SC8P053 User Manual

Enhanced OTP 8-bit CMOS microcontrollers

Rev.1.0.4

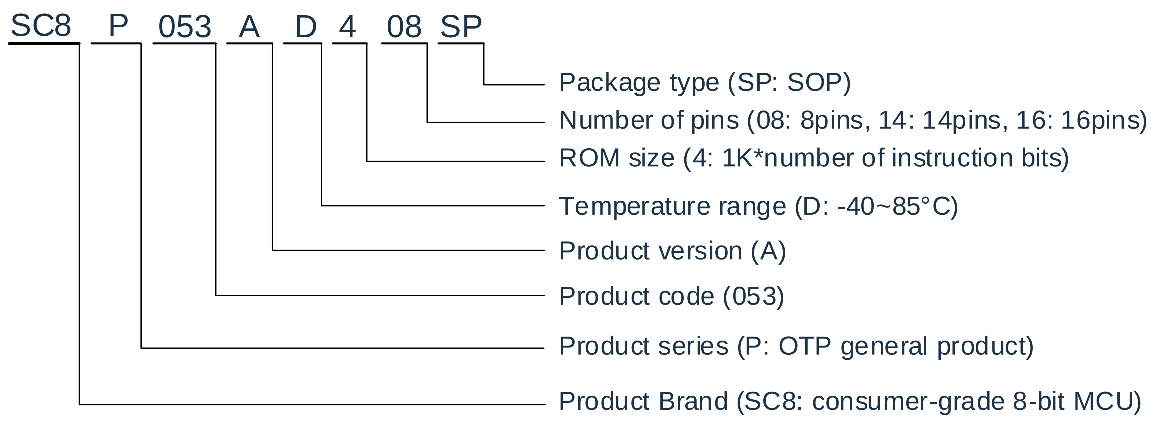
Table of Contents

1. Product Description

1.1 Features

- Memory
  - OTP: 1K×16Bit
  - Universal RAM: 80×8Bit
- 8-level stack buffer
- Short and clear instruction system (66 instructions)
- Built-in low voltage detection circuit
- Built-in WDT
- Interrupt sources
  - 2 timer interrupts
  - RA, RB ports interrupt on change
  - Other peripheral interrupts
- Timer
  - 8-bit timers: TIMER0, TIMER2
  - TIMER2 can select external 32.768Khz oscillating clock source.
- Built-in comparator module
  - Positive: RB1/resistor divider output
  - Negative: RB1/RB2/RB4/RB5/BG/resistor divider output
- Operating voltage: 3.0V~5.5V@16MHz/2T
  1.8V~5.5V@16MHz/4T
  Operating temperature: -40℃~85℃
- Internal RC oscillation: designed frequency of 16MHz
- Instruction period (single or dual instruction)
- Built-in PWM module
  - 5-channel PWM with 2 complementary outputs and selectable polarity.
  - 4-channel PWM common period, independent duty cycle
  - 1-channel PWM independent period, independent duty cycle
  - 10-bit PWM precision
- Built-in high-precision 1.2V reference voltage
- LVR can be selected from 1.8V, 2V, 2.5V, 3V

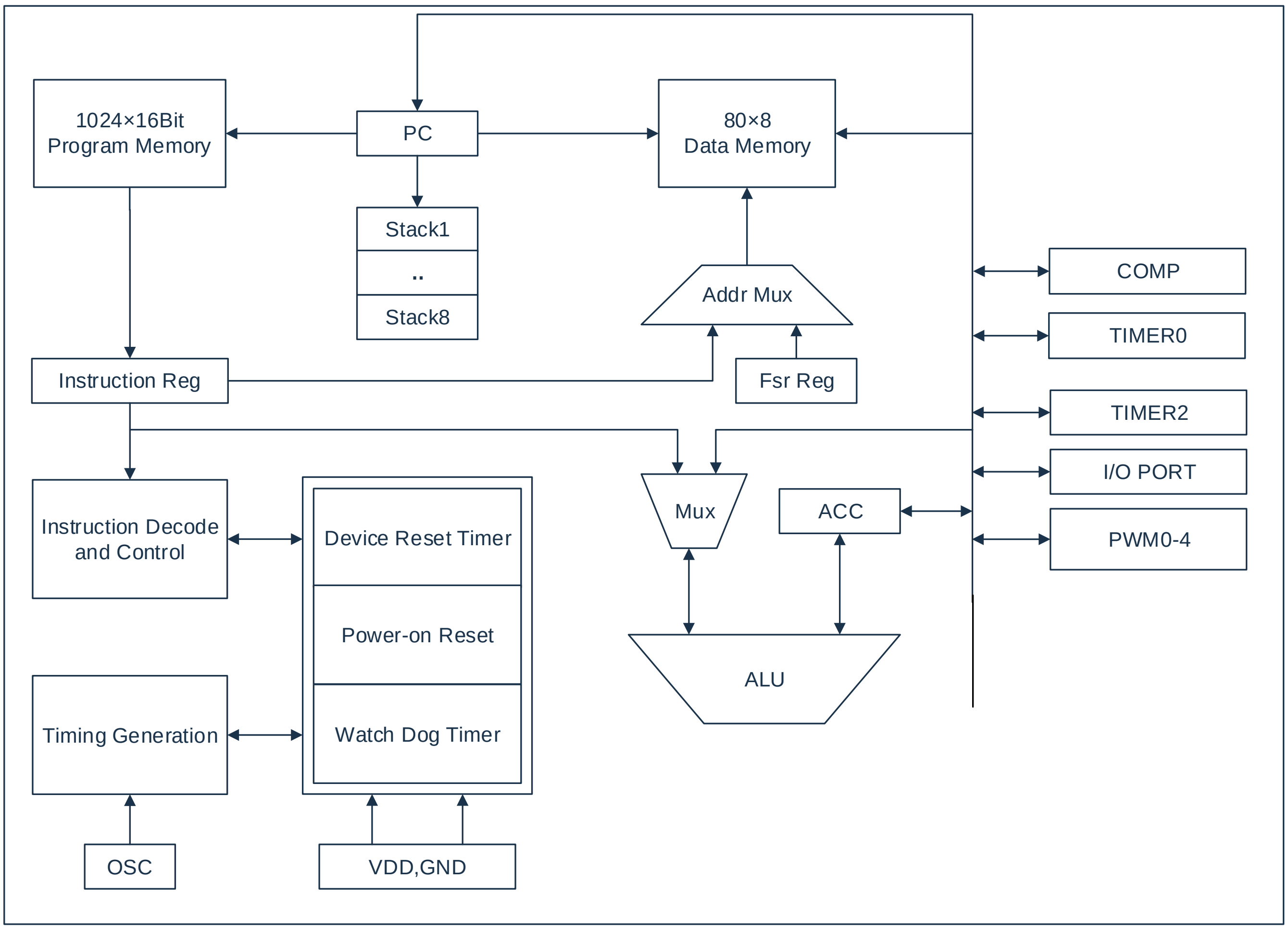
1.2 Product model list


SC8 P 053 A D 4 08 SP
Package type (SP: SOP)
Number of pins (08: 8pins, 14: 14pins, 16: 16pins)
ROM size (4: 1K*number of instruction bits)
Temperature range (D: -40~85°C)
Product version (A)
Product code (053)
Product series (P: OTP general product)
Product Brand (SC8: consumer-grade 8-bit MCU)

Model description

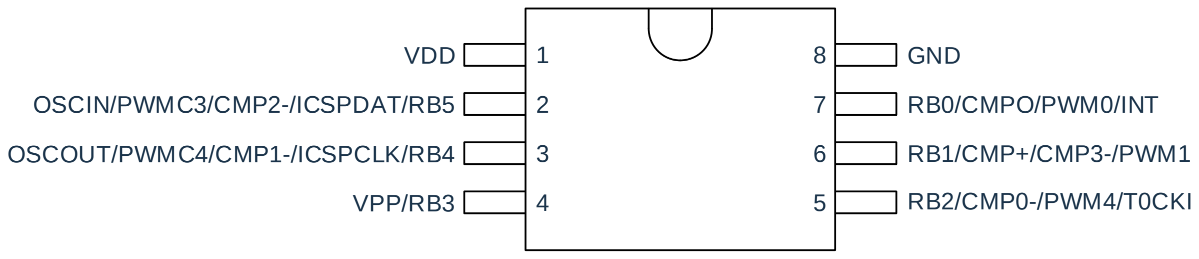
PRODUCT	ROM	RAM	PWM	ACOMP	I/O	TIMER	PACKAGE
SC8P053AD408SP	1K×16	80×8	3	1	6	2	SOP8
SC8P053AD414SP	1K×16	80×8	5	1	12	2	SOP14
SC8P053AD416SP	1K×16	80×8	5	1	14	2	SOP16

1.3 System structure diagram



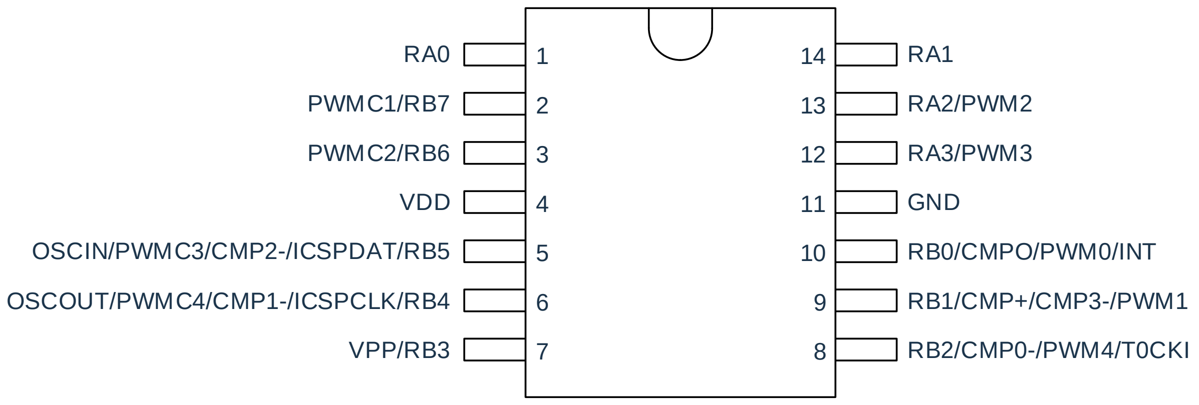
1.4 Top view

1.4.1 SC8P053AD408SP



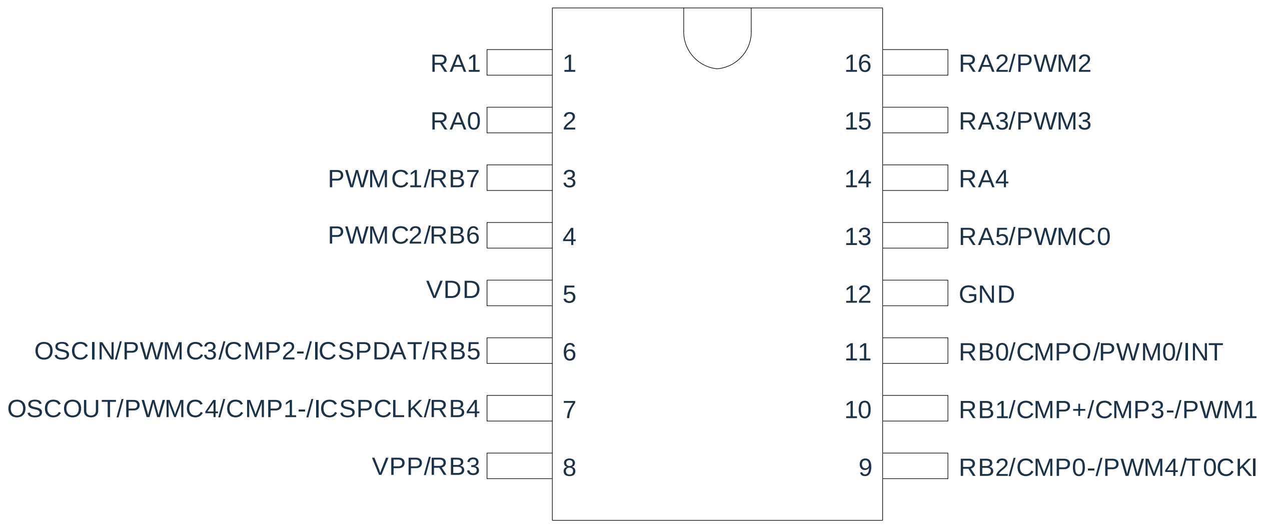
SC8P053AD408SP

1.4.2 SC8P053AD414SP



SC8P053AD414SP

1.4.3SC8P053AD416SP



SC8P053AD416SP

SC8P053 pin description:

Pin name	IO type	Pin description
VDD,GND	P	Supply voltage input pin, ground pin
RA0-RA5	I/O	Programmable as input pin, push-pull or open-drain output pin, with pull-up and pull-down resistor functionality, and interrupt-on-change function.
RB0-RB2,RB4-RB7	I/O	Programmable as input pin, push-pull or open-drain output pin, with pull-up resistor functionality, and interrupt-on-change function.
RB3	I/O	Programmable as input pin, open-drain output pin, with pull-up resistor functionality, and interrupt-on-change function.
ICSPCLK/ICSPDAT	I/O	Programmable clock/data pin
VPP	I	Programmable high-voltage input port
PWM0-PWM4	O	PWM output pin
PWMC0-PWMC4	O	PWM output pin
INT	I	External interrupt input pin
CMP+	I	Comparator positive input pin
CMP0-, CMP1-, CMP2-, CMP3-	I	Comparator negative input pin
CMPO	O	Comparator result output pin
T0CKI	I	TIMER0 external clock input pin
OSCIN/OSCOUT	I/O	32.768K crystal oscillator input/output pin

1.5 System configuration register

The System Configuration Register (CONFIG) is an OTP option for the MCU initial conditions. It can only be written by the SC programmer and cannot be accessed or manipulated by the user. It contains the following contents.

1. WDT (watchdog selection)

◆ ENABLE	Enable WDT
◆ DISABLE	Disable WDT

2. PROTECT (encrypted)

◆ DISABLE	ROM code is not encrypted
◆ ENABLE	ROM code is encrypted, and the value read out by the programmed emulator will be uncertain after encryption

3. LVR_SEL (low-voltage detection selection)
   - ◆ 1.8V
   - ◆ 2.0V
   - ◆ 2.5V
   - ◆ 3.0V
4. F_{CPU}_DIV (Instruction clock divison)

◆ 4T	Divided by 4, $F_{CPU}=F_{SYS}/4$
◆ 2T	Divided by 2, $F_{CPU}=F_{SYS}/2$

1.6 Online serial programming

The microcontroller can be programmed serially in the final application circuit. Programming can be done simply with the following 5 wires.

- Power wire
- Ground wire
- Data wire
- Clock wire
- High-voltage wire

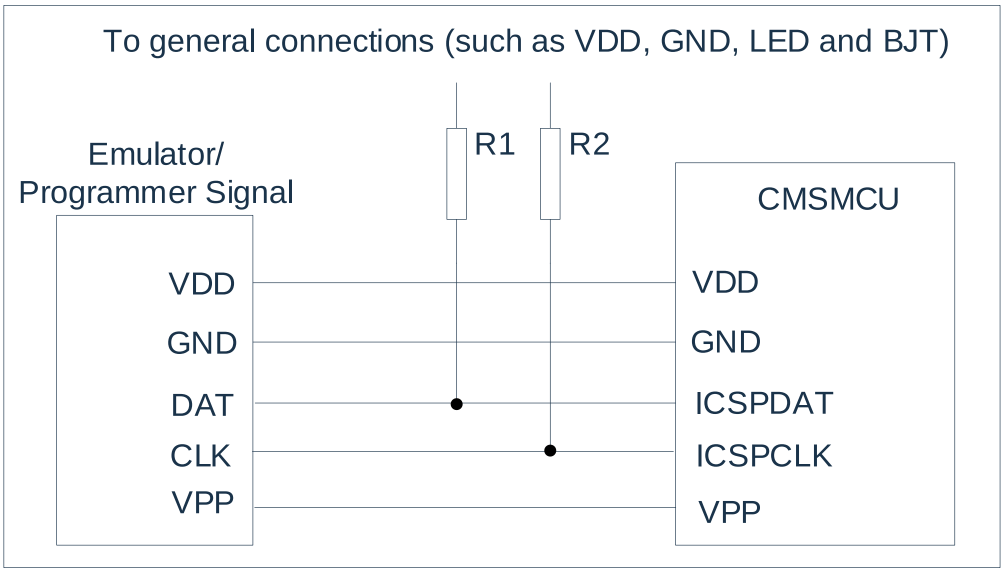

To general connections (such as VDD, GND, LED and BJT)
R1
R2
Emulator/ Programmer Signal
VDD
GND
DAT
CLK
VPP
CMSMCU
VDD
GND
ICSPDAT
ICSPCLK
VPP

Figure 1-1: Typical connection for online serial programming

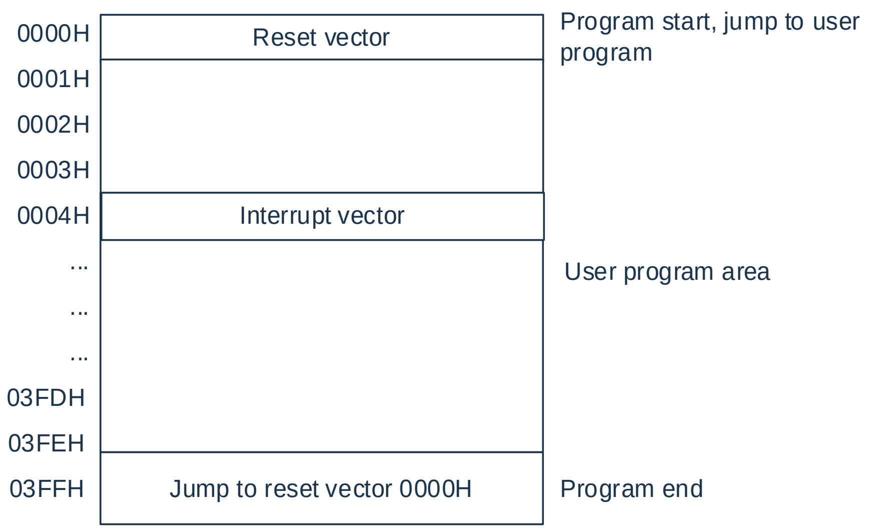
In the above figure, R1 and R2 are the electrical isolation devices, normally represented by resistors with the following resistance values: R1⩾4.7K, R2⩾4.7K.

2. Central Processing Unit (CPU)

2.1 Memory

2.1.1 Program memory

OTP: 1K



2.1.1.1 Reset vector (0000H)

The MCU has a 1-byte long system reset vector (0000H). It has 3 ways to reset:

- Power-on reset
- Watchdog reset
- Low voltage reset (LVR)

When any above reset happens, program will start to execute from 0000H, system register will be recovered to default value. PD and TO flag bits from the STATUS register can determine which reset is performed from above. The following program illustrates how to define the reset vector from OTP.

Example: define reset vector

```
                ORG             0000H               ;system reset vector
                JP              START
                ORG             0010H               ;start of user program
        START:
                ...                                 ;user program
                ...
                END                                 ;program end
```

2.1.1.2Interrupt vector

The address for interrupt vector is 0004H. Once the interrupt responds, the current value for program counter (PC) will be saved to stack buffer and jump to 0004H to execute interrupt service program. All interrupt will enter 0004H. Users will determine which interrupt to execute according to the bit of the interrupt request flag bit register. The following program illustrates how to write interrupt service program.

Example: define interrupt vector, interrupt program is placed after user program

```
            ORG       0000H           ;system reset vector
            JP        START
            ORG       0004H           ;start of user program
INT_START:
            CALL      PUSH            ;save ACC and STATUS
            …                         ;user interrupt program
            …
 INT_BACK:
            CALL      POP             ;back to ACC and STATUS
            RETI                      ;interrupt back
    START:
            …                         ;user program
            …
            END                       ;program end
```

Note: MCU does not provide specific unstack and push instructions, so users need to protect interrupt scene.

Example: interrupt-in protection

```
    PUSH:
            LD        ACC_BAK,A       ;save ACC to ACC_BAK
            SWAPA     STATUS          ;swap half-byte of STATUS
            LD        STATUS_BAK,A    ;save to STATUS_BAK
            RET                       ;back
```

Example: interrupt-out restore

```
     POP:
            SWAPA     STATUS_BAK      ;swap the half-byte data from STATUS_BAK to ACC
            LD        STATUS,A        ;pass the value in ACC to STATUS
            SWAPR     ACC_BAK         ;swap the half-byte data in ACC_BAK
            SWAPA     ACC_BAK         ;swap the half-byte data from ACC_BAK to ACC
            RET                       ;back
```

2.1.1.3Jump table

Jump table can achieve multi-address jump. Since the addition of PCL and ACC is the new value of PCL, multi-address jump is then achieved through adding different values of ACC to PCL. If the value of ACC is n, then PCL+ACC represents the current address plus n. After the execution of the current instructions, the value of PCL will add 1 (refer to the following examples). If PCL+ACC overflows, then PC will not carry. As such, user can achieve multi-address jump through setting different values of ACC.

PCLATH is the PC high bit buffer register. Before operating on PCL, value must be given to PCLATH.

Example: correct illustration of multi-address jump

```
OTP address
                LDIA        01H
                LD          PCLATH,A      ;load value to PCLATH
                …
  0110H:        ADDR        PCL           ;ACC+PCL
  0111H:        JP          LOOP1         ;ACC=0, jump to LOOP1
  0112H:        JP          LOOP2         ;ACC=1, jump to LOOP2
  0113H:        JP          LOOP3         ;ACC=2, jump to LOOP3
  0114H:        JP          LOOP4         ;ACC=3, jump to LOOP4
  0115H:        JP          LOOP5         ;ACC=4, jump to LOOP5
  0116H:        JP          LOOP6         ;ACC=5, jump to LOOP6
```

Example: wrong illustration of multi-address jump

```
OTP address
                CLR         PCLATH
                …
  00FCH:        ADDR        PCL           ;ACC+PCL
  00FDH:        JP          LOOP1         ;ACC=0, jump to LOOP1
  00FEH:        JP          LOOP2         ;ACC=1, jump to LOOP2
  00FFH:        JP          LOOP3         ;ACC=2, jump to LOOP3
  0100H:        JP          LOOP4         ;ACC=3, jump to 0000H
  0101H:        JP          LOOP5         ;ACC=4, jump to 0001H
  0102H:        JP          LOOP6         ;ACC=5, jump to 0002H
```

Note: Since PCL overflow will not carry to the higher bits, the program cannot be placed at the partition of the OTP space when using PCL to achieve multi-address jump.

