PIC16F1615/9

Full-Featured, Low Pin Count, High-Temperature Microcontrollers

Description

PIC16(L)F1615/9 microcontrollers deliver on-chip features that are unique to the design for embedded control of small motors and general purpose applications in 14/20-pin count packages. Features like 10-bit A/D, CCP, 24-bit SMT and Zero-Cross Detection offer an excellent solution to the variety of applications. The product family also has a CRC+ memory scan and Windowed Watchdog Timer to support safety-critical systems in home appliances, white goods and other end equipment.

Core Features

- C Compiler Optimized RISC Architecture
- Only 49 Instructions
- Operating Speed:
  - DC – 32 MHz clock input
  - 125 ns minimum instruction cycle
- Interrupt Capability
- 16-Level Deep Hardware Stack
- One 8-Bit Timer
- Four 16-bit Timers
- Low Current Power-on Reset (POR)
- Configurable Power-up Timer (PWRT)
- Brown-out Reset (BOR) with Selectable Trip Point
- Windowed Watchdog Timer (WWDT):
  - Variable prescaler selection
  - Variable window size selection
  - All sources configurable in hardware or software

Memory

- 4 KW Flash Program Memory
- 512 Bytes Data SRAM
- Direct, Indirect and Relative Addressing modes
- High-Endurance Flash Data Memory (HEF):
  - 128 B of nonvolatile data storage
  - 100K erase/write cycles

Operating Characteristics

- Operating Voltage Range:
  - 2.5V to 5.5V (PIC16LF1615/9)
- Temperature Range:
  - High Temp: -40°C to 150°C

Digital Peripherals

- Configurable Logic Cell (CLC):
  - Two CLCs
  - Integrated combinational and sequential logic
- Complementary Waveform Generator (CWG):
  - Rising and falling edge dead-band control
  - Full-bridge, half-bridge, 1-channel drive
  - Multiple signal sources
- Two Capture/Compare/PWM (CCP) modules
- Two 10-bit Pulse-Width Modulators (PWM)
- Two Signal Measurement Timers (SMT):
  - 24-bit timer/counter with prescaler
  - Multiple gate and clock inputs
- Angular Timer:
  - Single pulse
  - Multiple pulses with missing pulse recovery
- 8-Bit Timers (TMR2+HLT/4/6):
  - Up to 3 Timer2/4/6 with Hardware Limit Timer (HLT)
  - Monitors Fault Conditions: Stall, Stop, etc.
  - Multiple modes
  - 8-bit timer/counter with prescaler
  - 8-bit period register and postscaler
  - Asynchronous H/W Reset sources
- Math Accelerator with Proportional-Integral-Derivative (PID):
  - Four operation modes
  - Add and multiply
  - Simple multiplier
  - Multiply and Accumulate
  - Programmable PID controller
- Cyclic Redundancy Check with Memory Scan (CRC/SCAN):
  - Software configurable
- Serial Communications:
  - Enhanced USART (EUSART)
  - SPI, I^2C, RS-232, RS-485, LIN compatible
  - Auto-Baud Detect, Auto-Wake-up on start
- Up to 17 I/O Pins and One Input-only Pin:
  - Individually programmable pull-ups
  - Slew rate control
  - Interrupt-on-change with edge-select
  - Two High Current Drive pins
- Peripheral Pin Select (PPS):
  - Enables pin mapping of digital I/O

Intelligent Analog Peripherals

- 10-Bit Analog-to-Digital Converter (ADC):
  - Up to 12 external channels
  - Conversion available during Sleep
- Two Comparators (COMP):
  - Low-Power/High-Speed mode
  - Up to three external inverting inputs
  - Fixed Voltage Reference at non-inverting input(s)
  - Comparator outputs externally accessible
- 8-Bit Digital-to-Analog Converter (DAC):
  - 8-bit resolution, rail-to-rail
  - Positive Reference Selection
- Voltage Reference:
  - Fixed Voltage Reference (FVR): 1.024V, 2.048V and 4.096V output levels
- Zero-Cross Detect (ZCD):
  - Detect when AC signal on pin crosses ground
- Two High-Current Drive Pins:
  - 100mA @ 5V

