PIC18F2331/2431/4331/4431

FLASH Microcontroller Programming Specification

1.0 DEVICE OVERVIEW

This document includes the programming specifications for the following devices:

- PIC18F2331
- PIC18F2431
- PIC18F4331
- PIC18F4431

2.0 PROGRAMMING OVERVIEW OF THE PIC18FXX31

PIC18FXX31 devices can be programmed using either the high voltage In-Circuit Serial Programming™ (ICSP™) method, or the low voltage ICSP method. Both of these can be done with the device in the users' system. The low voltage ICSP method is slightly different than the high voltage method, and these differences are noted where applicable. This programming specification applies to PIC18FXX31 devices in all package types.

2.1 Hardware Requirements

In High Voltage ICSP mode, the PIC18FXX31 requires two programmable power supplies: one for VDD and one for $\overline{MCLR}$/VPP. Both supplies should have a minimum resolution of 0.25V. Refer to Section 6.0 for additional hardware parameters.

2.1.1 LOW VOLTAGE ICSP PROGRAMMING

In Low Voltage ICSP mode, the PIC18FXX31 can be programmed using a VDD source in the operating range. This only means that $\overline{MCLR}$/VPP does not have to be brought to a different voltage but can instead be left at the normal operating voltage. Refer to Section 6.0 for additional hardware parameters.

2.2 Pin Diagrams

The pin diagrams for the PIC18FXX31 family are shown in Figure 2-1, Figure 2-2, and Figure 2-3. The pin descriptions of these diagrams do not represent the complete functionality of the device types. Users should refer to the appropriate device data sheet for complete pin descriptions.

TABLE 2-1: PIN DESCRIPTIONS (DURING PROGRAMMING): PIC18FXX31

Pin Name	During Programming		
	Pin Name	**Pin Type**	**Pin Description**
$\overline{MCLR}$/VPP	VPP	P	Programming Enable
VDD(2)	VDD	P	Power Supply
VSS(2)	VSS	P	Ground
AVDD	AVDD	P	Analog Power Supply
AVSS	AVSS	P	Analog Ground
RB5	PGM	I	Low Voltage ICSP Input when LVP Configuration bit equals '1' (1)
RB6	SCLK	I	Serial Clock
RB7	SDATA	I/O	Serial Data

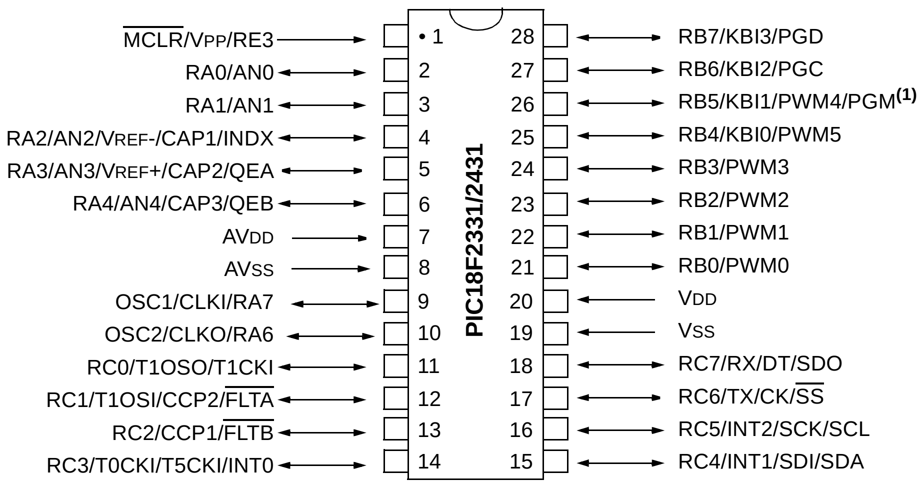
Legend: I = Input, O = Output, P = Power

Note 1: See Section 5.3 for more detail.

2: All power supply and ground must be connected, including AVDD and AVSS.

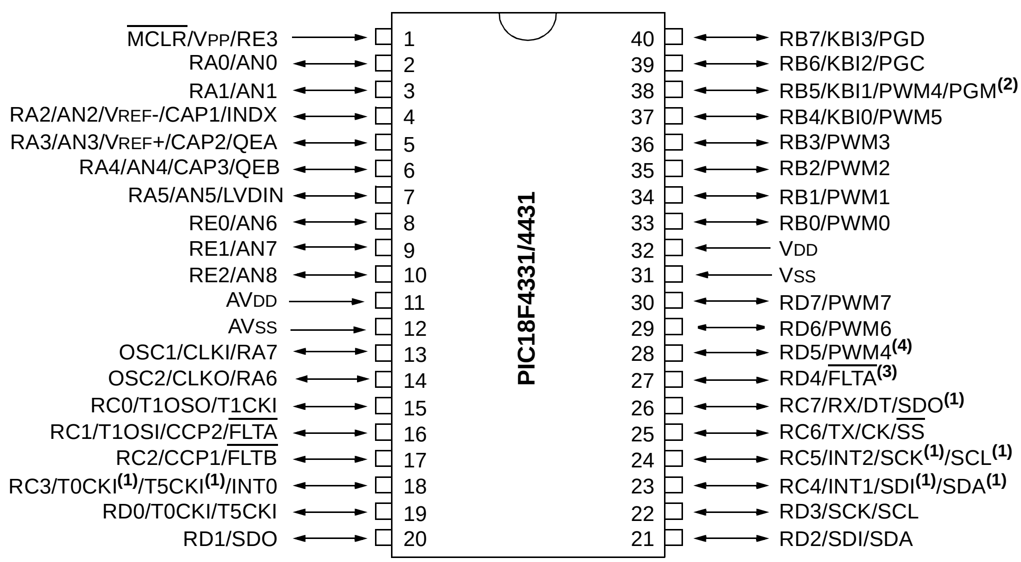
FIGURE 2-1: PIN DIAGRAMS

28-Pin SDIP, SOIC



Note 1: Low voltage programming must be enabled.

40-Pin PDIP



Note 1: RC3 is the alternate pin for T0CKI/T5CKI, RC4 is the alternate pin for SDI/SDA, RC5 is the alternate pin for SCK/SCL.

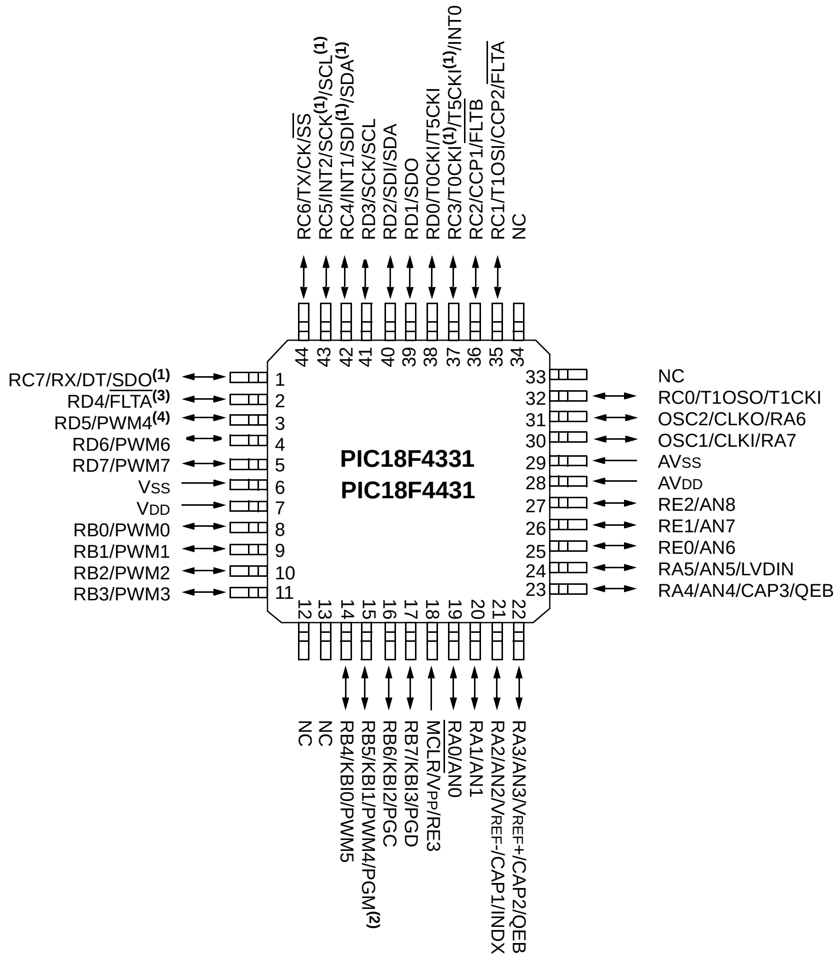
2: Low voltage programming must be enabled.

3: RD4 is the alternate pin for FLTA.

4: RD5 is the alternate pin for PWM4.

FIGURE 2-2: PIN DIAGRAMS (CONTINUED)

44-Pin TQFP



Note 1: RC3 is the alternate pin for T0CKI/T5CKI, RC4 is the alternate pin for SDI/SDA, RC5 is the alternate pin for SCK/SCL.

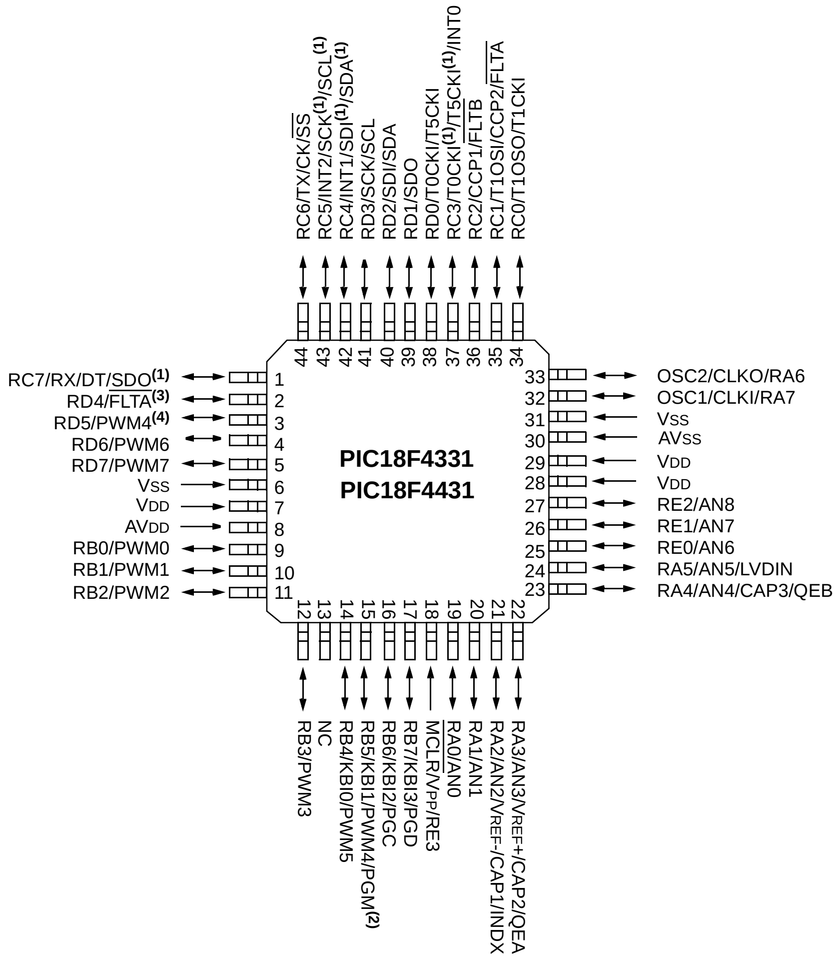
2: Low voltage programming must be enabled.

