16-bit Microcontrollers and Digital Signal Controllers

MICROCHIP

16-bit Embedded Control Solutions

PIC24 Microcontrollers • dsPIC® Digital Signal Controllers

16-bit Microcontrollers & dsPIC® Digital Signal Controllers

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



www.microchip.com/16bit

16-bit Embedded Control Solutions

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

Broad Portfolio

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

Efficient Energy

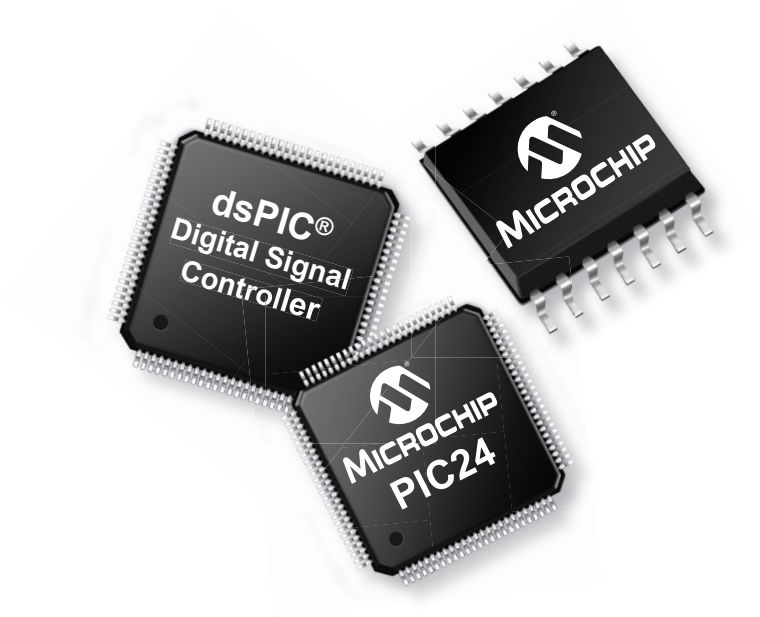
- Longer battery life in portable applications
- High efficiency motor control
- Platinum-rated digital power supplies

Easy Migration

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

High Performance Peripherals

- Fast and flexible PWMs
- Integrated ADCs, Op Amps, DACs, LCD
- Connectivity with USB, CAN, LIN



Free Software & Reference Designs

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

Resources available at www.microchip.com/16bit

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

Powerful 16-bit CPU

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

Flexible Flash

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

Integrated DSP

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

Innovative Peripherals

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

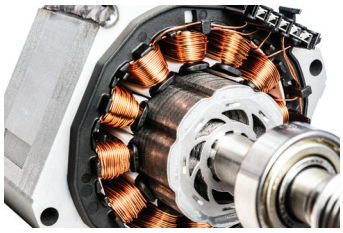
Power Saving Options

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

Small Packages

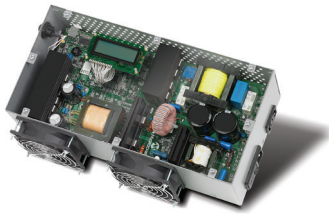
- Packages as small as 5 × 5 mm
- 16-bit MCU with 128 KB Flash in a 6 × 6 mm package
- Peripheral Pin Select allows access to the peripherals needed

16-bit Embedded Control Solutions



Advanced Motor Control with dsPIC® DSCs Portfolio

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



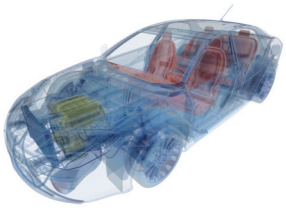
Digital Power for Improving Efficiency and Optimizing the BOM

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



eXtreme Low Power (XLP) Solutions

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



High Temperature Rated Devices Qualified to AEC-Q100 Requirements

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



Enhancing Connectivity to Your Embedded Control Applications

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



Graphics Display Solutions

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

Leading 16-bit Performance and Features

16-bit Microcontroller (MCU) Portfolio

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

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

PIC24F: Lowest Power 16-bit MCUs

With 16 MIPS performance and an extensive peripheral set, including a graphics controller, USB Device/Embedded Host/OTG and capacitive touch sense interface, the PIC24F MCUs are cost-effective and low power applications. Serial communication peripherals include up to 4 UARTs, 3 SPI and 3 I²C™. With the introduction of XLP Technology, select PIC24F devices have industry leading low power performance with sleep numbers as low as 10 nA and RTCC operation down to 400 nA.

PIC24E: Highest Performance 16-bit MCUs

PIC24 devices offer up to 70 MIPS performance with a combination of large memory and a wide variety of package options. They also includes large Flash in smaller packages (5 × 5 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 CAN modules, 4 UARTs (with IrDA support), 4 SPI, 2 I²C and USB Device/Embedded Host/OTG. High performance 16 channel Direct Memory Access (DMA) provides better data handling capability optimizing CPU throughput. AEC-Q100-qualified extended (125°C) and high-temperature (150°C) options for industrial and automotive applications are available.

