# W78ERD2/W78IRD2
# Application Notes

# WINBOND
# 8-BIT MICROCONTROLLER

*How To Use Programmable Counter Array (PCA)*
*in W78ERD2 & W78IRD2 ?*

**AN001**

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*Revision A1*

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# How to Use PCA in W78ERD2/W78IRD2?

## 1. INTRODUCTION TO PCA

The features of the programmable counter array (PCA) built in **W78ERD2** and **W78IRD2** are listed below.

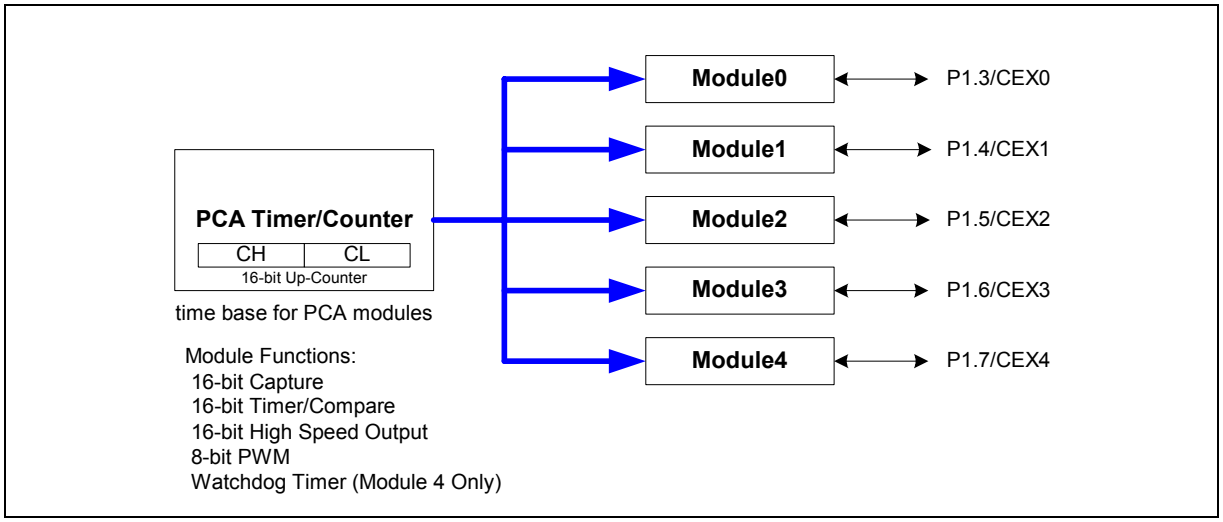


Figure 1 Programmable Counter Array (PCA)

1. Including one PCA counter and 5 modules(module0~module4).
2. PCA counter is a 16-bit Up-counter with 4 clock source: 1/6 osc(6-clock mode) or 1/12 osc(12-clock mode), 1/2 osc(6-clock mode) or 1/4 osc(12-clock mode), TM0 and P1.2
3. 6 Interrupt flag: one is from PCA counter overflow and 5 are produced by 5 modules. The 6 interrupt flags are logic-OR to be the PCA Interrupt.
4. Every module has 4 functions. Module 4 has **WDT function** additionally.
5. Each module has one 16-bit counter divided as CCAPxH and CCAPxL, x=0~4.
6. **Function1: *Rising and/or Falling edge Capture Mode.*** A level changed on pins(CEX0~4) will set interrupt flag. It can be used to measure the pulse width.
7. **Function2: *Timer/Compare Mode.*** Functions as a normal 16-bit timer.
8. **Function3: *High-Speed Output Mode.*** When timer overflow, toggle the output signal on pin CEX0~4
9. **Function4: *PWM.*** Duty is controlled by CCAPHx. Frequency is decided by the clock source of PCA.

