



Timer 2 功能使用方法

1 適用產品：

- 1.1 SM59R16A2/ SM59R08A2
- 1.2 SM59R16A5/ SM59R09A5/ SM59R05A5
- 1.3 SM59R16A3/ SM59R09A3/ SM59R05A3
- 1.4 SM59R04A2/ SM59R04A1/ SM59R03A1/ SM59R02A1

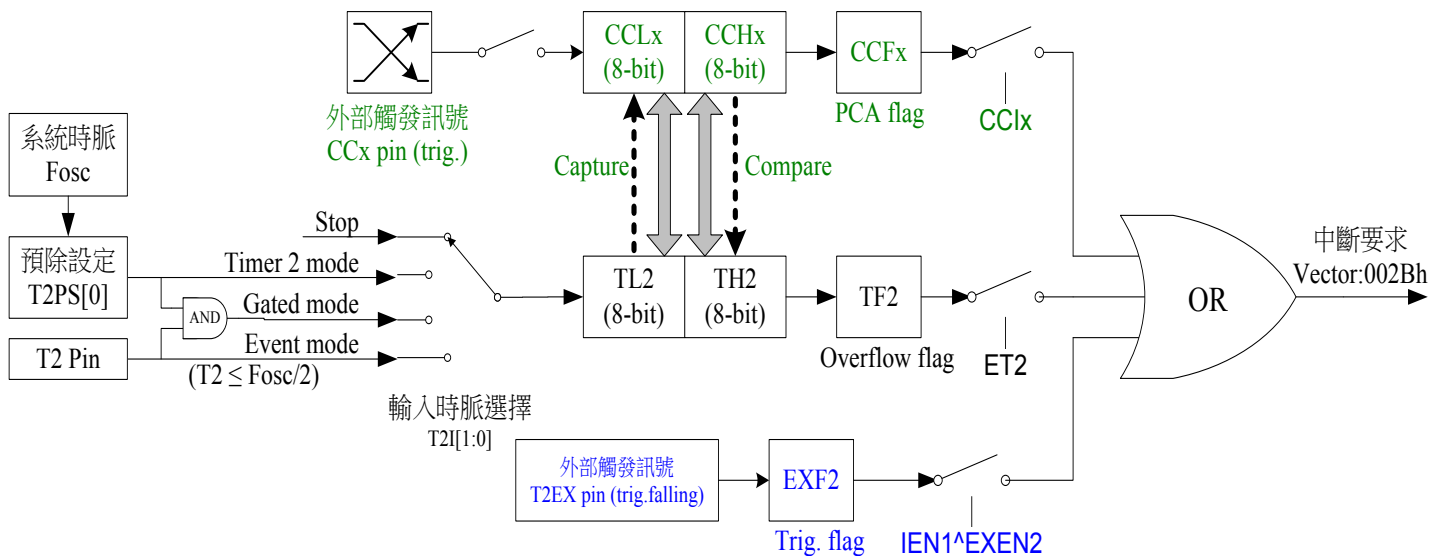
2 Timer 2 使用概述：

2.1 此功能共可區分為三個架構組成：

- (1) Timer2計時／計數輸入頻率
- (2) 重載功能(reload functions)
- (3) PCA功能，包括比較模式(compare)、捕獲模式(capture)

2.2 Timer2 計時／計數輸入頻率，有三種操作模式：

- (1) Timer 2 mode
- (2) Event counter mode
- (3) Gated timer mode





2.3 Timer 2 相關暫存器：

2.3.1 For SM59R04A2/ SM59R04A1/ SM59R03A1/ SM59R02A1 used

Mnemonic	Description	Direct	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	RST
Timer 2 and Capture Compare Unit											
AUX	Auxiliary register	91h	BRS	P4CC	P4SPI	P4UR1	P4IIC	P0KBI	-	DPS	00H

Mnemonic: AUX			Address: 91h							
7	6	5	4	3	2	1	0	Reset		
BRS	P4CC	P4SPI	P4UR1	P4IIC	P0KBI	-	DPS	00H		

P4CC: P4CC = 0 – Capture/Compare function on P1.

P4CC = 1 – Capture/Compare function on P4.

說明: SM59R16A2/ SM59R08A2 無此功能。

2.3.2 For SM59R16A2/ SM59R08A2/ SM59R04A2/ SM59R04A1/ SM59R03A1/ SM59R02A1 used

Mnemonic	Description	Direct	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	RST
Timer 2 and Capture Compare Unit											
T2CON	Timer 2 control	C8h	T2PS	CC0FR	-	T2R[1:0]		T2CM	T2I[1:0]		00h
CCEN	Compare/Capture Enable register	C1h	COCAH3	COCAL3	COCAH2	COCAL2	COCAH1	COCAL1	COCAH0	COCAL0	00h

Mnemonic: T2CON			Address: C8h						
7	6	5	4	3	2	1	0	Reset	
T2PS	CC0FR	-	T2R[1:0]		T2CM	T2I[1:0]		00h	

T2PS: Prescaler select bit 除頻選擇位元

T2PS = 0 – timer 2 輸入頻率預除 12

T2PS = 1 – timer 2 輸入頻率預除 24

CC0FR: Select active edge 觸發緣選擇位

(此位元只用在 PCA Capture mode 的 CC0 使用)

CC0FR = 0 – 負緣觸發

CC0FR = 1 – 正緣觸發

T2R[1:0]: Timer 2 reload mode selection 重載模式選擇位元

T2R[1:0] = 0X – 重載禁能(Reload disabled)

T2R[1:0] = 10 – Mode 0:

當 TH2/TL2 溢位，TH2/TL2 會從 CRCH/CRCL 自動重載

T2R[1:0] = 11 – Mode 1:

當 pin T2EX 有負緣訊號輸入時，TH2/TL2 會從 CRCH/CRCL 做重載。

T2CM: Timer 2 Compare mode selection 比較模式選擇位元

T2CM = 0 – Mode 0

T2CM = 1 – Mode 1



T2I[1:0]: Timer 2 input selection 選擇輸入頻率位元

T2I[1:0] = 00 – Timer 2 stop
停止計數

T2I[1:0] = 01 – Input frequency f/12 or f/24
輸入頻率由系統頻率產生，T2PS 選擇預除頻率

T2I[1:0] = 10 – Timer 2 is incremented by external signal at pin T2
頻率由 pin T2 輸入，並符合條件 $T2 \leq F_{osc}/2$ (unit: Hz)

T2I[1:0] = 11 – internal clock input is gated to the Timer 2
頻率由 Gate 產生 (pin T2 =1 致能；pin T2=0 禁能)

Mnemonic: CCEN

Address: C1h

7	6	5	4	3	2	1	0	Reset
COCAH3	COCAL3	COCAH2	COCAL2	COCAH1	COCAL1	COCAH0	COCAL0	00h

COCAH3,COCAL3: Compare/capture mode for Channel 3.

COCAH3	COCAL3	Function
0	0	Compare/capture disable 禁能
0	1	Capture on rising edge at pin CC3 正緣捕捉模式
1	0	Compare enable 比較模式
1	1	Capture on write operation into register CCL3 寫值 捕捉模式

COCAH2,COCAL2: Compare/Capture mode for Channel 2.

COCAH2	COCAL2	Function
0	0	Compare/capture disable 禁能
0	1	Capture on rising edge at pin CC2 正緣捕捉模式
1	0	Compare enable 比較模式
1	1	Capture on write operation into register CCL2 寫值 捕捉模式

COCAH1,COCAL1: Compare/Capture mode for Channel 1.

COCAH1	COCAL1	Function
0	0	Compare/capture disable 禁能
0	1	Capture on rising edge at pin CC1 正緣捕捉模式
1	0	Compare enable 比較模式
1	1	Capture on write operation into register CCL1 寫值 捕捉模式

COCAH0,COCAL0: Compare/Capture mode for CRC register (Channel 0)

COCAH0	COCAL0	Function
0	0	Compare/capture disable 禁能
0	1	Capture on falling/rising edge at pin CC0 正緣或負 緣(預設)捕捉模式，由 $T2CON \wedge CC0FR$ 決定。
1	0	Compare enable 比較模式
1	1	Capture on write operation into register CRCL 寫值 捕捉模式

2.3.3 For SM59R16A5/SM59R09A5/SM59R05A5/SM59R16A3/SM59R09A3/SM59R05A3



Mnemonic	Description	Direct	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	RESET
Timer 2 and Capture Compare Unit											
AUX	Auxiliary register	91h	BRS	-	P4SPI	P4UR1	P4IIC	P0KBI	P2PWM	DPS	00H
AUX2	Auxiliary register2	92h	-	-	-	-	-	-	P42CC[1:0]		
T2CON	Timer 2 control	C8h	T2PS[2:0]			T2R[1:0]		-	T2I[1:0]		00h
CCEN	Compare/Capture Enable register	C1h	-	COCAM1[2:0]			-	COCAM0[2:0]			00h
CCEN2	Compare/Capture Enable 2 register	D1h	-	COCAM3[2:0]			-	COCAM2[2:0]			00h

Mnemonic: AUX2 Address: 92h

7	6	5	4	3	2	1	0	Reset
							P42CC[1:0]	00H

- P42CC[1:0] 00: Capture/Compare function on Port1.
 01: Capture/Compare function on Port2
 10: Capture/Compare function on Port4
 11: reserved

