



模块 9

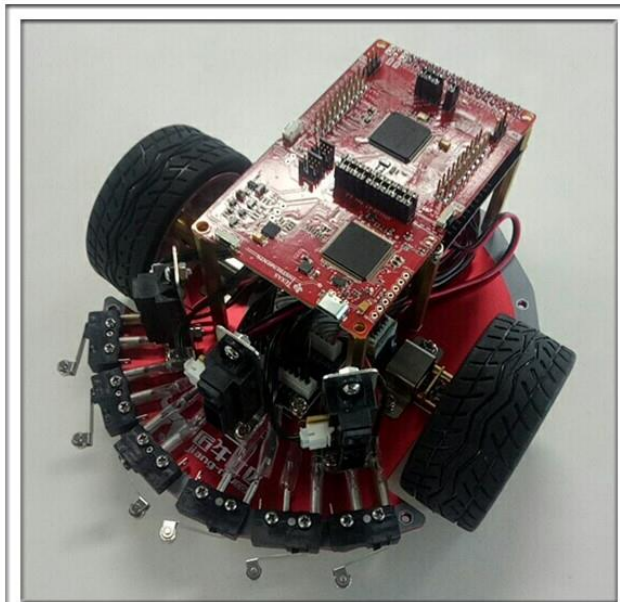
讲解：SysTick 定时器 - 理论



SysTick 定时器

在本模块中您将学到:

- SysTick定时器的基本原理
- 测量时间
 - 精度
 - 范围
 - 分辨率
- 软件延时





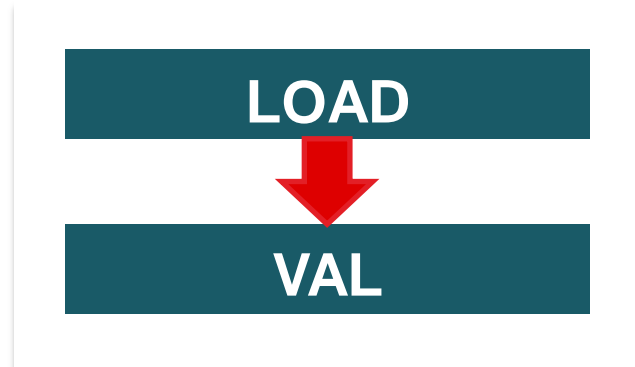
SysTick 定时器 :

SysTick在所有ARM中执行定时器/计数器操作

- 创建时间延迟
- 产生周期性的中断

它是如何运作的

- 24位递减计数器在总线时钟频率下递减
- 使用48 MHz总线时钟，每20.83 ns递减一次
- 软件将24位LOAD值设置为n
- 计数器VAL从n→0开始
 - 序列: n, n-1, n-2, n-3... 2, 1, 0, n, n-1...
- SysTick是模数n + 1计数器:
- $VAL = (VAL - 1) \bmod (n+1)$





SysTick 定时器初始化

31-24	23-17	16	15-3	2	1	0	名字
0	0	COUNT	0	CLK_SRC	INTEN	ENABLE	SysTick->CTRL
0	24位RELOAD值						SysTick->LOAD
0	SysTick计数器的24位CURRENT值						SysTick->VAL

Callouts: 标记 (points to bit 16), 总线定时器 (points to bit 2), 打开 (points to bit 0)

表 9.0 SysTick 寄存器

```
void SysTick_Init(void) {
    SysTick->LOAD = 0x00FFFFFF;
    SysTick->CTRL = 0x00000005;
}
```

在48 MHz时，它每隔349ms滚动一次



测量经过的时间

```
Start = SysTick->VAL;  
SystemUnderTest();  
Stop = SysTick->VAL;  
Delta = 0x00FFFFFF & (Start - Stop);
```

执行时间?

