SN8P1700A Series

USER'S MANUAL

Preliminary

SN8P1702A
SN8P1703A

SONiX 8-Bit Micro-Controller

AMENDMENT HISTORY

Version	Date	Description
VER 0.1	Jul. 2003	V1.0 Preliminary Version
VER 0.2	Jul. 2003	Change watchdog overflow table
VER 0.3	Jul. 2003 Aug. 2003	1. Modify selection table 2. DC current chars. Change 3. Feature change 4. Change SN8P1703 part number to SN8P1703A 5. Code option table has been relocated after pin description section. 6. Modify QTP approval sheet 7. Change Register description. 8. Add LVD typical value=1.8V in Elec. Char. 9. Add “Noise Filter” code option
VER 0.4	Sep. 2003	1. Add SN8P1702A SSOP20 for Mask Mass production. 2. Add TC1 Timer in Update table. 3. Modify Chap. 8 table/figure no. 4. Modify TC0/TC1 timer description and table. 5. Modify PWM description and table. 6. Modify electrical characteristic table
VER 0.5	Sep. 2003	1. Modify ADC convert time table 2. Modify the description of PEDGE register. 3. Modify the description of INTRQ register. 3. Remove approval sheet. 4. Separate the pin description section of SN8P1702A and SN8P1703A. 5. Remove PCB layout section 6. Add P-DIP 20 and Sop 20 package information. 7. Add SN8A1702B and SN8A1703A related description.

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1 PRODUCT OVERVIEW

GENERAL DESCRIPTION

The SN8P1702A/SN8P1703A is a series of 8-bit micro-controller. This chip is utilized with CMOS technology fabrication and featured with low power consumption and high performance by its unique electronic structure.

This chip is designed with the excellent IC structure including the large program memory OTP ROM, the massive data memory RAM, two 8-bit timer counters (TC0, TC1), a watchdog timer, three interrupt sources (TC0, TC1, INT0), an 4-channel ADC converter with 8-bit/12-bit resolution, two channels high speed PWM output (PWM0, PWM1), two channels buzzer output (BZ0, BZ1) and 8-level stack buffers.

Besides, the user can choose desired oscillator configurations for the controller. There are four oscillator configurations to select for generating system clock, including High/Low Speed crystal, ceramic resonator or cost-saving RC. This series also includes an internal RC oscillator for slow mode controlled by programming.

FEATURES SELECTION TABLE

CHIP	ROM	RAM	Stack	Timer			I/O	AVref	ADC	PWM	Wakeup	Package
				T0	TC0	TC1				Buzzer	Pin no.	
SN8P1702A	1K*16	128	8	-	V	V	12	-	4ch	2	3	DIP18/SOP18/SSOP20
SN8P1703A	1K*16	128		-	V	V	13	V	4ch	2	3	DIP20/SOP20/SSOP20

Table 1-1. Selection Table of SN8P1702A/SN8P1703A

MASK/OTP Relative Table

MASK Part Number	Package Form	OTP Chip for Verification	Assembler Declaration
SN8A1702A	DIP18/SOP18 /SSOP20	SN8P1702A	CHIP SN8P1702A
SN8A1702B	DIP18/SOP18 /SSOP20	SN8P1702A	CHIP SN8P1702AOTP
SN8A1703A	DIP20/SOP20 /SSOP20	SN8P1703A	CHIP SN8P1703A

ADC GRADE TABLE

CHIP	PARAMETER	MIN	MAX	UNITS
SN8P1702A SN8P1703A	Resolution		12	Bits
	No Mission Code	8	12	Bits
	Differential No linearity (DNL)		16	LSB
SN8P1702A-12 SN8P1703A-12	Resolution		12	Bits
	No Mission Code	10	12	Bits
	Differential No linearity (DNL)		4	LSB

Table 1-2. ADC Grade Table

UPGRADE FROM SN8P1702 (Old version OTP)

Chip	SN8P1702	SN8P1702A	SN8P1702A	SN8P1703A
Assembly Declaration	CHIP SN8P1702	CHIP SN8P1702A	CHIP SN8P1702AOTP	CHIP SN8P1703A
Standby current (3V)	3uA	< 1uA	< 1uA	< 1uA
4MHz Operating (3V)	1.5mA	< 1mA	< 1mA	< 1mA
4MHz Operating (5V)	7mA	< 3mA	< 3mA	< 3mA
Green Mode	-	Yes	Yes	Yes
P0.0 Interrupt Edge	Falling	Falling/Rising/Both	Falling/Rising/Both	Falling/Rising/Both
P1 wake up	Low Level	Level change	Level change	Level change
AVREFH	NO	Only SSOP20	Only SSOP20	Yes
ADC Channel	4	4	4	4
P4CON register	-	-	Yes	Yes
RAM size	64	64	128	128
GPIO	12	12	12	13
TC1 Timer	-	-	Yes	Yes
Fast PWM	-	-	Yes	Yes
Pull-up Resistor	By Port	By Port	By Pin	By Pin
Pull-up Register	@SET_PUR	@SET_PUR	PnUR	PnUR
SN8P1702 Pin Compatible	Yes	Yes	Yes	No
WDT clock source	High Clock	High Clock	High Clock Internal RC	High Clock Internal RC
Internal RC always ON and WDT clock source fixed at internal RC	-	-	Yes	Yes
Power On Delay at 4MHz/3V	~70ms	~200ms	~200ms	~200ms
MASK Type	SN8A1702A	SN8A1702A	SN8A1702B	SN8A1703A
Package	PDIP18/SOP18	PDIP18/SOP18/SSOP20	PDIP18/SOP18/SSOP20	PDIP20/SOP20/SSOP20

➢ *Notice: The SN8P1702 is not recommended for the new design.*

SN8P1702A/SN8P1703A FEATURES

- **Memory configuration**
  OTP ROM size: 1K * 16 bits.
  RAM size: 128 * 8 bits.

- **I/O pin configuration**
  Input only: P0
  Bi-directional: P1, P4, P5
  Wakeup: P0, P1
  Pull-up resisters: P0, P1, P4, P5
  External interrupt: P0
  P4 pins shared with ADC inputs.

- **Two 8-bit timer counters. (TC0, TC1).**
- **On chip watchdog timer.**
- **Eight levels stack buffer.**

- **59 powerful instructions**
  Four clocks per instruction cycle
  All of instructions are one word length.
  Most of instructions are one cycle only.
  All ROM area lookup table function (MOVC)

- **Three interrupt sources**
  Two internal interrupts: TC0, TC1
  One external interrupts: INT0.

- **An 4-channel 12-bit ADC**

- **Two channel high speed PWM output.**
- **Two channel Buzzer output. (BZ0/BZ1)**

- **Dual clock system offers four operating modes**
  External high clock: RC type up to 10 MHz
  External high clock: Crystal type up to 16 MHz
  Internal low clock: RC type 16KHz(3V), 32KHz(5V)
  Normal mode: Both high and internal low clock active
  Slow mode: Internal low clock only
  Green mode: Periodical wake-up by timer
  Sleep mode: Both high and internal low clock stop

- **Package (Chip form support)**
  SN8P1702A -- PDIP 18 / SOP 18 / SSOP20
  SN8P1703A-- PDIP 20 / SOP 20 / SSOP20

SYSTEM BLOCK DIAGRAM

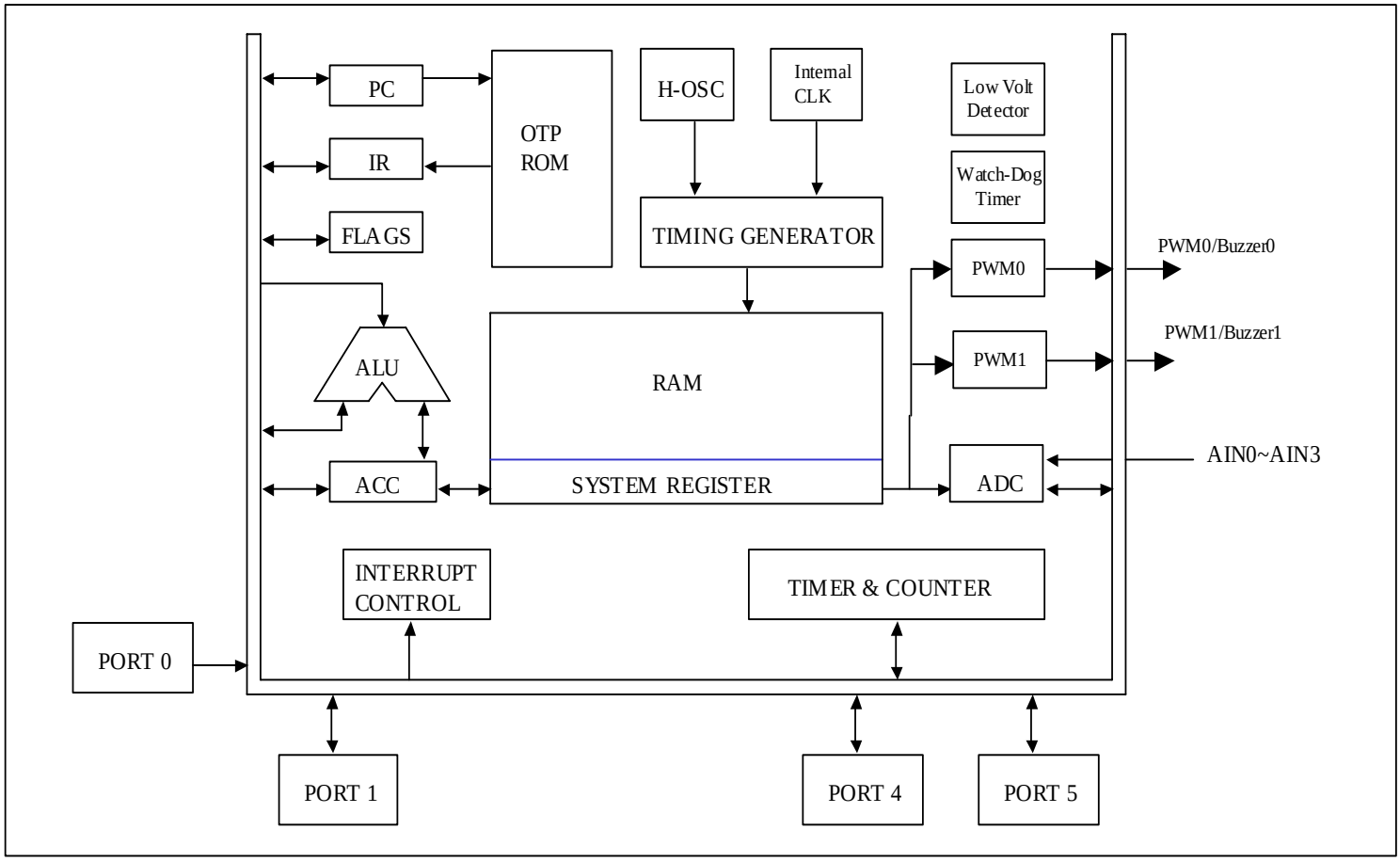


Figure 1-1.Simplified System Block Diagram

PIN ASSIGNMENT

Format Description：SN8P170XAY

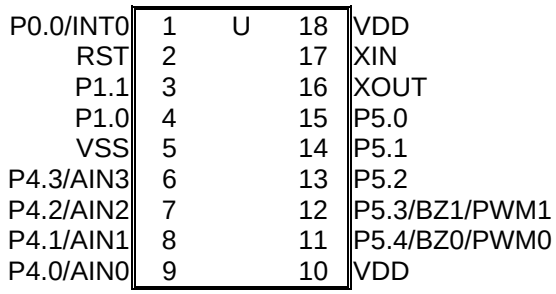
Y = P > PDIP, S > SOP, X> SSOP

SN8P1702A Pin Assignment

OTP Type:

SN8P1702AS (SOP 18PIN) / SN8P1702AP (PDIP 18PIN)

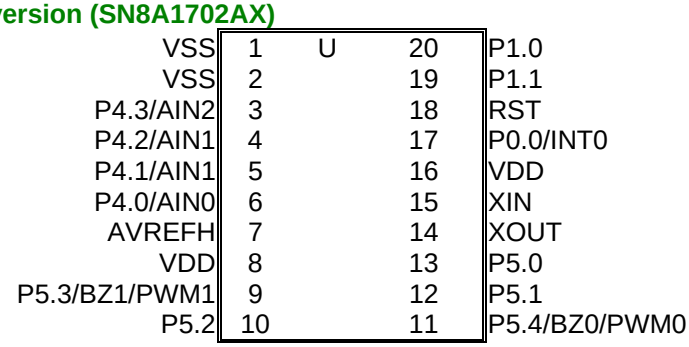
Pin compatible to the MASK version (SN8A1702AS/SN8A1702AP)



SN8P1702AP
SN8P1702AS

SN8P1702AX (SSOP 20PIN)

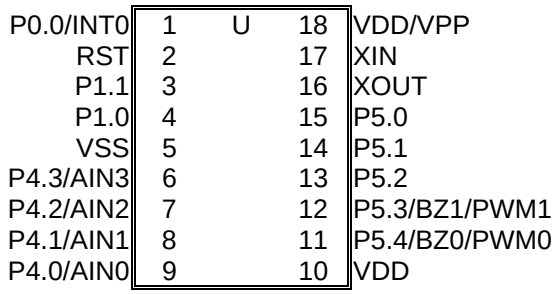
Pin compatible to the MASK version (SN8A1702AX)



SN8P1702AX

OLD Version OTP Type:

SN8P1702S (SOP 18PIN) / SN8P1702P (PDIP 18PIN)

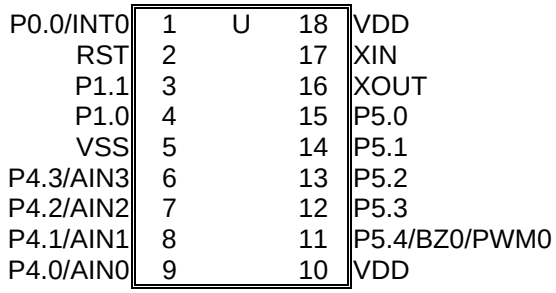


SN8P1702P
SN8P1702S

- ***Notice: The SN8P1702 is not recommended for the new design.***

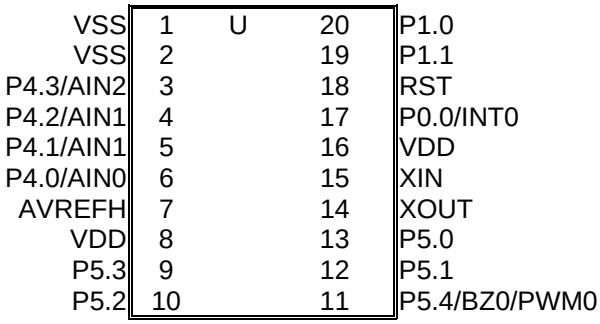
MASK Type:

SN8A1702AS (SOP 18PIN) / SN8A1702AP (PDIP 18PIN)
SN8A1702BS (SOP 18PIN) / SN8A1702BP (PDIP 18PIN)



SN8A1702AP
SN8A1702AS
SN8A1702BP
SN8A1702BS

SN8A1702AX (SSOP 20PIN)

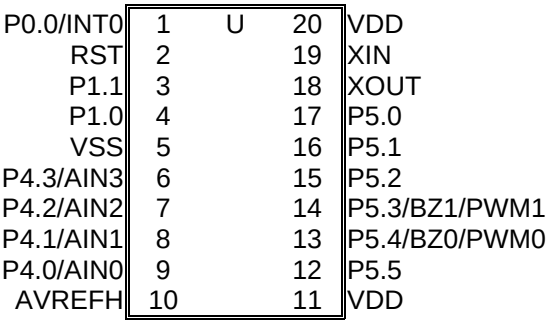


SN8A1702AX
SN8A1702BX

SN8P1703A Pin Assignment

OTP Type:

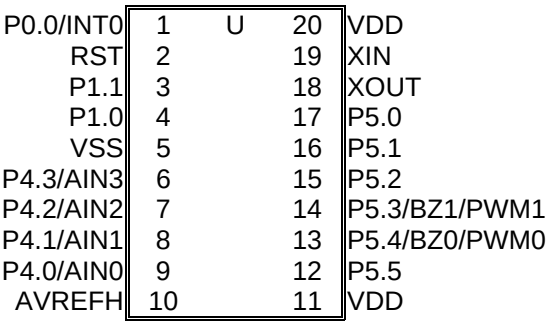
SN8P1703AS (SOP 20PIN) / SN8P1703AP (PDIP 20PIN) / SN8P1703AX (SSOP 20PIN)



SN8P1703AP
SN8P1703AS
SN8P1703AX

MASK Type:

SN8A1703AS (SOP 20PIN) / SN8A1703AP (PDIP 20PIN) / SN8A1703AX (SSOP 20PIN)



SN8A1703AP
SN8A1703AS
SN8A1703AX

PIN DESCRIPTIONS

PIN NAME	TYPE	DESCRIPTION
VDD, VSS	P	Power supply input pins for digital circuit.
RST	I	System reset input pin. Schmitt trigger structure, active “low”, normal stay to “high”.
XIN, XOUT	I, O	External oscillator pins. RC mode from XIN.
P0.0 / INT0	I	Port 0.0 and shared with INT0 trigger pin (Schmitt trigger) / Built-in pull-up resisters.
P1.0 ~ P1.1	I/O	Port 1.0~Port 1.1 bi-direction pins / Built-in pull-up resisters.
P4.0 ~ P4.3	I/O	Port 4.0~Port 4.3 bi-direction pins / Built-in pull-up resisters.
P5.0~P5.2, P5.5	I/O	Port 5.0~Port 5.2, P5.5 bi-direction pins / Built-in pull-up resisters.
P5.3 / BZ1 / PWM1	I/O	Port 5.3 bi-direction pin, TC1÷2 signal output pin for buzzer or PWM1 output pin. Built-in pull-up resisters.
P5.4 / BZ0 / PWM0	I/O	Port 5.4 bi-direction pin, TC0÷2 signal output pin for buzzer or PWM0 output pin. Built-in pull-up resisters.
AVREFH	I	A/D converter high analog reference voltage.
AIN0 ~ AIN3	I	Analog signal input pins for ADC converter.

Table 1-3. Pin Description

PIN CIRCUIT DIAGRAMS

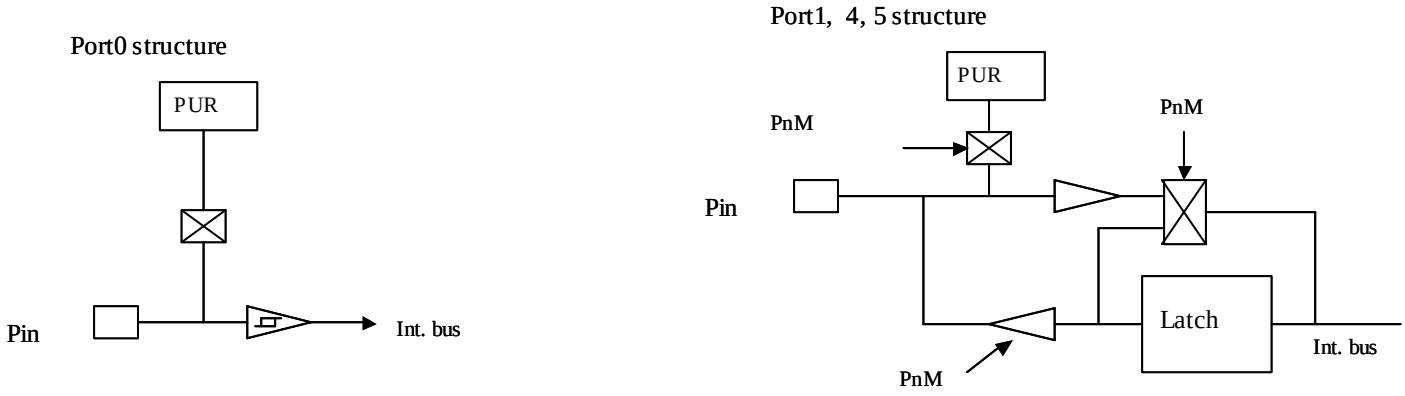


Figure 1-2. Pin Circuit Diagram

➢ ***Note: All of the latch output circuits are push-pull structures.***

2 CODE OPTION TABLE

Code Option	Content	Function Description
High_Clk	RC	Low cost RC for external high clock oscillator
	32K X'tal	Low frequency, power saving crystal (e.g. 32.768K) for external high clock oscillator
	12M X'tal	High speed crystal /resonator (e.g. 12M) for external high clock oscillator
	4M X'tal	Standard crystal /resonator (e.g. 3.58M) for external high clock oscillator
High_Clk / 2	Enable	External high clock divided by two, Fosc = high clock / 2
	Disable	Fosc = high clock
OSG	Enable	Enable Oscillator Safe Guard function
	Disable	Disable Oscillator Safe Guard function
Watch_Dog	Enable	Enable Watch Dog function
	Disable	Disable Watch Dog function
Security	Enable	Enable ROM code Security function
	Disable	Disable ROM code Security function
TC0_Counter	8-bit	TC0 as 8-bit counter.
	6-bit	TC0 as 6-bit counter.
	5-bit	TC0 as 5-bit counter.
	4-bit	TC0 as 4-bit counter.
TC1_Counter	8-bit	TC1 as 8-bit counter.
	6-bit	TC1 as 6-bit counter.
	5-bit	TC1 as 5-bit counter.
	4-bit	TC1 as 4-bit counter.
Noise Filter	Enable	Enable Noise Filter function to enhance EMI performance
	Disable	Disable Noise Filter function
Low Power	Enable	Enable Low Power function to save Operating current
	Disable	Disable Low Power function
INT_16K_RC	Always ON	Force Watch Dog Timer clock source come from INT 16K RC. Also INT 16K RC never stop both in power down and green mode that means Watch Dog Timer will always enable both in power down and green mode.
	By_CPUM	Enable or Disable internal 16K(at 3V) RC clock by CPUM register

Table 2-1. Code Option Table of SN8P1702A/SN8P1703A

Notice:

- ***In high noisy environment, enable "Noise Filter", "OSG" and disable "Low Power" is strongly recommended.***
- ***The side effect is to increase the lowest valid working voltage level if enable "Noise Filter" or "OSG" or "Low Power" code option.***
- Enable "Low Power" option will reduce operating current except in 32K X'tal or slow mode.
- ***If users select "32K X'tal" in "High_Clk" option, assembler will force "OSG" to be enabled.***
- ***If users select "RC" in "High_Clk" option, assembler will force "High_Clk / 2" to be enabled.***

3 ADDRESS SPACES

PROGRAM MEMORY (ROM)

OVERVIEW

ROM Maps for SN8P1702A/SN8P1703A devices provide 1K x 16-bit program memory. The SN8P1702A/SN8P1703A program memory is able to fetch instructions through 12-bit wide PC (Program Counter) and can look up ROM data by using ROM code registers (R, X, Y, Z). In standard configuration, the device's 1,024 x 16-bit program memory has four areas:

- 1-word reset vector addresses
- 1-word Interrupt vector addresses
- 5-words reserved area
- 1K words (SN8P1702)

All of the program memory is partitioned into three coding areas. The first area is located from 00H to 03H(The Reset vector area), the second area is a reserved area 04H ~07H, the third area is for the interrupt vector and the user code area from 0008H to 03FEH. The address 08H is the interrupt enter address point.

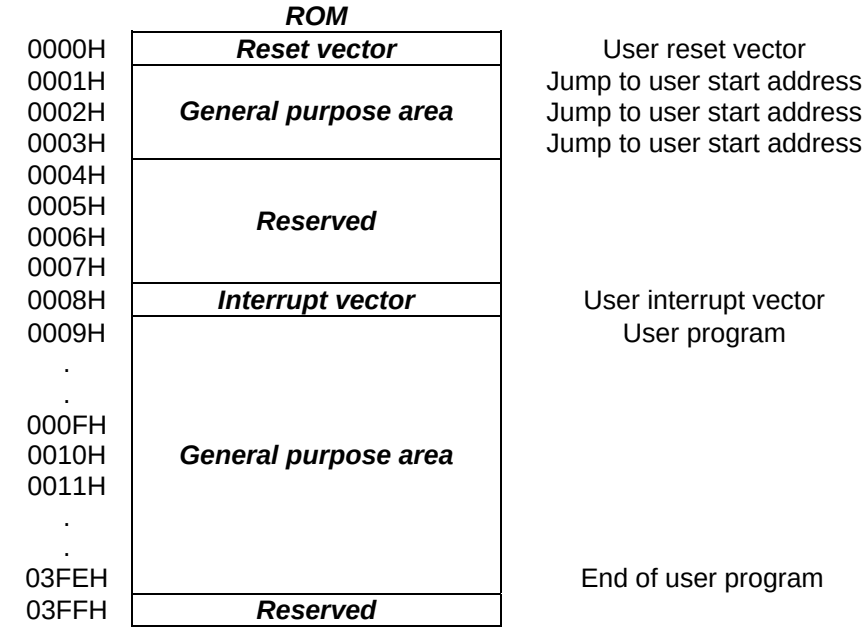


Figure 3-1. ROM Address Structure

USER RESET VECTOR ADDRESS (0000H)

A 1-word vector address area is used to execute system reset. After power on reset or watchdog timer overflow reset, then the chip will restart the program from address 0000h and all system registers will be set as default values. The following example shows the way to define the reset vector in the program memory.

➲ **Example: After power on reset, external reset active or reset by watchdog timer overflow.**

CHIP SN8P1702A

```
                ORG     0           ; 0000H
                JMP     START       ; Jump to user program address.
                .                   ; 0001H ~ 0007H are reserved

                ORG     10H
START:                              ; 0010H, The head of user program.
                .                   ; User program
                .
                .
                .
                ENDP                ; End of program
```

INTERRUPT VECTOR ADDRESS (0008H)

A 1-word vector address area is used to execute interrupt request. If any interrupt service is executed, the program counter (PC) value is stored in stack buffer and points to 0008h of program memory to execute the vectored interrupt. Users have to define the interrupt vector. The following example shows the way to define the interrupt vector in the program memory.

➲ **Example 1: This demo program includes interrupt service routine and the user program is behind the interrupt service routine.**

CHIP SN8P1702A

```
                ORG     0           ; 0000H
                JMP     START       ; Jump to user program address.
                .                   ; 0001H ~ 0007H are reserved

                ORG     8           ; Interrupt service routine
                B0XCH   A, ACCBUF   ; B0XCH doesn't change C, Z flag
                B0MOV   A, PFLAG
                B0MOV   PFLAGBUF, A ; Save PFLAG register in a buffer
                .
                .
                .
                B0MOV   A, PFLAGBUF
                B0MOV   PFLAG, A    ; Restore PFLAG register from buffer
                B0XCH   A, ACCBUF   ; B0XCH doesn't change C, Z flag
                RETI                ; End of interrupt service routine


START:                              ; The head of user program.
                .                   ; User program
                .
                .
                .
                JMP     START       ; End of user program

                ENDP                ; End of program
```

➲ **Example 2: The demo program includes interrupt service routine and the address of interrupt service routine is in a special address of general-purpose area.**

```
CHIP SN8P1702A
                ORG     0               ; 0000H
                JMP     START           ; Jump to user program address.
                .                       ; 0001H ~ 0007H are reserved
                .
                ORG     08
                JMP     MY_IRQ          ; 0008H, Jump to interrupt service routine address
                .
                ORG     10H
START:                                  ; 0010H, The head of user program.
                .                       ; User program
                .
                .
                .
                JMP     START           ; End of user program

MY_IRQ:                                 ; The head of interrupt service routine
                B0XCH   A, ACCBUF       ; B0XCH doesn't change C, Z flag
                B0MOV   A, PFLAG
                B0MOV   PFLAGBUF, A     ; Save PFLAG register in a buffer
                .
                .
                .
                B0MOV   A, PFLAGBUF
                B0MOV   PFLAG, A        ; Restore PFLAG register from buffer
                B0XCH   A, ACCBUF       ; B0XCH doesn't change C, Z flag
                RETI                    ; End of interrupt service routine
                .
                ENDP                    ; End of program
```

➢ ***Remark: It is easy to get the rules of SONIX program from demo programs given above. These points are as following.***

1. The address 0000H is a "JMP" instruction to make the program go to general-purpose ROM area. The 0004H~0007H are reserved. Users have to skip 0004H~0007H addresses. It is very important and necessary.

2. The interrupt service starts from 0008H. Users can put the whole interrupt service routine from 0008H (Example1) or to put a "JMP" instruction in 0008H then place the interrupt service routine in other general-purpose ROM area (Example2) to get more modularized coding style.

CHECKSUM CALCULATION

The ROM addresses 0004H~0007H and last address are reserved area. User should avoid these addresses (0004H~0007H and last address) when calculate the Checksum value.

➲ ***Example:***
The demo program shows how to avoid 0004H~0007H when calculated Checksum from 00H to the end of user's code

```
                MOV     A,#END_USER_CODE$L
                B0MOV   END_ADDR1,A         ; save low end address to end_addr1
                MOV     A,#END_USER_CODE$M
                B0MOV   END_ADDR2,A         ; Save middle end address to end_addr2
                CLR     Y                   ; Set Y to 00H
                CLR     Z                   ; Set Z to 00H
@@:
                CALL    YZ_CHECK            ; Call function of check yz value
                MOVC                        ;
                B0BSET  FC                  ; Clear C flag
                ADD     DATA1,A             ; Add A to Data1
                MOV     A,R
                ADC     DATA2,A             ; Add R to Data2
                JMP     END_CHECK           ; Check if the YZ address = the end of code
AAA:
                INCMS   Z                   ;Z=Z+1
                JMP     @B                  ; If Z! = 00H calculate to next address
                JMP     Y_ADD_1             ; If Z=00H increase Y
END_CHECK:
                MOV     A,END_ADDR1
                CMPRS   A,Z                 ; Check if Z = low end address
                JMP     AAA                 ; If Not jump to checksum calculate
                MOV     A,END_ADDR2
                CMPRS   A,Y                 ; If Yes, check if Y = middle end address
                JMP     AAA                 ; If Not jump to checksum calculate
                JMP     CHECKSUM_END        ; If Yes checksum calculated is done.
YZ_CHECK:                                   ;check if YZ=0004H
                MOV     A,#04H
                CMPRS   A,Z                 ;check if Z=04H
                RET                         ;if Not return to checksum calculate
                MOV     A,#00H
                CMPRS   A,Y                 ;if Yes, check if Y=00H
                RET                         ;if Not return to checksum calculate
                INCMS   Z                   ;if Yes, increase 4 to Z
                INCMS   Z
                INCMS   Z
                INCMS   Z
                RET                         ;set YZ=0008H then return
Y_ADD_1:
                INCMS   Y                   ;increase Y
                NOP
                JMP     @B                  ;jump to checksum calculate
CHECKSUM_END:
                ……
                ……
END_USER_CODE:                              ;Label of program end
```

GENERAL PURPOSE PROGRAM MEMORY AREA

The 992-word at ROM locations 0010H~0FEFH are used as general-purpose memory. The area is stored instruction's op-code and look-up table data. The SN8P1702A/SN8P1703A includes jump table function by using program counter (PC) and look-up table function by using ROM code registers (R, X, Y, Z).

