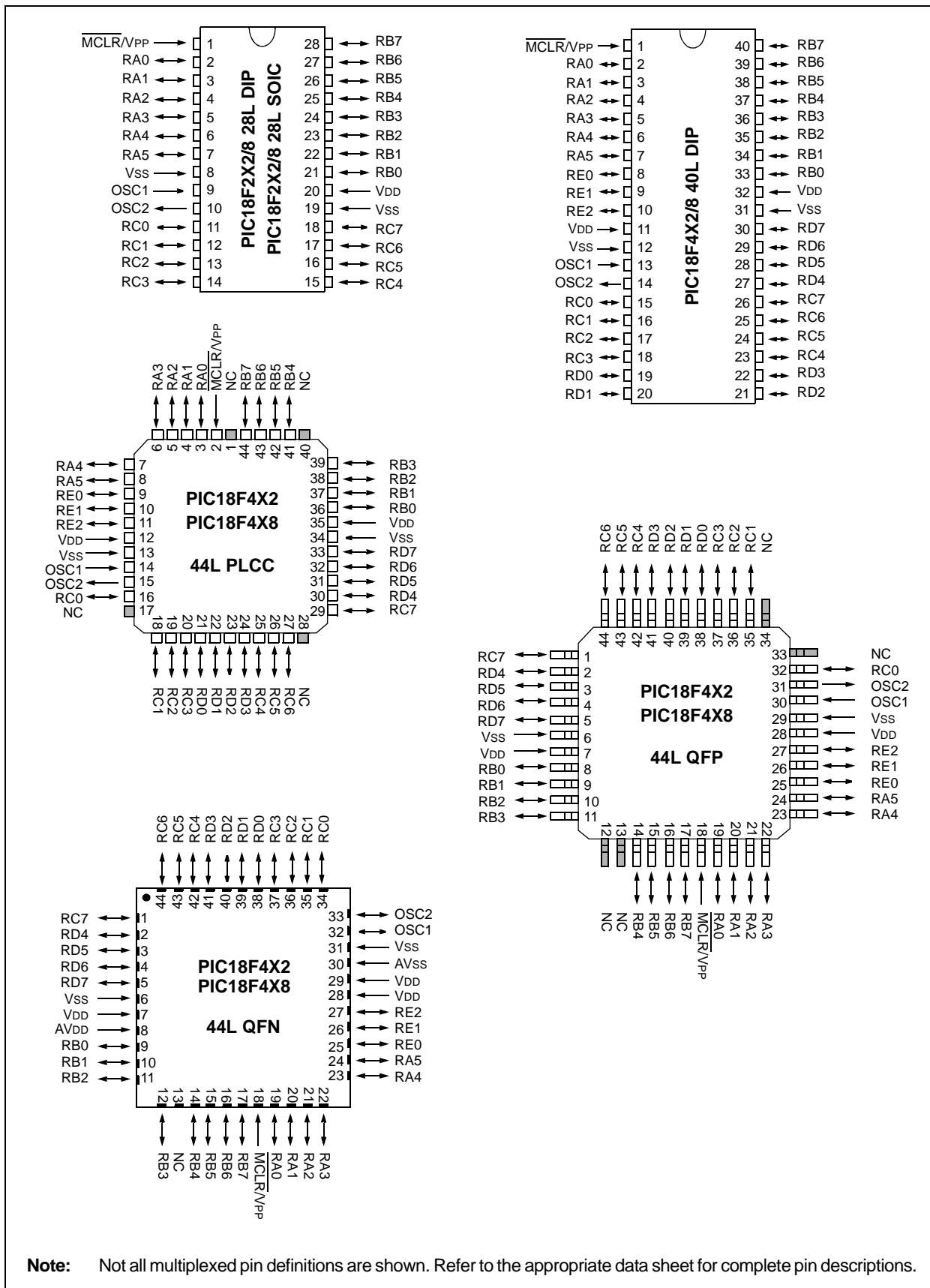


# PIC18FXX2/XX8

**FIGURE 2-1: PIC18FXX2/XX8 FAMILY PIN DIAGRAMS**





# PIC18FXX2/XX8

Users may store identification information (ID) in eight ID registers. These ID registers are mapped in addresses 200000h through 200007h. The ID locations read out normally, even after code protection is applied.

Locations 300001h through 30000Dh are reserved for the configuration bits. These bits may be set to select various device options, and are described in Section 5.0. These configuration bits read out normally even after code protected.

Locations 3FFFEh and 3FFFFh are reserved for the device ID bits. These bits may be used by the programmer to identify what device type is being programmed, and are described in Section 5.0. These configuration bits read out normally even after code protection.

## 2.3.1 MEMORY ADDRESS POINTER

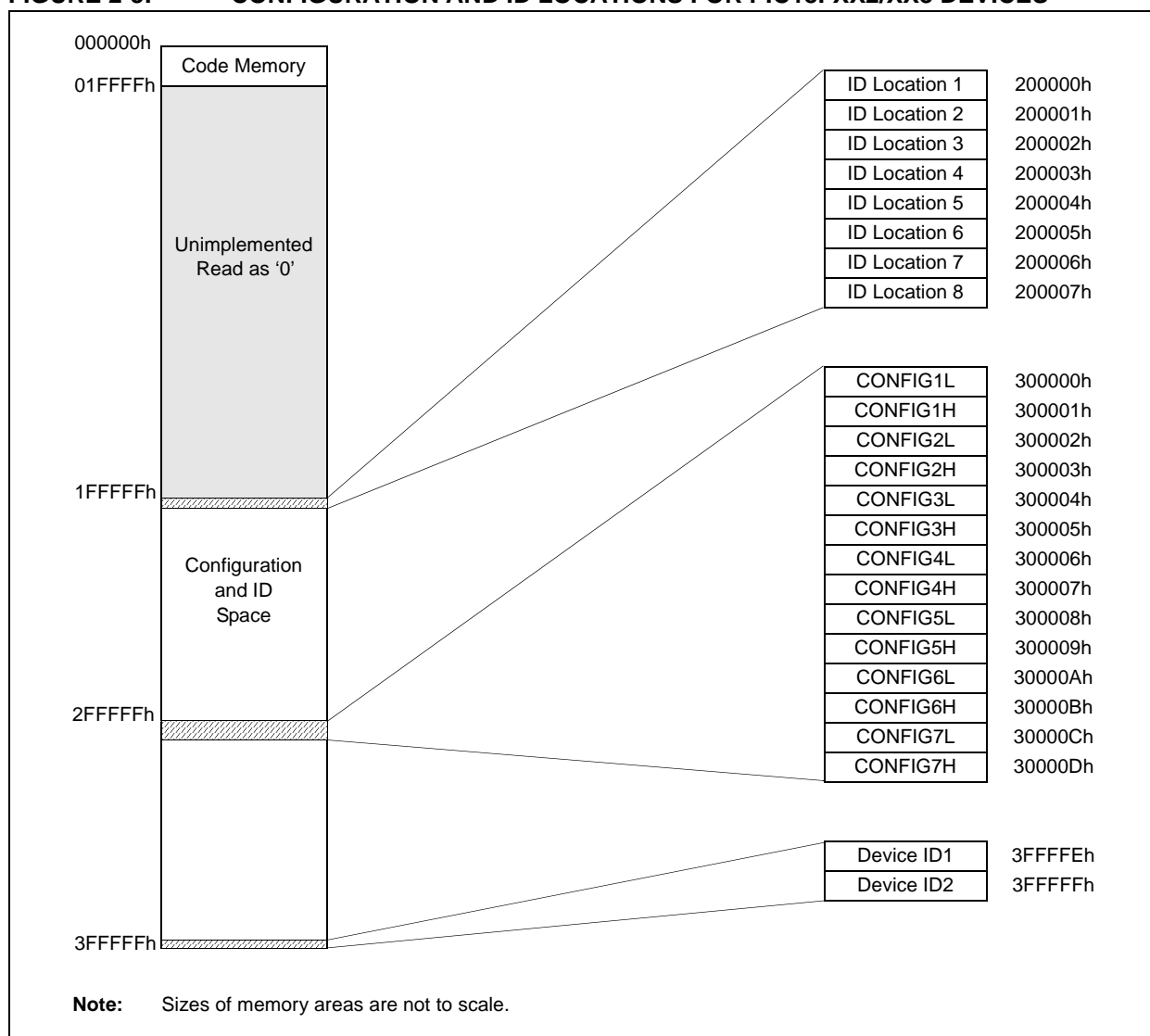
Memory in the address space 000000h to 3FFFFFFh is addressed via the Table Pointer, which is comprised of three pointer registers:

- TBLPTRU, at address 0FF8h
- TBLPTRH, at address 0FF7h
- TBLPTRL, at address 0FF6h

TBLPTRU	TBLPTRH	TBLPTRL
Addr[21:16]	Addr[15:8]	Addr[7:0]

The 4-bit command, '0000' (Core Instruction), is used to load the Table Pointer prior to using many Read or Write operations.

**FIGURE 2-3: CONFIGURATION AND ID LOCATIONS FOR PIC18FXX2/XX8 DEVICES**



## 2.4 High Level Overview of the Programming Process

Figure 2-5 shows the high level overview of the programming process. First, a bulk erase is performed. Next, the code memory, ID locations, and data EEPROM are programmed. These memories are then verified to ensure that programming was successful. If no errors are detected, the configuration bits are then programmed and verified.

## 2.5 Entering High Voltage ICSP Program/Verify Mode

The High Voltage ICSP Program/Verify mode is entered by holding SCLK and SDATA low, and then raising  $\overline{\text{MCLR/VPP}}$  to  $V_{\text{IH}}$  (high voltage). Once in this mode, the code memory, data EEPROM, ID locations, and configuration bits can be accessed and programmed in serial fashion.

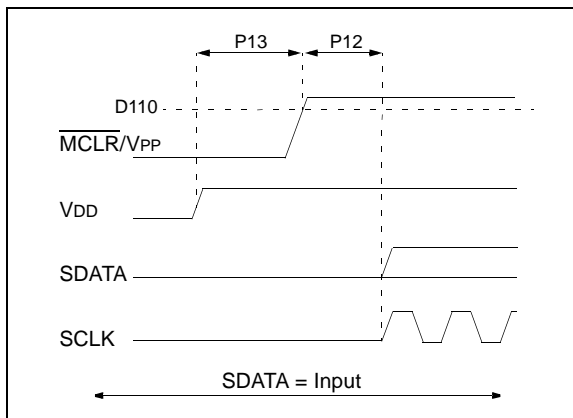
The sequence that enters the device into the Programming/Verify mode places all unused I/Os in the high impedance state.

### 2.5.1 ENTERING LOW VOLTAGE ICSP PROGRAM/VERIFY MODE

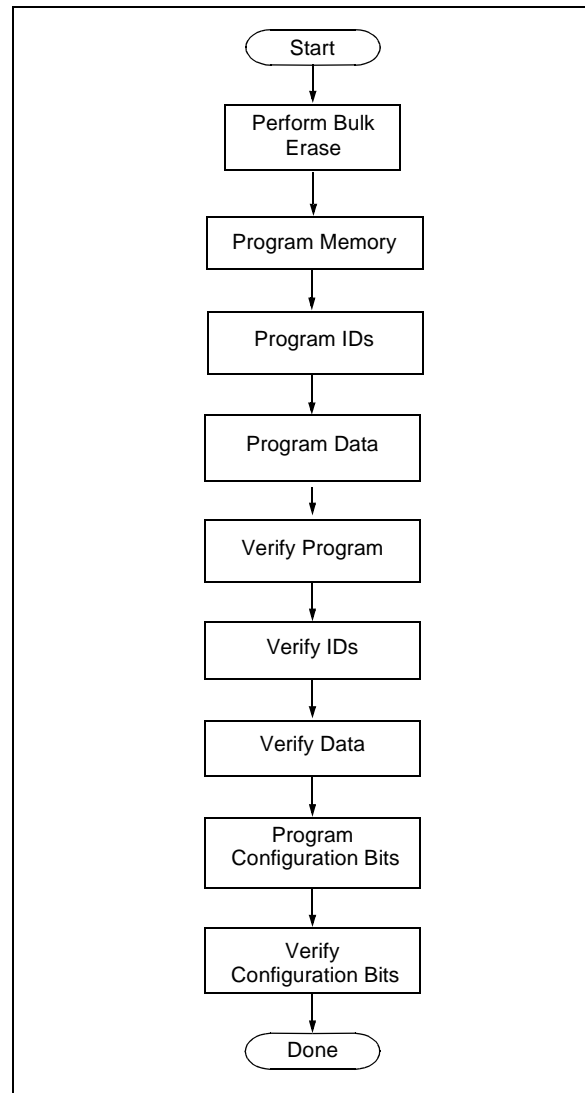
When the LVP configuration bit is '1' (see Section 5.3), the Low Voltage ICSP mode is enabled. Low Voltage ICSP Program/Verify mode is entered by holding SCLK and SDATA low, placing a logic high on PGM, and then raising  $\overline{\text{MCLR/VPP}}$  to  $V_{\text{IH}}$ . In this mode, the RB5/PGM pin is dedicated to the programming function and ceases to be a general purpose I/O pin.

The sequence that enters the device into the Programming/Verify mode places all unused I/Os in the high impedance state.

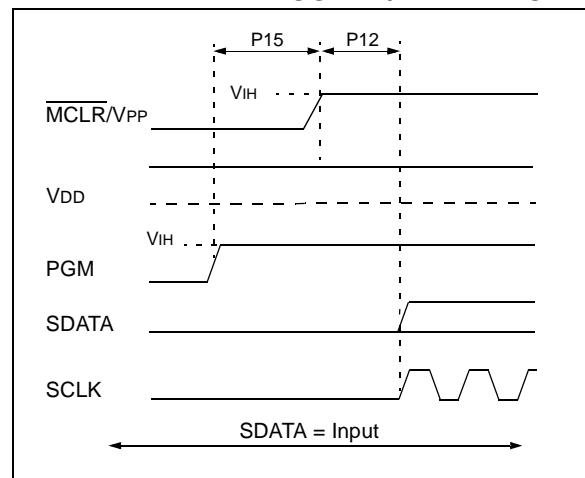
**FIGURE 2-4: ENTERING HIGH VOLTAGE PROGRAM/VERIFY MODE**



**FIGURE 2-5: HIGH LEVEL PROGRAMMING FLOW**



**FIGURE 2-6: ENTERING LOW VOLTAGE PROGRAM/VERIFY MODE**





## 3.0 DEVICE PROGRAMMING

### 3.1 High Voltage ICSP Bulk Erase

Erasing code or data EEPROM is accomplished by writing an “erase option” to address 3C0004h. Code memory may be erased portions at a time, or the user may erase the entire device in one action. “Bulk Erase” operations will also clear any code protect settings associated with the memory block erased. Erase options are detailed in Table 3-1.