2.1.2 Data memory

SC8P053 data memory list

	Add.		Add.		Add.		Add.
INDF	00H	INDF	80H	-----	100H	-----	180H
OPTION_REG	01H	TMR0	81H	-----	101H	-----	181H
PCL	02H	PCL	82H	-----	102H	-----	182H
STATUS	03H	STATUS	83H	-----	103H	-----	183H
FSR	04H	FSR	84H	-----	104H	-----	184H
TRISB	05H	TRISA	85H	-----	105H	-----	185H
PORTB	06H	PORTA	86H	-----	106H	-----	186H
WPDB	07H	WPDA	87H	-----	107H	-----	187H
WPUB	08H	WPUA	88H	-----	108H	-----	188H
IOCB	09H	IOCA	89H	-----	109H	-----	189H
PCLATH	0AH	PCLATH	8AH	-----	10AH	-----	18AH
INTCON	0BH	INTCON	8BH	-----	10BH	-----	18BH
ODCONB	0CH	ODCONA	8CH	-----	10CH	-----	18CH
PIR1	0DH	-----	8DH	-----	10DH	-----	18DH
PIE1	0EH	-----	8EH	-----	10EH	-----	18EH
CMPCON0	0FH	-----	8FH	-----	10FH	-----	18FH
CMPCON1	10H	-----	90H	-----	110H	-----	190H
PR2	11H	-----	91H	-----	111H	-----	191H
TMR2	12H	-----	92H	-----	112H	-----	192H
T2CON	13H	-----	93H	-----	113H	-----	193H
OSCCON	14H	-----	94H	-----	114H	-----	194H
PWMCON0	15H	-----	95H	-----	115H	-----	195H
PWMCON1	16H	-----	96H	-----	116H	-----	196H
PWMTL	17H	-----	97H	-----	117H	-----	197H
PWMTH	18H	-----	98H	-----	118H		198H
PWMD0L	19H	-----	99H	-----	119H		199H
PWMD1L	1AH	-----	9AH	-----	11AH		19AH
PWMD4L	1BH	PWMD2L	9BH	-----	11BH	-----	19BH
PWMT4L	1CH	PWMD3L	9CH	-----	11CH		19CH
PWMCON2	1DH	PWM23DT	9DH	-----	11DH		19DH
PWMD01H	1EH	PWMD23H	9EH	-----	11EH		19EH
PWM01DT	1FH	-----	9FH	-----	11FH		19FH
	20H	-----	A0H	-----	120H	-----	1A0H
Universal register 80-byte	5FH						
	60H						
			EFH		16FH		1EFH
		Fast memory Space 70H-7FH	F0H	-----	170H	-----	1F0H
			--		--		--
	7FH		FFH		17FH		1FFH
BANK0		BANK1		BANK2		BANK3	

Data memory is divided into two functional areas: special function registers and general-purpose data memory. Most of the data memory cells are readable/writable, but some are read-only. Special function registers are addressed from 00H-1FH, 80-9FH.

SC8P053 special function register summary Bank0

Add.	Name	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0	Reset value
00H	INDF	Addressing this unit will address data memory (not a physical register) using the contents of the FSR.								xxxxxxxx
01H	OPTION_REG	----	INTEDG	T0CS	T0SE	PSA	PS2	PS1	PS0	-1111011
02H	PCL	Program counter low byte								00000000
03H	STATUS	IRP	RP1	RP0	TO	PD	Z	DC	C	00011xxx
04H	FSR	Indirect data memory address pointer								xxxxxxxx
05H	TRISB	TRISB7	TRISB6	TRISB5	TRISB4	TRISB3	TRISB2	TRISB1	TRISB0	11111111
06H	PORTB	RB7	RB6	RB5	RB4	RB3	RB2	RB1	RB0	xxxxxxxx
07H	WPDB	WPDB7	WPDB6	WPDB5	WPDB4	----	WPDB2	WPDB1	WPDB0	0000-000
08H	WPUB	WPUB7	WPUB6	WPUB5	WPUB4	WPUB3	WPUB2	WPUB1	WPUB0	00000000
09H	IOCB	IOCB7	IOCB6	IOCB5	IOCB4	IOCB3	IOCB2	IOCB1	IOCB0	00000000
0AH	PCLATH	----	----	----	----	----	----	Write buffer for the high 2 bits of the program counter		-----00
0BH	INTCON	GIE	PEIE	T0IE	INTE	RBIE	T0IF	INTF	RBIF	00000000
0CH	ODCONB	ODCONB7	ODCONB6	ODCONB5	ODCONB4	----	ODCONB2	ODCONB1	ODCONB0	0000-000
0DH	PIR1	----	----	CMPIF	PWMIF	RAIF	----	TMR2IF	----	--000-0-
0EH	PIE1	----	----	CMPIE	PWMIE	RAIE	----	TMR2IE	----	--000-0-
0FH	CMPCON0	CMPEN	CMPPS	CMPNS2	CMPNS1	CMPNS0	CMPNV	CMPOUT	CMPOEN	00000000
10H	CMPCON1	CMPIM	AN_EN	RBIAS_H	RBIAS_L	LVDS<3:0>				00000000
11H	PR2	TIMER2 period register								11111111
12H	TMR2	TIMER2 module register								00000000
13H	T2CON	CLK_SEL	TOUTPS3	TOUTPS2	TOUTPS1	TOUTPS0	TMR2ON	T2CKPS1	T2CKPS0	00000000
14H	OSCCON	----	IRCF2	IRCF1	IRCF0	----	----	SWDTEN	-----	-101--1-
15H	PWMCON0	CLKDIV<2:0>			PWM4EN	PWM3EN	PWM2EN	PWM1EN	PWM0EN	00000000
16H	PWMCON1	----	PWM_IOSEL	PWM2DTEN	PWM0DTEN	----	----	DT_DIV<1:0>		-000--00
17H	PWMTL	PWM0~PWM1 period low 8-bit register								00000000
18H	PWMTH	----	----	PWM4D<9:8>		PWM4T<9:8>		PWMT<9:8>		--000000
19H	PWMD0L	PWM0 duty cycle lower 8 bits								00000000
1AH	PWMD1L	PWM1 duty cycle lower 8 bits								00000000
1BH	PWMD4L	PWM4 duty cycle lower 8 bits								00000000
1CH	PWMT4L	PWM4 period low 8-bit register								00000000
1DH	PWMCON2	----	----	----	PWM4DIR	PWM3DIR	PWM2DIR	PWM1DIR	PWM0DIR	---00000
1EH	PWMD01H	----	----	PWMD1<9:8>		----	----	PWMD0<9:8>		--00--00
1FH	PWM01DT	----	----	PWM01DT<5:0>						--000000

SC8P053 special function register summary Bank1

Add.	Name	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0	Reset value
80H	INDF	Addressing this unit will address data memory (not a physical register) using the contents of the FSR.								xxxxxxxx
81H	TMR0	TIMER0 data register								xxxxxxxx
82H	PCL	Program counter low byte								00000000
83H	STATUS	IRP	RP1	RP0	TO	PD	Z	DC	C	00011xxx
84H	FSR	Indirect data memory address pointer								xxxxxxxx
85H	TRISA	----	----	TRISA5	TRISA4	TRISA3	TRISA2	TRISA1	TRISA0	--111111
86H	PORTA	----	----	RA5	RA4	RA3	RA2	RA1	RA0	--xxxxxx
87H	WPDA	----	----	WPDA5	WPDA4	WPDA3	WPDA2	WPDA1	WPDA0	--000000
88H	WPUA	----	----	WPUA5	WPUA4	WPUA3	WPUA2	WPUA1	WPUA0	--000000
89H	IOCA	----	----	IOCA5	IOCA4	IOCA3	IOCA2	IOCA1	IOCA0	--000000
8AH	PCLATH	----	----	----	----	----	----	Write buffer for the high 2 bits of the program counter		-----00
8BH	INTCON	GIE	PEIE	T0IE	INTE	RBIE	T0IF	INTF	RBIF	00000000
8CH	ODCONA	----	----	ODCONA5	ODCONA4	ODCONA3	ODCONA2	ODCONA1	ODCONA0	--000000
9BH	PWMD2L	PWM2 duty cycle lower 8 bits								00000000
9CH	PWMD3L	PWM3 duty cycle lower 8 bits								00000000
9DH	PWM23DT	----	----	PWM23 dead delay time						--000000
9EH	PWMD23H	----	----	PWMD3<9:8>				PWMD2<9:8>		--00--00

2.2 Addressing mode

2.2.1 Direct addressing

It operates the RAM through the operation register (ACC).

Example: pass the value in ACC to 30H register

```
            LD              30H,A
```

Example: pass the value in 30H register to ACC

```
            LD              A,30H
```

2.2.2 Immediate addressing

Pass the immediate value to accumulator (ACC)

Example: pass the immediate value 12H to ACC

```
            LDIA            12H
```

2.2.3 Indirect addressing

Data memory can be addressed directly or indirectly. Direct addressing can be achieved through INDF register, and INDF is not a physical register. When INDF is accessed, it is addressed according to the value in the FSR register, and points to the register at that address. Therefore, after setting the FSR register, INDF register can be regarded as a target register. Read INDF (FSR=0) indirectly will produce 00H. Write to the INDF register indirectly will cause a null operation. The following example shows how indirect addressing works.

Example: application of FSR and INDF

```
            LDIA            30H
            LD              FSR,A           ;point to 30H for indirect addressing
            CLR             INDF            ;clear INDF, which means clearing the 30H address
                                            RAM that FSR points to
```

Example: clear RAM (20H-5FH) for indirect addressing

```
            LDIA            1FH
            LD              FSR,A           ;point to 1FH for indirect addressing
      LOOP:
            INCR            FSR             ;address add 1, and initial address is 20H
            CLR             INDF            ;clear the address where FSR points to
            LDIA            5FH
            SUBA            FSR
            SNZB            STATUS,C        ;clear until the address of FSR is 5FH
            JP              LOOP
```

2.3 Stack

Stack buffer of the chip has 8 levels. Stack buffer is not part of data memory nor program memory. It cannot be written nor read. Operation on the stack buffer is through the stack pointer (SP), which also cannot be written nor read. After the system is reset, the SP points to the top of the stack. When a subroutine call or interrupt occurs, values in the program counter (PC) will be transferred to the stack buffer. When return from interrupt or return from subroutine, values are transferred back to the PC. The following diagram illustrates how this works.

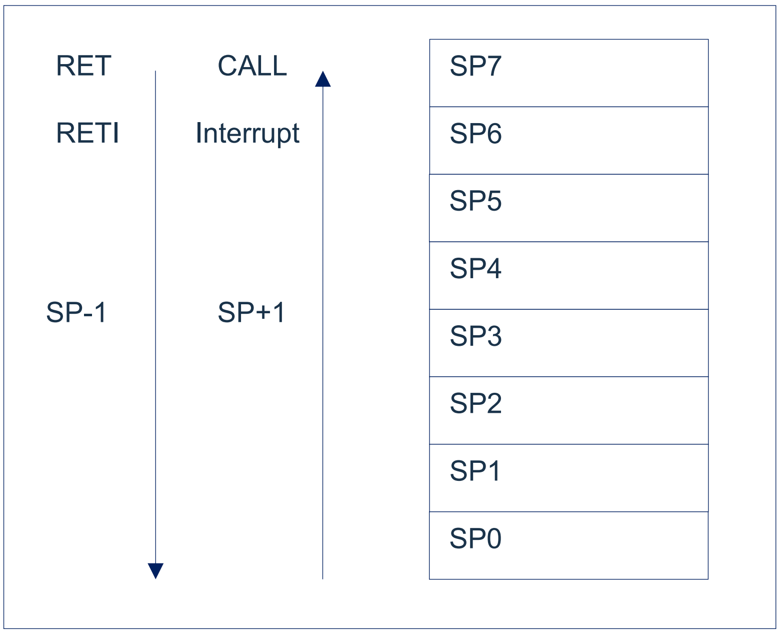


Figure 2-2: How the stack buffer works

Stack buffer will follow one principle: ‘first in last out’.

Note: Stack buffer has only 8 levels, if the stack is full and an interrupt happens which is non-maskable, then only the flag bit of the interrupt will be logged. The response for the interrupt will be suppressed until the pointer of stack starts to decrease. This feature can prevent overflow of the stack caused by the interrupt. Similarly, when stack is full and subroutine happens, then stack will overflow and the contents which enter the stack first will be lost, only the last 8 return addresses will be saved. Therefore, users should pay attention to this point when writing programs to avoid program loops.

2.4 Accumulator (ACC)

2.4.1 Overivew

ALU is an 8-bit arithmetic-logic unit. All math and logic related calculations in MCU are done by ALU. It can perform addition, subtraction, shift and logical calculation on data; ALU can also control STATUS to represent the status of the calculation result.

ACC register is an 8-bit register to store the ALU calculation result. It does not belong to data memory. It is in CPU and used by ALU during calculation. Hence it cannot be addressed. It can only be used through the provided instructions.

2.4.2 ACC application

Example: use ACC for data transferring

```
        LD          A,R01           ;load the value in register R01 to ACC
        LD          R02,A           ;load the value in ACC to register R02
```

Example: use ACC for immediate addressing

```
        LDIA        30H             ;load 30H to ACC
                                    ;perform 'AND' on ACC and 30H
        ANDIA       30H
                                    ;save the result to ACC
                                    ;perform 'XOR' on ACC and 30H
        XORIA       30H
                                    ;save the result to ACC
```

Example: use ACC as the first operand of a dual operand instruction

```
        HSUBA       R01             ;ACC-R01, save the result to ACC
        HSUBR       R01             ;ACC-R01, save the result to R01
```

Example: use ACC as the second operand of a dual operand instruction

```
        SUBA        R01             ;R01-ACC, save the result to ACC
        SUBR        R01             ;R01-ACC, save the result to R01
```

2.5 Program status register (STATUS)

STATUS register includes:

- ALU arithmetic status
- Reset status

Just like other registers, STATUS register can be the target register of any instruction. If an instruction that affects Z, DC or C bit that use STATUS as target register, then it cannot write on these 3 status bits. These bits are cleared or set to 1 according to device logic. TO and PD bit also cannot be written. Hence the instructions which use STATUS as target instruction may not result in what is predicted.

For example, CLRSTATUS will clear higher 3 bits and set the Z bit to 1. Hence the value of STATUS will be 000u u1uu (u will not change). It is recommended to only use CLRB, SETB, SWAPA and SWAPR instructions to change STATUS register because these will not affect any status bits.

Program status register STATUS (03H)

03H	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
STATUS	IRP	RP1	RP0	TO	PD	Z	DC	C
R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
Reset value	0	0	0	1	1	X	X	X

Bit7	IRP	Register memory select bit (indirect addressing)
	1=	Unused
	0=	Bank0 and Bank1 (00h~FFh)
Bit6~Bit5	RP[1:0]	Memory select bit
	00=	Select Bank0
	01=	Select Bank1
	10=	Unused
	10=	Unused
Bit4	TO:	Time out bit;
	1=	Power on or CLRWDT instruction or STOP instruction
	0=	WDT time out
Bit3	PD:	Power down bit
	1=	Power on or CLRWDT instruction
	0=	Execute STOP instruction
Bit2	Z:	Result bit
	1=	The result of an arithmetic or logical operation is zero
	0=	The result of an arithmetic or logical operation is not zero
Bit1	DC:	Half carry bit/borrow bit
	1=	Carry happens from the lower 4 bits to the higher bits, or no borrow from the lower 4 bits.
	0=	No carry from the lower 4 bits to the higher bits, or borrow from the lower 4 bits to the higher bits.
Bit0	C:	Carry/borrow bit
	1=	A carry from the highest bit, or no borrow.
	0=	No carry from the highest bit, or a borrow hanppens.

TO and PD flag bits can reflect the reason for chip reset. The following lists the events that affect the TO and PD and the status of the TO and PD after various resets.

Events	TO	PD
Power on	1	1
WDT overflow	0	X
STOP instruction	1	0
CLRWDT instruction	1	1
Sleep	1	0

Table of events affecting PD, TO

TO	PD	Reset reason
0	0	Sleep state WDT overflow
0	1	Non-sleep state WDT overflow
1	1	Power on
---	---	----

Status of TO/PD after reset

2.6 Pre-scaler (OPTION_REG)

OPTION_REG register is a readable/writable register that contains various control bits for configuration.

- WDT pre-scaler
- External interrupt trigger edge

Prescaler control register OPTION_REG (01H)

01H	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
OPTION_REG	---	INTEDG	T0CS	T0SE	PSA	PS2	PS1	PS0
R/W	---	R/W	R/W	R/W	R/W	R/W	R/W	R/W
Reset value	---	1	1	1	1	0	1	1

Bit7	Unused		
Bit6	INTEDG:	Trigger interrupt edge selection bit	
	1=	INT pin rising edge trigger interrupt.	
	0=	INT pin falling edge trigger interrupt.	
Bit5	T0CS:	TIMER0 clock source select bit	
	0=	Internal instruction period clock (F_{CPU})	
	1=	Transition edge on the T0CKI pin	
Bit4	T0SE:	TIMER0 clock source edge select bit	
	0=	Increase when T0CKI pin signal transited from low to high	
	1=	Increase when T0CKI pin signal transited from high to low	
Bit3	PSA:	Pre-scaler allocation bit	
	0=	Allocate pre-scaler to TIMER0 module	
	1=	Allocate pre-scaler to WDT	
Bit2~Bit0	PS2~PS0:	Pre-allocation parameter configure bit	

PS2	PS1	PS0	TMR0 frequency division ratio	WDT frequency division ratio
0	0	0	1:2	1:1
0	0	1	1:4	1:2
0	1	0	1:8	1:4
0	1	1	1:16	1:8
1	0	0	1:32	1:16
1	0	1	1:64	1:32
1	1	0	1:128	1:64
1	1	1	1:256	1:128

The pre-scaler register is an 8-bit counter. When surveil on register WDT, it is a postscaler; when it is used as a timer or counter, it is called pre-scaler. There is only 1 physical scaler and can only be used for WDT or TIMER0, but not at the same time. This means that if it is used for TIMER0, the WDT cannot use pre-scaler and vice versa.

When used for WDT, the CLRWDT instruction will clear pre-scaler and WDT timer.

When used for TIMER0, all instructions related to writing to TIMER0 (such as: CLR TMR0, SETB TMR0,1) will clear the pre-scaler.

2.7 Program counter (PC)

Program counter (PC) controls the instruction sequence in program memory OTP, it can address in the whole range of OTP. After obtaining the instruction code, PC will increase by 1 and point to the address of the next instruction code. When executing jump, condition jump, loading value to PCL, subroutine call, initializing reset, interrupt, interrupt return, subroutine return and other actions, PC will load the address which is related to the instruction, rather than the address of the next instruction.

When encountering a condition jump instruction and the condition is met, the next instruction to be read during current instruction execution will be discarded and an empty instruction period will be inserted. After this, the correct instruction can be obtained. If not, the next instruction is executed in sequence.

Program counter (PC) is 11-bit width, users can access lower 8 bits by PCL (02H). The higher 2 bits cannot be accessed. It can hold address for 1K×16Bit program. Assigning a value to PCL results in a short jump to the 256 addresses of the current page.

Note: When the programmer uses PCL to make a short jump, the programmer must first load a value to the PC high bit buffer register PCLATH.

The PC values for several special cases are given below

Reset	PC=0000;
Interrupt	PC=0004 (original PC+1 will be add to stack automatically);
CALL	PC=Program specified address (original PC+1 will be add to stack automatically);
RET, RETI, RETI	PC=Value from stack;
PCL operation	PC[9:8] unchanged, PC[7:0]=user defined value;
JP	PC=Program specified value;
Other instructions	PC=PC+1;

2.8 Watchdog timer (WDT)

Watch DogTimer (WDT) is an on-chip self-oscillating RC oscillator timer, without any peripheral components. Even if the chip's main clock stops working, the WDT can also keep time. WDT overflow will generate a reset.

2.8.1WDT period

WDT and TIMER0 share the same 8-bit prescaler. After all resets, the WDT overflow period is 128ms, if you need to change the WDT period, you can set the OPTION_REG register. The overflow period of the WDT will be affected by the ambient temperature, the supply voltage and other parameters.

The “CLRWDT” and “STOP” instructions clear the WDT timer and the count value in the prescaler (when the prescaler is assigned to the WDT). WDT generally is used to prevent the system and MCU program from being out of control. Under normal circumstances, the WDT should be cleared by the “CLRWDT” instruction before it overflows to prevent a reset. If program is out of control for some reason such that “CLRWDT” instruction is not able to execute before overflow, WDT overflow will then generate a reset to make sure the system restarts. If a reset is generated by the WDT overflow, then ‘TO’ bit of STATUS will be cleared to 0. Users can judge whether the reset is caused by WDT overflow according to this.

Note:

1. If WDT is used, ‘CLRWDT’ instruction must be placed somewhere is the program to make sure it is cleared before WDT overflow. If not, chip will keep resetting and the system cannot be operated normally.
2. It is not allowed to clear WDT during interrupt so that the main program ‘run away’ can be detected.
3. The program should have one WDT clearing operation in the main program, and try not to clear the WDT in multiple branches, this architecture can maximize the protection function of the watchdog counter.
4. The overflow time of the watchdog counter varies from chip to chip, so when setting the clear WDT time, there should be a greater redundancy with the WDT overflow time to avoid an unnecessary WDT reset.

2.8.2 Registers related to watchdog control

Oscillation control register OSCCON (14H)

14H	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
OSCCON	---	IRCF2	IRCF1	IRCF0	---	---	SWDTEN	---
R/W	---	R/W	R/W	R/W	---	---	R/W	---
Reset value	---	1	0	1	---	---	1	---

Bit7	Unused	
Bit6~Bit4	IRCF<2:0>:	Internal oscillator frequency selection bit;
	111=	$F_{SYS} = F_{HSI}/1$
	110=	$F_{SYS} = F_{HSI}/2$
	101=	$F_{SYS} = F_{HSI}/4$ (default)
	100=	$F_{SYS} = F_{HSI}/8$
	011=	$F_{SYS} = F_{HSI}/16$
	010=	$F_{SYS} = F_{HSI}/32$
	001=	$F_{SYS} = F_{HSI}/64$
	000=	F_{SYS} = 32KHz (F_{LSI})
Bit3~Bit2	Unused	
Bit1	SWDTEN:	Software enable or disable watchdog timer bit
	1=	Enable WDT
	0=	Disable WDT
Bit0	Unused.	

