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**PIC16(L)F151X/152X Memory Programming Specification**

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**This document includes the programming specifications for the following devices:**

- PIC16F1512    • PIC16LF1512
- PIC16F1513    • PIC16LF1513
- PIC16F1516    • PIC16LF1516
- PIC16F1517    • PIC16LF1517
- PIC16F1518    • PIC16LF1518
- PIC16F1519    • PIC16LF1519
- PIC16F1526    • PIC16LF1526
- PIC16F1527    • PIC16LF1527

## 1.0 OVERVIEW

The PIC16(L)F151X/152X devices can be programmed using either the high-voltage In-Circuit Serial Programming™ (ICSP™) method or the low-voltage ICSP™ method.

### 1.1 Hardware Requirements

#### 1.1.1 HIGH-VOLTAGE ICSP PROGRAMMING

In High-Voltage ICSP™ mode, these devices require two programmable power supplies; one for VDD and one for the MCLR/VPP pin.

#### 1.1.2 LOW-VOLTAGE ICSP PROGRAMMING

In Low-Voltage ICSP™ mode, these devices can be programmed using a single VDD source in the operating range. The MCLR/VPP pin does not have to be brought to a different voltage, but can instead be left at the normal operating voltage.

##### 1.1.2.1 Single-Supply ICSP Programming

The LVP bit in Configuration Word 2 enables single-supply (low-voltage) ICSP programming. The LVP bit defaults to a '1' (enabled) from the factory. The LVP bit may only be programmed to '0' by entering the High-Voltage ICSP mode, where the MCLR/VPP pin is raised to VIH. Once the LVP bit is programmed to a '0', only the High-Voltage ICSP mode is available and only the High-Voltage ICSP mode can be used to program the device.

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|---|
| <p><b>Note 1:</b> The High-Voltage ICSP mode is always available, regardless of the state of the LVP bit, by applying VIH to the MCLR/VPP pin.</p> <p><b>2:</b> While in Low-Voltage ICSP mode, MCLR is always enabled, regardless of the MCLRE bit, and the port pin can no longer be used as a general purpose input.</p> |
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# PIC16(L)F151X/152X

## 1.2 Pin Utilization

Five pins are needed for ICSP™ programming. The pins are listed in Table 1-1 and Table 1-2.

**TABLE 1-1: PIN DESCRIPTIONS DURING PROGRAMMING – PIC16(L)F1526 AND PIC16(L)F1527**

Pin Name	During Programming		
	Function	Pin Type	Pin Description
RB6	ICSPCLK	I	Clock Input – Schmitt Trigger Input
RB7	ICSPDAT	I/O	Data Input/Output – Schmitt Trigger Input
RG5/ $\overline{\text{MCLR}}$ /VPP	Program/Verify mode	P <sup>(1)</sup>	Program Mode Select/Programming Power Supply
VDD	VDD	P	Power Supply
VSS	VSS	P	Ground

**Legend:** I = Input, O = Output, P = Power

**Note 1:** The programming high voltage is internally generated. To activate the Program/Verify mode, high voltage needs to be applied to  $\overline{\text{MCLR}}$  input. Since the  $\overline{\text{MCLR}}$  is used for a level source,  $\overline{\text{MCLR}}$  does not draw any significant current.

**TABLE 1-2: PIN DESCRIPTIONS DURING PROGRAMMING – PIC16(L)F1512, PIC16(L)F1513, PIC16(L)F1516, PIC16(L)F1517, PIC16(L)F1518 and PIC16(L)F1519**

Pin Name	During Programming		
	Function	Pin Type	Pin Description
RB6	ICSPCLK	I	Clock Input – Schmitt Trigger Input
RB7	ICSPDAT	I/O	Data Input/Output – Schmitt Trigger Input
RE3/ $\overline{\text{MCLR}}$ /VPP	Program/Verify mode	P <sup>(1)</sup>	Program Mode Select/Programming Power Supply
VDD	VDD	P	Power Supply
VSS	VSS	P	Ground

**Legend:** I = Input, O = Output, P = Power

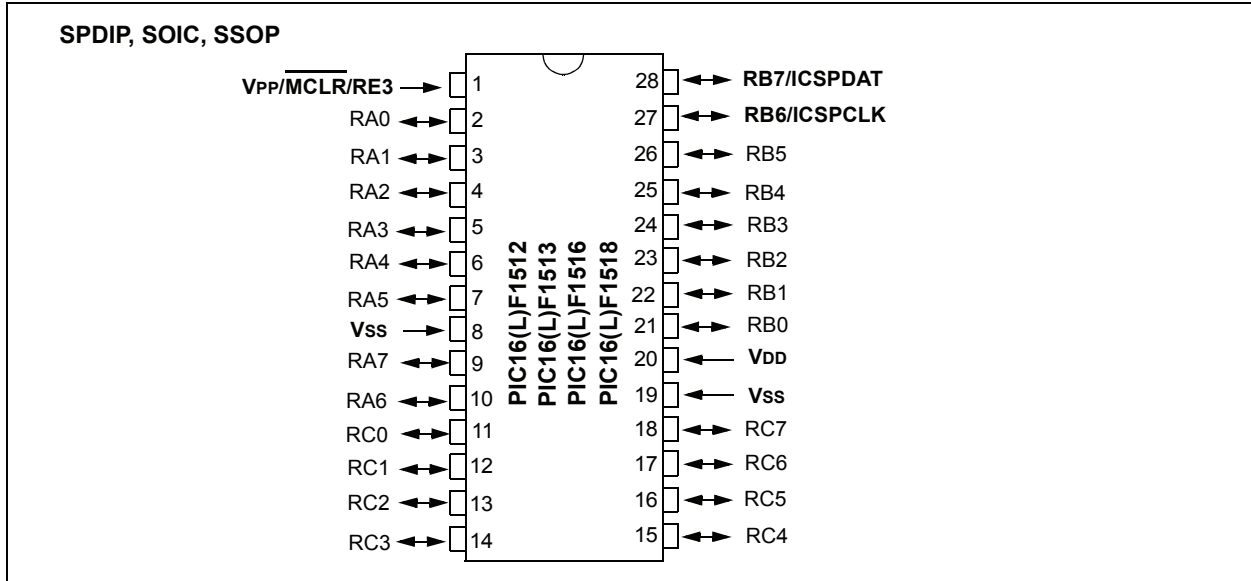
**Note 1:** The programming high voltage is internally generated. To activate the Program/Verify mode, high voltage needs to be applied to  $\overline{\text{MCLR}}$  input. Since the  $\overline{\text{MCLR}}$  is used for a level source,  $\overline{\text{MCLR}}$  does not draw any significant current.

# PIC16(L)F151X/152X

## 2.0 DEVICE PINOUTS

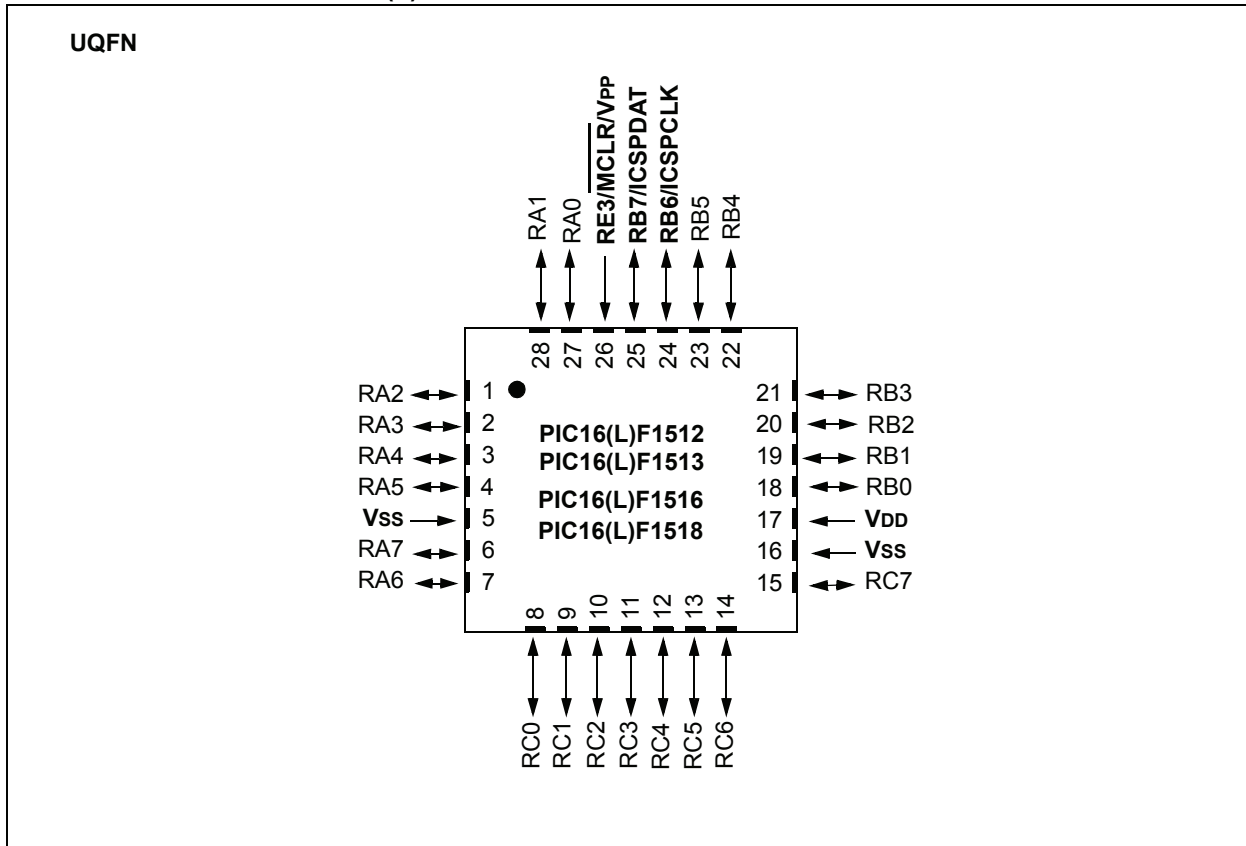
The pin diagrams for the PIC16(L)F151X/152X family are shown in Figure 2-1 through Figure 2-7. The pins that are required for programming are listed in Table 1-1 and shown in bold lettering in the pin diagrams.