## 2. REGISTERS USED IN PCA

The registers used in PCA are listed in the following table.

| CCON(D8H) | | | | | | | | CMOD(D9H) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CF | CR | - | CCF4 | CCF3 | CCF2 | CCF1 | CCF0 | CIDL | WDTE | - | - | - | CPS1 | CPS0 | ECF |
| **CCAPMn, n=0~4(DAH, DBH, DCH, DDH, DEH)** | | | | | | | | **CCAPnL, n=0~4(EAH, EBH, ECH, EDH, EEH)** | | | | | | | |
| - | ECONn | CAPPn | CAPNn | MATn | TOGn | PWMn | ECCFn | x | x | x | x | x | x | x | x |
| **CCAPnH, n=0~4(FAH, FBH, FCH, FDH, FEH)** | | | | | | | | **CH/CL (F9H/E9H)** | | | | | | | |
| x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x |

## 3. STRUCTURE OF PCA

### 3.1 PCA Timer/Counter

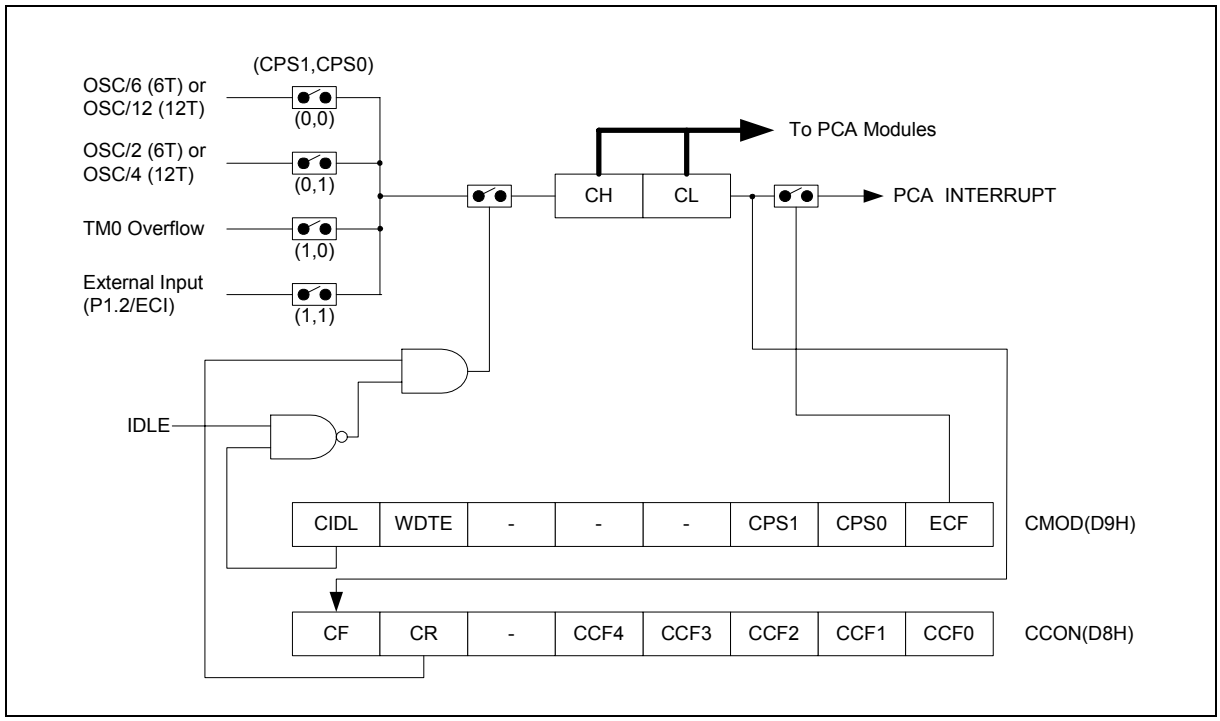


Figure 2 PCA Timer/Counter

### 3.2 PCA Interrupt System

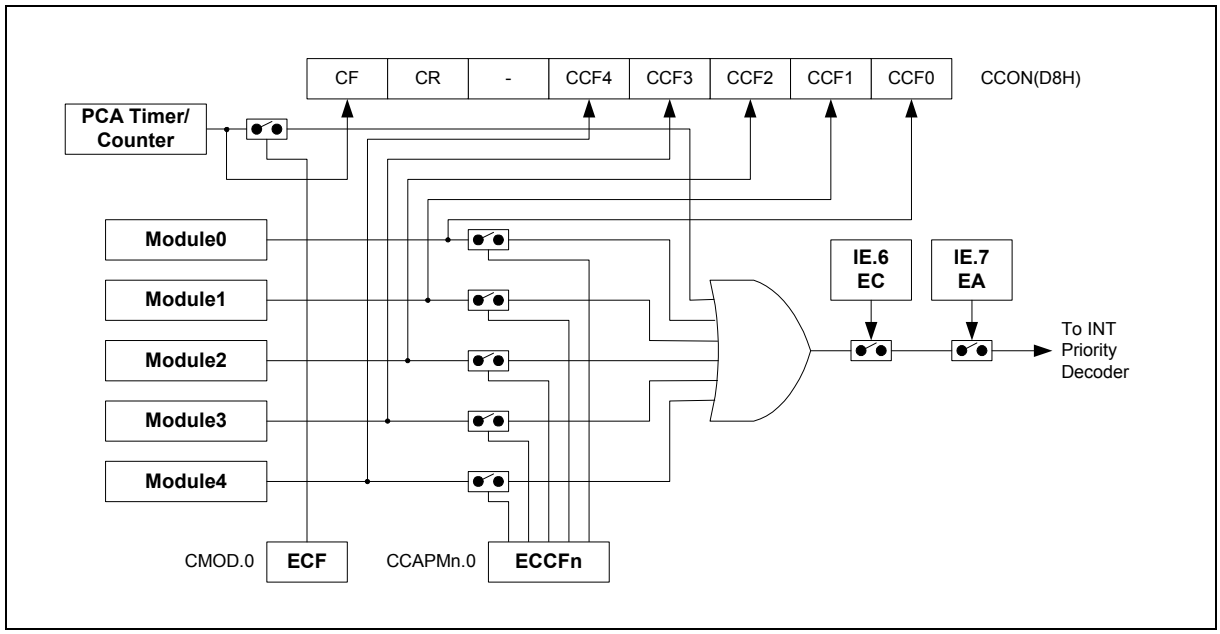


Figure 3 PCA Interrupt System

### 3.3 I/O Pins with PCA Functions

The PCA I/O pins, CEX0 to CEX4, share port 1 from P1.3 to P1.7.

In High speed output mode and PWM mode, the I/O pin is switched to function CEXn output. The output structure is shown as below.

