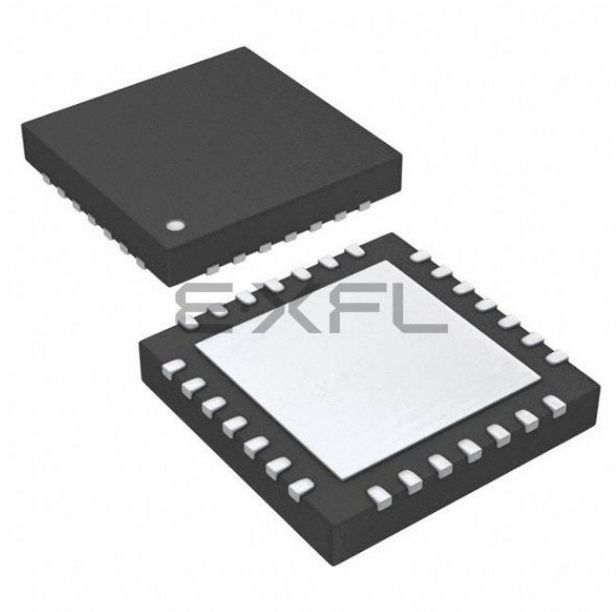


Welcome to E-XFL.COM

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	20MHz
Connectivity	-
Peripherals	Brown-out Detect/Reset, LCD, POR, PWM, WDT
Number of I/O	25
Program Memory Size	7KB (4K x 14)
Program Memory Type	FLASH
EEPROM Size	-
RAM Size	256 x 8
Voltage - Supply (Vcc/Vdd)	1.8V ~ 3.6V
Data Converters	A/D 11x10b
Oscillator Type	Internal
Operating Temperature	-40°C ~ 85°C (TA)
Mounting Type	Surface Mount
Package / Case	28-UFQFN Exposed Pad
Supplier Device Package	28-UQFN (4x4)
Purchase URL	https://www.e-xfl.com/product-detail/microchip-technology/pic16lf1903t-i-mv

TABLE 1-2: PIC16LF1902/3 PINOUT DESCRIPTION

Name	Function	Input Type	Output Type	Description
RA0/AN0/SEG12	RA0	TTL	CMOS	General purpose I/O.
	AN0	AN	—	A/D Channel 0 input.
	SEG12	—	AN	LCD Analog output.
RA1/AN1/SEG7	RA1	TTL	CMOS	General purpose I/O.
	AN1	AN	—	A/D Channel 1 input.
	SEG7	—	AN	LCD Analog output.
RA2/AN2/COM2	RA2	TTL	CMOS	General purpose I/O.
	AN2	AN	—	A/D Channel 2 input.
	COM2	—	AN	LCD Analog output.
RA3/AN3/VREF+/COM3/SEG15	RA3	TTL	CMOS	General purpose I/O.
	AN3	AN	—	A/D Channel 3 input.
	VREF+	AN	—	A/D Voltage Reference input.
	COM3	—	AN	LCD Analog output.
	SEG15	—	AN	LCD Analog output.
RA4/T0CKI/SEG4	RA4	TTL	CMOS	General purpose I/O.
	T0CKI	ST	—	Timer0 clock input.
	SEG4	—	AN	LCD Analog output.
RA5/AN4/SEG5	RA5	TTL	CMOS	General purpose I/O.
	AN4	AN	—	A/D Channel 4 input.
	SEG5	—	AN	LCD Analog output.
RA6/CLKOUT/SEG1	RA6	TTL	CMOS	General purpose I/O.
	CLKOUT	—	CMOS	FOSC/4 output.
	SEG1	—	AN	LCD Analog output.
RA7/CLKIN/SEG2	RA7	TTL	CMOS	General purpose I/O.
	CLKIN	CMOS	—	External clock input (EC mode).
	SEG2	—	AN	LCD Analog output.
RB0/AN12/INT/SEG0	RB0	TTL	CMOS	General purpose I/O.
	AN12	AN	—	A/D Channel 12 input.
	INT	ST	—	External interrupt.
	SEG0	—	AN	LCD Analog output.
RB1(1)/AN10/SEG24/VLCD1	RB1	TTL	CMOS	General purpose I/O.
	AN10	AN	—	A/D Channel 10 input.
	SEG24	—	AN	LCD Analog output.
	VLCD1	AN	—	LCD analog input.
RB2(1)/AN8/SEG25/VLCD2	RB2	TTL	CMOS	General purpose I/O.
	AN8	AN	—	A/D Channel 8 input.
	SEG25	—	AN	LCD Analog output.
	VLCD2	AN	—	LCD analog input.
RB3(1)/AN9/SEG26/VLCD3	RB3	TTL	CMOS	General purpose I/O.
	AN9	AN	—	A/D Channel 9 input.
	SEG26	—	AN	LCD Analog output.
	VLCD3	AN	—	LCD analog input.

Legend: AN = Analog input or output; CMOS = CMOS compatible input or output; OD = Open-Drain
TTL = TTL compatible input; ST = Schmitt Trigger input with CMOS levels; I^2C = Schmitt Trigger input with I^2C levels
HV = High Voltage; XTAL = Crystal

Note 1: These pins have interrupt-on-change functionality.

3.2 Data Memory Organization

The data memory is partitioned in 32 memory banks with 128 bytes in a bank. Each bank consists of (Figure 3-3):

- 12 core registers
- 20 Special Function Registers (SFR)
- Up to 80 bytes of General Purpose RAM (GPR)
- 16 bytes of common RAM

The active bank is selected by writing the bank number into the Bank Select Register (BSR). Unimplemented memory will read as '0'. All data memory can be accessed either directly (via instructions that use the file registers) or indirectly via the two File Select Registers (FSR). See **Section 3.5 "Indirect Addressing"** for more information.

Data Memory uses a 12-bit address. The upper seven bits of the address define the Bank address and the lower five bits select the registers/RAM in that bank.

3.2.1 CORE REGISTERS

The core registers contain the registers that directly affect the basic operation. The core registers occupy the first 12 addresses of every data memory bank (addresses x00h/x08h through x0Bh/x8Bh). These registers are listed below in **Table 3-2**. For for detailed information, see **Table 3-4**.

TABLE 3-2: CORE REGISTERS

Addresses	BANKx
x00h or x80h	INDF0
x01h or x81h	INDF1
x02h or x82h	PCL
x03h or x83h	STATUS
x04h or x84h	FSR0L
x05h or x85h	FSR0H
x06h or x86h	FSR1L
x07h or x87h	FSR1H
x08h or x88h	BSR
x09h or x89h	WREG
x0Ah or x8Ah	PCLATH
x0Bh or x8Bh	INTCON

3.2.1.1 STATUS Register

The STATUS register, shown in Register 3-1, contains:

- the arithmetic status of the ALU
- the Reset status

The STATUS register can be the destination for any instruction, like any other register. If the STATUS register is the destination for an instruction that affects the Z, DC or C bits, then the write to these three bits is disabled. These bits are set or cleared according to the device logic. Furthermore, the $\overline{TO}$ and $\overline{PD}$ bits are not writable. Therefore, the result of an instruction with the STATUS register as destination may be different than intended.

For example, `CLRF STATUS` will clear the upper three bits and set the Z bit. This leaves the STATUS register as '`000u u1uu`' (where u = unchanged).