Mnemonic: T2CON Address: C8h

7	6	5	4	3	2	1	0	Reset
T2PS[2:0]			T2R[1:0]		-	T2I[1:0]		00H

T2PS[2:0]: Prescaler select bit: 輸入頻率，預除頻選擇位元

- T2PS = 000 – timer 2 is clocked with the oscillator frequency.
- T2PS = 001 – timer 2 is clocked with 1/2 of the oscillator frequency. 預除 2
- T2PS = 010 – timer 2 is clocked with 1/4 of the oscillator frequency. 預除 4
- T2PS = 011 – timer 2 is clocked with 1/6 of the oscillator frequency. 預除 6
- T2PS = 100 – timer 2 is clocked with 1/8 of the oscillator frequency. 預除 8
- T2PS = 101 – timer 2 is clocked with 1/12 of the oscillator frequency. 預除 12
- T2PS = 110 – timer 2 is clocked with 1/24 of the oscillator frequency. 預除 24

T2R[1:0]: Timer 2 reload mode selection 重載模式選擇位元

- T2R[1:0] = 0X – Reload disabled
重載禁能
- T2R[1:0] = 10 – Mode 0
當 TH2/TL2 溢位，TH2/TL2 會從 CRCH/CRCL 自動重載
- T2R[1:0] = 11 – Mode 1
當 pin T2EX 有負緣訊號輸入時，TH2/TL2 會從 CRCH/CRCL 做重載

T2I[1:0]: Timer 2 input selection 選擇輸入頻率位元

- T2I[1:0] = 00 – Timer 2 stop
停止計數
- T2I[1:0] = 01 – Input frequency from T2PS
輸入頻率由系統頻率產生，T2PS 選擇預除頻率
- T2I[1:0] = 10 – Timer 2 is incremented by external signal at pin T2
頻率由 pin T2 輸入，並符合條件 $T2 \leq F_{osc}/2$ (unit: Hz)
- T2I[1:0] = 11 – internal clock input is gated to the Timer 2
頻率由 Gate 產生 (pin T2 =1 致能；pin T2=0 禁能)



Mnemonic: CCEN				Address: C1h				
7	6	5	4	3	2	1	0	Reset
--	COCAM1[2:0]		--	COCAM0[2:0]		00H		

- COCAM1[2:0] 000: Compare/Capture disable 禁能
 001: Compare enable but no output on Pin
 010: Compare mode 0
 011: Compare mode 1
 100: Capture on rising edge at pin CC1 正緣捕捉
 101: Capture on falling edge at pin CC1 負緣捕捉
 110: Capture on both rising and falling edge at pin CC1 正/負緣捕捉
 111: Capture on write operation into register CC1 寫值捕捉
- COCAM0[2:0] 000: Compare/Capture disable 禁能
 001: Compare enable but no output on Pin
 010: Compare mode 0
 011: Compare mode 1
 100: Capture on rising edge at pin CC0 正緣捕捉
 101: Capture on falling edge at pin CC0 負緣捕捉
 110: Capture on both rising and falling edge at pin CC0 正/負緣捕捉
 111: Capture on write operation into register CC0 寫值捕捉

Mnemonic: CCEN2				Address: D1h				
7	6	5	4	3	2	1	0	Reset
--	COCAM3[2:0]		--	COCAM2[2:0]		00H		

- COCAM3[2:0] 000: Compare/Capture disable 禁能
 001: Compare enable but no output on Pin
 010: Compare mode 0
 011: Compare mode 1
 100: Capture on rising edge at pin CC3 正緣捕捉
 101: Capture on falling edge at pin CC3 負緣捕捉
 110: Capture on both rising and falling edge at pin CC3 正/負緣捕捉
 111: Capture on write operation into register CC3 寫值捕捉
- COCAM2[2:0] 000: Compare/Capture disable 禁能
 001: Compare enable but no output on Pin
 010: Compare mode 0
 011: Compare mode 1
 100: Capture on rising edge at pin CC2 正緣捕捉
 101: Capture on falling edge at pin CC2 負緣捕捉
 110: Capture on both rising and falling edge at pin CC2 正/負緣捕捉
 111: Capture on write operation into register CC2 寫值捕捉

2.3.4 The Same Registers

Mnemonic	Description	Direct	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	RESET
----------	-------------	--------	-------	-------	-------	-------	-------	-------	-------	-------	-------

Specifications subject to change without notice, contact your sales representatives for the most recent information.



Timer 2 and Capture Compare Unit											
CCCON	Compare/Capture Control	C9h	CCI3	CCI2	CCI1	CCI0	CCF3	CCF2	CCF1	CCF0	00H
TL2	Timer 2, low byte	CCh	TL2[7:0]								00h
TH2	Timer 2, high byte	CDh	TH2[7:0]								00h
CRCL	Compare/Reload/Capture register, low byte	CAh	CRCL[7:0]								00h
CRCH	Compare/Reload/Capture register, high byte	CBh	CRCH[7:0]								00h
CCL1	Compare/Capture register 1, low byte	C2h	CCL1[7:0]								00h
CCH1	Compare/Capture register 1, high byte	C3h	CCH1[7:0]								00h
CCL2	Compare/Capture register 2, low byte	C4h	CCL2[7:0]								00h
CCH2	Compare/Capture register 2, high byte	C5h	CCH2[7:0]								00h
CCL3	Compare/Capture register 3, low byte	C6h	CCL3[7:0]								00h
CCH3	Compare/Capture register 3, high byte	C7h	CCH3[7:0]								00h

Compare/Capture Control Register:

Mnemonic: CCCON								Address: C9h	
7	6	5	4	3	2	1	0	Reset	
CCI3	CCI2	CCI1	CCI0	CCF3	CCF2	CCF1	CCF0	00H	

CCI3: Compare/Capture 3 interrupt control bit.
"1" is enable.

CCI2: Compare/Capture 2 interrupt control bit.
"1" is enable.

CCI1: Compare/Capture 1 interrupt control bit.
"1" is enable.

CCI0: Compare/Capture 0 interrupt control bit.
"1" is enable.

CCF3: Compare/Capture 3 flag set by hardware. This flag can be cleared by software.

CCF2: Compare/Capture 2 flag set by hardware. This flag can be cleared by software.

CCF1: Compare/Capture 1 flag set by hardware. This flag can be cleared by software.

CCF0: Compare/Capture 0 flag set by hardware. This flag can be cleared by software.

Compare/Capture interrupt share T2 interrupt vector: 2Bh.



3 Timer 2 功能說明：

3.1 Timer2 計時／計數輸入頻率，可選擇以下三種操作模式：

□ Timer mode

當 $T2CON^T2I=01$ ：timer 2輸入頻率由系統頻率 F_{osc} 產生，頻率預除由T2PS(除頻選擇位)設定。

□ Event counter mode

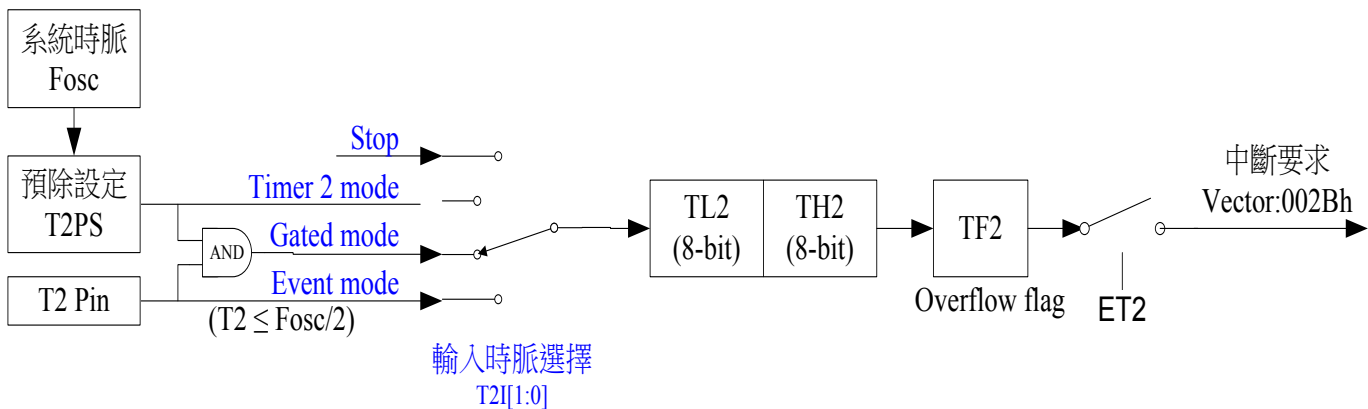
當 $T2CON^T2I=10$ ：timer 2輸入頻率可由外部訊號輸入至pin T2，可達到最快的取樣頻率，唯必須符合條件：取樣頻率 $T2 \leq F_{osc}/2$ 。

□ Gated timer mode

當 $T2CON^T2I=11$ ：timer 2輸入頻率由系統頻率 F_{osc} 產生，頻率預除由T2PS(除頻選擇位)設定，且會用pin T2做為硬體致能引腳：

