控制PWM风扇

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Mini51的PWM通道0 (P2.2) 控制4线式PWM风扇的转速，并且使用Timer 0的外部捕获脚位 (P3.2) 侦测风扇的每分钟转速。
BSP 版本	Mini51DE_Series_BSP_CMSIS_v3.02.000
开发平台	NuTiny-SDK-Mini54 V3.1 4线式PWM风扇

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1 功能介绍

1.1 简介

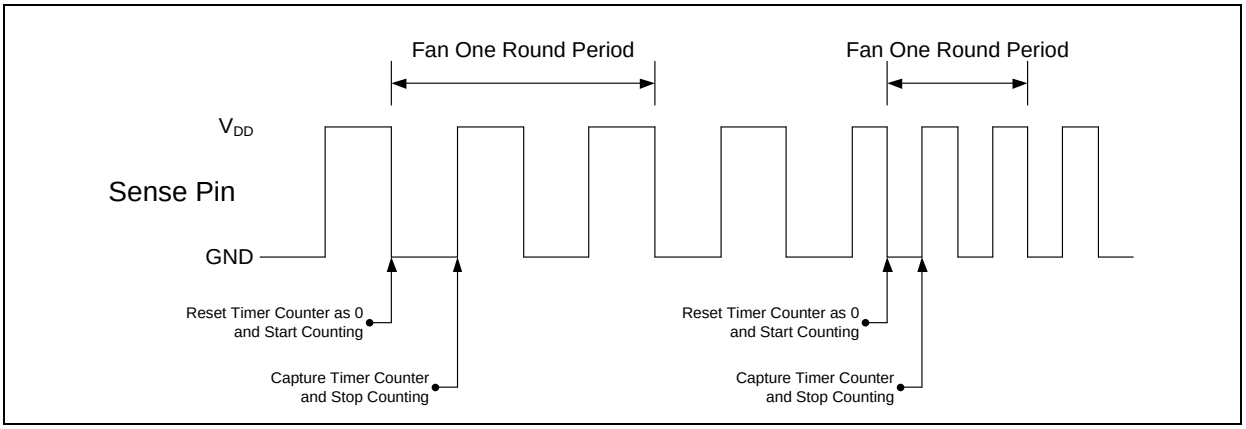
使用Mini51的PWM通道0 (P2.2) 控制4线式PWM风扇的转速，并且使用Timer 0的外部捕获脚位 (P3.2) 侦测风扇的每分钟转速。输入PWM波形到PWM风扇的control脚位，可以控制风扇的转速。藉由改变PWM的占空比，PWM风扇可以运作在适合的转速。PWM风扇的sense脚位会输出转速器讯号。此讯号在风扇的马达转动到下一个磁极时，会变更输出电平。藉由计算风扇转一圈需要的时间，使用者可以得到风扇的每分钟转速。

在使用这个范例程序前，用户需要将PWM通道0 (P2.2) 接到PWM风扇的control脚位，并且将Timer 0的外部捕获脚位 (P3.2) 接到风扇的sense脚位。

1.2 原理

为了在不同的情境下运作在适合的转速，4线式PWM风扇具有control脚位，可以接收PWM波形，并用来控制MOSFET开关。当增加PWM的占空比时，MOSFET开关开启越长，而风扇转速越快。基于Intel释出的规格，PWM输出频率应为25 kHz。

使用者也可以得到目前的风扇转速。4磁极马达的风扇在sense脚位所输出的转速器波形，如下所示：



当风扇马达转动到下一个磁极时，转速器波形会变更电平。使用者可以将Timer 0的外部捕获脚位 (T0EX) 接到风扇的sense脚位，并且使能触发计数捕获模式以及电平转换触发。当T0EX侦测到由高电平转换到低电平时，Timer 0会将计数器归零，并且开始计数。当T0EX侦测到由低电平转换到高电平时，Timer 0会停止计数，并且将计数器的值捕获到Timer Capture Data Register (TCAP)。由于PWM风扇的sense脚位是open-drain类型，使用者需要在此脚位使用上

