MICROCHIP

16-bit Embedded Control Solutions

- PIC24 Microcontrollers
- dsPIC® Digital Signal Controllers

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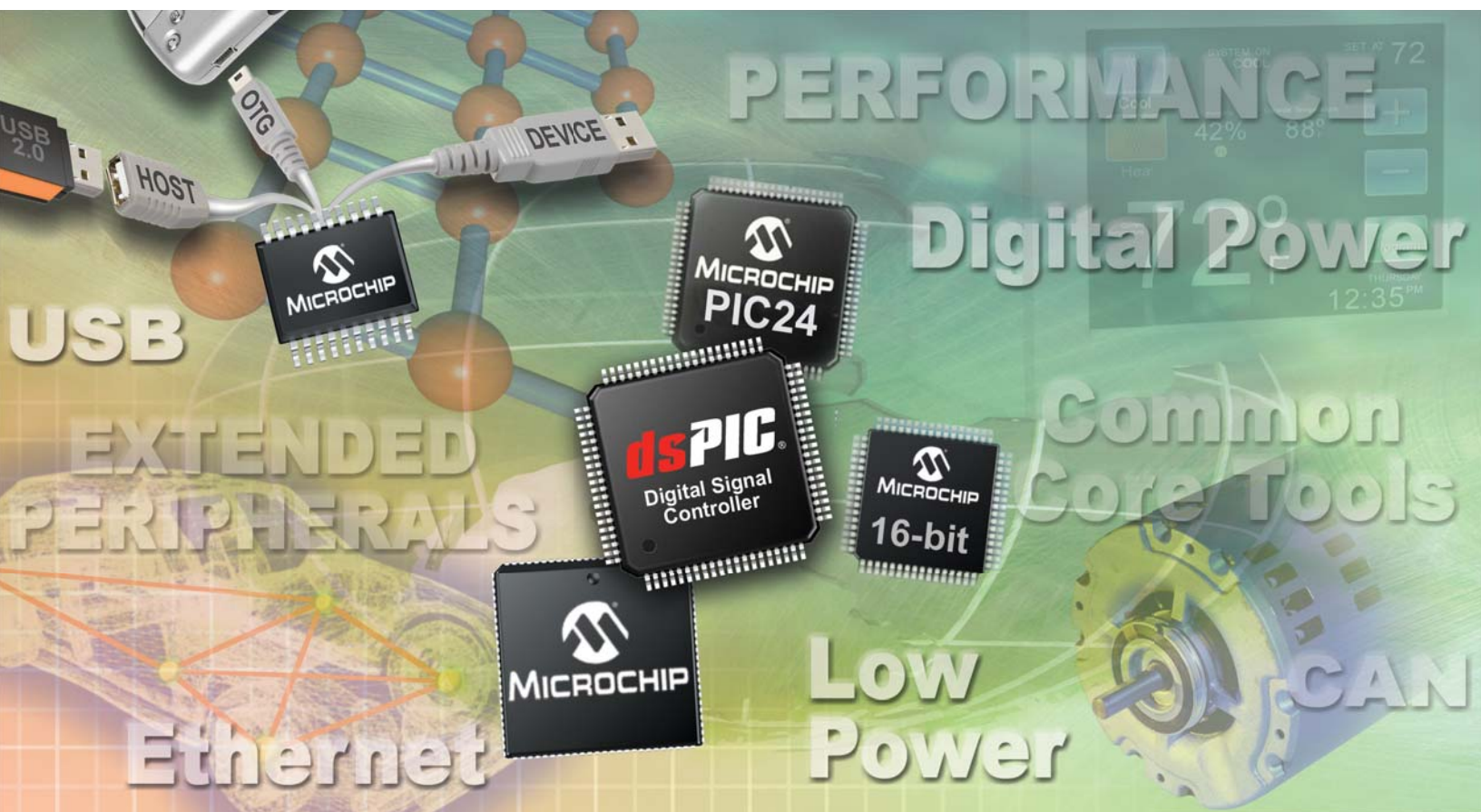
16-bit Embedded Control Solutions

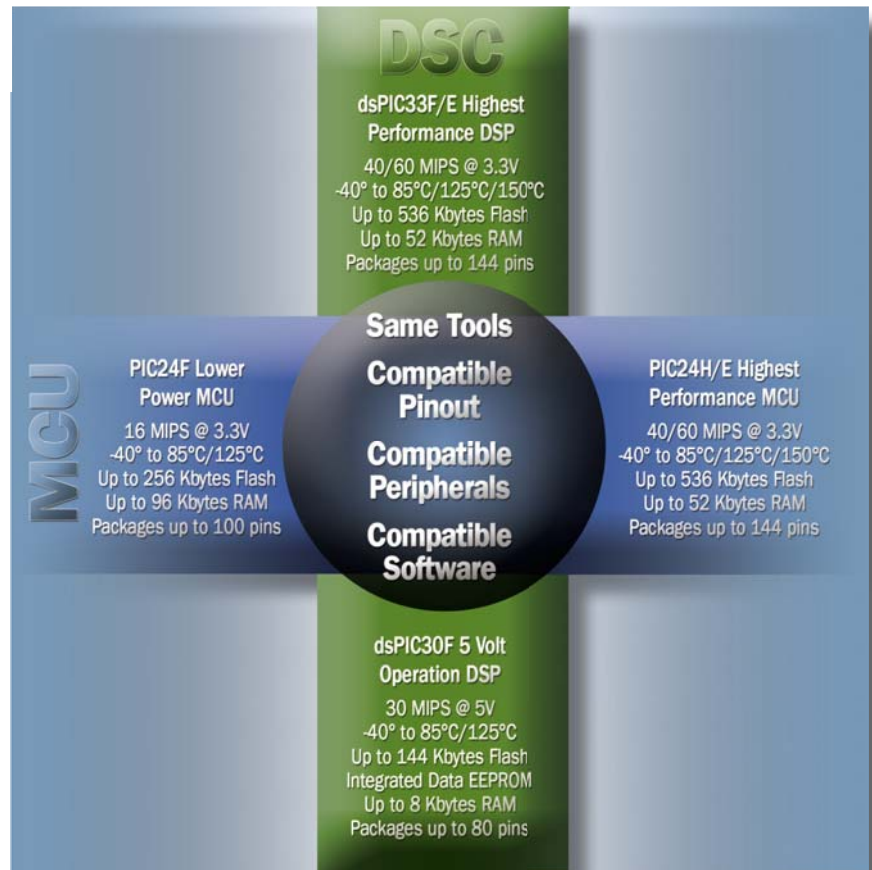*Are you enhancing your product performance and features to increase market share?*

Do you want to achieve an edge over your competition with added connectivity and graphical user interface?

Do you want to generate more profits by optimizing your design and development costs?

Microchip's 16-bit embedded control solutions can help you!

Microchip's 16-bit solutions are designed to be a broad platform which can serve your needs now and in the future. If you have designed using our 8-bit PIC® microcontrollers you will be pleased to see that the same MPLAB® Integrated Development Environment used on our smallest 6-pin MCUs and our largest 32-bit PIC32 microcontrollers also supports our 16-bit controllers. Our commitment to peripheral and pinout compatibility has been carried forward to our 16-bit product families. If you are new to Microchip, we offer powerful, low cost development tools, a compatible lineup of products that range from low cost to high performance, and a Company dedicated to serving your needs.

Microchip offers two 16-bit Microcontroller (MCU) families plus two 16-bit Digital Signal Controller (DSC) families that offer compatible options across a wide spectrum of price, performance and feature sets.

DSC

dsPIC33F/E Highest Performance DSP
40/60 MIPS @ 3.3V
-40° to 85°C/125°C/150°C
Up to 536 Kbytes Flash
Up to 52 Kbytes RAM
Packages up to 144 pins

MCU

PIC24F Lower Power MCU
16 MIPS @ 3.3V
-40° to 85°C/125°C
Up to 256 Kbytes Flash
Up to 96 Kbytes RAM
Packages up to 100 pins

Same Tools
Compatible Pinout
Compatible Peripherals
Compatible Software

PIC24H/E Highest Performance MCU
40/60 MIPS @ 3.3V
-40° to 85°C/125°C/150°C
Up to 536 Kbytes Flash
Up to 52 Kbytes RAM
Packages up to 144 pins

dsPIC30F 5 Volt Operation DSP
30 MIPS @ 5V
-40° to 85°C/125°C
Up to 144 Kbytes Flash
Integrated Data EEPROM
Up to 8 Kbytes RAM
Packages up to 80 pins

Advanced Motor Control with dsPIC Portfolio

dsPIC Motor Control DSCs feature a high-performance CPU with motor control peripherals. The silicon solutions are backed up by free software application libraries and motor control algorithms. Low-cost 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.

Extreme Low Power Solutions

nanoWatt XLP Technology brings together the circuit and process technologies needed to address today's low power applications. With sleep currents down to 20 nA and industry-leading integration that includes USB OTG, 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.

Speech and Audio for All Embedded Applications

Microchip's 16-bit microcontrollers and digital signal controllers have the performance, peripherals and memory to implement speech and audio applications. A suite of advanced solution libraries have been developed and are available for your application requirements. Visit **www.microchip.com/speech** for more information.

Graphics Display Solutions

Graphics displays are gaining popularity in user interface applications and they are easy to add to your application when you use any of Microchip's 16- or 32-bit MCU or DSC devices with PMP With Microchip's free graphics library and development tools, you can quickly integrate graphics display functions into your application in a single microcontroller. Visit **www.microchip.com/graphics** for more information.

16-bit Embedded Control Solutions

Digital Power for Improving the Efficiency and Optimizing the BOM Cost

Implementing advanced software digital control loops for power applications requires a high-performance DSP engine along with specialized peripherals. The dsPIC SMPS Family of DSCs feature a high-performance CPU and rich SMPS peripherals. SMPS peripherals include 4 MSPS 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/smps** for more information.

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. Microchip offers ZigBee® Pro, MiWi™, IrDA® Library stack for wireless connectivity and Ethernet, CAN and USB library stack for wired connectivity. Visit **www.microchip.com/connectivity** for more information.

High Temperature Rated Devices Qualified to AEC-Q100 Requirements

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

Adding Intelligence To Sensors

dsPIC DSCs and PIC24 MCUs with high performance DSP and 12-bit ADC enable more complex data processing to occur closer to the sensor. These devices are available in small packages and can operate in extended and high-temperature ranges.

Powerful 16-bit CPU
- 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 are available
- Program and data storage
- Self-program features

Integrated DSP
- Look and feel of MCU
- Single cycle 16x16 MAC
- 40-bit accumulators
- Dual operand fetches
- Saturation and rounding modes
- Many free libraries and low cost filter design tools

Innovative Peripherals
- Motor control peripherals
- SMPS peripherals
- Audio peripherals: DAC and I^{2}S
- Graphics controller
- CTMU for mTouch
- USB OTG
- CAN
- PMP for graphics

Power Saving Options
- eXtreme Low Power technology
- Deep sleep current as low as 20 nA
- Options to reduce speed or disable CPU
- Application software can alter clock speeds

Small Packages
- Packages as small as 5x5 mm
- 16-bit MCU with 128 KB Flash in a 6x6 mm package
- Peripheral Pin Select allows access to the peripherals needed

Resources available at www.microchip.com/16bit
- Product Information
- Application Solutions
- Design Tools
- Web Seminars
- Application Notes & Reference Designs

Leading 16-bit Performance and Features

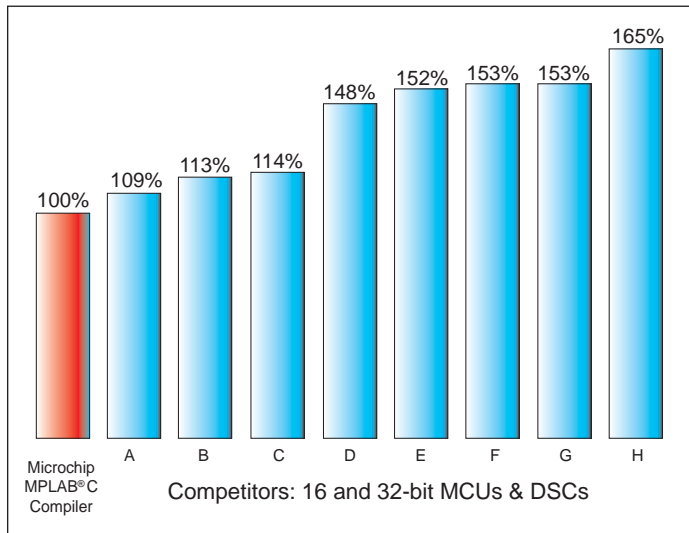## 16-bit Microcontroller (MCU) Portfolio

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. Microchip offers two compatible Flash-based 16-bit PIC24 MCU families. The 16 MIPS PIC24F family is designed for low power applications. The 40/60 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 OTG and capacitive touch sense interface, the PIC24F MCUs are cost-effective for the most demanding 16-bit applications. Serial communication peripherals include up to 4 UARTs, 3 SPI and 3 I2C™. With the introduction of nanoWatt XLP Technology, select PIC24F devices have industry leading low power performance with sleep numbers as low as 20 nA and RTCC operation down to 500 nA.

PIC24H/E: Highest Performance 16-bit MCUs

PIC24 devices offer 40/60 MIPS performance with a combination of large memory and a wide variety of package options. They also includes large Flash in smaller packages (5x5 mm). The built-in peripherals include high performance 12-bit ADC and general purpose and motor control 16-bit PWMs. Communication peripherals include up to 2 ECAN modules, 4 UARTs (with IrDA® support), 4 SPI, 2 I2C and USB 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.

Optimized C Compiler

Supporting the PIC24 MCU and dsPIC DSC families, Microchip's 16-bit architecture was designed to optimize C language code size. The architecture was co-developed by compiler writers who emphasized the need for an orthogonal instruction set, many general-purpose registers, powerful indirect with offset addressing and a software stack. Now you can achieve leadership code size in applications, helping your project team hit schedule and code size targets. Reduced code size provides the opportunity to use a smaller memory device, spend less time optimizing code size and respond to those marketing requests for "just one more feature."

Relative Code Size (in bytes) for 16-bit Applications

Relative Performance/MHz
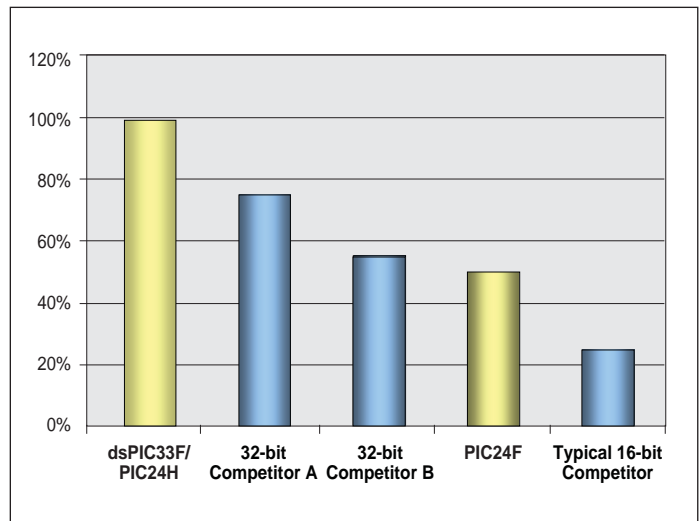
Benefits of Microchip's 16-bit Embedded Control Solutions

16-bit Digital Signal Controller (DSC) Portfolio

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

dsPIC® DSCs offer innovative peripherals and required performance for these needs. Our dsPIC family is a 100% PIC® MCU with great math. dsPIC DSCs blend the performance of DSP with the simplicity of an MCU.