It is recommended, therefore, that only `BCF`, `BSF`, `SWAPF` and `MOVWF` instructions are used to alter the STATUS register, because these instructions do not affect any Status bits. For other instructions not affecting any Status bits (Refer to **Section 20.0 "Instruction Set Summary"**).

Note:	The C and DC bits operate as $\overline{Borrow}$ and $\overline{Digit\ Borrow}$ out bits, respectively, in subtraction.

REGISTER 3-1: STATUS: STATUS REGISTER

U-0	U-0	U-0	R-1/q	R-1/q	R/W-0/u	R/W-0/u	R/W-0/u
—	—	—	$\overline{TO}$	$\overline{PD}$	Z	DC(1)	C(1)
bit 7							bit 0

Legend:		
R = Readable bit	W = Writable bit	U = Unimplemented bit, read as '0'
u = Bit is unchanged	x = Bit is unknown	-n/n = Value at POR and BOR/Value at all other Resets
'1' = Bit is set	'0' = Bit is cleared	q = Value depends on condition

bit 7-5 **Unimplemented:** Read as '0'

bit 4 **$\overline{TO}$:** Time-out bit
- 1 = After power-up, `CLRWDT` instruction or `SLEEP` instruction
- 0 = A WDT time-out occurred

bit 3 **$\overline{PD}$:** Power-down bit
- 1 = After power-up or by the `CLRWDT` instruction
- 0 = By execution of the `SLEEP` instruction

bit 2 **Z:** Zero bit
- 1 = The result of an arithmetic or logic operation is zero
- 0 = The result of an arithmetic or logic operation is not zero

bit 1 **DC:** Digit Carry/$\overline{Digit\ Borrow}$ bit (`ADDWF`, `ADDLW`, `SUBLW`, `SUBWF` instructions)(1)
- 1 = A carry-out from the 4th low-order bit of the result occurred
- 0 = No carry-out from the 4th low-order bit of the result

bit 0 **C:** Carry/$\overline{Borrow}$ bit(1) (`ADDWF`, `ADDLW`, `SUBLW`, `SUBWF` instructions)(1)
- 1 = A carry-out from the Most Significant bit of the result occurred
- 0 = No carry-out from the Most Significant bit of the result occurred

Note 1: For $\overline{Borrow}$, the polarity is reversed. A subtraction is executed by adding the two's complement of the second operand. For rotate (`RRF`, `RLF`) instructions, this bit is loaded with either the high-order or low-order bit of the source register.

TABLE 3-5: SPECIAL FUNCTION REGISTER SUMMARY (CONTINUED)

Addr	Name	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	Value on POR, BOR	Value on all other Resets
Bank 2											
10Ch	LATA	PORTA Data Latch								xxxx xxxx	uuuu uuuu
10Dh	LATB	PORTB Data Latch								xxxx xxxx	uuuu uuuu
10Eh	LATC	PORTC Data Latch								xxxx xxxx	uuuu uuuu
10Fh to 115h	—	Unimplemented								—	—
116h	BORCON	SBOREN	BORFS	—	—	—	—	—	BORRDY	10-- ---q	uu-- ---u
117h	FVRCON	FVREN	FVRRDY	TSEN	TSRNG	—	—	ADFVR1	ADFVR0	0q00 --00	0q00 --00
118h to 11Fh	—	Unimplemented								—	—
Bank 3											
18Ch	ANSELA	—	—	ANSA5	—	ANSA3	ANSA2	ANSA1	ANSA0	--1- 1111	--11 1111
18Dh	ANSELB	—	—	ANSB5	ANSB4	ANSB3	ANSB2	ANSB1	ANSB0	--11 1111	--11 1111
18Eh	—	Unimplemented								—	—
18Fh	—	Unimplemented								—	—
190h	—	Unimplemented								—	—
191h	PMADRL	Program Memory Address Register Low Byte								0000 0000	0000 0000
192h	PMADRH	—(2)	Program Memory Address Register High Byte							1000 0000	1000 0000
193h	PMDATL	Program Memory Read Data Register Low Byte								xxxx xxxx	uuuu uuuu
194h	PMDATH	—	—	Program Memory Read Data Register High Byte						--xx xxxx	--uu uuuu
195h	PMCON1	—(2)	CFGS	LWLO	FREE	WRERR	WREN	WR	RD	1000 x000	1000 q000
196h	PMCON2	Program Memory Control Register 2								0000 0000	0000 0000
197h to 19Fh	—	Unimplemented								—	—
Bank 4											
20Ch	—	Unimplemented								—	—
20Dh	WPUB	WPUB7	WPUB6	WPUB5	WPUB4	WPUB3	WPUB2	WPUB1	WPUB0	1111 1111	1111 1111
20Eh	—	Unimplemented								—	—
20Fh	—	Unimplemented								—	—
210h	WPUE	—	—	—	—	WPUE3	—	—	—	---- 1---	---- 1---
211h to 21Fh	—	Unimplemented								—	—
Bank 5											
28Ch — 29Fh	—	Unimplemented								—	—
Bank 6											
30Ch — 31Fh	—	Unimplemented								—	—

Legend: x = unknown, u = unchanged, q = value depends on condition, - = unimplemented, read as '0', r = reserved. Shaded locations are unimplemented, read as '0'.

Note 1: These registers can be addressed from any bank.

2: Unimplemented, read as '1'.

7.6 Interrupt Control Registers

7.6.1 INTCON REGISTER

The INTCON register is a readable and writable register, which contains the various enable and flag bits for TMR0 register overflow, interrupt-on-change and external INT pin interrupts.

Note: Interrupt flag bits are set when an interrupt condition occurs, regardless of the state of its corresponding enable bit or the Global Enable bit, GIE of the INTCON register. User software should ensure the appropriate interrupt flag bits are clear prior to enabling an interrupt.

REGISTER 7-1: INTCON: INTERRUPT CONTROL REGISTER

R/W-0/0	R/W-0/0	R/W-0/0	R/W-0/0	R/W-0/0	R/W-0/0	R/W-0/0	R-0/0
GIE	PEIE	TMR0IE	INTE	IOCIE	TMR0IF	INTF	IOCIF
bit 7							bit 0

Legend:		
R = Readable bit	W = Writable bit	U = Unimplemented bit, read as ‘0’
u = Bit is unchanged	x = Bit is unknown	-n/n = Value at POR and BOR/Value at all other Resets
‘1’ = Bit is set	‘0’ = Bit is cleared	

bit 7 **GIE:** Global Interrupt Enable bit
1 = Enables all active interrupts
0 = Disables all interrupts

bit 6 **PEIE:** Peripheral Interrupt Enable bit
1 = Enables all active peripheral interrupts
0 = Disables all peripheral interrupts

bit 5 **TMR0IE:** Timer0 Overflow Interrupt Enable bit
1 = Enables the Timer0 interrupt
0 = Disables the Timer0 interrupt

bit 4 **INTE:** INT External Interrupt Enable bit
1 = Enables the INT external interrupt
0 = Disables the INT external interrupt

bit 3 **IOCIE:** Interrupt-on-Change Interrupt Enable bit
1 = Enables the interrupt-on-change interrupt
0 = Disables the interrupt-on-change interrupt

bit 2 **TMR0IF:** Timer0 Overflow Interrupt Flag bit
1 = TMR0 register has overflowed
0 = TMR0 register did not overflow

bit 1 **INTF:** INT External Interrupt Flag bit
1 = The INT external interrupt occurred
0 = The INT external interrupt did not occur

bit 0 **IOCIF:** Interrupt-on-Change Interrupt Flag bit
1 = When at least one of the interrupt-on-change pins changed state
0 = None of the interrupt-on-change pins have changed state

TABLE 7-1: SUMMARY OF REGISTERS ASSOCIATED WITH INTERRUPTS

Name	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	Register on Page
INTCON	GIE	PEIE	TMR0IE	INTE	IOCIE	TMR0IF	INTF	IOCIF	60
OPTION_REG	$\overline{\text{WPUEN}}$	INTEDG	TMR0CS	TMR0SE	PSA	PS<2:0>			121
PIE1	TMR1GIE	ADIE	—	—	—	—	—	TMR1IE	61
PIE2	—	—	—	—	—	LCDIE	—	—	62
PIR1	TMR1GIF	ADIF	—	—	—	—	—	TMR1IF	63
PIR2	—	—	—	—	—	LCDIF	—	—	64

Legend: — = unimplemented location, read as '0'. Shaded cells are not used by interrupts.