**FIGURE 2-1: 28-PIN SPDIP, SOIC, SSOP DIAGRAM FOR PIC16(L)F1512, PIC16(L)F1513, PIC16(L)F1516 AND PIC16(L)F1518**



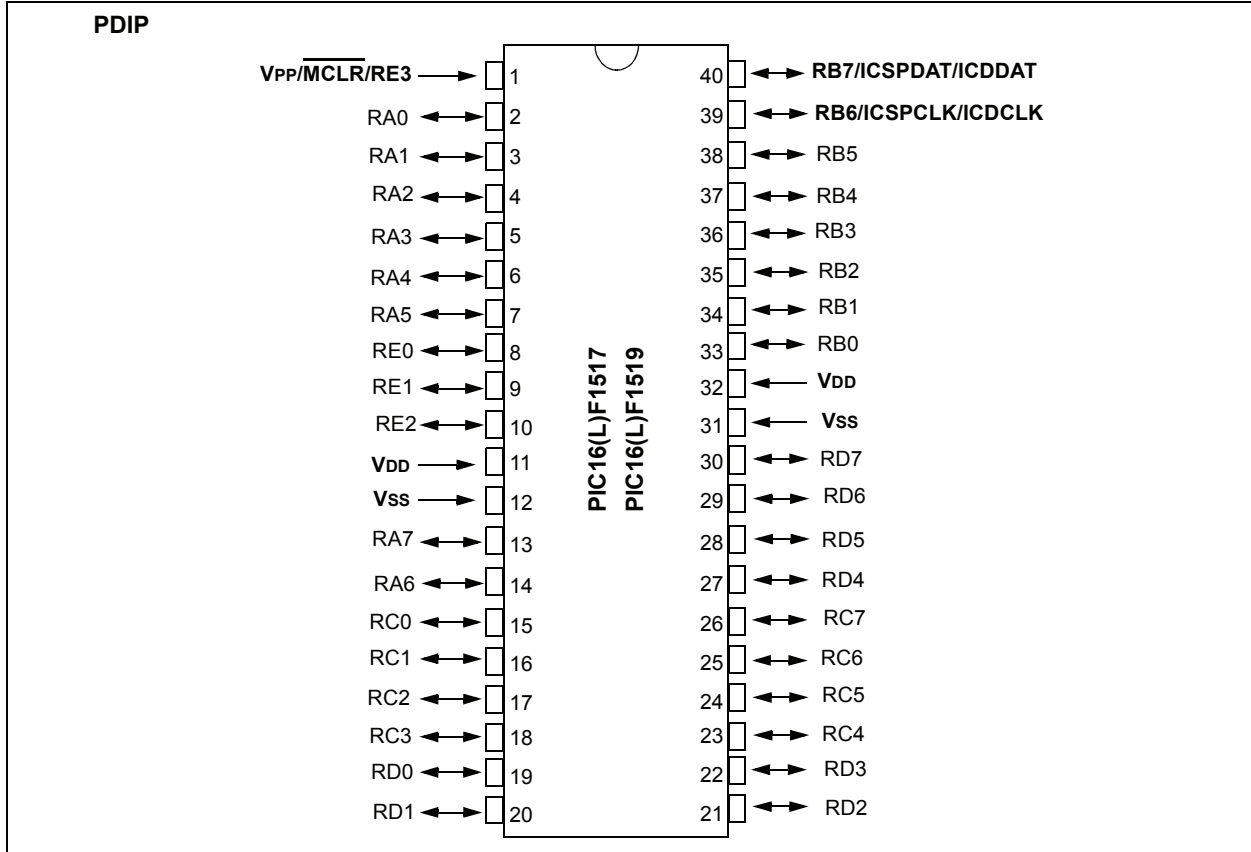
# PIC16(L)F151X/152X

FIGURE 2-2: 28-PIN UQFN DIAGRAM FOR PIC16(L)F1512, PIC16(L)F1513, PIC16(L)F1516 AND PIC16(L)F1518

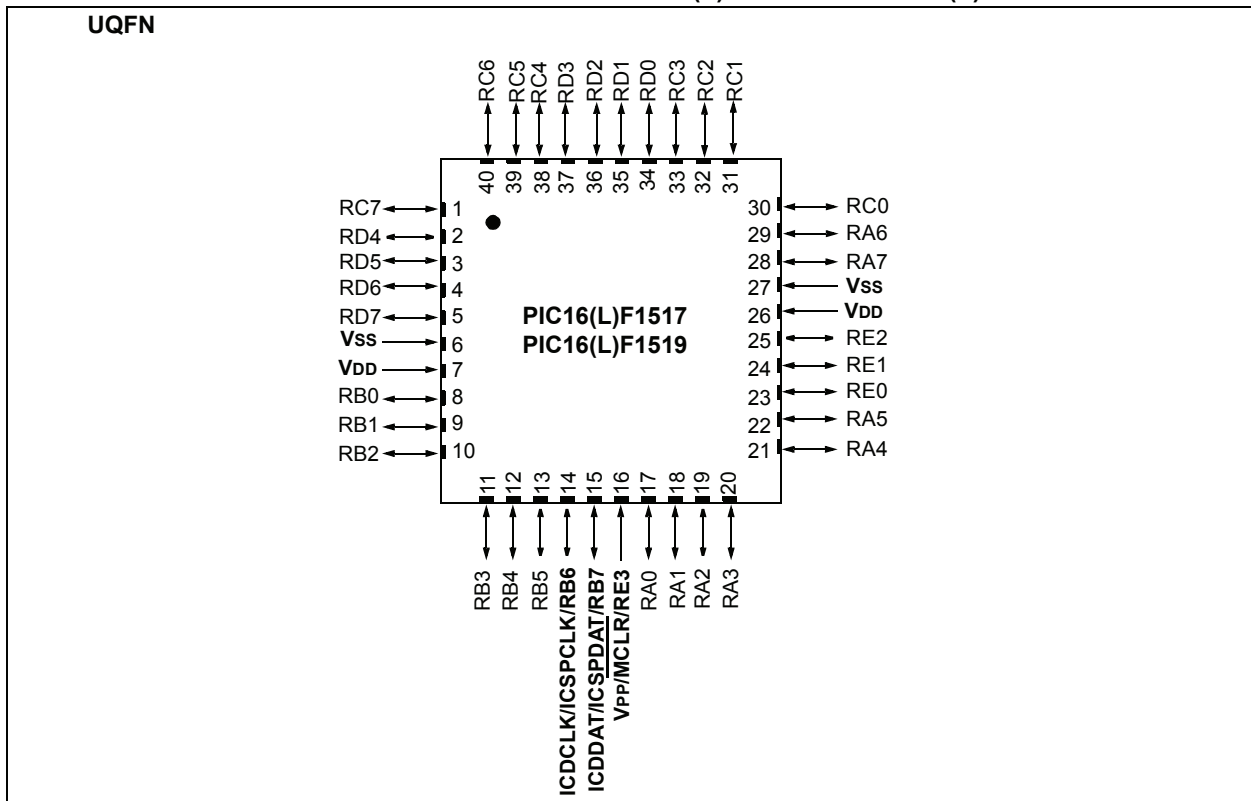


# PIC16(L)F151X/152X

**FIGURE 2-3: 40-PIN PDIP DIAGRAM FOR PIC16(L)F1517 AND PIC16(L)F1519**

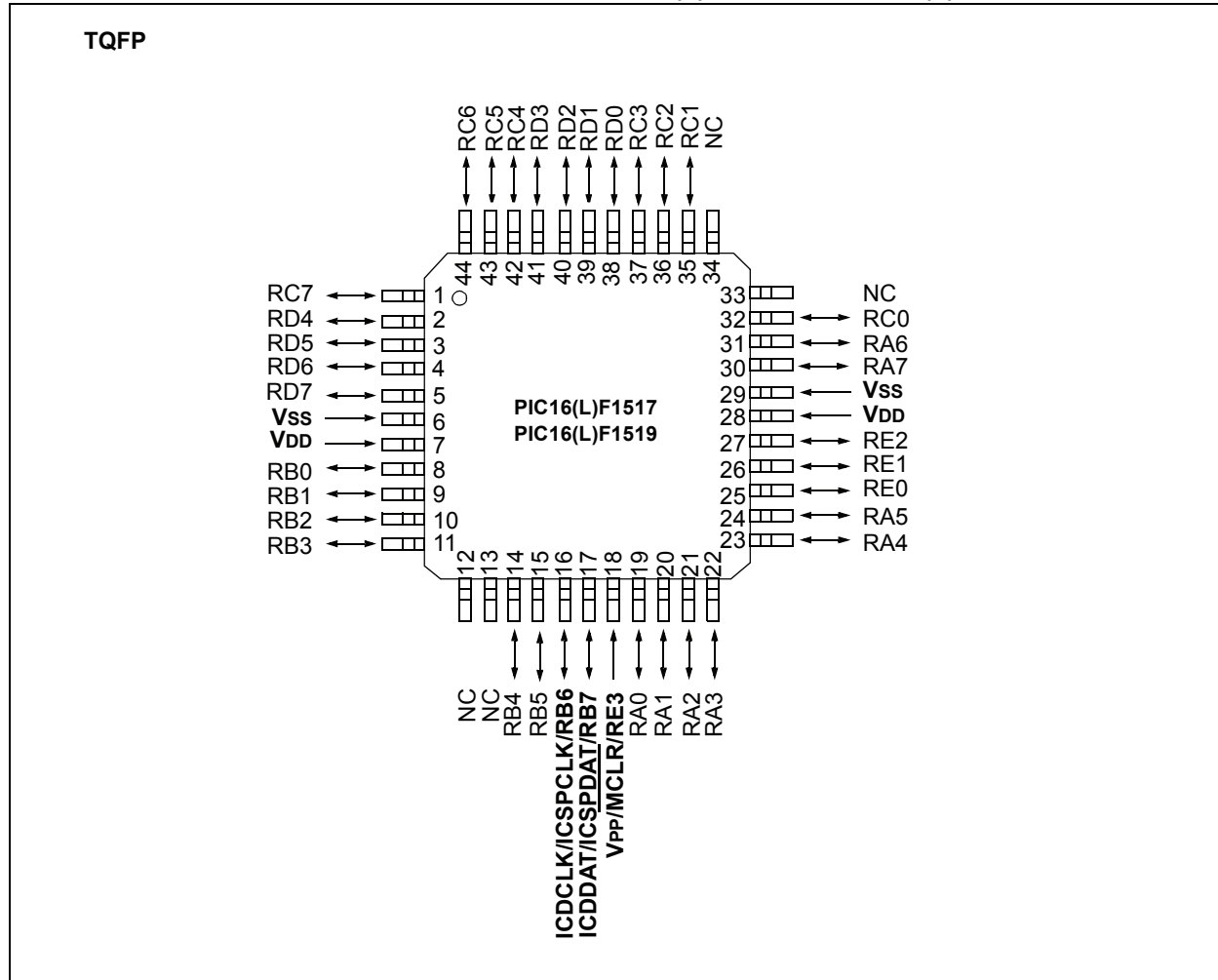


**FIGURE 2-4: 40-PIN UQFN DIAGRAM FOR PIC16(L)F1517 AND PIC16(L)F1519**



# PIC16(L)F151X/152X

FIGURE 2-5: 44-PIN TQFP DIAGRAM FOR PIC16(L)F1517 AND PIC16(L)F1519



# PIC16(L)F151X/152X

FIGURE 2-6: 64-PIN QFN DIAGRAM FOR PIC16(L)F1526 AND PIC16(L)F1527

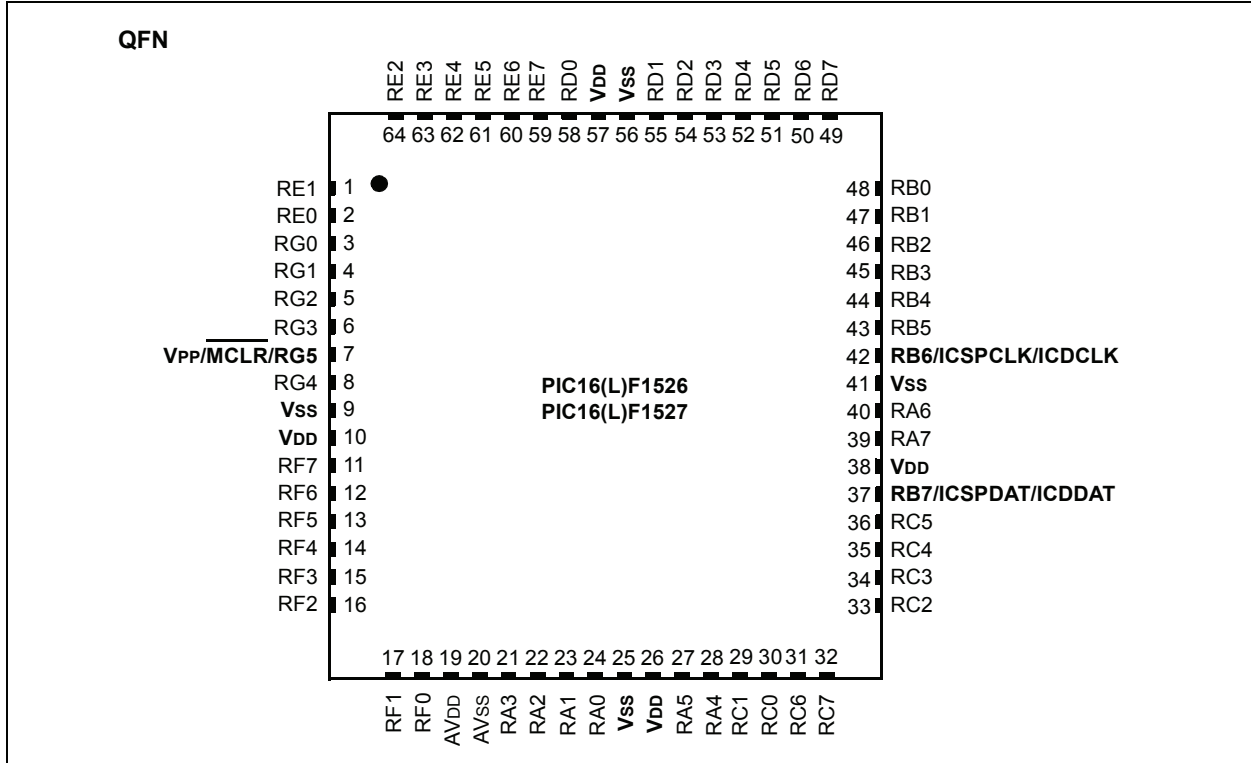
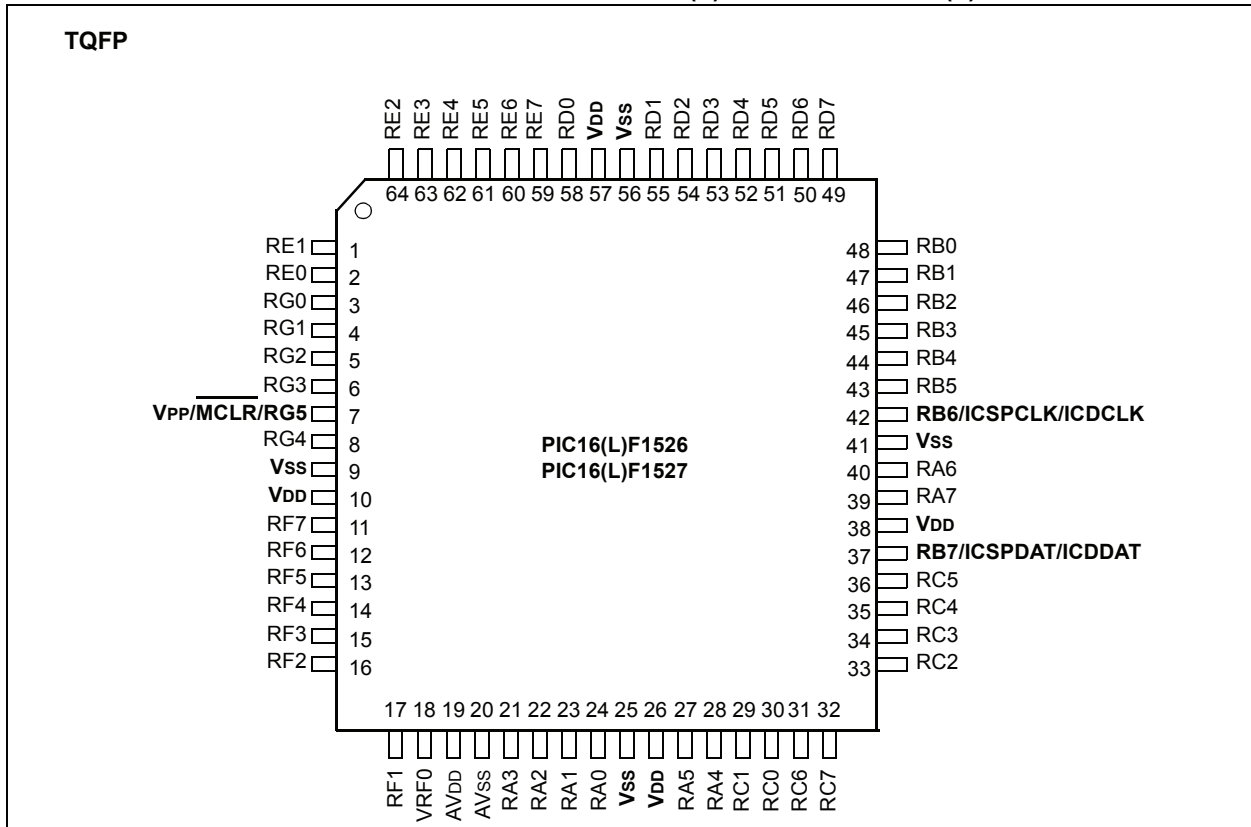


FIGURE 2-7: 64-PIN TQFP DIAGRAM FOR PIC16(L)F1526 AND PIC16(L)F1527

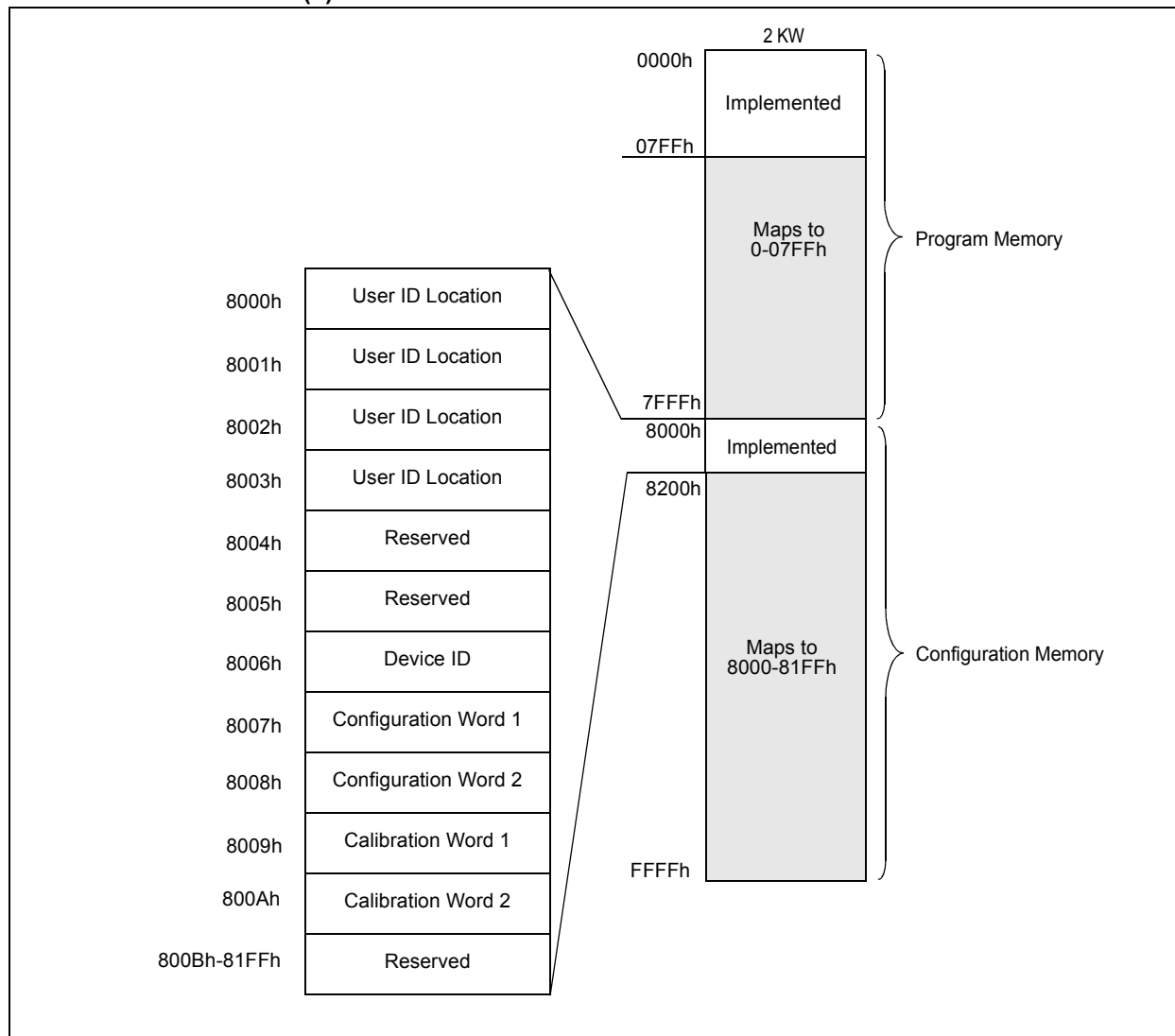


# PIC16(L)F151X/152X

## 3.0 MEMORY MAP

The memory for the PIC16(L)F151X/152X devices is broken into two sections: program memory and configuration memory. Only the size of the program memory changes between devices, the configuration memory remains the same.