Note: If the WDT configuration bit in CONFIG = 1, WDT is always enabled, regardless of the state of the SWDTEN control bit. If the WDT configuration bit in CONFIG = 0, the SWDTEN control bit can be used to enable or disable WDT.

3. System Clock

3.1 Overview

The clock signals are generated by an oscillator, which generates 4 non-overlapping quadrature clock signals, called Q1, Q2, Q3, and Q4. Each Q1 inside the IC increments the program counter (PC) by one, and Q4 removes the instruction from the program memory cell and locks it into the instruction register. The removed instruction is decoded and executed between the next Q1 and Q4, which means that it takes 4 clock cycles to execute an instruction. The following figure represents the clock versus instruction cycle execution timing diagram.

An instruction cycle contains four Q-cycles, and the instruction execution and fetching are in pipeline structure, fetching finger occupies one instruction cycle, while decoding and execution occupy another instruction cycle, but due to the pipeline structure, from a macro point of view, the effective execution time of each instruction is one instruction cycle. If an instruction causes the program counter address to change (e.g. JP) then the prefetched instruction opcode is invalid and it takes two instruction cycles to complete the instruction, which is the reason why all instructions operating on the PC take up two clock cycles.

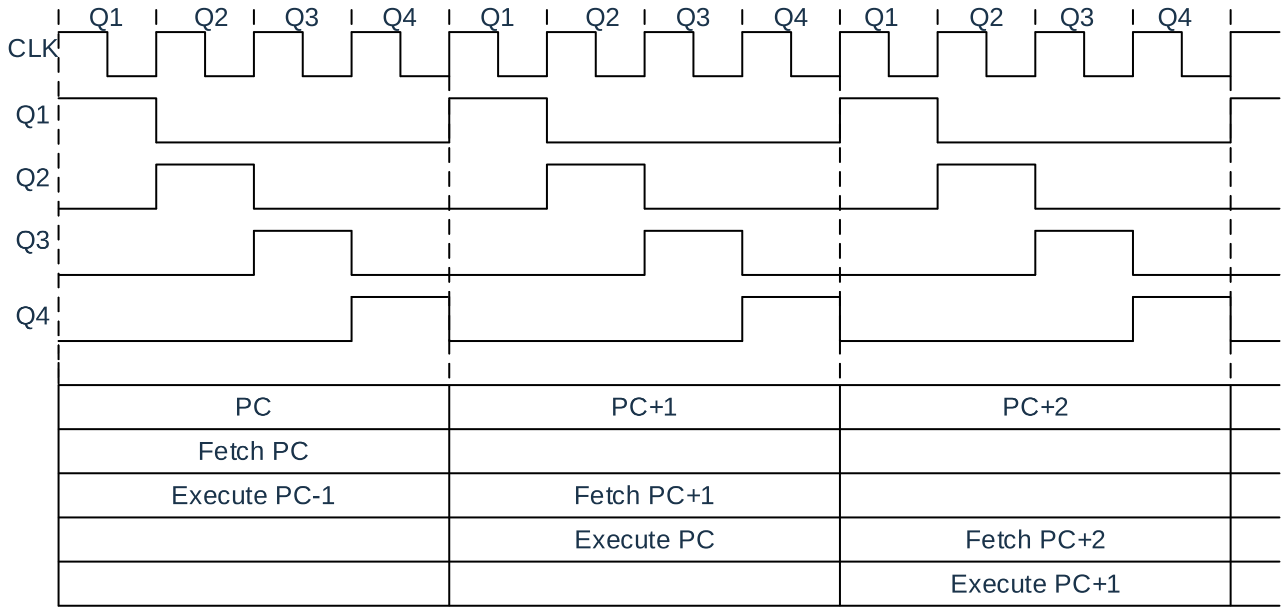
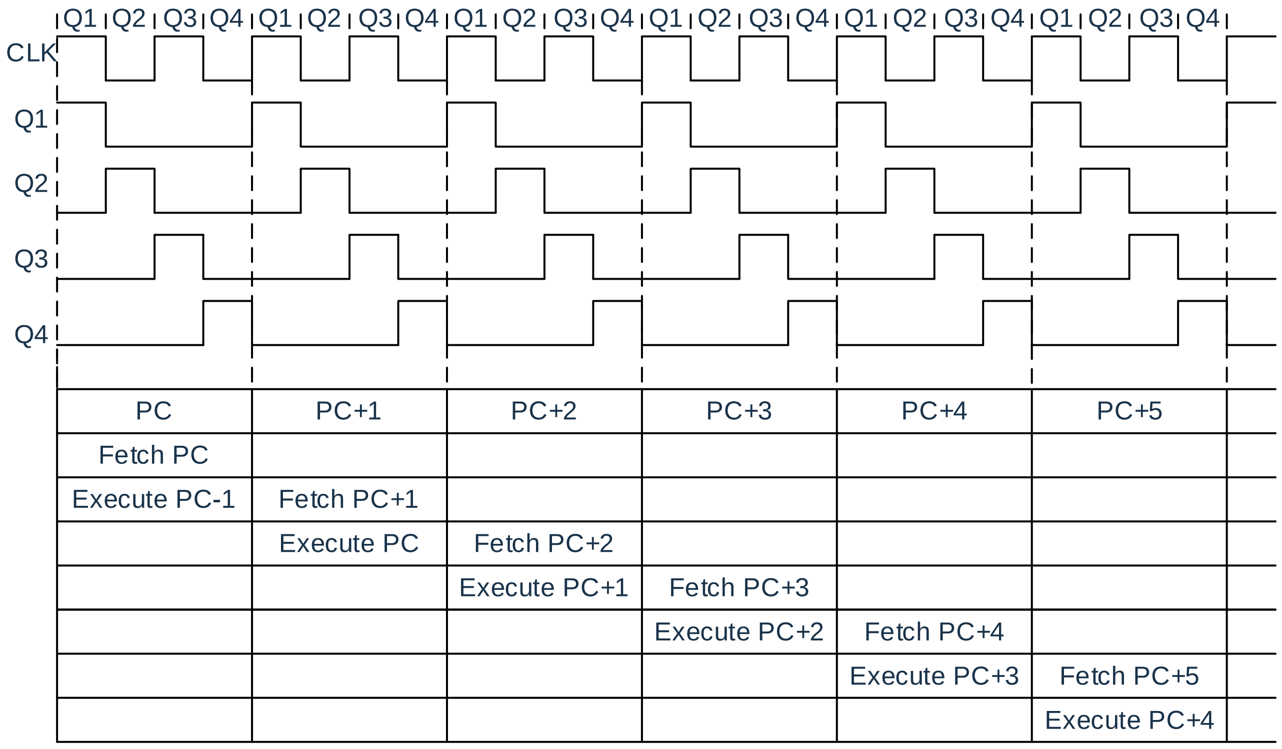


Figure 3-1: Clock and instruction cycle timing chart (F_{CPU}_DIV=4T)

Following is the relationship between working frequency of system and the speed of instructions when F_{CPU}_DIV=4T:

System frequency (F_{SYS})	Dual instruction period	Single instruction period
1MHz	8μs	4μs
2MHz	4μs	2μs
4MHz	2μs	1μs
8MHz	1μs	500ns
16MHz	500ns	250ns



PC	PC+1	PC+2	PC+3	PC+4	PC+5
Fetch PC					
Execute PC-1	Fetch PC+1				
	Execute PC	Fetch PC+2			
		Execute PC+1	Fetch PC+3		
			Execute PC+2	Fetch PC+4	
				Execute PC+3	Fetch PC+5
					Execute PC+4

Figure 3-2: Clock and instruction cycle timing chart (F_{CPU}_DIV=2T)

Following is the relationship between working frequency of system and the speed of instructions when F_{CPU}_DIV=2T:

System frequency (F_{SYS})	Dual instruction period	Single instruction period
1MHz	4μs	2μs
2MHz	2μs	1μs
4MHz	1μs	500ns
8MHz	500ns	250ns
16MHz	250ns	125ns

3.2 System oscillator

The chip has one type of oscillation: internal RC oscillation.

3.2.1 Internal RC oscillation

The default oscillation mode of the chip is internal RC oscillation, and the oscillation frequency is fixed at 16MHz. On this basis, the operating frequency of the chip can be set through the OSCCON register.

3.3 Reset time

Reset Time is the time from the chip reset to the chip oscillation stabilization, its design value is about 16ms.

Note: Reset time exists for both power on reset and other resets.

3.4 Oscillator control register

Oscillator Control (OSCCON) register controls the system clock and frequency selection.

Oscillator control register OSCCON (14FH)

14H	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
OSCCON	---	IRCF2	IRCF1	IRCF0	---	---	SWDTEN	---
R/W	---	R/W	R/W	R/W	---	---	R/W	---
Reset value	---	1	0	1	---	---	1	---

Bit7	Unused	
Bit6~Bit4	IRCF<2:0>:	Internal oscillator frequency selection bit
	111=	$F_{SYS} = F_{HSI}/1$
	110=	$F_{SYS} = F_{HSI}/2$
	101=	$F_{SYS} = F_{HSI}/4$ (default)
	100=	$F_{SYS} = F_{HSI}/8$
	011=	$F_{SYS} = F_{HSI}/16$
	010=	$F_{SYS} = F_{HSI}/32$
	001=	$F_{SYS} = F_{HSI}/64$
	000=	F_{SYS} = 32KHz(LFINTOSC)
Bit3~Bit2	Unused	
Bit1	SWDTEN:	Software enable or disable watchdog timer bit
	1=	Enable WDT
	0=	Disable WDT
Bit0	Unused	

3.5 Clock block diagram

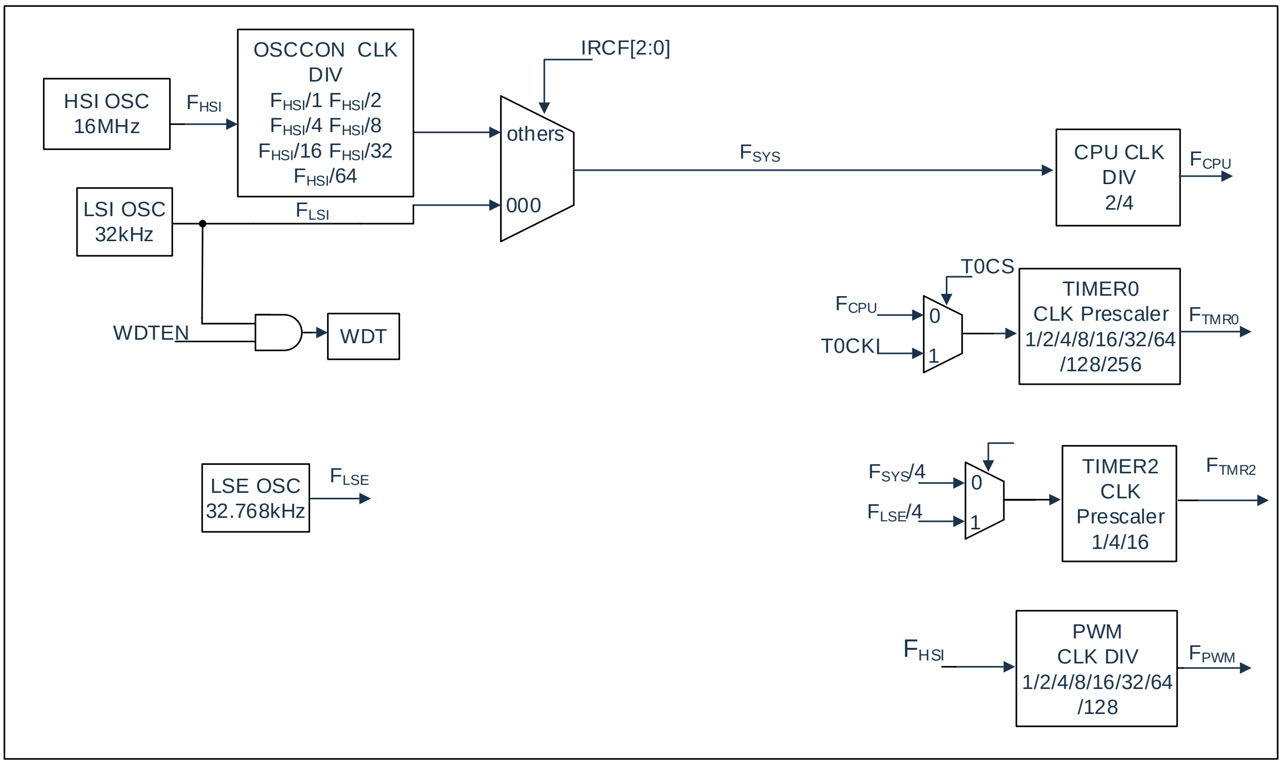


Figure 3-2: Clock block diagram

4. Reset

The chip can be reset in the following three ways:

- Power on reset
- Low voltage reset
- Watchdog overflow reset during normal operation

When any of the above reset occurs, all system registers will be restored to their default state, the program will stop running, and the program counter (PC) will be cleared to zero. At the same time, the program will start running from reset vector 0000H after the reset. The TO and PD flags of STATUS can give information about the reset state of the system (see the description of STATUS for details), and the user can control the program execution path according to the state of PD and TO.

Any kind of reset situation requires a certain response time, and the system provides a completed reset process to ensure that the reset action is carried out smoothly.

4.1 Power on reset

Power-on reset is closely related to LVR operation. The process of system power-on is in the form of a gradually rising curve and takes some time to reach the normal level value. The normal timing of the power-on reset is given below:

- Power-on: the system detects a rise in the supply voltage and waits for it to stabilize.
- System initialization: all system registers are set to their initial values.
- Oscillator start: the oscillator starts to supply the system clock.

Program execution: the power-on ends and the program start to run.

4.2 Power off reset

4.2.1 Overview

Power off reset is used for voltage drop caused by external factors (such as interference or change in external load). Voltage drop may enter system dead zone. System dead zone means power source cannot satisfy the minimal working voltage of the system.

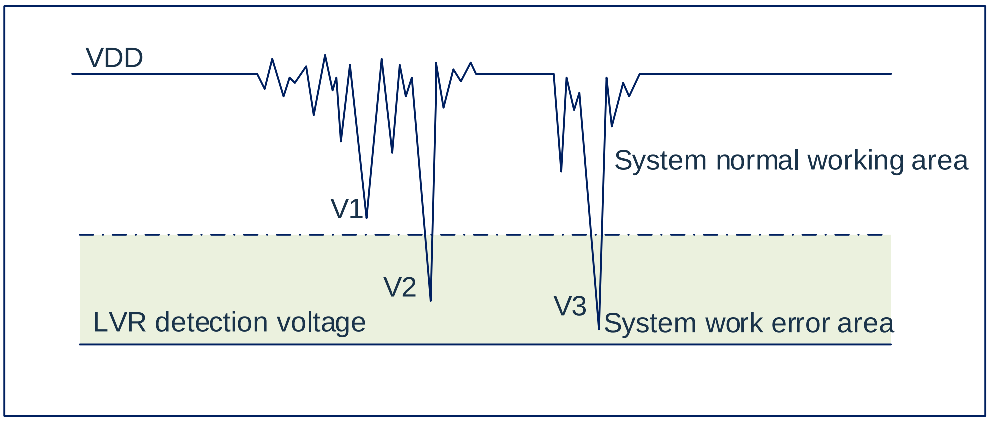


Figure 4-1: Power off reset

The diagram above is a typical power-off reset case. In the diagram, VDD is severely disturbed and the voltage value drops to a very low value. The system works normally in the area above the dotted line; in the area below the dotted line, the system enters an unknown operating state, and this area is called the dead zone. When VDD drops to V1, the system is still in the normal state; when VDD drops to V2 and V3, the system enters the dead zone, and it is easy to cause errors.

The system may enter a dead zone in the following cases:

- In DC applications:
  - Battery power is generally used in DC applications. When the battery voltage is too low or when the microcontroller drives the load, the system voltage may drop and enter the dead zone. At this time, the power supply will not drop further to the LVD detection voltage, so the system is maintained in the dead zone.
- In AC application:
  - When the system is powered by AC, the DC voltage value is affected by the noise in the AC power supply. When the external is over-loaded, such as when driving a motor, the interference generated by the load action also affects the DC power supply. if the VDD drops below the minimum operating voltage due to the interference, the system will likely enter an unstable operation state.
  - In AC application, the system has a long power up and down time. Among them, the power-on timing protection makes the system power up normally, but the power-off process is similar to the situation in DC applications, where the VDD voltage tends to enter the dead zone during the slow drop after the AC power is turned off.

As shown above, the system normal operating voltage is generally higher than the system reset voltage, while the reset voltage is determined by the low voltage detection (LVR) level. When the system execution speed increases, the system minimum operating voltage also increases accordingly. However, as the system reset voltage is fixed, there will be a voltage region between the system minimum operating voltage and the system reset voltage where the system cannot work normally and will not reset. This area is known as the dead zone.

4.2.2 Improvements for power off reset

Several suggestions to improve the system power-off reset performance:

- Select a higher LVR voltage, which contributes to a more reliable reset.
- Turn on the watchdog timer.
- Reduce the operating frequency of the system.
- Increase the voltage drop slope.

Watchdog timer

The watchdog timer is used to ensure the normal operation of the program. When the system enters the dead zone or the program runs with errors, the watchdog timer will overflow and the system will be reset.

Reduce the operating speed of the system

The faster the operating frequency of the system, the higher the minimum operating voltage of the system. Therefore, by increasing the range of the operating dead zone and reducing the operating speed of the system, the minimum operating voltage can be reduced and the chance of entering the dead zone can be effectively reduced.

Increase the voltage drop slope

This method is used under AC. Voltage drops slowly under AC and cause the system to stay longer at the dead zone. If the system is power on at this moment, error may happen. It is then suggested to insert a resistor between power source and ground to ensure the MCU pass the dead zone and enter the reset zone faster.

4.3 Watchdog reset

The watchdog reset is a protect configuration for the system. In the normal state, the watchdog timer is cleared to zero by the program. If something goes wrong, the system is in an unknown state and the watchdog timer overflows, at which point the system resets. After the watchdog reset, the system reboots into the normal state.

The timing of the watchdog reset is as follows:

- Watchdog timer status: the system detects whether the watchdog timer overflows, and if it does, the system resets.
- Initialization: all system registers are set to their default state.
- Oscillator start: the oscillator starts to provide the system clock.
- Program: the reset ends and the program starts running.

For application of watchdog timer, please refer to Section 2.8.

5. Sleep Mode

5.1 Enter sleep mode

System can enter sleep mode when executing STOP instructions. If WDT enabled, then:

- WDT is cleared and continue to run.
- PD bit of the STATUS register is cleared.
- TO bit set to 1.
- Turn off the oscillator driver.
- I/O port keep at the status before STOP (driver is high level, low level, or high impedance).

In sleep mode, to avoid current consumption, all I/O pins should keep at VDD or GND to make sure no external circuit is consuming the current from I/O pins. To avoid input pin, float and invoke current, high impedance I/O should be pulled to high or low level externally. Internal pull up resistance should also be considered.

5.2 Wake up from sleep mode

The device can be woken from sleep by any of the following events.

1. Watchdog timer wakeup;
2. PORTA interrupt on change;
3. PORTB interrupt on change or peripheral interrupt.

The two events described above are considered to be a continuation of program execution. The TO and PD bits in the STATUS register are used to determine the cause of device reset. The PD bit is set to 1 at power-on and cleared when the STOP instruction is executed. The TO bit is cleared when a WDT awaken occurs.

When the STOP instruction is executed, the next instruction (PC+1) is taken out in advance. If it is desired to awaken the device by an interrupt event, the corresponding interrupt enable bit must be set to 1 (enable). The awaken is not related to the GIE bit. If the GIE bit is cleared (disable), the device will continue to execute the instruction after the STOP instruction. If the GIE bit is set to 1 (enable), the device executes the instruction after the STOP instruction and then jumps to the interrupt address (0004h) to execute the code. If you do not want to execute the instruction after the STOP instruction, the user should set a NOP instruction after the STOP instruction. The WDT will all be cleared when the device awakens from sleep mode, regardless of the reason for awakening.

5.3 Interrupt wakeup

When the global interrupt is disabled (GIE is cleared) and there exist 1 interrupt source with its interrupt enable bit and flag bit set to 1, one event from the following will happen:

- If an interrupt is generated before the STOP instruction is executed, then the STOP instruction will be executed as a NOP instruction. Therefore, WDT and its pre-scaler and post-scaler (if enabled) will not be cleared. At the same time, the TO bit will not be set to 1 and the PD will not be cleared.
- If an interrupt is generated during or after the execution of the STOP instruction, the device will be immediately awakened from sleep mode. The STOP instruction will be executed before the wake-up. Therefore, the WDT and its pre-scaler and post-scaler (if enabled) will be cleared to zero and the TO bit will be set to 1, while the PD will also be cleared to zero. Even if the flag bit is checked to be 0 before the STOP instruction is executed, it may be set to 1 before the STOP instruction is completed. To determine if the STOP instruction is executed, the PD bit can be tested. If the PD bit is set to 1, then the STOP instruction is executed as a NOP instruction. Before executing the STOP instruction, a CLRWDT instruction must be executed to ensure that the WDT is cleared to zero.

5.4 Sleep mode application

Before the system enters the sleep mode, if the user needs to get a smaller sleep current, please confirm the status of all I/O ports, if there are floating I/O ports in the user's program, set all floating ports as output ports to make sure that each input port has a fixed state to avoid that when the I/O is an input state, the port level is in an unstable state which increases the sleep current; turn off the other peripheral modules, such as the AD module. According to the actual functional requirements of the program, the WDT function can be disabled to reduce the sleep current.

Example: procedures for entering sleep mode

```
SLEEP_MODE:
        CLR         INTCON          ;Disable interrupts
        LDIA        B'00000000'
        LD          TRISB,A         ;All I/Os set as output ports
        ...                         ;Disable other functions
        LDIA        0A5H
        LD          SP_FLAG,A       ;Set sleep status memory register (user-
                                    defined)
        CLRWDT                      ;Clear WDT
        STOP                        ;Execute STOP instruction
        NOP
        NOP
```

5.5 Sleep mode wake-up time

When the MCU is woken up from sleep, it needs to wait for an oscillation stabilization time (Reset Time). The relationship is shown in the following table.

