TI-RSLK

Texas Instruments Robotics System Learning Kit

Texas Instruments

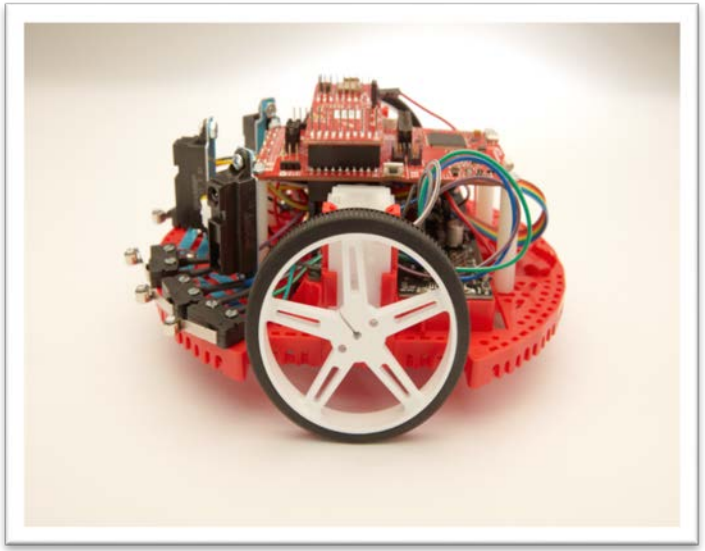
Module 9

Lecture: SysTick Timer - Theory

SysTick Timer

You will learn in this module

- Fundamentals of SysTick Timer
- Measure elapsed time
  - Precision
  - Range
  - Resolution
- Software delay



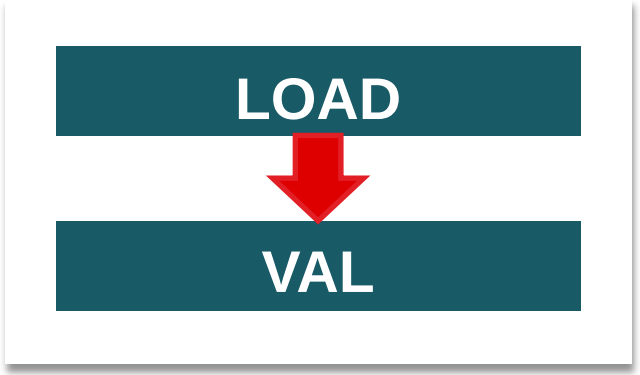
SysTick Timer :

SysTick performs Timer/Counter operation in all ARM

- Create time delays
- Generate periodic interrupts

How it works

- 24-bit down counter decrements at bus clock frequency
- With a 48 MHz bus clock, decrements every 20.83 ns
- Software sets a 24-bit LOAD value of n
- The counter, VAL, goes from n → 0
  - Sequence: n, n-1, n-2, n-3… 2, 1, 0, n, n-1…
- SysTick is a modulo n+1 counter:
- VAL = (VAL - 1) mod (n+1)



SysTick Timer Initialization

Flag

Bus clock

Turn on

31-24	23-17	16	15-3	2	1	0	Name
0	0	COUNT	0	CLK_SRC	INTEN	ENABLE	SysTick->CTRL
0	24-bit RELOAD value						SysTick->LOAD
0	24-bit CURRENT value of SysTick counter						SysTick->VAL

