



16-bit Embedded Control Solutions

PIC24 Microcontrollers • dsPIC® Digital Signal Controllers

16-bit Microcontrollers & dsPIC® Digital Signal Controllers

- Motor control and digital power peripherals
- eXtreme Low Power
- USB and CAN connectivity
- Integrated graphics drivers



16-bit Embedded Control Solutions

The top challenges facing today's embedded system designer are attaining product specification and performance goals, achieving on-time market launch and meeting cost targets. Microchip's 16-bit Microcontroller and Digital Signal Controller families deliver the performance, peripherals, software and hardware development tools to meet these objectives.

Broad Portfolio

- 16–70 MIPS, DSP options
- 4–512 KB Flash
- 256B–96 KB RAM
- 14–144 Pins

Efficient Energy

- Longer battery life in portable applications
- High-efficiency motor control
- Platinum-rated digital power supplies

Easy Migration

- Unified development environment
- Industry-leading code efficiency
- Lower total system cost
- Faster time-to-market

High Performance Peripherals

- Fast and flexible PWMs
- Integrated ADCs, op amps, DACs, LCD
- Connectivity with USB, CAN, LIN

Free Software & Reference Designs

- Shorten design cycle and reduce risk
- USB, TCP/IP, graphics and wireless stacks
- Motor control example software
- DSP math function library (FFT, IIR, etc.)
- Reference designs for digital power and lighting applications

Resources available at www.microchip.com/16bit

- Product Information
- Application Solutions
- Design Tools
- Web Seminars
- Application Notes and Reference Designs



Powerful 16-bit CPU

- CoreMark™/MHz 1.88 (EEMBC Certified)
- Single-cycle execution
- Deterministic interrupt response
- Single-cycle bit manipulation
- Single-cycle multiply
- Zero overhead looping
- Fast DMA: no cycle stealing

Flexible Flash

- High endurance, flexible and secure Flash
- Advanced security features
- Program and data storage
- Self-program features

Integrated DSP

- Look and feel of MCU
- Single-cycle 16 × 16 MAC
- 40-bit accumulators
- Dual operand fetches
- Saturation and rounding modes
- Free libraries and low-cost filter design tools

Innovative Peripherals

- Motor control peripherals
- SMPS peripherals
- Graphics controller
- CTMU for mTouch™ technology
- USB Device/Embedded Host/OTG
- CAN
- Peripheral trigger generator
- Intelligent analog

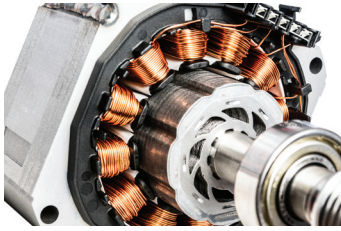
Power Saving Options

- eXtreme Low Power technology
- Deep sleep current as low as 10 nA
- Options to reduce speed or disable CPU
- Application software can alter clock speeds
- VBAT battery backup

Small Packages

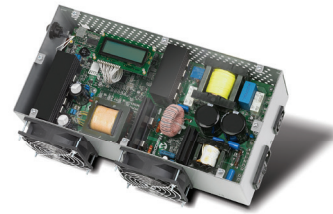
- Packages as small as 5 × 5 mm
- 16-bit MCU with 128 KB Flash in a 6 × 6 mm package
- Peripheral Pin Select allows access to the peripherals needed

16-bit Embedded Control Solutions



Advanced Motor Control with dsPIC® DSCs Portfolio

dsPIC Motor Control DSCs feature a high-performance CPU with motor control peripherals. The silicon solutions are backed up by free advanced software application libraries and motor control algorithms. Flexible motor control development boards support a wide variety of motors and help you to reduce your design risk and development efforts. Visit www.microchip.com/motor for more information.



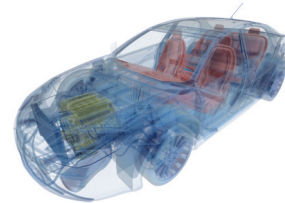
Digital Power for Improving Efficiency and Optimizing the BOM

Implementing advanced software digital control loops for power applications requires a high-performance DSP engine along with specialized peripherals. The dsPIC “GS” Family of DSCs feature a high-performance CPU and rich peripherals including 4 Msp/s 10-bit ADC, 1 nSec resolution PWM and analog comparator with 10 nSec response time. Complete reference designs and application solutions from Microchip will help you to get started. Visit www.microchip.com/power for more information.



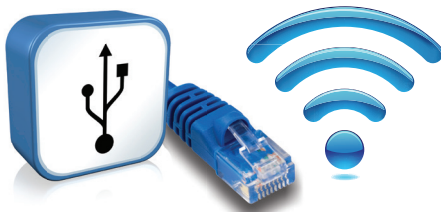
eXtreme Low Power (XLP) Solutions

XLP Technology brings together the design and process technologies needed to address today's low-power applications. With sleep currents down to 10 nA and industry-leading integration that includes USB, Peripheral Pin Select (PPS) and mTouch capacitive sensing, XLP products can help you extend the life of your battery-powered application. Visit www.microchip.com/xlp for more information.



High Temperature Rated Devices Qualified to AEC-Q100 Requirements

Several PIC24HJ and dsPIC33FJ devices are rated for operation up to 150°C ambient. These devices provide up to 20 MIPS processing power plus digital signal processing, LIN/CAN connectivity, motor control and 10/12-bit ADC performance for stringent automotive and industrial applications. AEC-Q100 Grade 0 (150°C) devices have been released as well. Visit www.microchip.com/hightemp for the latest products.



Enhancing Connectivity to Your Embedded Control Applications

Whether you are considering wired or wireless connectivity, Microchip supports a wide variety of communications protocols with extensive design resources and software libraries. It's easy to pair the PIC24 or dsPIC DSC devices with Microchip's Bluetooth® or Wi-Fi® modules for connecting to other systems. Microchip offers ZigBee® Pro, MiWi™ protocol and IrDA® library stacks for wireless connectivity and Ethernet, CAN and USB library stacks for wired connectivity. Visit www.microchip.com/connectivity for more information.



Graphics Display Solutions

Graphics displays are gaining popularity in user interface. They are easy to add to your application using the PIC24F “DA” family with integrated graphics controller and hardware acceleration. With Microchip's free graphics library and development tools, you can quickly integrate graphics display functions into your application using a single microcontroller. Visit www.microchip.com/graphics for more information.

Leading 16-bit Performance and Features

16-bit Microcontroller (MCU) Portfolio

Are costs, performance, low power and smaller packages important considerations for your next design?

PIC24 MCUs offer a variety of peripherals, memory sizes and packaging choices. The 16 MIPS PIC24F family is designed for low-power applications. The 40/70 MIPS PIC24H/E MCUs are designed for high-performance applications. Both families have the same instruction set, share basic peripherals, have common pinouts and use the same tools for development. The PIC24 families are compatible with dsPIC DSCs for easy migration when additional performance or DSP capability is required.

PIC24F: Lowest Power 16-bit MCUs

With 16 MIPS performance and an extensive peripheral set including a graphics controller, USB Device/Embedded Host/OTG and capacitive touch sense interface, the PIC24F MCUs are cost-effective for low-power applications. Serial communication peripherals include up to four UARTs, three SPI and three I²C™. With the introduction of XLP Technology, select PIC24F devices have industry-leading low-power performance with sleep numbers as low as 10 nA and RTCC operation down to 400 nA.

PIC24E: Highest Performance 16-bit MCUs

PIC24E devices offer up to 70 MIPS performance with a combination of large memory and a wide variety of package options. They also include large Flash in smaller packages (5 × 5 mm). The built-in peripherals include a high-performance 12-bit ADC and general purpose and motor control 16-bit PWMs. Communication peripherals include up to two CAN modules, four UARTs (with IrDA support), four SPI, two I²C and USB Device/Embedded Host/OTG. High-performance 16 channel Direct Memory Access (DMA) provides better data handling capability optimizing CPU throughput. AEC-Q100-qualified extended (125°C) and high-temperature (150°C) options for industrial and automotive applications are available.

16-bit Digital Signal Controller (DSC) Portfolio

Does your embedded control application demand performance for advanced motor control, digital power, speech and audio processing? Do you want to implement digital filters and FFT algorithms for signal analysis?

dsPIC DSCs offer innovative peripherals and the necessary performance to meet these needs. Our dsPIC family is a 100% PIC MCU with enhanced math capabilities. dsPIC DSCs blend the performance of DSP with the simplicity of an MCU.

dsPIC33: Highest Performance 16-bit MCU with Integrated DSP

The dsPIC33 core is designed to execute and control high-speed precision digital control loops and digital processing up to 70 MIPS. The optimized motor control and digital power conversion peripherals include the highest performance ADC, PWMs, and analog comparators. A wide variety of memory and package options, communication peripherals, 15 channel DMA and general purpose peripherals provide flexibility to your high-performance embedded control designs. AEC-Q100-qualified extended- and high-temperature options for industrial and automotive applications are available.