在 48 MHz

- 24位精度
- 20.83ns 分辨率
- 349ms 范围

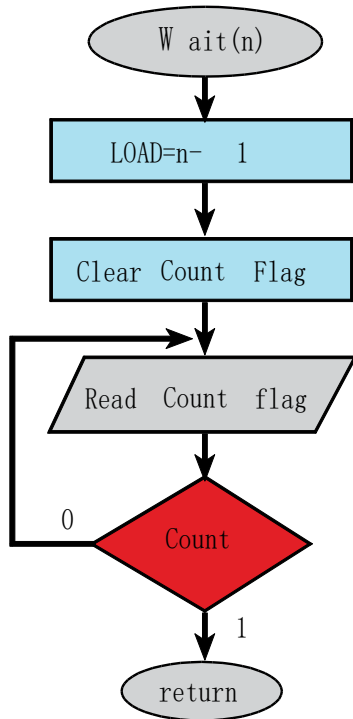
#不同的测量

最小的变化

最大的可能



SysTick定时器等待



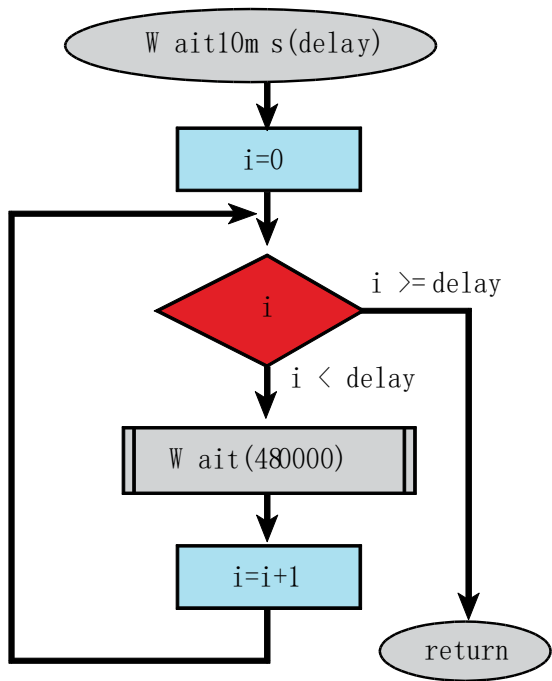
```
void SysTick_Wait(uint32_t n){  
    SysTick->LOAD = n-1;  
    SysTick->VAL = 0;    // clear Count  
    while((SysTick->CTRL&0x00010000)== 0){};  
}
```

在48 MHz时，它的工作时间可达349ms，
对于n = 0或n = 1不起作用

计数在第16
位



SysTick 定时器：生成 10 ms 等待



```
void SysTick_Wait10ms(uint32_t delay){  
    for(uint32_t i=0; i<delay; i++){  
        SysTick_Wait(480000);  
    }  
}
```