8.0 POWER-DOWN MODE (SLEEP)

The Power-Down mode is entered by executing a SLEEP instruction.

Upon entering Sleep mode, the following conditions exist:

1. WDT will be cleared but keeps running, if enabled for operation during Sleep.
2. $\overline{PD}$ bit of the STATUS register is cleared.
3. $\overline{TO}$ bit of the STATUS register is set.
4. CPU clock is disabled.
5. 31 kHz LFINTOSC is unaffected and peripherals that operate from it may continue operation in Sleep.
6. Secondary oscillator is unaffected and peripherals that operate from it may continue operation in Sleep.
7. ADC is unaffected, if the dedicated FRC clock is selected.
8. Capacitive Sensing oscillator is unaffected.
9. I/O ports maintain the status they had before SLEEP was executed (driving high, low or high-impedance).
10. Resets other than WDT are not affected by Sleep mode.

Refer to individual chapters for more details on peripheral operation during Sleep.

To minimize current consumption, the following conditions should be considered:

- I/O pins should not be floating
- External circuitry sinking current from I/O pins
- Internal circuitry sourcing current from I/O pins
- Current draw from pins with internal weak pull-ups
- Modules using 31 kHz LFINTOSC
- Modules using Secondary oscillator

I/O pins that are high-impedance inputs should be pulled to VDD or VSS externally to avoid switching currents caused by floating inputs.

Examples of internal circuitry that might be sourcing current include the FVR module. See **13.0 "Fixed Voltage Reference (FVR)"** for more information.

8.1 Wake-up from Sleep

The device can wake-up from Sleep through one of the following events:

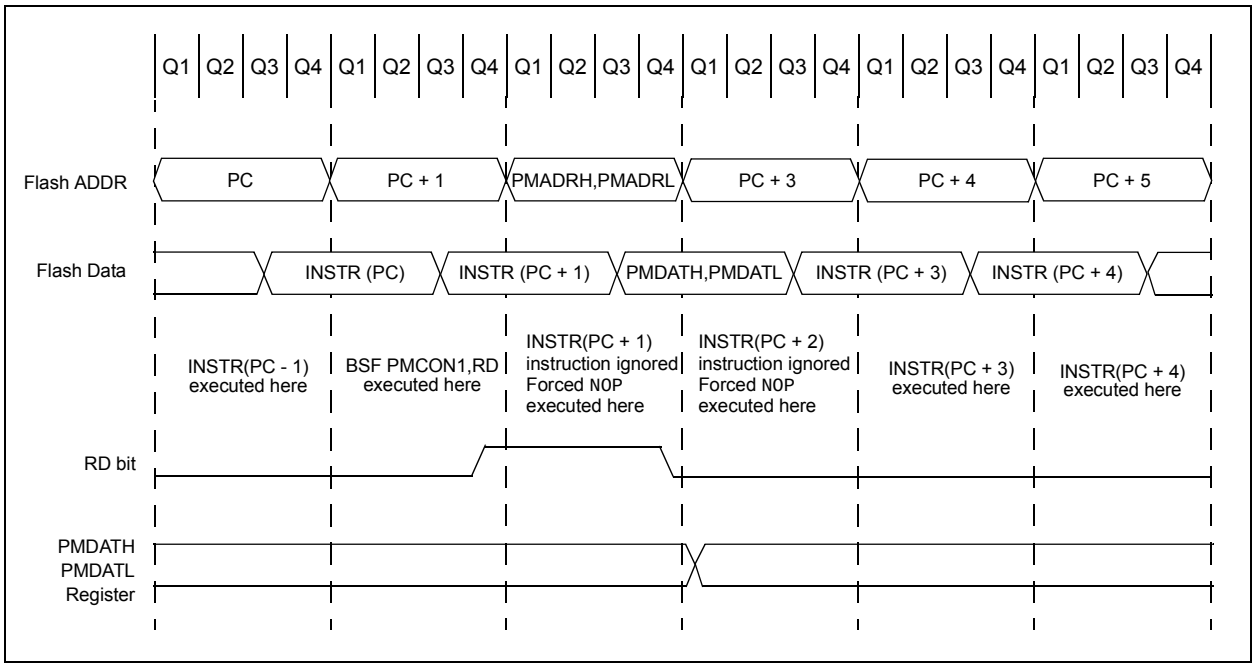
1. External Reset input on $\overline{MCLR}$ pin, if enabled
2. BOR Reset, if enabled
3. POR Reset
4. Watchdog Timer, if enabled
5. Any external interrupt
6. Interrupts by peripherals capable of running during Sleep (see individual peripheral for more information)

The first three events will cause a device Reset. The last three events are considered a continuation of program execution. To determine whether a device Reset or wake-up event occurred, refer to **Section 5.11, Determining the Cause of a Reset**.

When the SLEEP instruction is being executed, the next instruction (PC + 1) is prefetched. For the device to wake-up through an interrupt event, the corresponding interrupt enable bit must be enabled. Wake-up will occur regardless of the state of the GIE bit. If the GIE bit is disabled, the device continues execution at the instruction after the SLEEP instruction. If the GIE bit is enabled, the device executes the instruction after the SLEEP instruction, the device will then call the Interrupt Service Routine. In cases where the execution of the instruction following SLEEP is not desirable, the user should have a NOP after the SLEEP instruction.

The WDT is cleared when the device wakes up from Sleep, regardless of the source of wake-up.

FIGURE 10-2: FLASH PROGRAM MEMORY READ CYCLE EXECUTION



EXAMPLE 10-1: FLASH PROGRAM MEMORY READ

```
* This code block will read 1 word of program
* memory at the memory address:
    PROG_ADDR_HI : PROG_ADDR_LO
*   data will be returned in the variables;
*   PROG_DATA_HI, PROG_DATA_LO

    BANKSEL  PMADRL           ; Select Bank for PMCON registers
    MOVLW    PROG_ADDR_LO     ;
    MOVWF    PMADRL           ; Store LSB of address
    MOVLW    PROG_ADDR_HI     ;
    MOVWL    PMADRH           ; Store MSB of address

    BCF      PMCON1,CFGS      ; Do not select Configuration Space
    BSF      PMCON1,RD        ; Initiate read
    NOP                       ; Ignored (Figure 10-2)
    NOP                       ; Ignored (Figure 10-2)

    MOVF     PMDATL,W         ; Get LSB of word
    MOVWF    PROG_DATA_LO     ; Store in user location
    MOVF     PMDATH,W         ; Get MSB of word
    MOVWF    PROG_DATA_HI     ; Store in user location
```

