GigaDevice Semiconductor Inc.

使用 TIMER 对内部低速时钟的校准方法

应用笔记

AN064

目录

图索引

表索引

1. 简介

GD32 MCU 内部的低速时钟（IRC32K 或 IRC40K）可以担当一个低功耗时钟源的角色，其优点是不需要外部器件从而可以降低硬件成本。其频率大约为 40kHz 或 32kHz，可以为独立看门狗（FWDGT）和实时时钟（RTC）等外设提供时钟。其缺点是精确度相对较低，适用的场景不多，但是可以利用 TIMER 对其捕获从而进行校准。本文以 GD32F30x 系列 MCU 为例，介绍使用 TIMER 校准内部低速时钟的方法。

2. 校准原理

即使是同一个系列的 MCU，每一颗 MCU 的内部低速时钟都可能不同且有一定的偏差，因此当它给 RTC 或 FWDGT 提供时钟时，软件设置 RTC 或 FWDGT 的预分频时以 40K 的固定数值进行计算，会造成较大的误差（例如：若以 40K 时钟设置 RTC 预分频得到 1S 的时间基准，则将 RTC 的预分频值设为 39999，当 IRC40K 的实际频率小于 40K 时，会使 RTC 的计时效果偏快）。

GD32F30x 系列 MCU 可以通过软件配置重映射，将 TIMER4_CH3 通道与 IRC40K 在内部进行连接，如*图 2-1. TIMER4_CH3 的备用功能重映射*所示。

图 2-1. TIMER4_CH3 的备用功能重映射

表 8-6. TMER4 备用功能重映射

备用功能	TIMER4CH3_IREMAP = 0	TIMER4CH3_IREMAP = 1
TIMER4_CH3	TIMER4_CH3 与 PA3 相连	IRC40K 内部时钟与 TIMER4_CH3 输入相连，用于校正

1. 重映射适用于高密度、超高密度和互联型的产品。

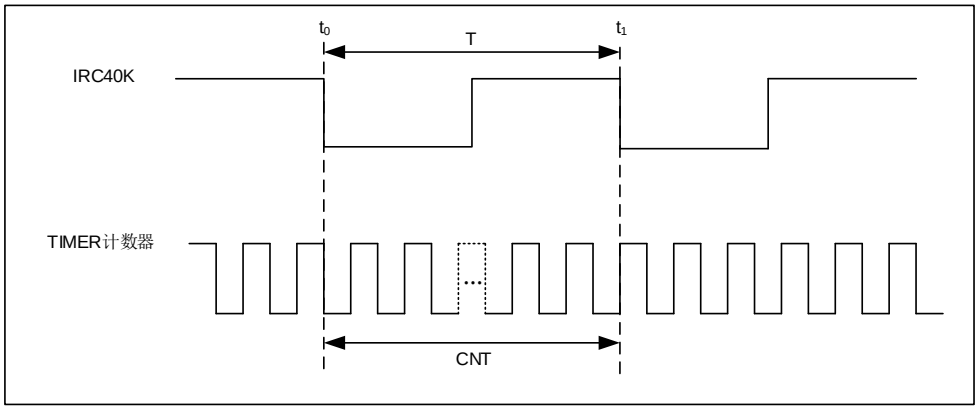
进而可以使用 TIMER4_CH3 通道捕获 IRC40K 边沿得到准确的时钟频率，如*图 2-2. TIMER4_CH3 捕获 IRC40K 边沿*所示。从而修改如 RTC 或 FWDGT 等外设的时钟分频值，获得更精确的时基。则有：

$$T = t_1 - t_0 = CNT / f_{ck} \quad (2\text{-}1)$$

$$f_{IRC40K} = 1 / T = f_{ck} / CNT \quad (2\text{-}2)$$

其中，t_0 为 TIMER4 第一次捕获到 IRC40K 下降沿的时间，t_1 为 TIMER4 第二次捕获到 IRC40K 下降沿的时间，T 为 IRC40K 的周期，f_{CK} 为 TIMER4 计数器的时钟。f_{CK} 是已知的，CNT 通过两次捕获分别读取 TIMER 计数器可以得到，则 f_{IRC40K} 通过式（2-2）计算得出。

图 2-2. TIMER4_CH3 捕获 IRC40K 边沿



以 RTC 的应用为例，在计算出 f_{IRC40K} 之后，可用实际的 IRC40K 频率来配置 RTC 的预分频值，用来产生 RTC 的时间基准 SC_CLK。通常情况下将预分频值设置为 f_{IRC40K}-1，得到 1S 的 RTC 时间基准，从而达到校准的目的。