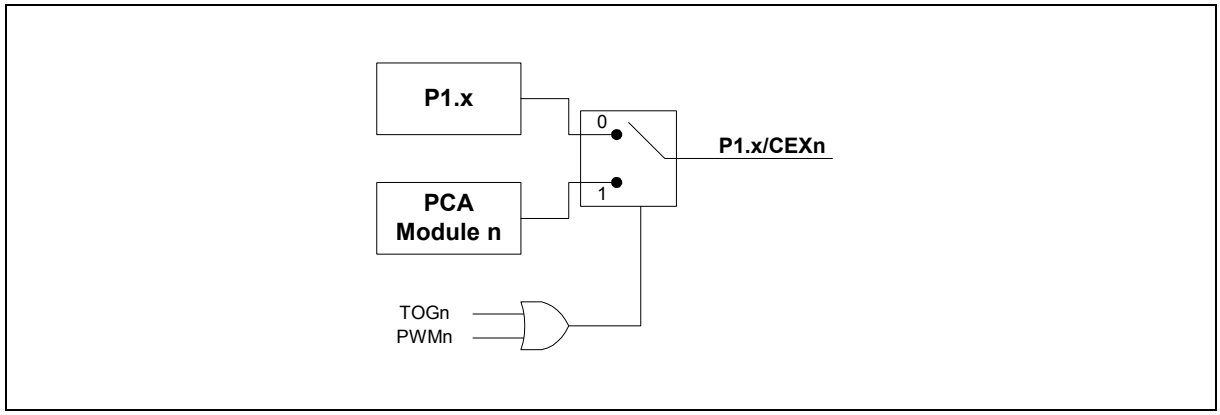


Figure 4 Structure of I/O Pins with PCA Function

## 4. PCA MODES

### 4.1 Capture Mode

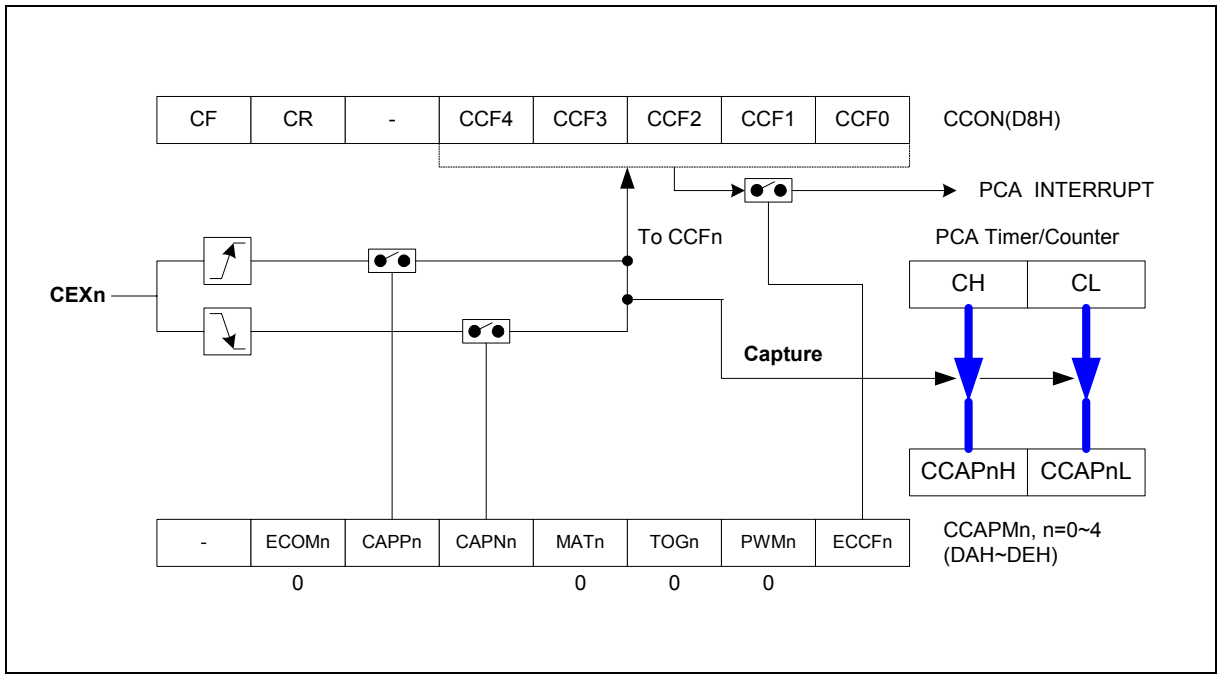


Figure 5 PCA Capture Mode

### 4.1.1 Example

```
;*********************************************************************
; 1. PCA Capture Mode                                                *
;*********************************************************************
PCA_Capture_Positive:
;---Set PCA Timer/Counter-----
        MOV         CCON,#00H           ;Clear all PCA related flags
        MOV         CMOD,#00H           ;PCA clock source is OSC/6(6 clock mode)
        MOV         CH,#00H             ;Reset PCA Counter
        MOV         CL,#00H
;---Set PCA Capture Mode-----
        MOV         CCAPM0,#20H         ;Set Module0 as a 16-bit capture positive mode
                                        ;triggered by pin CEX0
        SETB        CR                  ;Start PCA up-counter
        NOP
Repeat:
        JNB         CCF0,$              ;Wait CCF0 being set
        MOV         A,CCAP0H            ;Get module0 16-bit capture counter
        MOV         B,CCAP0L
        CLR         CCF0
                :
                :
        JMP         Repeat
```