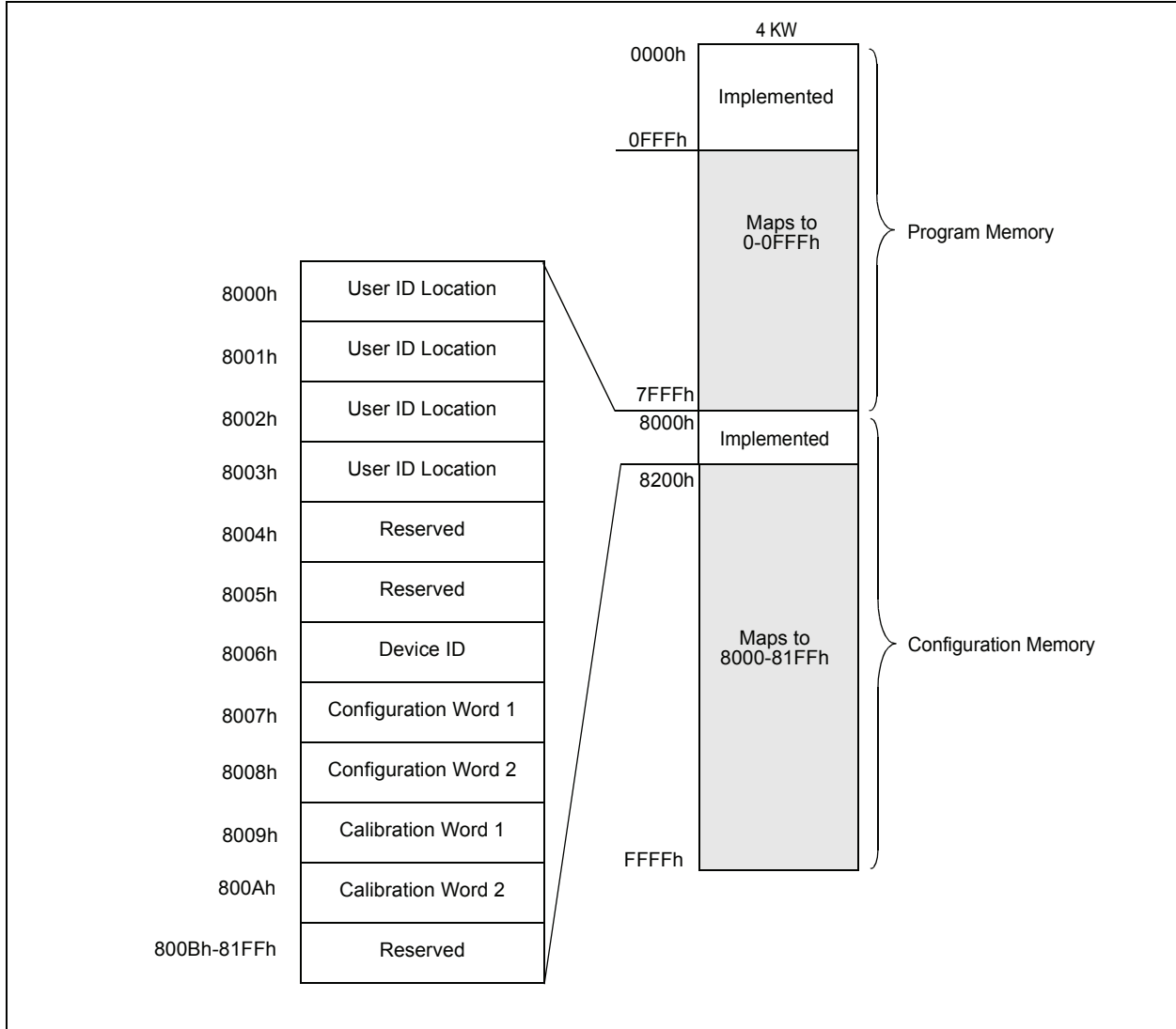
**FIGURE 3-1: PIC16(L)F1512 PROGRAM MEMORY MAPPING**





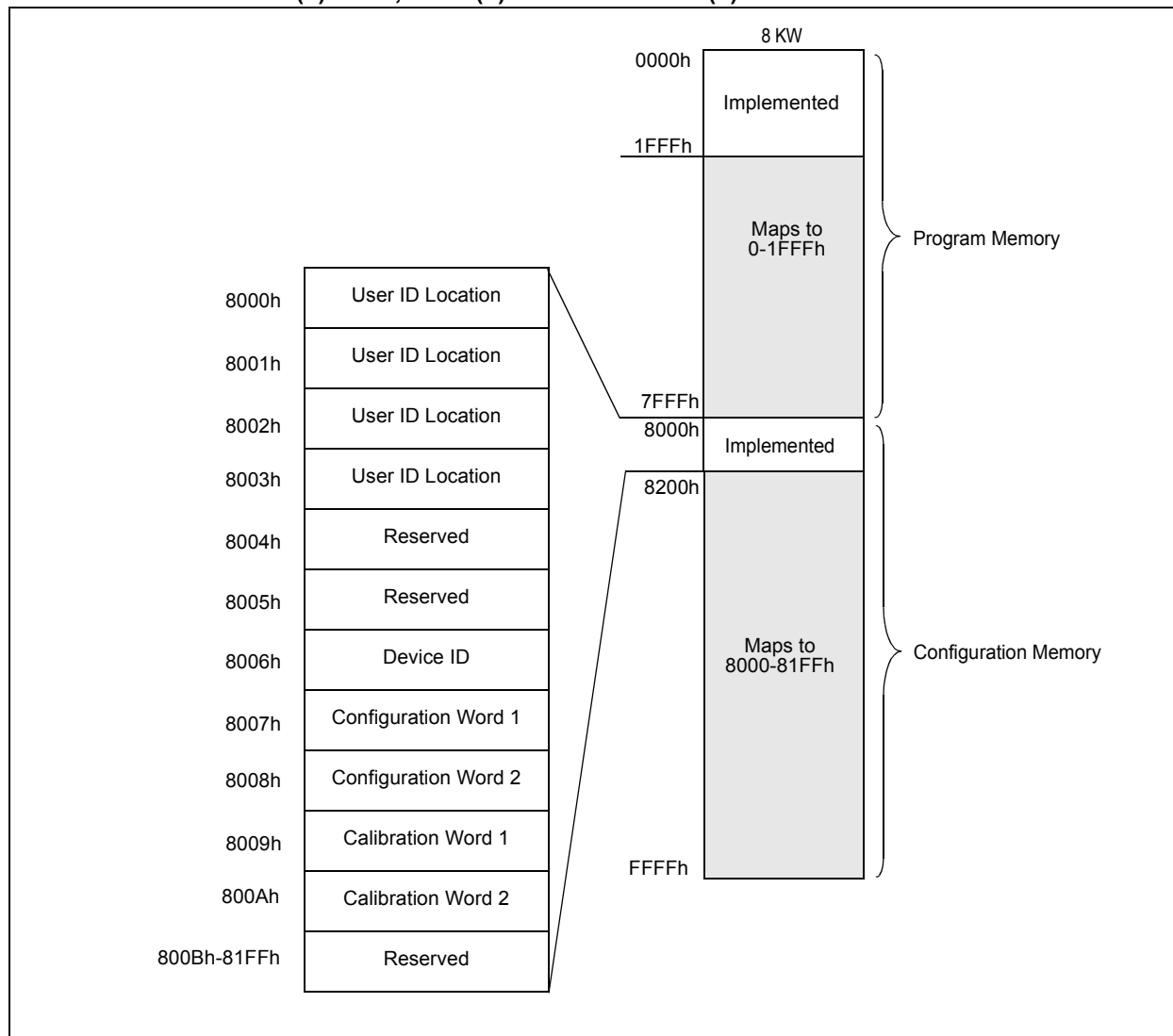
# PIC16(L)F151X/152X

**FIGURE 3-2: PIC16(L)F1513 PROGRAM MEMORY MAPPING**

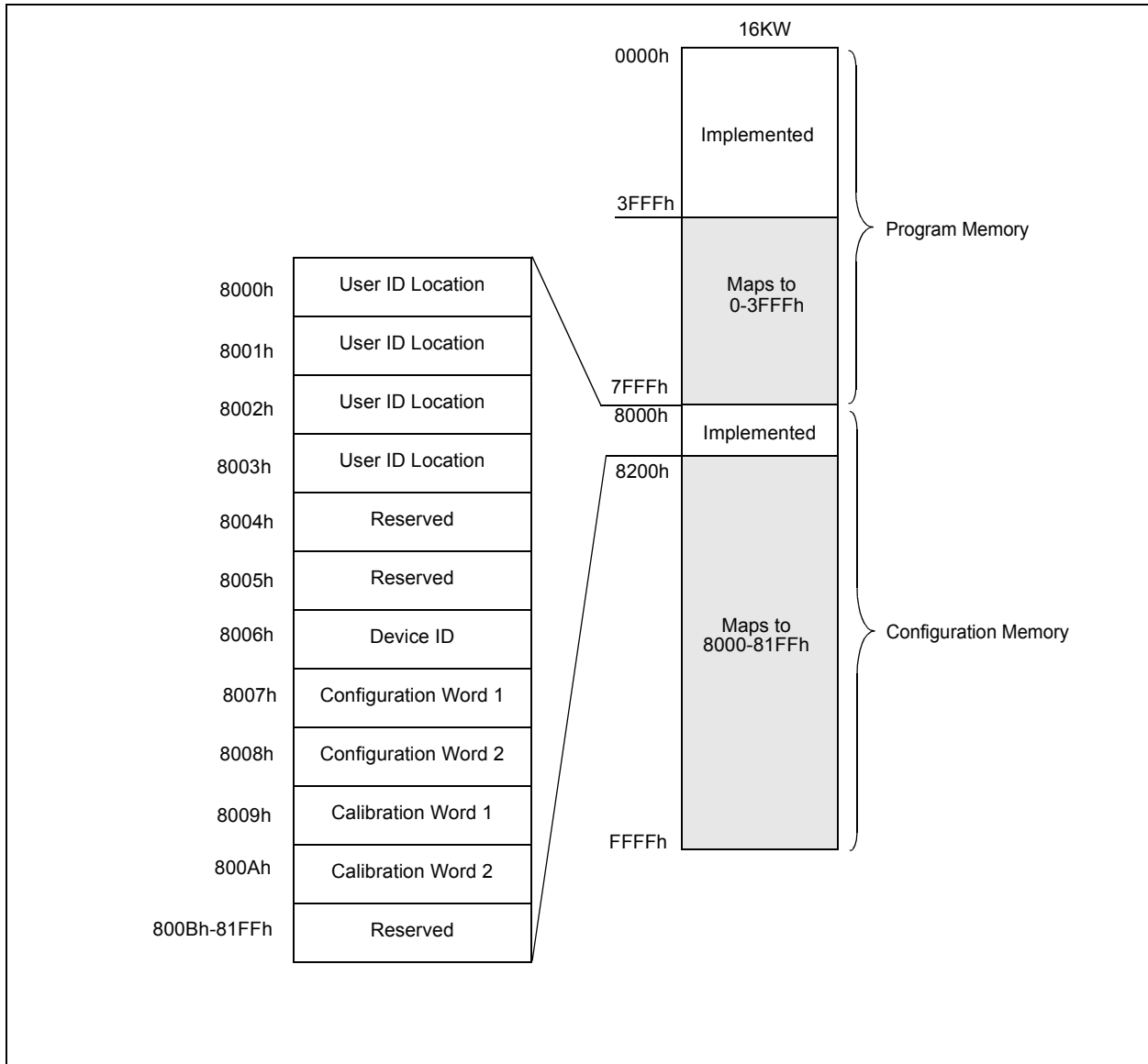


# PIC16(L)F151X/152X

**FIGURE 3-3: PIC16(L)F1526, PIC16(L)F1516 AND PIC16(L)F1517 PROGRAM MEMORY MAPPING**



**FIGURE 3-4: PIC16(L)F1527, PIC16(L)F1518 AND PIC16(L)F1519 PROGRAM MEMORY MAPPING**



# PIC16(L)F151X/152X

## 3.1 User ID Location

A user may store identification information (user ID) in four designated locations. The user ID locations are mapped to 8000h-8003h. Each location is 14 bits in length. Code protection has no effect on these memory locations. Each location may be read with code protection enabled or disabled.

**Note:** MPLAB® IDE only displays the 7 Least Significant bits (LSb) of each user ID location, the upper bits are not read. It is recommended that only the 7 LSbs be used if MPLAB IDE is the primary tool used to read these addresses.

## 3.2 Device ID

The device ID word is located at 8006h. This location is read-only and cannot be erased or modified.

**REGISTER 3-1: DEVICE ID: DEVICE ID REGISTER<sup>(1)</sup>**

R	R	R	R	R	R
DEV<8:3>					
bit 13			bit 8		

R	R	R	R	R	R	R	R
DEV<2:0>				REV<4:0>			
bit 7				bit 0			

<b>Legend:</b>	P = Programmable bit	U = Unimplemented bit, read as '0'
R = Readable bit	W = Writable bit	'0' = Bit is cleared
-n = Value at POR	'1' = Bit is set	x = Bit is unknown

- bit 13-5      **DEV<8:0>**: Device ID bits  
              These bits are used to identify the part number.
- bit 4-0      **REV<4:0>**: Revision ID bits  
              These bits are used to identify the revision.

**Note 1:** This location cannot be written.

**TABLE 3-1: DEVICE ID VALUES**

DEVICE	DEVICE ID VALUES	
	DEV	REV
PIC16F1527	0001 0101 101	x xxxxx
PIC16F1526	0001 0101 100	x xxxxx
PIC16LF1527	0001 0101 111	x xxxxx
PIC16LF1526	0001 0101 110	x xxxxx
PIC16F1519	0001 0110 111	x xxxxx
PIC16F1518	0001 0110 110	x xxxxx
PIC16F1517	0001 0110 101	x xxxxx
PIC16F1516	0001 0110 100	x xxxxx
PIC16F1513	0001 0110 010	x xxxxx
PIC16F1512	0001 0111 000	x xxxxx
PIC16LF1519	0001 0111 111	x xxxxx
PIC16LF1518	0001 0111 110	x xxxxx
PIC16LF1517	0001 0111 101	x xxxxx
PIC16LF1516	0001 0111 100	x xxxxx
PIC16LF1513	0001 0111 010	x xxxxx
PIC16LF1512	0001 0111 001	x xxxxx

### 3.3 Configuration Words

There are two Configuration Words, Configuration Word 1 (8007h) and Configuration Word 2 (8008h). The individual bits within these Configuration Words are used to enable or disable device functions such as the Brown-out Reset, code protection and Power-up Timer.

### 3.4 Calibration Words

The internal calibration values are factory calibrated and stored in Calibration Words 1 and 2 (8009h, 800Ah).

The Calibration Words do not participate in erase operations. The device can be erased without affecting the Calibration Words.