16-bit Digital Signal Controller (DSC) Portfolio

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

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

dsPIC33: Highest Performance 16-bit MCU with Integrated DSP

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

Example dsPIC® DSP Performance

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

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

High Performance CPU

- Single cycle execution (most instructions)
- C compiler optimized instruction set
- 16-bit wide data path
- 76 base instructions: mostly 1 word/1 cycle
- 16, 16-bit general purpose registers
- Software stack
- 16 × 16 signed fractional/integer multiplier
- 32/16 and 16/16 divide
- 40-stage barrel shifter
- DSC additions:
  - Adds 8 base DSP instructions
  - Two 40-bit accumulators with rounding and saturation options
  - Single core combines MCU and DSP features
  - Adds Modulo and Bit-reverse address modes
- Up to 15 DMA channels between RAM and peripherals

System Management

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

Interrupt Controller

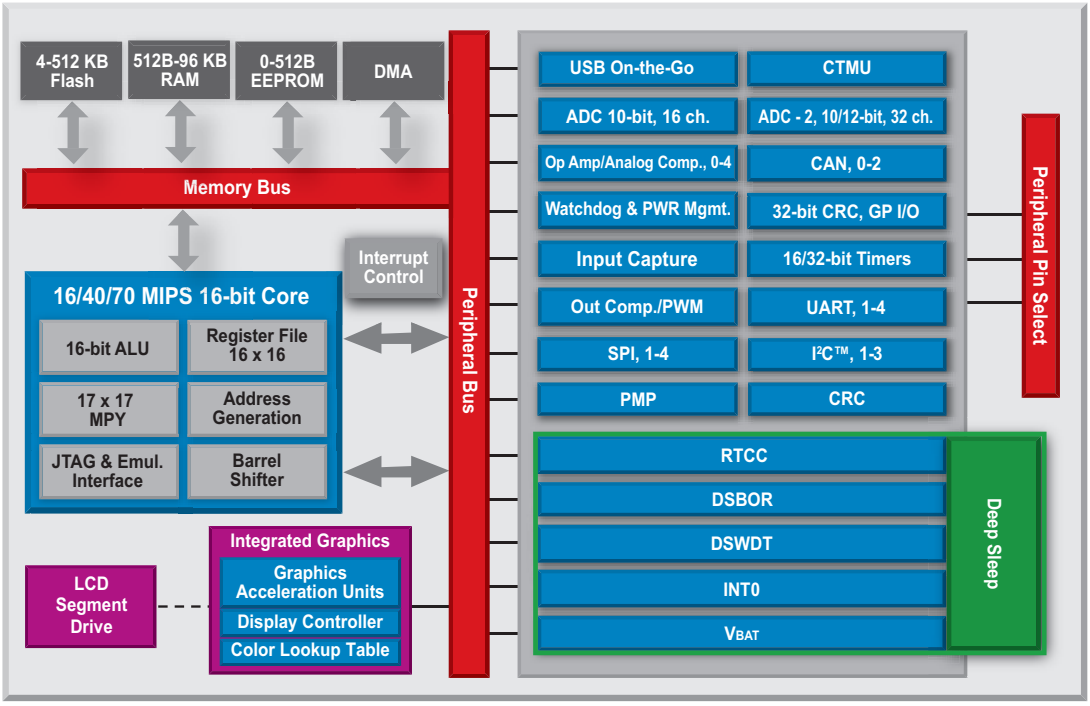
- 5 cycle fixed latency
- Up to 118 interrupt sources, up to 5 external
- 7 programmable priority levels
- 4 processor exceptions and software traps
- Vectored interrupts

Power Management

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

Flexible Integrated Peripherals

PIC24 & dsPIC DSC Family Block Diagram



Digital I/O

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

Communication Modules

- 3-wire SPI: up to 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 Device, Host & OTG
  - Internal Boost Regulator requires minimal external components
  - Separate 3.3V regulator
  - Transparent RAM buffer interface
- CAN 2.0 (up to 2 modules)

Digital Power Peripherals

- 10-bit ADC Up to 4 Msps, Up to 6 sample and holds
- PS PWM, 1 nS duty cycle resolution
- Analog comparators, 25 ns
- Programmable reference

Timers/Capture/Compare/PWM

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

Auxilary Functions

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

Analog Subsystems

- On-chip high speed op amps
  - Up to 10 MHz gain bandwidth
- Analog comparators (up to 4):
  - Programmable reference
- ADC
  - 10-bit up to 1.1 Msps, 4 S&H
  - 12-bit up to 500 ksps, 1 S&H
  - Configurable 10/12-bit options
  - Buffered outputor DMA
  - Autoscanning
  - Supports CVD touch

Motor Control Peripherals

- Motor Control PWM: up to 14 outputs
  - Up to 7 duty cycle generators
  - Independent or complementary mode
  - Programmable dead time settings
  - Edge or center-aligned PWMs
  - Manual output override control
  - Up to 10 fault inputs
  - ADC samples triggered by PWM module
- Quadrature encoder interface module
  - Up to 2 modules
  - Phase A, Phase B and index pulse input
- High current sink/source

16-bit Product Families

PIC24 16-bit Microcontrollers (MCUs)