Clocking Structure

- 16 MHz Internal Oscillator:
  - ±1% at calibration
  - Selectable frequency range from 32 MHz to 31 kHz
- 31 kHz Low-Power Internal Oscillator
- 4x Phase-Locked Loop (PLL):
  - For up to 32 MHz internal operation
- External Oscillator Block with:
  - Three external clock modes up to 32 MHz

Note: This document is supplemented by the "*PIC16(L)F1615/9 14/20-Pin, 8-Bit Flash Microcontroller" data sheet* (DS40001770). See **Section 1.0 "Device Overview"**.

TABLE 1: PIC12/16F161X FAMILY TYPES

Device	Data Sheet Index	Program Memory Flash (W)	Program Memory Flash (kB)	Data SRAM (bytes)	High Endurance Flash (bytes)	I/O Pins	8-bit Timer with HLT	16-bit Timer	Angular Timer	Windowed Watchdog Timer	24-bit SMT	Comparators	10-bit ADC (ch)	Zero-Cross Detect	CCP/10-bit PWM	CWG	CLC	CRC with Memory Scan	Math Accelerator with PID	High-Current I/O 100mA	PPS	EUSART	I^2C/SPI
PIC12F1612	(A)	2048	3.5	256	256	6	4	1	0	Y	1	1	4	1	2/0	1	0	Y	0	0	N	0	0
PIC16F1613	(A)	2048	3.5	256	256	12	4	1	0	Y	2	2	8	1	2/0	1	0	Y	0	0	N	0	0
PIC16F1614	(B)	4096	7	512	512	12	4	3	1	Y	2	2	8	1	2/2	1	2	Y	1	2	Y	1	1
PIC16F1615	(C)	8192	14	1024	128	12	4	3	1	Y	2	2	8	1	2/2	1	4	Y	1	2	Y	1	1
PIC16F1618	(B)	4096	7	512	512	18	4	3	1	Y	2	2	12	1	2/2	1	2	Y	1	2	Y	1	1
PIC16F1619	(C)	8192	14	1024	128	18	4	3	1	Y	2	2	12	1	2/2	1	4	Y	1	2	Y	1	1

Note 1: Debugging Methods: (I) – Integrated on Chip; E – using Emulation Product

Data Sheet Index:

A. DS40001737 PIC12(L)F1612/16(L)F1613 Data Sheet, 8/14-Pin, 8-bit Flash Microcontrollers

B. DS40001769 PIC16(L)F1614/8 Data Sheet, 14/20-Pin, 8-bit Flash Microcontrollers

C. DS40001770 PIC16(L)F1615/9 Data Sheet, 14/20-Pin, 8-bit Flash Microcontrollers

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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:

- PIC16F1615
- PIC16F1619

Note: This data sheet documents only the devices' features and specifications that are in addition to the features and specifications of the non-specialty PIC16F1615/9 devices. For information on the features and specifications shared by this document's high-temperature devices and the non-specialty devices, see the "*PIC16(L)F1615/9 14/20-Pin, 8-Bit Flash Microcontroller" data sheet* (DS40001770).

The PIC16F1615/9 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 PIC16F1615/9 devices are:

- All AC timing specifications are increased by 30%

  This derating factor includes parameters, such as TPWRT
- 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: PIC16F1619T-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 PIC16LF1614 and PIC16LF1618 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 DEVICE/REVISION ID REGISTERS

Note: For additional details on the Device ID, Revision ID or Configuration bits, refer to *Section 5.0 "Device Configuration"* in the "*PIC16(L)F1615/9 14/20-Pin, 8-Bit Flash Microcontroller" data sheet* (DS40001770)*"*. Device/Revision ID information presented in this section is for the high-temperature PIC16F1615/9 devices only.