**TABLE 3-1: BULK ERASE OPTIONS**

Description	Data
Chip Erase	80h
Erase Data EEPROM	81h
Erase Boot Block	83h
Erase Panel 1	88h
Erase Panel 2	89h
Erase Panel 3	8Ah
Erase Panel 4	8Bh

The actual Bulk Erase function is a self-timed operation. Once the erase has started (falling edge of the 4th SCLK after the WRITE command), serial execution will cease until the erase completes (parameter P11). During this time, SCLK may continue to toggle, but SDATA must be held low.

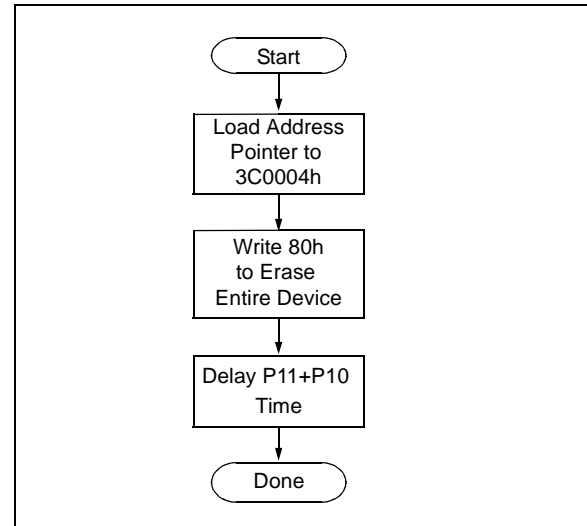
The code sequence to erase the entire device is shown in Figure 3-2 and the flowchart is shown in Figure 3-1.

**Note:** A bulk erase is the only way to reprogram code protect bits from an on state to an off state.

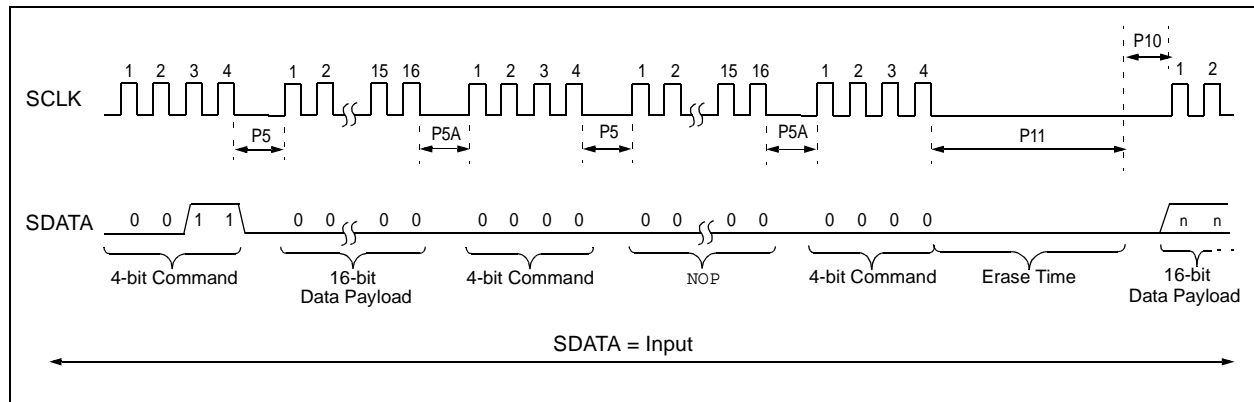
**TABLE 3-2: BULK ERASE COMMAND SEQUENCE**

4-Bit Command	Data Payload	Core Instruction
0000	0E 3C	MOVLW 3Ch
0000	6E F8	MOVWF TBLPTRU
0000	0E 00	MOVLW 00h
0000	6E F7	MOVWF TBLPTRH
0000	0E 04	MOVLW 04h
0000	6E F6	MOVWF TBLPTRL
1100	00 80	Write 80h TO 3C0004h to erase entire device.
0000	00 00	NOP
0000	00 00	Hold SDATA low until erase completes.

**FIGURE 3-1: BULK ERASE FLOW**



**FIGURE 3-2: BULK ERASE TIMING**



# PIC18FXX2/XX8

---

## 3.1.1 LOW VOLTAGE ICSP BULK ERASE

When using low voltage ICSP, the part must be supplied by the voltage specified in parameter D111, if a bulk erase is to be executed. All other bulk erase details as described above apply.

If it is determined that a program memory erase must be performed at a supply voltage below the bulk erase limit, refer to the erase methodology described in Sections 3.1.2 and 3.2.2.

If it is determined that a data EEPROM erase must be performed at a supply voltage below the bulk erase limit, follow the methodology described in Section 3.4 and write ones to the array.

## 3.1.2 ICSP MULTI-PANEL SINGLE ROW ERASE

Irrespective of whether high or low voltage ICSP is used, it is possible to erase single row (64 bytes of data) in all panels at once. For example, in the case of a 64-Kbyte device (8 panels), 512 bytes through 64 bytes in each panel, can be erased simultaneously during each erase sequence. In this case, the offset of the erase within each panel is the same (see Figure 3-5). Multi-Panel Single Row Erase is enabled by appropriately configuring the Programming Control register located at 3C0006h.

The multi-panel single row erase duration is externally timed and is controlled by SCLK. After a “Start Programming” command is issued (4-bit command, ‘1111’), a NOP is issued, where the 4th SCLK is held high for the duration of the programming time, P9.

After SCLK is brought low, the programming sequence is terminated. SCLK must be held low for the time specified by parameter P10 to allow high voltage discharge of the memory array.

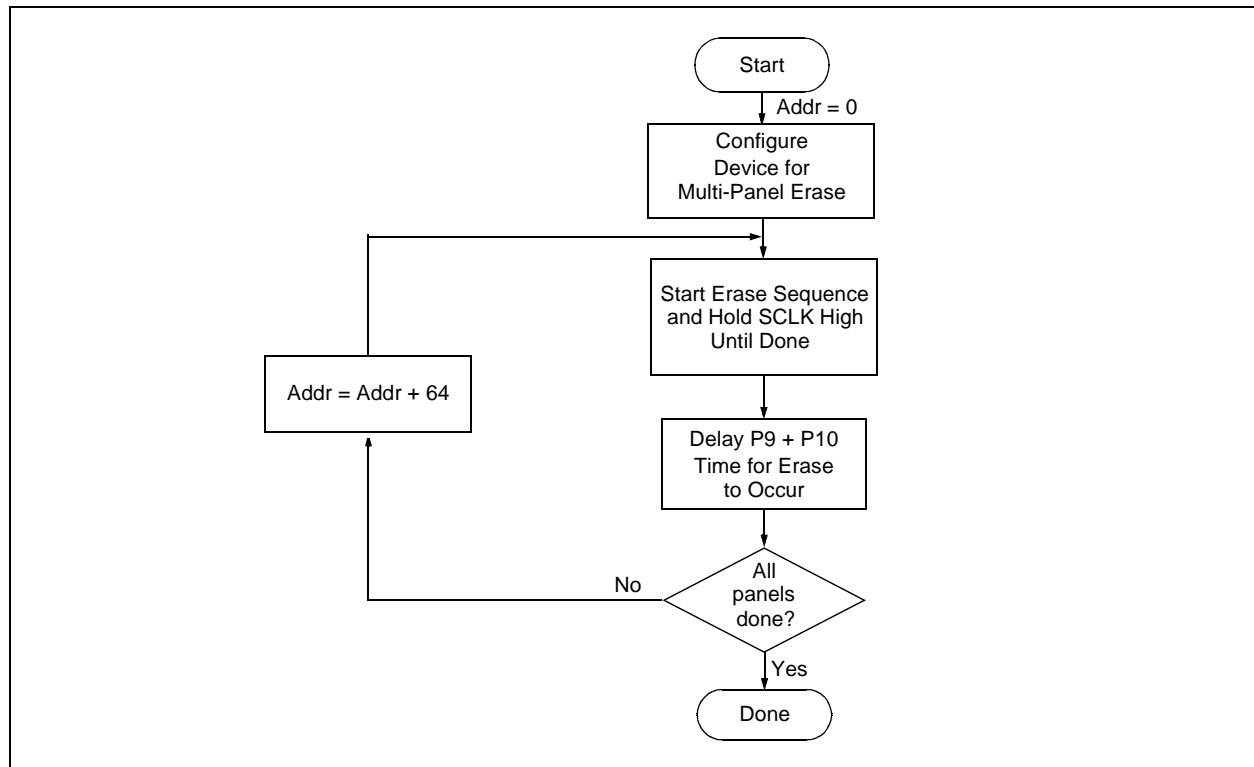
The code sequence to program a PIC18FXX2/XX8 device is shown in Table 3-3. The flowchart shown in Figure 3-3 depicts the logic necessary to completely erase a PIC18FXX2/XX8 device. The timing diagram that details the “Start Programming” command, and parameters P9 and P10 is shown in Figure 3-6.

<b>Note:</b> The TBLPTR register must contain the same offset value when initiating the programming sequence as it did when the write buffers were loaded.
--

**TABLE 3-3: ERASE CODE MEMORY CODE SEQUENCE**

4-Bit Command	Data Payload	Core Instruction
Step 1: Direct access to config memory.		
0000	8E A6	BSF EECON1, EEPGD
0000	8C A6	BSF EECON1, CFGS
0000	86 A6	BSF EECON1, WREN
Step 2: Configure device for multi-panel writes.		
0000	0E 3C	MOVLW 3Ch
0000	6E F8	MOVWF TBLPTRU
0000	0E 00	MOVLW 00h
0000	6E F7	MOVWF TBLPTRH
0000	0E 06	MOVLW 06h
0000	6E F6	MOVWF TBLPTRL
1100	00 40	Write 40h to 3C0006h to enable multi-panel erase.
Step 3: Direct access to code memory and enable erase.		
0000	8E A6	BSF EECON1, EEPGD
0000	9C A6	BCF EECON1, CFGS
0000	88 A6	BSF EECON1, FREE
0000	6A F8	CLRF TBLPTRU
0000	6A F7	CLRF TBLPTRH
0000	6A F6	CLRF TBLPTRL
Step 4: Erase single row of all panels at an offset.		
1111	<DummyLSB>	Write 2 dummy bytes and start programming.
0000	<DummyMSB>	
0000	00 00	NOP - hold SCLK high for time P9.
Step 5: Repeat step 4, with Address Pointer incremented by 64 until all panels are erased.		

**FIGURE 3-3: MULTI-PANEL SINGLE ROW ERASE CODE MEMORY FLOW**





# PIC18FXX2/XX8

---

## 3.2 Code Memory Programming

Programming code memory is accomplished by first loading data into the appropriate write buffers and then initiating a programming sequence. Each panel in the code memory space (see Figure 2-2) has an 8-byte deep write buffer that must be loaded prior to initiating a write sequence. The actual memory write sequence takes the contents of these buffers and programs the associated EEPROM code memory.

Typically, all of the program buffers are written in parallel (Multi-Panel Write mode). In other words, in the case of a 32-Kbyte device (4 panels with an 8-byte buffer per panel), 32 bytes will be simultaneously programmed during each programming sequence. In this case, the offset of the write within each panel is the same (see Figure 3-4). Multi-Panel Write mode is enabled by appropriately configuring the programming control register located at 3C0006h.

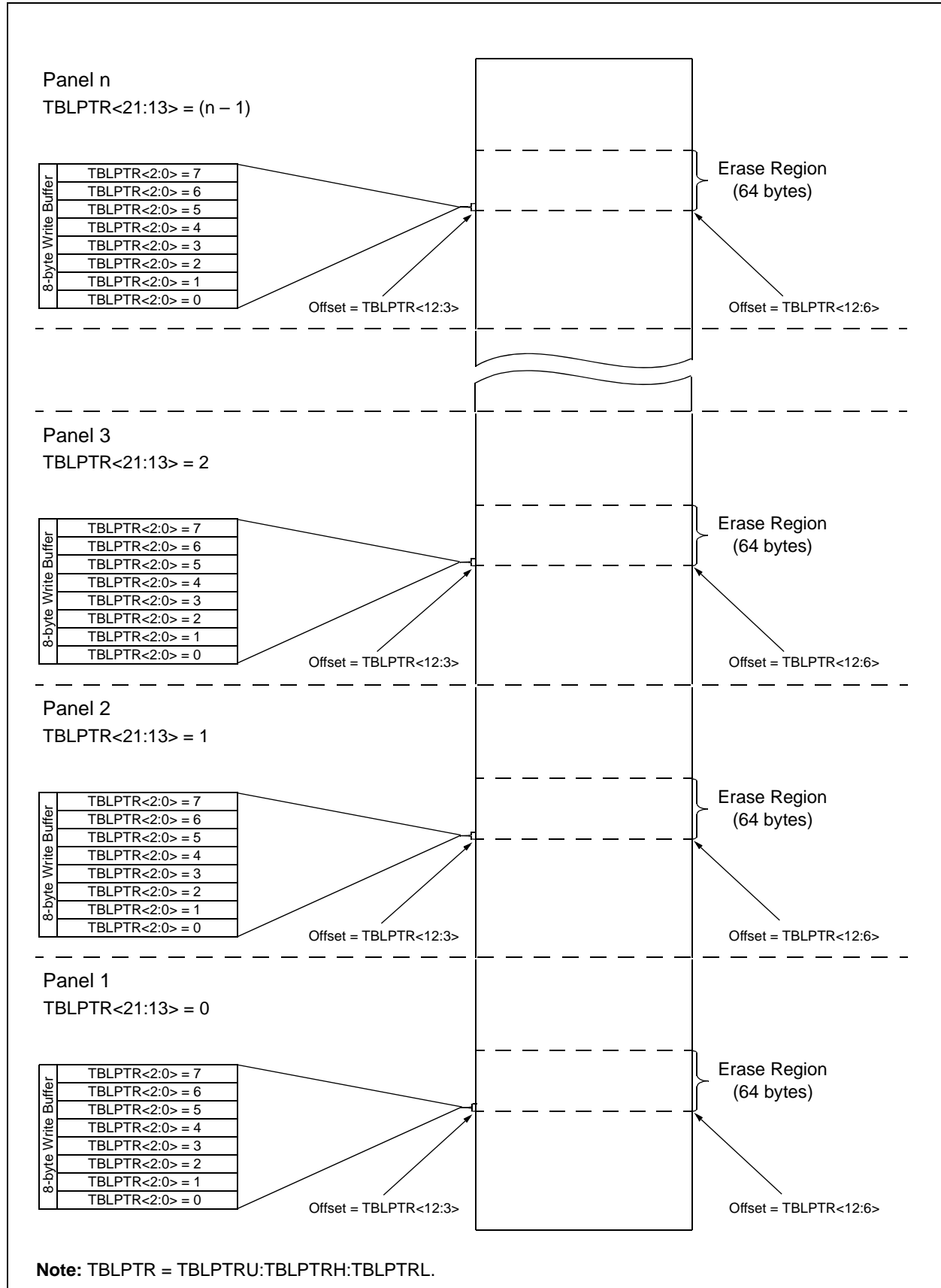
The programming duration is externally timed and is controlled by SCLK. After a “Start Programming” command is issued (4-bit command, ‘1111’), a NOP is issued, where the 4th SCLK is held high for the duration of the programming time, P9.