# PIC16(L)F151X/152X

## REGISTER 3-2: CONFIGURATION WORD 1

R/P-1	R/P-1	R/P-1	R/P-1	R/P-1	U-1
FCMEN	IESO	CLKOUTEN	BOREN<1:0>		—
bit 13					bit 8

R/P-1	R/P-1	R/P-1	R/P-1	R/P-1	R/P-1	R/P-1	R/P-1
CP	MCLRE	PWRTE	WDTE<1:0>		FOSC<2:0>		
bit 7							bit 0

### Legend:

R = Readable bit                      P = Programmable bit                      U = Unimplemented bit, read as '1'  
 '0' = Bit is cleared                      '1' = Bit is set                                      -n = Value when blank or after Bulk Erase

- bit 13            **FCMEN:** Fail-Safe Clock Monitor Enable bit  
 1 = Fail-Safe Clock Monitor is enabled  
 0 = Fail-Safe Clock Monitor is disabled
- bit 12            **IESO:** Internal External Switchover bit  
 1 = Internal/External Switchover mode is enabled  
 0 = Internal/External Switchover mode is disabled
- bit 11            **CLKOUTEN:** Clock Out Enable bit  
 1 = CLKOUT function is disabled. I/O or oscillator function on CLKOUT pin.  
 0 = CLKOUT function is enabled on CLKOUT pin
- bit 10-9        **BOREN<1:0>:** Brown-out Reset Enable bits<sup>(1)</sup>  
 11 = BOR enabled  
 10 = BOR enabled during operation and disabled in Sleep  
 01 = BOR controlled by SBOREN bit of the PCON register  
 00 = BOR disabled
- bit 8            **Unimplemented:** Read as '1'
- bit 7            **CP:** Code Protection bit<sup>(2)</sup>  
 1 = Program memory code protection is disabled  
 0 = Program memory code protection is enabled
- bit 6            **MCLRE:**  $\overline{\text{MCLR}}$ /VPP Pin Function Select bit  
 If LVP bit = 1:  
     This bit is ignored.  
 If LVP bit = 0:  
     1 =  $\overline{\text{MCLR}}$ /VPP pin function is  $\overline{\text{MCLR}}$ ; Weak pull-up enabled.  
     0 =  $\overline{\text{MCLR}}$ /VPP pin function is digital input;  $\overline{\text{MCLR}}$  internally disabled; Weak pull-up under control of WPUA register.
- bit 5            **PWRTE:** Power-up Timer Enable bit<sup>(1)</sup>  
 1 = PWRT disabled  
 0 = PWRT enabled
- bit 4-3        **WDTE<1:0>:** Watchdog Timer Enable bit  
 11 = WDT enabled  
 10 = WDT enabled while running and disabled in Sleep  
 01 = WDT controlled by the SWDTEN bit in the WDTCON register  
 00 = WDT disabled
- bit 2-0        **FOSC<2:0>:** Oscillator Selection bits  
 111 = ECH: External Clock, High-Power mode: on CLKIN pin  
 110 = ECM: External Clock, Medium-Power mode: on CLKIN pin  
 101 = ECL: External Clock, Low-Power mode: on CLKIN pin  
 100 = INTOSC oscillator: I/O function on OSC1 pin  
 011 = EXTRC oscillator: RC function on OSC1 pin  
 010 = HS oscillator: High-speed crystal/resonator on OSC2 pin and OSC1 pin  
 001 = XT oscillator: Crystal/resonator on OSC2 pin and OSC1 pin  
 000 = LP oscillator: Low-power crystal on OSC2 pin and OSC1 pin

- Note 1:** Enabling Brown-out Reset does not automatically enable Power-up Timer.  
**Note 2:** The entire program memory will be erased when the code protection is turned off.

# PIC16(L)F151X/152X

## REGISTER 3-3: CONFIGURATION WORD 2

R/P-1	R/P-1	R/P-1	R/P-1	R/P-1	U-1
LVP	DEBUG	LPBOR	BORV	STVREN	—
bit 13					bit 8

U-1	U-1	U-1	R/P-1	U-1	U-1	R/P-1	R/P-1
—	—	—	VCAPEN <sup>(2)</sup>	—	—	WRT<1:0>	
bit 7							bit 0

### Legend:

R = Readable bit                      P = Programmable bit                      U = Unimplemented bit, read as '1'  
 '0' = Bit is cleared                      '1' = Bit is set                                      -n = Value when blank or after Bulk Erase

- bit 13      **LVP:** Low-Voltage Programming Enable bit<sup>(1)</sup>  
 1 = Low-voltage programming enabled  
 0 = HV on MCLR/VPP must be used for programming
- bit 12      **DEBUG:** In-Circuit Debugger Mode bit  
 1 = In-Circuit Debugger disabled, ICSPCLK and ICSPDAT are general purpose I/O pins  
 0 = In-Circuit Debugger enabled, ICSPCLK and ICSPDAT are dedicated to the debugger
- bit 11      **LPBOR:** Low-Power BOR  
 1 = Low-Power BOR is disabled  
 0 = Low-Power BOR is enabled
- bit 10      **BORV:** Brown-out Reset Voltage Selection bit  
 1 = Brown-out Reset voltage (VBOR), low trip point selected  
 0 = Brown-out Reset voltage (VBOR), high trip point selected
- bit 9        **STVREN:** Stack Overflow/Underflow Reset Enable bit  
 1 = Stack Overflow or Underflow will cause a Reset  
 0 = Stack Overflow or Underflow will not cause a Reset
- bit 8-5     **Unimplemented:** Read as '1'
- bit 4        **VCAPEN:** Voltage Regulator Capacitor Enable bits<sup>(1)</sup>  
 0 = VCAP functionality is enabled on VCAP pin  
 1 = All VCAP pin functions are disabled
- bit 3-2     **Unimplemented:** Read as '1'
- bit 1-0     **WRT<1:0>:** Flash Memory Self-Write Protection bits  
2 kW Flash memory (PIC16(L)F1512):  
 11 = Write protection off  
 10 = 000h to 1FFh write-protected, 200h to 7FFh may be modified by PMCON control  
 01 = 000h to FFFh write-protected, 400h to 7FFh may be modified by PMCON control  
 00 = 000h to 7FFh write-protected, no addresses may be modified by PMCON control  
4 kW Flash memory (PIC16(L)F1513):  
 11 = Write protection off  
 10 = 000h to 1FFh write-protected, 200h to FFFh may be modified by PMCON control  
 01 = 000h to 7FFh write-protected, 800h to FFFh may be modified by PMCON control  
 00 = 000h to FFFh write-protected, no addresses may be modified by PMCON control  
8 kW Flash memory (PIC16F/LF1516/1517/1526):  
 11 = Write protection off  
 10 = 000h to 1FFh write-protected, 200h to 1FFFh may be modified by PMCON control  
 01 = 000h to FFFh write-protected, 1000h to 1FFFh may be modified by PMCON control  
 00 = 000h to 1FFFh write-protected, no addresses may be modified by PMCON control  
16 kW Flash memory (PIC16F/LF1518/1519/1527):  
 11 = Write protection off  
 10 = 000h to 1FFh write-protected, 200h to 3FFFh may be modified by PMCON control  
 01 = 000h to 1FFFh write-protected, 2000h to 3FFFh may be modified by PMCON control  
 00 = 000h to 3FFFh write-protected, no addresses may be modified by PMCON control

- Note 1:** The LVP bit cannot be programmed to '0' when Programming mode is entered via LVP.  
**Note 2:** Applies to PIC16F151X/152X devices only. On PIC16LF151X/152X, the VCAPEN bit is unimplemented.

# PIC16(L)F151X/152X

## 4.0 PROGRAM/VERIFY MODE

In Program/Verify mode, the program memory and the configuration memory can be accessed and programmed in serial fashion. ICSPDAT and ICSPCLK are used for the data and the clock, respectively. All commands and data words are transmitted LSb first. Data changes on the rising edge of the ICSPCLK and latched on the falling edge. In Program/Verify mode both the ICSPDAT and ICSPCLK are Schmitt Trigger inputs. The sequence that enters the device into Program/Verify mode places all other logic into the Reset state. Upon entering Program/Verify mode, all I/Os are automatically configured as high-impedance inputs and the address is cleared.

### 4.1 High-Voltage Program/Verify Mode Entry and Exit

There are two different methods of entering Program/Verify mode via high-voltage:

- VPP – First entry mode
- VDD – First entry mode

#### 4.1.1 VPP – FIRST ENTRY MODE

To enter Program/Verify mode via the VPP-first method the following sequence must be followed:

1. Hold ICSPCLK and ICSPDAT low. All other pins should be unpowered.
2. Raise the voltage on  $\overline{\text{MCLR}}$  from 0V to  $V_{IH}$ .
3. Raise the voltage on VDD FROM 0V to the desired operating voltage.

The VPP-first entry prevents the device from executing code prior to entering Program/Verify mode. For example, when Configuration Word 1 has  $\overline{\text{MCLR}}$  disabled ( $\text{MCLRE} = 0$ ), the power-up time is disabled ( $\text{PWRT} = 0$ ), the internal oscillator is selected ( $\text{FOSC} = 100$ ), and ICSPCLK and ICSPDAT pins are driven by the user application, the device will execute code. Since this may prevent entry, VPP-first entry mode is strongly recommended. See the timing diagram in [Figure 8-2](#).

#### 4.1.2 VDD – FIRST ENTRY MODE

To enter Program/Verify mode via the VDD-first method the following sequence must be followed:

1. Hold ICSPCLK and ICSPDAT low.
2. Raise the voltage on VDD from 0V to the desired operating voltage.
3. Raise the voltage on  $\overline{\text{MCLR}}$  from VDD or below to  $V_{IH}$ .

The VDD-first method is useful when programming the device when VDD is already applied, for it is not necessary to disconnect VDD to enter Program/Verify mode. See the timing diagram in [Figure 8-1](#).

#### 4.1.3 PROGRAM/VERIFY MODE EXIT

To exit Program/Verify mode take  $\overline{\text{MCLR}}$  to VDD or lower ( $V_{IL}$ ). See [Figures 8-3](#) and [8-4](#).

## 4.2 Low-Voltage Programming (LVP) Mode

The Low-Voltage Programming mode allows the PIC16(L)F151X/152X devices to be programmed using VDD only, without high voltage. When the LVP bit of Configuration Word 2 register is set to '1', the low-voltage ICSP programming entry is enabled. To disable the Low-Voltage ICSP mode, the LVP bit must be programmed to '0'. This can only be done while in the High-Voltage Entry mode.

Entry into the Low-Voltage ICSP Program/Verify modes requires the following steps:

1.  $\overline{\text{MCLR}}$  is brought to  $V_{IL}$ .
2. A 32-bit key sequence is presented on ICSPDAT, while clocking ICSPCLK.

The key sequence is a specific 32-bit pattern, '0100 1101 0100 0011 0100 1000 0101 0000' (more easily remembered as MCHP in ASCII). The device will enter Program/Verify mode only if the sequence is valid. The Least Significant bit of the Least Significant nibble must be shifted in first.

Once the key sequence is complete,  $\overline{\text{MCLR}}$  must be held at  $V_{IL}$  for as long as Program/Verify mode is to be maintained.

For low-voltage programming timing, see [Figure 8-8](#) and [Figure 8-9](#).

Exiting Program/Verify mode is done by no longer driving  $\overline{\text{MCLR}}$  to  $V_{IL}$ . See [Figure 8-8](#) and [Figure 8-9](#).

<b>Note:</b> To enter LVP mode, the LSB of the Least Significant nibble must be shifted in first. This differs from entering the key sequence on other parts.
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## 4.3 Program/Verify Commands

The PIC16(L)F151X/152X implements 10 programming commands; each six bits in length. The commands are summarized in Table 4-1.

Commands that have data associated with them are specified to have a minimum delay of TDLY between the command and the data. After this delay 16 clocks are required to either clock in or clock out the 14-bit data word. The first clock is for the Start bit and the last clock is for the Stop bit.

**TABLE 4-1: COMMAND MAPPING**

Command	Mapping		Data/Note
	Binary (MSb ... LSb)	Hex	
Load Configuration	x 0 0 0 0 0	00h	0, data (14), 0
Load Data For Program Memory	x 0 0 0 1 0	02h	0, data (14), 0
Read Data From Program Memory	x 0 0 1 0 0	04h	0, data (14), 0
Increment Address	x 0 0 1 1 0	06h	—
Reset Address	x 1 0 1 1 0	16h	—
Begin Internally Timed Programming	x 0 1 0 0 0	08h	—
Begin Externally Timed Programming	x 1 1 0 0 0	18h	—
End Externally Timed Programming	x 0 1 0 1 0	0Ah	—
Bulk Erase Program Memory	x 0 1 0 0 1	09h	Internally Timed
Row Erase Program Memory	x 1 0 0 0 1	11h	Internally Timed

### 4.3.1 LOAD CONFIGURATION

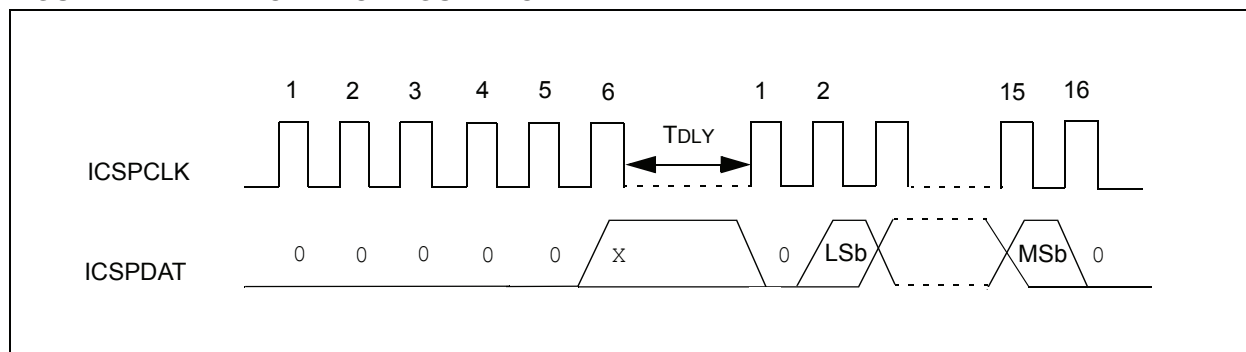
The Load Configuration command is used to access the configuration memory (User ID Locations, Configuration Words, Calibration Words). The Load Configuration command sets the address to 8000h and loads the data latches with one word of data (see Figure 4-1).

After issuing the Load Configuration command, use the Increment Address command until the proper address to be programmed is reached. The address is then programmed by issuing either the Begin Internally Timed Programming or Begin Externally Timed Programming command.

**Note:** Externally timed writes are not supported for Configuration and Calibration bits. Any externally timed write to the Configuration or Calibration Word will have no effect on the targeted word.

The only way to get back to the program memory (address 0) is to exit Program/Verify mode or issue the Reset Address command after the configuration memory has been accessed by the Load Configuration command.

**FIGURE 4-1: LOAD CONFIGURATION**

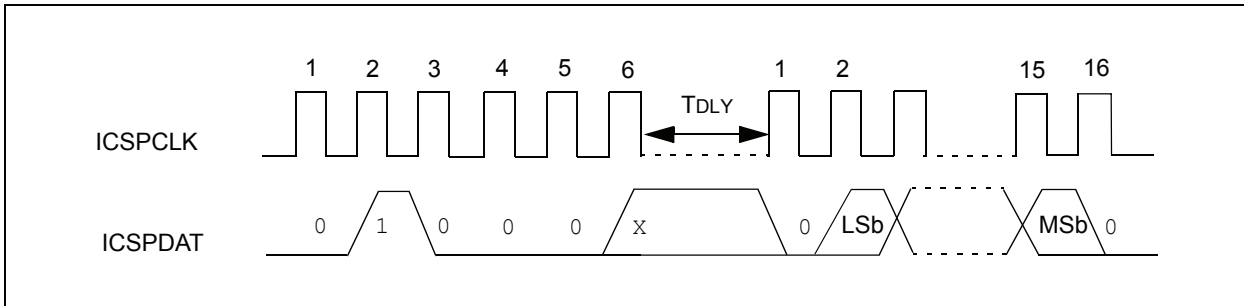


# PIC16(L)F151X/152X

## 4.3.2 LOAD DATA FOR PROGRAM MEMORY

The Load Data for Program Memory command is used to load one 14-bit word into the data latches. The word programs into program memory after the Begin Internally Timed Programming or Begin Externally Timed Programming command is issued (see Figure 4-2).

