PIC12F1501/16F1503/7/8/9

8/14/20-Pin Flash, 8-Bit, High-Temperature Microcontrollers

High-Performance RISC CPU:

- C Compiler Optimized Architecture
- Only 49 Instructions
- Operating Speed:
  - DC – 20 MHz clock input
  - DC – 200 ns instruction cycle
- Interrupt Capability with Automatic Context Saving
- 16-Level Deep Hardware Stack with Optional Overflow/Underflow Reset
- Direct, Indirect and Relative Addressing modes:
  - Two full 16-bit File Select Registers (FSRs)
  - FSRs can read program and data memory

Flexible Oscillator Structure:

- 16 MHz Internal Oscillator Block:
  - Factory calibrated to ±1%, typical
  - Software selectable frequency range from 16 MHz to 31 kHz
- 31 kHz Low-Power Internal Oscillator
- Three External Clock modes up to 20 MHz

Special Microcontroller Features:

- Operating Voltage Range:
  - 2.5V to 5.5V (PIC12F1501/16F1503/7/8/9)
- Self-Programmable under Software Control
- Power-on Reset (POR)
- Power-up Timer (PWRT)
- Extended Watchdog Timer (WDT):
  - Programmable period from 1 ms to 256s
- Programmable Code Protection
- In-Circuit Serial Programming™ (ICSP™) via Two Pins
- Enhanced Low-Voltage Programming (LVP)
- In-Circuit Debug (ICD) via Two Pins
- Power-Saving Sleep mode
- Integrated Temperature Indicator
- 128 Bytes High-Endurance Flash
  - 100,000 write Flash endurance (minimum)

Memory:

- Up to 8 Kwords Linear Program Memory Addressing
- Up to 512 bytes Linear Data Memory Addressing
- High-Endurance Flash Data Memory (HEF)
  - 128 bytes if nonvolatile data storage
  - 100k erase/write cycles

Peripheral Features:

- Analog-to-Digital Converter (ADC):
  - 10-bit resolution
  - Up to 12 external channels
  - Up to Three internal channels:
    - Fixed Voltage Reference
    - Digital-to-Analog Converter (DAC) (PIC12F1501/16F1503/8/9 only)
    - Temperature Indicator channel
  - Auto acquisition capability
  - Conversion available during Sleep
- 5-Bit Digital-to-Analog Converter (DAC) (PIC12F1501/16F1503/8/9 only):
  - Output available externally
  - Positive reference selection
  - Internal connections to comparators and ADC
- Up to Two Comparators (PIC12F1501/16F1503/8/9 only):
  - Rail-to-rail inputs
  - Power mode control
  - Software controllable hysteresis
- Voltage Reference:
  - 1.024V Fixed Voltage Reference (FVR) with 1x, 2x and 4x Gain output levels
- Up to 18 I/O Pins (1 Input-only Pin):
  - High-current sink/source 25 mA/25 mA
  - Individually programmable weak pull-ups
  - Individually programmable Interrupt-on-Change (IOC) pins
- Timer0: 8-Bit Timer/Counter with 8-Bit Programmable Prescaler
- Enhanced Timer1:
  - 16-bit timer/counter with prescaler
  - External Gate Input mode
- Timer2: 8-Bit Timer/Counter with 8-Bit Period Register, Prescaler and Postscaler
- Four 10-bit PWM modules
- Master Synchronous Serial Port (MSSP) with SPI and I^2C with (PIC16F1503/8/9 only):
  - 7-bit address masking
  - SMBus/PMBus™ compatibility
- Enhanced Universal Synchronous Asynchronous Receiver Transmitter (EUSART) (PIC16F1508/9 only)
  - RS-232, RS-485 and LIN compatible
  - Auto-Baud Detect
  - Auto-wake-up on Start

Peripheral Features (Continued):