The boundary of program memory is separated by the high-byte program counter (PCH) every 100H. In jump table function and look-up table function, the program counter can't leap over the boundary by program counter automatically. Users need to modify the PCH value to "PCH+1" as the PCL overflow (from 0FFH to 000H).

LOOKUP TABLE DESCRIPTION

In the ROM's data lookup function, the X register is pointed to the highest 8-bit, Y register to the middle 8-bit and Z register to the lowest 8-bit data of ROM address. After MOVC instruction is executed, the low-byte data of ROM then will be stored in ACC and high-byte data stored in R register.

➲ **Example: To look up the ROM data located "TABLE1".**

```
                B0MOV   Y, #TABLE1$M    ; To set lookup table1's middle address
                B0MOV   Z, #TABLE1$L    ; To set lookup table1's low address.
                MOVC                    ; To lookup data, R = 00H, ACC = 35H
                                        ;
                                        ; Increment the index address for next address
                INCMS   Z               ; Z+1
                JMP     @F              ; Not overflow
                INCMS   Y               ; Z overflow (FFH → 00), → Y=Y+1
                NOP                     ; Not overflow
                                        ;
@@:             MOVC                    ; To lookup data, R = 51H, ACC = 05H.
                .       .               ;
TABLE1:         DW      0035H           ; To define a word (16 bits) data.
                DW      5105H           ; "
                DW      2012H           ; "
```

➢ **CAUSION: The Y register can't increase automatically if Z register cross boundary from 0xFF to 0x00. Therefore, user must take care such situation to avoid loop-up table errors. If Z register overflow, Y register must be added one. The following INC_YZ macro shows a simple method to process Y and Z registers automatically.**

➢ ***Note: Because the program counter (PC) is only 12-bit, the X register is useless in the application. Users can omit "B0MOV X, #TABLE1$H". SONiX ICE support more larger program memory addressing capability. So make sure X register is "0" to avoid unpredicted error in loop-up table operation.***

➲ **Example: INC_YZ Macro**

```
INC_YZ          MACRO
                INCMS   Z               ; Z+1
                JMP     @F              ; Not overflow

                INCMS   Y               ; Y+1
                NOP                     ; Not overflow
@@:
                ENDM
```

The other coding style of loop-up table is to add Y or Z index register by accumulator. Be careful if carry happen. Refer following example for detailed information:

➲ **Example: Increase Y and Z register by B0ADD/ADD instruction**

```
        B0MOV   Y, #TABLE1$M    ; To set lookup table's middle address.
        B0MOV   Z, #TABLE1$L    ; To set lookup table's low address

        B0MOV   A, BUF          ; Z = Z + BUF.
        B0ADD   Z, A

        B0BTS1  FC              ; Check the carry flag.
        JMP     GETDATA         ; FC = 0
        INCMS   Y               ; FC = 1. Y+1.
        NOP

GETDATA:                        ;
        MOVC                    ; To lookup data. If BUF = 0, data is 0x0035
                                ; If BUF = 1, data is 0x5105
                                ; If BUF = 2, data is 0x2012
                                .
                                .
        .       .               ;
TABLE1: DW      0035H           ; To define a word (16 bits) data.
        DW      5105H           ; "
        DW      2012H           ; "
```

JUMP TABLE DESCRIPTION

The jump table operation is one of multi-address jumping function. Add low-byte program counter (PCL) and ACC value to get one new PCL. The new program counter (PC) points to a series jump instructions as a listing table. The way is easy to make a multi-stage program.

When carry flag occurs after executing of "ADD PCL, A", it will not affect PCH register. Users have to check if the jump table leaps over the ROM page boundary or the listing file generated by SONIX assembly software. If the jump table leaps over the ROM page boundary (e.g. from xxFFH to xx00H), move the jump table to the top of next program memory page (xx00H). **Here one page mean 256 words.**

➲ **Example : If PC = 0323H (PCH = 03H、PCL = 23H)**

```
        ORG     0X0100          ; The jump table is from the head of the ROM boundary

        B0ADD   PCL, A          ; PCL = PCL + ACC, the PCH can't be changed.
        JMP     A0POINT         ; ACC = 0, jump to A0POINT
        JMP     A1POINT         ; ACC = 1, jump to A1POINT
        JMP     A2POINT         ; ACC = 2, jump to A2POINT
        JMP     A3POINT         ; ACC = 3, jump to A3POINT
```

In following example, the jump table starts at 0x00FD. When execute B0ADD PCL, A. If ACC = 0 or 1, the jump table points to the right address. If the ACC is larger then 1 will cause error because PCH doesn't increase one automatically. We can see the PCL = 0 when ACC = 2 but the PCH still keep in 0. The program counter (PC) will point to a wrong address 0x0000 and crash system operation. It is important to check whether the jump table crosses over the boundary (xxFFH to xx00H). A good coding style is to put the jump table at the start of ROM boundary (e.g. 0100H).

➲ **Example: If "jump table" crosses over ROM boundary will cause errors.**

```
ROM Address
    .           .
    .           .
    .           .
0X00FD      B0ADD   PCL, A      ; PCL = PCL + ACC, the PCH can't be changed.
0X00FE      JMP     A0POINT     ; ACC = 0
0X00FF      JMP     A1POINT     ; ACC = 1
0X0100      JMP     A2POINT     ; ACC = 2  ← jump table cross boundary here
0X0101      JMP     A3POINT     ; ACC = 3
    .           .
    .           .
```

SONIX provides a macro for safe jump table function. This macro will check the ROM boundary and move the jump table to the right position automatically. The side effect of this macro is maybe wasting some ROM size. Notice the maximum jump table number for this macro is limited fewer than 254.

```
@JMP_A      MACRO   VAL
            IF      (($+1) !& 0XFF00) !!= (($+(VAL)) !& 0XFF00)
            JMP     ($ | 0XFF)
            ORG     ($ | 0XFF)
            ENDIF
            ADD     PCL, A
            ENDM
```

➢ ***Note: "VAL" is the number of the jump table listing number.***

➲ **Example: "@JMP_A" application in SONIX macro file called "MACRO3.H".**

```
B0MOV     A, BUF0       ; "BUF0" is from 0 to 4.
@JMP_A    5             ; The number of the jump table listing is five.
JMP       A0POINT       ; If ACC = 0, jump to A0POINT
JMP       A1POINT       ; ACC = 1, jump to A1POINT
JMP       A2POINT       ; ACC = 2, jump to A2POINT
JMP       A3POINT       ; ACC = 3, jump to A3POINT
JMP       A4POINT       ; ACC = 4, jump to A4POINT
```

If the jump table position is from 00FDH to 0101H, the "@JMP_A" macro will make the jump table to start from 0100h.

DATA MEMORY (RAM)

OVERVIEW

The SN8P1702A/SN8P1703A has internally built-in the data memory up to 256 bytes for storing the general-purpose data.

- 128 * 8-bit general purpose area in bank 0
- 128 * 8-bit system special register area

The memory is separated into bank 0 and bank 1. The user can program RAM bank selection bits of RBANK register to access all data in any of the two RAM banks. The bank 0, using the first 128-byte location assigned as general-purpose area, and the remaining 128-byte in bank 0 as system register.

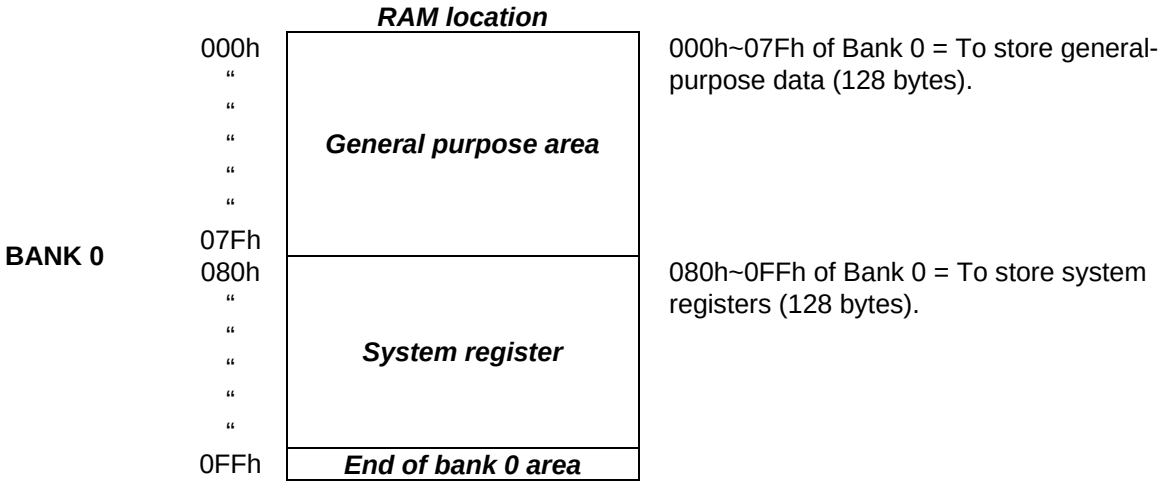


Figure 3-2. RAM Location

- ***Note: The undefined locations of system register area are logic “high” after executing read instruction “MOV A, M”.***

WORKING REGISTERS

The locations 82H to 84H of RAM bank 0 in data memory stores the specially defined registers such as register R, Z, Y, respectively shown in the following table. These registers can use as the general purpose of working buffer and be used to access ROM's and RAM's data. For instance, all of the ROM's table can be looked-up with R, Y and Z registers. The data of RAM memory can be indirectly accessed with Y and Z registers.

	82H	83H	84H
RAM	R	Z	Y
	R/W	R/W	R/W

Y, Z REGISTERS

The Y and Z registers are the 8-bit buffers. There are three major functions of these registers. First, Y and Z registers can be used as working registers. Second, these two registers can be used as data pointers for @YZ register. Third, the registers can be address ROM location in order to look-up ROM data.

Y initial value = 0000 0000

084H	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Y	YBIT7	YBIT6	YBIT5	YBIT4	YBIT3	YBIT2	YBIT1	YBIT0
	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W

Z initial value = 0000 0000

083H	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Z	ZBIT7	ZBIT6	ZBIT5	ZBIT4	ZBIT3	ZBIT2	ZBIT1	ZBIT0
	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W

The @YZ that is data point_1 index buffer located at address E7H in RAM bank 0. It employs Y and Z registers to addressing RAM location in order to read/write data through ACC. The Lower 4-bit of Y register is pointed to RAM bank number and Z register is pointed to RAM address number, respectively. The higher 4-bit data of Y register is truncated in RAM indirectly access mode.

➲ **Example: If want to read a data from RAM address 25H of bank 1, it can use indirectly addressing mode to access data as following.**

```
B0MOV   Y, #01H     ; To set RAM bank 1 for Y register
B0MOV   Z, #25H     ; To set location 25H for Z register
B0MOV   A, @YZ      ; To read a data into ACC
```

➲ **Example: Clear general-purpose data memory area of bank 1 using @YZ register.**

```
        MOV     A, #1
        B0MOV   Y, A        ; Y = 1, bank 1
        MOV     A, #07FH
        B0MOV   Z, A        ; Y = 7FH, the last address of the data memory area
CLR_YZ_BUF:
        CLR     @YZ         ; Clear @YZ to be zero

        DECMS   Z           ; Y – 1, if Y= 0, finish the routine
        JMP     CLR_YZ_BUF  ; Not zero

        CLR     @YZ
END_CLR:                    ; End of clear general purpose data memory area of bank 0
```

➢ ***Note: Please consult the "LOOK-UP TABLE DESCRIPTION" about Y, Z register look-up table application.***

R REGISTERS

There are two major functions of the R register. First, R register can be used as working registers. Second, the R registers can be store high-byte data of look-up ROM data. After MOVC instruction executed, the high-byte data of a ROM address will be stored in R register and the low-byte data stored in ACC.

R initial value = 0000 0000

082H	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
R	RBIT7	RBIT6	RBIT5	RBIT4	RBIT3	RBIT2	RBIT1	RBIT0
	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W

➢ ***Note: Please consult the "LOOK-UP TABLE DESCRIPTION" about R register look-up table application.***

PROGRAM FLAG

The PFLAG includes carry flag (C), decimal carry flag (DC) and zero flag (Z). If the result of operating is zero or there is carry, borrow occurrence, then these flags will be set to PFLAG register.

PFLAG initial value = xxxx x000

086H	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
PFLAG	-	-	-	-	-	C	DC	Z
	-	-	-	-	-	R/W	R/W	R/W

CARRY FLAG

C = 1: If executed arithmetic addition with occurring carry signal or executed arithmetic subtraction without borrowing signal or executed rotation instruction with shifting out logic "1".
C = 0: If executed arithmetic addition without occurring carry signal or executed arithmetic subtraction with borrowing signal or executed rotation instruction with shifting out logic "0".

DECIMAL CARRY FLAG

DC = 1: If executed arithmetic addition with occurring carry signal from low nibble or executed arithmetic subtraction without borrow signal from high nibble.
DC = 0: If executed arithmetic addition without occurring carry signal from low nibble or executed arithmetic subtraction with borrow signal from high nibble.

ZERO FLAG

Z = 1: After operation, the content of ACC is zero.
Z = 0: After operation, the content of ACC is not zero.

ACCUMULATOR

The ACC is an 8-bits data register responsible for transferring or manipulating data between ALU and data memory. If the result of operating is zero (Z) or there is carry (C or DC) occurrence, then these flags will be set to PFLAG register.

ACC is not in data memory (RAM), so ACC can't be access by "B0MOV" instruction during the instant addressing mode.

➲ **Example: Read and write ACC value.**

```
; Read ACC data and store in BUF data memory

                MOV     BUF, A
                .       .

; Write a immediate data into ACC

                MOV     A, #0FH
                .       .

; Write ACC data from BUF data memory

                MOV     A, BUF
                .       .
```

The system doesn't store ACC and PFLAG value as any interrupt service executed. ACC must be exchanged to another data memory defined by users. Thus, once interrupt occurs, these data must be stored in the data memory based on the user's program as follows.

➲ **Example: ACC and working registers protection.**

```
ACCBUF          EQU     00H             ; ACCBUF is ACC data buffer in bank 0.

INT_SERVICE:
                B0XCH   A, ACCBUF       ; B0XCH doesn't change C, Z flag

                B0XCH   A, ACCBUF       ; Store ACC value
                B0MOV   A, PFLAG        ; Store PFLAG value
                B0MOV   PFLAGBUF,A

                .

                B0MOV   A, PFLAGBUF     ; Re-load PFLAG value
                B0MOV   PFLAG,A
                B0XCH   A, ACCBUF       ; Re-load ACC

                B0XCH   A, ACCBUF       ; Re-load ACC

                RETI                    ; Exit interrupt service vector
```

➢ ***Notice: To save and re-load ACC data must be used "B0XCH" instruction, or the PLAGE value maybe modified by ACC.***

STACK OPERATIONS

OVERVIEW

The stack buffer of SN8P1702A/SN8P1703A has 8-level high area and each level is 12-bits length. This buffer is designed to save and restore program counter's (PC) data when interrupt service is executed. The STKP register is a pointer designed to point active level in order to save or restore data from stack buffer for kernel circuit. The STKnH and STKnL are the 12-bit stack buffers to store program counter (PC) data.

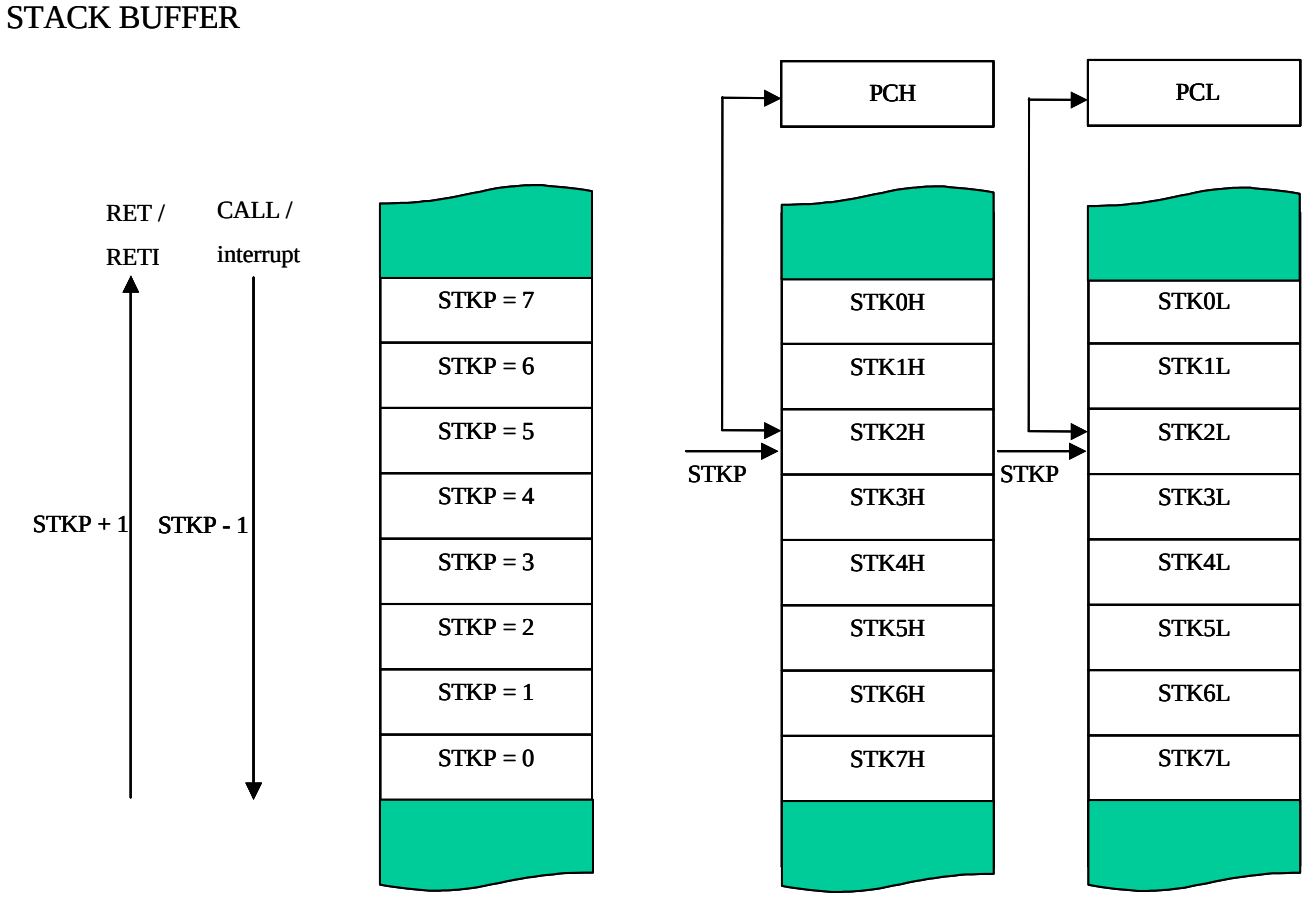


Figure 3-3 Stack-Save and Stack-Restore Operation

STACK REGISTERS

The stack pointer (STKP) is a 4-bit register to store the address used to access the stack buffer, 12-bits data memory (STKnH and STKnL) set aside for temporary storage of stack addresses.

The two stack operations are writing to the top of the stack (Stack-Save) and reading (Stack-Restore) from the top of stack. Stack-Save operation decrements the STKP and the Stack-Restore operation increments one time. That makes the STKP always points to the top address of stack buffer and writes the last program counter value (PC) into the stack buffer.

The program counter (PC) value is stored in the stack buffer before a CALL instruction executed or during interrupt service routine. Stack operation is a LIFO type (Last in and first out). The stack pointer (STKP) and stack buffer (STKnH and STKnL) are located in the system register area bank 0.

STKP (stack pointer) initial value = 0xxx 1111

0DFH	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
STKP	GIE	-	-	-	STKPB3	STKPB2	STKPB1	STKPB0
	R/W	-	-	-	R/W	R/W	R/W	R/W

STKPBn: Stack pointer. (n = 0 ~ 3)
GIE: Global interrupt control bit. 0 = disable, 1 = enable. More detail information is in interrupt chapter.

➲ **Example: Stack pointer (STKP) reset routine.**

```
MOV     A, #00001111B
B0MOV   STKP, A
```

STKn (stack buffer) initial value = xxxx xxxx xxxx xxxx, STKn = STKnH + STKnL (n = 7 ~ 0)

0F0H~0FFH	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
STKnH	-	-	-	-	-	-	SnPC9	SnPC8
	-	-	-	-	-	-	R/W	R/W

0F0H~0FFH	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
STKnL	SnPC7	SnPC6	SnPC5	SnPC4	SnPC3	SnPC2	SnPC1	SnPC0
	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W

STKnH: Store PCH data as interrupt or call executing. The n expressed 0 ~7.
STKnL: Store PCL data as interrupt or call executing. The n expressed 0 ~7.

STACK OPERATION EXAMPLE

The two kinds of Stack-Save operations to reference the stack pointer (STKP) and write the program counter contents (PC) into the stack buffer are CALL instruction and interrupt service. Under each condition, the STKP is decremented and points to the next available stack location. The stack buffer stores the program counter about the op-code address. The Stack-Save operation is as following table.

Stack Level	STKP Register				Stack Buffer		Description
	STKPB3	STKPB2	STKPB1	STKPB0	High Byte	Low Byte	
0	1	1	1	1	STK0H	STK0L	-
1	1	1	1	0	STK1H	STK1L	-
2	1	1	0	1	STK2H	STK2L	-
3	1	1	0	0	STK3H	STK3L	-
4	1	0	1	1	STK4H	STK4L	-
5	1	0	1	0	STK5H	STK5L	-
6	1	0	0	1	STK6H	STK6L	-
7	1	0	0	0	STK7H	STK7L	-
>8	-	-	-	-	-	-	**Stack Overflow**

Table 3-1. STKP, STKnH and STKnL relative of Stack-Save Operation

The RETI instruction is for interrupt service routine. The RET instruction is for CALL instruction. When a Stack-Restore operation occurs, the STKP is incremented and points to the next free stack location. The stack buffer restores the last program counter (PC) to the program counter registers. The Stack-Restore operation is as following table.

Stack Level	STKP Register				Stack Buffer		Description
	STKPB3	STKPB2	STKPB1	STKPB0	High Byte	Low Byte	
7	1	0	0	0	STK7H	STK7L	-
6	1	0	0	1	STK6H	STK6L	-
5	1	0	1	0	STK5H	STK5L	-
4	1	0	1	1	STK4H	STK4L	-
3	1	1	0	0	STK3H	STK3L	-
2	1	1	0	1	STK2H	STK2L	-
1	1	1	1	0	STK1H	STK1L	-
0	1	1	1	1	STK0H	STK0L	-

Table 3-2. STKP, STKnH and STKnL relative of Stack-Restore Operation

PROGRAM COUNTER

The program counter (PC) is a 12-bit binary counter separated into the high-byte 4 bits and the low-byte 8 bits. This counter is responsible for pointing a location in order to fetch an instruction for kernel circuit. Normally, the program counter is automatically incremented with each instruction during program execution.

Besides, it can be replaced with specific address by executing CALL or JMP instruction. When JMP or CALL instruction is executed, the destination address will be inserted to bit 0 ~ bit 11.

PC Initial value = xxxx 0000 0000 0000

	Bit 15	Bit 14	Bit 13	Bit 12	Bit 11	Bit 10	Bit 9	Bit 8	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
PC	-	-	-	-	-	-	0	0	0	0	0	0	0	0	0	0
	PCH								PCL							

PCH Initial value = xxxx 0000

0CFH	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
PCH	-	-	-	-	-	-	PC9	PC8
	-	-	-	-	-	-	R/W	R/W

PCL Initial value = 0000 0000

0CEH	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
PCL	PC7	PC6	PC5	PC4	PC3	PC2	PC1	PC0
	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W

ONE ADDRESS SKIPPING

There are 9 instructions (CMPRS, INCS, INCMS, DECS, DECMS, BTS0, BTS1, B0BTS0, B0BTS1) with one address skipping function. If the result of these instructions is matched, the PC will add 2 steps to skip next instruction.

If the condition of bit test instruction is matched, the PC will add 2 steps to skip next instruction.

```
            B0BTS1    FC          ; Skip next instruction, if Carry flag = 1
            JMP       C0STEP      ; Else jump to C0STEP.
            .
C0STEP:     NOP

            B0MOV     A, BUF0     ; Move BUF0 value to ACC.
            B0BTS0    FZ          ; Skip next instruction, if Zero flag = 0.
            JMP       C1STEP      ; Else jump to C1STEP.
            .
C1STEP:     NOP
```

If the ACC is equal to the immediate data or memory, the PC will add 2 steps to skip next instruction.

```
            CMPRS     A, #12H     ; Skip next instruction, if ACC = 12H.
            JMP       C0STEP      ; Else jump to C0STEP.
            .
C0STEP:     NOP
```

If the result after increasing or decreasing by 1 is 0xFF or 0x00, the PC will add 2 steps to skip next instruction.

INCS instruction:

```
            INCS      BUF0
            JMP       C0STEP      ; Jump to C0STEP if ACC is not zero.
            …
C0STEP:     NOP
```

INCMS instruction:

```
            INCMS     BUF0
            JMP       C0STEP      ; Jump to C0STEP if BUF0 is not zero.
            …
C0STEP:     NOP
```

DECS instruction:

```
            DECS      BUF0
            JMP       C0STEP      ; Jump to C0STEP if ACC is not zero.
            …
C0STEP:     NOP
```

DECMS instruction:

```
            DECMS     BUF0
            JMP       C0STEP      ; Jump to C0STEP if BUF0 is not zero.
            …
C0STEP:     NOP
```

MULTI-ADDRESS JUMPING

Users can jump round multi-address by either JMP instruction or ADD M, A instruction (M = PCL) to activate multi-address jumping function. If carry signal occurs after execution of ADD PCL, A, the carry signal will not affect PCH register.

➲ Example: If PC = 0323H (PCH = 03H、PCL = 23H)

```
; PC = 0323H
                MOV     A, #28H
                B0MOV   PCL, A          ; Jump to address 0328H
                .       .
                .       .
; PC = 0328H     .       .
                MOV     A, #00H
                B0MOV   PCL, A          ; Jump to address 0300H
```

➲ Example: If PC = 0323H (PCH = 03H、PCL = 23H)

```
; PC = 0323H
                B0ADD   PCL, A          ; PCL = PCL + ACC, the PCH cannot be changed.
                JMP     A0POINT         ; If ACC = 0, jump to A0POINT
                JMP     A1POINT         ; ACC = 1, jump to A1POINT
                JMP     A2POINT         ; ACC = 2, jump to A2POINT
                JMP     A3POINT         ; ACC = 3, jump to A3POINT
                .       .               ;
```

4 ADDRESSING MODE

OVERVIEW

The SN8P1702A/SN8P1703A provides three addressing modes to access RAM data, including immediate addressing mode, directly addressing mode and indirectly address mode. The main purpose of the three different modes is described in the following:

IMMEDIATE ADDRESSING MODE

The immediate addressing mode uses an immediate data to set up the location (MOV A, #I, B0MOV M,#I) in ACC or specific RAM.

Immediate addressing mode

```
MOV     A, #12H         ; To set an immediate data 12H into ACC
```

DIRECTLY ADDRESSING MODE

The directly addressing mode uses address number to access memory location (MOV A,12H, MOV 12H,A).

Directly addressing mode

```
B0MOV   A, 12H          ; To get a content of location 12H of bank 0 and save in ACC
```

INDIRECTLY ADDRESSING MODE

The indirectly addressing mode is to set up an address in data pointer registers (Y/Z) and uses MOV instruction to read/write data between ACC and @YZ register (MOV A,@YZ, MOV @YZ,A).

➲ **Example: Indirectly addressing mode with @YZ register**

```
CLR     Y               ; To clear Y register to access RAM bank 0.
B0MOV   Z, #12H         ; To set an immediate data 12H into Z register.
B0MOV   A, @YZ          ; Use data pointer @YZ reads a data from RAM location
                        ; 012H into ACC.
```

TO ACCESS DATA in RAM BANK 0

In the RAM bank 0, this area memory can be read/written by these three access methods.

➲ **Example 1: To use RAM bank0 dedicate instruction (Such as B0xxx instruction).**

```
B0MOV   A, 12H      ; To move content from location 12H of RAM bank 0 to ACC
```

➲ **Example 3: To use indirectly addressing mode with @YZ register.**

```
CLR     Y           ; To clear Y register for accessing RAM bank 0.
B0MOV   Z, #12H     ; To set an immediate data 12H into Z register.
B0MOV   A, @YZ      ; Use data pointer @YZ reads a data from RAM location
                    ; 012H into ACC.
```

5 SYSTEM REGISTER

OVERVIEW

The system special register is located at 80h~FFh. The main purpose of system registers is to control the peripheral hardware of the chip. Using system registers can control I/O ports, SIO, ADC, PWM, timers and counters by programming. The Memory map provides an easy and quick reference source for writing application program. To accessing these system registers is controlled by the select memory bank (RBANK = 0) or the bank 0 read/write instruction (B0MOV, B0BSET, B0BCLR…).

