PIC16F54

Memory Programming Specification

This document includes the programming specifications for the following devices:

- PIC16F54

1.0 PROGRAMMING THE PIC16F54

The PIC16F54 is programmed using a serial method. The Serial mode will allow the PIC16F54 to be programmed while in the user's system. This allows for increased design flexibility. This programming specification applies to PIC16F54 devices in all packages.

1.1 Hardware Requirements

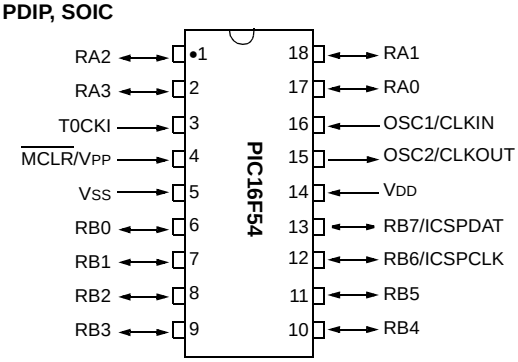
The PIC16F54 requires one power supply for V_{DD} (5.0V) and one for V_{PP} (12V).

1.2 Program/Verify Mode

The Program/Verify mode for the PIC16F54 allows programming of user program memory, special locations used for ID, and the configuration word.

Pin Diagrams

PDIP, SOIC



SSOP

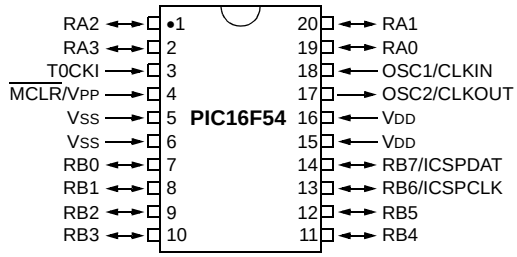


TABLE 1-1: PIN DESCRIPTIONS (DURING PROGRAMMING): PIC16F54

Pin Name	During Programming		
	Function	Pin Type	Pin Description
RB6	ICSPCLK	I	Clock input – Schmitt Trigger input
RB7	ICSPDAT	I/O	Data input/output – Schmitt Trigger input
$\overline{MCLR}/V_{PP}$	Program/Verify 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 PIC16F54, the programming high voltage is internally generated. To activate the Program/Verify mode, high voltage of I_{IHH} current capability (see Table 5-1) needs to be applied to $\overline{MCLR}$ input.

2.0 PROGRAM MODE ENTRY

2.1 Program Memory Map

The user memory space extends from 0x000 to 0x1FF. In Program/Verify mode, the program memory space extends from 0x000 to 0x3FF, with the first half (0x000-0x1FF) being user program memory and the second half (0x200-0x3FF) being configuration memory. The PC will increment from 0x000 to 0x1FF, then to 0x200 (not to 0x0000).

In the configuration memory space, 0x200-0x23F are physically implemented. However, only locations 0x200 through 0x203 are available. Other locations are reserved.

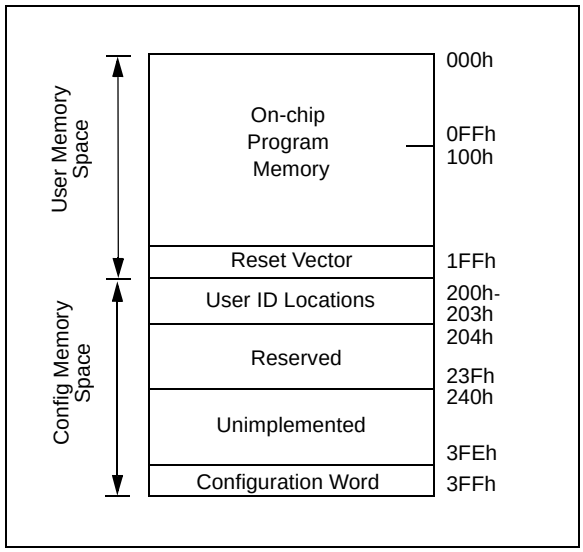
2.2 User ID Locations

A user may store Identification information (ID) in four user ID locations. The user ID locations are mapped in [0x200: 0x203]. It is recommended that the user use only the four Least Significant bits (LSb) of each user ID location and program the upper 8 bits as '1's. The user ID locations read out normally, even after code protection is enabled. It is recommended that user ID location is written as '1111 1111 bbbb' where 'bbbb' is user ID information.

2.3 Configuration Word

The configuration word is located at 0x3FF and is only available upon Program mode entry. Once an Increment Address command is issued, the configuration word is no longer accessible regardless of the address of the program counter.

FIGURE 2-1: PROGRAM MEMORY MAP



2.4 Program/Verify Mode

The Program/Verify mode is entered by holding pins ICSPCLK and ICSPDAT low while raising V_{DD} pin from V_{IL} to V_{DD}. Then raise V_{PP} from V_{IL} to V_{IHH}. Once in this mode, the user program memory and configuration memory can be accessed and programmed in serial fashion. Clock and data are Schmitt Trigger input in this mode.