- Up to Four Configurable Logic Cell (CLC) modules:
  - 16 selectable input source signals
  - Four inputs per module
  - Software control of combinational/sequential logic/state/clock functions
  - AND/OR/XOR/D Flop/D Latch/SR/JK
  - Inputs from external and internal sources
  - Output available to pins and peripherals
  - Operation while in Sleep
- Numerically Controlled Oscillator (NCO):
  - 20-bit accumulator
  - 16-bit increment
  - True linear frequency control
  - High-speed clock input
  - Selectable Output modes
    - Fixed Duty Cycle (FDC) mode
    - Pulse Frequency (PF) mode
- Complementary Waveform Generator (CWG):
  - Eight selectable signal sources
  - Selectable falling and rising edge dead-band control
  - Polarity control
  - Four auto-shutdown sources
  - Multiple input sources: PWM, CLC, NCO

Note: This document is supplemented by the following documents:

- *"PIC12(L)F1501 8-Pin, 8-Bit Microcontroller (*DS40001615)
- *"PIC16(L)F1503 14-Pin, 8-Bit Microcontroller (*DS40001607)
- *"PIC16(L)F1507 20-Pin, 8-Bit Microcontroller (*DS40001586)
- *"PIC16(L)F1508/9 20-Pin, 8-Bit Microcontroller (*DS40001609)

PIC12F1501/PIC16F150X FAMILY TYPES

Device	Data Sheet Index	Program Memory Flash (words)	Data SRAM (bytes)	I/O's(2)	10-bit ADC (ch)	Comparators	DAC	Timers (8/16-bit)	PWM	EUSART	MSSP (I^2C/SPI)	CWG	CLC	NCO	Debug(1)	XLP
PIC12F1501	(1)	1024	64	6	4	1	1	2/1	4	—	—	1	2	1	H	—
PIC16F1503	(2)	2048	128	12	8	2	1	2/1	4	—	1	1	2	1	H	—
PIC16F1507	(3)	2048	128	18	12	—	—	2/1	4	—	—	1	2	1	H	—
PIC16F1508	(4)	4096	256	18	12	2	1	2/1	4	1	1	1	4	1	I/H	Y
PIC16F1509	(4)	8192	512	18	12	2	1	2/1	4	1	1	1	4	1	I/H	Y

Note 1: Debugging Methods: (I) - Integrated on Chip; (H) - using Debug Header; (E) - using Emulation Header.
2: One pin is input-only.

Data Sheet Index:

1: DS40001615 PIC12(L)F1501 Data Sheet, 8-Pin Flash, 8-bit Microcontrollers.
2: DS40001607 PIC16(L)F1503 Data Sheet, 14-Pin Flash, 8-bit Microcontrollers.
3: DS40001586 PIC16(L)F1507 Data Sheet, 20-Pin Flash, 8-bit Microcontrollers.
4: DS40001609 PIC16(L)F1508/1509 Data Sheet, 20-Pin Flash, 8-bit Microcontrollers.

Note: For other small form-factor package availability and marking information, please visit **http://www.microchip.com/packaging** or contact your local sales office.

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An errata sheet, describing minor operational differences from the data sheet and recommended workarounds, may exist for current devices. As device/documentation issues become known to us, we will publish an errata sheet. The errata will specify the revision of silicon and revision of document to which it applies.

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1.0 DEVICE OVERVIEW

This document contains device-specific information for the following devices, operating in an ambient temperature range between -40°C and 150°C:

- PIC12F1501
- PIC16F1503
- PIC16F1507
- PIC16F1508
- PIC16F1509

Note: This data sheet documents only the devices' features and specifications that are in addition to the features and specifications of the non-specialty PIC12F1501/16F1503/7/8/9 devices. For information on the features and specifications shared by this document's high-temperature devices and the non-specialty devices, see the following documents:

- "*PIC12(L)F1501 8-Pin, 8-Bit Microcontroller (*DS40001615)
- "*PIC16(L)F1503 14-Pin, 8-Bit Microcontroller (*DS40001607)
- "*PIC16(L)F1507 20-Pin, 8-Bit Microcontroller (*DS40001586)
- "*PIC16(L)F1508/9 20-Pin, 8-Bit Microcontroller (*DS40001609)

The PIC12F1501/16F1503/7/8/9 devices offer Core Independent Peripherals (CIPs), Intelligent Analog modules, and several other features that allow for high-performance, low-cost, and low-power applications.