當pin T2=1，致能gated mode。

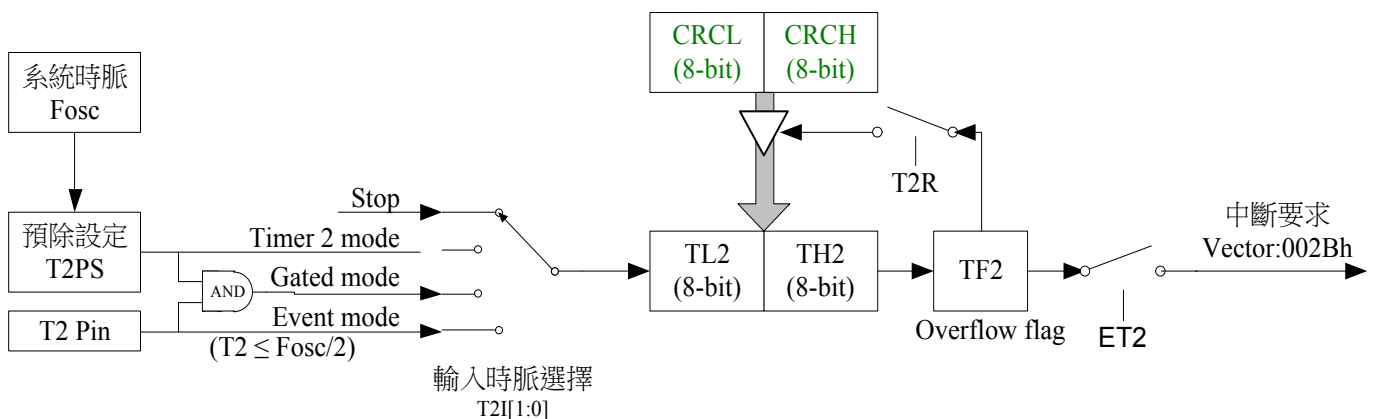
當pin T2=0，禁能gated mode。



3.2 重載模式 Auto-reload

重載模式有以下兩種：

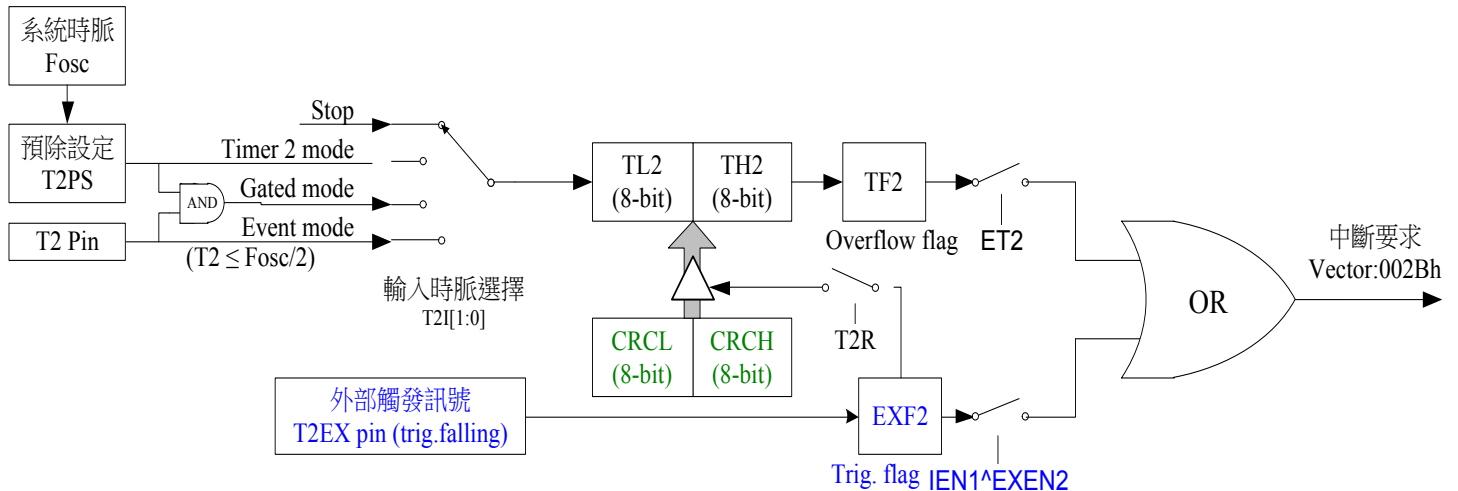
Mode 0: 當 $TH2/TL2$ 溢位， $TH2/TL2$ 會從 $CRCH/CRCL$ 自動重載。





Mode 1: 當pin T2EX有負緣訊號輸入時，TH2/TL2會從CRCH/CRCL做一次重載。

(另可由 IEN1 設定，當 pin T2EX 有負緣時，產生外部重載中斷 external reload，EXF2: Timer 2 external reload flag, must be cleared by software)



3.3 比較模式(compare)、捕獲模式(capture)功能說明

3.3.1 各系列功能腳位對應如下表

SM59R16A5/SM59R09A5/SM59R05A5/SM59R16A3/SM59R09A3/SM59R05A3 :

Output Register (CCx pin)	Shadow Register			
	00	01	10	11
AUX2	00	01	10	11
CC0	P1.0	P2.0	P4.0	-
CC1	P1.1	P2.1	P4.1	-
CC2	P1.3	P2.2	P4.2	-
CC3	P1.4	P2.3	P4.3	-

SM59R04A2/ SM59R04A1/ SM59R03A1/ SM59R02A1 :

Output Register (CCx pin)	Shadow Register			
	0	1	-	-
AUX^P4CC	0	1	-	-
CC0	P1.0	P4.0	-	-
CC1	P1.1	P4.1	-	-
CC2	P1.3	P4.2	-	-
CC3	P1.4	P4.3	-	-



SM59R16A2/ SM59R08A2 :

Output Register (CCx pin)	Shadow Register			
CC0	P1.4	-	-	-
CC1	P1.5	-	-	-
CC2	P1.2	-	-	-
CC3	P1.3	-	-	-

3.3.2 比較模式

Compare function (Timer 2 的比較模式)

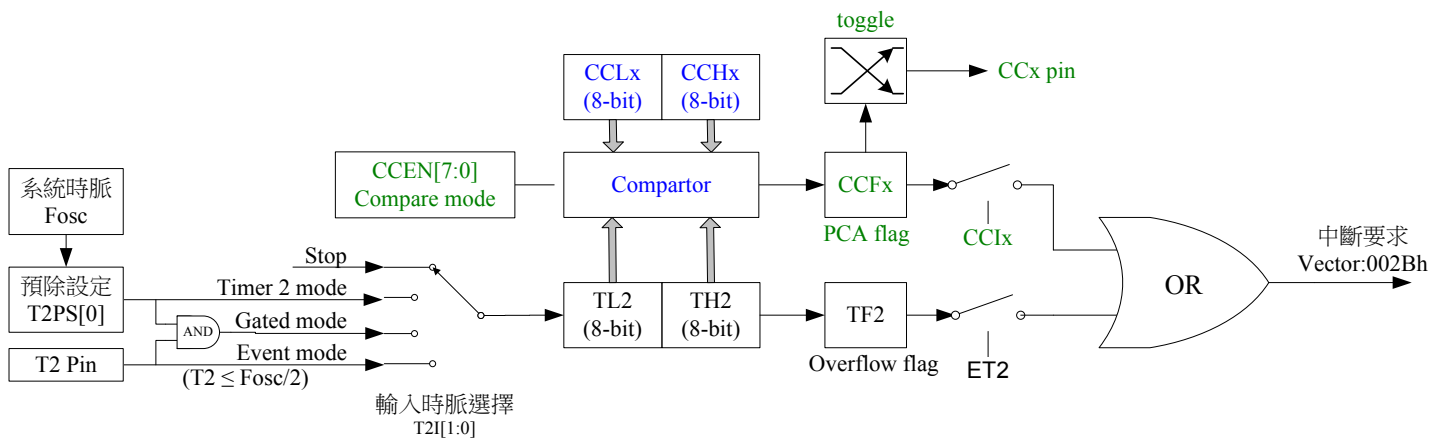
- 四個獨立的比較位，SFR [TH2:TL2]與SFR [CCHX:CCLX]內容做比較，比較的結果會輸出至 Output Register。
- 設定條件： $[TH2:TL2] < [CCHx:CCLx]$ (or $[CRCH:CRCL] < 0xFFFF$).

