容，作为外部RC滤波器。



4 目录信息

- EC_M031_PWM_Sine_Wave_V1.00
  - Library — Sample code header and source files
    - CMSIS — Cortex® Microcontroller Software Interface Standard (CMSIS) by Arm® Corp.
    - Device — CMSIS compliant device header file
    - StdDriver — All peripheral driver header and source files
  - SampleCode
    - ExampleCode — Source file of example code

5 如何执行范例程序

1. 根据目录信息章节进入 ExampleCode 路径中的 KEIL 文件夹，双击 EC_M031_PWM_Sine_Wave.uvprojx。
2. 进入编译模式接口
   a. 编译
   b. 下载代码至内存
   c. 进入 / 离开除错模式
3. 进入除错模式接口
   a. 执行代码

6 修订纪录

Date	Revision	Description
Nov. 22, 2019	1.00	1. 初始发布.

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