After SCLK is brought low, the programming sequence is terminated. SCLK must be held low for the time specified by parameter P10 to allow high voltage discharge of the memory array.

The code sequence to program a PIC18FXX2/XX8 device is shown in Figure 3-4. The flowchart shown in Figure 3-5 depicts the logic necessary to completely write a PIC18FXX2/XX8 device.

<b>Note:</b> The TBLPTR register must contain the same offset value when initiating the programming sequence as it did when the write buffers were loaded.
--

**FIGURE 3-4: ERASE AND WRITE BOUNDARIES**

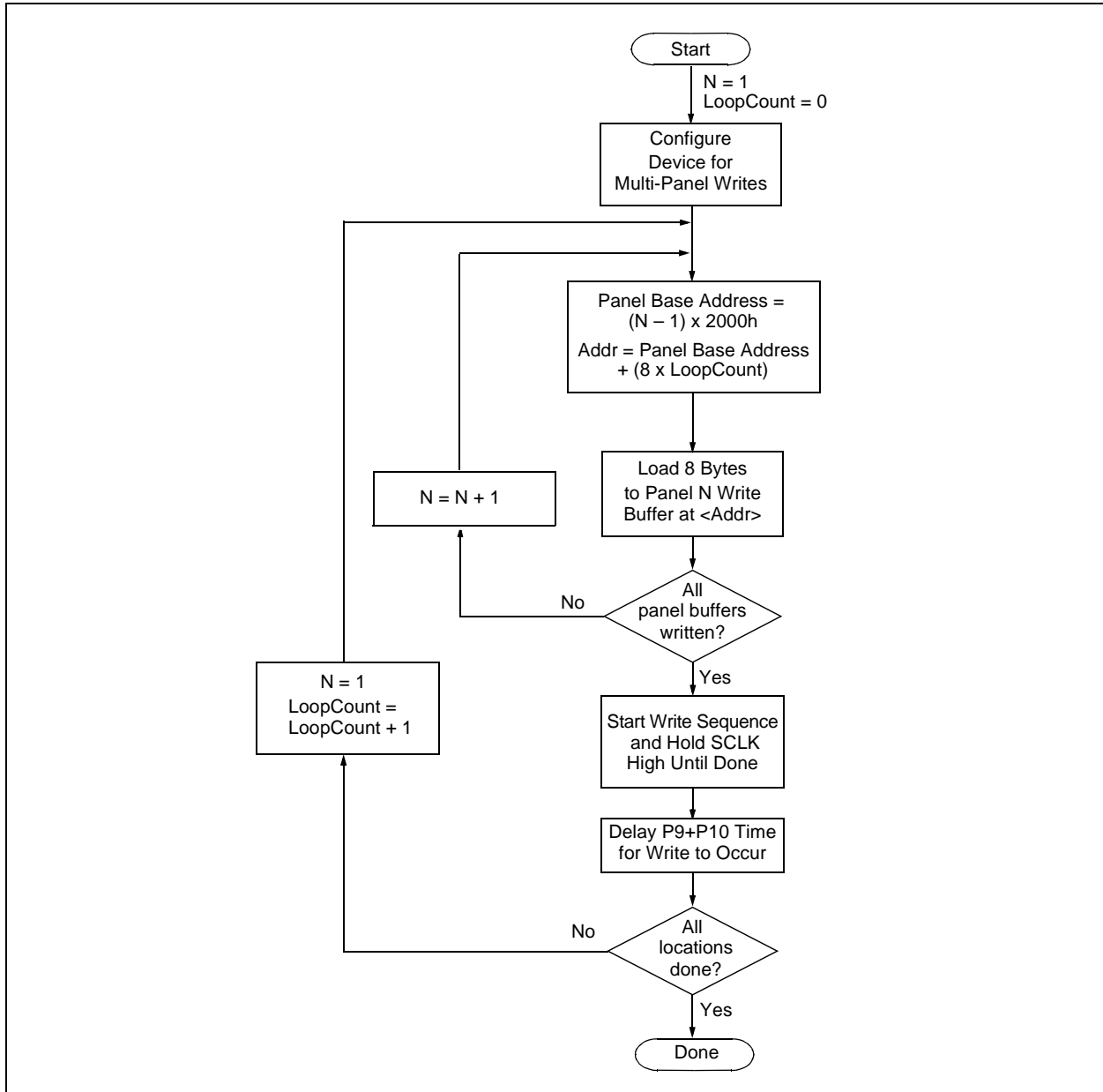


# PIC18FX2/XX8

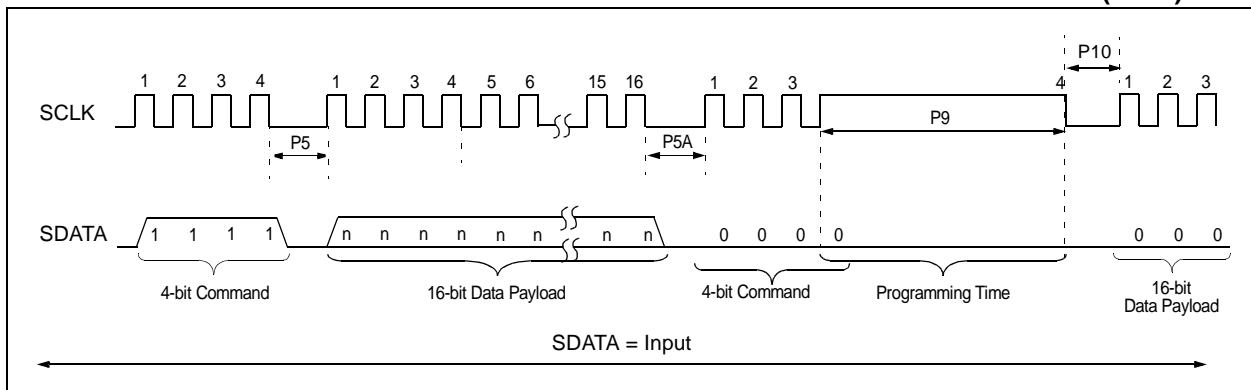
**TABLE 3-4: WRITE CODE MEMORY CODE SEQUENCE**

4-Bit Command	Data Payload	Core Instruction
Step 1: Direct access to config memory.		
0000	8E A6	BSF EECON1, EEPGD
0000	8C A6	BSF EECON1, CFGS
0000	86 A6	BSF EECON1, WREN
Step 2: Configure device for multi-panel writes.		
0000	0E 3C	MOVLW 3Ch
0000	6E F8	MOVWF TBLPTRU
0000	0E 00	MOVLW 00h
0000	6E F7	MOVWF TBLPTRH
0000	0E 06	MOVLW 06h
0000	6E F6	MOVWF TBLPTRL
1100	00 40	Write 40h to 3C0006h to enable multi-panel writes.
Step 3: Direct access to code memory.		
0000	8E A6	BSF EECON1, EEPGD
0000	9C A6	BCF EECON1, CFGS
Step 4: Load write buffer for Panel 1.		
0000	0E <Addr[21:16]>	MOVLW <Addr[21:16]>
0000	6E F8	MOVWF TBLPTRU
0000	0E <Addr[15:8]>	MOVLW <Addr[15:8]>
0000	6E F7	MOVWF TBLPTRH
0000	0E <Addr[7:0]>	MOVLW <Addr[7:0]>
0000	6E F6	MOVWF TBLPTRL
1101	<LSB><MSB>	Write 2 bytes and post-increment address by 2
1101	<LSB><MSB>	Write 2 bytes and post-increment address by 2
1101	<LSB><MSB>	Write 2 bytes and post-increment address by 2
1100	<LSB><MSB>	Write 2 bytes
Step 5: Repeat for Panel 2.		
Step 6: Repeat for all but the last panel (N – 1).		
Step 7: Load write buffer for last panel.		
0000	0E <Addr[21:16]>	MOVLW <Addr[21:16]>
0000	6E F8	MOVWF TBLPTRU
0000	0E <Addr[15:8]>	MOVLW <Addr[15:8]>
0000	6E F7	MOVWF TBLPTRH
0000	0E <Addr[7:0]>	MOVLW <Addr[7:0]>
0000	6E F6	MOVWF TBLPTRL
1101	<LSB><MSB>	Write 2 bytes and post-increment address by 2
1101	<LSB><MSB>	Write 2 bytes and post-increment address by 2
1101	<LSB><MSB>	Write 2 bytes and post-increment address by 2
1111	<LSB><MSB>	Write 2 bytes and start programming
0000	00 00	NOP - hold SCLK high for time P9
To continue writing data, repeat steps 2 through 5, where the Address Pointer is incremented by 8 in each panel at each iteration of the loop.		

**FIGURE 3-5: PROGRAM CODE MEMORY FLOW**



**FIGURE 3-6: TABLE WRITE AND START PROGRAMMING INSTRUCTION TIMING (1111)**



# PIC18FXX2/XX8

---

## 3.2.1 SINGLE PANEL PROGRAMMING

The programming example presented in Section 3.2 utilizes multi-panel programming. This technique greatly decreases the total amount of time necessary to completely program a device and is the recommended method of completely programming a device.

There may be situations, however, where it is advantageous to limit writes to a single panel. In such cases, the user only needs to disable the multi-panel write feature of the device by appropriately configuring the programming control register located at 3C0006h.

The single panel that will be written will automatically be enabled, based on the value of the Table Pointer.

<b>Note:</b> For single panel programming, the user must still fill the 8-byte write buffer for the given panel.
--

## 3.2.2 MODIFYING CODE MEMORY

All of the programming examples up to this point have assumed that the device is blank prior to programming. In fact, if the device is not blank, the direction has been to completely erase the device via a Bulk Erase operation (see Section 3.1) operation.

It may be the case, however, that the user wishes to modify only a section of an already programmed device. In such a situation, erasing the entire device is not a realistic option.

The minimum amount of data that can be written to the device is 8 bytes. This is accomplished by placing the device in Single Panel Write mode (see Section 3.2.1), loading the 8-byte write buffer for the panel, and then initiating a write sequence. In this case, however, it is assumed that the address space to be written already has data in it (i.e., it is not blank).

The minimum amount of code memory that may be erased at a given time is 64 bytes. Again, the device must be placed in Single Panel Write mode. The EECON1 register must then be used to erase the 64-byte target space prior to writing the data.

When using the EECON1 register to act on code memory, the EEPGD bit must be set (EECON1<7> = 1) and the CFGS bit must be cleared (EECON1<6> = 0). The WREN bit must be set (EECON1<2> = 1) to enable writes of any sort (e.g., erases), and this must be done prior to initiating a write sequence. The FREE bit must be set (EECON1<4> = 1) in order to erase the program space being pointed to by the Table Pointer. The erase sequence is initiated by the setting the WR bit (EECON1<1> = 1). It is strongly recommended that the WREN bit be set only when absolutely necessary.

To help prevent inadvertent writes when using the EECON1 register, EECON2 is used to “enable” the WR bit. This register must be sequentially loaded with 55h and then, AAh, immediately prior to asserting the WR bit in order for the write to occur.

The erase will begin on the falling edge of the 4th SCLK after the WR bit is set.

After the erase sequence terminates, SCLK must still be held low for the time specified by parameter P10 to allow high voltage discharge of the memory array.

**TABLE 3-5: MODIFYING CODE MEMORY**

4-Bit Command	Data Payload	Core Instruction
Step 1: Direct access to config memory.		
0000	8E A6	BSF EECON1, EEPGD
0000	8C A6	BSF EECON1, CFGS
Step 2: Configure device for single panel writes.		
0000	0E 3C	MOVLW 3Ch
0000	6E F8	MOVWF TBLPTRU
0000	0E 00	MOVLW 00h
0000	6E F7	MOVWF TBLPTRH
0000	0E 06	MOVLW 06h
0000	6E F6	MOVWF TBLPTRL
1100	00 00	Write 00h to 3C0006h to enable single-panel writes.
Step 3: Direct access to code memory.		
0000	8E A6	BSF EECON1, EEPGD
0000	9C A6	BCF EECON1, CFGS
Step 4: Set the Table Pointer for the block to be erased.		
0000	0E <Addr[21:16]>	MOVLW <Addr[21:16]>
0000	6E F8	MOVWF TBLPTRU
0000	0E <Addr[8:15]>	MOVLW <Addr[8:15]>
0000	6E F7	MOVWF TBLPTRH
0000	0E <Addr[7:0]>	MOVLW <Addr[7:0]>
0000	6E F6	MOVWF TBLPTRL
Step 5: Enable memory writes and setup an erase.		
0000	84 A6	BSF EECON1, WREN
0000	88 A6	BSF EECON1, FREE
Step 6: Perform required sequence.		
0000	0E 55	MOVLW 55h
0000	6E A7	MOVWF EECON2
0000	0E AA	MOVLW 0AAh
0000	6E A7	MOVWF EECON2
Step 7: Initiate erase.		
0000	82 A6	BSF EECON1, WR
0000	00 00	NOP
Step 8: Wait for P11+P10 and then disable writes.		
0000	94 A6	BCF EECON1, WREN
Step 9: Load write buffer for panel. The correct panel will be selected based on the Table Pointer.		
0000	0E <Addr[8:15]>	MOVLW <Addr[8:15]>
0000	6E F7	MOVWF TBLPTRH
0000	0E <Addr[7:0]>	MOVLW <Addr[7:0]>
0000	6E F6	MOVWF TBLPTRL
1101	<LSB><MSB>	Write 2 bytes and post-increment address by 2
1101	<LSB><MSB>	Write 2 bytes and post-increment address by 2
1101	<LSB><MSB>	Write 2 bytes and post-increment address by 2
1111	<LSB><MSB>	Write 2 bytes and start programming
0000	00 00	NOP - hold SCLK high for time P9
To continue writing data, repeat step 8, where the Address Pointer is incremented by 8 at each iteration of the loop.		