SYSTEM REGISTER ARRANGEMENT (BANK 0)

BYTES of SYSTEM REGISTER

SN8P1702

	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
8	-	-	R	Z	Y	-	PFLAG	-	-	-	-	-	-	-	-	-
9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	P4CON	-
B	-	ADM	ADB	ADR	-	-	-	-	-	-	-	-	-	-	-	PEDGE
C	P1W	P1M	-	-	P4M	P5M	-	-	INTRQ	INTEN	OSCM	-	-	TC0R	PCL	PCH
D	P0	P1	-	-	P4	P5	-	-	T0M	-	TC0M	TC0C	TC1M	TC0C	TC1R	STKP
E	P0UR	P1UR	-	-	P4UR	P5UR	-	@YZ	-	-	-	-	-	-	-	-
F	STK7	STK7	STK6	STK6	STK5	STK5	STK4	STK4	STK3	STK3	STK2	STK2	STK1	STK1	STK0	STK0

Table 5-1. System Register Arrangement

Description

PFLAG = ROM page and special flag register.
ADB = ADC's data buffer.
PnM = Port n input/output mode register.
INTRQ = Interrupts' request register.
OSCM = Oscillator mode register.
TC0/1M = Timer/Counter 0/1 mode register.
TC0/1C = Timer/Counter 0/1 counting register.
TC0/1R = Timer/Counter 0/1 auto-reload data buffer.
STKP = Stack pointer buffer.
@HL = RAM HL indirect addressing index pointer.

R = Working register and ROM lookup data buffer.
Y, Z = Working, @YZ and ROM addressing register.
RBANK = RAM Bank Select register.
ADM = ADC's mode register.
ADR = ADC's resolution selects register.
P1W = Port 1 wakeup register.
Pn = Port n data buffer.
PnUR= Pull-up register
INTEN = Interrupts' enable register.
PCH, PCL = Program counter.
STK0~STK7 = Stack 0 ~ stack 7 buffer.
@YZ = RAM YZ indirect addressing index pointer.

➢ ***Note:***

a). All of register names had been declared in SONiX 8-bit MCU assembler.
b). One-bit name had been declared in SONiX 8-bit MCU assembler with "F" prefix code.
c). It will get logic "H" data, when use instruction to check empty location.
d). The low nibble of ADR register is read only.
e). "b0bset", "b0bclr", "bset", "bclr" instructions only support "R/W" registers.

BITS of SYSTEM REGISTER

Address	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0	R/W	Remarks
082H	RBIT7	RBIT6	RBIT5	RBIT4	RBIT3	RBIT2	RBIT1	RBIT0	R/W	R
083H	ZBIT7	ZBIT6	ZBIT5	ZBIT4	ZBIT3	ZBIT2	ZBIT1	ZBIT0	R/W	Z
084H	YBIT7	YBIT6	YBIT5	YBIT4	YBIT3	YBIT2	YBIT1	YBIT0	R/W	Y
086H	-	-	-	-	-	C	DC	Z	R/W	PFLAG
0AEH	-	-	-	-	P4CON3	P4CON2	P4CON1	P4CON0	R/W	P4CON
0B1H	ADENB	ADS	EOC	GCHS	-	-	CHS1	CHS0	R/W	ADM mode register
0B2H	ADB11	ADB10	ADB9	ADB8	ADB7	ADB6	ADB5	ADB4	R	ADB data buffer
0B3H	-	ADCKS1	ADLEN	-	ADB3	ADB2	ADB1	ADB0	R/W	ADR register
0BFH	PEDGEN	-	-	P00G1	P00G0	-	-	-	R/W	PEDGE
0C0H	0	0	0	0	0	0	P11W	P10W	W	P1W wakeup register
0C1H	0	0	0	0	0	0	P11M	P10M	R/W	P1M I/O direction
0C4H	0	0	0	0	P43M	P42M	P41M	P40M	R/W	P4M I/O direction
0C5H	0	0	P55M	P54M	P53M	P52M	P51M	P50M	R/W	P5M I/O direction
0C8H	0	TC1IRQ	TC0IRQ	0	0	0	0	P00IRQ	R/W	INTRQ
0C9H	0	TC1IEN	TC0IEN	0	0	0	0	P00IEN	R/W	INTEN
0CAH	WTCKS	WDRST	WDRATE	CPUM1	CPUM0	CLKMD	STPHX	0	R/W	OSCM
0CDH	TC0R7	TC0R6	TC0R5	TC0R4	TC0R3	TC0R2	TC0R1	TC0R0	W	TC0R
0CEH	PC7	PC6	PC5	PC4	PC3	PC2	PC1	PC0	R/W	PCL
0CFH	-	-	-	-	-	-	PC9	PC8	R/W	PCH
0D0H	-	-	-	-	-	-	-	P00	R	P0 data buffer
0D1H	-	-	-	-	-	-	P11	P10	R/W	P1 data buffer
0D4H	-	-	-	-	P43	P42	P41	P40	R/W	P4 data buffer
0D5H	-	-	P55	P54	P53	P52	P51	P50	R/W	P5 data buffer
0D8H	-	-	-	-	TC1X8	TC0X8	TC0GN	-	R/W	T0M
0DAH	TC0ENB	TC0rate2	TC0rate1	TC0rate0	TC0CKS	ALOAD0	TC0OUT	PWM0OUT	R/W	TC0M
0DBH	TC0C7	TC0C6	TC0C5	TC0C4	TC0C3	TC0C2	TC0C1	TC0C0	R/W	TC0C
0DCH	TC1ENB	TC1rate2	TC1rate1	TC1rate0	0	ALOAD1	TC1OUT	PWM1OUT	R/W	TC1M
0DDH	TC1C7	TC1C6	TC1C5	TC1C4	TC1C3	TC1C2	TC1C1	TC1C0	R/W	TC1C
0DEH	TC1R7	TC1R6	TC1R5	TC1R4	TC1R3	TC1R2	TC1R1	TC1R0	W	TC1R
0DFH	GIE	-	-	-	STKPB3	STKPB2	STKPB1	STKPB0	R/W	STKP stack pointer
0E0H								P00R	R/W	P0UR
0E1H							P11R	P10R	R/W	P1UR
0E4H					P43R	P42R	P41R	P40R	R/W	P4UR
0E5H			P55R	P54R	P53R	P52R	P51R	P50R	R/W	P5UR
0E7H	@YZ7	@YZ6	@YZ5	@YZ4	@YZ3	@YZ2	@YZ1	@YZ0	R/W	@YZ index pointer
0F0H	S7PC7	S7PC6	S7PC5	S7PC4	S7PC3	S7PC2	S7PC1	S7PC0	R/W	STK7L
0F1H	-	-	-	-	-	-	S7PC9	S7PC8	R/W	STK7H
0F2H	S6PC7	S6PC6	S6PC5	S6PC4	S6PC3	S6PC2	S6PC1	S6PC0	R/W	STK6L
0F3H	-	-	-	-	-	-	S6PC9	S6PC8	R/W	STK6H
“	“	“	“	“	“	“	“	“	“	“
“	“	“	“	“	“	“	“	“	“	“
“	“	“	“	“	“	“	“	“	“	“
0FCH	S1PC7	S1PC6	S1PC5	S1PC4	S1PC3	S1PC2	S1PC1	S1PC0	R/W	STK1L
0FDH	-	-	-	-	-	-	S1PC9	S1PC8	R/W	STK1H
0FEH	S0PC7	S0PC6	S0PC5	S0PC4	S0PC3	S0PC2	S0PC1	S0PC0	R/W	STK0L
0FFH	-	-	-	-	-	-	S0PC9	S0PC8	R/W	STK0H

Table 5-2. Bit System Register Table

Note:
a). To avoid system error, please be sure to put all the “0” as it indicates in the above table
b). All of register name had been declared in SONiX 8-bit MCU assembler.
c). One-bit name had been declared in SONiX 8-bit MCU assembler with “F” prefix code.
d). “b0bset”, “b0bclr”, ”bset”, ”bclr” instructions only support “R/W” registers.

6 POWER ON RESET

OVERVIEW

This series provides two system resets. One is external reset and the other is low voltage detector (LVD). The external reset is a simple RC circuit connecting to the reset pin. The low voltage detector (LVD) is built in internal circuit. When one of the reset devices occurs, the system will reset and the system registers become initial value. The timing diagram is as following.

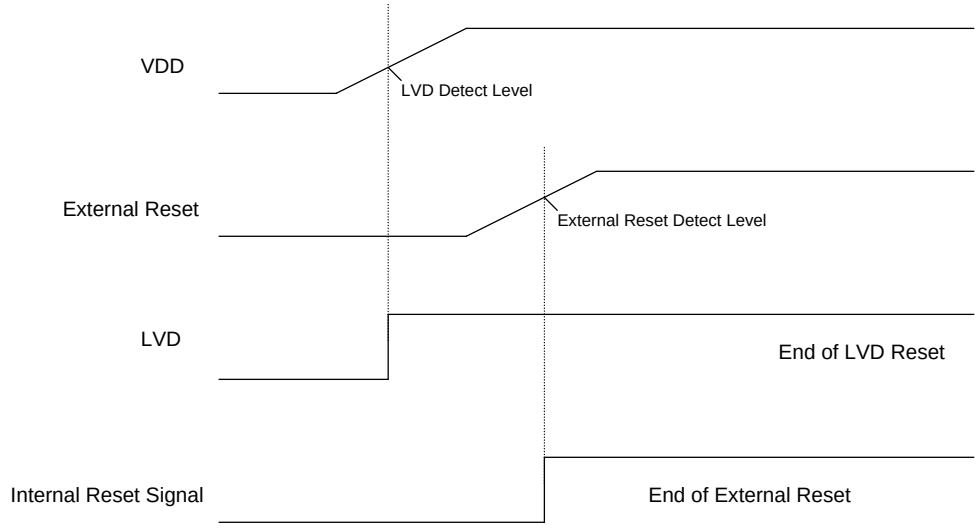


Figure 6-1 Power on Reset Timing Diagram

EXTERNAL RESET DESCRIPTION

The external reset is a low level active device. The reset pin receives the low voltage and resets the system. When the voltage detects high level, it stops resetting the system. Users can use an external reset circuit to control system operation. It is necessary that the VDD must be stable.

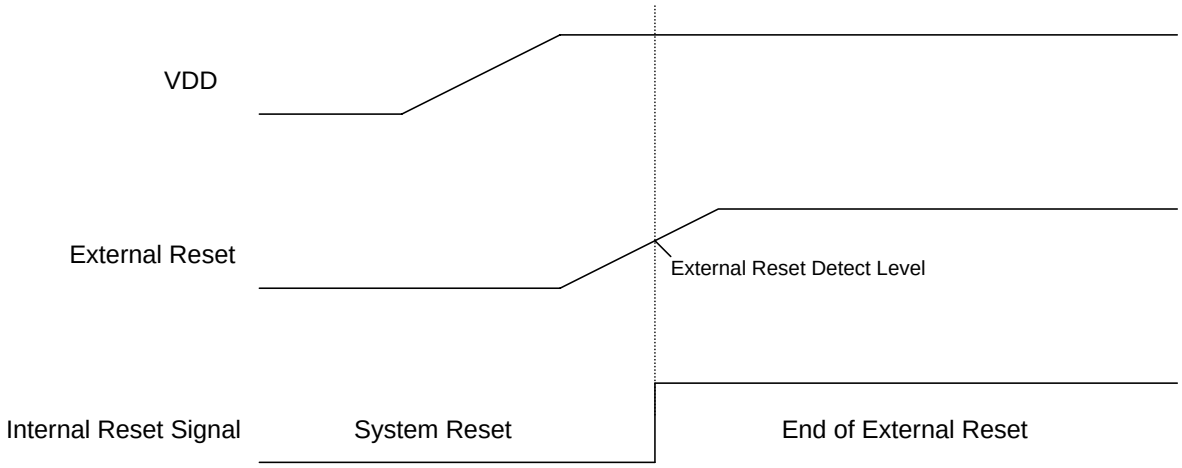


Figure 6-2 External Reset Timing Diagram

Users must to be sure the VDD stable earlier than external reset (Figure 5-2) or the external reset will fail. The external reset circuit is a simple RC circuit as following.

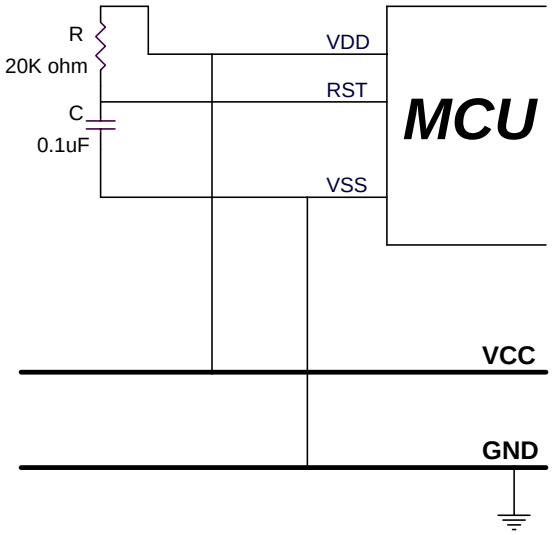


Figure 6-3. External Reset Circuit

In worse power, condition as brown out reset. The reset pin may keep high level but the VDD is low voltage. That makes the system reset fail and chip error. To connect a diode from reset pin to VDD is a good solution. The circuit can force the capacitor to release electric charge and drop the voltage, and solve the error.

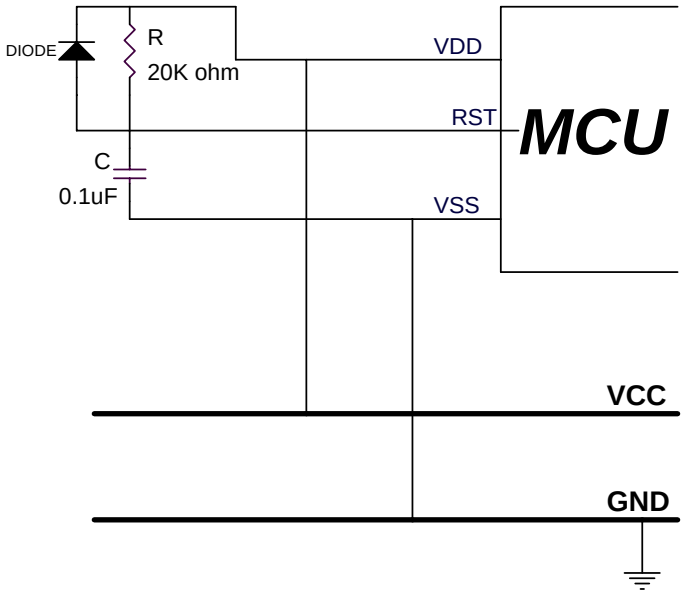


Figure 6-4. External Reset Circuit with Diode

7 OSCILLATORS

OVERVIEW

The SN8P1702A/SN8P1703A highly performs the dual clock micro-controller system. The dual clocks are high-speed clock and low-speed clock. The high-speed clock frequency is supplied through the external oscillator circuit. The low-speed clock frequency is supplied through on-chip RC oscillator circuit.

The external high-speed clock and the internal low-speed clock can be system clock (Fosc). And the system clock is divided by 4 to be the instruction cycle (Fcpu).

Fcpu = Fosc / 4

The system clock is required by the following peripheral modules:

- ✓ ***Timer counter 0 (TC0/TC1)***
- ✓ ***Watchdog timer***
- ✓ ***AD converter***
- ✓ ***PWM output (PWM0/PWM1)***
- ✓ ***Buzzer output (TC0OUT/TC1OUT)***

CLOCK BLOCK DIAGRAM

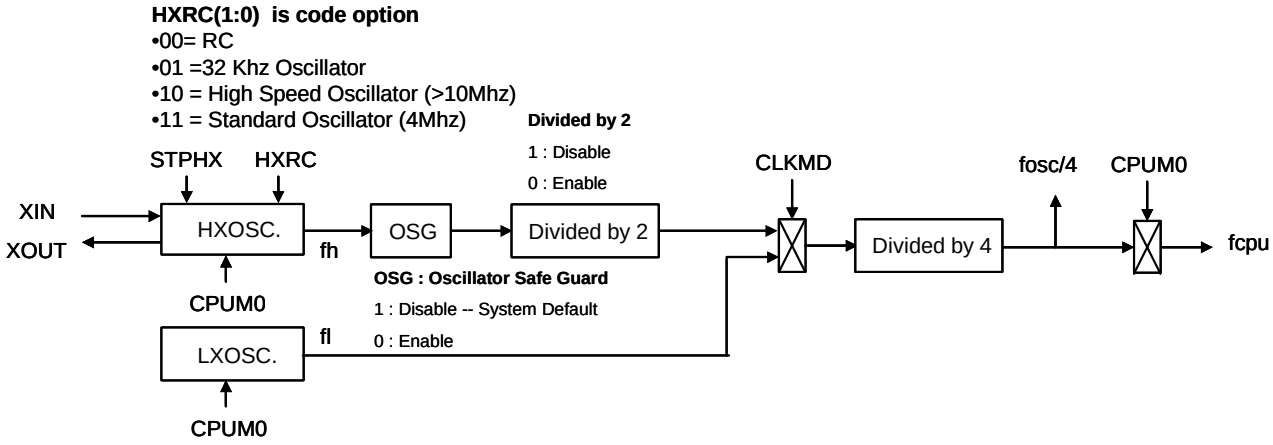


Figure 7-1. Clock Block Diagram

- ➢ HXOSC: External high-speed clock.
- ➢ LXOSC: Internal low-speed clock.
- ➢ OSG: Oscillator safe guard.

OSCM REGISTER DESCRIPTION

The OSCM register is a oscillator control register. It can control oscillator select, system mode, watchdog timer clock source and rate.

OSCM initial value = 000x 000x

0CAH	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
OSCM	WTCKS	WDRST	Wdrate	CPUM1	CPUM0	CLKMD	STPHX	0
	R/W	R/W	R/W	R/W	R/W	R/W	R/W	-

Bit1 **STPHX:** External high-speed oscillator control bit.
0 = free run,
1 = stop.

- ***Note: This bit only controls external high-speed oscillator. If STPHX=1, the internal low-speed RC oscillator is still running.***

Bit2 **CLKMD:** System high/Low speed mode select bit.
0 = normal (dual) mode,
1 = slow mode.

Bit[4:3] **CPUM[1:0]**: CPU operating mode control bit.
00 = normal,
01 = sleep (power down) mode,
10 = green mode,
11 = reserved.

Bit5 **Wdrate:** Watchdog timer rate select bit.
0 = Fcpu ÷ 2^{14}
1 = Fcpu ÷ 2^{8}
(The detail information is in watchdog timer chapter.)

Bit6 **WDRST:** Watchdog timer reset bit.
0 = Non reset,
1 = clear the watchdog timer's counter.
(The detail information is in watchdog timer chapter.)

Bit7 **WTCKS:** Watchdog clock source select bit.
0 = Fcpu,
1 = internal RC low clock.

EXTERNAL HIGH-SPEED OSCILLATOR

This series can be operated in four different oscillator modes. There are external RC oscillator modes, high crystal/resonator mode (12M code option), standard crystal/resonator mode (4M code option) and low crystal mode (32K code option). For different application, the users can select one of satiable oscillator mode by programming code option to generate system high-speed clock source after reset.

➲ **Example: Stop external high-speed oscillator.**

```
B0BSET    FSTPHX    ; To stop external high-speed oscillator only.

B0BSET    FCPUM0    ; To stop external high-speed oscillator and internal low-speed
                    ; oscillator called power down mode (sleep mode).
```

OSCILLATOR MODE CODE OPTION

This series has four oscillator modes for different applications. These modes are 4M, 12M, 32K and RC. The main purpose is to support different oscillator types and frequencies. High-speed crystal needs more current but the low one doesn't. For crystals, there are three steps to select. If the oscillator is RC type, to select "RC" and the system will divide the frequency by 2 automatically. User can select oscillator mode from Code Option table before compiling. The table is as follow.

Code Option	*Oscillator Mode*	*Remark*
00	RC mode	Output the Fcpu square wave from Xout pin.
01	32K	32768Hz
10	12M	12MHz ~ 16MHz
11	4M	3.58MHz

OSCILLATOR DEVIDE BY 2 CODE OPTION

This series has an external clock divide by 2 function. It is a code option called "High_Clk / 2". If "High_Clk / 2" is enabled, the external clock frequency is divided by 8 for the Fcpu. Fcpu is equal to Fosc/8. If "High_Clk / 2" is disabled, the external clock frequency is divided by 4 for the Fcpu. The Fcpu is equal to Fosc/4.

➢ ***Note: In RC mode, "High_Clk / 2" is always enabled.***

OSCILLATOR SAFE GUARD CODE OPTION

This series builds in an oscillator safe guard (OSG) to make oscillator more stable. It is a low-pass filter circuit and stops high frequency noise into system from external oscillator circuit. This function makes system to work better under AC noisy conditions.

SYSTEM OSCILLATOR CIRCUITS

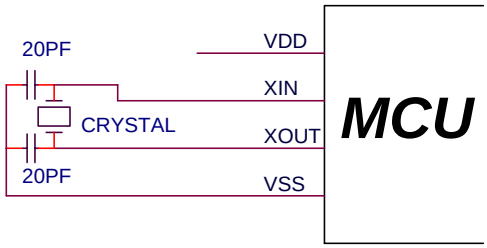


Figure 7-2. Crystal/Ceramic Oscillator

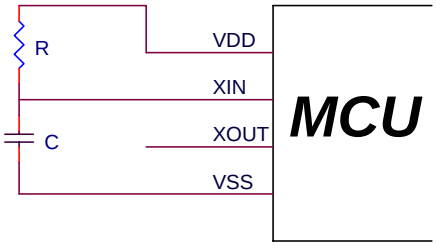


Figure 7-3. RC Oscillator

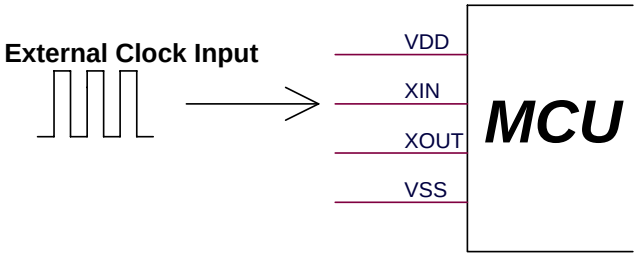


Figure 7-4. External clock input

- ***Note1: The VDD and VSS of external oscillator circuit must be from the micro-controller. Don't connect them from the neighbor power terminal.***
- ***Note2: The external clock input mode can select RC type oscillator or crystal type oscillator of the code option and input the external clock into XIN pin.***
- ***Note3: In RC type oscillator code option situation, the external clock's frequency is divided by 2.***
- ***Note4: The power and ground of external oscillator circuit must be connected from the micro-controller's VDD and VSS. It is necessary to step up the performance of the whole system.***

External RC Oscillator Frequency Measurement

There are two ways to get the Fosc frequency of external RC oscillator. One measures the XOUT output waveform. Under external RC oscillator mode, the XOUT outputs the square waveform whose frequency is Fcpu. The other measures the external RC frequency by instruction cycle (Fcpu). The external RC frequency is the Fcpu multiplied by 4. We can get the Fosc frequency of external RC from the Fcpu frequency. The sub-routine to get Fcpu frequency of external oscillator is as the following.

➲ Example: Fcpu instruction cycle of external oscillator

```
        B0BSET    P1M.0     ; Set P1.0 to be output mode for outputting Fcpu toggle
                              signal.

@@:
        B0BSET    P1.0      ; Output Fcpu toggle signal in low-speed clock mode.
        B0BCLR    P1.0      ; Measure the Fcpu frequency by oscilloscope.
        JMP       @B
```

INTERNAL LOW-SPEED OSCILLATOR

The internal low-speed oscillator is built in the micro-controller. The low-speed clock's source is a RC type oscillator circuit. The low-speed clock can supplies clock for system clock, timer counter, watchdog timer, SIO clock source and so on.

➲ **Example: Stop internal low-speed oscillator.**

```
B0BSET    FCPUM0      ; To stop external high-speed oscillator and internal low-speed
                      ; oscillator called power down mode (sleep mode).
```

➢ ***Note: The internal low-speed clock can't be turned off individually. It is controlled by CPUM0 bit of OSCM register.***

The low-speed oscillator uses RC type oscillator circuit. The frequency is affected by the voltage and temperature of the system. In common condition, the frequency of the RC oscillator is about 16KHz at 3V and 32KHz at 5V. The relative between the RC frequency and voltage is as following.

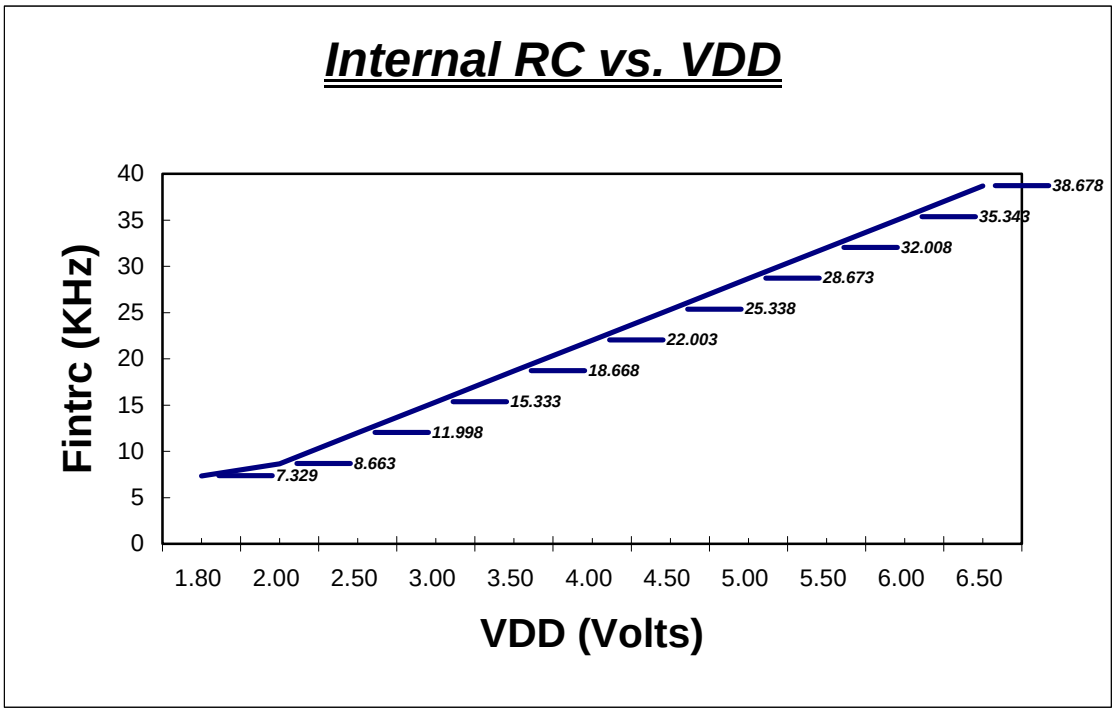


Figure 7-5. Internal RC vs. VDD Diagram

➲ **Example: To measure the internal RC frequency is by instruction cycle (Fcpu). The internal RC frequency is the Fcpu multiplied by 4. Therefore, we can get the Fosc frequency of internal RC from the Fcpu frequency.**

```
        B0BSET    P1M.0       ; Set P1.0 to be output mode for outputting Fcpu toggle signal.

        B0BSET    FCLKMD      ; Switch the system clock to internal low-speed clock mode.
@@:
        B0BSET    P1.0        ; Output Fcpu toggle signal in low-speed clock mode.
        B0BCLR    P1.0        ; Measure the Fcpu frequency by oscilloscope.
        JMP       @B
```

SYSTEM MODE DESCRIPTION

OVERVIEW

The chip is featured with low power consumption by switching around three different modes as following.

- High-speed mode
- Low-speed mode
- Power-down mode (Sleep mode)
- Green mode

In actual application, the user can adjust the chip's controller to work in these three modes by using OSCM register. At the high-speed mode, the instruction cycle (Fcpu) is Fosc/4. At the low-speed mode and 3V, the Fcpu is 16KHz/4.

NORMAL MODE

In normal mode, the system clock source is external high-speed clock. After power on, the system works under normal mode. The instruction cycle is fosc/4. When the external high-speed oscillator is 3.58MHz, the instruction cycle is 3.58MHz/4 = 895KHz. All software and hardware are executed and working. In normal mode, system can get into power down mode and slow mode.

SLOW MODE

In slow mode, the system clock source is internal low-speed RC clock. To set CLKMD = 1, the system switch to slow mode. In slow mode, the system works as normal mode but the slower clock. The system in slow mode can get into normal mode and power down mode. To set STPHX = 1 to stop the external high-speed oscillator, and then the system consumes less power.

GREEN MODE

The green mode is a less power consumption mode. Under green mode, there are only TC0 still counting and the other hardware stopping. The external high-speed oscillator or internal low-speed oscillator is operating. To set CPUM1 = 1 and CPUM0 = 0, the system gets into green mode. To set TC0GN = 1 (bit 1 of T0M) will enable TC0 green mode wakeup function. The system can be waked up to last system mode by TC0 timer timeout and P0 trigger signal.

The green mode provides a time-variable wakeup function. Users can decide wakeup time by setting TC0 timer. There are two channels into green mode. One is normal mode and the other is slow mode. In normal mode, the TC0 timer overflow time is very short. In slow mode, the overflow time is longer. Users can select appropriate situation for their applications. Under green mode, the power consumption is 5u amp in 3V condition.