Family	Pins	Flash Memory Kbytes	SRAM Kbytes	16-bit Timers Input Capture Output Compare	Analog	Communications Serial I/O	Additional Features
PIC24F Family: 16 MIPS, Lowest Cost, Lowest Power, General Purpose							
PIC24F K Families	14–48	4–32	0.5–2	3–5 Timers 1–3 IC 1–3 OC	10-bit ADC (500 ksps) or 10/12-bit ADC (200/100 ksps), 7–16 ch., 3 comparators	UART (2), SPI (1/2), I²C™ (1/2)	EEPROM, CTMU, RTCC, Deep Sleep
PIC24F G Families	28–100	16–256	4–96	5 Timers 5–9 IC 5–9 OC	10-bit ADC (500 ksps) or 10/12-bit ADC (200/100 ksps), 9–24 ch., 2/3 comparators, CTMU (0/1)	UART (2/4), SPI (2/3), I²C (2/3), USB-OTG	LCD, DMA, PPS, PMP, RTCC, CRC, Deep Sleep, JTAG, VBAT
PIC24F D Families	64–100	128–256	24–96	5 Timers 9 IC 9 OC	10-bit ADC (500 ksps), 16–24 ch., 3 comparators, CTMU	UART (4), SPI (3), I²C (3), USB-OTG	Graphics Display Controller PPS, PMP, RTCC, CRC, JTAG
PIC24H Family: 40 MIPS, High Performance, General Purpose							
PIC24H GP Families	18–100	12–256	1–16	3–9 Timers 4–8 IC 2–8 OC	User selectable 12-bit ADC (500 ksps) or 10-bit ADC (1.1 Msps), 8–32 ch., (0/2)	UART (1-2), SPI (1–2), I²C (1–2), CAN	8 ch. DMA, PPS, PMP, RTCC, CRC, JTAG,High Temperature (150°C) Options
PIC24E Family: 70 MIPS, High Performance, General Purpose and Motor Control							
PIC24E GP Families*	28–64	64	16	5 Timers 4 IC 4 OC	User selectable 12-bit ADC (500 ksps) or 10-bit ADC (1.1 Msps), 6–16 ch, 4 analog comparators, 3 Op Amps	UART, CAN, SPI, I²C	mTouch™, DMA
PIC24E MC Families*	28–64	64	16	5 Timers 4 IC 4 OC	User selectable 12-bit ADC (500 ksps) or 10-bit ADC (1.1 Msps), 6–16 ch, 4 analog comparators, 3 Op Amps	UART, CAN, SPI, I²C	mTouch, 6 Motor Control PWM Outputs, DMA
PIC24E GU Families*	64–144	256–512 + 24 Aux Flash	53	9 times, 16 IC, 16 OC	Two user selectable ADCs at 12-bit (500 ksps) or 10-bit (1.1 MSPS), 24–32 ch., 3 analog comparators	UART, CAN, SPI, I²C	USB, DMA, PMP parallel port

dsPIC® Digital Signal Controllers (DSCs)

Family	Max Speed	Pins	Program Memory (Kbytes)	RAM (Bytes)	8/16/32-bit Timers (×8, ×16, ×32)	A/D Ch.	A/D Res. (bits)	A/D Sample (KSPS)	Analog Comp	Communication Peripherals	PWM Ch.	PWM Type	Additional Features
16-bit DSCs: General Purpose													
dsPIC33F Families*	40 MIPS	18–100	12–256	1K–30K	3–9 × 16	6–32	10 or 12	500 or 1.1M	0–2	UART, I²C™, SPI, CAN, DCI	2–8	Standard	Flash security, JTAG, DMA, PMP, RTCC, DAC, CRC
dsPIC33E GP Families*	70 MIPS	28–64	32–512	4–48K	5 × 16	6–16	10 or 12	500 or 1.1M	4	UART, I²C, SPI, CAN	8	Standard	Flash security, on-chip op amps, mTouch, JTAG, DMA, CRC
16-bit DSCs: Motor Control													
dsPIC33F Families*	40 MIPS	20–100	12–256	1K–30K	3–9 × 16	4–24	10 or 12	500 or 1.1M	0–2	UART, I²C, SPI, CAN	6–8	Motor Ctrl.	Flash security, JTAG, DMA, PMP, RTCC, CRC, QEI
dsPIC33E MU Families*	70 MIPS	64–144	280–536	28K–52K	9 × 16	24–32	10 or 12	500 or 1.1M	3	UART, I²C, SPI, CAN, USB-OTG	14	Motor Ctrl.	Flash security, JTAG, DMA, PMP, RTCC, CRC, QEI
dsPIC33E MC Families*	70 MIPS	28–64	32–512	4–48K	5 × 16	6–16	10 or 12	500 or 1.1M	4	UART, I²C, SPI, CAN	6	Motor Ctrl.	Flash security, on-chip op amps, mTouch, JTAG, DMA, CRC, QEI
16-bit DSCs: Digital Power Conversion													
dsPIC33F GS Families	50 MIPS	18–100	6–64	256–9K	2–5 × 16	6–24	10	2M or 4M	0–4	UART, I²C, SPI, CAN	4–18	High-speed	Flash security, JTAG, DMA, 10-bit DAC Output

*Parts available with High Temperature options.
All parts available with Industrial and Extended Temperature options.

For a complete listing of 16-bit Microcontrollers and dsPIC Digital Signal Controllers, see the Product Selector Guide (DS01308) or visit www.microchip.com/16bit or use Micorchip's Advanced Product Selector Tool.

www.microchip.com/16-bit

PIC24 with eXtreme Low Power

16-bit eXtreme Low Power (XLP) Products

As more electronic applications require low power or battery power, energy conservations 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. Products with Microchip's eXtreme Low Power (XLP) technology offer the industry's lowest currents for sleep, where most applications spend 90–99% of their time. Ideal for applications including portable medical devices, thermostats, energy monitoring, wireless sensors, energy harvesting and security applications.