SM59R16A5/SM59R09A5/SM59R05A5/SM59R16A3/SM59R09A3/SM59R05A3:

- 比較模式由CCEN致能及選擇Compare mode 0或1。

SM59R16A2/ SM59R08A2/ SM59R04A2/ SM59R04A1/ SM59R03A1/ SM59R02A1:

- 比較模式由CCEN致能，T2COM^T2CM選擇Compare mode 0或1。



Compare Mode 0

當設定[COCAHx:COCALx]=[1:0]為比較模式：

1. Timer 2 start count：若[TH2:TL2]沒有設定初始值，[TH2:TL2]將由0h開始計數。此時CCx pin會一直維持低電位，直到轉態發生。
2. Toggle occur：當[TH2:TL2] > [CCHx:CCLx](或[CRCH:CRCL])時，即為轉態發生(toggle occur)。CCx pin輸出由低電位轉為高電位。
3. **Overflow occur**：當[TH2:TL2] > FFFFh時產生溢位若[TH2:TL2]沒有設定初始值，[TH2:TL2]將由0h開始重新計數。**CCx pin輸出由高電位轉為低電位。**



設定說明：

1. 此模式可應用於PWM，對於CCx pin只可當作輸出，無法輸入。
2. 此模式輸出頻率可以T2CON決定，duty cycle由[CCHx:CCLx](or [CRCH:CRCL])決定。

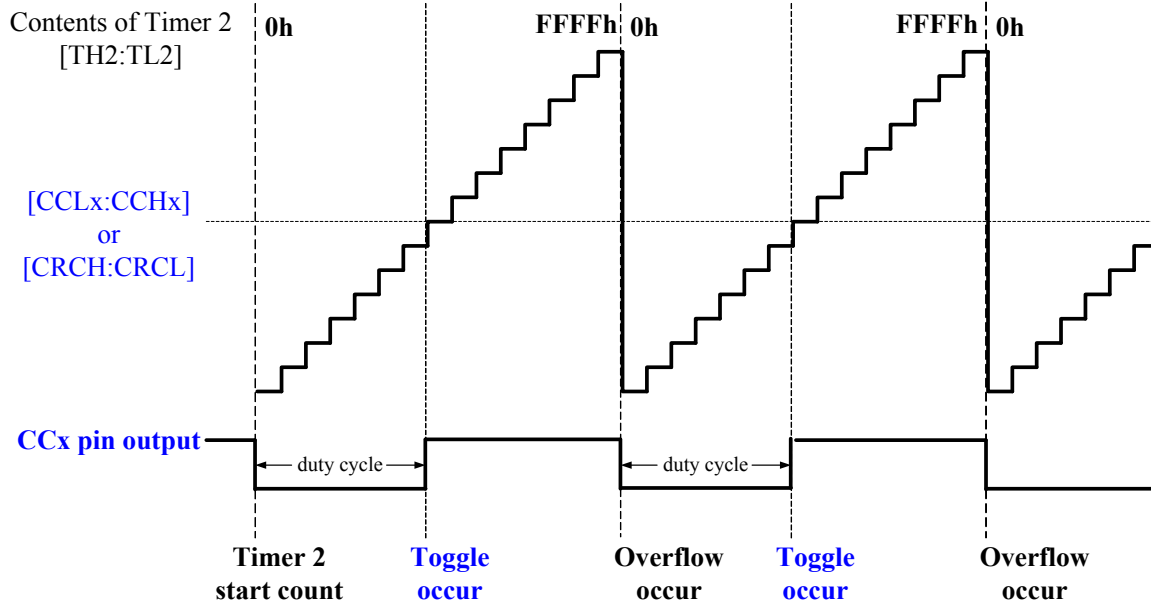


Fig. Compare mode 0 function

Compare Mode 0 + H/W Auto reload Function

當設定[COCAHx:COCALx]=[1:0]為比較模式，及T2R[1:0]設定啟動重載：

1. Timer 2 start count：若[TH2:TL2]沒有設定初始值，[TH2:TL2]將由0h開始計數。此時CCx pin會一直維持低電位(預設)，直到轉態發生。
2. Toggle occur：當[TH2:TL2] > [CCHx:CCLx]時，即為轉態發生(toggle occur)。CCx pin輸出由低電位轉為高電位。
3. **Overflow occur**：當[TH2:TL2] > FFFFh時產生溢位，同時[TH2:TL2]會由[CRCH:CRCL]硬件自動重載。**CCx pin輸出由高電位轉為低電位。**

設定說明：

1. 當Compare output及H/W Auto reload同時致能，只可以使用CC1~CC3 pin當做輸出；因[CRCH:CRCL]被當做[TH2:TL2]的重載暫存器，所以CC0不可再當做Compare output使用。
2. 設定條件：[TH2:TL2] < [CCHx:CCLx] < 0xFFFF。
3. 此模式可應用於PWM產生，對於CCx pin只可當作輸出，無法輸入。
4. 此模式輸出頻率由T2CON及[CRCH:CRCL]決定，duty cycle由[CCHx:CCLx]決定。

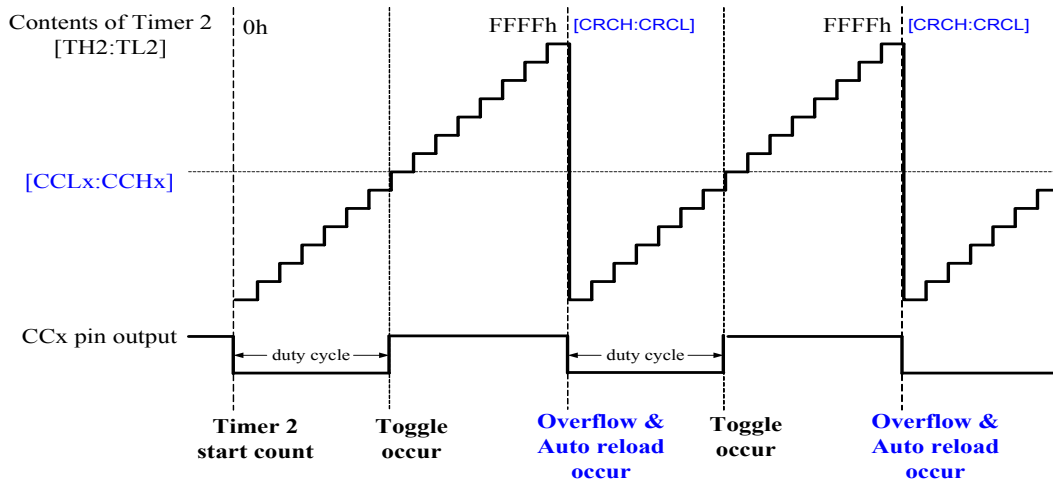


Fig. Compare mode 0 + H/W Auto reload

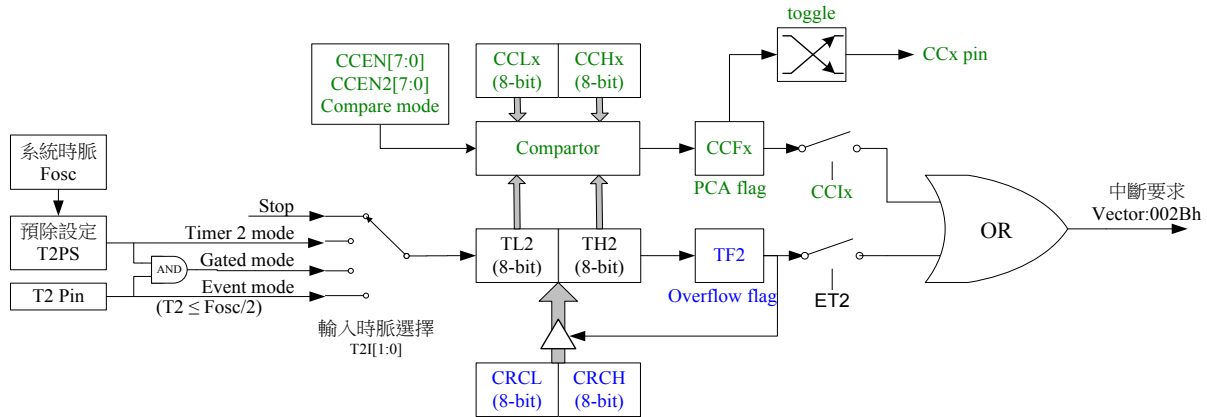
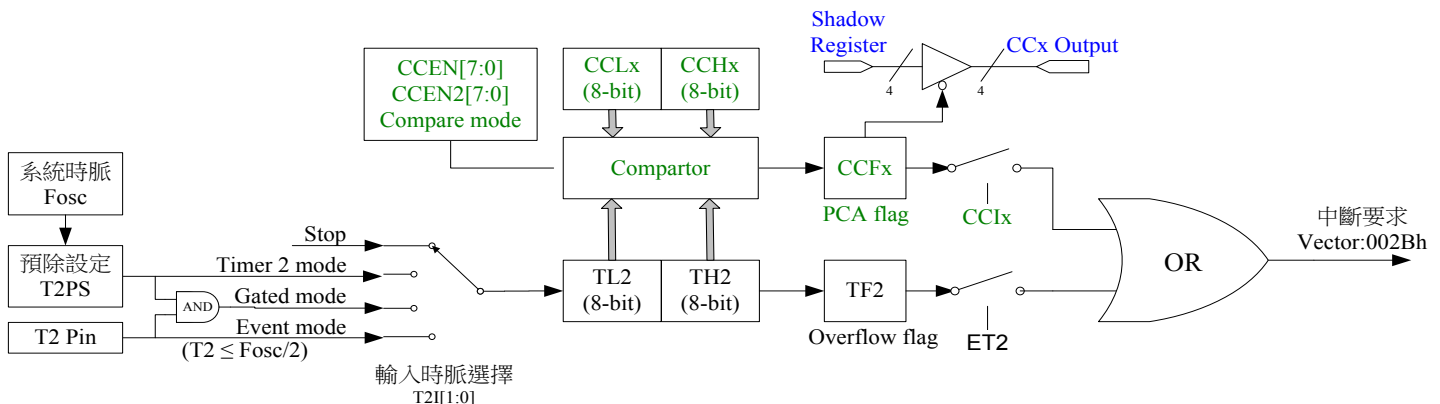