Versatile 5 Volt dsPIC30F DSCs

The 30 MIPS dsPIC30F family is developed for applications that benefit from a wide operating voltage (2.5 to 5.5V), extremely low standby current, integrated EEPROM, and for those that prefer 5V operation due to system considerations.

dsPIC33F/E: Highest Performance 16-bit MCU with Integrated DSP

The 40/60 MIPS dsPIC33 core is designed to execute and control the high speed precision digital control loops and digital audio and speech processing. The optimized motor control and digital power conversion peripherals include the highest performance ADC, PWMs, USB OTG and analog comparators. A wide variety of memory and package options, audio peripherals, 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.
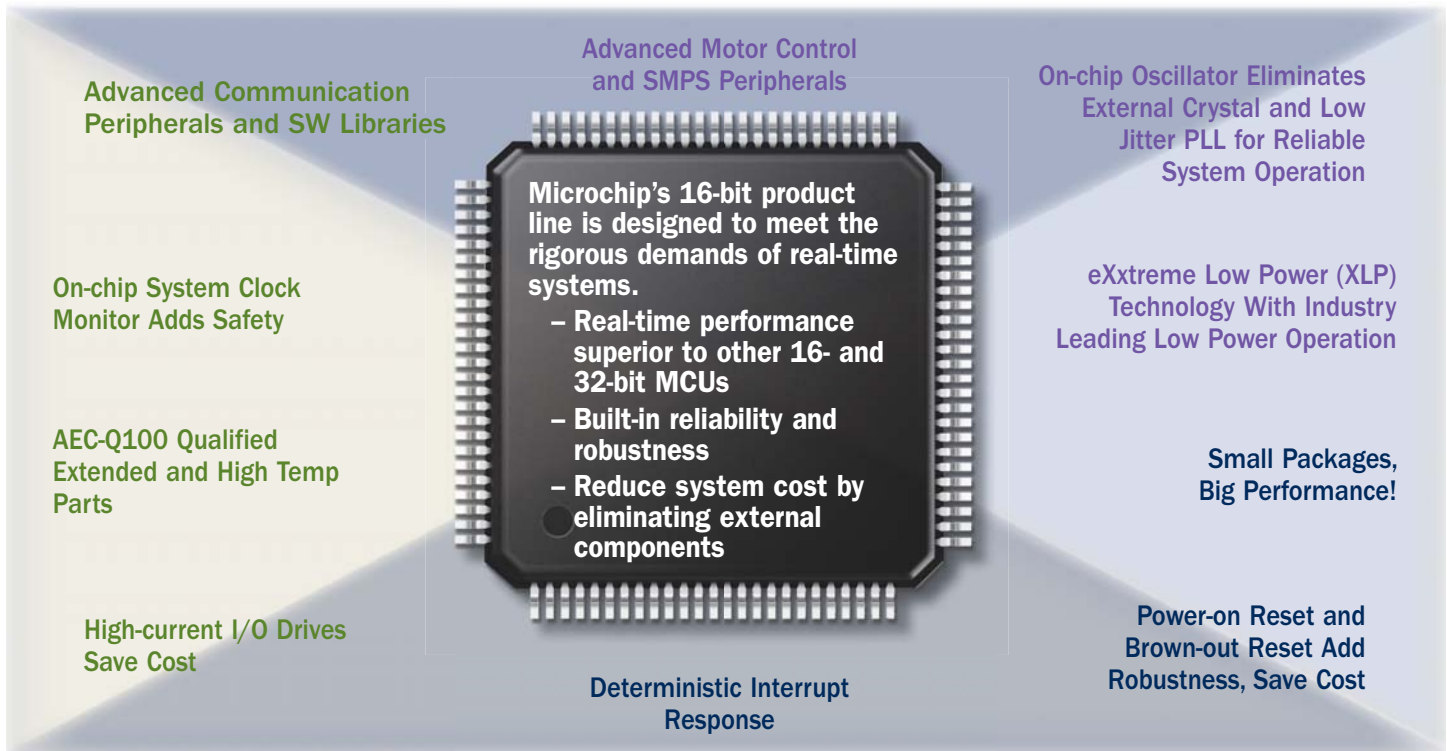
Example dsPIC® DSP Performance

Function	Conditions*	Execution Time @60 MIPS
Complex FFT**	N=64	63.6 µs
Block FIR	N=32, M=32	19.5 µs
Block IIR Canonic	N=32, S=4	20.0 µs
Matrix Add	C=8, R=8	3.7 µs
Matrix Transpose	C=8, R=8	4.0 µs
Vector Dot Product	N=32	2.0 µs

*C = # columns, N = # samples, M = # taps, S = # sections, R = # rows
**Complex FFT routine inherently prevents overflow.
1 cycle = 16.67 nanoseconds @ 60 MIPS

Designed for real-time control, Microchip's 16-bit DSCs and MCUs offer high performance, innovative features, outstanding reliability, robustness and reduced system cost.

Advanced Communication Peripherals and SW Libraries

Advanced Motor Control and SMPS Peripherals

On-chip Oscillator Eliminates External Crystal and Low Jitter PLL for Reliable System Operation

On-chip System Clock Monitor Adds Safety

Microchip's 16-bit product line is designed to meet the rigorous demands of real-time systems.
– Real-time performance superior to other 16- and 32-bit MCUs
– Built-in reliability and robustness
– Reduce system cost by eliminating external components

eXxtreme Low Power (XLP) Technology With Industry Leading Low Power Operation

AEC-Q100 Qualified Extended and High Temp Parts

Small Packages, Big Performance!

High-current I/O Drives Save Cost

Deterministic Interrupt Response

Power-on Reset and Brown-out Reset Add Robustness, Save Cost

16-bit Product Features Overview

CPU, Systems & Memory

Operating Range PIC24F

DC to 16 MIPS
V$_{DD}$ range: 1.8 to 3.6V
Ind. (-40° to 85°C) Ext. (-40° to 125°C)

Operating Range PIC24H/E & dsPIC33F/E

DC to 40/60 MIPS
V$_{DD}$ range: 3.0 to 3.6V
Ind. (-40° to 85°C) Ext. (-40° to 125°C) High-Temp (-40° to 150°C)

Operating Range dsPIC30F

DC to 30 MIPS
V$_{DD}$ range: 2.5 to 5.5V
Ind. (-40° to 85°C) Ext. (-40° to 125°C)

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 x 16 signed fractional/integer multiplier
32/16 and 16/16 divide
40-stage barrel shifter
DSC additions (dsPIC30 & dsPIC33):   · Adds 8 base DSP instructions   · 2 40-bit accumulators with rounding and saturation options   · Single core combines MCU & DSP features   · Adds Modulo and Bit-reverse address modes

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

Interrupt Controller

5 cycle fixed latency
Up to 118 interrupt sources, up to 5 external
7 programmable priority levels
4 processor exceptions and software traps

*Peripheral, Mini-Host, OTG

Power Management

Switch between clock sources in real-time
Programmable power-on reset start up
Programmable low-voltage detect (dsPIC30F)
Programmable brown-out reset
Idle, Sleep and Deep Sleep modes with fast wake up

On-chip Flash, Data EEPROM and RAM

Flash program memory: up to 512 KB   Auxiliary Flash memory: up to 24 KB
Data EEPROM   · dsPIC30F: up to 4 KB   – 1 million erase/write cycles typical   · PIC24F: up to 512B
Data RAM: up to 96 KB

Peripherals

Digital I/O

Peripheral Pin Select (PPS)   · Remap digital I/O   · Support most digital peripherals
Up to 122 programmable digital I/O pins
Wake-up/Interrupt-on-change on up to 24 pins
High current sink/source (PIC24F & dsPIC30F)

Communication Modules

3-wire SPI: up to 3 modules   · Framing supports I/O interface to simple codecs
I²C™: up to 3 modules   · Full Multi-master and Slave mode support   · 7-bit and 10-bit addressing
UART: up to 4 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 OTG*   · Internal Boost Regulator requires minimal external components   · Separate 3.3V regulator   · Transparent RAM buffer interface
Codec interface module   · Supports I²S and AC97 protocols

Timers/Capture/Compare/PWM

Timer/counters: up to nine 16-bit timers   · Can pair up to make 32-bit timers   · 1 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   · Single or dual 16-bit compare mode   · 16-bit glitchless PWM mode

Auxiliary Functions

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):   · 8-bit Parallel IO, highly configurable   · 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

Hardware DMA PIC24H/E & dsPIC33F/E

Up to 15 channel DMA between dual port RAM & peripherals

Analog Subsystems

Analog comparators (up to 3):   · Programmable reference
Audio DAC: · 2 ch. 16-bit 100 ksps   · Differential output
10-bit ADC: · PIC24F: 500 ksps, 1 module   · dsPIC30F: 1 Msps, 1 module
12-bit ADC: · PIC24F: 100 ksps 1 module   · dsPIC30F: 200 ksps 1 module
10-/12-bit ADC (user selectable):   · Available on PIC24H and dsPIC33F   · 10-bit: 1.1 Msps, 4 S&H   · 12-bit: 500 ksps, 1 S&H   · Some devices have 2 modules
Common ADC features: Buffered output or DMA   · dsPIC30F & PIC24F: up to 16 channels auto scanning   · PIC24H/E & dsPIC33F/E: up to 32 channels auto scanning

Motor Control Peripherals

Motor Control PWM: up to 14 outputs   · 4 duty cycle generators   · Independent or complementary mode   · Programmable dead time settings   · Edge or center-aligned   · Manual output override control   · Up to 2 fault inputs   · ADC samples triggered by PWM module
Quadrature encoder interface module   · Up to 2 modules   · Phase A, Phase B and index pulse input
High current sink/source (PIC24F & dsPIC30F)

Switch Mode Power Peripherals

10-bit ADC Up to 4 Msps, Up to 6 sample and holds
PS PWM, 1 nS duty cycle resolution
Analog comparators   · Programmable reference

PIC24F MCU Family

16 MIPS, Low Cost/Low Power

The PIC24F family is ideal for cost-sensitive applications or applications migrating from 8-bit designs for a boost in performance or memory. In addition to a wide range of general purpose peripherals the PIC24F families include nanoWatt XLP low power technology, USB OTG, a Charge Time Measurement Unit (CTMU) for capacitive touch sense and a PMP that allows easy interface to a graphical user interface.

Product	Pins	I/O Pins	Flash KB	RAM KB	Graphics	Timer	Capture	Output Compare/ PWM	RTCC	ADC 10-bit 500 ksps	Analog Comparators	UART	SPI	I²C™	PMP	PPS	CTMU	USB OTG	JTAG	Package Code
PIC24FJ16GA002	28	21	16	4	–	5	5	5	Y	1 ADC, 10 ch	2	2	2	2	Y	Y	–	–	Y	ML, SO, SP, SS
PIC24FJ32GA002	28	21	32	8	–	5	5	5	Y	1 ADC, 10 ch	2	2	2	2	Y	Y	–	–	Y	ML, SO, SP, SS
PIC24FJ64GA002	28	21	64	8	–	5	5	5	Y	1 ADC, 10 ch	2	2	2	2	Y	Y	–	–	Y	ML, SO, SP, SS
PIC24FJ16GA004	44	35	16	4	–	5	5	5	Y	1 ADC, 13 ch	2	2	2	2	Y	Y	–	–	Y	ML, PT
PIC24FJ32GA004	44	35	32	8	–	5	5	5	Y	1 ADC, 13 ch	2	2	2	2	Y	Y	–	–	Y	ML, PT
PIC24FJ64GA004	44	35	64	8	–	5	5	5	Y	1 ADC, 13 ch	2	2	2	2	Y	Y	–	–	Y	ML, PT
PIC24FJ64GA006	64	53	64	8	–	5	5	5	Y	1 ADC, 16 ch	2	2	2	2	Y	–	–	–	Y	PT
PIC24FJ64GA106	64	53	64	16	–	5	9	9	Y	1 ADC, 16 ch	3	4	3	3	Y	Y	Y	–	Y	PT, MR
PIC24FJ64GB106	64	52	64	16	–	5	9	9	Y	1 ADC, 16 ch	3	4	3	3	Y	Y	Y	Y	Y	PT
PIC24FJ64GA108	64	53	64	16	–	5	9	9	Y	1 ADC, 16 ch	3	4	3	3	Y	Y	Y	–	Y	PT, MR
PIC24FJ64GA110	64	53	64	16	–	5	9	9	Y	1 ADC, 16 ch	3	4	3	3	Y	Y	Y	–	Y	PT, MR
PIC24FJ128DA106	64	52	128	24	Y	5	9	9	Y	1 ADC, 16 ch	3	4	3	3	Y	Y	Y	Y	Y	PT, MR
PIC24FJ128DA206	64	52	128	96	Y	5	9	9	Y	1 ADC, 16 ch	3	4	3	3	Y	Y	Y	Y	Y	PT, MR
PIC24FJ128GA006	64	53	128	8	–	5	5	5	Y	1 ADC, 16 ch	2	2	2	2	Y	–	–	–	Y	PT
PIC24FJ128GA106	64	53	128	16	–	5	9	9	Y	1 ADC, 16 ch	3	4	3	3	Y	Y	Y	–	Y	PT, MR
PIC24FJ128GB106	64	52	128	16	–	5	9	9	Y	1 ADC, 16 ch	3	4	3	3	Y	Y	Y	Y	Y	PT, MR
PIC24FJ128GB206	64	52	128	96	–	5	9	9	Y	1 ADC, 16 ch	3	4	3	3	Y	Y	Y	Y	Y	PT, MR
PIC24FJ256DA106	64	52	256	24	Y	5	9	9	Y	1 ADC, 16 ch	3	4	3	3	Y	Y	Y	Y	Y	PT, MR
PIC24FJ256DA206	64	52	256	96	Y	5	9	9	Y	1 ADC, 16 ch	3	4	3	3	Y	Y	Y	Y	Y	PT, MR
PIC24FJ256GA106	64	53	256	16	–	5	9	9	Y	1 ADC, 16 ch	3	4	3	3	Y	Y	Y	–	Y	PT, MR
PIC24FJ256GB106	64	52	256	16	–	5	9	9	Y	1 ADC, 16 ch	3	4	3	3	Y	Y	Y	Y	Y	PT, MR
PIC24FJ256GB206	64	52	256	96	–	5	9	9	Y	1 ADC, 16 ch	3	4	3	3	Y	Y	Y	Y	Y	PT, MR
PIC24FJ64GA008	80	69	64	8	–	5	5	5	Y	1 ADC, 16 ch	2	2	2	2	Y	–	–	–	Y	PT
PIC24FJ64GB108	80	68	64	16	–	5	9	9	Y	1 ADC, 16 ch	3	4	3	3	Y	Y	Y	Y	Y	PT
PIC24FJ128GA008	80	69	128	8	–	5	5	5	Y	1 ADC, 16 ch	2	2	2	2	Y	–	–	–	Y	PT
PIC24FJ128GA108	80	69	128	16	–	5	9	9	Y	1 ADC, 16 ch	3	4	3	3	Y	Y	Y	–	Y	PT
PIC24FJ128GB108	80	68	128	16	–	5	9	9	Y	1 ADC, 16 ch	3	4	3	3	Y	Y	Y	Y	Y	PT
PIC24FJ256GA108	80	69	256	16	–	5	9	9	Y	1 ADC, 16 ch	3	4	3	3	Y	Y	Y	–	Y	PT
PIC24FJ256GB108	80	68	256	16	–	5	9	9	Y	1 ADC, 16 ch	3	4	3	3	Y	Y	Y	Y	Y	PT
PIC24FJ64GA010	100	85	64	8	–	5	5	5	Y	1 ADC, 16 ch	2	2	2	2	Y	–	–	–	Y	PF, PT
PIC24FJ64GB110	100	84	64	16	–	5	9	9	Y	1 ADC, 16 ch	3	4	3	3	Y	Y	Y	Y	Y	PT
PIC24FJ128DA110	100	84	128	24	Y	5	9	9	Y	1 ADC, 16 ch	3	4	3	3	Y	Y	Y	Y	Y	PT, BG
PIC24FJ128DA210	100	84	128	96	Y	5	9	9	Y	1 ADC, 16 ch	3	4	3	3	Y	Y	Y	Y	Y	PT, BG
PIC24FJ128GA010	100	85	128	8	–	5	5	5	Y	1 ADC, 16 ch	2	2	2	2	Y	–	–	–	Y	PF, PT
PIC24FJ128GA110	100	85	128	16	–	5	9	9	Y	1 ADC, 16 ch	3	4	3	3	Y	Y	Y	–	Y	PT
PIC24FJ128GB110	100	84	128	16	–	5	9	9	Y	1 ADC, 16 ch	3	4	3	3	Y	Y	Y	Y	Y	PT
PIC24FJ128GB210	100	84	128	96	–	5	9	9	Y	1 ADC, 16 ch	3	4	3	3	Y	Y	Y	Y	Y	PT, BG
PIC24FJ256GA110	100	85	256	16	–	5	9	9	Y	1 ADC, 16 ch	3	4	3	3	Y	Y	Y	–	Y	PT
PIC24FJ256GB110	100	84	256	16	–	5	9	9	Y	1 ADC, 16 ch	3	4	3	3	Y	Y	Y	Y	Y	PT
PIC24FJ256GB210	100	84	256	96	–	5	9	9	Y	1 ADC, 16 ch	3	4	3	3	Y	Y	Y	Y	Y	PT, BG

PIC24F MCU Family

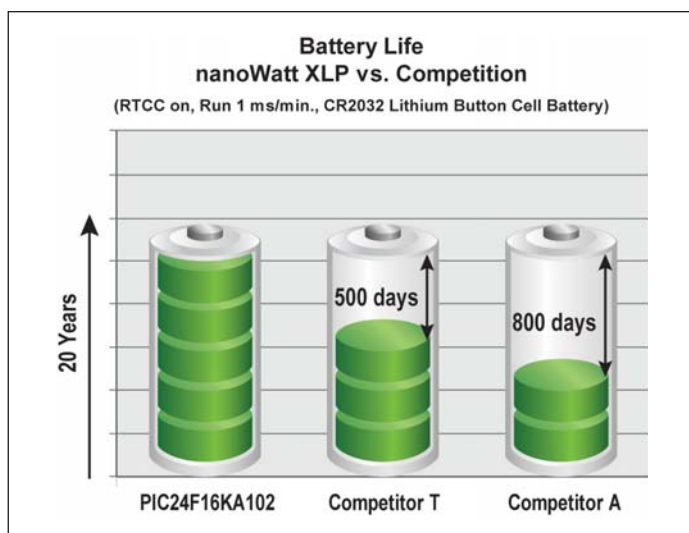## PIC24F MCU Devices with NanoWatt XLP Technology

Microchip products with nanoWatt XLP Technology offer the industry's lowest currents for Sleep, where extreme low power applications spend more than 99% of their time. Visit **www.microchip.com/XLP** for more XLP product information.