# PIC18FXX2/XX8

## 3.3 Data EEPROM Programming

Data EEPROM is accessed one byte at a time via an Address Pointer, EEADR, and a data latch, EEDATA. Data EEPROM is written by loading EEADR with the desired memory location, EEDATA with the data to be written, and initiating a memory write by appropriately configuring the EECON1 and EECON2 registers. A byte write automatically erases the location and writes the new data (erase-before-write).

When using the EECON1 register to perform a data EEPROM write, the EEPGD bit must be cleared (EECON1<7> = 0) and the CFGS bit must be cleared (EECON1<6> = 0). The WREN bit must be set (EECON1<2> = 1) to enable writes of any sort, and this must be done prior to initiating a write sequence. The write sequence is initiated by the setting the WR bit (EECON1<1> = 1). It is strongly recommended that the WREN bit be set only when absolutely necessary.

To help prevent inadvertent writes when using the EECON1 register, EECON2 is used to "enable" the WR bit. This register must be sequentially loaded with 55h and then, AAh, immediately prior to asserting the WR bit in order for the write to occur.

The write will begin on the falling edge of the 4th SCLK after the WR bit is set.

After the programming sequence terminates, SCLK must still be held low for the time specified by parameter P10 to allow high voltage discharge of the memory array.

FIGURE 3-7: PROGRAM DATA FLOW

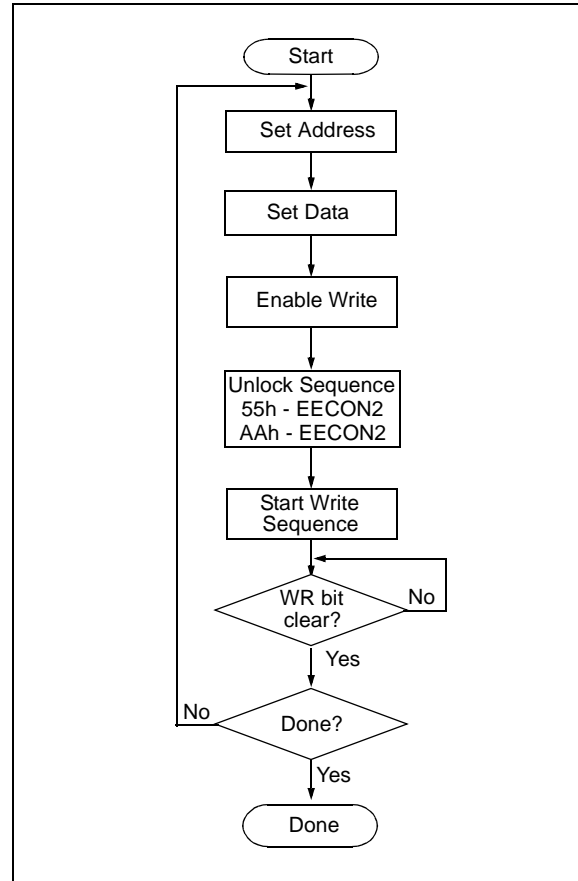
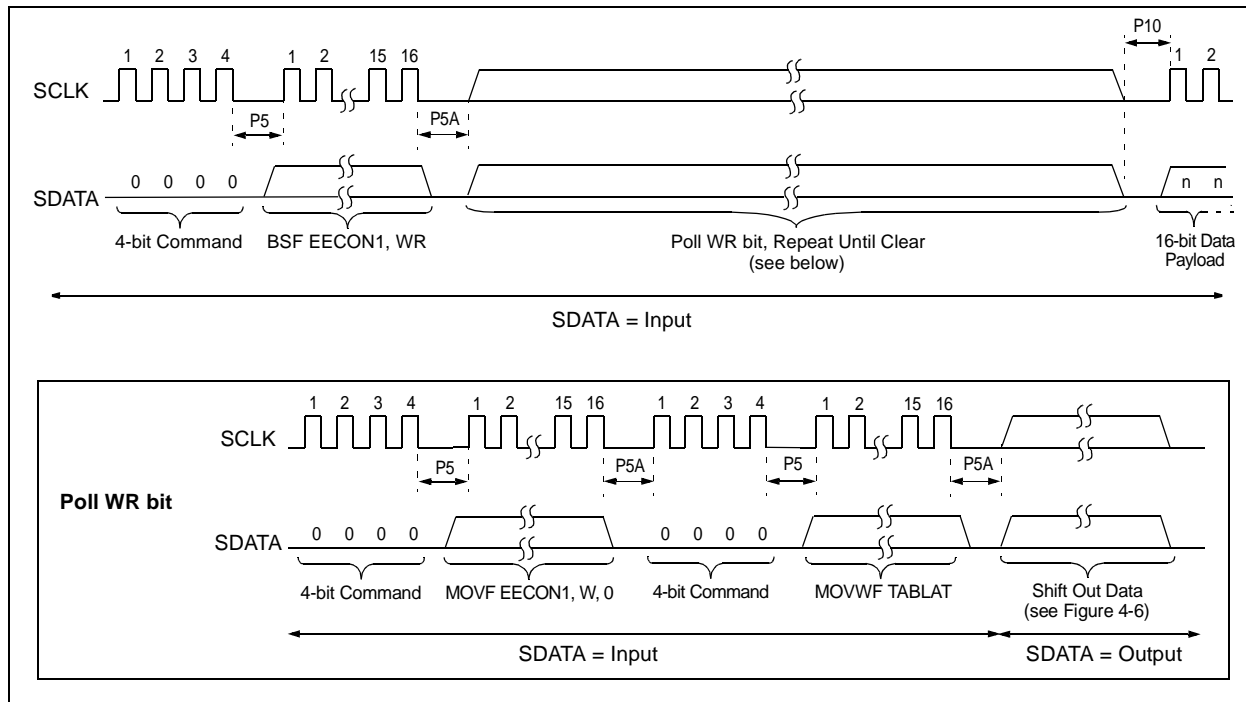


FIGURE 3-8: DATA EEPROM WRITE TIMING



**TABLE 3-6: PROGRAMMING DATA MEMORY**

4-Bit Command	Data Payload	Core Instruction
Step 1: Direct access to data EEPROM.		
0000	9E A6	BCF EECON1, EEPGD
0000	9C A6	BCF EECON1, CFGS
Step 2: Set the data EEPROM Address Pointer.		
0000	0E <Addr>	MOVLW <Addr>
0000	6E A9	MOVWF EEADR
0000	0E <AddrH>	MOVLW <AddrH>
0000	6E AA	MOVWF EEADRH
Step 3: Load the data to be written.		
0000	0E <Data>	MOVLW <Data>
0000	6E A8	MOVWF EEDATA
Step 4: Enable memory writes.		
0000	84 A6	BSF EECON1, WREN
Step 5: Perform required sequence.		
0000	0E 55	MOVLW 0X55
0000	6E A7	MOVWF EECON2
0000	0E AA	MOVLW 0XAA
0000	6E A7	MOVWF EECON2
Step 6: Initiate write.		
0000	82 A6	BSF EECON1, WR
Step 7: Poll WR bit, repeat until the bit is clear.		
0000	50 A6	MOVF EECON1, W, 0
0000	6E F5	MOVWF TABLAT
0010	<LSB><MSB>	Shift out data <sup>(1)</sup>
Step 8: Disable writes.		
0000	94 A6	BCF EECON1, WREN
Repeat steps 2 through 8 to write more data.		

**Note 1:** See Figure 4-4 for details on Shift Out Data timing.



# PIC18FXX2/XX8

## 3.4 ID Location Programming

The ID locations are programmed much like the code memory, except that multi-panel writes must be disabled. The single panel that will be written will automatically be enabled, based on the value of the Table Pointer. The ID registers are mapped in addresses 200000h through 200007h. These locations read out normally, even after code protection.

**Note:** For single panel programming, the user must still fill the 8-byte data buffer for the panel.

Figure 3-7 demonstrates the code sequence required to write the ID locations.

**TABLE 3-7: WRITE ID SEQUENCE**

4-Bit Command	Data Payload	Core Instruction
Step 1: Direct access to config memory.		
0000	8E A6	BSF EECON1, EEPGD
0000	8C A6	BSF EECON1, CFGS
Step 2: Configure device for single panel writes.		
0000	0E 3C	MOVLW 3Ch
0000	6E F8	MOVWF TBLPTRU
0000	0E 00	MOVLW 00h
0000	6E F7	MOVWF TBLPTRH
0000	0E 06	MOVLW 06h
0000	6E F6	MOVWF TBLPTRL
1100	00 00	Write 00h to 3C0006h to enable single panel writes.
Step 3: Direct access to code memory.		
0000	8E A6	BSF EECON1, EEPGD
0000	9C A6	BCF EECON1, CFGS
Step 4: Load write buffer. Panel will be automatically determined by address.		
0000	0E 20	MOVLW 20h
0000	6E F8	MOVWF TBLPTRU
0000	0E 00	MOVLW 00h
0000	6E F7	MOVWF TBLPTRH
0000	0E 00	MOVLW 00h
0000	6E F6	MOVWF TBLPTRL
1101	<LSB><MSB>	Write 2 bytes and post-increment address by 2
1101	<LSB><MSB>	Write 2 bytes and post-increment address by 2
1101	<LSB><MSB>	Write 2 bytes and post-increment address by 2
1111	<LSB><MSB>	Write 2 bytes and start programming
0000	00 00	NOP - hold SCLK high for time P9

In order to modify the ID locations, refer to the methodology described in Section 3.2.2, "Modifying Code Memory". As with code memory, the ID locations must be erased before modified.

## 3.5 Boot Block Programming

The Boot Block segment is programmed in exactly the same manner as the ID locations (see Section 3.4). Multi-panel writes must be disabled so that only addresses in the range 0000h to 01FFh will be written.

The code sequence detailed in Figure 3-7 should be used, except that the address data used in “Step 3” will be in the range 000000h to 0001FFh.

## 3.6 Configuration Bits Programming

Unlike code memory, the configuration bits are programmed a byte at a time. The “Table Write, Begin Programming” (4-bit command, ‘1111’) is used, but only 8 bits of the following 16-bit payload will be written. The LSB of the payload will be written to even addresses, and the MSB will be written to odd addresses. The code sequence to program two consecutive configuration locations is shown in Figure 3-8.

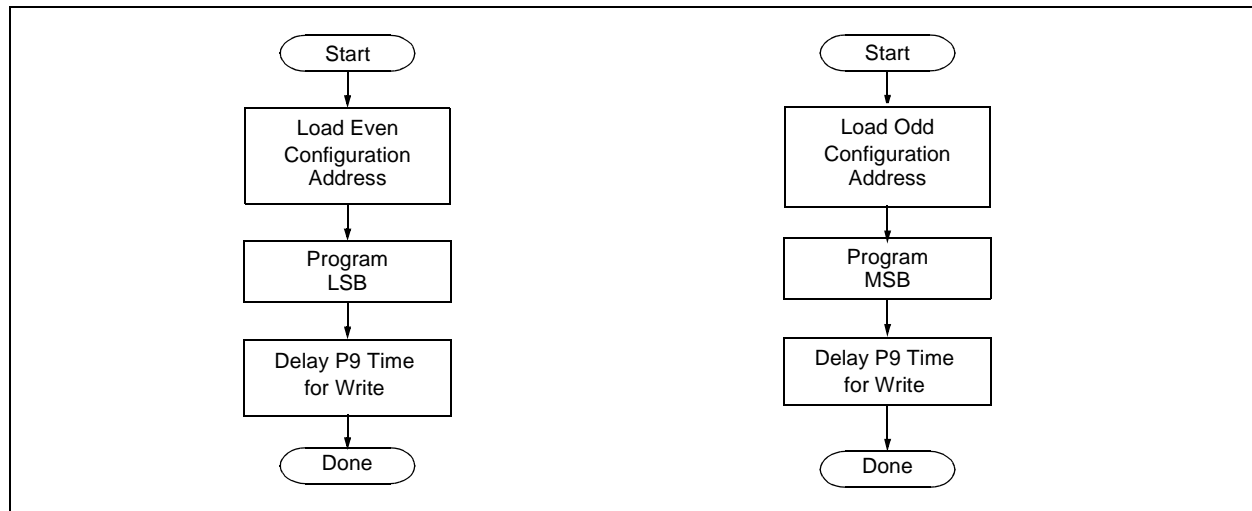
**TABLE 3-8: SET ADDRESS POINTER TO CONFIGURATION LOCATION**

4-Bit Command	Data Payload	Core Instruction
Step 1: Direct access to config memory.		
0000	8E A6	BSF EECON1, EEPGD
0000	8C A6	BSF EECON1, CFGS
Step 2: Position the program counter <sup>(1)</sup> .		
0000	EF 00	GOTO 100000h
0000	F8 00	
Step 3 <sup>(2)</sup> : Set Table Pointer for config byte to be written. Write even/odd addresses.		
0000	0E 30	MOVLW 30h
0000	6E F8	MOVWF TBLPTRU
0000	0E 00	MOVLW 00h
0000	6E F7	MOVWF TBLPRTH
0000	0E 00	MOVLW 00h
0000	6E F6	MOVWF TBLPTRL
1111	<LSB><MSB ignored>	Load 2 bytes and start programming
0000	00 00	NOP - hold SCLK high for time P9
0000	2A F6	INCF TBLPTRL
1111	<LSB ignored><MSB>	Load 2 bytes and start programming
0000	00 00	NOP - hold SCLK high for time P9

**Note 1:** If the code protection bits are programmed while the program counter resides in the same block, then the interaction of code protection logic may prevent further table writes. To avoid this situation, move the program counter outside the code protection area (e.g., GOTO 100000h).

**Note 2:** Enabling the write protection of configuration bits (WRTC = 0 in CONFIG6H) will prevent further writing of configuration bits. Always write all the configuration bits before enabling the write protection for configuration bits.