System main clock source	System clock frequency (IRCF<2:0>)	Sleep wakeup wait time T_{WAIT}
Internal high-speed RC oscillation (F_{HSI})	$F_{SYS}=F_{HSI}$	$T_{WAIT}=136*1/F_{HSI}+16*1/F_{HSI}$
	$F_{SYS}= F_{HSI} /2$	$T_{WAIT}=136*2/F_{HSI}+16*1/F_{HSI}$
	…	…
	$F_{SYS}= F_{HSI} /64$	$T_{WAIT}=136*64/F_{HSI}+16*1/F_{HSI}$
Internal low-speed RC oscillation ($F_{LFINTOSC}$)	----	$T_{WAIT}=11/F_{LSI}$

6. I/O Ports

The chip has two I/O ports: PORTA, PORTB (up to 14 I/Os). These ports can be accessed directly from the read/write port data registers.

Port	Bit	Pin description	I/O
PORTA	0	Schmitt trigger input, configurable as push-pull or open-drain outputs	I/O
	1	Schmitt trigger input, configurable as push-pull or open-drain outputs	I/O
	2	Schmitt trigger input, configurable as push-pull or open-drain outputs, PWM2 output	I/O
	3	Schmitt trigger input, configurable as push-pull or open-drain outputs, PWM3 output	I/O
	4	Schmitt trigger input, configurable as push-pull or open-drain outputs	I/O
	5	Schmitt trigger input, configurable as push-pull or open-drain outputs, PWMC0 output	I/O
PORTB	0	Schmitt trigger input, configurable as push-pull or open-drain outputs, PWM0 output, CMP output, external interrupt input	I/O
	1	Schmitt trigger input, configurable as push-pull or open-drain outputs, PWM1 output, CMP positive or negative input	I/O
	2	Schmitt trigger input, configurable as push-pull or open-drain outputs, PWM4 output, CMP negative input	I/O
	3	Schmitt trigger input, open-drain output, Programming high-voltage input	I/O
	4	Schmitt trigger input, configurable as push-pull or open-drain outputs, programming clock input, CMP negative input, PWMC4 output	I/O
	5	Schmitt trigger input, configurable as push-pull or open-drain outputs, programming data input/output, CMP negative input, PWMC3 output	I/O
	6	Schmitt trigger input, configurable as push-pull or open-drain outputs, PWMC2 output	I/O
	7	Schmitt trigger input, configurable as push-pull or open-drain outputs, PWMC1 output	I/O

<Table 6-1: Port configuration overview>

6.1 I/O port structure

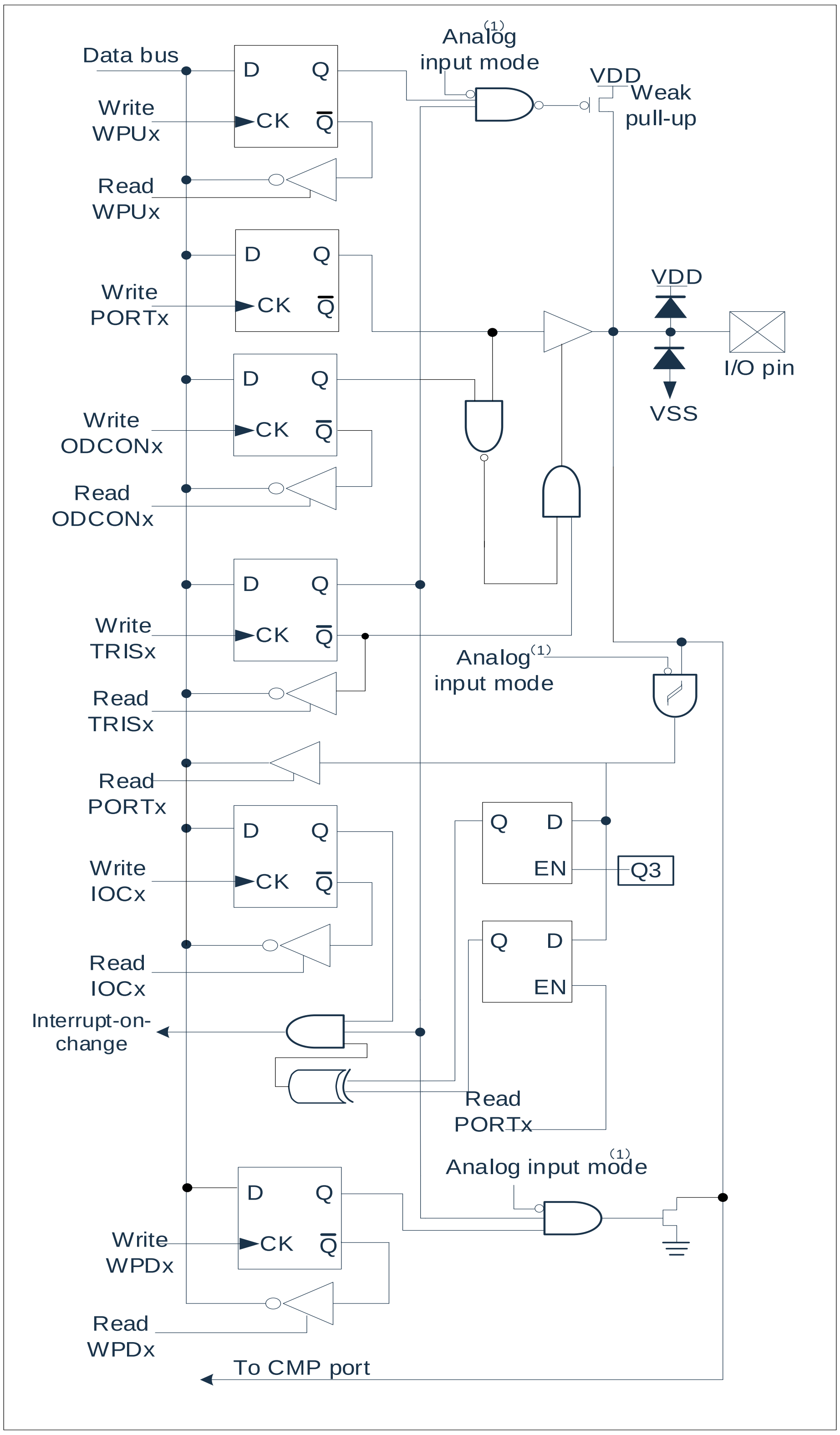


Figure 6-1: I/O port stucture

Note: AN_EN determines the analog input mode.

6.2 PORTA

6.2.1PORTA data and direction

PORTA is a 6-bit bi-directional port. Its corresponding data direction register is TRISA. Setting one bit of TRISA to 1 (=1) can configure the corresponding pin to be input. Setting one bit of TRISA to 0 (=0) can configure the corresponding PORTA pin to be output.

Reading the PORTA register reads the state of the pin while writing the register will write to the port latch. All write operation procedure is reading-modifying-writing. Therefore, writing a port means reading the pin level of that port at first, then modifying the read value, and finally writing the modified value to the port data latch. Even when the PORTA pin is used as an analog input, the TRISA register still controls the direction of the PORTA pin. When using the PORTA pin as an analog input, the user must ensure that the bit in the TRISA register remains as 1. I/O pins configured as analog inputs always read 0.

The registers related to the PORTA port are PORTA, TRISA, WPUA, WPDA, ODCONA, IOCA and so on.

PORTA data register PORTA(86H)

86H	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
PORTA	---	---	RA5	RA4	RA3	RA2	RA1	RA0
R/W	---	---	R/W	R/W	R/W	R/W	R/W	R/W
Reset value	---	---	X	X	X	X	X	X

Bit7~Bit6	Unused	
Bit5~Bit0	PORTA<5:0>:	PORTAI/O pin bit
	1=	Port pin level>V_{IH}
	0=	Port pin level<V_{IL}

PORTA direction register TRISA(85H)

85H	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
TRISA	---	---	TRISA5	TRISA4	TRISA3	TRISA2	TRISA1	TRISA0
R/W	---	---	R/W	R/W	R/W	R/W	R/W	R/W
Reset value	---	---	1	1	1	1	1	1

Bit7~Bit6	Unused	
Bit5~Bit0	TRISA<5:0>:	PORTA tristate control bit
	1=	PORTA pin set to be input (tristate)
	0=	PORTA pin set to be output

Example: PORTA procedure

```
LDIA        B'00110000'        ;set PORTA<3:0> as output port, PORTA<5:4>as input port
LD          TRISA,A
LDIA        03H                ;PORTA<1:0>output high level, PORTA<3:2>output low level
LD          PORTA,A            ;since PORTA<5:4> is an input port, loading 0 or 1 has no
                               effect.
```

6.2.2 PORTA open-drain output control

Each PORTA pin has individually configurable open-drain output enable control bits.

PORTA open-drain output enable register ODCONA(8CH)

8CH	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
ODCONA	---	---	ODCONA5	ODCONA4	ODCONA3	ODCONA2	ODCONA1	ODCONA0
R/W	---	---	R/W	R/W	R/W	R/W	R/W	R/W
Reset value	---	---	0	0	0	0	0	0

Bit7~Bit6	Unused	
Bit5~Bit0	ODCONA<5:0>:	PORTA open-drain output enable
	1=	Enable open-drain output
	0=	Disable open-drain output

6.2.3 PORTA pull-up resistor

Each PORTA pin has an individually configurable internal weak pull-up. Control bits WPUA<5:0> enable or disable each weak pull-up. When a port pin is configured as an output, its weak pull-up is automatically cut off.

PORTA pull-up resistor register WPUA(88H)

88H	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
WPUA	---	---	WPUA5	WPUA4	WPUA3	WPUA2	WPUA1	WPUA0
R/W	---	---	R/W	R/W	R/W	R/W	R/W	R/W
Reset value	---	---	0	0	0	0	0	0

Bit7~Bit6	Unused	
Bit5~Bit0	WPUA<5:0>:	Weak pull-up register bit
	1=	Enable pull-up
	0=	Disable pull-up

Note: If the pin is configured as an output, a weak pull up will be automatically disabled.

6.2.4PORTA pull-down resistor

Each PORTA pin has an internal weak pull-down that can be individually configured. The control bits WPDA<5:0> enable or disable each weak pull down. When a port pin is configured as an output, its weak pull-down is automatically cut off.

PORTA pull-down resistor register WPDA(87H)

87H	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
WPDA	---	---	WPDA5	WPDA4	WPDA3	WPDA2	WPDA1	WPDA0
R/W	---	---	R/W	R/W	R/W	R/W	R/W	R/W
Reset value	---	---	0	0	0	0	0	0

Bit7~Bit6	Unused	
Bit6~Bit0	WPDA<5:0>:	Weak pull-down register bit
	1=	Enable pull-down
	0=	Disable pull-down

Note: If pin is configured as output, weak pull-down will be automatically disabled.

6.2.5PORTA interrupt on change

All PORTA pins can be individually configured as interrupt on change pins. The control bit IOCA<5:0> enables or disables the interrupt function of each pin. Disable pin level change interrupt function when power on reset.

For the pin that has allowed level change interrupt, compare the value on the pin with the old value latched when PORTA was read last time. Perform a logical OR operation with the output “mismatch” of the last read operation to set the PORTA level change interrupt flag (RAIF) of the PIR1 register as 1.

This interrupt can wake up the device from sleep mode, and the user can clear the interrupt in the interrupt service program by the following ways:

- Read from or write to PORTA. This will end the mismatch state of the pin level.
- Clear the flag bit RAIF.

The mismatch status will continuously set the RAIF flag bit as 1. Reading or writing PORTA will end the mismatch state and allow the RAIF flag to be cleared.

Note: If the level of the I/O pin changes during the read operation (beginning of the Q2 cycle), the RAIF interrupt flag bit will not be set as 1. In addition, since reading or writing to a port affects all bits of the port, special care must be taken when using multiple pins in interrupt-on-change mode. When dealing with the level change of one pin, you may not notice the level change on the other pin.

PORTA interrupt-on-change register IOCA(89H)

89H	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
IOCA	---	---	IOCA5	IOCA4	IOCA3	IOCA2	IOCA1	IOCA0
R/W	---	---	R/W	R/W	R/W	R/W	R/W	R/W
Reset value	---	---	0	0	0	0	0	0

Bit7~Bit6	Unused	
Bit5~Bit0	IOCA<5:0>	PORTA interrupt-on-change control bit.
	1=	Enable interrupt-on-change.
	0=	Disable interrupt-on-change.

6.3 PORTB

6.3.1PORTB data and direction

PORTB is a 7-bit wide bi-directional port. The corresponding data direction register is TRISB. Setting one bit of TRISB to 1 (=1) can configure the corresponding PORTB pin to be input. Setting one bit of TRISB to 0 (=0) can configure the corresponding PORTB pin to be output.

Reading the PORTB register reads the pin status and writing to the register will write the port latch. All write operations are read-modify-write operations. Therefore, writing a port means to read the pin level of the port first, modify the read value, and then write the modified value into the port data latch. Even when the PORTB pin is used as an analog input, the TRISB register still controls the direction of the PORTB pin. When using the PORTB pin as an analog input, the user must ensure that the bits in the TRISB register remain set as 1. I/O pin is always read 0 when configured as analog input.

The registers related to the PORTB port are PORTB, TRISB, WPUB, WPDB, IOCB, ODCONB and so on.

PORTB data register PORTB(06H)

06H	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
PORTB	RB7	RB6	RB5	RB4	RB3	RB2	RB1	RB0
R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
Reset value	X	X	X	X	X	X	X	X

Bit7~Bit0	PORTB<7:0>:	PORTBI/O pin bit.
	1=	Port pin level>V_{IH}.
	0=	Port pin level<V_{IL}.

Note: The RB3 port is fixed as an open-drain output, and can only output low level or high resistance state.

PORTB direction register TRISB (05H)

05H	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
TRISB	TRISB7	TRISB6	TRISB5	TRISB4	TRISB3	TRISB2	TRISB1	TRISB0
R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
Reset value	1	1	1	1	1	1	1	1

Bit7~Bit0	TRISB<7:0>:	PORTB tristate control bit.
	1=	PORTB pin configured as input(tristate).
	0=	PORTB pin configured as output.

Example: PORTB procedure

```
CLR         PORTB           ;clear data register
LDIA        B'00110000'     ;set PORTB<5:4> as input port, others as output port
LD          TRISB,A
```

6.3.2 PORTB open-drain output control

Each PORTB pin has individually configurable open-drain output enable control bits (except RB3).

PORTB open drain output enable register ODCONB(0CH)

0CH	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
ODCONB	ODCONB7	ODCONB6	ODCONB5	ODCONB4	---	ODCONB2	ODCONB1	ODCONB0
R/W	R/W	R/W	R/W	R/W	---	R/W	R/W	R/W
Reset value	0	0	0	0	---	0	0	0

Bit7~Bit4	ODCONB<7:4>:		PORTB open-drain output enable
		1=	Enable open-drain output
		0=	Disable open-drain output
Bit3	Unused		
Bit2~Bit0	ODCONB<2:0>:		PORTB open-drain output enable
		1=	Enable open-drain output
		0=	Disable open-drain output

Note: The RB3 port is fixed as an open-drain output, and can only output low level or high resistance state.

6.3.3 PORTB pull-up resistor

Each PORTB pin has an internal weak pull up that can be individually configured. The control bits WPUB<7:0> enable or disable each weak pull up. When a port pin is configured as an output, its weak pull-up is automatically cut off.

PORTB pull-up resistor register WPUB(08H)

08H	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
WPUB	WPUB7	WPUB6	WPUB5	WPUB4	WPUB3	WPUB2	WPUB1	WPUB0
R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
Reset value	0	0	0	0	0	0	0	0

Bit7~Bit0	WPUB<7:0>:		PORTB weak pull-up enable bit
		1=	Enable pull-up
		0=	Disable pull-up

Note: When RB0~RB2, RB4~RB7 pins are configured as outputs or analog inputs, the weak pull-ups will be disabled automatically.
When RB3 is configured as an output, its weak pull-up will not be disabled.

6.3.4PORTB pull-down resistor

Each PORTB pin has an individually configurable internal weak pull-down (except RB3). Control bits WPDB<7:0> enable or disable each weak pull-down. When a port pin is configured as an output, its weak pull-down is automatically cut off.

PORTB pull-down resistor register WPDB(07H)

07H	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
WPDB	WPDB7	WPDB6	WPDB5	WPDB4	---	WPDB2	WPDB1	WPDB0
R/W	R/W	R/W	R/W	R/W	---	R/W	R/W	R/W
Reset value	0	0	0	0	---	0	0	0

Bit7~Bit4	WPDB<7:4>:	PORTB weak pull-down enable bit
	1=	Enable pull-down
	0=	Disable pull-down
Bit3	Unused.	
Bit2~Bit0	WPDB<2:0>:	PORTB weak pull-down enable bit
	1=	Enable pull-down
	0=	Disable pull-down

Note: RB0~RB2, RB4~RB7 pins are configured as outputs or analog inputs, the weak pull-down is automatically disabled.
There is no weak pull-down on pin RB3.

6.3.5PORTB interrupt on change

All PORTB pins can be individually configured as interrupt on change pins. The control bit IOCB<7:0> allows or disables the interrupt function of each pin. Disable pin level change interrupt function when power on reset.

For the pin that has allowed interrupt on change, compare the value on the pin with the old value latched when PORTB was read last time. Perform a logical OR operation with the output “mismatch” of the last read operation to set the PORTB level change interrupt flag (RBIF) in the INTCON register as 1.

This interrupt can wake up the device from sleep mode, and the user can clear the interrupt in the interrupt service program in the following ways:

- Read or write to PORTB. This will end the mismatch state of the pin level.
- Clear the flag bit RBIF.

The mismatch status will continuously set the RBIF flag bit as 1. Reading or writing PORTB will end the mismatch state and allow the RBIF flag to be cleared. The latch will keep the last read value from the under voltage reset. After reset, if the mismatch still exists, the RBIF flag will continue to be set as 1.

Note: If the level of the I/O pin changes during the read operation (beginning of the Q2 cycle), the RBIF interrupt flag bit will not be set as 1. In addition, since reading or writing to a port affects all bits of the port, special care must be taken when using multiple pins in interrupt-on-change mode. When dealing with the level change of one pin, you may not notice the level change on the other pin.

PORTB interrupt-on-change register IOCB(09H)

09H	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
IOCB	IOCB7	IOCB6	IOCB5	IOCB4	IOCB3	IOCB2	IOCB1	IOCB0
R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
Reset value	0	0	0	0	0	0	0	0

Bit7~Bit0	IOCB<7:0>		PORTB interrupt-on-change control bit.
		1=	Enabele interrupt-on-change.
		0=	Disable interrupt-on-change.

6.4 I/O usage

6.4.1 Write to I/O port

The chip's I/O port register, like the universal register, can be written through data transfer instructions, bit manipulation instructions, etc.

Example: write to I/O port program

```
        LD          PORTB,A         ;load ACC to PORTB
        CLRB        PORTB,1         ;clear PORTB.1
        SET         PORTB           ;set all output ports of PORTB to 1
        SETB        PORTB,1         ;set PORTB.1 to 1
```

6.4.2 Read from I/O port

Example: read from I/O port program

```
        LD          A,PORTB         ;load PORTB to ACC
        SNZB        PORTB,1         ;check if PORTB,1 is 1, if it is 1, skip the next statement
        SZB         PORTB,1         ;check if PORTB,1 is 0, if it is 0, skip the next statement
```

Note: When the user reads the status of an I/O port, if the I/O port is an input port, the data read back by the user will be the state of the external level of the port line. If the I/O port is an output port then the read value will be the data of the internal output register of this port.

6.5 Cautions on I/O port usage

When operating the I/O port, pay attention to the following aspects:

1. When I/O is converted from output to input, it is necessary to wait for several instruction periods for the I/O port to stabilize.
2. If the internal pull up resistor is used, when the I/O is converted from output to input, the stable time of the internal level is related to the capacitance connected to the I/O port. The user should set the waiting time according to the actual situation. Prevent the I/O port from scanning the level by mistake.
3. When the I/O port is an input port, its input level should be between “VDD+0.3V” and “GND-0.3V”. If the input port voltage is not within this range, the method shown in the figure below can be used.

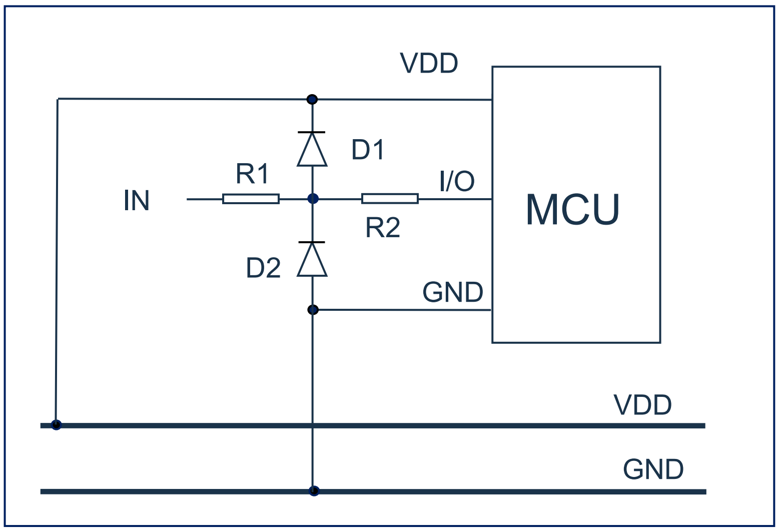


Figure 6-3: I/O port caution connection diagram

4. If long wires are connected to the I/O ports, add current limiting resistors near the I/O ports of the chip to enhance the MCU’s EMC resistance.

7. Interrupt

7.1 Overview

The chip has the following interrupt sources:

- PORTA interrupt on change;
- TIMER0 overflow interrupt;
- PWM interrupt;
- CMP interrupt;
- PORTB interrupt on change;
- TIMER2 match interrupt;
- INT interrupt;

The interrupt control register (INTCON) and the peripheral interrupt request register (PIR1) record various interrupt requests in their respective flag bits. The INTCON register also contains the individual interrupt enable bits and the global interrupt enable bits.

The global interrupt enables bit GIE (INTCON<7>) allows all unmasked interrupts when set to 1, and prohibits all interrupts when cleared. Each interrupt can be prohibited through the corresponding enable bits in the INTCON and PIE1 registers. GIE is cleared when reset.

Executing the “return from interrupt” instructions, RETI, will exit the interrupt service program and set the GIE bit to 1, thereby re-allowing unmasked interrupt.

