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What is "Embedded - Microcontrollers"?

"Embedded - Microcontrollers" refer to small, integrated circuits designed to perform specific tasks within larger systems. These microcontrollers are essentially compact computers on a single chip, containing a processor core, memory, and programmable input/output peripherals. They are called "embedded" because they are embedded within electronic devices to control various functions, rather than serving as standalone computers. Microcontrollers are crucial in modern electronics, providing the intelligence and control needed for a wide range of applications.

Applications of "Embedded - Microcontrollers"

Details	
Product Status	Active
Core Processor	PIC
Core Size	8-Bit
Speed	4MHz
Connectivity	-
Peripherals	Brown-out Detect/Reset, POR, WDT
Number of I/O	13
Program Memory Size	3.5KB (2K x 14)
Program Memory Type	OTP
EEPROM Size	128 x 8
RAM Size	128 x 8
Voltage - Supply (Vcc/Vdd)	3V ~ 5.5V
Data Converters	-
Oscillator Type	External
Operating Temperature	-40°C ~ 85°C (TA)
Mounting Type	Surface Mount
Package / Case	20-SSOP (0.209", 5.30mm Width)
Supplier Device Package	20-SSOP
Purchase URL	https://www.e-xfl.com/product-detail/microchip-technology/pic16ce625-04i-ss

TABLE 1-1: PIC16CE62X FAMILY OF DEVICES

		PIC16CE623	PIC16CE624	PIC16CE625
Clock	Maximum Frequency of Operation (MHz)	20	20	20
Memory	EPROM Program Memory (x14 words)	512	1K	2K
	Data Memory (bytes)	96	96	128
Peripherals	EEPROM Data Memory (bytes)	128	128	128
	Timer Module(s)	TMR0	TMR0	TMR0
	Comparators(s)	2	2	2
	Internal Reference Voltage	Yes	Yes	Yes
Features	Interrupt Sources	4	4	4
	I/O Pins	13	13	13
	Voltage Range (Volts)	2.5-5.5	2.5-5.5	2.5-5.5
	Brown-out Reset	Yes	Yes	Yes
	Packages	18-pin DIP, SOIC; 20-pin SSOP	18-pin DIP, SOIC; 20-pin SSOP	18-pin DIP, SOIC; 20-pin SSOP

All PIC® Family devices have Power-on Reset, selectable Watchdog Timer, selectable code protect and high I/O current capability.
All PIC16CE62X Family devices use serial programming with clock pin RB6 and data pin RB7.

4.2.2.2 OPTION REGISTER

The OPTION register is a readable and writable register which contains various control bits to configure the TMR0/WDT prescaler, the external RB0/INT interrupt, TMR0 and the weak pull-ups on PORTB.

Note: To achieve a 1:1 prescaler assignment for TMR0, assign the prescaler to the WDT (PSA = 1).

REGISTER 4-2: OPTION REGISTER (ADDRESS 81H)

R/W-1	R/W-1	R/W-1	R/W-1	R/W-1	R/W-1	R/W-1	R/W-1
$\overline{\text{RBPU}}$	INTEDG	T0CS	T0SE	PSA	PS2	PS1	PS0
bit7							bit0

R = Readable bit
W = Writable bit
U = Unimplemented bit, read as '0'
-n = Value at POR reset
-x = Unknown at POR reset

bit 7: **$\overline{\text{RBPU}}$**: PORTB Pull-up Enable bit
1 = PORTB pull-ups are disabled
0 = PORTB pull-ups are enabled by individual port latch values

bit 6: **INTEDG**: Interrupt Edge Select bit
1 = Interrupt on rising edge of RB0/INT pin
0 = Interrupt on falling edge of RB0/INT pin

bit 5: **T0CS**: TMR0 Clock Source Select bit
1 = Transition on RA4/T0CKI pin
0 = Internal instruction cycle clock (CLKOUT)

bit 4: **T0SE**: TMR0 Source Edge Select bit
1 = Increment on high-to-low transition on RA4/T0CKI pin
0 = Increment on low-to-high transition on RA4/T0CKI pin

bit 3: **PSA**: Prescaler Assignment bit
1 = Prescaler is assigned to the WDT
0 = Prescaler is assigned to the Timer0 module

bit 2-0: **PS<2:0>**: Prescaler Rate Select bits

Bit Value	TMR0 Rate	WDT Rate
000	1 : 2	1 : 1
001	1 : 4	1 : 2
010	1 : 8	1 : 4
011	1 : 16	1 : 8
100	1 : 32	1 : 16
101	1 : 64	1 : 32
110	1 : 128	1 : 64
111	1 : 256	1 : 128

5.0 I/O PORTS

The PIC16CE62X parts have two ports, PORTA and PORTB. Some pins for these I/O ports are multiplexed with an alternate function for the peripheral features on the device. In general, when a peripheral is enabled, that pin may not be used as a general purpose I/O pin.

5.1 PORTA and TRISA Registers

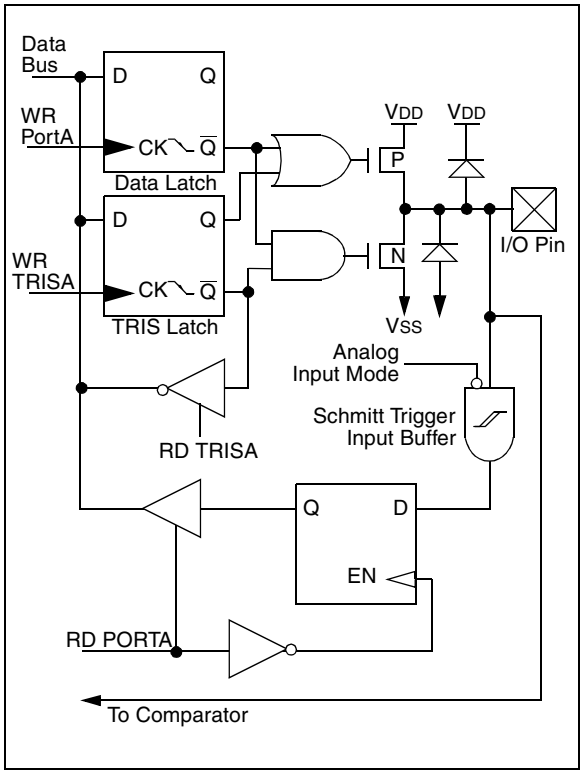
PORTA is a 5-bit wide latch. RA4 is a Schmitt Trigger input and an open drain output. Port RA4 is multiplexed with the T0CKI clock input. All other RA port pins have Schmitt Trigger input levels and full CMOS output drivers. All pins have data direction bits (TRIS registers), which can configure these pins as input or output.

A '1' in the TRISA register puts the corresponding output driver in a hi- impedance mode. A '0' in the TRISA register puts the contents of the output latch on the selected pin(s).

Reading the PORTA register reads the status of the pins, whereas writing to it will write to the port latch. All write operations are read-modify-write operations. So a write to a port implies that the port pins are first read, then this value is modified and written to the port data latch.

The PORTA pins are multiplexed with comparator and voltage reference functions. The operation of these pins are selected by control bits in the CMCON (Comparator Control Register) register and the VRCON (Voltage Reference Control Register) register. When selected as a comparator input, these pins will read as '0's.

FIGURE 5-1: BLOCK DIAGRAM OF RA<1:0> PINS



Note:	On reset, the TRISA register is set to all inputs. The digital inputs are disabled and the comparator inputs are forced to ground to reduce excess current consumption.

