

PIC12F6XX/16F6XX Memory Programming Specification

This document includes the programming specifications for the following device:

- PIC12F635
- PIC12F683
- PIC16F631
- PIC16F636
- PIC16F639
- PIC16F677
- PIC16F684
- PIC16F685
- PIC16F687
- PIC16F688
- PIC16F689
- PIC16F690

1.0 PROGRAMMING THE PIC12F6XX/16F6XX DEVICES

The PIC12F6XX/16F6XX devices are programmed using a serial method. The Serial mode will allow the PIC12F6XX/16F6XX devices to be programmed while in the user's system. This programming specification applies to the PIC12F6XX/16F6XX devices in all packages.

1.1 Hardware Requirements

PIC12F6XX/16F6XX devices require one power supply for VDD (5.0V) and one for VPP (12.0V).

1.2 Program/Verify Mode

The Program/Verify mode for the PIC12F6XX/16F6XX devices allow programming of user program memory, data memory, user ID locations, Calibration Word and the Configuration Word.

Programming and verification can take place on any memory region, independent of the remaining regions. This allows independent programming of program and data memory regions. Therefore, unprotected data memory can be reprogrammed and protected without losing the content in the program memory.

TABLE 1-1: PIN DESCRIPTIONS IN PROGRAM/VERIFY MODE

Pin Name	During Programming		
	Function	Pin Type	Pin Description
GP1/RA1	ICSPCLK	I	Clock input – Schmitt Trigger input
GP0/RA0	ICSPDAT	I/O	Data input/output – Schmitt Trigger input
MCLR	Program/Verify mode	P ⁽¹⁾	Program Mode Select
VDD	VDD	P	Power Supply
VSS	VSS	P	Ground

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

Note 1: In the PIC12F6XX/16F6XX, the programming high voltage is internally generated. To activate the Program/Verify mode, high voltage needs to be applied to MCLR input. Since the MCLR is used for a level source, MCLR does not draw any significant current.

PIC12F6XX/16F6XX

FIGURE 1-1: 8-PIN PDIP, SOIC, DFN-S DIAGRAM FOR PIC12F635/683

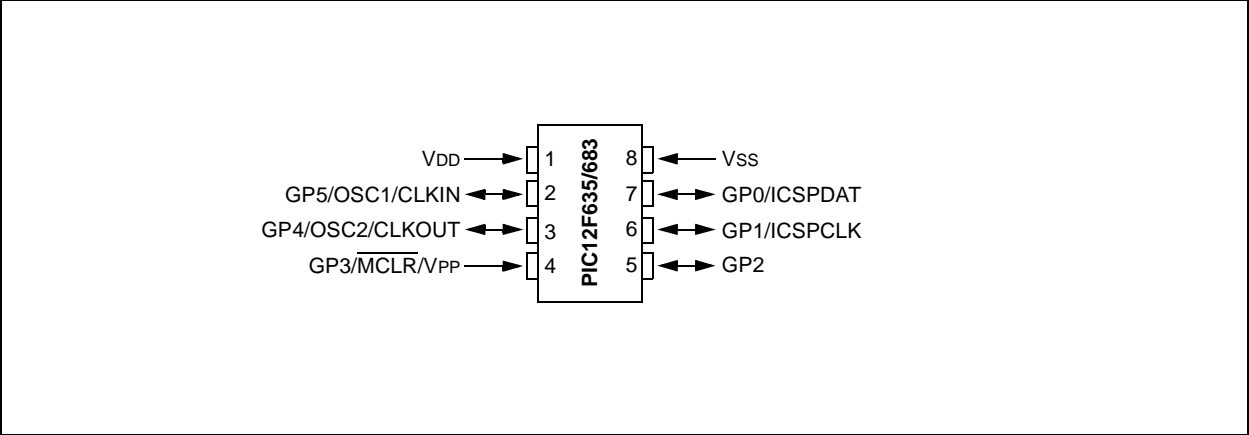


FIGURE 1-2: 14-PIN PDIP, SOIC, TSSOP DIAGRAM FOR PIC16F636/684/688

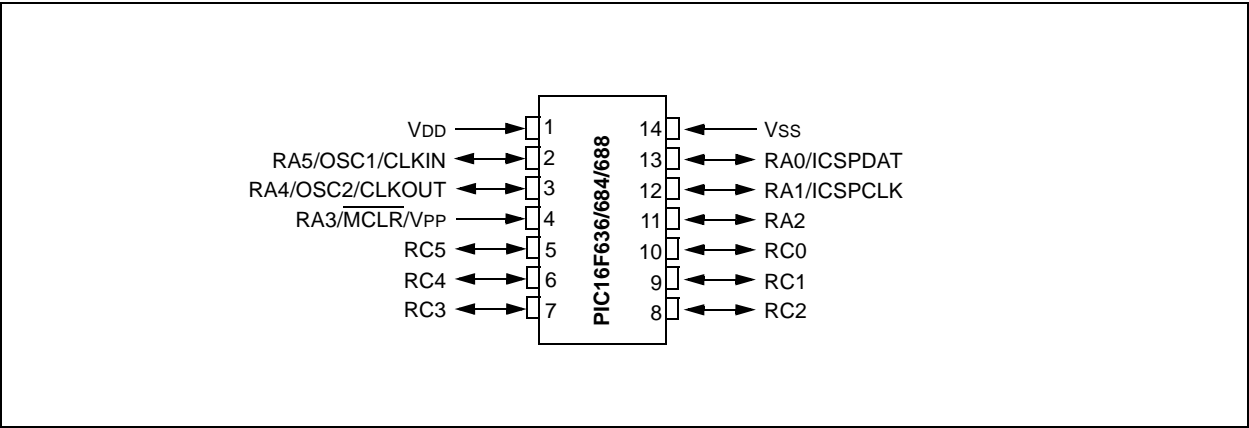


FIGURE 1-3: 16-PIN QFN DIAGRAMS FOR PIC16F636/684/688

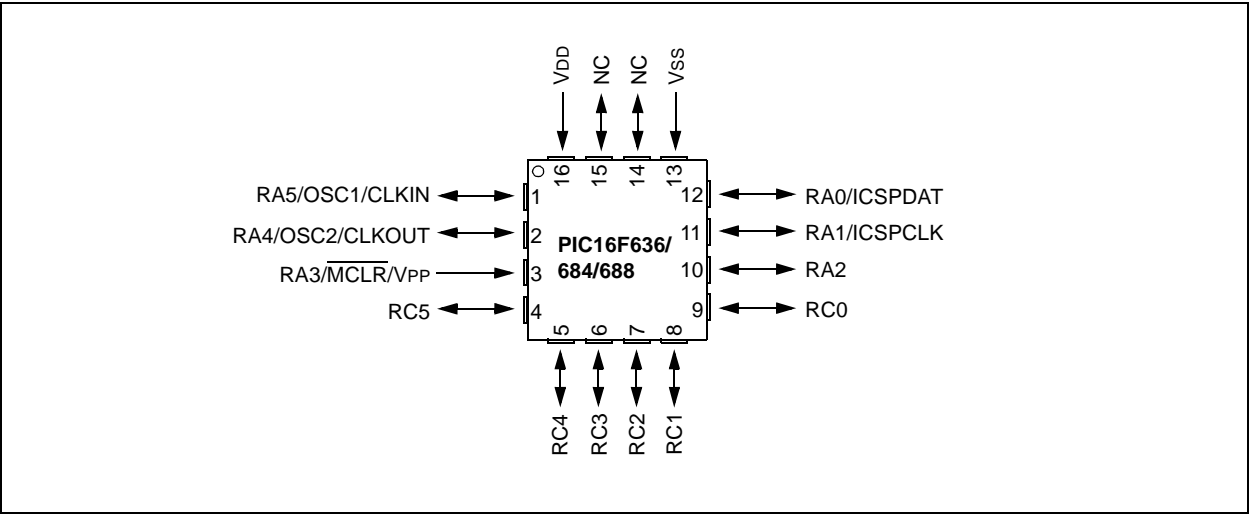


FIGURE 1-4: 20-PIN PDIP, SOIC⁽¹⁾, SSOP DIAGRAMS

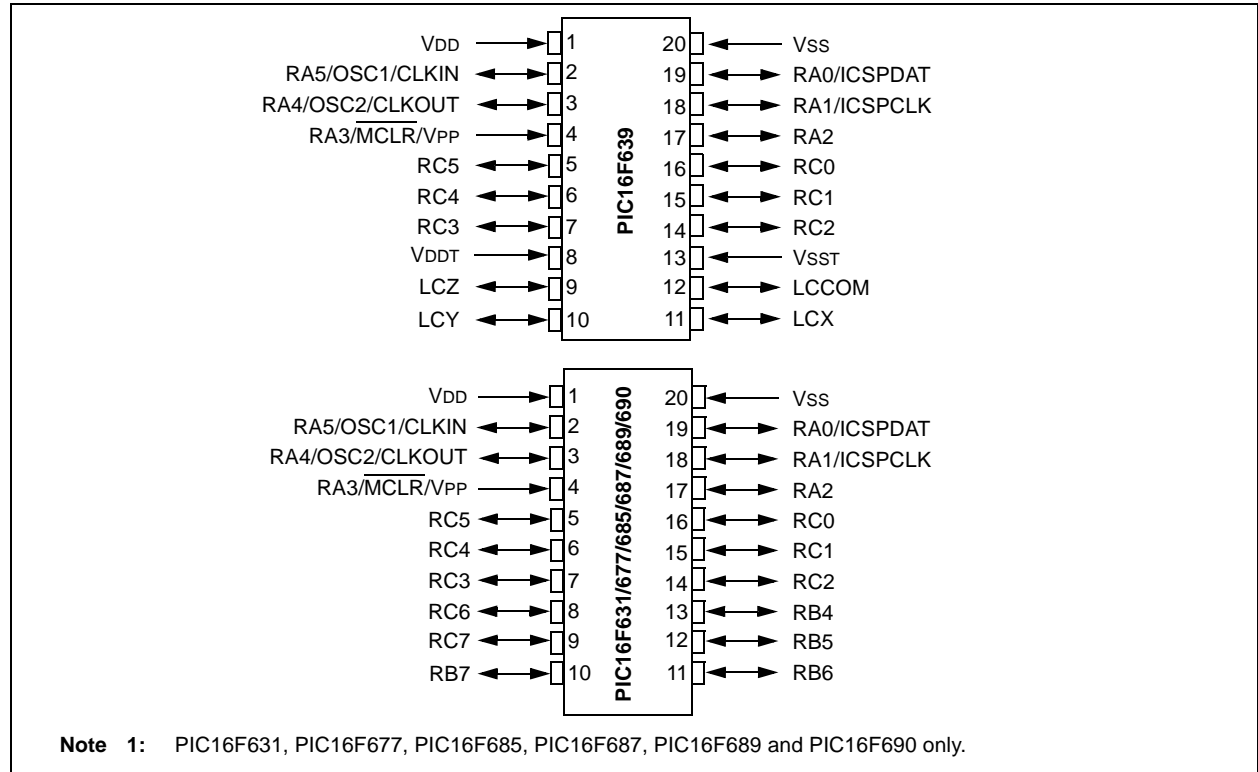
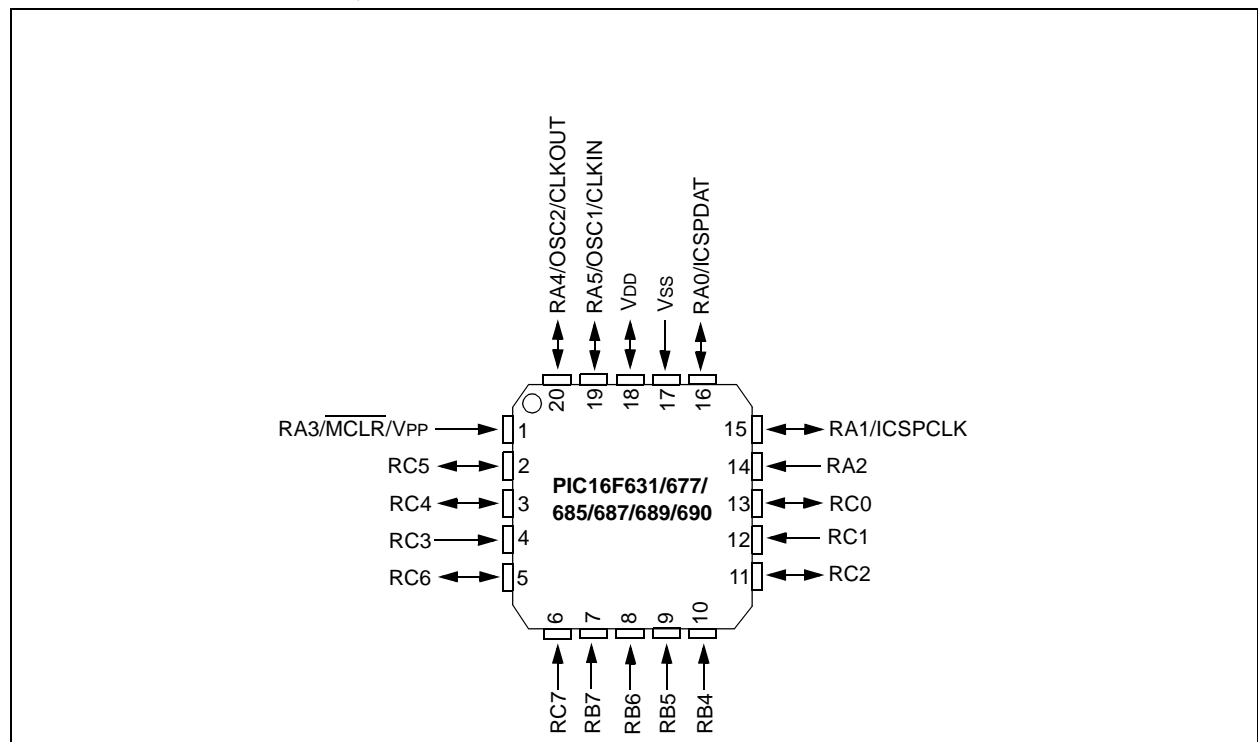


FIGURE 1-5: 20-PIN QFN DIAGRAM FOR PIC16F631/677/685/687/689/690



PIC12F6XX/16F6XX

2.0 MEMORY DESCRIPTION

2.1 Program Memory Map

The user memory space extends from 0x0000 to 0x1FFF. In Program/Verify mode, the program memory space extends from 0x0000 to 0x3FFF, with the first half (0x0000-0x1FFF) being user program memory and the second half (0x2000-0x3FFF) being configuration memory. The PC will increment from 0x0000 to 0x1FFF and wrap to 0x000, 0x2000 to 0x3FFF and wraparound to 0x2000 (not to 0x0000). Once in configuration memory, the highest bit of the PC stays a '1', thus always pointing to the configuration memory. The only way to point to user program memory is to reset the part and re-enter Program/Verify mode as described in **Section 3.0 "Program/Verify Mode"**.

For the PIC12F6XX/16F6XX (not including PIC12F635/636/639) devices, the configuration memory space, 0x2000 to 0x2008 are physically implemented. However, only locations 0x2000 to 0x2003, 0x2007 and 0x2008 are available. Other locations are reserved.

For the PIC12F635/636/639 devices, the configuration memory space (0x2000-0x2009) are physically implemented. However, only locations 0x2000 to 0x2003 and locations 0x2006 to 0x2009 are available. Other locations are reserved.

2.2 User ID Locations

A user may store identification information (user ID) in four designated locations. The user ID locations are mapped in 0x2000 to 0x2003. It is recommended that the user use only the seven Least Significant bits (LSb) of each user ID location. The user ID locations read out normally, even after code protection is enabled. It is recommended that ID locations are written as 'xx xxxx xbbb bbbb' where 'bbb bbbb' is user ID information.

