PIC16F627A/628A/648A EEPROM Memory Programming Specification

This document includes the programming specifications for the following devices:

- PIC16F627A
- PIC16F628A
- PIC16F648A
- PIC16LF627A
- PIC16LF628A
- PIC16LF648A

Note:	All references to PIC16F627A/628A/648A also apply to PIC16LF62XA devices.

1.0 PROGRAMMING THE PIC16F627A/628A/648A

The PIC16F627A/628A/648A is programmed using a serial method. The Serial mode will allow the PIC16F627A/628A/648A to be programmed while in the user's system. This allows for increased design flexibility. This programming specification applies to PIC16F627A/628A/648A devices in all packages.

1.1 Hardware Requirements

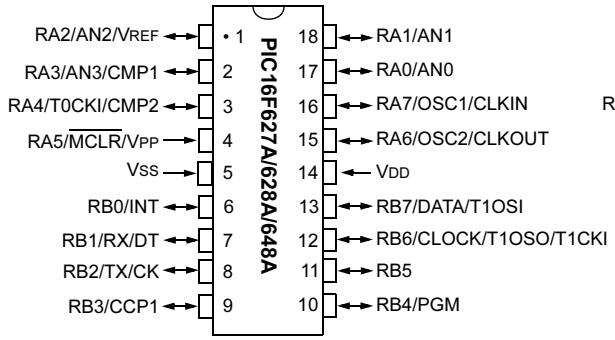
The PIC16F627A/628A/648A requires one programmable power supply for VDD (2.0V to 5.5V) and a VPP of 12V to 14V, or VPP of 4.5V to 5.5V, when using low voltage. Both supplies should have a minimum resolution of 0.25V.

1.2 Programming Mode

The Programming mode for the PIC16F627A/628A/648A allows programming of user program memory, data memory, special locations used for ID, and the configuration word.

FIGURE 1-1: PIN DIAGRAM

PDIP, SOIC



SSOP

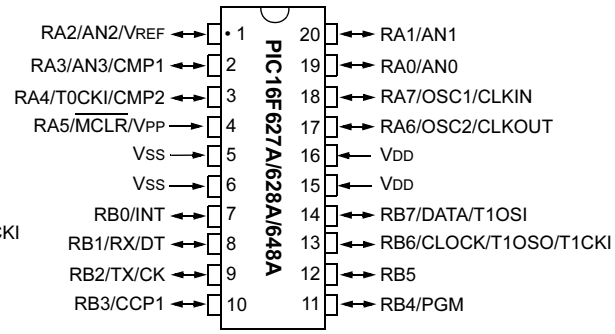


FIGURE 1-2: 28-PIN QFN PIC16F627A/628A/648A DIAGRAM

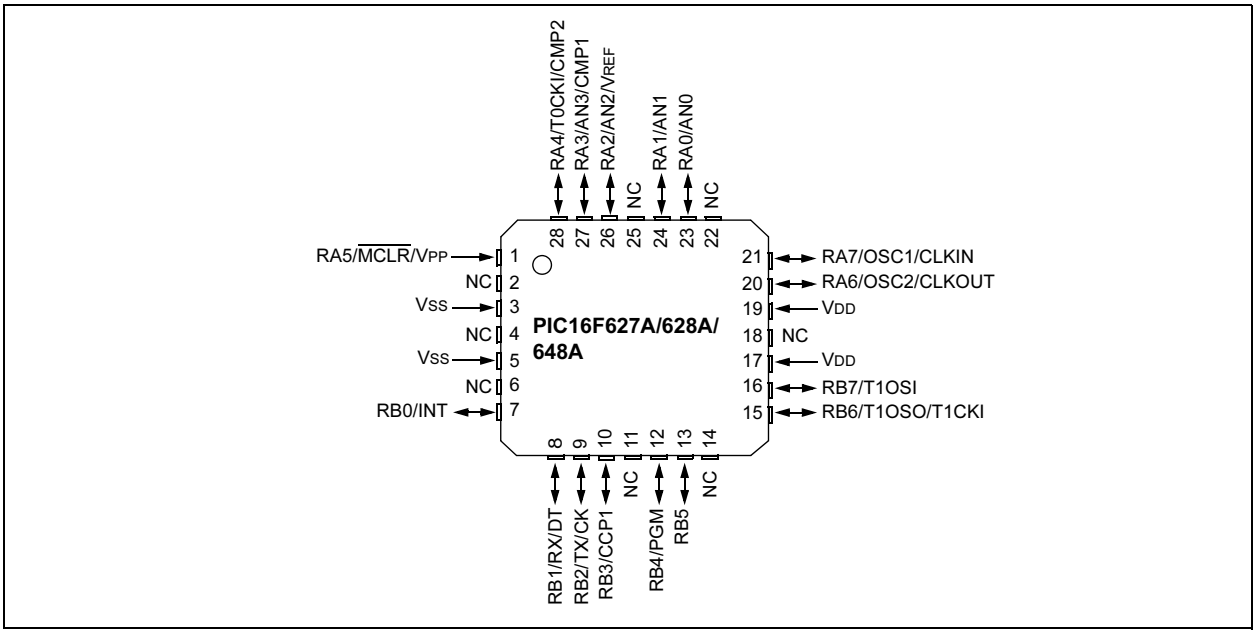


TABLE 1-1: PIN DESCRIPTIONS (DURING PROGRAMMING): PIC16F627A/628A/648A

Pin Name	During Programming		
	Function	Pin Type	Pin Description
RB4	PGM	I	Low Voltage Programming input if configuration bit equals 1
RB6	CLOCK	I	Clock input
RB7	DATA	I/O	Data input/output
$\overline{MCLR}/V_{PP}$	Programming Mode	P(1)	Program Mode Select
V_{DD}	V_{DD}	P	Power Supply
V_{SS}	V_{SS}	P	Ground

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

Note 1: In the PIC16F627A/628A/648A, the programming high voltage is internally generated. To activate the Programming mode, high voltage needs to be applied to $\overline{MCLR}$ input. Since the $\overline{MCLR}$ is used for a level source, this means that $\overline{MCLR}$ does not draw any significant current.

2.0 PROGRAM DETAILS

2.1 User Program Memory Map

The user memory space extends from 0x0000 to 0x1FFF. In Programming mode, the program memory space extends from 0x0000 to 0x3FFF, with the first half (0x0000-0x1FFF) being user program memory and the second half (0x2000-0x3FFF) being configuration memory. In the user program memory space, the PC will increment from 0x0000 to the end of implemented user program memory (see Figure 2-1) and wraps around to 0x0000. Additionally, the high order bit is not affected by the Increment Address command. Thus, in configuration memory, the PC increments from 0x2000 to 0x3FFF and wraps around to 0x2000 (not to 0x0000). The only way to set the PC back to user program memory is to reset the part and re-enter Program/Verify mode as described in Section 2.4.

Configuration memory space is entered via the Load Configuration command (see Section 2.4.3). Only addresses 0x2000 - 0x200F of configuration memory space are physically implemented. However, only locations 0x2000 through 0x2007 are available. Other locations are reserved. Locations beyond 0x200F will physically access user memory.

2.2 User ID Locations

A user may store identification information (User ID) in four User ID locations. The User ID locations are mapped in [0x2000 : 0x2003]. These locations read out normally even after the code protection is enabled.

Note 1:	All other locations in PICmicro® MCU configuration memory are reserved and should not be programmed.
2:	Only the low order 4 bits of the User ID locations may be included in the device checksum. See Section 3.9 for checksum calculation details.