REGISTER 2-1: DEVID: DEVICE ID REGISTER

R	R	R	R	R	R
DEV<13:8>					
bit 13					bit 8

R	R	R	R	R	R	R	R
DEV<7:0>							
bit 7							bit 0

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

bit 13-0 **DEV<13:0>:** Device ID bits

Device	DEVID<13:0> Values
PIC16F1615	11 0000 0111 1100 (307Ch)
PIC16F1619	11 0000 0111 1101 (307Dh)

REGISTER 2-2: REVID: REVISION ID REGISTER 2

R-1	R-0	R	R	R	R
REV<13:8>					
bit 13					bit 8

R	R	R	R	R	R	R	R
REV<7:0>							
bit 7							bit 0

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

bit 13-0 **DEV<13:0>:** Revision ID bits

Note: The upper two bits of the Revision ID register will always read '10'.

3.0 ELECTRICAL CHARACTERISTICS

Note: Other than some basic data, this section documents only the high-temperature PIC16F1615/9 devices' specifications that differ from those of the non-specialty PIC16F1615/9 devices. For detailed information on the electrical specifications shared by the high-temperature and non-specialty devices, see the "*PIC16(L)F1615/9 14/20-Pin, 8-Bit Flash Microcontroller" data sheet* (DS40001770).

3.1 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 Table-35-6: "Thermal Characteristics" to calculate device specifications.

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

.

† 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.

3.2 Standard Operating Conditions

The standard operating conditions for any device are defined as:

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

V_{DD} — Operating Supply Voltage

PIC16F1615/9

V_{DDMIN} (Fosc ≤ 16 MHz) ..... +2.5V
V_{DDMIN} (Fosc > 32 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

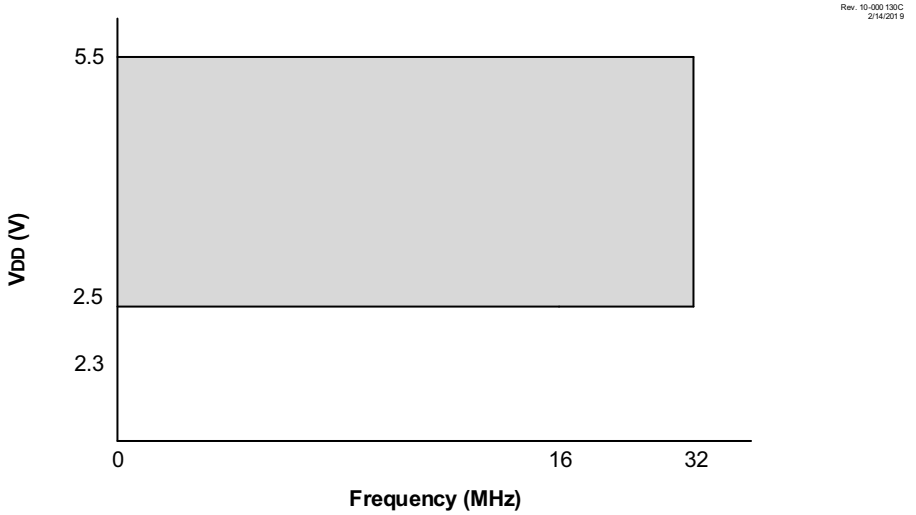
3.3 DC Characteristics

TABLE 3-1: SUPPLY VOLTAGE (-40°C ≤ TA ≤ +150°C)

PIC16F1615/9			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	$F_{OSC} \leq 16$ MHz $F_{OSC} \leq 32$ 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	V	1x V_{FVR}, $V_{DD} \geq 2.5$V 2x V_{FVR}, $V_{DD} \geq 2.5$V 4x V_{FVR}, $V_{DD} \geq 4.75$V

† 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 3-1: VOLTAGE-FREQUENCY GRAPH, -40°C ≤ TA ≤ +150°C