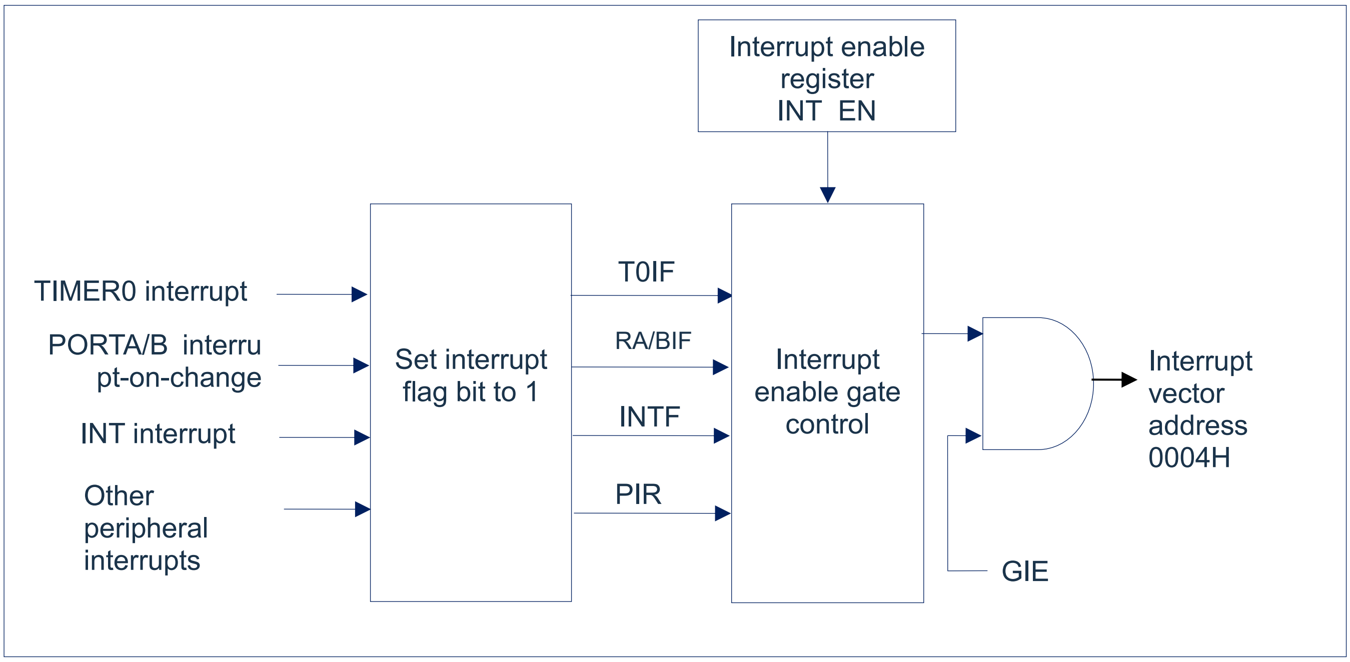

Interrupt enable register INT EN
TIMER0 interrupt
PORTA/B interrupt-on-change
INT interrupt
Other peripheral interrupts
Set interrupt flag bit to 1
T0IF
RA/BIF
INTF
PIR
Interrupt enable gate control
Interrupt vector address 0004H
GIE

Figure 7-1: Schematic diagram of interrupt principle

7.2 Interrupt control register

7.2.1 Interrupt control register

Interrupt control register (INTCON) is a readable and writable register, including the enable and flag bits for TMR0 register overflow and PORTB port interrupt on change.

When an interrupt occurs, regardless of the state of the corresponding interrupt enable bit or the global enable bit GIE (in the INTCON register), the interrupt flag bit will be set to 1. The user software should ensure that the corresponding interrupt flag bit is cleared before allowing an interrupt.

Interrupt control register INTCON (0BH)

0BH	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
INTCON	GIE	PEIE	T0IE	INTE	RBIE	T0IF	INTF	RBIF
R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
Reset value	0	0	0	0	0	0	0	0

Bit7	GIE:	Global interrupt enable bit;
	1=	Enable all unshielded interrupt;
	0=	Disable all interrupt
Bit6	PEIE:	Peripheral interrupt enable bit;
	1=	Enable all unshielded peripherals interrupt;
	0=	Disable all peripherals interrupt.
Bit5	T0IE:	TIMER0 overflow interrupt enable bit;
	1=	Enable TIMER0 interrupt;
	0=	Disable TIMER0 interrupt
Bit4	INTE:	INT external interrupt enable bit;
	1=	Enable INT external interrupt;
	0=	Disable INT external interrupt
Bit3	RBIE:	PORTB level change interrupt enable bit (1);
	1=	Enable PORTB level change interrupt;
	0=	Disable PORTB level change interrupt
Bit2	T0IF:	TIMER0 overflow interrupt enable bit (2);
	1=	TMR0 register overflow already (must clear through software);
	0=	TMR0 register not overflow
Bit1	INTF:	INT external interrupt flag bit;
	1=	INT external interrupt happens (must clear through software);
	0=	INT external interrupt not happen
Bit0	RBIF:	PORTB level change interrupt flag bit;
	1=	The level of at least one pin in the PORTB port has changed (must clear through software);
	0=	None of the PORTB universal I/O pin status has changed.

Note:
1. The IOCB register must also be enabled, and the corresponding port must be set to input state.
2. The T0IF bit is set as 1 when TMR0 rolls over to 0. Reset will not change TMR0 and should be initialized before clearing the T0IF bit.

7.2.2Peripheral interrupt enable register

The peripheral interrupt enable register has PIE1, before allowing any peripheral interrupt, you must first set the PEIE bit of the INTCON register to 1.

Peripheral interrupt enable register PIE1(0EH)

0EH	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
PIE1	----	----	CMPIE	PWMIE	RAIE	----	TMR2IE	----
R/W	----	----	R/W	R/W	R/W	----	R/W	----
Reset value	----	----	0	0	0	----	0	----

Bit7~Bit6	Unused	
Bit5	CMPIE:	Comparator interrupt enable bit
	1=	Enable comparator interrupt
	0=	Disable comparator interrupt
Bit4	PWMIE:	PWM interrupt enable bit (PWM0/1/2/3)
	1=	Enable PWM interrupt
	0=	Disable PWM interrupt
Bit3	RAIE:	PORTA interrupt-on-change enable bit
	1=	Enable PORTA interrupt-on-change
	0=	Disable PORTA interrupt-on-change
Bit2	Unused	
Bit1	TMR2IE:	TIMER2 and PR2 match interrupt enable bit
	1=	Enable TMR2 and PR2 match interrupt
	0=	Disable TMR2 and PR2 match interrupt
Bit0	Unused	

7.2.3Peripheral interrupt request register

The peripheral interrupt request register is PIR1. When an interrupt condition is generated, the interrupt flag bit will be set to 1 regardless of the status of the corresponding interrupt enable bit or the global enable bit GIE. The user software should ensure that the corresponding interrupt flag bit is cleared before allowing an interrupt.

Peripheral interrupt request register PIR1(0DH)

0DH	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
PIR1	----	----	CMPIF	PWMIF	RAIF	----	TMR2IF	----
R/W	----	----	R/W	R/W	R/W	----	R/W	----
Reset value	----	----	0	0	0	----	0	----

Bit7~Bit6	Unused	
Bit5	CMPIF:	Comparator interrupt flag bit (must be cleared by software)
	1=	Comparator interrupt occurs
	0=	No comparator interrupt occurred
Bit4	PWMIF:	PWM interrupt flag bits (PWM0/1/2/3) (must be cleared by software)
	1=	PWM interrupt occurs
	0=	No PWM interrupt occurred
Bit3	RAIF:	PORTA interrupt-on-change flag bit
	1=	PORTA port where the level of at least one pin has changed (must be cleared by software).
	0=	None of the PORTA general I/O pins have changed their state.
Bit2	Unused.	
Bit1	TMR2IF:	TIMER2 and PR2 match interrupt flag bit (must be cleared by software)
	1=	TMR2 has matched with PR2 interrupt.
Bit0	0=	No interrupt caused by TMR2 matching with PR2.
	Unused	

7.3 Protection methods for interrupt

After an interrupt request occurs and is responded, the program goes to 0004H to execute the interrupt subroutine. Before responding to the interrupt, the contents of ACC and STATUS must be saved. The chip does not provide dedicated stack saving and unstack recovery instructions, and the user needs to protect ACC and STATUS by himself to avoid possible program operation errors after the interrupt ends.

Example: Stack protection for ACC and STATUS

```
                ORG     0000H
                JP      START           ;start of user program address
                ORG     0004H
                JP      INT_SERVICE     ;interrupt service program
                ORG     0008H
        START:
                ...
                ...
  INT_SERVICE:
        PUSH:                           ;entrance for interrupt service program, save ACC and
                                        STATUS
                LD      ACC_BAK,A       ;save the value of ACC (ACC_BAK needs to be defined)
                SWAPA   STATUS
                LD      STATUS_BAK,A    ;save the value of STATUS (STATUS_BAK needs to be
                                        defined)
                ...
                ...
         POP:                           ;exit for interrupt service program, restore ACC and
                                        STATUS
                SWAPA   STATUS_BAK
                LD      STATUS,A        ;restore STATUS
                SWAPR   ACC_BAK         ;restore ACC
                SWAPA   ACC_BAK
                RETI
```

7.4 Interrupt priority and multi-interrupt nesting

The priority of each interrupt of the chip is equal. When an interrupt is in progress, it will not respond to the other interrupt. Only after the "RETI" instructions are executed, the next interrupt can be responded to.

When multiple interrupts occur at the same time, the MCU does not have a preset interrupt priority. First, the priority of each interrupt must be set in advance; second, the interrupt enable bit and the interrupt control bit are used to control whether the system responds to the interrupt. In the program, the interrupt control bit and interrupt request flag must be checked.

8. TIMER0

8.1 TIMER0 overview

TIMER0 is composed of the following functions:

- 8-bit timer/counter register (TMR0);
- 8-bit pre-scaler (shared with watchdog timer);
- Programmable internal or external clock source;
- Programmable external clock edge selection;
- Overflow interrupt.

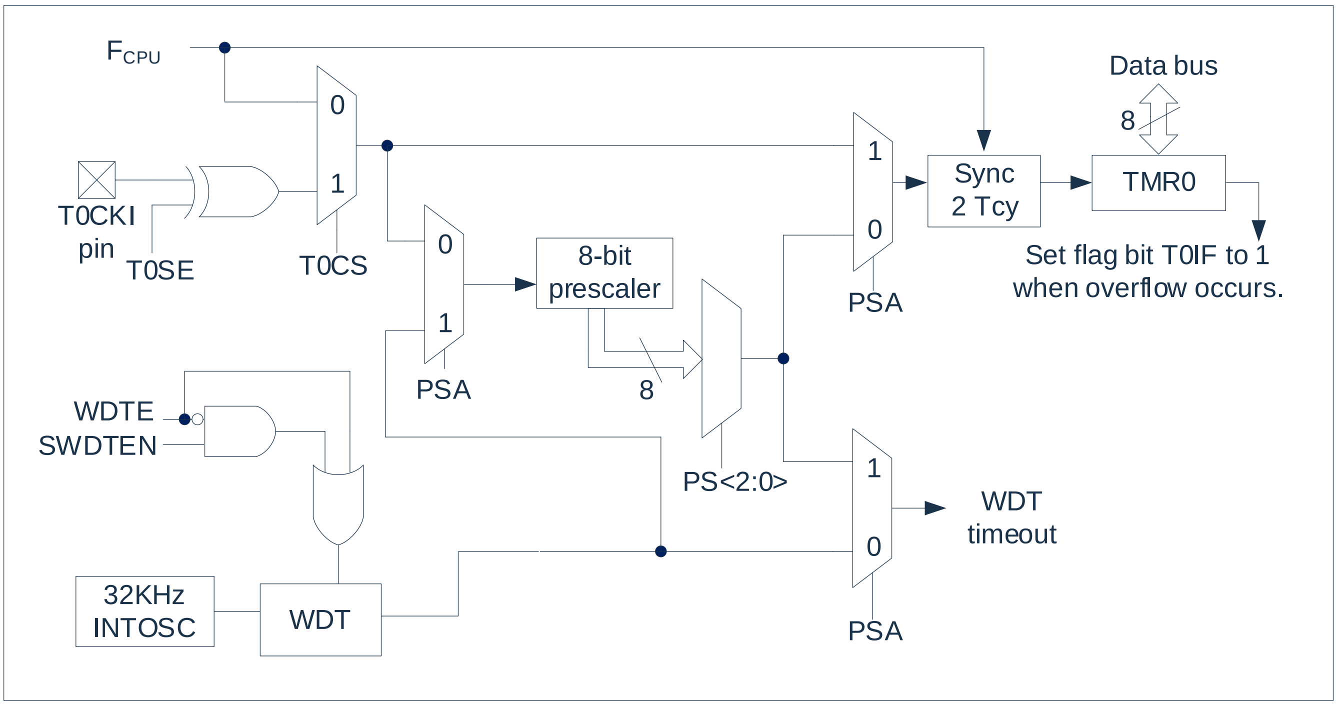


Figure 8-1: TIMER0/WDT mod structure

Note:
1. T0SE, T0CS, PSA, PS<2:0> are the bits in OPTION_REG register.
2. SWDTEN is a bit in the OSCCON register.
3. WDTEN bit is in CONFIG.

8.2 Working principle of TIMER0

TIMER0 mod can be used as an 8-bit timer or an 8-bit counter.

8.2.1 8-bit timer mode

When used as a timer, the TIMER0 mod will be incremented every instruction period (without pre-scaler). The timer mode can be selected by clearing the T0CS bit of the OPTION_REG register to 0. If a write operation is performed to the TMR0 register, the next two instruction periods will be prohibited from incrementing. The value written to the TMR0 register can be adjusted so that a delay of two instruction periods is included when writing to TMR0.

8.2.2 8-bit counter mode

When used as a counter, the TIMER0 mod will increment on every rising or falling edge of the T0CKI pin. The incrementing edge depends on the T0SE bit of the OPTION_REG register. The counter mode can be selected by setting the T0CS bit of the OPTION_REG register to 1.

8.2.3 Software programmable pre-scaler

TIMER0 and watchdog timer (WDT) share a software programmable pre-scaler, but they cannot be used at the same time. The allocation of the pre-scaler is controlled by the PSA bit of the OPTION_REG register. To allocate the pre-scaler to TIMER0, the PSA bit must be cleared to 0.

TIMER0 mod has 8 selections of prescaler ratio, ranging from 1:2 to 1:256. The prescaler ratio can be selected through the PS<2:0> bits of the OPTION_REG register. To make TIMER0 mod have a 1:1 prescaler, the pre-scaler must be assigned to the WDT mod.

The pre-scaler is not readable and writable. When the pre-scaler is assigned to the TIMER0 mod, all instructions written to the TMR0 register will clear the pre-scaler. When the pre-scaler is assigned to the WDT, the CLRWDT instructions will also clear the pre-scaler and WDT.

8.2.4 Switch prescaler between TIMER0 and WDT module

Whether to use the prescaler from TIMER0 or WDT is completely controlled by software and can be changed dynamically. In order to avoid undesired chip reset, the following instruction should be executed when switching from TIMER0 to WDT.

```
CLR         TMR0            ;clear TMR0
CLRWDT                      ;clear WDT
LDIA        B’00xx1111’
LD          OPTION_REG,A
LDIA        B’00xx1xxx’     ;set new pre-scaler
LD          OPTION_REG,A
```

To change the pre-scaler from WDT to TIMER0 mod, the following sequence of instructions must be executed.

```
CLRWDT                      ;clear WDT
LDIA        B’00xx0xxx’     ;set new pre-scaler
LD          OPTION_REG,A
```

8.2.5 TIMER0 interrupt

When the TMR0 register overflows from FFh to 00h, a TIMER0 interrupt is generated. Every time the TMR0 register overflows, regardless of whether TIMER0 interrupt is allowed, the T0IF interrupt flag bit of the INTCON register will be set to 1. The T0IF bit must be cleared in software. TIMER0 interrupt enable bit is the T0IE bit of the INTCON register.

Note: The TIMER0 interrupt cannot wake up the processor because the timer is off in the sleep state.

8.3 TIMER0 related registers

There are two registers related to TIMER0, 8-bit timer/counter (TMR0), and 8-bit programmable control register (OPTION_REG).

TMR0 is an 8-bit readable and writable timer/counter, OPTION_REG is an 8-bit write-only register, the user can change the value of OPTION_REG to change the working mode of TIMER0, etc. Please refer to Section 2.6 Prescaler Register (OPTION_REG) Application.

8-bit timer/counter TMR0 (81H)

81H	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
TMR0								
R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
Reset value	X	X	X	X	X	X	X	X

OPTION_REG register (01H)

01H	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
OPTION_REG	---	INTEDG	T0CS	T0SE	PSA	PS2	PS1	PS0
R/W	---	R/W	R/W	R/W	R/W	R/W	R/W	R/W
Reset value	---	1	1	1	1	0	1	1

Bit7	Unused	
Bit6	INTEDG:	Interrupt edge selection bit.
	1=	The rising edge of the INT pin triggers interrupt.
	0=	The falling edge of the INT pin triggers interrupt.
Bit5	T0CS:	TMR0 clock source selection bit.
	1=	Transition edge of T0CKI pin.
	0=	Internal instruction period clock (F_{CPU}).
Bit4	T0SE:	TIMER0 clock source edge selection bit.
	1=	Increment when the T0CKI pin signal transitions from high to low.
	0=	Increment when the T0CKI pin signal transitions from low to high.
Bit3	PAS:	Pre-scaler allocation bit.
	1=	Pre-scaler allocated to WDT.
	0=	Pre-scaler allocated toTIMER0 mod.
Bit2~Bit0	PS2~PS0:	Pre-allocated parameter configuration bits.

PS2	PS1	PS0	TMR0 frequency division ratio	WDT frequency division ratio
0	0	0	1:2	1:1
0	0	1	1:4	1:2
0	1	0	1:8	1:4
0	1	1	1:16	1:8
1	0	0	1:32	1:16
1	0	1	1:64	1:32
1	1	0	1:128	1:64
1	1	1	1:256	1:128

9. TIMER2

9.1 TIMER2 overview

TIMER2 is an 8-bit timer/counter with the following characteristics:

1. 8-bit timer register (TMR2)
2. 8-bit period register (PR2)
3. Interrupt when TMR2 matches PR2
4. Software programmable prescaler ratio (1:1, 1:4 and 1:16)
5. Software programmable postscaler ratio (1:1 to 1:16)
6. External 32.768KHz oscillating clock can be selected

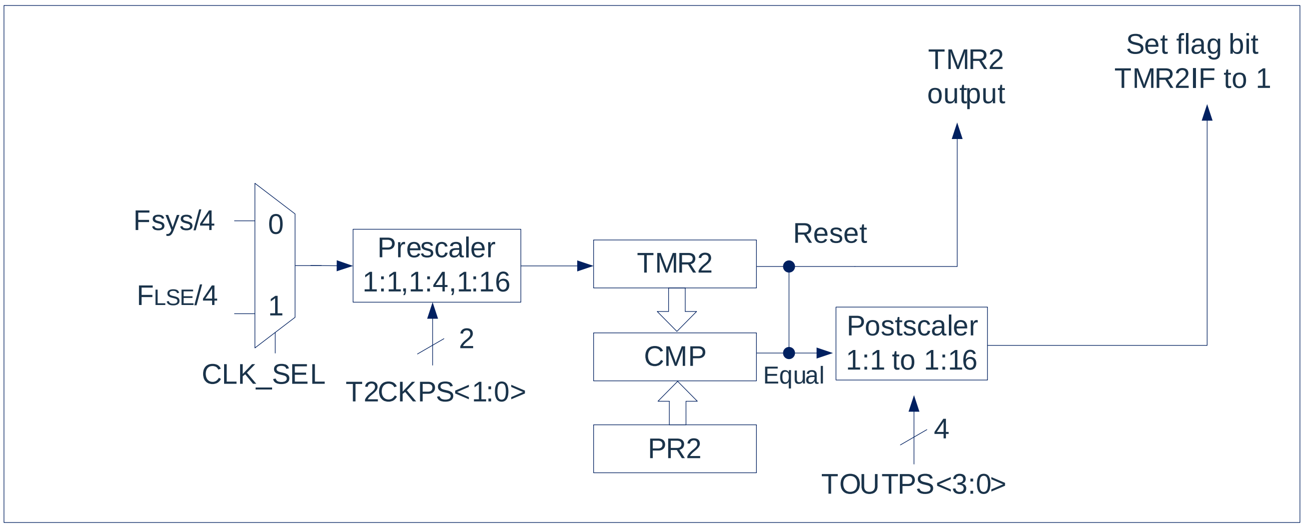


Figure 9-1: Block diagram of TIMER2

9.2 Working principle of TIMER2

The input clock to the TIMER2 module is the system command clock (F_{SYS}/4) or an external 32.768 kHz oscillation (F_{LSE}). The clock is input to the TIMER2 prescaler, which is available in the following ratios: 1:1, 1:4 or 1:16. The output of the prescaler is then used to increment the TMR2 register.

Continue to compare the values of TMR2 and PR2 to determine when they match. TMR2 will increase from 00h until it matches the value in PR2. When a match occurs, the following two events will occur:

- TMR2 is reset to 00h in the next increment period;
- TIMER2 post-scaler increment.

The matching output of the TIMER2 and PR2 comparator is then input to the post-scaler of TIMER2. The post-scaler has a prescaler ratio of 1:1 to 1:16 to choose from. The output of the TIMER2 post-scaler is used to make PIR1 The TMR2IF interrupt flag bit of the register is set to 1.

Both TMR2 and PR2 registers can be read and written. At any reset, TMR2 register is set to 00h and PR2 register is set to FFh.

Enable TIMER2 by setting the TMR2ON bit of the T2CON register; disable TIMER2 by clearing the TMR2ON bit.

The TIMER2 pre-scaler is controlled by the T2CKPS bit of the T2CON register; the TIMER2 postscaler is controlled by the TOUTPS bit of the T2CON register.

The pre-scaler and postscaler counters are cleared under the following conditions:

1. When TMR2ON=0.
2. Any device reset (power-on reset, watchdog timer reset or undervoltage reset) occurs.

Note: Writing to T2CON does not clear TMR2. When TMR2ON=0, the TMR2 register cannot be written.

9.3 TIMER2 related registers

There are 3 registers related to TIMER2, namely data register TMR2, period register PR2 and control register T2CON.