The 14 bits may be programmed, but only the 7 LSb's are displayed by MPLAB[®] IDE. The xxxx's are "don't care" bits and are not read by MPLAB[®] IDE.

2.3 Calibration Word

For the PIC16F631/677/685/687/689/690 (not including PIC12F635/636/639) devices, the 8 MHz Internal Oscillator (INTOSC), the Power-on Reset (POR) and the Brown-out Reset (BOR) modules are factory calibrated. These values are stored in the Calibration Word (0x2008). See the applicable device data sheet for more information.

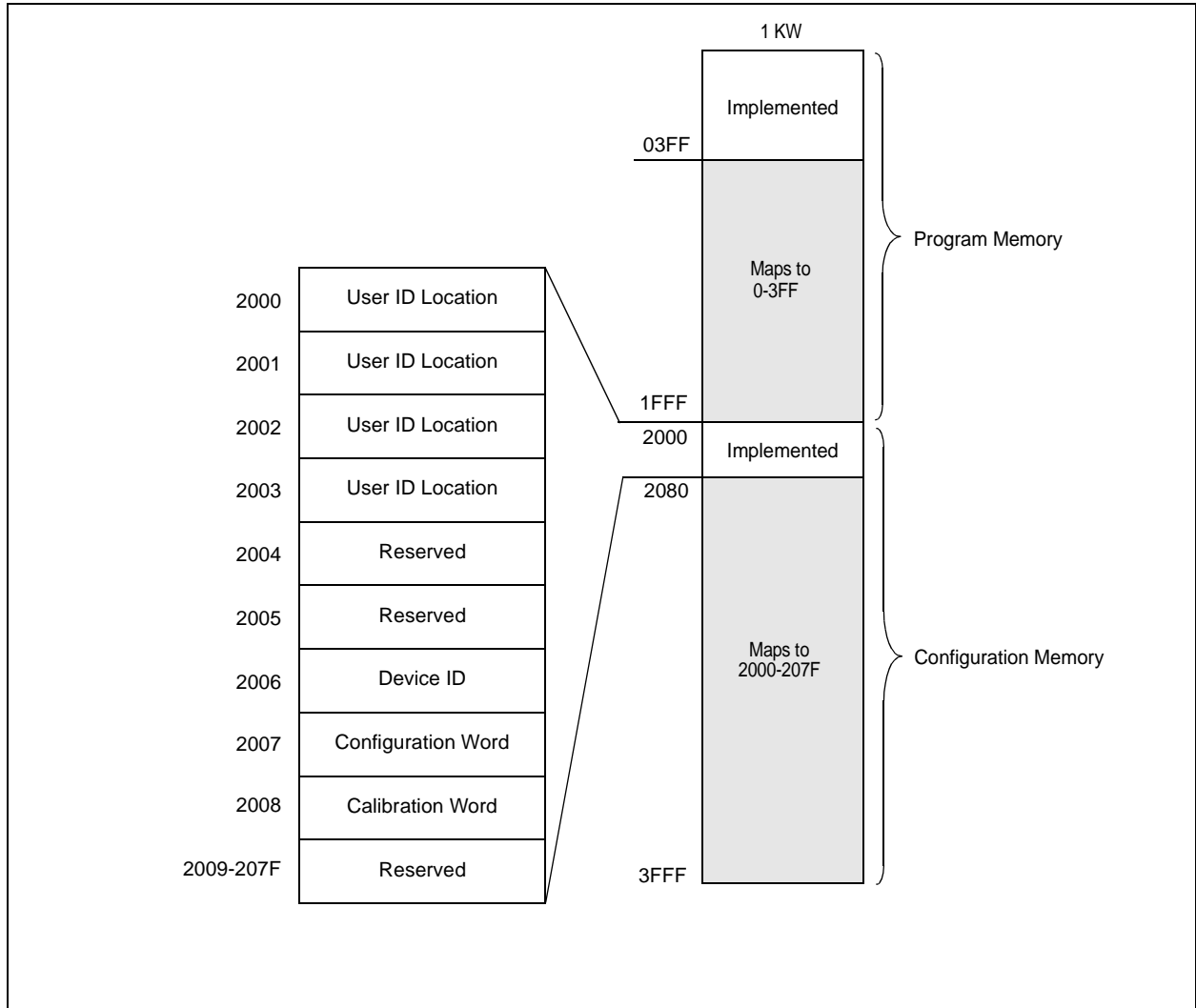
For the PIC12F635/636/639 devices, the 8 MHz Internal Oscillator (INTOSC), the Power-on Reset and the Brown-out Reset modules are factory calibrated and stored in the Calibration Word (0x2008). The Wake-up Reset (WUR) and Low-Voltage Detect (LVD) modules are factory calibrated and stored in the Calibration Word (0x2009). See the applicable device data sheet for more information.

The Calibration Word does not necessarily participate in the erase operation unless a specific procedure is executed. Therefore, the device can be erased without affecting the Calibration Word. This simplifies the erase procedure, for these values do not need to be read and restored after the device is erased. See **Section 3.1.5.12 "Row Erase Program Memory"** for more information on the various erase sequences.

TABLE 1: MEMORY CAPACITY

Device	EEDATA	Program Flash
PIC12F635	128 x 8	1k x 14
PIC12F683	256 x 8	2k x 14
PIC16F631	128 x 8	1k x 14
PIC16F636	256 x 8	2k x 14
PIC16F639	256 x 8	2k x 14
PIC16F677	256 x 8	2k x 14
PIC16F684	256 x 8	2k x 14
PIC16F685	256 x 8	4k x 14
PIC16F687	256 x 8	2k x 14
PIC16F688	256 x 8	4k x 14
PIC16F689	256 x 8	4k x 14
PIC16F690	256 x 8	4k x 14

FIGURE 2-1: PIC16F631 PROGRAM MEMORY MAPPING



PIC12F6XX/16F6XX

FIGURE 2-2: PIC12F635 PROGRAM MEMORY MAPPING

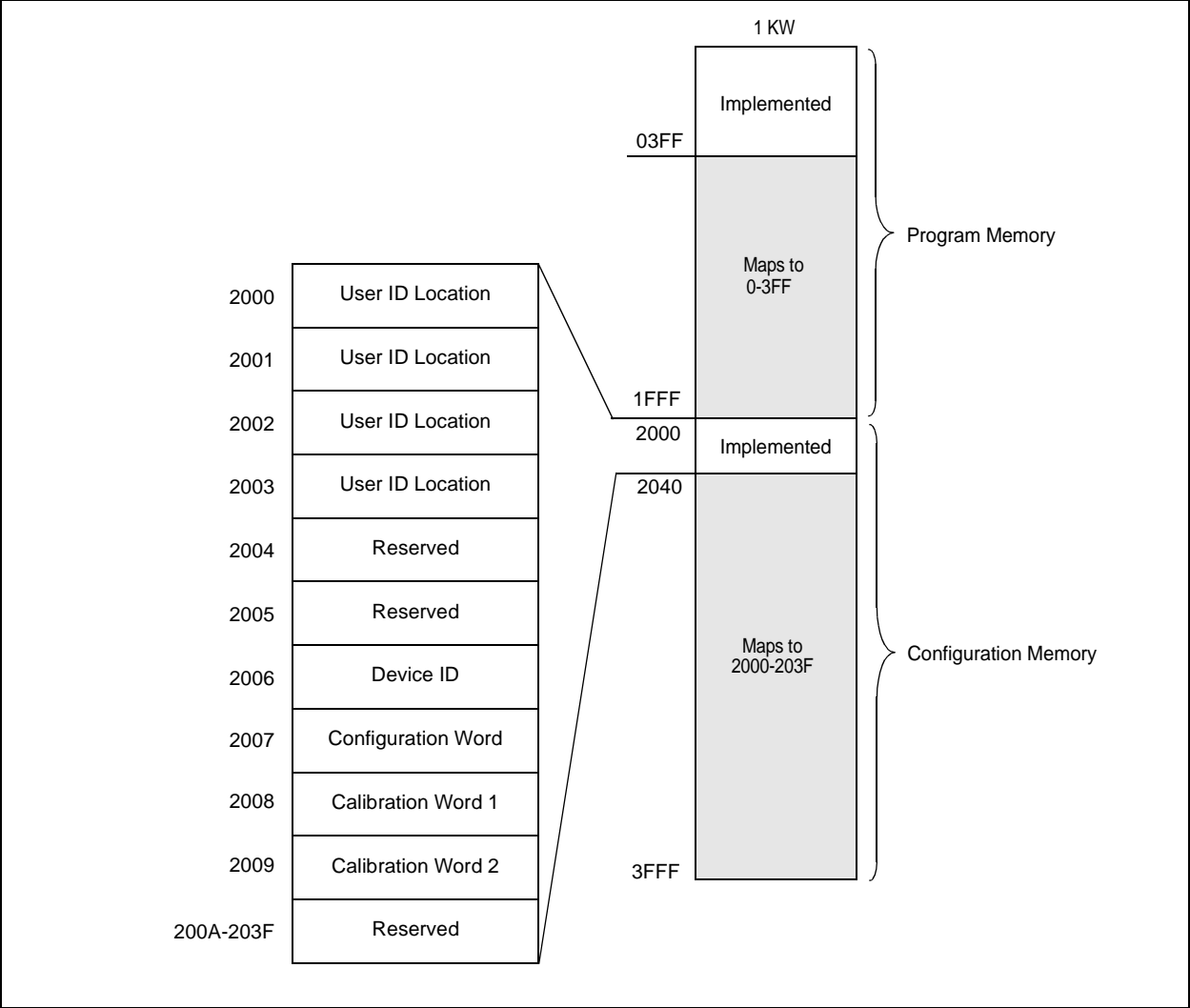
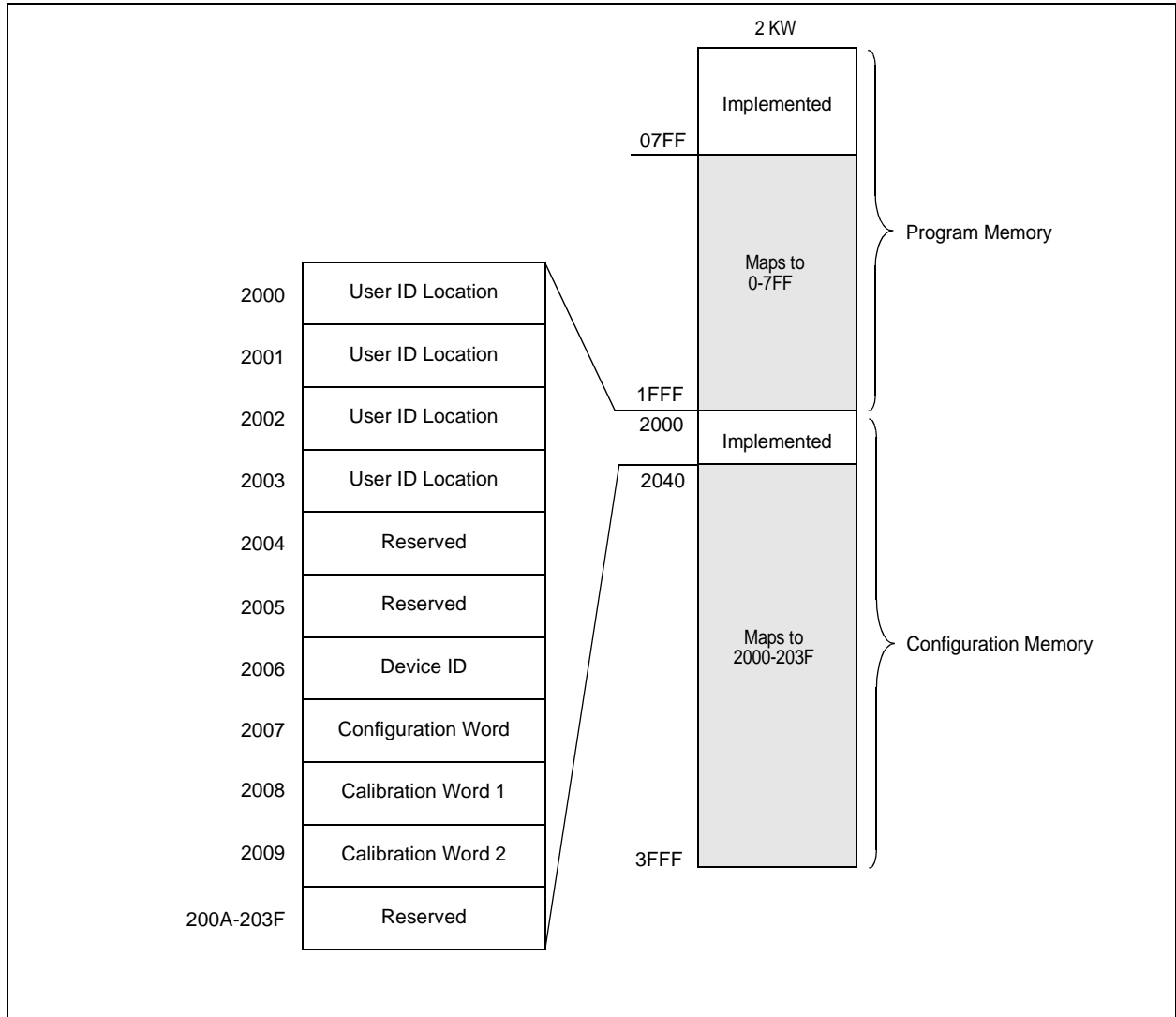