**FIGURE 3-9: CONFIGURATION PROGRAMMING FLOW**



# PIC18FXX2/XX8

## 4.0 READING THE DEVICE

### 4.1 Read Code Memory, ID Locations, and Configuration Bits

Code memory is accessed one byte at a time, via the 4-bit command, '1001' (Table Read, post-increment). The contents of memory pointed to by the Table Pointer (TBLPTRU:TBLPTRH:TBLPTRL) are loaded into the Table Latch and then serially output on SDATA.

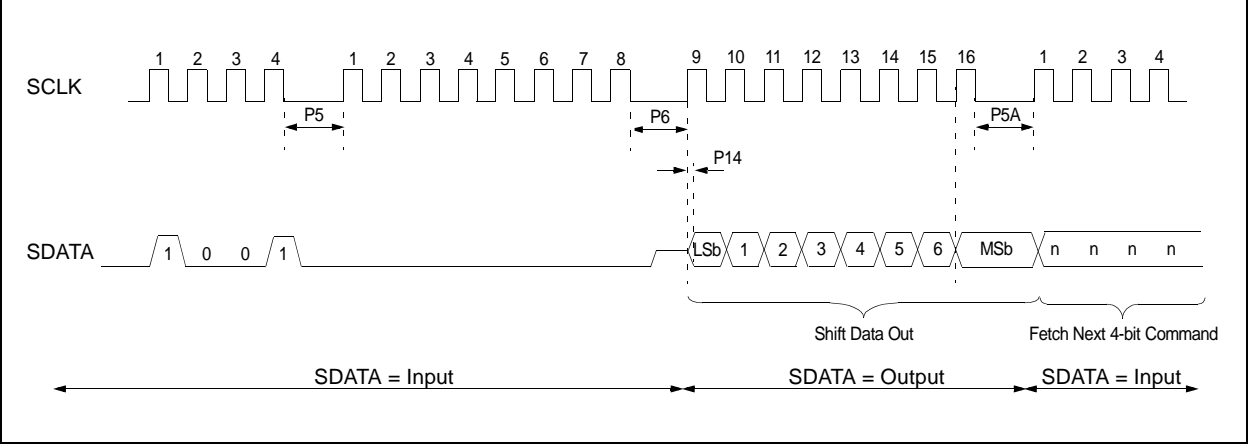
The 4-bit command is shifted in LSb first. The Read is executed during the next 8 clocks, then shifted out on SDATA during the last 8 clocks, LSb to MSb. A delay of P6 must be introduced after the falling edge of the 8th SCLK of the operand to allow SDATA to transition from an input to an output. During this time, SCLK must be held low (see Table 4-1). This operation also increments the Table Pointer pointer by one, pointing to the next byte in code memory for the next read.

This technique will work to read any memory in the 000000h to 3FFFFFFh address space, so it also applies to the reading of the ID and configuration registers.

TABLE 4-1: READ CODE MEMORY SEQUENCE

4-Bit Command	Data Payload	Core Instruction
Step 1: Set Table Pointer.		
0000	0E <Addr[21:16]>	MOVLW Addr[21:16]
0000	6E F8	MOVWF TBLPTRU
0000	0E <Addr[15:8]>	MOVLW <Addr[15:8]>
0000	6E F7	MOVWF TBLPTRH
0000	0E <Addr[7:0]>	MOVLW <Addr[7:0]>
0000	6E F6	MOVWF TBLPTRL
Step 2: Read memory into Table Latch and then shift out on SDATA, LSb to MSb.		
1001	00 00	TBLRD *+

FIGURE 4-1: TABLE READ POST-INCREMENT INSTRUCTION TIMING (1001)

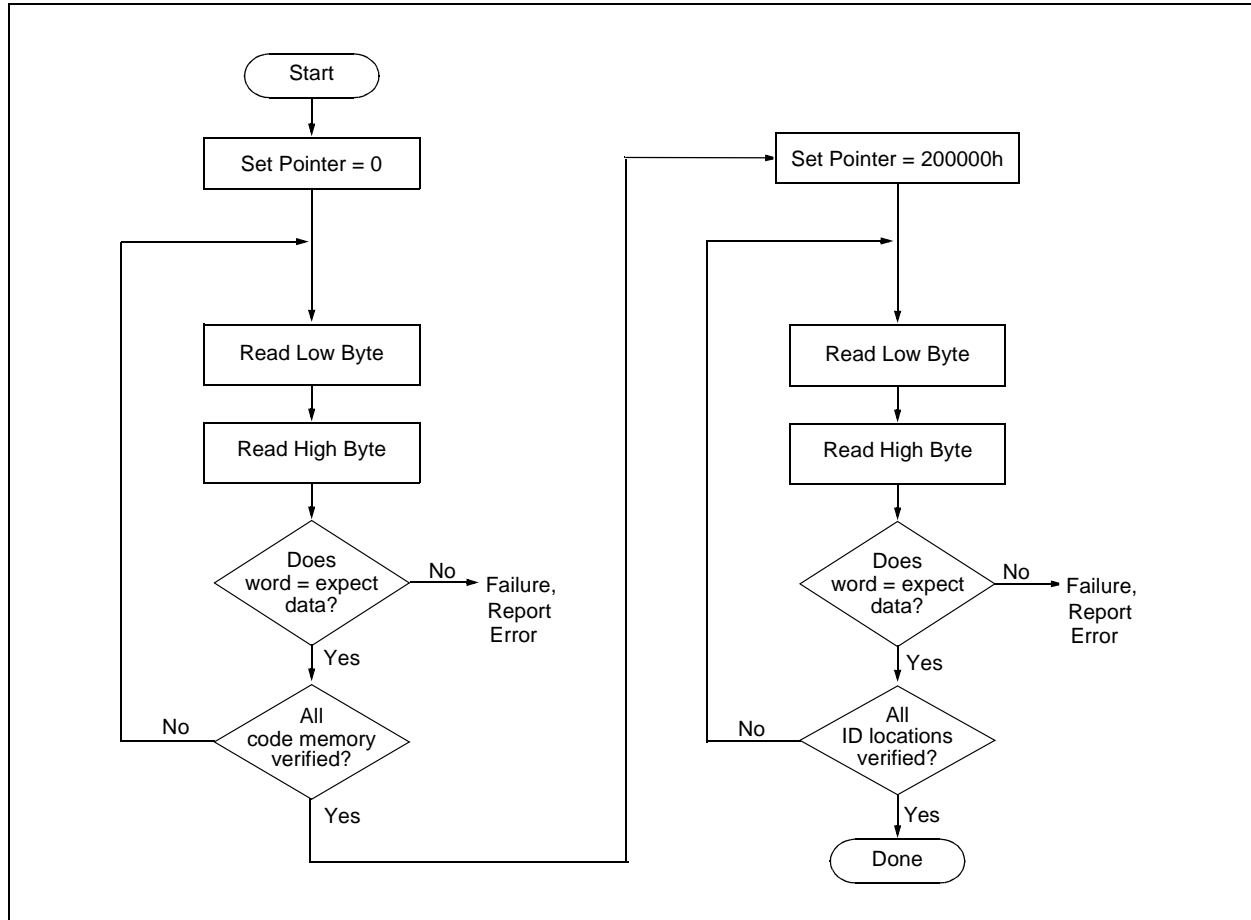


## 4.2 Verify Code Memory and ID locations

The verify step involves reading back the code memory space and comparing against the copy held in the programmer's buffer. Memory reads occur a single byte at a time, so two bytes must be read to compare against the word in the programmer's buffer. Refer to Section 4.1 for implementation details of reading code memory.

The Table Pointer must be manually set to 200000h (base address of the ID locations) once the code memory has been verified. The post-increment feature of the Table Read 4-bit command may not be used to increment the Table Pointer beyond 1FFFFFh.

**FIGURE 4-2: VERIFY CODE MEMORY FLOW**



# PIC18FXX2/XX8

## 4.3 Verify Configuration Bits

A configuration address may be read and output on SDATA via the 4-bit command, '1001'. Configuration data is read and written in a bitwise fashion, so it is not necessary to merge two bytes into a word prior to a compare. The result may then be immediately compared to the appropriate configuration data in the programmer's memory for verification. Refer to Section 4.1 for implementation details of reading configuration data.

## 4.4 Read Data EEPROM Memory

Data EEPROM is accessed one byte at a time via an Address Pointer, EEADR, and a data latch, EEDATA. Data EEPROM is read by loading EEADR with the desired memory location and initiating a memory read by appropriately configuring the EECON1 register. The data will be loaded into EEDATA, where it may be serially output on SDATA via the 4-bit command, '0010' (shift out data holding register). A delay of P6 must be introduced after the falling edge of the 8th SCLK of the operand to allow SDATA to transition from an input to an output. During this time, SCLK must be held low (see Figure 4-4).

The command sequence to read a single byte of data is shown in Figure 4-2.

FIGURE 4-3: READ DATA EEPROM FLOW

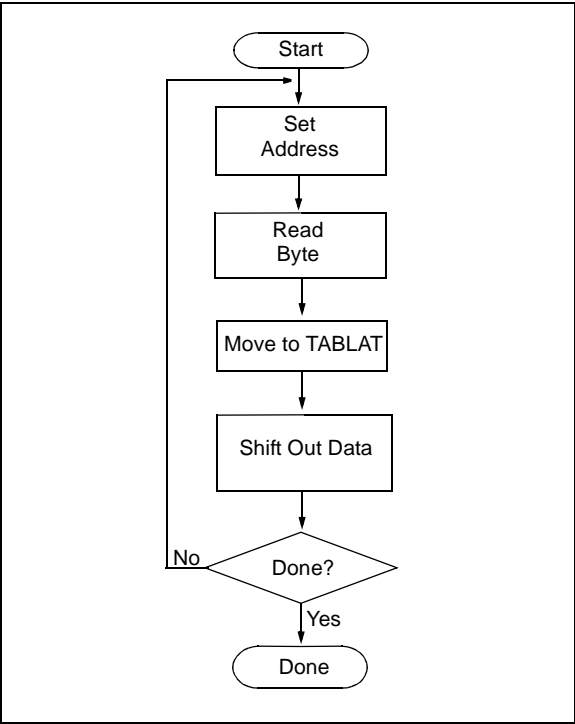
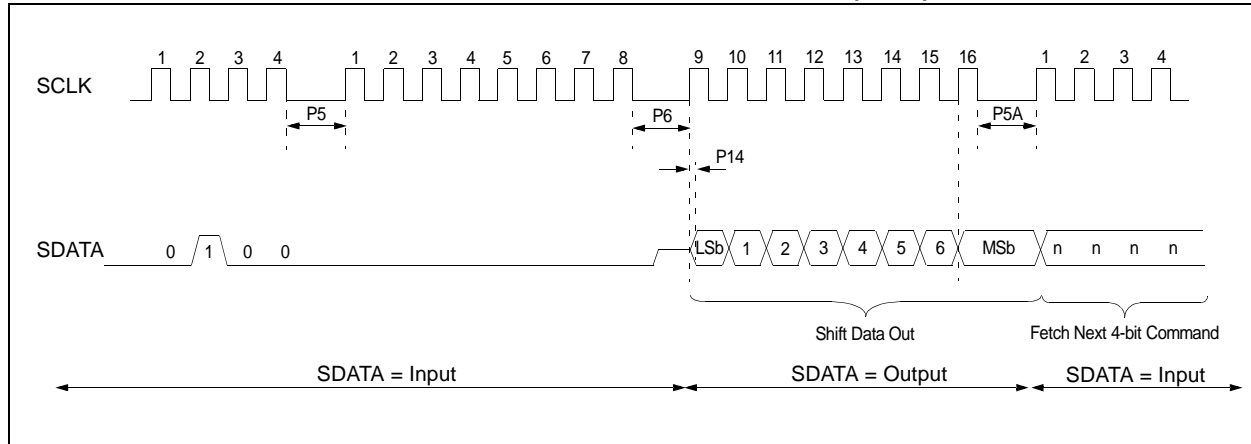


TABLE 4-2: READ DATA EEPROM MEMORY

4-Bit Command	Data Payload	Core Instruction
Step 1: Direct access to data EEPROM.		
0000	9E A6	BCF EECON1, EEPGD
0000	9C A6	BCF EECON1, CFGS
Step 2: Set the data EEPROM Address Pointer.		
0000	0E <Addr>	MOVLW <Addr>
0000	6E A9	MOVWF EEADR
0000	0E <AddrH>	MOVLW <AddrH>
0000	6E AA	MOVWF EEADRH
Step 3: Initiate a memory read.		
0000	80 A6	BSF EECON1, RD
Step 4: Load data into the serial data holding register.		
0000	50 A8	MOVF EEDATA, W, 0
0000	6E F5	MOVWF TABLAT
0010	<LSB><MSB>	Shift Out Data <sup>(1)</sup>

**Note 1:** The <LSB> is undefined. The <MSB> is the data.

**FIGURE 4-4: SHIFT OUT DATA HOLDING REGISTER TIMING (0010)**



## 4.5 Verify Data EEPROM

A data EEPROM address may be read via a sequence of core instructions (4-bit command, '0000') and then output on SDATA via the 4-bit command, '0010' (shift out data holding register). The result may then be immediately compared to the appropriate data in the programmer's memory for verification. Refer to Section 4.4 for implementation details of reading data EEPROM.

## 4.6 Blank Check

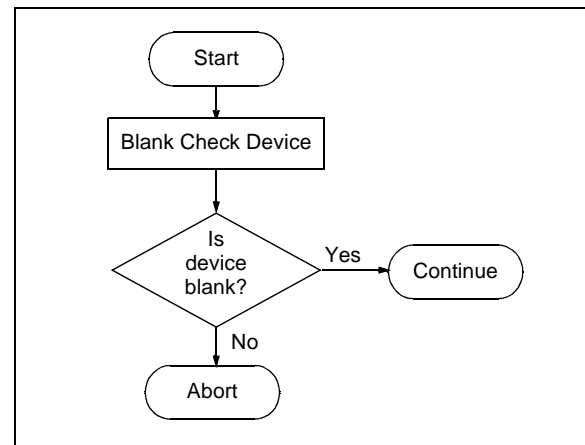
The term "Blank Check" means to verify that the device has no programmed memory cells. All memories must be verified: code memory, data EEPROM, ID locations, and configuration bits. The Device ID registers (3FFFFEh:3FFFFFh) should be ignored.

A "blank" or "erased" memory cell will read as a '1'. So, "Blank Checking" a device merely means to verify that all bytes read as FFh, except the configuration bits. Unused (reserved) configuration bits will read '0' (programmed). Refer to Table 5-2 for blank configuration expect data for the various PIC18FXX2/XX8 devices.

If it is determined that the device is not blank, then the device should be Bulk Erased (see Section 3.1) before any attempt to program is made.