3: RD4 is the alternate pin for FLTA.

4: RD5 is the alternate pin for PWM4.

FIGURE 2-3: PIN DIAGRAMS (CONTINUED)

44-Pin QFN



Note 1: RC3 is the alternate pin for T0CKI/T5CKI, RC4 is the alternate pin for SDI/SDA, RC5 is the alternate pin for SCK/SCL.

2: Low voltage programming must be enabled.

3: RD4 is the alternate pin for FLTA.

4: RD5 is the alternate pin for PWM4.

2.3 Memory Map

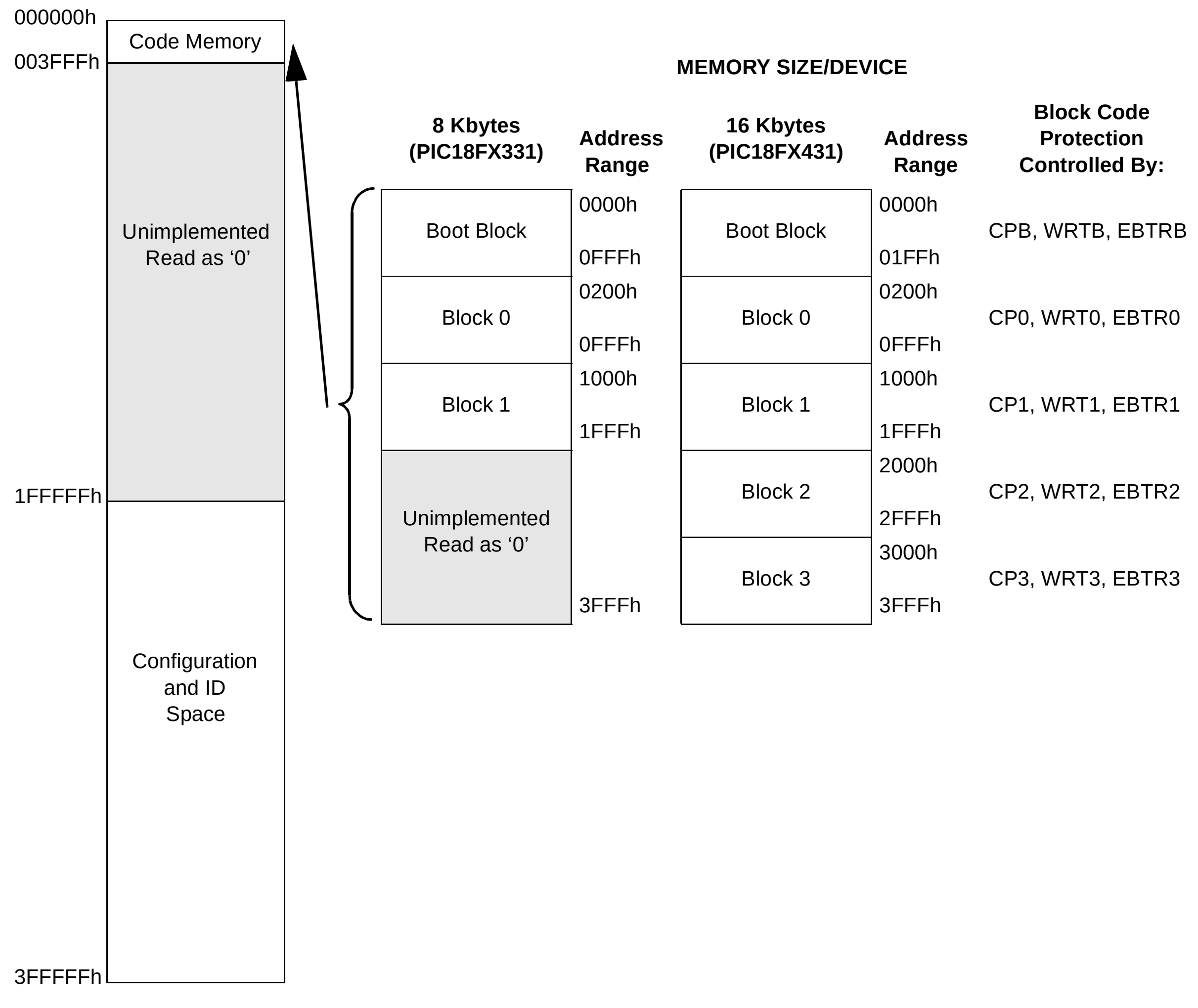
The code memory space extends from 0000h to 3FFFh (16 Kbytes) in four 4-Kbyte blocks. Addresses 0000h through 01FFh, however, define a "Boot Block" region that is treated separately from Block 0. All of these blocks define code protection boundaries within the code memory space.

In contrast, code memory panels are defined in 8-Kbyte boundaries. Panels are discussed in greater detail in Section 3.2.

TABLE 2-2: IMPLEMENTATION OF CODE MEMORY

Device	Code Memory Size (Bytes)
PIC18F2331	000000h - 001FFFh (8K)
PIC18F4331	
PIC18F2431	000000h - 003FFFh (16K)
PIC18F4431	

FIGURE 2-4: MEMORY MAP AND THE CODE MEMORY SPACE FOR PIC18FXX31 DEVICES



Note: Sizes of memory areas not to scale.

In addition to the code memory space, there are three blocks in the configuration and ID space that are accessible to the user through table reads and table writes. Their locations in the memory map are shown in Figure 2-5.

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 300000h through 30000Dh are reserved for the configuration bits. These bits select various device options and are described in Section 5.0. These configuration bits read out normally even after code protection.

Locations 3FFFFEh and 3FFFFFh 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 device ID bits read out normally even after code protection.

2.3.1 MEMORY ADDRESS POINTER

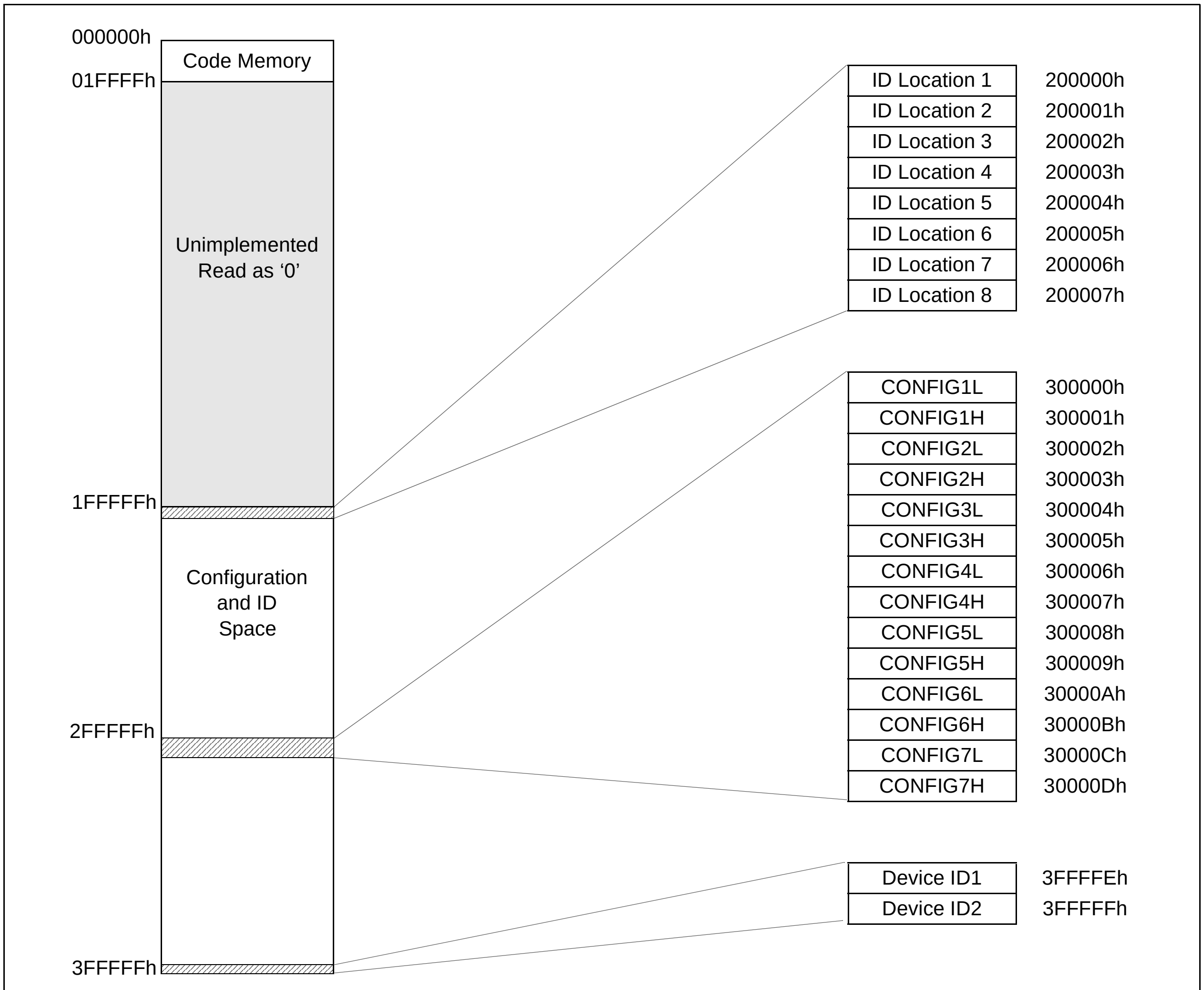
Memory in the address space 0000000h to 3FFFFFh is addressed via the table pointer which is comprised of three pointer registers:

- TBLPTRU, at RAM address 0FF8h
- TBLPTRH, at RAM address 0FF7h
- TBLPTRL, at RAM 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 2-5: CONFIGURATION AND ID LOCATIONS FOR PIC18FXX31 DEVICES



Note: Sizes of memory areas are not to scale.

2.4 High Level Overview of the Programming Process

Figure 2-7 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 $\overline{MCLR}$/VPP to VIHH (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 Program/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 $\overline{MCLR}$/VPP to VIH. 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 Program/Verify mode places all unused I/Os in the high impedance state.