## 4.2 16-bit Software Timer Mode

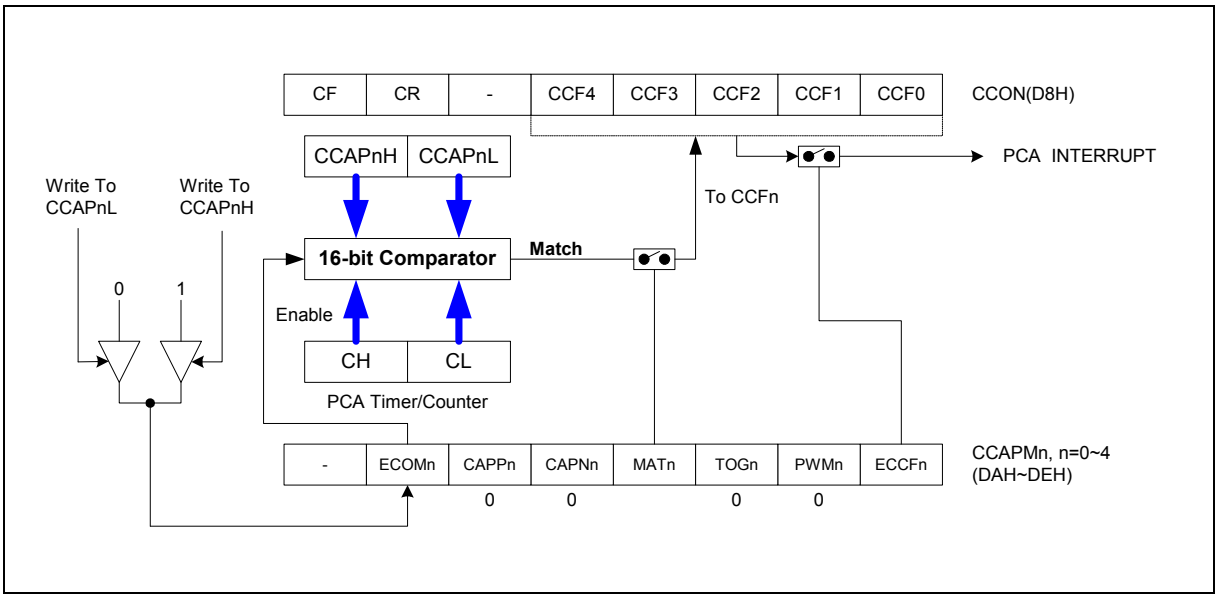


Figure 6. PCA 16-bit Timer Comparator Mode

### 4.2.1 Example

```
;*****************************************************************
; 2. PCA 16-bit Timer/Compare Mode                               *
;*****************************************************************
PCA_Compare_Mode:
;---Set PCA Timer/Counter-----
        MOV         CCON,#00H           ;Clear all PCA related flags
        MOV         CMOD,#00H           ;PCA clock source is OSC/6(6 clock mode)
        MOV         CH,#00H             ;Reset PCA Counter
        MOV         CL,#00H
;---Set PCA Compare Mode-----
        MOV         CCAPM0,#08H         ;Set Module0 as a 16-bit compare mode
        MOV         CCAP0L,#xxH         ;Write Low byte data to CCAP0L and disable Comparator
        MOV         CCAP0H,#yyH         ;Write High byte data to CCAP0H and enable Comparator
        SETB        CR                  ;Start PCA up-counter
        JNB         CCF0,$              ;Wait for comparing match
```