2.3 EE Data Memory

The EE Data memory space extends from 0x00 to 0xFF and is separate from both program memory space and RAM space.

Only the lower 128 bytes are implemented in the PIC16F627A/628A devices, while the PIC16F648A implements the full 256 bytes.

Programming the EE Data memory uses the same PC as program memory, though only the lower bits are decoded and used.

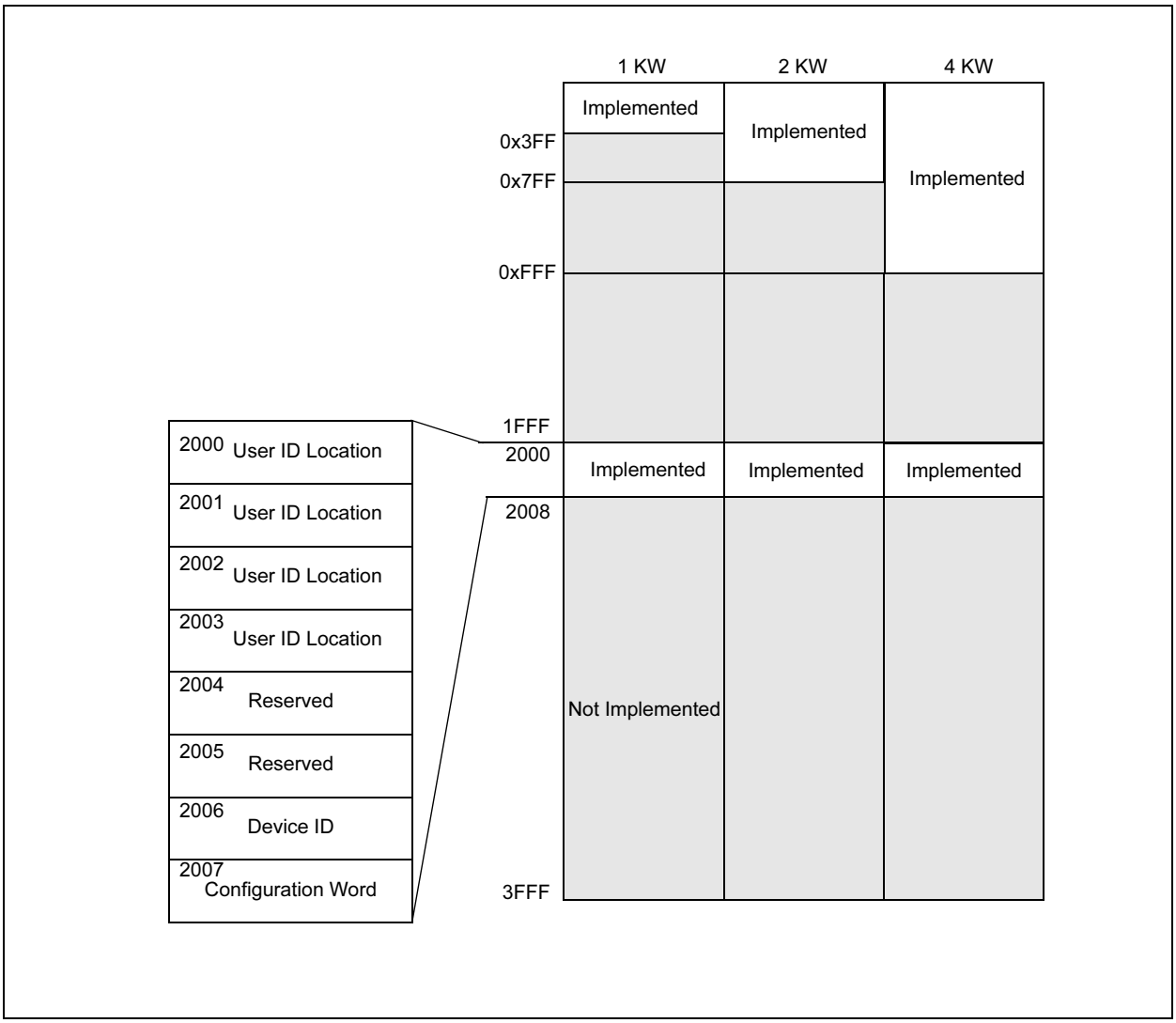
TABLE 2-1: EE DATA CAPACITY

Device	EE Data Memory	PC Bits Decoded
PIC16F627A/628A	128	7
PIC16F648A	256	8

TABLE 2-2: PROGRAM FLASH

Device	Program FLASH
PIC16F627A	1K
PIC16F628A	2K
PIC16F648A	4K

FIGURE 2-1: PROGRAM MEMORY MAPPING



2.4 Program/Verify Mode

The programming module operates on simple command sequences entered in serial fashion with the data being latched on the falling edge of the clock pulse. The sequences are entered serially, via the CLOCK and DATA lines, which are Schmitt Trigger inputs in this mode. The general form for all command sequences consists of a 6-bit command and conditionally a 16-bit data word. Both command and data word are clocked LSb first.

The signal on pin DATA is required to have a minimum setup and hold time (see AC/DC specifications), with respect to the falling edge of the clock. Commands that have data associated with them (read and load), require a minimum delay of Tdly1 between the command and the data.

The 6-bit command sequences are shown in Table 2-3.

TABLE 2-3: COMMAND MAPPING FOR PIC16F627A/PIC16F628A/PIC16F648A

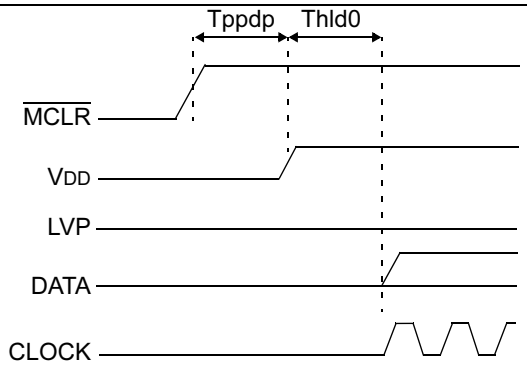
Command	Mapping (MSb … LSb)						Data
Load Configuration	X	X	0	0	0	0	0, data (14), 0
Load Data for Program Memory	X	X	0	0	1	0	0, data (14), 0
Load Data for Data Memory	X	X	0	0	1	1	0, data (8), zero (6), 0
Increment Address	X	X	0	1	1	0	
Read Data from Program Memory	X	X	0	1	0	0	0, data (14), 0
Read Data from Data Memory	X	X	0	1	0	1	0, data (8), zero (6), 0
Begin Programming Only Cycle	X	0	1	0	0	0	
Bulk Erase Program Memory	X	X	1	0	0	1	
Bulk Erase Data Memory	X	X	1	0	1	1	

The optional 16-bit data word will either be an input to, or an output from the PICmicro® microcontroller, depending on the command. Load Data commands will be input, and Read Data commands will be output. The 16-bit data word only contains 14 bits of data to conform to the 14-bit program memory word. The 14 bits are centered within the 16-bit word, padded with a leading and trailing zero.

Program/Verify mode may be entered via one of two methods. High voltage Program/Verify is entered by holding CLOCK and DATA pins low while raising $\overline{MCLR}$ first, then V_{DD} as shown in Figure 2-2. Low voltage Program/Verify mode is entered by raising V_{DD}, then $\overline{MCLR}$ and PGM, as shown in Figure 2-3. The PC will be set to 0 upon entering into Program/Verify mode. The PC can be changed by the execution of either an increment PC command, or a Load Configuration command, which sets the PC to 0x2000.