Table 9.0 SysTick Registers

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

At 48 MHz, it rolls over about every 349ms

Measure Elapsed Time

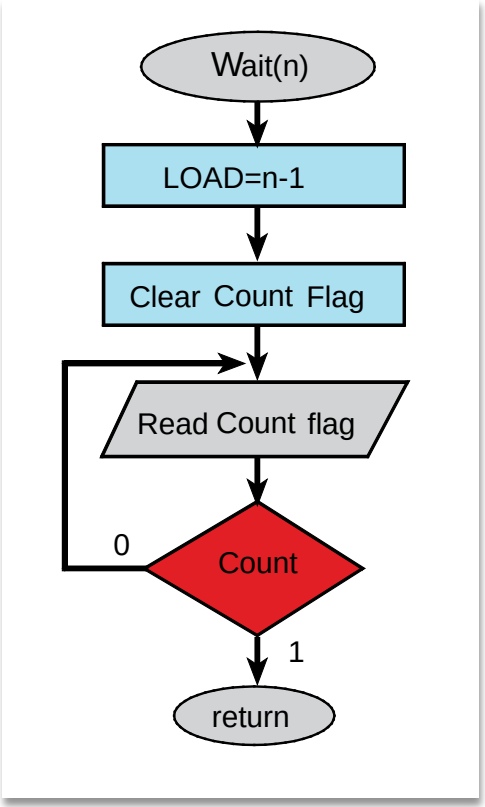
```
Start = SysTick->VAL;
SystemUnderTest();
Stop = SysTick->VAL;
Delta = 0x00FFFFFF&(Start-Stop);
```

Time to execute?

At 48 MHz

- 24-bit precision ← # of distinct measurements
- 20.83ns resolution ← Smallest change
- 349ms range ← Largest possible

SysTick Timer Wait

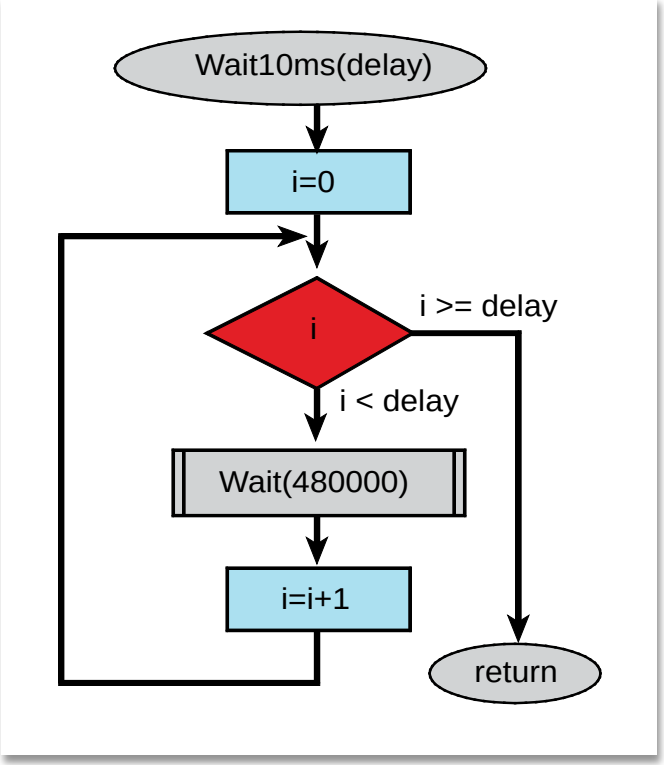



```
void SysTick_Wait(uint32_t n){
 SysTick->LOAD = n-1;
 SysTick->VAL = 0;    // clear Count
 while((SysTick->CTRL&0x00010000)== 0){};
}
```