拉电阻。

使用如下所示的计算公式，使用者可以计算出风扇的每分钟转速。

$$风扇的每分钟转速 = \frac{Timer\ 0\ 时钟源频率 * 60}{(马达磁极数) * (Timer\ 0\ 捕获数值)}$$

1.3 执行结果

范例程序首先使用100%占空比的PWM波形，侦测风扇的最快转速。然后使用0%占空比的PWM波形，侦测风扇的最慢转速。每次改变PWM占空比时，需要等待3秒钟的时间，确保风扇已经稳定。在完成上述动作后，使用者可以输入更多的动作，控制PWM占空比增加10%或1%，或是减少10%或1%。

结果如下图所示：

```
CPU @ 22118400 Hz
+------------------------------------------------------------------+
|    4-wire PWM Fan Control Sample Code                            |
|    Use PWM Channel 0 to control fan speed                        |
|    and use Timer 0 Capture mode to detect fan speed in RPM.      |
|    Please connect PWM Channel 0 (P2.2) to fan control pin        |
|    and connect Timer 0 external capture pin (P3.2) to fan        |
|    sense pin.                                                    |
+------------------------------------------------------------------+
The maximum fan speed is 1440 RPM.
The mimimum fan speed is 660 RPM.


Current PWM duty is 60%, please enter your action.
(1: Increase 10%; 2: Increase 1%; 3: Decrease 10%; 4: Decrease 1%)
1
Changing... Current fan speed is 1140 RPM.


Current PWM duty is 70%, please enter your action.
(1: Increase 10%; 2: Increase 1%; 3: Decrease 10%; 4: Decrease 1%)
_
```

2 代码介绍

初始化Timer 0并且使能触发计数捕获模式信道0捕获功能以及电平转换触发

```
void TMR0_Init(void)
{
    /*---------------------------------------------------------------------------------------------*/
    /* Init Timer 0                                                                                */
    /*---------------------------------------------------------------------------------------------*/
    /* Reset IP */
    SYS_ResetModule(TMR0_RST);

    /* Give a dummy target frequency here. Will over write capture resolution with macro
*/
    TIMER_Open(TIMER0, TIMER_PERIODIC_MODE, 1000000);

    /* Update prescale to set proper resolution */
    TIMER_SET_PRESCALE_VALUE(TIMER0, 0);

    /* Set compare value as large as possible, so don't need to worry about counter
overrun too frequently */
    TIMER_SET_CMP_VALUE(TIMER0, 0xFFFFFF);

    /* Configure Timer 0 trigger counting mode and level change trigger.
       The high to low transition on Timer 0 external capture pin is detected to
       reset TDR as 0 and then starts counting, while low to high transition stops
       counting. */
    TIMER_EnableCapture(TIMER0, TIMER_CAPTURE_TRIGGER_COUNTING_MODE,
TIMER_CAPTURE_FALLING_THEN_RISING_EDGE);

    /* Enable T0EX debounce function */
    TIMER0->TEXCON |= TIMER_TEXCON_TEXDB_Msk;

    /* Enable timer interrupt */
    TIMER_EnableCaptureInt(TIMER0);
    NVIC_EnableIRQ(TMR0_IRQn);
}
```

初始化PWM信道0的频率为25 kHz。

```
void PWM_Init(void)
{
    /*---------------------------------------------------------------------------------------------*/
```

```
    /* Init PWM Channel 0                                                     */
    /*------------------------------------------------------------------------*/
    /* Reset IP */
    SYS_ResetModule(PWM_RST);

    /* Set PWM Channel 0 frequency to 25 kHz and initial duty 100% */
    PWM_ConfigOutputChannel(PWM, 0, 25000, 100);

    /* Enable PWM Channel 0 output */
    PWM_EnableOutput(PWM, BIT0);
}
```