Product	Pins	I/O Pins	Flash KB	RAM KB	EEPROM (bytes)	Timer	Capture	Output Compare/ PWM	RTCC	ADC	Comparators	UART	SPI	I²C	PMP	PPS	CTMU	USB OTG	JTAG	Deep Sleep	Package Code
PIC24F04KA200	14	12	4	0.5	–	3	1	1	–	7 ch, 10-bit	2	1	1	1	–	–	Y	–	–	Y	P, ST
PIC24F04KA201	20	18	4	0.5	–	3	1	1	–	9 ch, 10-bit	2	1	1	1	–	–	Y	–	–	Y	P, SO, SS, MQ
PIC24F08KA101	20	18	8	1.5	512	3	1	1	Y	9 ch, 10-bit	2	2	1	1	–	–	Y	–	–	Y	P, SO, SS, MQ
PIC24F16KA101	20	18	16	1.5	512	3	1	1	Y	9 ch, 10-bit	2	2	1	1	–	–	Y	–	–	Y	P, SO, SS, MQ
PIC24F16KA301	20	18	16	2	512	5	3	3	Y	9 ch, 12-bit	3	2	2	2	–	–	Y	–	Y	Y	SP, SS, SO
PIC24F32KA301	20	18	32	2	512	5	3	3	Y	9 ch, 12-bit	3	2	2	2	–	–	Y	–	Y	Y	SP, SS, SO
PIC24F08KA101	28	24	8	1.5	512	3	1	1	Y	9 ch, 10-bit	2	2	1	1	–	–	Y	–	–	Y	P, SO, SS, MQ
PIC24F16KA101	28	24	16	1.5	512	3	1	1	Y	9 ch, 10-bit	2	2	1	1	–	–	Y	–	–	Y	P, SO, SS, MQ
PIC24F16KA302	28	24	16	2	512	5	3	3	Y	10 ch, 12-bit	3	2	2	2	–	–	Y	–	Y	Y	SP, SS, SO, ML
PIC24FJ32GA102	28	21	32	8	–	5	5	5	Y	10 ch, 10-bit	3	2	2	2	Y	Y	Y	–	Y	Y	SP, SO, SS, ML
PIC24FJ32GB002	28	21	32	8	–	5	5	5	Y	10 ch, 10-bit	3	2	2	2	Y	Y	Y	Y	Y	Y	SP, SO, SS, ML
PIC24F32KA302	28	24	32	2	512	5	3	3	Y	10 ch, 12-bit	3	2	2	2	–	–	Y	–	Y	Y	SP, SS, SO, ML
PIC24FJ64GA102	28	21	64	8	–	5	5	5	Y	10 ch, 10-bit	3	2	2	2	Y	Y	Y	–	Y	Y	SP, SO, SS, ML
PIC24FJ64GB002	28	21	64	8	–	5	5	5	Y	10 ch, 10-bit	3	2	2	2	Y	Y	Y	Y	Y	Y	SP, SO, SS, ML
PIC24FJ32GA104	44	35	32	8	–	5	5	5	Y	13 ch, 10-bit	3	2	2	2	Y	Y	Y	–	Y	Y	PT, ML
PIC24FJ32GB004	44	35	32	8	–	5	5	5	Y	13 ch, 10-bit	3	2	2	2	Y	Y	Y	Y	Y	Y	PT, ML
PIC24FJ64GA104	44	35	64	8	–	5	5	5	Y	13 ch, 10-bit	3	2	2	2	Y	Y	Y	–	Y	Y	PT, ML
PIC24FJ64GB004	44	35	64	8	–	5	5	5	Y	13 ch, 10-bit	3	2	2	2	Y	Y	Y	Y	Y	Y	PT, ML
PIC24F16KA304	44/48	38	16	2	512	5	3	3	Y	16 ch, 12-bit	3	2	2	2	–	–	Y	–	Y	Y	PT, ML, MV
PIC24F32KA304	44/48	38	32	2	512	5	3	3	Y	16 ch, 12-bit	3	2	2	2	–	–	Y	–	Y	Y	PT, ML, MV

nanoWatt XLP eXtreme Low Power MCUs

As more electronic applications require low power or battery power, energy conservation becomes paramount. Today's applications must consume little power, and in extreme cases, last up to 15-20 years, while running from a single battery. To enable applications like these, products with Microchip's nanoWatt XLP Technology offer the industry's lowest currents for Sleep, where extreme low power applications spend 90%-99% of their time. Benefits of nanoWatt XLP Technology:

- Sleep currents down to 20 nA
- Brown-out Reset down to 45 nA
- Watch-dog Timer down to 400 nA
- Real-time Clock/Calendar down to 500 nA

Battery Life
nanoWatt XLP vs. Competition
(RTCC on, Run 1 ms/min., CR2032 Lithium Button Cell Battery)

20 Years — PIC24F16KA102
500 days — Competitor T
800 days — Competitor A

PIC24H MCU General Purpose Family

40 MIPS, High MCU Performance

Microchip's PIC24H general purpose microcontroller family features the highest 16-bit MCU performance and excellent code density. The PIC24H family offers CAN communication, superior ADC performance, easier graphic display interface through 8-bit parallel master port and extensive data movement through DMA channels. PIC24H devices are available in small packages with scalable memory and extended (125°C) and high temp (150°C) options.

Product	Pins	I/O Pins	Flash KB	RAM KB	DMA # ch	Timer 16-bit	Input Capture	Output Compare/PWM	ADC 10-/12-bit† 1.1/0.5 Msps	Analog Comparators	UART	SPI	I²C™	PMP	PPS	RTCC	CAN	JTAG	Package Code
PIC24HJ12GP201	18	13	12	1	–	3	4	2	1 ADC, 6 ch	–	1	1	1	–	Y	–	–	–	P, SO
PIC24HJ12GP202	28	21	12	1	–	3	4	2	1 ADC, 10 ch	–	1	1	1	–	Y	–	–	Y	SP, SO, ML, SS
PIC24HJ32GP202*	28	21	32	2	–	3	4	2	1 ADC, 10 ch	–	1	1	1	–	Y	–	–	Y	SP, SO, MM
PIC24HJ32GP302	28	21	32	4	8	5	4	4	1 ADC 10 ch	2	2	2	1	1	Y	1	–	Y	SO, SP, MM
PIC24HJ64GP202	28	21	64	8	8	5	4	4	1 ADC 10 ch	2	2	2	1	1	Y	1	–	Y	SO, SP, MM
PIC24HJ64GP502*	28	21	64	8	8	5	4	4	1 ADC 10 ch	2	2	2	1	1	Y	1	1	Y	SO, SP, MM
PIC24HJ128GP202	28	21	128	8	8	5	4	4	1 ADC 10 ch	2	2	2	1	1	Y	1	–	Y	SO, SP, MM
PIC24HJ128GP502*	28	21	128	8	8	5	4	4	1 ADC 10 ch	2	2	2	1	1	Y	1	1	Y	SO, SP, MM
PIC24HJ16GP304*	44	35	16	2	–	3	4	2	1 ADC 13 ch	–	1	1	1	–	Y	–	–	Y	PT, ML
PIC24HJ32GP204*	44	35	32	2	–	3	4	2	1 ADC 13 ch	–	1	1	1	–	Y	–	–	Y	PT, ML
PIC24HJ32GP304	44	35	32	4	8	5	4	4	1 ADC 13 ch	2	2	2	1	1	Y	1	–	Y	PT, ML
PIC24HJ64GP204	44	35	64	8	8	5	4	4	1 ADC 13 ch	2	2	2	1	1	Y	1	–	Y	PT, ML
PIC24HJ64GP504*	44	35	64	8	8	5	4	4	1 ADC 13 ch	2	2	2	1	1	Y	1	1	Y	PT, ML
PIC24HJ128GP204	44	35	128	8	8	5	4	4	1 ADC 13 ch	2	2	2	1	1	Y	1	–	Y	PT, ML
PIC24HJ128GP504*	44	35	128	8	8	5	4	4	1 ADC 13 ch	2	2	2	1	1	Y	1	1	Y	PT, ML
PIC24HJ64GP206A	64	53	64	8	8	9	8	8	1 ADC, 18 ch	–	2	2	1	–	N	–	–	Y	PT, MR
PIC24HJ64GP506A	64	53	64	8	8	9	8	8	1 ADC, 18 ch	–	2	2	2	–	N	–	1	Y	PT, MR
PIC24HJ128GP206A	64	53	128	8	8	9	8	8	1 ADC, 18 ch	–	2	2	2	–	N	–	–	Y	PT, MR
PIC24HJ128GP306A	64	53	128	16	8	9	8	8	1 ADC, 18 ch	–	2	2	2	–	N	–	–	Y	PT, MR
PIC24HJ128GP506A*	64	53	128	8	8	9	8	8	1 ADC, 18 ch	–	2	2	2	–	N	–	1	Y	PT, MR
PIC24HJ256GP206A	64	53	256	16	8	9	8	8	1 ADC, 18 ch	–	2	2	2	–	N	–	–	Y	PT, MR
PIC24HJ64GP210A	100	85	64	8	8	9	8	8	1 ADC, 32 ch	–	2	2	2	–	N	–	–	Y	PT, PF
PIC24HJ64GP510A	100	85	64	8	8	9	8	8	1 ADC, 32 ch	–	2	2	2	–	N	–	1	Y	PT, PF
PIC24HJ128GP210A	100	85	128	8	8	9	8	8	1 ADC, 32 ch	–	2	2	2	–	N	–	–	Y	PT, PF
PIC24HJ128GP310A	100	85	128	16	8	9	8	8	1 ADC, 32 ch	–	2	2	2	–	N	–	–	Y	PT, PF
PIC24HJ128GP510A*	100	85	128	8	8	9	8	8	1 ADC, 32 ch	–	2	2	2	–	N	–	1	Y	PT, PF
PIC24HJ256GP210A	100	85	256	16	8	9	8	8	1 ADC, 32 ch	–	2	2	2	–	N	–	–	Y	PT, PF
PIC24HJ256GP610A	100	85	256	16	8	9	8	8	2 ADC, 32 ch	–	2	2	2	–	N	–	2	Y	PT, PF

†PIC24H devices feature one or two user-selectable 1.1 Msps 10-bit ADC (4 Sample and Hold) or 500 ksps 12-bit ADC (1 Sample and Hold).
*Parts available with High Temperature options.

PIC24E MCU General Purpose Family

60 MIPS, Highest Performance MCU

Microchip's PIC24E general purpose microcontroller family features the highest speed 60 MIPS core with excellent performance and code density. It offers superior ADC performance, enhanced CAN communication, easier graphic display interface through 8-bit parallel master port and up to 15 DMA channels for extensive data movement. These devices are available in various packages and with extended (125°C) temp option.

Product	Pins	I/O Pins	Flash† KB	RAM* KB	DMA # ch	Timer 16-bit	Input Capture	Output Compare/PWM	ADC 10-/12-bit† 1.1/0.5 Msps	Analog Comparators	USB OTG	UART	SPI	I²C™	PMP	PPS	RTCC	ECAN	JTAG	Pkg Code
PIC24EP256GU810	100	83	280	28	15	9	16	16	2 A/D, 32 ch	3	1	4	4	2	1	Y	1	2	Y	PF, PT, BG
PIC24EP512GU810	100	83	536	52	15	9	16	16	2 A/D, 32 ch	3	1	4	4	2	1	Y	1	2	Y	PF, PT, BG
PIC24EP256GU814	144	122	280	28	15	9	16	16	2 A/D, 32 ch	3	1	4	4	2	1	Y	1	2	Y	PL, PH
PIC24EP512GU814	144	122	536	52	15	9	16	16	2 A/D, 32 ch	3	1	4	4	2	1	Y	1	2	Y	PL, PH

†Flash size is inclusive of 24 Kbytes of auxiliary Flash
*RAM size is inclusive of 4 Kbytes of DMA RAM.

dsPIC33F DSC Product Family

General Purpose Family

The 40 MIPS dsPIC33F general purpose digital signal controllers offer the performance of DSP with the simplicity of an MCU. The dsPIC33F core is designed to execute digital filter algorithms, high speed precision digital control loops and digital audio and speech processing. A wide variety of memory and package options, audio peripherals, communication peripherals, DMA and general purpose peripherals provide flexibility to high performance embedded control designs.