POWER DOWN MODE

The power down mode is also called sleep mode. The chip stops working as sleeping status. The power consumption is very less almost to zero. The power down mode is usually applied to low power consuming system as battery power productions. To set CUPM0 = 1, the system gets into power down mode. The external high-speed and low-speed oscillators are turned off. The system can be waked up by P0, P1 trigger signal.

SYSTEM MODE CONTROL

SYSTEM MODE BLOCK DIAGRAM

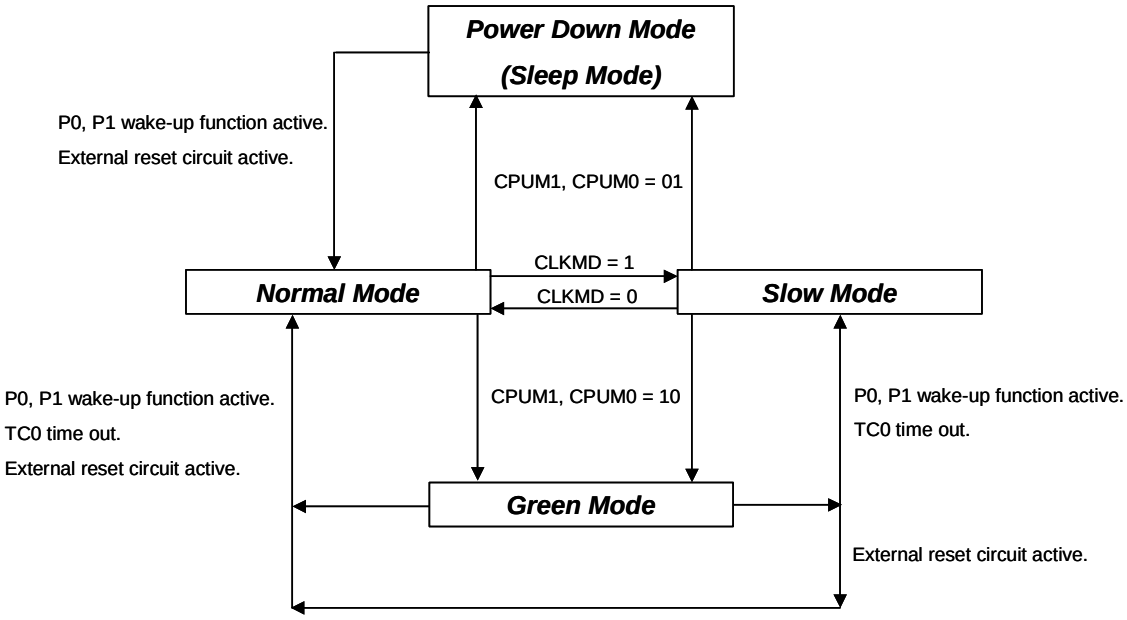


Figure 7-6. System Mode Block Diagram

Operating mode description

MODE	NORMAL	SLOW	GREEN	POWER DOWN (SLEEP)	REMARK
HX osc.	Running	By STPHX	By STPHX	Stop	
LX osc.	Running	Running	Running	Stop	
CPU instruction	Executing	Executing	Stop	Stop	
TC0 timer	*Active	*Active	*Active	Inactive	* Active by program
Watchdog timer	Active	Active	By INT_16K_RC	By INT_16K_RC	
Internal interrupt	All active	All active	TC0	All inactive	
External interrupt	All active	All active	All active	All inactive	
Wakeup source	-	-	P0, P1, TC0 Reset	P0, P1, Reset	

Table 7-1. Operating Mode Description

SYSTEM MODE SWITCHING

Switch normal/slow mode to power down (sleep) mode.
CPUM0 = 1

```
        B0BSET      FCPUM0          ; Set CPUM0 = 1.
```

During the sleep, only the wakeup pin and reset can wakeup the system back to the normal mode.

Switch normal mode to slow mode.

```
        B0BSET      FCLKMD          ;To set CLKMD = 1, Change the system into slow mode
        B0BSET      FSTPHX          ;To stop external high-speed oscillator for power saving.
```

➢ ***Note: To stop high-speed oscillator is not necessary and user can omit it.***

Switch slow mode to normal mode (The external high-speed oscillator is still running)

```
        B0BCLR      FCLKMD          ;To set CLKMD = 0
```

Switch slow mode to normal mode (The external high-speed oscillator stops)
If external high clock stop and program want to switch back normal mode. It is necessary to delay at least 10mS for external clock stable.

```
        B0BCLR      FSTPHX          ; Turn on the external high-speed oscillator.

        B0MOV       Z, #27          ; If VDD = 5V, internal RC=32KHz (typical) will delay
@@:     DECMS       Z               ; 0.125ms X 81 = 10.125ms for external clock stable
        JMP         @B
                                    ;
        B0BCLR      FCLKMD          ; Change the system back to the normal mode
```

➲ **Example: Go into Green mode and enable TC0 wakeup function.**

```
; Set TC0 timer wakeup function.
        B0BCLR      FTC0IEN         ; To disable TC0 interrupt service
        B0BCLR      FTC0ENB         ; To disable TC0 timer
        MOV         A,#20H          ;
        B0MOV       TC0M,A          ; To set TC0 clock = Fcpu / 64
        MOV         A,#74H
        B0MOV       TC0C,A          ; To set TC0C initial value = 74H (To set TC0 interval = 10
                                    ms)
        B0BCLR      FTC0IEN         ; To disable TC0 interrupt service
        B0BCLR      FTC0IRQ         ; To clear TC0 interrupt request
        B0BSET      FTC0ENB         ; To enable TC0 timer
        B0BSET      FTC0GN          ; To enable TC0 wakeup function
; Go into green mode
        B0BCLR      FCPUM0          ;To set CPUMx = 10
        B0BSET      FCPUM1
```

➢ ***Note: If TC0ENB = 0 or TC0GN = 0, TC0 will not wakeup from green mode to normal/slow mode function.***

WAKEUP TIME

OVERVIEW

The external high-speed oscillator needs a delay time from stopping to operating. The delay is very necessary and makes the oscillator to work stably. Some conditions during system operating, the external high-speed oscillator often runs and stops. Under these conditions, the delay time for external high-speed oscillator restart is called wakeup time.

There are two conditions need wakeup time. One is power down mode to normal mode. The other one is slow mode to normal mode. For the first case, SN8P1702A/SN8P1703A provides 2048 oscillator clocks to be the wakeup time. But in the last case, users need to make the wakeup time by themselves.

HARDWARE WAKEUP

When the system is in power down mode (sleep mode), the external high-speed oscillator stops. When waked up from power down mode, MCU waits for 2048 external high-speed oscillator clocks as the wakeup time to stable the oscillator circuit. After the wakeup time, the system goes into the normal mode. The value of the wakeup time is as the following.

The Wakeup time = 1/Fosc * 2048 (sec) + X'tal settling time

The x'tal settling time is depended on the x'tal type. Typically, it is about 2~4mS.

➲ **Example: In power down mode (sleep mode), the system is waked up by P0 or P1 trigger signal. After the wakeup time, the system goes into normal mode. The wakeup time of P0, P1 wakeup function is as the following.**

*The wakeup time = 1/Fosc * 2048 = 0.57 ms (Fosc = 3.58MHz)*

The total wakeup time = 0.57ms + x'tal settling time

Under power down mode (sleep mode), there are only I/O ports with wakeup function wake the system up to normal mode. The Port 0 and Port 1 have wakeup function. Port 0 wakeup function always enables, but the Port 1 is controlled by the P1W register.

P1W initial value = xxxx xx00

0C0H	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
P1W	0	0	0	0	0	0	P11W	P10W
	-	-	-	-	-	-	W	W

Bit[1:0] **P11W,P10W:**Port 1 wakeup function control bits.
0 = Disable each pin of Port1 wakeup function,
1 = Enable each pin of Port 1 wakeup function

EXTERNAL WAKEUP TRIGGER CONTROL

In the SN8P1702A/SN8P1703A, the wakeup trigger direction is control by PEDGE register.

PEDGE initial value = 0xx0 0xxx

0BFH	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
PEDGE	PEDGEN	-	-	P00G1	P00G0	-	-	-
	R/W	-	-	R/W	R/W	-	-	-

Bit7 **PEDGEN:** Interrupt and wakeup trigger edge control bit.
0 = Disable edge trigger function.
Port 0: Low-level wakeup trigger and falling edge interrupt trigger.
Port 1: Low-level wakeup trigger.
1 = Enable edge trigger function.
P0.0: Wakeup and interrupt trigger is controlled by P00G1 and P00G0 bits.
Port 1: Level change (falling or rising edge) wakeup trigger.

Bit[4:3] **P00G[1:0]:** Port 0.0 edge select bits.
00 = reserved,
01 = rising edge,
10 = falling edge,
11 = rising/falling bi-direction.

8 TIMERS COUNTERS

WATCHDOG TIMER (WDT)

The watchdog timer (WDT) is a binary up counter designed for monitoring program execution. If the program gets in the unknown status by noise interference, The WDT's overflow signal will reset this chip and restart operation. The instruction that clear the watch-dog timer (B0BSET FWDRST) should be executed at proper points in a program within a given period. If an instruction that clears the watchdog timer is not executed within the period and the watchdog timer overflows, reset signal is generated and system is restarted with reset status. In order to generate different output timings, the user can control watchdog timer by modifying the Wdrate control bits of OSCM register. The watchdog timer will be disabled at green and power down modes.

OSCM initial value = 0000 000x

0CAH	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
OSCM	WTCKS	WDRST	Wdrate	CPUM1	CPUM0	CLKMD	STPHX	-
	R/W	R/W	R/W	R/W	R/W	R/W	R/W	-

Bit1 **STPHX:** External high-speed oscillator control bit.
0 = free run,
1 = stop.
Note: This bit only controls external high-speed oscillator. If STPHX=1, the internal low-speed RC oscillator is still running.

Bit2 **CLKMD:** System high/Low speed mode select bit.
0 = normal (dual) mode,
1 = slow mode.

Bit[4:3] **CPUM[1:0]**: CPU operating mode control bit.
00 = normal,
01 = sleep (power down) mode,
10 = green mode,
11 = reserved.

Bit5 **Wdrate:** Watchdog timer rate select bit.
0 = Fcpu ÷ 2^{14}
1 = Fcpu ÷ 2^{8}

Bit6 **WDRST:** Watchdog timer reset bit.
0 = Non reset,
1 = clear the watchdog timer's counter.
(The detail information is in watchdog timer chapter.)

Bit7 **WTCKS:** Watchdog clock source select bit.
0 = Fcpu,
1 = internal RC low clock.

WTCKS	WTRATE	CLKMD	Watchdog Timer Overflow Time
0	0	0	1 / (Fcpu ÷ 2^{14} ÷ 16) = 293 ms, Fosc=3.58MHz
0	1	0	1 / (Fcpu ÷ 2^{8} ÷ 16) = 500 ms, Fosc=32768Hz
0	0	1	1 / (Fcpu ÷ 2^{14} ÷ 16) = 65.5s, Fosc=16KHz@3V
0	1	1	1 / (Fcpu ÷ 2^{8} ÷ 16) = 1s, Fosc=16KHz@3V
1	-	-	1 / (16K ÷ 512 ÷ 16) ~ 0.5s @3V

Table 8-1. Watchdog timer overflow timetable

➢ ***Note: The watch dog timer can be enabled or disabled by the code option.***

➲ **Example: An operation of watchdog timer is as following. To clear the watchdog timer's counter in the top of the main routine of the program.**

```
Main:
        B0BSET      FWDRST          ; Clear the watchdog timer's counter.
        .           .
        CALL        SUB1
        CALL        SUB2
        .           .
        .           .
        .           .
        JMP         MAIN
```

T0M Register

T0M initial value = xxxx 000x

0D8H	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
T0M	-	-	-	-	TC1X8	TC0X8	TC0GN	-
	-	-	-	-	R/W	R/W	R/W	-

Bit3 **TC1X8:** Multiple TC1 timer speed eight times. Refer TC1M register for detailed information.
0 = Disable
1 = Enable

Bit2 **TC0X8:** Multiple TC0 timer speed eight times. Refer TC0M register for detailed information.
0 = Disable
1 = Enable

Bit0 **TC0GN:** Enable TC0 green mode wakeup function
0 = Disable
1 = Enable

TIMER COUNTER 0 (TC0)

OVERVIEW

The timer counter 0 (TC0) is used to generate an interrupt request when a specified time interval has elapsed. TC0 has a auto re-loadable counter that consists of two parts: an 8-bit reload register (TC0R) into which you write the counter reference value, and an 8-bit counter register (TC0C) whose value is automatically incremented by counter logic.

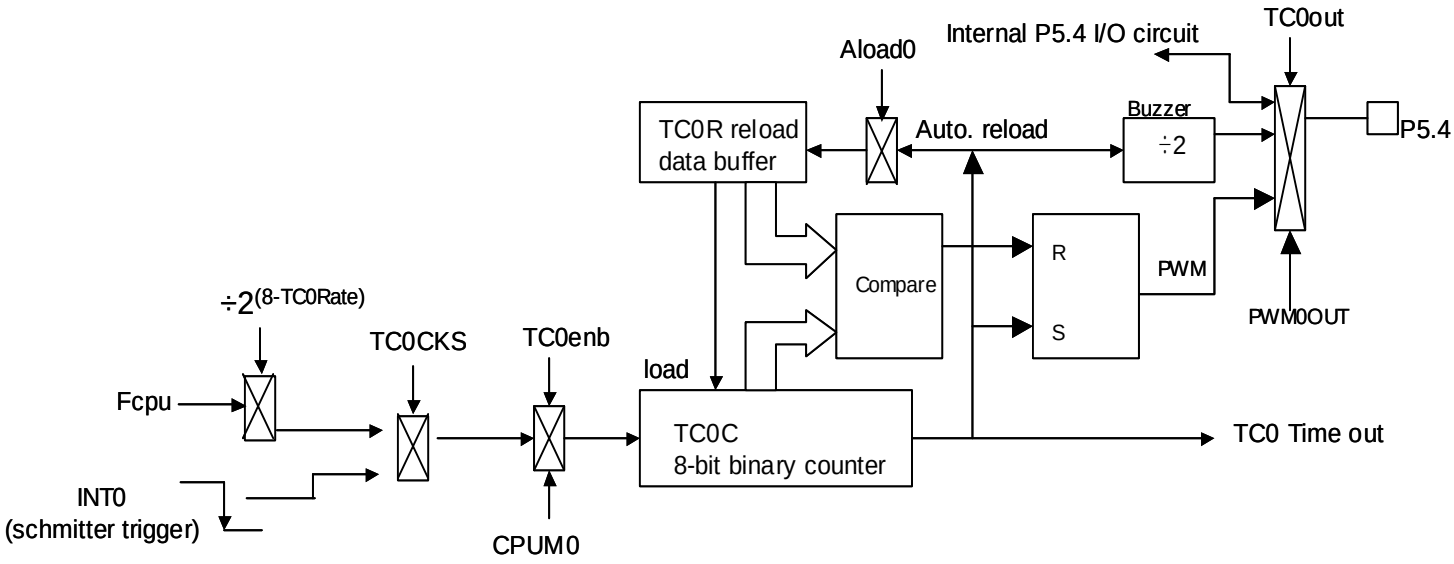


Figure 8-1. TC0 Block Diagram

The main purposes of the TC0 timer counter is as following.

- **8-bit programmable timer:** Generates interrupts at specific time intervals based on the selected clock frequency.
- **Arbitrary frequency output (Buzzer output):** Outputs selectable clock frequencies to the BZ0 pin (P5.4).
- **PWM function:** PWM output can be generated by the PWM1OUT bit and output to PWM0OUT pin (P5.4).

TC0M MODE REGISTER

The TC0M is the timer counter mode register, which is an 8-bit read/write register. By loading different value into the TC0M register, users can modify the timer counter clock frequency dynamically when program executing.

Eight rates for TC0 timer can be selected by TC0RATE0 ~ TC0RATE2 and TC0X8 bits of T0M register. If TC0X8=1 the TC0 will faster 8 times than TC0X8=0 (Initial value). The bit7 of TC0M named TC0ENB is the control bit to start TC0 timer.

TC0M initial value = 0000 0000

0DAH	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
TC0M	TC0ENB	TC0RATE2	TC0RATE1	TC0RATE0	TC0CKS	ALOAD0	TC0OUT	PWM0OUT
	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W

Bit7 **TC0ENB:** TC0 counter/BZ0/PWM0OUT enable bit.
0 = disable,
1 = enable.

Bit [6:4] **TC0RATE[2:0]:** TC0 clock source selection bits. TC0X8 is bit 2 of T0M register.

TC0RATE [2:0]	TC0 Clock Source	
	TC0X8 = 0	TC0X8 = 1
000	Fcpu/256 = Fosc/1024	Fosc/128
001	Fcpu/128 = Fosc/512	Fosc/64
…	…	…
110	Fcpu/4 = Fosc/16	Fosc/2
111	Fcpu/2 = Fosc/8	Fosc

Note: Fcpu = Fosc / 4

Bit3 **TC0CKS:** TC0 clock source select bit.
0 = Fcpu,
1 = External clock comes from INT0/P0.0 pin.

Bit2 **ALOAD0:** TC0 auto-reload function control bit.
0 = none auto-reload,
1 = auto-reload.

Bit1 **TC0OUT:** TC0 time-out toggle signal output control bit.
0 = to disable TC0 signal output and to enable P5.4's I/O function,
1 = to enable TC0's signal output and to disable P5.4's I/O function. (Auto-disable the PWM0OUT function.)

Bit0 **PWM0OUT:** TC0's PWM output control bit.
0 = to disable the PWM output,
1 = to enable the PWM output (The TC0OUT control bit must = 0)

➢ ***Note: When TC0CKS=1, TC0 became an external event counter. No more P0.0 interrupt request will be raised. (P0.0IRQ will be always 0)***

TC0C COUNTING REGISTER

TC0C is an 8-bit counter register for the timer counter (TC0). TC0C must be reset whenever the TC0ENB is set "1" to start the timer counter. TC0C is incremented by one with a clock pulse which the frequency is determined by TC0RATE0 ~ TC0RATE2. When TC0C has incremented to "0FFH", it is will be cleared to "00H" in next clock and an overflow is generated. Under TC0 interrupt service request (TC0IEN) enable condition, the TC0 interrupt request flag will be set "1" and the system executes the interrupt service routine.

TC0C initial value = xxxx xxxx

0DBH	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
TC0C	TC0C7	TC0C6	TC0C5	TC0C4	TC0C3	TC0C2	TC0C1	TC0C0
	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W

TC0 Overflow Time

TC0 rate is determinate by TC0Rate and Code Option TC0_Counter, TC0Rate can set TC0 clock frequency and TC0_Counter set TC0 became 8-bit, 6-bit, 5-bit or 4-bit counter.
The equation of TC0C initial value is as following.

TC0C initial value = N - (TC0 interrupt interval time * input clock)

Which N is determinate by code option: TC0_Counter

TC0_Counter	N	Max. TC0C value
8-bit	256	255
6-bit	64	63
5-bit	32	31
4-bit	16	15

➢ ***Note: TheTC0C must small or equal than Max. TC0 value.***

➲ **Example: To set 10ms interval time for TC0 interrupt at Fosc = 3.58MHz**
TC0C value (74H) = 256 - (10ms * fcpu/64) (TC0RATE=010, TC0_Counter=8-bit, TC0X8=0)

TC0C initial value = 256 - (TC0 interrupt interval time * input clock)
= 256 - (10ms * 3.58 * 10^6 / 4 / 64)
= 256 - (0.01 * 3.58 * 10^6 / 4 / 64)
= 116
= 74H

➲ **Example: To set 1.25ms interval time for TC0 interrupt at Fosc = 3.58MHz**
TC0C value (74H) = 256 - (10ms * fcpu/64) (TC0RATE=010, TC0_Counter=8-bit, TC0X8=1)

TC0C initial value = 256 - (TC0 interrupt interval time * input clock)
= 256 - (1.25ms * 3.58 * 10^6 / 32)
= 256 - (0.00125 * 3.58 * 10^6 / 32)
= 116
= 74H

➲ **Example: To set 1ms interval time for TC0 interrupt at Fosc = 3.58MHz**
TC0C value (32H) = 64 - (1ms * fcpu/64) (TC0RATE=010, TC0_COunter=6-bit, TC0X8=0)

TC0C initial value = 64 - (TC0 interrupt interval time * input clock)
= 64 - (1ms * 3.58 * 10^6 / 4 / 64)
= 64 - (0.001 * 3.58 * 10^6 / 4 / 64)
= 64 - 14
= 32H

TC0_Counter=8-bit, TC0X8=0

TC0RATE	TC0CLOCK	High speed mode (Fcpu = 3.58MHz / 4)		Low speed mode (Fosc = 32768Hz / 4)	
		Max overflow interval	One step = max/256	Max overflow interval	One step = max/256
000	Fcpu/256	73.2 ms	286us	8000 ms	31.25 ms
001	Fcpu/128	36.6 ms	143us	4000 ms	15.63 ms
010	Fcpu/64	18.3 ms	71.5us	2000 ms	7.8 ms
011	Fcpu/32	9.15 ms	35.8us	1000 ms	3.9 ms
100	Fcpu/16	4.57 ms	17.9us	500 ms	1.95 ms
101	Fcpu/8	2.28 ms	8.94us	250 ms	0.98 ms
110	Fcpu/4	1.14 ms	4.47us	125 ms	0.49 ms
111	Fcpu/2	0.57 ms	2.23us	62.5 ms	0.24 ms

TC0_Counter=6-bit , TC0X8=0

TC0RATE	TC0CLOCK	High speed mode (Fcpu = 3.58MHz / 4)		Low speed mode (Fcpu = 32768Hz / 4)	
		Max overflow interval	One step = max/64	Max overflow interval	One step = max/64
000	Fcpu/256	18.3 ms	286us	2000 ms	31.25 ms
001	Fcpu/128	9.15 ms	143us	1000 ms	15.63 ms
010	Fcpu/64	4.57 ms	71.5us	500 ms	7.8 ms
011	Fcpu/32	2.28 ms	35.8us	250 ms	3.9 ms
100	Fcpu/16	1.14 ms	17.9us	125 ms	1.95 ms
101	Fcpu/8	0.57 ms	8.94us	62.5 ms	0.98 ms
110	Fcpu/4	0.285 ms	4.47us	31.25 ms	0.49 ms
111	Fcpu/2	0.143 ms	2.23us	15.63 ms	0.24 ms

TC0_Counter=5-bit, TC0X8=0

TC0RATE	TC0CLOCK	High speed mode (Fcpu = 3.58MHz / 4)		Low speed mode (Fcpu = 32768Hz / 4)	
		Max overflow interval	One step = max/32	Max overflow interval	One step = max/32
000	Fcpu/256	9.15 ms	286us	1000 ms	31.25 ms
001	Fcpu/128	4.57 ms	143us	500 ms	15.63 ms
010	Fcpu/64	2.28 ms	71.5us	250 ms	7.8 ms
011	Fcpu/32	1.14 ms	35.8us	125 ms	3.9 ms
100	Fcpu/16	0.57 ms	17.9us	62.5 ms	1.95 ms
101	Fcpu/8	0.285 ms	8.94us	31.25 ms	0.98 ms
110	Fcpu/4	0.143 ms	4.47us	15.63 ms	0.49 ms
111	Fcpu/2	71.25 us	2.23us	7.81 ms	0.24 ms

TC0_Counter=4-bit, TC0X8=0

TC0RATE	TC0CLOCK	High speed mode (Fcpu = 3.58MHz / 4)		Low speed mode (Fcpu = 32768Hz / 4)	
		Max overflow interval	One step = max/16	Max overflow interval	One step = max/16
000	Fcpu/256	4.57 ms	286us	500 ms	31.25 ms
001	Fcpu/128	2.28 ms	143us	250 ms	15.63 ms
010	Fcpu/64	1.14 ms	71.5us	125 ms	7.8 ms
011	Fcpu/32	0.57 ms	35.8us	62.5 ms	3.9 ms
100	Fcpu/16	0.285 ms	17.9us	31.25 ms	1.95 ms
101	Fcpu/8	0.143 ms	8.94us	15.63 ms	0.98 ms
110	Fcpu/4	71.25 us	4.47us	7.81 ms	0.49 ms
111	Fcpu/2	35.63 us	2.23us	3.91 ms	0.24 ms

TC0_Counter=8-bit, TC0X8=1

TC0RATE	TC0CLOCK	High speed mode (Fosc = 3.58MHz)		Low speed mode (Fosc = 32768Hz)	
		Max overflow interval	One step = max/256	Max overflow interval	One step = max/256
000	Fosc/128	9.153 ms	35.754us	1000 ms	3.91 ms
001	Fosc/64	4.58 ms	17.877us	500 ms	1.95 ms
010	Fosc/32	2.29 ms	8.939us	250 ms	0.977 ms
011	Fosc/16	1.14 ms	4.470us	125 ms	0.488 ms
100	Fosc/8	0.57 ms	2.235us	62.5 ms	0.244 ms
101	Fosc/4	0.29 ms	1.117us	31.25 ms	0.122 ms
110	Fosc/2	0.14 ms	0.587us	15.63 ms	0.061 ms
111	Fosc	71.5 us	0.279us	7.81ms	0.03 ms

TC0_Counter=6-bit , TC0X8=1

TC0RATE	TC0CLOCK	High speed mode (Fosc = 3.58MHz)		Low speed mode (Fosc = 32768Hz)	
		Max overflow interval	One step = max/64	Max overflow interval	One step = max/64
000	Fosc/128	2.29 ms	35.754us	250 ms	3.91 ms
001	Fosc/64	1.14 ms	17.877us	125 ms	1.95 ms
010	Fosc/32	0.57 ms	8.939us	62.5 ms	0.977 ms
011	Fosc/16	0.29 ms	4.470us	31.25 ms	0.488 ms
100	Fosc/8	0.14 ms	2.235us	15.63 ms	0.244 ms
101	Fosc/4	71.5 us	1.117us	7.81ms	0.122 ms
110	Fosc/2	35.75 us	0.587us	3.905 ms	0.061 ms
111	Fosc	17.875 us	0.279us	1.953 ms	0.03 ms

TC0_Counter=5-bit, TC0X8=1

TC0RATE	TC0CLOCK	High speed mode (Fosc = 3.58MHz)		Low speed mode (Fosc = 32768Hz)	
		Max overflow interval	One step = max/32	Max overflow interval	One step = max/32
000	Fosc/128	1.14 ms	35.754us	125 ms	3.91 ms
001	Fosc/64	0.57 ms	17.877us	62.5 ms	1.95 ms
010	Fosc/32	0.29 ms	8.939us	31.25 ms	0.977 ms
011	Fosc/16	0.14 ms	4.470us	15.63 ms	0.488 ms
100	Fosc/8	71.5 us	2.235us	7.81ms	0.244 ms
101	Fosc/4	35.75 us	1.117us	3.905 ms	0.122 ms
110	Fosc/2	17.875 us	0.587us	1.953 ms	0.061 ms
111	Fosc	8.936 us	0.279us	0.976 ms	0.03 ms

TC0_Counter=4-bit, TC0X8=1

TC0RATE	TC0CLOCK	High speed mode (Fosc = 3.58MHz)		Low speed mode (Fosc = 32768Hz)	
		Max overflow interval	One step = max/16	Max overflow interval	One step = max/16
000	Fosc/128	0.57 ms	35.754us	62.5 ms	3.91 ms
001	Fosc/64	0.29 ms	17.877us	31.25 ms	1.95 ms
010	Fosc/32	0.14 ms	8.939us	15.63 ms	0.977 ms
011	Fosc/16	71.5 us	4.470us	7.81ms	0.488 ms
100	Fosc/8	35.75 us	2.235us	3.905 ms	0.244 ms
101	Fosc/4	17.875 us	1.117us	1.953 ms	0.122 ms
110	Fosc/2	8.936 us	0.587us	0.976 ms	0.061 ms
111	Fosc	4.468 us	0.279us	0.488 ms	0.03 ms

Table 8-2. The Timing Table of Timer Counter TC0

TC0R AUTO-LOAD REGISTER

TC0R is an 8-bit register for the TC0 auto-reload function. TC0R's value applies to TC0OUT and PWM0OUT functions. Under TC0OUT application, users must enable and set the TC0R register. The main purpose of TC0R is as following.

- Store the auto-reload value and set into TC0C when the TC0C overflow. (ALOAD0 = 1).
- Store the duty value of PWM0OUT function.

TC0R initial value = xxxx xxxx

0CDH	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
TC0R	TC0R7	TC0R6	TC0R5	TC0R4	TC0R3	TC0R2	TC0R1	TC0R0
	W	W	W	W	W	W	W	W

The equation of TC0R initial value is like TC0C as following.

TC0R initial value = N - (TC0 interrupt interval time * input clock)

Which N is determinate by code option: TC0_Counter

TC0_Counter	N	Max. TC0R value
8-bit	256	255
6-bit	64	63
5-bit	32	31
4-bit	16	15

- ***Note: TheTC0R must small or equal than Max. TC0R value.***
- ***Note: The TC0R is write-only register can't be process by INCMS, DECMS instructions.***

TC0 TIMER COUNTER OPERATION SEQUENCE

The TC0 timer counter's sequence of operation can be following.

- Set the TC0C initial value to setup the interval time.
- Set the TC0ENB to be "1" to enable TC0 timer counter.
- TC0C is incremented by one with each clock pulse which frequency is corresponding to TC0M selection.
- TC0C overflow when TC0C from FFH to 00H.
- When TC0C overflow occur, the TC0IRQ flag is set to be "1" by hardware.
- Execute the interrupt service routine.
- Users reset the TC0C value and resume the TC0 timer operation.