FIGURE 2-3: PIC16F636/639 PROGRAM MEMORY MAPPING



PIC12F6XX/16F6XX

FIGURE 2-4: PIC12F683/684 PROGRAM MEMORY MAPPING

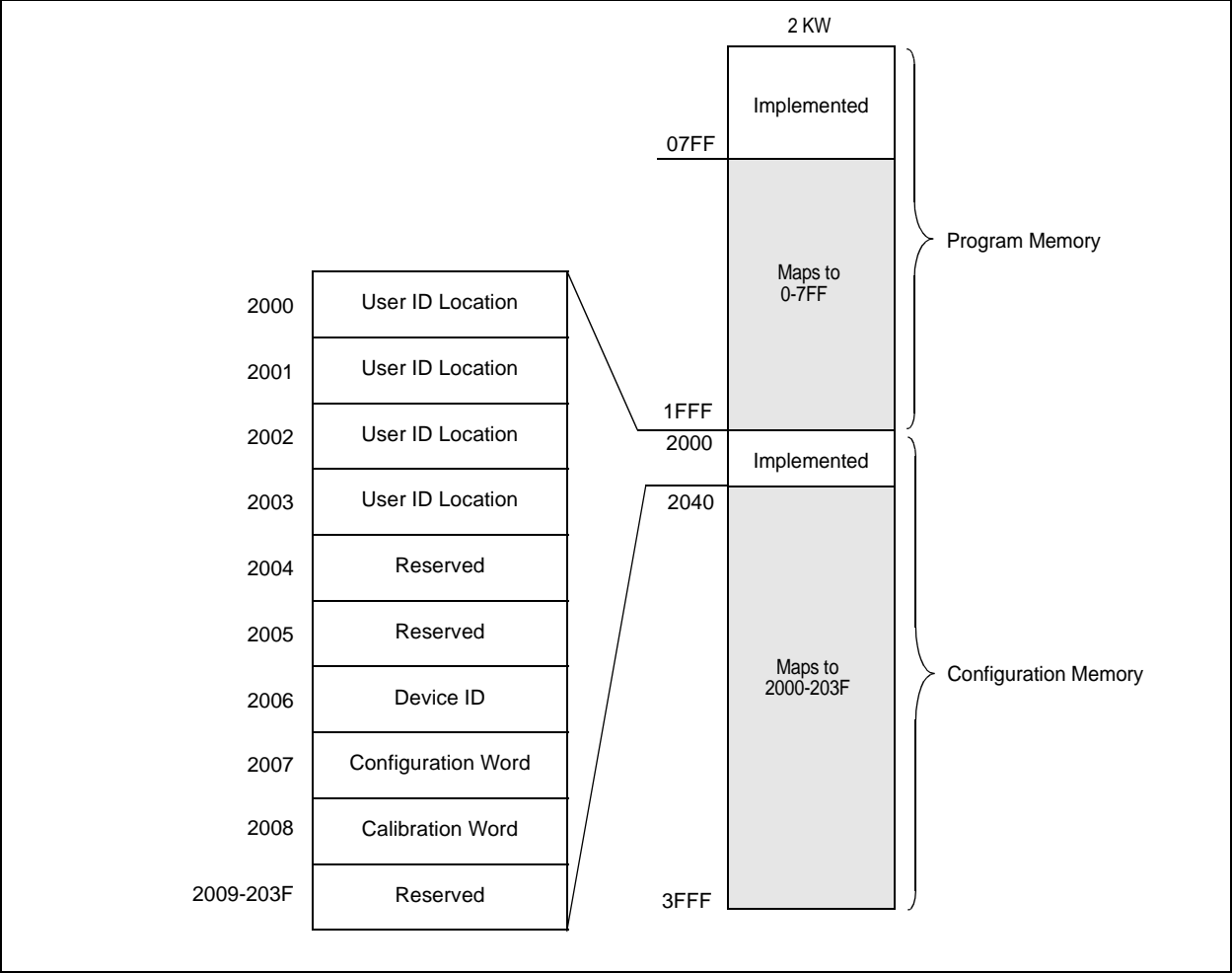
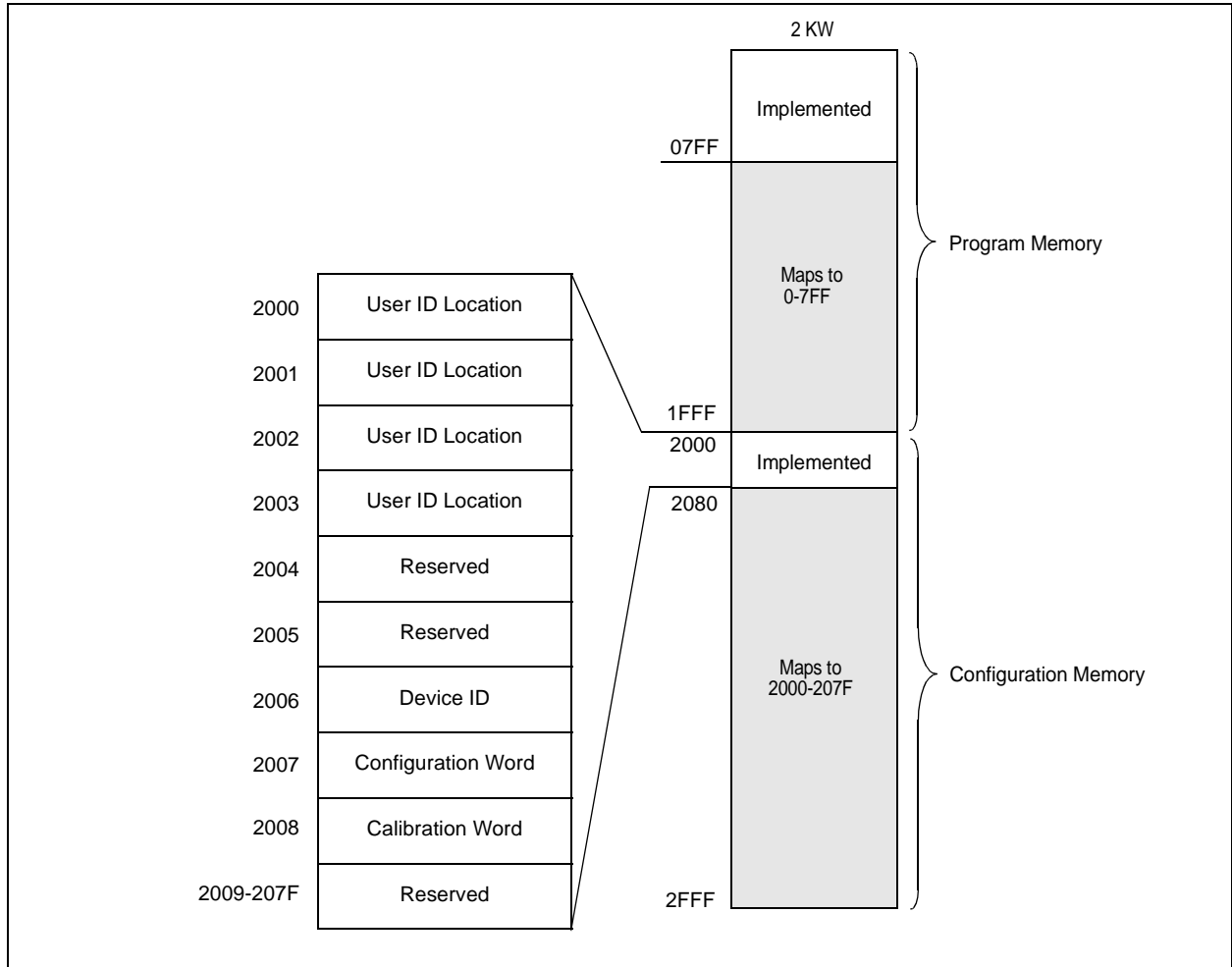


FIGURE 2-5: PIC16F677/687 PROGRAM MEMORY MAPPING



PIC12F6XX/16F6XX

FIGURE 2-6: PIC16F688 PROGRAM MEMORY MAPPING

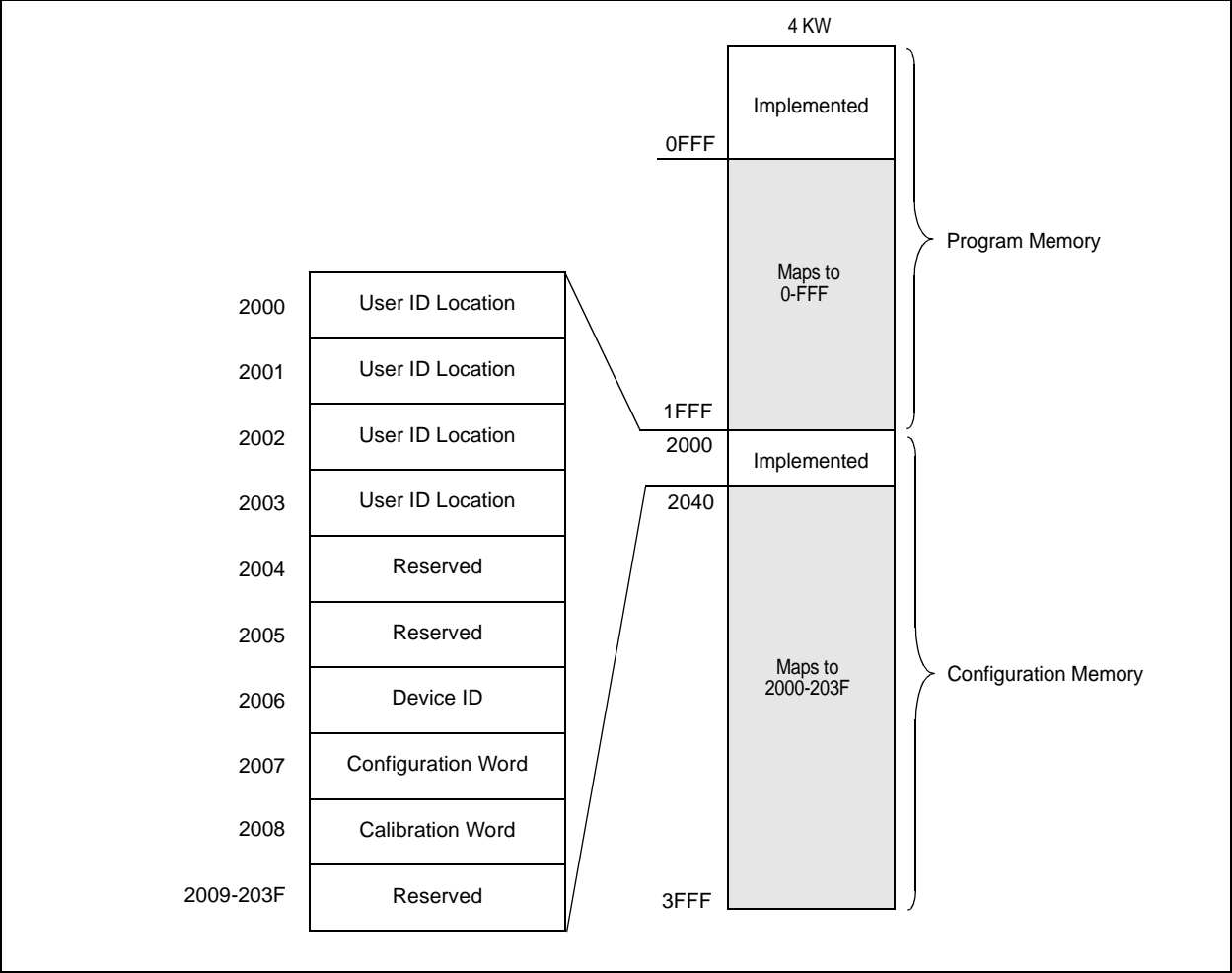
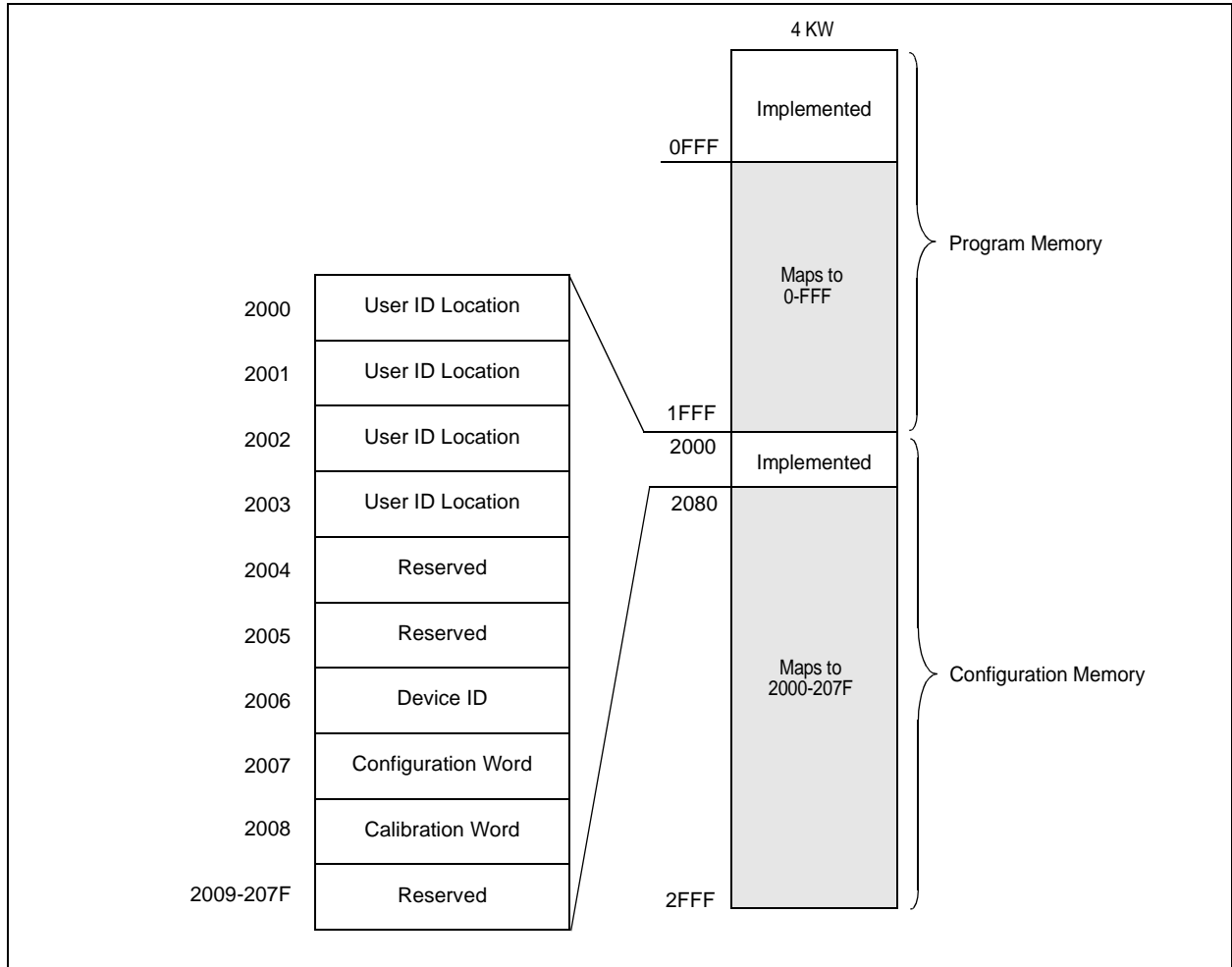


FIGURE 2-7: PIC16F685/689/690 PROGRAM MEMORY MAPPING



PIC12F6XX/16F6XX

3.0 PROGRAM/VERIFY MODE

Two methods are available to enter Program/Verify mode. The “VPP-first” is entered by holding ICSPDAT and ICSPCLK low while raising MCLR pin from V_{IL} to V_{IH} (high voltage), then applying VDD and data. This method can be used for any Configuration Word selection and **must** be used if the INTOSC and internal MCLR options are selected ($FOSC<2:0> = 100$ or 101 and $MCLRE = 0$). The VPP-first entry prevents the device from executing code prior to entering Program/Verify mode. See the timing diagram in Figure 3-1.

The second entry method, “VDD-first”, is entered by applying VDD, holding ICSPDAT and ICSPCLK low, then raising MCLR pin from V_{IL} to V_{IH} (high voltage), followed by data. This method can be used for any Configuration Word selection **except** when INTOSC and internal MCLR options are selected ($FOSC<2:0> = 100$ or 101 and $MCLRE = 0$). This technique 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 3-2.

Once in this mode, the program memory, data memory and configuration memory can be accessed and programmed in serial fashion. ICSPDAT and ICSPCLK are Schmitt Trigger inputs in this mode. RA4 is tri-state regardless of fuse setting.

The sequence that enters the device into the Programming/Verify mode places all other logic into the Reset state (the MCLR pin was initially at V_{IL}). Therefore, all I/O's are in the Reset state (high-impedance inputs) and the Program Counter (PC) is cleared.

To prevent a device configured with INTOSC and internal MCLR from executing after exiting Program/Verify mode, VDD needs to power-down before VPP. See Figure 3-3 for the timing.