FIGURE 2-7: HIGH LEVEL PROGRAMMING FLOW

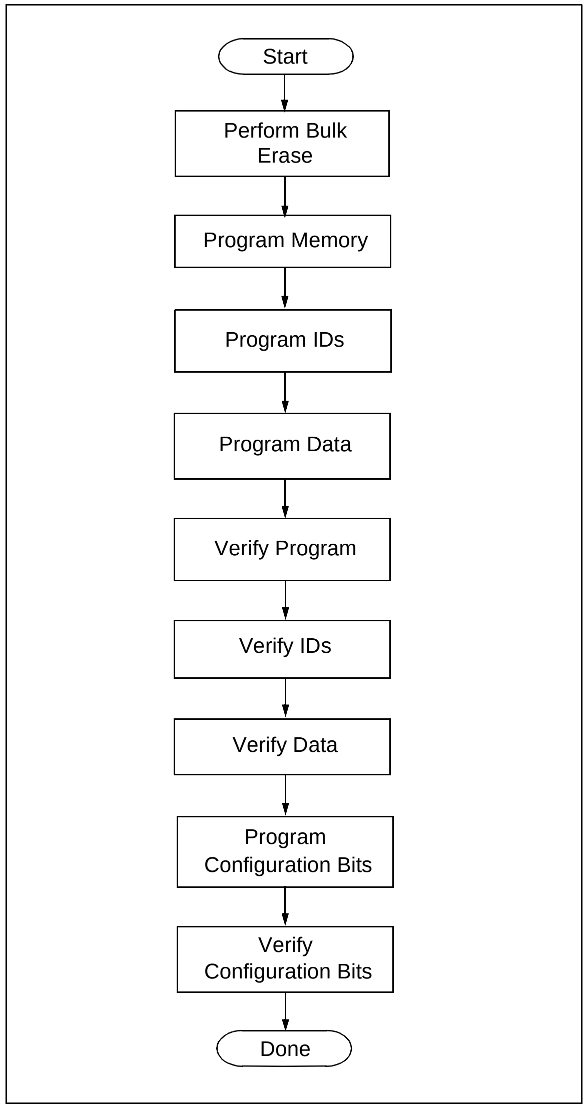


FIGURE 2-6: ENTERING HIGH VOLTAGE PROGRAM/VERIFY MODE

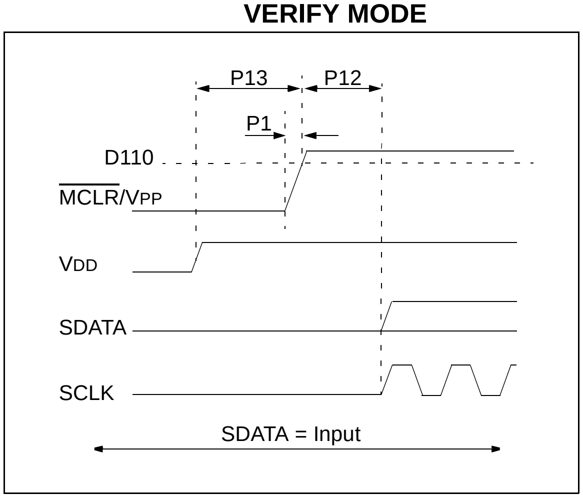
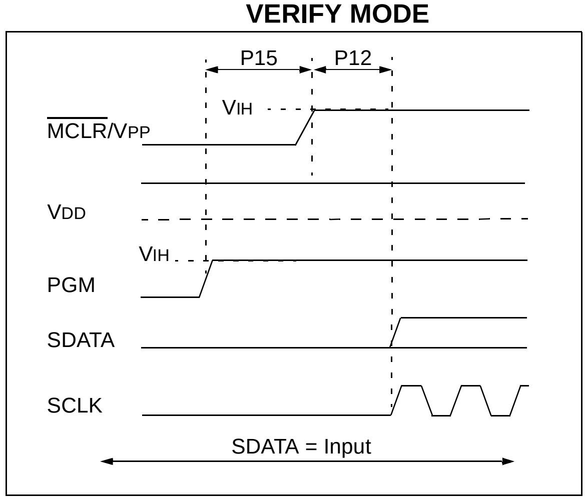


FIGURE 2-8: ENTERING LOW VOLTAGE PROGRAM/VERIFY MODE



2.6 Serial Program/Verify Operation

The SCLK pin is used as a clock input pin and the SDATA pin is used for entering command bits and data input/output during serial operation. Commands and data are transmitted on the rising edge of SCLK, latched on the falling edge of SCLK, and are Least Significant bit (LSb) first.

2.6.1 4-BIT COMMANDS

All instructions are 20 bits, consisting of a leading 4-bit command followed by a 16-bit operand, which depends on the type of command being executed. To input a command, SCLK is cycled four times. The commands needed for programming and verification are shown in Table 2-3.

Depending on the 4-bit command, the 16-bit operand represents 16 bits of input data, or 8 bits of input data and 8 bits of output data.

Throughout this specification, commands and data are presented as illustrated in Table 2-4. The 4-bit command is shown MSb first. The command operand, or "Data Payload", is shown <MSB><LSB>. Figure 2-9 demonstrates how to serially present a 20-bit command/operand to the device.

2.6.2 CORE INSTRUCTION

The core instruction passes a 16-bit instruction to the CPU core for execution. This is needed to setup registers as appropriate for use with other commands.

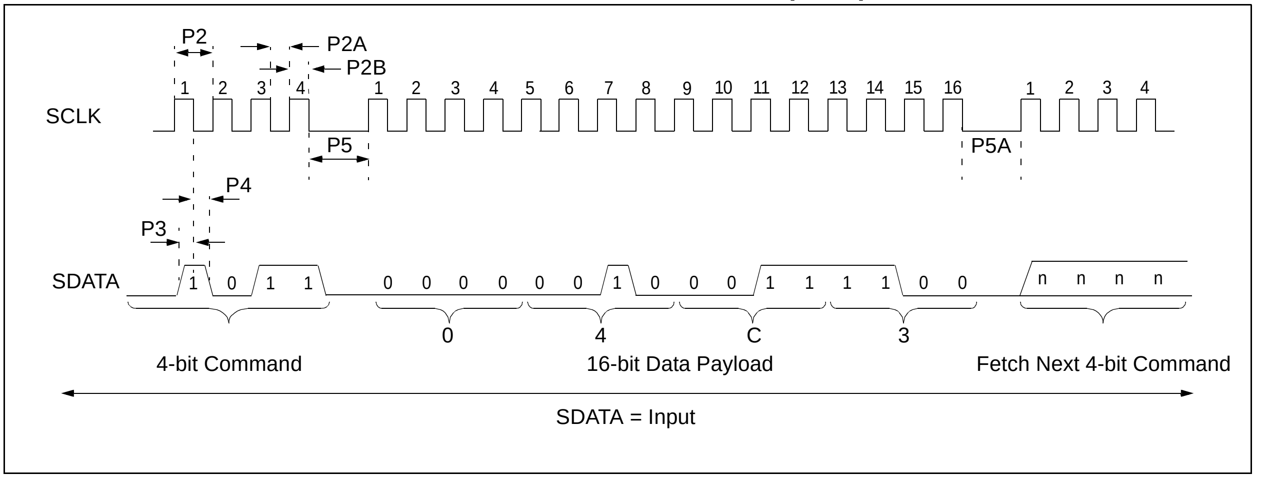
TABLE 2-3: COMMANDS FOR PROGRAMMING

Description	4-Bit Command
Core Instruction (Shift in16-bit instruction)	`0000`
Shift out TABLAT register	`0010`
Table Read	`1000`
Table Read, post-increment	`1001`
Table Read, post-decrement	`1010`
Table Read, pre-increment	`1011`
Table Write	`1100`
Table Write, post-increment by 2	`1101`
Table Write, post-decrement by 2	`1110`
Table Write, start programming	`1111`

TABLE 2-4: SAMPLE COMMAND SEQUENCE

4-Bit Command	Data Payload	Core Instruction
`1101`	`3C 40`	`Table Write,` `post-increment by 2`

FIGURE 2-9: TABLE WRITE, POST-INCREMENT TIMING (`1101`)



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 Block 1	88h
Erase Block 2	89h
Erase Block 3	8Ah
Erase Block 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 NOP 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 Table 3-2 and the flow chart 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.
> Non-code protect bits are not returned to default settings by a bulk erase. These bits should be programmed to ones, as outlined in Section 3.6, “Configuration Bits Programming”.

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

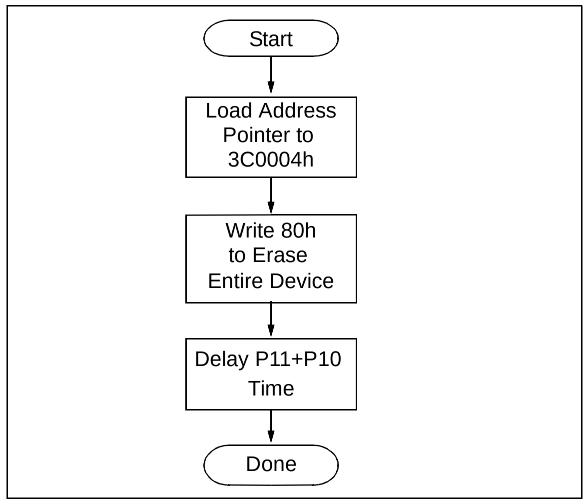
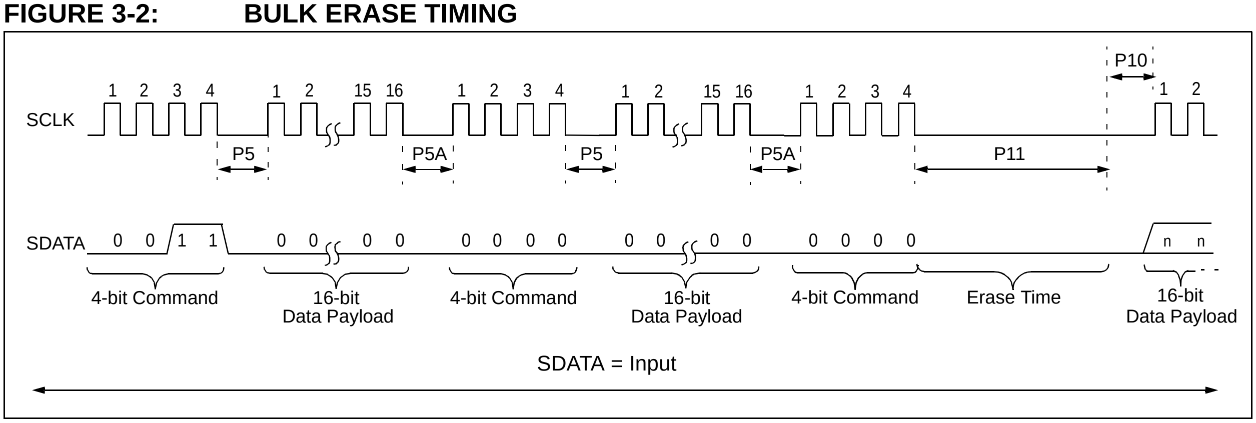


FIGURE 3-2: BULK ERASE TIMING



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 3.3 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 16-Kbyte device (4 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, ‘`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.

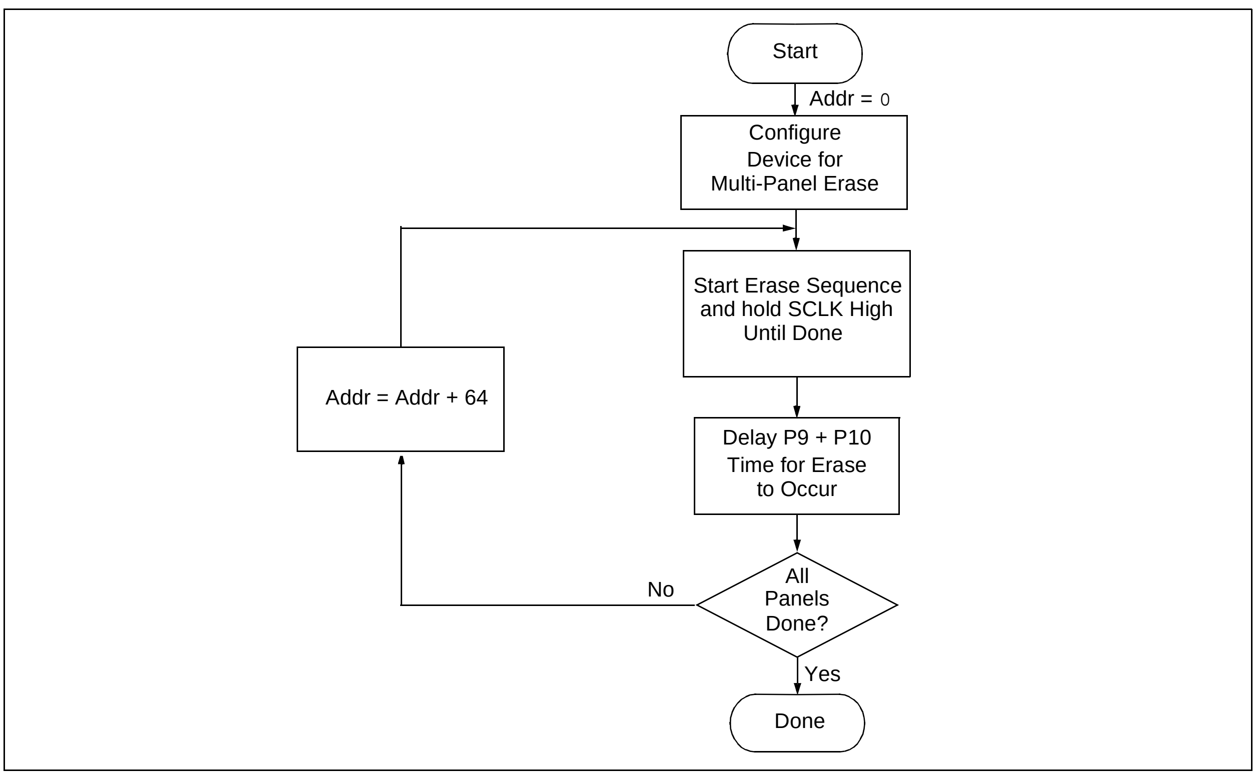
The code sequence to program a PIC18FXX31 device is shown in Table 3-3. The flow chart shown in Figure 3-3 depicts the logic necessary to completely erase a PIC18FXX31 device. The timing diagram that details the “Start Programming” command, and parameters P9 and P10 is shown in Figure 3-6.