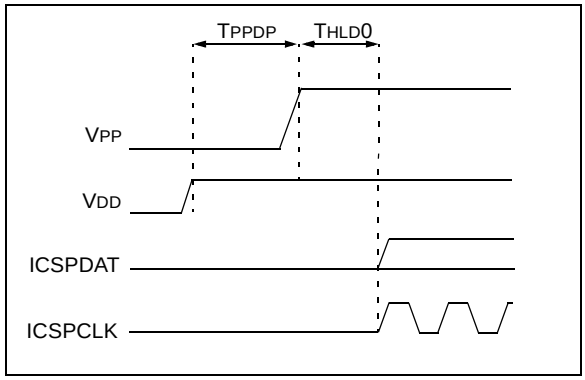
The sequence that enters the device into the Programming/Verify mode places all other logic into the Reset state (the $\overline{MCLR}$ pin was initially at V_{IL}). This means that all I/O are in the Reset state (high-impedance inputs).

2.4.1 PROGRAMMING

The programming sequence loads a word, programs, verifies, and finally increments the PC. See Figure 2-9.

Program/Verify mode entry will set the PC to 0x3FF (Configuration Word address). The Increment Address command will increment the PC. The available commands are shown in Table 2-1.

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



2.4.2 SERIAL PROGRAM/VERIFY OPERATION

The ICSPCLK pin is used for clock input and the ICSPDAT pin is used for data input/output during serial operation. To input a command, the clock pin is cycled six times. Each command bit is latched on the falling edge of the clock with the LSb of the command being input first. The data must adhere to the setup (TSET1) and hold (THLD1) times with respect to the falling edge of the clock (see Table 5-1).

Commands that do not have data associated with them are required to wait a minimum of TDLY2 measured from the falling edge of the last command clock to the rising edge of the next command clock (see Table 5-1). Commands that do have data associated with them (Read and Load), are also required to wait TDLY2 between the command and the data segment. This is measured from the falling edge of the last command clock to the rising edge of the first data clock. The data segment, consisting of 16 clock cycles, can begin after this delay.

The first and last clock pulses during the data segment correspond to the Start and Stop bits respectively. Input data is a “don't care” during the Start and Stop cycles. The 14 clock pulses between the Start and Stop cycles, clock the 14 bits of input/output data. Data is transferred LSb first.

Note:	After every End Programming command, a delay of TDIS is required.

During Read commands, in which the data is output from the PIC16FXXXX, the ICSPDAT pin transitions from the high-impedance state to the low-impedance output state at the rising edge of the second data clock (first clock edge after the Start cycle). The ICSPDAT pin returns to the high-impedance state at the rising edge of the 16th data clock (first edge of the Stop cycle). See Figure 2-4.

The commands that are available are described in Table 2-1.

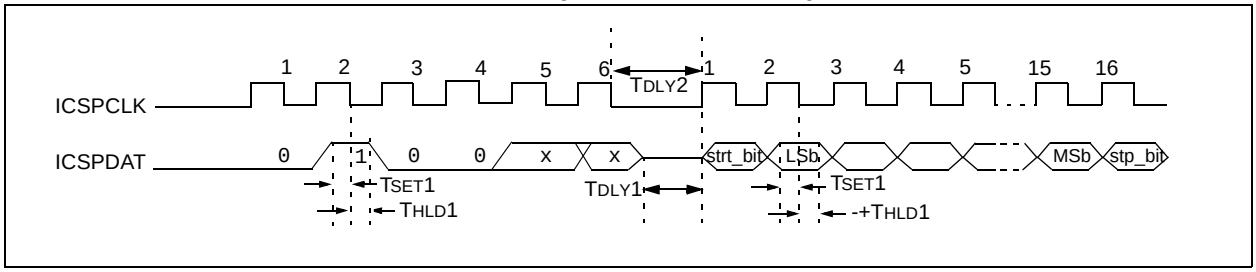
TABLE 2-1: COMMAND MAPPING FOR PIC16F54

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

2.4.2.1 Load Data For Program Memory

After receiving this command, the chip will load in a 14-bit “data word” when 16 cycles are applied, as described previously. Because this is a 12-bit core, the two MSb’s of the data word are ignored. A timing diagram for the Load Data command is shown in Figure 2-3.

FIGURE 2-3: LOAD DATA COMMAND (PROGRAM/VERIFY)