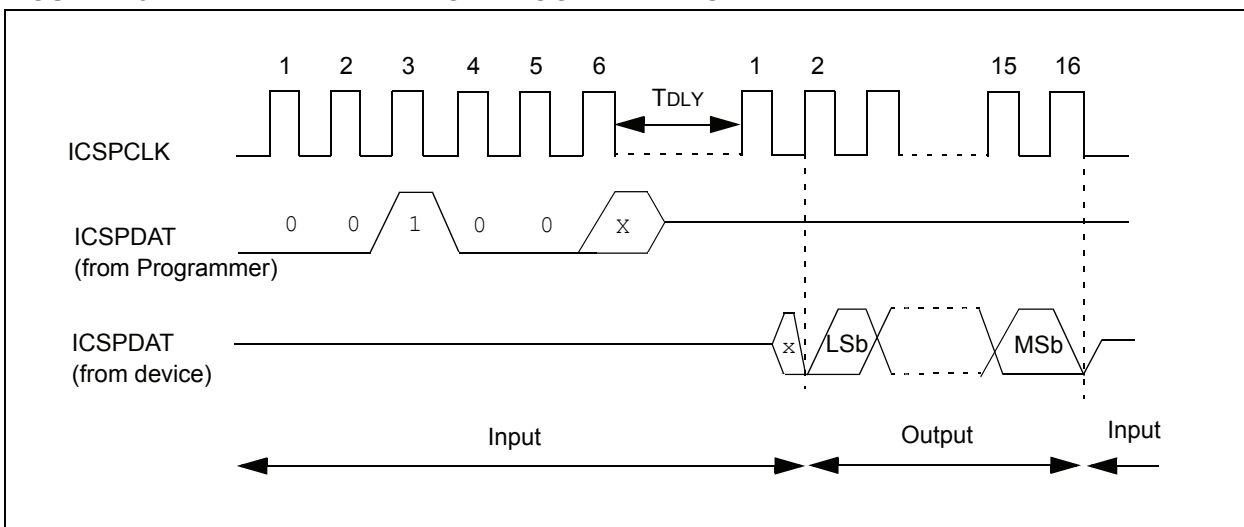
**FIGURE 4-2: LOAD DATA FOR PROGRAM MEMORY**



## 4.3.3 READ DATA FROM PROGRAM MEMORY

The Read Data from Program Memory command will transmit data bits out of the program memory map currently accessed, starting with the second rising edge of the clock input. The ICSPDAT pin will go into Output mode on the first falling clock edge, and it will revert to Input mode (high-impedance) after the 16th falling edge of the clock. If the program memory is code-protected ( $\overline{CP}$ ), the data will be read as zeros (see Figure 4-3).

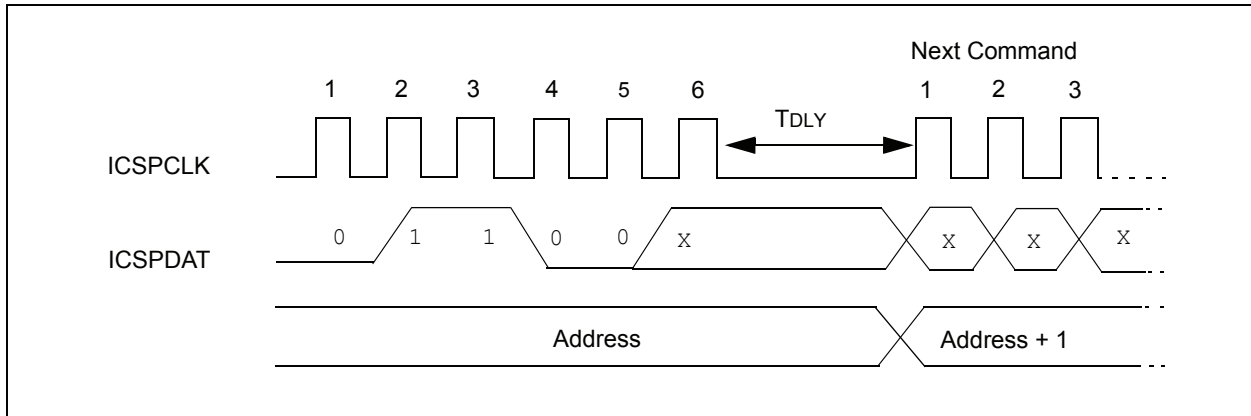
**FIGURE 4-3: READ DATA FROM PROGRAM MEMORY**



## 4.3.4 INCREMENT ADDRESS

The address is incremented when this command is received. It is not possible to decrement the address. To reset this counter, the user must use the Reset Address command or exit Program/Verify mode and re-enter it. If the address is incremented from address 7FFFh, it will wrap-around to location 0000h. If the address is incremented from FFFFh, it will wrap-around to location 8000h.

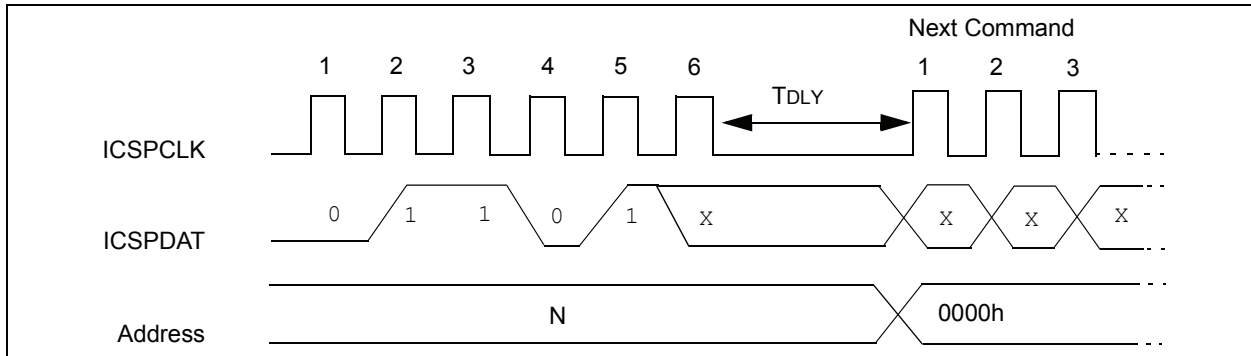
**FIGURE 4-4: INCREMENT ADDRESS**



## 4.3.5 RESET ADDRESS

The Reset Address command will reset the address to 0000h, regardless of the current value. The address is used in program memory or the configuration memory.

**FIGURE 4-5: RESET ADDRESS**



# PIC16(L)F151X/152X

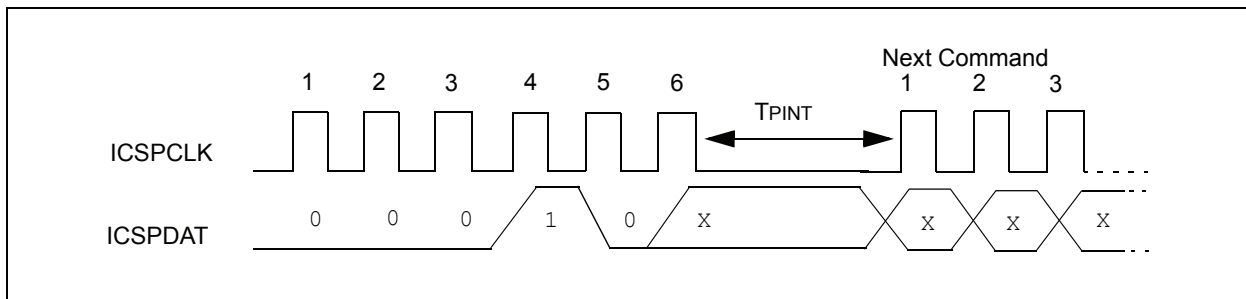
## 4.3.6 BEGIN INTERNALLY TIMED PROGRAMMING

A Load Configuration or Load Data for Program Memory command must be given before every Begin Programming command. Programming of the addressed memory will begin after this command is received. An internal timing mechanism executes the write. The user must allow for the program cycle time,  $T_{PINT}$ , for the programming to complete.

The End Externally Timed Programming command is not needed when the Begin Internally Timed Programming is used to start the programming.

The program memory address that is being programmed is not erased prior to being programmed.

**FIGURE 4-6: BEGIN INTERNALLY TIMED PROGRAMMING**

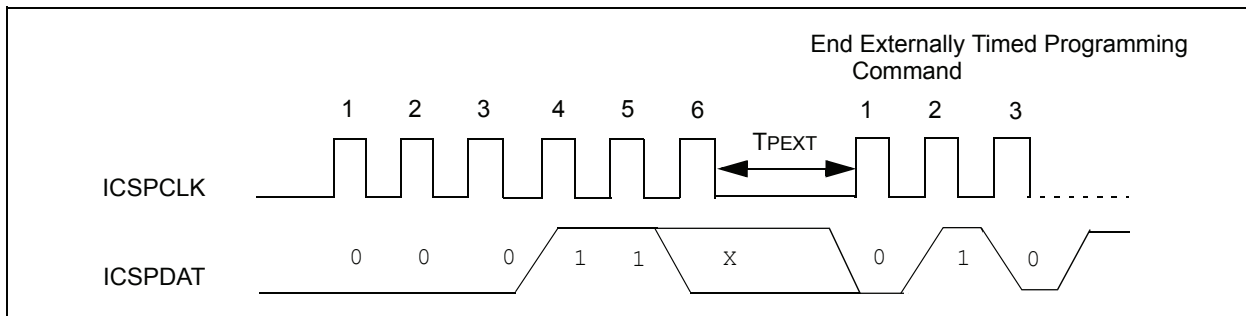


## 4.3.7 BEGIN EXTERNALLY TIMED PROGRAMMING

A Load Configuration or Load Data for Program Memory command must be given before every Begin Programming command. Programming of the addressed memory will begin after this command is received. To complete the programming the End Externally Timed Programming command must be sent in the specified time window defined by  $T_{PEXT}$  (see [Figure 4-7](#)).

Externally timed writes are not supported for Configuration and Calibration bits. Any externally timed write to the Configuration or Calibration Word will have no effect on the targeted word.

**FIGURE 4-7: BEGIN EXTERNALLY TIMED PROGRAMMING**

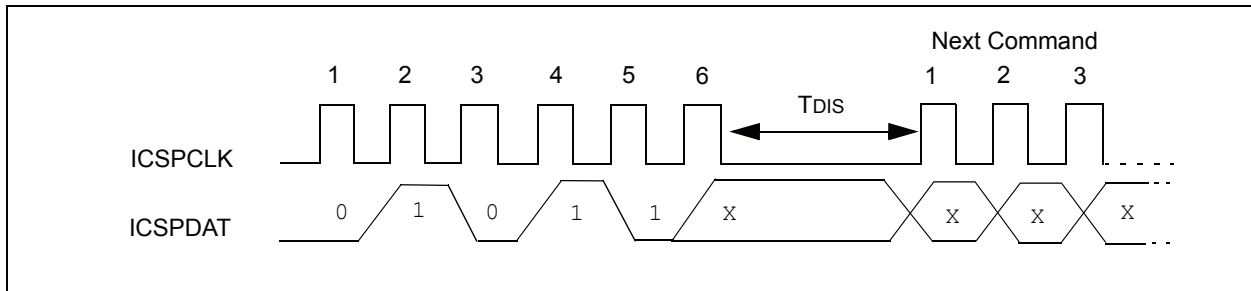


## 4.3.8 END EXTERNALLY TIMED PROGRAMMING

This command is required after a Begin Externally Timed Programming command is given. This command must be sent within the time window specified by TPEXT after the Begin Externally Timed Programming command is sent.

After sending the End Externally Timed Programming command, an additional delay (TDIS) is required before sending the next command. This delay is longer than the delay ordinarily required between other commands (see Figure 4-8).

**FIGURE 4-8: END EXTERNALLY TIMED PROGRAMMING**



## 4.3.9 BULK ERASE PROGRAM MEMORY

The Bulk Erase Program Memory command performs two different functions dependent on the current state of the address.

Address 0000h-7FFFh:

- Program Memory is erased
- Configuration Words are erased

Address 8000h-8008h:

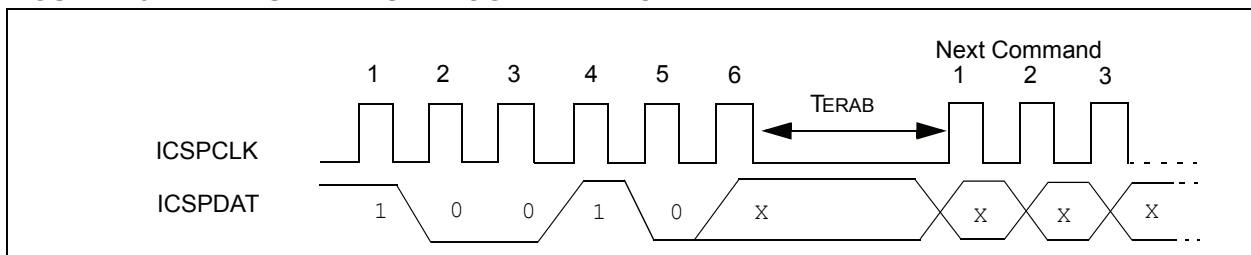
- Program Memory is erased
- Configuration Words are erased
- User ID Locations are erased

A Bulk Erase Program Memory command should not be issued when the address is greater than 8008h.

After receiving the Bulk Erase Program Memory command the erase will not complete until the time interval, TERAB, has expired.

**Note:** The code protection Configuration bit (CP) has no effect on the Bulk Erase Program Memory command.

**FIGURE 4-9: BULK ERASE PROGRAM MEMORY**



# PIC16(L)F151X/152X

## 4.3.10 ROW ERASE PROGRAM MEMORY

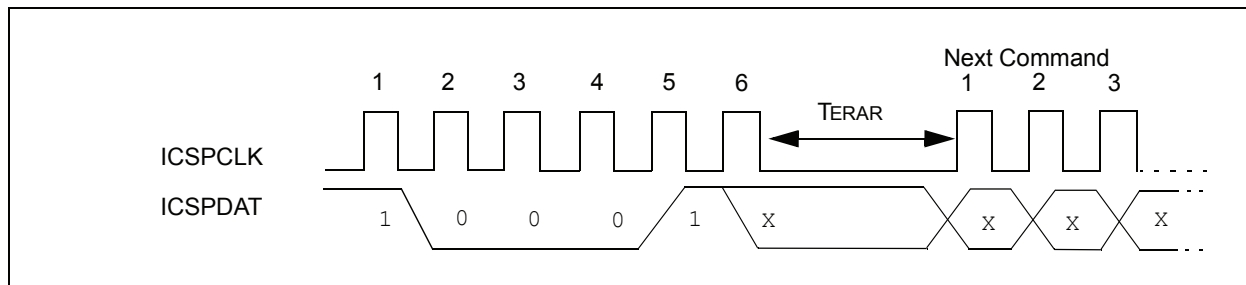
The Row Erase Program Memory command will erase an individual row. Refer to [Table 4-2](#) for row sizes of specific devices and the PC bits used to address them. If the program memory is code-protected the Row Erase Program Memory command will be ignored. When the address is 8000h-8008h the Row Erase Program Memory command will only erase the user ID locations regardless of the setting of the  $\overline{CP}$  Configuration bit.

After receiving the Row Erase Program Memory command the erase will not complete until the time interval, TERAR, has expired.