Note:	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> <DummyMSB>	Write 2 dummy bytes and start programming.
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



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 2-4) 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 16-Kbyte device (2 panels with an 8-byte buffer per panel), 16 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.

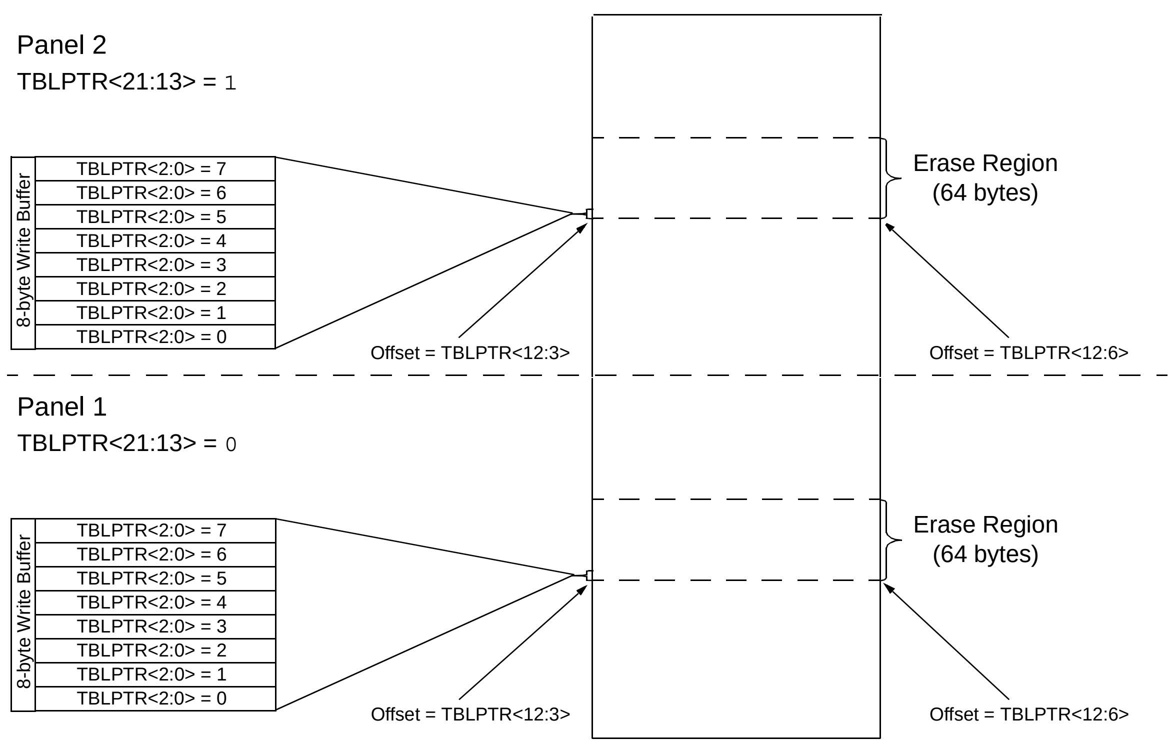
The programming duration is externally timed and is controlled by SCLK. After a “Start Programming” command is issued (4-bit command, ‘1111’), a NOP is issued, where the 4th SCLK is held high for the duration of the programming time, P9.

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 PIC18FXX31 device is shown in Table 3-4. The flow chart shown in Figure 3-5 depicts the logic necessary to completely write a PIC18FXX31 device. The timing diagram that details the “Start Programming” command, and parameters P9 and P10, is shown in Figure 3-6.

Note:	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



Note: TBLPTR = TBLPTRU:TBLPTRH:TBLPTRL.

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

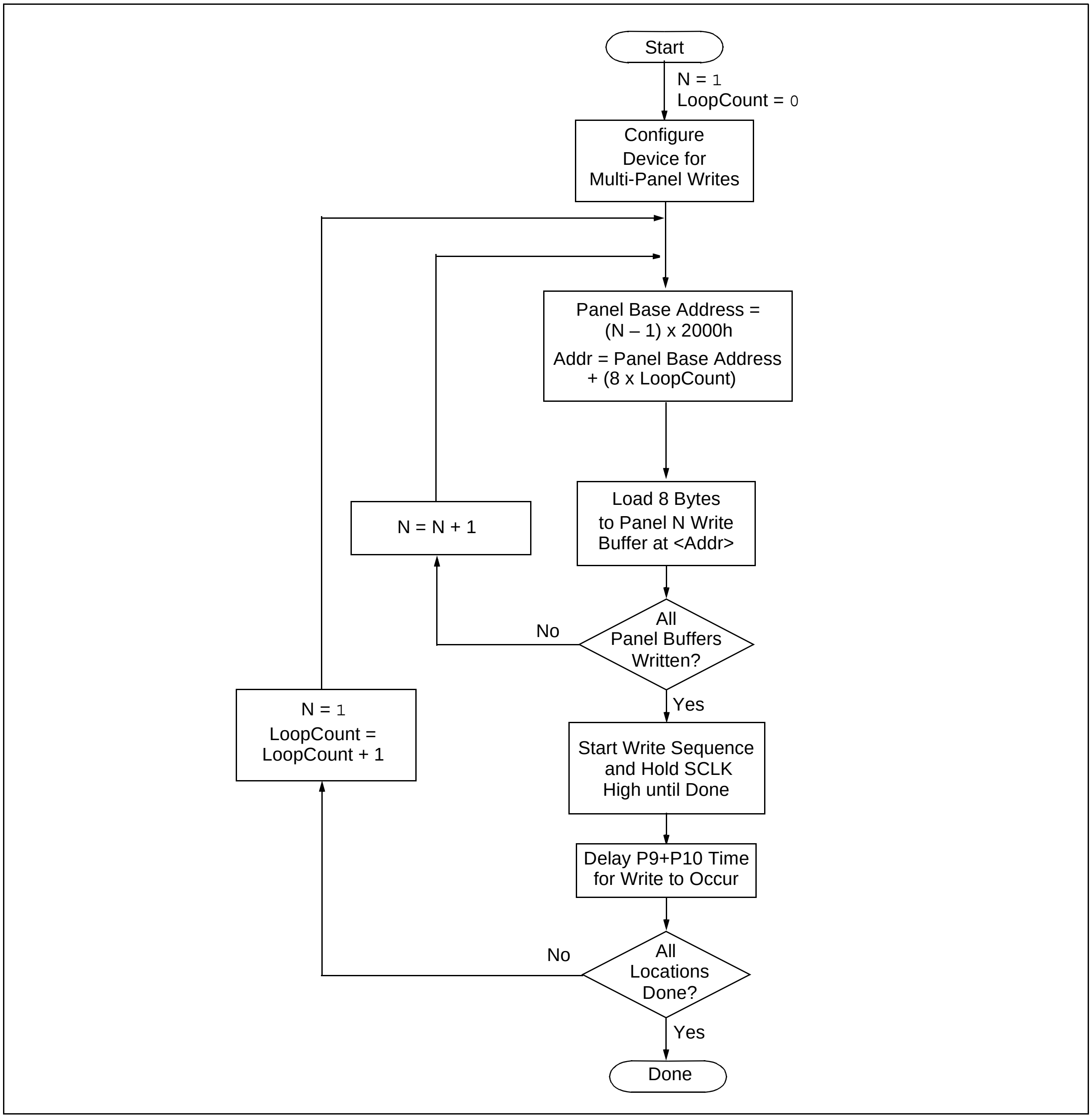
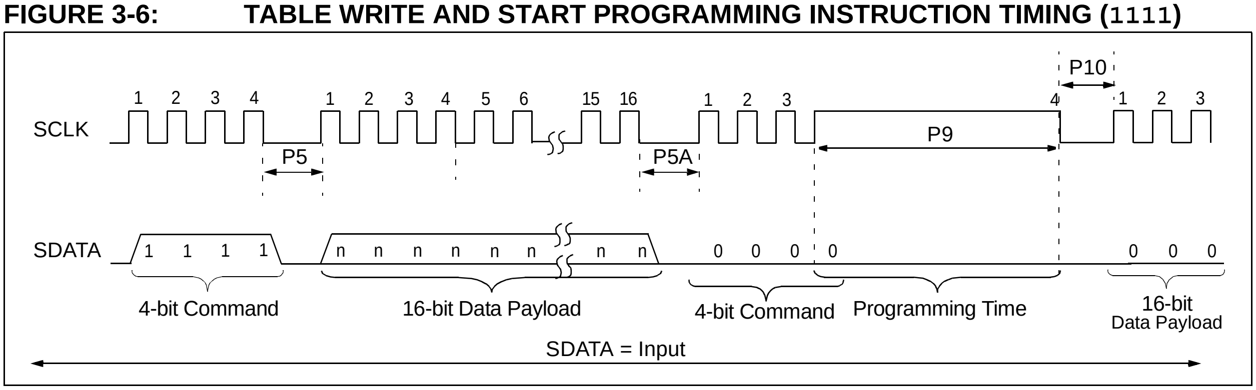


FIGURE 3-6: TABLE WRITE AND START PROGRAMMING INSTRUCTION TIMING (1111)



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.

Note:	Even though multi-panel writes are disabled, 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 has been bulk erased prior to programming (see Section 3.1). It may be the case, however, that the user wishes to modify only a section of an already programmed device.

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 set up 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.		

3.3 Data EEPROM Programming

Data EEPROM is accessed one byte at a time via an address pointer (register pair EEADR:EEADRH) and a data latch (EEDATA). Data EEPROM is written by loading EEADR:EEADRH 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, both the EEPGD and CFGS bits must be cleared (EECON1<7:6> = `00`). 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 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 begins on the falling edge of the 4th SCLK after the WR bit is set. It ends when the WR bit is cleared by hardware.