Example dsPIC® DSP Performance

| Function | Conditions* | Execution Time @70 MIPS |
|--------------------|---------------|-------------------------|
| Vector Dot Product | N = 32 | 1.7 μs |
| Matrix Add | C = 8, R = 8 | 3.1 μs |
| Matrix Transpose | C = 8, R = 8 | 3.4 μs |
| Block IIR Canonic | N = 32, S = 4 | 17.0 μs |
| Block FIR | N = 32 M = 32 | 17.5 μs |
| Complex FFT** | N = 64 | 55.6 μs |

*C = # columns, N = # samples, M = # taps, S = # sections, R = # rows
**Complex FFT routine inherently prevents overflow.
1 cycle = 14.29 nanoseconds @ 70 MIPS

High-Performance CPU

- Single-cycle execution (most instructions)
- C compiler optimized instruction set
- 16-bit wide data path
- 76 base instructions: mostly 1 word/1 cycle
- 16, 16-bit general purpose registers
- Software stack
- 16 × 16 signed fractional/integer multiplier
- 32/16 and 16/16 divide
- 40-stage barrel shifter
- DSC additions:
 - Adds eight base DSP instructions
 - Two 40-bit accumulators with rounding and saturation options
 - Single core combines MCU and DSP features
 - Adds Modulo and Bit-reverse address modes
- Up to 15 DMA channels between RAM and peripherals

System Management

- Flexible clock options:
 - Primary external clock, crystal, resonator
 - Secondary lower power 32 kHz oscillator
 - Internal RC: fast or low power
 - Integrated low jitter PLL (PLL sourced by ext. and int. clock sources)
- Programmable power-up timer
- Oscillator start-up timer/stabilizer
- Watchdog timer with its own RC oscillator
- Clock switching/fail-safe clock monitor
- Support for 3V and 5V applications
- Flexible temperature ranges
 - -40 to 85°C industrial temp.
 - -40 to 125°C extended temp.
 - -40 to 150°C high temp.

Interrupt Controller

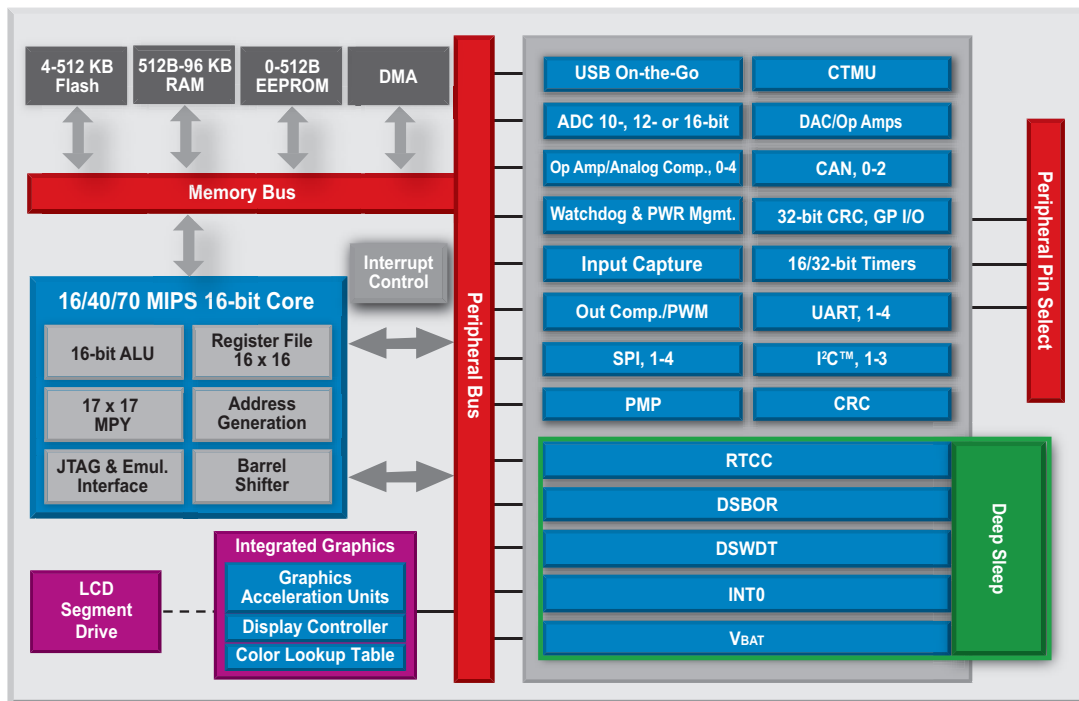
- Five cycle fixed latency
- Up to 118 interrupt sources, up to five external
- Seven programmable priority levels
- Four processor exceptions and software traps
- Vectored interrupts

Power Management

- Switch between clock sources in real-time
- Programmable power-on reset start up
- Programmable high/low voltage detect (HLVD)
- Programmable brown-out reset
- Idle, sleep and deep sleep modes with fast wake-up
- VBAT for battery backup with RTCC

Flexible Integrated Peripherals

PIC24 & dsPIC DSC Family Block Diagram



Digital I/O

- Peripheral Pin Select (PPS)
 - Remap digital I/O
 - Supports most digital peripherals
- Up to 122 programmable digital I/O pins
- Wake-up/Interrupt-on-change on up to 52 pins
- High current sink/source

Communication Modules

- 3-wire SPI: up to three modules
 - Framing supports I/O interface to simple codecs
- I²C™: up to three modules
 - Full multi-master and slave mode support
 - 7-bit and 10-bit addressing
- UART: up to four modules
 - Interrupt-on-address bit detect
 - Wake-up on Start bit from Sleep mode
 - 4-character TX and RX FIFO buffers
 - LIN and IrDA support
- USB Device, Host and OTG
 - Internal Boost Regulator requires minimal external components
 - Separate 3.3V regulator
 - Transparent RAM buffer interface
- CAN 2.0 (up to two modules)

Digital Power Peripherals

- 10-bit ADC up to 4 Msps, Up to six sample and holds
- PS PWM, 1 nS duty cycle resolution
- Analog comparators, 25 ns
- Programmable reference

Timers/Capture/Compare/PWM

- Timer/counters: up to nine 16-bit timers
 - Can pair up to make 32-bit timers
 - One timer can run as real-time clock
- Input capture: up to 16 channels
 - Capture on rising, falling or both edges
 - 4-deep FIFO on each capture
- Output compare: up to 16 channels
 - Dedicated timer
 - Single or dual 16-bit compare mode
 - 16-bit glitchless PWM mode

Auxiliary Functions

- LCD Segment Driver:
 - 60 Segment x8 Common Driver
- Graphics Controller Features:
 - 3x graphics hardware acceleration units
 - Color look-up table with up to 256 entries
 - Direct interface to monochrome, C-STN, TFT, OLED
- Parallel Master Slave Port (PMP/PSP):
 - Communicates with external data memory, communications peripherals, LCDs
 - Supports 8-bit or 16-bit data
 - Supports 16 address lines
- Hardware Real-Time Clock/Calendar (RTCC):
 - Provides clock, calendar and alarm functions
- Programmable CRC generator
- Charge time measurement unit (CTMU)
 - Capacitive touch sense keypad I/F
 - Provides 1 ns resolution time measurements
 - Temperature sensing
- Peripheral Trigger Generator (PTG)

Analog Subsystems

- On-chip high-speed op amps
 - Up to 10 MHz gain bandwidth
- Analog comparators (up to 4):
 - Programmable reference
- DAC
- ADC
 - 10-bit up to 1.1 Msps, 4 S&H
 - 12-bit up to 1 Msps
 - 16-bit Sigma Delta ADC, two channels
 - Buffered output DMA
 - Autoscanning
 - Supports CVD touch

Motor Control Peripherals

- Motor Control PWM: up to 14 outputs
 - Up to seven duty cycle generators
 - Independent or complementary mode
 - Programmable dead time settings
 - Edge- or center-aligned PWMs
 - Manual output override control
 - Up to 10 fault inputs
 - ADC samples triggered by PWM module
- Quadrature encoder interface module
 - Up to two modules
 - Phase A, Phase B and index pulse input
- High current sink/source

Intelligent Analog

PIC® MCUs with Intelligent Analog



Summary

Analog design is difficult and consumes precious development time. Microchip's intelligent PIC® MCUs integrate analog functions such as high-performance Analog-to-Digital Converters (ADCs), Digital-to-Analog Converters (DACs) and operational amplifiers (op amps), providing simple-to-use interfaces that ease analog design. This single-chip solution enables reduced system noise and provides higher throughput, while dramatically reducing design time and cost.

Benefits of Analog Integration

- Eliminates the complicated task of debugging the noise sources that reduce analog signal integrity
- Removes the bottleneck of communicating to the microcontroller from analog
- Provides consistent analog performance that can be leveraged from design to design, eliminating analog design rework
- Through intelligent connections made inside the chip, the analog is fully controlled by software
- Benefits include a simplified design cycle, board space savings, faster throughput and better signal integrity
- Intelligent analog leads to lower-cost designs that are brought to market faster

Target Applications

- Environmental quality sensors
- Portable medical equipment (glucose meters, portable ECGs, pulse oximeters, blood pressure meters)
- Industrial equipment (gas sensors, handheld multi-meters, lab instrumentation, e-meters, sensor arrays)

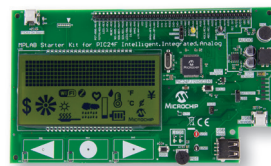
Featuring the PIC24FJ128GC010 Family with Intelligent Analog

The PIC24 “GC” Family integrates a precision 16-bit ADC, high-speed 12-bit ADC, DAC and op amps with interconnect fabric providing the most analog integration available in a PIC MCU. With on-chip USB and segmented LCD driver, this family is ideal for portable devices with user interfaces.