10.2.2 FLASH MEMORY UNLOCK SEQUENCE

The unlock sequence is a mechanism that protects the Flash Program Memory from unintended self-write programming or erasing. The sequence must be executed and completed without interruption to successfully complete any of the following operations:

- Row Erase
- Load program memory write latches
- Write of program memory write latches to program memory
- Write of program memory write latches to User IDs

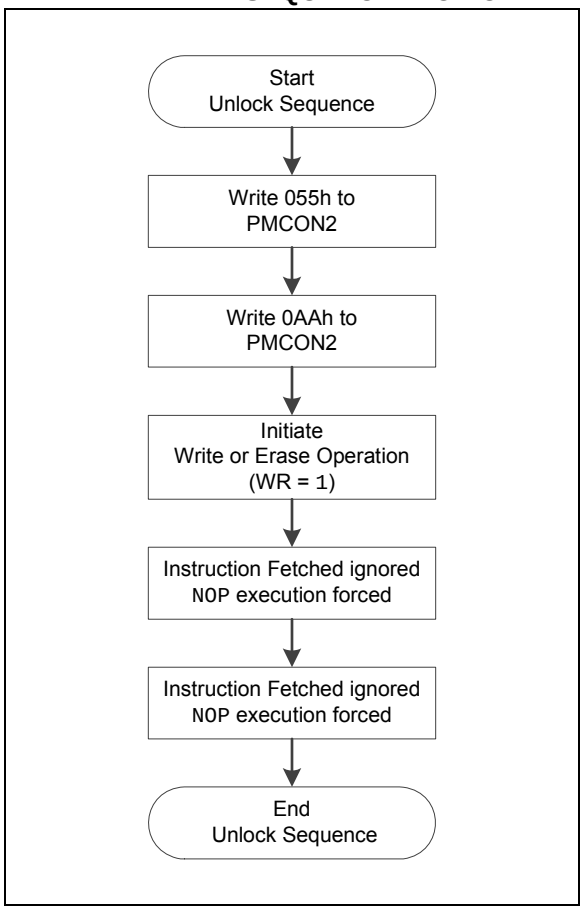
The unlock sequence consists of the following steps:

1. Write 55h to PMCON2
2. Write AAh to PMCON2
3. Set the WR bit in PMCON1
4. NOP instruction
5. NOP instruction

Once the WR bit is set, the processor will always force two NOP instructions. When an Erase Row or Program Row operation is being performed, the processor will stall internal operations (typical 2 ms), until the operation is complete and then resume with the next instruction. When the operation is loading the program memory write latches, the processor will always force the two NOP instructions and continue uninterrupted with the next instruction.

Since the unlock sequence must not be interrupted, global interrupts should be disabled prior to the unlock sequence and re-enabled after the unlock sequence is completed.

FIGURE 10-3: FLASH PROGRAM MEMORY UNLOCK SEQUENCE FLOWCHART



REGISTER 10-6: PMCON2: PROGRAM MEMORY CONTROL 2 REGISTER

W-0/0	W-0/0	W-0/0	W-0/0	W-0/0	W-0/0	W-0/0	W-0/0
Program Memory Control Register 2							
bit 7							bit 0

Legend:		
R = Readable bit	W = Writable bit	U = Unimplemented bit, read as '0'
S = Bit can only be set	x = Bit is unknown	-n/n = Value at POR and BOR/Value at all other Resets
'1' = Bit is set	'0' = Bit is cleared	

bit 7-0 **Flash Memory Unlock Pattern bits**

To unlock writes, a 55h must be written first, followed by an AAh, before setting the WR bit of the PMCON1 register. The value written to this register is used to unlock the writes. There are specific timing requirements on these writes.

TABLE 10-3: SUMMARY OF REGISTERS ASSOCIATED WITH FLASH PROGRAM MEMORY

Name	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	Register on Page
PMCON1	—(1)	CFGS	LWLO	FREE	WRERR	WREN	WR	RD	86
PMCON2	Program Memory Control Register 2								87
PMADRL	PMADRL<7:0>								85
PMADRH	—(1)	PMADRH<6:0>							85
PMDATL	PMDATL<7:0>								85
PMDATH	—	—	PMDATH<5:0>						85
INTCON	GIE	PEIE	TMR0IE	INTE	IOCIE	TMR0IF	INTF	IOCIF	60

Legend: — = unimplemented location, read as '0'. Shaded cells are not used by Flash Program Memory module.

Note 1: Unimplemented, read as '1'.

TABLE 10-4: SUMMARY OF CONFIGURATION WORD WITH FLASH PROGRAM MEMORY

Name	Bits	Bit -/7	Bit -/6	Bit 13/5	Bit 12/4	Bit 11/3	Bit 10/2	Bit 9/1	Bit 8/0	Register on Page
CONFIG1	13:8	—	—	—	—	$\overline{\text{CLKOUTEN}}$	BOREN<1:0>		—	34
	7:0	$\overline{\text{CP}}$	MCLRE	$\overline{\text{PWRTE}}$	WDTE<1:0>		—	FOSC<1:0>		
CONFIG2	13:8	—	—	LVP	$\overline{\text{DEBUG}}$	$\overline{\text{LPBOR}}$	BORV	STVREN	—	35
	7:0	—	—	—	—	—	—	WRT<1:0>		

Legend: — = unimplemented location, read as '0'. Shaded cells are not used by clock sources.

18.0 LIQUID CRYSTAL DISPLAY (LCD) DRIVER MODULE

The Liquid Crystal Display (LCD) Driver module generates the timing control to drive a static or multiplexed LCD panel. In the PIC16LF1902/3 device, the module drives the panels of up to four commons and up to 72 total segments. The LCD module also provides control of the LCD pixel data.

The LCD Driver module supports:

- Direct driving of LCD panel
- Three LCD clock sources with selectable prescaler
- Up to four common pins:
  - Static (1 common)
  - 1/2 multiplex (2 commons)
  - 1/3 multiplex (3 commons)
  - 1/4 multiplex (4 commons)
- 19 Segment pins
- Static, 1/2 or 1/3 LCD Bias