➲ Example: Setup the TC0M and TC0C without auto-reload function. (TC0_Counter=8-bit)

```
B0BCLR      FTC0X8      ;
B0BCLR      FTC0IEN     ; To disable TC0 interrupt service
B0BCLR      FTC0ENB     ; To disable TC0 timer
MOV         A,#20H      ;
B0MOV       TC0M,A      ; To set TC0 clock = Fcpu / 64
MOV         A,#74H      ; To set TC0C initial value = 74H
B0MOV       TC0C,A      ;(To set TC0 interval = 10 ms)

B0BSET      FTC0IEN     ; To enable TC0 interrupt service
B0BCLR      FTC0IRQ     ; To clear TC0 interrupt request
B0BSET      FTC0ENB     ; To enable TC0 timer
```

➲ Example: Setup the TC0M and TC0C with auto-reload function. (TC0_Counter=8-bit)

```
B0BCLR      FTC0X8      ; To select TC0=Fcpu/2 as clock source
B0BCLR      FTC0IEN     ; To disable TC0 interrupt service
B0BCLR      FTC0ENB     ; To disable TC0 timer
MOV         A,#20H      ;
B0MOV       TC0M,A      ; To set TC0 clock = Fcpu / 64
MOV         A,#74H      ; To set TC0C initial value = 74H
B0MOV       TC0C,A      ; (To set TC0 interval = 10 ms)
B0MOV       TC0R,A      ; To set TC0R auto-reload register

B0BSET      FTC0IEN     ; To enable TC0 interrupt service
B0BCLR      FTC0IRQ     ; To clear TC0 interrupt request
B0BSET      FTC0ENB     ; To enable TC0 timer
B0BSET      ALOAD0      ; To enable TC0 auto-reload function.
```

➲ **Example: TC0 interrupt service routine without auto-reload function. (TC0_Counter=8-bit)**

```
                ORG         8               ; Interrupt vector
                JMP         INT_SERVICE
INT_SERVICE:

                B0XCH       A, ACCBUF       ; Store ACC value.
                B0MOV       A, PFLAG
                B0MOV       PFLAGBUF, A

                B0BTS1      FTC0IRQ         ; Check TC0IRQ
                JMP         EXIT_INT        ; TC0IRQ = 0, exit interrupt vector

                B0BCLR      FTC0IRQ         ; Reset TC0IRQ
                MOV         A,#74H          ; Reload TC0C
                B0MOV       TC0C,A
                .           .               ; TC0 interrupt service routine
                .           .
                JMP         EXIT_INT        ; End of TC0 interrupt service routine and exit interrupt
                                            vector
                .           .
                .           .
EXIT_INT:
                B0MOV       A, PFLAGBUF
                B0MOV       PFLAG, A
                B0XCH       A, ACCBUF       ; Restore ACC value.

                RETI                        ; Exit interrupt vector
```

➲ **Example: TC0 interrupt service routine with auto-reload. (TC0_Counter=8-bit)**

```
                ORG         8               ; Interrupt vector
                JMP         INT_SERVICE
INT_SERVICE:

                B0XCH       A, ACCBUF       ; Store ACC value.
                B0MOV       A, PFLAG
                B0MOV       PFLAGBUF, A

                B0BTS1      FTC0IRQ         ; Check TC0IRQ
                JMP         EXIT_INT        ; TC0IRQ = 0, exit interrupt vector

                B0BCLR      FTC0IRQ         ; Reset TC0IRQ
                .           .               ; TC0 interrupt service routine
                .           .
                JMP         EXIT_INT        ; End of TC0 interrupt service routine and exit interrupt
                                            vector
                .           .
                .           .
EXIT_INT:
                B0MOV       A, PFLAGBUF
                B0MOV       PFLAG, A
                B0XCH       A, ACCBUF       ; Restore ACC value.

                RETI                        ; Exit interrupt vector
```

TC0 CLOCK FREQUENCY OUTPUT (BUZZER)

TC0 timer counter provides a frequency output function. By setting the TC0 clock frequency, the clock signal is output to P5.4 and the P5.4 general purpose I/O function is auto-disable. The TC0 output signal divides by 2. The TC0 clock has many combinations and easily to make difference frequency. This function applies as buzzer output to output multi-frequency.

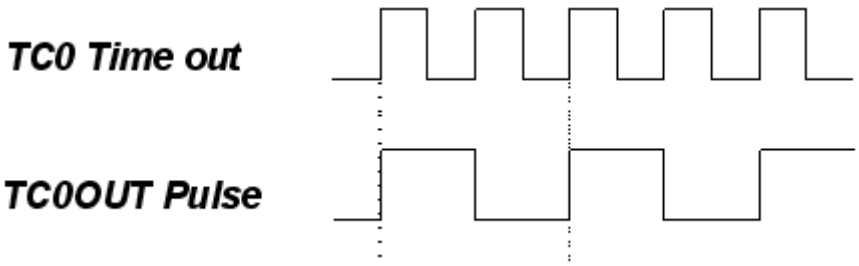


Figure 8-2. The TC0OUT Pulse Frequency

➲ **Example: Setup TC0OUT output from TC0 to TC0OUT (P5.4). The external high-speed clock is 4MHz. The TC0OUT frequency is 1KHz. Because the TC0OUT signal is divided by 2, set the TC0 clock to 2KHz. The TC0 clock source is from external oscillator clock. TC0 rate is Fcpu/4. The TC0RATE2~TC0RATE1 = 110, TC0C = TC0R = 131, TC0X8 = 0, TC0_Counter=8-bit**

```
B0BCLR      FTC0X8          ; Set TC0X8 to 0
MOV         A,#01100000B
B0MOV       TC0M,A          ; Set the TC0 rate to Fcpu/4

MOV         A,#131          ; Set the auto-reload reference value
B0MOV       TC0C,A
B0MOV       TC0R,A

B0BSET      FTC0OUT         ; Enable TC0 output to P5.4 and disable P5.4 I/O function
B0BSET      FALOAD0         ; Enable TC0 auto-reload function
B0BSET      FTC0ENB         ; Enable TC0 timer
```

TC0OUT FREQUENCY TABLE

***Fosc = 4MHz, TC0 Rate = Fcpu/8, TC0_Counter=8-bit*, TC0X8=0**

TC0R	TC0OUT (KHz)	TC0R	TC0OUT (KHz)	TC0R	TC0OUT (KHz)	TC0R	TC0OUT (KHz)	TC0R	TC0OUT (KHz)
0	0.2441	56	0.3125	112	0.4340	168	0.7102	224	1.9531
1	0.2451	57	0.3141	113	0.4371	169	0.7184	225	2.0161
2	0.2461	58	0.3157	114	0.4401	170	0.7267	226	2.0833
3	0.2470	59	0.3173	115	0.4433	171	0.7353	227	2.1552
4	0.2480	60	0.3189	116	0.4464	172	0.7440	228	2.2321
5	0.2490	61	0.3205	117	0.4496	173	0.7530	229	2.3148
6	0.2500	62	0.3222	118	0.4529	174	0.7622	230	2.4038
7	0.2510	63	0.3238	119	0.4562	175	0.7716	231	2.5000
8	0.2520	64	0.3255	120	0.4596	176	0.7813	232	2.6042
9	0.2530	65	0.3272	121	0.4630	177	0.7911	233	2.7174
10	0.2541	66	0.3289	122	0.4664	178	0.8013	234	2.8409
11	0.2551	67	0.3307	123	0.4699	179	0.8117	235	2.9762
12	0.2561	68	0.3324	124	0.4735	180	0.8224	236	3.1250
13	0.2572	69	0.3342	125	0.4771	181	0.8333	237	3.2895
14	0.2583	70	0.3360	126	0.4808	182	0.8446	238	3.4722
15	0.2593	71	0.3378	127	0.4845	183	0.8562	239	3.6765
16	0.2604	72	0.3397	128	0.4883	184	0.8681	240	3.9063
17	0.2615	73	0.3415	129	0.4921	185	0.8803	241	4.1667
18	0.2626	74	0.3434	130	0.4960	186	0.8929	242	4.4643
19	0.2637	75	0.3453	131	0.5000	187	0.9058	243	4.8077
20	0.2648	76	0.3472	132	0.5040	188	0.9191	244	5.2083
21	0.2660	77	0.3492	133	0.5081	189	0.9328	245	5.6818
22	0.2671	78	0.3511	134	0.5123	190	0.9470	246	6.2500
23	0.2682	79	0.3531	135	0.5165	191	0.9615	247	6.9444
24	0.2694	80	0.3551	136	0.5208	192	0.9766	248	7.8125
25	0.2706	81	0.3571	137	0.5252	193	0.9921	249	8.9286
26	0.2717	82	0.3592	138	0.5297	194	1.0081	250	10.4167
27	0.2729	83	0.3613	139	0.5342	195	1.0246	251	12.5000
28	0.2741	84	0.3634	140	0.5388	196	1.0417	252	15.6250
29	0.2753	85	0.3655	141	0.5435	197	1.0593	253	20.8333
30	0.2765	86	0.3676	142	0.5482	198	1.0776	254	31.2500
31	0.2778	87	0.3698	143	0.5531	199	1.0965	255	62.5000
32	0.2790	88	0.3720	144	0.5580	200	1.1161		
33	0.2803	89	0.3743	145	0.5631	201	1.1364		
34	0.2815	90	0.3765	146	0.5682	202	1.1574		
35	0.2828	91	0.3788	147	0.5734	203	1.1792		
36	0.2841	92	0.3811	148	0.5787	204	1.2019		
37	0.2854	93	0.3834	149	0.5841	205	1.2255		
38	0.2867	94	0.3858	150	0.5896	206	1.2500		
39	0.2880	95	0.3882	151	0.5952	207	1.2755		
40	0.2894	96	0.3906	152	0.6010	208	1.3021		
41	0.2907	97	0.3931	153	0.6068	209	1.3298		
42	0.2921	98	0.3956	154	0.6127	210	1.3587		
43	0.2934	99	0.3981	155	0.6188	211	1.3889		
44	0.2948	100	0.4006	156	0.6250	212	1.4205		
45	0.2962	101	0.4032	157	0.6313	213	1.4535		
46	0.2976	102	0.4058	158	0.6378	214	1.4881		
47	0.2990	103	0.4085	159	0.6443	215	1.5244		
48	0.3005	104	0.4112	160	0.6510	216	1.5625		
49	0.3019	105	0.4139	161	0.6579	217	1.6026		
50	0.3034	106	0.4167	162	0.6649	218	1.6447		
51	0.3049	107	0.4195	163	0.6720	219	1.6892		
52	0.3064	108	0.4223	164	0.6793	220	1.7361		
53	0.3079	109	0.4252	165	0.6868	221	1.7857		
54	0.3094	110	0.4281	166	0.6944	222	1.8382		
55	0.3109	111	0.4310	167	0.7022	223	1.8939		

Table 8-3. TC0OUT Frequency Table for Fosc = 4MHz, TC0 Rate = Fcpu/8

Fosc = 16MHz, TC0 Rate = Fcpu/8, TC0_Counter=8-bit

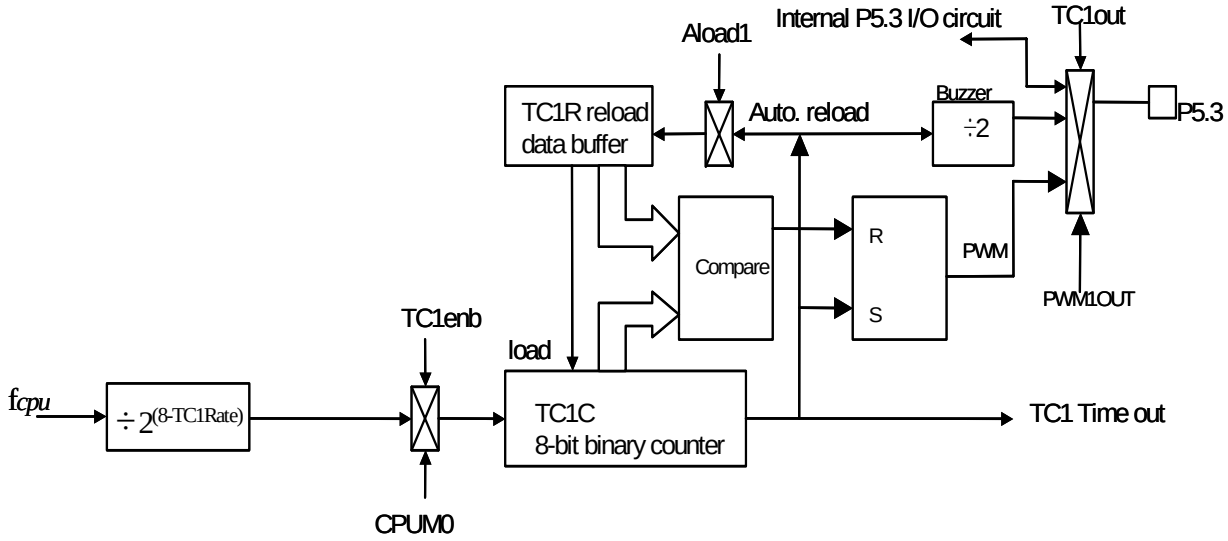
TC0R	TC0OUT (KHz)	TC0R	TC0OUT (KHz)	TC0R	TC0OUT (KHz)	TC0R	TC0OUT (KHz)	TC0R	TC0OUT (KHz)
0	0.9766	56	1.2500	112	1.7361	168	2.8409	224	7.8125
1	0.9804	57	1.2563	113	1.7483	169	2.8736	225	8.0645
2	0.9843	58	1.2626	114	1.7606	170	2.9070	226	8.3333
3	0.9881	59	1.2690	115	1.7730	171	2.9412	227	8.6207
4	0.9921	60	1.2755	116	1.7857	172	2.9762	228	8.9286
5	0.9960	61	1.2821	117	1.7986	173	3.0120	229	9.2593
6	1.0000	62	1.2887	118	1.8116	174	3.0488	230	9.6154
7	1.0040	63	1.2953	119	1.8248	175	3.0864	231	10.0000
8	1.0081	64	1.3021	120	1.8382	176	3.1250	232	10.4167
9	1.0121	65	1.3089	121	1.8519	177	3.1646	233	10.8696
10	1.0163	66	1.3158	122	1.8657	178	3.2051	234	11.3636
11	1.0204	67	1.3228	123	1.8797	179	3.2468	235	11.9048
12	1.0246	68	1.3298	124	1.8939	180	3.2895	236	12.5000
13	1.0288	69	1.3369	125	1.9084	181	3.3333	237	13.1579
14	1.0331	70	1.3441	126	1.9231	182	3.3784	238	13.8889
15	1.0373	71	1.3514	127	1.9380	183	3.4247	239	14.7059
16	1.0417	72	1.3587	128	1.9531	184	3.4722	240	15.6250
17	1.0460	73	1.3661	129	1.9685	185	3.5211	241	16.6667
18	1.0504	74	1.3736	130	1.9841	186	3.5714	242	17.8571
19	1.0549	75	1.3812	131	2.0000	187	3.6232	243	19.2308
20	1.0593	76	1.3889	132	2.0161	188	3.6765	244	20.8333
21	1.0638	77	1.3966	133	2.0325	189	3.7313	245	22.7273
22	1.0684	78	1.4045	134	2.0492	190	3.7879	246	25.0000
23	1.0730	79	1.4124	135	2.0661	191	3.8462	247	27.7778
24	1.0776	80	1.4205	136	2.0833	192	3.9063	248	31.2500
25	1.0823	81	1.4286	137	2.1008	193	3.9683	249	35.7143
26	1.0870	82	1.4368	138	2.1186	194	4.0323	250	41.6667
27	1.0917	83	1.4451	139	2.1368	195	4.0984	251	50.0000
28	1.0965	84	1.4535	140	2.1552	196	4.1667	252	62.5000
29	1.1013	85	1.4620	141	2.1739	197	4.2373	253	83.3333
30	1.1062	86	1.4706	142	2.1930	198	4.3103	254	125.0000
31	1.1111	87	1.4793	143	2.2124	199	4.3860	255	250.0000
32	1.1161	88	1.4881	144	2.2321	200	4.4643		
33	1.1211	89	1.4970	145	2.2523	201	4.5455		
34	1.1261	90	1.5060	146	2.2727	202	4.6296		
35	1.1312	91	1.5152	147	2.2936	203	4.7170		
36	1.1364	92	1.5244	148	2.3148	204	4.8077		
37	1.1416	93	1.5337	149	2.3364	205	4.9020		
38	1.1468	94	1.5432	150	2.3585	206	5.0000		
39	1.1521	95	1.5528	151	2.3810	207	5.1020		
40	1.1574	96	1.5625	152	2.4038	208	5.2083		
41	1.1628	97	1.5723	153	2.4272	209	5.3191		
42	1.1682	98	1.5823	154	2.4510	210	5.4348		
43	1.1737	99	1.5924	155	2.4752	211	5.5556		
44	1.1792	100	1.6026	156	2.5000	212	5.6818		
45	1.1848	101	1.6129	157	2.5253	213	5.8140		
46	1.1905	102	1.6234	158	2.5510	214	5.9524		
47	1.1962	103	1.6340	159	2.5773	215	6.0976		
48	1.2019	104	1.6447	160	2.6042	216	6.2500		
49	1.2077	105	1.6556	161	2.6316	217	6.4103		
50	1.2136	106	1.6667	162	2.6596	218	6.5789		
51	1.2195	107	1.6779	163	2.6882	219	6.7568		
52	1.2255	108	1.6892	164	2.7174	220	6.9444		
53	1.2315	109	1.7007	165	2.7473	221	7.1429		
54	1.2376	110	1.7123	166	2.7778	222	7.3529		
55	1.2438	111	1.7241	167	2.8090	223	7.5758		

Table 8-4TC0OUT Frequency Table for Fosc = 16MHz, TC0 Rate = Fcpu/8

TIMER COUNTER 1 (TC1)

OVERVIEW

The timer counter 1 (TC1) is used to generate an interrupt request when a specified time interval has elapsed. TC1 has a auto re-loadable counter that consists of two parts: an 8-bit reload register (TC1R) into which you write the counter



reference value, and an 8-bit counter register (TC1C) whose value is automatically incremented by counter logic.

Figure 8-3. Timer Counter TC1 Block Diagram

The main purposes of the TC1 timer is as following.

- **8-bit programmable timer:** Generates interrupts at specific time intervals based on the selected clock frequency.
- **Arbitrary frequency output (Buzzer output):** Outputs selectable clock frequencies to the BZ1 pin (P5.3).
- **PWM function:** PWM output can be generated by the PWM1OUT bit and output to PWM1OUT pin (P5.3).

TC1M MODE REGISTER

The TC1M is the timer mode register, which is an 8-bit read/write register. By loading different value into the TC1M register, users can modify the timer counter clock frequency dynamically when program executing.

Eight rates for TC1 timer can be selected by TC1RATE0 ~ TC1RATE2 and TC1X8 bits of T0M register. If TC1X8=1 the TC1 will faster 8 times than TC1X8=0 (Initial value). The bit7 of TC1M named TC1ENB is the control bit to start TC1 timer.

TC1M initial value = 0000 0000

0DCH	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
TC1M	TC1ENB	TC1RATE2	TC1RATE1	TC1RATE0	0	ALOAD1	TC1OUT	PWM1OUT
	R/W	R/W	R/W	R/W	-	R/W	R/W	R/W

Bit7 **TC1ENB:** TC1 counter/BZ1/PWM1OUT enable bit.
0 = disable,
1 = enable.

Bit[6:4] **TC1RATE[2:0]:** TC1 clock source selection bits. TC1X8 is bit 3 of T0M register.

TC1RATE [2:0]	TC1 Clock Source	
	TC1X8 = 0	TC1X8 = 1
000	Fcpu/256 = Fosc/1024	Fosc/128
001	Fcpu/128 = Fosc/512	Fosc/64
…	…	…
110	Fcpu/4 = Fosc/16	Fosc/2
111	Fcpu/2 = Fosc/8	Fosc

Note: Fcpu = Fosc / 4

Bit2 **ALOAD1:** TC1 auto-reload function control bit.
0 = none auto-reload
1 = auto-reload.

Bit1 **TC01UT:** TC1 time-out toggle signal output control bit.
0 = to disable TC1 signal output and to enable P5.3's I/O function,
1 = to enable TC1's signal output and to disable P5.3's I/O function. (Auto-disable the PWM0OUT function.)

Bit0 **PWM1OUT:** TC1's PWM output control bit.
0 = to disable the PWM output,
1 = to enable the PWM output (The TC1OUT control bit must = 0)

- ***Note: TC1 doesn't support event counter mode because SN8P1702A and SN8P1703A hasn't P0.1 for TC1 event counter clock input.***
- ***Note: Bit3 must set to "0".***

TC1C COUNTING REGISTER

TC1C is an 8-bit counter register for the timer counter (TC1). TC1C must be reset whenever the TC1ENB is set "1" to start the timer. TC0C is incremented by one with a clock pulse which the frequency is determined by TC0RATE0 ~ TC0RATE2. When TC0C has incremented to "0FFH", it is will be cleared to "00H" in next clock and an overflow is generated. Under TC1 interrupt service request (TC1IEN) enable condition, the TC1 interrupt request flag will be set "1" and the system executes the interrupt service routine.

TC1C initial value = xxxx xxxx

0DDH	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
TC1C	TC1C7	TC1C6	TC1C5	TC1C4	TC1C3	TC1C2	TC1C1	TC1C0
	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W

TC1 Overflow Time

TC1 rate is determinate by TC1Rate and Code Option TC1_Counter, TC1Rate can set TC1 clock frequency from Fcpu and TC1_Counter set TC1 became 8-bit, 6-bit, 5-bit or 4-bit counter.
The equation of TC1C initial value is as following.

TC1C initial value = N - (TC1 interrupt interval time * input clock)

Which N is determinate by code option: TC1_Counter

TC1_Counter	N	Max. TC1C value
8-bit	256	255
6-bit	64	63
5-bit	32	31
4-bit	16	15

➢ ***Note: TheTC1C must small or equal than Max. TC1 value.***

➲ **Example: To set 10ms interval time for TC1 interrupt at Fosc = 3.58MHz**
TC1C value (74H) = 256 - (10ms * fcpu/64) (TC1RATE=010, TC1_Counter=8-bit, TC1X8=0)

$$TC1C\ initial\ value = 256 - (TC0\ interrupt\ interval\ time * input\ clock)$$
$$= 256 - (10ms * 3.58 * 10^6 / 4 / 64)$$
$$= 256 - (0.01 * 3.58 * 10^6 / 4 / 64)$$
$$= 116$$
$$= 74H$$

➲ **Example: To set 1.25ms interval time for TC1 interrupt at Fosc = 3.58MHz**
TC1C value (74H) = 256 - (10ms * fcpu/64) (TC1RATE=010, TC1_Counter=8-bit, TC1X8=1)

$$TC1C\ initial\ value = 256 - (TC0\ interrupt\ interval\ time * input\ clock)$$
$$= 256 - (1.25ms * 3.58 * 10^6 / 32)$$
$$= 256 - (0.00125 * 3.58 * 10^6 / 32)$$
$$= 116$$
$$= 74H$$

➲ **Example: To set 1ms interval time for TC1 interrupt at Fosc = 3.58MHz**
TC1C value (32H) = 64 - (1ms * fcpu/64) (TC1RATE=010, TC1_COunter=6-bit, TC1X8=0)

$$TC1C\ initial\ value = 64 - (TC0\ interrupt\ interval\ time * input\ clock)$$
$$= 64 - (1ms * 3.58 * 10^6 / 4 / 64)$$
$$= 64 - (0.001 * 3.58 * 10^6 / 4 / 64)$$
$$= 64 - 14$$
$$= 32H$$

TC1_Counter=8-bit, TC1X8=0

TC1RATE	TC1CLOCK	High speed mode (Fcpu = 3.58MHz / 4)		Low speed mode (Fosc = 32768Hz / 4)	
		Max overflow interval	One step = max/256	Max overflow interval	One step = max/256
000	Fcpu/256	73.2 ms	286us	8000 ms	31.25 ms
001	Fcpu/128	36.6 ms	143us	4000 ms	15.63 ms
010	Fcpu/64	18.3 ms	71.5us	2000 ms	7.8 ms
011	Fcpu/32	9.15 ms	35.8us	1000 ms	3.9 ms
100	Fcpu/16	4.57 ms	17.9us	500 ms	1.95 ms
101	Fcpu/8	2.28 ms	8.94us	250 ms	0.98 ms
110	Fcpu/4	1.14 ms	4.47us	125 ms	0.49 ms
111	Fcpu/2	0.57 ms	2.23us	62.5 ms	0.24 ms

TC1_Counter=6-bit , TC1X8=0

TC1RATE	TC1CLOCK	High speed mode (Fcpu = 3.58MHz / 4)		Low speed mode (Fcpu = 32768Hz / 4)	
		Max overflow interval	One step = max/64	Max overflow interval	One step = max/64
000	Fcpu/256	18.3 ms	286us	2000 ms	31.25 ms
001	Fcpu/128	9.15 ms	143us	1000 ms	15.63 ms
010	Fcpu/64	4.57 ms	71.5us	500 ms	7.8 ms
011	Fcpu/32	2.28 ms	35.8us	250 ms	3.9 ms
100	Fcpu/16	1.14 ms	17.9us	125 ms	1.95 ms
101	Fcpu/8	0.57 ms	8.94us	62.5 ms	0.98 ms
110	Fcpu/4	0.285 ms	4.47us	31.25 ms	0.49 ms
111	Fcpu/2	0.143 ms	2.23us	15.63 ms	0.24 ms

TC1_Counter=5-bit, TC1X8=0

TC1RATE	TC1CLOCK	High speed mode (Fcpu = 3.58MHz / 4)		Low speed mode (Fcpu = 32768Hz / 4)	
		Max overflow interval	One step = max/32	Max overflow interval	One step = max/32
000	Fcpu/256	9.15 ms	286us	1000 ms	31.25 ms
001	Fcpu/128	4.57 ms	143us	500 ms	15.63 ms
010	Fcpu/64	2.28 ms	71.5us	250 ms	7.8 ms
011	Fcpu/32	1.14 ms	35.8us	125 ms	3.9 ms
100	Fcpu/16	0.57 ms	17.9us	62.5 ms	1.95 ms
101	Fcpu/8	0.285 ms	8.94us	31.25 ms	0.98 ms
110	Fcpu/4	0.143 ms	4.47us	15.63 ms	0.49 ms
111	Fcpu/2	71.25 us	2.23us	7.81 ms	0.24 ms

TC1_Counter=4-bit, TC1X8=0

TC1RATE	TC1CLOCK	High speed mode (Fcpu = 3.58MHz / 4)		Low speed mode (Fcpu = 32768Hz / 4)	
		Max overflow interval	One step = max/16	Max overflow interval	One step = max/16
000	Fcpu/256	4.57 ms	286us	500 ms	31.25 ms
001	Fcpu/128	2.28 ms	143us	250 ms	15.63 ms
010	Fcpu/64	1.14 ms	71.5us	125 ms	7.8 ms
011	Fcpu/32	0.57 ms	35.8us	62.5 ms	3.9 ms
100	Fcpu/16	0.285 ms	17.9us	31.25 ms	1.95 ms
101	Fcpu/8	0.143 ms	8.94us	15.63 ms	0.98 ms
110	Fcpu/4	71.25 us	4.47us	7.81 ms	0.49 ms
111	Fcpu/2	35.63 us	2.23us	3.91 ms	0.24 ms

TC1_Counter=8-bit, TC1X8=1

TC1RATE	TC1CLOCK	High speed mode (Fosc = 3.58MHz)		Low speed mode (Fosc = 32768Hz)	
		Max overflow interval	One step = max/256	Max overflow interval	One step = max/256
000	Fosc/128	9.153 ms	35.754us	1000 ms	3.91 ms
001	Fosc/64	4.58 ms	17.877us	500 ms	1.95 ms
010	Fosc/32	2.29 ms	8.939us	250 ms	0.977 ms
011	Fosc/16	1.14 ms	4.470us	125 ms	0.488 ms
100	Fosc/8	0.57 ms	2.235us	62.5 ms	0.244 ms
101	Fosc/4	0.29 ms	1.117us	31.25 ms	0.122 ms
110	Fosc/2	0.14 ms	0.587us	15.63 ms	0.061 ms
111	Fosc	71.5 us	0.279us	7.81ms	0.03 ms

TC1_Counter=6-bit , TC1X8=1

TC1RATE	TC1CLOCK	High speed mode (Fosc = 3.58MHz)		Low speed mode (Fosc = 32768Hz)	
		Max overflow interval	One step = max/64	Max overflow interval	One step = max/64
000	Fosc/128	2.29 ms	35.754us	250 ms	3.91 ms
001	Fosc/64	1.14 ms	17.877us	125 ms	1.95 ms
010	Fosc/32	0.57 ms	8.939us	62.5 ms	0.977 ms
011	Fosc/16	0.29 ms	4.470us	31.25 ms	0.488 ms
100	Fosc/8	0.14 ms	2.235us	15.63 ms	0.244 ms
101	Fosc/4	71.5 us	1.117us	7.81ms	0.122 ms
110	Fosc/2	35.75 us	0.587us	3.905 ms	0.061 ms
111	Fosc	17.875 us	0.279us	1.953 ms	0.03 ms

TC1_Counter=5-bit, TC1X8=1

TC1RATE	TC1CLOCK	High speed mode (Fosc = 3.58MHz)		Low speed mode (Fosc = 32768Hz)	
		Max overflow interval	One step = max/32	Max overflow interval	One step = max/32
000	Fosc/128	1.14 ms	35.754us	125 ms	3.91 ms
001	Fosc/64	0.57 ms	17.877us	62.5 ms	1.95 ms
010	Fosc/32	0.29 ms	8.939us	31.25 ms	0.977 ms
011	Fosc/16	0.14 ms	4.470us	15.63 ms	0.488 ms
100	Fosc/8	71.5 us	2.235us	7.81ms	0.244 ms
101	Fosc/4	35.75 us	1.117us	3.905 ms	0.122 ms
110	Fosc/2	17.875 us	0.587us	1.953 ms	0.061 ms
111	Fosc	8.936 us	0.279us	0.976 ms	0.03 ms

TC1_Counter=4-bit, TC1X8=1

TC1RATE	TC1CLOCK	High speed mode (Fosc = 3.58MHz)		Low speed mode (Fosc = 32768Hz)	
		Max overflow interval	One step = max/16	Max overflow interval	One step = max/16
000	Fosc/128	0.57 ms	35.754us	62.5 ms	3.91 ms
001	Fosc/64	0.29 ms	17.877us	31.25 ms	1.95 ms
010	Fosc/32	0.14 ms	8.939us	15.63 ms	0.977 ms
011	Fosc/16	71.5 us	4.470us	7.81ms	0.488 ms
100	Fosc/8	35.75 us	2.235us	3.905 ms	0.244 ms
101	Fosc/4	17.875 us	1.117us	1.953 ms	0.122 ms
110	Fosc/2	8.936 us	0.587us	0.976 ms	0.061 ms
111	Fosc	4.468 us	0.279us	0.488 ms	0.03 ms

Table 8-5. The Timing Table of Timer Counter TC1

TC1R AUTO-LOAD REGISTER

TC1R is an 8-bit register for the TC1 auto-reload function. TC1R's value applies to TC1OUT and PWM1OUT functions. Under TC1OUT application, users must enable and set the TC1R register. The main purpose of TC1R is as following.