Fig. Compare mode 0 + H/W auto reload function

Compare Mode 1

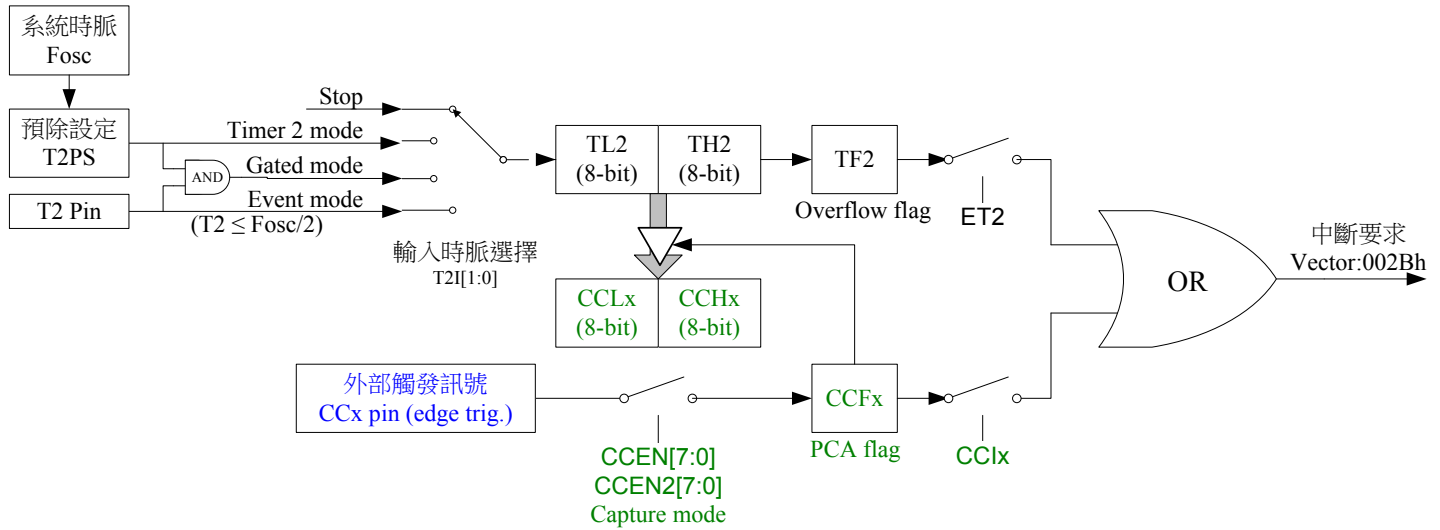
當[TH2:TL2]等於[CCHx:CCLx]或[CRCH:CRCL]時，會將Shadow Register的狀態輸出至CCx；當[TH2:TL2]溢位時不會有任何輸出訊號改變。



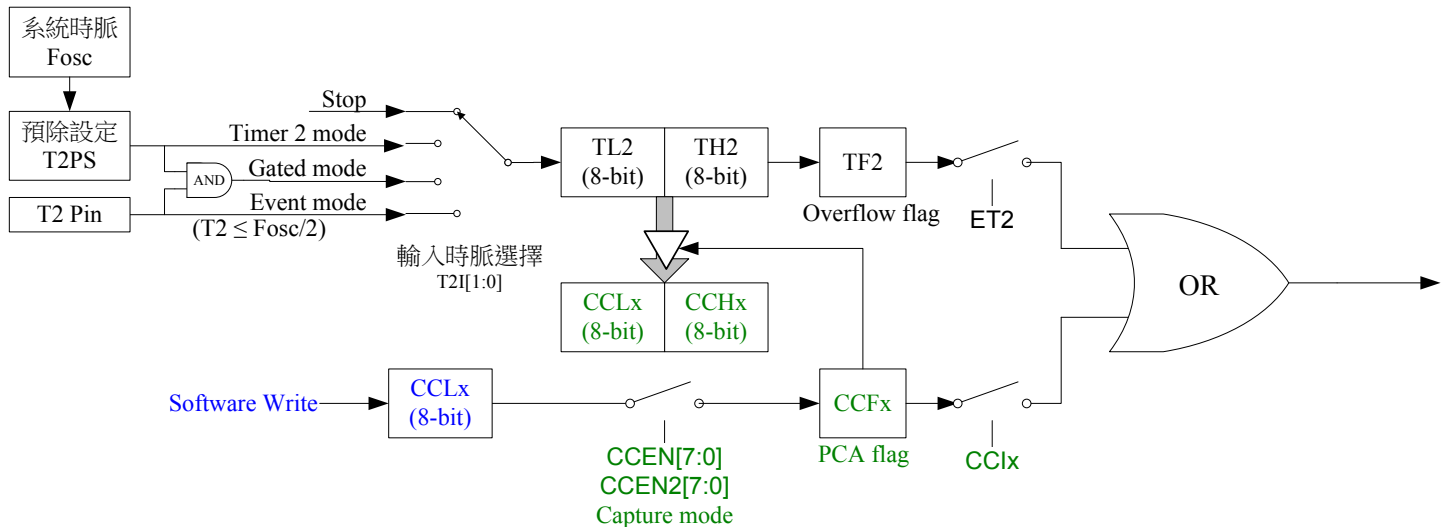


3.3.3 捕獲模式 Capture function

緣捕提(edge trig.)：當pin CCx有負(或正)緣訊號時，執行捕獲，將TL2:TH2載至CCLx:CCHx，可應用於脈寬偵測。



寫值捕提(software write)：當暫存器CCLx寫入任意值時，執行捕獲模式，將TL2:TH2載至CCLx:CCHx。





3.4 Timer 2 中斷

3.4.1 中斷向量表(Interrupt vectors table) :

Table 11-1: Interrupt vectors

Interrupt Request Flags	Interrupt Vector Address	Interrupt Number *(use Keil C Tool)
IE0 – External interrupt 0	0003h	0
TF0 – Timer 0 interrupt	000Bh	1
IE1 – External interrupt 1	0013h	2
TF1 – Timer 1 interrupt	001Bh	3
RI0/TI0 – Serial channel 0 interrupt	0023h	4
TF2/EXF2 – Timer 2 interrupt	002Bh	5
PWMIF – PWM interrupt	0043h	8
SPIIF – SPI interrupt	004Bh	9
ADCIF – A/D converter interrupt	0053h	10
KBIIF – keyboard Interface interrupt	005Bh	11
LVIIIF – Low Voltage Interrupt	0063h	12
IICIF – IIC interrupt	006Bh	13
RI1/TI1 – Serial channel 1 interrupt	0083h	16

*See Keil C about C51 User's Guide about Interrupt Function description

3.4.2 中斷相關暫存器(Interrupt SFR)

Mnemonic	Description	Direct	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	RESET
Interrupt											
IEN0	Interrupt Enable 0 register	A8h	EA	-	ET2	ES0	ET1	EX1	ET0	EX0	00h
IEN1	Interrupt Enable 1 register	B8h	EXEN2	-	IEIIC	IELVI	IEKBI	IEADC	IESPI	IEPWM	00h
IEN2	Interrupt Enable 2 register	9Ah	-	-	-	-	-	-	-	ES1	00h
IRCON	Interrupt request register	C0h	EXF2	TF2	IICIF	LVIIIF	KBIIF	ADCIF	SPIIF	PWMIF	00h
IP0	Interrupt priority level 0	A9h	-	-	IP0.5	IP0.4	IP0.3	IP0.2	IP0.1	IP0.0	00h
IP1	Interrupt priority level 1	B9h	-	-	IP1.5	IP1.4	IP1.3	IP1.2	IP1.1	IP1.0	00h



Interrupt Enable 0 register(IEN0)

Mnemonic: IEN0							Address: A8h	
7	6	5	4	3	2	1	0	Reset
EA	-	ET2	ES0	ET1	EX1	ET0	EX0	00h

EA: EA = 0 : disable all interrupt.

EA = 1 : enable all interrupt.

ET2: ET2 = 0 : 禁能 Timer 2 溢位中斷及 Timer 2 T2EX 外部中斷。

(disable Timer 2 overflow interrupt or Timer 2 external reload interrupt.)

ET2 = 1 : 致能 Timer 2 溢位中斷及 Timer 2 T2EX 外部中斷。

(enable Timer 2 overflow interrupt or Timer 2 external reload interrupt.)

ES0: ES0=0 – Disable Serial channel 0 interrupt.

ES0=1 – Enable Serial channel 0 interrupt.

ET1: ET1=0 – Disable Timer 1 overflow interrupt.

ET1=1 – Enable Timer 1 overflow interrupt.

EX1: EX1=0 – Disable external interrupt 1.

EX1=1 – Enable external interrupt 1.

ET0: ET0=0 – Disable Timer 0 overflow interrupt.

ET0=1 – Enable Timer 0 overflow interrupt.

EX0: EX0=0 – Disable external interrupt 0.

EX0=1 – Enable external interrupt 0.

Interrupt Enable 1 register(IEN1)

Mnemonic: IEN1							Address: B8h	
7	6	5	4	3	2	1	0	Reset
EXEN2	-	IEIIC	-	IEEEI	IEADC	IESPI		00h

EXEN2: Timer 2 外部中斷致能位(Timer 2 reload interrupt enable)。

若使用該功能時 IEN0^ET2 也必須致能

EXEN2 = 0 : 禁能 Timer 2 溢位中斷及 Timer 2 T2EX 外部中斷。

(disable Timer 2 external reload interrupt.)

EXEN2 = 1 : 致能 Timer 2 T2EX 外部中斷。

(enable Timer 2 external reload interrupt.)

IEIIC: IIC interrupt enable.

IEIICS = 0 – Disable IIC interrupt.