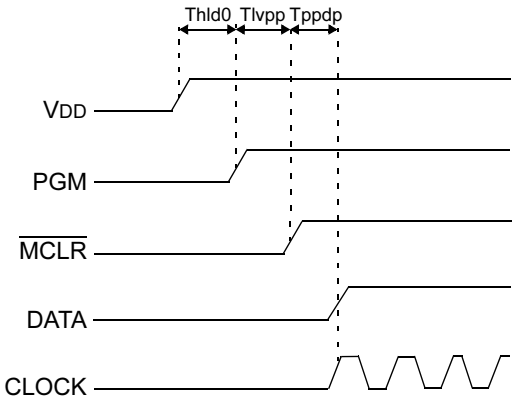
All other logic is held in the RESET state while in Program/Verify mode. This means that all I/O are in the RESET state (high impedance inputs).

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



Note: If the LVP fuse is enabled, PGM should be held low to prevent inadvertent entry into LVP mode.

FIGURE 2-3: ENTERING LOW VOLTAGE PROGRAM/VERIFY MODE

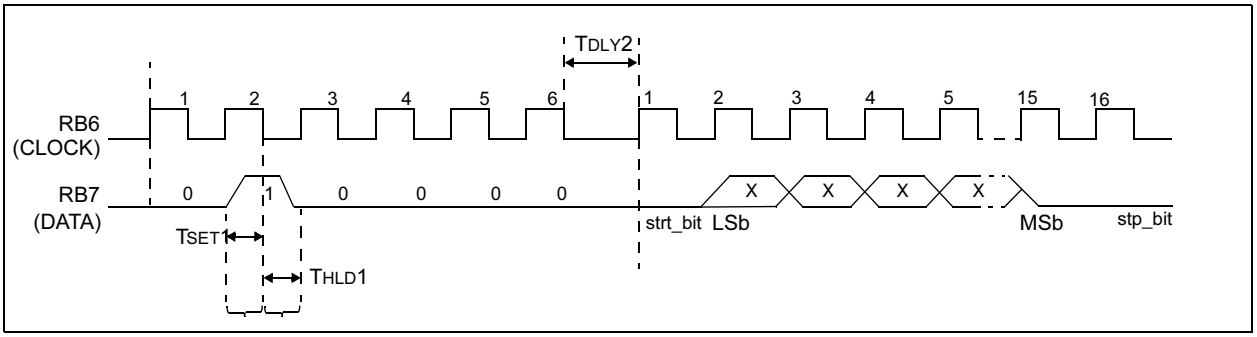


Note: If the device is in LVP mode, raising V_{PP} to V_{IHH} will override LVP mode.

2.4.1 LOAD DATA FOR PROGRAM MEMORY

Load data for program memory receives a 14-bit word, and readies it to be programmed at the PC location. See Figure 2-4 for timing details.

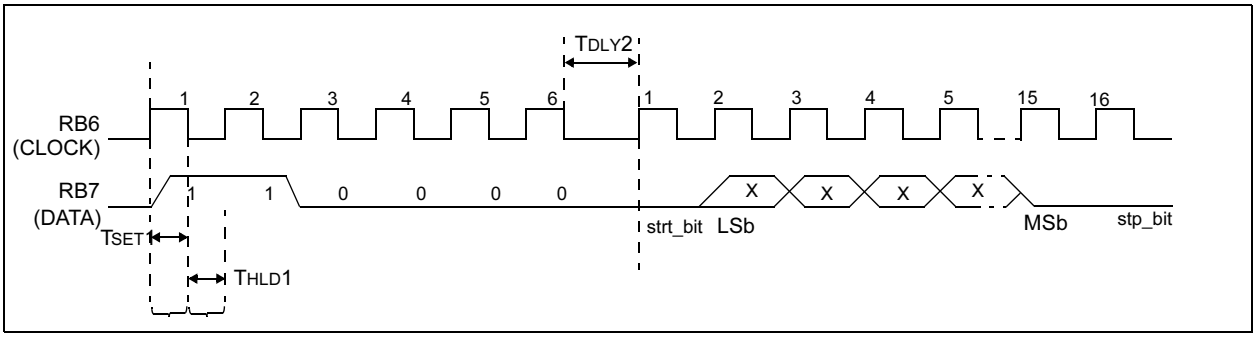
FIGURE 2-4: LOAD DATA COMMAND FOR PROGRAM MEMORY



2.4.2 LOAD DATA FOR DATA MEMORY

Load data for data memory receives an 8-bit byte and readies it to be programmed into data memory. Though the data byte is only 8-bits wide, all 16 clock cycles are required to allow the programming module to reset properly.

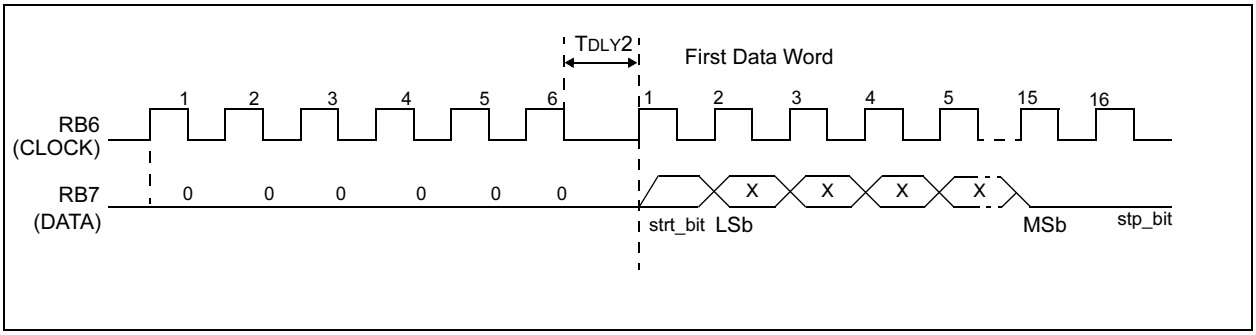
FIGURE 2-5: LOAD DATA COMMAND FOR DATA MEMORY



2.4.3 LOAD DATA FOR CONFIGURATION MEMORY

The Load Configuration command advances the PC to the start of configuration memory (0x2000-0x200F), and loads the data for the first ID location. Once it is set to the configuration region, only exiting and re-entering Program/Verify mode will reset PC to the user memory space.

FIGURE 2-6: LOAD CONFIGURATION

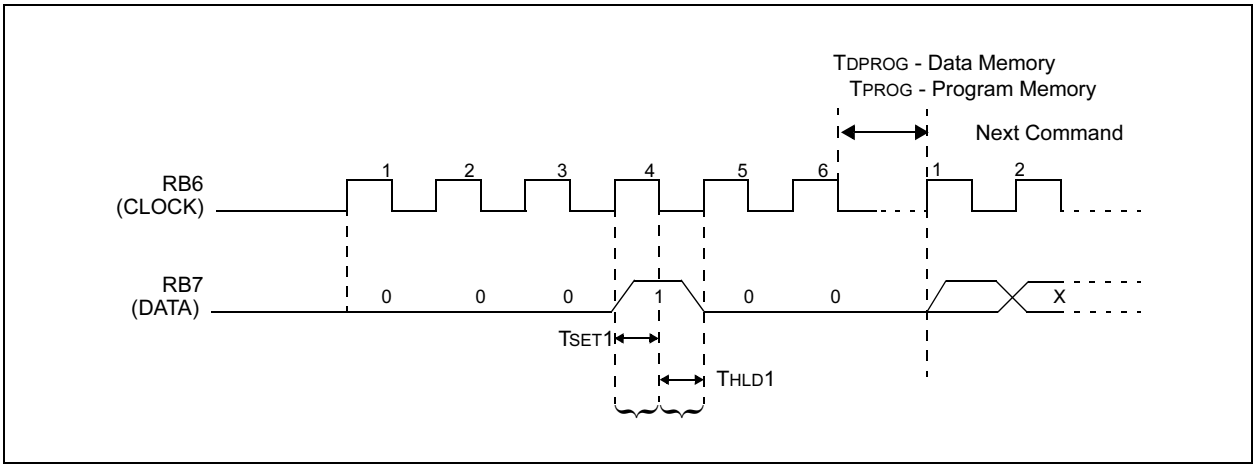


2.4.4 BEGIN PROGRAMMING ONLY CYCLE

Begin programming only cycle programs the previously loaded word into the appropriate memory (User Program, Data or Configuration memory). **A Load command must be given before every Programming command**. Programming begins after this command is received and decoded. An internal timing mechanism executes the write. The user must allow for program cycle time before issuing the next command. No “End Programming” command is required.