Given that "Blank Checking" is merely code and data EEPROM verification with FFh expect data, refer to Section 4.4 and Section 4.2 for implementation details.

**FIGURE 4-5: BLANK CHECK FLOW**



# PIC18FXX2/XX8

## 5.0 CONFIGURATION WORD

The PIC18FXX2/XX8 has several configuration words. These bits can be set or cleared to select various device configurations. All other memory areas should be programmed and verified prior to setting configuration words. These bits may be read out normally, even after read or code protected.

### 5.1 ID Locations

A user may store identification information (ID) in eight ID locations mapped in 200000h:200007h. It is recommended that the most significant nibble of each ID be 0Fh. In doing so, if the user code inadvertently tries to execute from the ID space, the ID data will execute as NOP.

### 5.2 Device ID Word

The device ID word for the PIC18FXX2/XX8 is located at 3FFFFEh:3FFFFFh. These bits may be used by the programmer to identify what device type is being programmed and read out normally, even after code or read protected.

## 5.3 Low Voltage Programming (LVP) Bit

The LVP bit in configuration register CONFIG4L enables low voltage ICSP programming. The LVP bit defaults to a '1' from the factory.

If Low Voltage Programming mode is not used, the LVP bit can be programmed to a '0' and RB5/PGM becomes a digital I/O pin. However, the LVP bit may only be programmed by entering the High Voltage ICSP mode, where MCLR/VPP is raised to V<sub>IHH</sub>. 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.

**Note 1:** The normal ICSP mode is always available, regardless of the state of the LVP bit, by applying V<sub>IHH</sub> to the MCLR/VPP pin.

**2:** While in Low Voltage ICSP mode, the RB5 pin can no longer be used as a general purpose I/O. The RB5 pin should be held low during normal operation to protect against inadvertent ICSP mode entry.

TABLE 5-1: DEVICE ID VALUE

Device	Device ID Value	
	DEVID2	DEVID1
PIC18F242	04h	100x xxxx
PIC18F248	08h	000x xxxx
PIC18F252	04h	000x xxxx
PIC18F258	08h	010x xxxx
PIC18F442	04h	101x xxxx
PIC18F448	08h	001x xxxx
PIC18F452	04h	001x xxxx
PIC18F458	08h	011x xxxx

**TABLE 5-2: PIC18FXX2/XX8 CONFIGURATION BITS AND DEVICE IDS**

File Name	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	Erased or "Blank" Value
300000h CONFIG1L	—	—	—	—	—	—	—	—	0000 0000
300001h CONFIG1H	—	—	OSCEN	—	—	FOSC2	FOSC1	FOSC0	0010 0111
300002h CONFIG2L	—	—	—	—	BORV1	BORV2	BOREN	PWRTÉ	0000 1111
300003h CONFIG2H	—	—	—	—	WDTPS2	WDTPS1	WDTPS0	WDTEN	0000 1111
300004h CONFIG3L	—	—	—	—	—	—	—	—	0000 0000
300005h CONFIG3H	—	—	—	—	—	—	—	CCP2MX*	0000 0001
300006h CONFIG4L	BKBUG	—	—	—	—	LVP	—	STVREN	1000 0101
300007h CONFIG4H	—	—	—	—	—	—	—	—	0000 0000
300008h CONFIG5L	—	—	—	—	CP3	CP2	CP1	CP0	0000 1111
300009h CONFIG5H	CPD	CPB	—	—	—	—	—	—	1100 0000
30000Ah CONFIG6L	—	—	—	—	WRT3	WRT2	WRT1	WRT0	0000 1111
30000Bh CONFIG6H	WRTD	WRTB	WRTC	—	—	—	—	—	1110 0000
30000Ch CONFIG7L	—	—	—	—	EBTR3	EBTR2	EBTR1	EBTR0	0000 1111
30000Dh CONFIG7H	—	EBTRB	—	—	—	—	—	—	0100 0000
3FFFFEh DEVID1	DEV2	DEV1	DEV0	REV4	REV3	REV2	REV1	REV0	Table 5-1
3FFFFFh DEVID2	DEV10	DEV9	DEV8	DEV7	DEV6	DEV5	DEV4	DEV3	Table 5-1

\* This bit only applies to the PIC18FXX2 devices.



# PIC18FXX2/XX8

**TABLE 5-3: PIC18FXX2/XX8 BIT DESCRIPTION**

Bit Name	Configuration Words	Description
OSCEN	CONFIG1H	Low Power System Clock Option (Timer1) Enable bit 1 = Disabled 0 = Timer1 oscillator system clock option enabled
FOSC2:FOSC0	CONFIG1H	Oscillator Selection bits 111 = RC oscillator w/ OSC2 configured as RA6 110 = HS oscillator w/ PLL enabled 101 = EC oscillator w/ OSC2 configured as RA6 100 = RC oscillator w/ OSC2 configured as “divide by 4 clock output” 011 = RC oscillator 010 = HS oscillator 001 = XT oscillator 000 = LP oscillator
BORV1:BORV0	CONFIG2L	Brown-out Reset Voltage bits 11 = VBOR set to 2.0V 10 = VBOR set to 2.7V 01 = VBOR set to 4.2V 00 = VBOR set to 4.5V
BOREN	CONFIG2L	Brown-out Reset Enable bit 1 = Brown-out Reset enabled 0 = Brown-out Reset disabled
PWRTEN	CONFIG2L	Power-up Timer Enable bit 1 = PWRT disabled 0 = PWRT enabled
WDTPS2:WDTPS0	CONFIG2H	Watchdog Timer Postscaler Select bits 111 = 1:128 110 = 1:64 101 = 1:32 100 = 1:16 011 = 1:8 010 = 1:4 001 = 1:2 000 = 1:1
WDTEN	CONFIG2H	Watchdog Timer Enable bit 1 = WDT enabled 0 = WDT disabled (control is placed on SWDTEN bit)
CCP2MX <sup>(1)</sup>	CONFIG3H	CCP2 MUX bit 1 = CCP2 input/output is multiplexed with RC1 0 = CCP2 input/output is multiplexed with RB3
BKBUG	CONFIG4L	Background Debugger Enable bit 1 = Background debugger disabled 0 = Background debugger enabled
LVP	CONFIG4L	Low Voltage Programming Enable bit 1 = Low voltage programming enabled 0 = Low voltage programming disabled
STVREN	CONFIG4L	Stack Overflow/Underflow Reset Enable bit 1 = Stack overflow/underflow will cause RESET 0 = Stack overflow/underflow will not cause RESET

**Note 1:** This bit only applies to the PIC18FXX2 devices.

**2:** These bits only apply to the PIC18FX52/X58 devices.

**TABLE 5-3: PIC18FXX2/XX8 BIT DESCRIPTION (CONTINUED)**

Bit Name	Configuration Words	Description
CP0	CONFIG5L	Code Protection bits (code memory area 0200h - 1FFFh) 1 = Code memory not code protected 0 = Code memory code protected
CP1	CONFIG5L	Code Protection bits (code memory area 2000h - 3FFFh) 1 = Code memory not code protected 0 = Code memory code protected
CP2 <sup>(2)</sup>	CONFIG5L	Code Protection bits (code memory area 4000h - 5FFFh) 1 = Code memory not code protected 0 = Code memory code protected
CP3 <sup>(2)</sup>	CONFIG5L	Code Protection bits (code memory area 6000h - 7FFFh) 1 = Code memory not code protected 0 = Code memory code protected
CPD	CONFIG5H	Code Protection bits (data EEPROM) 1 = Data EEPROM not code protected 0 = Data EEPROM code protected
CPB	CONFIG5H	Code Protection bits (boot block, memory area 0000h - 01FFh) 1 = Boot block not code protected 0 = Boot block code protected
WRT0	CONFIG6L	Table Write Protection bit (code memory area 0200h - 1FFFh) 1 = Code memory not write protected 0 = Code memory write protected
WRT1	CONFIG6L	Table Write Protection bit (code memory area 2000h - 3FFFh) 1 = Code memory not write protected 0 = Code memory write protected
WRT2 <sup>(2)</sup>	CONFIG6L	Table Write Protection bit (code memory area 4000h - 5FFFh) 1 = Code memory not write protected 0 = Code memory write protected
WRT3 <sup>(2)</sup>	CONFIG6L	Table Write Protection bit (code memory area 6000h - 7FFFh) 1 = Code memory not write protected 0 = Code memory write protected
WRTD	CONFIG6H	Table Write Protection bit (data EEPROM) 1 = Data EEPROM not write protected 0 = Data EEPROM write protected
WRTB	CONFIG6H	Table Write Protection bit (boot block, memory area 0000h - 01FFh) 1 = Boot block not write protected 0 = Boot block write protected
WRTC	CONFIG6H	Table Write Protection bit (Configuration registers) 1 = Configuration registers not write protected 0 = Configuration registers write protected

**Note 1:** This bit only applies to the PIC18FXX2 devices.

**2:** These bits only apply to the PIC18FX52/X58 devices.

# PIC18FXX2/XX8

TABLE 5-3: PIC18FXX2/XX8 BIT DESCRIPTION (CONTINUED)

Bit Name	Configuration Words	Description
EBTR0	CONFIG7L	Table Read Protection bit (code memory area 0200h - 01FFFh) 1 = Code memory not protected from table reads executed in other blocks 0 = Code memory protected from table reads executed in other blocks
EBTR1	CONFIG7L	Table Read Protection bit (code memory area 2000h - 3FFFh) 1 = Code memory not protected from table reads executed in other blocks 0 = Code memory protected from table reads executed in other blocks
EBTR2 <sup>(2)</sup>	CONFIG7L	Table Read Protection bit (code memory area 4000h - 5FFFh) 1 = Code memory not protected from table reads executed in other blocks 0 = Code memory protected from table reads executed in other blocks
EBTR3 <sup>(2)</sup>	CONFIG7L	Table Read Protection bit (code memory area 6000h - 7FFFh) 1 = Code memory not protected from table reads executed in other blocks 0 = Code memory protected from table reads executed in other blocks
EBTRB	CONFIG7H	Table Read Protection bit (boot block, memory area 0000h - 01FFh) 1 = Boot block not protected from table reads executed in other blocks 0 = Boot block protected from table reads executed in other blocks
DEV10:DEV3	DEVID2	Device ID bits These bits are used with the DEV2:DEV0 bits in the DEVID1 register to identify part number.
DEV2:DEV0	DEVID1	Device ID bits These bits are used with the DEV10:DEV3 bits in the DEVID2 register to identify part number.
REV4:REV0	DEVID1	These bits are used to indicate the revision of the device.

**Note 1:** This bit only applies to the PIC18FXX2 devices.

**2:** These bits only apply to the PIC18FX52/X58 devices.

## 5.4 Embedding Configuration Word Information in the HEX File

To allow portability of code, a PIC18FXX2/XX8 programmer is required to read the configuration word locations from the HEX file. If configuration word information is not present in the HEX file, then a simple warning message should be issued. Similarly, while saving a HEX file, all configuration word information must be included. An option to not include the configuration word information may be provided. When embedding configuration word information in the HEX file, it should start at address 300000h.

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

## 5.5 Checksum Computation

The checksum is calculated by summing the following:

- The contents of all code memory locations
- The configuration word, appropriately masked
- ID locations

The Least Significant 16-bits of this sum are the checksum.

Table 5-4 describes how to calculate the checksum for each device.

**Note 1:** The checksum calculation differs depending on the code protect setting. Since the code memory locations read out differently depending on the code protect setting, the table describes how to manipulate the actual code memory values to simulate the values that would be read from a protected device. When calculating a checksum by reading a device, the entire code memory can simply be read and summed. The configuration word and ID locations can always be read.

**TABLE 5-4: CHECKSUM COMPUTATION**

Device	Code Protect	Checksum	Blank Value	0xAA at 0 and Max Address
PIC18F242	None	SUM(0000:01FF)+SUM(0200:1FFF)+SUM(2000:3FFF)+(CFGW1L & 0000)+(CFGW1H & 0027)+(CFGW2L & 000F)+(CFGW2H & 000F)+(CFGW3L & 0000)+(CFGW3H & 0001)+(CFGW4L & 0085)+(CFGW4H & 0000)+(CFGW5L & 0003)+(CFGW5H & 00C0)+(CFGW6L & 0003)+(CFGW6H & 00E0)+(CFGW7L & 0003)+(CFGW7H & 0040)	C2B4	C20A
	Boot Block	SUM(0200:1FFF)+SUM(2000:3FFF)+(CFGW1L & 0000)+(CFGW1H & 0027)+(CFGW2L & 000F)+(CFGW2H & 000F)+(CFGW3L & 0000)+(CFGW3H & 0001)+(CFGW4L & 0085)+(CFGW4H & 0000)+(CFGW5L & 0003)+(CFGW5H & 00C0)+(CFGW6L & 0003)+(CFGW6H & 00E0)+(CFGW7L & 0003)+(CFGW7H & 0040)+SUM(IDs)	C491	C437
	Boot/Panel1/Panel2	(CFGW1L & 0000)+(CFGW1H & 0027)+(CFGW2L & 000F)+(CFGW2H & 000F)+(CFGW3L & 0000)+(CFGW3H & 0001)+(CFGW4L & 0085)+(CFGW4H & 0000)+(CFGW5L & 0003)+(CFGW5H & 00C0)+(CFGW6L & 0003)+(CFGW6H & 00E0)+(CFGW7L & 0003)+(CFGW7H & 0040)+SUM(IDs)	028E	289
	All	(CFGW1L & 0000)+(CFGW1H & 0027)+(CFGW2L & 000F)+(CFGW2H & 000F)+(CFGW3L & 0000)+(CFGW3H & 0001)+(CFGW4L & 0085)+(CFGW4H & 0000)+(CFGW5L & 0003)+(CFGW5H & 00C0)+(CFGW6L & 0003)+(CFGW6H & 00E0)+(CFGW7L & 0003)+(CFGW7H & 0040)+SUM(IDs)	028E	289
PIC18F248	None	SUM(0000:01FF)+SUM(0200:1FFF)+SUM(2000:3FFF)+(CFGW1L & 0000)+(CFGW1H & 0027)+(CFGW2L & 000F)+(CFGW2H & 000F)+(CFGW3L & 0000)+(CFGW3H & 0000)+(CFGW4L & 0085)+(CFGW4H & 0000)+(CFGW5L & 0003)+(CFGW5H & 00C0)+(CFGW6L & 0003)+(CFGW6H & 00E0)+(CFGW7L & 0003)+(CFGW7H & 0040)	C2B3	C209
	Boot Block	SUM(0200:1FFF)+SUM(2000:3FFF)+(CFGW1L & 0000)+(CFGW1H & 0027)+(CFGW2L & 000F)+(CFGW2H & 000F)+(CFGW3L & 0000)+(CFGW3H & 0000)+(CFGW4L & 0085)+(CFGW4H & 0000)+(CFGW5L & 0003)+(CFGW5H & 00C0)+(CFGW6L & 0003)+(CFGW6H & 00E0)+(CFGW7L & 0003)+(CFGW7H & 0040)+SUM(IDs)	C48F	C435
	Boot/Panel1/Panel2	(CFGW1L & 0000)+(CFGW1H & 0027)+(CFGW2L & 000F)+(CFGW2H & 000F)+(CFGW3L & 0000)+(CFGW3H & 0000)+(CFGW4L & 0085)+(CFGW4H & 0000)+(CFGW5L & 0003)+(CFGW5H & 00C0)+(CFGW6L & 0003)+(CFGW6H & 00E0)+(CFGW7L & 0003)+(CFGW7H & 0040)+SUM(IDs)	028C	287
	All	(CFGW1L & 0000)+(CFGW1H & 0027)+(CFGW2L & 000F)+(CFGW2H & 000F)+(CFGW3L & 0000)+(CFGW3H & 0000)+(CFGW4L & 0085)+(CFGW4H & 0000)+(CFGW5L & 0003)+(CFGW5H & 00C0)+(CFGW6L & 0003)+(CFGW6H & 00E0)+(CFGW7L & 0003)+(CFGW7H & 0040)+SUM(IDs)	028C	287