IEIICS = 1 – Enable IIC interrupt.

IELVI: LVI interrupt enable.

IELVI = 0 – Disable LVI interrupt.

IELVI = 1 – Enable LVI interrupt.



- IEKBI: KBI interrupt enable.
IEKBI = 0 – Disable KBI interrupt.
IEKBI = 1 – Enable KBI interrupt.
- IEADC: A/D converter interrupt enable
IEADC = 0 – Disable ADC interrupt.
IEADC = 1 – Enable ADC interrupt.
- IESPI: SPI interrupt enable.
IESPI = 0 – Disable SPI interrupt.
IESPI = 1 – Enable SPI interrupt.
- IEPWM: PWM interrupt enable.
IEPWM = 0 – Disable PWM interrupt.
IEPWM = 1 – Enable PWM interrupt.

Interrupt request register(IRCON)

Mnemonic: IRCON									Address: C0h
7	6	5	4	3	2	1	0	Reset	
EXF2	TF2	IICIF	LVIIIF	KBIIF	ADCIF	SPIIF	PWMIF	00H	

EXF2: Timer 2 external reload flag. Must be cleared by software.

TF2: Timer 2 overflow flag. Must be cleared by software.

IICIF: IIC interrupt flag. Must be cleared by software.

LVIIIF: LVI interrupt flag. Must be cleared by software.

KBIIF: KBI interrupt flag. Must be cleared by software.

ADCIF: A/D converter end interrupt flag. Must be cleared by software.

SPIIF: SPI interrupt flag. Must be cleared by software.

PWMIF: PWM interrupt flag. Must be cleared by software.

3.4.3 Timer 2 中斷應用參考程式及設定：

(1) 中斷致能設定：

```
IEN0 |= 0xA0; //Enable interrupt All & Timer 2 interrupt
IEN1 |= 0x80; //Enable Timer 2 external reload interrupt
```

(2) 中斷程式表示：

```
void T2_interrupt(void) interrupt 5
{
    if(EXF2==1)
    {
        EXF2=0; //T2EX - external interrupt
    }
}
```

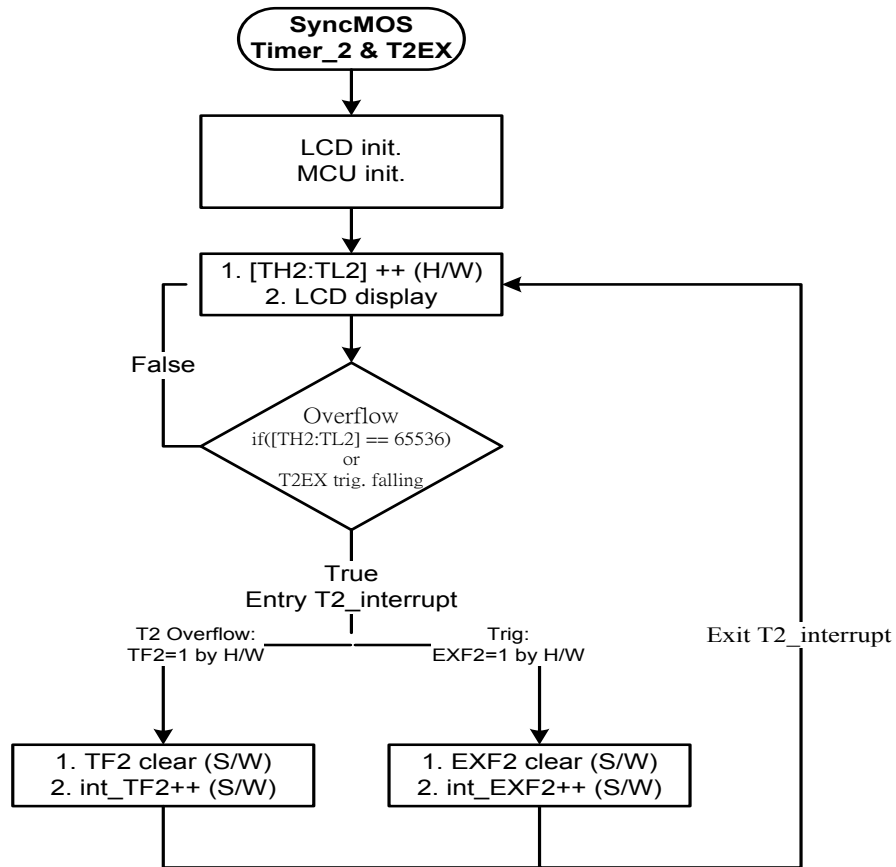



```

}
if (TF2==1)
{
    TF2=0;           //over flow interrupt
}
P2 =~P2;           //detect interrupt freq.
}
    
```

3.5 Timer 2 範例程式

3.5.1 Timer 2 範例程式(一)的流程圖:



3.5.2 Timer 2 應用的範例程式(一)

Description	1. 此範例可觀看 Timer_2 溢位中斷斷旗及 Timer_2 外部中斷旗標之變化。
--------------------	--



	<ol style="list-style-type: none"> 2. 兩中斷共同使用中斷向量位址 (002Bh) , 可用旗標在中斷副程式區分。 3. [TH2:TL2]使用軟體重載(歸零)方式(software reload)。 4. 當[TH2:TL2]溢位時, 觸發 TF2, Timer_2 溢位中斷產生。 5. 當 Pin T2EX 有負緣訊號時, 觸發 EXF2, Timer_2 外部中斷產生。
<p>Main program</p>	<pre>//===== // // S Y N C M O S T E C H N O L O G Y // //===== // Device:SM59R16A2/SM59R08A2 // Description: // 1. Timer_2 overflow interrupt & Timer_2 External interrupt(EXT2)use // the same interrupt vector(002Bh) // 2. Entry Timer_2 interrupt when overflow ([TH2:TL2]=65536) or pin // T2EX trigger a falling signal. //===== #include "..\h\SM59R16A2.h" #include "..\h\SM59R16A2_ExtraDef.h" #include "..\MISC\Delay.h" #include "..\LCD\LCD16x2.h" unsigned int Temp_TF2 =0, Temp_EXF2 =0; void T2_interrupt(void) interrupt 5 { if(TF2==1) { TF2=0; //over flow interrupt Temp_TF2++; } if(EXF2==1) { EXF2=0; //T2EX - external interrupt Temp_EXF2++; } TH2=0x00; TL2=0x00; P5 = ~P5; // test, detect T2 interrupt } void OSD(void) { PrintLcdStrLX(1, 0, "TF2= "); PrintLcdStrLX(2, 0, "EXF2= "); }</pre>



```

        SetCursorAddr(1, 5);    PrintLcdDec(Temp_TF2);
        SetCursorAddr(2, 5);    PrintLcdDec(Temp_EXF2);
    }

void MCU_init(void)
{
    // Timer 2=====
    TH2 = 0x00;    // PWM period= 0~65536 clk
    TL2 = 0x00;
    T2CON = 0x01;    // Counter from Timer2 = OSC/12
// T2CON = 0x81;    // Counter from Timer2 = OSC/24

    // Timer 2 interrupt setting=====
    IEN0 |= 0x80;    // All interrupt Enable
    IEN0 |= 0x20;    // Enable Timer 2 overflow interrupt
    IEN1 |= 0x80;    // Enable Timer 2 External interrupt
}

void main(void)
{
    Delay10mSec(2); //wait for system stable
    LCD_Init();
    MCU_init();

    while(1)
    {
        OSD();
        Delay10mSec(2);
    }
}

```

3.5.3 Timer 2應用的範例程式(二)

Description	<ol style="list-style-type: none"> 1. 此為上一範例的進一步應用，使用的特殊功能暫存器相同，在中斷部分及 OSD 顯示有些差異，主要可利用 (1) Timer_2 溢位中斷斷旗及 (2) Timer_2 外部中斷原理，可做為量測外部訊號的頻率週期。 2. Timer_2 一個完整的計時週期為 65536 個 clock。 3. Timer_2 溢位元中斷的 int_TF2，紀錄完整的 Timer_2 週期(65536 倍數)。 4. Timer_2 外部中斷的 Temp_TH2 及 Temp_TL2，紀錄小於 65536 clock 的頻率。 5. 測量啟始結束皆由 Timer_2 外部中斷為準。 6. 若 Timer_2 輸入頻率使用 OSC/12，因預除 12 而降低了取樣頻率；若選擇 T2 (條件: T2 ≤ Fosc/2) 輸入頻率則可提高。
--------------------	--