- 16-bit Sigma Delta ADC
- 12-bit 10 Msps Pipeline ADC
- 10-bit 1 Msps DAC
- Dual op amps
- eXtreme Low Power: 18 nA deep sleep, 180µA/MHz Run



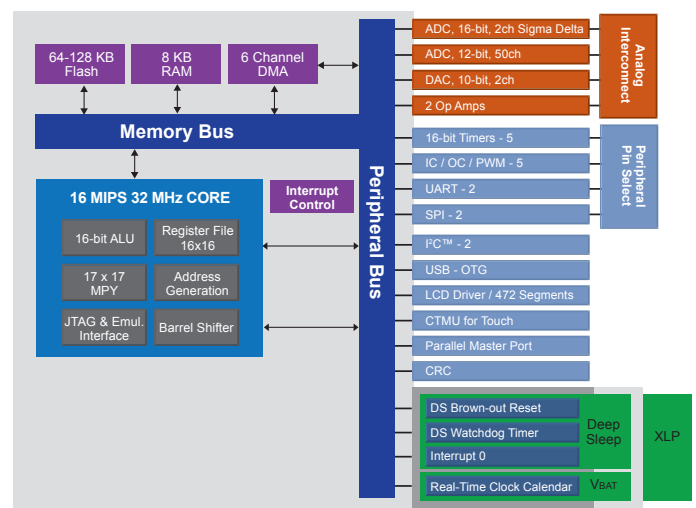
MPLAB® Starter Kit for PIC24F Intelligent Integrated Analog (DM240015)



This kit includes an analog header for clean analog signals and plugs into breadboards. The board includes connections for microphone, headphones as well as on-board light and temperature sensors. The

segmented display showcases custom icons and a scrolling banner. The board also includes cap touch buttons, USB connection and easy connection for RF modules.

PIC24FJ128GC010 Block Diagram



PIC24 with eXtreme Low Power

16-bit eXtreme Low Power (XLP) Products

Energy conservation is becoming essential for the growing number of electronic applications. Many require low power and, in extreme cases, need to be able to run for up to 15–20 years from a single battery. Products with Microchip’s eXtreme Low Power (XLP) technology offer the industry’s lowest currents for sleep, where most applications spend 90–99% of their time. These devices are ideal for a variety of applications including portable medical devices, thermostats, energy monitoring, wireless sensors, energy harvesting and security.

- eXtreme Low Power (XLP)—the benchmark in low power
 - Down to 10 nA in Deep Sleep
 - As low as 400 nA with RTCC active
- Fast wake-up from Deep Sleep
 - Minimizes CPU run time
 - Flexible wake-up sources
- Efficient instruction set; 90% single-cycle instruction
 - Active mode currents as low as 150 μ A/MHz
 - CoreMark/MHz of 1.88, 12.53 CoreMark/mA

Software and Application Notes

XLP Battery Life Estimator

The XLP Battery Life Estimator is a free software utility to aid you in developing low-power applications. The tool estimates average current consumption and battery life. The utility allows users to select the target device, battery type, the application’s operating conditions (such as voltage and temperature) and model the active and power-down times for their application. The tool comes pre-loaded with specifications of Microchip’s PIC microcontrollers featuring nanoWatt XLP technology and commonly used batteries in embedded applications.

App Notes

- AN1416: *Low Power Design Guide: A single source for low power consumption from the viewpoint of the MCU*
- AN1267: *nanoWatt XLP Technology: An Introduction to Microchip’s Low-Power Devices*

Development Tools

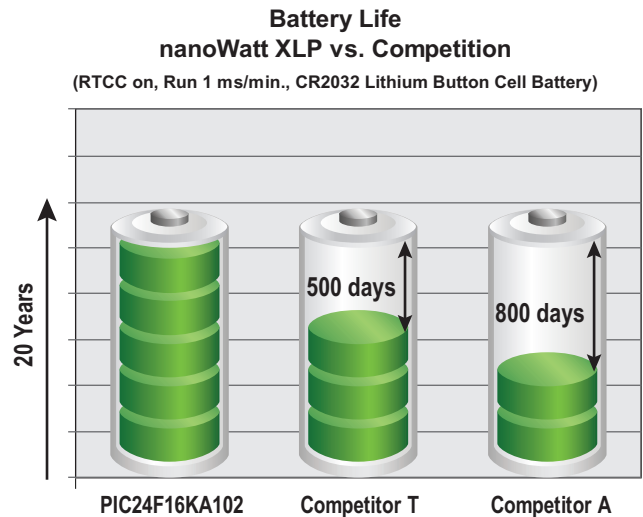
nanoWatt XLP 16-bit Development Board (DM240311)



The XLP 16-bit Development Board is designed with eXtreme Low Power in mind. Designed as a true platform for low-power development, it enables designs with sleep currents as low as 10 nA. The board is suitable for prototyping many low-power applications including RF sensors, data loggers, temperature sensors, electronic door locks, metering sensors, remote controls, security sensors, smart cards and energy harvesting. The PICtail™ interface supports Microchip’s extensive line of daughter cards for easy evaluation of your next low-power application.

MPLAB REAL ICE™ In-Circuit Emulator Power Monitor (AC244008)

This add-on board fills the need for low-power monitoring and debugging. Breakpoints indicate when current exceeds a specified threshold and provides a graph of current, voltage and time versus code execution. It also uses time-stamping with 100 ns resolution to find large current codes.



Featured XLP Products

| PIC® MCU with XLP Technology | Flash (KB) | Pins | Sleep (nA) | Deep Sleep (nA) | WDT (nA) | 32 kHz SOSC/RTCC (nA) | μ A/MHz |
|------------------------------|------------|----------|------------|-----------------|----------|-----------------------|-------------|
| PIC24F16KL402 | 4–16 | 14/20/28 | 30 | – | 210 | 690 | 150 |
| PIC24FJ64GB004 | 32–64 | 28/44 | 200 | 20 | 200 | 500 | 250 |
| PIC24FJ128GA310 | 64–128 | 64/100 | 330 | 10 | 270 | 400 | 150 |
| PIC24FJ128GC010 | 64–128 | 64/100 | 330 | 10 | 270 | 400 | 150 |

Motor Control



16-bit Motor Control Products

- High-performance dsPIC DSC core with DSP instructions for precise control
 - Variable speed with constant torque using PI controllers
 - Field oriented control (FOC) for greater efficiency
- Industry-leading motor control peripherals
- Dedicated motor control PWM modules
- High-performance on-chip op amps
- Intelligent, high-speed ADC
- Algorithms and App Notes for
 - BLDC, PMSM, ACIM
 - Sensorless control
 - Field oriented control
 - Certified class B safety software
- Dual motor control with FOC controlling each motor
- Multiple package options, ranging from 28–144 pins
- Scalable motor control tools with low- and high-voltage options

Webinar Topics (www.microchip.com/motor)

- Sensorless Field Oriented Control for ACIM
- Sensorless Field Oriented Control for PMSM
- Sensorless BLDC Motor Control Using a Majority Function
- Brushed DC Motor Basics
- Stepper Motor Control

Featured Motor Control Products

| Product | MIPS | Pins | Flash (KB) | RAM (KB) | DMA Ch. | Input Capture | Output Compare/Std. PWM | MC PWM | QEI | Internal Op Amps | ADC 10/12-bit 1.1/0.5 Msps | UART |
|-------------------|------|---------|------------|----------|---------|---------------|-------------------------|--------|-----|------------------|----------------------------|------|
| dsPIC33EP512GM710 | 70 | 100/121 | 128–512 | 16–48 | 4 | 8 | 8 | 12 Ch | 2 | 4 | 2, 49 Ch | 4 |
| dsPIC33EP512GM706 | 70 | 64 | 128–512 | 16–48 | 4 | 8 | 8 | 12 Ch | 2 | 4 | 2, 30 Ch | 4 |
| dsPIC33EP512GM604 | 70 | 44 | 128–512 | 16–48 | 4 | 8 | 8 | 12 Ch | 2 | 4 | 2, 18 Ch | 4 |
| dsPIC33EP256MC202 | 70 | 28 | 32–256 | 4–32 | 4 | 4 | 4 | 6 Ch | 1 | 3 | 1, 6 Ch | 2 |
| dsPIC33EP256MC204 | 70 | 44 | 32–256 | 4–32 | 4 | 4 | 4 | 6 Ch | 1 | 3 | 1, 9 Ch | 2 |
| dsPIC33EP256MC206 | 70 | 64 | 32–256 | 4–32 | 4 | 4 | 4 | 6 Ch | 1 | 3 | 1, 16 Ch | 2 |
| dsPIC33FJ32MC101 | 16 | 20 | 16–32 | 1–2 | 0 | 3 | 2 | 6 Ch | 0 | 0 | 1, 4 Ch | 1 |
| dsPIC33FJ32MC102 | 16 | 28/36 | 16–32 | 1–2 | 0 | 3 | 2 | 6 Ch | 0 | 0 | 1, 8 Ch | 1 |
| dsPIC33FJ32MC104 | 16 | 44 | 32 | 2 | 0 | 3 | 2 | 6 Ch | 0 | 0 | 1, 14 Ch | 1 |

www.microchip.com/motor

Software & App Notes

| Motor Type | Algorithm | App Note |
|--------------------|--|----------------|
| Stepper Motor | Full and Half-Stepping | AN1307 |
| | Micro-Stepping | AN1307 |
| BLDC and PMSM | Sensored | AN957 |
| | Sensored Sinusoidal | AN1017 |
| | Sensorless BEMF | AN901 AN992 |
| | Sensorless Filtered BEMF with Majority Detect | AN1160 |
| | Sensorless Dual-Shunt FOC with SMO Estimator and Field Weakening | AN1078 |
| | Sensorless Dual-Shunt FOC with SMO and PFC | AN1208 |
| | Sensorless Dual-Shunt FOC with PLL Estimator and Field Weakening | AN1292 |
| | Sensorless Single-Shunt FOC with SMO Estimator and Field Weakening | AN1299 |
| AC Induction Motor | Open Loop V/F | AN984 |
| | Closed Loop Vector Control | AN980 |
| | Sensorless Dual-Shunt FOC with PLL Estimator | AN1162 |
| | Sensorless Dual-Shunt FOC with PLL Estimator and Field Weakening | AN1206 |
| Other | PFC | AN1106 |
| | Class B Safety Software (IEC 60730) | AN1229 |
| | Motor Control Sensor Feedback Circuits | AN894 |
| | MOSFET Driver Selection | AN898 |
| | Current Sensing Circuit Concepts and Fundamentals | AN1332 |