FIGURE 3-1: VPP-FIRST PROGRAM/VERIFY MODE ENTRY

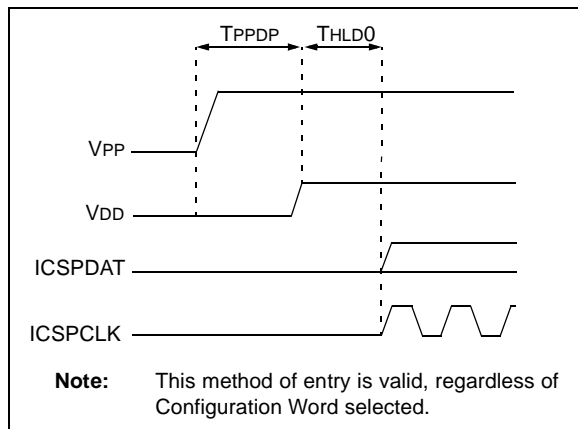


FIGURE 3-2: VDD-FIRST PROGRAM/VERIFY MODE ENTRY

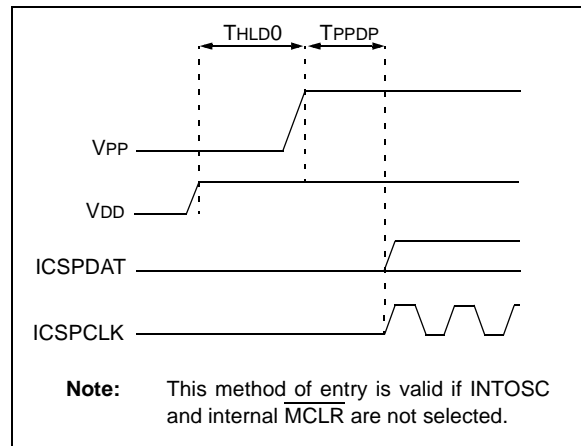
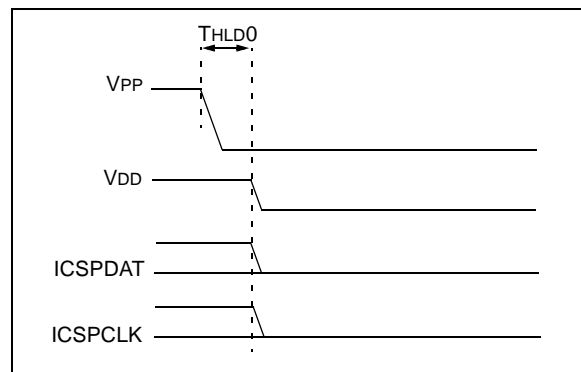


FIGURE 3-3: PROGRAM/VERIFY MODE EXIT



3.1 Program/Erase Algorithms

The PIC12F6XX/16F6XX program memory may be written in two ways. The fastest method writes four words at a time. However, one-word writes are also supported for backward compatibility with previous 8-pin and 14-pin Flash devices. The four-word algorithm is used to program the program memory only. The one-word algorithm can write any available memory location (i.e., program memory, configuration memory and data memory).

After writing the array, the PC may be reset and read back to verify the write. It is not possible to verify immediately following the write because the PC can only increment, not decrement.

A device Reset will clear the PC and set the address to '0'. The Increment Address command will increment the PC. The Load Configuration command will set the PC to 0x2000. The available commands are shown in Table 3-1.

3.1.1 FOUR-WORD PROGRAMMING

Only the program memory can be written using this algorithm. Data and configuration memory (>0x2000) must use the one-word programming algorithm (**Section 3.1.2 “One-Word Programming”**).

This algorithm writes four sequential addresses in program memory. The four addresses must point to a four-word block with addresses modulo 4 of 0, 1, 2 and 3. For example, programming address 4 through 7 can be programmed together. Programming addresses 2 through 5 will create an unexpected result.

The sequence for programming four words of program memory at a time is as follows:

1. Load a word at the current program memory address using Load Data For Program Memory command.
2. Issue a Increment Address command.
3. Load a word at the current program memory address using Load Data For Program Memory command.
4. Repeat Step 2 and Step 3 two times.
5. Issue a Begin Programming command either internally or externally timed.
6. Wait TPROG1 (internally timed) or TPROG2 (externally timed).
7. Issue a End Programming command if externally timed.
8. Issue a Increment Address command.
9. Repeat this sequence as required to write program memory.

See Figure 3-17 for more information.

3.1.2 ONE-WORD PROGRAMMING

The program memory may also be written one word at a time to allow compatibility with other 8-pin and 14-pin Flash PICmicro® devices. Configuration memory (>0x2000) and data memory must be written one word (or byte) at a time.

Note:	The four write latches must be reset after programming the device ID (0x2006), Configuration Word (0x2007) or Calibration Words (0x2008-0x2009). See Section 3.1.3 “Resetting Write Latches” .
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The sequence for programming one word of program memory at a time is as follows:

1. Load a word at the current program memory address using Load Data For Program Memory command.
2. Issue a Begin Programming command either internally or externally timed.
3. Wait TPROG1 (internally timed) or TPROG2 (externally timed).
4. Issue a End Programming command if externally timed.
5. Issue a Increment Address command.
6. Repeat this sequence as required to write program, data or configuration memory.

See Figure 3-16 for more information.

3.1.3 RESETTING WRITE LATCHES

The device ID (0x2006), Configuration Word (0x2007) and Calibration Words (0x2008-0x2009) are mapped into the configuration memory, but do not physically reside in it. As a result, the write latches are not reset when programming these locations and must be reset by the programmer. This can be done in two ways, either loading all four latches with '1's or by exiting Program/Verify mode.

The sequence for manually resetting the write latches is as follows:

1. Load a word using Load Data For Program Memory or Load Data For Configuration Memory command with a data word of all '1's.
2. Issue a Increment Address command.
3. Repeat this sequence three times to reset all four write latches.

PIC12F6XX/16F6XX

3.1.4 ERASE ALGORITHMS

The PIC12F6XX/16F6XX will erase different memory locations depending on the Program Counter (PC), CP and CPD values and which erase command executed. The following sequences can be used to erase noted memory locations. In each sequence, the data memory will be erased if the $\overline{\text{CPD}}$ bit in the Configuration Word is programmed (clear).

To erase the program memory and Configuration Word (0x2007), the following sequence must be performed. Note the Calibration Words (0x2008-0x2009) and user ID (0x2000-0x2003) **will not** be erased.

1. Do a Bulk Erase Program Memory command.
2. Wait TERA to complete erase.

To erase the user ID (0x2000-0x2003), Configuration Word (0x2007) and program memory, use the following sequence. Note that the Calibration Words (0x2008-0x2009) **will not** be erased.

1. Perform Load Configuration with dummy data to point the Program Counter (PC) to 0x2000.
2. Perform a Bulk Erase Program Memory command.
3. Wait TERA to complete erase.

To erase the user ID (0x2000-0x2003), Configuration Word (0x2007), Calibration Word (0x2008) and program memory, use the following sequence. Note that the Calibration Word (0x2008) **will** be erased.

1. Perform Load Configuration with dummy data to point the Program Counter (PC) to 0x2000.
2. Perform 8 Increment Address commands to point the PC to the Calibration Word at 0x2008.
3. Do a Bulk Erase Program Memory command.
4. Wait TERA to complete erase.

To erase the user ID (0x2000-0x2003), Configuration Word (0x2007), Calibration Words (0x2008-0x2009) and program memory, use the following sequence. Note that the Calibration Words (0x2008-0x2009) will be erased.

1. Perform Load Configuration with dummy data to point the Program Counter (PC) to 0x2000.
2. Perform 9 Increment Address commands to point the PC to the Calibration Word at 0x2009.
3. Do a Bulk Erase Program Memory command.
4. Wait TERA to complete erase.

To erase the data memory, use the following sequence:

1. Perform a Bulk Erase Data Memory command.
2. Wait TERA to complete erase.

3.1.5 SERIAL PROGRAM/VERIFY OPERATION

The ICSPCLK pin is used as a clock input and the ICSPDAT pin is used for entering command bits and data input/output during serial operation. To input a command, ICSPCLK is cycled six times. Each command bit is latched on the falling edge of the clock with the LSb of the command being input first. The data input onto the ICSPDAT pin is required to have a minimum setup and hold time (see Table 6-1), with respect to the falling edge of the clock. Commands that have data associated with them (Read and Load) are specified to have a minimum delay of 1 μs between the command and the data. After this delay, the clock pin is cycled 16 times with the first cycle being a Start bit and the last cycle being a Stop bit.

During a read operation, the LSb will be transmitted onto ICSPDAT pin on the rising edge of the second cycle. For a load operation, the LSb will be latched on the falling edge of the second cycle. A minimum 1 μs delay is also specified between consecutive commands, except for the End Programming command, which requires a 100 μs TDIS.

All commands and data words are transmitted LSb first. Data is transmitted on the rising edge and latched on the falling edge of the ICSPCLK. To allow for decoding of commands and reversal of data pin configuration, a time separation of at least 1 μs is required between a command and a data word.

The commands that are available are described in Table 3-1.

TABLE 3-1: COMMAND MAPPING FOR PIC12F6XX/16F6XX

Command	Mapping (MSb ... LSb)						Data
Load Configuration	x	x	0	0	0	0	0, data (14), 0
Load Data for Program Memory	x	x	0	0	1	0	0, data (14), 0
Load Data for Data Memory	x	x	0	0	1	1	0, data (8), zero (6), 0
Read Data from Program Memory	x	x	0	1	0	0	0, data (14), 0
Read Data from Data Memory	x	x	0	1	0	1	0, data (8), zero (6), 0
Increment Address	x	x	0	1	1	0	
Begin Programming	x	0	1	0	0	0	Internally Timed
Begin Programming	x	1	1	0	0	0	Externally Timed
End Programming	x	0	1	0	1	0	
Bulk Erase Program Memory	x	x	1	0	0	1	Internally Timed
Bulk Erase Data Memory	x	x	1	0	1	1	Internally Timed
Row Erase Program Memory	x	1	0	0	0	1	Internally Timed

3.1.5.1 Load Configuration

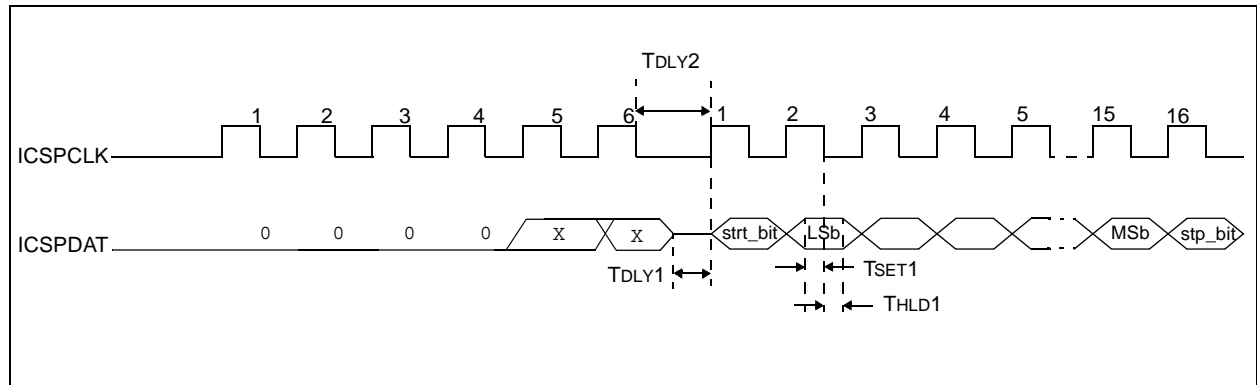
The Load Configuration command is used to access the Configuration Word (0x2007), user ID (0x2000-0x2003) and Calibration Words (0x2008-0x2009). This command sets the Program Counter (PC) to address 0x2000 and loads the data latches with one word of data.

To access the configuration memory, send the Load Configuration command. Individual words within the configuration memory can be accessed by sending Increment Address commands and issuing load or read data for program memory.

After the 6-bit command is input, the ICSPCLK pin is cycled an additional 16 times for the Start bit, 14 bits of data and a Start bit (see Figure 3-4).

After the configuration memory is entered, the only way to get back to the program memory is to exit the Program/Verify mode by taking MCLR low (VIL).

FIGURE 3-4: LOAD CONFIGURATION COMMAND

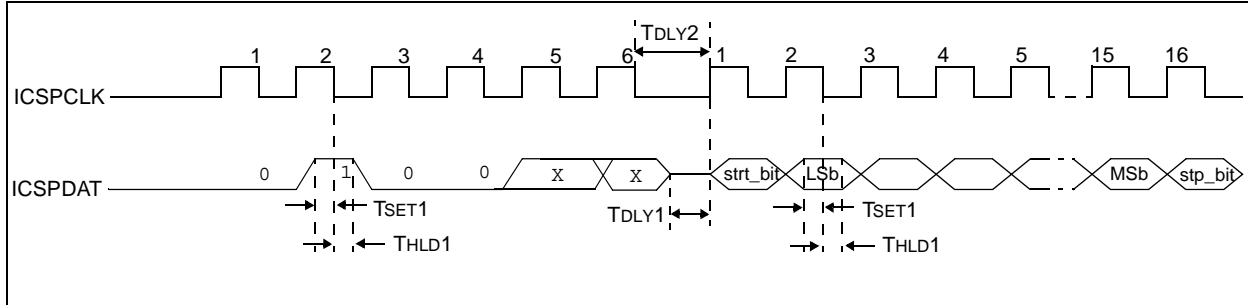


PIC12F6XX/16F6XX

3.1.5.2 Load Data For Program Memory

After receiving this command, the chip will load in a 14-bit “data word” when 16 cycles are applied, as described previously. A timing diagram for the Load Data For Program Memory command is shown in Figure 3-5.

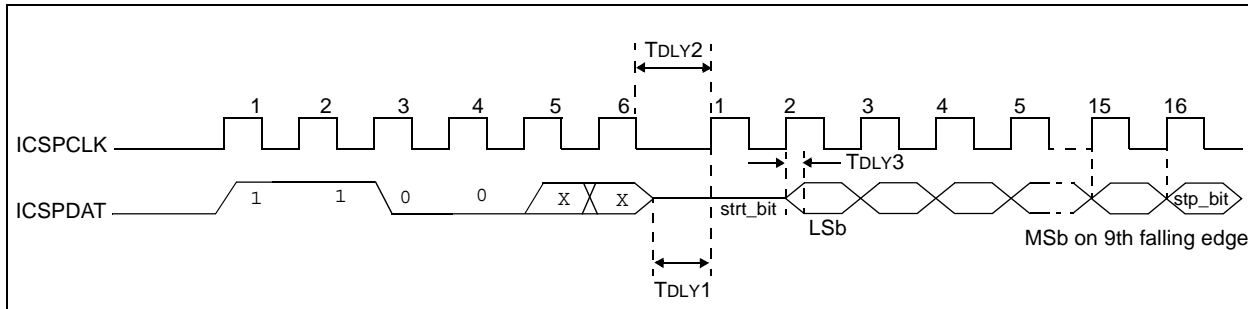
FIGURE 3-5: LOAD DATA FOR PROGRAM MEMORY COMMAND



3.1.5.3 Load Data For Data Memory

After receiving this command, the chip will load in a 14-bit “data word” when 16 cycles are applied. However, the data memory is only 8 bits wide and thus, only the first 8 bits of data after the Start bit will be programmed into the data memory. It is still necessary to cycle the clock the full 16 cycles in order to allow the internal circuitry to reset properly. The data memory contains 256 bytes.