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

TABLE 3-2: DC CHARACTERISTICS: SUPPLY CURRENT(1,2)

PIC16F1615/9		Standard Operating Conditions (unless otherwise stated) Operating Temperature: -40°C ≤ TA ≤ +150°C for High Temperature					
Param. No.	Device Characteristics	Min.	Typ†	Max.	Units	Conditions	
						VDD	Note
D013		—	—	**135**	µA	2.5	FOSC = 1 MHz, External Clock (ECM), Medium-Power mode
		—	—	**160**	µA	3.0	
		—	—	**210**	µA	5.0	
D014		—	—	**365**	µA	2.5	FOSC = 4 MHz, External Clock (ECM), Medium-Power mode
		—	—	**420**	µA	3.0	
		—	—	**530**	µA	5.0	
D017*		—	—	**1100**	µA	2.5	FOSC = 8 MHz, HFINTOSC
		—	—	**1300**	µA	3.0	
		—	—	**1400**	µA	5.0	
D018		—	—	**1600**	µA	2.5	FOSC = 16 MHz, HFINTOSC
		—	—	**1900**	µA	3.0	
		—	—	**2100**	µA	5.0	
D020C		—	—	**65**	µA	2.5	FOSC = 500 kHz, External Clock (ECL), Low-Power mode
		—	—	**100**	µA	3.0	
		—	—	**110**	µA	5.0	

* 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: The test conditions for all IDD measurements in active operation mode are: OSC1 = external square wave, from rail-to-rail; all I/O pins tri-stated, pulled to VSS; $\overline{MCLR}$ = VDD; WDT disabled.

2: The supply current is mainly a function of the operating voltage and frequency. Other factors, such as I/O pin loading and switching rate, oscillator type, internal code execution pattern and temperature, also have an impact on the current consumption.

TABLE 3-3: DC CHARACTERISTICS: POWER-DOWN CURRENTS (IPD)(1,2,3)

PIC16F1615/9			Standard Operating Conditions (unless otherwise stated) VREPGM = 1			
			Max. +150°C	Units	Conditions	
Param No.	Symbol	Device Characteristic			VDD	Notes
D023			**16**	uA	2.5	WDT Current
			20	uA	3.0	
			22	uA	5.0	
D023A			**37**	uA	2.5	FVR Current
			38	uA	3.0	
			39	uA	5.0	
D024A			**—**	uA	2.5	LPBOR Current
			15	uA	3.0	
			17	uA	5.0	
D026			**15**	uA	2.5	ADC Current No conversion in progress
			17	uA	3.0	
			20	uA	5.0	
D027			**37**	uA	2.5	Comparator, CxSP = 0
			38	uA	3.0	
			45	uA	5.0	

† 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: The peripheral current is the sum of the base IPD and the additional current consumed when this peripheral is enabled. The peripheral Δ current can be determined by substracting the base IDD or IPD current from this limit. Max. values should be used when calculating total current consumption.

2: The power-down current in Sleep mode does not depend on the oscillator type. Power-down current is measured with the part in Sleep mode, with all I/O pins in high-impedance state and tied to VSS.

3: All peripheral currents listed are on a per-peripheral basis if more than one instance of a peripheral is available.

4: ADC clock source is ADCRC.

3.4 AC Characteristics

TABLE 3-4: MEMORY PROGRAMMING REQUIREMENTS FOR PIC16F1615/9 (HIGH TEMP)

PIC16F16F1615/1619			Standard Operating Conditions (unless otherwise stated) Operating Temperature: -40°C ≤ TA ≤ +150°C for High Temperature				
Param No.	**Symbol**	**Device Characteristic**	**Min.**	**Typ.†**	**Max.**	**Units**	**Conditions**
		Program Flash Memory					
D121	EP	Cell Endurance	—	—	—	—	Programming the Flash memory above +125°C is not permitted
D124	TRETD	Data Retention	—	20	—	Years	

Note:

TABLE 3-5: INTERNAL OSCILLATOR PARAMETERS FOR PIC16F1615/9 (HIGH TEMP)