The device must be bulk erased before starting a series of programming only cycles.

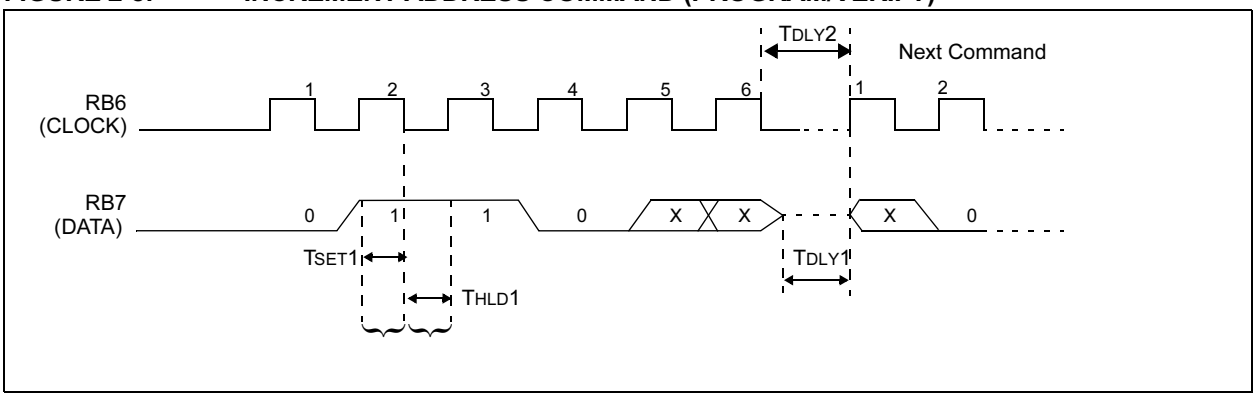
FIGURE 2-7: BEGIN PROGRAMMING ONLY CYCLE



2.4.5 INCREMENT ADDRESS

The PC is incremented when this command is received. See Figure 2-8.

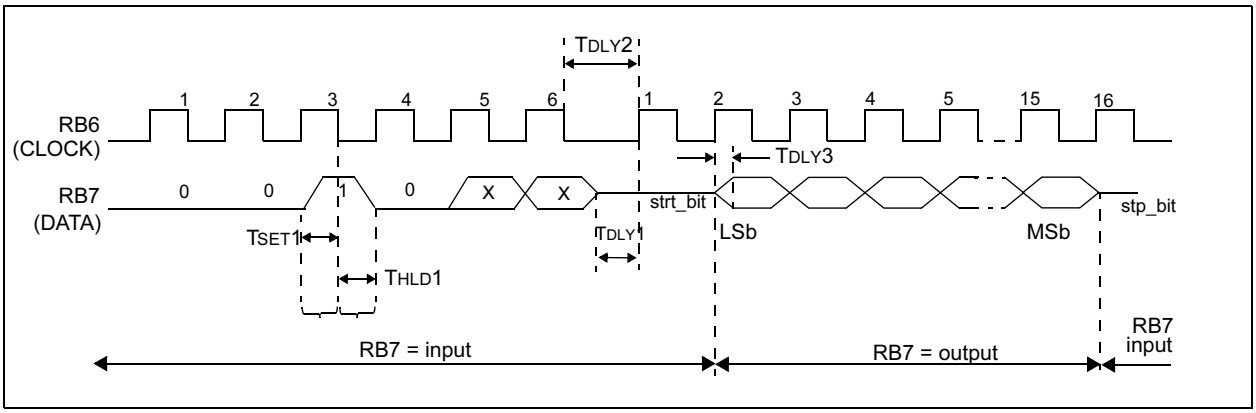
FIGURE 2-8: INCREMENT ADDRESS COMMAND (PROGRAM/VERIFY)



2.4.6 READ DATA FROM PROGRAM MEMORY

Read data from program memory reads the word addressed by the PC and transmits it on the DATA pin during the data phase of the command. This command will report words from either user or configuration memory, depending on the PC setting. The DATA pin will go into Output mode on the second rising clock edge and revert back to Input mode (hi-impedance) after the 16th rising edge.

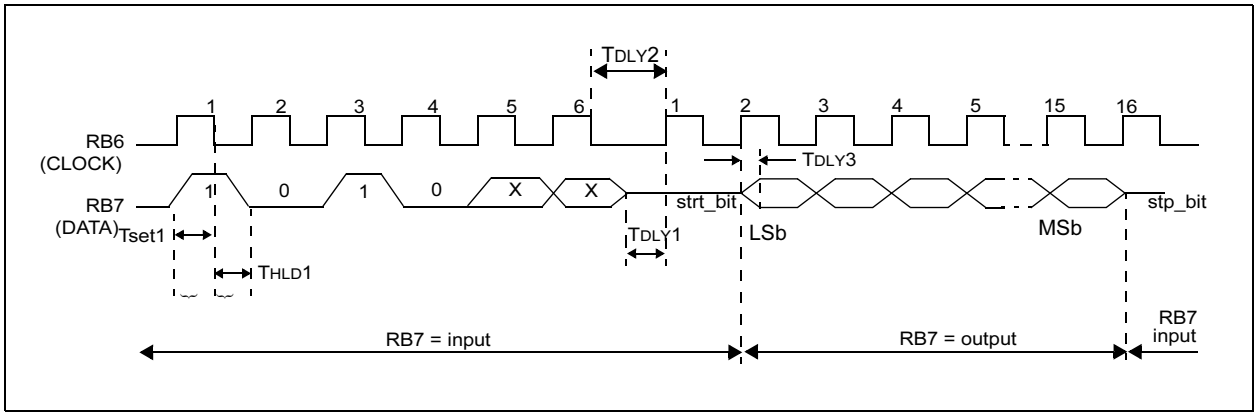
FIGURE 2-9: READ DATA FROM PROGRAM MEMORY



2.4.7 READ DATA FROM DATA MEMORY

Read data from data memory reads the byte in data memory addressed by the low order bits of PC and transmits it on the DATA pin during the data phase of the command. The DATA pin will go into Output mode on the second rising clock edge and revert back to Input mode (hi-impedance) after the 16th rising edge. As only 8 bits are transmitted, the last 8 bits are zero padded.

FIGURE 2-10: READ DATA FROM DATA MEMORY



3.0 COMMON PROGRAMMING TASKS

These programming commands may be combined in several ways, in order to accomplish different programming goals.

3.1 Bulk Erase Program Memory

The program memory can be erased with the Bulk Erase Program Memory command.