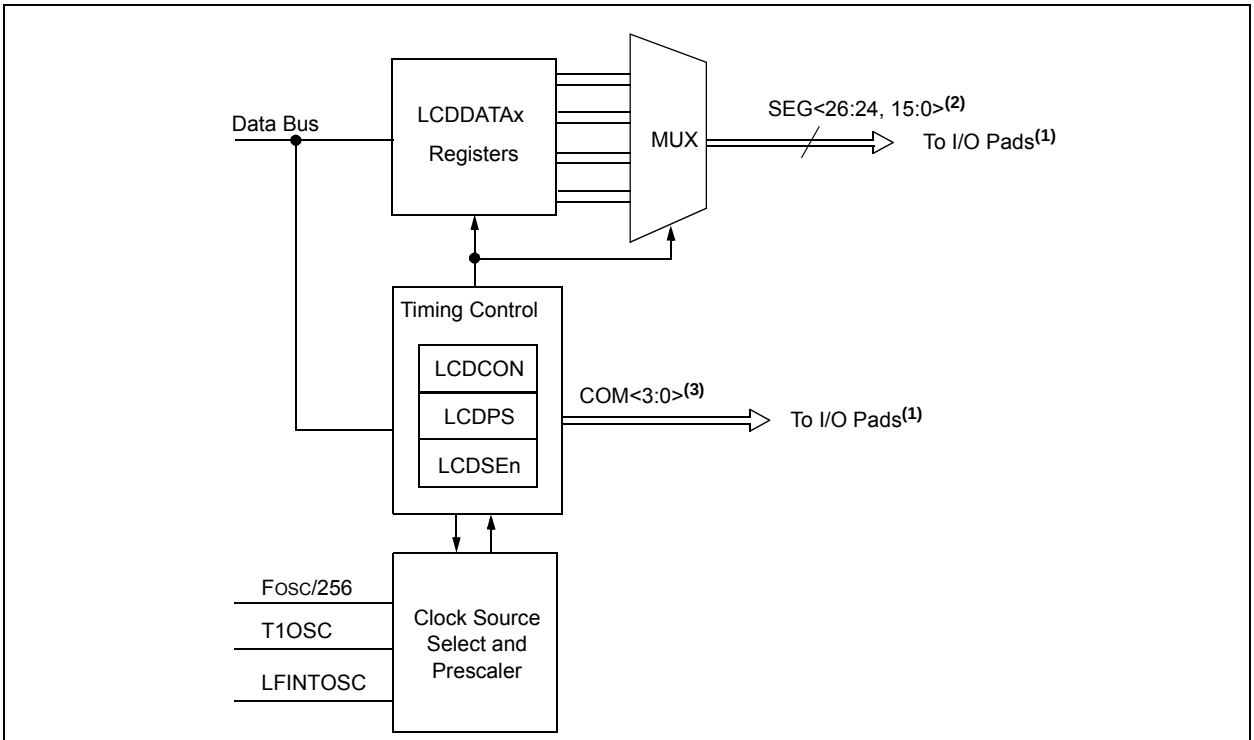
Note:	COM3 and SEG15 share the same physical pin on the PIC16LF1902/3, therefore SEG15 is not available when using 1/4 multiplex displays.

18.1 LCD Registers

The module contains the following registers:

- LCD Control register (LCDCON)
- LCD Phase register (LCDPS)
- LCD Reference Ladder register (LCDRL)
- LCD Contrast Control register (LCDCST)
- LCD Reference Voltage Control register (LCDREF)
- Up to 3 LCD Segment Enable registers (LCDSEn)
- Up to 12 LCD data registers (LCDDATAn)

FIGURE 18-1: LCD DRIVER MODULE BLOCK DIAGRAM



Note 1: These are not directly connected to the I/O pads, but may be tri-stated, depending on the configuration of the LCD module.

2: COM3 and SEG15 share the same physical pin, therefore SEG15 is not available when using 1/4 multiplex displays.

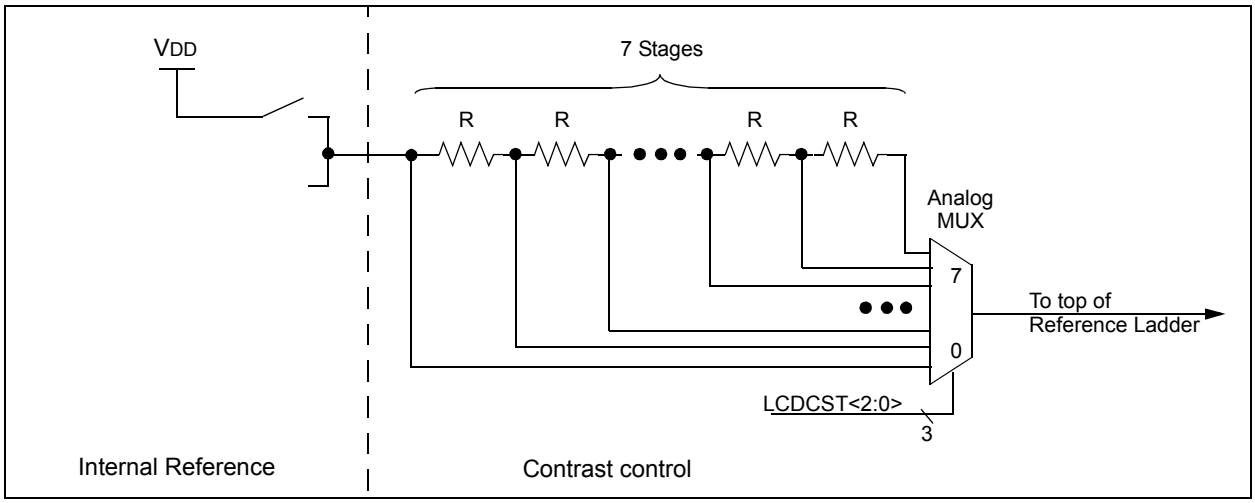
18.4.4 CONTRAST CONTROL

The LCD contrast control circuit consists of a 7-tap resistor ladder, controlled by the LCDCST bits. Refer to Figure 18-7.

The contrast control circuit is used to decrease the output voltage of the signal source by a total of approximately 10%, when LCDCST = 111.

Whenever the LCD module is inactive (LCDA = 0), the contrast control ladder will be turned off (open).

FIGURE 18-7: INTERNAL REFERENCE AND CONTRAST CONTROL BLOCK DIAGRAM



18.4.5 INTERNAL REFERENCE

Under firmware control, an internal reference for the LCD bias voltages can be enabled. When enabled, the source of this voltage can be VDD. When no internal reference is selected, the LCD contrast control circuit is disabled and LCD bias must be provided externally.

Whenever the LCD module is inactive (LCDA = 0), the internal reference will be turned off.

When the internal reference is enabled and the Fixed Voltage Reference is selected, the LCDIRI bit can be used to minimize power consumption by tying into the LCD reference ladder automatic power mode switching. When LCDIRI = 1 and the LCD reference ladder is in Power mode 'B', the LCD internal FVR buffer is disables.

Note:	The LCD module automatically turns on the Fixed Voltage Reference when needed.