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

Software & App Notes

XLP Battery Life Estimator

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

App Notes

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

Development Tools

nanoWatt XLP 16-bit Development Board (DM240311)

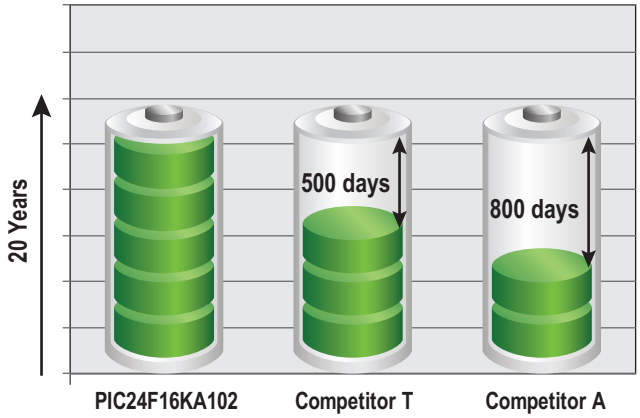


The XLP 16-bit Development Board is designed with eXtreme Low Power in mind. Designed as a true platform for low power development, it enables designs with sleep currents as low as 10 nA. The board is suitable for prototyping many low power applications including RF sensors, data loggers, temperature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

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

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

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



Featured XLP Products

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

www.microchip.com/xlp

Motor Control



16-bit Motor Control Products

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

Webinar Topics (www.microchip.com/motor)

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

Software & App Notes

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

Featured Motor Control Products

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

www.microchip.com/motor

Motor Control Development Boards

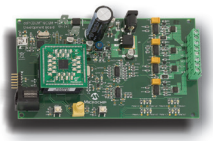
dsPIC33 Development Systems

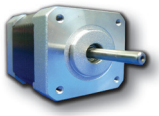
Motor Control Starter Kit (MCSK) with mTouch Sensing (DM330015)



This starter kit with mTouch sensing is a complete, integrated development platform based on the dsPIC33FJ16MC102. It includes a USB interfaced debugger programmer, a complete drive circuit featuring Microchip's TC4428 dual 1.5A gate drivers, an on-board BLDC motor, a user configurable switch and an mTouch slider with LED indicators for speed control. Simply power the board using the included 9V supply and the pre-loaded code begins to execute.

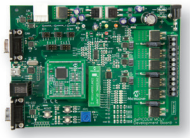
dsPICDEM™ MCSM Stepper Motor: Motor Control Development Board/Kit (DM330022)/(DV330021)





This development board is intended for low-voltage (up to 80 volts at 3 amps) 2-phase uni-polar or bi-polar stepper motor (4, 6 or 8 wire) applications. It provides a low-cost system for users to evaluate and develop applications using dsPIC33 motor control DSCs via a Plug-In Module (PIM) or 28-pin SOIC socket. A USB serial interface for RTDM is provided. Feedback support includes current and voltage. Demo software to run motors in open-loop or closed-loop with full or variable micro-stepping is provided. A DMCI/RTDM GUI for controlling step commands, motor parameter input and operation modes is included. The kit also includes a stepper motor and a 24-volt power supply. MPLAB ICD 3 In-Circuit Debugger or REAL ICE In-Circuit Emulator is required for programming or debugging operations.

dsPICDEM MCLV-2 Development Board (DM330021-2)



This development board is intended for low-voltage (up to 48 volts at 10 amps) BLDC sensored or sensorless applications. It provides a low-cost system for users to evaluate and develop applications using dsPIC33F/E motor control DSCs via a Plug-In Module (PIM) or 28-pin SOIC socket. With the MCLV-2 either the internal, on chip op amps or the external op amps on the MCLV-2 board can be used. Microchip provides PIMs for using either the internal or external op amps. The MCLV-2 is fully backwards compatible with the original MCLV and all Motor Control Processor Plug-In Modules (PIMs). Serial interfaces include: RS-232C, CAN, LIN and USB (for RTDM). Feedback support includes: Hall- Effect Sensors, Shaft Encoder, Back EMF voltages and single or dual shunt resistors for current. PICkit 3 Debug Express, MPLAB ICD 3 In-Circuit Debugger or REAL ICE In-Circuit Emulator is required for programming or debugging operations.

dsPICDEM MCHV-2 Development System (DM330023-2)



This development system is intended for high-voltage (up to 400 volts at 6.5 amps) BLDC, PMSM and ACIM sensored or sensorless applications. It provides a low-cost Integrated Power Module (IPM) based system for users to evaluate and develop applications using dsPIC33F/E motor control DSCs via a Plug-In Module (PIM) or a 28-pin SOIC socket. With the MCHV-2 either the internal, on chip op amps or the external op amps on the MCHV-2 board can be used. Microchip provides PIMs for using either the internal or external op amps. The MCHV-2 is fully backwards compatible with the original MCHV and all Motor Control Processor Plug-In Modules (PIMs). Isolated serial interfaces include RS-232C and USB (for RTDM). Feedback support includes: Hall-Effect Sensors, Shaft Encoder, Back EMF voltages and single or dual current shunt resistors. A PFC circuit is provided to meet regulatory requirements. An isolated built-in debugger (similar to a starter kit programmer/debugger) permits a direct connection with a PC.

dsPIC33E Dual Motor Control Plug-In Module (PIM) (MA330027)



This Dual Motor Control PIM is designed to facilitate the development of motor control applications using two motors and one dsPIC33E Digital Signal Controller (DSC). Two Microchip PIM based motor control development boards can be used with this PIM to control two BLDC, PMSM, ACIM or stepper motors. A flexible cable connects the two boards together and routes all signals to the appropriate pins on the dsPIC33E DSC. The configuration of the cable and signals was carefully chosen to support a wide range of dual motor configuration application notes written for the dsPICDEM MCLV-2, MCHV-2 and MCSM development boards.

