

# MECE336– Microprocessors I

## Timer/Counter

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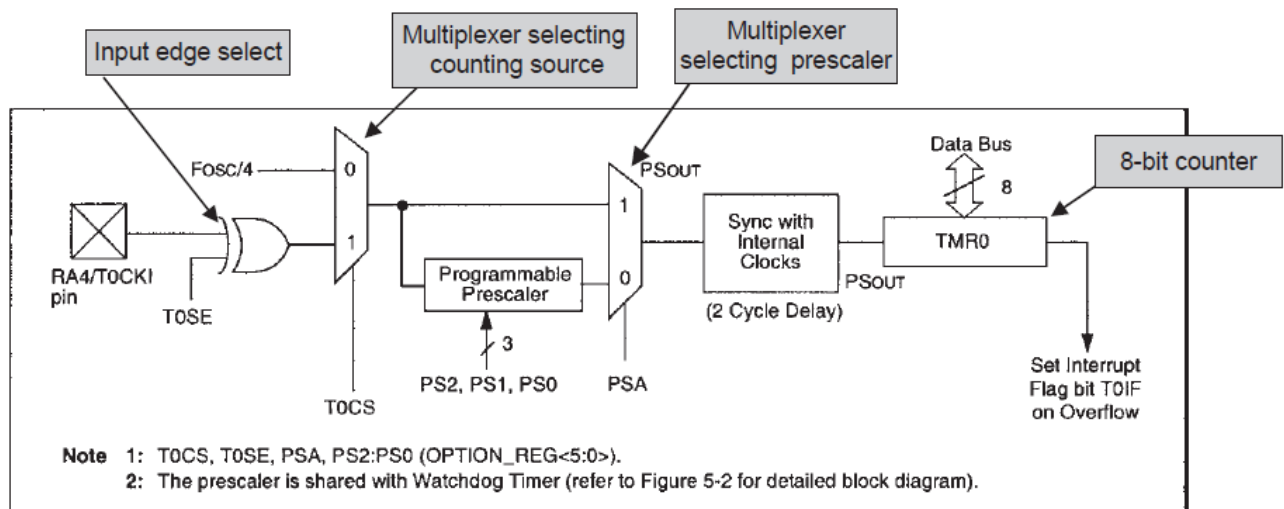
Department of Mechatronics Engineering – Çankaya University

Compulsory Course in Mechatronics Engineering  
Credits (3/2/4)

Course Webpage: <http://MECE336.cankaya.edu.tr>

## Timer0: Basics

### Block Diagram



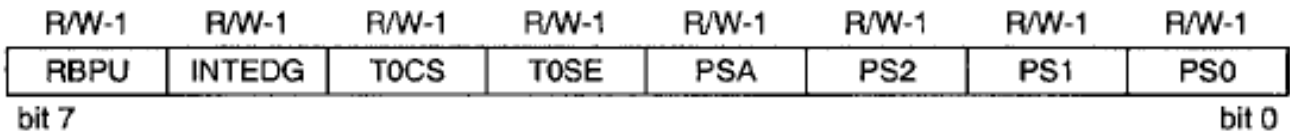
### Main Components

- 8-bit counter
- Prescaler
- Different counting sources
- Edge select for external clock

# Timer: Basics

## Properties of Timer0 on the PIC16F84A

- 8-bit counter (SFR in the data memory: address 0x01, bank 0)
- Configurable using different bits in the OPTION\_REG