FIGURE 3-6: LOAD DATA FOR DATA MEMORY COMMAND

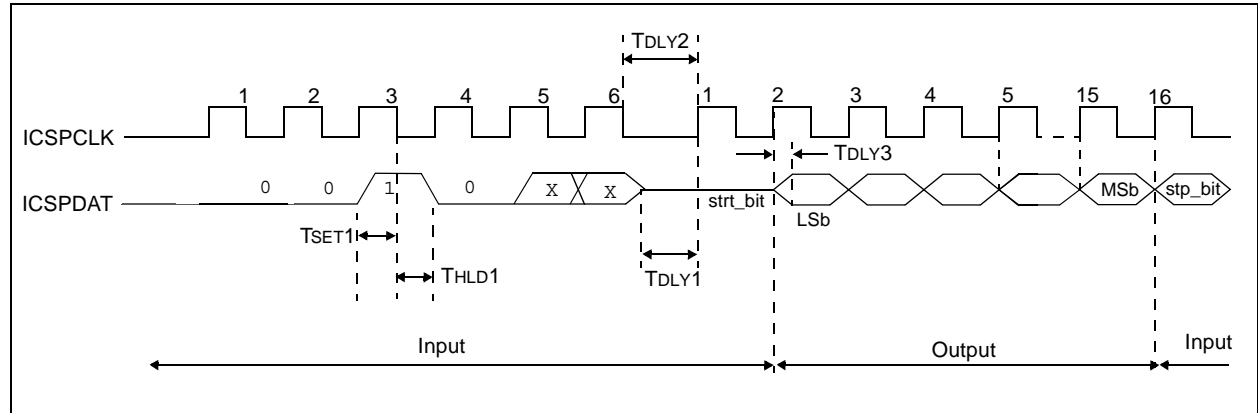


3.1.5.4 Read Data From Program Memory

After receiving this command, the chip will transmit data bits out of the program memory (user or Configuration) currently accessed, starting with the second rising edge of the clock input. The data pin will go into Output mode on the second rising clock edge, and it will revert to Input mode (high-impedance) after the 16th rising edge.

If the program memory is code-protected ($\overline{CP} = 0$), the data is read as zeros.

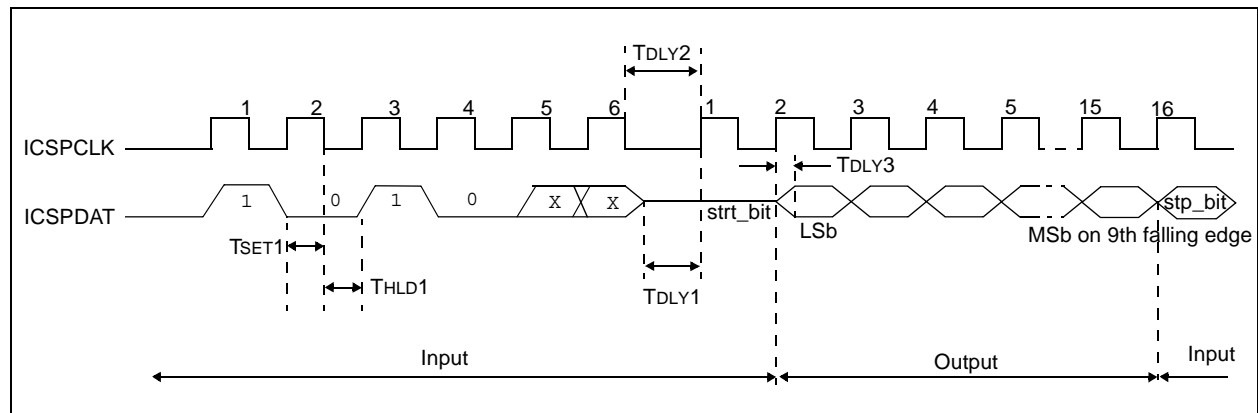
FIGURE 3-7: READ DATA FROM PROGRAM MEMORY COMMAND



3.1.5.5 Read Data From Data Memory

After receiving this command, the chip will transmit data bits out of the data memory, starting with the second rising edge of the clock input. The ICSPDAT pin will go into Output mode on the second rising edge and it will revert to Input mode (high-impedance) after the 16th rising edge. As previously stated, the data memory is 8 bits wide and, therefore, only the first 8 bits that are output are actual data. If the data memory is code-protected, the data is read as all zeros. A timing diagram of this command is shown in Figure 3-8.

FIGURE 3-8: READ DATA FROM DATA MEMORY COMMAND



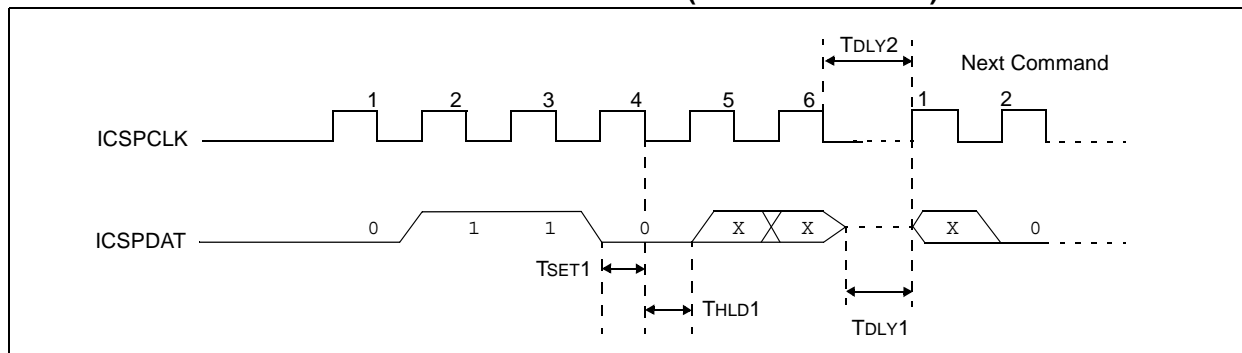
PIC12F6XX/16F6XX

3.1.5.6 Increment Address

The PC is incremented when this command is received. A timing diagram of this command is shown in Figure 3-9.

It is not possible to decrement the address counter. To reset this counter, the user should exit and re-enter Program/Verify mode.

FIGURE 3-9: INCREMENT ADDRESS COMMAND (PROGRAM/VERIFY)

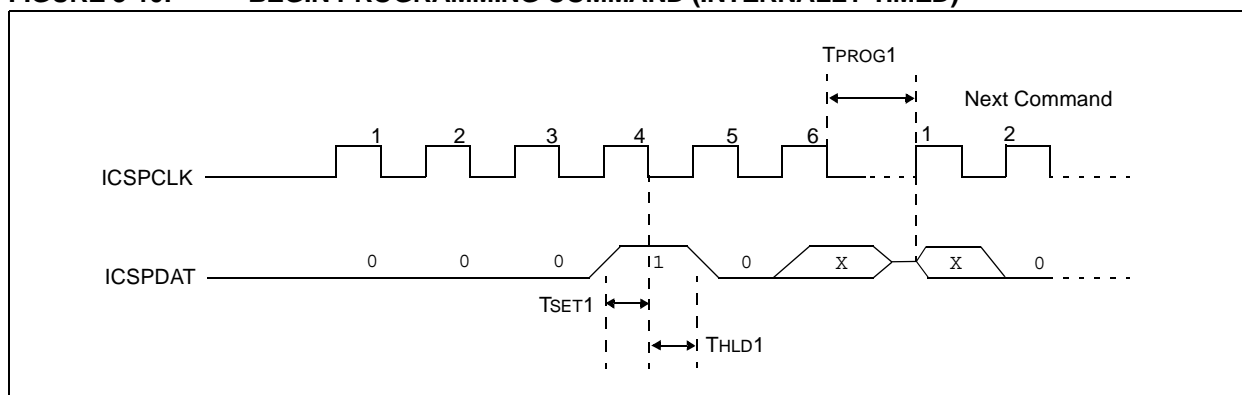


3.1.5.7 Begin Programming (Internally Timed)

A Load command must be given before every Begin Programming command. Programming of the appropriate memory (user program memory, configuration memory or data memory) will begin after this command is received and decoded. An internal timing mechanism executes a write. The user must allow for program cycle time for programming to complete. No End Programming command is required.

The addressed location is not erased before programming.

FIGURE 3-10: BEGIN PROGRAMMING COMMAND (INTERNALLY TIMED)

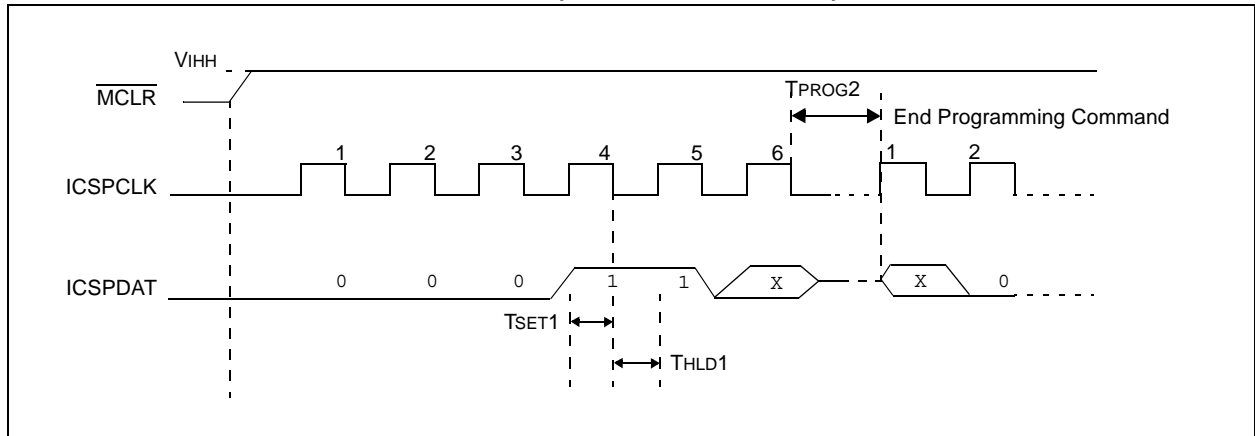


3.1.5.8 Begin Programming (Externally Timed)

A Load command must be given before every Begin Programming command. Programming of the appropriate memory (program memory, configuration or data memory) will begin after this command is received and decoded. Programming requires (T_{PROG2}) time and is terminated using an End Programming command.

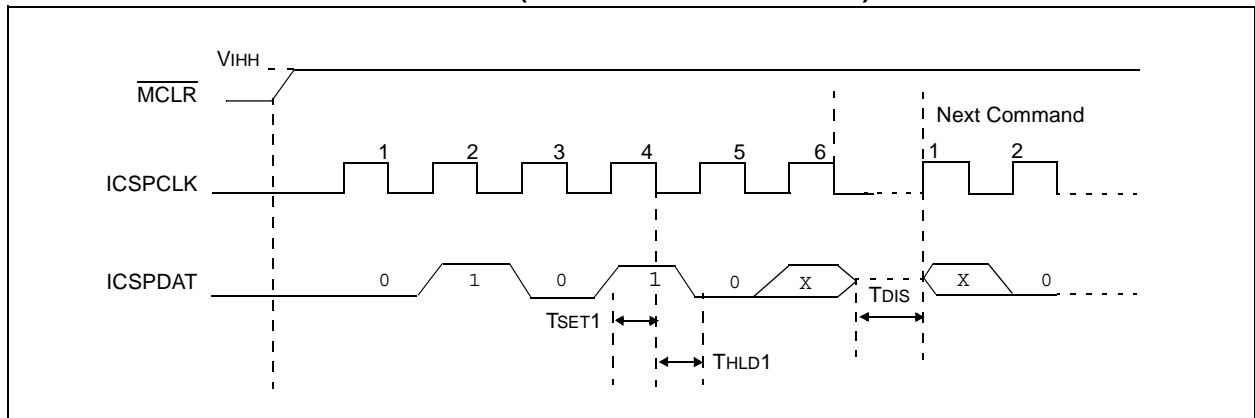
The addressed location is not erased before programming.

FIGURE 3-11: BEGIN PROGRAMMING (EXTERNALLY TIMED)



3.1.5.9 End Programming

FIGURE 3-12: END PROGRAMMING (SERIAL PROGRAM/VERIFY)

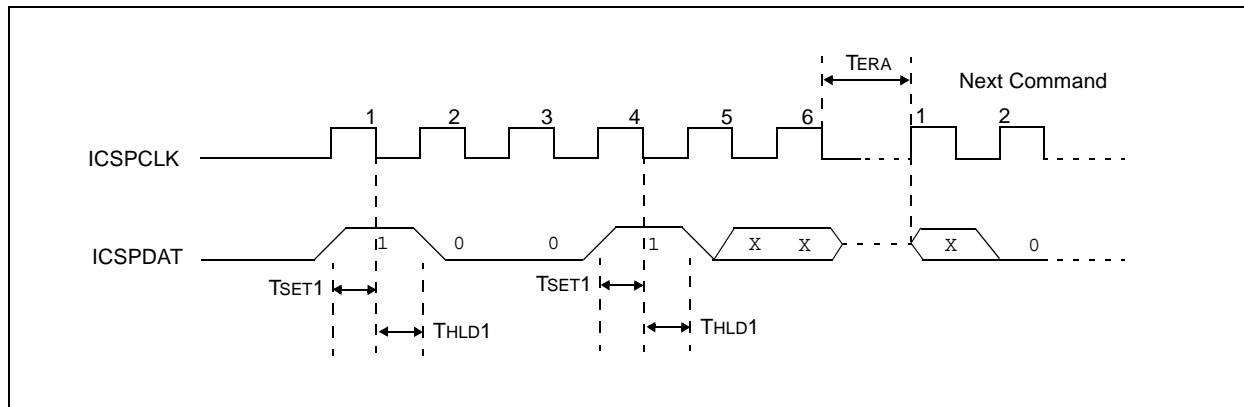


PIC12F6XX/16F6XX

3.1.5.10 Bulk Erase Program Memory

After this command is performed, the entire program memory and Configuration Word (0x2007) is erased. Data memory will also be erased if the CPD bit in the Configuration Word is programmed (clear). See **Section 3.1.4 “Erase Algorithms”** for erase sequences.

FIGURE 3-13: BULK ERASE PROGRAM MEMORY COMMAND



3.1.5.11 Bulk Erase Data Memory

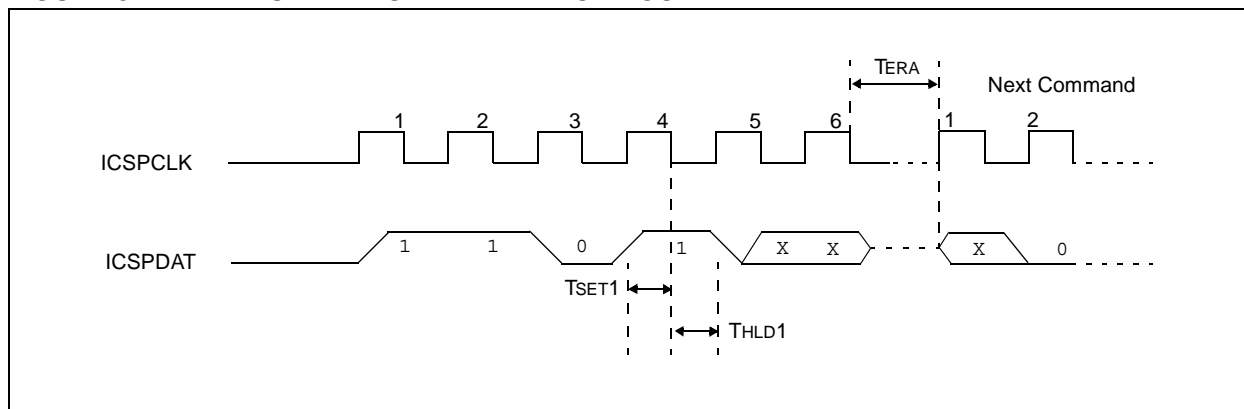
To perform an erase of the data memory, the following sequence must be performed.

1. Perform a Bulk Erase Data Memory command.
2. Wait TERA to complete bulk erase.

Data memory won't erase if code-protected ($\overline{\text{CPD}} = 0$).

Note: All bulk erase operations must take place between 4.5V and 5.5V V_{DD} for PIC12F6XX/16F6XX and 2.0V to 5.5V V_{DD} for PIC12F6XX/16F6XX-ICD.