Product	Pins	I/O Pins	Flash KB	RAM KB	DMA # Ch	Timer 16-bit	Input Capture	Output Compare/ Standard PWM	Codec Interface	ADC 10-/12-bit† 1.1/0.5 Msps	16-bit Audio DAC	Analog Comparators	UART	SPI	I²C™	PMP	PPS	RTCC	CAN	JTAG	Package Code
dsPIC33FJ12GP201	18	13	12	1	–	3	4	2	–	1 ADC, 8 ch	–	–	1	1	1	–	Y	–	–	N	P, SO
dsPIC33FJ12GP202	28	21	12	1	–	3	4	2	–	1 ADC, 10 ch	–	–	1	1	1	–	Y	–	–	Y	SO, SP, ML, SS
dsPIC33FJ32GP202	28	21	32	2	–	3	4	2	–	1 ADC, 10 ch	–	–	1	1	1	–	Y	–	–	Y	SO, SP, MM
dsPIC33FJ32GP302	28	21	32	4	8	5	4	4	1	1 ADC 10 ch	–	2	2	2	1	1	Y	1	–	Y	SO,SP, MM
dsPIC33FJ64GP202	28	21	64	8	8	5	4	4	1	1 ADC 10 ch	–	2	2	2	1	1	Y	1	–	Y	SO, SP, MM
dsPIC33FJ64GP802*	28	21	64	16	8	5	4	4	1	1 ADC 10 ch	2 ch	2	2	2	1	1	Y	1	1	Y	SO, SP, MM
dsPIC33FJ128GP202	28	21	128	8	8	5	4	4	1	1 ADC 10 ch		2	2	2	1	1	Y	1	–	Y	SO, SP, MM
dsPIC33FJ128GP802	28	21	128	16	8	5	4	4	1	1 ADC 10 ch	2 ch	2	2	2	1	1	Y	1	1	Y	SO, SP, MM
dsPIC33FJ16GP304	44	35	16	2	–	3	4	2	–	1 ADC, 13 ch	–	–	1	1	1	–	Y	–	–	Y	PT, ML
dsPIC33FJ32GP204	44	35	32	2	–	3	4	2	–	1 ADC, 13 ch	–	–	1	1	1	–	Y	–	–	Y	PT, ML
dsPIC33FJ32GP304	44	35	32	4	8	5	4	4	1	1 ADC 13 ch	–	2	2	2	1	1	Y	1	–	Y	PT, ML
dsPI33FJ64GP204	44	35	64	8	8	5	4	4	1	1 ADC 13 ch	–	2	2	2	1	1	Y	1	–	Y	PT, ML
dsPIC33FJ64GP804	44	35	64	16	8	5	4	4	1	1 ADC 13 ch	2 ch	2	2	2	1	1	Y	1	1	Y	PT, ML
dsPIC33FJ128GP204	44	35	128	8	8	5	4	4	1	1 ADC 13 ch		2	2	2	1	1	Y	1	–	Y	PT, ML
dsPIC33FJ128GP804	44	35	128	16	8	5	4	4	1	1 ADC 13 ch	2 ch	2	2	2	1	1	Y	1	1	Y	PT, ML
dsPIC33FJ64GP206A	64	53	64	8	8	9	8	8	1	1 ADC, 18 ch	–	–	2	2	1	–	N	–	–	Y	PT, MR
dsPIC33FJ64GP306A	64	53	64	16	8	9	8	8	1	1 ADC, 18 ch	–	–	2	2	2	–	N	–	–	Y	PT, MR
dsPIC33FJ64GP706A	64	53	64	16	8	9	8	8	1	2 ADC, 18 ch	–	–	2	2	2	–	N	–	2	Y	PT, MR
dsPIC33FJ128GP206A	64	53	128	8	8	9	8	8	1	1 ADC, 18 ch	–	–	2	2	1	–	N	–	–	Y	PT, MR
dsPIC33FJ128GP306A	64	53	128	16	8	9	8	8	1	1 ADC, 18 ch	–	–	2	2	2	–	N	–	–	Y	PT, MR
dsPIC33FJ128GP706A	64	53	128	16	8	9	8	8	1	2 ADC, 18 ch	–	–	2	2	2	–	N	–	2	Y	PT, MR
dsPIC33FJ256GP506A	64	53	256	16	8	9	8	8	1	1 ADC, 18 ch	–	–	2	2	2	–	N	–	1	Y	PT
dsPIC33FJ64GP708A	80	69	64	16	8	9	8	8	1	2 ADC, 24 ch	–	–	2	2	2	–	N	–	2	Y	PT
dsPIC33FJ128GP708A	80	69	128	16	8	9	8	8	1	2 ADC, 24 ch	–	–	2	2	2	–	N	–	2	Y	PT
dsPIC33FJ64GP310A	100	85	64	16	8	9	8	8	1	1 ADC, 32 ch	–	–	2	2	2	–	N	–	–	Y	PT, PF
dsPIC33FJ64GP710A	100	85	64	16	8	9	8	8	1	2 ADC, 32 ch	–	–	2	2	2	–	N	–	2	Y	PT, PF
dsPIC33FJ128GP310A	100	85	128	16	8	9	8	8	1	1 ADC, 32 ch	–	–	2	2	2	–	N	–	–	Y	PT, PF
dsPIC33FJ128GP710A	100	85	128	16	8	9	8	8	1	2 ADC, 32 ch	–	–	2	2	2	–	N	–	2	Y	PT, PF
dsPIC33FJ256GP510A	100	85	256	16	8	9	8	8	1	1 ADC, 32 ch	–	–	2	2	2	–	N	–	1	Y	PT, PF
dsPIC33FJ256GP710A	100	85	256	30	8	9	8	8	1	2 ADC, 32 ch	–	–	2	2	2	–	N	–	2	Y	PT, PF

†dsPIC33 devices feature one or two user-selectable 1.1 Msps 10-bit ADC (4 Sample and Hold) or 500 ksps 12-bit ADC (1 Sample and Hold)
*Parts available with High Temperature options.

dsPIC33F DSC Product Family

Motor Control and Power Conversion Family

Microchip's 16-bit dsPIC33F motor control family of Digital Signal Controllers (DSCs) provide high performance 16-bit MCUs with integrated DSP and on-chip peripherals. These DSCs enable the design of high-performance, precision motor control systems that are more energy efficient, quieter in operation, have greater range and an extended life. These motor control DSCs can be used to control brushless DC, permanent magnet synchronous, AC induction and stepper motors. These devices are also ideal for switched mode power supplies and power factor correction applications.

Product	Pins	I/O Pins	Flash KB	RAM KB	DMA # Ch	Timer 16-bit	Input Capture	Output Compare/ Standard PWM	MC PWM	QEI	ADC 10-/12-bit† 1.1/0.5 Msps	16-bit Audio DAC	Analog Comparators	UART	SPI	I²C™	PMP	PPS	RTCC	CAN	JTAG	Package Code
dsPIC33FJ12MC201	20	15	12	1	–	3	4	2	4+2 ch	1	1 ADC, 4 ch	–	–	1	1	1	–	Y	–	–	N	SO, P, SS
dsPIC33FJ12MC202	28	21	12	1	–	3	4	2	6+2 ch	1	1 ADC, 6 ch	–	–	1	1	1	–	Y	–	–	Y	SO, SP, ML, SS
dsPIC33FJ32MC202*	28	21	32	2	–	3	4	2	6+2 ch	1	1 ADC, 6 ch	–	–	1	1	1	–	Y	–	–	Y	SO, SP, MM
dsPIC33FJ32MC302	28	21	32	4	8	5	4	4	6+2 ch	2	1 ADC 6 ch	–	2	2	2	1	1	Y	1	–	Y	SO, SP, MM
dsPIC33FJ64MC202	28	21	64	8	8	5	4	4	6+2 ch	2	1 ADC 6 ch	–	2	2	2	1	1	Y	1	–	Y	SO, SP, MM
dsPIC33FJ64MC802*	28	21	64	16	8	5	4	4	6+2 ch	2	1 ADC 6 ch	–	2	2	2	1	1	Y	1	1	Y	SO, SP, MM
dsPIC33FJ128MC202	28	21	128	8	8	5	4	4	6+2 ch	2	1 ADC 6 ch	–	2	2	2	1	1	Y	1	–	Y	SO, SP, MM
dsPIC33FJ128MC802*	28	21	128	16	8	5	4	4	6+2 ch	2	1 ADC 6 ch	–	2	2	2	1	1	Y	1	1	Y	SO, SP, MM
dsPIC33FJ16MC304*	44	35	16	2	–	3	4	2	6+2 ch	1	1 ADC, 9 ch	–	–	1	1	1	–	Y	–	–	Y	PT,ML
dsPIC33FJ32MC204*	44	35	32	2	–	3	4	2	6+2 ch	1	1 ADC, 9 ch	–	–	1	1	1	–	Y	–	–	Y	PT,ML
dsPIC33FJ32MC304	44	35	32	4	8	5	4	4	6+2 ch	2	1 ADC 9 ch	–	2	2	2	1	1	Y	1	–	Y	PT, ML
dsPIC33FJ64MC204	44	35	64	8	8	5	4	4	6+2 ch	2	1 ADC 9 ch	–	2	2	2	1	1	Y	1	–	Y	PT, ML
dsPIC33FJ64MC804*	44	35	64	16	8	5	4	4	6+2 ch	2	1 ADC 9 ch	2 ch	2	2	2	1	1	Y	1	1	Y	PT, ML
dsPIC33FJ128MC204	44	35	128	8	8	5	4	4	6+2 ch	2	1 ADC 9 ch	–	2	2	2	1	1	Y	1	–	Y	PT, ML
dsPIC33FJ128MC804*	44	35	128	16	8	5	4	4	8 ch	2	1 ADC 9 ch	2 ch	2	2	2	1	1	Y	1	1	Y	PT, ML
dsPIC33FJ64MC506A	64	53	64	8	8	9	8	8	8 ch	1	1 ADC, 16 ch	–	–	2	2	2	–	N	–	1	Y	PT, MR
dsPIC33FJ64MC706A	64	53	64	16	8	9	8	8	8 ch	1	2 ADC, 16 ch	–	–	2	2	2	–	N	–	1	Y	PT, MR
dsPIC33FJ128MC506A*	64	53	128	8	8	9	8	8	8 ch	1	1 ADC, 16 ch	–	–	2	2	2	–	N	–	1	Y	PT, MR
dsPIC33FJ128MC706A*	64	53	128	16	8	9	8	8	8 ch	1	2 ADC, 16 ch	–	–	2	2	2	–	N	–	1	Y	PT, MR
dsPIC33FJ64MC508A	80	69	64	8	8	9	8	8	8 ch	1	1 ADC, 18 ch	–	–	2	2	2	–	N	–	1	Y	PT
dsPIC33FJ128MC708A	80	69	128	16	8	9	8	8	8 ch	1	2 ADC, 18 ch	–	–	2	2	2	–	N	–	2	Y	PT
dsPIC33FJ64MC510A	100	85	64	8	8	9	8	8	8 ch	1	1 ADC, 24 ch	–	–	2	2	2	–	N	–	1	Y	PT, PF
dsPIC33FJ64MC710A	100	85	64	16	8	9	8	8	8 ch	1	2 ADC, 24 ch	–	–	2	2	2	–	N	–	2	Y	PT, PF
dsPIC33FJ128MC510A	100	85	128	8	8	9	8	8	8 ch	1	1 ADC, 24 ch	–	–	2	2	2	–	N	–	1	Y	PT, PF
dsPIC33FJ128MC710A*	100	85	128	16	8	9	8	8	8 ch	1	2 ADC, 24 ch	–	–	2	2	2	–	N	–	2	Y	PT, PF
dsPIC33FJ256MC510A	100	85	256	16	8	9	8	8	8 ch	1	1 ADC, 24 ch	–	–	2	2	2	–	N	–	1	Y	PT, PF
dsPIC33FJ256MC710A	100	85	256	30	8	9	8	8	8 ch	1	2 ADC, 24 ch	–	–	2	2	2	–	N	–	2	Y	PT, PF

†dsPIC33 devices feature one or two user-selectable 1.1 Msps 10-bit ADC (4 Sample and Hold) or 500 ksps 12-bit ADC (1 Sample and Hold)
*Parts available with High Temperature options.

dsPIC33E DSC Product Family

60 MIPS Motor Control and General Purpose Family

Microchip's dsPIC33E motor control family of digital signal controllers (DSCs) features a 60 MIPS dsPIC DSC core with integrated DSP and enhanced on-chip peripherals. These DSCs enable the design of high-performance, precision motor control systems that are more energy efficient, quieter in operation, have a great range and extended life. They can be used to control brushless DC, permanent magnet synchronous, AC induction and stepper motors. These devices are also ideal for high-performance general purpose applications.

Product	Pins	I/O Pins	Flash KB	RAM KB	DMA # Ch	Timer 16-bit	Input Capture	Output Compare/ Standard PWM	MC PWM	QEI	ADC 10-/12-bit† 1.1/0.5 Msps	Analog Comparators	USB OTG	UART	SPI	I²C™	PMP	PPS	RTCC	ECAN	JTAG	Pkg Code
dsPIC33EP256MU806	64	51	280	28	15	9	16	16	8 ch	2	2 ADC, 24 ch	3	1	4	4	2	Y	Y	1	2	Y	MR, PT
dsPIC33EP256MU810	100	83	280	28	15	9	16	16	12 ch	2	2 ADC, 32 ch	3	1	4	4	2	Y	Y	1	2	Y	PF, PT, BG
dsPIC33EP256MU814	144	122	280	28	15	9	16	16	14 ch	2	2 ADC, 32 ch	3	1	4	4	2	Y	Y	1	2	Y	PL, PH
dsPIC33EP512MU810	100	83	536	52	15	9	16	16	12 ch	2	2 ADC, 32 ch	3	1	4	4	2	Y	Y	1	2	Y	PF, PT, BG
dsPIC33EP512MU814	144	122	536	52	15	9	16	16	14 ch	2	2 ADC, 32 ch	3	1	4	4	2	Y	Y	1	2	Y	PL, PH

†Flash size is inclusive of 24 Kbytes of auxiliary Flash
*RAM size is inclusive of 4 Kbytes of DMA RAM.

dsPIC33F DSC Product Family

SMPS and Digital Power Conversion Family

Implementing high speed precision digital control loops for power conversion applications requires a high-performance DSP engine along with specialized Switch Mode Power Supplies (SMPS) peripherals. Microchip's 16-bit dsPIC33F SMPS DSCs provide on-chip peripherals specifically designed for high-performance, digital power supplies. SMPS peripherals include high speed PWM, ADC and analog comparators. The dsPIC33F SMPS family supports applications such as, induction cooking, UPS, inverter, intelligent battery chargers, power factor correction, HID lighting, fluorescent lighting, LED lighting, AD-DC and DC-DC conversion and motor control applications.

Product	Pins	I/O Pins	Flash KB	RAM Bytes	Timer 16-bit	DMA # Ch	Input Capture	Output Compare/ Standard PWM	PS PWM	QEI	ADC 10-bit 2/4 Msps	10-bit DAC o/p	Analog Comparators	UART	SPI	I²C™	ECAN	JTAG	Package Code
dsPIC33FJ06GS101	18	13	6	256	2	–	–	1	4		1 ADC, 6 ch, 3 S&H	–	–	1	1	1	–	N	SO
dsPIC33FJ06GS102	28	21	6	256	2	–	–	1	4		1 ADC, 6 ch, 3 S&H	–	–	1	1	1	–	Y	SO, MM, SP
dsPIC33FJ06GS202	28	21	6	1K	2	–	1	1	4		1 ADC, 6 ch, 3 S&H	1	2	1	1	1	–	Y	SO, MM, SP
dsPIC33FJ16GS402	28	21	16	2K	3	–	2	2	6		1 ADC, 8 ch, 4 S&H	–	–	1	1	1	–	Y	SO, MM, SP
dsPIC33FJ16GS502	28	21	16	2K	3	–	2	2	8		2 ADC, 8 ch, 6 S&H*	1	4	1	1	1	–	Y	SO, MM, SP
dsPIC33FJ16GS404	44	35	16	2K	3	–	2	2	6		1 ADC, 8 ch, 4 S&H	–	–	1	1	1	–	Y	ML, PT
dsPIC33FJ16GS504	44	35	16	2K	3	–	2	2	8		2 ADC, 12 ch, 6 S&H*	1	4	1	1	1	–	Y	ML, PT
dsPIC33FJ32GS406	64	53	32	4K	4	–	4	4	12	1	1 ADC, 16 Ch, 5 S&H	–	–	2	2	2	–	Y	PT,MR
dsPIC33FJ32GS606	64	53	32	4K	4	–	4	4	12	2	2 ADC,16 Ch, 6 S&H*	1	4	2	2	2	–	Y	PT,MR
dsPIC33FJ64GS406	64	53	64	8K	4	–	4	4	12	1	1 ADC, 16 Ch, 5 S&H	–	–	2	2	2	–	Y	PT,MR
dsPIC33FJ64GS606	64	53	64	9K	4	4	4	4	12	2	2 ADC, 16 Ch, 6 S&H*	1	4	2	2	2	1	Y	PT,MR
dsPIC33FJ32GS608	80	69	32	4K	4	–	4	4	16	2	2 ADC, 18 Ch, 6 S&H*	1	4	2	2	2	–	Y	PT
dsPIC33FJ64GS608	80	69	64	9K	4	4	4	4	16	2	2 ADC, 18 Ch, 6 S&H*	1	4	2	2	2	1	Y	PT
dsPIC33FJ32GS610	100	85	32	4K	4	–	4	4	18	2	2 ADC, 24 Ch, 6 S&H*	1	4	2	2	2	–	Y	PT, PF
dsPIC33FJ64GS610	100	85	64	9K	4	4	4	4	18	2	2 ADC, 24 Ch, 6 S&H*	1	4	2	2	2	1	Y	PT, PF

*4 Msps devices.