<p><b>bit 7</b>     <b>RBPU:</b> PORTB Pull-up Enable bit                  1 = PORTB pull-ups are disabled                  0 = PORTB pull-ups are enabled by individual port latch values</p> <p><b>bit 6</b>     <b>INTEDG:</b> Interrupt Edge Select bit                  1 = Interrupt on rising edge of RB0/INT pin                  0 = Interrupt on falling edge of RB0/INT pin</p> <p><b>bit 5</b>     <b>T0CS:</b> TMR0 Clock Source Select bit                  1 = Transition on RA4/T0CKI pin                  0 = Internal instruction cycle clock (CLKOUT)</p> <p><b>bit 4</b>     <b>T0SE:</b> TMR0 Source Edge Select bit                  1 = Increment on high-to-low transition on RA4/T0CKI pin                  0 = Increment on low-to-high transition on RA4/T0CKI pin</p>	<p><b>bit 3</b>     <b>PSA:</b> Prescaler Assignment bit                  1 = Prescaler is assigned to the WDT                  0 = Prescaler is assigned to the Timer 0 module</p> <p><b>bit 2-0</b>     <b>PS2:PS0:</b> Prescaler Rate Select bits</p> <table border="1" style="width: 100%; border-collapse: collapse; text-align: center;"> <thead> <tr> <th>Bit Value</th> <th>TMR0 Rate</th> <th>WDT Rate</th> </tr> </thead> <tbody> <tr><td>000</td><td>1 : 2</td><td>1 : 1</td></tr> <tr><td>001</td><td>1 : 4</td><td>1 : 2</td></tr> <tr><td>010</td><td>1 : 8</td><td>1 : 4</td></tr> <tr><td>011</td><td>1 : 16</td><td>1 : 8</td></tr> <tr><td>100</td><td>1 : 32</td><td>1 : 16</td></tr> <tr><td>101</td><td>1 : 64</td><td>1 : 32</td></tr> <tr><td>110</td><td>1 : 128</td><td>1 : 64</td></tr> <tr><td>111</td><td>1 : 256</td><td>1 : 128</td></tr> </tbody> </table>	Bit Value	TMR0 Rate	WDT Rate	000	1 : 2	1 : 1	001	1 : 4	1 : 2	010	1 : 8	1 : 4	011	1 : 16	1 : 8	100	1 : 32	1 : 16	101	1 : 64	1 : 32	110	1 : 128	1 : 64	111	1 : 256	1 : 128
Bit Value	TMR0 Rate	WDT Rate																										
000	1 : 2	1 : 1																										
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101	1 : 64	1 : 32																										
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111	1 : 256	1 : 128																										

# Timer: Configuration

## Flags in OPTION\_REG

- T0CS (bit 5): TMR0 clock source select bit (source of the clock tick for incrementing the counter)
  - T0CS = 1: Transition on RA4 pin generates clock
  - T0CS = 0: Internal instruction cycle generates clock
- T0SE (bit 4): TMR0 source edge select bit
  - T0SE = 1: clock tick on falling edge at RA4 pin
  - T0SE = 0: clock tick on rising edge at RA4 pin
- PSA (bit 3): Prescaler assignment bit
  - PSA = 1: Prescaler is assigned to the watchdog timer (WDT)
  - PSA = 0: Prescaler is assigned to TMR0
- PS2 to PS0 (bit 2 to 0): Prescaler rate select bit

Bits	TMR0 rate	Bits	TMR0 rate	Bits	TMR0 rate	Bits	TMR0 rate
000	1:2	010	1:8	100	1:32	110	1:128
001	1:4	011	1:16	101	1:64	111	1:256

## Timer: Usage

### TMRO as Timer Module

- Select timer mode by clearing the TOCS in OPTION\_REG
- TMRO starts counting if a value is written in the TMRO register
- If the prescaler value is  $p$ , then TMRO is incremented every  $p$  instruction cycles
  - Prescaler is used to slow down the counting operation

### Example

## Timer: Interrupt

### TMRO Interrupt

- TMRO interrupt is enabled if  $TOIE = 1$  in INTCON
- TMRO interrupt is generated if the TMRO register overflows: value changes from  $0xFF$  to  $0x00$ .
- $TOIF = 1$  if TMRO interrupt occurs

### Example

## Timer: Example Program

### Task

Write a program that increments PORTB whenever TMR0 overflows. Use a prescaler value of 128.

## Timer: Example Program

## Timer: Delay

### Timer Delay

- Assume TMR0 is initialized with the value  $k$  and the prescaler value is  $p$ 
  - $(256 - k) \cdot p$  instruction cycles until TMR0 overflow
  - Delay for oscillator frequency  $f$ :  $(256 - k) \cdot p \cdot 4/f$

### Example

Initialize the timer for a delay of 1 msec. The oscillator frequency is 4 Mhz.

## Timer: Usage as Counter

### Counter Configuration

- $TOCS = 1$  in `OPTION_REG`: Counter operation is selected (clock tick from pin RA4)
- $TOSE = 1$ : Clock tick on falling edge at RA4
- $TOSE = 0$ : Clock tick on rising edge at RA4

### Example

Configure TMR0 as a counter that is incremented with every falling edge at RA4