Legend: Item      Description  
CFGW = Configuration Word  
SUM[a:b] = Sum of locations a to b inclusive  
SUM\_ID = Byte-wise sum of lower four bits of all customer ID locations  
+ = Addition  
& = Bitwise AND

# PIC18FXX2/XX8

**TABLE 5-4: CHECKSUM COMPUTATION (CONTINUED)**

Device	Code Protect	Checksum	Blank Value	0xAA at 0 and Max Address
PIC18F252	None	SUM(0000:01FF)+SUM(0200:1FFF)+SUM(2000:3FFF)+SUM(4000:5FFF)+SUM(6000:7FFF)+(CFGW1L & 0000)+(CFGW1H & 0027)+(CFGW2L + 000F)+(CFGW2H & 000F)+(CFGW3L & 0000)+(CFGW3H & 0001)+(CFGW4L & 0085)+(CFGW4H & 0000)+(CFGW5L & 000F)+(CFGW5H & 00C0)+(CFGW6L & 000F)+(CFGW6H & 00E0)+(CFGW7L & 000F)+(CFGW7H & 0040)	82D8	822E
	Boot Block	SUM(0200:1FFF)+SUM(2000:3FFF)+SUM(4000:5FFF)+SUM(6000:7FFF)+(CFGW1L & 0000)+(CFGW1H & 0027)+(CFGW2L + 000F)+(CFGW2H & 000F)+(CFGW3L & 0000)+(CFGW3H & 0001)+(CFGW4L & 0085)+(CFGW4H & 0000)+(CFGW5L & 000F)+(CFGW5H & 00C0)+(CFGW6L & 000F)+(CFGW6H & 00E0)+(CFGW7L & 000F)+(CFGW7H & 0040)+SUM(IDs)	84B7	845D
	Boot/Panel1/Panel2	SUM(4000:5FFF)+SUM(6000:7FFF)+(CFGW1L & 0000)+(CFGW1H & 0027)+(CFGW2L + 000F)+(CFGW2H & 000F)+(CFGW3L & 0000)+(CFGW3H & 0001)+(CFGW4L & 0085)+(CFGW4H & 0000)+(CFGW5L & 000F)+(CFGW5H & 00C0)+(CFGW6L & 000F)+(CFGW6H & 00E0)+(CFGW7L & 000F)+(CFGW7H & 0040)+SUM(IDs)	C2B4	C25A
	All	(CFGW1L & 0000)+(CFGW1H & 0027)+(CFGW2L + 000F)+(CFGW2H & 000F)+(CFGW3L & 0000)+(CFGW3H & 0001)+(CFGW4L & 0085)+(CFGW4H & 0000)+(CFGW5L & 000F)+(CFGW5H & 00C0)+(CFGW6L & 000F)+(CFGW6H & 00E0)+(CFGW7L & 000F)+(CFGW7H & 0040)+SUM(IDs)	02A8	02A3
PIC18F258	None	SUM(0000:01FF)+SUM(0200:1FFF)+SUM(2000:3FFF)+SUM(4000:5FFF)+SUM(6000:7FFF)+(CFGW1L & 0000)+(CFGW1H & 0027)+(CFGW2L + 000F)+(CFGW2H & 000F)+(CFGW3L & 0000)+(CFGW3H & 0000)+(CFGW4L & 0085)+(CFGW4H & 0000)+(CFGW5L & 000F)+(CFGW5H & 00C0)+(CFGW6L & 000F)+(CFGW6H & 00E0)+(CFGW7L & 000F)+(CFGW7H & 0040)	82D7	822D
	Boot Block	SUM(0200:1FFF)+SUM(2000:3FFF)+SUM(4000:5FFF)+SUM(6000:7FFF)+(CFGW1L & 0000)+(CFGW1H & 0027)+(CFGW2L + 000F)+(CFGW2H & 000F)+(CFGW3L & 0000)+(CFGW3H & 0000)+(CFGW4L & 0085)+(CFGW4H & 0000)+(CFGW5L & 000F)+(CFGW5H & 00C0)+(CFGW6L & 000F)+(CFGW6H & 00E0)+(CFGW7L & 000F)+(CFGW7H & 0040)+SUM(IDs)	84B5	845B
	Boot/Panel1/Panel2	SUM(4000:5FFF)+SUM(6000:7FFF)+(CFGW1L & 0000)+(CFGW1H & 0027)+(CFGW2L + 000F)+(CFGW2H & 000F)+(CFGW3L & 0000)+(CFGW3H & 0000)+(CFGW4L & 0085)+(CFGW4H & 0000)+(CFGW5L & 000F)+(CFGW5H & 00C0)+(CFGW6L & 000F)+(CFGW6H & 00E0)+(CFGW7L & 000F)+(CFGW7H & 0040)+SUM(IDs)	C2B2	C258
	All	(CFGW1L & 0000)+(CFGW1H & 0027)+(CFGW2L + 000F)+(CFGW2H & 000F)+(CFGW3L & 0000)+(CFGW3H & 0000)+(CFGW4L & 0085)+(CFGW4H & 0000)+(CFGW5L & 000F)+(CFGW5H & 00C0)+(CFGW6L & 000F)+(CFGW6H & 00E0)+(CFGW7L & 000F)+(CFGW7H & 0040)+SUM(IDs)	02A6	02A1

Legend: **Item**      **Description**  
CFGW =      Configuration Word  
SUM[a:b] =      Sum of locations a to b inclusive  
SUM\_ID =      Byte-wise sum of lower four bits of all customer ID locations  
+ =      Addition  
& =      Bitwise AND

**TABLE 5-4: CHECKSUM COMPUTATION (CONTINUED)**

Device	Code Protect	Checksum	Blank Value	0xAA at 0 and Max Address
PIC18F442	None	SUM(0000:01FF)+SUM(0200:1FFF)+SUM(2000:3FFF)+(CFGW1L & 0000)+(CFGW1H & 0027)+(CFGW2L + 000F)+(CFGW2H & 000F)+(CFGW3L & 0000)+(CFGW3H & 0001)+(CFGW4L & 0085)+(CFGW4H & 0000)+(CFGW5L & 0003)+(CFGW5H & 00C0)+(CFGW6L & 0003)+(CFGW6H & 00E0)+(CFGW7L & 0003)+(CFGW7H & 0040)	C3B4	C20A
	Boot Block	SUM(0200:1FFF)+SUM(2000:3FFF)+(CFGW1L & 0000)+(CFGW1H & 0027)+(CFGW2L + 000F)+(CFGW2H & 000F)+(CFGW3L & 0000)+(CFGW3H & 0001)+(CFGW4L & 0085)+(CFGW4H & 0000)+(CFGW5L & 0003)+(CFGW5H & 00C0)+(CFGW6L & 0003)+(CFGW6H & 00E0)+(CFGW7L & 0003)+(CFGW7H & 0040)+SUM(IDs)	C491	C437
	Boot/Panel1/Panel2	(CFGW1L & 0000)+(CFGW1H & 0027)+(CFGW2L + 000F)+(CFGW2H & 000F)+(CFGW3L & 0000)+(CFGW3H & 0001)+(CFGW4L & 0085)+(CFGW4H & 0000)+(CFGW5L & 0003)+(CFGW5H & 00C0)+(CFGW6L & 0003)+(CFGW6H & 00E0)+(CFGW7L & 0003)+(CFGW7H & 0040)+SUM(IDs)	028E	289
	All	(CFGW1L & 0000)+(CFGW1H & 0027)+(CFGW2L + 000F)+(CFGW2H & 000F)+(CFGW3L & 0000)+(CFGW3H & 0001)+(CFGW4L & 0085)+(CFGW4H & 0000)+(CFGW5L & 0003)+(CFGW5H & 00C0)+(CFGW6L & 0003)+(CFGW6H & 00E0)+(CFGW7L & 0003)+(CFGW7H & 0040)+SUM(IDs)	028E	289
PIC18F448	None	SUM(0000:01FF)+SUM(0200:1FFF)+SUM(2000:3FFF)+(CFGW1L & 0000)+(CFGW1H & 0027)+(CFGW2L + 000F)+(CFGW2H & 000F)+(CFGW3L & 0000)+(CFGW3H & 0000)+(CFGW4L & 0085)+(CFGW4H & 0000)+(CFGW5L & 0003)+(CFGW5H & 00C0)+(CFGW6L & 0003)+(CFGW6H & 00E0)+(CFGW7L & 0003)+(CFGW7H & 0040)	C2B3	C209
	Boot Block	SUM(0200:1FFF)+SUM(2000:3FFF)+(CFGW1L & 0000)+(CFGW1H & 0027)+(CFGW2L + 000F)+(CFGW2H & 000F)+(CFGW3L & 0000)+(CFGW3H & 0000)+(CFGW4L & 0085)+(CFGW4H & 0000)+(CFGW5L & 0003)+(CFGW5H & 00C0)+(CFGW6L & 0003)+(CFGW6H & 00E0)+(CFGW7L & 0003)+(CFGW7H & 0040)+SUM(IDs)	C48F	C435
	Boot/Panel1/Panel2	(CFGW1L & 0000)+(CFGW1H & 0027)+(CFGW2L + 000F)+(CFGW2H & 000F)+(CFGW3L & 0000)+(CFGW3H & 0000)+(CFGW4L & 0085)+(CFGW4H & 0000)+(CFGW5L & 0003)+(CFGW5H & 00C0)+(CFGW6L & 0003)+(CFGW6H & 00E0)+(CFGW7L & 0003)+(CFGW7H & 0040)+SUM(IDs)	028C	287
	All	(CFGW1L & 0000)+(CFGW1H & 0027)+(CFGW2L + 000F)+(CFGW2H & 000F)+(CFGW3L & 0000)+(CFGW3H & 0000)+(CFGW4L & 0085)+(CFGW4H & 0000)+(CFGW5L & 0003)+(CFGW5H & 00C0)+(CFGW6L & 0003)+(CFGW6H & 00E0)+(CFGW7L & 0003)+(CFGW7H & 0040)+SUM(IDs)	028C	287

Legend: Item      Description  
CFGW = Configuration Word  
SUM[a:b] = Sum of locations a to b inclusive  
SUM\_ID = Byte-wise sum of lower four bits of all customer ID locations  
+ = Addition  
& = Bitwise AND

# PIC18FXX2/XX8

**TABLE 5-4: CHECKSUM COMPUTATION (CONTINUED)**

Device	Code Protect	Checksum	Blank Value	0xAA at 0 and Max Address
PIC18F452	None	SUM(0000:01FF)+SUM(0200:1FFF)+SUM(2000:3FFF)+SUM(4000:5FFF)+SUM(6000:7FFF)+(CFGW1L & 0000)+(CFGW1H & 0027)+(CFGW2L + 000F)+(CFGW2H & 000F)+(CFGW3L & 0000)+(CFGW3H & 0001)+(CFGW4L & 0085)+(CFGW4H & 0000)+(CFGW5L & 000F)+(CFGW5H & 00C0)+(CFGW6L & 000F)+(CFGW6H & 00E0)+(CFGW7L & 000F)+(CFGW7H & 0040)	82D8	822E
	Boot Block	SUM(0200:1FFF)+SUM(2000:3FFF)+SUM(4000:5FFF)+SUM(6000:7FFF)+(CFGW1L & 0000)+(CFGW1H & 0027)+(CFGW2L + 000F)+(CFGW2H & 000F)+(CFGW3L & 0000)+(CFGW3H & 0001)+(CFGW4L & 0085)+(CFGW4H & 0000)+(CFGW5L & 000F)+(CFGW5H & 00C0)+(CFGW6L & 000F)+(CFGW6H & 00E0)+(CFGW7L & 000F)+(CFGW7H & 0040)+SUM(IDs)	84B7	845D
	Boot/Panel1/Panel2	SUM(4000:5FFF)+SUM(6000:7FFF)+(CFGW1L & 0000)+(CFGW1H & 0027)+(CFGW2L + 000F)+(CFGW2H & 000F)+(CFGW3L & 0000)+(CFGW3H & 0001)+(CFGW4L & 0085)+(CFGW4H & 0000)+(CFGW5L & 000F)+(CFGW5H & 00C0)+(CFGW6L & 000F)+(CFGW6H & 00E0)+(CFGW7L & 000F)+(CFGW7H & 0040)+SUM(IDs)	C2B4	C25A
	All	(CFGW1L & 0000)+(CFGW1H & 0027)+(CFGW2L + 000F)+(CFGW2H & 000F)+(CFGW3L & 0000)+(CFGW3H & 0001)+(CFGW4L & 0085)+(CFGW4H & 0000)+(CFGW5L & 000F)+(CFGW5H & 00C0)+(CFGW6L & 000F)+(CFGW6H & 00E0)+(CFGW7L & 000F)+(CFGW7H & 0040)+SUM(IDs)	02A8	02A3
PIC18F458	None	SUM(0000:01FF)+SUM(0200:1FFF)+SUM(2000:3FFF)+SUM(4000:5FFF)+SUM(6000:7FFF)+(CFGW1L & 0000)+(CFGW1H & 0027)+(CFGW2L + 000F)+(CFGW2H & 000F)+(CFGW3L & 0000)+(CFGW3H & 0000)+(CFGW4L & 0085)+(CFGW4H & 0000)+(CFGW5L & 000F)+(CFGW5H & 00C0)+(CFGW6L & 000F)+(CFGW6H & 00E0)+(CFGW7L & 000F)+(CFGW7H & 0040)	82D7	822D
	Boot Block	SUM(0200:1FFF)+SUM(2000:3FFF)+SUM(4000:5FFF)+SUM(6000:7FFF)+(CFGW1L & 0000)+(CFGW1H & 0027)+(CFGW2L + 000F)+(CFGW2H & 000F)+(CFGW3L & 0000)+(CFGW3H & 0000)+(CFGW4L & 0085)+(CFGW4H & 0000)+(CFGW5L & 000F)+(CFGW5H & 00C0)+(CFGW6L & 000F)+(CFGW6H & 00E0)+(CFGW7L & 000F)+(CFGW7H & 0040)+SUM(IDs)	84B5	845B
	Boot/Panel1/Panel2	SUM(4000:5FFF)+SUM(6000:7FFF)+(CFGW1L & 0000)+(CFGW1H & 0027)+(CFGW2L + 000F)+(CFGW2H & 000F)+(CFGW3L & 0000)+(CFGW3H & 0000)+(CFGW4L & 0085)+(CFGW4H & 0000)+(CFGW5L & 000F)+(CFGW5H & 00C0)+(CFGW6L & 000F)+(CFGW6H & 00E0)+(CFGW7L & 000F)+(CFGW7H & 0040)+SUM(IDs)	C2B2	C258
	All	(CFGW1L & 0000)+(CFGW1H & 0027)+(CFGW2L + 000F)+(CFGW2H & 000F)+(CFGW3L & 0000)+(CFGW3H & 0000)+(CFGW4L & 0085)+(CFGW4H & 0000)+(CFGW5L & 000F)+(CFGW5H & 00C0)+(CFGW6L & 000F)+(CFGW6H & 00E0)+(CFGW7L & 000F)+(CFGW7H & 0040)+SUM(IDs)	02A6	02A1