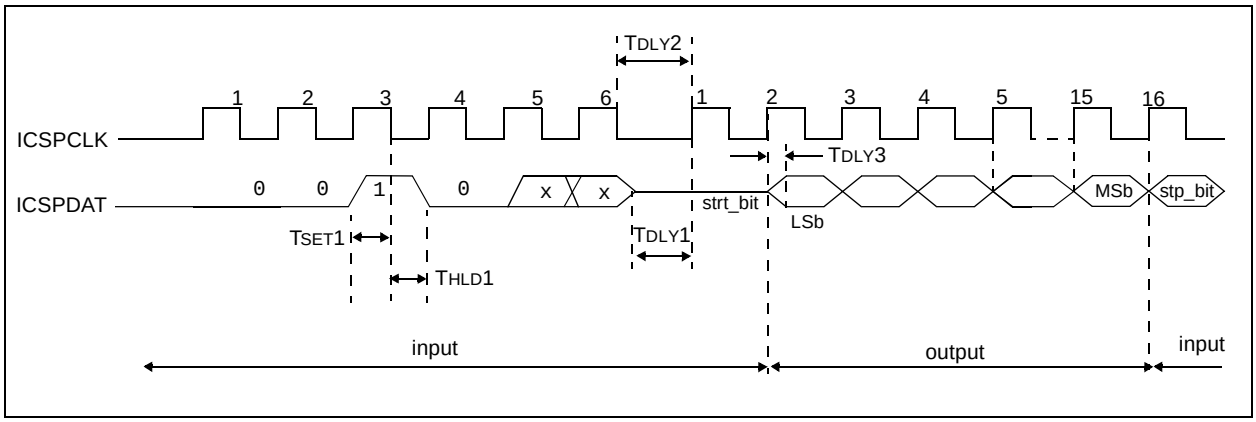


2.4.2.2 Read Data From Program Memory

After receiving this command, the chip will transmit data bits out of the program memory (user or configuration) currently addressed, starting with the second rising edge of the clock input. The data pin will go into Output mode on the second rising clock edge, and it will revert to Input mode (high-impedance) after the 16th rising edge. Because this is a 12-bit core, the two MSbs of the 14-bit word will be read as '0's.

If the program memory is code protected ($\overline{CP}$ = 0), portions of the program memory will be read as zeros. See **Section 4.0 "Code Protection"** for details.

FIGURE 2-4: READ DATA FROM PROGRAM MEMORY COMMAND

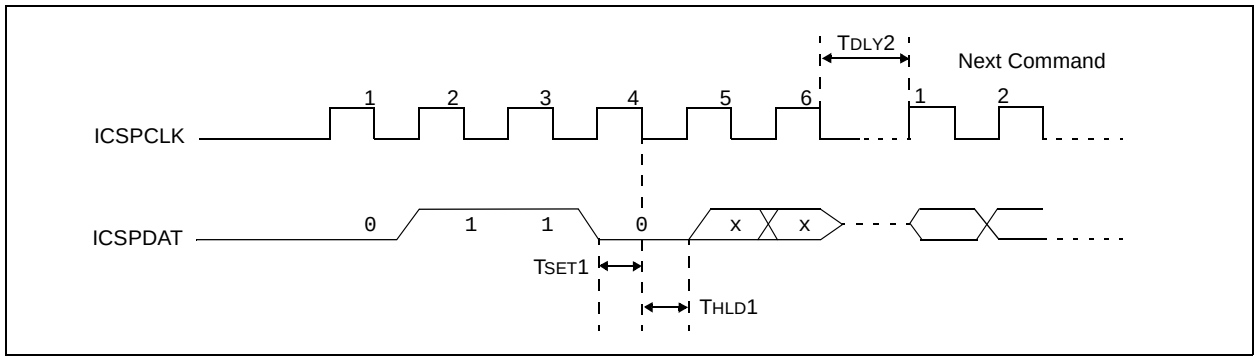


2.4.2.3 Increment Address

The PC is incremented when this command is received. A timing diagram of this command is shown in Figure 2-5.

It is not possible to decrement the address counter. To reset this counter, the user must either exit and re-enter Program/Verify mode or increment the PC from 0x3FF to 0X000.

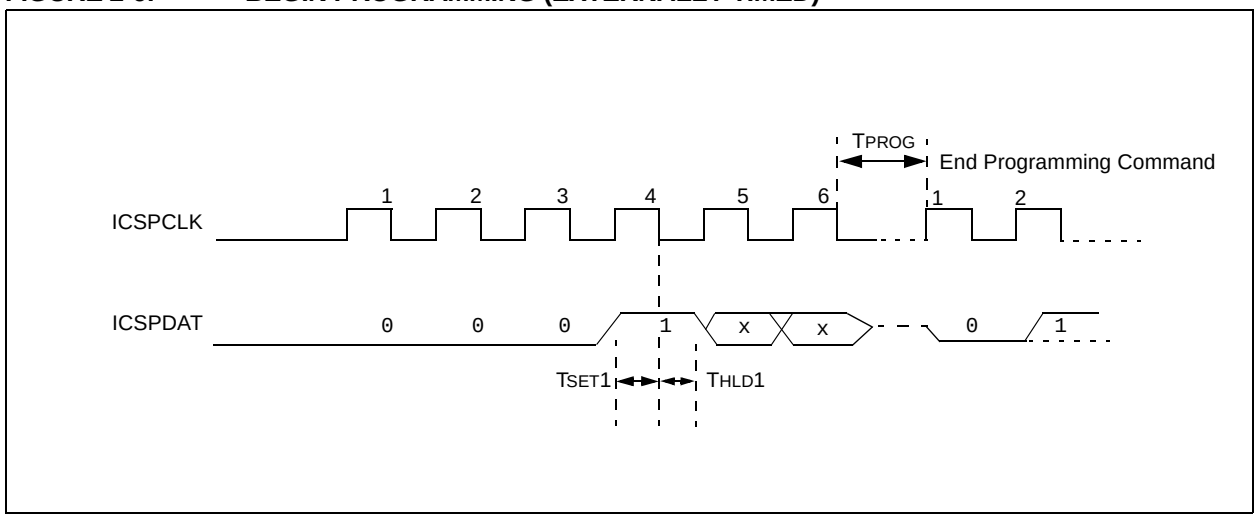
FIGURE 2-5: INCREMENT ADDRESS COMMAND



2.4.2.4 Begin Programming (Externally Timed)

A Load command must be given before every Begin Programming command**.** Programming will begin after this command is received and decoded. Programming requires (TPROG) time and is terminated using an End Programming command. This command programs the current location, no erase is performed.