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

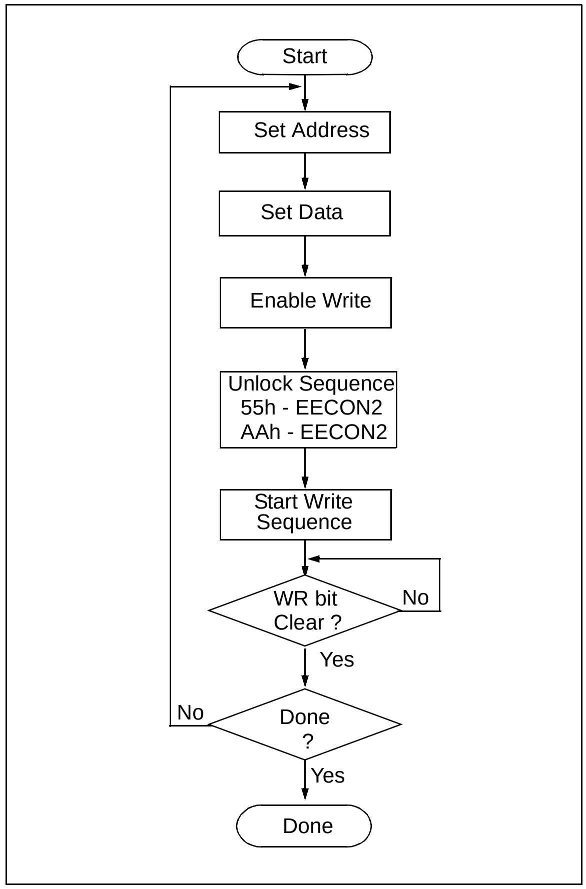


FIGURE 3-8: DATA EEPROM WRITE TIMING

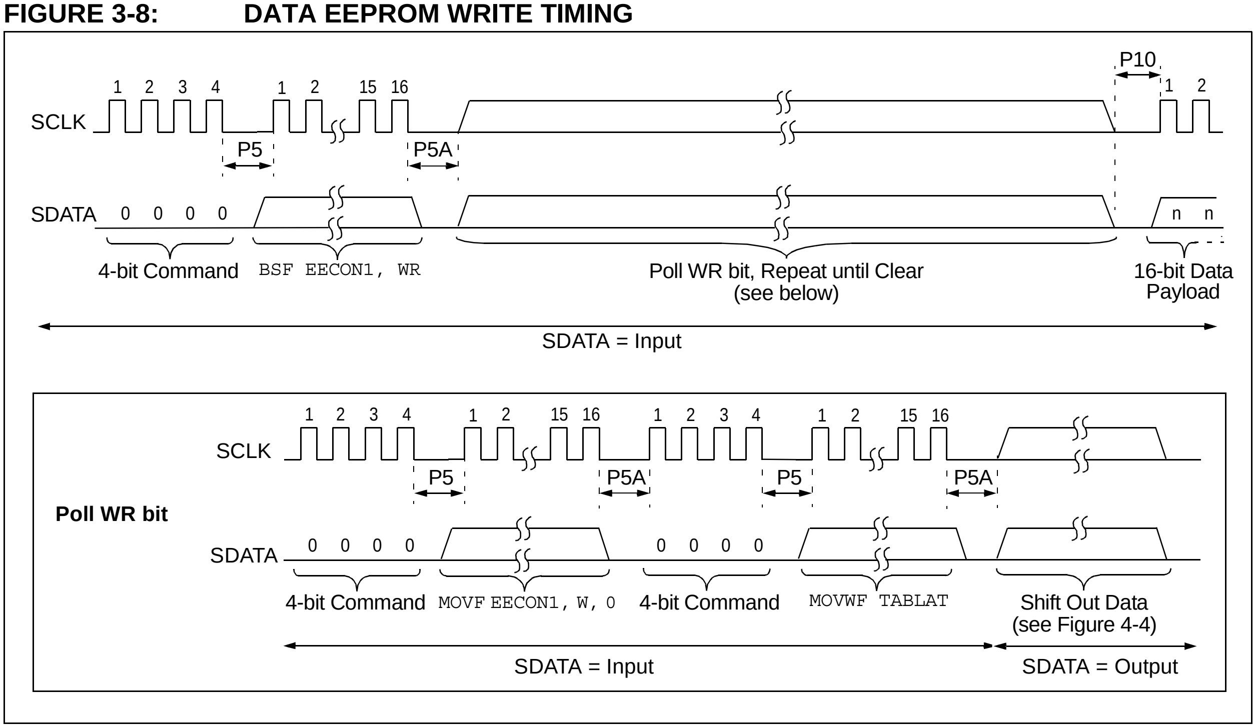


TABLE 3-6: PROGRAMMING DATA MEMORY

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

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:	Even though multi-panel writes are disabled, the user must still fill the 8-byte data buffer for the panel.

Table 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 Table 3-7 should be used, except that the address data used in “Step 2” 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 Table 3-8.

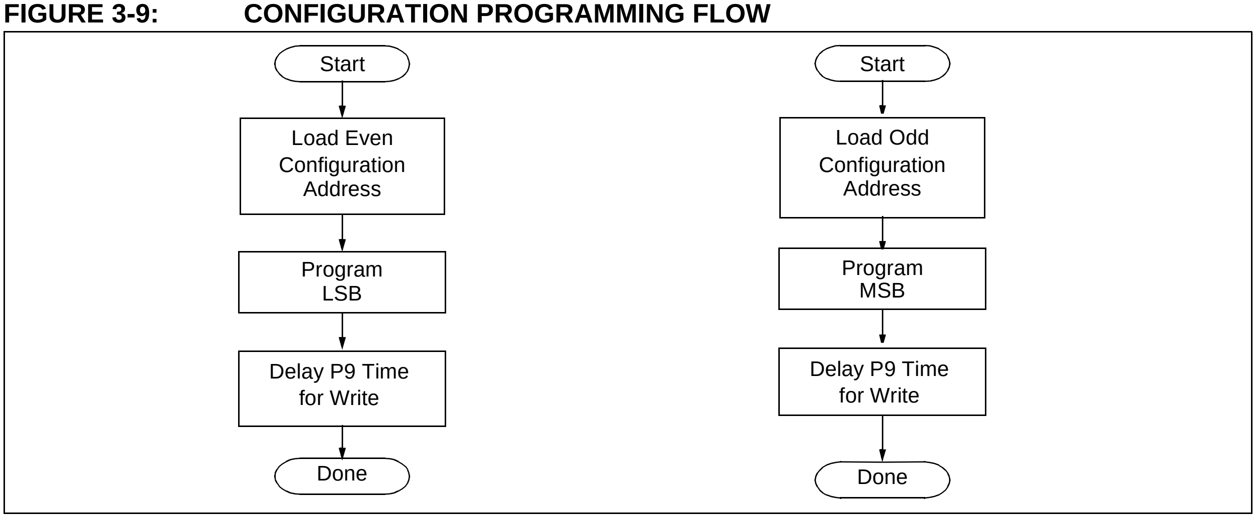
TABLE 3-8: SET ADDRESS POINTER TO CONFIGURATION LOCATION

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[(1)].		
0000	EF 00	GOTO 100000h
0000	F8 00	
Step 3[(2)]: 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 write. To avoid this situation, move the program counter outside the code protection area (e.g., `GOTO 100000h`).

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



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.

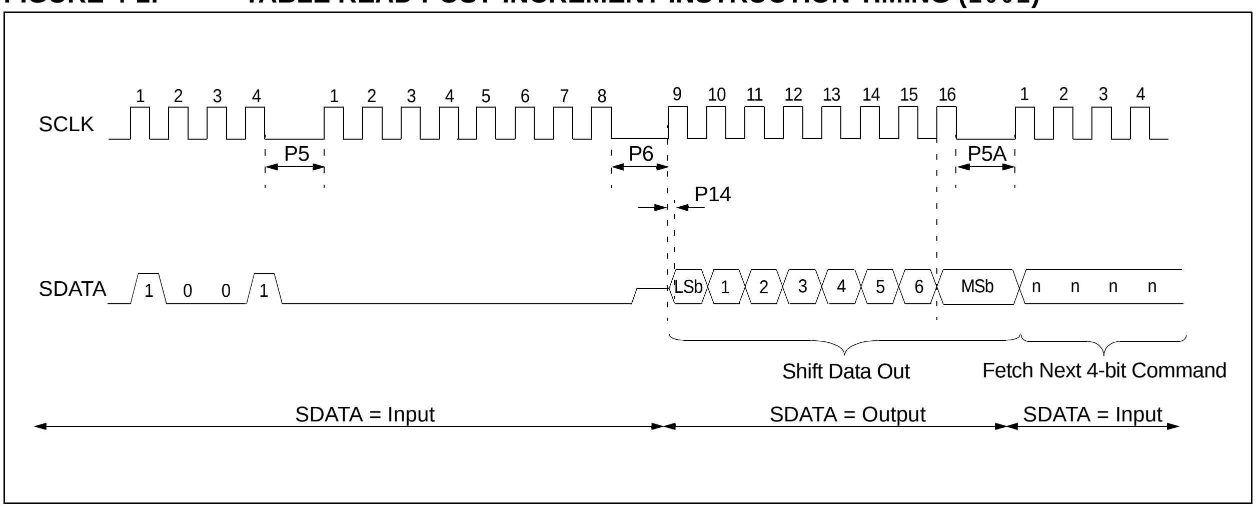
The 4-bit command is shifted in LSb first. The table read is executed during the next 8 clocks, then shifted out on SDATA during the last 8 clocks, LSb to MSb. A delay of P6 must be introduced after the falling edge of the 8th SCLK of the operand to allow SDATA to transition from an input to an output. During this time, SCLK must be held low (see Figure 4-1). This operation also increments the table 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 3FFFFFh 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 0000 0000 0000 0000 0000	0E <Addr[21:16]> 6E F8 0E <Addr[15:8]> 6E F7 0E <Addr[7:0]> 6E F6	MOVLW Addr[21:16] MOVWF TBLPTRU MOVLW <Addr[15:8]> MOVWF TBLPTRH MOVLW <Addr[7:0]> 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)