**TABLE 4-2: PROGRAMMING ROW SIZE AND LATCHES**

Devices	PC	Row Size	Number of Latches
PIC16(L)F151X/152X	<15:5>	32	32

**FIGURE 4-10: ROW ERASE PROGRAM MEMORY**



## 5.0 PROGRAMMING ALGORITHMS

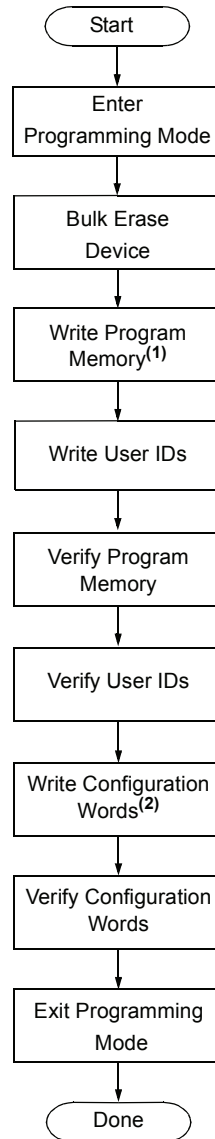
The devices use internal latches to temporarily store the 14-bit words used for programming. Refer to [Table 4-2](#) for specific latch information. The data latches allow the user to write the program words with a single Begin Externally Timed Programming or Begin Internally Timed Programming command. The Load Program Data or the Load Configuration command is used to load a single data latch. The data latch will hold the data until the Begin Externally Timed Programming or Begin Internally Timed Programming command is given.

The data latches are aligned with the LSbs of the address. The PC's address at the time the Begin Externally Timed Programming or Begin Internally Timed Programming command is given will determine which location(s) in memory are written. Writes cannot cross the physical boundary. For example, with the PIC16F1527, attempting to write from address 0002h-0009h will result in data being written to 0008h-000Fh.

If more than the maximum number of data latches are written without a Begin Externally Timed Programming or Begin Internally Timed Programming command, the data in the data latches will be overwritten. The following figures show the recommended flowcharts for programming.

# PIC16(L)F151X/152X

FIGURE 5-1: DEVICE PROGRAM/VERIFY FLOWCHART

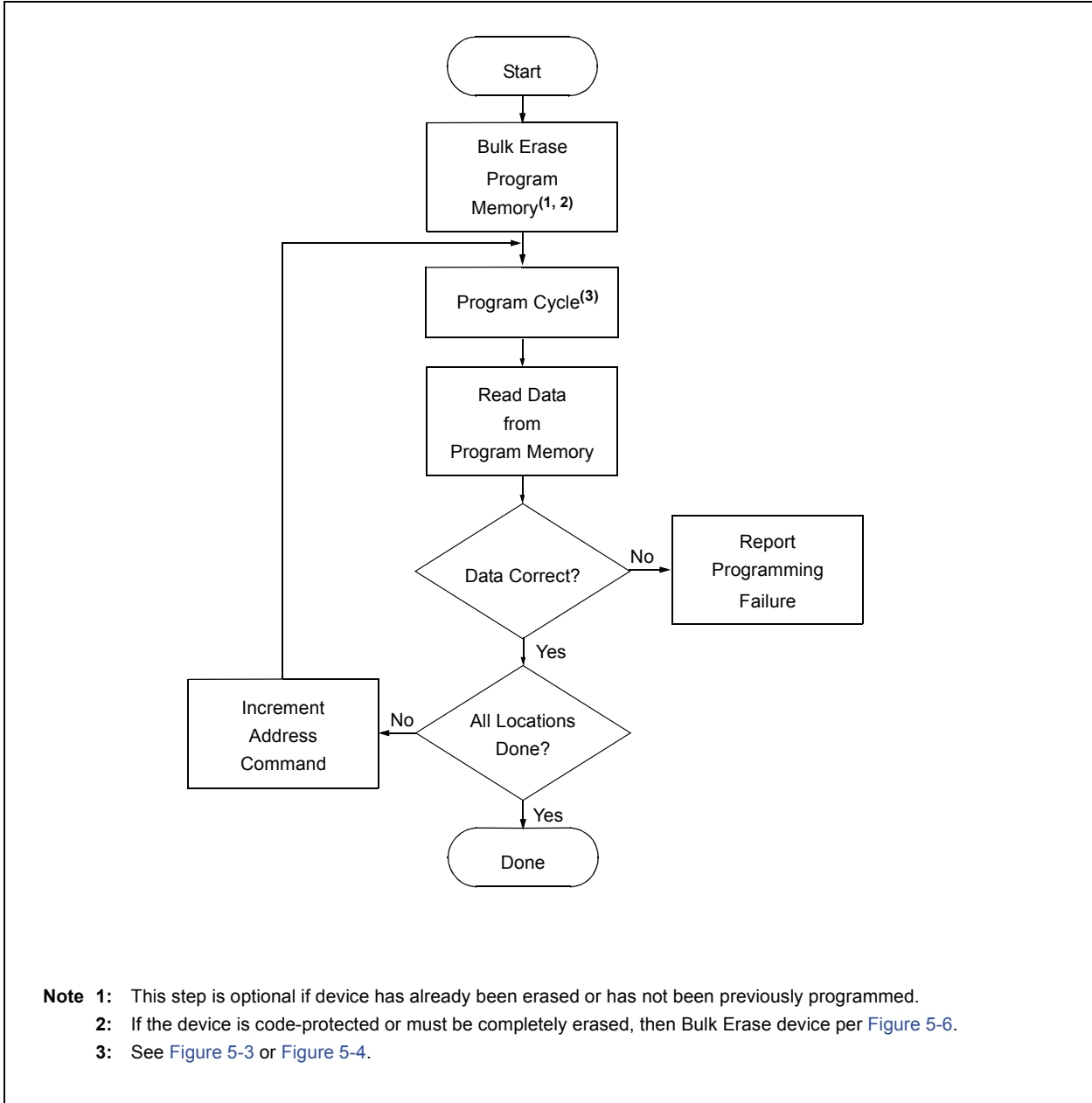


**Note 1:** See [Figure 5-2](#).

**Note 2:** See [Figure 5-5](#).



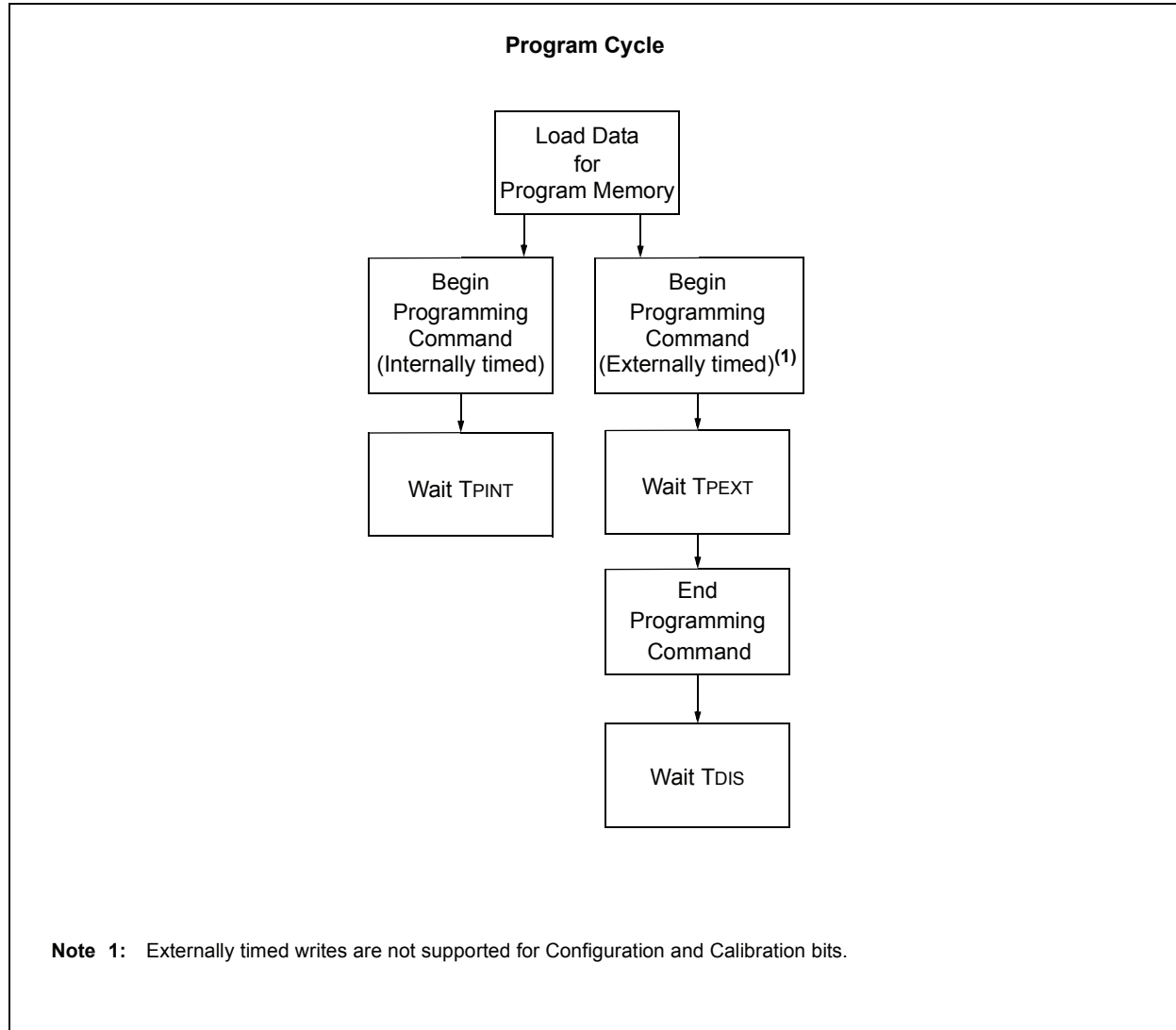
FIGURE 5-2: PROGRAM MEMORY FLOWCHART



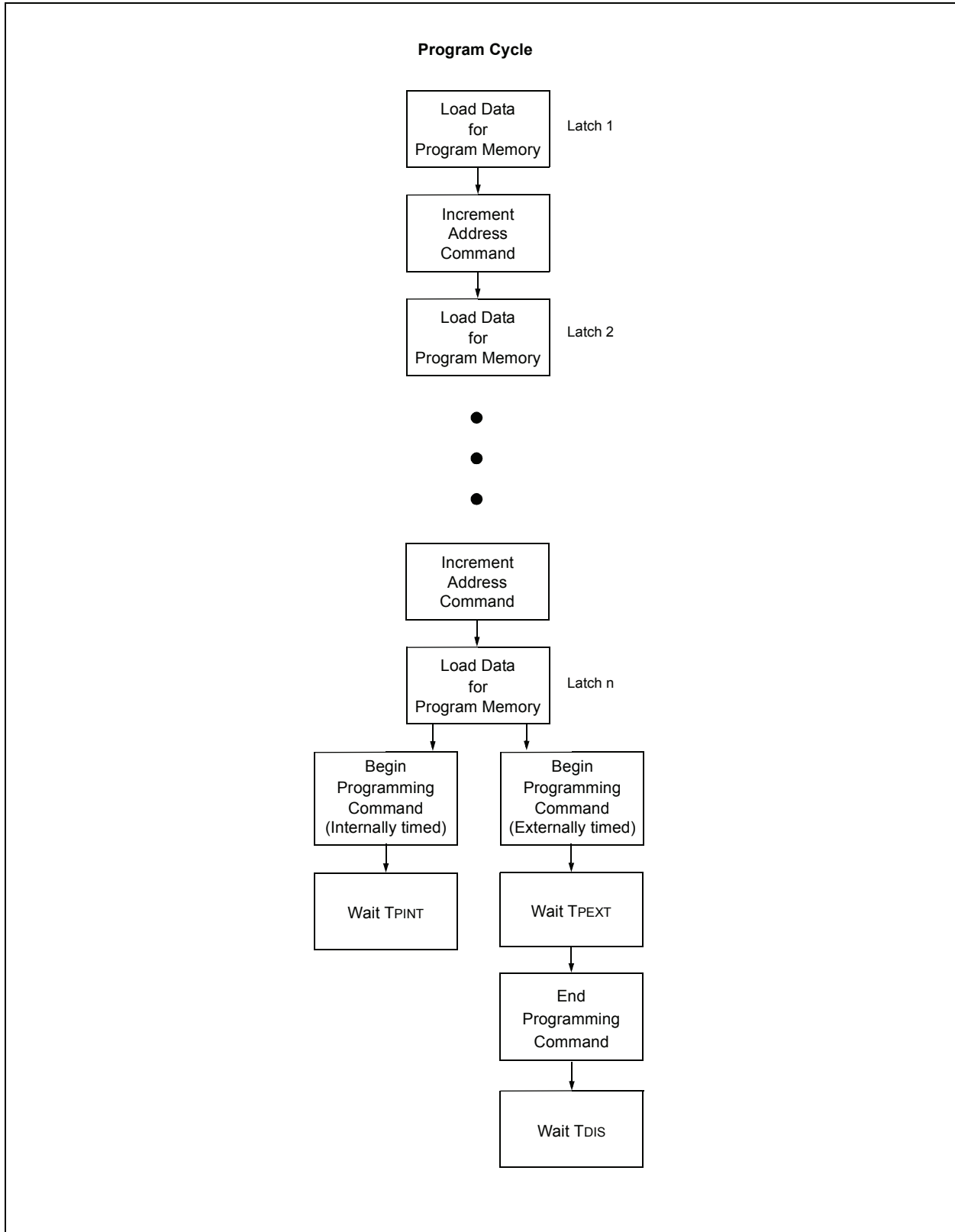
- Note 1:** This step is optional if device has already been erased or has not been previously programmed.  
**Note 2:** If the device is code-protected or must be completely erased, then Bulk Erase device per [Figure 5-6](#).  
**Note 3:** See [Figure 5-3](#) or [Figure 5-4](#).