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*
- AC300023: *220V, AC Induction Motor*



Digital Power and Lighting

16-bit Digital Power and Lighting Products

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



Webinar Topics (www.microchip.com/power)

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

Software and App Notes

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

Featured Digital Power Products

Product	Pins	Flash (KB)	RAM (Bytes)	IC/OC	PS PWM	ADC	Analog Compare	UART/I²C™/ SPI	CAN
dsPIC33FJ06GS001	18/20	6	256	0/0	4	6 Ch, 2 S&H	2	0/1/0	0
dsPIC33FJ09GS302	28/36	9	1K	1/1	6	8 Ch, 3 S&H	2	1/1/1	0
dsPIC33FJ16GS504	44	16	2K	2/2	8	12 Ch, 6 S&H	4	1/1/1	0
dsPIC33FJ32GS406	64	32	4K	4/4	12	16 Ch, 5 S&H	0	2/2/2	0
dsPIC33FJ64GS606	64	64	9K	4/4	12	16 Ch, 5 S&H	4	2/2/2	1
dsPIC33FJ64GS610	100	64	9K	4/4	18	24 Ch, 6 S&H	4	2/2/2	1

www.microchip.com/power

Digital Power and Lighting Reference Designs & Development Boards

Reference Designs

Platinum Rated 720W AC/DC Reference Design



This reference design demonstrates the flexibility and power of dsPIC Digital Signal Controllers in switch-mode power supplies. This reference design has a peak efficiency of 94.1% and achieves the ENERGY STAR CSCI Platinum Level. It features a 2-phase interleaved power factor correction boost converter followed by a 2-phase interleaved two-switch forward converter with synchronous rectification.

Quarter Brick DC/DC Converter Reference Design



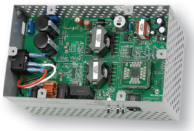
This reference design provides an easy method to evaluate the performance, and features of SMPS DSCs in high density quarter brick DC-DC converters for Intermediate Bus Architectures (IBA). This reference design is implemented using a single dsPIC33F "GS" digital power DSC that provides full digital control of the power conversion as well as system management functions.

DC/DC LLC Resonant Converter Reference Design



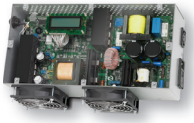
This reference design operates over a wide input voltage range (350-420V DC) with a nominal input of 400V, providing a 12V DC output, while maintaining high-voltage isolation between the primary and secondary. This reference design is implemented using a single dsPIC33F "GS" digital power DSC that provides full digital control of the power conversion and system management functions.

Digital Power Interleaved PFC Reference Design



High performance power supplies are used in a wide variety of applications ranging from telecommunication equipment, industrial equipment, digital televisions, lighting, air conditioners and other home appliances. They all need solutions for power factor correction to improve overall efficiency, improve the input power factor, voltage regulation and Total Harmonic Distortion (THD) of the input current.

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



This reference design demonstrates how digital power techniques 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.

Grid Connected Solar Micro Inverter Reference Design

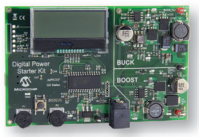


This reference design ensures maximum power point tracking for PV panel voltages between 20V to 45V DC and has a maximum output power of 215 Watts. High efficiency was achieved by implementing a novel interleaved active-clamp flyback topology with Zero Voltage Switching (ZVS). dsPIC33F 'GS' devices enable designers to easily and cost effectively develop products using advanced switching techniques/topologies that lower switching losses and improve overall system efficiency. Two versions of this design are available to support 120V and 230V grids

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

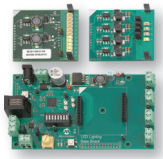
Development Boards

MPLAB® Starter Kit for Digital Power (DM330017)



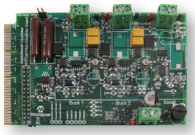
This Starter Kit allows the user to easily explore the capabilities and features of the dsPIC33F GS Digital Power Conversion family. It is a digitally controlled power supply board that consists of one independent DC/DC synchronous Buck converter and one independent DC/DC Boost converter. Each power stage includes a MOSFET controlled 5W resistive load. The starter kit includes an On-Board Debugger/Programmer.

Digital LED Lighting Development Kit (DM330014)



This LED lighting development kit enables designers to quickly leverage the capabilities and performance of the dsPIC33 'GS' DSCs to create a 100% digitally controlled ballast function, while including advanced features such as dimming and color hue control. The dsPIC33 'GS' devices can support an entire system implementation for LED lighting products, including power-conversion circuits, such as AC-to-DC and DC-to-DC conversion, along with functions such as Power Factor Correction (PFC).