The primary differentiating features and specifications of the high-temperature PIC12F1501/16F1503/7/8/9 devices are as follows:

- All AC timing specifications are increased by 30%
- This derating factor includes parameters, such as T_{PWRT}
- Maximum HS frequency of operation is 20 MHz
- Oscillator tolerances and V_{DD} operation range are revised

Note 1: The test duration for AEC-Q100 reliability testing for devices operating at 150°C is 1,000 hours. Any design operating at 125°C to 150°C for longer than that period is not warranted without prior written approval from Microchip Technology Inc.

2: Writes are not allowed for Flash program memory above 125°C.

3: The temperature range indicator in the catalog part number and device marking is "H" for -40°C and 150°C.

Example: PIC16F1509-H/SL indicates the device is shipped in tape and reel configuration in the SOIC package and is rated for operation from -40°C and 150°C.

4: The low-voltage versions of these devices PIC12LF1501/16LF1503/7/8/9 are not released for operation above 125°C.

5: Only SOIC (SL), TSSOP (ST), SSOP (SS) and QFN (ML) packages will be offered, not PDIP or UQFN.

2.0 ELECTRICAL CHARACTERISTICS

Note: Other than some basic data, this section documents only the high-temperature PIC12F1501/16F1503/7/8/9 devices' specifications that differ from those of the non-specialty PIC12F1501/16F1503/7/8/9 devices. For detailed information on the electrical specifications shared by the high-temperature and non-specialty devices, see the following data sheets:

- "*PIC12(L)F1501 8-Pin, 8-Bit Microcontroller (*DS40001615)
- "*PIC16(L)F1503 14-Pin, 8-Bit Microcontroller (*DS40001607)
- "*PIC16(L)F1507 20-Pin, 8-Bit Microcontroller (*DS40001586)
- "*PIC16(L)F1508/9 20-Pin, 8-Bit Microcontroller (*DS40001609)

2.1 Absolute Maximum Ratings(†)

Parameter	Condition	Value
Max. Current: V_{DD}	Source	15 mA
Max. Current: V_{SS}	Sink	15 mA
Max. Current: Pin	Source	5 mA
Max. Current: Pin	Sink	5 mA
Max. Storage Temperature	—	-65°C to +155°C
Max. Junction Temperature	Under Bias	+155°C
Ambient Temperature	Under Bias	-40°C to +150°C

Note 1: Maximum current rating requires even load distribution across I/O pins. Maximum current rating may be limited by the device package power dissipation characterizations, see the "Thermal Characteristics" section in the data sheet to calculate device specifications.

2: Power dissipation is calculated as follows: $P_{DIS} = V_{DD} \times \{I_{DD} - \sum I_{OH}\} + \sum \{(V_{DD} - V_{OH}) \times I_{OH}\} + \sum(V_{OL} \times I_{OL})$.

† NOTICE: Stresses above those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. This is a stress rating only and functional operation of the device at those or any other conditions above those indicated in the operation listings of this specification is not implied. Exposure above maximum rating conditions for extended periods may affect device reliability.

2.2 Standard Operating Conditions

The standard operating conditions for any device are defined as:

Operating Voltage: $V_{DDMIN} \le V_{DD} \le V_{DDMAX}$
Operating Temperature: $T_{A\_MIN} \le T_A \le T_{A\_MAX}$