在Timer 0的中断处理中，停止Timer 0，并且计算风扇转速。

```
void TMR0_IRQHandler(void)
{
    uint32_t u32_FanRPM;

    /* Stop Timer 0 */
    TIMER_Stop(TIMER0);

    /* Calculate RPM = (Timer 0 Clock Source Frequency / (Fan_Pole * Timer 0 Capture
Value)) * 60 */
    u32_FanRPM = (22118400 / (Fan_Pole * TIMER_GetCaptureData(TIMER0))) * 60;
    printf("%d RPM.\n", u32_FanRPM);

    /* Clear Timer 0 Capture interrupt flag */
    TIMER_ClearCaptureIntFlag(TIMER0);

    /* Set Detect done flag*/
    g_u8DetectFlag = 1;
}
```

测试风扇的最快和最慢转速。

```
    /* Test maximum fan speed */
    /* Start PWM Channel 0 */
    PWM_Start(PWM, BIT0);
    /* Wait 3 seconds */
    Delay_mS(3000);
    /* Start Timer 0 to detect the time which fan takes when rotating one round */
    g_u8DetectFlag = 0;
    printf("The maximum fan speed is ");
    TIMER_Start(TIMER0);
```

```
    while (!g_u8DetectFlag);

    /* Test maximum fan speed */
    /* Force PWM Channel 0 output low */
    PWM->PHCHG = PWM->PHCHGNXT & ~(PWM_PHCHGNXT_PWM0_Msk | PWM_PHCHGNXT_D0_Msk);
    /* Wait 3 seconds */
    Delay_mS(3000);
    /* Start Timer 0 to detect the time which fan takes when rotating one round */
    g_u8DetectFlag = 0;
    printf("The mimimum fan speed is ");
    TIMER_Start(TIMER0);

    while (!g_u8DetectFlag);
```

根据使用者的输入动作，增加或减少PWM的占空比。

```
    while (1)
    {
        printf("\n\nCurrent PWM duty is %d%%, please enter your action.\n", g_u8PWMDuty);
        printf("(1: Increase 10%%; 2: Increase 1%%; 3: Decrease 10%%; 4: Decrease
1%%)\n");
        u8Action = getchar();
        printf("%c\n", u8Action);

        switch (u8Action)
        {
            case '1':
            {
                /* Increase PWM duty 10% */
                (g_u8PWMDuty > 90) ? (g_u8PWMDuty = 100) : (g_u8PWMDuty += 10);

                break;
            }

            case '2':
            {
                /* Increase PWM duty 1% */
                (g_u8PWMDuty > 99) ? (g_u8PWMDuty = 100) : (g_u8PWMDuty++);

                break;
            }
```

```
            case '3':
            {
                /* Decrease PWM duty 10% */
                (g_u8PWMDuty < 10) ? (g_u8PWMDuty = 0) : (g_u8PWMDuty -= 10);

                break;
            }

            case '4':
            {
                /* Decrease PWM duty 1% */
                (g_u8PWMDuty < 1) ? (g_u8PWMDuty = 0) : (g_u8PWMDuty--);

                break;
            }

            default:
            {
                continue;
            }
        }

        /* Set PWM Channel 0 frequency and duty */
        if (g_u8PWMDuty > 0)
        {
            PWM->PHCHG |= PWM_PHCHGNXT_PWM0_Msk;
            PWM_ConfigOutputChannel(PWM, 0, 25000, g_u8PWMDuty);
        }
        else
            PWM->PHCHG = PWM->PHCHGNXT & ~(PWM_PHCHGNXT_PWM0_Msk | PWM_PHCHGNXT_D0_Msk);

        /* Wait 3 seconds */
        printf("Changing... ");
        Delay_mS(3000);
        /* Start Timer 0 to detect the time which fan takes when rotating one round */
        g_u8DetectFlag = 0;
        printf("Current fan speed is ");
        TIMER_Start(TIMER0);

        while (!g_u8DetectFlag);
    }
```