Buck/Boost Converter PICtail Plus Card (AC164133)



A low-cost development platform for dsPIC33F 'GS' devices, the buck/boost converter PICtail Plus card has two buck stage outputs and one boost stage output. Various performance measures like digital control loop performance of power conversion, dynamic load performance, multi-phase buck and synchronous buck converter operation, parallel operation of two buck converters and multiple output control with a single dsPIC device can be evaluated. This board can be used with either the Explorer 16 board or the 16-bit 28-pin starter board.

Connectivity for PIC24 MCU & dsPIC DSC Families



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

USB

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

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

Ethernet

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

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

IrDA

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

CAN & LIN

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

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

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

Wireless

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

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

www.microchip.com/connectivity

Display & Touch



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

Segmented LCD Displays

The PIC24FJ128GA310 family features integrated segmented display driver with up to 480 segments. Key advantages include:

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

Graphical Displays

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

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

Touch Buttons: Keys & Sliders

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

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

Development Tools

LCD Explorer Development Board (DM240314)



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

PIC24FJ256DA210 Development Kit (DV164039)



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

Remote Control Demo Board (DM240315-2)



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

Software & App Notes

FREE Microchip Graphics Library

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

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

FREE Microchip Graphics Display Designer

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

mTouch Sensing Technology Source Code and Demos

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

App Notes

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

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

General Purpose Development & Evaluation Tools

Development Boards

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

Starter Kits

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

MPLAB Starter Kit for PIC24F MCUs (DM240011)



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

dsPIC33E/PIC24E USB Starter Kit (DM330012/DM240012)



These starter kits provide a low-cost modular development system for Microchip's enhanced 16-bit Digital Signal Controllers or High-Performance Microcontrollers (MCUs). They come with preloaded demo software for the user to explore the new features of the dsPIC33E DSC family or the PIC24E MCU family.

Microsticks

Microsticks are USB-powered and include an on-board debugger/programmer. They are the lowest cost way to get started evaluating PIC24 MCUs or dsPIC DSCs since no external debugger or power source is needed.

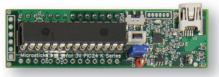
The Microsticks are fully supported by MPLAB X IDE and provide easy plug-in to a standard breadboard with access to device signals for prototyping. These boards have a very small form factor and include free demo code.

Microstick for 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.

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



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

Microstick II Development Board (DM330013-2)



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

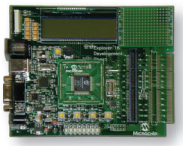
General Purpose 16-bit Development Boards

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

*For use with 3V PIC24 K-series devices

General Purpose Development & Evaluation Tools

Explorer 16 Development Board (DM240001/DM240002)



This development board offers an economical way to evaluate Microchip's 16-bit MCUs and dsPIC DSC families. The combination of versatility and expandability and 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 100-pin PIMs, one each for the PIC24FJ128GA010 and the dsPIC33FJ256GP710 DSC
  - DM240002: features a PIM for the 44-pin PIC24FJ64GA004 and dsPIC33FJ32GP204 MCUs
  - Many other processor PIMs available for easy device swapping
- Alpha-numeric 16 × 2 LCD display
- Interfaces to MPLAB ICD 3 In-Circuit Debugger, REAL ICE In-Circuit Emulator and RS-232
- Includes Microchip's TC1047A high accuracy, analog output temperature sensor
- Expansion connector to access full devices pin-out and bread board prototyping area
- PICtail Plus connector for expansion boards
- Full documentation includes user's guide, schematics and PCB layout at www.microchip.com/explorer16.

PICtail Plus Daughter Boards

- 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	Devices Supported	
		PIC24	dsPIC® DSC
Consumer-band BPSK 7.2 kbps PLM PICtail™ Plus Daughter Board	AC164142	–	✓
Utility-Band BPSK 6.0 kbps PLM PICtail Plus Daughter Board	AC164145	–	✓
CAN/LIN PICtail Plus Daughter Board • Two ECAN MCP2551 transceivers • Two LIN MCP2021-330 transceivers	AC163130	✓	✓
PICtail Plus Daughter Board for SD/MMC • SPI to SD/MMC interface	AC164122	✓	✓
IrDA® PICtail Plus Daughter Board • IrDA transceiver for IrDA enabled UART	AC164124	✓	✓
Speech Playback PICtail Plus Daughter Board • Adaptive Differential Pulse Code Modulation (ADPCM) speech playback and recording	AC164125	✓	✓
Prototype PICtail Plus Daughter Board • PICtail Plus Expansion Board	AC164126	✓	✓
Graphic PICtail Plus Daughter Board • Enables Graphics display via PMP	AC164127-3	✓	✓
Audio PICtail Plus Daughter Board • Full Duplex Speech and Audio applications	AC164129	✓	✓
USB PICtail Plus Daughter Board • USB Device, Host and OTG Expansion	AC164131	✓	✓
Fast 100 Mbps Ethernet PICtail Plus Daughter Board • Stand Alone ENC624J600 Ethernet Controller	AC164132	✓	✓
Buck/Boost Converter PICtail Plus Daughter Board • Two independent DC/DC synchronous buck converters • Independent DC/DC boost converter	AC164133	–	✓
Thermal/Linear Intelligent Sensor PICtail Plus Daughter Board • Signal input and conditioning for thermocouples and linear sensors • TC1047/1047A Temperature to Voltage Converter	AC164135	✓	✓
MCP2515 PICtail Plus Daughter Board • Stand Alone CAN Controller expansion board	MCP2515DM	✓	✓
MCP42XX PICtail Plus Daughter Board • MCP42XX Digital Potentiometer expansion board	MCP42XXDM	✓	✓
MCP4725 PICtail Plus Daughter Board • 12-bit DAC + non-volatile memory	MCP4725DM	✓	✓
Wireless MRF24J40MB 802.15.4 PICtail/PICtail Plus with PCB Antenna (2.4 GHz)	AC164134-2	✓	✓
Wireless MRF89XAM8A PICtail/PICtail Plus Daughter Board (868 MHz)	AC164138-1	✓	✓
Wireless MRF89XAM9A PICtail/PICtail Plus Daughter Board (915 MHz)	AC164138-2	✓	✓
Wireless MRF24J40MC 802.15.4 PICtail/PICtail Plus with U.FL Connector (2.4 GHz)	AC164143	✓	✓
Wireless RN-131 Wi-Fi® Long Range PICtail Development Board	RN-131-PICTAIL	✓	–
Wireless RN-171 Wi-Fi Low Range PICtail Development Board	RN-171-PICTAIL	✓	–