Motor Control Development Boards

dsPIC33 Development Systems

Motor Control Starter Kit (MCSK) with mTouch Sensing (DM330015)



This starter kit with mTouch sensing is a complete, integrated development platform based on the dsPIC33FJ16MC102. It includes a USB

interfaced debugger programmer, a complete drive circuit featuring Microchip's TC4428 dual 1.5A gate drivers, an on-board BLDC motor, a user-configurable switch and an mTouch slider with LED indicators for speed control. Simply power the board using the included 9V supply and the pre-loaded code begins to execute.

dsPICDEM™ MCSM Stepper Motor: Motor Control Development Board/Kit (DM330022)/(DV330021)

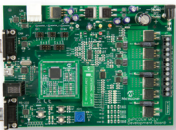


This development board is intended for low-voltage (up to 80 volts at 3 amps) 2-phase uni-polar or bi-polar stepper motor (4, 6 or 8 wire) applications. It provides a low-cost system for users to evaluate and develop applications using dsPIC33 motor control DSCs via a Plug-In Module (PIM) or 28-pin SOIC socket. A USB serial interface for RTDM is provided. Feedback

support includes current and voltage. Demo software to run motors in open-loop or closed-loop with full or variable micro-stepping is provided. A DMCI/RTDM GUI for controlling step commands, motor parameter input and operation modes is included. The kit also includes a stepper motor and a 24-volt power supply. MPLAB ICD 3 In-Circuit Debugger or MPLAB REAL ICE In-Circuit Emulator is required for programming or debugging operations.



dsPICDEM MCLV-2 Development Board (DM330021-2)



This development board is intended for low-voltage (up to 48 volts at 10 amps) BLDC sensored or sensorless applications. It provides a low-cost system for users to evaluate and

develop applications using dsPIC33F/E motor control DSCs via a Plug-In Module (PIM) or 28-pin SOIC socket. With the MCLV-2, either the internal on-chip op amps or the external op amps on the MCLV-2 board can be used. Microchip provides PIMs for using either the internal or external op amps. The MCLV-2 is fully backwards-compatible with the original MCLV and all Motor Control Processor Plug-In Modules (PIMs). Serial interfaces include RS-232C, CAN, LIN and USB (for RTDM). Feedback support includes Hall-Effect Sensors, Shaft Encoder, Back EMF voltages and single or dual shunt resistors for current. PICKit™ 3 Debug Express, MPLAB ICD 3 In-Circuit Debugger or MPLAB REAL ICE In-Circuit Emulator is required for programming or debugging operations.

dsPICDEM MCHV-2 Development System (DM330023-2)



This development system is intended for high-voltage (up to 400 volts at 6.5 amps) BLDC, PMSM and ACIM sensored or sensorless applications. It provides a low-cost Integrated Power Module (IPM) based system for users

to evaluate and develop applications using dsPIC33F/E motor control DSCs via a Plug-In Module (PIM) or a 28-pin SOIC socket. With the MCLV-2, either the internal on-chip op amps or the external op amps on the MCLV-2 board can be used. Microchip provides PIMs for using either the internal or external op amps. The MCLV-2 is fully backwards-compatible with the original MCLV and all Motor Control Processor Plug-In Modules (PIMs). Isolated serial interfaces include RS-232C and USB (for RTDM). Feedback support includes Hall-Effect Sensors, Shaft Encoder, Back EMF voltages and single or dual current shunt resistors. A PFC circuit is provided to meet regulatory requirements. An isolated built-in debugger (similar to a starter kit programmer/debugger) permits a direct connection with a PC.

Motors

You can provide your own motor or purchase one of the motors used in our application notes which are guaranteed to run right out of the box:

- AC300024: 2-phase, 8-wire Stepper Motor
- AC300020: 24V BLDC Motor
- AC300022: 24V BLDC Motor with Shaft Encoder
- AC300023: 220V, AC Induction Motor



Digital Power and Lighting

16-bit Digital Power and Lighting Products

- Streamlined interoperation between PWM, ADC and CPU
- High-performance core with DSP instructions
 - High-speed control loop execution for demanding power conversion applications
 - Fast and predictable interrupts
 - Zero wait-state execution from flash memory
- High-resolution PWMs for digital power
 - Very precise resolution of 1ns for duty cycle, phase shift, period and dead time
 - Flexibility to control numerous power topologies
- Optimized digital power conversion ADC
 - Hardware triggered for precision sampling and low CPU overhead
- Complete reference designs and algorithms
 - AC/DC converter meeting platinum specification
 - LLC resonant DC/DC converter
 - Quarter brick DC/DC converter
 - Solar micro inverter
 - Interleaved power factor correction
 - Offline UPS



Webinar Topics (www.microchip.com/power)

- Building a dsPIC DSC SMPS System
- SMPS Components and Their Effects on System Design
- Control System Design for Power Converters
- SMPS Topologies: The Buck Converter
- Switch Mode Power Supply Topologies: The Forward Converter
- Interleaved Power Factor Correction
- Offline UPS using the dsPIC DSC

Software and App Notes

| Application Solution | AN # | Description |
|---|--------|--|
| Power Factor Correction in Power Conversion Applications Using the dsPIC® DSC | AN1106 | This application note focuses primarily on the study, design and implementation of Power Factor Correction (PFC) using a Digital Signal Controller (DSC). |
| Switch Mode Power Supply (SMPS) Topologies (Part I) | AN1114 | This application note explains the basics of different types of SMPS topologies and their applications. The pros and cons of different SMPS topologies are also explained to guide the user to select an appropriate topology for a given application, while providing useful information regarding selection of components for a given SMPS design. |
| Switch Mode Power Supply (SMPS) Topologies (Part II) | AN1207 | This application note is the second of a two-part series on Switch Mode Power Supply (SMPS) topologies. This series expands on the previous material in Part I, and presents the basic tools needed to design a power converter. |
| Offline UPS Reference Design | AN1279 | The application note describes the design of an Offline Uninterruptible Power Supply (UPS) using a Switch Mode Power Supply (SMPS) dsPIC Digital Signal Controller (DSC). |
| Digital Power Interleaved PFC Reference Design | AN1278 | The application note describes the design of a Digital Power Interleaved PFC (IPFC) using a Switch Mode Power Supply (SMPS) dsPIC Digital Signal Controller (DSC). |
| Quarter Brick DC-DC Reference Design | AN1335 | This application note describes the design of Quarter Brick DC-DC Reference Design using Switch Mode Power Supply (SMPS) dsPIC Digital Signal Controller (DSC) |
| DC-DC LLC Resonant Converter Reference Design | AN1336 | This application note describes the design of DC-DC LLC Resonant Converter Reference Design using Switch Mode Power Supply (SMPS) dsPIC Digital Signal Controller (DSC) |
| Grid Connected Solar Microinverter | AN1338 | This application note describes the design of Grid Connected Solar Microinverter Reference Design using Switch Mode Power Supply (SMPS) dsPIC Digital Signal Controller (DSC) |
| Platinum-rated AC/DC Reference Design Using the dsPIC DSC | AN1421 | This application note presents a fully digital-controlled 720W AC-to-DC (AC/DC) power supply, which meets all CSCI Platinum Specifications, as well as provides a variety of additional, application-specific features and functions. |

Featured Digital Power Products

| Product | Pins | Flash (KB) | RAM (Bytes) | IC/OC | PS PWM | ADC | Analog Compare | UART/I ² C™/SPI | CAN |
|------------------|-------|------------|-------------|-------|--------|--------------|----------------|----------------------------|-----|
| dsPIC33FJ06GS001 | 18/20 | 6 | 256 | 0/0 | 4 | 6 Ch, 2 S&H | 2 | 0/1/0 | 0 |
| dsPIC33FJ09GS302 | 28/36 | 9 | 1K | 1/1 | 6 | 8 Ch, 3 S&H | 2 | 1/1/1 | 0 |
| dsPIC33FJ16GS504 | 44 | 16 | 2K | 2/2 | 8 | 12 Ch, 6 S&H | 4 | 1/1/1 | 0 |
| dsPIC33FJ32GS406 | 64 | 32 | 4K | 4/4 | 12 | 16 Ch, 5 S&H | 0 | 2/2/2 | 0 |
| dsPIC33FJ64GS606 | 64 | 64 | 9K | 4/4 | 12 | 16 Ch, 5 S&H | 4 | 2/2/2 | 1 |
| dsPIC33FJ64GS610 | 100 | 64 | 9K | 4/4 | 18 | 24 Ch, 6 S&H | 4 | 2/2/2 | 1 |

www.microchip.com/power

Digital Power and Lighting Reference Designs and Development Boards

Reference Designs

Platinum Rated 720W AC/DC Reference Design



This reference design demonstrates the flexibility and power of dsPIC Digital Signal Controllers in Switch Mode Power Supplies. This reference design has a peak efficiency of 94.1% and achieves the ENERGY STAR® CSCI Platinum Level. It features a 2-phase

interleaved power factor correction boost converter followed by a 2-phase interleaved two-switch forward converter with synchronous rectification.

Quarter Brick DC/DC Converter Reference Design



This reference design provides an easy method to evaluate the performance and features of SMPS DSCs in high-density quarter brick DC-DC converters for Intermediate Bus Architectures

(IBA). This reference design is implemented using a single dsPIC33F “GS” digital power DSC that provides full digital control of the power conversion as well as system management functions.