- Store the auto-reload value and set into TC1C when the TC1C overflow. (ALOAD1 = 1).
- Store the duty value of PWM1OUT function.

TC1R initial value = xxxx xxxx

0DEH	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
TC1R	TC1R7	TC1R6	TC1R5	TC1R4	TC1R3	TC1R2	TC1R1	TC1R0
	W	W	W	W	W	W	W	W

The equation of TC1R initial value is like TC1C as following.

TC1R initial value = N - (TC1 interrupt interval time * input clock)

Which N is determinate by code option: TC1_Counter

TC1_Counter	N	Max. TC1R value
8-bit	256	255
6-bit	64	63
5-bit	32	31
4-bit	16	15

- ***Note: TheTC1R must small or equal than Max. TC1R value.***
- ***Note: The TC1R is write-only register can't be process by INCMS, DECMS instructions.***

TC1 TIMER COUNTER OPERATION SEQUENCE

The TC1 timer's sequence of operation can be following.

- Set the TC1C initial value to setup the interval time.
- Set the TC1ENB to be "1" to enable TC1 timer counter.
- TC1C is incremented by one with each clock pulse which frequency is corresponding to TC1M selection.
- TC1C overflow if TC1C from FFH to 00H.
- When TC1C overflow occur, the TC1IRQ flag is set to be "1" by hardware.
- Execute the interrupt service routine.
- Users reset the TC1C value and resume the TC1 timer operation.

➲ Example: Setup the TC1M and TC1C without auto-reload function.(TC1_Counter=8-bit, TC1X8=0)

```
B0BCLR      FTC1X8      ;
B0BCLR      FTC1IEN     ; To disable TC1 interrupt service
B0BCLR      FTC1ENB     ; To disable TC1 timer
MOV         A,#20H      ;
B0MOV       TC1M,A      ; To set TC1 clock = Fcpu / 64
MOV         A,#74H      ; To set TC1C initial value = 74H
B0MOV       TC1C,A      ;(To set TC1 interval = 10 ms)

B0BSET      FTC1IEN     ; To enable TC1 interrupt service
B0BCLR      FTC1IRQ     ; To clear TC1 interrupt request
B0BSET      FTC1ENB     ; To enable TC1 timer
```

➲ Example: Setup the TC1M and TC1C with auto-reload function. (TC1_Counter=8-bit, TC1X8=0)

```
B0BCLR      FTC1X8      ; To select TC1=Fcpu/2 as clock source
B0BCLR      FTC1IEN     ; To disable TC1 interrupt service
B0BCLR      FTC1ENB     ; To disable TC1 timer
MOV         A,#20H      ;
B0MOV       TC1M,A      ; To set TC1 clock = Fcpu / 64
MOV         A,#74H      ; To set TC1C initial value = 74H
B0MOV       TC1C,A      ; (To set TC1 interval = 10 ms)
B0MOV       TC1R,A      ; To set TC1R auto-reload register

B0BSET      FTC1IEN     ; To enable TC1 interrupt service
B0BCLR      FTC1IRQ     ; To clear TC1 interrupt request
B0BSET      FTC1ENB     ; To enable TC1 timer
B0BSET      ALOAD1      ; To enable TC1 auto-reload function.
```

➲ **Example: TC1 interrupt service routine without auto-reload function. (TC1_Counter=8-bit, TC1X8=0)**

```
                ORG         8               ; Interrupt vector
                JMP         INT_SERVICE
INT_SERVICE:
                B0XCH       A, ACCBUF       ; Store ACC value.
                B0MOV       A, PFLAG
                B0MOV       PFLAGBUF, A


                B0BTS1      FTC1IRQ         ; Check TC1IRQ
                JMP         EXIT_INT        ; TC1IRQ = 0, exit interrupt vector

                B0BCLR      FTC1IRQ         ; Reset TC1IRQ
                MOV         A,#74H          ; Reload TC1C
                B0MOV       TC1C,A
                .           .               ; TC1 interrupt service routine
                .           .
                JMP         EXIT_INT        ; End of TC1 interrupt service routine and exit interrupt
                                            vector
                .           .
                .           .
EXIT_INT:
                B0MOV       A, PFLAGBUF
                B0MOV       PFLAG, A
                B0XCH       A, ACCBUF       ; Restore ACC value.

                RETI                        ; Exit interrupt vector
```

➲ **Example: TC1 interrupt service routine with auto-reload. (TC1_Counter=8-bit, TC1X8=0)**

```
                ORG         8               ; Interrupt vector
                JMP         INT_SERVICE
INT_SERVICE:
                B0XCH       A, ACCBUF       ; Store ACC value.
                B0MOV       A, PFLAG
                B0MOV       PFLAGBUF, A


                B0BTS1      FTC1IRQ         ; Check TC1IRQ
                JMP         EXIT_INT        ; TC1IRQ = 0, exit interrupt vector

                B0BCLR      FTC1IRQ         ; Reset TC1IRQ
                .           .               ; TC1 interrupt service routine
                .           .
                JMP         EXIT_INT        ; End of TC1 interrupt service routine and exit interrupt
                                            vector
                .           .
                .           .
EXIT_INT:
                B0MOV       A, PFLAGBUF
                B0MOV       PFLAG, A
                B0XCH       A, ACCBUF       ; Restore ACC value.

                RETI                        ; Exit interrupt vector
```

TC1 CLOCK FREQUENCY OUTPUT (BUZZER)

TC1 timer counter provides a frequency output function. By setting the TC1 clock frequency, the clock signal is output to P5.3 and the P5.3 general purpose I/O function is auto-disable. The TC1 output signal divides by 2. The TC1 clock has many combinations and easily to make difference frequency. This function applies as buzzer output to output multi-frequency.

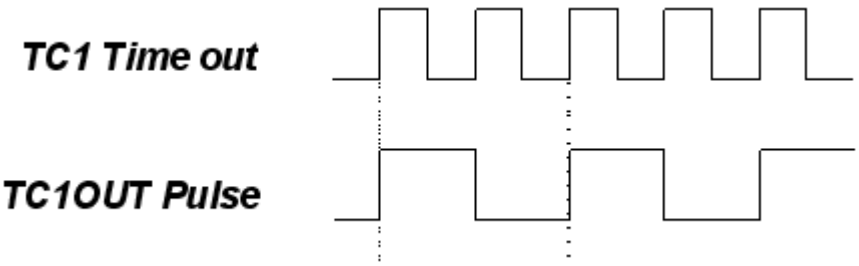


Figure 8-4The TC1OUT Pulse Frequency

➲ **Example: Setup TC1OUT output from TC1 to TC1OUT (P5.3). The external high-speed clock is 4MHz. The TC1OUT frequency is 1KHz. Because the TC1OUT signal is divided by 2, set the TC1 clock to 2KHz. The TC1 clock source is from external oscillator clock. TC1 rate is Fcpu/4. The TC1RATE2~TC1RATE1 = 110, TC1C = TC1R = 131, TC1_Counter=8-bit, TC1X8=0**

```
B0BCLR      FTC1X8          ; Set TC1X8 to 0
MOV         A,#01100000B
B0MOV       TC1M,A          ; Set the TC1 rate to Fcpu/4

MOV         A,#131          ; Set the auto-reload reference value
B0MOV       TC1C,A
B0MOV       TC1R,A

B0BSET      FTC1OUT         ; Enable TC1 output to P5.3 and disable P5.3 I/O function
B0BSET      FALOAD1         ; Enable TC1 auto-reload function
B0BSET      FTC1ENB         ; Enable TC1 timer
```

PWM FUNCTION DESCRIPTION

OVERVIEW

PWM function is generated by TC0/TC1 timer counter and output the PWM signal to PWM0OUT pin (P5.4)/ PWM1OUT pin (P5.3). When code option TC0/TC1_Counter= 8-bit, the counter counts modulus 256, from 0-255, inclusive. The value of the 8-bit counter is compared to the contents of the reference register (TC0R/TC1R). When the reference register value (TC0R/TC1R) is equal to the counter value (TC0C/TC1C), the PWM output goes low. When the counter reaches zero, the PWM output is forced high. Following table listed the low-to-high ratio (duty) of the PWM0/PWM1 output.

For example, TC0_Counter=8-bit, all PWM outputs remain inactive during the first 256 input clock signals. Then, when the counter value (TC0C/TC1C) changes from FFH back to 00H, the PWM output is forced to high level. The pulse width ratio (duty cycle) is defined by the contents of the reference register (TC0R/TC1R) and is programmed in increments of 1:256. The 8-bit PWM data register TC0R/TC1R is write-only register. Different code option of TC0_Counter/TC1_Counter will cause different PWM Duty, so user can generate different PWM output by selection different TC0_Counter/TC1_Counter.

PWM output can be held at low level by continuously loading the reference register with 00H. Under PWM operating, to change the PWM's duty cycle is to modify the TC0R/TC1R.

TC0X8/TC1X8	PWM0 Frequency	PWM1 Frequency
0	$Fosc/(2^{10\text{-}TC0RATE})/N$	$Fosc/(2^{10\text{-}TC1RATE})/N$
1	$Fosc/(2^{7\text{-}TC0RATE})/N$	$Fosc/(2^{7\text{-}TC1RATE})/N$

The value of N depend on code option TC0_Counter/TC1_Counter

TC0_Counter/TC1_Counter	N	PWM Duty Cycle
8-bit	256	0/256 ~ 255/256
6-bit	64	0/64 ~ 63/64
5-bit	32	0/32 ~ 31/32
4-bit	16	0/16 ~ 15/16

Table 8-6. The PWM Frequency Calculation Formula

TC0X8 TC1X8	TC0_Counter TC1_Counter	TC0 Overflow boundary TC1 Overflow boundary	PWM Duty Cycle	Max PWM Frequency (Fosc = 4MHz)	Note
0	8-bit	FFh to 00h	0/256 ~ 255/256	1.953125K	Overflow per 256 count
0	6-bit	3Fh to 40h	0/64 ~ 63/64	7.8125K	Overflow per 64 count
0	5-bit	1Fh to 20h	0/32 ~ 31/32	15.625K	Overflow per 32 count
0	4-bit	0Fh to 10h	0/16 ~ 15/16	31.25K	Overflow per 16 count
1	8-bit	FFh to 00h	0/256 ~ 255/256	15.625	Overflow per 256 count
1	6-bit	3Fh to 40h	0/64 ~ 63/64	62.5K	Overflow per 64 count
1	5-bit	1Fh to 20h	0/32 ~ 31/32	125K	Overflow per 32 count
1	4-bit	0Fh to 10h	0/16 ~ 15/16	250K	Overflow per 16 count

Table 8-7. The Maximum PWM Frequency Example (TC0RATE/TC1RATE = 111)

Reference Register Value (TC0R/TC1R)	TC0/1_Counter=8-bit Duty Cycle	TC0/1_Counter=6-bit Duty Cycle	TC0/1_Counter=5-bit Duty Cycle	TC0/1_Counter=4-bit Duty Cycle
0000 0000	0/256	0/64	0/32	0/16
0000 0001	1/256	1/64	1/32	1/16
0000 0010	2/256	2/64	2/32	2/16
...	...	...	...	...
0000 1110	14/256	14/64	14/32	14/16
0000 1111	15/256	15/64	15/32	15/16
0001 0000	16/256.	16/64	16/32	N/A
...	...	...	...	N/A
0001 1110	30/256	30/64	30/32	N/A
0001 1111	31/256	31/64	31/32	N/A
0010 0000	32/256.	32/64	N/A	N/A
...	...	...	N/A	N/A
0011 1110	62/256	62/64	N/A	N/A
0011 1111	63/256	63/64	N/A	N/A
0100 0000	64/256.	N/A	N/A	N/A
...	...	N/A	N/A	N/A
1111 1110	254/256	N/A	N/A	N/A
1111 1111	255/256	N/A	N/A	N/A

Table 8-8. The PWM Duty Cycle Table

➢ ***Note: Functionality is not guaranteed in shaded area.***

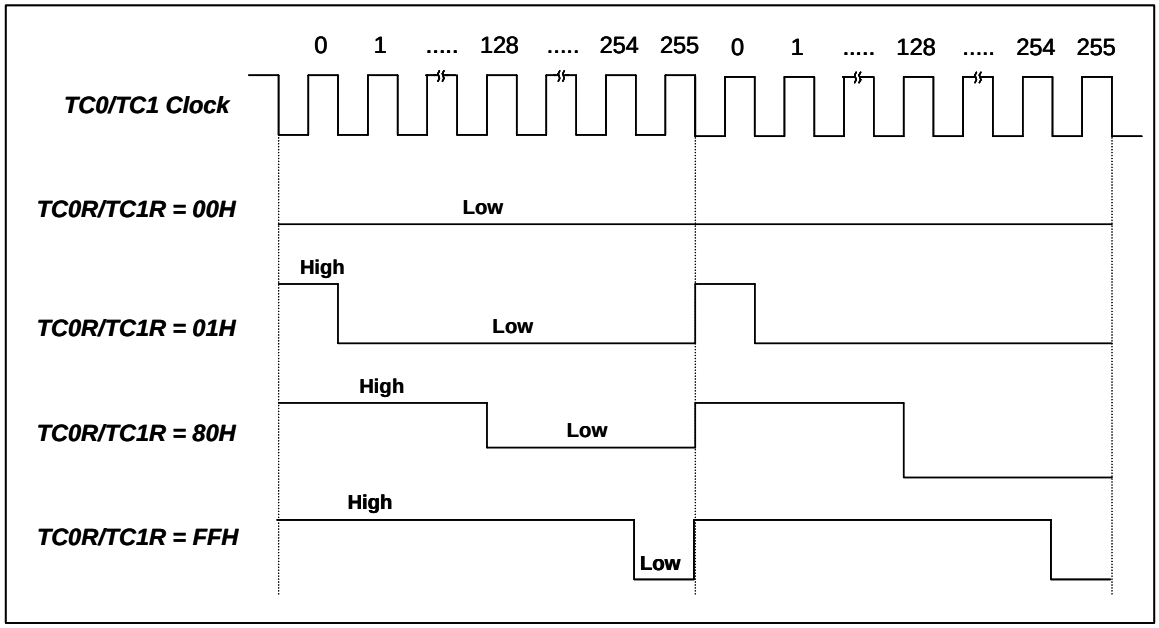


Figure 8-5 The Output of PWM with different TC0R/TC1R. (TC0/TC1_Counter=8-bit)

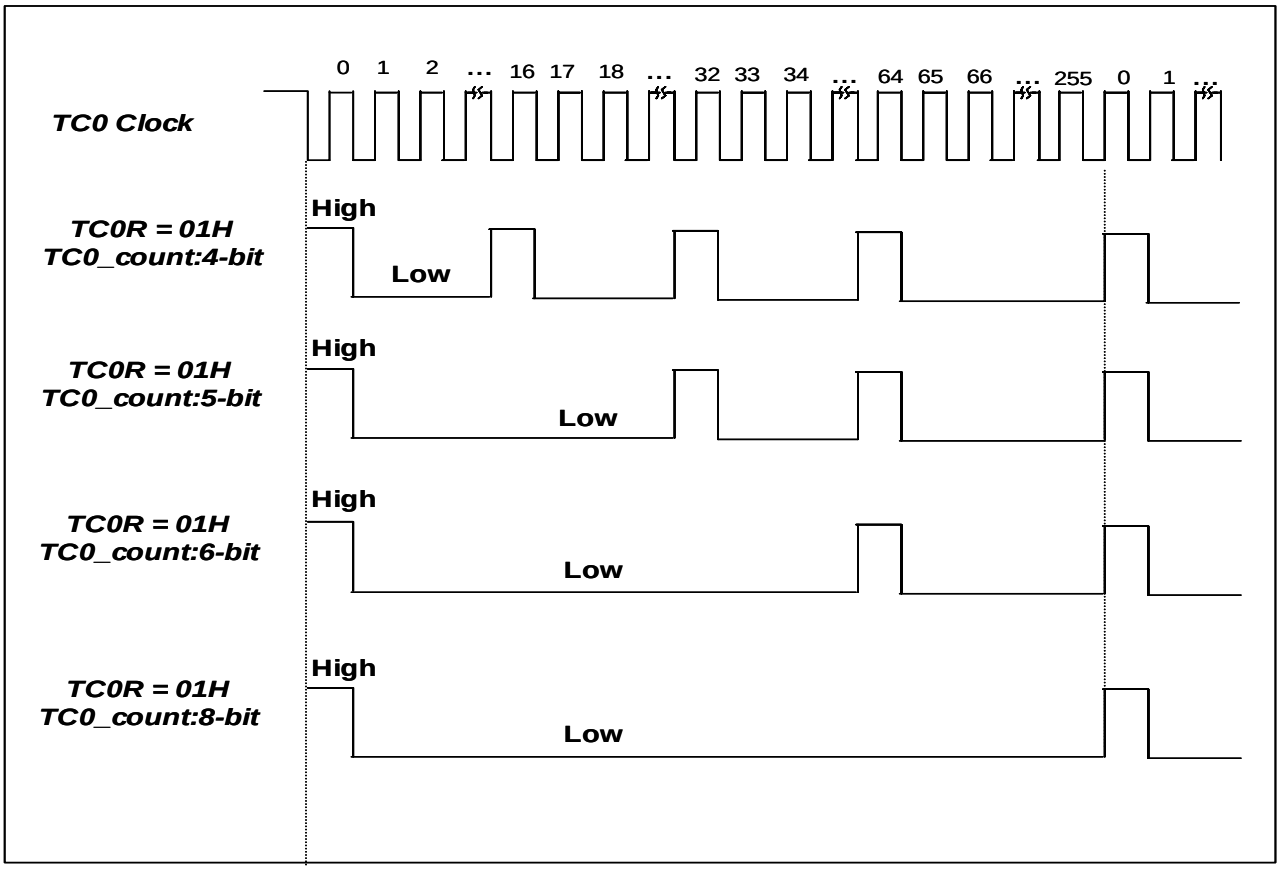


Figure 8-6 The Output of PWM with different TC0_Counter

PWM PROGRAM DESCRIPTION

➲ **Example: Setup PWM0 output from TC0 to PWM0OUT (P5.4). The external high-speed oscillator clock is 4MHz. The duty of PWM is 30/256. The PWM frequency is about 1KHz. The PWM clock source is from external oscillator clock. TC0 rate is Fcpu/4. The TC0RATE2~TC0RATE1 = 110, TC0C = TC0R = 30, TC0X8 =0, TC0_Counter=8-bit**

```
B0BCLR      FTC0X8
MOV         A,#01100000B
B0MOV       TC0M,A          ; Set the TC0 rate to Fcpu/4
MOV         A,#0x00         ;First Time Initial TC0
B0MOV       TC0C,A
MOV         A,#30           ; Set the PWM duty to 30/256

B0MOV       TC0R,A

B0BCLR      FTC0OUT         ; Disable TC0OUT function.
B0BSET      FPWM0OUT        ; Enable PWM0 output to P5.4 and disable P5.4 I/O function
B0BSET      FTC0ENB         ; Enable TC0 timer
```

- ***Note1: The TC0R and TC1R are write-only registers. Don't process them using INCMS, DECMS instructions.***
- ***Note2: Set TC0C at initial is to make first duty-cycle correct. After TC0 is enabled, don't modify TC0R value to avoid duty cycle error of PWM output.***

➲ **Example: Modify TC0R/TC1R registers' value.**

```
MOV         A, #30H         ; Input a number using B0MOV instruction.
B0MOV       TC0R, A

INCMS       BUF0            ; Get the new TC0R value from the BUF0 buffer defined by
B0MOV       A, BUF0         ; programming.
B0MOV       TC0R, A
```

- ***Note2: That is better to set the TC0C and TC0R value together when PWM0 duty modified. It protects the PWM0 signal no glitch as PWM0 duty changing. That is better to set the TC1C and TC1R value together when PWM1 duty modified. It protects the PWM1 signal no glitch as PWM1 duty changing.***
- ***Note3: The TC0OUT function must be set "0" when PWM0 output enable. The TC1OUT function must be set "0" when PWM1 output enable.***
- ***Note4: The PWM can work with interrupt request.***

9 INTERRUPT

OVERVIEW

The SN8P1702A/SN8P1703A provides 3 interrupt sources, including two internal interrupts (TC0, TC1) and one external interrupts (INT0). The external interrupt can wakeup the chip from power down mode to high-speed normal mode. The external clock input pins of INT0 are shared with P0.0 pins. Once interrupt service is executed, the GIE bit in STKP register will clear to “0” for stopping other interrupt request. When interrupt service exits, the GIE bit will set to “1” to accept the next interrupts’ request. All of the interrupt request signals are stored in INTRQ register. The user can program the chip to check INTRQ’s content for setting executive priority.

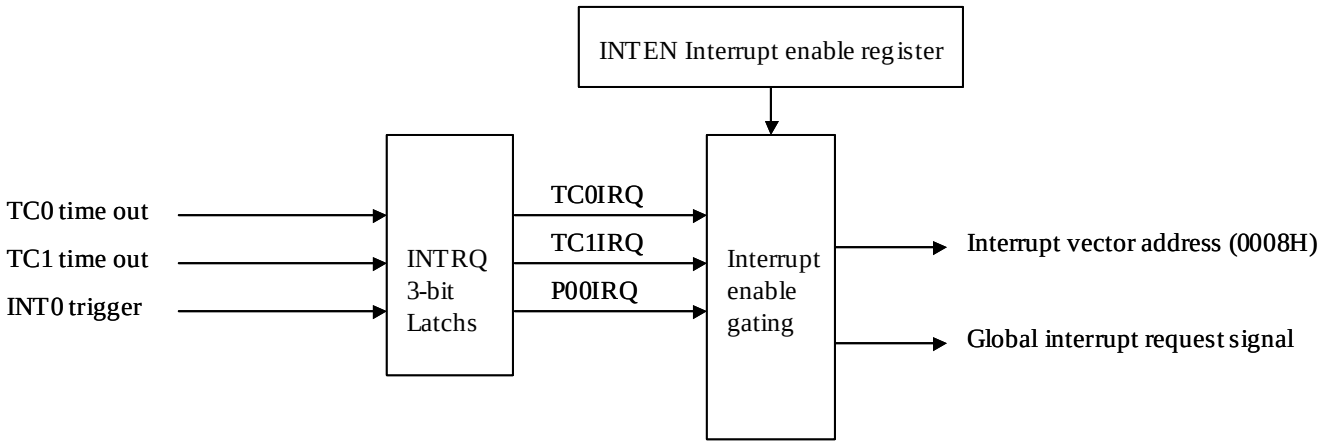


Figure 9-1. The 7 Interrupts

➢ ***Note: The GIE bit must enable and all interrupt operations work.***

INTEN INTERRUPT ENABLE REGISTER

INTEN is the interrupt request control register including two internal interrupts, one external interrupts enable control bits. One of the register to be set "1" is to enable the interrupt request function. Once of the interrupt occur, the program jump to ORG 8 to execute interrupt service routines. The program exits the interrupt service routine when the returning interrupt service routine instruction (RETI) is executed.

INTEN initial value = x000 0000

0C9H	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
INTEN	0	TC1IEN	TC0IEN	0	0	0	0	P00IEN
	-	R/W	R/W	-	-	-	-	R/W

Bit0 **P00IEN:**External P0.0 interrupt control bit.
0 = disable,
1 = enable.
Bit5 **TC0IEN:**Timer interrupt control bit.
0 = disable,
1 = enable.
Bit6 **TC1IEN:**Timer interrupt control bit.
0 = disable,
1 = enable.

INTRQ INTERRUPT REQUEST REGISTER

INTRQ is the interrupt request flag register. The register includes all interrupt request indication flags. Each one of these interrupt request occurs, the bit of the INTRQ register would be set "1". The INTRQ value needs to be clear by programming after detecting the flag. In the interrupt vector of program, users know the any interrupt requests occurring by the register and do the routine corresponding of the interrupt request.

INTRQ initial value = x000 0000

0C8H	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
INTRQ	0	TC1IRQ	TC0IRQ	0	0	0	0	P00IRQ
	-	R/W	R/W	-	-	-	-	R/W

Bit0 **P00IRQ:**External P0.0 interrupt request bit.
0 = non-request
1 = request.
Bit5 **TC0IRQ:**TC0 timer interrupt request controls bit.
0 = non request
1 = request.
Bit6 **TC1IRQ:**TC1 timer interrupt request controls bit.
0 = non request
1 = request.

When interrupt occurs, the related request bit of INTRQ register will be set to "1" no matter the related enable bit of INTEN register is enabled or disabled. If the related bit of INTEN = 1 and the related bit of INTRQ is also set to be "1". As the result, the system will execute the interrupt vector (ORG 8). If the related bit of INTEN = 0, moreover, the system won't execute interrupt vector even when the related bit of INTRQ is set to be "1". Users need to be cautious with the operation under multi-interrupt situation.

INTERRUPT OPERATION DESCRIPTION

SN8P1702A/SN8P1703A provides 3 interrupts. The operation of the 3 interrupts is as following.

GIE GLOBAL INTERRUPT OPERATION

GIE is the global interrupt control bit. All interrupts start work after the GIE = 1. It is necessary for interrupt service request. One of the interrupt requests occurs, and the program counter (PC) points to the interrupt vector (ORG 8) and the stack add 1 level.

STKP initial value = 0xxx 1111

0DFH	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
STKP	GIE	-	-	-	STKPB3	STKPB2	STKPB1	STKPB0
	R/W	-	-	-	R/W	R/W	R/W	R/W

Bit7 **GIE:**Global interrupt control bit.
0 = disable
1 = enable.

➲ **Example: Set global interrupt control bit (GIE).**

```
B0BSET      FGIE        ; Enable GIE
```

➢ ***Note: The GIE bit must enable and all interrupt operations work.***

INT0 (P0.0) INTERRUPT OPERATION

The P0.0 interrupt trigger direction is control by PEDGE register.

PEDGE initial value = 0xx0 0xxx

0BFH	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
PEDGE	PEDGEN	-	-	P00G1	P00G0	-	-	-
	R/W	-	-	R/W	R/W	-	-	-

Bit7 **PEDGEN:** Interrupt and wakeup trigger edge control bit.
0 = Disable edge trigger function.
Port 0: Low-level wakeup trigger and falling edge interrupt trigger.
Port 1: Low-level wakeup trigger.
1 = Enable edge trigger function.
P0.0: Wakeup and interrupt trigger is controlled by P00G1 and P00G0 bits.
Port 1: Level change (falling or rising edge) wakeup trigger.

Bit[4:3] **P00G[1:0]:** Port 0.0 edge select bits.
00 = reserved,
01 = rising edge,
10 = falling edge,
11 = rising/falling bi-direction.

➲ **Example: INT0 interrupt request setup.**

```
        B0BSET      FP00IEN         ; Enable INT0 interrupt service
        B0BCLR      FP00IRQ         ; Clear INT0 interrupt request flag
        B0BSET      FGIE            ; Enable GIE
```

➲ **Example: INT0 interrupt service routine.**

```
        ORG         8               ; Interrupt vector
        JMP         INT_SERVICE
INT_SERVICE:

        B0XCH       A, ACCBUF       ; Store ACC value.
        B0MOV       A, PFLAG
        B0MOV       PFLAGBUF, A

        B0BTS1      FP00IRQ         ; Check P00IRQ
        JMP         EXIT_INT        ; P00IRQ = 0, exit interrupt vector

        B0BCLR      FP00IRQ         ; Reset P00IRQ
        .           .               ; INT0 interrupt service routine
        .           .
EXIT_INT:
        B0MOV       A, PFLAGBUF
        B0MOV       PFLAG, A
        B0XCH       A, ACCBUF       ; Restore ACC value.

        RETI                        ; Exit interrupt vector
```

When the INT0 trigger occurs, the P00IRQ will be set to “1” no matter the P00IEN is enable or disable. If the P00IEN = 1 and the trigger event P00IRQ is also set to be “1”. As the result, the system will execute the interrupt vector (ORG 8). If the P00IEN = 0 and the trigger event P00IRQ is still set to be “1”. Moreover, the system won’t execute interrupt vector even when the P00IRQ is set to be “1”. Users need to be cautious with the operation under multi-interrupt situation.

TC0 INTERRUPT OPERATION

When the TC0C counter occurs overflow, the TC0IRQ will be set to “1” however the TC0IEN is enable or disable. If the TC0IEN = 1, the trigger event will make the TC0IRQ to be “1” and the system enter interrupt vector. If the TC0IEN = 0, the trigger event will make the TC0IRQ to be “1” but the system will not enter interrupt vector. Users need to care for the operation under multi-interrupt situation.