# PIC16(L)F151X/152X

FIGURE 5-3: ONE-WORD PROGRAM CYCLE

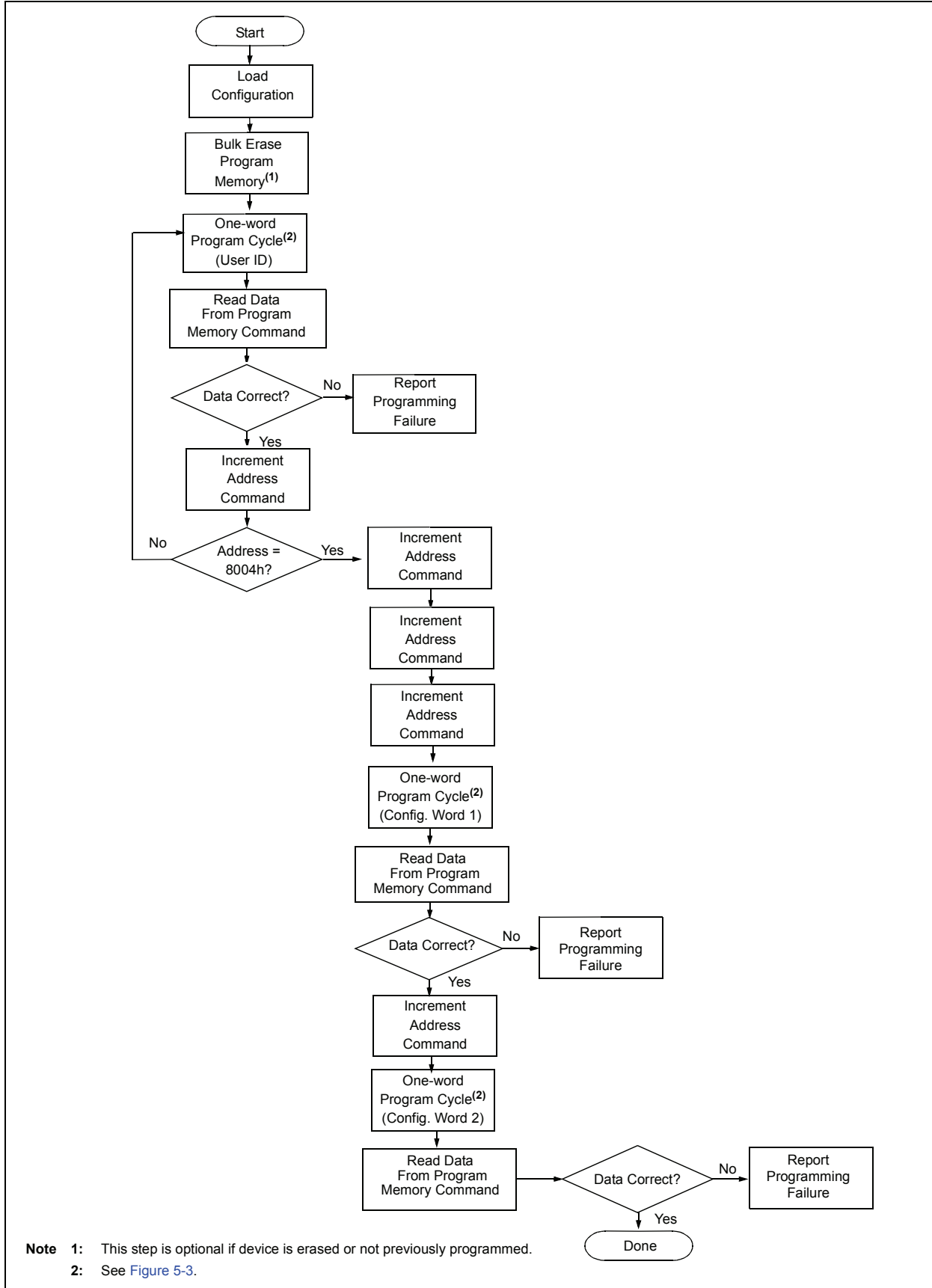


**FIGURE 5-4: MULTIPLE-WORD PROGRAM CYCLE**

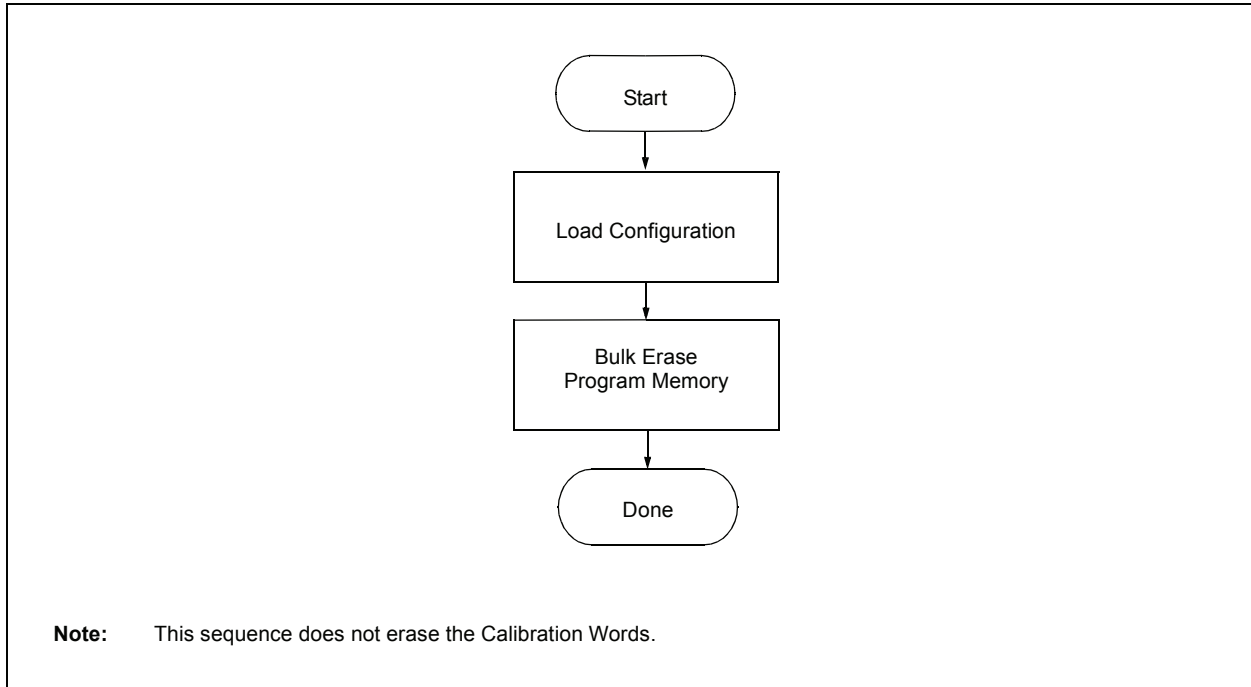


# PIC16(L)F151X/152X

**FIGURE 5-5: CONFIGURATION MEMORY PROGRAM FLOWCHART**



**FIGURE 5-6: ERASE FLOWCHART**



# PIC16(L)F151X/152X

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## 6.0 CODE PROTECTION

Code protection is controlled using the  $\overline{CP}$  bit in Configuration Word 1. When code protection is enabled, all program memory locations (0000h-7FFFh) read as all '0'. Further programming is disabled for the program memory (0000h-7FFFh).

The user ID locations and Configuration Words can be programmed and read out regardless of the code protection settings.

### 6.1 Program Memory

Code protection is enabled by programming the  $\overline{CP}$  bit in Configuration Word 1 register to '0'.

The only way to disable code protection is to use the Bulk Erase Program Memory command.

## 7.0 HEX FILE USAGE

In the hex file there are two bytes per program word stored in the Intel® INHX32 hex format. Data is stored LSB first, MSB second. Because there are two bytes per word, the addresses in the hex file are 2x the address in program memory. (Example: Configuration Word 1 is stored at 8007h on the PIC16(L)F151X/152X. In the hex file this will be referenced as 1000Eh-1000Fh).

### 7.1 Configuration Word

To allow portability of code, it is strongly recommended that the programmer is able to read the Configuration Words and user ID locations from the hex file. If the Configuration Words information was not present in the hex file, a simple warning message may be issued. Similarly, while saving a hex file, Configuration Words and user ID information should be included.

### 7.2 Device ID and Revision

If a device ID is present in the hex file at 1000Ch-1000Dh (8006h on the part), the programmer should verify the device ID (excluding the revision) against the value read from the part. On a mismatch condition the programmer should generate a warning message.

## 7.3 Checksum Computation

The checksum is calculated by two different methods dependent on the setting of the  $\overline{CP}$  Configuration bit.

**TABLE 7-1: CONFIGURATION WORD MASK VALUES**

Device	Config. Word 1 Mask	Config. Word 2 Mask
PIC16F1512	3EFFh	3E13h
PIC16F1513	3EFFh	3E13h
PIC16F1516	3EFFh	3E13h
PIC16F1517	3EFFh	3E13h
PIC16F1518	3EFFh	3E13h
PIC16F1519	3EFFh	3E13h
PIC16LF1512	3EFFh	3E03h
PIC16LF1513	3EFFh	3E03h
PIC16LF1516	3EFFh	3E03h
PIC16LF1517	3EFFh	3E03h
PIC16LF1518	3EFFh	3E03h
PIC16LF1519	3EFFh	3E03h
PIC16F1526	3EFFh	3E13h
PIC16F1527	3EFFh	3E13h
PIC16LF1526	3EFFh	3E03h
PIC16LF1527	3EFFh	3E03h

### 7.3.1 PROGRAM CODE PROTECTION DISABLED

With the program code protection disabled, the checksum is computed by reading the contents of the PIC16(L)F151X/152X program memory locations and adding up the program memory data starting at address 0000h, up to the maximum user addressable location. Any Carry bit exceeding 16 bits are ignored. Additionally, the relevant bits of the Configuration Words are added to the checksum. All unimplemented Configuration bits are masked to '0'.

# PIC16(L)F151X/152X

## EXAMPLE 7-1: CHECKSUM COMPUTED WITH PROGRAM CODE PROTECTION DISABLED PIC16F1527, BLANK DEVICE

PIC16F1527	Sum of Memory addresses 0000h-3FFFh <sup>(1)</sup>	C000h
	Configuration Word 1 <sup>(2)</sup>	3FFFh
	Configuration Word 1 mask <sup>(3)</sup>	3EFFh
	Configuration Word 2 <sup>(2)</sup>	3FFFh
	Configuration Word 2 mask <sup>(3)</sup>	3E13h
	Checksum	= C000h + (3FFFh and 3EFFh) + (3FFFh and 3E13h)
		= C000h + 3EFFh + 3E13h
		= 3D12h

- Note 1:** Sum of memory addresses = (Total number of program memory address locations) x (3FFFh) = C000h, truncated to 16 bits.
- 2:** Configuration Word 1 and 2 = all bits are '1'; thus, code-protect is disabled.
- 3:** Configuration Word 1 and 2 Mask = all bits are set to '1', except for unimplemented bits that are '0'.

## EXAMPLE 7-2: CHECKSUM COMPUTED WITH PROGRAM CODE PROTECTION DISABLED PIC16LF1527, 00AAh AT FIRST AND LAST ADDRESS

PIC16LF1527	Sum of Memory addresses 0000h-3FFFh <sup>(1)</sup>	4156h
	Configuration Word 1 <sup>(2)</sup>	3FFFh
	Configuration Word 1 mask <sup>(3)</sup>	3EFFh
	Configuration Word 2 <sup>(2)</sup>	3FFFh
	Configuration Word 2 mask <sup>(4)</sup>	3E03h
	Checksum	= 4156h + (3FFFh and 3EFFh) + (3FFFh and 3E03h)
		= 4156h + 3EFFh + 3E03h
		= BE58h

- Note 1:** Total number of Program memory address locations: 3FFFh + 1 = 4000h. Then, 4000h - 2 = 3FFEh. Thus, [(3FFEh x 3FFFh) + (2 x 00AAh)] = 4156h, truncated to 16 bits.
- 2:** Configuration Word 1 and 2 = all bits are '1'; thus, code-protect is disabled.
- 3:** Configuration Word 1 Mask = all Configuration Word bits are set to '1', except for unimplemented bits that are '0'.
- 4:** On the PIC16LF1527 device, the  $\overline{\text{VCAPEN}}$  bit is not implemented in Configuration Word 2; Thus, all unimplemented bits are '0'.



## 7.3.2 PROGRAM CODE PROTECTION ENABLED

With the program code protection enabled, the checksum is computed in the following manner: The Least Significant nibble of each user ID is used to create a 16-bit value. The masked value of user ID location 8000h is the Most Significant nibble. This sum of user IDs is summed with the Configuration Words (all unimplemented Configuration bits are masked to '0').

### EXAMPLE 7-3: CHECKSUM COMPUTED WITH PROGRAM CODE PROTECTION ENABLED PIC16F1527, BLANK DEVICE

PIC16F1527	Configuration Word 1 <sup>(2)</sup>	3F7Fh
	Configuration Word 1 mask <sup>(3)</sup>	3EFFh
	Configuration Word 2 <sup>(2)</sup>	3FFFh
	Configuration Word 2 mask <sup>(3)</sup>	3E13h
	User ID (8000h) <sup>(1)</sup>	0006h
	User ID (8001h) <sup>(1)</sup>	0007h
	User ID (8002h) <sup>(1)</sup>	0001h
	User ID (8003h) <sup>(1)</sup>	0002h
	Sum of User IDs <sup>(4)</sup>	= (0006h and 000Fh) << 12 + (0007h and 000Fh) << 8 + (0001h and 000Fh) << 4 + (0002h and 000Fh) = 6000h + 0700h + 0010h + 0002h = 6712h
	Checksum	= (3F7Fh and 3EFFh) + (3FFFh and 3E13h) + Sum of User IDs = 3E7Fh + 3713h + 6712h = DCA4h

**Note 1:** User ID values in this example are random values.  
**2:** Configuration Word 1 and 2 = all bits are '1' except the code-protect enable bit.  
**3:** Configuration Word 1 and 2 Mask = all Configuration Word bits are set to '1', except for unimplemented bits which read '0'.  
**4:** << = shift left, thus the LSb of the first user ID value is the MSb of the sum of user IDs and so on, until the LSb of the last user ID value becomes the LSb of the sum of user IDs.

# PIC16(L)F151X/152X

## EXAMPLE 7-4: CHECKSUM COMPUTED WITH PROGRAM CODE PROTECTION ENABLED PIC16LF1527, 00AAh AT FIRST AND LAST ADDRESS

PIC16LF1527	Configuration Word 1 <sup>(2)</sup>	3F7Fh
	Configuration Word 1 mask <sup>(3)</sup>	3EFFh
	Configuration Word 2 <sup>(2)</sup>	3FFFh
	Configuration Word 2 mask <sup>(3), (5)</sup>	3E03h
	User ID (8000h) <sup>(1)</sup>	000Eh
	User ID (8001h) <sup>(1)</sup>	0008h
	User ID (8002h) <sup>(1)</sup>	0005h
	User ID (8003h) <sup>(1)</sup>	0008h
	Sum of User IDs <sup>(4)</sup>	= (000Eh and 000Fh) << 12 + (0008h and 000Fh) << 8 + (0005h and 000Fh) << 4 + (0008h and 000Fh) = E000h + 0800h + 0050h + 0008h = E858h
	Checksum	= (3F7Fh and 3EFFh) + (3FFFh and 3E03h) + Sum of User IDs = 3E7Fh + 3E03h + E858h = 64DAh

- Note 1:** User ID values in this example are random values.
- 2:** Configuration Word 1 and 2 = all bits are '1' except the code-protect enable bit.
- 3:** Configuration Word 1 and 2 Mask = all Configuration Word bits are set to '1', except for unimplemented bits which read '0'.
- 4:** << = shift left, thus the LSb of the first user ID value is the MSb of the sum of user IDs and so on, until the LSb of the last user ID value becomes the LSb of the sum of user IDs.
- 5:** On the PIC16LF1527 device, the  $\overline{\text{VCAPEN}}$  bit is not implemented in Configuration Word 2; thus, all unimplemented bits are '0'.

# PIC16(L)F151X/152X

## 8.0 ELECTRICAL SPECIFICATIONS

Refer to device specific data sheet for absolute maximum ratings.