V_{DD} — Operating Supply Voltage

PIC12F1501/16F1503/7/8/9

V_{DDMIN} (Fosc ≤ 20 MHz) ..... +2.5V

V_{DDMAX} ..... +5.5V

T_A — Operating Ambient Temperature Range

High Temperature

T_{A_MIN} ..... -40°C

T_{A_MAX} ..... +150°C

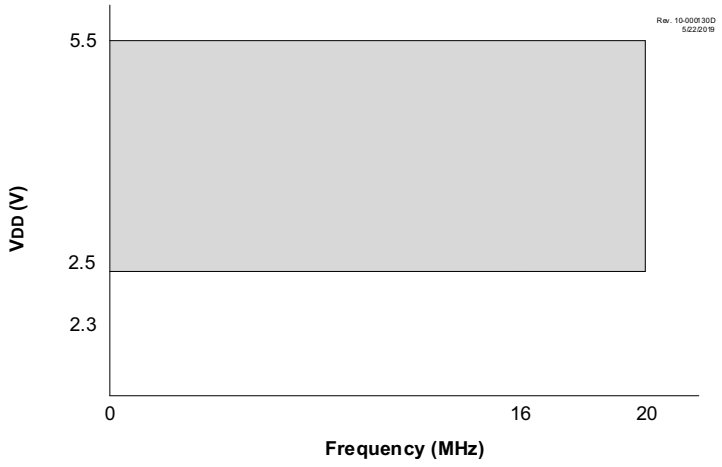
2.3 DC Characteristics

TABLE 2-1: SUPPLY VOLTAGE (-40°C ≤ T_A ≤ +150°C)

PIC12F1501/16F1503/7/8/9			Standard Operating Conditions (unless otherwise stated)				
Param No.	**Symbol**	**Characteristic**	**Min.**	**Typ.†**	**Max.**	**Units**	**Conditions**
Supply Voltage							
D001	V_{DD}	Supply Voltage	**2.5**	—	5.5	V	F_{OSC} ≤ 16 MHz F_{OSC} ≤ 20 MHz
D002	V_{DR}	RAM Data Retention Voltage	**2.1**	—	—	V	Device in Sleep mode
D003A	V_{ADFVR}	FVR Gain Voltage Accuracy for ADC	**-10**	—	**+10**	%	1x V_{FVR}, V_{DD} ≥ 2.5V 2x V_{FVR}, V_{DD} ≥ 2.5V 4x V_{FVR}, V_{DD} ≥ 4.75V

† Data in "Typ." column is at 3.0V, 25°C unless otherwise stated. These parameters are for design guidance only and are not tested.

FIGURE 2-1: VOLTAGE-FREQUENCY GRAPH, -40°C ≤ T_A ≤ +150°C



Note 1: The shaded region indicates the permissible combinations of voltage and frequency.

2.4 AC Characteristics

TABLE 2-2: INTERNAL OSCILLATOR PARAMETERS FOR PIC12F1501/16F1503/7/8/9 (HIGH TEMP)

PIC12F1501/16F1503/7/8/9			Standard Operating Conditions (unless otherwise stated) Operating Temperature: -40°C ≤ TA ≤ +150°C for High Temperature					
Param No.	**Symbol**	**Device Characteristic**	**Frequency Tolerance**	**Min.**	**Typ.†**	**Max.**	**Units**	**Conditions**
OS08	HFOSC	Internal-Calibrated HFINTOSC Frequency	—	—	**16**	—	MHz	See Figure 2-2 for details.

* These parameters are characterized but not tested.

† Data in "Typ" column is at 3.0V, 25°C unless otherwise stated. These parameters are for design guidance only and are not tested.

Note 1: To ensure these oscillator frequency tolerances, VDD and VSS must be capacitively decoupled as close to the device as possible. 0.1 µF and 0.01 µF values in parallel are recommended.