Legend: **Item**      **Description**  
CFGW =      Configuration Word  
SUM[a:b] =      Sum of locations a to b inclusive  
SUM\_ID =      Byte-wise sum of lower four bits of all customer ID locations  
+ =      Addition  
& =      Bitwise AND

## 5.6 Embedding Data EEPROM Information In the HEX File

To allow portability of code, a PIC18FXX2/XX8 programmer is required to read the data EEPROM information from the HEX file. If data EEPROM information is not present, a simple warning message should be issued. Similarly, when saving a HEX file, all data EEPROM information must be included. An option to not include the data EEPROM information may be provided. When embedding data EEPROM information in the HEX file, it should start at address F00000h.

Microchip Technology Inc. believes that this feature is important for the benefit of the end customer.



# PIC18FXX2/XX8

## 6.0 AC/DC CHARACTERISTICS TIMING REQUIREMENTS FOR PROGRAM/VERIFY TEST MODE

Standard Operating Conditions Operating Temperature: 10°C to 50°C unless otherwise indicated						
Param No.	Sym	Characteristic	Min	Max	Units	Conditions
D110	VIHH	High Voltage Programming Voltage on MCLR/VPP	9.00	13.25	V	
D110A	VIHL	Low Voltage Programming Voltage on MCLR/VPP	2.00	5.50	V	
D111	VDD	Supply Voltage during programming	2.00	5.50	V	Normal programming
			4.50	5.50	V	Bulk erase operations
D112	IPP	Programming Current on MCLR/VPP	—	300	μA	
D113	IDDP	Supply Current during programming	—	5	mA	
D031	VIL	Input Low Voltage	VSS	0.2 VSS	V	
D041	VIH	Input High Voltage	0.8 VDD	VDD	V	
D080	VOL	Output Low Voltage	—	0.6	V	IOL = 8.5 mA
D090	VOH	Output High Voltage	VDD – 0.7	—	V	IOH = -3.0 mA
D012	CIO	Capacitive loading on I/O pin (SDATA)	—	50	pF	To meet AC specifications
P2	Tclk	Serial Clock (SCLK) period	100	—	ns	VDD = 5.0V
			1	—	μs	VDD = 2.0V
P2A	TclkL	Serial Clock (SCLK) Low time	40	—	ns	VDD = 5.0V
			400	—	ns	VDD = 2.0V
P2B	TclkH	Serial Clock (SCLK) High time	40	—	ns	VDD = 5.0V
			400	—	ns	VDD = 2.0V
P3	Tset1	Input Data Setup Time to serial clock ↓	15	—	ns	
P4	Thld1	Input Data Hold Time from SCLK ↓	15	—	ns	
P5	Tdly1	Delay between 4-bit command and command operand	20	—	ns	
P5A	Tdly1a	Delay between 4-bit command operand and next 4-bit command	20	—	ns	
P6	Tdly2	Delay between last SCLK ↓ of command byte to first SCLK ↑ of read of data word	20	—	ns	
P9	Tdly5	SCLK High time (minimum programming time)	1	—	ms	
P10	Tdly6	SCLK Low time after programming (high voltage discharge time)	5	—	μs	
P11	Tdly7	Delay to allow self-timed data write or bulk erase to occur	10	—	ms	
P12	Thld2	Input Data Hold time from MCLR/VPP ↑	2	—	μs	
P13	Tset2	VDD ↑ Setup time to MCLR/VPP ↑	100	—	ns	
P14	Tvalid	Data Out Valid from SCLK ↑	10	—	ns	
P15	Tset3	PGM ↑ Setup time to MCLR/VPP ↑	2	—	μs	

---

**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."

Code protection is constantly evolving. We at Microchip are committed to continuously improving the code protection features of our products. Attempts to break Microchip's code protection feature may be a violation of the Digital Millennium Copyright Act. If such acts allow unauthorized access to your software or other copyrighted work, you may have a right to sue for relief under that Act.

---

Information contained in this publication regarding device applications and the like is provided only for your convenience and may be superseded by updates. It is your responsibility to ensure that your application meets with your specifications. MICROCHIP MAKES NO REPRESENTATIONS OR WARRANTIES OF ANY KIND WHETHER EXPRESS OR IMPLIED, WRITTEN OR ORAL, STATUTORY OR OTHERWISE, RELATED TO THE INFORMATION, INCLUDING BUT NOT LIMITED TO ITS CONDITION, QUALITY, PERFORMANCE, MERCHANTABILITY OR FITNESS FOR PURPOSE. Microchip disclaims all liability arising from this information and its use. Use of Microchip devices in life support and/or safety applications is entirely at the buyer's risk, and the buyer agrees to defend, indemnify and hold harmless Microchip from any and all damages, claims, suits, or expenses resulting from such use. No licenses are conveyed, implicitly or otherwise, under any Microchip intellectual property rights.

#### **Trademarks**

The Microchip name and logo, the Microchip logo, dsPIC, KEELOQ, KEELOQ logo, MPLAB, PIC, PICmicro, PICSTART, rPIC and UNI/O are registered trademarks of Microchip Technology Incorporated in the U.S.A. and other countries.


FilterLab, Hampshire, HI-TECH C, Linear Active Thermistor, MXDEV, MXLAB, SEEVAL and The Embedded Control Solutions Company are registered trademarks of Microchip Technology Incorporated in the U.S.A.

Analog-for-the-Digital Age, Application Maestro, CodeGuard, dsPICDEM, dsPICDEM.net, dsPICworks, dsSPEAK, ECAN, ECONOMONITOR, FanSense, HI-TIDE, In-Circuit Serial Programming, ICSP, Mindi, MiWi, MPASM, MPLAB Certified logo, MPLIB, MPLINK, mTouch, Octopus, Omniscient Code Generation, PICC, PICC-18, PICDEM, PICDEM.net, PICkit, PICtail, PIC<sup>32</sup> logo, REAL ICE, rLAB, Select Mode, Total Endurance, TSHARC, UniWinDriver, WiperLock and ZENA are trademarks of Microchip Technology Incorporated in the U.S.A. and other countries.

SQTP is a service mark of Microchip Technology Incorporated in the U.S.A.

All other trademarks mentioned herein are property of their respective companies.

© 2010, Microchip Technology Incorporated, Printed in the U.S.A., All Rights Reserved.

 Printed on recycled paper.

**QUALITY MANAGEMENT SYSTEM**  
**CERTIFIED BY DNV**  
**== ISO/TS 16949:2002 ==**

*Microchip received ISO/TS-16949:2002 certification for its worldwide headquarters, design and wafer fabrication facilities in Chandler and Tempe, Arizona; Gresham, Oregon and design centers in California and India. The Company's quality system processes and procedures are for its PIC® MCUs and dsPIC® DSCs, KEELOQ® code hopping devices, Serial EEPROMs, microperipherals, nonvolatile memory and analog products. In addition, Microchip's quality system for the design and manufacture of development systems is ISO 9001:2000 certified.*



## WORLDWIDE SALES AND SERVICE

### AMERICAS

#### Corporate Office

2355 West Chandler Blvd.  
Chandler, AZ 85224-6199  
Tel: 480-792-7200  
Fax: 480-792-7277  
Technical Support:  
<http://support.microchip.com>  
Web Address:  
[www.microchip.com](http://www.microchip.com)

#### Atlanta

Duluth, GA  
Tel: 678-957-9614  
Fax: 678-957-1455

#### Boston

Westborough, MA  
Tel: 774-760-0087  
Fax: 774-760-0088

#### Chicago

Itasca, IL  
Tel: 630-285-0071  
Fax: 630-285-0075

#### Cleveland

Independence, OH  
Tel: 216-447-0464  
Fax: 216-447-0643

#### Dallas

Addison, TX  
Tel: 972-818-7423  
Fax: 972-818-2924

#### Detroit

Farmington Hills, MI  
Tel: 248-538-2250  
Fax: 248-538-2260

#### Kokomo

Kokomo, IN  
Tel: 765-864-8360  
Fax: 765-864-8387

#### Los Angeles

Mission Viejo, CA  
Tel: 949-462-9523  
Fax: 949-462-9608

#### Santa Clara

Santa Clara, CA  
Tel: 408-961-6444  
Fax: 408-961-6445

#### Toronto

Mississauga, Ontario,  
Canada  
Tel: 905-673-0699  
Fax: 905-673-6509

### ASIA/PACIFIC

#### Asia Pacific Office

Suites 3707-14, 37th Floor  
Tower 6, The Gateway  
Harbour City, Kowloon  
Hong Kong  
Tel: 852-2401-1200  
Fax: 852-2401-3431

#### Australia - Sydney

Tel: 61-2-9868-6733  
Fax: 61-2-9868-6755

#### China - Beijing

Tel: 86-10-8528-2100  
Fax: 86-10-8528-2104

#### China - Chengdu

Tel: 86-28-8665-5511  
Fax: 86-28-8665-7889

#### China - Chongqing

Tel: 86-23-8980-9588  
Fax: 86-23-8980-9500

#### China - Hong Kong SAR

Tel: 852-2401-1200  
Fax: 852-2401-3431

#### China - Nanjing

Tel: 86-25-8473-2460  
Fax: 86-25-8473-2470

#### China - Qingdao

Tel: 86-532-8502-7355  
Fax: 86-532-8502-7205

#### China - Shanghai

Tel: 86-21-5407-5533  
Fax: 86-21-5407-5066

#### China - Shenyang

Tel: 86-24-2334-2829  
Fax: 86-24-2334-2393

#### China - Shenzhen

Tel: 86-755-8203-2660  
Fax: 86-755-8203-1760

#### China - Wuhan

Tel: 86-27-5980-5300  
Fax: 86-27-5980-5118

#### China - Xian

Tel: 86-29-8833-7252  
Fax: 86-29-8833-7256

#### China - Xiamen

Tel: 86-592-2388138  
Fax: 86-592-2388130

#### China - Zhuhai

Tel: 86-756-3210040  
Fax: 86-756-3210049

### ASIA/PACIFIC

#### India - Bangalore

Tel: 91-80-3090-4444  
Fax: 91-80-3090-4123

#### India - New Delhi

Tel: 91-11-4160-8631  
Fax: 91-11-4160-8632

#### India - Pune

Tel: 91-20-2566-1512  
Fax: 91-20-2566-1513

#### Japan - Yokohama

Tel: 81-45-471- 6166  
Fax: 81-45-471-6122

#### Korea - Daegu

Tel: 82-53-744-4301  
Fax: 82-53-744-4302

#### Korea - Seoul

Tel: 82-2-554-7200  
Fax: 82-2-558-5932 or  
82-2-558-5934

#### Malaysia - Kuala Lumpur

Tel: 60-3-6201-9857  
Fax: 60-3-6201-9859

#### Malaysia - Penang

Tel: 60-4-227-8870  
Fax: 60-4-227-4068

#### Philippines - Manila

Tel: 63-2-634-9065  
Fax: 63-2-634-9069

#### Singapore

Tel: 65-6334-8870  
Fax: 65-6334-8850

#### Taiwan - Hsin Chu

Tel: 886-3-6578-300  
Fax: 886-3-6578-370

#### Taiwan - Kaohsiung

Tel: 886-7-536-4818  
Fax: 886-7-536-4803

#### Taiwan - Taipei

Tel: 886-2-2500-6610  
Fax: 886-2-2508-0102

#### Thailand - Bangkok

Tel: 66-2-694-1351  
Fax: 66-2-694-1350

### EUROPE

#### Austria - Wels

Tel: 43-7242-2244-39  
Fax: 43-7242-2244-393

#### Denmark - Copenhagen

Tel: 45-4450-2828  
Fax: 45-4485-2829

#### France - Paris

Tel: 33-1-69-53-63-20  
Fax: 33-1-69-30-90-79

#### Germany - Munich

Tel: 49-89-627-144-0  
Fax: 49-89-627-144-44

#### Italy - Milan

Tel: 39-0331-742611  
Fax: 39-0331-466781

#### Netherlands - Drunen

Tel: 31-416-690399  
Fax: 31-416-690340

#### Spain - Madrid

Tel: 34-91-708-08-90  
Fax: 34-91-708-08-91

#### UK - Wokingham

Tel: 44-118-921-5869  
Fax: 44-118-921-5820

01/05/10