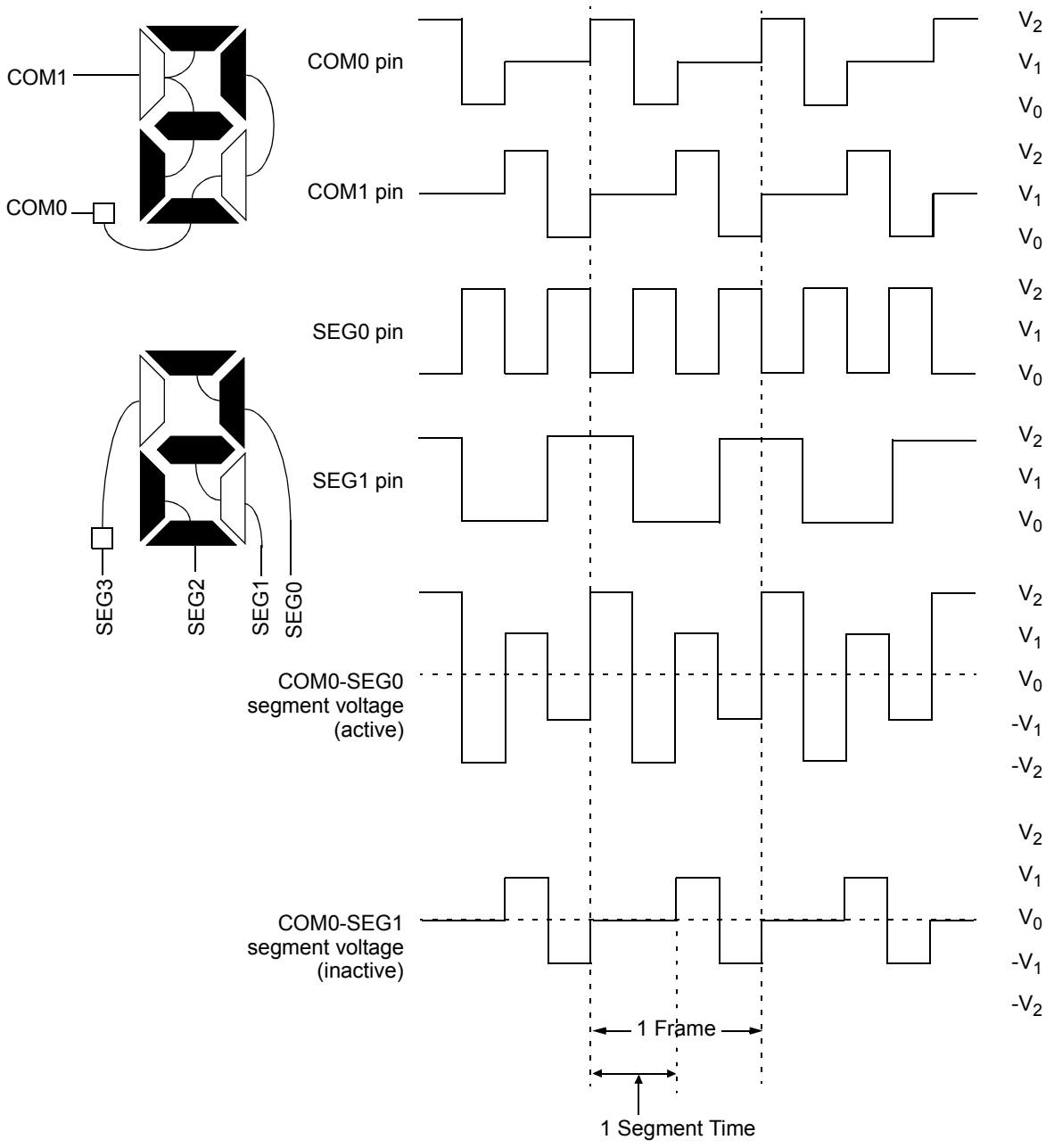
18.4.6 VLCD<3:1> PINS

The VLCD<3:1> pins provide the ability for an external LCD bias network to be used instead of the internal ladder. Use of the VLCD<3:1> pins does not prevent use of the internal ladder. Each VLCD pin has an independent control in the LCDREF register (Register 18-3), allowing access to any or all of the LCD Bias signals. This architecture allows for maximum flexibility in different applications

For example, the VLCD<3:1> pins may be used to add capacitors to the internal reference ladder, increasing the drive capacity.

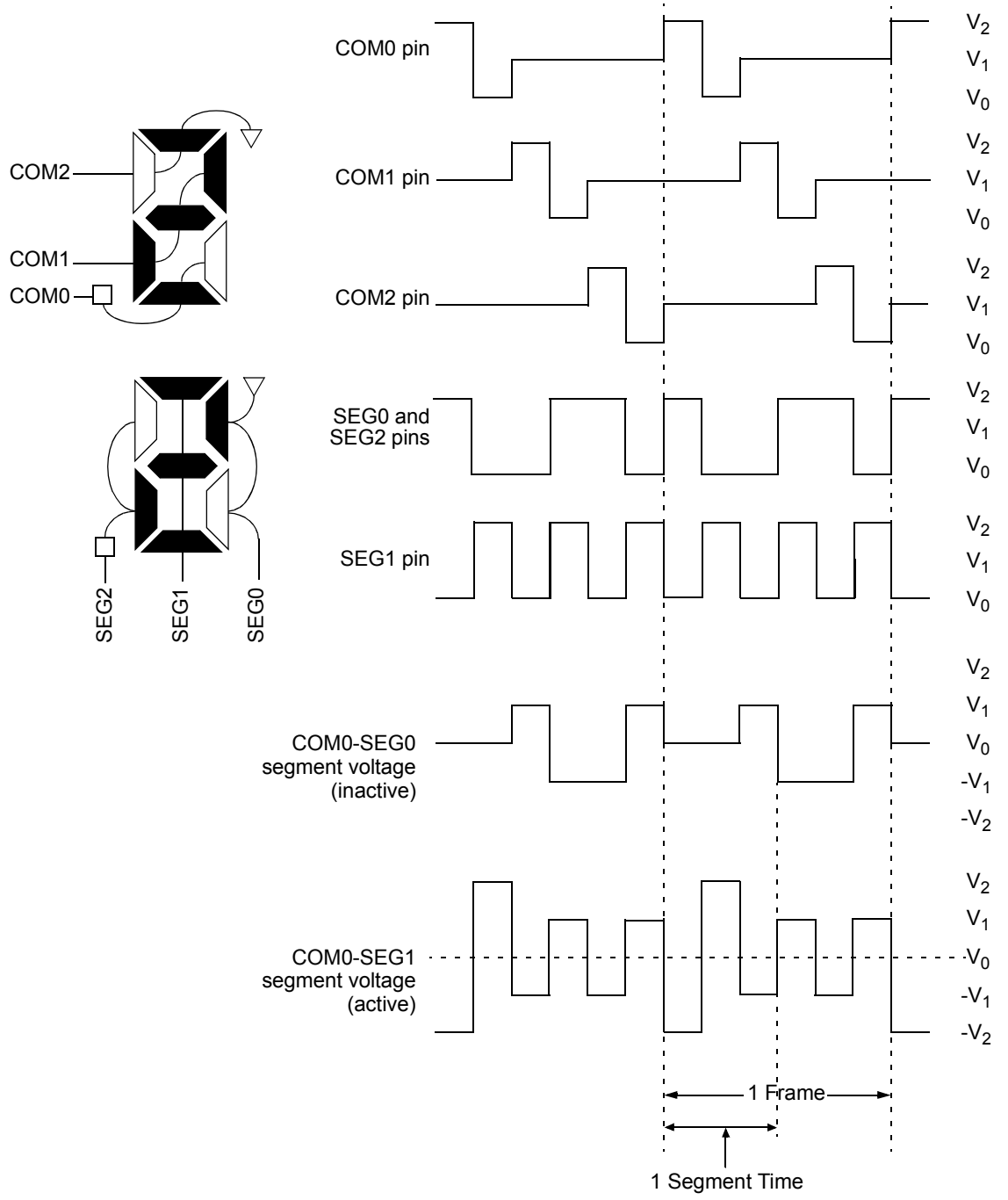
For applications where the internal contrast control is insufficient, the firmware can choose to only enable the VLCD3 pin, allowing an external contrast control circuit to use the internal reference divider.

FIGURE 18-9: TYPE-A WAVEFORMS IN 1/2 MUX, 1/2 BIAS DRIVE



Note: 1 Frame = 2 single segment times.

FIGURE 18-13: TYPE-A WAVEFORMS IN 1/3 MUX, 1/2 BIAS DRIVE



Note: 1 Frame = 2 single segment times.