3. 实现方法

3.1. IRC40K 边沿捕获

通过配置 TIMER4_CH3 捕获 IRC40K 的下降沿，代码*表 3-1. TIMER 配置*如所示。

表 3-1. TIMER 配置

```
/* TIMER4 configuration: input capture mode --------------------
the RTC signal is connected to TIMER4 CH3
the rising edge is used as active edge
the TIMER4 CH3CV is used to compute the frequency value
------------------------------------------------------------ */
timer_ic_parameter_struct timer_icinitpara;
timer_parameter_struct timer_initpara;

/* connect IRC40K clock to the TIMER4_CH3 input for calibration */
rcu_periph_clock_enable(RCU_AF);
gpio_pin_remap_config(GPIO_TIMER4CH3_IREMAP, ENABLE);

rcu_periph_clock_enable(RCU_TIMER4);
timer_deinit(TIMER4);

/* initialize TIMER init parameter struct */
timer_struct_para_init(&timer_initpara);
/* TIMER4 configuration */
timer_initpara.prescaler         = 0;
timer_initpara.alignedmode       = TIMER_COUNTER_EDGE;
timer_initpara.counterdirection  = TIMER_COUNTER_UP;
timer_initpara.period            = 0xFFFF;
timer_initpara.clockdivision     = TIMER_CKDIV_DIV1;
timer_init(TIMER4, &timer_initpara);

/* TIMER4  configuration */
/* initialize TIMER channel input parameter struct */
timer_channel_input_struct_para_init(&timer_icinitpara);
/* TIMER4 CH3 input capture configuration */
timer_icinitpara.icpolarity  = TIMER_IC_POLARITY_FALLING;
timer_icinitpara.icselection = TIMER_IC_SELECTION_DIRECTTI;
timer_icinitpara.icprescaler = TIMER_IC_PSC_DIV1;
timer_icinitpara.icfilter    = 0x0;
timer_input_capture_config(TIMER4, TIMER_CH_3, &timer_icinitpara);
```

```
/* auto-reload preload enable */
timer_auto_reload_shadow_enable(TIMER4);
/* clear channel 3 interrupt bit */
timer_interrupt_flag_clear(TIMER4, TIMER_INT_FLAG_CH3);
/* channel 3 interrupt enable */
timer_interrupt_enable(TIMER4, TIMER_INT_CH3);

/* TIMER4 counter enable */
timer_enable(TIMER4);
```

TIMER4_CH3 捕获到 IRC40K 的下降沿将触发捕获中断，中断处理代码如*表 3-2. 中断处理*所示。

表 3-2. 中断处理

```
void TIMER4_IRQHandler(void)
{
    if(SET == timer_interrupt_flag_get(TIMER4, TIMER_INT_CH3)){
        /* clear channel 3 interrupt bit */
        timer_interrupt_flag_clear(TIMER4, TIMER_INT_CH3);

        timer_capture_num++;
        if(1 == timer_capture_num){
            /* get the input capture value */
            timer_capture1 = timer_channel_capture_value_register_read(TIMER4,
TIMER_CH_3);
        }else if(2 == timer_capture_num){
            /* get the input capture value */
            timer_capture2 = timer_channel_capture_value_register_read(TIMER4,
TIMER_CH_3);

            /* end capture, disable TIMER4 and CH3 interrupt */
            timer_interrupt_disable(TIMER4, TIMER_INT_CH3);
            timer_disable(TIMER4);
        }
    }
}
```

3.2. IRC40K 频率计算

经过两次捕获，TIMER4 计数器的值分别为 timer_capture1 和 timer_capture2，则 IRC40K 的频率可以计算出来并配置 RTC 的预分频值，如*表 3-3. IRC40K 实际频率计算*所示。

表 3-3. IRC40K 实际频率计算

```
temp_capture1 = timer_capture1;
```

```
temp_capture2 = timer_capture2;
timer_period = temp_capture2 - temp_capture1 + 1;

/* compute the actual frequency of the IRC40K (TIMER4_CLK = 2 * CK_APB1) */
if(0 != timer_period){
    irc_freq = ((rcu_clock_freq_get(CK_APB1) * 2) / timer_period);
}

printf("timer_capture1 = %d, timer_capture2 = %d, irc_freq = %d\n", temp_capture1, temp_capture2,
irc_freq);

/* adjust the RTC prescaler value to calibrate the clock */
rtc_lwoff_wait();
rtc_prescaler_set(irc_freq - 1);
rtc_lwoff_wait();
```

4. 版本历史

表 4-1. 版本历史

版本号.	说明	日期
1.0	首次发布	2022 年 5 月 20 日

Important Notice

This document is the property of GigaDevice Semiconductor Inc. and its subsidiaries (the "Company"). This document, including any product of the Company described in this document (the “Product”), is owned by the Company under the intellectual property laws and treaties of the People’s Republic of China and other jurisdictions worldwide. The Company reserves all rights under such laws and treaties and does not grant any license under its patents, copyrights, trademarks, or other intellectual property rights. The names and brands of third party referred thereto (if any) are the property of their respective owner and referred to for identification purposes only.

The Company makes no warranty of any kind, express or implied, with regard to this document or any Product, including, but not limited to, the implied warranties of merchantability and fitness for a particular purpose. The Company does not assume any liability arising out of the application or use of any Product described in this document. Any information provided in this document is provided only for reference purposes. It is the responsibility of the user of this document to properly design, program, and test the functionality and safety of any application made of this information and any resulting product. Except for customized products which has been expressly identified in the applicable agreement, the Products are designed, developed, and/or manufactured for ordinary business, industrial, personal, and/or household applications only. The Products are not designed, intended, or authorized for use as components in systems designed or intended for the operation of weapons, weapons systems, nuclear installations, atomic energy control instruments, combustion control instruments, airplane or spaceship instruments, transportation instruments, traffic signal instruments, life-support devices or systems, other medical devices or systems (including resuscitation equipment and surgical implants), pollution control or hazardous substances management, or other uses where the failure of the device or Product could cause personal injury, death, property or environmental damage ("Unintended Uses"). Customers shall take any and all actions to ensure using and selling the Products in accordance with the applicable laws and regulations. The Company is not liable, in whole or in part, and customers shall and hereby do release the Company as well as it’s suppliers and/or distributors from any claim, damage, or other liability arising from or related to all Unintended Uses of the Products. Customers shall indemnify and hold the Company as well as it’s suppliers and/or distributors harmless from and against all claims, costs, damages, and other liabilities, including claims for personal injury or death, arising from or related to any Unintended Uses of the Products.

Information in this document is provided solely in connection with the Products. The Company reserves the right to make changes, corrections, modifications or improvements to this document and Products and services described herein at any time, without notice.