PIC16F1615/1619			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	-40°C ≤ TA ≤ 125°C VDD ≥ 2.5V
			+/-10%	—	**16**	—	MHz	-40°C ≤ TA ≤ 150°C VDD ≥ 2.5V
OS09	LFOSC	Internal LFINTOSC Frequency	—	—	**31**	—	kHz	-40°C ≤ TA ≤ 125°C VDD ≥ 2.5V
			+/-35%	—	**31**	—	kHz	-40°C ≤ TA ≤ 150°C VDD ≥ 2.5V

* 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 3-2: HFINTOSC FREQUENCY ACCURACY OVER VDD AND TEMPERATURE

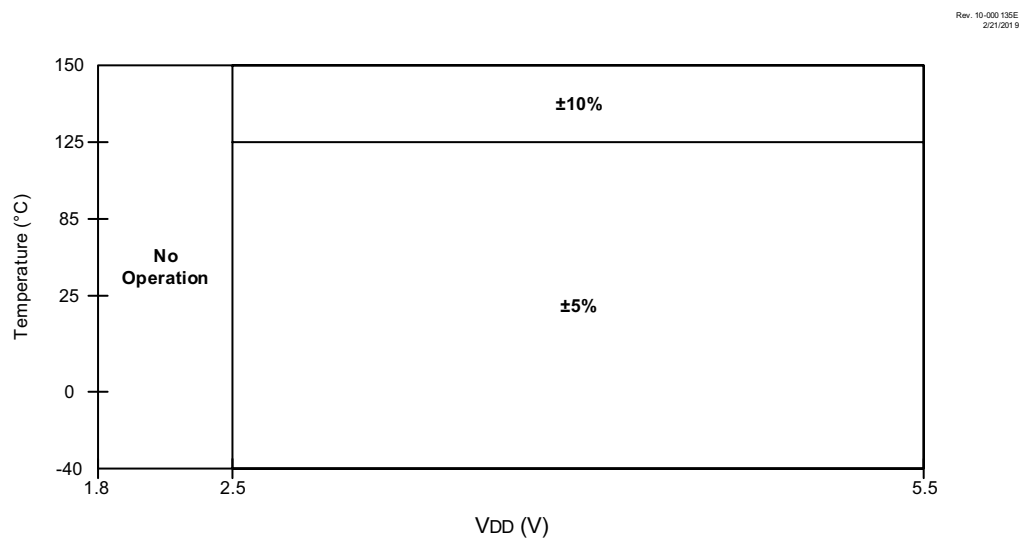


TABLE 3-6: RESET, WATCHDOG TIMER, OSCILLATOR START-UP TIMER, POWER-UP TIMER, BROWN-OUT TIMER AND LOW-POWER BROWN-OUT RESET SPECIFICATIONS

PIC16F1615/9			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		**33**	ms	VDD = 3.3V-5V, 1:512 Prescaler used
35	VBOR	Brown-out Reset Voltage	—	—	**2.9**	V	BORV = 0
			—	—	—	—	BORV = 1

TABLE 3-7: 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 3-8: 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 (2/2019)

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:	PIC16F1615, PIC16F1619	
Tape and Reel Option:	Blank T	= Standard packaging (tube or tray) = Tape and Reel(1)
Temperature Range:	I E	= -40°C to +85°C (Industrial) = -40°C to +125°C (Extended)
Package:(2)	ML P SL ST GZ	= QFN (16-Lead and 20-Lead) = Plastic DIP = SOIC (14-Lead) = TSSOP = UQFN (20-Lead)
Pattern:	QTP, SQTP, Code or Special Requirements (blank otherwise)	

Examples:

a) PIC16F1615T - I/SL
Tape and Reel,
Industrial temperature,
SOIC package

b) PIC16F1619 - I/P
Industrial temperature
PDIP package

c) PIC16F1619 - E/ML 298
Extended 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.

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

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