48个周期是1us

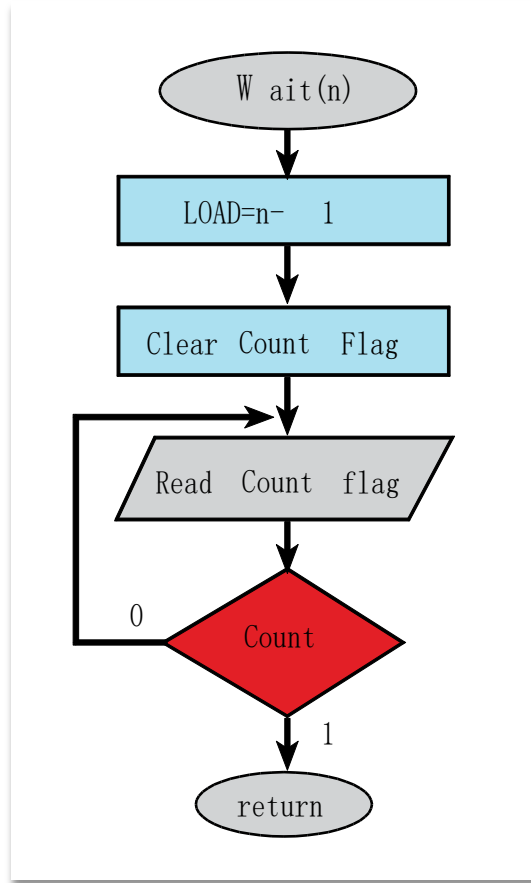
48,000个周期是1ms

480,000个周期是10ms



总结

- SysTick是一款内置定时器
 - 测量经过的时间
 - 创建软件延时





模块 9

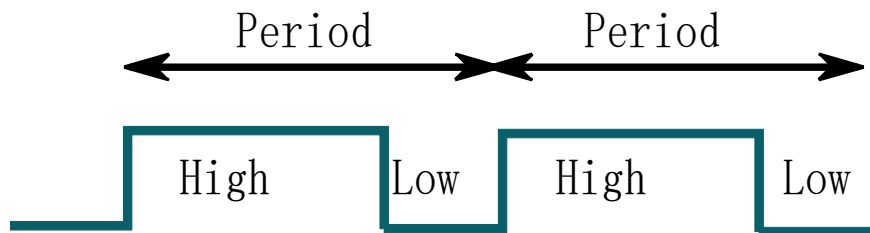
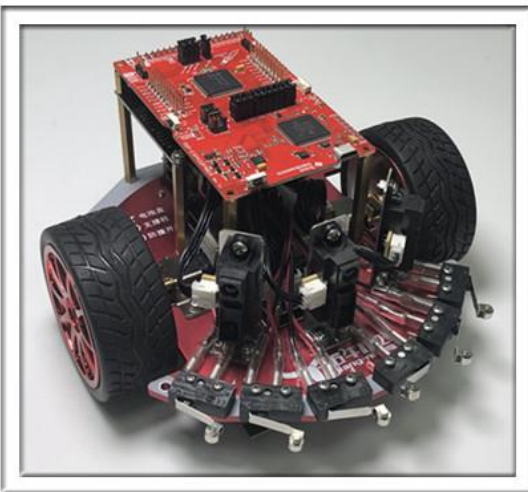
讲解: SysTick 定时器 - PWM



SysTick 定时器

在本模块中您将学到:

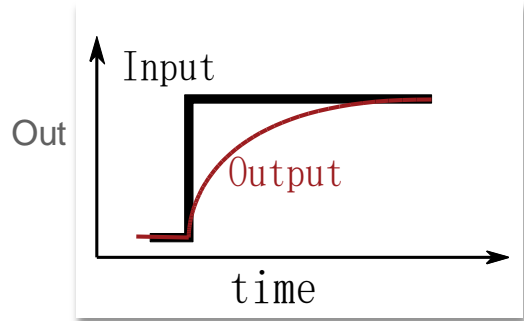
- 脉宽调制 (PWM) 与占空比的概念
- 用SysTick Timer Delay创建脉宽调制 (PWM) 信号
- 用PWM控制LED的亮度
- 应用PWM实现数模转换器 (DAC)





这个装置有多快？

更改输入 (步骤更改)
测量输出响应



$$\text{Out}(t) = A + Be^{-t/\tau}$$

时间常数 τ 达到最后0.63的时间

时间常数, τ

HLMP-4700 LED 90ns

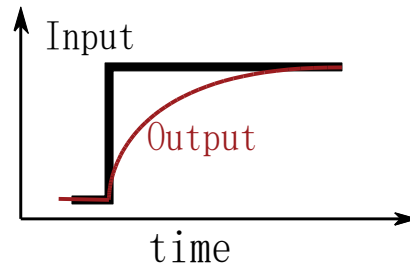
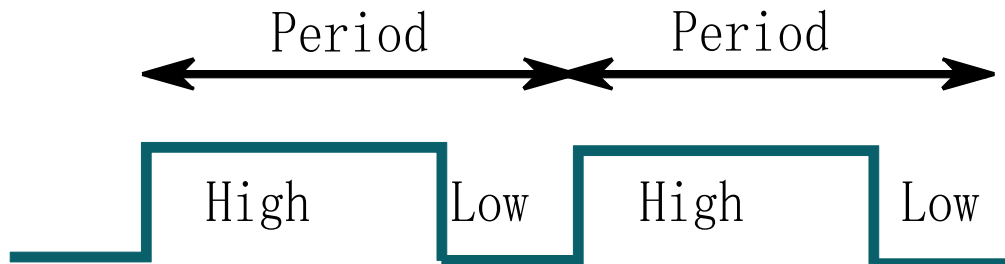
DC motor 100ms