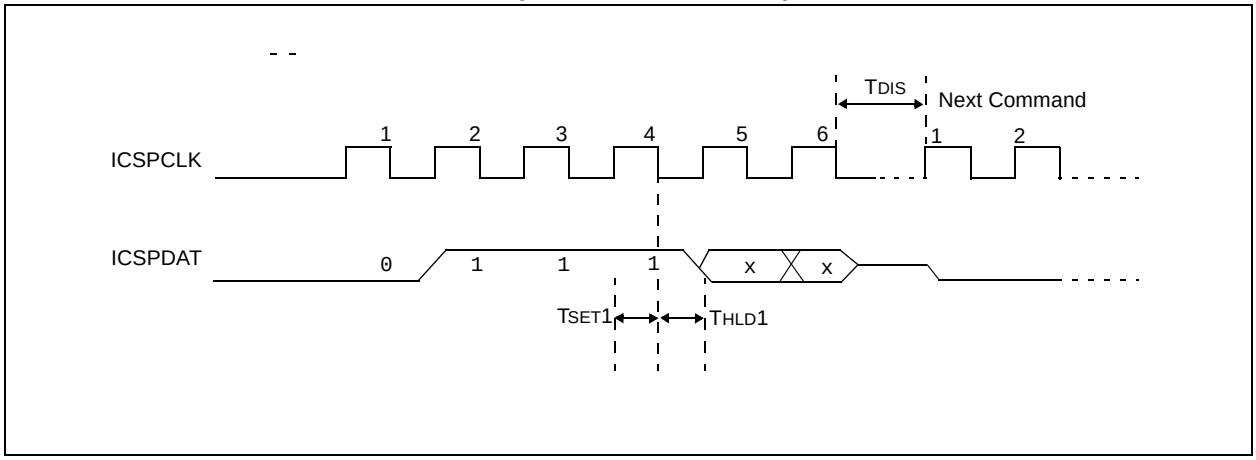
FIGURE 2-6: BEGIN PROGRAMMING (EXTERNALLY TIMED)



2.4.2.5 End Programming

The End Programming command terminates the program process by removing the high programming voltage from the memory cells. A delay of TDIS (see Table 5-1) is required before the next command to allow the internal programming voltage to discharge (see Figure 2-7).

FIGURE 2-7: END PROGRAMMING (EXTERNALLY TIMED)



2.4.2.6 Bulk Erase Program Memory

After this command is performed, the entire program memory and configuration word is erased.

To perform a bulk erase of the program memory and configuration fuses, the following sequence must be performed (see Figure 2-11).

1. Enter Program/Verify mode. PC is set to Configuration Word address.
2. Perform a Bulk Erase Program Memory command
3. Wait TERA to complete bulk erase

To perform a bulk erase of the program memory, configuration fuses and user IDs, the following sequence must be performed (see Figure 2-12).

1. Enter Program/Verify mode
2. Increment PC to 0x200 (first user ID location)
3. Perform a Bulk Erase command
4. Wait TERA to complete bulk erase