Count is in bit 16

At 48 MHz, it works up to 349ms
Doesn't work for n=0 or n=1

SysTick Timer : Generate 10 ms Wait




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

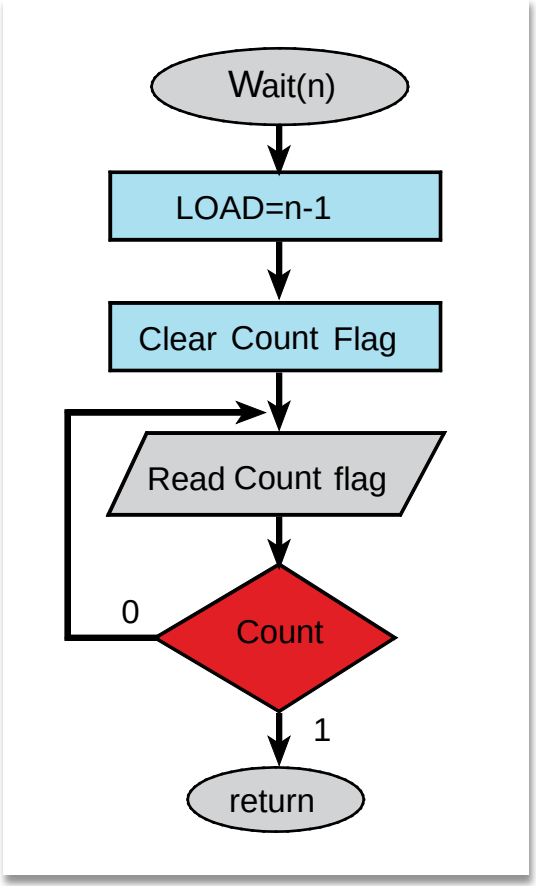
48 cycles is 1us

48,000 cycles is 1ms

480,000 cycles is 10ms

Summary

- SysTick is a built in timer
  - Measuring elapsed time
  - Creating software delay



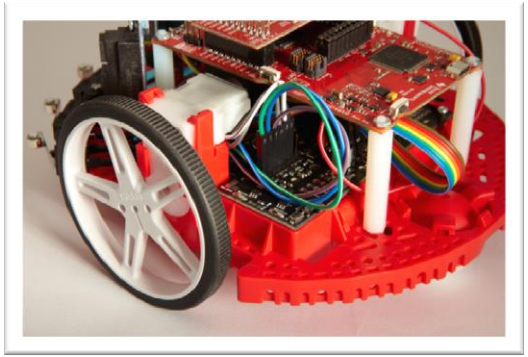
Module 9

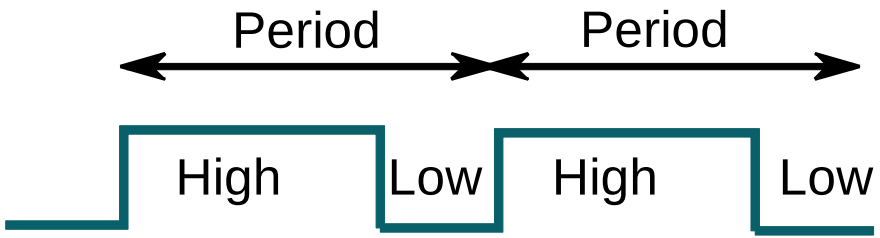
Lecture: SysTick Timer - PWM

SysTick Timer

You will learn in this module

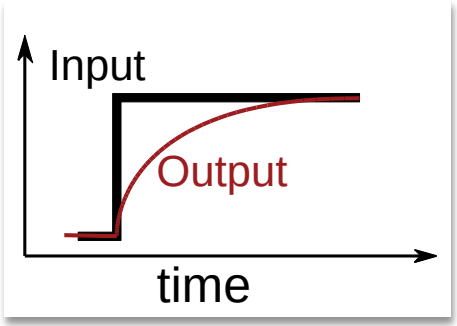
- Concept of **Pulse Width Modulation** (PWM) and Duty Cycle
- Create pulse width modulated (PWM) signals using SysTick Timer Delay
- Use PWM to control brightness of an LED
- Apply PWM to create digital to analog converter (DAC)





How fast is the device?

Change the input (step change)
Measure the output response



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

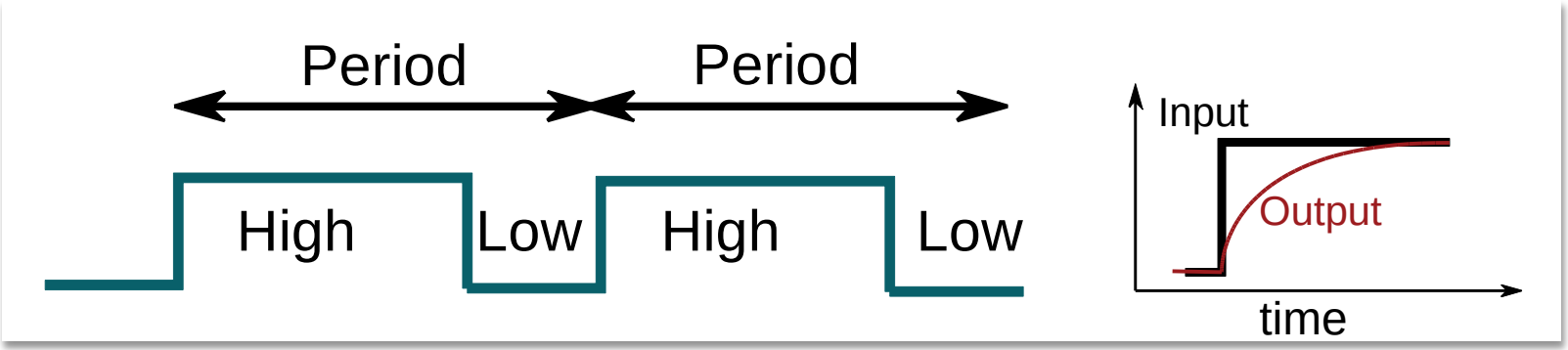
Time constant, τ, is the time to reach 0.63 of final