Note:	All bulk erase operations must take place with VDD between 4.5-5.5V.

To perform a bulk erase of the program memory, the following sequence must be performed:

1. Execute a Load Data for Program Memory with the data word set to all '1's (0x3FFF).
2. Execute a Bulk Erase Program Memory command
3. Wait TERA for the erase cycle to complete.

If the address is pointing to the Configuration memory (0x2000-0x200F), then both User ID locations and Program memory will be erased.

FIGURE 3-1: BULK ERASE PROGRAM MEMORY

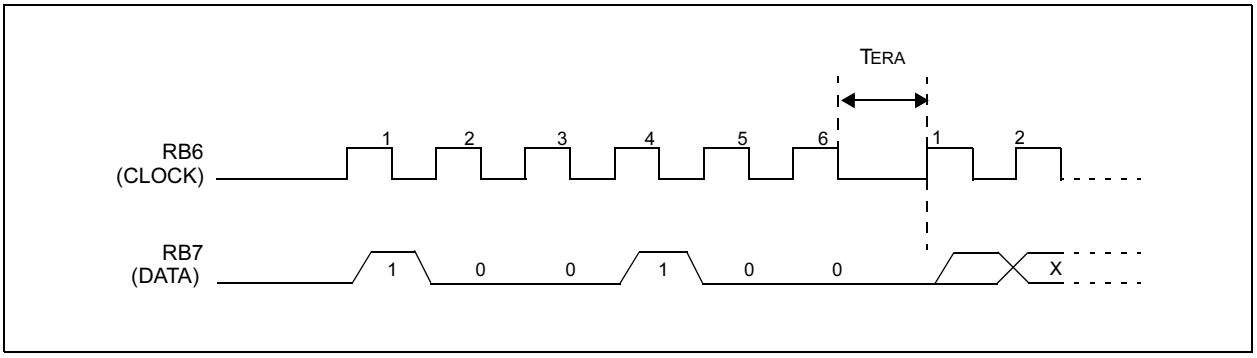


TABLE 3-1: EFFECTS OF ERASING CODE PROTECTED MEMORY

ACTION Serial & Parallel Operation	Initial State			Result				
	$\overline{CP}$ ON=0 OFF=1	$\overline{CPD}$ ON=0 OFF=1	PC= Config Mem	Program Memory	Data EE Memory	Config Word	User ID location	Comment
Bulk Erase Data Memory	X	OFF	X	Unaffected	Erased	Unaffected	Unaffected	
Bulk Erase Data Memory	X	ON	X	Unaffected	Erased	Unaffected	Unaffected	CPD=ON
Bulk Erase Program Memory	X	ON	YES	Erased	Erased	Erased	Erased	
Bulk Erase Program Memory	X	OFF	YES	Erased	Unaffected	Erased	Erased	
Bulk Erase Program Memory	X	ON	NO	Erased	Erased	Erased	Unaffected	
Bulk Erase Program Memory	X	OFF	NO	Erased	Unaffected	Erased	Unaffected	

3.2 Bulk Erase Data Memory

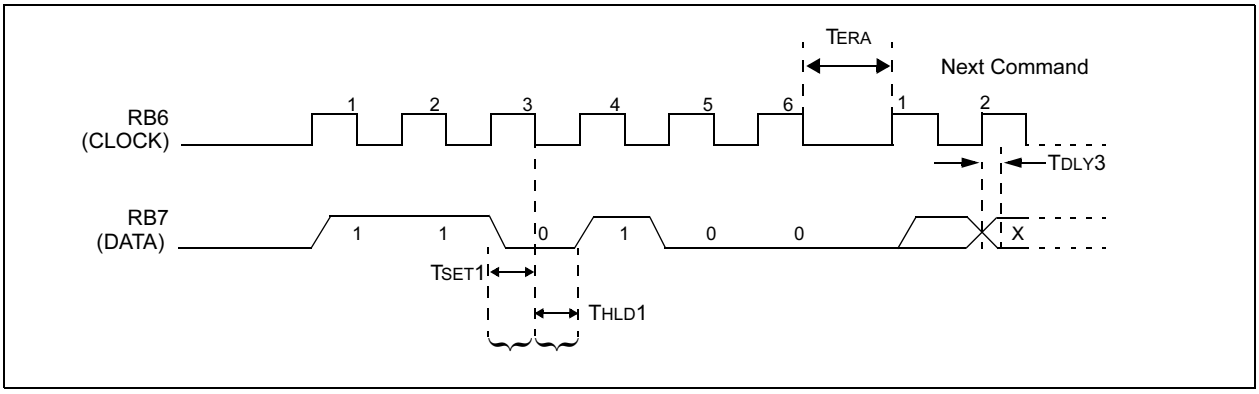
The data memory can be erased with the Bulk Erase Data memory command.

To perform a bulk erase of the data memory, the following sequence must be performed:

1. Execute a Bulk Erase Data memory command.
2. Wait TERA for the erase cycle to complete.

Note:	All Bulk Erase operations must take place with VDD between 4.5-5.5V

FIGURE 3-2: BULK ERASE DATA MEMORY COMMAND



3.3 Programming Program Memory

FIGURE 3-3: PROGRAM FLOW CHART - PIC16F627A/628A/648A PROGRAM MEMORY

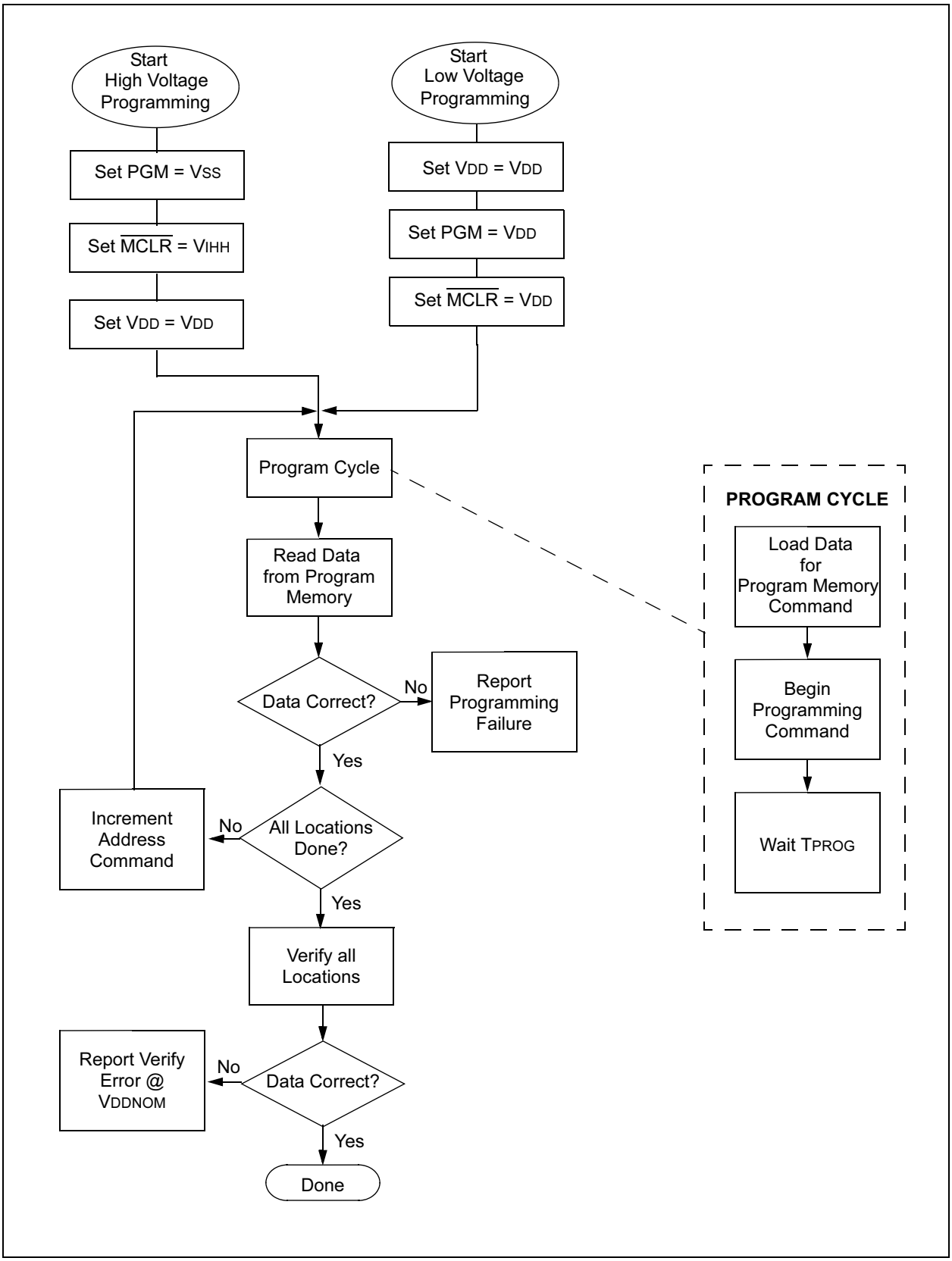
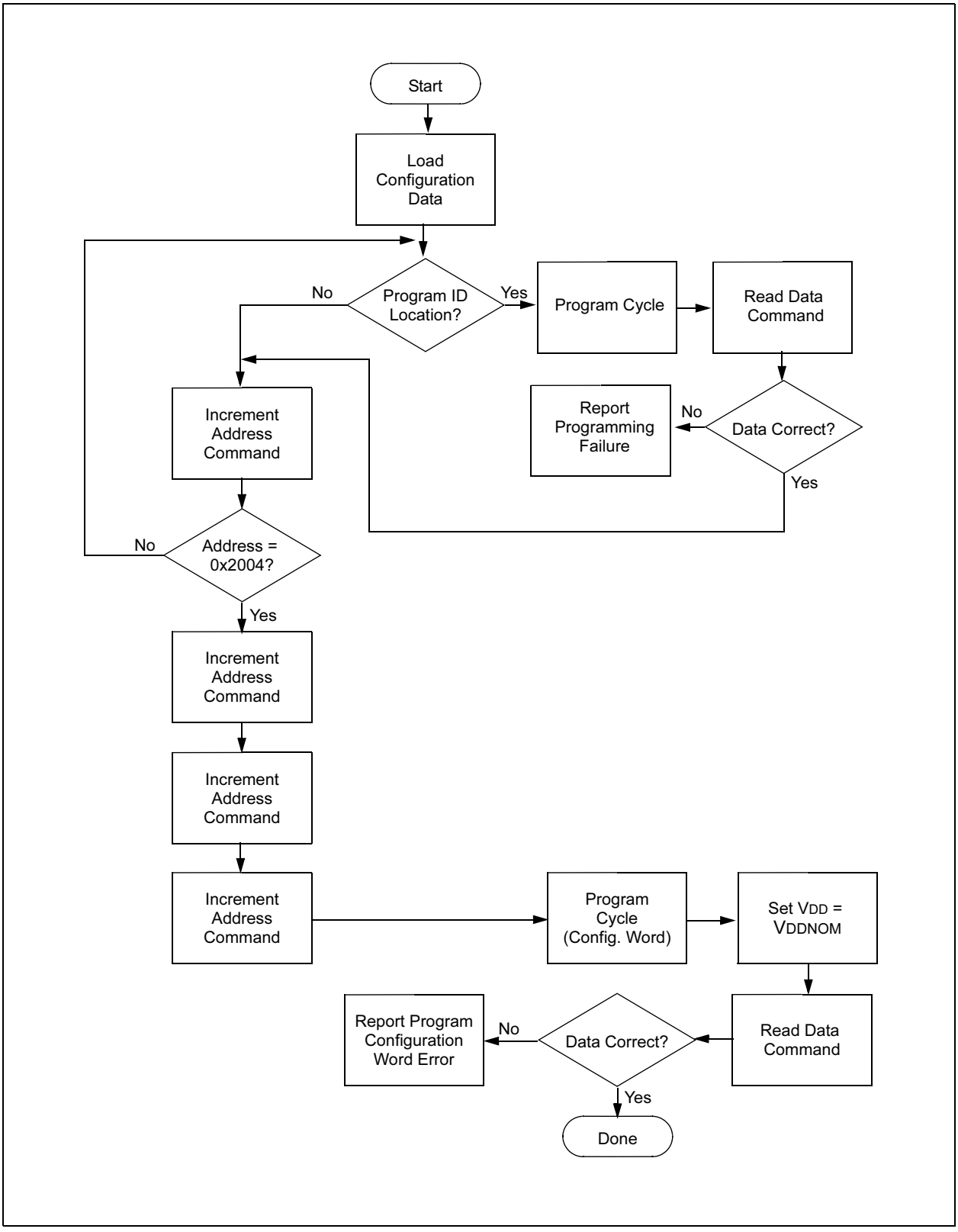
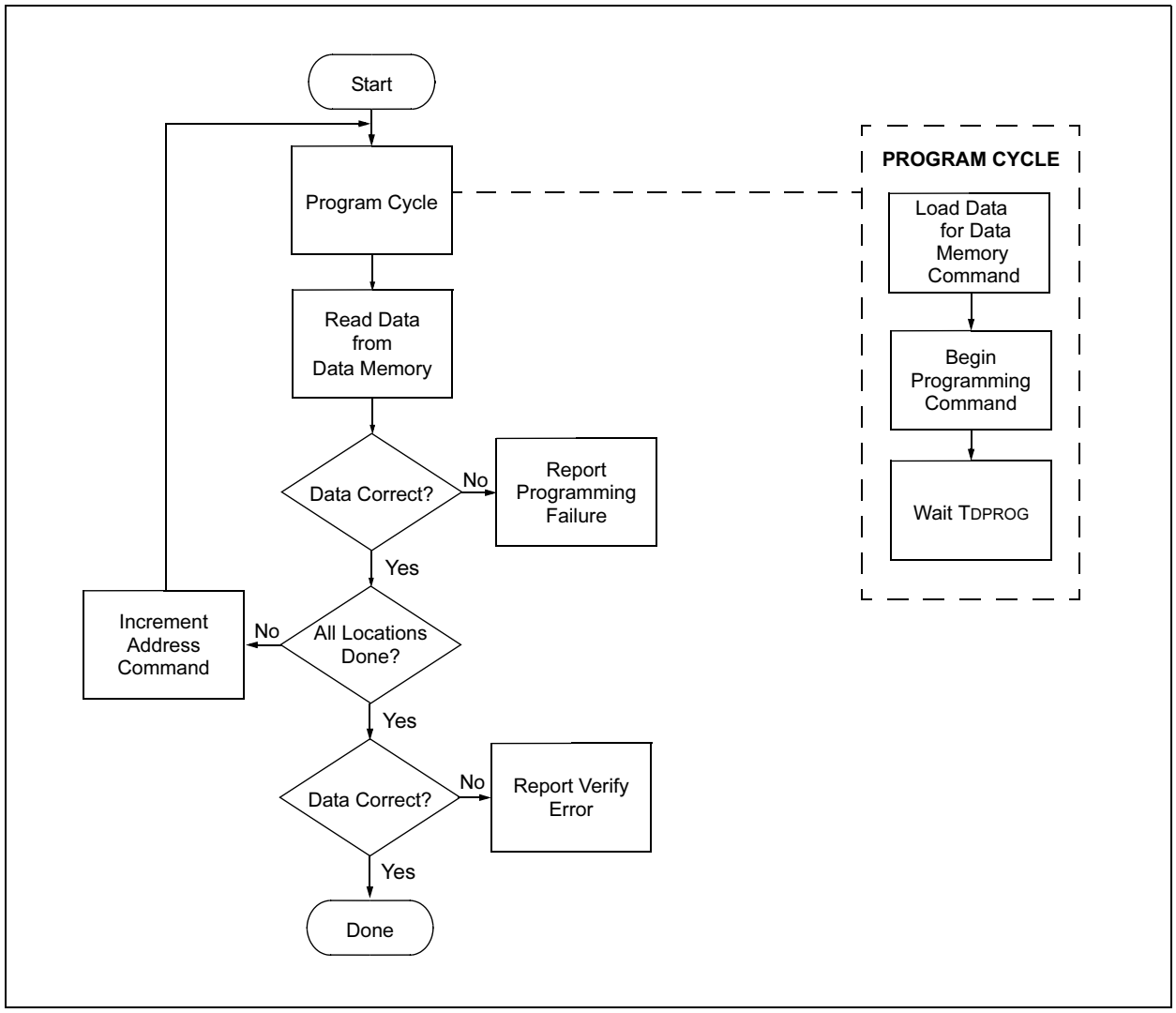