FIGURE 2-8: BULK ERASE PROGRAM MEMORY COMMAND

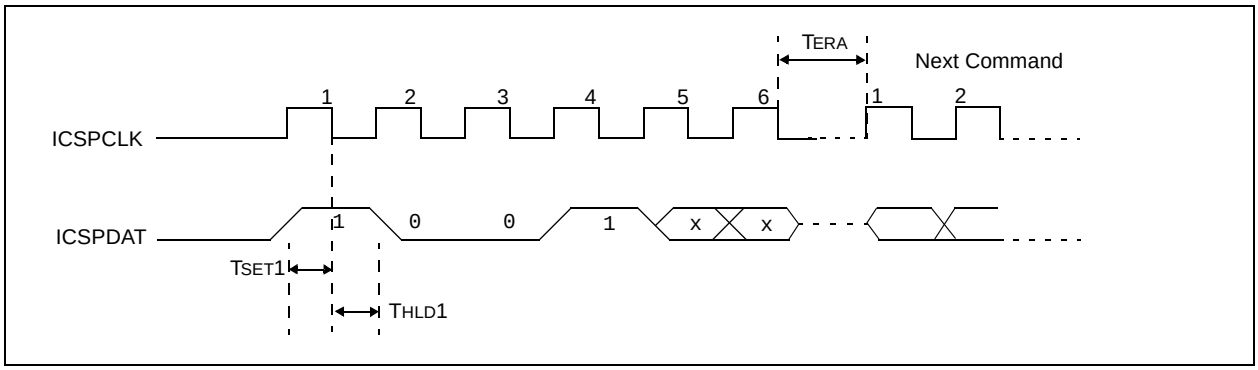


FIGURE 2-9: ONE-WORD PROGRAM FLOW CHART – PIC16F54 PROGRAM MEMORY

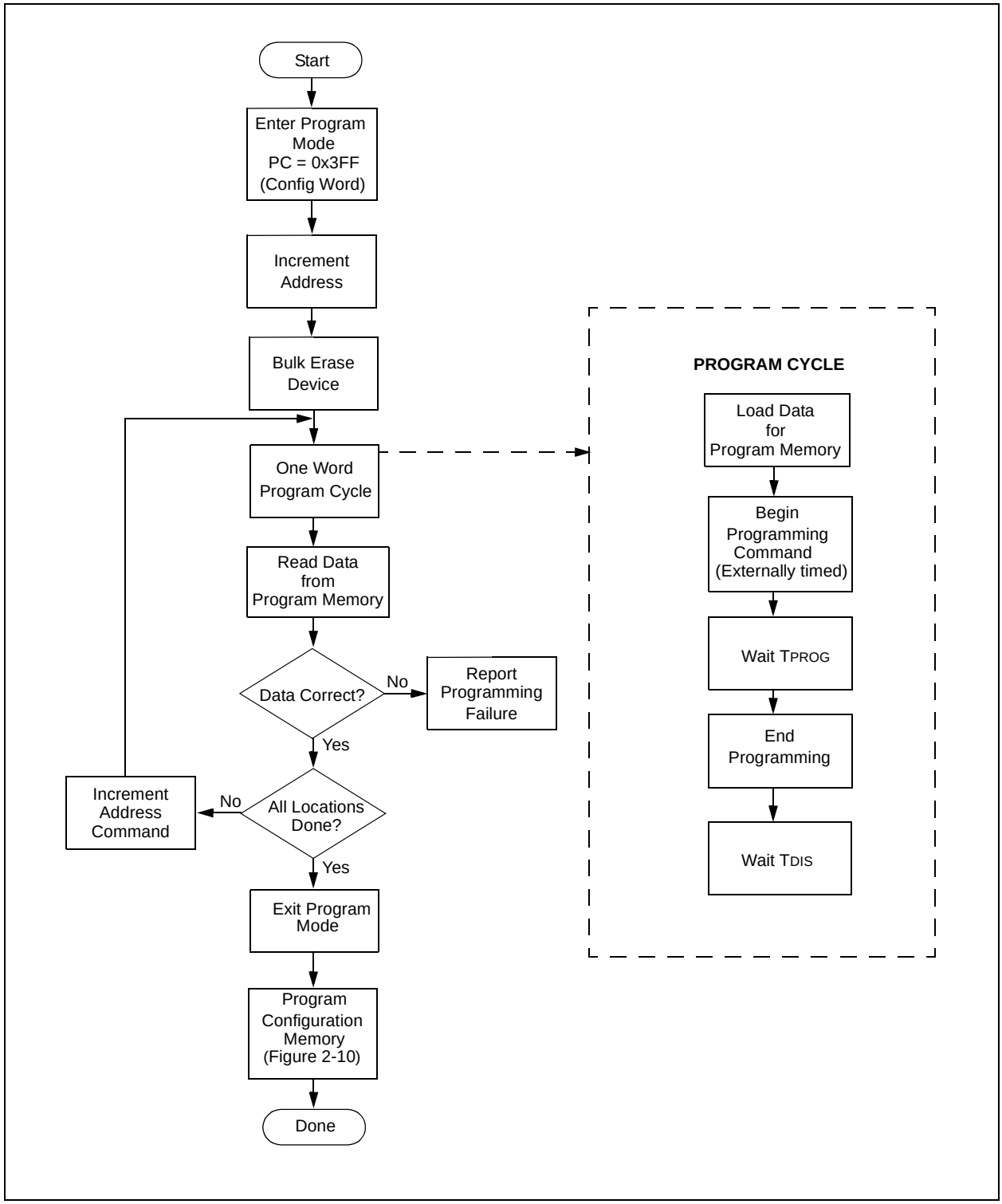


FIGURE 2-10: PROGRAM FLOW CHART – PIC16F54 CONFIGURATION MEMORY

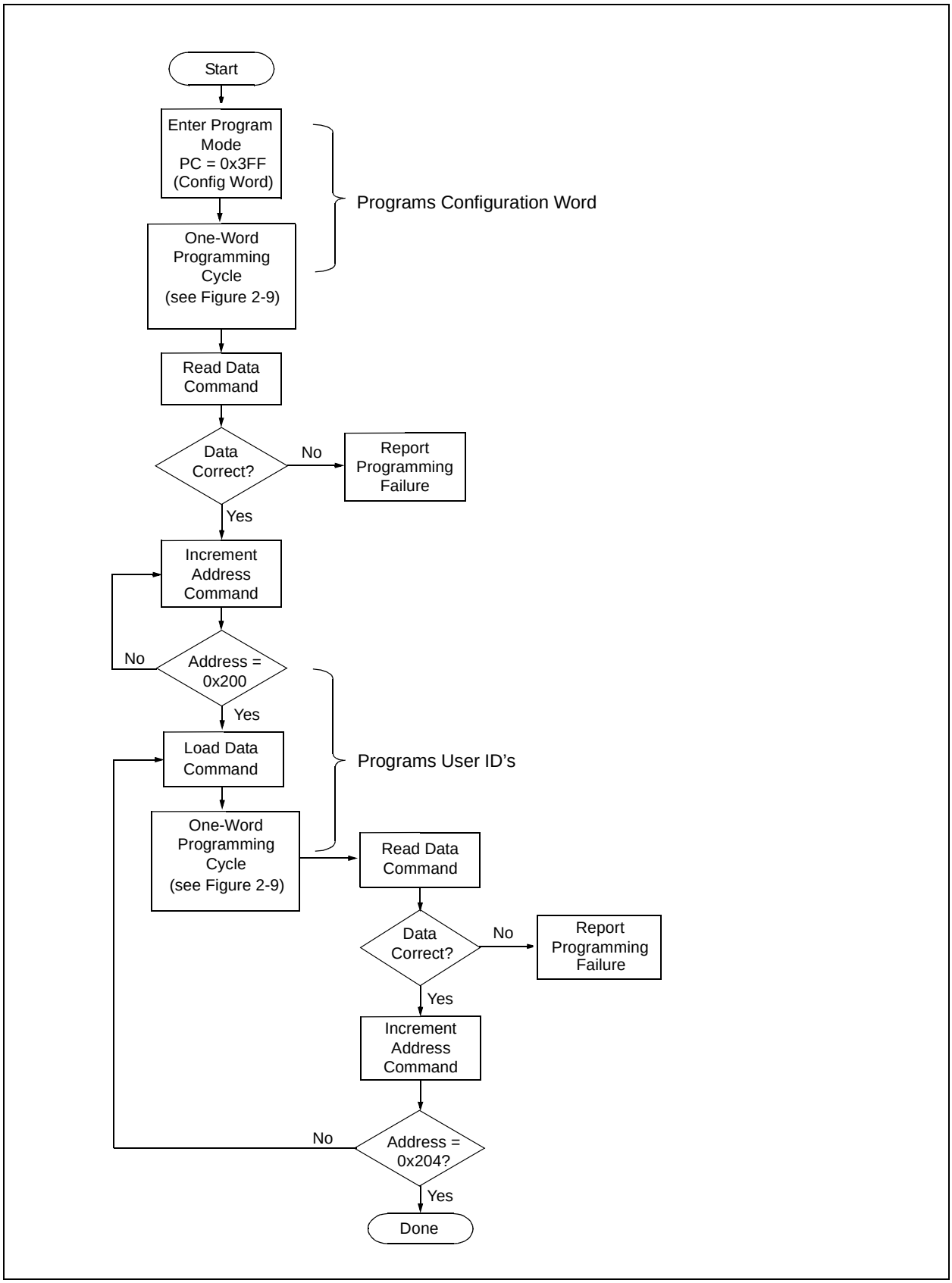


FIGURE 2-11: PROGRAM FLOW CHART – ERASE PROGRAM MEMORY, CONFIGURATION WORD

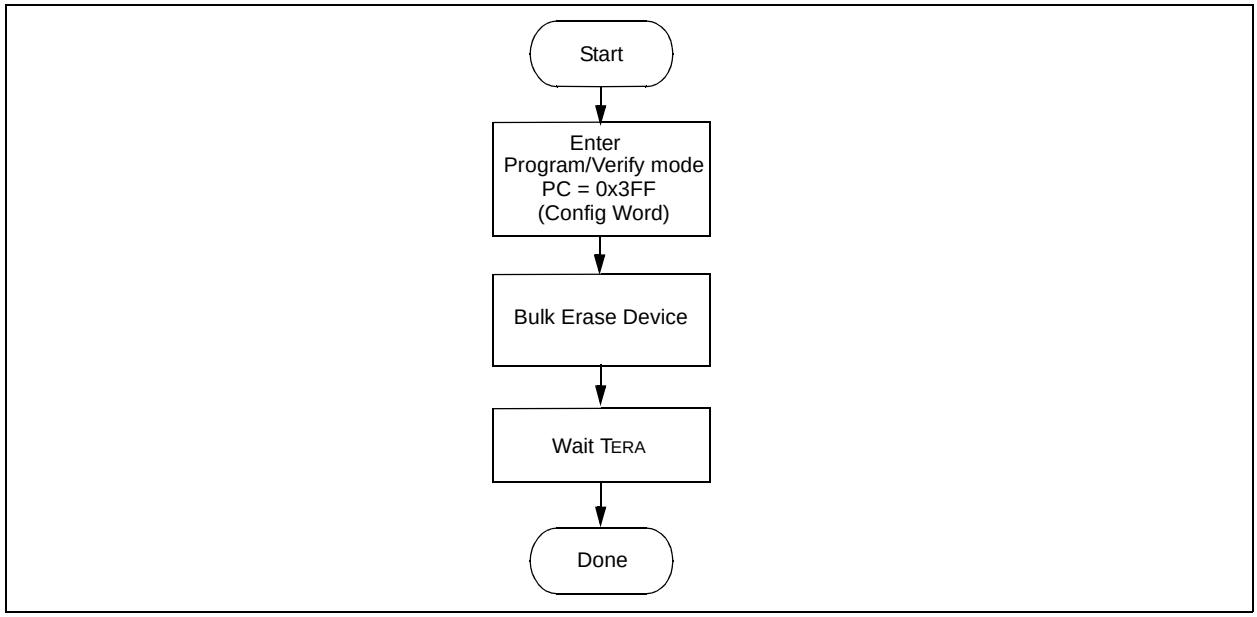
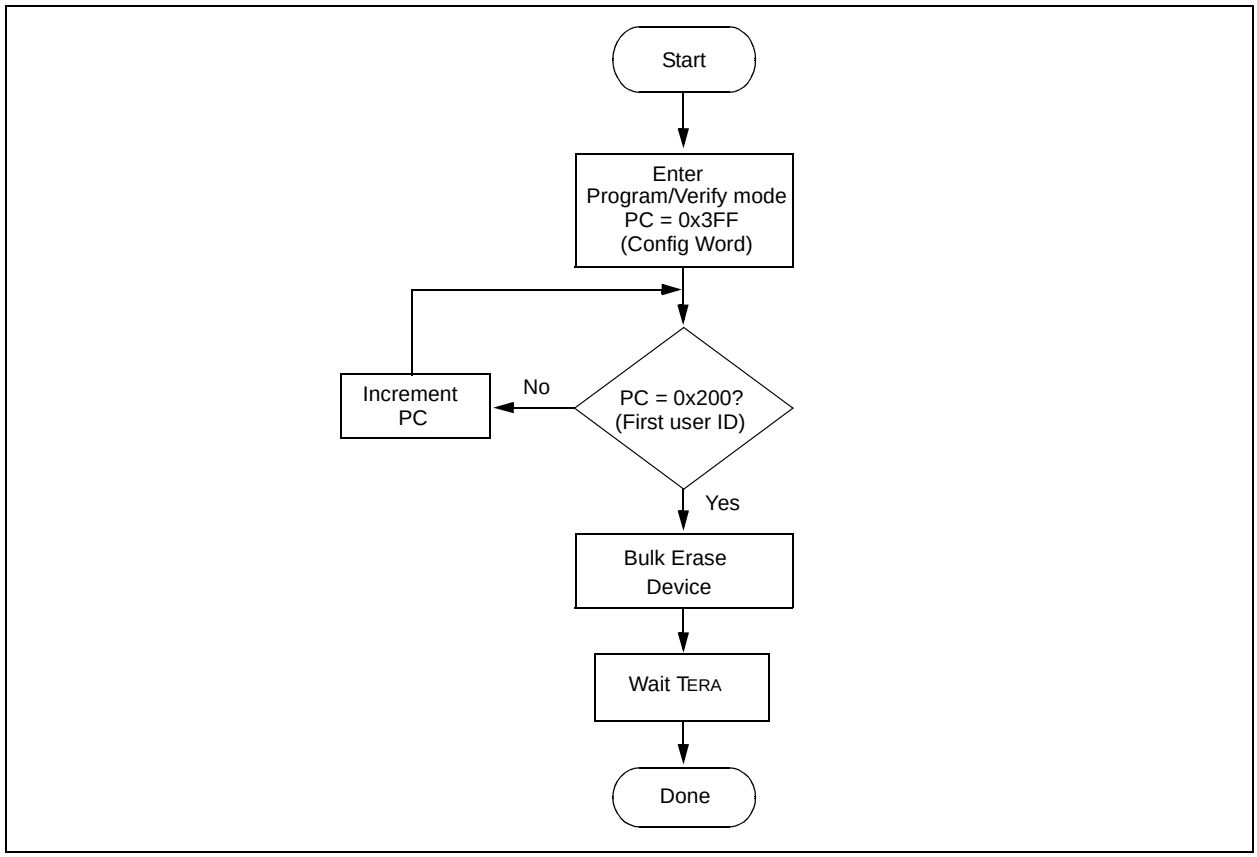


FIGURE 2-12: PROGRAM FLOW CHART – ERASE PROGRAM MEMORY, CONFIGURATION WORD AND USER ID



3.0 CONFIGURATION WORD

The PIC16F54 has several configuration bits. These bits can be programmed (reads '0'), or left unchanged (reads '1'), to select various device configurations.

REGISTER 3-1: CONFIGURATION WORD

—	—	—	—	—	—	—	—	$\overline{CP}$	WDTE	FOSC1	FOSC0

bit 11 bit 0

bit 11-4: **Unimplemented**: Read as '1'