FIGURE 3-14: BULK ERASE DATA MEMORY COMMAND



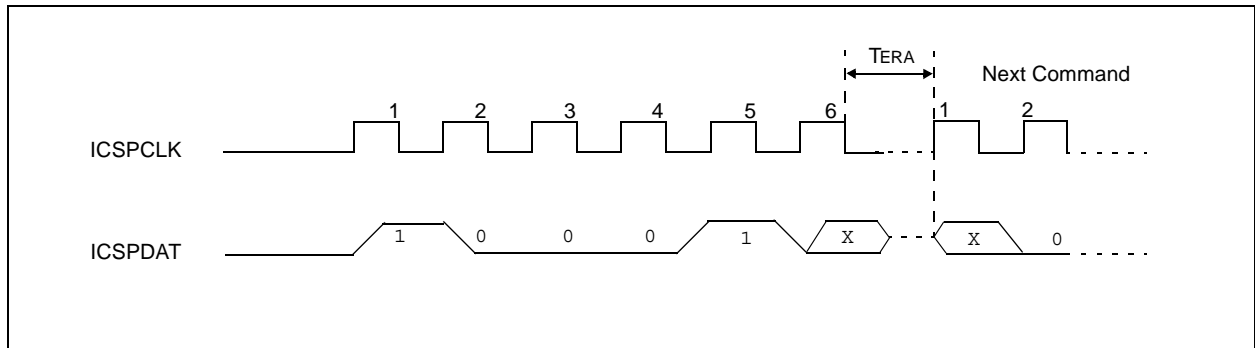
3.1.5.12 Row Erase Program Memory

This command erases the 16-word row of program memory pointed to by PC<11:4>. If the program memory array is protected ($\overline{CP} = 0$) or the PC points to configuration memory (>0x2000), the command is ignored.

To perform a Row Erase Program Memory, the following sequence must be performed.

1. Execute a Row Erase Program Memory command.
2. Wait TERA to complete a row erase.

FIGURE 3-15: ROW ERASE PROGRAM MEMORY COMMAND



PIC12F6XX/16F6XX

FIGURE 3-16: ONE-WORD PROGRAMMING FLOWCHART

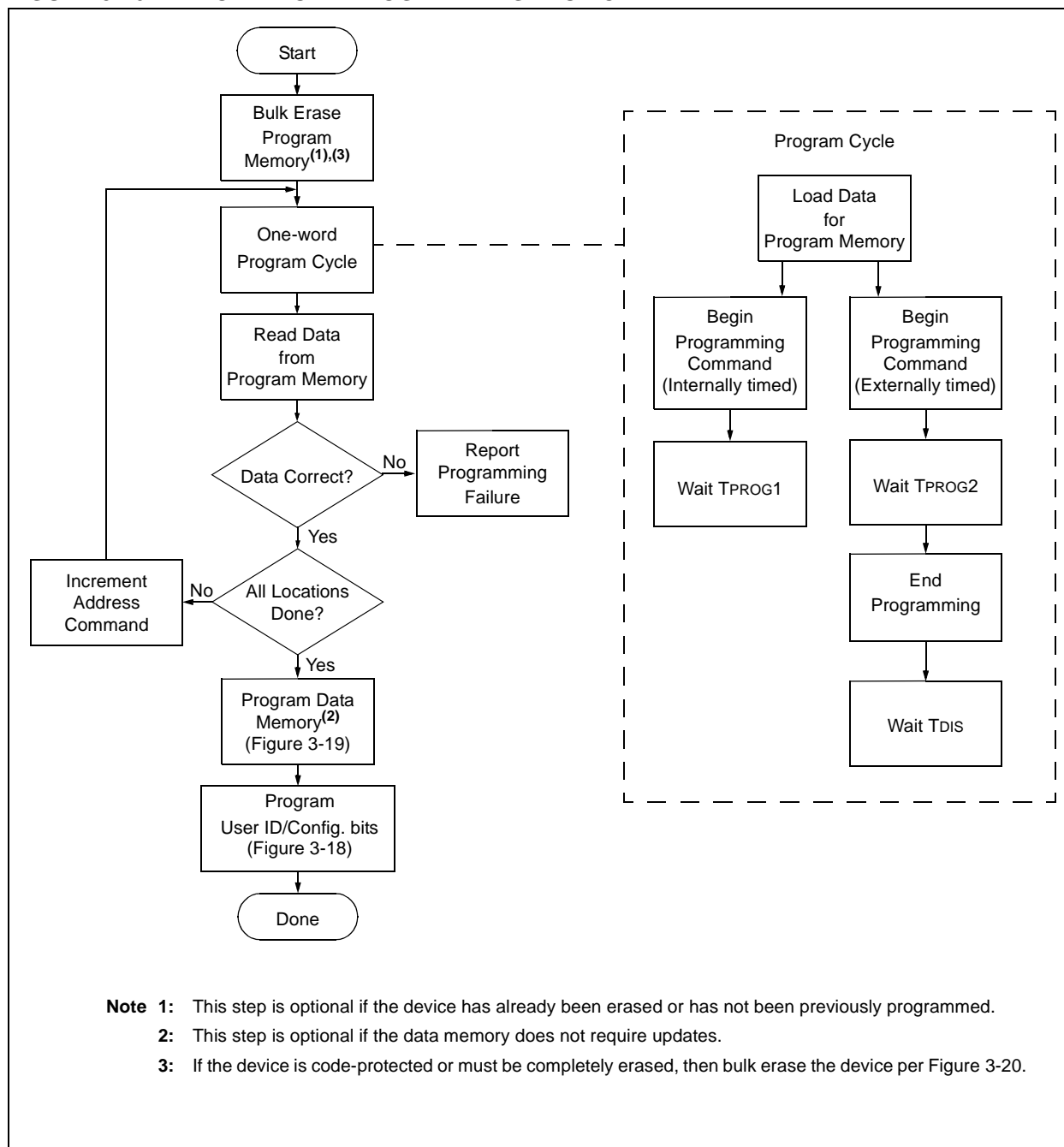
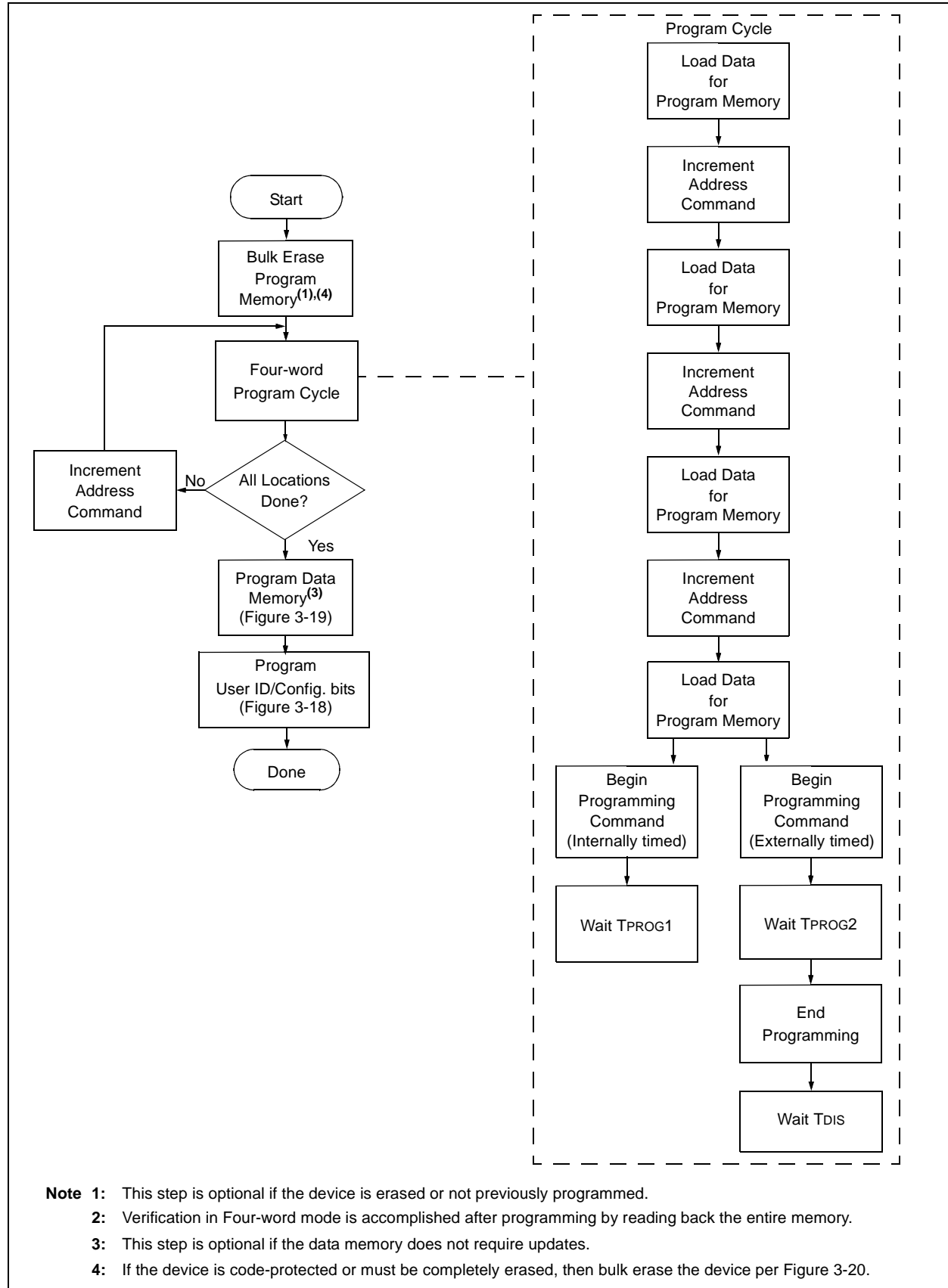


FIGURE 3-17: FOUR-WORD PROGRAMMING FLOWCHART



PIC12F6XX/16F6XX

FIGURE 3-18: PROGRAM FLOWCHART – PIC12F6XX/16F6XX CONFIGURATION MEMORY

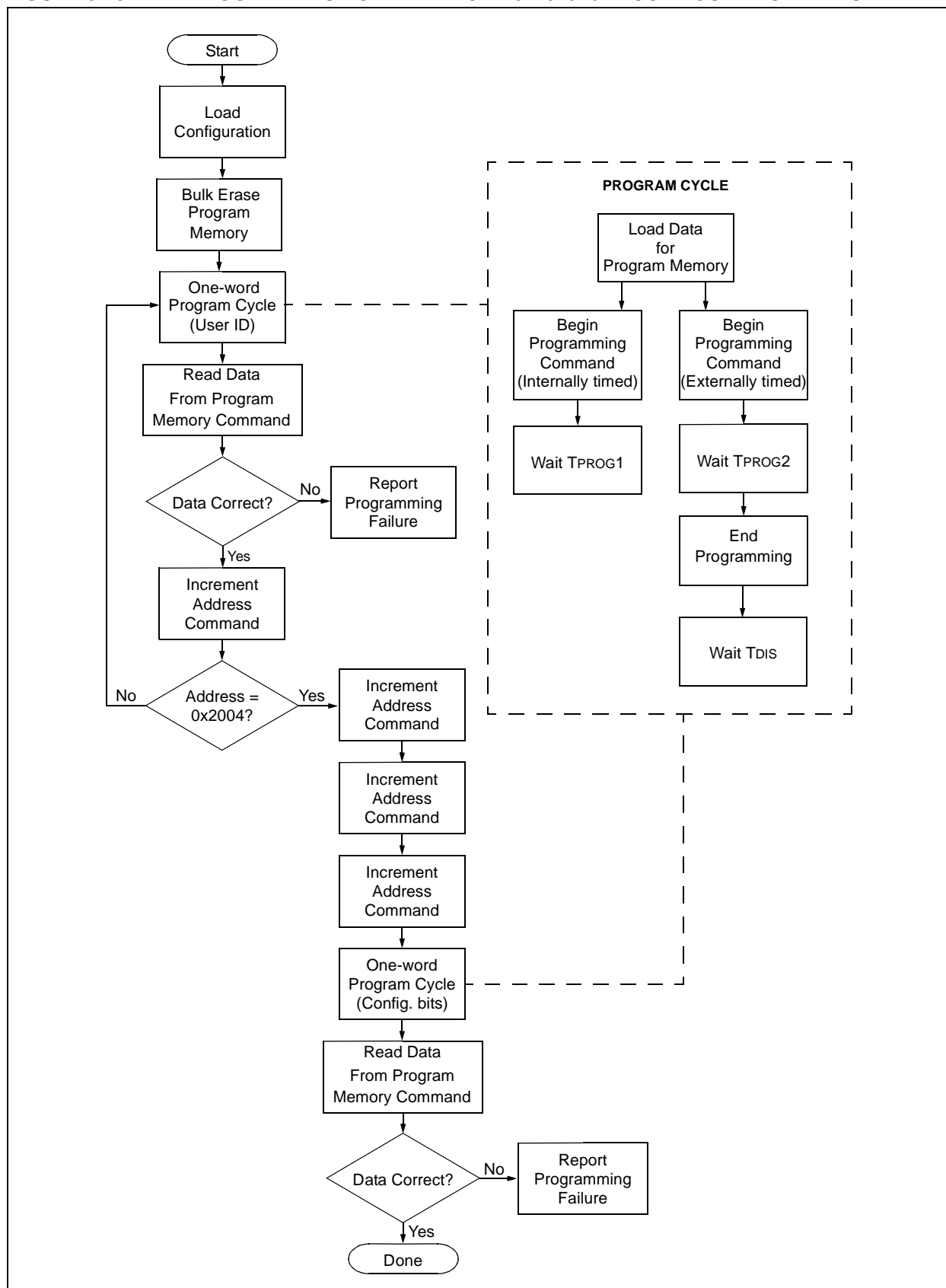
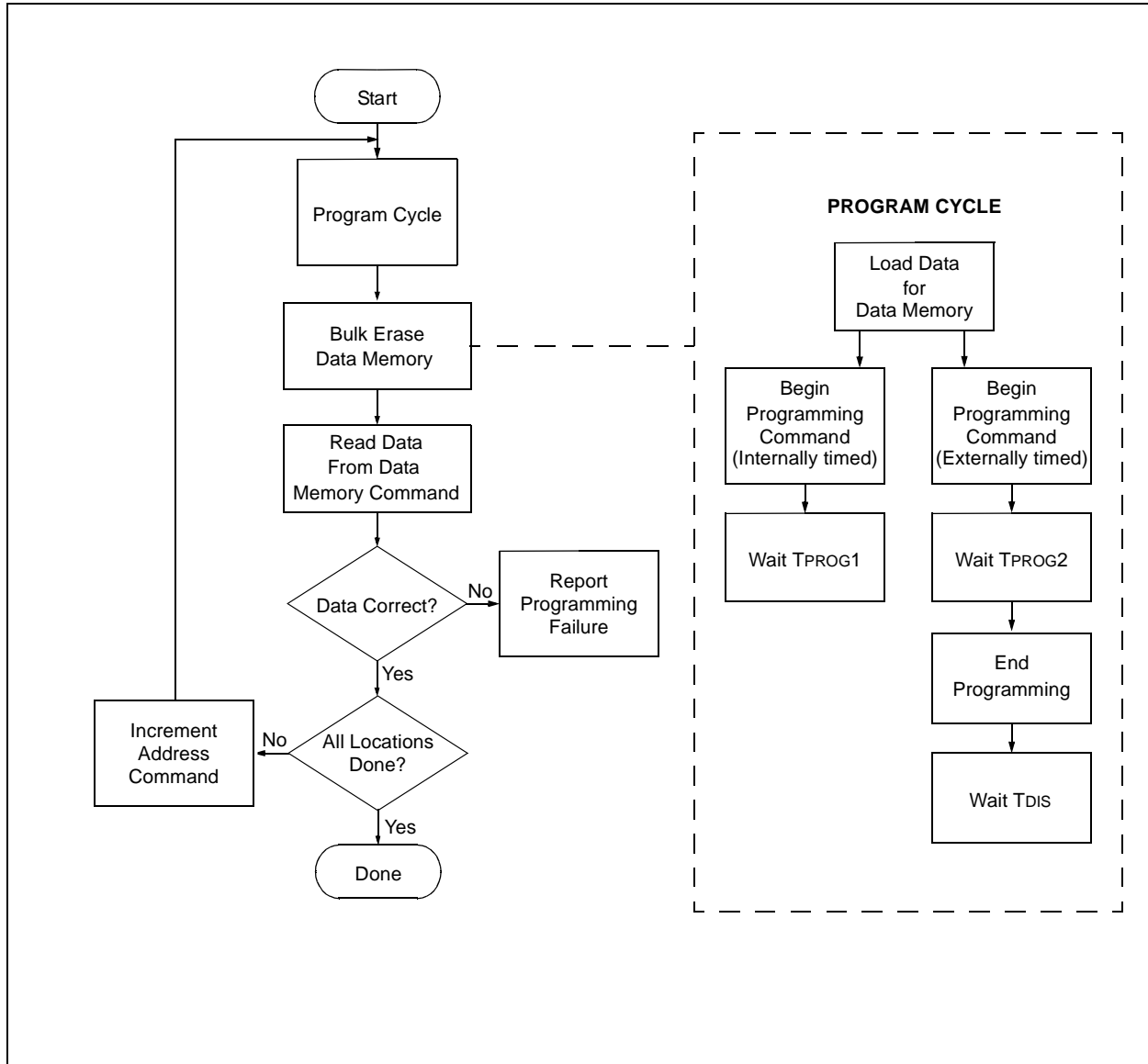
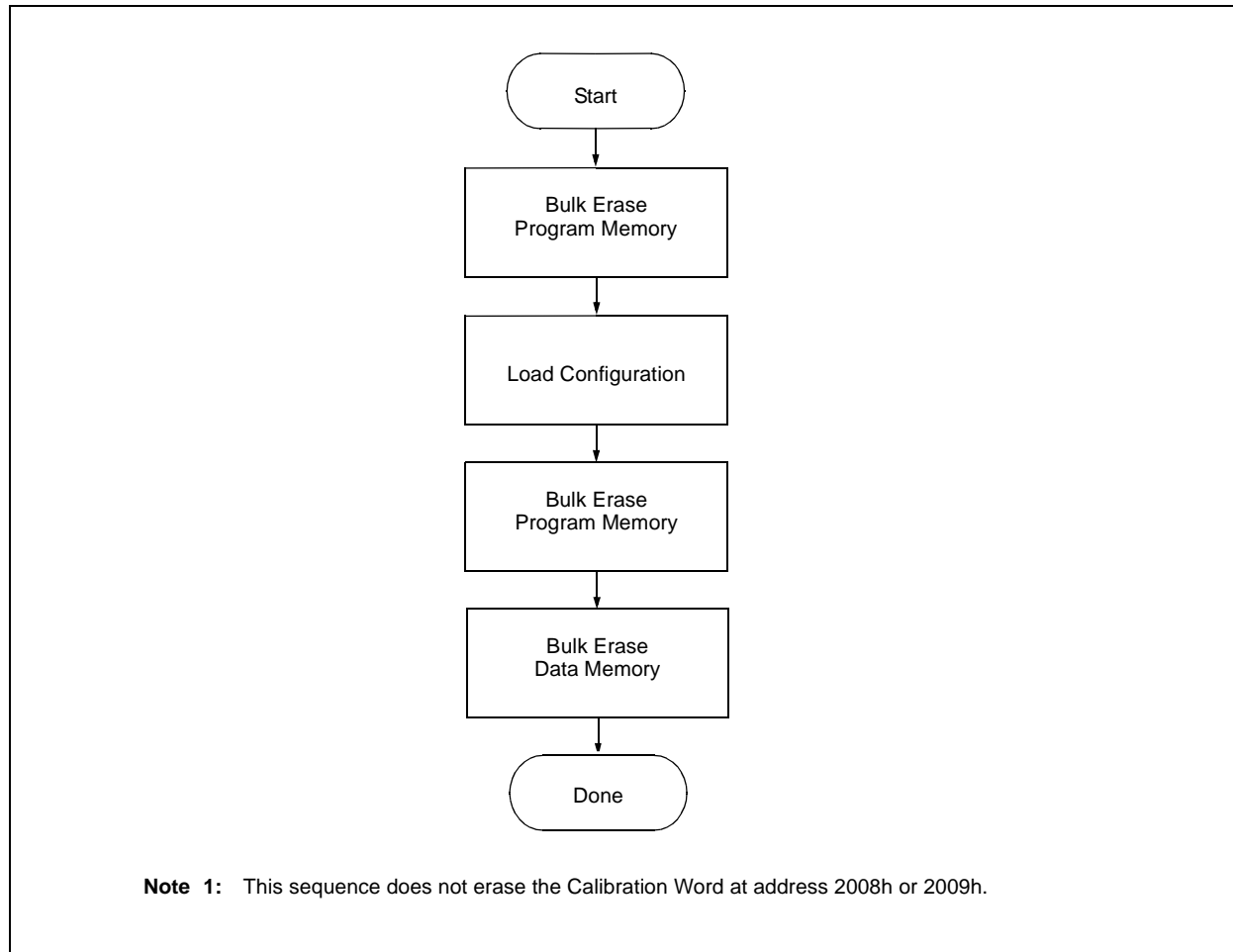