Main program	<pre>//===== // // S Y N C M O S T E C H N O L O G Y // //===== // Device:SM59R16A2/SM59R08A2 // Description:Use Timer_2 detect external signal period // 1. Timer_2 overflow interrupt & Timer_2 External interrupt(EXT2)use // the same interrupt vector(002Bh) // 2. Entry Timer_2 interrupt when overflow ([TH2:TL2]=65536) or pin // T2EX trigger a falling signal. // 3. [Sample rate] Fosc=24MHz, Timer 2 input select:Fosc/12 =2MHz, T=0.5us // 4. [improve] Timer 2 input select:Event counter mode, use faster frequency, // can improve performance //===== #include "..\h\SM59R16A2.h" #include "..\h\SM59R16A2_ExtraDef.h" #include "..\MISC\Delay.h" #include "..\LCD\LCD16x2.h" unsigned char Temp_TH2=0,Temp_TL2 =0, Temp_int_TF2 =0 ,int_TF2 =0; unsigned long Result_T=0; bit flag=0; void T2_interrupt(void) interrupt 5 { if(EXF2) { EXF2 =0; if(~flag) { Temp_TH2 =TH2; //remainder Temp_TL2 =TL2; //Temp_TH2 =CCH1; //remainder //Temp_TL2 =CCL1; Temp_int_TF2 =int_TF2; //Integral count flag =1; } int_TF2 =0; P5 =~P5; //test, ferg =EXF2/2 } //if(TF2) else { TF2=0; } }</pre>
---------------------	--



```
        int_TF2++;
    }

    TH2 = 0x00;
    TF2 = 0x00;
}

void MCU_init(void)
{
    IFCON |= 0x80;        //1T mode
    //IFCON &= (~0x80); //2T mode
    IEN0 |= 0x80;        // Enable interrupt All(EA)
    IEN0 |= 0x20;        // Enable Timer 2 interrupt(ET2)
    IEN1 |= 0x80;        // Enable Timer 2 reload interrupt(EXEN2) from T2EX

//=====
    T2CON = ( 0x00);    // Timer 2 Clear
//=====
// T2CON |= 0x40;      // CC0 Trig rising
// T2CON &= (~0x40);   // CC0 Trig falling
//=====
//Timer 2 input selection 輸入選擇(T2 sample clock)
// T2CON &= (~0X03);   // Clear
// T2CON &= (~0X03);   // T2I[1:0] = 00 - Timer 2 stop 停止
    T2CON |= ( 0X01);   // T2I[1:0] = 01 - Timer 2 mode: 輸入頻率預除 12 或 24
// T2CON |= ( 0X02);   // T2I[1:0] = 10 - Event counter mode: 輸入頻率由外部
pin T2 產生 ( T2<=Fosc/2 )
// T2CON |= ( 0X03);   // T2I[1:0] = 11 - Gated timer mode: 輸入頻率由 Gate
產生 (pin T2 =1 致能; pin T2=0 禁能)
//=====
//Timer 2 reload mode 重載模式選擇:
// T2CON &= (~0x18);   // Clear
// T2CON &= (~0x18);   // Reload disable
// T2CON |= 0x10;      // Reload mode 0 //TH2/TL2 will auto reload when
Timer 2 overflow
// T2CON |= 0x18;      // Reload mode 1 //TH2/TL2 will reload from
CRCH/CRCL when T2EX falling
//PCA Cpature=====
// CCEN = 0x55;        // 0101 0101 :capture when pin CCx trig rising
// CCEN = 0x04;        // 0000 0100 :capture when pin CC1 trig rising
// CCEN = 0xFF;        // 1111 1111 :capture when COCALx writed value
// CCEN = 0x0C;        // 0000 1100 :capture when COCAL1 writed value
//=====
//=====
    TH2 = 0x00;
}
```



```

    TL2 = 0x00;
}

void OSD(void)
{
    PrintLcdStrLX( 1, 0, "T=          us");

    PrintLcdStrLX( 2, 0, "          ");

    Result_T = (Temp_int_TF2*65536 +Temp_TH2*256 +Temp_TL2)/2; //T=0.5us
// Result_T = (Temp_TH2*256 +Temp_TL2)/2; //T=0.5us
    SetCursorAddr(1, 3);    PrintLcdDec2(Result_T);
    SetCursorAddr(2, 0);    PrintLcdDec(Temp_int_TF2);
    SetCursorAddr(2, 6);    PrintLcdDec(Temp_TH2);
    SetCursorAddr(2, 12);   PrintLcdDec(Temp_TL2);
    flag=0;
}

void main(void)
{
    Delay10mSec(1); //wait for system stable
    MCU_init();
    LCD_Init();
    while(1)
    {
        Delay10mSec(20);
        if(flag) OSD();
    };
}

```

3.5.4 Timer 2 Hardware reload應用的範例程式

Description	<ol style="list-style-type: none"> 1. 在程式 define Reload_mode 三種模式 (1) disable (2) auto (3) T2EX。 2. 量測 P5 變化，亦可在 OSD 觀看其差異。
Main program	<pre> //===== // // S Y N C M O S T E C H N O L O G Y // //===== // Device:SM59R16A2/SM59R08A2 // Description: // Reload Function: // mode 0 : TH2/TL2 auto reload from CRCH/CRCL when TH2/TL2 overflow // mode 1 : TH2/TL2 reload from CRCH/CRCL when T2EX trigger falling </pre>



```
//=====
#include "..\h\SM59R16A2.h"
#include "..\h\SM59R16A2_ExtraDef.h"
#include "..\MISC\Delay.h"
#include "..\LCD\LCD16x2.h"

#define Reload_mode T2EX_Reload
#define Disable_Reload 0 //disable
#define Auto_Reload 1 //mode 0
#define T2EX_Reload 2 //mode 1

unsigned int int_TF2=0, int_EXF2=0;

void T2_interrupt(void) interrupt 5
{
    if(TF2==1)
    {
        TF2=0; //over flow interrupt
        int_TF2++;
    }
    if(EXF2==1)
    {
        EXF2=0; //T2EX - external interrupt
        int_EXF2++;
    }

    P2 =int_EXF2; //test, detect interrupt freq.
    P5=~P5;
}

void MCU_init(void)
{
    IFCON |= 0x80; //1T mode
    // IFCON &= (~0x80); //2T mode
    IEN0 |= 0x80; // Enable interrupt All(EA)
    IEN0 |= 0x20; // Enable Timer 2 interrupt(ET2)
    //=====
    T2CON = ( 0x00); // Timer 2 Clear
    //=====
    // T2CON |= 0x40; // Trig rising
    // T2CON &= (~0x40); // Trig falling
    //=====
    //Timer 2 input selection 輸入選擇(T2 sample clock)
    // T2CON &= (~0X03); // Clear
    // T2CON &= (~0X03); // T2I[1:0] = 00 - Timer 2 stop 停止
}
```




```
T2CON |= ( 0X01);    // T2I[1:0] = 01 - Timer 2 mode: 輸入頻率預除 12 或 24
// T2CON |= ( 0X02);    // T2I[1:0] = 10 - Event counter mode: 輸入頻率由外部
pin T2 產生 ( T2<=Fosc/2 )
// T2CON |= ( 0X03);    // T2I[1:0] = 11 - Gated timer mode: 輸入頻率由 Gate
產生 (pin T2 =1 致能; pin T2=0 禁能)
//=====
// CCEN = 0x0C;        // capture when pin CC1 trig rising
//=====
TH2  = 0xD8;
TL2  = 0xF0;
CRCH = 0xD8;
CRCL = 0xF0;
//=====
//Timer 2 reload mode 重載模式選擇:
// T2CON &= (~0x18);    // Clear
switch(Reload_mode)
{
    case Disable_Reload:
        IEN1 &= (~0x80);    // Disable Timer 2 External interrupt (EXEN2)
from pin T2EX
        T2CON &= (~0x18);    // Reload mode disable
        break;
    case Auto_Reload:
        IEN1 &= (~0x80);    // Disable Timer 2 External interrupt (EXEN2)
from pin T2EX
        T2CON |= 0x10;        // Reload mode 0    //TH2/TL2 will auto
reload from CRCH/CRCL when Timer 2 overflow
        break;
    case T2EX_Reload:
        IEN1 |= 0x80;        // Enable Timer 2 External interrupt (EXEN2)
from pin T2EX
        T2CON |= 0x18;        // Reload mode 1    //TH2/TL2 will reload
from CRCH/CRCL when T2EX falling
        break;
}
}

void OSD(void)
{
    switch(Reload_mode)
    {
        case Disable_Reload:
            PrintLcdStrLX( 2, 0, "Dis. EXF2=    ");
            break;
        case Auto_Reload:

```



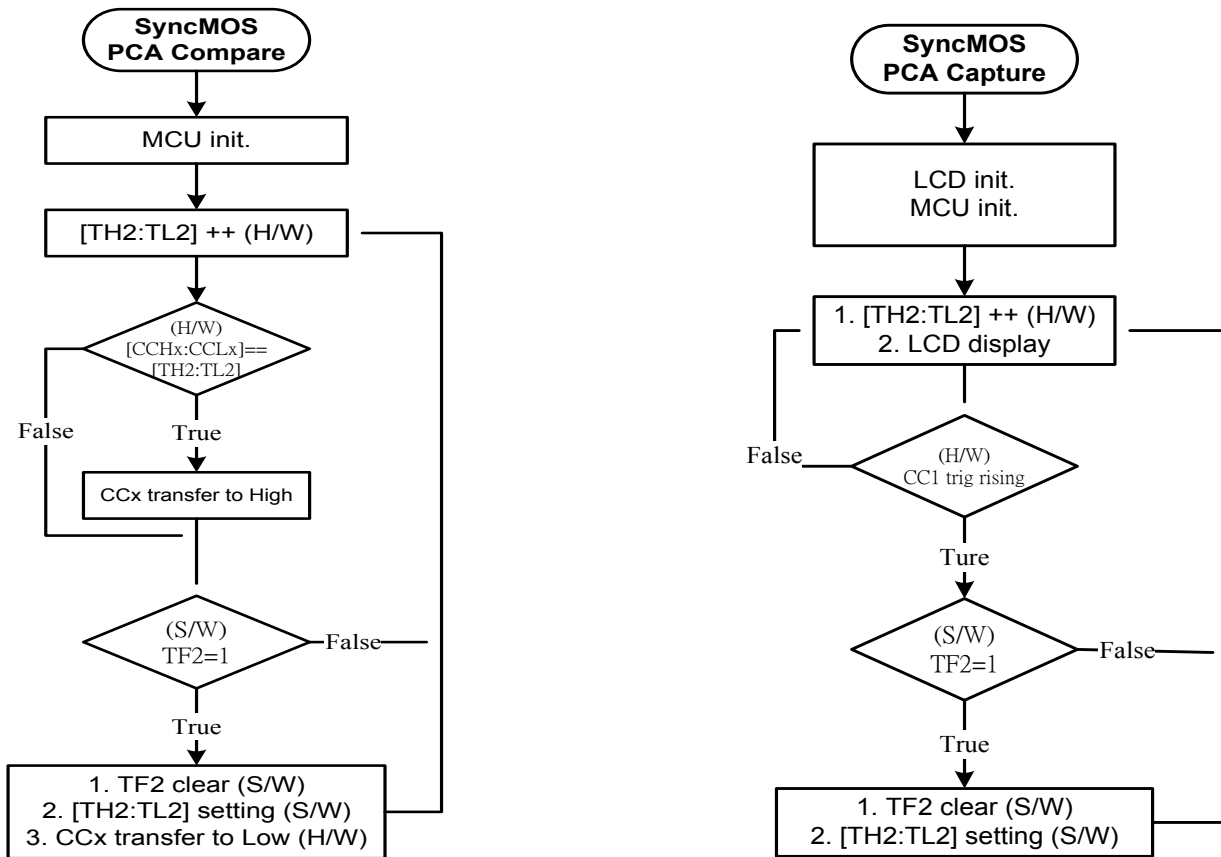
```
        PrintLcdStrLX( 2, 0, "Auto EXF2=  ");
        break;
    case T2EX_Reload:
        PrintLcdStrLX( 2, 0, "T2EX EXF2=  ");
        break;
    }

    PrintLcdStrLX( 1, 0, "Mode TF2 =  ");
    SetCursorAddr(1, 11);   PrintLcdDec(int_TF2);
    SetCursorAddr(2, 11);   PrintLcdDec(int_EXF2);
}

void main(void)
{
    Delay10mSec(1); //wait for system stable
    MCU_init();
    LCD_Init();
    while(1)
    {
        OSD();
        Delay10mSec(10);
    };
}
```

3.6 Timer 2 PCA Compare 及 Capture 範例程式:

3.6.1 流程圖:



3.6.2 Timer 2 PCA Compare應用的範例程式

Description	應用 PCA Compare 功能可實現四組硬體 PWM 輸出，由 P1.2~1.5 即可量測。
Main program	<pre>//===== // // S Y N C M O S T E C H N O L O G Y // //===== // Device:SM59R16A2/SM59R08A2 // Description: // Use Timer2_PCA compare function to genrate PWM duty signal. // (1) PWM period from TH2/TL2 setting, TH2/TL2 count from seting value to 10000h(65536) // (2) P1.2~1.5 normal low. // (3) P1.2~1.5 will transfer to high, if(TH2/TL2=CCHx/CCLx) // (4) When TH2/TL2 count to 65536, occur overflow // (5) occur T2 interrupt, if(overflow & T2 int enable) //===== #include "..\h\SM59R16A2.h" #include "..\MISC\Delay.h"</pre>



```
void T2_interrupt(void) interrupt 5
{
    TF2 = 0;          // flag clear
    TH2 = 0x00; // PWM period= 0~65536 clk
    TL2 = 0x00;
    P5 = ~P5;        // test, detect T2 interrupt freq.
}

void MCU_init(void)
{
    //PAC compare out duty cycle set=====
    CRCH = 0x10;     // P1.4 //CCH0 low= 1000h= 4096 clk
    CRCL = 0x00;     // P1.4 //CCL0
    CCH1 = 0x20;     // P1.5 low= 2000h= 8192 clk
    CCL1 = 0x00;     // P1.5
    CCH2 = 0x40;     // P1.2 low= 4000h= 16348 clk
    CCL2 = 0x00;     // P1.2
    CCH3 = 0x80;     // P1.3 low= 8000h= 32768 clk
    CCL3 = 0x00;     // P1.3

    // PCA compare mode enable=====
    CCEN = 0xAA;
    // Timer 2=====
    TH2 = 0x00; // PWM period= 0~65536 clk
    TL2 = 0x00;
    T2CON = 0x01; // Counter from Timer2 = OSC/12
// T2CON = 0x81; // Counter from Timer2 = OSC/24
    // Timer 2 interrupt setting=====
// IEN0 |= 0x80; // All interrupt Enable
// IEN0 &= (~0x80); // All interrupt Disable
// IEN0 |= 0x20; // Enable Timer 2 interrupt
// IEN1 |= 0x80; // Enable Timer 2 EXEN2:external reload interrupt
}

void main(void)
{
    Delay1mSec(10);
    MCU_init();

    while(1)
    {
        if(TF2==1)
        {
            TH2 =0x00;
            TL2 =0x00;
        }
    }
}
```



```

        TF2 =0;

    }

};

}

```

3.6.3 Timer 2 PCA Capture應用範例程式

Description	//此範例可觀看當引腳 CC1 有外部(負緣)訊號觸發時，[CCH1:CCL1]之變化。
Main program	<pre> //===== // // S Y N C M O S T E C H N O L O G Y // //===== // Device:SM59R16A2/SM59R08A2 // Description: // Capture function: // [CCHx:CCLx] will capture [TH2:TL2] when condition success. // CCEN = 0x55; // 0101 0101 :capture when pin CCx trig rising // CCEN = 0x04; // 0000 0100 :capture when pin CC1 trig rising // CCEN = 0xFF; // 1111 1111 :capture when COCALx writed value // CCEN = 0x0C; // 0000 1100 :capture when COCAL1 writed value //===== #include "..\h\SM59R16A2.h" #include "..\h\SM59R16A2_ExtraDef.h" #include "..\MISC\Delay.h" #include "..\LCD\LCD16x2.h" #define Reload_mode T2EX_Reload #define Disable_Reload 0 //disable #define Auto_Reload 1 //mode 0 #define T2EX_Reload 2 //mode 1 unsigned int int_TF2=0, int_EXF2=0; void T2_interrupt(void) interrupt 5 { if(TF2==1) { TF2=0; //over flow interrupt int_TF2++; } /* if(EXF2==1) { EXF2=0; //T2EX - external interrupt int_EXF2++; } </pre>



```
    }*/
    TH2 = 0x00;
    TL2 = 0x00;
    P5=~P5;          //test, detect T2 freq.
}

void MCU_init(void)
{
    IFCON |= 0x80;    //1T mode
// IFCON &= (~0x80); //2T mode
// IEN0 |= 0x80;    // Enable interrupt All(EA)
// IEN0 |= 0x20;    // Enable Timer 2 interrupt(ET2)
// IEN1 |= 0x80;    // Enable Timer 2 External interrupt(EXEN2) from pin
T2EX
//=====
    T2CON = ( 0x00);    // Timer 2 Clear
//=====
// T2CON |= 0x40;    // CC0 Trig rising
// T2CON &= (~0x40); // CC0 Trig falling
//=====
//Timer 2 input selection 輸入選擇(T2 sample clock)
// T2CON &= (~0X03); // Clear
// T2CON &= (~0X03); // T2I[1:0] = 00 - Timer 2 stop 停止
    T2CON |= ( 0X01); // T2I[1:0] = 01 - Timer 2 mode: 輸入頻率預除 12 或 24
// T2CON |= ( 0X02); // T2I[1:0] = 10 - Event counter mode: 輸入頻率由外部
pin T2 產生 ( T2<=Fosc/2 )
// T2CON |= ( 0X03); // T2I[1:0] = 11 - Gated timer mode: 輸入頻率由 Gate
產生 (pin T2 =1 致能; pin T2=0 禁能)
//=====
// CCEN = 0x55;    // 0101 0101 :capture when pin CCx trig rising
    CCEN = 0x04;    // 0000 0100 :capture when pin CC1 trig rising
// CCEN = 0xFF;    // 1111 1111 :capture when COCALx writed value
// CCEN = 0x0C;    // 0000 1100 :capture when COCAL1 writed value
//=====
    TH2 = 0x00;
    TL2 = 0x00;
    //CRCH = 0x00;
    //CRCL = 0x00;
    //CCH1 = 0x80;
    //CCL1 = 0x00;
//=====
//Timer 2 reload mode 重載模式選擇:
// T2CON &= (~0x18); // Clear
}
```



```
void OSD(void)
{
    PrintLcdStrLX( 1, 0, "CCH1=      ");
    PrintLcdStrLX( 2, 0, "CCL1=      ");
    SetCursorAddr(1, 6);    PrintLcdDec(CCH1);
    SetCursorAddr(2, 6);    PrintLcdDec(CCL1);
}

void main(void)
{
    Delay10mSec(1); //wait for system stable
    LCD_Init();
    MCU_init();
    while(1)
    {
        if(TF2==1)
        {
            TH2 =0x00;
            TL2 =0x00;
            TF2 =0;
        }
        OSD();
        //Delay10mSec(20);
    };
}
```