FIGURE 3-4: PROGRAM FLOW CHART - PIC16F627A/628A/648A CONFIGURATION MEMORY



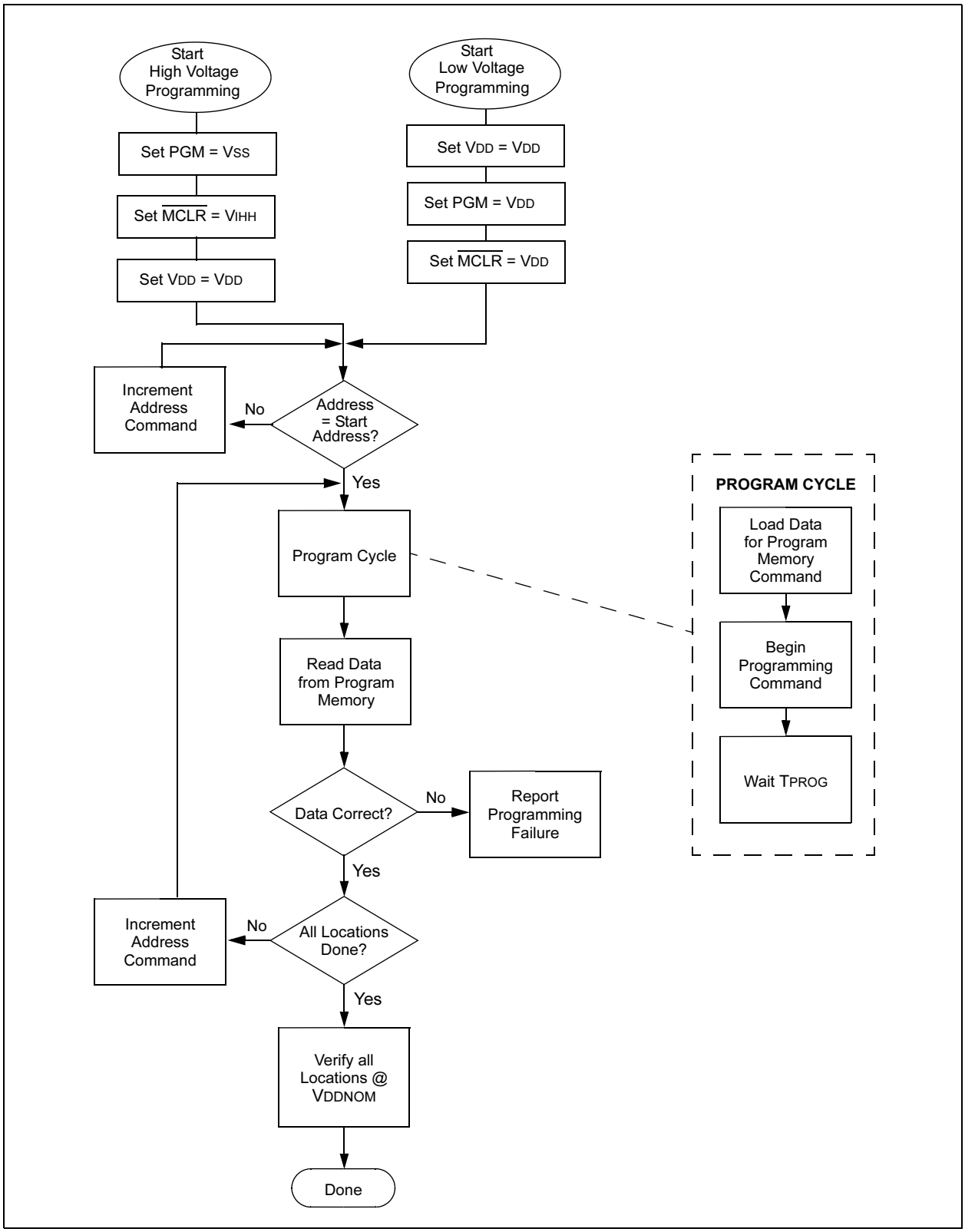
3.4 Program Data Memory

FIGURE 3-5: PROGRAM FLOW CHART - PIC16F627A/628A/648A DATA MEMORY



3.5 Programming Range of Program Memory

FIGURE 3-6: PROGRAM FLOW CHART - PIC16F627A/628A/648A PROGRAM MEMORY



3.6 Configuration Word

The PIC16F627A/628A/648A has several configuration bits. These bits can be set (reads '0'), or left unchanged (reads '1'), to select various device configurations.

3.7 Device ID Word

The device ID word for the PIC16F627A/628A/648A is hard coded at 2006h.

TABLE 3-2: DEVICE ID VALUES

Device	Device ID Value	
	Dev	Rev
PIC16F627A	01 0000 101	x xxxx
PIC16F628A	01 0000 011	x xxxx
PIC16F648A	01 0001 000	x xxxx

REGISTER 3-1: CONFIGURATION WORD FOR PIC16F627A/PIC16F628A/PIC16F648A (ADDRESS: 2007h)