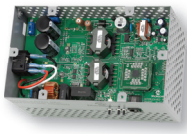
DC/DC LLC Resonant Converter Reference Design



This reference design operates over a wide input voltage range (350-420V DC) with a nominal input of 400V, providing a 12V DC output while maintaining high-voltage isolation between the primary and secondary. This reference

design is implemented using a single dsPIC33F “GS” digital power DSC that provides full digital control of the power conversion and system management functions.

Digital Power Interleaved PFC Reference Design



High-performance power supplies are used in a wide variety of applications ranging from telecommunication equipment, industrial equipment, digital televisions, lighting, air conditioners and

other home appliances. They all need solutions for power factor correction to improve overall efficiency, improve the input power factor, voltage regulation and Total Harmonic Distortion (THD) of the input current.

Digital Pure Sine Wave Uninterruptible Power Supply (UPS) Reference Design



This reference design demonstrates how digital power techniques applied to UPS applications enable easy modifications through software and allow for the use of smaller magnetics, intelligent battery

charging, higher efficiency, compact designs, reduction in audible and electrical noise via a purer sine-wave output, USB communication and low-cost overall bill-of-materials.

Grid Connected Solar Micro Inverter Reference Design



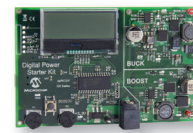
This reference design ensures maximum power point tracking for PV panel voltages between 20V to 45V DC and has a maximum output power of 215 Watts.

High efficiency was achieved by implementing a novel interleaved active-clamp flyback topology with Zero Voltage Switching (ZVS). Using dsPIC33F ‘GS’ devices, designers can easily and cost effectively develop products using advanced switching techniques/topologies that lower switching losses and improve overall system efficiency. Two versions of this design are available to support 120V and 230V grids

Additional information for all reference designs is available at www.microchip.com/power.

Development Boards

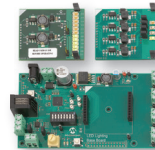
MPLAB Starter Kit for Digital Power (DM330017)



This starter kit allows the user to easily explore the capabilities and features of the dsPIC33F GS Digital Power Conversion family. It is a digitally controlled power supply board that

consists of one independent DC/DC synchronous Buck converter and one independent DC/DC Boost converter. Each power stage includes a MOSFET controlled 5W resistive load. The starter kit includes an on-board debugger/programmer.

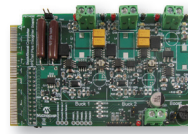
Digital LED Lighting Development Kit (DM330014)



This LED lighting development kit enables designers to quickly leverage the capabilities and performance of the dsPIC33 ‘GS’ DSCs to create a 100% digitally controlled ballast function, while including advanced features such as

dimming and color hue control. The dsPIC33 ‘GS’ devices can support an entire system implementation for LED lighting products, including power-conversion circuits, such as AC-to-DC and DC-to-DC conversion, along with functions such as Power Factor Correction (PFC).

Buck/Boost Converter PICTail Plus Card (AC164133)



A low-cost development platform for dsPIC33F ‘GS’ devices, the buck/boost converter PICTail Plus card has two buck stage outputs and one boost stage output. Various performance measures

like digital control loop performance of power conversion, dynamic load performance, multi-phase buck and synchronous buck converter operation, parallel operation of two buck converters and multiple output control with a single dsPIC device can be evaluated. This board can be used with either the Explorer 16 board or the 16-bit 28-pin starter board.

Connectivity for PIC24 MCU and dsPIC DSC Families



Ethernet



CAN



Microchip offers support for a variety of wired and wireless communication protocols, including peripheral devices and solutions that are integrated with a microcontroller or digital signal controller. Many of these communication libraries are integrated into the Microchip Libraries for Applications (MLA) which can be downloaded at www.microchip.com/MLA. This includes software libraries, drivers and demo code. Additional software libraries are listed at www.microchip.com/libraries.

USB

There are many PIC24 MCU and dsPIC DSC families with integrated USB which include support for device, host and On-The-Go functionality. These products are supported by the PIC24F Starter Kit (DM240011), dsPIC DSC USB Starter Kit (DM330012) as well as the Explorer 16 Board (DM240001) with USB PICtail Plus Daughter Card (AC164131) and one of the USB Processor Plug-In Modules (PIMs).

Microchip's free USB framework includes USB software libraries as well as a comprehensive set of host and device drivers including Human Interface Device (HID) class for user interfaces, and Mass Storage Device (MSD) class for memory devices as well as CDC, PHDC, custom, audio, printer and demo code including thumb drive bootloader, and printer host. The USB libraries, drivers and demo code are all available with the MLA download.

Ethernet

Applications using PIC24 MCU and dsPIC DSC products often need to connect to the internet via wired or wireless capability. Any of our PIC24 MCU and dsPIC DSC products can easily be matched with the ENC624J600 100 Mbps Ethernet MAC/PHY controller to add Ethernet connection. An Ethernet PICtail Plus Daughter Board (AC164132) is available to plug into the Explorer 16 (DM240001) for developing embedded Ethernet applications.

Microchip's free TCP/IP stack is also available as part of the MLA and includes modular protocol services for standard TCP/IP-based applications such as HTTP server or FTP server and includes support for SSL, DNS, TCP and UDP.

IrDA

The IrDA standard is an inexpensive method for providing wireless point-to-point communication. Microchip's free IrDA stack is available to support 16-bit MCUs with integrated IrDA support, enabling a cost effective wireless connection with plenty of computing power left for other tasks.

CAN and LIN

Many of the dsPIC DSCs and PIC24 products include integrated CAN functionality which is ideal for applications requiring robust communications with a high-speed, reliable industry standard protocol. Vector CANbedded™ and osCAN™ development solutions support PIC24 MCU and dsPIC DSC products with embedded CAN Controllers.

LIN support is integrated into many products for low-cost, single-wire serial communication for automotive applications.

A CAN/LIN PICtail Plus Daughter Board (AC164130-2) is available to plug into the Explorer 16 (DM240001) for developing embedded CAN or LIN applications. This must be used with a processor Plug-In Module (PIM) for a compatible PIC24 MCU or dsPIC DSC product.

Wireless

Microchip offers a wide range of wireless modules ranging from Wi-Fi, Bluetooth, and various Personal Area Networks. These fully-certified surface mount modules allow designers to quickly and seamlessly add wireless connectivity to their applications. For wireless sensors and other battery operated applications, the XLP PIC24 MCUs are ideal companions to Microchip's wireless modules, running the protocol stacks and offering very long battery life.

Stacks for these wireless protocols are available for the PIC24 MCU and dsPIC DSC families including Embedded Wi-Fi, ZigBee and MiWi wireless networking protocol.

www.microchip.com/connectivity

Display and Touch



Many 16-bit designs incorporate modern user interfaces to increase the usability, functionality and look of end products. More sophisticated displays and touch interfaces create higher impact designs, yet they must be cost effective and easy to integrate. Microchip's solutions allow for driving segmented or graphical displays with a single chip and offer integrated peripherals for touch buttons.

Segmented LCD Displays

The PIC24FJ128GA310 and PIC24FJ128GC010 families feature integrated segmented display drivers with up to 480 segments. Key advantages include:

- Direct drive of inexpensive, low-power displays
- Integrated analog for sensor applications like temperature sensing in thermostats
- Integrated touch sensing function for buttons or sliders

Graphical Displays

The PIC24FJ256DA210 family features integrated graphics acceleration and a display controller to directly drive displays up to 4.3" WQVGA with 480 × 272 resolution. This "DA" family includes:

- Dedicated graphics clock for a continuous, flicker-free display
- On-chip display controller provides direct interface to TFT, STN and OLED displays
- Easy to use graphics processing units for hardware acceleration allow for moving and copying rectangles, decompressing images and rendering text without CPU intervention
- Integrated color look-up table and 96 KB frame buffer support up to 8 bpp QVGA with internal memory

Touch Buttons: Keys and Sliders

Many PIC24 MCUs and dsPIC DSC products include touch sensing capability for implementing keys or sliders as an alternative to traditional push button switches using CVD or CTMU technology. This enables more modern and stylish designs, lower manufacturing costs and increased reliability.

- Longer battery life with eXtreme Low Power MCUs
- Sensing through metal, plastic or glass
- High noise immunity and low emissions
- Free mTouch sensing solutions software library enables easy integration

Development Tools

LCD Explorer Development Board (DM240314)



The LCD Explorer provides an ideal platform to evaluate a MCU with a × 8 Common LCD Driver on a 38 segment × 8 common LCD display.

PIC24FJ256DA210 Development Kit (DV164039)



This kit bundles the PIC24FJ256DA210 Development Board (DM240312), a 3.2" Truly 240 × 320 TFT Display Board (AC164127-4), three Graphics Display Prototype Boards (AC164139), the MPLAB ICD 3 Debugger (DV164035) and also includes a USB Cable and accessories.

Remote Control Demo Board (DM240315-2)



This board integrates graphics, mTouch technology, USB and RF4CE into a single demo. It features the PIC24FJ256DA210 MCU, a 3.5" Graphical TFT LCD with resistive touch screen, capacitive touch keys with plastic overlay, an MRF24J40 2.4 GHz transceiver and a ZENA™ wireless adapter.