16-bit Packages

P: 40-pin PDIP
(52.27x15.24x3.81 mm)
(Lead Pitch: 2.54 mm)

PL: 144-pin LQFP
(20x20x1.4 mm)
(Lead Pitch: 0.5 mm)

PF: 80-pin TQFP
(14x14x1 mm)
(Lead Pitch: 0.65 mm)

PT: 44-pin TQFP
(10x10x1 mm)
(Lead Pitch: 0.8 mm)

SS: 28-pin SSOP
(10.2x7.8x2 mm)

MQ: 28-pin QFN
(5x5x0.9 mm)
(Lead Pitch: 0.5 mm)

SP: 28-pin SPDIP
(34.67x7.87x3.3 mm)
(Lead Pitch: 2.54 mm)

PH: 144-pin TQFP
(16x16x1 mm)
(Lead Pitch: 0.4 mm)

PT: 80-pin TQFP
(12x12x1 mm)
(Lead Pitch: 0.5 mm)

SO: 28-pin SOIC
(17.88x10.34x2.31 mm)

SS: 20-pin SSOP
(7.2x7.85x1.85 mm)

MM & ML: 28-pin QFN
(6x6x0.9 mm)
(Lead Pitch: 0.65 mm)

P: 20-pin PDIP
(26.24x7.87x3.3 mm)
(Lead Pitch: 2.54 mm)

PF: 100-pin TQFP
(14x14x1 mm)
(Lead Pitch: 0.5 mm)

PF: 64-pin TQFP
(14x14x1 mm)
(Lead Pitch: 0.8 mm)

SO: 20-pin SOIC
(12.80x10.34x2.31 mm)

ST: 14-pin TSSOP
(5.0x6.4x1.2 mm)

ML: 44-pin QFN
(8x8x0.65 mm)
(Lead Pitch: 0.65 mm)

P: 18-pin PDIP
(22.81x7.95x3.3 mm)
(Lead Pitch: 2.54 mm)

PT: 100-pin TQFP
(12x12x1 mm)
(Lead Pitch: 0.4 mm)

PT: 64-pin TQFP
(10x10x1 mm)
(Lead Pitch: 0.5 mm)

SO: 18-pin SOIC
(11.53x10.34x2.31 mm)

MR: 64-pin QFN
(9x9x0.9 mm)
(Lead Pitch: 0.5 mm)

BG: 121-pin BGA
(10x10x1.2 mm)
(Lead Pitch: 0.8 mm)

dsPIC30F DSC Product Family

General Purpose Family

The 30 MIPS dsPIC30F family is developed for applications that benefit from a wide operating voltage (2.5 to 5.5V), extremely low standby current, integrated EEPROM and for those that prefer 5V operation due to system considerations. The variants with Codec interfaces are well suited for speech and audio applications.

Product	Pins	Flash Memory Kbytes	RAM Bytes	EEPROM Bytes	Timer 16-bit	Input Capture	Output Compare/ Standard PWM	Codec Interface	ADC 12-bit 200 ksps	Flash Security Segments	UART	SPI	I²C™	CAN	Package Code
dsPIC30F3014	40/44	24	2048	1024	3	2	2	–	13 ch, 1 S/H	1	2	1	1	–	P, , PT, ML
dsPIC30F4013	40/44	48	2048	1024	5	4	4	AC97, I²S	13 ch, 1 S/H	3	2	1	1	1	P, PT, ML
dsPIC30F5011	64	66	4096	1024	5	8	8	AC97, I²S	16 ch, 1 S/H	3	2	2	1	2	PT
dsPIC30F6011A	64	132	6144	2048	5	8	8	–	16 ch, 1 S/H	3	2	2	1	2	PF, PT
dsPIC30F6012A	64	144	8192	4096	5	8	8	AC97, I²S	16 ch, 1 S/H	3	2	2	1	2	PF, PT
dsPIC30F5013	80	66	4096	1024	5	8	8	AC97, I²S	16 ch, 1 S/H	3	2	2	1	2	PT
dsPIC30F6013A	80	132	6144	2048	5	8	8	–	16 ch, 1 S/H	3	2	2	1	2	PF, PT
dsPIC30F6014A	80	144	8192	4096	5	8	8	AC97, I²S	16 ch, 1 S/H	3	2	2	1	2	PF, PT

Sensor Family

The dsPIC30F Sensor family products have features designed to support high-performance, cost-sensitive and space-constrained applications. Offered in packages as small as 6x6 mm and with pin counts as low as 18 pins.

Product	Pins	Flash Memory Kbytes	RAM Bytes	EEPROM Bytes	Timer 16-bit	Input Capture	Output Compare/ Standard PWM	ADC 12-bit 200 ksps	UART	SPI	I²C™	I/O Pins (Max.)	Package Code
dsPIC30F2011	18	12	1024	–	3	2	2	8 ch, 1 S/H	1	1	1	12	P, SO, 28-pin ML
dsPIC30F3012	18/44	24	2048	1024	3	2	2	8 ch, 1 S/H	1	1	1	12	P, SO, 44-pin ML
dsPIC30F2012	28	12	1024	–	3	2	2	10 ch, 1 S/H	1	1	1	20	SP, SO, 28-pin ML
dsPIC30F3013	28/44	24	2048	1024	3	2	2	10 ch, 1 S/H	2	1	1	20	SP, SO, 44-pin ML

Motor Control and Power Conversion Family

This dsPIC30F family supports motor control applications, such as brushless DC, single- and 3-phase induction and switched reluctance motors. These are also ideal for UPS, inverter and power factor correction applications.

Product	Pins	Flash Memory Kbytes	RAM Bytes	EEPROM Bytes	Timer 16-bit	Input Capture	Output Compare/ Standard PWM	Motor Control PWM	QEI	ADC 10-bit 1 Msps	Flash Security Segments	UART	SPI	I²C™	CAN	Package Code
dsPIC30F2010	28	12	512	1024	3	4	2	6 ch	Y	6 ch, 4 S/H	1	1	1	1	–	SP, SO, MM
dsPIC30F3010	28/44	24	1024	1024	5	4	2	6 ch	Y	6 ch, 4 S/H	1	1	1	1	–	SP, SO, 44-pin ML
dsPIC30F4012	28/44	48	2048	1024	5	4	2	6 ch	Y	6 ch, 4 S/H	1	1	1	1	1	SP, SO, 44-pin ML
dsPIC30F3011	40/44	24	1024	1024	5	4	4	6 ch	Y	9 ch, 4 S/H	1	2	1	1	–	P, PT, ML
dsPIC30F4011	40/44	48	1024	1024	5	4	4	6 ch	Y	9 ch, 4 S/H	1	2	1	1	1	P, PT, ML
dsPIC30F5015	64	66	2048	1024	5	4	4	8 ch	Y	16 ch, 4 S/H	1	1	2	1	1	PT
dsPIC30F6015	64	144	8192	4096	5	8	8	8 ch	Y	16 ch, 4 S/H	3	2	2	1	1	PT
dsPIC30F5016	80	66	2048	1024	5	4	4	8 ch	Y	16 ch, 4 S/H	1	1	2	1	1	PT
dsPIC30F6010A	80	144	8192	4096	5	8	8	8 ch	Y	16 ch, 4 S/H	3	2	2	1	2	PF, PT

Terms and Definitions

ADC	Analog-to-Digital Converter	PMP	Parallel Master Port
DAC	Digital-to-Analog Converter	PPS	Peripheral Pin Select
DMA	Direct Memory Access	PWM	Pulse Width Modulator
ECAN	Enhanced Controller Area Network	QEI	Quadrature Encoder Interface
I2C™	Inter-Integrated Circuit	SPI	Serial Peripheral Interface
JTAG	Joint Test Action Group	UART	Universal Asynchronous Receiver Transmitter

World Class Development Tools

MPLAB® Integrated Development Environment (IDE)

Microchip's 16-bit controllers are supported by MPLAB Integrated Development Environment. MPLAB IDE is a FREE development environment that is common to all Microchip 8-, 16- and 32-bit products, making it possible to use across many of your designs. When combined with Microchip's PICkit™ 3 In-Circuit Debugger, you can get started with a complete development tool chain for as little as $44.95.

All of Microchip's MCU and DSC tools operate cohesively under the MPLAB IDE umbrella. The powerful and easy-to-use MPLAB IDE has all of the advanced edit/build/debug features you would expect from a 32-bit debug environment. MPLAB IDE integrates not only software, but all of Microchip's hardware tools and many third party tools. Key features of MPLAB IDE incvlude:

- Project build and management
- Flexible watch windows
- Mouse over variable inspection
- MATLAB Device Blocks for MPLAB IDE (for dsPIC30 and dsPIC33 DSCs)
- Full feature code editor with color context
- Source level debug in ASM and C
- Searchable trace buffers
- Version control integration
- Real-time data monitoring

Available for MPLAB IDE

Assembler/Linker/Librarian

The MPLAB ASM30 is a full-featured macro assembler. User defined macros, conditional assembly and a variety of assembler directives make the MPLAB ASM30 a powerful code generation tool.

MPLAB SIM Software Simulator

The MPLAB 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.

MATLAB/Simulink Device Blocks for dsPIC DSCs

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 IDE.

Powerful Project Manager handles multiple projects and all file types

Color-keyed editor makes source code debug easier

Status bar updates on single step or run

Set break/trace points with a click of the mouse

Simply move your mouse over a variable to view or modify

Fully customizable watch windows to view and modify registers and memory locations

World Class Development Tools

MPLAB® X IDE

MPLAB X IDE is the new Integrated Development Environment (IDE) from Microchip. It brings many changes to the PIC® microcontroller development tool chain. Unlike previous versions of MPLAB which were developed completely in-house, MPLAB X is based on the open source NetBeans IDE from Oracle. This facilitates to add many frequently requested features very quickly and easily while also providing a much more extensible architecture to bring even more new features in the future. Equipped with a powerful and functional set of features, this new IDE is the next generation foundation of integrated toolset for the development of embedded applications using Microchip's PIC microcontrollers and dsPIC® digital signal controllers.

Integrated Tool Set
- Single, unified graphical interface for Microchip and third-party tools
- Seamless interface for MPLAB development tools
- Easy migration between tools from software simulators to hardware debugging and programming tools

Open-Source Platform
- Based on the NetBeans Platform
- Free software components and plug-ins

Powerful Yet User-Friendly
- Flexible and customizable interface
- Feature-rich editor
- Project-based workspace

Cross-Platform Support
- Windows®
- Mac OS X
- Linux
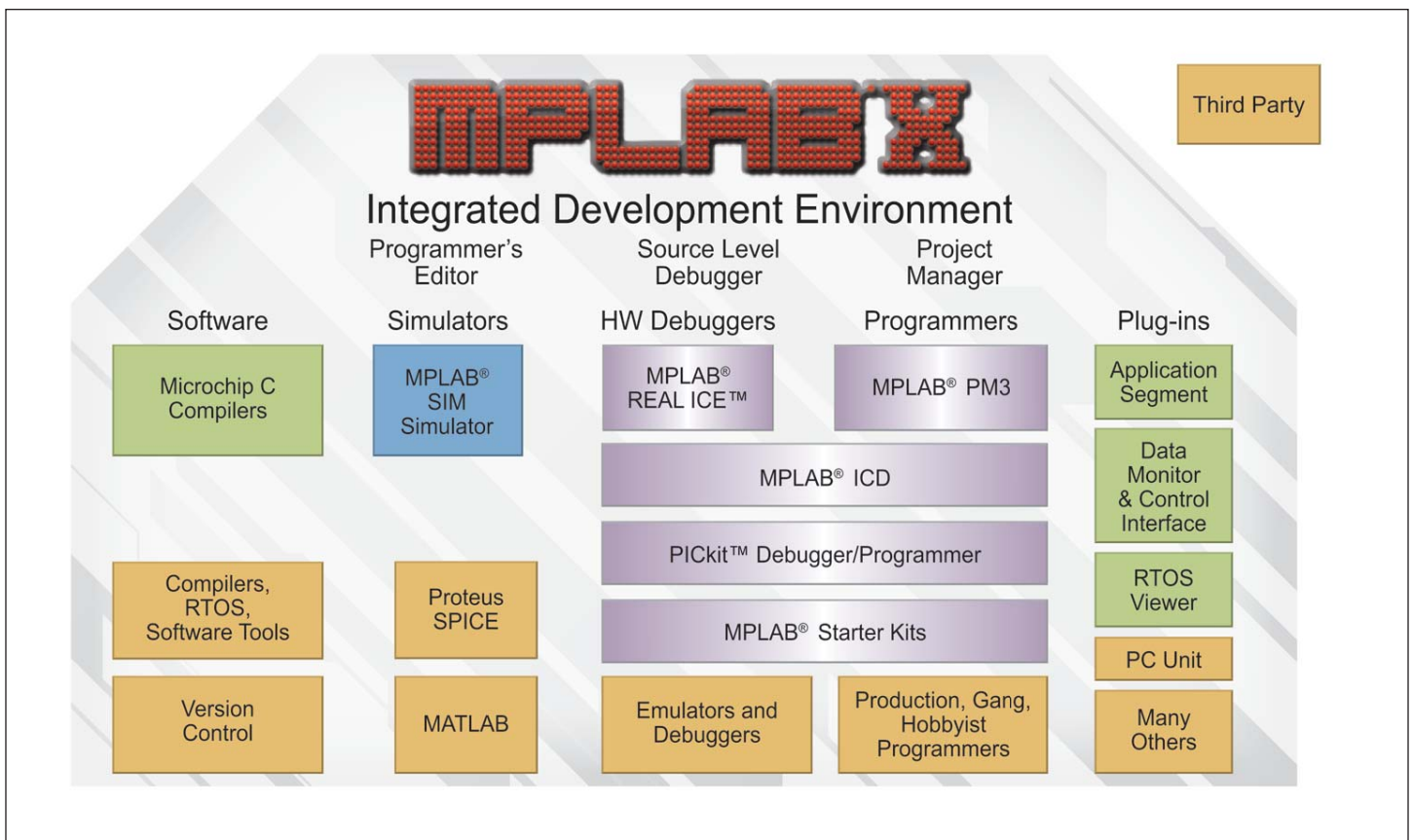
World Class Development Tools

Popular C Compilers

MPLAB® C Compilers

Microchip's MPLAB C compilers are full-featured, ANSI compliant high-performance tools tightly integrated with MPLAB IDE. Source level debugging allows single stepping through C source code and inspecting variables and structures at critical points in the code. Integration with MPLAB IDE means there is a single, consistent environment to write code and to debug with the free MPLAB SIM simulator or with MPLAB in-circuit debuggers and emulators.

Code can be programmed into the target using the hardware debuggers or with Microchip's device programmers. Compiler switches and linker customizations are done within MPLAB IDE to provide a full graphical front end to these powerful compilers. Editing errors and breakpoints instantly switch to the corresponding lines in source code. Watch windows show data structures with defined data types, including floating point.

MPLAB C Compiler for PIC24 MCUs and dsPIC® DSCs

The MPLAB C Compiler for PIC24 MCUs and dsPIC DSCs includes a complete ANSI C standard library, including string manipulation, dynamic memory allocation, data conversion, timekeeping and math libraries. The MPLAB C Compiler has a powerful code optimizer; other 16-bit MCUs generate as much as 165 percent larger code for the same application.

Math Libraries

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® 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.

Library	Features
FREE **Peripheral Driver Library**	This library provides over 300 C utility functions.

FREE **Math Libraries: Standard, Floating-Point & Fixed-Point**	■ ANSI C standard math functions
	■ IEEE-754 compliant floating point math
	  Support for both single and double-precision
	■ I/Q math for fixed point numbers
	  Support for both 1.15 and 16.16 formats

FREE **DSP Algorithm Library**	This extensive DSP building block library is fully optimized in assembly code for execution speed.