R/P-1	U-1	U-1	U-1	U-1	R/P-1	R/P-1	R/P-1	R/P-1	R/P-1	R/P-1	R/P-1	R/P-1	R/P-1
$\overline{CP}$	—	—	—	—	$\overline{CPD}$	LVP	BOREN	MCLRE	FOSC2	$\overline{PWRTE}$	WDTE	FOSC1	FOSC0
bit 13													bit 0

bit 13 **$\overline{CP}$**: FLASH Program Memory Code Protection bit
(PIC16F648A)
1 = Code protection off
0 = 0000h to 0FFFh code protected
(PIC16F628A)
1 = Code protection off
0 = 0000h to 07FFh code protected
(PIC16F627A)
1 = Code protection off
0 = 0000h to 03FFh code protected

bit 12-9 **Unimplemented**: Read as '1'

bit 8 **$\overline{CPD}$**: Data Code Protection bit(2)
1 = Data memory code protection off
0 = Data memory code protected

bit 7 **LVP**: Low Voltage Programming Enable bit
1 = RB4/PGM pin has PGM function, low voltage programming enabled
0 = RB4/PGM is digital I/O, HV on $\overline{MCLR}$ must be used for programming

bit 6 **BOREN**: Brown-out Reset Enable bit(1)
1 = BOR enabled
0 = BOR disabled

bit 5 **MCLRE**: RA5/$\overline{MCLR}$ Pin Function Select bit
1 = RA5/$\overline{MCLR}$ pin function is $\overline{MCLR}$
0 = RA5/$\overline{MCLR}$ pin function is digital I/O, $\overline{MCLR}$ internally tied to V_{DD}

bit 3 **$\overline{PWRTE}$**: Power-up Timer Enable bit(1)
1 = PWRT disabled
0 = PWRT enabled

bit 2 **WDTE**: Watchdog Timer Enable bit
1 = WDT enabled
0 = WDT disabled

bit 4, 1-0 **FOSC<2:0>**: Oscillator Selection bits(3)
111 = RC oscillator: CLKOUT function on RA6/OSC2/CLKOUT pin, Resistor & Capacitor on RA7/OSC1/CLKIN
110 = RC oscillator: I/O function on RA6/OSC2/CLKOUT pin, Resistor & Capacitor on RA7/OSC1/CLKIN
101 = INTOSC internal oscillator: CLKOUT function on RA6/OSC2/CLKOUT pin, I/O function on RA7/OSC1/CLKIN
100 = INTOSC internal oscillator: I/O function on RA6/OSC2/CLKOUT pin, I/O function on RA7/OSC1/CLKIN
011 = EXTCLK: I/O function on RA6/OSC2/CLKOUT pin, I/O function on RA7/OSC1/CLKIN
010 = HS oscillator: High speed crystal/resonator on RA6/OSC2/CLKOUT and RA7/OSC1/CLKIN
001 = XT oscillator: Crystal/resonator on RA6/OSC2/CLKOUT and RA7/OSC1/CLKIN
000 = LP oscillator: Low power crystal on RA6/OSC2/CLKOUT and RA7/OSC1/CLKIN

Note 1: Enabling Brown-out Reset does not automatically enable the Power-up Timer (PWRT).
2: Only a Bulk Erase will reset the configuration word, including the CP bits.
3: While $\overline{MCLR}$ is asserted in INTOSC mode, the internal clock oscillator is disabled.

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

3.8 Embedding Configuration Word and ID Information in the HEX File

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

Specifically for the PIC16F627A/628A/648A, the EEPROM data memory should also be embedded in the HEX file (see Section 4.1).

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

3.9 Embedding Data EEPROM Contents in HEX File

The programmer should be able to read data EEPROM information from a HEX file and conversely (as an option) write data EEPROM contents to a HEX file, along with program memory information and fuse information.

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

3.10 Checksum Computation

3.10.1 CHECKSUM

Checksum is calculated by reading the contents of the PIC16F627A/628A/648A memory locations and adding up the opcodes up to the maximum user addressable location (e.g., 0x7FF for the PIC16F628A). Any carry bits exceeding 16 bits are neglected. Finally, the configuration word (appropriately masked) is added to the checksum. Checksum computation for each member of the PIC16F627A/628A/648A devices is shown in Table 3-3.

The checksum is calculated by summing the following:

- The contents of all program memory locations
- The configuration word, appropriately masked
- Masked ID locations (when applicable)

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

The following table describes how to calculate the checksum for each device.

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

TABLE 3-3: CHECKSUM COMPUTATION

Device	Code Protect	Checksum*	Blank Value	0x25E6 at 0 and Max Address
PIC16F627A	OFF	SUM[0x0000:0x03FF] + CFGW & 0x21FF	1DFF	E9CD
	ON	CFGW & 0x21FF + SUM_ID	1FFE	EBCC
PIC16F628A	OFF	SUM[0x0000:0x7FF] + CFGW & 0x21FF	19FF	E5CD
	ON	CFGW & 0x21FF + SUM_ID	1BFE	E7CC
PIC16F648A	OFF	SUM[0x0000:0x0FFF] + CFGW & 0x21FF	11FF	DDCD
	ON	CFGW & 0x21FF + SUM_ID	13FE	DFCC

Legend: CFGW = Configuration Word
SUM[a:b] = [Sum of locations a to b inclusive]
SUM_ID = ID locations masked by 0xF then made into a 16-bit value with ID0 as the Most Significant nibble.
For example, ID0 = 0x1, ID1 = 0x2, ID3 = 0x3, ID4 = 0x4, then SUM_ID = 0x1234
*Checksum = [Sum of all the individual expressions] **MODULO** [0xFFFF]
+ = Addition
& = Bitwise AND

4.0 PROGRAM/VERIFY MODE ELECTRICAL CHARACTERISTICS

TABLE 4-1: AC/DC CHARACTERISTICS TIMING REQUIREMENTS FOR PROGRAM/VERIFY MODE

AC/DC Characteristics	Standard Operating Conditions (unless otherwise stated) Operating Temperature: 0°C ≤ TA ≤ +70°C Operating Voltage: 4.5V ≤ VDD ≤ 5.5V					
Characteristics	**Sym**	**Min**	**Typ**	**Max**	**Units**	**Conditions/ Comments**
General						
VDD level for word operations, program memory	VDD	2.0	—	5.5	V	
VDD level for word operations, data memory	VDD	2.0	—	5.5	V	
VDD level for bulk erase operations, program and data memory	VDD	4.5	—	5.5	V	
High voltage on $\overline{\text{MCLR}}$	VIHH	10.0	—	13.5	V	
$\overline{\text{MCLR}}$ rise time (VSS to VIHH) for Programming mode entry	TVHHR	—	—	1.0	μs	
Hold time after $\overline{\text{MCLR}}$↑	TPPDP	5	—	—	μs	
Hold time after LVP↑	TLVPP	5	—	—	μs	
(CLOCK, DATA) input high level	VIH1	0.8 VDD	—	—	V	Schmitt Trigger input
(CLOCK, DATA) input low level	VIL1	—	—	0.2 VDD	V	Schmitt Trigger input
CLOCK, DATA setup time before $\overline{\text{MCLR}}$↑	TSET0	100	—	—	ns	
Hold time after VDD↑	THLD0	5	—	—	μs	
Serial Program/Verify						
Data in setup time before clock↓	TSET1	100	—	—	ns	
Data in hold time after clock↓	THLD1	100	—	—	ns	
Data input not driven to next clock input (delay required between command/data or command/ command)	TDLY1	1.0	—	—	μs	
Delay between clock↓ to clock↑ of next command or data	TDLY2	1.0	—	—	μs	
Clock↑ to data out valid (during read data)	TDLY3	—	—	80	ns	
Programming cycle time	TPROG	—	—	2.5	ms	
Data EEPROM Programming cycle time	TDPROG	—	—	6	ms	
Bulk Erase cycle time	TERA	—	—	6	ms	

NOTES:

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.

Trademarks

Microchip received QS-9000 quality system certification for its worldwide headquarters, design and wafer fabrication facilities in Chandler and Tempe, Arizona in July 1999 and Mountain View, California in March 2002. The Company's quality system processes and procedures are QS-9000 compliant for its PICmicro® 8-bit MCUs, KEELOQ® code hopping devices, Serial EEPROMs, microperipherals, non-volatile memory and analog products. In addition, Microchip's quality system for the design and manufacture of development systems is ISO 9001 certified.

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