Software and App Notes

FREE Microchip Graphics Library

The Microchip Graphics Library is highly modular, easy to use and has an open documented interface for driver or controller support. The library supports the following features:

- Pre-made graphics objects
- Multiple fonts and languages
- User interface for mTouch sensing
- Buttons, charts, check boxes, scroll bars, list boxes, images and basic animation

FREE Microchip Graphics Display Designer

The Microchip Graphics Display Designer for MPLAB X IDE (GDD X) is a visual design tool that provides a quick and easy way of creating Graphical User Interface (GUI) screens for graphical interface applications on Microchip MCUs.

mTouch Sensing Technology Source Code and Demos

Microchip's mTouch sensing solutions provide a free and easy method for designers to add capacitive touch sensing to applications utilizing PIC microcontrollers without the cost of fee-based licensing and royalty agreements. This source-code solution helps engineers quickly integrate touch sensing functionality with their existing application code in a single, standard microcontroller.

App Notes

- *Segmented LCD Biasing & Contrast Control Methods* (AN1428)
- *Developing Graphics Applications Using an MCU with Integrated Graphics Controllers* (AN1368)
- *mTouch Sensing Solutions Acquisition Methods Capacitive Voltage Divider* (AN1478)

www.microchip.com/graphics
www.microchip.com/LCD
www.microchip.com/mtouch

General Purpose Development and Evaluation Tools

Development Boards

A variety of hardware development boards are available for the PIC24 MCU and dsPIC DSC, enabling designers to shorten their design cycle and quickly develop prototypes. These boards are designed to allow easy connection to an MPLAB ICD 3 In-Circuit Debugger, MPLAB REAL ICE In-Circuit Emulator or MPLAB PM3 device programmer. All development boards include documentation and example source code to accelerate your design.

Starter Kits

MPLAB starter kits are designed to demonstrate the key features of the device family they represent. In addition to the external circuit needed to support and demonstrate the device, the starter kits include the circuitry necessary to debug and program the MCUs and DSCs. When combined with the MPLAB X IDE and the MPLAB XC16 Compiler, these starter kits allow designers to quickly gain knowledge and experience in using the 16-bit MCU and dsPIC DSC products.

MPLAB Starter Kit for PIC24F MCUs (DM240011)



This starter kit is based on the PIC24FJ256GB110 family and is equipped with the hardware and software necessary to demonstrate the USB Device/Embedded Host/OTG peripheral and mTouch Capacitive Touch Sense technology.

dsPIC33E/PIC24E USB Starter Kit (DM330012/DM240012)



These starter kits provide a low-cost modular development system for Microchip's enhanced 16-bit DSCs or high-performance MCUs. They come with preloaded demo software to allow the user to explore the new features of the dsPIC33E DSC family or the PIC24E MCU family.

Microsticks

Microsticks are USB-powered and include an on-board debugger/programmer. Requiring no external debugger or power source, they are the most economical way to get started evaluating PIC24 MCUs or dsPIC DSCs.

The Microsticks are fully supported by MPLAB X IDE and provide easy plug-in to a standard breadboard with access to device signals for prototyping. These boards have a very small form factor and include free demo code.

Microstick for 3V PIC24 K-series Development Board (DM240013-1)



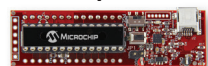
Microstick for 3V PIC24F K-series is a flexible, USB powered development platform. It's the perfect solution for those looking to get started with Microchip's lowest cost 16-bit microcontroller families, the PIC24F K-series, for extremely cost-sensitive applications.

Microstick II Development Board (DM330013-2)



Microstick II delivers a low-cost, easy-to-use development platform for Microchip's 16- and 32-bit microcontrollers and digital signal controllers. The USB-powered kit includes an on-board debugger/programmer, a DUT socket for easy device swapping, a user LED and a reset button.

Microstick for 5V PIC24 K-series Development Board (DM240013-2)



Microstick for 5V PIC24 K-series MCUs is a low-cost, extremely portable USB powered platform. It includes an on-board programmer/debugger and helps designers get started with Microchip's 5V PIC24 K-series microcontrollers.

General Purpose 16-bit Development Boards

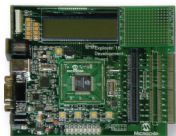
| Description | Part Number | Devices Supported | | |
|--|--------------|-------------------|----------|------------|
| | | PIC24F | PIC24H/E | dsPIC33F/E |
| MPLAB Starter Kit for PIC24F MCUs | DM240011 | ✓ | - | - |
| PIC24E USB Starter Kit | DM240012 | - | ✓ | - |
| dsPIC33E USB Starter Kit | DM330012 | - | - | ✓ |
| Microstick for dsPIC33F and PIC24H Development Board | DM330013 | - | ✓ | ✓ |
| Microstick for 3V PIC24 K-series Development Board | DM240013-1* | ✓ | - | - |
| Microstick II Development Board | DM330013-2 | ✓ | ✓ | ✓ |
| Microstick for 5V PIC24 K-series Development Board | DM240013-2** | ✓ | - | - |
| Explorer 16 Development Board | DM240001 | ✓ | ✓ | ✓ |

*For use with 3V PIC24 K-series devices

**For use with 5V PIC24 K-series devices

General Purpose Development and Evaluation Tools

Explorer 16 Development Board (DM240001/DM240002)



This development board offers an economical way to evaluate Microchip's 16-bit MCUs and dsPIC DSC families. The combination of versatility and expandability and the supporting PICTail

Plus daughter cards allow designers to evaluate complex software libraries and hardware with minimal time and effort. Features include:

- Processor Plug-In Modules (PIMs)
 - DM240001: two interchangeable 100-pin PIMs, one each for the PIC24FJ128GA010 and the dsPIC33FJ256GP710 DSC

- DM240002: features a PIM for the 44-pin PIC24FJ64GA004 and dsPIC33FJ32GP204 MCUs
- Many other processor PIMs available for easy device swapping

- Alpha-numeric 16 × 2 LCD display
- Interfaces to MPLAB ICD 3 In-Circuit Debugger, MPLAB REAL ICE In-Circuit Emulator and RS-232
- Includes Microchip's TC1047A high-accuracy analog output temperature sensor
- Expansion connector to fully access device's pin-out and breadboard prototyping area
- PICTail Plus connector for expansion boards
- Full documentation includes user's guide, schematics and PCB layout at www.microchip.com/explorer16.

PICTail Plus Daughter Boards

- Allow for the easy addition of complex hardware
- Allow for the easy evaluation of software libraries
- Provide expansion for application-specific hardware

| Description | Part Number | Devices Supported | |
|---|----------------|-------------------|------------|
| | | PIC24 | dsPIC® DSC |
| Consumer-band BPSK 7.2 kbps PLM PICTail™ Plus Daughter Board | AC164142 | – | ✓ |
| Utility-Band BPSK 6.0 kbps PLM PICTail Plus Daughter Board | AC164145 | – | ✓ |
| CAN/LIN PICTail Plus Daughter Board <ul style="list-style-type: none"> • Two ECAN MCP2551 transceivers • Two LIN MCP2021-330 transceivers | AC163130 | ✓ | ✓ |
| PICTail Plus Daughter Board for SD/MMC <ul style="list-style-type: none"> • SPI to SD/MMC interface | AC164122 | ✓ | ✓ |
| IrDA® PICTail Plus Daughter Board <ul style="list-style-type: none"> • IrDA transceiver for IrDA enabled UART | AC164124 | ✓ | ✓ |
| Speech Playback PICTail Plus Daughter Board <ul style="list-style-type: none"> • Adaptive Differential Pulse Code Modulation (ADPCM) speech playback and recording | AC164125 | ✓ | ✓ |
| Prototype PICTail Plus Daughter Board <ul style="list-style-type: none"> • PICTail Plus Expansion Board | AC164126 | ✓ | ✓ |
| Graphic PICTail Plus Daughter Board <ul style="list-style-type: none"> • Enables Graphics display via PMP | AC164127-3 | ✓ | ✓ |
| Audio PICTail Plus Daughter Board <ul style="list-style-type: none"> • Full Duplex Speech and Audio applications | AC164129 | ✓ | ✓ |
| USB PICTail Plus Daughter Board <ul style="list-style-type: none"> • USB Device, Host and OTG Expansion | AC164131 | ✓ | ✓ |
| Fast 100 Mbps Ethernet PICTail Plus Daughter Board <ul style="list-style-type: none"> • Stand Alone ENC624J600 Ethernet Controller | AC164132 | ✓ | ✓ |
| Buck/Boost Converter PICTail Plus Daughter Board <ul style="list-style-type: none"> • Two independent DC/DC synchronous buck converters • Independent DC/DC boost converter | AC164133 | – | ✓ |
| Thermal/Linear Intelligent Sensor PICTail Plus Daughter Board <ul style="list-style-type: none"> • Signal input and conditioning for thermocouples and linear sensors • TC1047/1047A Temperature to Voltage Converter | AC164135 | ✓ | ✓ |
| MCP2515 PICTail Plus Daughter Board <ul style="list-style-type: none"> • Stand Alone CAN Controller expansion board | MCP2515DM | ✓ | ✓ |
| MCP42XX PICTail Plus Daughter Board <ul style="list-style-type: none"> • MCP42XX Digital Potentiometer expansion board | MCP42XXDM | ✓ | ✓ |
| MCP4725 PICTail Plus Daughter Board <ul style="list-style-type: none"> • 12-bit DAC + non-volatile memory | MCP4725DM | ✓ | ✓ |
| Wireless MRF24J40MB 802.15.4 PICTail/PICTail Plus with PCB Antenna (2.4 GHz) | AC164134-2 | ✓ | ✓ |
| Wireless MRF89XAM8A PICTail/PICTail Plus Daughter Board (868 MHz) | AC164138-1 | ✓ | ✓ |
| Wireless MRF89XAM9A PICTail/PICTail Plus Daughter Board (915 MHz) | AC164138-2 | ✓ | ✓ |
| Wireless MRF24J40MC 802.15.4 PICTail/PICTail Plus with U.FL Connector (2.4 GHz) | AC164143 | ✓ | ✓ |
| Wireless RN-131 Wi-Fi® Long Range PICTail Development Board | RN-131-PICTAIL | ✓ | – |
| Wireless RN-171 Wi-Fi Low Range PICTail Development Board | RN-171-PICTAIL | ✓ | – |

World Class Development Tools

MPLAB X IDE

Universal and Integrated Tool Set

MPLAB X IDE is a single, universal graphical user interface for Microchip and third party software and hardware development tools. It is the industry's only IDE to support an entire portfolio of 8-bit, 16-bit and 32-bit PIC MCUs, dsPIC DSCs and memory devices.