TIMER2 data register TMR2 (12H)

12H	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
TMR2								
R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
Reset value	0	0	0	0	0	0	0	0

TIMER2 period register PR2 (11H)

11H	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
PR2								
R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
Reset value	1	1	1	1	1	1	1	1

TIMER2 control register T2CON(13H)

13H	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
T2CON	CLK_SEL	TOUTPS3	TOUTPS2	TOUTPS1	TOUTPS0	TMR2ON	T2CKPS1	T2CKPS0
R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
Reset value	0	0	0	0	0	0	0	0

Bit7	CLK_SEL:	Clock source selection
	1=	Select external F_{LSE}/4 as TMR2 clock source (continue counting in sleep state)
	0=	Select internal F_{SYS}/4 as TMR2 clock source
Bit6~Bit3	TOUTPS<3:0>:	TIMER2 output postscaler ratio select bit
	0000=	1:1
	0001=	1:2
	0010=	1:3
	0011=	1:4
	0100=	1:5
	0101=	1:6
	0110=	1:7
	0111=	1:8
	1000=	1:9
	1001=	1:10
	1010=	1:11
	1011=	1:12
	1100=	1:13
	1101=	1:14
	1110=	1:15
	1111=	1:16
Bit2	TMR2ON:	TIMER2 enable bit
	1=	Enable TIMER2
	0=	Disable TIMER2
Bit1~Bit0	T2CKPS<1:0>:	TIMER2 clock prescaler ratio select bit
	00=	1
	01=	4
	1x=	16

10. 10-Bit PWM Module

The chip contains a 10-bit PWM module, which can be configured as 4 common periods, independent duty cycle outputs or 1 group complementary output.

10.1 Pin configuration

The corresponding PWM pin should be configured as output by setting the corresponding TRIS control bit to 0.

10.2 Related register description

PWM control register PWMCON0(15H)

15H	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
PWMCON0	CLKDIV[2:0]			PWM4EN	PWM3EN	PWM2EN	PWM1EN	PWM0EN
R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
Reset value	0	0	0	0	0	0	0	0

Bit7~Bit5	CLKDIV[2:0]:	PWM clock frequency division
	111=	$F_{HSI}/128$
	110=	$F_{HSI}/64$
	101=	$F_{HSI}/32$
	100=	$F_{HSI}/16$
	011=	$F_{HSI}/8$
	010=	$F_{HSI}/4$
	001=	$F_{HSI}/2$
	000=	$F_{HSI}/1$
Bit4~Bit0	PWM0/1/2/3/4EN:	PWM0/1/2/3/4 enable bit
	1=	Enable PWM0/1/2/3/4
	0=	Disable PWM0/1/2/3/4

PWM control register PWMCON1(16H)

16H	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
PWMCON1	---	PWM_IOSEL	PWM2DTEN	PWM0DTEN	---	---	DT_DIV<1:0>	
R/W	---	R/W	R/W	R/W	---	---	R/W	R/W
Reset value	---	0	0	0	---	---	0	0

Bit7	Unused	
Bit6	PWM_IOSEL:	PWM output port selection
	1=	PWM0~PWM4 are respectively on RA5, RB7, RB6, RB5, RB4
	0=	PWM0~PWM4 are respectively on RB0, RB1, RA2, RA3, RB2
Bit5	PWM2DTEN:	PWM2 dead zone enable bit.
	1=	Enable the dead zone function for PWM2. PWM2 and PWM3 form a complementary output pair.
	0=	Disable the dead zone function for PWM2.
Bit4	PWM0DTEN:	PWM0 dead zone enable bit.
	1=	Enable the dead zone function for PWM0. PWM0 and PWM1 form a complementary output pair.
	0=	Disable the dead zone function for PWM0.
Bit3~Bit2	Unused	
Bit1~Bit0	DT_DIV[1:0]:	Dead zone clock source division
	11=	$F_{HSI}/8$

10= $F_{HSI}/4$
01= $F_{HSI}/2$
00= $F_{HSI}/1$

PWM control register PWMCON2(1DH)

1DH	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
PWMCON2	---	---	---	PWM4DIR	PWM3DIR	PWM2DIR	PWM1DIR	PWM0DIR
R/W	---	---	---	R/W	R/W	R/W	R/W	R/W
Reset value	---	---	---	0	0	0	0	0

Bit7~Bit5	Unused		
Bit4~Bit0	PWM0/1/2/3/4DIR PWM output inverse control bit		
		1=	PWM0/1/2/3/4 inverted output
		0=	PWM0/1/2/3/4 normal output

PWM0~PWM3 period low bit register PWMTL (17H)

17H	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
PWMTL	PWMT<7:0>							
R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
Reset value	0	0	0	0	0	0	0	0

Bit7~Bit0 PWMT[7:0]: PWM0~PWM3 period low 8 bits

PWM4 period low bit register PWMT4L(1CH)

1CH	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
PWMT4L	PWM4T<7:0>							
R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
Reset value	0	0	0	0	0	0	0	0

Bit7~Bit0 PWM4T<7:0>: PWM4 period low 8 bits

Period high bit register PWMTH (18H)

18H	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
PWMTH	---	---	PWMD4<9:8>		PWM4T<9:8>		PWMT<9:8>	
R/W	---	---	R/W	R/W	R/W	R/W	R/W	R/W
Reset value	---	---	0	0	0	0	0	0

Bit7~Bit6	Unused	
Bit5~Bit4	PWMD4<9:8>:	Higher 2 bits of PWM4 duty register
Bit3~Bit2	PWM4T<9:8>:	Higher 2 bits of PWM4 period register
Bit1~Bit0	PWMT<9:8>:	Higher 2 bits of PWM0~PWM3 period register

Note: Writing PWMD4<9:8> does not take effect immediately, it needs to be written to PWMD4L to take effect.

PWM0 duty cycle low bit register PWMD0L (19H)

19H	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
PWMD0L	PWMD0<7:0>							
R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
Reset value	0	0	0	0	0	0	0	0

Bit7~Bit0 PWMD0<7:0>: PWM0 duty cycle low 8 bits

PWM1 duty cycle low bit register PWMD1L (1AH)

1AH	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
PWMD1L	PWMD1<7:0>							
R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
Reset value	0	0	0	0	0	0	0	0

Bit7~Bit0 PWMD1<7:0>: PWM1 duty cycle low 8 bits

PWM2 duty cycle low bit register PWMD2L (9BH)

9BH	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
PWMD2L	PWMD2[7:0]							
R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
Reset value	0	0	0	0	0	0	0	0

Bit7~Bit0 PWMD2[7:0]: PWM0 duty cycle low 8 bits

PWM3 duty cycle low bit register PWMD3L (9CH)

9CH	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
PWMD3L	PWMD3[7:0]							
R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
Reset value	0	0	0	0	0	0	0	0

Bit7~Bit0 PWMD3[7:0]: PWM3 duty cycle low 8 bits

PWM4 duty cycle low bit register PWMD4L (1BH)

1BH	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
PWMD4L	PWMD4<7:0>							
R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
Reset value	0	0	0	0	0	0	0	0

Bit7~Bit0 PWMD4<7:0>: PWM4 duty cycle low 8 bits

PWM0 and PWM1 duty cycle high bit register PWMD01H (1EH)

1EH	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
PWMD01H	---	---	PWMD1<9:8>		---	---	PWMD0<9:8>	
R/W	---	---	R/W	R/W	---	----	R/W	R/W
Reset value	---	---	0	0	---	----	0	0

Bit7~Bit6	Unused	
Bit5~Bit4	PWMD1<9:8>:	PWM1 duty cycle high 2 bits
Bit3~Bit2	Unused	
Bit1~Bit0	PWMD0<9:8>:	PWM0 duty cycle high 2 bits

Note: Writing PWMD0<9:8> does not take effect immediately, it needs to write PWMD0L to take effect.
Writing PWMD1<9:8> does not take effect immediately, it needs to write PWMD1L to take effect.

PWM2 and PWM3 duty cycle high bit register PWMD23H (9EH)

9EH	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
PWMD23H	---	---	PWMD3[9:8]		---	---	PWMD2[9:8]	
R/W	---	---	R/W	R/W	---	----	R/W	R/W
Reset value	---	---	0	0	---	----	0	0

Bit7~Bit6	Unused	
Bit5~Bit4	PWMD3[9:8]:	PWM3 duty cycle high 2 bits
Bit3~Bit2	Unused	
Bit1~Bit0	PWMD2[9:8]:	PWM2 duty cycle high 2 bits

Note: Writing PWMD2<9:8> does not take effect immediately, it needs to write PWMD2L to take effect.
Writing PWMD3<9:8> does not take effect immediately, you need to write PWMD3L to take effect.

PWM0 and PWM1 dead time register PWM01DT(1FH)

1FH	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
PWM01DT	---	---	PWM01DT<5:0>					
R/W	---	---	R/W	R/W	R/W	R/W	R/W	R/W
Reset value	---	---	0	0	0	0	0	0

Bit7~Bit6	Unused	
Bit5~Bit0	PWM01DT<5:0>:	PWM0 and PWM1 dead time

PWM2 and PWM3 dead time register PWM23DT(9DH)

9DH	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
PWM23DT	---	---	PWM23DT<5:0>					
R/W	---	---	R/W	R/W	R/W	R/W	R/W	R/W
Reset value	---	---	0	0	0	0	0	0

Bit7~Bit6	Unused	
Bit5~Bit0	PWM23DT<5:0>:	PWM2 and PWM3 dead time

10.3 10-bit PWM register write sequence

Since the 10-bit PWM duty cycle value is allocated in two registers, when modifying the duty cycle, the program always modifies these two registers successively. In order to ensure the correctness of the duty cycle value, the chip is designed with an internal cache loading function. To operate the 10-digit duty cycle value, the following sequence should be strictly followed.

1) Write the higher 2-bit value, the high 2-bit value is just written to the internal cache;

2) Write the lower 8 bits, then the full 10-bit duty cycle value is latched;

3) The above operations are only for PWM0, PWM1, PWM2, PWM3, PWM4 duty cycle registers.

10.4 10-bit PWM period

The PWM period is specified by writing the PWMTH and PWMTL registers.

Formula 1: PWM cycle calculation formula.

$$\text{PWM period}=[\text{PWMT}+1]*T_{HSI}*(\text{CLKDIV prescaler value})$$

Note: $T_{HSI}=1/F_{HSI}$

When the PWM cycle counter is equal to PWMT, the following three events occur during the next incremental counting cycle:

- PWM period counter is cleared;
- PWMx pin is set to 1;
- New period of PWM is latched;
- New duty cycle of PWM is latched;
- Generate a PWM interrupt flag bit (No interrupt for PWM4);

10.5 10-bit PWM duty cycle

The PWM duty cycle can be specified by writing a 10-bit value to the following multiple registers: PWMDxL, PWMDxxH.

The PWM duty cycle can be specified by writing a 10-bit value to the following multiple registers:

Formula 2: Pulse width calculation formula

$$\text{Pulse width} = (PWMDx[9:0]+1)*T_{HSI}*(CLKDIV\ \text{prescaler value})$$

Formula 3: PWM duty cycle calculation formula

$$\text{Duty cycle}=\frac{PWMDx[9:0]+1}{PWMT[9:0]+1}$$

Internal chip is used to provide double buffering for the PWM duty cycle. This double buffering structure is extremely important to avoid glitches during the PWM operation.

10.6 System clock frequency change

The PWM frequency is only related to the chip oscillation clock. Any change in the system clock frequency will not change the PWM frequency.

10.7 Programmable dead time delay mode

The complementary output mode can be enabled by setting PWMxDT_EN, and the dead time delay function is automatically enabled after the complementary output is enabled.

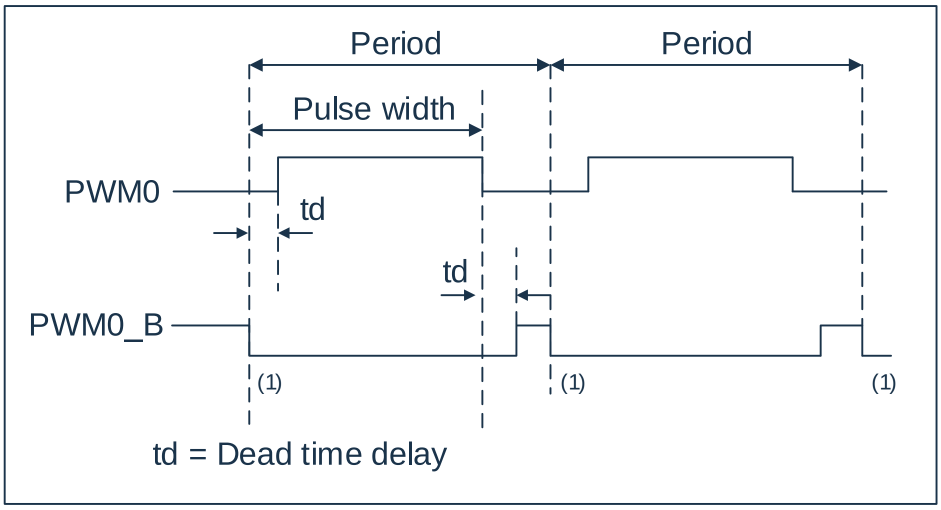


Figure 10-1: Example of PWM dead time delay output

The dead time calculation formula is:

$$td=(PWMxxDT[5:0]+1)*T_{HSI}*(DT\_DIV\ prescaler\ time)$$

10.8 10-bit PWM configuration

The following steps should be performed when using the PWM module.

1. Set the corresponding TRIS bit to 1 to make it as an input pin.
2. Set the PWM period by loading the PWMTH and PWMTL registers.
3. Set the PWM duty cycle by loading the PWMDxL and PWMDxxH registers.
4. Clear the PWMIF flag bit.
5. Set the PWMENx bit to enable the corresponding PWM outputs.
6. After the new PWM period starts, enable PWM output:
   - Wait for PWMIF bit set to 1.
   - Enable the PWM pin output driver by clearing the corresponding TRIS bit.

11. Comparator (COMP)

11.1 Features

- Internally integrated with one comparator.
- Comparator offset voltage is≤±13mV.
- Input common-mode voltage range: 0V~VDD-1.3V.
- Built-in resistor divider module with VDD as the reference voltage.
- The comparator result can be triggered by either rising or falling edge and generate an interrupt.
- The comparator result can be output from RB0 port and supports inverted output.

11.2 Block diagram

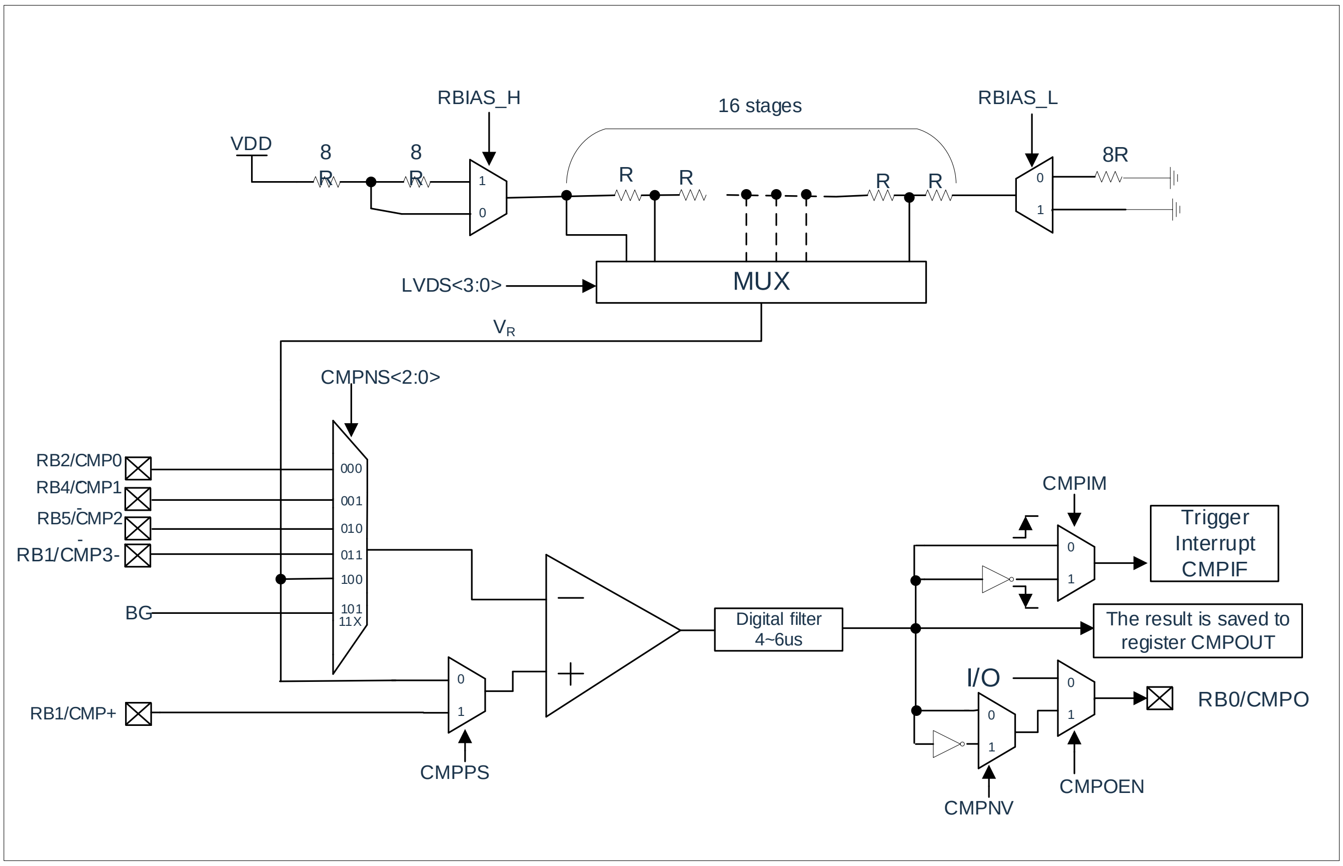


Figure 11-1: Functional block diagram of comparator

11.3 Comparator related function

11.3.1 Comparator function description

The SC8P053 chip integrates one comparator module internally, as shown in Figure 11-1. The positive input of the comparator can be used for selecting the CMP+ port or the internal resistor voltage divider output V_R by configuring CMPPS bit of the CMPCON0 register. The negative input can be used for selecting the CMPx- port, the internal resistor voltage divider output V_R, or the 1.2V BG voltage by configuring the CMPNS<2:0> bits of the CMPCON0 register. When the voltage at the positive input of the comparator is greater than the voltage at the negative input, the comparator outputs 1 after digital filtering. Conversely, if the voltage at the positive input is less than the voltage at the negative input, the comparator outputs 0 after digital filtering.

11.3.2 Comparator internal resistor voltage divider output

The comparator integrates an internal resistor voltage divider module with a reference voltage of VDD. Different resistor voltage divider outputs V_R can be obtained by configuring the values of the control bits RBIAS_H, RBIAS_L, and LVDS<3:0> of the CMPCON1 register. The four calculation formulas for V_R are as follows:

RBIAS_H	RBIAS_L	V_R calculation formula
0	0	$V_R=\frac{1}{4}*VDD+\frac{n+1}{32}*VDD$
0	1	$V_R=\frac{n+1}{24}*VDD$
1	0	$V_R=\frac{1}{5}*VDD+\frac{n+1}{40}*VDD$
1	1	$V_R=\frac{n+1}{32}*VDD$

Note: n is the value of LVDS<3:0>, i.e., n = 0, 1, 2, ..., 14, 15.

11.3.3 Comparator for monitoring power supply voltage

According to the comparator structure block diagram in Figure 11-1 and the formula in section 11.3.2, when the negative end of the comparator selects BG 1.2V, and the positive end selects the internal resistor voltage divider output V_R, the power supply voltage can be monitored by the comparator. When the power supply voltage is lower than the set value, the comparator outputs 0, and when the power supply voltage is higher than the set value, the comparator outputs 1. By configuring the values of RBIAS_H, RBIAS_L, LVDS[3:0], different voltage monitoring points can be set as follows.

RBIAS_H	RBIAS_L	LVDS[3:0]	Monitoring value(V)	RBIAS_H	RBIAS_L	LVDS[3:0]	Monitoring value(V)	RBIAS_H	RBIAS_L	LVDS[3:0]	Monitoring value(V)
0	1	0101	4.80	0	0	0100	2.95	1	0	1101	2.18
1	0	0010	4.36	0	1	1001	2.88	0	0	1001	2.13
0	0	0000	4.27	1	0	1000	2.82	1	0	1110	2.09
0	1	0110	4.11	0	0	0101	2.74	0	1	1101	2.06
1	0	0011	4.00	1	0	1001	2.67	0	0	1010	2.02
0	0	0001	3.84	0	1	1010	2.62	1	0	1111	2.00
1	0	0100	3.69	0	0	0110	2.56	-	-	-	-
0	1	0111	3.60	1	0	1010	2.53	-	-	-	-
0	0	0010	3.49	0	0	0111	2.40	-	-	-	-
1	0	0101	3.43	1	0	1100	2.29	-	-	-	-
0	0	0011	3.20	0	0	1000	2.26	-	-	-	-

11.3.4 Comparator interrupt usage

To use the interrupt function of the comparator, the comparator interrupt can be enabled through the following configuration steps:

- Configure the CMPPS bit of the CMPCON0 register to select the positive input.
- Configure the CMPNS<2:0> bits of the CMPCON0 register to select the negative input.
- Configure the CMPIM bit of the CMPCON1 register to select the rising or falling edge trigger for the interrupt.
- Set the CMPEN bit of the CMPCON0 register to enable the comparator.
- Delay for 10us.
- Clear the CMPIF bit of the PIR1 register.
- Set the CMPIE bit of the PIE1 register to 1 to enable the comparator interrupt.
- Set the PEIE and GIE bits of the INTCON register to 1 to enable peripheral and global interrupts.

11.3.5 Comparator interrupt sleep wake-up

The comparator interrupt can wake up the chip from sleep mode. The specific configuration can be found in the following program routine:

Example: Comparator interrupt sleep wake-up program

```
SLEEP_MODE:
            LDIA      B'00000110'
            LD        TRISB,A         ;Configure RB1/CMP+ and RB2/CMP0- as
                                      input ports
            ...                       ;Disable other functions
            LDIA      00H
            LD        CMPCON0,A       ;CMPNS<2:0>=000, select RB2/CMP0- as
                                      the negative input
            SETB      CMPCON0,6       ;CMPPS=1, select RB1/CMP+ as the positive
                                      input
            SETB      CMPCON1,6       ;ANSEL=1, set CMP+ and CMP0- as analog
                                      ports to reduce sleep power consumption
            SETB      CMPCON1,7       ;CMPIM=1, select falling edge trigger for the
                                      comparator interrupt
            SETB      CMPCON0,7       ;Enable the comparator
            CALL      DELAY10US       ;Delay to ensure stable output from the
                                      comparator after enabling it
            CLRB      PIR1,5          ;Clear CMPIF (necessary)
            SETB      PIE1,5          ;Enable the comparator interrupt
            SETB      INTCON,6        ;Enable peripheral interrupts
            SETB      INTCON,7        ;Enable global interrupts, the program will
                                      jump to the interrupt vector address 0004H
                                      after waking up
            CLRWDT                    ;Clear the WDT
            STOP                      ;Execute the STOP instruction
            NOP
            NOP
```

11.3.6 Comparator result output pin configuration

After digital filtering, the result of the comparator can be obtained by reading the CMPOUT bit of the CMPCON0 register. It can also be output to the RB0/CMPO pin through the following configuration steps:

- Set TRISB0 to 0 to configure RB0/CMPO as an output pin.
- Configure the CMPNV bit of the CMPCON0 register to select normal or inverted output.
- Set the CMPOEN bit of the CMPCON0 register to 1 to enable the output of CMPOUT to the RB0/CMPO pin.