Time constant , τ	
HLMP-4700 LED	90ns
DC motor	100ms

Pulse Width Modulation

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

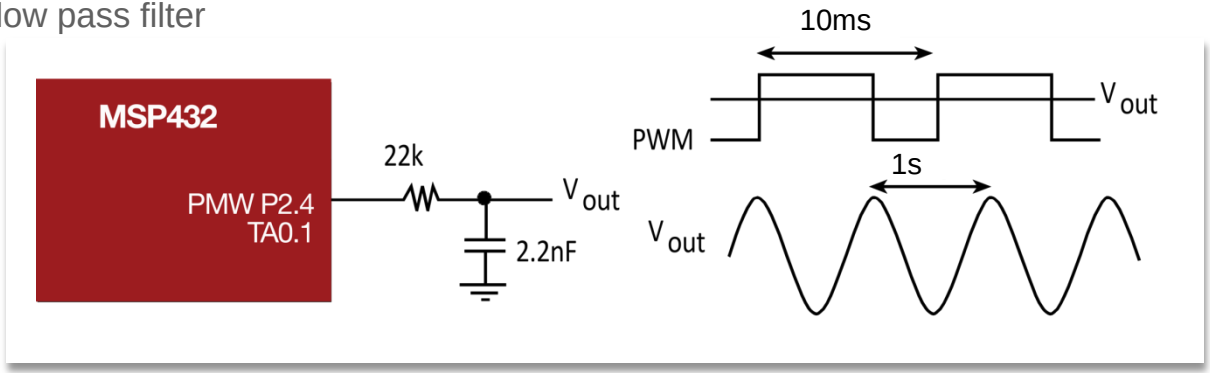
$$\text{Dutycycle} = \frac{\texttt{High}}{\texttt{High}+\texttt{Low}} = \frac{\texttt{High}}{\texttt{Period}}$$

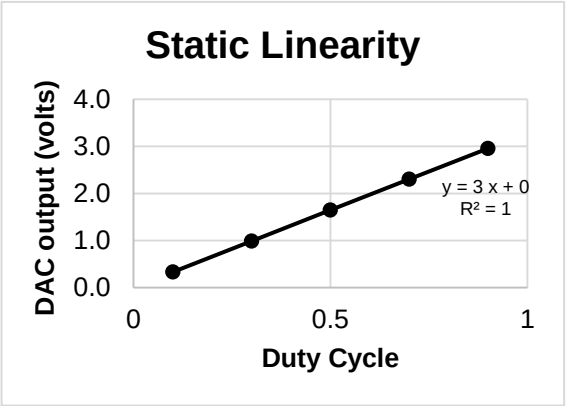


`High+Low` is a constant
If fast enough, the device responses to the average

PWM - Digital to Analog Converter

PWM + low pass filter





LPF cutoff:

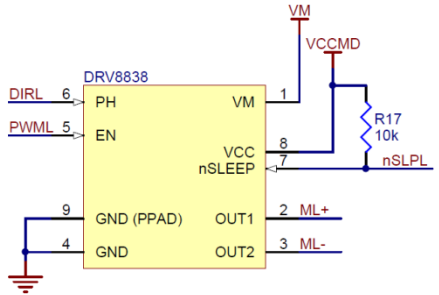
$f_c = 1/(2\pi RC)$

f_c > analog wave

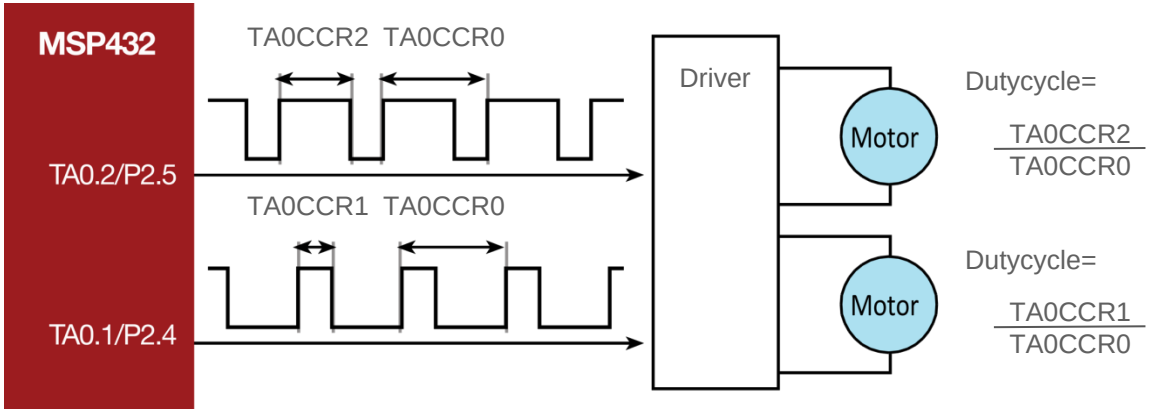
f_c < digital frequency

Applications of PWM:

- Control brightness of LEDS
- 120V /60Hz appliances
- Use it to make a DAC
- Transfer power to control motors



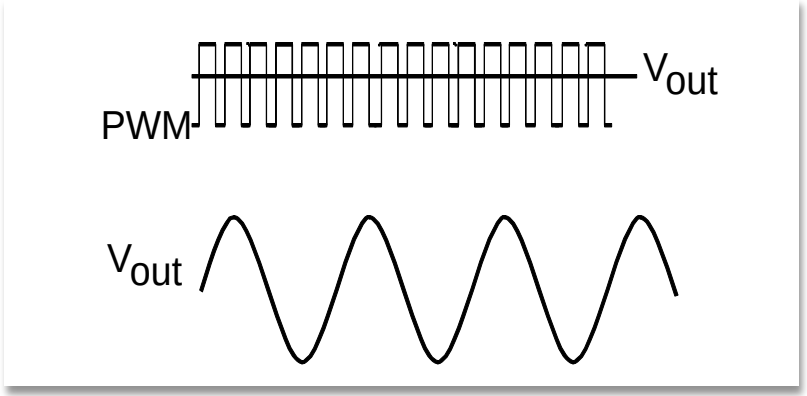
Motor driver TI DRV8838

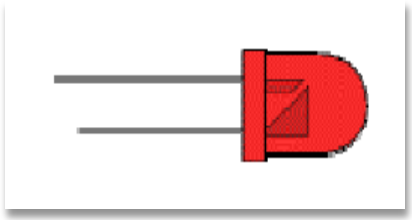


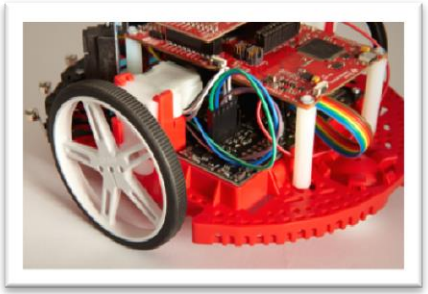
Interface TI Launchpad with Motor driver TI DRV8838 using PWM

Summary

- SysTick is a built in timer
  - Measuring elapsed time
  - Creating software delay
- PWM
  - Implemented with software delays (inefficient)
  - Choose the fixed frequency faster than the device
  - Device responds linearly to duty cycle
  - Provides for high precision outputs
- Applications
  - Dimming
  - DAC
  - Motors







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