MPLAB X supports Microchip's compilers, emulators, debuggers and starter kits, as well as many third-party tools. Moving between all of your favorite Microchip tools and upgrading from software simulators to hardware debugging and programming tools is simple with this IDE's seamless user interface.

Powerful Yet User-Friendly Interface

With complete project management, visual call graphs, a configurable watch window and a feature-rich editor that includes code-completion, context menus and a task navigator, MPLAB X is flexible and friendly enough for new users.

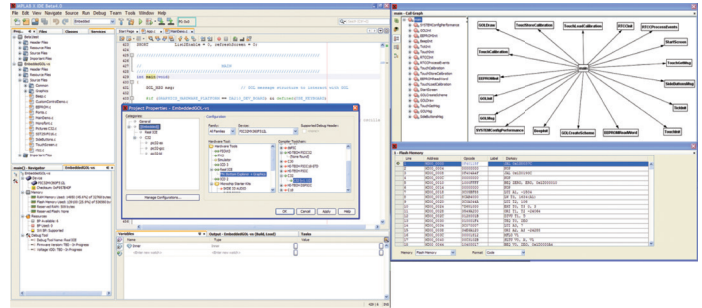
MPLAB X is also fully equipped for the needs of experienced users with the ability to support multiple tools on multiple projects with multiple configurations and simultaneous debugging.

Open-Source Platform

Based on the NetBeans™ Platform, MPLAB X supports a host of free software components and plug-ins from the NetBeans community for high-performance application development customized to your needs. In addition to local file history, MPLAB X is also compatible with revision control plug-ins and Bugzilla.

Cross-Platform

Using MPLAB X, users can run their favorite toolset and develop their next embedded application on Windows®, Linux® or Mac® OS X.



MPLAB XC16 C Compiler for PIC24 MCUs and dsPIC DSCs

The MPLAB XC16 C Compiler includes a complete ANSI C standard library, including string manipulation, dynamic memory allocation, data conversion, timekeeping and math libraries. The compiler has a powerful code optimizer. Other 16-bit MCU compilers generate as much as 165% larger code for the same application.

The assembler comes with the MPLAB XC C Compiler and may be used with the compiler or as an assembler. It is a full-featured macro assembler. User defined macros, conditional assembly and a variety of assembler directives make the assembler a power code generation tool.



Download a full-featured, time-restricted evaluation version of the MPLAB XC16 C Compiler for PIC24 MCUs or dsPIC DSCs from the Microchip web site.

www.microchip.com/compilers

Available for MPLAB X IDE



MPLAB X SIM Software Simulator

The MPLAB X SIM Software Simulator is a full-featured, cycle-accurate software simulator. In addition to simulating the CPU and the instruction set, it also supports key peripherals.

Software Tools for Easy Debug and Development: DSP and Math Libraries and Advanced Debug

dsPIC DSP Library

The dsPIC DSP Library provides a set of speed optimized functions for the most common digital signal processing applications. In total, 49 functions are supported by the DSP Library. It is part of the 16-bit Language Tools Libraries. The DSP Library provides significant performance savings over equivalent functions coded in C and allows developers to dramatically shorten their development time. The functions are callable from both C and Assembly.

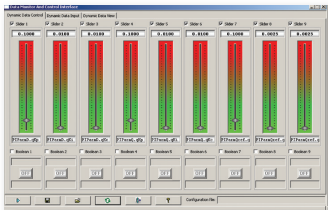
Fixed Point Math Library for PIC24 MCUs and dsPIC DSCs

The I/Q Fixed Point Math Library provides a set of speed-optimized functions for the most common digital signal processing applications. This library provides significant performance savings over equivalent functions coded in C and allows developers to dramatically shorten their development time. The I/Q math library includes over 65 general-purpose functions composed of 28 functions supporting Q15 math and thirty seven functions supporting Q16 math. The IQ math functions are callable from both 'C' and Assembly.

Floating Point Math Library for PIC24 MCUs and dsPIC DSCs

The IEEE-754 Compliant Floating Point Math Library is the compiled version of the math library that is distributed with the highly optimized, ANSI-compliant MPLAB XC16 C Compiler. It contains advanced single and double-precision floating-point arithmetic and trigonometric functions from the standard C header file <math.h>. The library delivers small program code size and data size, reduced cycles and high accuracy.

Real-Time Data Monitor (RTDM)



The Real-Time Data Monitor saves development and testing time for embedded control applications. RTDM allows users to make a change to a software parameter and see the effect immediately without

stopping the application execution. A serial USB or UART cable supports bi-directional data transfers between the host PC and the MCU/DSC.

Data Monitor & Control Interface: A Free MPLAB X IDE Plug-in

The Data Monitor and Control Interface (DMCI) provides dynamic access and control of software variables. It is useful for tuning application parameters and viewing run-time application data graphically. Software parameter changes are updated during run-time. Feature highlights include:

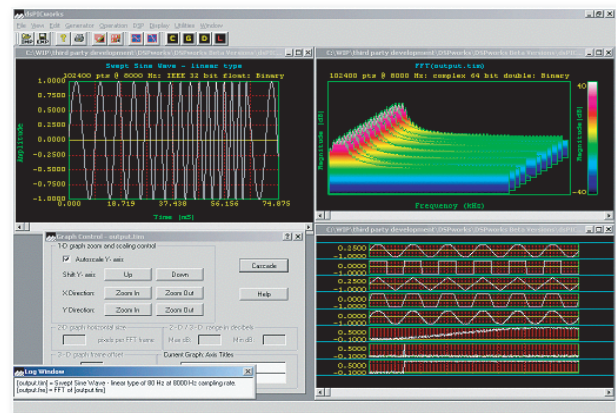
- MPLAB X project aware: The current device and software variables are recognized automatically by DMCI
- Compiler independent
- Debug tool independent
- Provides effortless graphical analysis of application data

MATLAB Device Blocks for MPLAB X IDE

The Microchip Device Blocksets for MATLAB Simulink provide a set of interface-compliant configuration and run-time peripheral blocks for the dsPIC30 and dsPIC33 DSCs.

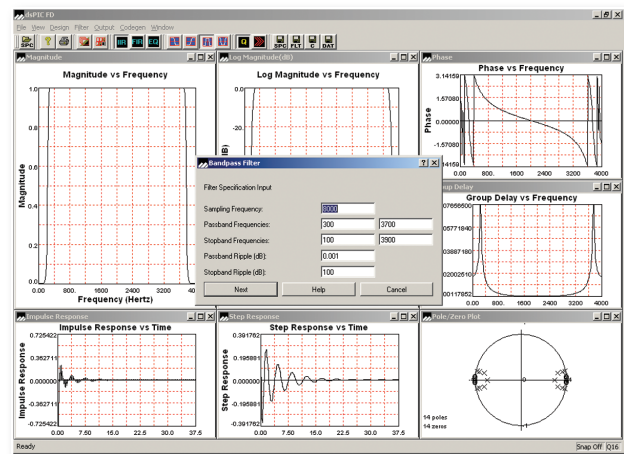
Complete applications can be created in the form of a MATLAB/SIMULINK model using blocksets provided by Microchip and Simulink. C code for the application will be generated. These blocksets are compatible with the MATLAB plug-in available in MPLAB X IDE. Many examples in the form of demo models are also provided, including a complete BLDC motor control application.

dsPICworks™ Data Analysis and DSP Software



The dsPICworks Data Analysis and DSP Software makes it easy to evaluate and analyze DSP algorithms. You can run a variety of DSP and arithmetic operations and analyze your data in both time and frequency domain.




Digital Filter Design Tool



The Digital Filter Design Tool makes designing and analyzing FIR and IIR filters easy. When the user enters frequency specifications, the tool automatically generates the filter code and coefficients. Graphical output windows provide the desired filter's characteristics.