3 软件与硬件环境

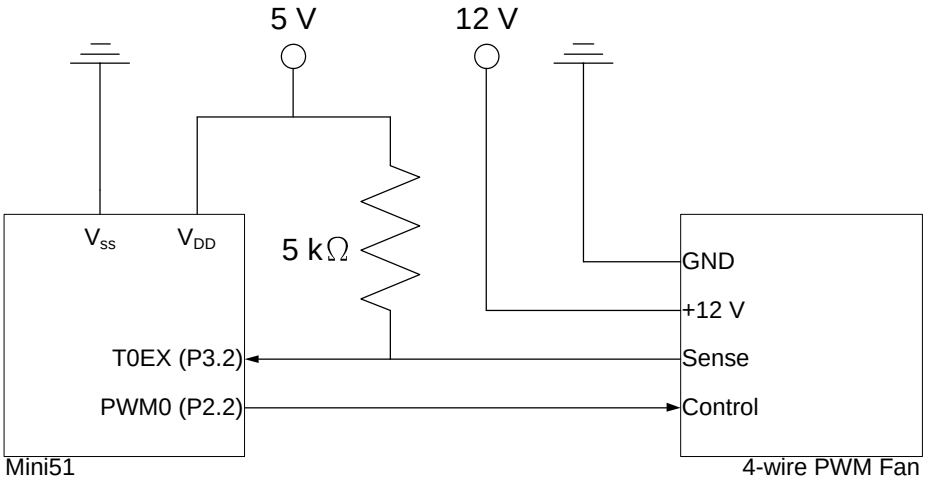
● 软件环境

- ■ BSP 版本
  - ◆ Mini51DE Series BSP CMSIS v3.02.000
- ■ IDE 版本
  - ◆ Keil uVersion 5.26

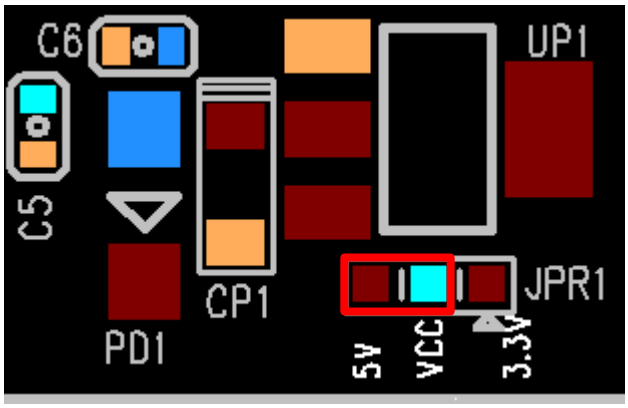
● 硬件环境

- ■ 电路组件
  - ◆ NuTiny-SDK-Mini54 V3.1
  - ◆ 4 线式 PWM 风扇
- ■ 示意图

将Mini51的PWM通道0 (P2.2) 连接到4线式PWM风扇的control脚位，控制风扇转速。并将Timer 0的外部捕获脚位 (T0EX) (P3.2) 连接到4线式PWM风扇的sense脚位，侦测风扇的每分钟转速，并且使用5 kΩ的上拉电阻。



为了使NuTiny-SDK-Mini54运作在5 V，使用者需要将Nu-Link-Me的JPR1上的0 Ω电阻，从3.3 V改到5 V。


C6
C5
CP1
PD1
UP1
JPR1
5V
VCC
3.3V

4 目录信息

- EC_Mini51_PWM_Fan_Control_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 Mini51_PWM_Fan_Control.uvproj。
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. 将 12 V 电源供应连接到 4 线式 PWM 风扇。
4. 将 4 线式 PWM 风扇的 control 和 sense 脚位连接到 NuTiny-SDK-Mini54。
5. 进入除错模式接口
   a. 执行代码
6. 使用终端机软件，获得风扇转速讯息，并且输入动作来改变目前的 PWM 占空比。

6 修订纪录

Date	Revision	Description
July 25, 2019	1.00	1. 初始发布.

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