➲ Example: TC0 interrupt request setup.

```
        B0BCLR      FTC0IEN         ; Disable TC0 interrupt service
        B0BCLR      FTC0ENB         ; Disable TC0 timer
        MOV         A, #20H         ;
        B0MOV       TC0M, A         ; Set TC0 clock = Fcpu / 64
        MOV         A, #74H         ; Set TC0C initial value = 74H
        B0MOV       TC0C, A         ; Set TC0 interval = 10 ms

        B0BSET      FTC0IEN         ; Enable TC0 interrupt service
        B0BCLR      FTC0IRQ         ; Clear TC0 interrupt request flag
        B0BSET      FTC0ENB         ; Enable TC0 timer

        B0BSET      FGIE            ; Enable GIE
```

➲ Example: TC0 interrupt service routine.

```
        ORG         8               ; Interrupt vector
        JMP         INT_SERVICE
INT_SERVICE:
        B0XCH       A, ACCBUF       ; Store ACC value.
        B0MOV       A, PFLAG
        B0MOV       PFLAGBUF, A



        B0BTS1      FTC0IRQ         ; Check TC0IRQ
        JMP         EXIT_INT        ; TC0IRQ = 0, exit interrupt vector

        B0BCLR      FTC0IRQ         ; Reset TC0IRQ
        MOV         A, #74H
        B0MOV       TC0C, A         ; Reset TC0C.
        .               .           ; TC0 interrupt service routine
        .               .
EXIT_INT:
        B0MOV       A, PFLAGBUF
        B0MOV       PFLAG, A
        B0XCH       A, ACCBUF       ; Restore ACC value.



        RETI                        ; Exit interrupt vector
```

TC1 INTERRUPT OPERATION

When the TC1C counter occurs overflow, the TC1IRQ will be set to “1” however the TC1IEN is enable or disable. If the TC1IEN = 1, the trigger event will make the TC1IRQ to be “1” and the system enter interrupt vector. If the TC1IEN = 0, the trigger event will make the TC1IRQ to be “1” but the system will not enter interrupt vector. Users need to care for the operation under multi-interrupt situation.

➲ Example: TC1 interrupt request setup.

```
        B0BCLR      FTC1IEN         ; Disable TC1 interrupt service
        B0BCLR      FT C1ENB        ; Disable TC1 timer
        MOV         A, #20H         ;
        B0MOV       TC1M, A         ; Set TC1 clock = Fcpu / 64
        MOV         A, #74H         ; Set TC1C initial value = 74H
        B0MOV       TC1C, A         ; Set TC1 interval = 10 ms

        B0BSET      FTC1IEN         ; Enable TC1 interrupt service
        B0BCLR      FTC1IRQ         ; Clear TC1 interrupt request flag
        B0BSET      FTC1ENB         ; Enable TC1 timer

        B0BSET      FGIE            ; Enable GIE
```

➲ Example: TC1 interrupt service routine.

```
        ORG         8               ; Interrupt vector
        JMP         INT_SERVICE
INT_SERVICE:
        B0XCH       A, ACCBUF       ; Store ACC value.
        B0MOV       A, PFLAG
        B0MOV       PFLAGBUF, A


                                    ;
        B0BTS1      FTC1IRQ         ; Check TC1IRQ
        JMP         EXIT_INT        ; TC1IRQ = 0, exit interrupt vector

        B0BCLR      FTC1IRQ         ; Reset TC1IRQ
        MOV         A, #74H
        B0MOV       TC1C, A         ; Reset TC1C.
        .               .           ; TC1 interrupt service routine
        .               .
EXIT_INT:
        B0MOV       A, PFLAGBUF
        B0MOV       PFLAG, A
        B0XCH       A, ACCBUF       ; Restore ACC value.


        RETI                        ; Exit interrupt vector
```

MULTI-INTERRUPT OPERATION

In most conditions, the software designer uses more than one interrupt request. Processing multi-interrupt request needs to set the priority of these interrupt requests. The IRQ flags of the 7 interrupt are controlled by the interrupt event occurring. But the IRQ flag set doesn't mean the system to execute the interrupt vector. The IRQ flags can be triggered by the events without interrupt enable. Just only any the event occurs and the IRQ will be logic "1". The IRQ and its trigger event relationship is as the below table.

Interrupt Name	*Trigger Event Description*
P00IRQ	P0.0 trigger. Falling/Rising/Both.
TC0IRQ	TC0C overflow.
TC1IRQ	TC1C overflow.

There are two things need to do for multi-interrupt. One is to make a good priority for these interrupt requests. Two is using IEN and IRQ flags to decide executing interrupt service routine or not. Users have to check interrupt control bit and interrupt request flag in interrupt vector. There is a simple routine as following.

➲ **Example: How does users check the interrupt request in multi-interrupt situation?**

```
        ORG     8               ; Interrupt vector

        B0XCH   A, ACCBUF       ; Store ACC value.
        B0MOV   A, PFLAG
        B0MOV   PFLAGBUF, A
                                ;
INTP00CHK:                      ; Check INT0 interrupt request
        B0BTS1  FP00IEN         ; Check P00IEN
        JMP     INTTC0CHK       ; Jump check to next interrupt
        B0BTS0  FP00IRQ         ; Check P00IRQ
        JMP     INTP00          ; Jump to INT0 interrupt service routine
INTTC0CHK:                      ; Check TC0 interrupt request
        B0BTS1  FTC0IEN         ; Check TC0IEN
        JMP     INTTC1CHK       ; Jump check to next interrupt
        B0BTS0  FTC0IRQ         ; Check TC0IRQ
        JMP     INTTC0          ; Jump to TC0 interrupt service routine
INTTC1HK:                       ; Check TC1 interrupt request
        B0BTS1  FTC1IEN         ; Check TC1IEN
        JMP     INT_EXIT        ; Jump check to next interrupt
        B0BTS0  FTC1IRQ         ; Check TC1IRQ
        JMP     INTTC1          ; Jump to TC1 interrupt service routine
INT_EXIT:
        B0MOV   A, PFLAGBUF
        B0MOV   PFLAG, A
        B0XCH   A, ACCBUF       ; Restore ACC value.

        RETI                    ; Exit interrupt vector
```

10 I/O PORT

OVERVIEW

The SN8P1702A/SN8P1703A provides up to 4 ports for users' application, consisting of one input only port (P0), four I/O ports (P1, P4, P5). The direction of I/O port is selected by PnM register and PnUR register (N=0,1,4,5) is defined for user setting pull-up register. After the system resets, all ports work as input function without pull-up resistors.

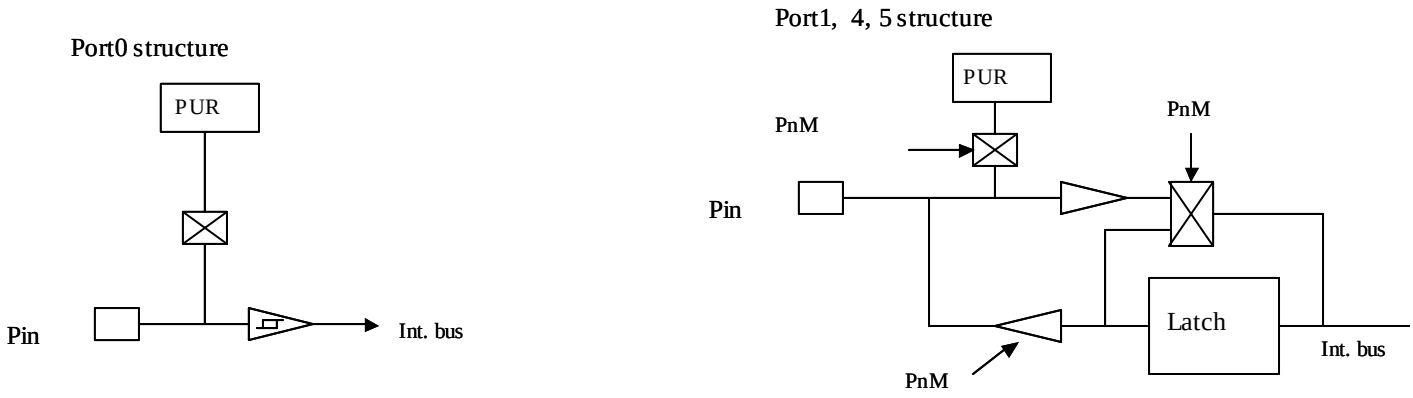


Figure 10-1. The I/O Port Block Diagram

➢ ***Note : All of the latch output circuits are push-pull structures.***

I/O PORT FUNCTION TABLE

Port/Pin	I/O	Function Description	Remark
P0.0	I	General-purpose input function	
		External interrupt (INT0)	
		Wakeup for power down mode	
P1.0~P1.1	I/O	General-purpose input/output function	
		Wakeup for power down mode	
P4.0~P4.3	I/O	General-purpose input/output function	
		ADC analog signal input	
P5.0~P5.5	I/O	General-purpose input/output function	

Table 10-1. I/O Function Table

PULL-UP RESISTERS

SN8P1702A/SN8P1703A series chips built-in pull-up resisters in port 0, port 1, port4 and port 5. User can set pull-up register by pin

Register Name	P0UR							
Address	E0H							
Bit	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Bit's Name	-	-	-	-	-	-	-	P00R
Read/Write	-	-	-	-	-	-	-	R/W
After reset	0	0	0	0	0	0	0	0

Register Name	P1UR							
Address	E1H							
Bit	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Bit's Name	-	-	-	-	-	-	P11R	P10R
Read/Write	-	-	-	-	-	-	R/W	R/W
After reset	0	0	0	0	0	0	0	0

Register Name	P4UR							
Address	E4H							
Bit	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Bit's Name	-	-	-	-	P43R	P42R	P41R	P40R
Read/Write	-	-	-	-	R/W	R/W	R/W	R/W
After reset	0	0	0	0	0	0	0	0

Register Name	P5UR							
Address	0E0H							
Bit	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Bit's Name	-	-	P55R	P54R	P53R	P52R	P51R	P50R
Read/Write	-	-	R/W	R/W	R/W	R/W	R/W	R/W
After reset	0	0	0	0	0	0	0	0

CHIP SN8P1703A

```
        ORG 0x10
Main:
        MOV     A, #01H
        B0MOV   P0UR,A          ; Enable port 0.0 pull-up resisters
```

➲ Example 2: Enable all pull-up resisters

CHIP SN8P1703A

```
        ORG 0x10
Main:
        MOV     A, #01H
        B0MOV   P0UR,A          ; Enable port 0 pull-up resisters
        MOV     A, #03H
        B0MOV   P1UR,A          ; Enable port 1 pull-up resisters
        MOV     A, #0FH
        B0MOV   P4UR,A          ; Enable port 4 pull-up resisters
        MOV     A, #01FH
        B0MOV   P5UR,A          ; Enable port 5 pull-up resisters
```

Note:

Enable on-chip pull-up resisters of port 0 and port 1 to avoid unpredicted wakeup in sleep mode.

I/O PORT MODE

The port direction is programmed by PnM register. Port 0 is always input mode. Port 1,2,4 and 5 can select input or output direction.

P1M initial value = xxxx xx00

0C1H	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
P1M	0	0	0	0	0	0	P11M	P10M
	-	-	-	-	-	-	R/W	R/W

Bit[1:0] **P1[1:0]M:**P1.0~P1.1 I/O direction control bit.
0 = input mode
1 = output mode.

P4M initial value = xxxx 0000

0C4H	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
P4M	0	0	0	0	P43M	P42M	P41M	P40M
	-	-	-	-	R/W	R/W	R/W	R/W

Bit[3:0] **P4[3:0]M:**P4.0~P4.3 I/O direction control bit.
0 = input mode
1 = output mode.

P5M initial value = xx00 0000

0C5H	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
P5M	0	0	P55M	P54M	P53M	P52M	P51M	P50M
	-	-	R/W	R/W	R/W	R/W	R/W	R/W

Bit[5:0] **P5[5:0]M:** P5.0~P5.5 I/O direction control bit.
0 = input mode
1 = output mode.

The each bit of PnM is set to “0”, the I/O pin is input mode. The each bit of PnM is set to “1”, the I/O pin is output mode. Input mode is with pull-up resistor controlled by setting @SET_UP macro. The output mode disables the pull-up resistors no matter pull-up resistors is set or not.

- ***The PnM registers are read/write bi-direction registers. Users can program them by bit control instructions (B0BSET, B0BCLR).***

➲ **Example: I/O mode selecting.**

```
CLR     P1M         ; Set all ports to be input mode.
CLR     P4M
CLR     P5M


MOV     A, #0FFH    ; Set all ports to be output mode.
B0MOV   P1M, A
B0MOV   P4M, A
B0MOV   P5M, A

B0BCLR  P1M.0       ; Set P1.0 to be input mode.

B0BSET  P1M.0       ; Set P1.0 to be output mode.
```

I/O PORT DATA REGISTER

P0 initial value = xxxx x000

0D0H	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
P0	-	-	-	-	-	-	-	P00
	-	-	-	-	-	-	-	R

P1 initial value = xx00 0000

0D1H	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
P1	-	-	-	-	-	-	P11	P10
	-	-	-	-	-	-	R/W	R/W

P4 initial value = 0000 0000

0D4H	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
P4	-	-	-	-	P43	P42	P41	P40
	-	-	-	-	R/W	R/W	R/W	R/W

P5 initial value = 0000 0000

0D5H	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
P5	-	-	P55	P54	P53	P52	P51	P50
	-	-	R/W	R/W	R/W	R/W	R/W	R/W

➲ **Example: Read data from input port.**

```
B0MOV     A, P0      ; Read data from Port 0
B0MOV     A, P1      ; Read data from Port 1
B0MOV     A, P4      ; Read data from Port 4
B0MOV     A, P5      ; Read data from Port 5
```

➲ **Example: Write data to output port.**

```
MOV       A, #55H    ; Write data 55H to Port 1, Port 4, Port 5
B0MOV     P1, A
B0MOV     P4, A
B0MOV     P5, A
```

➲ **Example: Write one bit data to output port.**

```
B0BSET      P1.1        ; Set P1.1 and P4.0 to be “1”.
B0BSET      P4.0

B0BCLR      P1.0        ; Set P1.0 and P5.5 to be “0”.
B0BCLR      P5.5
```

➲ **Example: Port bit test.**

```
B0BTS1      P0.0        ; Bit test 1 for P0.0
.
B0BTS0      P1.1        ; Bit test 0 for P1.1
```

11 4-CHANNEL ANALOG TO DIGITAL CONVERTER

OVERVIEW

This analog to digital converter of SN8P1702A/SN8P1703A has 4-input sources with up to 4096-step resolution to transfer analog signal into 12-bits digital data. The sequence of ADC operation is to select input source (AIN0 ~ AIN3) at first, then set GCHS and ADS bit to "1" to start conversion. When the conversion is complete, the ADC circuit will set EOC bit to "1" and final value output in ADB register. This ADC circuit can select between 8-bit and 12-bit resolution operation by programming ADLEN bit in ADR register.

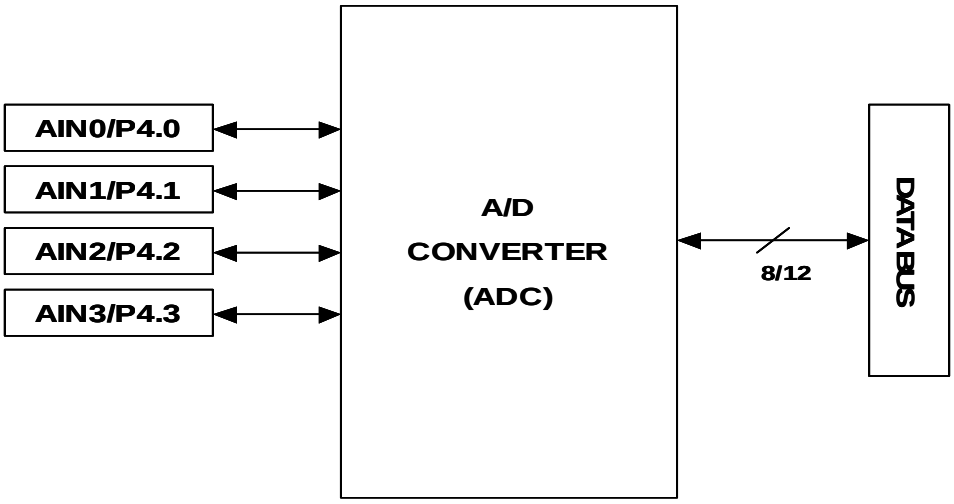


Figure 11-1. AD Converter Function Diagram

- ***Note: For 8-bit resolution, the conversion time is 12 steps.***
  For 12-bit resolution, the conversion time is 16 steps.
- ***Note: The analog input level must be between the AVREFH and VSS.***
- ***Note: The AVREFH level must be between the VDD and VSS+1.2V.***

ADM REGISTER

ADM initial value = 0000 x000

0B1H	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
ADM	ADENB	ADS	EOC	GCHS	-	-	CHS1	CHS0
	R/W	R/W	R/W	R/W	-	-	R/W	R/W

Bit[1:0] **CHS[1:0]:** ADC input channels select bit.
00 = AIN0
01 = AIN1
10 = AIN2
11 = AIN3

Bit4 **GCHS:**Global channel select bit.
0 = to disable AIN channel
1 = to enable AIN channel.

Bit5 **EOC:** ADC status bit.
0 = Progressing
1 = End of converting and reset ADENB bit.

Bit6 **ADS:**ADC start bit.
0 = stop
1 = starting.

Bit7 **ADENB:**ADC control bit.
0 = disable
1 = enable.

ADR REGISTERS

ADR initial value = x00x 0000

0B3H	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
ADR	-	ADCKS1	ADLEN	ADCKS0	ADB3	ADB2	ADB1	ADB0
	-	R/W	R/W	R/W	R	R	R	R

Bit[3:0] **ADBn:** ADC data buffer.
ADB11~ADB4 data for 8-bit ADC.
ADB11~ADB0 data for 12-bit ADC.

Bit5 **ADLEN:** ADC's resolution select bits.
0 = 8-bit
1 = 12-bit.

Bit6,Bit4 **ADCKS1, ADCKS0:** ADC's clock source select bit.

ADCKS1	ADCKS0	ADC Clock Source	Note
0	0	Fcpu/4	Both validate in Normal mode and Slow mode
0	1	Fcpu/2	Both validate in Normal mode and Slow mode
1	0	Fhosc	Only validate in Normal mode
1	1	Fhosc/2	Only validate in Normal mode

ADB REGISTERS

ADB initial value = xxxx xxxx

0B2H	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
ADB	ADB11	ADB10	ADB9	ADB8	ADB7	ADB6	ADB5	ADB4
	R	R	R	R	R	R	R	R

ADB is ADC data buffer to store AD converter result. The ADB is only 8-bit register including bit4~bit11 ADC data. To combine ADB register and the low-nibble of ADR will get full 12-bit ADC data buffer. The ADC buffer is a read-only register. In 8-bit ADC mode, the ADC data is stored in ADB register. In 12-bit ADC mode, the ADC data is stored in ADB and ADR registers.

➢ ***Note: ADB[0:11] value is unknown when power on.***

P4CON REGISTERS

ADB initial value = xxxx 0000

0AEH	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
P4CON	0	0	0	0	P4CON3	P4CON2	P4CON1	P4CON0
	-	-	-	-	R/W	R/W	R/W	R/W

P4CON is Port4 Configuration register. This register can avoid current leakage in unselected ADC channel, which connected to an analog input source. P4CON [3:0] sets to high will isolate related Port4 digital input path outside chip. For example, both AIN0 (Port4.0) and AIN1 (Port4.1) are connected to analog input signal, and AIN0 be selected as conversion channel (CHS [1:0] = 00), this mean the unselected channel P4.1 maybe in digital input mode (if P41M = 0) In this condition will possible leak current from analog input source. Set P4CON1 = "1" can block P4.1 digital input path to avoid the current leakage from AIN1.

For the same reason, P4CON0 must set to "1" when conversion channel is AIN1. So any Port4 pin be connected to analog input source should be set related bit of P4CON as high to avoid unpredictable current leakage. Especially before entering Sleep mode, remember to set related bit of P4CON as "1".

Bit [3:0] **P4CON:** Port4 Configuration register.

P4CON3	0	Pass P4.3 digital path into chip.
	1	Isolate P4.3 digital path into chip
P4CON2	0	Pass P4.2 digital path into chip.
	1	Isolate P4.2 digital path into chip
P4CON1	0	Pass P4.1 digital path into chip.
	1	Isolate P4.1 digital path into chip
P4CON0	0	Pass P4.0 digital path into chip.
	1	Isolate P4.0 digital path into chip

- ***Note 1: When Port4 is general I/O port, set related P4CON [3:0] = "0"***
- ***Note 2: When Port4 is ADC input channel, set related P4CON [3:0] = "1"***

The AIN's input voltage vs. ADB's output data

AIN n	ADB11	ADB10	ADB9	ADB8	ADB7	ADB6	ADB5	ADB4	ADB3	ADB2	ADB1	ADB0
0/4096*AVREFH	0	0	0	0	0	0	0	0	0	0	0	0
1/4096*AVREFH	0	0	0	0	0	0	0	0	0	0	0	1
.	.	.	.	.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.	.	.	.	.
4094/4096*AVREFH	1	1	1	1	1	1	1	1	1	1	1	0
4095/4096*AVREFH	1	1	1	1	1	1	1	1	1	1	1	1

For different applications, users maybe need more than 8-bit resolution but less than 12-bit ADC converter. To process the ADB and ADR data can make the job well. First, the AD resolution must be set 12-bit mode and then to execute ADC converter routine. Then delete the LSB of ADC data and get the new resolution result. The table is as following.

ADC Resolution	**ADB**								**ADR**			
	ADB11	**ADB10**	**ADB9**	**ADB8**	**ADB7**	**ADB6**	**ADB5**	**ADB4**	**ADB3**	**ADB2**	**ADB1**	**ADB0**
8-bit	O	O	O	O	O	O	O	O	x	x	x	x
9-bit	O	O	O	O	O	O	O	O	O	x	x	x
10-bit	O	O	O	O	O	O	O	O	O	O	x	x
11-bit	O	O	O	O	O	O	O	O	O	O	O	x
12-bit	O	O	O	O	O	O	O	O	O	O	O	O
O = Selected, x = Delete												

ADC CONVERTING TIME

12-bit ADC conversion time = 1/(ADC clock /4)*16 sec

8-bit ADC conversion time = 1/(ADC clock /4)*12 sec

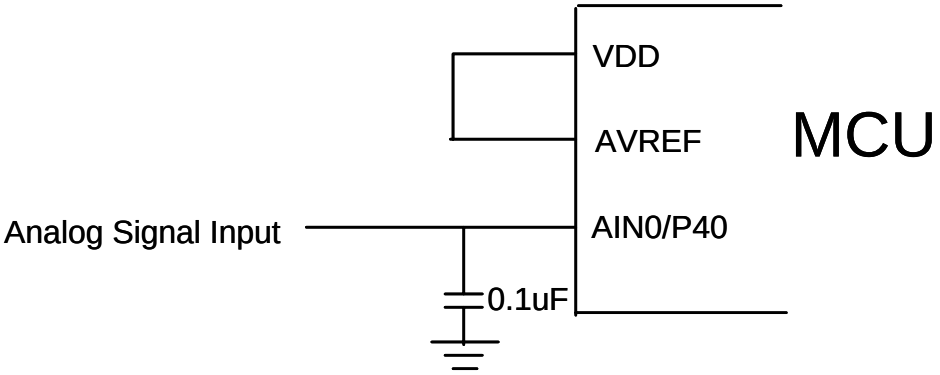
High clock (Fosc) is @3.58MHz

ADLEN	ADCKS1	ADCKS0	ADC Clock	ADC conversion time
0 (8-bit)	0	0	Fcpu/4	1/((3.58MHz/4)/4/4)*12 = 214.5 us
	0	1	Fcpu/2	1/((3.58MHz/4)/2/4)*12 = 107.3 us
	1	0	Fhosc	1/(3.58MHz/4)*12 = 13.4 us
	1	1	Fhosc/2	1/(3.58MHz/2/4)*12 = 26.8 us
1 (12-bit)	0	0	Fcpu/4	1/((3.58MHz/4)/4/4)*16 = 286 us
	0	1	Fcpu/2	1/((3.58MHz/4)/2/4)*16 = 143 us
	1	0	Fhosc	1/(3.58MHz/4)*16 = 17.9 us
	1	1	Fhosc/2	1/(3.58MHz/2/4)*16 = 35.8 us

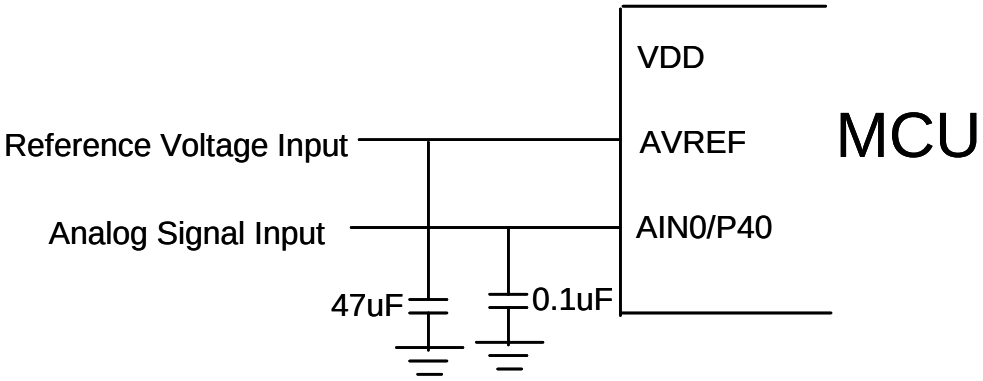
➲ Example: To set AIN0 ~ AIN1 for ADC input and executing 12-bit ADC

```
ADC0:
        MOV     A, #60H
        B0MOV   ADR, A          ; To set 12-bit ADC and ADC clock = Fosc.
        B0SET   FP4CON1         ;Isolate AIN1 signal to avoid current leakage
        B0CLR   FP4CON0         ;Pass AIN0 signal into ADC
        MOV     A,#90H
        B0MOV   ADM,A           ; To enable ADC and set AIN0 input
        B0SET   P4CON1          ; To enable ADC and set AIN0 input
        B0BSET  FADS            ; To start conversion
WADC0:
        B0BTS1  FEOC            ; To skip, if end of converting =1
        JMP     WADC0           ; else, jump to WADC0
        B0MOV   A,ADB           ; To get AIN0 input data
ADC1:
        B0SET   FP4CON0         ;Isolate AIN0 signal to avoid current leakage
        B0CLR   FP4CON1         ;Pass AIN1 signal into ADC
        MOV     A,#91H          ;
        B0MOV   ADM,A           ; To enable ADC and set AIN1 input
        B0BSET  FADS            ; To start conversion
        .       .               .
QEXADC:
        B0BCLR  FGCHS           ; To release AINx input channel
```

ADC CIRCUIT



AVREFH is connected to VDD.



AVREFH is connected to external AD reference voltage.