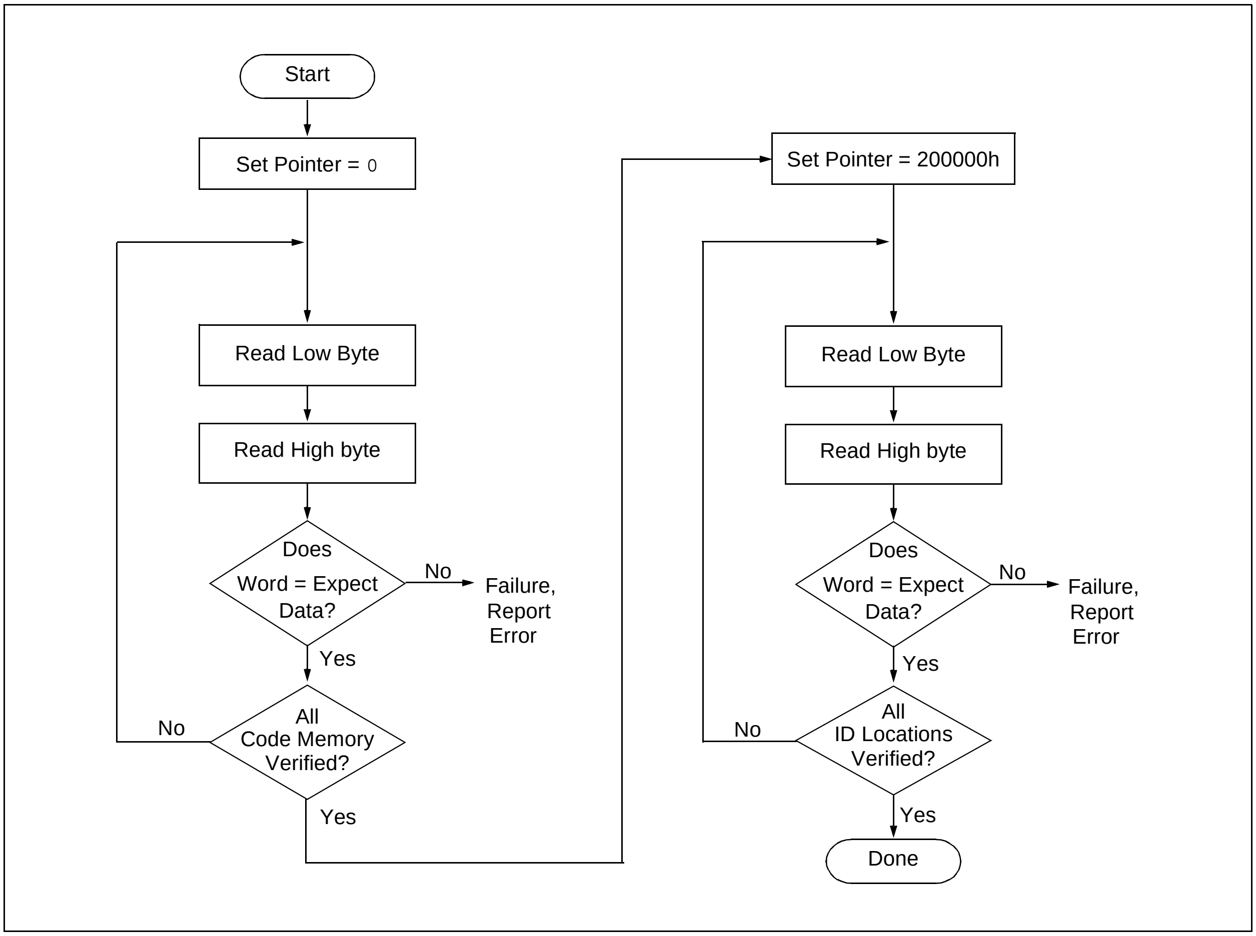


4.2 Verify Code Memory and ID Locations

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 the code memory space. In a 16-Kbyte device, for example, a post-increment read of address 3FFFh will wrap the table pointer back to 0000h, rather than point to unimplemented address 4000h.

FIGURE 4-2: VERIFY CODE MEMORY FLOW



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 byte-wise 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 (register pair EEADR:EEADRH) and a data latch (EEDATA). Data EEPROM is read by loading EEADR:EEADRH 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 Table 4-2.

FIGURE 4-3: READ DATA EEPROM FLOW

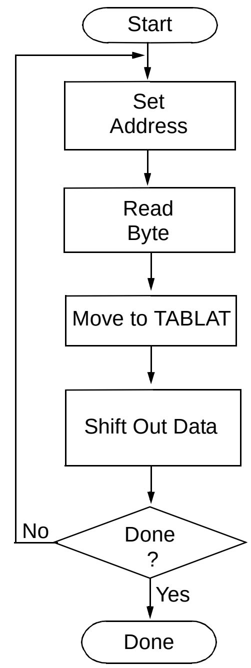
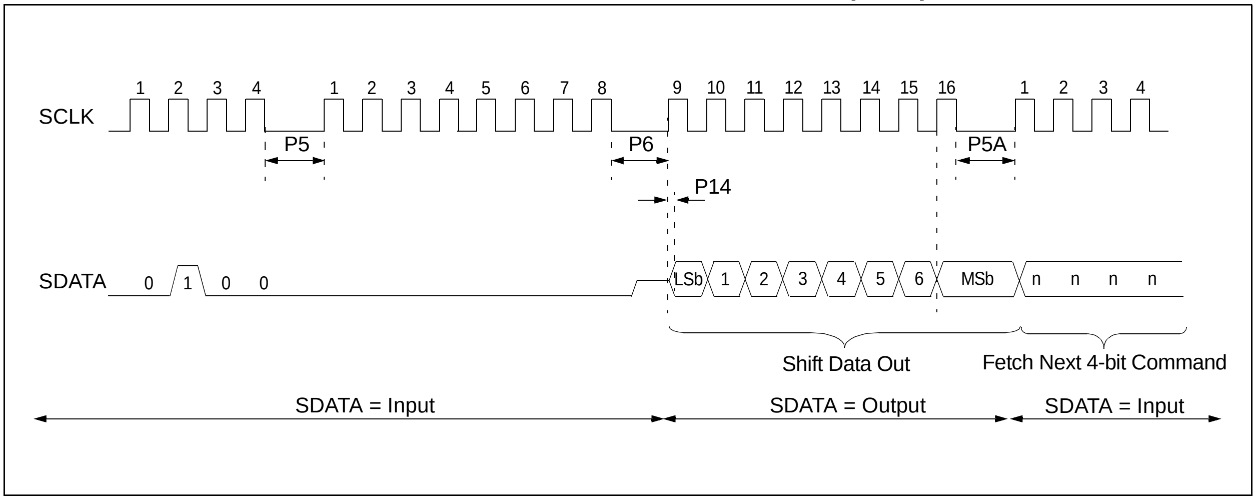


TABLE 4-2: READ DATA EEPROM MEMORY

4-Bit Command	Data Payload	Core Instruction
Step 1: Direct access to data EEPROM.		
0000 0000	9E A6 9C A6	BCF EECON1, EEPGD BCF EECON1, CFGS
Step 2: Set the data EEPROM address pointer.		
0000 0000 0000 0000	0E <Addr> 6E A9 OE <AddrH> 6E AA	MOVLW <Addr> MOVWF EEADR MOVLW <AddrH> 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 0000 0010	50 A8 6E F5 <LSB><MSB>	MOVF EEDATA, W, 0 MOVWF TABLAT Shift Out Data(1)

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.

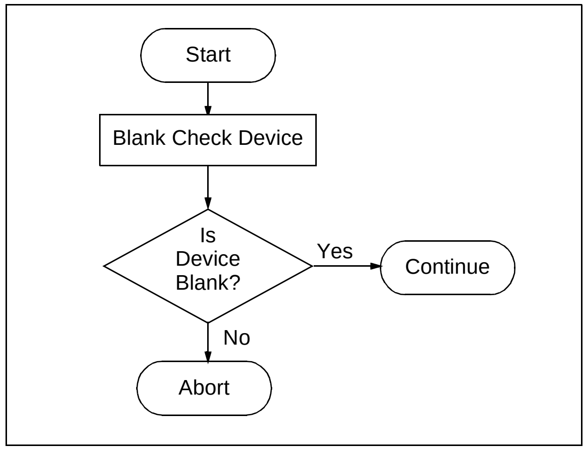
4.6 Blank Check

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 and Table 5-3 for blank configuration expect data for the various PIC18FXX31 devices.

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



5.0 CONFIGURATION WORD

The PIC18FXX31 devices have 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 protection.

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 PIC18FXX31 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 protection.

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 $\overline{\text{MCLR}}/V_{PP}$ is raised to V_{IHH}. 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_{IHH} to the $\overline{\text{MCLR}}/V_{PP}$ pin.

2: While in Low Voltage ICSP mode, the RB5 pin can no longer be used as a general purpose I/O.

TABLE 5-1: DEVICE ID VALUES

Device	Device ID Value	
	DEVID2	**DEVID1**
PIC18F2331	08h	E0h
PIC18F2431	08h	C0h
PIC18F4331	08h	A0h
PIC18F4431	08h	80h

Note: The 'x's in DEVID1 contain the device revision code.

TABLE 5-2: PIC18FX431 CONFIGURATION BITS AND DEVICE IDS

File Name		Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	Default/ Unprogrammed Value
300001h	CONFIG1H	IESO	FCMEM	—	—	FOSC3	FOSC2	FOSC1	FOSC0	1100 1111
300002h	CONFIG2L	—	—	—	—	BORV1	BORV0	BODEN	$\overline{\text{PWRTEN}}$	0000 1111
300003h	CONFIG2H	—	—	WINEN	WDPS3	WDTPS2	WDTPS1	WDTPS0	WDTEN	0011 1111
300004h	CONFIG3L	—	—	$\overline{\text{T5REN}}$	HPOL	LPOL	PWMPIN	—	—	0011 1100
300005h	CONFIG3H	MCLRE	—	—	EXCLKMX	PWM4MX	SSPMX	—	FLTAMX	1001 1101
300006h	CONFIG4L	$\overline{\text{DEBUG}}$	—	—	—	—	LVP	—	STVREN	1000 0101
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

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

TABLE 5-3: PIC18FX331 CONFIGURATION BITS AND DEVICE IDS

File Name		Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	Default/ Unprogrammed Value
300001h	CONFIG1H	IESO	FCMEM	—	—	FOSC3	FOSC2	FOSC1	FOSC0	1100 1111
300002h	CONFIG2L	—	—	—	—	BORV1	BORV0	BODEN	$\overline{\text{PWRTEN}}$	0000 1111
300003h	CONFIG2H	—	—	WINEN	WDPS3	WDTPS2	WDTPS1	WDTPS0	WDTEN	0011 1111
300004h	CONFIG3L	—	—	$\overline{\text{T5REN}}$	HPOL	LPOL	PWMPIN	—	—	0011 1100
300005h	CONFIG3H	MCLRE	—	—	EXCLKMX	PWM4MX	SSPMX	—	FLTAMX	1001 1101
300006h	CONFIG4L	$\overline{\text{DEBUG}}$	—	—	—	—	LVP	—	STVREN	1000 0101
300008h	CONFIG5L	—	—	—	—	—	—	CP1	CP0	0000 0011
300009h	CONFIG5H	CPD	CPB	—	—	—	—	—	—	1100 0000
30000Ah	CONFIG6L	—	—	—	—	—	—	WRT1	WRT0	0000 0011
30000Bh	CONFIG6H	WRTD	WRTB	WRTC	—	—	—	—	—	1110 0000
30000Ch	CONFIG7L	—	—	—	—	—	—	EBTR1	EBTR0	0000 0011
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

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

TABLE 5-4: PIC18FXX31 CONFIGURATION BIT DESCRIPTIONS

Bit Name	Configuration Words	Description
IESO	CONFIG1H	Internal External Switch Over bit 1 = Internal External Switch Over mode enabled 0 = Internal External Switch Over mode disabled
FCMEN	CONFIG1H	Fail-Safe Clock Monitor Enable bit 1 = Fail-Safe Clock Monitor enabled 0 = Fail-Safe Clock Monitor disabled
FOSC<3:0>	CONFIG1H	Oscillator Selection bits 11xx = External RC oscillator, CLKO function on RA6 101x = External RC oscillator, CLKO function on RA6 1001 = Internal RC oscillator, CLKO function on RA6, and port function on RA7 1000 = Internal RC oscillator, port function on RA6, and port function on RA7 0111 = External RC oscillator, port function on RA6 0110 = HS oscillator, PLL enabled (clock frequency = 4 x FOSC1) 0101 = EC oscillator, port function on RA6 0100 = EC oscillator, CLKO function on RA6 0011 = External RC oscillator, CLKO function on RA6 0010 = HS oscillator 0001 = XT oscillator 0000 = LP oscillator
BORV<1:0>	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 = Disabled
$\overline{\text{PWRTEN}}$	CONFIG2L	Power-up Timer Enable bit 1 = PWRT disabled 0 = Enabled

Note 1: Polarity control bits HPOL and LPOL define PWM signal output active and inactive states, PWM states generated by the fault inputs or PWM manual override.

2: PWM6 and PWM7 output channels are only available on the PIC18F4X21 devices.

3: When PWMPIN = 0, PWMEN<2:0> = 101 if device has eight PWM output pins (40 and 44-pin devices) and PWMEN<2:0> = 100 if the device has six PWM output pins (28-pin device). PWM output polarity is defined by HPOL and LPOL.

4: This bit is reserved on PIC18F2X31 devices and should be maintained set (i.e., equal to ‘1’).

5: For PIC18FX431 devices only.