16-bit Product Families

PIC24 16-bit Microcontrollers (MCUs)

| Family | Pins | Flash Memory Kbytes | SRAM Kbytes | 16-bit Timers Input Capture Output Compare | Analog | Communications Serial I/O | Additional Features |
|--|--------|------------------------------|-------------|--|---|---|--|
| PIC24F Family: 16 MIPS, Lowest Cost, Lowest Power, General Purpose | | | | | | | |
|  PIC24F K Families | 14–48 | 4–32 | 0.5–2 | 3–5 Timers 1–3 IC 1–3 OC | 10-bit ADC (500 ksp/s) or 10/12-bit ADC (200/100 ksp/s), 7–16 ch., 3 comparators | UART (2), SPI (1/2), I ² C™ (1/2) | EEPROM, CTMU, RTCC, Deep Sleep |
|  PIC24F GA/GB Families | 28–100 | 16–256 | 4–96 | 5 Timers 5–9 IC 5–9 OC | 10-bit ADC (500 ksp/s) or 10/12-bit ADC (200/100 ksp/s), 9–24 ch., 2/3 comparators, CTMU | UART (2/4), SPI (2/3), I ² C (2/3), USB-OTG | LCD, DMA, PPS, PMP, RTCC, CRC, Deep Sleep, JTAG, VBAT |
|  PIC24F GC Families | 64–100 | 64–128 | 8 | 5 Timers 5 IC 5 OC | 16-bit Sigma Delta ADC, 2 ch. 12-bit 10 Msp/s ADC, 50 ch. 10-bit DAC, 2 ch. 2 op amps CTMU | UART (2) SPI (2) I ² C (2) USB-OTG | LCD, DMA, PPS, PMP, RTCC, CRC, Deep Sleep, JTAG, VBAT |
| PIC24F D Families | 64–100 | 128–256 | 24–96 | 5 Timers 9 IC 9 OC | 10-bit ADC (500 ksp/s), 16–24 ch., 3 comparators, CTMU | UART (4), SPI (3), I ² C (3), USB-OTG | Graphics Display Controller PPS, PMP, RTCC, CRC, JTAG |
| PIC24H Family: 40 MIPS, High Performance, General Purpose | | | | | | | |
| PIC24H GP Families | 18–100 | 12–256 | 1–16 | 3–9 Timers 4–8 IC 2–8 OC | User selectable 12-bit ADC (500 ksp/s) or 10-bit ADC (1.1 Msp/s), 8–32 ch. | UART (1-2), SPI (1–2), I ² C (1–2), CAN | 8 ch. DMA, PPS, PMP, RTCC, CRC, JTAG, High Temperature (150°C) Options |
| PIC24E Family: 70 MIPS, High Performance, General Purpose and Motor Control | | | | | | | |
| PIC24E GP Families* | 28–64 | 64 | 16 | 5 Timers 4 IC 4 OC | User selectable 12-bit ADC (500 ksp/s) or 10-bit ADC (1.1 Msp/s), 6–16 ch., 4 analog comparators, 3 op amps | UART, CAN, SPI, I ² C | mTouch™, DMA |
| PIC24E MC Families* | 28–64 | 64 | 16 | 5 Timers 4 IC 4 OC | User selectable 12-bit ADC (500 ksp/s) or 10-bit ADC (1.1 Msp/s), 6–16 ch., 4 analog comparators, 3 op amps | UART, CAN, SPI, I ² C | mTouch, 6 Motor Control PWM Outputs, DMA |
| PIC24E GU Families* | 64–144 | 256–512 + 24 Aux Flash | 53 | 9 timers 16 IC 16 OC | Two user selectable ADCs at 12-bit (500 ksp/s) or 10-bit (1.1 MSPS), 24–32 ch., 3 analog comparators | UART, CAN, SPI, I ² C | USB, DMA, PMP parallel port |

dsPIC® Digital Signal Controllers (DSCs)

| Family | Max Speed | Pins | Program Memory (Kbytes) | RAM (Bytes) | 8/16/32-bit Timers (x8, x16, x32) | A/D Ch. | A/D Res. (bits) | A/D Sample (Ksp/s) | Analog Comp | Communication Peripherals | PWM Ch. | PWM Type | Additional Features |
|--|-----------|--------|-------------------------|-------------|-----------------------------------|---------|-----------------|--------------------|-------------|---|---------|-------------|--|
| 16-bit DSCs: General Purpose | | | | | | | | | | | | | |
| dsPIC33F Families* | 40 MIPS | 18–100 | 12–256 | 1K–30K | 3–9 × 16 | 6–32 | 10 or 12 | 500k or 1.1M | 0–2 | UART, I ² C™, SPI, CAN, DCI | 2–8 | Standard | Flash security, JTAG, DMA, PMP, RTCC, DAC, CRC |
| dsPIC33E GP Families* | 70 MIPS | 28–64 | 32–512 | 4–48K | 5 × 16 | 6–16 | 10 or 12 | 500k or 1.1M | 4 | UART, I ² C, SPI, CAN | 8 | Standard | Flash security, on-chip op amps, mTouch, JTAG, DMA, CRC |
| 16-bit DSCs: Motor Control | | | | | | | | | | | | | |
| dsPIC33F Families* | 40 MIPS | 20–100 | 12–256 | 1K–30K | 3–9 × 16 | 4–24 | 10 or 12 | 500k or 1.1M | 0–2 | UART, I ² C, SPI, CAN | 6–8 | Motor Ctrl. | Flash security, JTAG, DMA, PMP, RTCC, CRC, QEI |
| dsPIC33E MU Families* | 70 MIPS | 64–144 | 280–536 | 28K–52K | 9 × 16 | 24–32 | 10 or 12 | 500k or 1.1M | 3 | UART, I ² C, SPI, CAN, USB-OTG | 14 | Motor Ctrl. | Flash security, JTAG, DMA, PMP, RTCC, CRC, QEI, Dual ADC |
| dsPIC33E MC Families* | 70 MIPS | 28–64 | 32–512 | 4–48K | 5 × 16 | 6–16 | 10 or 12 | 500k or 1.1M | 4 | UART, I ² C, SPI, CAN | 6 | Motor Ctrl. | Flash security, on-chip op amps, mTouch, JTAG, DMA, CRC, QEI, PTG, PMP |
| dsPIC33E GM Families* | 70 MIPS | 44–121 | 128–512 | 16–48K | 9 × 16, 4 × 32 | 18–49 | 10 or 12 | 500k or 1.1M | 5 | UART, I ² C, SPI, CAN, DCI | 12 | Motor Ctrl. | Flash security, on-chip op amps, mTouch, JTAG, DMA, CRC, QEI, PTG, PMP, Dual ADC |
| 16-bit DSCs: Digital Power Conversion | | | | | | | | | | | | | |
| dsPIC33F GS Families | 50 MIPS | 18–100 | 6–64 | 256–9K | 2–5 × 16 | 6–24 | 10 | 2M or 4M | 0–4 | UART, I ² C, SPI, CAN | 4–18 | High-speed | Flash security, JTAG, DMA, 10-bit DAC Output |





















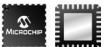








*Parts available with High Temperature options.

All parts available with Industrial and Extended Temperature options.

For a complete listing of 16-bit Microcontrollers and dsPIC Digital Signal Controllers, see the Product Selector Guide (DS00001308) or visit www.microchip.com/16bit or use Micorchip's Advanced Product Selector Tool.

www.microchip.com/16-bit

16-bit Packages

| | | | | |
|---|--|---|--|--|
|  36-lead VTLA (TL) 5 × 5 × 0.9 mm (Lead Pitch: 0.5 mm) |  20-lead SSOP (SS) 7.2 × 7.85 × 1.85 mm (Lead Pitch: 0.65 mm) |  44-lead TQFP (PT) 10 × 10 × 1 mm (Lead Pitch: 0.8 mm) |  64-lead TQFP (PF) 14 × 14 × 1 mm (Lead Pitch: 0.8 mm) |  14-lead PDIP (P) 19 × 6.35 × 3.3 mm (Lead Pitch: 0.1 inches) |
|  44-lead VTLA (TL) 6 × 6 × 0.9 mm (Lead Pitch: 0.5 mm) |  28-lead SSOP (SS) 10.2 × 7.8 × 2 mm (Lead Pitch: 0.65 mm) |  64-lead TQFP (PT) 10 × 10 × 1 mm (Lead Pitch: 0.5 mm) |  80-lead TQFP (PF) 14 × 14 × 1 mm (Lead Pitch: 0.65 mm) |  18-lead PDIP (P) 22.81 × 7.95 × 3.3 mm (Lead Pitch: 0.1 inches) |
|  20-lead QFN (MQ) 5 × 5 × 0.9 mm (Lead Pitch: 0.65 mm) |  14-lead TSSOP (ST) 5.0 × 6.4 × 1.2 mm (Lead Pitch: 0.65 mm) |  80-lead TQFP (PT) 12 × 12 × 1 mm (Lead Pitch: 0.5 mm) |  100-lead TQFP (PF) 14 × 14 × 1 mm (Lead Pitch: 0.5 mm) |  20-lead PDIP (P) 26.24 × 7.87 × 3.3 mm (Lead Pitch: 0.1 inches) |
|  28-lead QFN (MQ) 5 × 5 mm (Lead Pitch: 0.65 mm) |  18-lead SOIC (SO) 11.53 × 10.34 × 2.31 mm (Lead Pitch: 1.27 mm) |  100-lead TQFP (PT) 12 × 12 × 1 mm (Lead Pitch: 0.4 mm) |  144-lead TQFP (PH) 16 × 16 × 1 mm (Lead Pitch: 0.4 mm) |  28-lead SPDIP (SP) 34.67 × 7.87 × 3.3 mm (Lead Pitch: 0.1 inches) |
|  28-lead QFN (MM & ML) 6 × 6 × 0.9 mm (Lead Pitch: 0.65 mm) |  20-lead SOIC (SO) 12.80 × 10.34 × 2.31 mm (Lead Pitch: 1.27 mm) |  121-ball BGA (BG) 10 × 10 × 0.8 mm (Lead Pitch: 0.8 mm) |  144-lead LQFP (PL) 20 × 20 × 1.4 mm (Lead Pitch: 0.5 mm) |  40-lead PDIP (P) 52.27 × 15.24 × 3.81 mm (Lead Pitch: 0.1 inches) |
|  44-lead QFN (ML) 8 × 8 × 0.65 mm (Lead Pitch: 0.65 mm) |  28-lead SOIC (SO) 17.88 × 10.34 × 2.31 mm (Lead Pitch: 1.27 mm) |  Die/Wafer (WLCSP) | | |
|  64-lead QFN (MR) 9 × 9 × 0.5 mm (Lead Pitch: 0.5 mm) | | | | |

For more information about chip-scale packaging options, please visit www.microchip.com/packaging.

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