FIGURE 2-2: HFINTOSC FREQUENCY ACCURACY OVER VDD AND TEMPERATURE

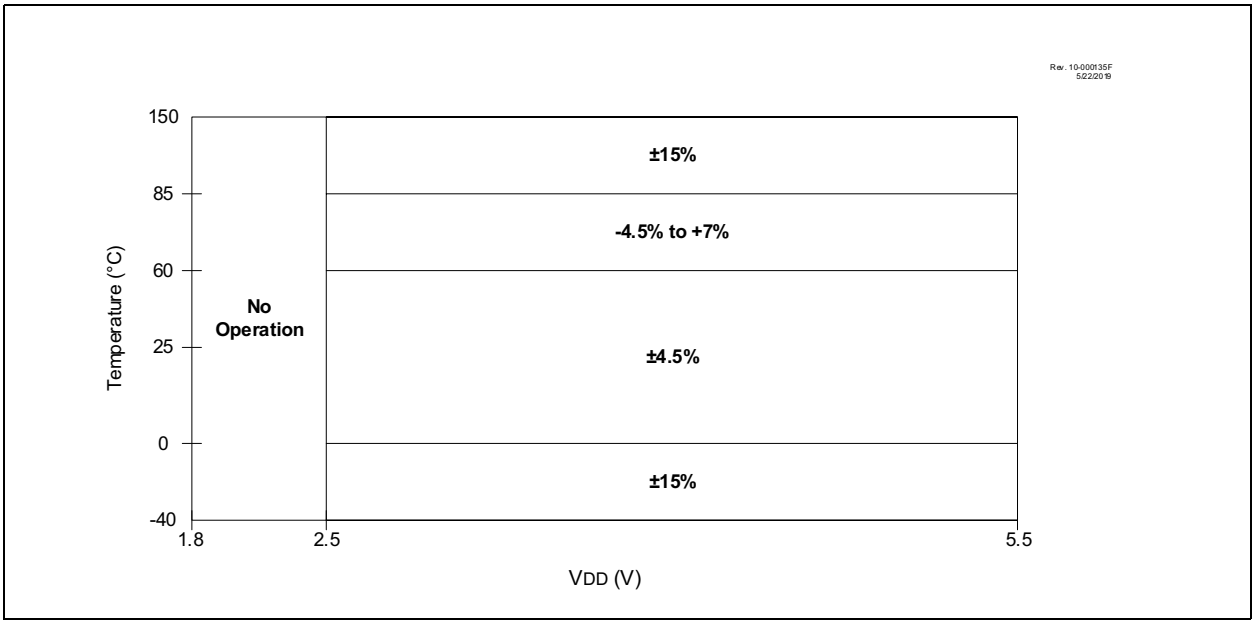


TABLE 2-3: RESET, WATCHDOG TIMER, OSCILLATOR START-UP TIMER, POWER-UP TIMER, BROWN-OUT TIMER AND LOW-POWER BROWN-OUT RESET SPECIFICATIONS

PIC12F1501/16F1503/7/8/9			Standard Operating Conditions (unless otherwise stated) Operating Temperature: -40°C ≤ TA ≤ +150°C for High Temperature				
			Min.	Typ.†	Max. +150°C	Units	Conditions
31	TWDTLP	Low-Power Watchdog Timer Time-out Period	7	16	**33**	ms	VDD = 3.3V-5V, 1:16 Prescaler used (PIC16F1508/9) 1:512 Prescaler used (PIC12F1501/16F1503/7)

TABLE 2-4: ANALOG-TO-DIGITAL CONVERTER (ADC) CHARACTERISTICS

Standard Operating Conditions (unless otherwise stated) VDD = 3.0V, TA = 150°C							
Param. No.	Sym.	Characteristic	Min.	Typ.†	Max.	Units	Conditions
AD04	EOFF	Offset Error	—	—	**±3.5**	LSb	VREF = 3.0V

TABLE 2-5: COMPARATOR SPECIFICATIONS

Standard Operating Conditions (unless otherwise stated) VDD = 3.0V, TA = 150°C							
Param. No.	Sym.	Characteristic	Min.	Typ.†	Max.	Units	Conditions
CM01	VIOFF	Input Offset Voltage	—	—	**±70**	mV	CxSP = 1, VICM = VDD/2

APPENDIX A: REVISION HISTORY

Revision A (July 2019)

Initial release of document.

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PART NO.	[X](1)	-	X	/XX	XXX
Device	Tape and Reel Option		Temperature Range	Package	Pattern

Device:	PIC12F1501 PIC16F1503 PIC16F1507 PIC16F1508 PIC16F1509	
Tape and Reel Option:	Blank T	= Standard packaging (tube or tray) = Tape and Reel(1)
Temperature Range:	H	= -40°C to +150°C (High Temperature)
Package:(2)	ML SL SS ST	= QFN (16-Lead and 20-Lead) = SOIC (14-Lead) = SSOP (20-Lead) = TSSOP (14-Lead)
Pattern:	QTP, SQTP, Code or Special Requirements (blank otherwise)	

Examples:

a) PIC16F1508T - H/SL
Tape and Reel,
High temperature,
SOIC package

b) PIC16F1509 - H/ML 298
High temperature,
QFN package
QTP pattern #298

Note 1: Tape and Reel identifier only appears in the catalog part number description. This identifier is used for ordering purposes and is not printed on the device package. Check with your Microchip Sales Office for package availability with the Tape and Reel option.

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