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

www.microchip.com/compilers

General Purpose Development and Evaluation Tools

PICkit™ 3 In-Circuit Debugger (PG164130)

The MPLAB® PICkit 3 allows debugging and programming of PIC® and dsPIC® Flash microcontrollers at a most affordable price point using the powerful graphical user interface of the MPLAB Integrated Development Environment (IDE).

MPLAB ICD 3 In-Circuit Debugger/Programmer (DV164035)

The MPLAB ICD 3 In-Circuit Debugger/Programmer is a powerful, low-cost development tool. Running under MPLAB IDE, MPLAB ICD 3 can debug ASM or C source code, watch and modify variables, single step and set breakpoints.

MPLAB REAL ICE™ In-Circuit Emulation System (DV244005)

The MPLAB REAL ICE In-Circuit Emulator is Microchip's next-generation emulation and debugging system. This system provides a powerful in-circuit emulation platform for easy and rapid application development and debugging. The emulation is performed using special hardware logic on the target device itself, eliminating the need for a separate emulator device.

MPLAB PM3 Device Programmer (DV007004)

MPLAB PM3 Device Programmer is a full-featured, production quality universal device programmer. Using interchangeable socket modules, the MPLAB PM3 supports virtually all programmable devices from Microchip. MPLAB PM3 has improved programming time for many devices and offers a built-in interface for robust ICSP™.

MPLAB 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® IDE and the MPLAB C Compiler for PIC24 MCUs or dsPIC DSCs (Evaluation Edition), the starter kit allows designers to gain quick knowledge and experience with 16-bit MCU and DSC products.

MPLAB Starter Kit for dsPIC Digital Signal Controllers (DM330011)

The MPLAB starter kit for dsPIC Digital Signal Controllers is an excellent low cost platform to evaluate or learn about the dsPIC architecture. It is equipped with the hardware and software necessary to code and debug simple applications and also demonstrates the audio capability of the dsPIC DSC.

MPLAB Starter Kit for PIC24H MCUs (DM240021)

This starter kit is a complete hardware and software kit for exploring the power of PIC24H family of MCUs. The on-board PIC24HJ128GP504 controller is equipped with necessary software to demonstrate accelerometer based sample program with visual display and speech playback.

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 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 Digital Signal Controllers or High-Performance Microcontrollers (MCUs). It comes with a preloaded demo software for the user to explore the new features of the dsPIC33E DSC family or the PIC24E MCU family.

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. 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.

dsPICDEM™ 80-pin Starter Development Board (DM300019)
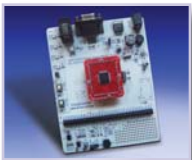
This development board offers an economical way to evaluate the 80-pin dsPIC30F General Purpose and Motor Control families as well as the dsPIC33F devices.

16-bit 28-pin Starter Development Board (DM300027)

This low cost development board provides an easy way to get started with any of Microchip's 28-pin 16-bit MCU or DSC devices.

dsPICDEM 1.1 Plus General Purpose Development Board (DM300024)

This board provides development support for general purpose, speech and audio-related applications.

dsPICDEM 2 Development Board (DM300018)

This development board provides a cost effective way to start designing solutions for all 18-, 28- and 40-pin DIP-packaged dsPIC30F DSC devices.

nanoWatt XLP 16-bit Development Board (DM240311)

The nanoWatt XLP development board provides a platform for eXtreme low power applications.

Microstick for dsPIC33F and PIC24H Development Board (DM330013)

The Microstick for dsPIC33F and PIC24H devices is designed to provide designers with an easy to use, economical development environment for 16-bit digital signal controllers and microcontrollers.

PIC24H mTouch™ Capacitive Touch Evaluation Board (AC243026)

This evaluation board is designed to facilitate the development of capacitive touch-based applications using PIC24H-series microcontrollers. This board is intended to supplement the motherboard portfolio already included in the mTouch Capacitive Touch Evaluation Kit (DM183026-2).

PIC24FJ256DA210 Development Kit (DV164039)

This low cost development kit is an efficient means to evaluate the features and performance of the PIC24FJ256DA210 with integrated graphics, mTouch™ and USB. This kit is an ideal platform for new graphical human interface developers. It bundles the PIC24FJ256DA210 Development Board (DM240312), a 3.2″ Truly 240x320 TFT Display Board (AC164127-4), three Graphics Display Prototype Boards (AC164139), the MPLAB ICD 3 Debugger with USB Cable (DV164035) and accessories. For those interested in purchasing the kit components, each item can also be purchased separately.

Enhanced mTouch Capacitive Touch Evaluation Kit (DM183026-2)

This evaluation kit provides a simple platform for developing a variety of capacitive touch sense applications using PIC16F, PIC18F, PIC24F and PIC32 microcontrollers. The diagnostic tool provided allows the user to analyze application-critical information in real-time as it relates to touch sensor behavior.

Explorer 16 and PICtail™ Plus Daughter Board System

Explorer 16 Development Board (DM240001/DM240002)

This development board offers an economical way to evaluate Microchip's 16- and 32-bit MCUs, and dsPIC33F DSC families. The combination of versatility and expandability and supporting PICtail™ Plus daughter cards allows designer's to evaluate complex software libraries and hardware with minimal time and effort. Features include:

- Processor PIMs (Plug-In Modules)
  - DM240001: two interchangeable PIMs, one each for the PIC24FJ128GA010 and the dsPIC33FJ256GP710 DSC
  - DM240002: features a PIM for the PIC24FJ64GA004 and dsPIC33FJ32GP204

- Alpha-numeric 16 x 2 LCD display
- Interfaces to MPLAB® ICD 3 In-Circuit Debugger, REAL ICE™ In-Circuit Emulator and RS-232
- Includes Microchip's TC1047A high accuracy, analog output temperature sensor
- Full documentation CD includes user's guide, schematics and PCB layout
- Expansion connector to access full devices pin-out and bread board prototyping area
- PICtail Plus connector for expansion boards

PICtail Plus Daughter Boards

- Allows for the easy addition of complex hardware
- Allows for the easy evaluation of software libraries
- Provides expansion for application specific hardware

Description	Part Number	List Price[1]	Devices Supported		
			PIC24F	PIC24H	dsPIC33F
Consumer-band BPSK 7.2 kbps PLM PICtail™ Plus Daughter Board	AC164142	$249.99	–	–	✓
Wireless PICtail Plus Daughter Board – 2.4 GHz daughter card with the Microchip MRF24J40 transceiver	AC163027	$39.99	✓	✓	✓
ECAN/LIN PICtail Plus Daughter Board – Two ECAN MCP2551 transceivers – Two LIN MCP2021-330 transceivers	AC163130	$45.00	–	✓	✓
PICtail Plus Daughter Board for SD/MMC – SPI to SD/MMC interface	AC164122	$37.99	✓	✓	✓
Ethernet PICtail Plus Daughter Board – Stand Alone ENC24J60 10Base-T Ethernet Controller	AC164123	$39.99	✓	✓	✓
IrDA® PICtail Plus Daughter Board – IrDA transceiver for IrDA enabled UART	AC164124	$25.00	✓	✓	✓
Speech Playback PICtail Plus Daughter Board – Adaptive Differential Pulse Code Modulation (ADPCM) speech playback and recording	AC164125	$45.00	✓	✓	✓
Prototype PICtail Plus Daughter Board – PICtail ™ Plus Expansion Board	AC164126	$20.00	✓	✓	✓
Graphic PICtail Plus Daughter Board – Enables Graphics display via PMP	AC164127-3	$154.99	✓	✓	✓
Audio PICtail Plus Daughter Board – Full Duplex Speech and Audio applications	AC164129	$80.00	–	✓	✓
USB PICtail Plus Daughter Board –USB Device, Host and OTG Expansion	AC164131	$60.00	✓	–	–
Buck/Boost Converter PICtail Plus Daughter Board – Two independent DC/DC synchronous buck converters – Independent DC/DC boost converter	AC164133	$89.99	–	–	✓
Thermal/Linear Intelligent Sensor PICtail Plus Daughter Board – Signal input and conditioning for thermocouples and linear sensors – TC1047/1047A Temperature to Voltage Converter	AC164135	$49.99	–	✓	✓
MCP2515 PICtail Plus Daughter Board – Stand Alone CAN Controller expansion board	MCP2515DM	$40.00	✓	✓	✓
MCP42XX PICtail Plus Daughter Board – MCP42XX Digital Potentiometer expansion board	MCP42XXDM	$20.00	✓	✓	✓
MCP4725 PICtail Plus Daughter Board – 12-bit DAC + non-volatile memory	MCP4725DM	$15.00	✓	✓	✓

Note 1: List price may change without notice.

Advanced Development Boards and Reference Designs for Motor Control Applications

Microchip offers a number of hardware tools to assist in the development of motor control applications. These tools work with Microchip's MPLAB® IDE and an in-circuit debugger to download and debug application software. Our systems make it easy to customize the software from our application notes and demo code to run different motors.

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 includes a stepper motor and a 24-volt power supply. MPLAB ICD 3 In-Circuit Debugger or REAL ICE™ In-Circuit Emulator is required for programming or debugging operations.

dsPICDEM MCLV Development Board (DM330021)

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 dsPIC33 motor control DSCs via a Plug-In Module (PIM) or 28-pin SOIC socket. 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. MPLAB ICD 3 In-Circuit Debugger or REAL ICE In-Circuit Emulator is required for programming or debugging operations.

dsPICDEM MCHV Development System (DM330023)

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 IPM-based system for users to evaluate and develop applications using dsPIC33 motor control DSCs via a Plug-In Module (PIM) or a 28-pin SOIC socket. 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 MPLAB ICD 3) permits a direct connection with a PC.

Motor Control Development Systems for dsPIC30F

PICDEM™ MC LV Motor Control Development Board (DM183021)

The PICDEM MC LV development board is intended for low-voltage (up to 48V at 2 amps), Brushless DC (BLDC) sensored or sensorless applications. It provides a low-cost board for users to evaluate and develop applications using Microchip's 28-pin PIC18FXX31 and dsPIC30F motor control devices. An 18-pin translator board (AC162078) is also available and allows the PIC18F1330 to be installed on the board. Feedback support includes Hall-Effect Sensors and Back EMF voltages. MPLAB ICD 3 In-Circuit Debugger or REAL ICE In-Circuit Emulator is required for programming or debugging operations.

dsPICDEM MC1/MC1L/MC1H (DM300020/DM300022/DM300021)

This modular full-featured system provides a method for users to evaluate and develop applications using dsPIC30F motor control DSCs via a Plug-In-Module (PIM). The MC1 includes a dsPIC30F6010A PIM. The MC1H provides isolated user interfaces for safe operation. MPLAB ICD 3 In-Circuit Debugger or REAL ICE In-Circuit Emulator is required for programming or debugging operations.

DSC Family	Input Voltage	Development Board	Power Module	Motor
dsPIC30F	≤ 48 volts DC, 600W	dsPICDEM MC1 (DM300020)	dsPICDEM MC1L 3-Phase Low Voltage Power Module (DM300022)	AC300020 or AC300022
dsPIC30F	≤ 240 volts AC, 800W	dsPICDEM MC1 (DM300020)	dsPICDEM MC1H 3-Phase High Voltage Power Module (DM300021)	AC300021

Motors

You can provide your own motor or purchase one of the motors used in our application notes and 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
- AC300021 – 208V, 1/3 HP 3-phase AC induction motor

Advanced Development Boards and Reference Designs for Digital Power Applications

AC/DC Reference Design

This design is a completely digitally controlled full-featured 300W (5V/23A and 3.3V/69A) power supply with active PFC. The design offers a universal AC input with active power factor correction followed by two stages of DC/DC power conversion. The first stage converts the high-voltage DC link to a 12V DC bus via a zero voltage transition full-bridge converter incorporating secondary side synchronous rectification. The second stage consists of single-phase and multi-phase buck converters.

Buck/Boost Converter PICtail™ Plus Card (AC164133)

A low-cost development platform for dsPIC33FGS SMPS devices, the buck/boost converter PICtail Plus card has two buck stage outputs and one boost stage output. The buck/boost converter operates from an input supply of +9V to + 15V DC. 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 for dsPIC33FGS SMPS solutions. This board can be used with either the Explorer 16 board or the 16-bit 28-pin starter board and the dsPIC33F SMPS and digital power conversion devices.

Quarter Brick DC/DC Converter Reference Design

This reference design provides an easy method to evaluate the power, 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 from Microchip that provides the full digital control of the power conversion and 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 DSCs from Microchip that provides the 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 interleaved power factor correction methods provide many benefits over older PFC techniques.

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

This reference design is based on the dsPIC33F "GS" series of digital power DSCs. This reference design demonstrates how digital power techniques when applied to UPS applications enable easy modifications through software, 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.

Digital LED Lighting Development Kit

This LED lighting development kit enables designers to quickly leverage the capabilities and performance of the dsPIC33 'GS' DSCs and this reference design 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), which are necessary for a complete product and lower overall system cost.

## Grid Connected Solar Micro Inverter Reference Design

This reference design demonstrates the flexibility and power of SMPS DSCs in grid connected power conversion systems. This reference design works with any PV panel of maximum of 220W having open circuit voltage between 25V to 55V DC. This reference design will ensure maximum power tracking for PV panel voltage between 25V to 45V DC. Two versions of this reference design are available to support 110V and 220V grid.

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

Develop DSP Algorithms and
Debug Application Sofware: The Easy Way

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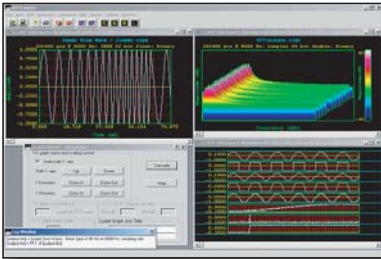
The dsPICworks Data Analysis and DSP Software makes it easy to evaluate and analyze DSP algorithms. You can run a variety of DSP and arithmetic operations and analyze your data in both time and frequency domain.

Key features of the dsPICworks Data Analysis and DSP Software:

- Visually analyze time and frequency domain data
- DSP operations: FFT, convolution, correlation, DCT and filtering
- Waveform synthesis
- Tool generates one-, two- and three-dimensional frequency graphs
- Data import/export options to interface with MPLAB IDE and MPLAB ASM30
- Support for fractional, integer and IEEE floating point data in decimal and hexadecimal notation

Digital Filter Design Tool
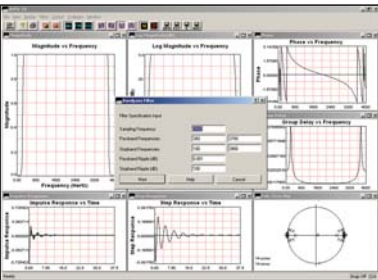
The Digital Filter Design Tool makes designing and analyzing FIR and IIR filters easy. Enter frequency specifications and filter code and coefficients are generated automatically. Graphical output windows provide the desired filter's characteristics.

Digital Filter Design Lite Tool

Not ready to purchase the whole Digital Filter package? Why not start Lite? The Digital Filter Design Lite Tool includes most of the features of the full-featured version at a fraction of the cost.