FIGURE 3-19: PROGRAM FLOWCHART – PIC12F6XX/16F6XX DATA MEMORY



PIC12F6XX/16F6XX

FIGURE 3-20: PROGRAM FLOWCHART – ERASE FLASH DEVICE⁽¹⁾



4.0 CONFIGURATION WORD

The PIC12F6XX/16F6XX has several Configuration bits. These bits can be programmed (reads '0') or left unchanged (reads '1'), to select various device configurations.

REGISTER 4-1: CONFIG⁽¹⁾: CONFIGURATION WORD (ADDRESS:2007h) – PIC12F635/PIC16F636/PIC16F639

U-1	R/P-1	R/P-1	R/P-1	R/P-1	R/P-1	R/P-1
—	$\overline{\text{WURE}}$	FCMEN	IESO	BOREN1	BOREN0	$\overline{\text{CPD}}$
bit 13						bit 7

R/P-1	R/P-1	R/P-1	R/P-1	R/P-1	R/P-1	R/P-1
$\overline{\text{CP}}$	MCLRE	$\overline{\text{PWRTE}}$	WDTE	FOSC2	FOSC1	FOSC0
bit 6						bit 0

Legend:

R = Readable bit	W = Writable bit	U = Unimplemented bit, read as '0'
-n = Value at POR	'1' = Bit is set	'0' = Bit is cleared
		x = Bit is unknown

bit 13	Unimplemented: Read as '1'
bit 12	WURE: Wake-up Reset Enable bit 1 = Standard wake-up and continue enabled 0 = Wake-up and Reset enabled
bit 11	FCMEN: Fail-Safe Clock Monitor Enable bit 1 = Fail-Safe Clock Monitor enabled 0 = Fail-Safe Clock Monitor disabled
bit 10	IESO: Internal-External Switch Over bit 1 = Internal External Switchover mode enabled 0 = Internal External Switchover mode disabled
bit 8-9	BOREN<1:0>: Brown-out Reset Enable bits 11 = BOR enabled and SBOREN bit disabled 10 = BOR enabled while running and disabled in Sleep. SBOREN bit disabled. 01 = SBOREN in the PCON register controls BOR function 00 = BOR and SBOREN disabled
bit 7	CPD: Data Code Protection bit ⁽²⁾ 1 = Data memory is not protected 0 = Data memory is external read-protected
bit 6	CP: Code Protection bit ⁽³⁾ 1 = Program memory is not code-protected 0 = Program memory is external read and write-protected
bit 5	MCLRE: MCLR Pin Function Select bit ⁽⁵⁾ 1 = MCLR pin is MCLR function and weak internal pull-up is enabled 0 = MCLR pin is alternate function, MCLR function is internally disabled
bit 4	PWRTE: Power-up Timer Enable bit ⁽⁴⁾ 1 = PWRT disabled 0 = PWRT enabled
bit 3	WDTE: Watchdog Timer Enable bit 1 = WDT enabled 0 = WDT disabled and can be enabled using SWDTEN in the WDTCON register
bit 2-0	FOSC<2:0>: Oscillator Selection bits 000 = LP oscillator: Low-power crystal on RA5(GP5)/OSC1/CLKIN and RA4(GP4)/OSC2/CLKOUT 001 = XT oscillator: Crystal/resonator on RA5(GP5)/OSC1/CLKIN and RA4(GP4)/OSC2/CLKOUT 010 = HS oscillator: High-speed crystal/resonator on RA5(GP5)/OSC1/CLKIN and RA4(GP4)/OSC2/CLKOUT 011 = EC: I/O function on RA4(GP4)/OSC2/CLKOUT, CLKIN on RA5(GP5)/OSC1/CLKIN 100 = INTOSCIO oscillator: I/O function on RA4(GP4)/OSC2/CLKOUT, I/O function on RA5(GP5)/OSC1/CLKIN 101 = INTOSC oscillator: CLKOUT function on RA4(GP4)/OSC2/CLKOUT, I/O function on RA5(GP5)/OSC1/CLKIN 110 = EXTRCIO oscillator: I/O function on RA4(GP4)/OSC2/CLKOUT, RC on RA5(GP5)/OSC1/CLKIN 111 = EXTRC oscillator: CLKOUT function on RA4(GP4)/OSC2/CLKOUT, RC on RA5(GP5)/OSC1/CLKIN

- Note**
- 1: This Configuration Word register applies to PIC12F635/PIC16F636/PIC16F639 devices only.
 - 2: The entire data memory will be erased when the code protection is turned off.
 - 3: The entire program memory will be erased when the code protection is turned off.
 - 4: Enabling Brown-out Detect does not automatically enable Power-up Timer.
 - 5: When MCLR is asserted in INTOSC or RC mode, the internal clock oscillator is disabled.

REGISTER 4-2: CONFIG⁽¹⁾: CONFIGURATION WORD (ADDRESS:2007h) – PIC12F683, PIC16F631/677/684/685/687/688/689/690

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

bit 13-12	Unimplemented: Read as '1'
bit 11	FCMEN: Fail-Safe Clock Monitor Enable bit 1 = Fail-Safe Clock Monitor enabled 0 = Fail-Safe Clock Monitor disabled
bit 10	IESO: Internal-External Switch Over bit 1 = Internal External Switchover mode enabled 0 = Internal External Switchover mode disabled
bit 9-8	BOREN<1:0>: Brown-out Reset Enable bits ⁽⁴⁾ 11 = BOR enabled and SBOREN bit disabled 10 = BOR enabled while running and disabled in Sleep. SBOREN bit disabled. 01 = SBOREN in the PCON register controls BOR function 00 = BOR and SBOREN disabled
bit 7	CPD: Code Protection Data bit ⁽²⁾ 1 = Data memory is not protected 0 = Data memory is external read-protected
bit 6	CP: Code Protection bit ⁽³⁾ 1 = Program memory is not code-protected 0 = Program memory is external read and write-protected
bit 5	MCLR: <u>MCLR</u> Pin Function Select ⁽⁵⁾ bit 1 = <u>MCLR</u> pin is MCLR function and <u>weak</u> internal pull-up is enabled 0 = MCLR pin is alternate function, MCLR function is internally disabled
bit 4	PWRT: Power-up Timer Enable bit ⁽⁴⁾ 1 = PWRT disabled 0 = PWRT enabled
bit 3	WDTE: Watchdog Timer Enable bit 1 = WDT enabled 0 = WDT disabled and can be enabled using SWDTEN in the WDTCON register
bit 2-0	FOSC<2:0>: Oscillator Selection bits 000 = LP oscillator: Low-power crystal on RA5(GP5)/OSC1/CLKIN and RA4(GP4)/OSC2/CLKOUT 001 = XT oscillator: Crystal/resonator on RA5(GP5)/OSC1/CLKIN and RA4(GP4)/OSC2/CLKOUT 010 = HS oscillator: High-speed crystal/resonator on RA5(GP5)/OSC1/CLKIN and RA4(GP4)/OSC2/CLKOUT 011 = EC: I/O function on RA4(GP4)/OSC2/CLKOUT, CLKIN on RA5(GP5)/OSC1/CLKIN 100 = INTOSCIO oscillator: I/O function on RA4(GP4)/OSC2/CLKOUT, I/O function on RA5(GP5)/OSC1/CLKIN 101 = INTOSC oscillator: CLKOUT function on RA4(GP4)/OSC2/CLKOUT, I/O function on RA5(GP5)/OSC1/CLKIN 110 = EXTRCIO oscillator: I/O function on RA4(GP4)/OSC2/CLKOUT, RC on RA5(GP5)/OSC1/CLKIN 111 = EXTRC oscillator: CLKOUT function on RA4(GP4)/OSC2/CLKOUT, RC on RA5(GP5)/OSC1/CLKIN

- Note**
- 1: This Configuration Word register applies to PIC16F631/677/685/687/689/690 (not including PIC12F635/PIC16F636/PIC16F639) only.
 - 2: The entire data memory will be erased when the code protection is turned off.
 - 3: The entire program memory will be erased when the code protection is turned off.
 - 4: Enabling Brown-out Detect does not automatically enable Power-up Timer.
 - 5: When MCLR is asserted in INTOSC or RC mode, the internal clock oscillator is disabled.
 - 6: For PIC16F685/PIC16F687/PIC16F689/PIC16F690, the pin is RA4/AN3/T1G/OSC2/CLKOUT.

PIC12F6XX/16F6XX

REGISTER 4-3: CALIB⁽¹⁾: CALIBRATION WORD (ADDRESS: 2008h) – PIC12F683/684/688^{(2), (3)}

U-1	P/P-1	R/P-1	R/P-1	R/P-1	R/P-1	R/P-1
—	FCAL6	FCAL5	FCAL4	FCAL3	FCAL2	FCAL1
bit 13						bit 7

R/P-1	U-1	R/P-1	R/P-1	R/P-1	R/P-1	R/P-1
FCAL0	—	POR1	POR0	BOR2	BOR1	BOR0
bit 6						bit 0

Legend:

R = Readable bit

W = Writable bit

U = Unimplemented bit, read as '0'

-n = Value at POR

'1' = Bit is set

'0' = Bit is cleared

x = Bit is unknown

bit 13 **Unimplemented:** Read as '0'

bit 12-6 **FCAL<6:0>:** Internal Oscillator Calibration bits

0111111 = Maximum frequency

•

•

0000001

0000000 = Center frequency

1111111

•

•

1000000 = Minimum frequency

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

bit 4-3 **POR<1:0>:** POR Calibration bits

00 = Lowest POR voltage

11 = Highest POR voltage

bit 2-0 **BOR<2:0>:** BOR Calibration bits

000 = Reserved

001 = Lowest BOR voltage

111 = Highest BOR voltage

Note 1: This Calibration Word register applies to PIC12F683/PIC16F684/PIC16F688 devices only.

2: This location does not participate in bulk erase operations if the procedure in Figure 3-20 is used.

3: Calibration bits are reserved for factory calibration. These values can and will change across the entire range, therefore, specific values and available adjustment range can not be specified.