TABLE 5-4: PIC18FXX31 CONFIGURATION BIT DESCRIPTIONS (CONTINUED)

Bit Name	Configuration Words	Description
WINEN	CONFIG2H	Watchdog Timer Window Enable bit 1 = Enable window comparison 0 = Disable window comparison
WDPS<3:0>	CONFIG2H	Watchdog Timer Postscale Select bits 1111 = 1:32,768 1110 = 1:16,384 1101 = 1:8,192 1100 = 1:4,096 1011 = 1:2,048 1010 = 1:1,024 1001 = 1:512 1000 = 1:256 0111 = 1:128 0110 = 1:64 0101 = 1:32 0100 = 1:16 0011 = 1:8 0010 = 1:4 0001 = 1:2 0000 = 1:1
WDTEN	CONFIG2H	Watchdog Timer Enable bit 1 = WDT enabled 0 = WDT disabled (control is placed on the SWDTEN bit in WDTCON register)
$\overline{\text{GPTREN}}$	CONFIG3L	GPT Reset upon CAP1 Special Event Trigger bit 1 = Special Event Reset enable ($\overline{\text{RESEN}}$ in TMR5CON register) is inactive. 0 = Special Event Reset enable ($\overline{\text{RESEN}}$ in TMR5CON register) is active and can enable the special event trigger signal from IC1 to reset the TMR5 time base.
HPOL(1)	CONFIG3L	High Side Transistors Polarity bit (i.e., Odd PWM Output Polarity Control bit) 1 = PWM 1, 3, 5, and 7 are active high (default) 0 = PWM 1, 3, 5, and 7 are active low
LPOL(1)	CONFIG3L	Low Side Transistors Polarity bit (i.e., Even PWM Output Polarity Control bit) 1 = PWM 0, 2, 4, and 6 are active high (default) 0 = PWM 0, 2, 4, and 6 are active low
PWMPIN(2)	CONFIG3L	PWM Output Pins RESET State Control bit 1 = PWM outputs disabled upon RESET (default) 0 = PWM outputs drive active states upon RESET(3)

Note 1: Polarity control bits HPOL and LPOL define PWM signal output active and inactive states, PWM states generated by the fault inputs or PWM manual override.

2: PWM6 and PWM7 output channels are only available on the PIC18F4X21 devices.

3: When PWMPIN = 0, PWMEN<2:0> = 101 if device has eight PWM output pins (40 and 44-pin devices) and PWMEN<2:0> = 100 if the device has six PWM output pins (28-pin device). PWM output polarity is defined by HPOL and LPOL.

4: This bit is reserved on PIC18F2X31 devices and should be maintained set (i.e., equal to ‘1’).

5: For PIC18FX431 devices only.

TABLE 5-4: PIC18FXX31 CONFIGURATION BIT DESCRIPTIONS (CONTINUED)

Bit Name	Configuration Words	Description
MCLRE	CONFIG3H	$\overline{\text{MCLR}}$ Pin Enable bit 1 = $\overline{\text{MCLR}}$ pin enabled; RE3 input pin disabled 0 = RE3 input pin enabled; $\overline{\text{MCLR}}$ disabled
EXCLKMX(4)	CONFIG3H	TMR0/GPCKI External Clock Mux bit 1 = TMR0/T5CKI external clock input is multiplexed with RC3 0 = TMR0/T5CKI external clock input is multiplexed with RD0
PWM4MX(4)	CONFIG3H	PWM4 Mux bit 1 = PWM4 output is multiplexed with RB5 0 = PWM4 output is multiplexed with RD5
SSPMX(4)	CONFIG3H	SSP I/O Mux bit 1 = SCK/SCL clocks and SDA/SDI data are multiplexed with RC5 and RC4, respectively. SDO output is multiplexed with RC7. 0 = SCK/SCL clocks and SDA/SDI data are multiplexed with RD3 and RD2, respectively. SDO output is multiplexed with RD1.
FLTAMX(4)	CONFIG3H	$\overline{\text{FLTA}}$ Mux bit 1 = $\overline{\text{FLTA}}$ input is multiplexed with RC1 0 = $\overline{\text{FLTA}}$ input is multiplexed with RD4
$\overline{\text{BKBUG}}$	CONFIG4L	Background Debugger Enable bit 1 = Background debugger disabled (RB6,RB7 have I/O port function) 0 = Background debugger functions enabled (RB6, RB7 have ICSP serial communication function)
LVP	CONFIG4L	Low Voltage Programming Enable bit 1 = Low voltage programming enabled 0 = Low voltage programming disabled
STVREN	CONFIG4L	Stack Overflow Reset Enable bit 1 = RESET on stack overflow/underflow enabled 0 = RESET on stack overflow/underflow disabled
CP3(5)	CONFIG5L	Code Protection bit 1 = Block 3 (003000h-003FFFh) not code protected 0 = Block 3 (003000h-003FFFh) code protected
CP2(5)	CONFIG5L	Code Protection bit 1 = Block 2 (002000h-002FFFh) not code protected 0 = Block 2 (002000h-002FFFh) code protected
CP1	CONFIG5L	Code Protection bit 1 = Block 1 (001000h-001FFFh) not code protected 0 = Block 1 (001000h-001FFFh) code protected
CP0	CONFIG5L	Code Protection bit 1 = Block 0 (000200h-000FFFh) not code protected 0 = Block 0 (000200h-000FFFh) code protected

Note 1: Polarity control bits HPOL and LPOL define PWM signal output active and inactive states, PWM states generated by the fault inputs or PWM manual override.

2: PWM6 and PWM7 output channels are only available on the PIC18F4X21 devices.

3: When PWMPIN = 0, PWMEN<2:0> = 101 if device has eight PWM output pins (40 and 44-pin devices) and PWMEN<2:0> = 100 if the device has six PWM output pins (28-pin device). PWM output polarity is defined by HPOL and LPOL.

4: This bit is reserved on PIC18F2X31 devices and should be maintained set (i.e., equal to ‘1’).

5: For PIC18FX431 devices only.

TABLE 5-4: PIC18FXX31 CONFIGURATION BIT DESCRIPTIONS (CONTINUED)

Bit Name	Configuration Words	Description
CPD	CONFIG5H	Code Protection bit Data EEPROM 1 = Data EEPROM not code protected 0 = Data EEPROM code protected
CPB	CONFIG5H	Code Protection bit 1 = Boot block (000000-0001FFh) not code protected 0 = Boot block (000000-0001FFh) code protected
WRT3[(5)]	CONFIG6L	Write Protection bit 1 = Block 3 (003000h-003FFFh) not write protected 0 = Block 3 (003000h-003FFFh) write protected
WRT2[(5)]	CONFIG6L	Write Protection bit 1 = Block 2 (002000h-002FFFh) not write protected 0 = Block 2 (002000h-002FFFh) write protected
WRT1	CONFIG6L	Write Protection bit 1 = Block 1 (001000h-001FFFh) not write protected 0 = Block 1 (001000h-001FFFh) write protected
WRT0	CONFIG6L	Write Protection bit 1 = Block 0 (000200h-000FFFh) not write protected 0 = Block 0 (000200h-000FFFh) write protected
WRTD	CONFIG6H	Write Protection bit Data EEPROM 1 = Data EEPROM not write protected 0 = Data EEPROM write protected
WRTB	CONFIG6H	Write Protection bit 1 = Boot block (000000h-0001FFh) not write protected 0 = Boot block (000000h-0001FFh) write protected
WRTC	CONFIG6H	Write Protection bit[(1)] 1 = Configuration registers (300000h-3000FF) not write protected 0 = Configuration registers (300000h-3000FF) write protected

Note 1: Polarity control bits HPOL and LPOL define PWM signal output active and inactive states, PWM states generated by the fault inputs or PWM manual override.

2: PWM6 and PWM7 output channels are only available on the PIC18F4X21 devices.

3: When PWMPIN = 0, PWMEN<2:0> = 101 if device has eight PWM output pins (40 and 44-pin devices) and PWMEN<2:0> = 100 if the device has six PWM output pins (28-pin device). PWM output polarity is defined by HPOL and LPOL.

4: This bit is reserved on PIC18F2X31 devices and should be maintained set (i.e., equal to ‘1’).

5: For PIC18FX431 devices only.

TABLE 5-4: PIC18FXX31 CONFIGURATION BIT DESCRIPTIONS (CONTINUED)

Bit Name	Configuration Words	Description
EBTR3(5)	CONFIG7L	Table Read Protection bit 1 = Block 3 (003000h-003FFFh) not protected from table reads executed in other blocks 0 = Block 3 (003000h-003FFFh) protected from table reads executed in other blocks
EBTR2(5)	CONFIG7L	Table Read Protection bit 1 = Block 2 (002000h-002FFFh) not protected from table reads executed in other blocks 0 = Block 2 (002000h-002FFFh) protected from table reads executed in other blocks
EBTR1	CONFIG7L	Table Read Protection bit 1 = Block 1 (001000h-001FFFh) not protected from table reads executed in other blocks 0 = Block 1 (001000h-001FFFh) protected from table reads executed in other blocks
EBTR0	CONFIG7L	Table Read Protection bit 1 = Block 0 (000200h-000FFFh) not protected from table reads executed in other blocks 0 = Block 0 (000200h-000FFFh) protected from table reads executed in other blocks
EBTRB	CONFIG7H	Table Read Protection bit 1 = Boot block (000000h-0001FFh) not protected from table reads executed in other blocks 0 = Boot block (000000h-0001FFh) protected from table reads executed in other blocks
DEV<2:0>	DEVID1	Device ID bits These bits are used with the DEV<10:3> bits in the Device ID Register 2 to identify the part number.
REV<4:0>	DEVID1	Revision ID bits These bits are used to indicate the device revision.
DEV<10:3>	DEVID2	Device ID bits These bits are used with the DEV<2:0> bits in the Device ID Register 1 to identify the part number.

Note 1: Polarity control bits HPOL and LPOL define PWM signal output active and inactive states, PWM states generated by the fault inputs or PWM manual override.

2: PWM6 and PWM7 output channels are only available on the PIC18F4X21 devices.

3: When PWMPIN = 0, PWMEN<2:0> = 101 if device has eight PWM output pins (40 and 44-pin devices) and PWMEN<2:0> = 100 if the device has six PWM output pins (28-pin device). PWM output polarity is defined by HPOL and LPOL.

4: This bit is reserved on PIC18F2X31 devices and should be maintained set (i.e., equal to ‘1’).

5: For PIC18FX431 devices only.