脉宽调制

```
while(1) {  
    P1->OUT |= 0x01;    // red LED on  
    SysTick_Wait(High);  
    P1->OUT &= ~0x01;  // red LED off  
    SysTick_Wait(Low);  
}
```

$$\text{Dutycycle} = \frac{\text{High}}{\text{High} + \text{Low}} = \frac{\text{High}}{\text{Period}}$$



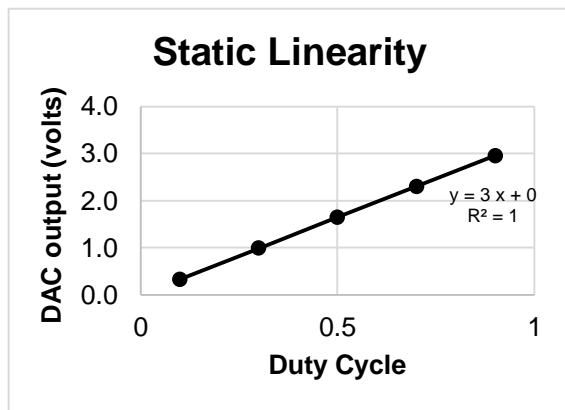
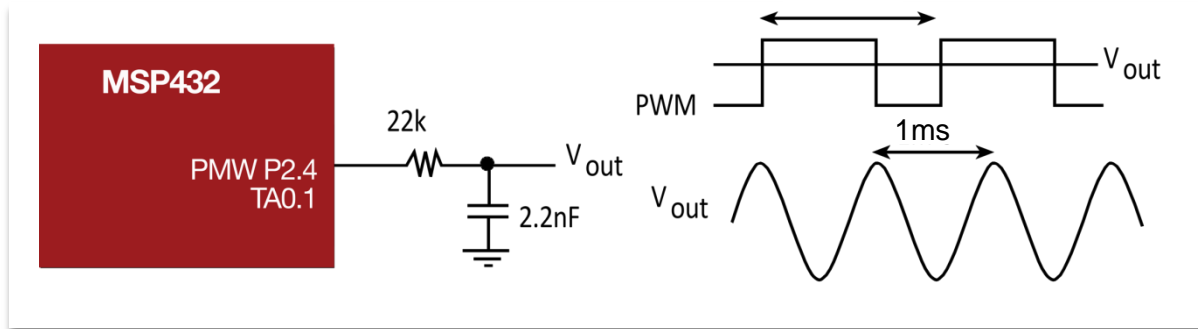
High+Low是常数

如果足够快，设备会响应平均值



PWM - 数模转换器

PWM + 低通滤波器



低通滤波器截止频率:

$$f_c = 1/(2\pi RC)$$

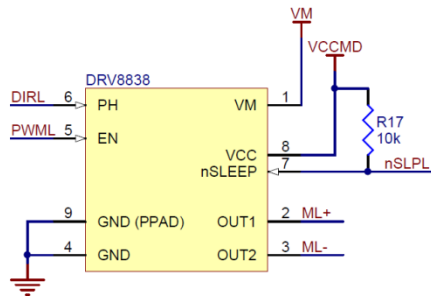
$f_c >$ 模拟波

$f_c <$ 数字频率

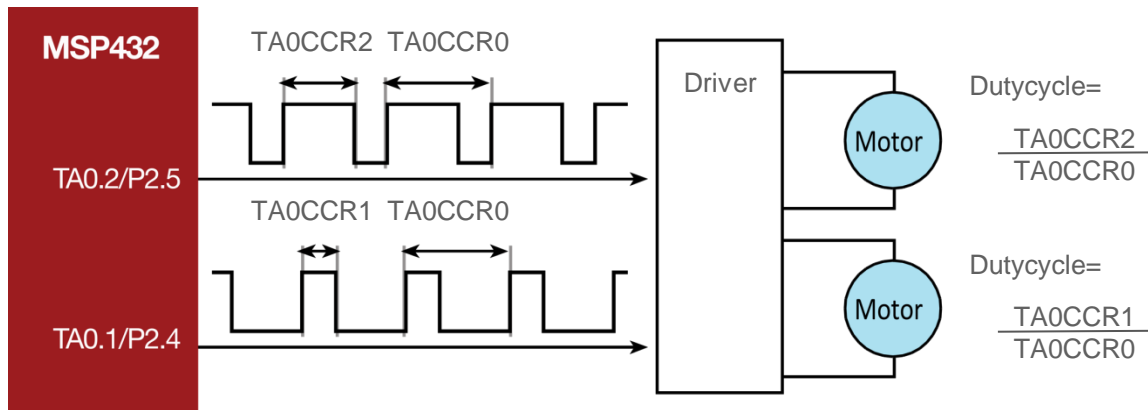


PWM的应用:

- 控制LED的亮度
- 120V /60Hz 电器
- 用它来制作DAC
- 将功率传递给控制电机



电机驱动 TI DRV8838

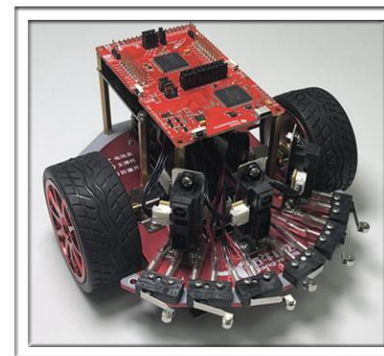
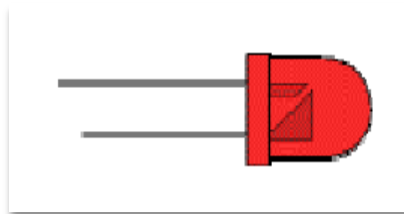
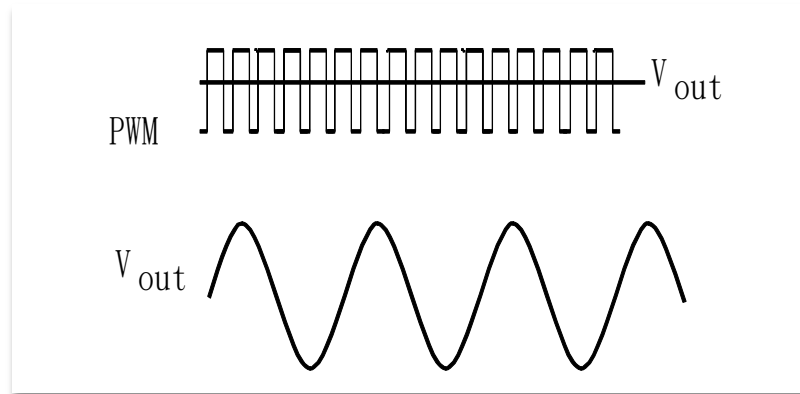


使用PWM将电机驱动器TI DRV8838与TI Launchpad连接



总结

- SysTick是一款内置定时器
 - 测量经过的时间
 - 创建软件延时
- PWM
 - 实现软件延迟（低效）
 - 选择比设备更快的固定频率
 - 设备线性响应占空比
 - 提供高精度输出
- 应用
 - 调光
 - 数模转换器
 - 电机



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