PIC12F6XX/16F6XX

**REGISTER 4-4: CALIB⁽¹⁾: CALIBRATION WORD (ADDRESS: 2008h)–
PIC16F631/677/685/687/689/690^{(2), (3), (4)}**

U-1	P/P-1	R/P-1	R/P-1	R/P-1	R/P-1	R/P-1
—	FCAL6	FCAL5	FCAL4	FCAL3	FCAL2	FCAL1
bit 13						bit7

R/P-1	P/P-1	R/P-1	R/P-1	R/P-1	R/P-1	R/P-1
FCAL0	POR2	POR1	POR0	BOR2	BOR1	BOR0
bit 6						bit 0

Legend:

R = Readable bit

W = Writable bit

U = Unimplemented bit, read as '0'

-n = Value at POR

'1' = Bit is set

'0' = Bit is cleared

x = Bit is unknown

bit 13 **Unimplemented:** Read as '0'

bit 12-6 **FCAL<6:0>:** Internal Oscillator Calibration bits

0111111 = Maximum frequency

•

•

0000001

0000000 = Center frequency

1111111

•

•

1000000 = Minimum frequency

bit 5-3 **POR<2:0>:** POR Calibration bits

111 = Maximum POR voltage

110

101

100 = Center POR voltage

000 = Center POR voltage

001

010

011 = Minimum POR voltage

bit 2-0 **BOR<2:0>:** BOR Calibration bits

111 = Maximum BOR voltage

110

101

100 = Center BOR voltage

000 = Center BOR voltage

001

010

011 = Minimum BOR voltage

Note 1: This Calibration Word register applies to PIC16F631/677/685/687/689/690 devices only.

2: This location does not participate in bulk erase operations if the procedure in Figure 3-20 is used.

3: Calibration bits are reserved for factory calibration. These values can and will change across the entire range, therefore, specific values and available adjustment range can not be specified.

4: The calibration bits must be read, preserved, then replaced by the user during Program Memory Bulk Erase operation with PC = 2008h.

PIC12F6XX/16F6XX

REGISTER 4-5: CALIB1: CALIBRATION WORD 1 (ADDRESS: 2008H) – PIC12F635/636/639⁽¹⁾

U-1	P/P-1	R/P-1	R/P-1	R/P-1	R/P-1	R/P-1
—	FCAL6	FCAL5	FCAL4	FCAL3	FCAL2	FCAL1
bit 13						bit7

R/P-1	P/P-1	R/P-1	R/P-1	R/P-1	R/P-1	R/P-1
FCAL0	POR2	POR1	POR0	BOR2	BOR1	BOR0
bit 6						bit 0

Legend:

R = Readable bit

W = Writable bit

U = Unimplemented bit, read as '0'

-n = Value at POR

'1' = Bit is set

'0' = Bit is cleared

x = Bit is unknown

bit 13 **Unimplemented:** Read as '0'

bit 12-6 **FCAL<6:0>:** Internal Oscillator Calibration bits

0111111 = Maximum frequency

•

•

0000001

0000000 = Center frequency. Oscillator is running at the calibrated frequency

1111111

•

•

1000000 = Minimum frequency

bit 5-3 **POR<2:0>:** POR Calibration bits

111 = Maximum POR voltage

110

101

100 = Center POR voltage

000 = Center POR voltage

001

010

011 = Minimum POR voltage

bit 2-0 **BOR<2:0>:** BOR Calibration bits

111 = Maximum BOR voltage

110

101

100 = Center BOR voltage

000 = Center BOR voltage

001

010

011 = Minimum BOR voltage

Note 1: This location does not participate in bulk erase operation, unless PC = 2008h.

PIC12F6XX/16F6XX

REGISTER 4-6: CALIB2 – CALIBRATION WORD 2 (ADDRESS: 2009h) – PIC12F635/636/639⁽¹⁾

U-1	U-1	U-1	U-1	U-1	U-1	U-1
—	—	—	—	—	—	—
bit 13						bit 7

U-1	P/P-1	R/P-1	R/P-1	R/P-1	R/P-1	R/P-1
—	WUR2	WUR1	WUR0	LVD2	LVD1	LVD0
bit 6						bit 0

Legend:

R = Readable bit

W = Writable bit

U = Unimplemented bit, read as '0'

-n = Value at POR

'1' = Bit is set

'0' = Bit is cleared

x = Bit is unknown

bit 13-6 **Unimplemented:** Read as '0'

bit 5-3 **WUR<2:0>:** WUR Calibration bits

111 = Maximum WUR voltage

110

101

100 = Center WUR voltage

000 = Center WUR voltage

001

010

011 = Minimum WUR voltage

bit 2-0 **LVD<2:0>:** LVD Calibration bits

111 = Maximum LVD voltage

110

101

100 = Center LVD voltage

000 = Center LVD voltage

001

010

011 = Minimum LVD voltage

Note 1: This location does not participate in bulk erase operation, unless PC = 2009h.

4.1 Device ID Word

The device ID word for the PIC12F6XX/16F6XX is located at 2006h. This location can not be erased.

TABLE 4-1: DEVICE ID VALUES

Device	Device ID Values	
	Dev	Rev
PIC12F635	00 1111 101	x xxxxx
PIC12F683	00 0100 011	x xxxxx
PIC16F631	01 0100 001	x xxxxx
PIC16F636	01 0000 101	x xxxxx
PIC16F639	01 0000 101	x xxxxx
PIC16F677	01 0100 010	x xxxxx
PIC16F684	01 0000 100	x xxxxx
PIC16F685	00 0100 101	x xxxxx
PIC16F687	01 0011 001	x xxxxx
PIC16F688	01 0001 100	x xxxxx
PIC16F689	01 0011 010	x xxxxx
PIC16F690	01 0100 000	x xxxxx

5.0 CODE PROTECTION

For PIC12F6XX/16F6XX, once the \overline{CP} bit is programmed to '0', all program memory locations read all '0's. The user ID locations and the Configuration Word read out in an unprotected fashion. Further programming is disabled for the entire program memory.

Data memory is protected with its own code-protect bit (\overline{CPD}). When enabled, the data memory can still be programmed and read using the EECON1 register (see the applicable data sheet for more information).

The user ID locations and the Configuration Word can be programmed regardless of the state of the \overline{CP} and \overline{CPD} bits.

5.1 Disabling Code Protection

It is recommended to use the procedure in Figure 3-20 to disable code protection of the device. This sequence will erase the program memory, data memory, Configuration Word (0x2007) and user ID locations (0x2000-0x2003). The Calibration Words (0x2008-0x2009) **will not** be erased.

Note: To ensure system security, if \overline{CPD} bit = 0, Bulk Erase Program Memory command will also erase data memory.

5.2 Embedding Configuration Word and User ID Information in the Hex File

To allow portability of code, the programmer is required to read the Configuration Word and user ID locations from the hex file when loading the hex file. If Configuration Word information was not present in the hex file, a simple warning message may be issued. Similarly, while saving a hex file, Configuration Word and user ID information must be included. An option to not include this information may be provided.

Specifically for the PIC12F6XX/16F6XX, the data memory should also be embedded in the hex file (see **Section 5.3.2 "Embedding Data Memory Contents in Hex File"**).

Microchip Technology Incorporated feels strongly that this feature is important for the benefit of the end customer.

5.3 Checksum Computation

5.3.1 CHECKSUM

Checksum is calculated by reading the contents of the PIC12F6XX/16F6XX memory locations and adding up the opcodes up to the maximum user addressable location (e.g., 0x7FF for the PIC16F684). Any Carry bits exceeding 16 bits are neglected. Finally, the Configuration Word (appropriately masked) is added to the checksum. Checksum computation for the PIC12F6XX/16F6XX devices is shown in Table 5-1.

The checksum is calculated by summing the following:

- The contents of all program memory locations
- The Configuration Word, appropriately masked
- Masked user ID locations (when applicable)

The Least Significant 16 bits of this sum is the checksum.

The following table describes how to calculate the checksum for each device. Note that the checksum calculation differs depending on the code-protect setting. Since the program memory locations read out zeroes when code-protected, the table describes how to manipulate the actual program memory values to simulate values that would be read from a protected device. When calculating a checksum by reading a device, the entire program memory can simply be read and summed. The Configuration Word and user ID locations can always be read regardless of the code-protect setting.

Note: Some older devices have an additional value added in the checksum. This is to maintain compatibility with older device programmer checksums.

PIC12F6XX/16F6XX

TABLE 5-1: CHECKSUM COMPUTATIONS

Device	Code Protect	Checksum*	Blank Value	0x25E6 at 0 and Max. Address
PIC12F635	$\overline{CP} = 1, \overline{CPD} = 1$ $\overline{CP} = 0, \overline{CPD} = 1$	SUM[0x000:0x03FF] + (CFGW & 1FFF) (CFGW & 1FFF) + SUM_ID	0x1BFF 0x3BBE	0xE7CD 0x078C
PIC12F683	$\overline{CP} = 1, \overline{CPD} = 1$ $\overline{CP} = 0, \overline{CPD} = 1$	SUM[0x000:0x07FF] + (CFGW & 0FFF) (CFGW & 0x0FFF) + SUM_ID	0x07FF 0x17BE	0xD3CD 0xE38C
PIC16F631	$\overline{CP} = 1, \overline{CPD} = 1$ $\overline{CP} = 0, \overline{CPD} = 1$	SUM[0x000:0x03FF] + (CFGW & 0FFF) (CFGW & 0FFF) + SUM_ID	0x0BFF 0x1BBE	0xD7CD 0xE78C
PIC16F636	$\overline{CP} = 1, \overline{CPD} = 1$ $\overline{CP} = 0, \overline{CPD} = 1$	SUM[0x000:0x07FF] + (CFGW & 1FFF) (CFGW & 0x1FFF) + SUM_ID	0x17FF 0x37BE	0xE3CD 0x038C
PIC16F639	$\overline{CP} = 1, \overline{CPD} = 1$ $\overline{CP} = 0, \overline{CPD} = 1$	SUM[0x000:0x07FF] + (CFGW & 1FFF) (CFGW & 0x1FFF) + SUM_ID	0x17FF 0x37BE	0xE3CD 0x038C
PIC16F677	$\overline{CP} = 1, \overline{CPD} = 1$ $\overline{CP} = 0, \overline{CPD} = 1$	SUM[0x000:0x07FF] + (CFGW & 0FFF) (CFGW & 0x0FFF) + SUM_ID	0x07FF 0x17BE	0xD3CD 0xE38C
PIC16F684	$\overline{CP} = 1, \overline{CPD} = 1$ $\overline{CP} = 0, \overline{CPD} = 1$	SUM[0x000:0x07FF] + (CFGW & 0FFF) (CFGW & 0x0FFF) + SUM_ID	0x07FF 0x17BE	0xD3CD 0xE38C
PIC16F685	$\overline{CP} = 1, \overline{CPD} = 1$ $\overline{CP} = 0, \overline{CPD} = 1$	SUM[0x000:0x0FFF] + (CFGW & 0FFF) (CFGW & 0x0FFF) + SUM_ID	0xFFFF 0x0FBE	0xCBCD 0xDB8C
PIC16F687	$\overline{CP} = 1, \overline{CPD} = 1$ $\overline{CP} = 0, \overline{CPD} = 1$	SUM[0x000:0x07FF] + (CFGW & 0FFF) (CFGW & 0x0FFF) + SUM_ID	0x07FF 0x17BE	0xD3CD 0xE38C
PIC16F688	$\overline{CP} = 1, \overline{CPD} = 1$ $\overline{CP} = 0, \overline{CPD} = 1$	SUM[0x000:0x0FFF] + (CFGW & 0FFF) (CFGW & 0x0FFF) + SUM_ID	0xFFFF 0x0FBE	0xCBCD 0xDB8C
PIC16F689	$\overline{CP} = 1, \overline{CPD} = 1$ $\overline{CP} = 0, \overline{CPD} = 1$	SUM[0x000:0x0FFF] + (CFGW & 0FFF) (CFGW & 0x0FFF) + SUM_ID	0xFFFF 0x0FBE	0xCBCD 0xDB8C
PIC16F690	$\overline{CP} = 1, \overline{CPD} = 1$ $\overline{CP} = 0, \overline{CPD} = 1$	SUM[0x000:0x0FFF] + (CFGW & 0FFF) (CFGW & 0x0FFF) + SUM_ID	0xFFFF 0x0FBE	0xCBCD 0xDB8C

Legend: CFGW = Configuration Word. Example calculations assume Configuration Word is erased (all '1's).

SUM[a:b] = [Sum of locations a to b inclusive]

SUM_ID = User ID locations masked by 0xF then made into a 16-bit value with ID0 as the Most Significant nibble.

For example, ID0 = 0x1, ID1 = 0x2, ID3 = 0x3, ID4 = 0x4, then SUM_ID = 0x1234.

The 4 LSB's of the unprotected checksum is used for the example calculations.

*Checksum = [Sum of all the individual expressions] MODULO [0xFFFF]

+ = Addition

& = Bitwise AND

5.3.2 EMBEDDING DATA MEMORY CONTENTS IN HEX FILE

The programmer should be able to read data memory information from a hex file and conversely (as an option), write data memory contents to a hex file along with program memory information and Configuration Word (0x2007) and user ID (0x2000-0x2003) information.

The 256 data memory locations are logically mapped starting at address 0x2100. The format for data memory storage is one data byte per address location, LSb aligned.

6.0 PROGRAM/VERIFY MODE ELECTRICAL CHARACTERISTICS

TABLE 6-1: AC/DC CHARACTERISTICS TIMING REQUIREMENTS FOR PROGRAM/VERIFY MODE

AC/DC CHARACTERISTICS		Standard Operating Conditions (unless otherwise stated) Operating Temperature $-40^{\circ}\text{C} \leq T_A \leq +85^{\circ}\text{C}$ Operating Voltage $4.5\text{V} \leq V_{DD} \leq 5.5\text{V}$				
Sym.	Characteristics	Min.	Typ.	Max.	Units	Conditions/Comments
General						
VDD	VDD level for read/write operations, program and data memory	2.0	—	5.5	V	
	VDD level for bulk erase operations, program and data memory	2.0 4.5	— —	5.5 5.5	V V	PIC12F6XX/16F6XX-ICD PIC12F6XX/16F6XX
VIHH	High voltage on $\overline{\text{MCLR}}$ for Program/Verify mode entry	10	—	13	V	
TVHHR	$\overline{\text{MCLR}}$ rise time (V_{SS} to V_{HH}) for Program/Verify mode entry	—	—	1.0	μs	
TPDP	Hold time after V_{PP} changes	5	—	—	μs	
VIH1	(ICSPCLK, ICSPDAT) input high level	0.8 V_{DD}	—	—	V	
VIL1	(ICSPCLK, ICSPDAT) input low level	0.2 V_{DD}	—	—	V	
TSET0	ICSPCLK, ICSPDAT setup time before $\overline{\text{MCLR}}\uparrow$ (Program/Verify mode selection pattern setup time)	100	—	—	ns	
THLD0	Hold time after VDD changes	0	—	2	μs	
Serial Program/Verify						
TSET1	Data in setup time before clock \downarrow	100	—	—	ns	
THLD1	Data in hold time after clock \downarrow	100	—	—	ns	
TDLY1	Data input not driven to next clock input (delay required between command/data or command/command)	1.0	—	—	μs	
TDLY2	Delay between clock \downarrow to clock \uparrow of next command or data	1.0	—	—	μs	
TDLY3	Clock \uparrow to data out valid (during a Read Data command)		—	80	ns	
TERA	Erase cycle time	—	5	6	ms	
TPROG1	Programming cycle time (internally timed)	3 6	— —	— —	ms ms	Program memory Data memory
TPROG2	Programming cycle time (externally timed)	3	—	—	ms	$10^{\circ}\text{C} \leq T_A \leq +40^{\circ}\text{C}$ Program memory
TDIS	Time delay from program to compare (HV discharge time)	100	—	—	μs	

PIC12F6XX/16F6XX

NOTES:

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

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