	Filter Design	Filter Design Lite
List Price	$249	$29
Low-pass	✓	✓
High-pass	✓	✓
Band-pass	✓	✓
Band-stop	✓	✓
FIR Taps	Up to 513	Up to 64
IIR Taps for LP, HP	Up to 10	Up to 4
IIR Taps for BP, BS	Up to 20	Up to 8
Generate ASM Code	✓	✓
Export to MPLAB® IDE	✓	✓
Export to MPLAB® C Compilers	✓	✓
32-bit IIR Filter	✓	–

FREE Data Monitor & Control Interface – A Free MPLAB 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 Project Aware – The current device and software variables are recognized automatically by DMCI
- Compiler Independent
- Debug Tool Independent
- Provides Effortless Graphical Analysis of Application Historical Data

FREE 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.
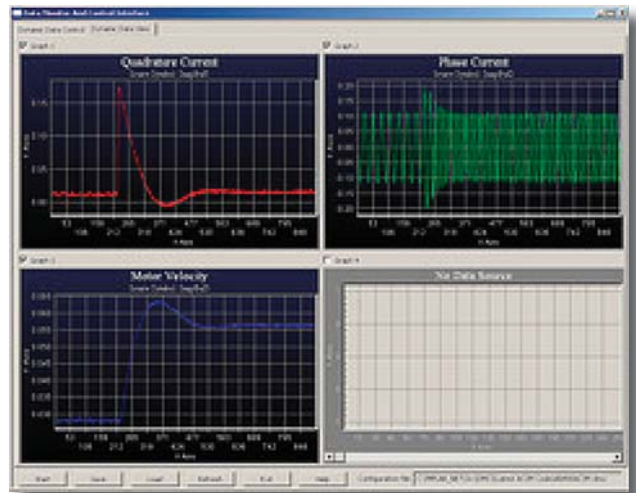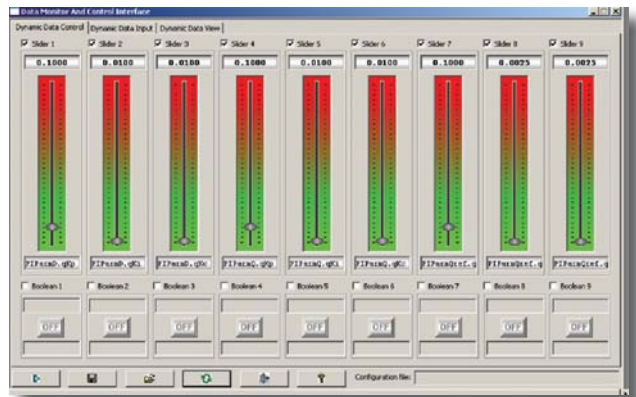
Libraries for Speech and Audio Applications

Speech Encoding/Decoding Libraries

Three options exist for a variety of speech compression/encoding and decompression/decoding applications:

- **FREE** ■ The library is an implementation of the ITU-T G.711 standard which uses A-law or μ-law companding to achieve 2:1 compression.
- **FREE** ■ G.726A is an implementation of the ITU-T G.726 Annex A standard which uses Adaptive Differential Pulse Code Modulation (ADPCM) encoding algorithm. It can achieve up to an 8:1 compression ratio depending on output bit rate selected.
- ■ Speex is a popular standard in the open source software community which has been adapted for the dsPIC DSC. It uses Code Excited Linear Prediction (CELP) algorithm. It can achieve a 26:1 compression ratio.

Vocoder	Incoming Data Rate (16-bit)	Output Rate	Speech Quality (MOS)	MIPS[1]	Flash (KB)	RAM (KB)	Target
G.711	8 kHz	64 kbps	4.3-4.5	1	3	3.6	PIC24/dsPIC DSC
G.726A	8 kHz	16-40 kbps	4.3-4.5	15	6	4	dsPIC DSC
Speex	8/16 kHz	8-12.8 kbps	3.7-4.2	20/24	24/38	7.6/12	dsPIC DSC

Note 1: Includes both encoder and decoder processing in full duplex.

Noise Suppression Library

This application library suppresses the noise interference in a speech signal, such as ambient noise picked up by a microphone while capturing speech. This algorithm is particularly useful for systems such as hands-free phones, speakerphones, intercoms and headsets where an isolated noise reference is not available. The algorithm handles 0-4 kHz audio bandwidth and provides adjustable noise reduction up to 44 dB.
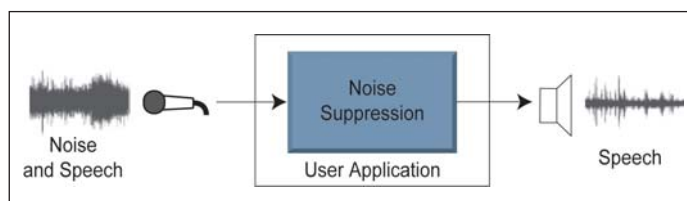
Acoustic Echo Cancellation Library

This library provides a function to eliminate the echo generated in the acoustic path between a speaker and a microphone, such as in a speakerphone or an intercom system. This library is compatible with the G.167 standard and provides 16, 32, 64 or 128 ms echo delays. It handles 0-4 kHz audio bandwidth and provides echo cancellation of 40-50 dB. It also includes some sample rate conversion functions.
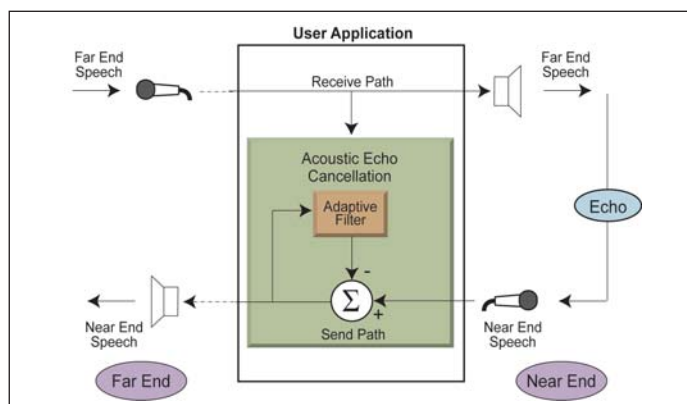
Line Echo Cancellation Library

This library provides a function to cancel electrical line echoes caused by 2- to 4-wire conversion hybrids in telephone lines. The library can be used in long distance voice communication applications, especially in links involving satellite networks and intercontinental long haul networks, as well as digital networks, such as Voice over IP (VoIP). This library is compatible with the ITU-T G.168 recommendation. The library can be used for full-duplex operation. It handles 0-4 kHz audio bandwidth (8 kHz sampling of 16-bit speech data).

FREE Equalizer Library

The Equalizer library allows applications to change the tonal properties of a signal by offering an 8-band frequency band amplitude control. The library processes an 8 kHz sampled signal. The library works readily with the rest of Microchip's dsPIC DSC Speech and Audio Processing Algorithms.

FREE dsPIC® DSC Automatic Gain Control Library

The dsPIC® DSC Automatic Gain Control Library automatically adjusts the amplitude of a speech signal to match a set level. This is useful in speech applications where the distance between the speech source and the microphone is not fixed. The Automatic Gain Control Library can be used readily with Microchip's Speech and Audio Solutions for speech signal pre-processing.

FREE Speech and Audio Fast Forward (SAFF)

The dsPIC DSC Speech and Audio Fast Forward tool provides user's with real-time control of Microchip's Speech and Audio Processing Algorithms as they are running in a embedded system application. This PC GUI tool facilitates code generation and easy tuning of Microchip's Noise Suppression, Acoustic Echo Cancellation, Line Echo Cancellation and Equalizer algorithms in speech and audio applications by simplifying parametric tuning of algorithms.

Connectivity Libraries

USB On-The-Go Library

Microchip's USB support consist of a series of application notes with software that demonstrate and support the development of embedded host, peripheral and On-The-Go functions. Specific driver classes include Human Interface Device (HID) class for user interfaces, and Mass Storage Device (MSD) class for memory devices and a Microchip custom device class driver. USB application demos include thumb drive bootloader, mass storage, USB charger and a printer host. PIC18, PIC24F and PIC32 MCUs are supported by Microchip's USB Framework. All USB application notes are available free of charge at **www.microchip.com/usb**

Microchip's Free TCP/IP Stack Software (ENC28J60 and ENC624J600 Driver)

The Microchip TCP/IP Stack is a free suite of programs that provide services for standard TCP/IP-based applications (HTTP server, FTP server, etc.) or it can be used in a custom TCP/IP-based application. The stack is portable across all PIC18, PIC24, dsPIC30F and dsPIC33F products. It contains support for MPLAB C18, HI-TECH PIC18 and MPLAB C Compiler for PIC24 MCUs and dsPIC DSCs.

ZigBee® PRO Wireless Networking Protocol Stack

ZigBee PRO is a wireless network protocol specifically designed for low data rate sensors and control Networks. There are a number of applications that can benefit from the ZigBee protocol including building automation networks, home security systems, industrial control networks, remote metering and PC peripherals. ZigBee may be the appropriate solution if your product must interact with other vendor's products on a wireless network. Microchip offers a ZigBee PRO Compliant Platform, ZigBee RF4CE compliant Platform, and ZigBee application profiles.

MiWi™ Wireless Networking Protocol Stacks

The MiWi and MiWi P2P Wireless Networking Protocols are simple, easy to use protocols designed for low data rate, short distance,low-cost networks. These protocols operate on both the IEEE 802.15.4and Sub-GHz RF transceivers for Wireless Personal Area Networks (WPANs). The MiWi protocols provide an easy-to-use alternative for wireless communication. In particular, the MiWi protocols target peer-to-peer, star, or mesh networks with few hops between nodes. The MiWi Protocol stacks are applicable with Microchip's MRF24J40 2.4 GHz Transceiver/modules for IEEE 802.15.4 compliant networks and Microchip's Sub-GHz transceivers.

IrDA® Standard Stack for Microchip 16-bit MCUs

The IrDA Standard is a highly popular, inexpensive method for providing wireless point-to-point communication. This free stack coupled with Microchip's 16-bit microcontrollers and DSCs, with their built-in IrDA standard support, provide an inexpensive wireless connection with plenty of computing power left for other tasks.

Libraries, Methods and Modules Ready to Use

Embedded Control Libraries

Encryption Libraries

Implement reliable secure applications using the Symmetric and Asymmetric Key Embedded Encryption Libraries. Developed for Microchip by NTRU Cryptosystems Inc., these libraries are both proven and optimized. Library functions can be easily called by your C or assembly code.

Alternatively, the 256-bit key AES and Triple-DES Libraries developed by Microchip are available for a production license fee of $5.00 from microchipDIRECT.

File System for PIC18, PIC24, PIC32 MCUs and dsPIC® DSCs

Microchip's memory disk drive file system interface library brings the ability to transfer and share portable memory devices between an embedded system and a personal computer. Most SD cards, CF cards and MMCs MultiMedia Cards, particularly those sized below 2 gigabytes (GB), use the FAT16 standard. The FAT32 standard can be used to address memory sized between 2 GB and 2 terabytes (TB). This library with complimentary application note (AN1045) provides a method to read and/or write to these storage devices through a microcontroller. The data of these storage devices can be read by a PC, and the data written by a PC can be read by a microcontroller. Most operating systems (i.e., Windows® XP) support the FAT16 and FAT32 file systems.

Graphics Library for PIC24 & PIC32 MCUs and dsPIC DSCs

The Microchip Graphics Library is highly modular and is optimized for Microchip's 16- and 32-bit microcontrollers. The software package includes: full source code, schematics, drivers, documentation and utilities. Graphics Library supports:

- Up to 480x272 (WQVGA) resolution
- Up to 16-bit or 65K colors
- 2D and 3D Objects
- Image and Animation
- Resistive touch screen and keypad
- Foreign fonts

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. Being a source-code solution further helps engineers quickly integrate touch sensing functionality with their existing application code in a single, standard microcontroller, thus reducing the total system cost associated with current designs.

Methods

Emulating Data EEPROM for PIC18 and PIC24 MCUs, dsPIC DSCs and PIC32

For devices that do not have on-chip EEPROM, emulating EEPROM with on-chip Flash memory my be an important option. This application note presents an interface similar to an internal data EEPROM, but uses available on-chip Flash memory to improve endurance by a factor as high as 500. (Application Note: AN1095)

Achieving Higher ADC Resolution Using Oversampling

This application note describes oversampling as a method to add additional bits of accuracy to the 12-bit ADC conversion in a dsPIC DSC. (Application Note: AN1152)

Bootloader for PIC24 MCUs and dsPIC DSCs

This application note describes a UART-based bootloader for all 16-bit MCU and DSC families. (Application Note: AN1094)

A Serial Bootloader for PIC24F Devices

This application note describes a UART-based bootloader and includes Microchip's PIC24F Quick Programmer (P24QP) Windows-based graphical programming interface. (Application Note: AN1157)

Implementing Digital Lock-In Amplifiers Using the dsPIC® DSC

Conventionally, lock-in amplifiers use complicated (and expensive) analog circuitry to perform the phase sensitive detection and filtering. However, modern Digital Signal Controllers (DSCs), such as the dsPIC30F and dsPIC33F families, can be used to remove large amounts of the analog circuitry by performing the necessary operations in software. This capability provides a number of additional benefits including increased reliability, resistance to temperature and aging effects, and the ease with which the system can be modified in the field. (Application Note: AN1115)

Modules

Cyclic Redundancy Code (CRC) Module

CRC is one of the most versatile error checking algorithm used in various digital communication systems. This application note illustrates how to use the hardware CRC module on selected 16-bit MCUs and DSCs. Users can program any user-defined generator polynomial into this module for CRC computation. (Application Note: AN1148)

MATLAB Device Blocks for MPLAB 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 IDE. Also provided are many examples in the form of demo models, including a complete BLDC motor control application.

Power Conversion and Motor Control Application Software

Application Type	Application Solution	AN Number	Description
Brushless DC Motor Control	Sensored BLDC Motor Control	AN957	This application note describes a fully-tested 3-phase BLDC motor control algorithm with 3 Hall-effect sensors.
	Sensorless BLDC Motor Control Using the dsPIC30F of dsPIC33F	AN901	This application note describes how to provide sensorless BLDC motor control with the dsPIC DSC device.
	Sensorless BLDC Control with Back-EMF Filtering Using a Majority Function	AN1160	This application note describes a sensorless Brushless Direct Current (BLDC) motor control algorithm, implemented using the dsPIC® Digital Signal Controller (DSC).The algorithm works by the use of a majority function for digitally filtering the Back-Electromotive Force (BEMF). Each phase of the motor is filtered to determine when to commutate the motor drive voltages.
AC Induction Motor Control	Vector Control of an ACIM Using Optical Encoder	AN908	This application note describes a fully-tested vector, or field oriented, control algorithm for a 3-phase ACIM. The motor currents, torque and velocity are regulated in control loops.
	Introduction to ACIM Control	AN984	This application note describes volts per hertz control of an AC Induction Motor.
	Sensorless Field Oriented Control (FOC) of an AC Induction Motor (ACIM)	AN1162	This application note presents a solution for sensorless Field Oriented Control (FOC) of induction motors using a dsPIC® Digital Signal Controller (DSC). The benefits of field oriented control can be directly realized as lower energy consumption, higher efficiency, lower operating costs and reduced cost of drive components.
	Sensorless Field Oriented Control (FOC) of an AC Induction Motor (ACIM) Using Field Weakening	AN1206	This application note presents one solution for sensorless Field Oriented Control (FOC) with Field Weakening (FW) of induction motors using a dsPIC Digital Signal Controller (DSC).
Permanent Magnet Syncronous Motor Control	Sinusoidal PMSM Motor Control	AN1017	This application note provides a fully working and highly flexible solution for using the dsPIC DSC to control a permanent magnet synchronous motor using three hall sensors with sinusoidal voltages.
	Sensorless Field-Oriented Control for PMSM Motors with Field Weakening Using Slide Mode Controller	AN1078	This application note describes how to apply a dsPIC DSC to control a permanent magnet synchronous motor using the field oriented control algorithm. Shunt resistors are used to estimate rotor position.
	Sensorless Field Oriented Control (FOC) of an AC Induction Motor (ACIM) Using Field Weakening	AN1206	This application note presents one solution for sensorless Field Oriented Control (FOC) with Field Weakening (FW) of induction motors using a dsPIC Digital Signal Controller (DSC).
	Sensorless Field Oriented Control (FOC) for a Permanent Magnet Synchronous Motor (PMSM) Using a PLL Estimator and Field Weakening (FW)	AN1292	This application note desribes the sensorless FOC algorithm for PMSM motor using a Phase Locked Loop (PLL) position and speed estimators.
	Integrated Power Factor Correction (PFC) and Sensorless Field Oriented Control (FOC) System	AN1208	This application note describes the process of integrating two complex applications: PFC and Sensorless FOC. These applications are implemented on a Permanent Magnet Synchronous Motor (PMSM). In addition, this application note also describes the integration of the algorithms, lists the necessary hardware requirements, and provides the guidelines to optimize the development procedure.
	Single-Shunt Three-Phase Current Reconstruction Algorithm for Sensorless FOC of a PMSM	AN1299	This dsPIC33F application note describes a motor control technique where a single-shunt resistor circuit is used to measure the motor phase current.
Stepper Motor Control	Stepper Motor Control with dsPIC DSCs	AN1307	This application note describes how to drive a stepper motor with a dsPIC33F motor control family DSC.
SMPS/ Digital Power	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 an 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)
Class B Software	Class B Safety Software Library for PIC MCUs and dsPIC DSCs	AN1229	This application note describes the Class B Safety Software Library routines that detect the occurrence of Faults in a single channel CPU. These routines have been developed in accordance with the IEC 60730 standard to support the Class B certification process.