11.4 Related registers

Comparator control register CMPCON0(0FH)

0FH	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
CMPCON0	CMPEN	CMPPS	CMPNS2	CMPNS1	CMPNS0	CMPNV	CMPOUT	CMPOEN
R/W	R/W	R/W	R/W	R/W	R/W	R/W	R	R/W
Reset value	0	0	0	0	0	0	0	0

Bit7	CMPEN:	CMP enable bit
	1=	Enable CMP
	0=	Disable CMP
Bit6	CMPPS:	CMP positive input select bit
	1=	CMP+ port voltage
	0=	VDD voltage after dividing by internal resistor
Bit5~Bit3	CMPNS<2:0>:	CMP negative input select bit
	000=	CMP0- port voltage
	001=	CMP1- port voltage
	010=	CMP2- port voltage
	011=	CMP3- port voltage
	100=	VDD voltage after dividing by internal resistor
	101=	BG
	11x=	BG
Bit2	CMPNV:	CMPO port output inverse control bit
	1=	Invert CMPOUT output at CMPO port
	0=	Normal CMPOUT output at CMPO port
Bit1	CMPOUT:	CMP result bit
Bit0	CMPOEN:	CMPO port output enable bit
	1=	Enable CMPOUT output at CMPO port
	0=	Disable CMPOUT output at CMPO port

Comparator control register CMPCON1(10H)

10H	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
CMPCON1	CMPIM	AN_EN	RBIAS_H	RBIAS_L	LVDS<3:0>			
R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
Reset value	0	0	0	0	0	0	0	0

Bit7	CMPIM:	CMP interrupt trigger edge selection
	1=	Falling edge of the CMP output triggers an interrupt
	0=	Rising edge of CMP output triggers interrupt
Bit6	AN_EN:	Analog port enable bit, enables analog functionality for CMP+ and CMPX-
	1=	Analog port
	0=	Digital port
Bit5	RBIAS_H:	Specific usage refers to the comparator block diagram
Bit4	RBIAS_L:	Specific usage refers to the comparator block diagram
Bit3~Bit0	LVDS<3:0>:	Internal resistor divider ratio selection bit

Note: The AN_EN bit is only valid for the IO port selected for comparator function.

12. Electrical Parameters

12.1 Limit parameters

Supply voltage	GND-0.3V~GND+6.0V
Storage temperature	-50°C~125°C
Working temperature	-40°C~85°C
Port input voltage	GND-0.3V~VDD+0.3V
Maximum positive current for all ports	200mA
Maximum negative current for all ports	-150mA

Note: If the device operating conditions exceed the above “limit parameters”, it may cause permanent damage to the device. The above values are only the maximum value of the operating conditions. We do not recommend that the device operate outside the range specified in this specification. The stability of the device will be affected if it is operated for a long period of time under extreme conditions.

12.2 DC characteristics

(VDD=5V, T_A= 25℃, unless otherwise specified)

Symbol	Item	Test condition		Min.	Typ.	Max.	Unit
		VDD	Condition				
VDD	Operating voltage	-	F_{SYS}=16MHz/2T	3.0	-	5.5	V
		-	F_{SYS}=16MHz/4T	1.8	-	5.5	V
I_{DD}	Operating current	5V	F_{SYS}=16MHz, disable all analog modules.	-	2.5	-	mA
		5V	F_{SYS}=8MHz, disable all analog modules.	-	1.0	-	mA
		3V	F_{SYS}=16MHz, disable all analog modules.	-	1.5	-	mA
		3V	F_{SYS}=8MHz, disable all analog modules.	-	0.5	-	mA
I_{STB}	Static current	5V	WDT=DIS	-	1.1	5	uA
		3V	WDT=DIS	-	0.6	3	uA
		5V	WDT=EN	-	4.8	12	uA
		3V	WDT=EN	-	2.1	5.5	uA
V_{IL}	Low level input voltage	-	----	-	-	0.3VDD	V
V_{IH}	High level input voltage	-	----	0.7VDD	-	-	V
V_{OH}	High level output voltage	-	No load	0.9VDD	-	-	V
V_{OL}	Low level output voltage	-	No load	-	-	0.1VDD	V
R_{PH}	Pull-up resistor value	5V	Vo=0.5VDD	-	51	-	KΩ
		3V	Vo=0.5VDD	-	85	-	KΩ
R_{PL}	Pull-down resistor value	5V	Vo=0.5VDD	-	33	-	KΩ
		3V	Vo=0.5VDD	-	45	-	KΩ
I_{OL}	Output port positive current	5V	V_{OL}=0.3VDD	-	37	-	mA
		3V	V_{OL}=0.3VDD	-	17	-	mA
I_{OH}	Output port negative current	5V	V_{OH}=0.7VDD	-	-16	-	mA
		3V	V_{OH}=0.7VDD	-	-7	-	mA
V_{BG}	Internal reference voltage 1.2V	VDD=2.0~5.5V T_A=25℃		-3.5%	1.2	+3.5%	V
		VDD=2.0~5.5V T_A=-40~85℃		-5%	1.2	+5%	V

12.3 Comparator characteristics

(T_A= 25℃, unless otherwise specified)

Symbol	Item	Test condition	Min.	Typ.	Max.	Unit
VDD	Operating voltage range	-	2.0	-	5.5	V
Temp	Temperature range	-	-40	-	85	℃
Iwork	Operating current	VDD=5V COMP+=2V COMP-=2V	-	34	46	uA
		VDD=3V COMP+=1V COMP-=1V	-	20	26	uA
I_{BG}	BG operating current	VDD=5V	-	35	46	uA
		VDD=3V	-	33	44	uA
V_{IN}	Input common mode voltage range	-	0	-	VDD-1.3	V
Vos	Offset voltage	-	-	-	±13	mV
LSB	Minimum resolution	-	-	10	20	mV
Tr	Response time	-	-	-	6	us
-	Internal resistor voltage divider error	VDD=5V V_R>1V	-1%	-	+1%	-
		VDD=5V V_R<1V	-2%	-	+2%	-

Note: V_R is the internal resistor voltage divider output value.

12.4 Power on reset characteristics

(T_A= 25℃, unless otherwise specified)

Symbol	Item	Test condition	Min.	Typ.	Max.	Unit
T_{VDD}	VDD rising rate	-	0.05			V/ms
V_{LVR1}	LVR set voltage=1.8V	VDD=1.6~5.5V	1.7	1.8	1.9	V
V_{LVR2}	LVR set voltage=2.0V	VDD=1.8~5.5V	1.9	2.0	2.1	V
V_{LVR3}	LVR set voltage=2.5V	VDD=2.3~5.5V	2.4	2.5	2.6	V
V_{LVR4}	LVR set voltage=3.0V	VDD=2.8~5.5V	2.9	3.0	3.1	V

12.5 AC electrical characteristics

(T_A= 25℃, unless otherwise specified)

Symbol	Item	Test condition		Min.	Typ.	Max.	Unit
		VDD	Condition				
F_{WDT}	WDT clock source	VDD=2.5~5.5V	T_A=25℃	-20%	32	+20%	KHz
		VDD=1.8~5.5V	T_A=25℃	-30%	32	+30%	KHz
		VDD=2.5~5.5V	T_A=-40~85℃	-30%	32	+30%	KHz
		VDD=1.8~5.5V	T_A=-40~85℃	-50%	32	+50%	KHz
F_{INTRC}	Internal frequency 16MHz	VDD=4.0~5.5V	T_A=25℃	-2.0%	16	+2.0%	MHz
		VDD=2.5~5.5V	T_A=25℃	-2.5%	16	+2.5%	MHz
		VDD=1.8~5.5V	T_A=25℃	-4.0%	16	+4.0%	MHz
		VDD=4.0~5.5V	T_A= -40~85℃	-3.5%	16	+3.5%	MHz
		VDD=2.5~5.5V	T_A= -40~85℃	-4.0%	16	+4.0%	MHz
		VDD=1.8~5.5V	T_A= -40~85℃	-5.0%	16	+5.0%	MHz

12.6 LSE characteristics

(TA= 25°C, unless otherwise specified)

Symbol	Item	Test condition	Min.	Typ.	Max.	Unit
VDD	Operating voltage range	-	1.8	-	5.5	V
F_{LSE}	LSE oscillator frequency	-	-	32.768	-	KHz
C_1	OSCIN pin matching capacitance	-	-	22	-	pF
C_2	OSCOUT pin matching capacitance	-	-	22	-	pF
I_{LSE}	LSE operating current	VDD=5V C1=22 pF C2=22pF	-	20	-	uA
		VDD=3V C1=22 pF C2=22pF	-	8	-	uA
T_{LSE}	LSE stabilization time	VDD=5V C1=22 pF C2=22pF	-	260	700	ms
		VDD=3V C1=22 pF C2=22pF	-	300	1000	ms

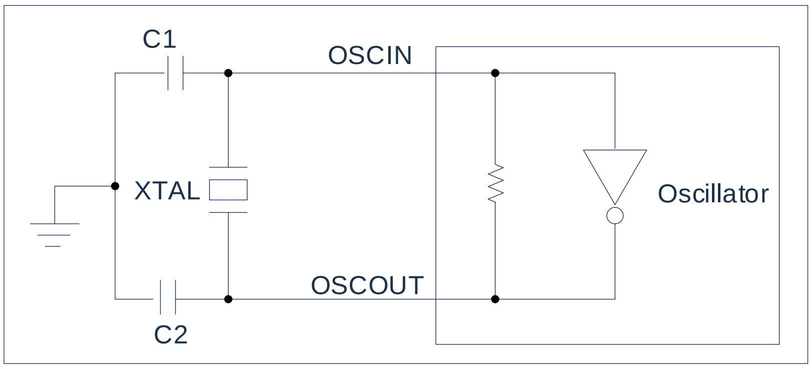


Figure 12-1: LSE typical application circuit

13. Instructions

13.1 Instruction set

mnemonic		operation	period	symbol
control				
NOP		Empty operation	1	None
STOP		Enter sleep mode	1	TO,PD
CLRWDT		Clear watchdog timer	1	TO,PD
data transfer				
LD	[R],A	Transfer content to ACC to R	1	LD
LD	A,[R]	Transfer content to R to ACC	1	LD
TESTZ	[R]	Transfer the content of data memory data memory	1	TESTZ
LDIA	i	Transfer i to ACC	1	LDIA
logic operation				
CLRA		Clear ACC	1	Z
SET	[R]	Set data memory R	1	SET
CLR	[R]	Clear data memory R	1	CLR
ORA	[R]	Perform ‘OR’ on R and ACC, save the result to ACC	1	ORA
ORR	[R]	Perform ‘OR’ on R and ACC, save the result to R	1	ORR
ANDA	[R]	Perform ‘AND’ on R and ACC, save the result to ACC	1	ANDA
ANDR	[R]	Perform ‘AND’ on R and ACC, save the result to R	1	ANDR
XORA	[R]	Perform ‘XOR’ on R and ACC, save the result to ACC	1	XORA
XORR	[R]	Perform ‘XOR’ on R and ACC, save the result to R	1	XORR
SWAPA	[R]	Swap R register high and low half byte, save the result to ACC	1	SWAPA
SWAPR	[R]	Swap R register high and low half byte, save the result to R	1	SWAPR
COMA	[R]	The content of R register is reversed, and the result is stored in ACC	1	COMA
COMR	[R]	The content of R register is reversed and the result is stored in R	1	COMR
XORIA	i	Perform ‘XOR’ on i and ACC, save the result to ACC	1	XORIA
ANDIA	i	Perform ‘AND’ on i and ACC, save the result to ACC	1	ANDIA
ORIA	i	Perform ‘OR’ on i and ACC, save the result to ACC	1	ORIA
shift operation				
RRCA	[R]	Data memory rotates one bit to the right with carry, the result is stored in ACC	1	RRCA
RRCR	[R]	Data memory rotates one bit to the right with carry, the result is stored in R	1	RRCR
RLCA	[R]	Data memory rotates one bit to the left with carry, the result is stored in ACC	1	RLCA
RLCR	[R]	Data memory rotates one bit to the left with carry, the result is stored in R	1	RLCR
RLA	[R]	Data memory rotates one bit to the left without carry, and the result is stored in ACC	1	RLA
RLR	[R]	Data memory rotates one bit to the left without carry, and the result is stored in R	1	RLR
RRA	[R]	Data memory does not take carry and rotates to the right by one bit, and the result is stored in ACC	1	RRA
RRR	[R]	Data memory does not take carry and rotates to the right by one bit, and the result is stored in R	1	RRR
increase/decrease				
INCA	[R]	Increment data memory R, result stored in ACC	1	INCA
INCR	[R]	Increment data memory R, result stored in R	1	INCR
DECA	[R]	Decrement data memory R, result stored in ACC	1	DECA
DECR	[R]	Decrement data memory R, result stored in R	1	DECR

mnemonic	operation	period	symbol
bit operation			
CLRB [R],b	Clear some bit in data memory R	1	CLRB
SETB [R],b	Set some bit in data memory R to 1	1	SETB
math operation			
ADDA [R]	ACC+[R]→ACC	1	ADDA
ADDR [R]	ACC+[R]→R	1	ADDR
ADDCA [R]	ACC+[R]+C→ACC	1	ADDCA
ADDCR [R]	ACC+[R]+C→R	1	ADDCR
ADDIA i	ACC+i→ACC	1	ADDIA
SUBA [R]	[R]-ACC→ACC	1	SUBA
SUBR [R]	[R]-ACC→R	1	SUBR
SUBCA [R]	[R]-ACC-C→ACC	1	SUBCA
SUBCR [R]	[R]-ACC-C→R	1	SUBCR
SUBIA i	i-ACC→ACC	1	SUBIA
HSUBA [R]	ACC-[R]→ACC	1	HSUBA
HSUBR [R]	ACC-[R]→R	1	HSUBR
HSUBCA [R]	ACC-[R]- $\overline{C}$ →ACC	1	HSUBCA
HSUBCR [R]	ACC-[R]- $\overline{C}$ →R	1	HSUBCR
HSUBIA i	ACC-i→ACC	1	HSUBIA
unconditional transfer			
RET	Return from subroutine	2	NONE
RET i	Return from subroutine, save I to ACC	2	RET
RETI	Return from interrupt	2	NONE
CALL ADD	Subroutine call	2	CALL
JP ADD	Unconditional jump	2	JP
conditional transfer			
SZB [R],b	If the b bit of data memory R is "0", skip the next instruction	1 or 2	SZB
SNZB [R],b	If the b bit of data memory R is "1", skip the next instruction	1 or 2	SNZB
SZA [R]	data memory R is sent to ACC, if the content is "0", skip the next instruction	1 or 2	SZA
SZR [R]	If the content of data memory R is "0", skip the next instruction	1 or 2	SZR
SZINCA [R]	Add "1" to data memory R and put the result into ACC, if the result is "0", skip the next oneinstructions	1 or 2	SZINCA
SZINCR [R]	Add "1" to data memory R, put the result into R, if the result is "0", skip the next instruction	1 or 2	SZINCR
SZDECA [R]	Data memory R minus "1", the result is put into ACC, if the result is "0", skip the next instruction	1 or 2	SZDECA
SZDECR [R]	Data memory R minus "1", put the result into R, if the result is "0", skip the next instruction	1 or 2	SZDECR

13.2 Instruction description

ADDA	**[R]**
operation:	Add ACC to R, save the result to ACC
period:	1
affected flag bit:	C, DC, Z, OV
example:	

```
LDIA       09H            ;load 09H to ACC
LD         R01,A          ;load ACC (09H) to R01
LDIA       077H           ;load 77H to ACC
ADDA       R01            ;execute: ACC=09H + 77H =80H
```

ADDR	**[R]**
operation:	Add ACC to R, save the result to R
period:	1
affected flag bit:	C, DC, Z, OV
example:	

```
LDIA       09H            ;load 09H to ACC
LD         R01,A          ;load ACC (09H) to R01
LDIA       077H           ;load 77H to ACC
ADDR       R01            ;execute: R01=09H + 77H =80H
```

ADDCA	**[R]**
operation:	Add ACC to C, save the result to ACC
period:	1
affected flag bit:	C, DC, Z, OV
example:	

```
LDIA       09H            ; load 09H to ACC
LD         R01,A          ; load ACC (09H) to R01
LDIA       077H           ; load 77H to ACC
ADDCA      R01            ;execute: ACC= 09H + 77H + C=80H (C=0)
                                    ACC= 09H + 77H + C=81H (C=1)
```

ADDCR	**[R]**
operation:	Add ACC to C, save the result to R
period:	1
affected flag bit:	C, DC, Z, OV
example:	

```
LDIA     09H       ; load 09H to ACC
LD       R01,A     ; load ACC (09H) to R01
LDIA     077H      ; load 77H to ACC
ADDCR    R01       ; execute: R01 = 09H + 77H + C=80H (C=0)
                              R01 = 09H + 77H + C=81H (C=1)
```

ADDIA	**i**
operation:	Add i to ACC, save the result to ACC
period:	1
affected flag bit:	C, DC, Z, OV
example:	

```
LDIA     09H       ;load 09H to ACC
ADDIA    077H      ;execute: ACC = ACC(09H) + i(77H)=80H
```

ANDA	**[R]**
operation:	Perform ‘AND’ on register R and ACC, save the result to ACC
period:	1
affected flag bit:	Z
example:	

```
LDIA     0FH       ;load 0FH to ACC
LD       R01,A     ;load ACC (0FH) to R01
LDIA     77H       ;load 77H to ACC
ANDA     R01       ;execute: ACC=(0FH and 77H)=07H
```

ANDR	**[R]**
operation:	Perform ‘AND’ on register R and ACC, save the result to R
period:	1
affected flag bit:	Z
example:	

```
LDIA     0FH       ;load 0FH to ACC
LD       R01,A     ;load ACC (0FH) to R01
LDIA     77H       ;load 77H to ACC
ANDR     R01       ;execute: R01= (0FH and 77H)=07H
```

ANDIA	**i**		
operation:	Perform ‘AND’ on i and ACC, save the result to ACC		
period:	1		
affected flag bit:	Z		
example:			
	LDIA	0FH	;load 0FH to ACC
	ANDIA	77H	;execute: ACC =(0FH and 77H)=07H

CALL	**add**		
operation:	Call subroutine		
period:	2		
affected flag bit:	None		
example:			
	CALL	LOOP	;Call the subroutine address whose name is defined as “LOOP”

CLRA			
operation:	ACC clear		
period:	1		
affected flag bit:	Z		
example:			
	CLRA		;execute: ACC=0

CLR	**[R]**		
operation:	Register R clear		
period:	1		
affected flag bit:	Z		
example:			
	CLR	R01	;execute: R01=0

CLRB	**[R],b**		
operation:	Clear b bit on register R		
period:	1		
affected flag bit:	None		
example:			
	CLRB	R01,3	;execute: 3rd bit of R01 is 0

CLRWDT			
operation:	Clear watchdog timer		
period:	1		
affected flag bit:	TO, PD		
example:			
	CLRWDT		;watchdog timer clear

COMA	**[R]**
operation:	Reverse register R, save the result to ACC
period:	1
affected flag bit:	Z
example:	

```
LDIA      0AH       ;load 0AH to ACC
LD        R01,A     ;load ACC (0AH) to R01
COMA      R01       ;execute: ACC=0F5H
```

COMR	**[R]**
operation:	Reverse register R, save the result to R
period:	1
affected flag bit:	Z
example:	

```
LDIA      0AH       ;load 0AH to ACC
LD        R01,A     ;load ACC (0AH) to R01
COMR      R01       ;execute: R01=0F5H
```

DECA	**[R]**
operation:	Decrement value in register, save the result to ACC
period:	1
affected flag bit:	Z
example:	

```
LDIA      0AH       ;load 0AH to ACC
LD        R01,A     ;load ACC (0AH) to R01
DECA      R01       ;execute: ACC=(0AH-1)=09H
```

DECR	**[R]**
operation:	Decrement value in register, save the result to R
period:	1
affected flag bit:	Z
example:	

```
LDIA      0AH       ;load 0AH to ACC
LD        R01,A     ;load ACC (0AH) to R01
DECR      R01       ;execute: R01=(0AH-1)=09H
```

HSUBA	**[R]**
operation:	ACC subtract R, save the result to ACC
period:	1
affected flag bit:	C,DC,Z,OV
example:	

```
LDIA      077H        ;load 077H to ACC
LD        R01,A       ;load ACC (077H) to R01
LDIA      080H        ;load 080H to ACC
HSUBA     R01         ;execute: ACC=(80H-77H)=09H
```

HSUBR	**[R]**
operation:	ACC subtract R, save the result to R
period:	1
affected flag bit:	C,DC,Z,OV
example:	

```
LDIA      077H        ;load 077H to ACC
LD        R01,A       ;load ACC (077H) to R01
LDIA      080H        ;load 080H to ACC
HSUBR     R01         ;execute: R01=(80H-77H)=09H
```

HSUBCA	**[R]**
operation:	ACC subtract $\overline{C}$, save the result to ACC
period:	1
affected flag bit:	C,DC,Z,OV
example:	

LDIA 077H ;load 077H to ACC
LD R01,A ;load ACC (077H) to R01
LDIA 080H ;load 080H to ACC
HSUBCA R01 ;execute: ACC=(80H-77H-$\overline{C}$)= 08H(C=0)
ACC=(80H-77H-$\overline{C}$)= 09H(C=1)

HSUBCR	**[R]**
operation:	ACC subtract $\overline{C}$, save the result to R
period:	1
affected flag bit:	C,DC,Z,OV
example:	

LDIA 077H ;load 077H to ACC
LD R01,A ;load ACC (077H) to R01
LDIA 080H ;load 080H to ACC
HSUBCR R01 ;execute: R01=(80H-77H-$\overline{C}$)=08H(C=0)
R01=(80H-77H-$\overline{C}$)=09H(C=1)