TRISA controls the direction of the RA pins, even when they are being used as comparator inputs. The user must make sure to keep the pins configured as inputs when using them as comparator inputs.

The RA2 pin will also function as the output for the voltage reference. When in this mode, the VREF pin is a very high impedance output. The user must configure TRISA<2> bit as an input and use high impedance loads.

In one of the comparator modes defined by the CMCON register, pins RA3 and RA4 become outputs of the comparators. The TRISA<4:3> bits must be cleared to enable outputs to use this function.

EXAMPLE 5-1: INITIALIZING PORTA

```
CLRF   PORTA       ;Initialize PORTA by setting
                   ;output data latches
MOVLW  0X07        ;Turn comparators off and
MOVWF  CMCON       ;enable pins for I/O
                   ;functions
BSF    STATUS, RP0 ;Select Bank1
MOVLW  0x1F        ;Value used to initialize
                   ;data direction
MOVWF  TRISA       ;Set RA<4:0> as inputs
                   ;TRISA<7:5> are always
                   ;read as '0'.
```

FIGURE 5-2: BLOCK DIAGRAM OF RA2 PIN

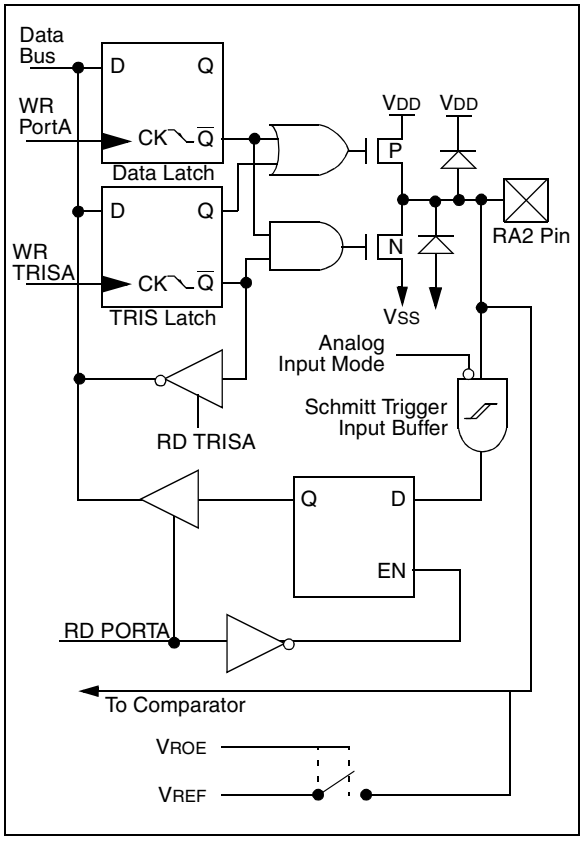


FIGURE 5-3: BLOCK DIAGRAM OF RA3 PIN

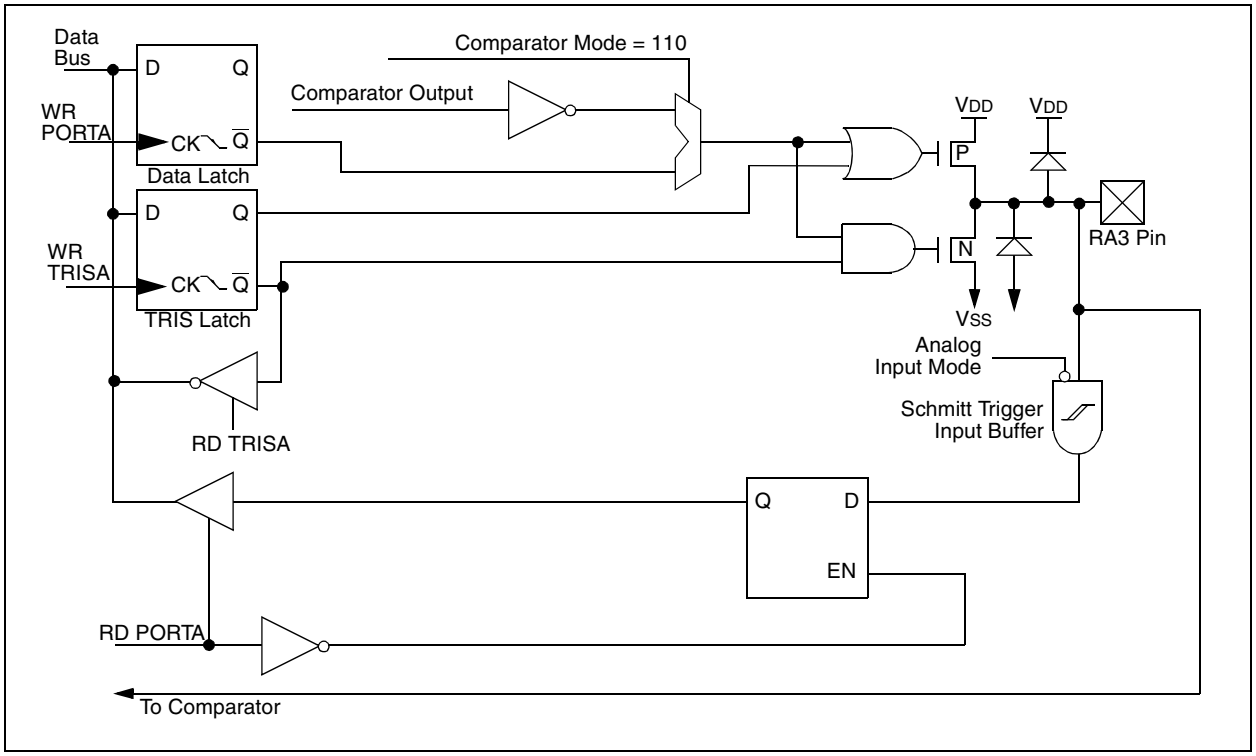
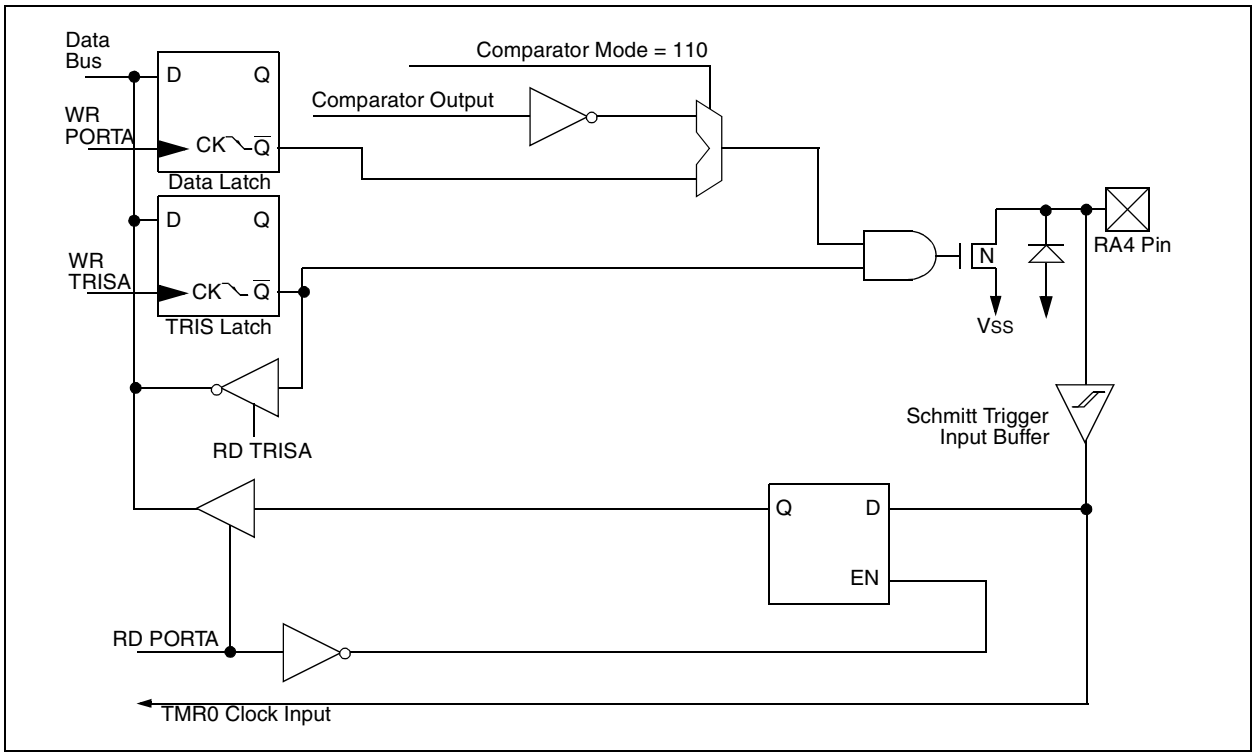