Embedded Control Software & Techniques

Software

Encryption Libraries

Implement reliable security for embedded applications. The encryption library features the symmetric key encryption/decryption functions Advanced Encryption Standard (AES) and Triple-Data Encryption Algorithm (Triple-DES). These algorithms are also recommended by most Internet Engineering Task Force (IETF), Federal Information Processing Standards (FIPS) and IPSec standards. (Application Note: AN1044)

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 support the FAT16 and FAT32 file systems.

Cyclic Redundancy Check (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. (AN1148)

PMBus Stack

Microchip's PMBus stack implements the PMBus protocol over the traditional I²C™ communication interface for dsPIC SMPS Digital Signal Controllers from "GS" family and mid-range PIC microcontrollers from the PIC16F88X family.

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. (AN1152)

Bootloaders

Two App Notes exist to help customers develop UART-based bootloaders for PIC24 MCU and dsPIC DSC products. First, AN1094 describes a UART-based bootloader with command line interface. Next, AN1157 focuses on the PIC24F family and also includes the PIC24F Quick Programmer (P24QP) Windows-based graphical programming interface (GUI).

VDE Certified Class B Safety Library

Microchip's certified class B library contains 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 (AN1229).

www.microchip.com/16-bit

World Class Development Tools

MPLAB X IDE

Universal and Integrated Tool Set

MPLAB X IDE is a single, universal graphical user interface for Microchip and third party software and hardware development tools. It is the industry's only IDE to support an entire portfolio of 800+ 8-bit, 16-bit and 32-bit PIC MCUs, dsPIC DSCs and memory devices.

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

Powerful Yet User-Friendly Interface

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

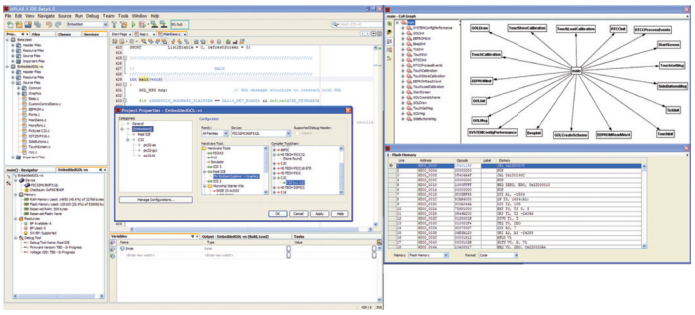
MPLAB X is also fully equipped for the needs of experienced users with the ability to support multiple tools on multiple projects with multiple configurations and simultaneous debugging.

Open-Source Platform

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

Cross-Platform

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



MPLAB XC16 C Compiler for PIC24 MCUs and dsPIC DSCs

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

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

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

www.microchip.com/compilers

Available for MPLAB X IDE

FREE MPLAB X SIM Software Simulator

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

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

dsPIC DSP Library

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

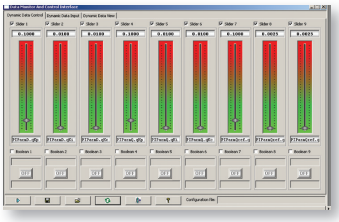
Fixed Point Math Library for PIC24 MCUs and dsPIC DSCs

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

Floating Point Math Library for PIC24 MCUs and dsPIC DSCs

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

Real-Time Data Monitor (RTDM)



The Real-Time Data Monitor saves development and testing time for embedded control applications. RTDM allows users to make a change to a software parameter and see the effect immediately without stopping the application execution. A serial USB or UART cable supports bi-directional data transfers between the host PC and the MCU/DSC.