## 4.3 High Speed Output Mode

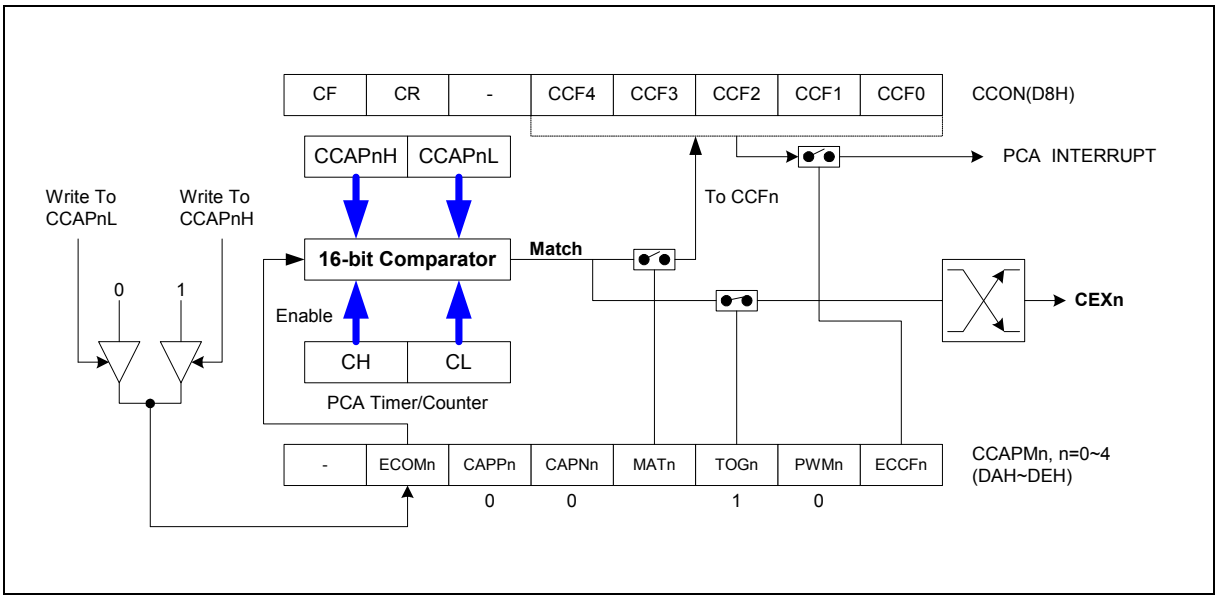


Figure 7. High speed Output Mode

### 4.3.1 Example

```
;*****************************************************************************
; 3. PCA High Speed Output Mode                                              *
;*****************************************************************************
PCA_High_Speed_Mode:
;---Set PCA Timer/Counter-----
        MOV         CCON,#00H           ;Clear all PCA related flags
        MOV         CMOD,#00H           ;PCA clock source is OSC/6(6 clock mode)
        MOV         CH,#00H             ;Reset PCA Counter
        MOV         CL,#00H
;---Set PCA High Speed Output Mode-----
        MOV         CCAPM0,#04H         ;Set 16-bit PCA High Speed Output Mode
        MOV         CCAP0L,#xxH         ;Write Low byte data to CCAP0L and disable Comparator
        MOV         CCAP0H,#yyH         ;Write High byte data to CCAP0H and enable Comparator
        SETB        CR                  ;Start PCA up-counter
        JMP         $                   ;Pin CEX0 outputs the High Speed Output signal
```

## 4.4 PWM Mode

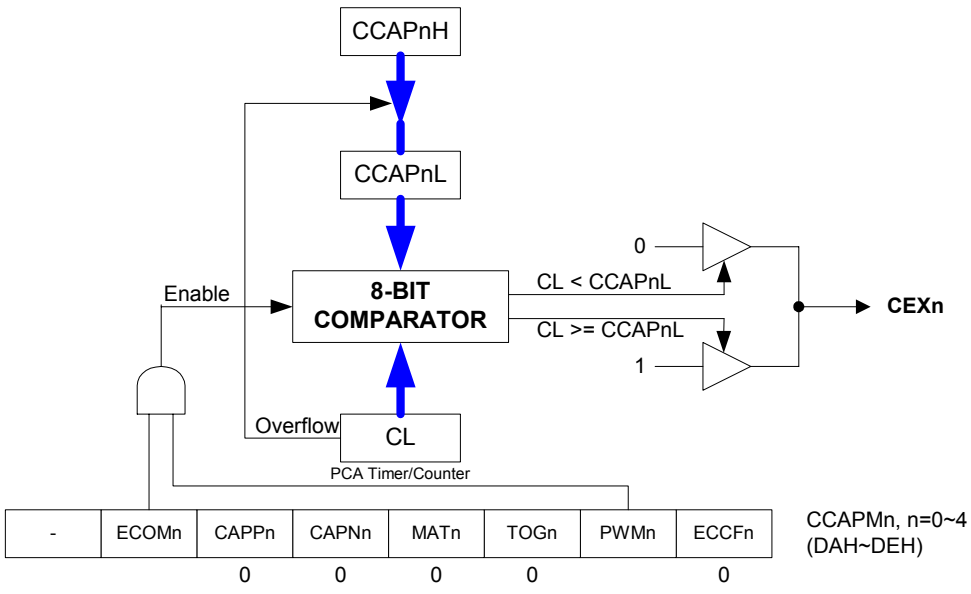


Figure 8. PWM Mode

### 4.4.1 Example

```
;*****************************************************************
; 4. PCA PWM Mode                                                *
;*****************************************************************
PCA_PWM_Mode:
;---Set PCA Timer/Counter-----
        MOV         CCON,#00H           ;Clear all PCA related flags
        MOV         CMOD,#00H           ;PCA clock source is OSC/6(6 clock mode)
        MOV         CH,#00H             ;Reset PCA Counter
        MOV         CL,#00H
;---set PCA PWM Mode----
        MOV         CCAPM0,#42H         ;Set 8-bit PCA PWM Mode
        MOV         CCAP0H,#xxH         ;PWM Duty Cycle=(1-CCAPnH/256)
        MOV         CCAP0L,CCAP0H       ;To ensure the duty cycle in the 1st cycle after PWM starts
                                        ;CL <  CCAPnL, CEXn outputs "0"
                                        ;CL >= CCAPnL, CEXn outputs "1"
        SETB        CR                  ;Start PCA up-counter
        JMP         $                   ;PWM output is from pin CEX0
```