FIGURE 5-4: BLOCK DIAGRAM OF RA4 PIN



6.3 Write Operations

6.3.1 BYTE WRITE

Following the start signal from the processor, the device code (4 bits), the don't care bits (3 bits), and the R/$\overline{W}$ bit, which is a logic low, is placed onto the bus by the processor. This indicates to the EEPROM that a byte with a word address will follow after it has generated an acknowledge bit during the ninth clock cycle. Therefore, the next byte transmitted by the processor is the word address and will be written into the address pointer of the EEPROM. After receiving another acknowledge signal from the EEPROM, the processor will transmit the data word to be written into the addressed memory location. The EEPROM acknowledges again and the processor generates a stop condition. This initiates the internal write cycle, and during this time, the EEPROM will not generate acknowledge signals (Figure 6-5).

6.3.2 PAGE WRITE

The write control byte, word address and the first data byte are transmitted to the EEPROM in the same way as in a byte write. But instead of generating a stop condition, the processor transmits up to eight data bytes to the EEPROM, which are temporarily stored in the on-chip page buffer and will be written into the memory after the processor has transmitted a stop condition. After the receipt of each word, the three lower order address pointer bits are internally incremented by one. The higher order five bits of the word address remains constant. If the processor should transmit more than eight words prior to generating the stop condition, the address counter will roll over and the previously received data will be overwritten. As with the byte write operation, once the stop condition is received, an internal write cycle will begin (Figure 6-6).

6.4 Acknowledge Polling

Since the EEPROM will not acknowledge during a write cycle, this can be used to determine when the cycle is complete (this feature can be used to maximize bus throughput). Once the stop condition for a write command has been issued from the processor, the EEPROM initiates the internally timed write cycle. ACK polling can be initiated immediately. This involves the processor sending a start condition followed by the control byte for a write command (R/$\overline{W}$ = 0). If the device is still busy with the write cycle, then no ACK will be returned. If no ACK is returned, then the start bit and control byte must be re-sent. If the cycle is complete, then the device will return the ACK and the processor can then proceed with the next read or write command. See Figure 6-4 for flow diagram.

FIGURE 6-4: ACKNOWLEDGE POLLING FLOW

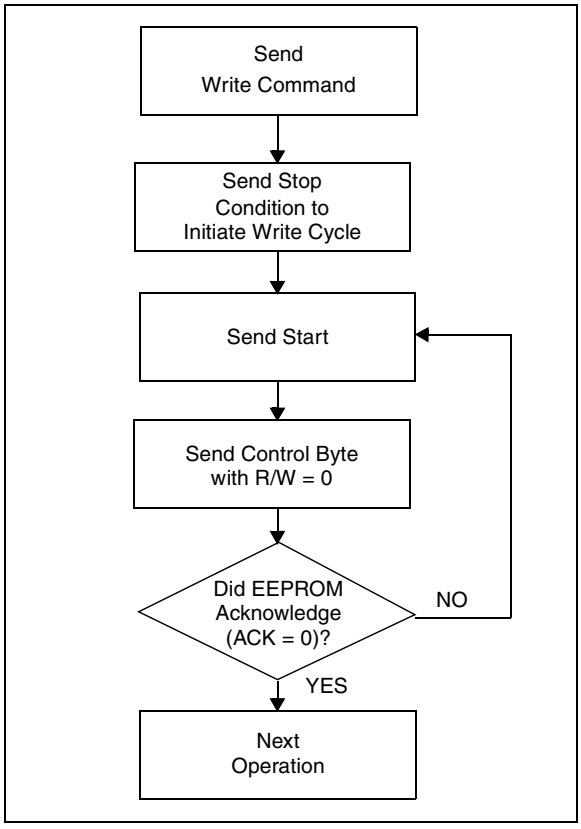


FIGURE 6-5: BYTE WRITE

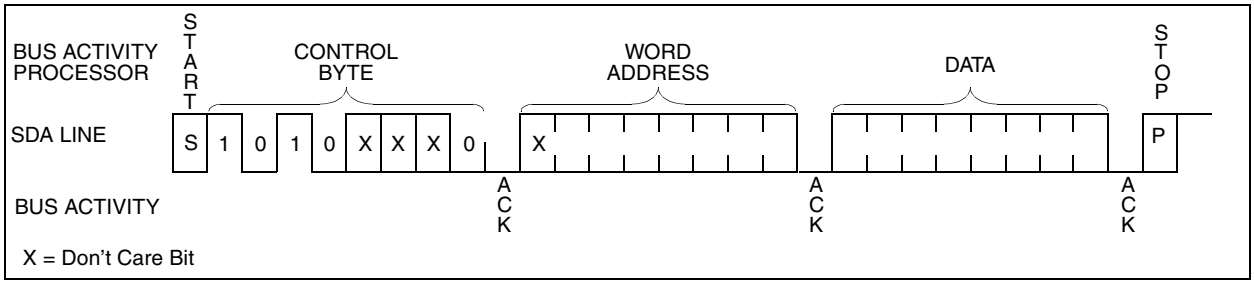
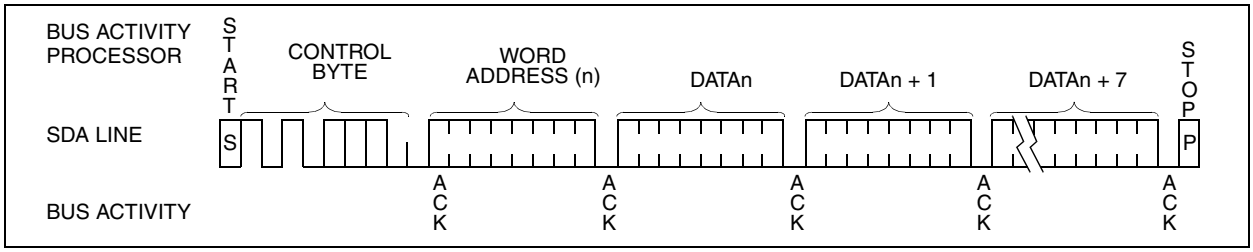


FIGURE 6-6: PAGE WRITE



6.5 Read Operation

Read operations are initiated in the same way as write operations with the exception that the R/$\overline{W}$ bit of the EEPROM address is set to one. There are three basic types of read operations: current address read, random read, and sequential read.