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

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

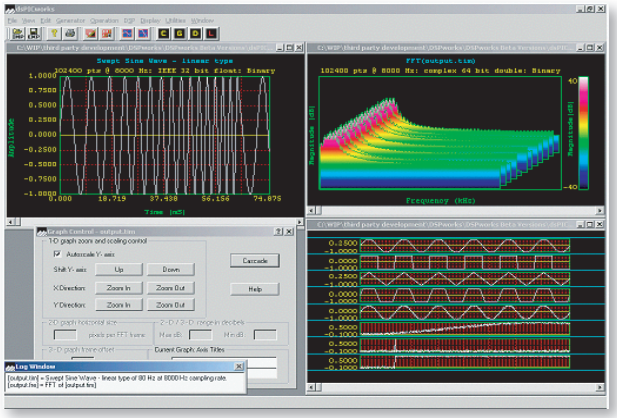
- MPLAB X project aware: The current device and software variables are recognized automatically by DMCI
- Compiler independent
- Debug tool independent
- Provides effortless graphical analysis of application data

MATLAB Device Blocks for MPLAB X IDE

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

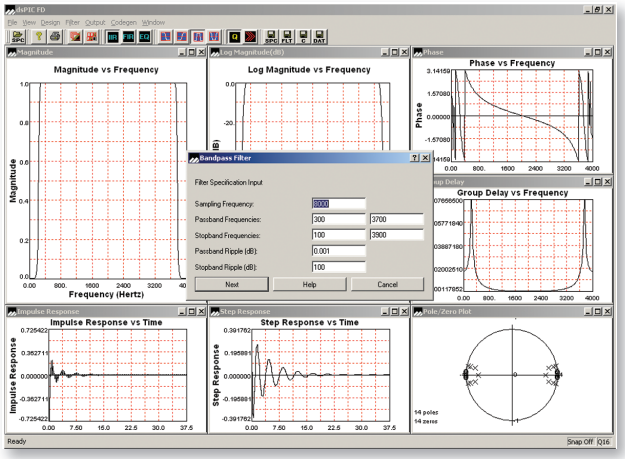
Complete applications can be created in the form of a MATLAB/SIMULINK model using blocksets provided by Microchip and Simulink. C code for the application will be generated. These blocksets are compatible with the MATLAB plug-in available in MPLAB X IDE. Also provided are many examples in the form of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

dsPICworks™ Data Analysis and DSP Software



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

Digital Filter Design Tool



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

16-bit Packages



36-lead VTLA (TL)
5 × 5 × 0.9 mm
(Lead Pitch: 0.5 mm)



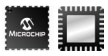
44-lead VTLA (TL)
6 × 6 × 0.9 mm
(Lead Pitch: 0.5 mm)



20-lead QFN (MQ)
5 × 5 × 0.9 mm
(Lead Pitch: 0.65 mm)



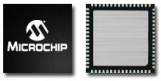
28-lead QFN (MQ)
5 × 5 mm
(Lead Pitch: 0.65 mm)



28-lead QFN (MM & ML)
6 × 6 × 0.9 mm
(Lead Pitch: 0.65 mm)



44-lead QFN (ML)
8 × 8 × 0.65 mm
(Lead Pitch: 0.65 mm)



64-lead QFN (MR)
9 × 9 × 0.5 mm
(Lead Pitch: 0.5 mm)



20-lead SSOP (SS)
7.2 × 7.85 × 1.85 mm
(Lead Pitch: 0.65 mm)



28-lead SSOP (SS)
10.2 × 7.8 × 2 mm
(Lead Pitch: 0.65 mm)



14-lead TSSOP (ST)
5.0 × 6.4 × 1.2 mm
(Lead Pitch: 0.65 mm)



18-lead SOIC (SO)
11.53 × 10.34 × 2.31 mm
(Lead Pitch: 1.27 mm)



20-lead SOIC (SO)
12.80 × 10.34 × 2.31 mm
(Lead Pitch: 1.27 mm)



28-lead SOIC (SO)
17.88 × 10.34 × 2.31 mm
(Lead Pitch: 1.27 mm)



44-lead TQFP (PT)
10 × 10 × 1 mm
(Lead Pitch: 0.8 mm)



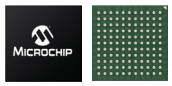
64-lead TQFP (PT)
10 × 10 × 1 mm
(Lead Pitch: 0.5 mm)



80-lead TQFP (PT)
12 × 12 × 1 mm
(Lead Pitch: 0.5 mm)



100-lead TQFP (PT)
12 × 12 × 1 mm
(Lead Pitch: 0.4 mm)



121-ball BGA (BG)
10 × 10 × 0.8 mm
(Lead Pitch: 0.8 mm)



64-lead TQFP (PF)
14 × 14 × 1 mm
(Lead Pitch: 0.8 mm)



80-lead TQFP (PF)
14 × 14 × 1 mm
(Lead Pitch: 0.65 mm)



100-lead TQFP (PF)
14 × 14 × 1 mm
(Lead Pitch: 0.5 mm)



144-lead TQFP (PH)
16 × 16 × 1 mm
(Lead Pitch: 0.4 mm)



144-lead LQFP (PL)
20 × 20 × 1.4 mm
(Lead Pitch: 0.5 mm)



14-lead PDIP (P)
19 × 6.35 × 3.3 mm
(Lead Pitch: 0.1 inches)



18-lead PDIP (P)
22.81 × 7.95 × 3.3 mm
(Lead Pitch: 0.1 inches)



20-lead PDIP (P)
26.24 × 7.87 × 3.3 mm
(Lead Pitch: 0.1 inches)



28-lead SPDIP (SP)
34.67 × 7.87 × 3.3 mm
(Lead Pitch: 0.1 inches)



40-lead PDIP (P)
52.27 × 15.24 × 3.81 mm
(Lead Pitch: 0.1 inches)

Die/Wafer
(WLCSP)

For more information about chipscale packaging options, please visit www.microchip.com/packaging.

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