**TABLE 8-1: AC/DC CHARACTERISTICS TIMING REQUIREMENTS FOR PROGRAM/VERIFY MODE**

AC/DC CHARACTERISTICS			Standard Operating Conditions Production tested at 25°C				
Sym.	Characteristics	Min.	Typ.	Max.	Units	Conditions/Comments	
<b>Supply Voltages and Currents</b>							
VDD	Supply Voltage (VDDMIN, VDDMAX)	PIC16F151X	2.3	—	5.5	V	
		PIC16F152X	1.8	—	3.6	V	
VPEW	Read/Write and Row Erase operations	VDDMIN	—	VDDMAX	V		
VPBE	Bulk Erase operations	2.7	—	VDDMAX	V		
IDDI	Current on VDD, Idle	—	—	1.0	mA		
IDDP	Current on VDD, Programming	—	—	3.0	mA		
<b>VPP</b>							
IPP	Current on MCLR/VPP	—	—	600	μA		
VIHH	High voltage on MCLR/VPP for Program/Verify mode entry	8.0	—	9.0	V		
TVHHR	MCLR rise time (VIL to VIHH) for Program/Verify mode entry	—	—	1.0	μs		
<b>I/O pins</b>							
VIH	(ICSPCLK, ICSPDAT, MCLR/VPP) input high level	0.8 VDD	—	—	V		
VIL	(ICSPCLK, ICSPDAT, MCLR/VPP) input low level	—	—	0.2 VDD	V		
VOH	ICSPDAT output high level	VDD-0.7 VDD-0.7 VDD-0.7	—	—	V	IOH = 3.5 mA, VDD = 5V IOH = 3 mA, VDD = 3.3V IOH = 2 mA, VDD = 1.8V	
VOL	ICSPDAT output low level	—	—	VSS+0.6 VSS+0.6 VSS+0.6	V	IOH = 8 mA, VDD = 5V IOH = 6 mA, VDD = 3.3V IOH = 3 mA, VDD = 1.8V	
<b>Programming Mode Entry and Exit</b>							
TENTS	Programing mode entry setup time: ICSPCLK, ICSPDAT setup time before VDD or MCLR↑	100	—	—	ns		
TENTH	Programing mode entry hold time: ICSPCLK, ICSPDAT hold time after VDD or MCLR↑	250	—	—	μs		
<b>Serial Program/Verify</b>							
TCKL	Clock Low Pulse Width	100	—	—	ns		
TCKH	Clock High Pulse Width	100	—	—	ns		
Tds	Data in setup time before clock↓	100	—	—	ns		
TDH	Data in hold time after clock↓	100	—	—	ns		
TCO	Clock↑ to data out valid (during a Read Data command)	0	—	80	ns		
TLZD	Clock↓ to data low-impedance (during a Read Data command)	0	—	80	ns		
THZD	Clock↓ to data high-impedance (during a Read Data command)	0	—	80	ns		
TDLY	Data input not driven to next clock input (delay required between command/data or command/command)	1.0	—	—	μs		
TERAB	Bulk Erase cycle time	—	—	5	ms		
TERAR	Row Erase cycle time	—	—	2.5	ms		

**Note 1:** Externally timed writes are not supported for Configuration and Calibration bits.

# PIC16(L)F151X/152X

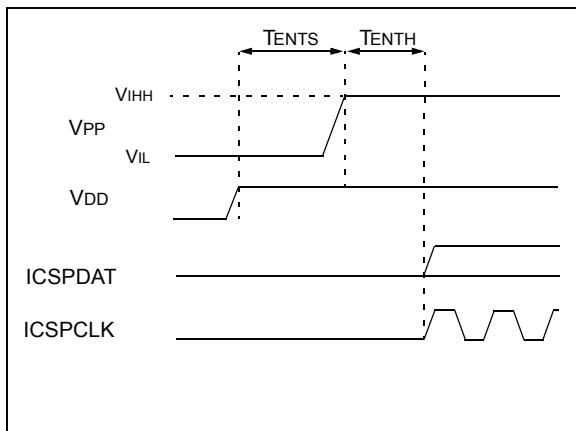
**TABLE 8-1: AC/DC CHARACTERISTICS TIMING REQUIREMENTS FOR PROGRAM/VERIFY**

AC/DC CHARACTERISTICS		Standard Operating Conditions Production tested at 25°C				
Sym.	Characteristics	Min.	Typ.	Max.	Units	Conditions/Comments
TPINT	Internally timed programming operation time	—	—	2.5	ms	Program memory
		—	—	5	ms	Configuration Words
TPEXT	Externally timed programming pulse	1.0	—	2.1	ms	<b>Note 1</b>
TDIS	Time delay from program to compare (HV discharge time)	300	—	—	μs	
TEXTIT	Time delay when exiting Program/Verify mode	1	—	—	μs	

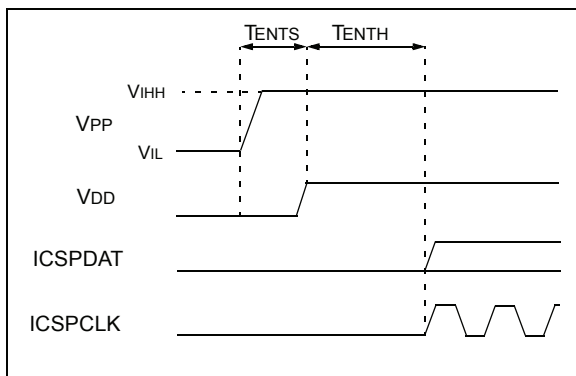
**Note 1:** Externally timed writes are not supported for Configuration and Calibration bits.

## 8.1 AC Timing Diagrams

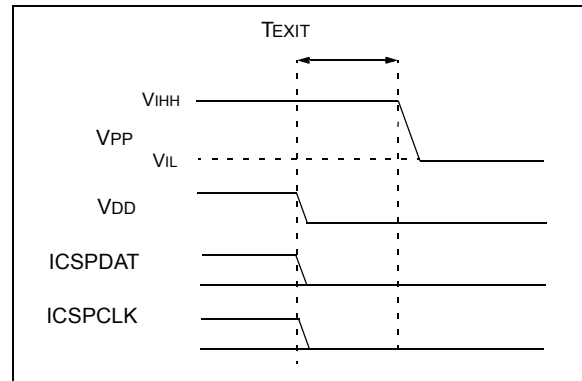
**FIGURE 8-1: PROGRAMMING MODE ENTRY – V<sub>DD</sub> FIRST**



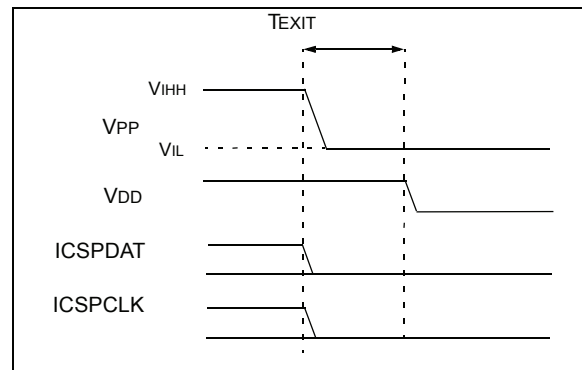
**FIGURE 8-2: PROGRAMMING MODE ENTRY – V<sub>PP</sub> FIRST**



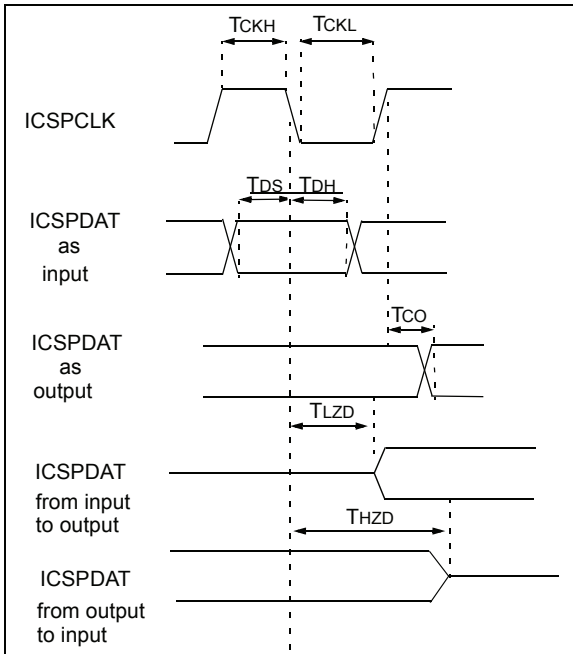
**FIGURE 8-3: PROGRAMMING MODE EXIT – V<sub>PP</sub> LAST**



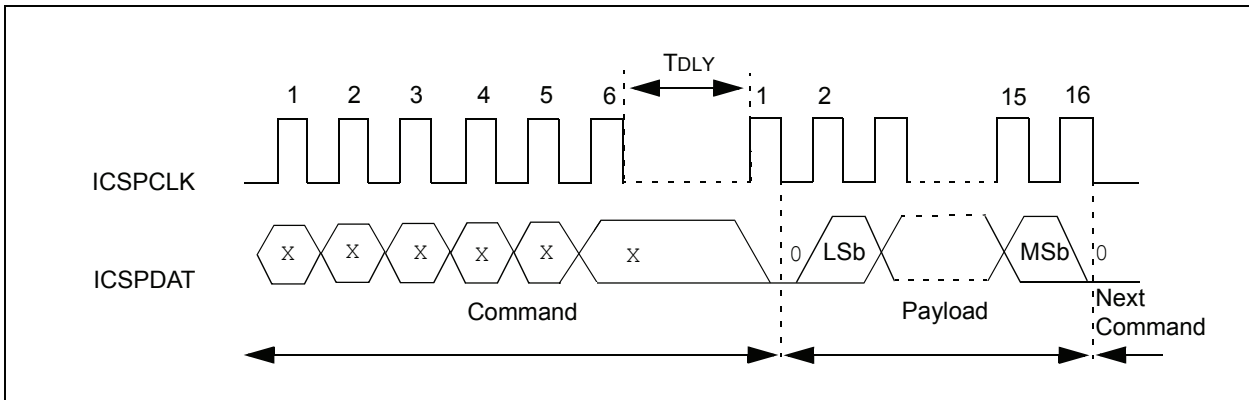
**FIGURE 8-4: PROGRAMMING MODE EXIT – V<sub>DD</sub> LAST**



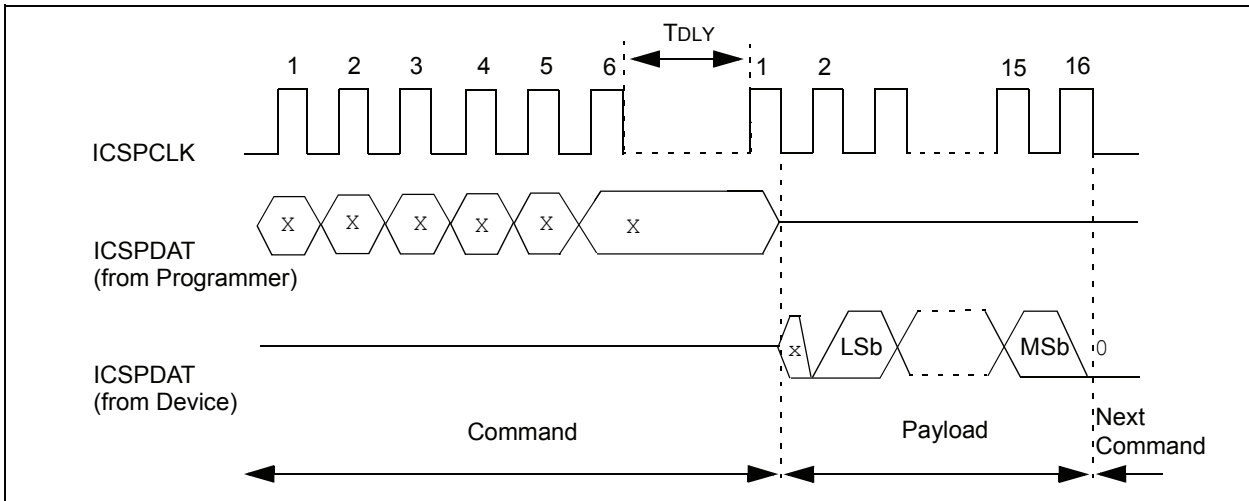
**FIGURE 8-5: CLOCK AND DATA TIMING**



**FIGURE 8-6: WRITE COMMAND-PAYLOAD TIMING**

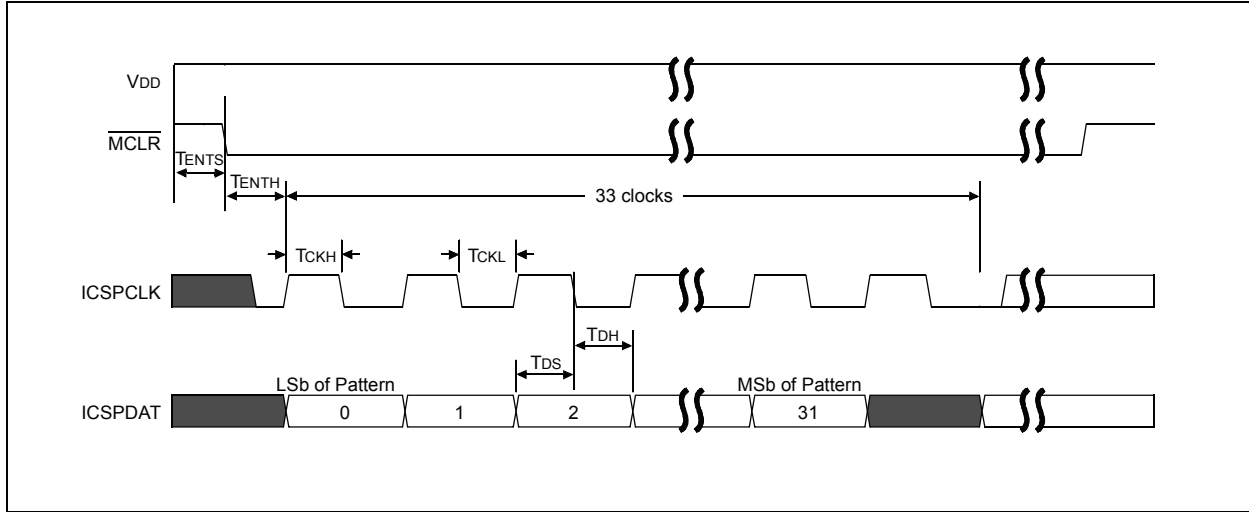


**FIGURE 8-7: READ COMMAND-PAYLOAD TIMING**

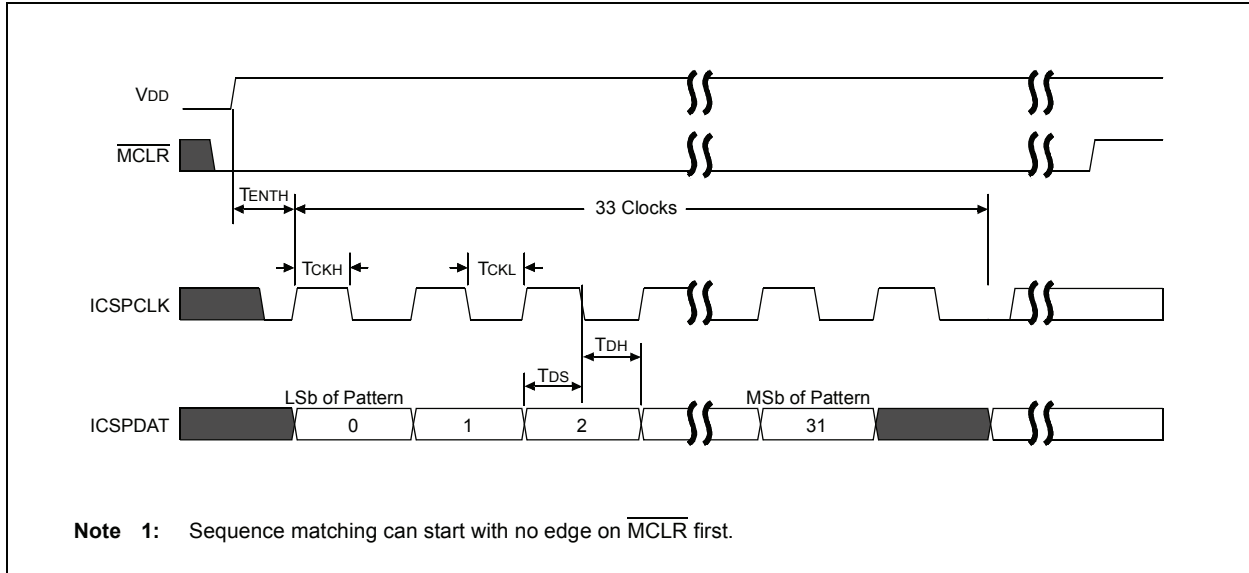


# PIC16(L)F151X/152X

**FIGURE 8-8: LVP ENTRY (POWERED)**



**FIGURE 8-9: LVP ENTRY (POWERING UP)**



## **APPENDIX A: REVISION HISTORY**

### **Revision A (08/2010)**

Original release of this document.

### **Revision B (09/2011)**

Added PIC16(L)F1512/1513 devices; Added new Figures 3-1 and 3-2; Updated Registers 3-1, 3-2 and 3-3 to new format; Updated Register 3-3 to add 2 kW and 4 kW Flash memory; Added Notes to Examples 7-1 to 7-4; Updated Table 8-1; Other minor corrections.

# PIC16(L)F151X/152X

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NOTES:



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**Note the following details of the code protection feature on Microchip devices:**

- Microchip products meet the specification contained in their particular Microchip Data Sheet.
- Microchip believes that its family of products is one of the most secure families of its kind on the market today, when used in the intended manner and under normal conditions.
- There are dishonest and possibly illegal methods used to breach the code protection feature. All of these methods, to our knowledge, require using the Microchip products in a manner outside the operating specifications contained in Microchip's Data Sheets. Most likely, the person doing so is engaged in theft of intellectual property.
- Microchip is willing to work with the customer who is concerned about the integrity of their code.
- Neither Microchip nor any other semiconductor manufacturer can guarantee the security of their code. Code protection does not mean that we are guaranteeing the product as “unbreakable.”

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