6.6 Current Address Read

The EEPROM contains an address counter that maintains the address of the last word accessed, internally incremented by one. Therefore, if the previous access (either a read or write operation) was to address n, the next current address read operation would access data from address n + 1. Upon receipt of the EEPROM address with R/$\overline{W}$ bit set to one, the EEPROM issues an acknowledge and transmits the eight bit data word. The processor will not acknowledge the transfer, but does generate a stop condition and the EEPROM discontinues transmission (Figure 6-7).

6.7 Random Read

Random read operations allow the processor to access any memory location in a random manner. To perform this type of read operation, first the word address must be set. This is done by sending the word address to the EEPROM as part of a write operation. After the word address is sent, the processor generates a start condition following the acknowledge. This terminates the write operation, but not before the internal address pointer is set. Then the processor issues the control byte again, but with the R/$\overline{W}$ bit set to a one. The EEPROM will then issue an acknowledge and transmits the eight bit data word. The processor will not acknowledge the transfer, but does generate a stop condition and the EEPROM discontinues transmission (Figure 6-8).

6.8 Sequential Read

Sequential reads are initiated in the same way as a random read except that after the EEPROM transmits the first data byte, the processor issues an acknowledge as opposed to a stop condition in a random read. This directs the EEPROM to transmit the next sequentially addressed 8-bit word (Figure 6-9).

To provide sequential reads, the EEPROM contains an internal address pointer which is incremented by one at the completion of each operation. This address pointer allows the entire memory contents to be serially read during one operation.

6.9 Noise Protection

The EEPROM employs a VCC threshold detector circuit, which disables the internal erase/write logic if the VCC is below 1.5 volts at nominal conditions.

The SCL and SDA inputs have Schmitt trigger and filter circuits, which suppress noise spikes to assure proper device operation even on a noisy bus.

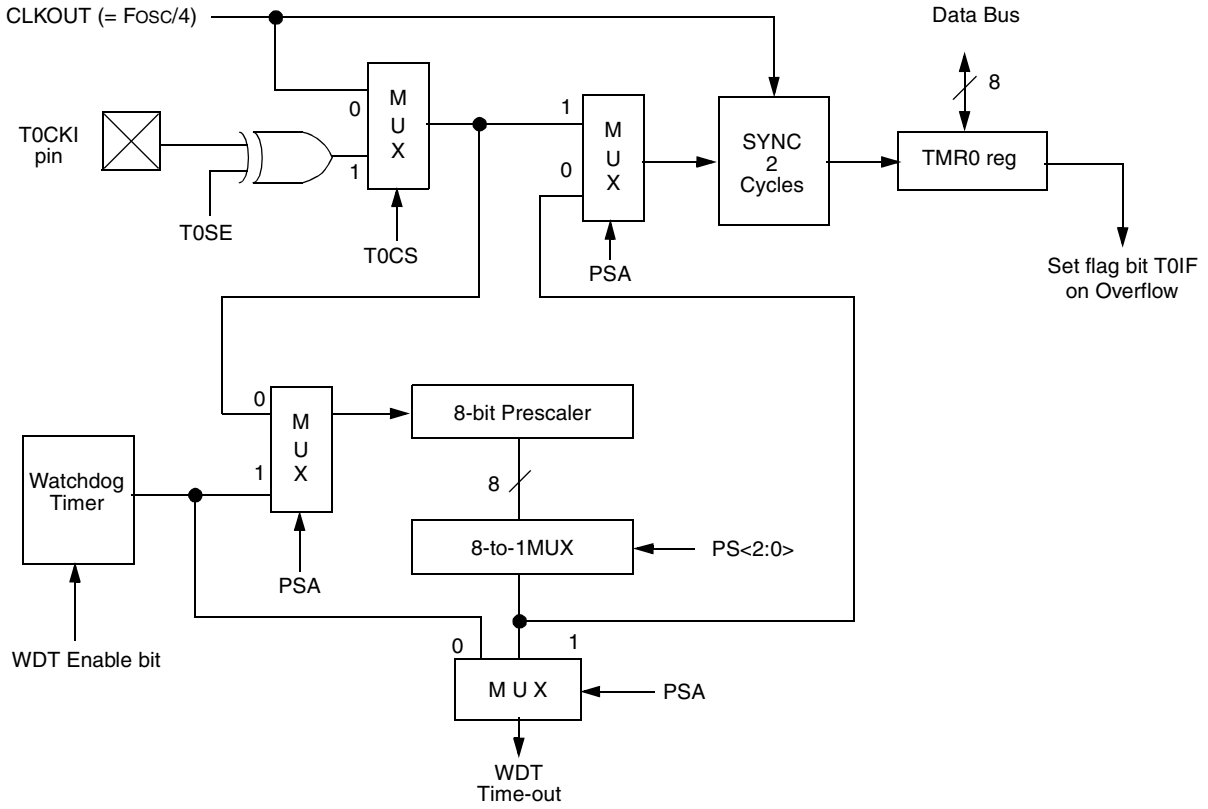
7.3 Prescaler

An 8-bit counter is available as a prescaler for the Timer0 module, or as a postscaler for the Watchdog Timer, respectively (Figure 7-6). For simplicity, this counter is being referred to as “prescaler” throughout this data sheet. Note that there is only one prescaler available which is mutually exclusive between the Timer0 module and the Watchdog Timer. Thus, a prescaler assignment for the Timer0 module means that there is no prescaler for the Watchdog Timer and vice-versa.

The PSA and PS<2:0> bits (OPTION<3:0>) determine the prescaler assignment and prescale ratio.

When assigned to the Timer0 module, all instructions writing to the TMR0 register (i.e., `CLRF 1, MOVWF 1, BSF 1,x`....etc.) will clear the prescaler. When assigned to WDT, a `CLRWDT` instruction will clear the prescaler along with the Watchdog Timer. The prescaler is not readable or writable.

FIGURE 7-6: BLOCK DIAGRAM OF THE TIMER0/WDT PRESCALER



Note: T0SE, T0CS, PSA, PS<2:0> are bits in the OPTION register.