FIGURE 18-20: SLEEP ENTRY/EXIT WHEN SLPEN = 1

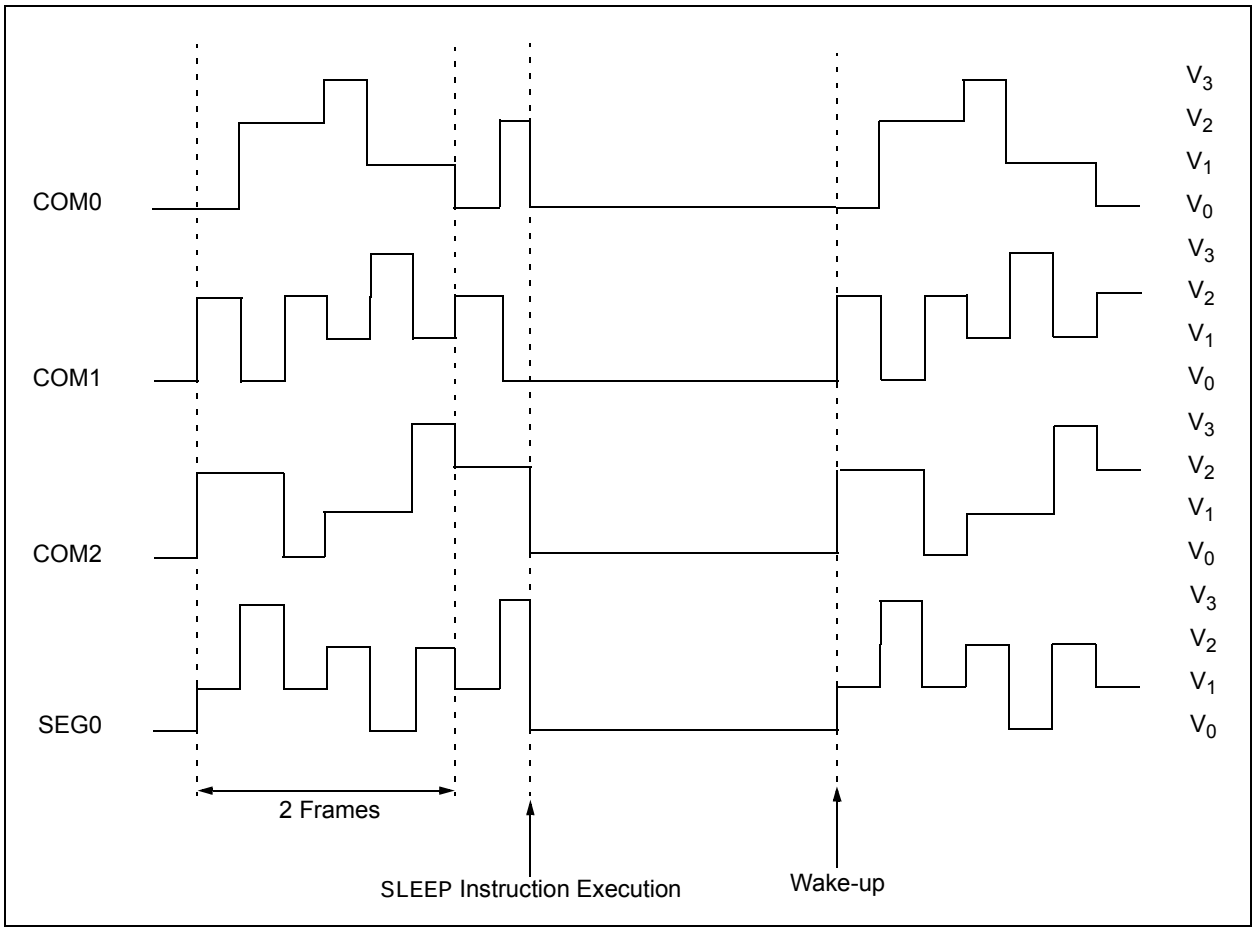
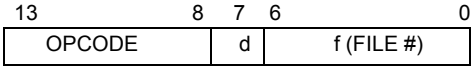


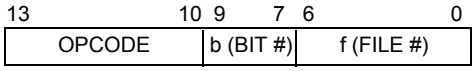
FIGURE 20-1: GENERAL FORMAT FOR INSTRUCTIONS

Byte-oriented file register operations



d = 0 for destination W
d = 1 for destination f
f = 7-bit file register address

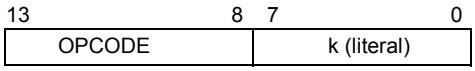
Bit-oriented file register operations



b = 3-bit bit address
f = 7-bit file register address

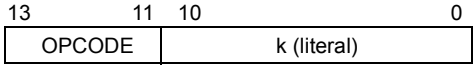
Literal and control operations

General



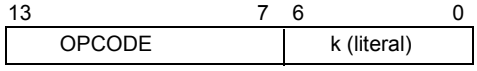
k = 8-bit immediate value

CALL and GOTO instructions only



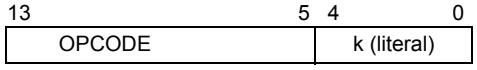
k = 11-bit immediate value

MOVLP instruction only



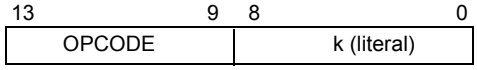
k = 7-bit immediate value

MOVLB instruction only



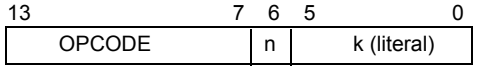
k = 5-bit immediate value

BRA instruction only



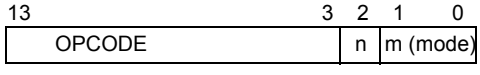
k = 9-bit immediate value

FSR Offset instructions



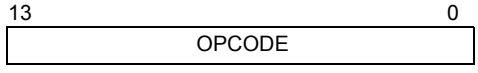
n = appropriate FSR
k = 6-bit immediate value

FSR Increment instructions



n = appropriate FSR
m = 2-bit mode value

OPCODE only



RETFIE **Return from Interrupt**

Syntax: [*label*] RETFIE k

Operands: None

Operation: TOS → PC,
1 → GIE

Status Affected: None

Description: Return from Interrupt. Stack is POPed and Top-of-Stack (TOS) is loaded in the PC. Interrupts are enabled by setting Global Interrupt Enable bit, GIE (INTCON<7>). This is a 2-cycle instruction.

Words: 1

Cycles: 2

Example:

```
RETFIE
```

After Interrupt
PC = TOS
GIE = 1

RETLW **Return with literal in W**

Syntax: [*label*] RETLW k

Operands: 0 ≤ k ≤ 255

Operation: k → (W);
TOS → PC

Status Affected: None

Description: The W register is loaded with the 8-bit literal 'k'. The program counter is loaded from the top of the stack (the return address). This is a 2-cycle instruction.

Words: 1

Cycles: 2

Example:

```
CALL TABLE;W contains table
    ;offset value
•   ;W now has table value
•
•
ADDWF PC  ;W = offset
RETLW k1  ;Begin table
RETLW k2  ;
•
•
•
RETLW kn  ; End of table
```

Before Instruction
W = 0x07
After Instruction
W = value of k8

RETURN **Return from Subroutine**

Syntax: [*label*] RETURN

Operands: None

Operation: TOS → PC

Status Affected: None

Description: Return from subroutine. The stack is POPed and the top of the stack (TOS) is loaded into the program counter. This is a 2-cycle instruction.

RLF **Rotate Left f through Carry**

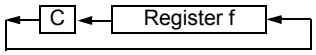
Syntax: [*label*] RLF f,d

Operands: 0 ≤ f ≤ 127
d ∈ [0,1]

Operation: See description below

Status Affected: C

Description: The contents of register 'f' are rotated one bit to the left through the Carry flag. If 'd' is '0', the result is placed in the W register. If 'd' is '1', the result is stored back in register 'f'.