Figure 11-2. The AINx and AVREFH Circuit of AD Converter

- ***Note: The capacitor between AIN and GND is a bypass capacitor. It is helpful to stable the analog signal. Users can omit it.***

12 CODING ISSUE

TEMPLATE CODE

```
;*************************************************************************
; FILENAME  : TEMPLATE.ASM
; AUTHOR    : SONiX
; PURPOSE   : Template Code for SN8X17XX
; REVISION  : 09/01/2002 V1.0   First issue
;*************************************************************************
;*  (c) Copyright 2002, SONiX TECHNOLOGY CO., LTD.
;*************************************************************************
CHIP    SN8P1703A                   ; Select the CHIP

;-------------------------------------------------------------------------
;                           Include Files
;-------------------------------------------------------------------------
.nolist                             ; do not list the macro file

    INCLUDESTD  MACRO1.H
    INCLUDESTD  MACRO2.H
    INCLUDESTD  MACRO3.H

.list                               ; Enable the listing function

;-------------------------------------------------------------------------
;                           Constants Definition
;-------------------------------------------------------------------------
;   ONE         EQU     1

;-------------------------------------------------------------------------
;                           Variables Definition
;-------------------------------------------------------------------------
.DATA

                org     0h          ;Bank 0 data section start from RAM address 0x000
    Wk00B0      DS      1           ;Temporary buffer for main loop
    Iwk00B0     DS      1           ;Temporary buffer for ISR
    AccBuf      DS      1           ;Accumulator buffer
    PflagBuf    DS      1           ;PFLAG buffer

                org     100h        ;Bank 1 data section start from RAM address 0x100
    BufB1       DS      20          ;Temporary buffer in bank 1

;-------------------------------------------------------------------------
;                           Bit Flag Definition
;-------------------------------------------------------------------------
    Wk00B0_0    EQU     Wk00B0.0    ;Bit 0 of Wk00B0
    Iwk00B0_1   EQU     Iwk00B0.1   ;Bit 1 of Iwk00
```

```
;-------------------------------------------------------------------------------
;                           Code section
;-------------------------------------------------------------------------------

.CODE

    ORG         0                   ;Code section start
    jmp         Reset               ;Reset vector
                                    ;Address 4 to 7 are reserved
    ORG         8
    jmp         Isr                 ;Interrupt vector

    ORG         10h
;-------------------------------------------------------------------------------
;   Program reset section
;-------------------------------------------------------------------------------
Reset:
    mov         A,#07Fh             ;Initial stack pointer and
    b0mov       STKP,A              ;disable global interrupt
    b0mov       PFLAG,#00h          ;pflag = x,x,x,x,x,c,dc,z
    b0mov       RBANK,#00h          ;Set initial RAM bank in bank 0
    mov         A,#40h              ;Clear watchdog timer and initial system mode
    b0mov       OSCM,A

    call        ClrRAM              ;Clear RAM
    call        SysInit             ;System initial
    b0bset      FGIE                ;Enable global interrupt

;-------------------------------------------------------------------------------
;   Main routine
;-------------------------------------------------------------------------------
Main:
    b0bset      FWDRST              ;Clear watchdog timer

    call        MnApp

    jmp         Main

;-------------------------------------------------------------------------------
;   Main application
;-------------------------------------------------------------------------------
MnApp:

    ; Put your main program here

    ret

;-----------------------------------
;   Jump table routine
;-----------------------------------
    ORG         0x0100              ;The jump table should start from the head
                                    ;of boundary.
    b0mov       A,Wk00
    and         A,#3
    ADD         PCL,A
    jmp         JmpSub0
    jmp         JmpSub1
    jmp         JmpSub2
;-----------------------------------
```

```
JmpSub0:
    ; Subroutine 1
    jmp         JmpExit

JmpSub1:
    ; Subroutine 2
    jmp         JmpExit

JmpSub2:
    ; Subroutine 3
    jmp         JmpExit

JmpExit:
    ret                             ;Return Main

;-------------------------------------------------------------------------------
; Isr (Interrupt Service Routine)
; Arguments :
; Returns   :
; Reg Change:
;-------------------------------------------------------------------------------
Isr:
;-----------------------------------
;   Save ACC and system registers
;-----------------------------------
    b0xch       A,AccBuf            ;B0xch instruction do not change C,Z flag
    b0mov       A,PFLAG
    b0mov       PflagBuf,A

;-----------------------------------
;   Check which interrupt happen
;-----------------------------------
IntP00Chk:
    b0bts1      FP00IEN
    jmp         IntTc0Chk           ;Modify this line for another interrupt
    b0bts0      FP00IRQ
    jmp         P00isr

    ;If necessary, insert another interrupt checking here

IntTc0Chk:
    b0bts1      FTC0IEN
    jmp         IsrExit             ;Suppose TC0 is the last interrupt which you
    b0bts0      FTC0IRQ             ;want to check
    jmp         TC0isr

;-----------------------------------
; Exit interrupt service routine
;-----------------------------------

IsrExit:

    ; Following two lines for SN8X1702 only
    b0mov      A,PFLAG
    b0mov      PflagBuf,A
    b0xch       A,AccBuf            ;B0xch instruction do not change C,Z flag
    reti                            ;Exit the interrupt routine
```

```
;-------------------------------------------------------------------------------
;   INT0 interrupt service routine
;-------------------------------------------------------------------------------
P00isr:
    b0bclr      FP00IRQ

    ;Process P0.0 external interrupt here

    jmp         IsrExit

;-------------------------------------------------------------------------------
;   TC0 interrupt service routine
;-------------------------------------------------------------------------------
TC0isr:
    b0bclr      FTC0IRQ

    ;Process TC0 timer interrupt here

    jmp         IsrExit

;-------------------------------------------------------------------------------
;   SysInit
;   Initialize I/O, Timer, Interrupt, etc.
;-------------------------------------------------------------------------------
SysInit:
    ret

;-------------------------------------------------------------------------------
; ClrRAM
; Use index @YZ to clear RAM  (00h~7Fh)
;-------------------------------------------------------------------------------

ClrRAM:

; RAM Bank 0
    clr         Y                   ;Select bank 0
    b0mov       Z,#0x7f             ;Set @YZ address from 7fh

ClrRAM10:
    clr         @YZ                 ;Clear @YZ content
    decms       Z                   ;z = z - 1 , skip next if z=0
    jmp         ClrRAM10
    clr         @YZ                 ;Clear address 0x00

; RAM Bank 1
    mov         A,#1
    b0mov       Y,A                 ;Select bank 1
    b0mov       Z,#0x7f             ;Set @YZ address from 17fh

ClrRAM20:
    clr         @YZ                 ;Clear @YZ content
    decms       Z                   ;z = z - 1 , skip next if z=0
    jmp         ClrRAM20
    clr         @YZ                 ;Clear address 0x100
    ret

;-------------------------------------------------------------------------------
    ENDP
```

PROGRAM CHECK LIST

Item	Description
Pull-up Resister	Use PnUR register to enable or disable on-chip pull-up resisters. Refer I/O port chapter for detailed information.
Undefined Bits	All bits those are marked as “0” (undefined bits) in system registers should be set “0” to avoid unpredicted system errors.
ADC	Set ADC input pin I/O direction as input mode and disable pull-up resister of ADC input pin
PWM0	Set PWM0 (P5.4) pin as output mode.
PWM1	Set PWM1 (P5.3) pin as output mode.
Interrupt	Do not enable interrupt before initializing RAM.
Non-Used I/O	Non-used I/O ports should be pull-up or pull-down in input mode, or be set as low in output mode to save current consumption.
Sleep Mode	Enable on-chip pull-up resisters of port 0 and port 1 to avoid unpredicted wakeup.
Stack Buffer	Be careful of function call and interrupt service routine operation. Don’t let stack buffer overflow or underflow.
System Initial	1. Write 0x7F into STKP register to initial stack pointer and disable global interrupt 2. Clear all RAM. 3. Initialize all system register even unused registers.
Noisy Immunity	1. Enable OSG and High_Clk / 2 code option together 2. Enable the watchdog option and internal RC for the watchdog clock to protect system crash. 3. Non-used I/O ports should be set as output low mode or input with pull-up resistors. 4. Constantly refresh important system registers and variables in RAM to avoid system crash by a high electrical fast transient noise.

13 INSTRUCTION SET TABLE

Field	Mnemonic		Description	C	DC	Z	Cycle
	MOV	A,M	A ← M	-	-	√	1
M	MOV	M,A	M ← A	-	-	-	1
O	B0MOV	A,M	A ← M (bank 0)	-	-	√	1
V	B0MOV	M,A	M (bank 0) ← A	-	-	-	1
E	MOV	A,I	A ← I	-	-	-	1
	B0MOV	M,I	M ← I, (M = only for Working registers R, Y, Z , RBANK & PFLAG)	-	-	-	1
	XCH	A,M	A ←→M	-	-	-	1
	B0XCH	A,M	A ←→M (bank 0)	-	-	-	1
	MOVC		R, A ← ROM [Y,Z]	-	-	-	2
	ADC	A,M	A ← A + M + C, if occur carry, then C=1, else C=0	√	√	√	1
A	ADC	M,A	M ← A + M + C, if occur carry, then C=1, else C=0	√	√	√	1
R	ADD	A,M	A ← A + M, if occur carry, then C=1, else C=0	√	√	√	1
I	ADD	M,A	M ← A + M, if occur carry, then C=1, else C=0	√	√	√	1
T	B0ADD	M,A	M (bank 0) ← M (bank 0) + A, if occur carry, then C=1, else C=0	√	√	√	1
H	ADD	A,I	A ← A + I, if occur carry, then C=1, else C=0	√	√	√	1
M	SBC	A,M	A ← A - M - /C, if occur borrow, then C=0, else C=1	√	√	√	1
E	SBC	M,A	M ← A - M - /C, if occur borrow, then C=0, else C=1	√	√	√	1
T	SUB	A,M	A ← A - M, if occur borrow, then C=0, else C=1	√	√	√	1
I	SUB	M,A	M ← A - M, if occur borrow, then C=0, else C=1	√	√	√	1
C	SUB	A,I	A ← A - I, if occur borrow, then C=0, else C=1	√	√	√	1
	DAA		To adjust ACC's data format from HEX to DEC.	√	-	-	1
	AND	A,M	A ← A and M	-	-	√	1
L	AND	M,A	M ← A and M	-	-	√	1
O	AND	A,I	A ← A and I	-	-	√	1
G	OR	A,M	A ← A or M	-	-	√	1
I	OR	M,A	M ← A or M	-	-	√	1
C	OR	A,I	A ← A or I	-	-	√	1
	XOR	A,M	A ← A xor M	-	-	√	1
	XOR	M,A	M ← A xor M	-	-	√	1
	XOR	A,I	A ← A xor I	-	-	√	1
	SWAP	M	A (b3~b0, b7~b4) ←M(b7~b4, b3~b0)	-	-	-	1
P	SWAPM	M	M(b3~b0, b7~b4) ← M(b7~b4, b3~b0)	-	-	-	1
R	RRC	M	A ← RRC M	√	-	-	1
O	RRCM	M	M ← RRC M	√	-	-	1
C	RLC	M	A ← RLC M	√	-	-	1
E	RLCM	M	M ← RLC M	√	-	-	1
S	CLR	M	M ← 0	-	-	-	1
S	BCLR	M.b	M.b ← 0	-	-	-	1
	BSET	M.b	M.b ← 1	-	-	-	1
	B0BCLR	M.b	M(bank 0).b ← 0	-	-	-	1
	B0BSET	M.b	M(bank 0).b ← 1	-	-	-	1
	CMPRS	A,I	ZF,C ← A - I, If A = I, then skip next instruction	√	-	√	1 + S
B	CMPRS	A,M	ZF,C ← A – M, If A = M, then skip next instruction	√	-	√	1 + S
R	INCS	M	A ← M + 1, If A = 0, then skip next instruction	-	-	-	1 + S
A	INCMS	M	M ← M + 1, If M = 0, then skip next instruction	-	-	-	1 + S
N	DECS	M	A ← M - 1, If A = 0, then skip next instruction	-	-	-	1 + S
C	DECMS	M	M ← M - 1, If M = 0, then skip next instruction	-	-	-	1 + S
H	BTS0	M.b	If M.b = 0, then skip next instruction	-	-	-	1 + S
	BTS1	M.b	If M.b = 1, then skip next instruction	-	-	-	1 + S
	B0BTS0	M.b	If M(bank 0).b = 0, then skip next instruction	-	-	-	1 + S
	B0BTS1	M.b	If M(bank 0).b = 1, then skip next instruction	-	-	-	1 + S
	JMP	d	PC15/14 ← RomPages1/0, PC13~PC0 ← d	-	-	-	2
	CALL	d	Stack ← PC15~PC0, PC15/14 ← RomPages1/0, PC13~PC0 ← d	-	-	-	2
M	RET		PC ← Stack	-	-	-	2
I	RETI		PC ← Stack, and to enable global interrupt	-	-	-	2
S	NOP		No operation	-	-	-	1
C	@SET_PUR	VAL	Enable or disable pull-up resisters. Bit N of VAL: "0" disable port N pull-up, "1" enable port N pull-up	-	-	√	-

Table 13-1. Instruction Set Table

Note 1: Any instruction that read/write from 0SCM, will add an extra cycle.

14 ELECTRICAL CHARACTERISTIC

ABSOLUTE MAXIMUM RATING

(All of the voltages referenced to Vss)

Supply voltage (Vdd)..... - 0.3V ~ 6.0V
Input in voltage (Vin).....Vss - 0.2V ~ Vdd + 0.2V
Operating ambient temperature (Topr).....-20°C ~ + 70°C
Storage ambient temperature (Tstore).....-30°C ~ + 125°C
Power consumption (Pc).....500 mW

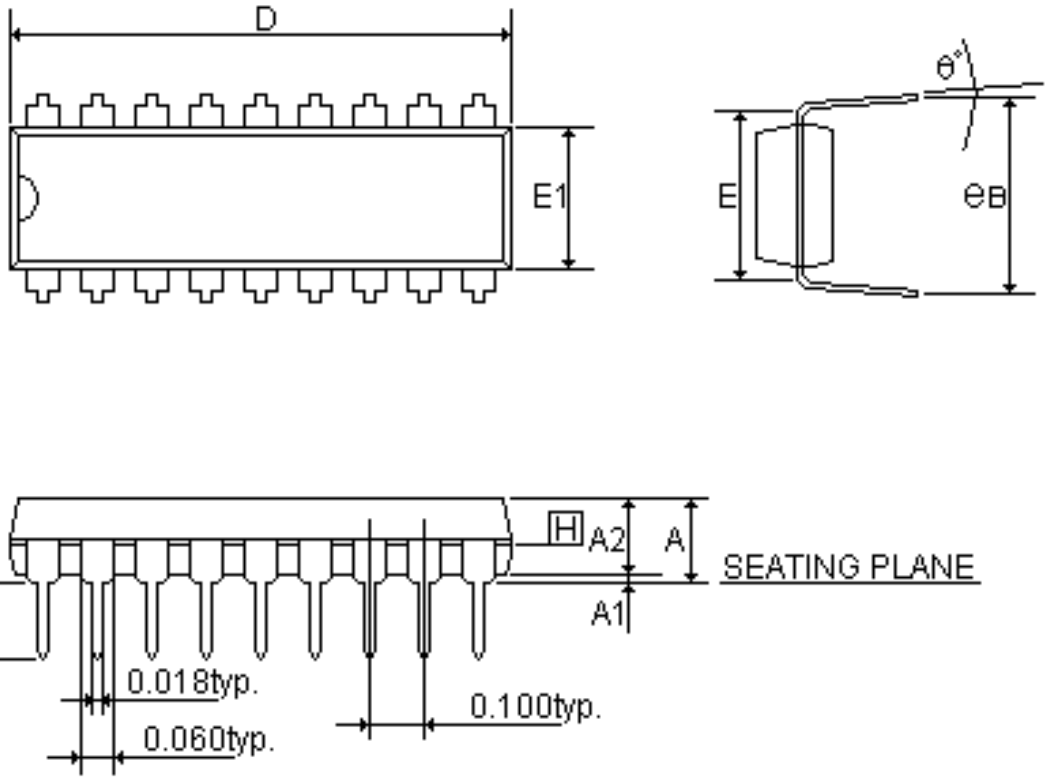
STANDARD ELECTRICAL CHARACTERISTIC

(All of voltages referenced to Vss, Vdd = 5.0V, Fosc = 3.579545 MHz, ambient temperature is 25℃ unless otherwise note.)

PARAMETER	SYM.	DESCRIPTION		MIN.	TYP.	MAX.	UNIT
Operating voltage	Vdd	Normal mode, Vpp = Vdd		2.2	5.0	5.5	V
		Programming mode, Vpp = 12.5V		4.5	5.0	5.5	
RAM Data Retention voltage	Vdr			-	1.5	-	V
Internal POR	Vpor	Vdd rise rate to ensure internal power-on reset		-	0.05	-	V/ms
Input Low Voltage	ViL1	All input pins except those specified below		Vss	-	0.3Vdd	V
	ViL2	Input with Schmitt trigger buffer - Port0		Vss	-	0.2Vdd	V
	ViL3	Reset pin ; Xin (in RC mode)		Vss	-	0.2Vdd	V
	ViL4	Xin (in X'tal mode)		Vss	-	0.3Vdd	V
Input High Voltage	ViH1	All input pins except those specified below		0.7Vdd	-	Vdd	V
	ViH2	Input with Schmitt trigger buffer –Port0		0.8Vdd	-	Vdd	V
	ViH3	Reset pin ; Xin (in RC mode)		0.9Vdd	-	Vdd	V
	ViH4	Xin (in X'tal mode)		0.7Vdd	-	Vdd	V
Reset pin leakage current	Ilekg	Vin = Vdd		-	-	2	uA
I/O port pull-up resistor	Rup	Vin = Vss , Vdd = 5V		-	100	-	KΩ
I/O port input leakage current	Ilekg	Pull-up resistor disable, Vin = Vdd		-	-	2	uA
Port1 output source current	IoH	Vop = Vdd - 0.5V		-	15	-	mA
sink current	IoL	Vop = Vss + 0.5V		-	15	-	
Port4 output source current	IoH	Vop = Vdd - 0.5V		-	15	-	mA
sink current	IoL	Vop = Vss + 0.5V		-	15	-	
Port5 output source current	IoH	Vop = Vdd - 0.5V		-	15	-	mA
sink current	IoL	Vop = Vss + 0.5V		-	15	-	
INTn trigger pulse width	Tint0	INT0 interrupt request pulse width		2/fcpu	-	-	cycle
AVREFH input voltage	AVref	Vdd = 5.0V		1.2V	-	Vdd	V
AIN0 ~ AIN3 input voltage	Vani			Vss+0.2	-	AVref	V
Oscillator Frequency	Fhosc	Crystal type or ceramic resonator		32768	4M	16M	Hz
		VDD = 3V, RC type for external mode		-	6M	-	
		VDD = 5V, RC type for external mode		-	10M	-	
Supply Current (Disable ADC)	Idd1	Run Mode (Low Power Disable)	Vdd= 5V 4Mhz	-	2.5	6	mA
			Vdd= 3V 4Mhz	-	1	2	mA
			Vdd= 3V 32768Hz	-	40	80	uA
	Idd2	Run Mode (Low Power Enable)	Vdd= 5V 4Mhz	-	1.6	3	mA
			Vdd= 3V 4Mhz	-	0.7	1.5	mA
	Idd3	Slow mode (Stop High Clock)	Vdd= 5V 32KHz Int. RC	-	30	60	uA
			Vdd= 3V 16KHz Int. RC	-	7	20	uA
	Idd4	Sleep mode	Vdd= 5V	-	1	2	uA
			Vdd= 3V	-	0.6		uA
	Idd5	Green Mode (Stop High Clock)	Vdd= 5V 32KHz Int. RC	-	16	40	uA
			Vdd= 3V 16KHz Int. RC		3	10	
ADC current consumption	IADC	Vdd=5.0V		-	0.6	1	mA
		Vdd=3.0V		-	0.4	0.8	mA
LVD Detect Voltage	Vdet	Low voltage detect level		-	1.8	-	V

15 PACKAGE INFORMATION

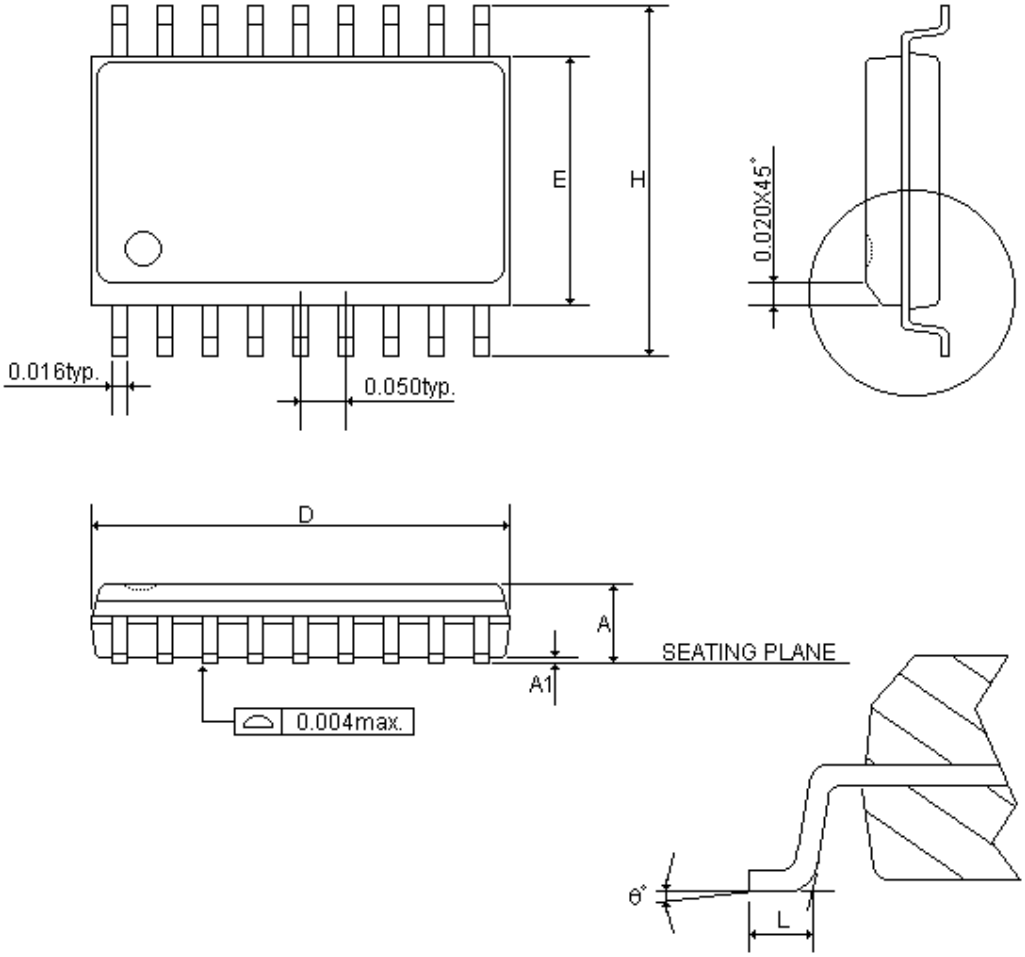
P-DIP18 PIN



Symbols	MIN.	NOR.	MAX.
A	-	-	0.210
A1	0.015	-	-
A2	0.125	0.130	0.135
D	0.880	0.900	0.920
E		0.300BSC.	
E1	0.245	0.250	0.255
L	0.115	0.130	0.150
eB	0.335	0.355	0.375
θ °	0	7	15

UNIT : INCH

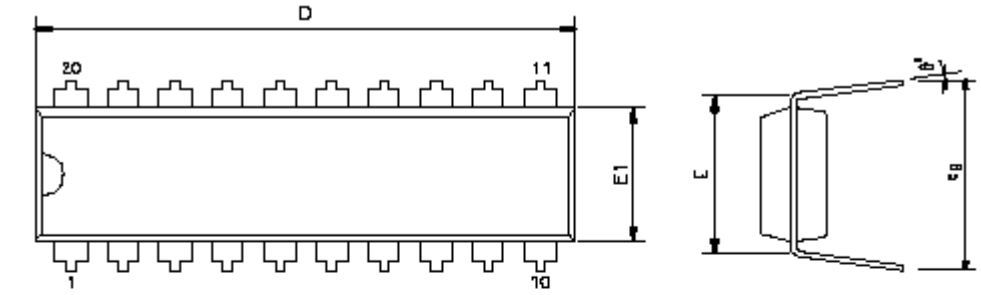
SOP18 PIN

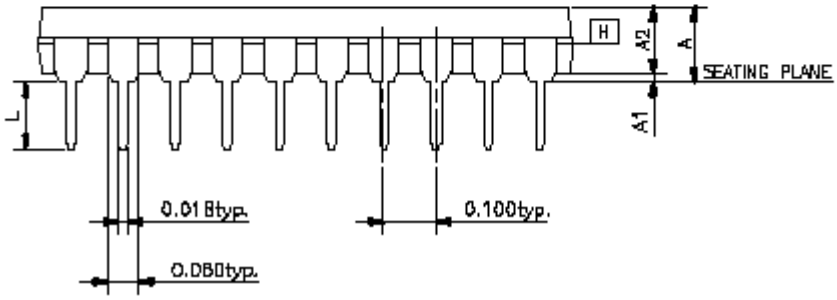


Symbols	MIN.	MAX.
A	0.093	0.104
A1	0.004	0.012
D	0.447	0.463
E	0.291	0.299
H	0.394	0.419
L	0.016	0.050
θ °	0	8

UNIT : INCH

P-DIP 20 PIN





SYMBOLS	MIN.	NOR.	MAX.
A	–	–	0.210
A1	0.015	–	–
A2	0.125	0.130	0.135
D	0.98	1.030	1.060
E		0.300 BSC.	
E1	0.245	0.250	0.255
L	0.115	0.130	0.150
e_B	0.335	0.355	0.375
θ°	0	7	15

UNIT : INCH

NOTES:

1.JEDEC OUTLINE : MS-001 AD

2."D","E1" DIMENSIONS DO NOT INCLUDE MOLD FLASH OR PROTRUSIONS.MOLD FLASH OR PROTRUSIONS SHALL NOT EXCEED .010 INCH.

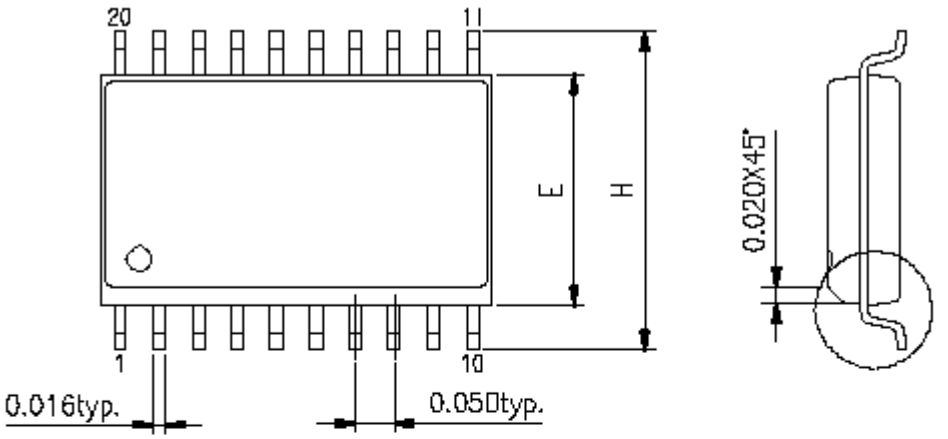
3.eB IS MEASURED AT THE LEAD TIPS WITH THE LEADS UNCONSTRAINED.

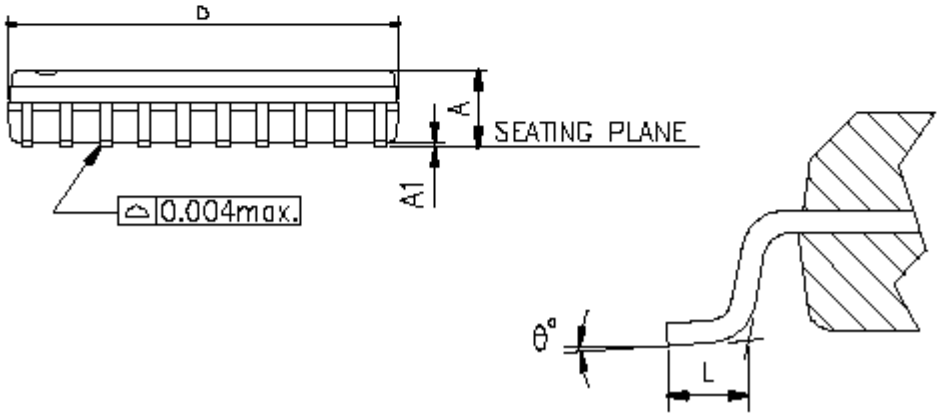
4.POINTED OR ROUNDED LEAD TIPS ARE PREFERRED TO EASE INSERTION.

5.DISTANCE BETWEEN LEADS INCLUDING DAM BAR PROTRUSIONS TO BE .005 INCH MININUM.

6.DATUM PLANE [H] COINCIDENT WITH THE BOTTOM OF LEAD, WHERE LEAD EXITS BODY.

SOP 20 PIN



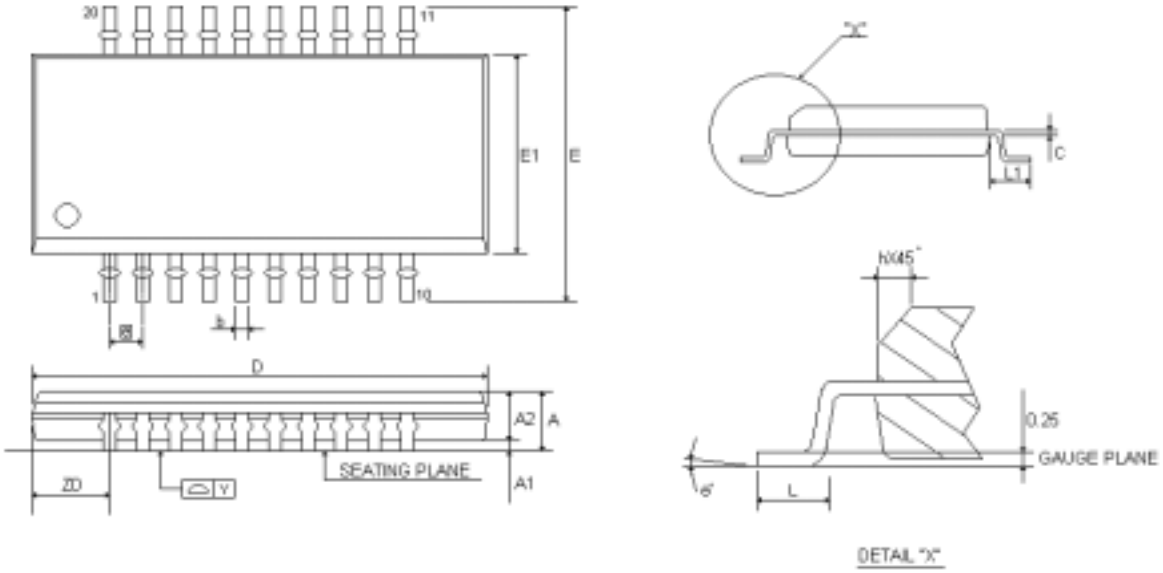


SYMBOLS	MIN.	MAX.
A	0.093	0.104
A1	0.004	0.012
D	0.496	0.508
E	0.291	0.299
H	0.394	0.419
L	0.016	0.050
θ°	0	8

UNIT : INCH

NOTES:
1.JEDEC OUTLINE : MS-013 AC
2.DIMENSIONS "D" DOES NOT INCLUDE MOLD FLASH, PROTRUSIONS OR GATE BURRS.MOLD FLASH, PROTRUSIONS AND GATE BURRS SHALL NOT EXCEED .15mm (.006in) PER SIDE.
3.DIMENSIONS "E" DOES NOT INCLUDE INTER-LEAD FLASH, OR PROTRUSIONS. INTER-LEAD FLASH AND PROTRUSIONS SHALL NOT EXCEED .25mm (.010in) PER SIDE.

SSOP20 PIN



Symbols	DIMENSION (MM)			DIMENSION (MIL)		
	MIN,	NOM.	MAX.	MIN.	NOM.	MAX.
A	1.35	1.60	1.75	53	63	69
A1	0.10	0.15	0.25	4	6	10
A2	-	-	1.50	-	-	59
b	0.20	0.254	0.30	8	10	12
b1	0.20	0.254	0.28	8	11	11
C	0.18	0.203	0.25	7	8	10
C1	0.18	0.203	0.23	7	8	9
D	8.56	8.66	8.74	337	341	344
E	5.80	6.00	6.20	228	236	244
E1	3.80	3.90	4.00	150	154	157
e	0.635 BSC			25 BSC		
h	0.25	0.42	0.50	10	17	20
L	0.40	0.635	1.27	16	25	50
L1	1.00	1.05	1.10	39	41	43
ZD	1.50 REF			58 REF		
Y	-	-	0.10	-	-	4
θ °	0°	-	8°	0°	-	8°

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