## 4.5 Watchdog Timer Mode

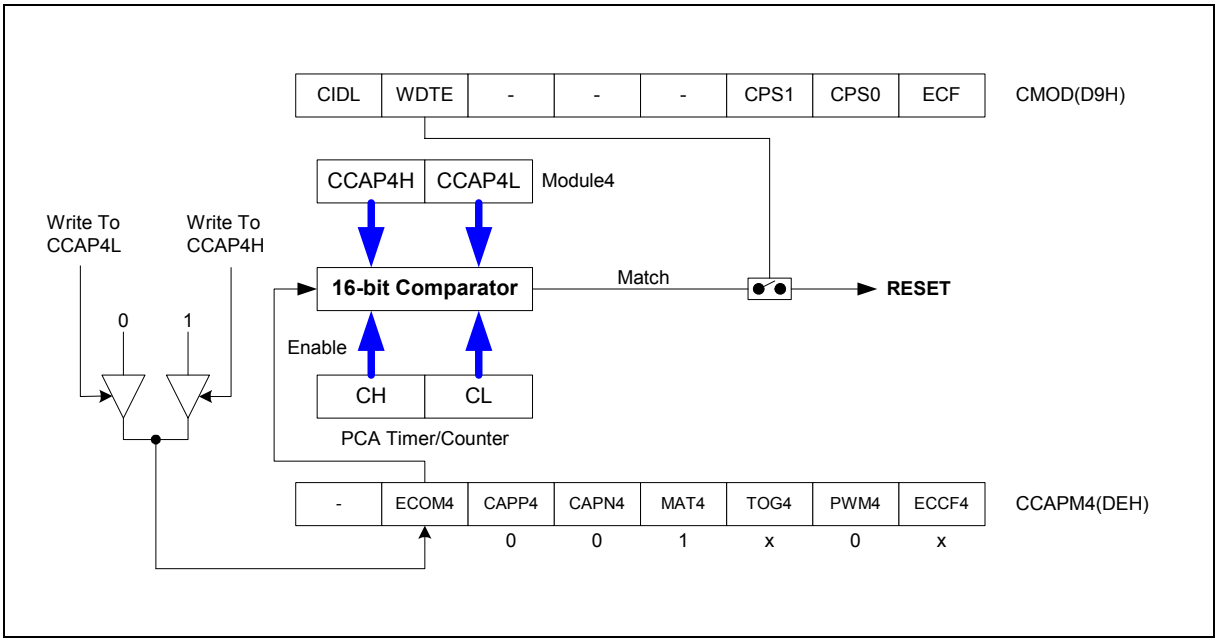


Figure 9. Watchdog Timer Mode

### 4.5.1 Example

```
;*****************************************************************************
; 5. PCA Watchdog Timer Mode(Module4 Only)                    *
;*****************************************************************************
PCA_Watchdog_Timer_Mode:
;---Set PCA Timer/Counter-----
        MOV         CCON,#00H           ;Clear all PCA related flags
        MOV         CMOD,#40H           ;PCA clock source is OSC/6 (6 clock mode)
                                        ;Enable Watchdog Timer(WDTE=1)
        MOV         CH,#00H             ;Reset PCA Counter
        MOV         CL,#00H
;---Set PCA PWM Mode----
        MOV         CCAPM4,#08H         ;Set 16-bit PCA Watchdog Timer Mode
        MOV         CCAP4L,#xxH         ;Set Watchdog Timer Delay Time
        MOV         CCAP4H,#yyH         ;Set high byte and Enable Watchdog Timer Comparator
        SETB    CR                      ;Start PCA up-counter
;-------------------------------------------------------------------------------------------------------------
;The Watchdog Timer is running.
;If (CCAP4H,CCAP4L) and (CH,CL) match, CPU will be reset
;User must change CCAP4L/CCAP4H periodically before comparator match occurs
;-------------------------------------------------------------------------------------------------------------
        JMP         $
```

## 5. REVISION HISTORY

| VERSION | DATE | PAGE | DESCRIPTION |
|---|---|---|---|
| A1 | August, 2004 | - | Initial issue |

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