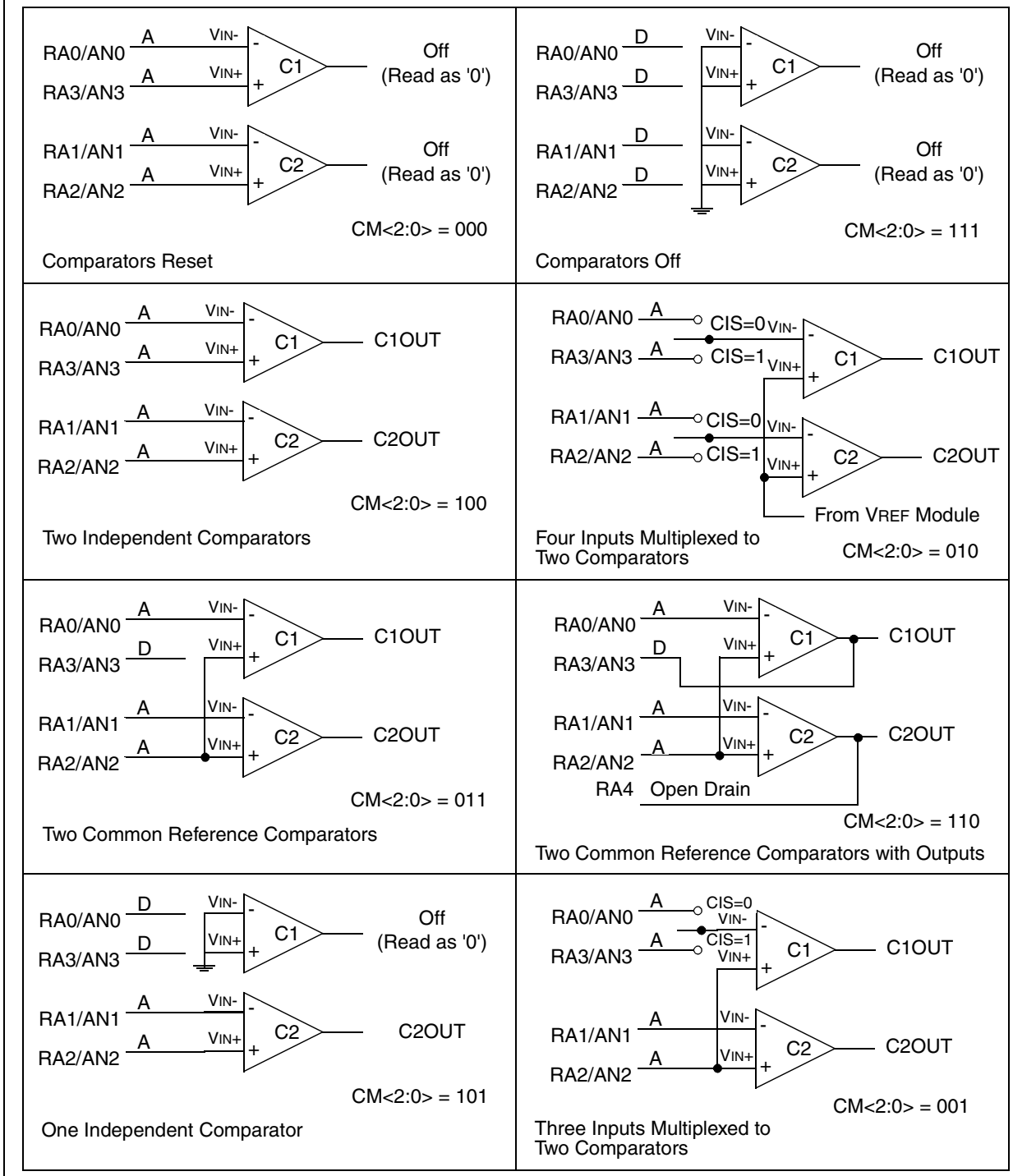
NOTES:

8.1 Comparator Configuration

There are eight modes of operation for the comparators. The CMCON register is used to select the mode. Figure 8-1 shows the eight possible modes. The TRISA register controls the data direction of the comparator pins for each mode. If the comparator mode is changed, the comparator output level may not be valid for the specified mode change delay shown in Table 13-1.

Note:	Comparator interrupts should be disabled during a comparator mode change, otherwise a false interrupt may occur.

FIGURE 8-1: COMPARATOR I/O OPERATING MODES



A = Analog Input, Port Reads Zeros Always
D = Digital Input
CIS = CMCON<3>, Comparator Input Switch

The code example in Example 8-1 depicts the steps required to configure the comparator module. RA3 and RA4 are configured as digital output. RA0 and RA1 are configured as the V- inputs and RA2 as the V+ input to both comparators.

EXAMPLE 8-1: INITIALIZING COMPARATOR MODULE

```
FLAG_REG EQU          0X20
CLRF     FLAG_REG     ;Init flag register
CLRF     PORTA        ;Init PORTA
MOVF     CMCON,W      ;Move comparator contents to W
ANDLW    0xC0         ;Mask comparator bits
IORWF    FLAG_REG,F   ;Store bits in flag register
MOVLW    0x03         ;Init comparator mode
MOVWF    CMCON        ;CM<2:0> = 011
BSF      STATUS,RP0   ;Select Bank1
MOVLW    0x07         ;Initialize data direction
MOVWF    TRISA        ;Set RA<2:0> as inputs
                      ;RA<4:3> as outputs
                      ;TRISA<7:5> always read '0'
BCF      STATUS,RP0   ;Select Bank 0
CALL     DELAY 10     ;10µs delay
MOVF     CMCON,F      ;Read CMCONtoendchangecondition
BCF      PIR1,CMIF    ;Clear pending interrupts
BSF      STATUS,RP0   ;Select Bank 1
BSF      PIE1,CMIE    ;Enable comparator interrupts
BCF      STATUS,RP0   ;Select Bank 0
BSF      INTCON,PEIE  ;Enable peripheral interrupts
BSF      INTCON,GIE   ;Global interrupt enable
```

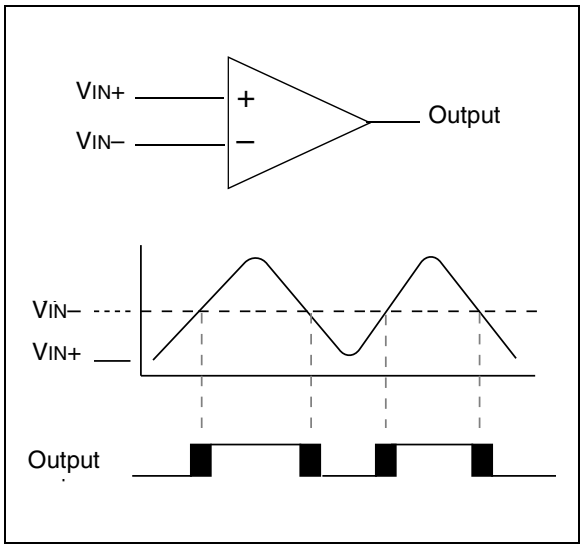
8.2 Comparator Operation

A single comparator is shown in Figure 8-2 along with the relationship between the analog input levels and the digital output. When the analog input at VIN+ is less than the analog input VIN–, the output of the comparator is a digital low level. When the analog input at VIN+ is greater than the analog input VIN–, the output of the comparator is a digital high level. The shaded areas of the output of the comparator in Figure 8-2 represent the uncertainty due to input offsets and response time.

8.3 Comparator Reference

An external or internal reference signal may be used depending on the comparator operating mode. The analog signal that is present at VIN– is compared to the signal at VIN+, and the digital output of the comparator is adjusted accordingly (Figure 8-2).

FIGURE 8-2: SINGLE COMPARATOR



8.3.1 EXTERNAL REFERENCE SIGNAL

When external voltage references are used, the comparator module can be configured to have the comparators operate from the same or different reference sources. However, threshold detector applications may require the same reference. The reference signal must be between VSS and VDD and can be applied to either pin of the comparator(s).

8.3.2 INTERNAL REFERENCE SIGNAL

The comparator module also allows the selection of an internally generated voltage reference for the comparators. Section 13, Instruction Sets, contains a detailed description of the Voltage Reference Module that provides this signal. The internal reference signal is used when the comparators are in mode CM<2:0>=010 (Figure 8-1). In this mode, the internal voltage reference is applied to the VIN+ pin of both comparators.