INCA	**[R]**
operation:	Register R increment 1, save the result to ACC
period:	1
affected flag bit:	Z
example:	

```
LDIA        0AH         ;load 0AH to ACC
LD          R01,A       ;load ACC (0AH) to R01
INCA        R01         ;execute: ACC=(0AH+1)=0BH
```

INCR	**[R]**
operation:	Register R increment 1, save the result to R
period:	1
affected flag bit:	Z
example:	

```
LDIA        0AH         ;load 0AH to ACC
LD          R01,A       ;load ACC (0AH) to R01
INCR        R01         ;execute: R01=(0AH+1)=0BH
```

JP	**add**
operation:	Jump to add address
period:	2
affected flag bit:	None
example:	

```
JP          LOOP        ;jump to the subroutine address whose name is defined as “LOOP”
```

LD	**A,[R]**
operation:	Load the value of R to ACC
period:	1
affected flag bit:	Z
example:	

```
LD          A,R01       ;load R01 to ACC
LD          R02,A       ;load ACC to R02, achieve data transfer from R01→R02
```

LD	**[R],A**
operation:	Load the value of ACC to R
period:	1
affected flag bit:	None
example:	

```
LDIA        09H         ;load 09H to ACC
LD          R01,A       ;execute: R01=09H
```

LDIA	**i**
operation:	Load i to ACC
period:	1
affected flag bit:	None
example:	

```
LDIA      0AH            ; load 0AH to ACC
```

NOP	
operation:	Empty instructions
period:	1
affected flag bit:	None
example:	

```
NOP
NOP
```

ORIA	**i**
operation:	Perform ‘OR’ on I and ACC, save the result to ACC
period:	1
affected flag bit:	Z
example:	

```
LDIA      0AH            ;load 0AH to ACC
ORIA      030H           ;execute: ACC =(0AH   or   30H)=3AH
```

ORA	**[R]**
operation:	Perform ‘OR’ on R and ACC, save the result to ACC
period:	1
affected flag bit:	Z
example:	

```
LDIA      0AH            ;load 0AH to ACC
LD        R01,A          ;load ACC (0AH) to R01
LDIA      30H            ;load 30H to ACC
ORA       R01            ;execute: ACC=(0AH or 30H)=3AH
```

ORR	**[R]**
operation:	Perform ‘OR’ on R and ACC, save the result to R
period:	1
affected flag bit:	Z
example:	

```
LDIA      0AH            ;load 0AH to ACC
LD        R01,A          ;load ACC (0AH) to R01
LDIA      30H            ;load 30H to ACC
ORR       R01            ;execute: R01=(0AH or 30H)=3AH
```

RET

operation:	Return from subroutine
period:	2
affected flag bit:	None
example:	

```
        CALL    LOOP        ;call subroutine LOOP
        NOP                 ;this statement will be executed after RET instructions return
        …                   ;others
LOOP:
        …                   ;subroutine
        RET                 ;return
```

RET   i

operation:	Return with parameter from the subroutine, and put the parameter in ACC
period:	2
affected flag bit:	None
example:	

```
        CALL    LOOP        ;call subroutine LOOP
        NOP                 ;this statement will be executed after RET instructions return
        …                   ;others
LOOP:
        …                   ;subroutine
        RET     35H         ;return, ACC=35H
```

RETI

operation:	Interrupt return
period:	2
affected flag bit:	None
example:	

```
INT_START                   ;interrupt entrance
        …                   ;interrupt procedure
        RETI                ;interrupt return
```

RLCA   [R]

operation:	Register R rotates to the left with C and save the result into ACC
period:	1
affected flag bit:	C
example:	

```
        LDIA    03H         ;load 03H to ACC
        LD      R01,A       ;load ACC to R01, R01=03H
        RLCA    R01         ;operation result: ACC=06H(C=0);
                                        ACC=07H(C=1)
                                        C=0
```

RLCR	**[R]**
operation:	Register R rotates one bit to the left with C, and save the result into R
period:	1
affected flag bit:	C
example:	

```
LDIA        03H             ;load 03H to ACC
LD          R01,A           ;load ACC to R01, R01=03H
RLCR        R01             ;operation result: R01=06H(C=0);
                                          R01=07H(C=1);
                                          C=0
```

RLA	**[R]**
operation:	Register R without C rotates to the left, and save the result into ACC
period:	1
affected flag bit:	None
example:	

```
LDIA        03H             ;load 03H to ACC
LD          R01,A           ;load ACC to R01, R01=03H
RLA         R01             ;operation result: ACC=06H
```

RLR	**[R]**
operation:	Register R without C rotates to the left, and save the result to R
period:	1
affected flag bit:	None
example:	

```
LDIA        03H             ;load 03H to ACC
LD          R01,A           ;load ACC to R01, R01=03H
RLR         R01             ;operation result: R01=06H
```

RRCA	**[R]**
operation:	Register R rotates one bit to the right with C, and puts the result into ACC
period:	1
affected flag bit:	C
example:	

```
LDIA        03H             ;load 03H to ACC
LD          R01,A           ;load ACC to R01, R01=03H
RRCA        R01             ;operation result: ACC=01H(C=0);
                                          ACC=081H(C=1);
                                          C=1
```

RRCR	**[R]**
operation:	Register R rotates one bit to the right with C, and save the result into R
period:	1
affected flag bit:	C
example:	

```
LDIA      03H        ;load 03H to ACC
LD        R01,A      ;load ACC to R01, R01=03H
RRCR      R01        ;operation result: R01=01H(C=0);
                                        R01=81H(C=1);
                                        C=1
```

RRA	**[R]**
operation:	Register R without C rotates one bit to the right, and save the result into ACC
period:	1
affected flag bit:	None
example:	

```
LDIA      03H        ;load 03H to ACC
LD        R01,A      ;load ACC to R01, R01=03H
RRA       R01        ;operation result: ACC=81H
```

RRR	**[R]**
operation:	Register R without C rotates one bit to the right, and save the result into R
period:	1
affected flag bit:	None
example:	

```
LDIA      03H        ;load 03H to ACC
LD        R01,A      ;load ACC to R01, R01=03H
RRR       R01        ;operation result: R01=81H
```

SET	**[R]**
operation:	Set all bits in register R as 1
period:	1
affected flag bit:	None
example:	

```
SET       R01        ;operation result: R01=0FFH
```

SETB	**[R],b**
operation:	Set b bit in register R to 1
period:	1
affected flag bit:	None
example:	

```
CLR       R01        ;R01=0
SETB      R01,3      ;operation result: R01=08H
```

STOP

operation:	Enter sleep		
period:	1		
affected flag bit:	TO, PD		
example:			
	STOP		;the chip enters the power saving mode, the CPU and oscillator stop working, and the IO port keeps the original state

SUBIA **i**

operation:	I minus ACC, save the result to ACC		
period:	1		
affected flag bit:	C,DC,Z,OV		
example:			
	LDIA	077H	;load 77H to ACC
	SUBIA	80H	;operation result: ACC=80H-77H=09H

SUBA **[R]**

operation:	Register R minus ACC, save the result to ACC		
period:	1		
affected flag bit:	C,DC,Z,OV		
example:			
	LDIA	080H	;load 80H to ACC
	LD	R01,A	;load ACC to R01, R01=80H
	LDIA	77H	;load 77H to ACC
	SUBA	R01	;operation result: ACC=80H-77H=09H

SUBR **[R]**

operation:	Register R minus ACC, save the result to R		
period:	1		
affected flag bit:	C,DC,Z,OV		
example:			
	LDIA	080H	;load 80H to ACC
	LD	R01,A	;load ACC to R01, R01=80H
	LDIA	77H	;load 77H to ACC
	SUBR	R01	;operation result: R01=80H-77H=09H

SUBCA	**[R]**
operation:	Register R minus ACC minus C, save the result to ACC
period:	1
affected flag bit:	C,DC,Z,OV
example:	

```
LDIA      080H        ; load 80H to ACC
LD        R01,A       ; load ACC to R01, R01=80H
LDIA      77H         ; load 77H to ACC
SUBCA     R01         ;operation result: ACC=80H-77H-C=09H(C=0);
                                         ACC=80H-77H-C=08H(C=1);
```

SUBCR	**[R]**
operation:	Register R minus ACC minus C, the result is put into R
period:	1
affected flag bit:	C,DC,Z,OV
example:	

```
LDIA      080H        ;load 80H to ACC
LD        R01,A       ;load ACC to R01, R01=80H
LDIA      77H         ;load 77H to ACC
SUBCR     R01         ;operation result: R01=80H-77H-C=09H(C=0)
                                         R01=80H-77H-C=08H(C=1)
```

SWAPA	**[R]**
operation:	Register R high and low half byte swap, the save result into ACC
period:	1
affected flag bit:	None
example:	

```
LDIA      035H        ;load 35H to ACC
LD        R01,A       ;load ACC to R01, R01=35H
SWAPA     R01         ;operation result: ACC=53H
```

SWAPR	**[R]**
operation:	Register R high and low half byte swap, the save result into R
period:	1
affected flag bit:	None
example:	

```
LDIA      035H        ;load 35H to ACC
LD        R01,A       ;load ACC to R01, R01=35H
SWAPR     R01         ;operation result: R01=53H
```

SZB	**[R],b**
operation:	Determine the bit b of register R, if it is 0 then jump, otherwise execute in sequence
period:	1 or 2
affected flag bit:	None
example:	

```
SZB     R01,3       ;determine 3rd bit of R01
JP      LOOP        ;if is 1, execute, jump to LOOP
JP      LOOP1       ;if is 0, jump, execute, jump to LOOP1
```

SNZB	**[R],b**
operation:	Determine the bit b of register R, if it is 1 then jump, otherwise execute in sequence
period:	1 or 2
affected flag bit:	None
example:	

```
SNZB    R01,3       ;determine 3rd bit of R01
JP      LOOP        ;if is 0, execute, jump to LOOP
JP      LOOP1       ;if is 1, jump, execute, jump to LOOP1
```

SZA	**[R]**
operation:	Load the value of R to ACC, if it is 0 then jump, otherwise execute in sequence
period:	1 or 2
affected flag bit:	None
example:	

```
SZA     R01         ;R01→ACC
JP      LOOP        ;if R01 is not 0, execute, jump to LOOP
JP      LOOP1       ;if R01 is 0, jump, execute, jump to LOOP1
```

SZR	**[R]**
operation:	Load the value of R to R, if it is 0 then jump, otherwise execute in sequence
period:	1 or 2
affected flag bit:	None
example:	

```
SZR     R01         ;R01→R01
JP      LOOP        ;if R01 is not 0, execute, jump to LOOP
JP      LOOP1       ;if R01 is 0, jump, execute, jump to LOOP1
```

SZINCA	**[R]**
operation:	Increment register by 1, save the result to ACC, if it is 0 then jump, otherwise execute in sequence
period:	1 or 2
affected flag bit:	None
example:	

```
SZINCA    R01          ;R01+1→ACC
JP        LOOP         ;if ACC is not 0, execute, jump to LOOP
JP        LOOP1        ;if ACC is 0, jump, execute, jump to LOOP1
```

SZINCR	**[R]**
operation:	Increment register by 1, save the result to R, if it is 0 then jump, otherwise execute in sequence
period:	1 or 2
affected flag bit:	None
example:	

```
SZINCR    R01          ;R01+1→R01
JP        LOOP         ;if R01 is not 0, execute, jump to LOOP
JP        LOOP1        ;if R01 is 0, jump, execute, jump to LOOP1
```

SZDECA	**[R]**
operation:	decrement register by 1, save the result to ACC, if it is 0 then jump, otherwise execute in sequence
period:	1 or 2
affected flag bit:	None
example:	

```
SZDECA    R01          ;R01-1→ACC
JP        LOOP         ;if ACC is not 0, execute, jump to LOOP
JP        LOOP1        ;if ACC is 0, jump, execute, jump to LOOP1
```

SZDECR	**[R]**
operation:	Decrement register by 1, save the result to R, if it is 0 then jump, otherwise execute in sequence
period:	1 or 2
affected flag bit:	None
example:	

```
SZDECR    R01          ;R01-1→R01
JP        LOOP         ;if R01 is not 0, execute, jump to LOOP
JP        LOOP1        ;if R01 is 0, jump, execute, jump to LOOP1

…
ORG       0115H
DW        1234H
```

TESTZ	**[R]**
operation:	Pass the R to R, as affected Z flag bit
period:	1
affected flag bit:	Z
example:	

```
TESTZ       R0            ;Pass the value of register R0 to R0, which is used to influence the
                          Z flag bit
SZB         STATUS,Z      ;check Z flag bit, if it is 0 then jump
JP          Add1          ;if R0 is 0, jump to address Add1
JP          Add2          ;if R0 is not 0, jump to address Add2
```

XORIA	**i**
operation:	Perform ‘XOR’ on I and ACC, save the result to ACC
period:	1
affected flag bit:	Z
example:	

```
LDIA        0AH           ;load 0AH to ACC
XORIA       0FH           ;execute: ACC=05H
```

XORA	**[R]**
operation:	Perform ‘XOR’ on I and ACC, save the result to ACC
period:	1
affected flag bit:	Z
example:	

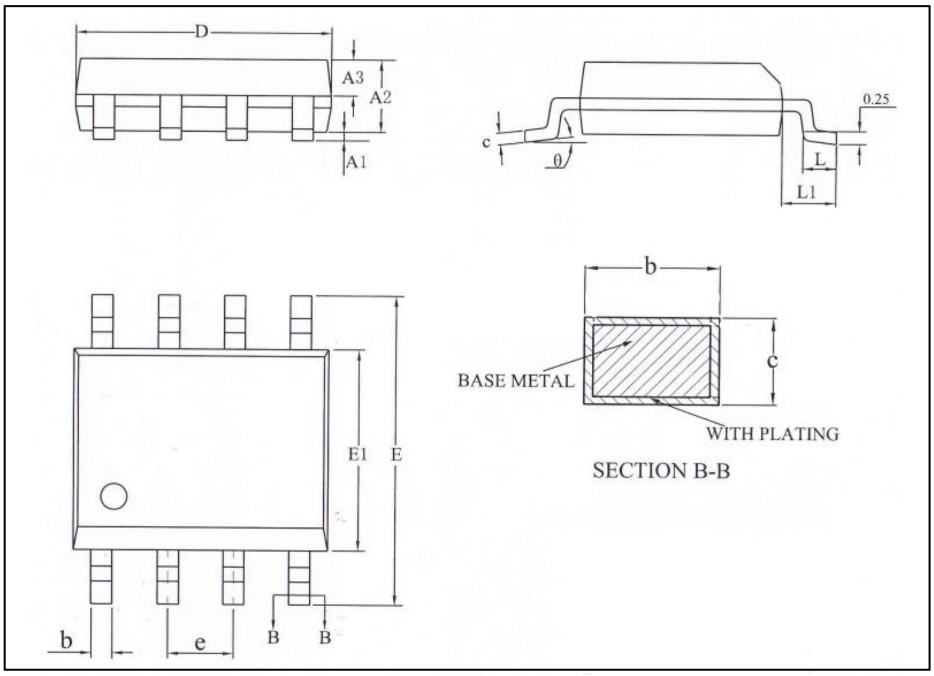
```
LDIA        0AH           ;load 0AH to ACC
LD          R01,A         ;load ACC to R01, R01=0AH
LDIA        0FH           ;load 0FH to ACC
XORA        R01           ;execute: ACC=05H
```

XORR	**[R]**
operation:	Perform ‘XOR’ on R and ACC, save the result to R
period:	1
affected flag bit:	Z
example:	

```
LDIA        0AH           ;load 0AH to ACC
LD          R01,A         ;load ACC to R01, R01=0AH
LDIA        0FH           ;load 0FH to ACC
XORR        R01           ;execute: R01=05H
```

14. Package

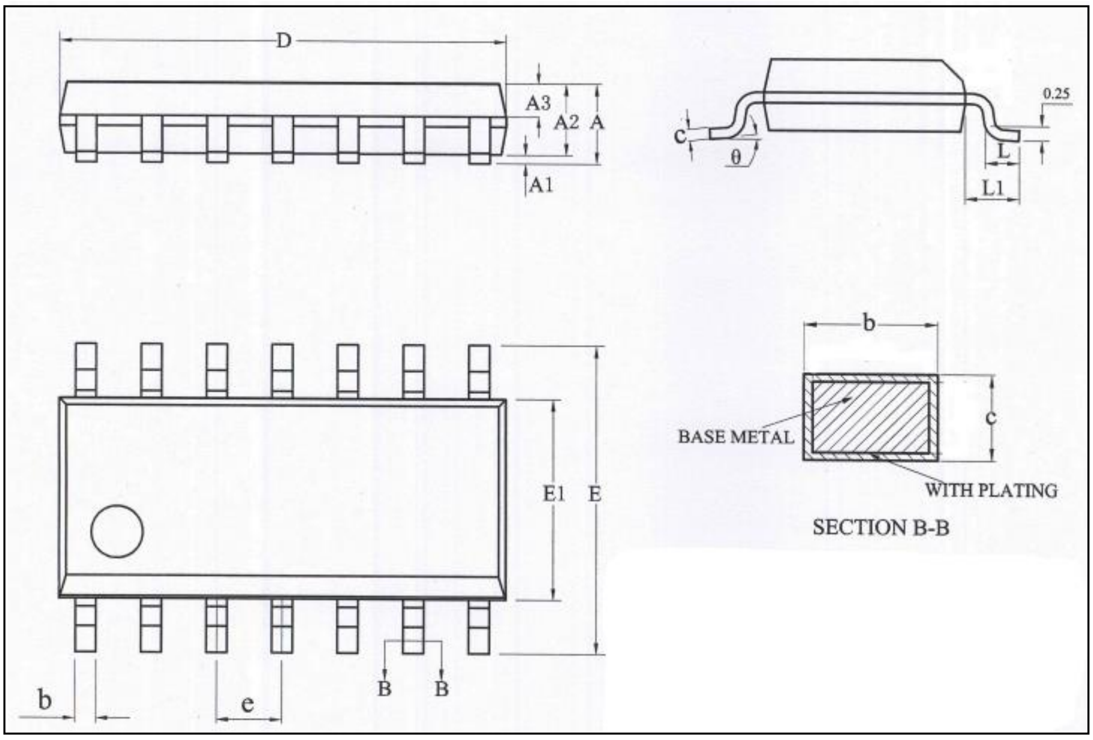
14.1 SOP8



Symbol	Millimeter		
	Min	Nom	Max
A1	0.05	-	0.25
A2	1.30	1.40	1.60
A3	0.55	-	0.70
b	0.33	-	0.51
c	0.17	-	0.26
D	4.70	-	5.10
E	5.80	6.00	6.20
E1	3.70	-	4.10
e	1.27BSC		
L	0.40	-	0.80
L1	1.05REF		
θ	0	-	8°

Caution: Package dimensions do not include mold flash or gate burrs.

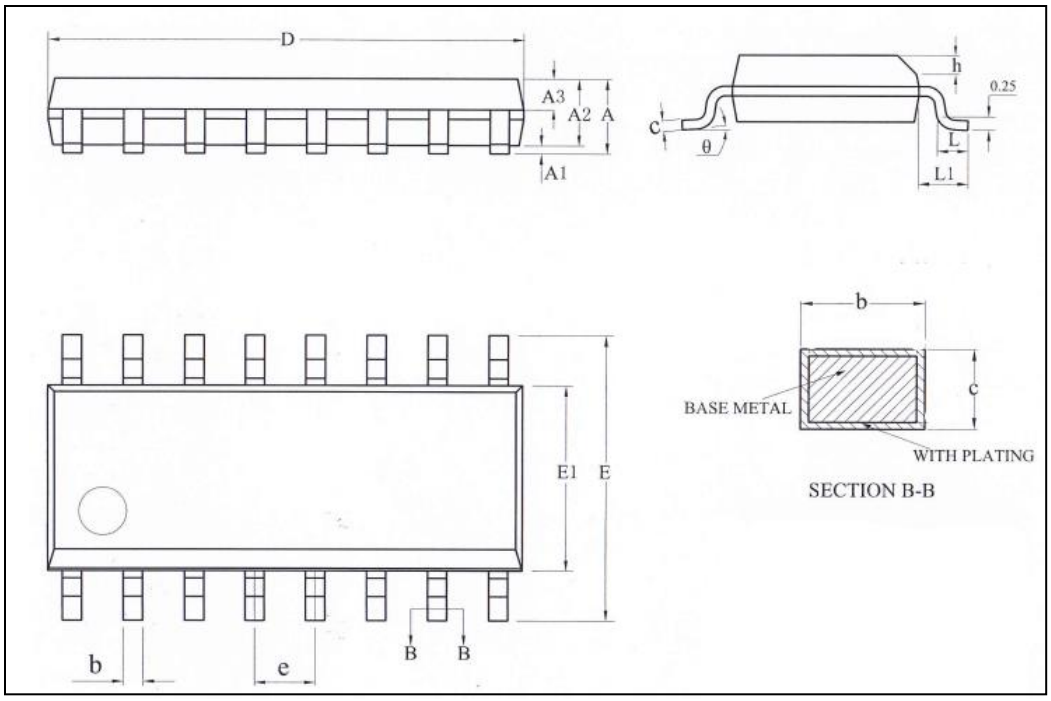
14.2 SOP14



Symbol	Millimeter		
	Min	Nom	Max
A	-	-	1.85
A1	0.05	-	0.25
A2	1.30	-	1.60
A3	0.60	0.65	0.70
b	0.356	-	0.47
c	0.193	-	0.26
D	8.45	-	8.85
E	5.80	6.00	6.20
E1	3.70	-	4.10
e	1.27BSC		
L	0.40	-	0.80
L1	1.05REF		
θ	0	-	8°

Caution: Package dimensions do not include mold flash or gate burrs.

14.3 SOP16



Symbol	Millimeter		
	Min	Nom	Max
A	-	-	1.85
A1	0.05	-	0.25
A2	1.30	-	1.60
A3	0.60	-	0.71
b	0.356	-	0.51
c	0.20	-	0.26
D	9.70	-	10.10
E	5.80	6.00	6.20
E1	3.70	-	4.10
e	1.27BSC		
h	0.25	-	0.50
L	0.40	-	0.80
L1	1.05REF		
θ	0	-	8°

Caution: Package dimensions do not include mold flash or gate burrs.

15. Revision History

Version	Date	Revision content
V1.0.0	February 2023	Initial version
V1.0.1	January 2024	Modified some parameters in section 12.3 Comparator characteristics
V1.0.2	July 2024	Added SC8P053AD416SP model, description of registers related to RA4 and RA5 pins, and description of PWMC0 function of RA5
V1.0.3	September 2024	Revised the cover page and open Fast memory space
V1.0.4	October 2024	Modified SOP8/SOP14/SOP16 package dimensions