Motor Control Tuning Guides

Tuning guides describe the procedure and setup necessary for tuning the Motor control algorithms; they simplify motor control design and optimize solutions.

Description	Tuning Guide
Sensorless Dual-Shunt FOC with SMO estimator BLDC/PMSM	AN1078 Tuning Guide
Sensorless Dual-Shunt FOC with PLL estimator BLDC/PMSM	AN1292 Tuning Guide
Sensorless Single-Shunt FOC with SMO estimator BLDC/PMSM	AN1299 Tuning Guide
Sensorless BLDC Control with Back-EMF Filtering Using a Majority Function	AN1160 Tuning Guide
Stepper Motor Control	AN1307 Tuning Guide

Resources for Self-paced Learning

Web Seminars

Microchip offers extensive online resources for designers ranging from downloadable documentation to web seminars (webinars) to online discussion groups. All of these helpful resources are accessible at **www.microchip.com/webseminars** and are updated frequently with the most current information on our products and services.

For more information about additional self-paced learning resources, please visit www.microchip.com/training

Application Area	Webinar Topic
Motor Control	Sensorless Field Oriented Control for ACIM Sensorless Field Oriented Control for PMSM Sensorless BLDC Motor Control Using a Majority Function Brushed DC Motor Basics
Speech & Audio	dsPIC® DSC Speech and Audio Solutions A Look at the dsPIC Audio and Speech Starter Kit Audio DAC Peripheral on DSC Devices
Graphics & Display	Graphics LCD System and PIC24 Interface Microchip Graphics QVGA Display Solution Microchip Graphics Library Architecture
Connectivity	TCP/IP Networking CAN Design Considerations Using the IrDA Standard Protocol
Power Management	Building a dsPIC SMPS System SMPS Components and Their Affects on System Design Control System Design for Power Converters SMPS Topologies – The Buck Converter Switch Mode Power Supply Topologies – the Forward Converter Deep Sleep Mode on Microchip PIC18 and PIC24 Microcontrollers
Capacitive Touch Sense	Introduction to mTouch™ Capacitive Touch Sensing Capacitive mTouch Sensing Solutions: Design Guidelines Overview of Charge Time Measurement Unit (CTMU)
Chip Functionality	Introduction to the PIC24F MCU Introduction to the dsPIC DSC dsPIC DSC Peripherals PIC24F Peripherals Power Management Modes dsPIC DSC Architecture, Addressing Modes, DSP Engine CodeGuard™ Security Overview of Charge Time Measurement Unit Peripheral Pin Select Deep Sleep Mode on Microchip PIC18 and PIC24 Microcontrollers
Tools	dsPIC Development Tools Overview Tutorial on the MPLAB® Starter Kit for PIC24H MCUs Introduction to Microchip SIMULINK Blocksets MATLAB Plug-in for MPLAB IDE
USB	USB On-The-Go Introduction
Sensors	Hardware Conditioning of Sensor Signals

Microchip Technical Training Centers

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Software Development Tools and Operating Systems

Development Tool	Product Name	Description	Part Number	List Price[1]	Devices Supported			
					PIC24F	PIC24H/E	dsPIC30F	dsPIC33F/E
Integrated Development Environment	MPLAB® IDE*	Integrated Development Environment	SW007002	Free	✓	✓	✓	✓
	Green Hills Multi	Integrated Development Environment	–	Contact GHS	✓	✓	✓	✓
C Compilers	MPLAB C Compiler for PIC24 MCUs and dsPIC® DSCs	ANSI C compiler, assembler, linker and librarian	SW006012	$895	✓	✓	✓	✓
	MPLAB C Compiler for PIC24 MCUs	ANSI C compiler, assembler, linker and librarian	SW006014	$495	✓	✓	–	–
	MPLAB C Compiler for dsPIC DSCs	ANSI C compiler, assembler, linker and librarian	SW006013	$495	–	–	✓	✓
	Embedded Workbench for dsPIC30F	ISO/ANSI C and Embedded C++ compiler in a professional, extensible IDE, (Windows® NT/2000/Windows XP®) special DSP support included	EWdsPIC 1	Contact IAR	✓	✓	✓	✓
	CCS PCD C-Compiler for PIC24 MCUs and dsPIC DSCs	Command-line C Compiler for Microchip PIC24 MCU and dsPIC DSC families, integrates with MPLAB® IDE	SW500021	$250	✓	✓	✓	✓
Operating Systems	AVIX-RT AVIX	AVIX is an RTOS specifically developed for Microchip's PIC24 MCUs and dsPIC DSCs	–	Contact AVIX	✓	✓	✓	✓
	CMX-Tiny+™ for dsPIC DSCs	Preemptive Real-time Operating System (RTOS) for dsPIC30F	SW300032	$3000	✓	✓	✓	✓
	CMX-RTX™ for dsPIC DSCs	Fully preemptive Real-time Operating System (RTOS) for dsPIC30F	SW300031	$4000	✓	✓	✓	✓
	CMX Scheduler™	Multi-tasking, preemptive scheduler for dsPIC30F	SW300030	Free	✓	✓	✓	✓
	Express Logic Thread X MCU	ThreadX MCU Edition RTOS is a fully preemptive, deterministic, real-time operating system designed for Microchip's PIC24 MCUs.	SW500130	$5990	✓	✓	–	–
		ThreadX MCU Edition RTOS is a fully preemptive, deterministic, real-time operating system designed for Microchip's dsPIC DSCs	SW500131	$5990	–	–	✓	✓
	FreeRTOS.org™	Portable, open source, mini real time kernel	–	Contact freeRTOS.org™	✓	✓	✓	✓
	Lassar Systems AVA	A unique and powerful RTOS designed exclusively for Microchip's PIC24 MCUs and dsPIC DSCs	–	Contact Lassar Systems	✓	✓	✓	✓
	Micrium µC/OS-II	Portable, scalable, preemptive real-time, multitasking kernel	–	Contact Micrium	✓	✓	✓	✓
	osCAN for dsPIC DSC	OSEK/VDX v2.2	–	Contact Vector	–	✓	✓	✓
	Pumpkin's Salvo RTOS	Salvo RTOS is a full-featured multitasking priority-based event-driven RTOS for all Microchip microcontrollers	–	Contact Pumpkin	✓	✓	✓	✓
	RoweBots DSPnano	DSPnano POSIX RTOS is a tiny, fully preemptive, deterministic, real-time operating system designed for Microchip's PIC24 MCUs and dsPIC30/33 processors	–	Contact RoweBots	✓	✓	✓	✓
	SEGGER embOS	Real-time operating system for embedded applications	–	Contact SEGGER	✓	✓	✓	✓
DSP	dsPICworks™	Data analysis and DSP software	SW300023	Free	✓	✓	✓	✓
	Digital Filter Design	Full featured graphical IIR and FIR filter design package for dsPIC30F	SW300001	$249	–	–	✓	✓
	Digital Filter Design Lite	Graphical IIR and FIR filter design package for dsPIC30F	SW300001-LT	$29	–	–	✓	✓

Note 1: List price may change without notice.
*Includes MPLAB ASM30, MPLAB SIM, MPLAB VDI.

Development Boards and Reference Designs

Development Tool	Description	Part Number	List Price[1]	PIC24F	PIC24H/E	dsPIC30F	dsPIC33F/E
Development Tool Starter Kits (Includes Debug Capability)	MPLAB® ICD 3 with Explorer 16 Kit	DV164037	$299.99	✓	✓	–	✓
	MPLAB Starter Kit for dsPIC® DSCs	DM330001	$59.98	–	–	–	✓
	MPLAB Starter Kit for PIC24H MCUs	DM240021	$59.98	–	✓	–	–
	MPLAB Starter Kit for PIC24F MCUs	DM240011	$59.98	✓	–	–	–
	PIC24E USB Starter Kit	DM240012	$65.00	–	✓	–	–
	dsPIC33E USB Starter Kit	DM330012	$65.00	–	–	–	✓
Starter Development Boards	Explorer 16 Development Board	DM240001	$129.99	✓	✓	–	✓
	dsPICDEM™ 80-pin Starter Development Board	DM300019	$79.99	–	–	✓	✓
	16-bit 28-pin Starter Development Board	DM300027	$79.99	–	–	✓	✓
	dsPICDEM 2 Development Board	DM300018	$99.99	–	–	✓	–
General Purpose Development Board	dsPICDEM 1.1 Plus General Purpose Development Board	DM300024	$299.99	–	–	✓	✓
	nanoWatt XLP 16-bit Development Board	DM240311	$59.99	✓	–	–	–
Motor Control Development Boards	PICDEM™ MC LV Development Board	DM183021	$129.99	–	–	✓	–
	dsPICDEM MCLV Development Board	DM330021	$150	–	–	–	✓
	dsPICDEM MCHV Development Board	DM330023	$650	–	–	–	✓
	dsPICDEM MCSM Development Board	DM330022	129.99	–	–	–	✓
	dsPICDEM MCSM Development Kit	DV330021	269.99	–	–	–	✓
	dsPICDEM MC1 Motor Control Development Board	DM300020	$300	–	–	✓	–
	dsPICDEM MC1H 3-Phase High Voltage Power Module	DM300021	$800	–	–	✓	✓
	3-Phase ACIM High Voltage Motor (208/460V)	AC300021	$120	–	–	✓	✓
	dsPICDEM MC1L 3-Phase Low Voltage Power Module	DM300022	$700	–	–	✓	✓
	3-Phase BLDC Low Voltage Motor (24V)	AC300020	$120	–	–	✓	✓
Graphics Development Boards	PIC24FJ256DA210 Development Kit	DV164039	$399.99	✓	–	–	–
	PIC24FJ256GA210 Development Board	DM240312	$89.99	✓	–	–	–
	Graphics Display Truly 3.2″ 240 x 320 Board	AC164127-4	$99.99	✓	✓	–	✓
SMPS Development Board	dsPICDEM SMPS Buck Development Board	DM300023	$99.99	–	–	✓	–
	Buck/Boost Converter PICtail™ Card	AC164133	$89.99	–	–	–	✓
	LED Lighting Development Kit	DM330014	$249.00	–	–	–	✓
Capacitive Touch Sense Development Boards	PICDEM Touch Sense 2 Development Kit	DM164128	$99.99	✓	–	–	–
	Enhanced mTouch™ Capacitive Evaluation Kit	DM183026-2	$99.95	✓	–	–	–
	PIC24H mTouch Capacitive Touch Evaluation Board	AC243026	$24.95	–	✓	–	–

Note 1: List price may change without notice.

Hardware Development Tools

Development Tool	Description	Part Number	List Price[1]	PIC24F	PIC24H	dsPIC30F	dsPIC33F
MPLAB® ICD 3	In-Circuit Debugger/Programmer	DV164035	$219.99	✓	✓	✓	✓
MPLAB® REAL ICE™	In-Circuit Emulator System	DV244005	$499.98	✓	✓	✓	✓
	Performance Pak	AC244002	$159.98	✓	✓	✓	✓
MPLAB® PM3	Full Featured Device Programmer, Base Unit	DV007004	$895	✓	✓	✓	✓
Third Party Programmers	BP Microsystems	–	–	✓	✓	✓	✓
	Data I/O	–	–	✓	✓	✓	✓

Note 1: List price may change without notice.

Plug-in Modules Supporting Explorer 16 Development and Other Development Boards

A Plug-in Module (PIM) is a daughter board with a PIC® MCU or dsPIC® DSC soldered on top and header socket strips on the bottom. This method allows for easy swapping of devices onto the various development boards, without having to unsolder and resoler parts. For a complete listing of available PIMs please go to **www.microchip.com/explorer16.**

Software Application Libraries

Application	Application Library	Device Support						Part Number	List Price[1]
		PIC24F	PIC24H	PIC24E	dsPIC30F	dsPIC33F	dsPIC33E		
Speech, Audio and Communication	dsPIC DSC Noise Suppression Library				✓	✓	✓	SW300040-5K*	2500
								SW300040-EVAL	Free
	dsPIC DSC Acoustic Echo Cancellation Library				✓	✓	✓	SW300060-5K*	$2500
								SW300060-EVAL	Free
	dsPIC DSC Line Echo Cancellation Library				✓	✓	✓	SW300080-5K*	$2500
								SW300080-EVAL	Free
	dsPIC DSC Equalizer Library				✓	✓	✓	–	Free
	dsPIC DSC Automatic Gain Control Library				✓	✓	✓	–	Free
	PIC24/dsPIC DSC G.711 Speech Encoding/Decoding Library	✓	✓	✓	✓	✓	✓	SW300026	Free
	dsPIC DSC G.726A Speech Encoding/Decoding Library				✓	✓	✓	SW300090-5K*	$2500
								SW300090-EVAL	Free
	dsPIC DSC Speex Speech Encoding/Decoding Library				✓	✓	✓	SW300070-5K*	$2500
								SW300070-EVAL	Free
	DTMF Library					✓	✓	–	–
Encryption and Security	dsPIC DSC Symmetric Key Embedded Encryption Library				✓	✓	P	SW300050-5K*	$2500
								SW300050-EVAL	$5
	dsPIC DSC Asymmetric Key Embedded Encryption Library				✓	✓	P	SW300055-5K*	$2500
								SW300055-EVAL	$5
	Triple DES/AES Encryption Libraries	✓	✓	P	✓	✓	P	SW300052	$5
DSP and Math	dsPIC DSC DSP Library				✓	✓	P	SW300022	Free
	PIC24/dsPIC DSC Math Library	✓	✓	✓	✓	✓	✓	Included in MPLAB® C Compiler	Free
	PIC24/dsPIC DSC Fixed Point Math Library	✓	✓	✓	✓	✓	✓	Included in MPLAB C Compiler	Free
Peripherals	PIC24/dsPIC DSC Peripheral Library	✓	✓	✓	✓	✓	✓	SW300021	Free
Graphics	Microchip Graphics Library	✓	✓	P		✓	P	–	Free
	Graphics Display Designer	✓	✓	✓	✓	✓	✓	–	Free
mTouch™ Capacitive Touch	Capacitive Touch Library	✓		P			P	–	Free
Wired and Wireless Connectivity	Microchip TCP/IP Stack Software (ENC28J60/ENC628J600 Driver)	✓	✓	✓		✓	✓	SW300024	Free
	Microchip USB Framework	✓						–	Free
	IEEE 802.15.4: MiWi™ and MiWi P2P	✓	✓	P		✓	P	–	Free
	IEEE 802.15.4: ZigBee®, ZigBee PRO, ZigBee Smart Energy Profile Suite	✓	✓	P		✓	P	–	Free
	IrDA® Stack	✓	✓	P		✓	P	–	–
	Bluetooth®					✓	✓	SW500151	–
File System and Memory	Microchip FAT File System for PIC24 & PIC32 MCUs and dsPIC DSCs	✓	✓	P		✓	P	SW300027	Free
	Data EEPROM Emulation for PIC18, PIC24 & PIC32 MCUs and dsPIC DSCs	✓	✓			✓		–	Free
	SD/MMC	✓				✓	✓	–	–
Other	PMBus Stack					✓		–	Free
	Class B Safety Software Library for PIC® MCUs and dsPIC DSCs			P		✓	P	–	Free

Note 1: List price may change without notice.
*Software library license up to 5K units.
P = Planned to be compatible in the future.

Third Party Contact Information

Company	Phone	E-mail	Web Site
CMX Systems, Inc.	+1 904 880 1840	cmx@cmx.com	www.cmx.com
FreeRTOS.org™	–	–	www.freertos.org
IAR	+46 18 16 78 00	info@iar.se	www.iar.se
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VOCAL Technologies, LTD	+1 716 688 4675	sales@vocal.com	www.vocal.com

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