9.0 VOLTAGE REFERENCE MODULE

The Voltage Reference is a 16-tap resistor ladder network that provides a selectable voltage reference. The resistor ladder is segmented to provide two ranges of VREF values and has a power-down function to conserve power when the reference is not being used. The VRCON register controls the operation of the reference as shown in Register 9-1. The block diagram is given in Figure 9-1.

9.1 Configuring the Voltage Reference

The Voltage Reference can output 16 distinct voltage levels for each range.

The equations used to calculate the output of the Voltage Reference are as follows:

if VRR = 1: VREF = (VR<3:0>/24) x VDD

if VRR = 0: VREF = (VDD x 1/4) + (VR<3:0>/32) x VDD

The setting time of the Voltage Reference must be considered when changing the VREF output (Table 13-1). Example 9-1 shows an example of how to configure the Voltage Reference for an output voltage of 1.25V with VDD = 5.0V.

REGISTER 9-1: VRCON REGISTER (ADDRESS 9Fh)

R/W-0	R/W-0	R/W-0	U-0	R/W-0	R/W-0	R/W-0	R/W-0
VREN	VROE	VRR	—	VR3	VR2	VR1	VR0
bit7							bit0

R = Readable bit
W = Writable bit
U = Unimplemented bit, read as '0'
- n = Value at POR reset

bit 7: **VREN:** VREF Enable
1 = VREF circuit powered on
0 = VREF circuit powered down, no IDD drain

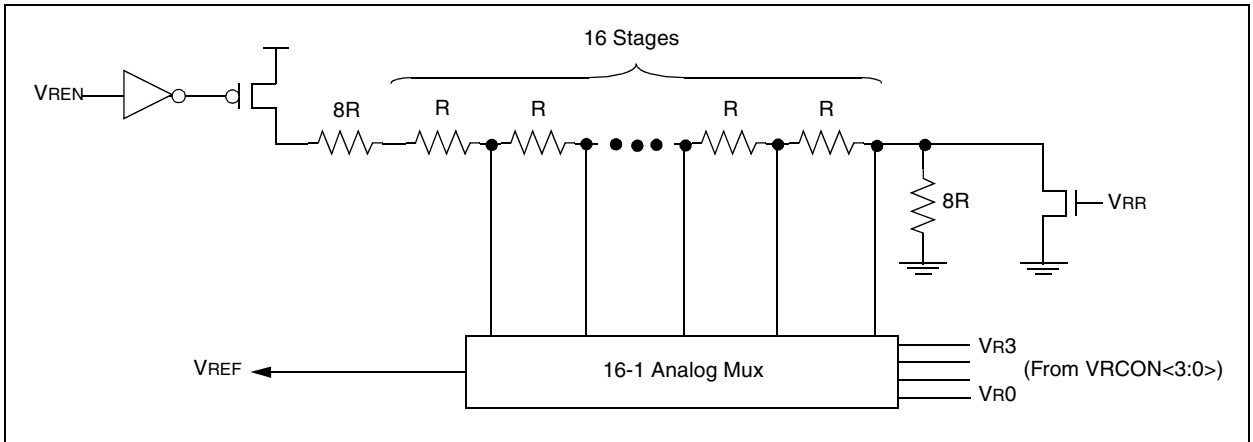
bit 6: **VROE:** VREF Output Enable
1 = VREF is output on RA2 pin
0 = VREF is disconnected from RA2 pin

bit 5: **VRR:** VREF Range selection
1 = Low Range
0 = High Range

bit 4: **Unimplemented:** Read as '0'

bit 3-0: **VR<3:0>**: VREF value selection 0 ≤ VR [3:0] ≤ 15
when VRR = 1: VREF = (VR<3:0>/ 24) * VDD
when VRR = 0: VREF = 1/4 * VDD + (VR<3:0>/ 32) * VDD

FIGURE 9-1: VOLTAGE REFERENCE BLOCK DIAGRAM



Note: R is defined in Table 13-2.

10.1 Configuration Bits

The configuration bits can be programmed (read as '0') or left unprogrammed (read as '1') to select various device configurations. These bits are mapped in program memory location 2007h.

The user will note that address 2007h is beyond the user program memory space. In fact, it belongs to the special test/configuration memory space (2000h – 3FFFh), which can be accessed only during programming.

REGISTER 10-1: CONFIGURATION WORD

CP1	CP0(2)	CP1	CP0(2)	CP1	CP0(2)	—	BODEN(1)	CP1	CP0(2)	$\overline{\text{PWRTE}}$(1)	WDTE	F0SC1	F0SC0
bit13													bit0

CONFIG Address
REGISTER: 2007h

bit 13-8, 5-4: **CP1:CP0 Pairs:** Code protection bit pairs(2)
Code protection for 2K program memory
11 = Program memory code protection off
10 = 0400h-07FFh code protected
01 = 0200h-07FFh code protected
00 = 0000h-07FFh code protected
Code protection for 1K program memory
11 = Program memory code protection off
10 =Program memory code protection on
01 = 0200h-03FFh code protected
00 = 0000h-03FFh code protected
Code protection for 0.5K program memory
11 = Program memory code protection off
10 = Program memory code protection off
01 = Program memory code protection off
00 = 0000h-01FFh code protected

bit 7: **Unimplemented**: Read as '1'

bit 6: **BODEN**: Brown-out Reset Enable bit (1)
1 = BOD enabled
0 = BOD disabled

bit 3: **$\overline{\text{PWRTE}}$**: Power-up Timer Enable bit (1)
1 = PWRT disabled
0 = PWRT enabled

bit 2: **WDTE**: Watchdog Timer Enable bit
1 = WDT enabled
0 = WDT disabled

bit 1-0: **FOSC1:FOSC0**: Oscillator Selection bits
11 = RC oscillator
10 = HS oscillator
01 = XT oscillator
00 = LP oscillator

Note 1: Enabling Brown-out Reset automatically enables Power-up Timer (PWRT), regardless of the value of bit $\overline{\text{PWRTE}}$. Ensure the Power-up Timer is enabled anytime Brown-out Reset is enabled.
2: All of the CP<1:0> pairs have to be given the same value to enable the code protection scheme listed.