Words: 1

Cycles: 1

Example:

```
RLF     REG1,0
```

Before Instruction
REG1 = 1110 0110
C = 0
After Instruction
REG1 = 1110 0110
W = 1100 1100
C = 1

SWAPF **Swap Nibbles in f**

Syntax:	[*label*] SWAPF f,d
Operands:	$0 \le f \le 127$ $d \in [0,1]$
Operation:	(f<3:0>) → (destination<7:4>), (f<7:4>) → (destination<3:0>)
Status Affected:	None
Description:	The upper and lower nibbles of register 'f' are exchanged. If 'd' is '0', the result is placed in the W register. If 'd' is '1', the result is placed in register 'f'.

TRIS **Load TRIS Register with W**

Syntax:	[*label*] TRIS f
Operands:	$5 \le f \le 7$
Operation:	(W) → TRIS register 'f'
Status Affected:	None
Description:	Move data from W register to TRIS register. When 'f' = 5, TRISA is loaded. When 'f' = 6, TRISB is loaded. When 'f' = 7, TRISC is loaded.

XORLW **Exclusive OR literal with W**

Syntax:	[*label*] XORLW k
Operands:	$0 \le k \le 255$
Operation:	(W) .XOR. k → (W)
Status Affected:	Z
Description:	The contents of the W register are XOR'ed with the 8-bit literal 'k'. The result is placed in the W register.

XORWF **Exclusive OR W with f**

Syntax:	[*label*] XORWF f,d
Operands:	$0 \le f \le 127$ $d \in [0,1]$
Operation:	(W) .XOR. (f) → (destination)
Status Affected:	Z
Description:	Exclusive OR the contents of the W register with register 'f'. If 'd' is '0', the result is stored in the W register. If 'd' is '1', the result is stored back in register 'f'.

21.3 AC Characteristics

The timing parameter symbols have been created with one of the following formats:

1. TppS2ppS
2. TppS

T			
F	Frequency	T	Time

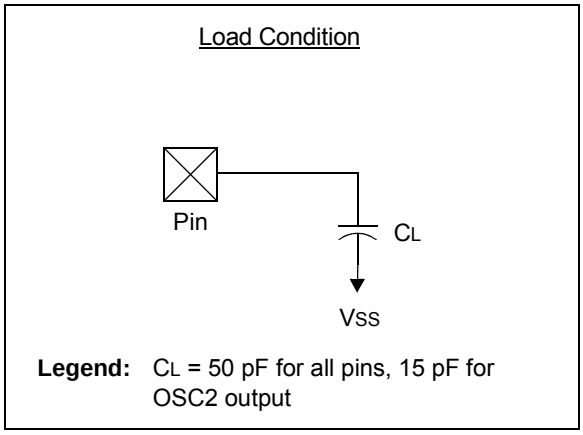
Lowercase letters (pp) and their meanings:

pp			
cc	CCP1	osc	OSC1
ck	CLKOUT	rd	$\overline{RD}$
cs	$\overline{CS}$	rw	$\overline{RD}$ or $\overline{WR}$
di	SDI	sc	SCK
do	SDO	ss	$\overline{SS}$
dt	Data in	t0	T0CKI
io	I/O PORT	t1	T1CKI
mc	$\overline{MCLR}$	wr	$\overline{WR}$

Uppercase letters and their meanings:

S			
F	Fall	P	Period
H	High	R	Rise
I	Invalid (High-Impedance)	V	Valid
L	Low	Z	High-Impedance

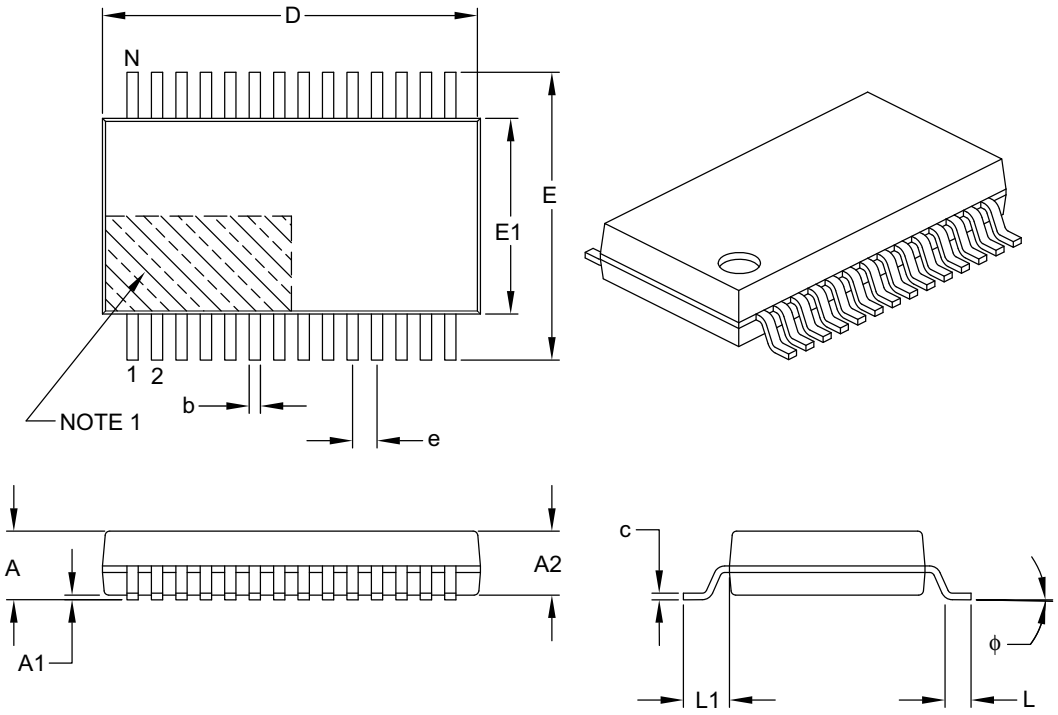
FIGURE 21-4: LOAD CONDITIONS



Legend: C_L = 50 pF for all pins, 15 pF for OSC2 output

28-Lead Plastic Shrink Small Outline (SS) – 5.30 mm Body [SSOP]

Note: For the most current package drawings, please see the Microchip Packaging Specification located at http://www.microchip.com/packaging



Units		MILLIMETERS		
Dimension Limits		MIN	NOM	MAX
Number of Pins	N		28	
Pitch	e		0.65 BSC	
Overall Height	A	–	–	2.00
Molded Package Thickness	A2	1.65	1.75	1.85
Standoff	A1	0.05	–	–
Overall Width	E	7.40	7.80	8.20
Molded Package Width	E1	5.00	5.30	5.60
Overall Length	D	9.90	10.20	10.50
Foot Length	L	0.55	0.75	0.95
Footprint	L1		1.25 REF	
Lead Thickness	c	0.09	–	0.25
Foot Angle	ϕ	0°	4°	8°
Lead Width	b	0.22	–	0.38

Notes:

1. Pin 1 visual index feature may vary, but must be located within the hatched area.
2. Dimensions D and E1 do not include mold flash or protrusions. Mold flash or protrusions shall not exceed 0.20 mm per side.
3. Dimensioning and tolerancing per ASME Y14.5M.

BSC: Basic Dimension. Theoretically exact value shown without tolerances.
REF: Reference Dimension, usually without tolerance, for information purposes only.

Microchip Technology Drawing C04-073B