bit 3: **$\overline{CP}$:** Code Protection bit.
- 1 = Code protection off
- 0 = Code protection on

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

bit 1-0: **FOSC1:FOSC0:** Oscillator Selection bits
- 00 = LP oscillator
- 01 = XT oscillator
- 10 = HS oscillator
- 11 = RC oscillator

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

4.0 CODE PROTECTION

For the PIC16F54, once code protection is enabled, all program memory locations above 0x3F read all '0's. Program memory locations 0x00-0x3F are always unprotected. The ID locations and the configuration word read out in an unprotected fashion. It is possible to program the ID locations and the configuration word after code protect is enabled.

4.1 Disabling Code Protection

It is recommended that the following procedure be performed before any other programming is attempted. It is also possible to turn code protection off ($\overline{CP}$ = 1) using this procedure. However, ***all data within the program memory will be erased when this procedure is executed, and thus, the security of the code is not compromised.***

To disable code protect:

a) Enter Program mode

b) Execute Bulk Erase Program Memory command (001001)

c) Wait TERA

4.2 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.

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

4.3 Checksum Computation

4.3.1 CHECKSUM

Checksum is calculated by reading the contents of the PIC16F54 memory locations and adding up the opcodes up to the maximum user addressable location, (e.g., 0x1FF for the PIC16F54). Any carry bits exceeding 16 bits are neglected. Finally, the configuration word (appropriately masked) is added to the checksum. Checksum computation for the PIC16F54 is shown in Table 4-1.