10.3 Reset

The PIC16CE62X differentiates between various kinds of reset:

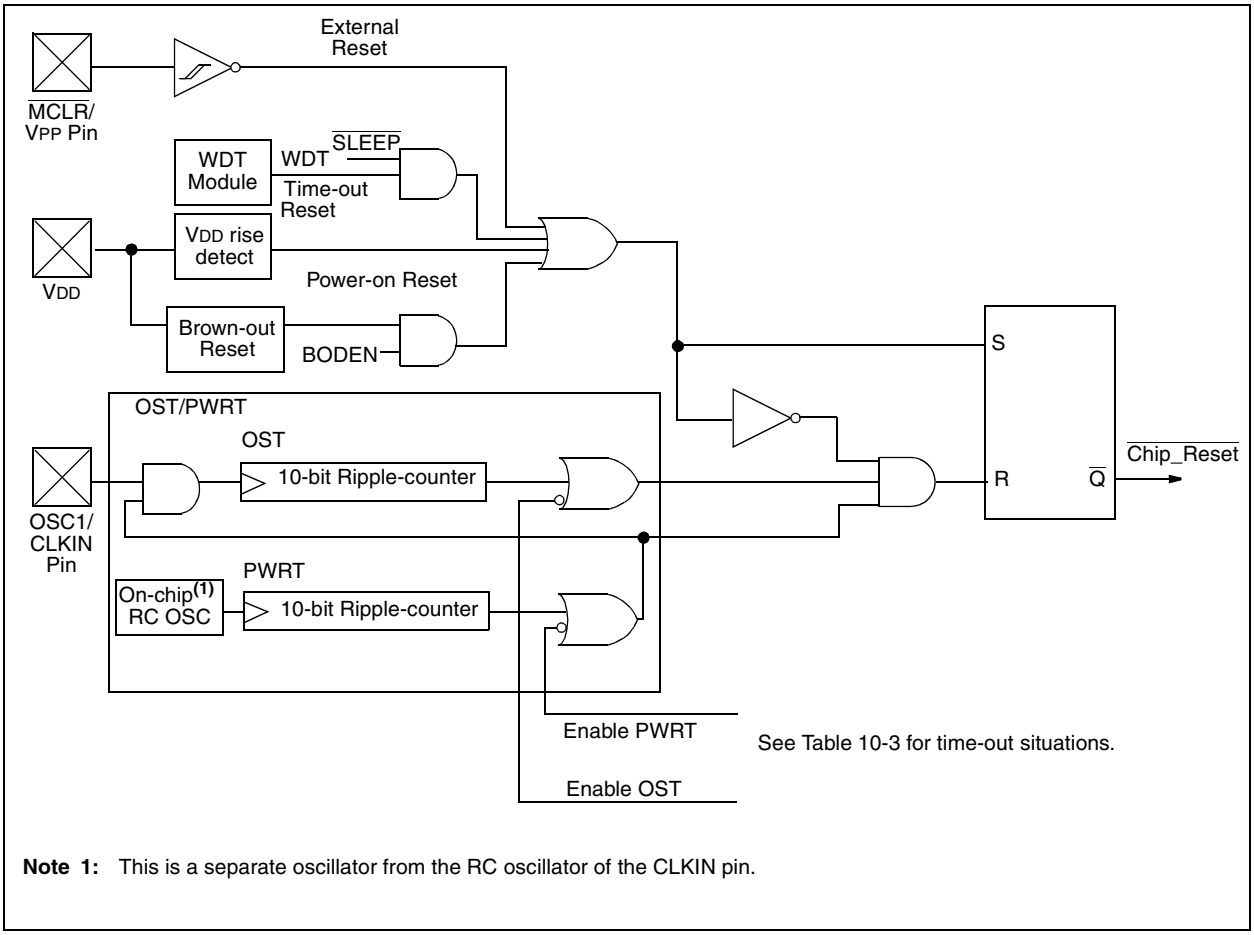
a) Power-on reset (POR)
b) $\overline{MCLR}$ reset during normal operation
c) $\overline{MCLR}$ reset during SLEEP
d) WDT reset (normal operation)
e) WDT wake-up (SLEEP)
f) Brown-out Reset (BOD)

Some registers are not affected in any reset condition. Their status is unknown on POR and unchanged in any other reset. Most other registers are reset to a "reset state" on Power-on reset, $\overline{MCLR}$ reset, WDT reset and $\overline{MCLR}$ reset during SLEEP. They are not affected by a WDT wake-up, since this is viewed as the resumption of normal operation. $\overline{TO}$ and $\overline{PD}$ bits are set or cleared differently in different reset situations as indicated in Table 10-4. These bits are used in software to determine the nature of the reset. See Table 10-6 for a full description of reset states of all registers.

A simplified block diagram of the on-chip reset circuit is shown in Figure 10-6.

The $\overline{MCLR}$ reset path has a noise filter to detect and ignore small pulses. See Table 13-5 for pulse width specification.

FIGURE 10-6: SIMPLIFIED BLOCK DIAGRAM OF ON-CHIP RESET CIRCUIT



Note 1: This is a separate oscillator from the RC oscillator of the CLKIN pin.

GOTO **Unconditional Branch**

Syntax: [*label*] GOTO k

Operands: 0 ≤ k ≤ 2047

Operation: k → PC<10:0>
PCLATH<4:3> → PC<12:11>

Status Affected: None

Encoding:

10	1kkk	kkkk	kkkk

Description: GOTO is an unconditional branch. The eleven bit immediate value is loaded into PC bits <10:0>. The upper bits of PC are loaded from PCLATH<4:3>. GOTO is a two-cycle instruction.

Words: 1

Cycles: 2

Example
```
GOTO THERE
```
After Instruction
PC = Address THERE

INCF **Increment f**

Syntax: [*label*] INCF f,d

Operands: 0 ≤ f ≤ 127
d ∈ [0,1]

Operation: (f) + 1 → (dest)

Status Affected: Z

Encoding:

00	1010	dfff	ffff

Description: The contents of register 'f' are incremented. If 'd' is 0, the result is placed in the W register. If 'd' is 1, the result is placed back in register 'f'.

Words: 1

Cycles: 1

Example
```
INCF    CNT, 1
```
Before Instruction
CNT = 0xFF
Z = 0
After Instruction
CNT = 0x00
Z = 1

INCFSZ **Increment f, Skip if 0**

Syntax: [*label*] INCFSZ f,d

Operands: 0 ≤ f ≤ 127
d ∈ [0,1]

Operation: (f) + 1 → (dest), skip if result = 0

Status Affected: None

Encoding:

00	1111	dfff	ffff

Description: The contents of register 'f' are incremented. If 'd' is 0, the result is placed in the W register. If 'd' is 1, the result is placed back in register 'f'.
If the result is 0, the next instruction, which is already fetched, is discarded. A NOP is executed instead making it a two-cycle instruction.

Words: 1

Cycles: 1(2)

Example
```
HERE     INCFSZ    CNT, 1
         GOTO      LOOP
CONTINUE •
         •
         •
```
Before Instruction
PC = address HERE
After Instruction
CNT = CNT + 1
if CNT= 0,
PC = address CONTINUE
if CNT≠ 0,
PC = address HERE +1

IORLW **Inclusive OR Literal with W**

Syntax: [*label*] IORLW k

Operands: 0 ≤ k ≤ 255

Operation: (W) .OR. k → (W)

Status Affected: Z

Encoding:

11	1000	kkkk	kkkk

Description: The contents of the W register are OR'ed with the eight bit literal 'k'. The result is placed in the W register.