5.4 Embedding Configuration Word Information in the HEX File

To allow portability of code, a PIC18FXX31 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 5-5 (pages 34 through 36) 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 5-5: CHECKSUM COMPUTATION

Device	Code Protect	Checksum	Blank Value	0xAA at 0 and Max Address
PIC18F2331	None	SUM(0000:01FF)+SUM(0200:0FFF)+SUM(1000:1FFF)+ (CONFIG0 & 0000)+(CONFIG1 & 00CF)+(CONFIG2 & 000F)+ (CONFIG3 & 003F)+(CONFIG4 & 003C)+(CONFIG5 & 009D)+ (CONFIG6 & 0085)+(CONFIG7 & 0000)+(CONFIG8 & 0003)+ (CONFIG9 & 00C0)+(CONFIG10 & 0003)+(CONFIG11 & 00E0)+ (CONFIG12 & 0003)+(CONFIG13 & 0040)	E464	E3BA
	Boot Block	SUM(0200:0FFF)+SUM(1000:1FFF)+(CONFIG0 & 0000)+ (CONFIG1 & 00CF)+(CONFIG2 & 000F)+(CONFIG3 & 003F)+ (CONFIG4 & 003C)+(CONFIG5 & 009D)+(CONFIG6 & 0085)+ (CONFIG7 & 0000)+(CONFIG8 & 0003)+(CONFIG9 & 00C0)+ (CONFIG10 & 0003)+(CONFIG11 & 00E0)+(CONFIG12 & 0003)+ (CONFIG13 & 0040)+SUM(IDs)	E640	E5F5
	Boot Block/ Block 0	(CONFIG0 & 0000)+(CONFIG1 & 00CF)+(CONFIG2 & 000F)+ (CONFIG3 & 003F)+(CONFIG4 & 003C)+(CONFIG5 & 009D)+ (CONFIG6 & 0085)+(CONFIG7 & 0000)+(CONFIG8 & 0003)+ (CONFIG9 & 00C0)+(CONFIG10 & 0003)+(CONFIG11 & 00E0)+ (CONFIG12 & 0003)+(CONFIG13 & 0040)+SUM(IDs)	043D	0447
	All	(CONFIG0 & 0000)+(CONFIG1 & 00CF)+(CONFIG2 & 000F)+ (CONFIG3 & 003F)+(CONFIG4 & 003C)+(CONFIG5 & 009D)+ (CONFIG6 & 0085)+(CONFIG7 & 0000)+(CONFIG8 & 0003)+ (CONFIG9 & 00C0)+(CONFIG10 & 0003)+(CONFIG11 & 00E0)+ (CONFIG12 & 0003)+(CONFIG13 & 0040)+SUM(IDs)	043D	0447

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
- & = Bit-wise AND

TABLE 5-5: CHECKSUM COMPUTATION (CONTINUED)

Device	Code Protect	Checksum	Blank Value	0xAA at 0 and Max Address
PIC18F2431	None	SUM(0000:01FF)+SUM(0200:0FFF)+SUM(1000:1FFF)+ SUM(2000:2FFF)+SUM(3000:3FFF)+(CONFIG0 & 0000)+ (CONFIG1 & 00CF)+(CONFIG2 & 000F)+(CONFIG3 & 003F)+ (CONFIG4 & 003C)+(CONFIG5 & 009D)+(CONFIG6 & 0085)+ (CONFIG7 & 0000)+(CONFIG8 & 000F)+(CONFIG9 & 00C0)+ (CONFIG10 & 000F)+(CONFIG11 & 00E0)+(CONFIG12 & 000F)+ (CONFIG13 & 0040)	C488	C3DE
	Boot Block	SUM(0200:0FFF)+SUM(1000:1FFF)+SUM(2000:2FFF)+ SUM(3000:3FFF)+(CONFIG0 & 0000)+(CONFIG1 & 00CF)+ (CONFIG2 & 000F)+(CONFIG3 & 003F)+(CONFIG4 & 003C)+ (CONFIG5 & 009D)+(CONFIG6 & 0085)+(CONFIG7 & 0000)+ (CONFIG8 & 000F)+(CONFIG9 & 00C0)+(CONFIG10 & 000F)+ (CONFIG11 & 00E0)+(CONFIG12 & 000F)+(CONFIG13 & 0040)+ SUM(IDs)	C668	C61D
	Boot Block/ Block 0	SUM(2000:2FFF)+SUM(3000:3FFF)+(CONFIG0 & 0000)+ (CONFIG1 & 00CF)+(CONFIG2 & 000F)+(CONFIG3 & 003F)+ (CONFIG4 & 003C)+(CONFIG5 & 009D)+(CONFIG6 & 0085)+ (CONFIG7 & 0000)+(CONFIG8 & 000F)+(CONFIG9 & 00C0)+ (CONFIG10 & 000F)+(CONFIG11 & 00E0)+(CONFIG12 & 000F)+ (CONFIG13 & 0040)+SUM(IDs)	E465	E41A
	All	(CONFIG0 & 0000)+(CONFIG1 & 00CF)+(CONFIG2 & 000F)+ (CONFIG3 & 003F)+(CONFIG4 & 003C)+(CONFIG5 & 009D)+ (CONFIG6 & 0085)+(CONFIG7 & 0000)+(CONFIG8 & 000F)+ (CONFIG9 & 00C0)+(CONFIG10 & 000F)+(CONFIG11 & 00E0)+ (CONFIG12 & 000F)+(CONFIG13 & 0040)+SUM(IDs)	0459	0463

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
- & = Bit-wise AND

TABLE 5-5: CHECKSUM COMPUTATION (CONTINUED)

Device	Code Protect	Checksum	Blank Value	0xAA at 0 and Max Address
PIC18F4331	None	SUM(0000:01FF)+SUM(0200:0FFF)+SUM(1000:1FFF)+ (CONFIG0 & 0000)+(CONFIG1 & 00CF)+(CONFIG2 & 000F)+ (CONFIG3 & 003F)+(CONFIG4 & 003C)+(CONFIG5 & 009D)+ (CONFIG6 & 0085)+(CONFIG7 & 0000)+(CONFIG8 & 0003)+ (CONFIG9 & 0003)+(CONFIG10 & 00E0)+(CONFIG11 & 0003)+ (CONFIG12 & 0040)+(CONFIG13 & 0000)	E3A4	E2FA
	Boot Block	SUM(0200:0FFF)+SUM(1000:1FFF)+(CONFIG0 & 0000)+ (CONFIG1 & 00CF)+(CONFIG2 & 000F)+(CONFIG3 & 003F)+ (CONFIG4 & 003C)+(CONFIG5 & 009D)+(CONFIG6 & 0085)+ (CONFIG7 & 0000)+(CONFIG8 & 0003)+(CONFIG9 & 0003)+ (CONFIG10 & 00E0)+(CONFIG11 & 0003)+(CONFIG12 & 0040)+ (CONFIG13 & 0000)+SUM(IDs)	E5C3	E578
	Boot Block/ Block 0/ Block 1	(CONFIG0 & 0000)+(CONFIG1 & 00CF)+(CONFIG2 & 000F)+ (CONFIG3 & 003F)+(CONFIG4 & 003C)+(CONFIG5 & 009D)+ (CONFIG6 & 0085)+(CONFIG7 & 0000)+(CONFIG8 & 0003)+ (CONFIG9 & 0003)+(CONFIG10 & 00E0)+(CONFIG11 & 0003)+ (CONFIG12 & 0040)+(CONFIG13 & 0000)+SUM(IDs)	03C0	03CA
	All	(CONFIG0 & 0000)+(CONFIG1 & 00CF)+(CONFIG2 & 000F)+ (CONFIG3 & 003F)+(CONFIG4 & 003C)+(CONFIG5 & 009D)+ (CONFIG6 & 0085)+(CONFIG7 & 0000)+(CONFIG8 & 0003)+ (CONFIG9 & 0003)+(CONFIG10 & 00E0)+(CONFIG11 & 0003)+ (CONFIG12 & 0040)+(CONFIG13 & 0000)+SUM(IDs)	03C0	03CA

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
& = Bit-wise AND

TABLE 5-5: CHECKSUM COMPUTATION (CONTINUED)

Device	Code Protect	Checksum	Blank Value	0xAA at 0 and Max Address
PIC18F4431	None	SUM(0000:01FF)+SUM(0200:0FFF)+SUM(1000:1FFF)+ SUM(2000:2FFF)+SUM(3000:3FFF)+(CONFIG0 & 0000)+ (CONFIG1 & 00CF)+(CONFIG2 & 000F)+(CONFIG3 & 003F)+ (CONFIG4 & 003C)+(CONFIG5 & 009D)+(CONFIG6 & 0085)+ (CONFIG7 & 0000)+(CONFIG8 & 000F)+(CONFIG9 & 00C0)+ (CONFIG10 & 000F)+(CONFIG11 & 00E0)+(CONFIG12 & 000F)+ (CONFIG13 & 0040)	C488	C3DE
	Boot Block	SUM(0200:0FFF)+SUM(1000:1FFF)+SUM(2000:2FFF)+ SUM(3000:3FFF)+(CONFIG0 & 0000)+(CONFIG1 & 00CF)+ (CONFIG2 & 000F)+(CONFIG3 & 003F)+(CONFIG4 & 003C)+ (CONFIG5 & 009D)+(CONFIG6 & 0085)+(CONFIG7 & 0000)+ (CONFIG8 & 000F)+(CONFIG9 & 00C0)+(CONFIG10 & 000F)+ (CONFIG11 & 00E0)+(CONFIG12 & 000F)+(CONFIG13 & 0040)+ SUM(IDs)	C668	C61D
	Boot Block/ Block 0/ Block 1	SUM(2000:2FFF)+SUM(3000:3FFF)+(CONFIG0 & 0000)+ (CONFIG1 & 00CF)+(CONFIG2 & 000F)+(CONFIG3 & 003F)+ (CONFIG4 & 003C)+(CONFIG5 & 009D)+(CONFIG6 & 0085)+ (CONFIG7 & 0000)+(CONFIG8 & 000F)+(CONFIG9 & 00C0)+ (CONFIG10 & 000F)+(CONFIG11 & 00E0)+(CONFIG12 & 000F)+ (CONFIG13 & 0040)+SUM(IDs)	E465	E41A
	All	(CONFIG0 & 0000)+(CONFIG1 & 00CF)+(CONFIG2 & 000F)+ (CONFIG3 & 003F)+(CONFIG4 & 003C)+(CONFIG5 & 009D)+ (CONFIG6 & 0085)+(CONFIG7 & 0000)+(CONFIG8 & 000F)+ (CONFIG9 & 00C0)+(CONFIG10 & 000F)+(CONFIG11 & 00E0)+ (CONFIG12 & 000F)+(CONFIG13 & 0040)+SUM(IDs)	0459	0463

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
- & = Bit-wise AND

5.6 Embedding Data EEPROM Information In the HEX File

To allow portability of code, a PIC18FXX31 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.

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	V_{IHH}	High Voltage Programming Voltage on $\overline{MCLR}/V_{PP}$	9.00	13.25	V	
D110A	V_{IHL}	Low Voltage Programming Voltage on $\overline{MCLR}/V_{PP}$	2.00	5.50	V	
D111	V_{DD}	Supply Voltage during programming	2.00	5.50	V	Normal programming
			4.50	5.50	V	Bulk erase operations
D112	I_{PP}	Programming Current on $\overline{MCLR}/V_{PP}$	—	300	μA	
D113	I_{DDP}	Supply Current during programming	—	5	mA	
D031	V_{IL}	Input Low Voltage	V_{SS}	0.2 V_{SS}	V	
D041	V_{IH}	Input High Voltage	0.8 V_{DD}	V_{DD}	V	
D080	V_{OL}	Output Low Voltage	—	0.6	V	I_{OL} = 8.5 mA
D090	V_{OH}	Output High Voltage	V_{DD} – 0.7	—	V	I_{OH} = -3.0 mA
D012	C_{IO}	Capacitive Loading on I/O pin (SDATA)	—	50	pF	To meet AC specifications
P2	Tsclk	Serial Clock (SCLK) period	100	—	ns	V_{DD} = 5.0V
			1	—	μs	V_{DD} = 2.0V
P2A	TsclkL	Serial Clock (SCLK) Low Time	40	—	ns	V_{DD} = 5.0V
			400	—	ns	V_{DD} = 2.0V
P2B	TsclkH	Serial Clock (SCLK) High Time	40	—	ns	V_{DD} = 5.0V
			400	—	ns	V_{DD} = 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	5	—	ms	
P12	Thld2	Input Data Hold Time from $\overline{MCLR}/V_{PP}$ ↑	2	—	μs	
P13	Tset2	V_{DD} ↑ Setup Time to $\overline{MCLR}/V_{PP}$ ↑	100	—	ns	
P14	Tvalid	Data Out Valid from SCLK ↑	10	—	ns	
P15	Tset3	PGM ↑ Setup Time to $\overline{MCLR}/V_{PP}$ ↑	2	—	μs	

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