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. The configuration word and ID locations can always be read regardless of the code protect settings.

TABLE 4-1: CHECKSUM COMPUTATIONS(1)

Device	Code Protect	Checksum*	Blank Value	0x723 at 0 and Max Address
PIC16F54	OFF	SUM[0x000:0x1FF] + CFGW & 0x00F + 0xFF0	0x0DFF	0xFC47
	ON	SUM[0x00:0x3F] + CFGW & 0x00F + 0xFF0 + SUM_ID	0x1DB6	0x0322

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, ID2 = 0x3, ID3 = 0x4, then SUM_ID = 0x1234.
*Checksum = [Sum of all the individual expressions] MODULO [0xFFFF]
+ = Addition
& = Bitwise AND

Note: Checksum shown assumes that SUM_ID contains the unprotected checksum.

5.0 PROGRAM/VERIFY MODE ELECTRICAL CHARACTERISTICS

TABLE 5-1: AC/DC CHARACTERISTICS TIMING REQUIREMENTS FOR PROGRAM/VERIFY MODE

AC/DC CHARACTERISTICS		Standard Operating Conditions (unless otherwise stated) Operating Temperature 10°C ≤ TA ≤ 40°C Operating Voltage 4.5V ≤ VDD ≤ 5.5V				
Sym	**Characteristics**	**Min**	**Typ**	**Max**	**Units**	**Conditions/Comments**
General						
VDDPROG	VDD level for read/write operations, program memory	TBD	—	5.5	V	
VDDERA	VDD level for bulk erase/write operations, program memory	4.5	—	5.5	V	
IDDPROG	IDD level for read/write operations, program memory	TBD	—	TBD	mA	
IDDERA	IDD level for bulk erase/write operations, program memory	TBD	—	TBD	mA	
VIHH	High voltage on $\overline{\text{MCLR}}$ for Program/Verify mode entry	12.5	—	13.5	V	
IIHH	$\overline{\text{MCLR}}$ pin current during Program/Verify mode	—	0.5	TBD	mA	
TVHHR	$\overline{\text{MCLR}}$ rise time (VSS to VIHH) for Program/Verify mode entry	—	—	1.0	µs	
TPPDP	Hold time after VPP↑	5	—	—	µs	
VIH1	(ICSPCLK, ICSPDAT) input high level	0.8 VDD	—	—	V	
VIL1	(ICSPCLK, ICSPDAT) input low level	—	—	0.2 VDD	V	
TSET0	ICSPCLK, ICSPDAT setup time before $\overline{\text{MCLR}}$↑ (Program/Verify mode selection pattern setup time)	100	—	—	ns	
THLD0	ICSPCLK, ICSPDAT hold time after $\overline{\text{MCLR}}$↑ (Program/Verify mode selection pattern setup time)	5	—	—	µs	
Serial Program/Verify						
TSET1	Data in setup time before clock↓	100	—	—	ns	
THLD1	Data in hold time after clock↓	100	—	—	ns	
TDLY1	Data input not driven to next clock input (delay required between command/data or command/command)	1.0	—	—	µs	
TDLY2	Delay between clock↓ to clock↑ of next command or data	1.0	—	—	µs	
TDLY3	Clock↑ to data out valid (during Read Data)		—	80	ns	
TERA	Erase cycle time	—	6	10**(1)**	ms	
TPROG	Programming cycle time (externally timed)	—	1	2**(1)**	ms	
TDIS	Time delay for internal programming voltage discharge	100	—	—	µs	
TRESET	Time between exiting Program mode with VDD and VPP at GND and then re-entering Program mode by applying VDD	—	10	—	ms	

Note 1: Minimum time to ensure that function completes successfully over voltage, temperature and device variations.

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.
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Fax: 86-10-85282104

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Chengdu 610016, China
Tel: 86-28-86766200
Fax: 86-28-86766599

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Fuzhou 350001, China
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Fax: 86-591-7503521

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Shenzhen 518033, China
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Fax: 86-755-8295-1393

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Tung Hua North Road
Taipei, 105, Taiwan
Tel: 886-2-2717-7175 Fax: 886-2-2545-0139

EUROPE

Austria
Durisolstrasse 2
A-4600 Wels
Austria
Tel: 43-7242-2244-399
Fax: 43-7242-2244-393

Denmark
Regus Business Centre
Lautrup hoj 1-3
Ballerup DK-2750 Denmark
Tel: 45-4420-9895 Fax: 45-4420-9910

France
Parc d'Activite du Moulin de Massy
43 Rue du Saule Trapu
Batiment A - ler Etage
91300 Massy, France
Tel: 33-1-69-53-63-20
Fax: 33-1-69-30-90-79

Germany
Steinheilstrasse 10
D-85737 Ismaning, Germany
Tel: 49-89-627-144-0
Fax: 49-89-627-144-44

Italy
Via Quasimodo, 12
20025 Legnano (MI)
Milan, Italy
Tel: 39-0331-742611
Fax: 39-0331-466781

Netherlands
Waegenburghtplein 4
NL-5152 JR, Drunen, Netherlands
Tel: 31-416-690399
Fax: 31-416-690340

United Kingdom
505 Eskdale Road
Winnersh Triangle
Wokingham
Berkshire, England RG41 5TU
Tel: 44-118-921-5869
Fax: 44-118-921-5820

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