Words: 1

Cycles: 1

Example
```
IORLW   0x35
```
Before Instruction
W = 0x9A
After Instruction
W = 0xBF
Z = 1

13.5 Timing Diagrams and Specifications

FIGURE 13-5: EXTERNAL CLOCK TIMING

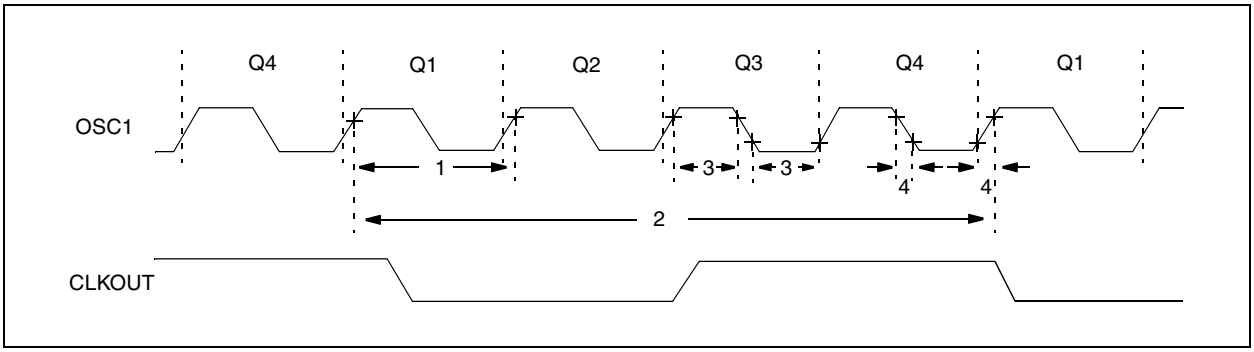


TABLE 13-3: EXTERNAL CLOCK TIMING REQUIREMENTS

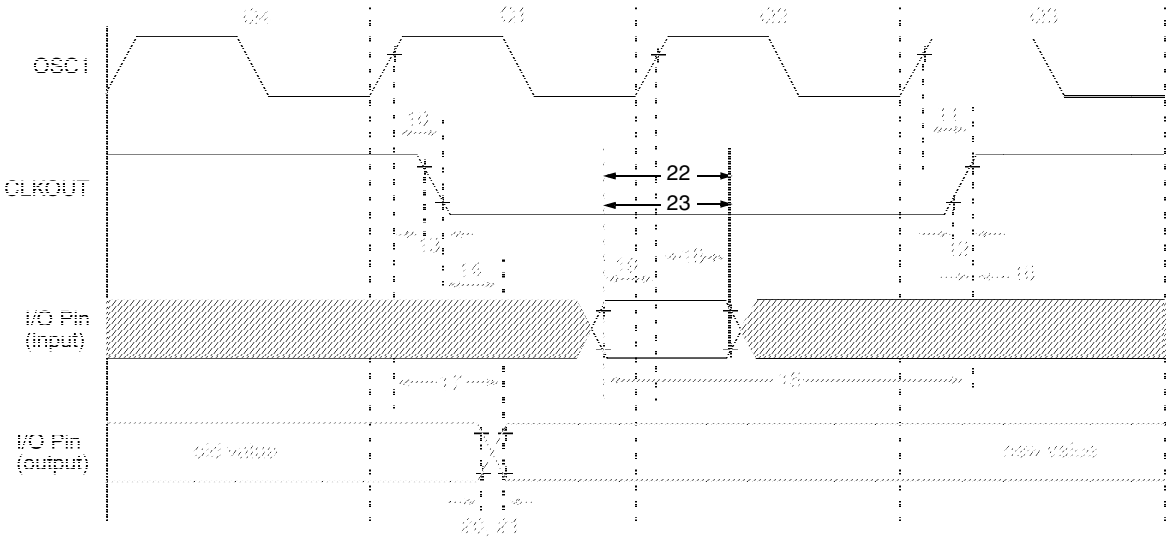
Parameter No.	Sym	Characteristic	Min	Typ†	Max	Units	Conditions
1A	Fosc	**External CLKIN Frequency (Note 1)**	DC	—	4	MHz	XT and RC osc mode, VDD=5.0V
			DC	—	20	MHz	HS osc mode
			DC	—	200	kHz	LP osc mode
		Oscillator Frequency (Note 1)	DC	—	4	MHz	RC osc mode, VDD=5.0V
			0.1	—	4	MHz	XT osc mode
			1	—	20	MHz	HS osc mode
			DC	–	200	kHz	LP osc mode
1	Tosc	**External CLKIN Period (Note 1)**	250	—	—	ns	XT and RC osc mode
			50	—	—	ns	HS osc mode
			5	—	—	µs	LP osc mode
		Oscillator Period (Note 1)	250	—	—	ns	RC osc mode
			250	—	10,000	ns	XT osc mode
			50	—	1,000	ns	HS osc mode
			5	—	—	µs	LP osc mode
2	TCY	**Instruction Cycle Time (Note 1)**	200	—	DC	ns	TCY=FOSC/4
3*	TosL, TosH	External Clock in (OSC1) High or Low Time	100*	—	—	ns	XT oscillator, TOSC L/H duty cycle
			2*	—	—	µs	LP oscillator, TOSC L/H duty cycle
			20*	—	—	ns	HS oscillator, TOSC L/H duty cycle
4*	TosR, TosF	External Clock in (OSC1) Rise or Fall Time	25*	—	—	ns	XT oscillator
			50*	—	—	ns	LP oscillator
			15*	—	—	ns	HS oscillator

* These parameters are characterized but not tested.

† Data in "Typ" column is at 5.0V, 25°C unless otherwise stated. These parameters are for design guidance only and are not tested.

Note 1: Instruction cycle period (TCY) equals four times the input oscillator time-base period. All specified values are based on characterization data for that particular oscillator type under standard operating conditions with the device executing code. Exceeding these specified limits may result in an unstable oscillator operation and/or higher than expected current consumption. All devices are tested to operate at "min." values with an external clock applied to the OSC1 pin. When an external clock input is used, the "Max." cycle time limit is "DC" (no clock) for all devices.

FIGURE 13-6: CLKOUT AND I/O TIMING



Note: All tests must be do with specified capacitance loads (Figure 13-4) 50 pF on I/O pins and CLKOUT

TABLE 13-4: CLKOUT AND I/O TIMING REQUIREMENTS

Parameter #	Sym	Characteristic	Min	Typ†	Max	Units
10*	TosH2ckL	OSC1↑ to CLKOUT↓ (1)	—	75	200	ns
11*	TosH2ckH	OSC1↑ to CLKOUT↑ (1)	—	75	200	ns
12*	TckR	CLKOUT rise time (1)	—	35	100	ns
13*	TckF	CLKOUT fall time (1)	—	35	100	ns
14*	TckL2ioV	CLKOUT ↓ to Port out valid (1)	—	—	20	ns
15*	TioV2ckH	Port in valid before CLKOUT ↑ (1)	Tosc +200 ns	—	—	ns
16*	TckH2ioI	Port in hold after CLKOUT ↑ (1)	0	—	—	ns
17*	TosH2ioV	OSC1↑ (Q1 cycle) to Port out valid	—	50	150	ns
18*	TosH2ioI	OSC1↑ (Q2 cycle) to Port input invalid (I/O in hold time)	100	—	—	ns
19*	TioV2osH	Port input valid to OSC1↑ (I/O in setup time)	0	—	—	ns
20*	TioR	Port output rise time	—	10	40	ns
21*	TioF	Port output fall time	—	10	40	ns
22*	Tinp	RB0/INT pin high or low time	25	—	—	ns
23	Trbp	RB<7:4> change interrupt high or low time	TCY	—	—	ns

* These parameters are characterized but not tested

† Data in "Typ" column is at 5.0V, 25°C unless otherwise stated. These parameters are for design guidance only and are not tested.

Note 1: Measurements are taken in RC Mode where CLKOUT output is 4 x TOSC.

NOTES:

NOTES:

APPENDIX A: CODE FOR ACCESSING EEPROM DATA MEMORY

Please check our web site at www.microchip.com for code availability.

APPENDIX B:REVISION HISTORY

Revision D (January 2013)

Added a note to each package outline drawing.

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