MICROCHIP

16-bit Embedded Control Solutions

PIC24 Microcontrollers • dsPIC® Digital Signal Controllers

www.microchip.com/16bit

Microchip's PIC24 Microcontrollers and dsPIC® Digital Signal Controllers

In today's embedded world, meeting product specification and performance goals are among the top challenges. For a competitive advantage, it is also important to focus on solution cost and a fast time to market. To meet these objectives, Microchip's 16-bit microcontroller and digital signal controller portfolio offers several product families including the PIC24F, PIC24H, PIC24E, dsPIC33F and dsPIC33E families.

PIC24F Family

The PIC24F is a cost-effective, low-power family of microcontrollers, featuring devices with eXtreme Low Power (XLP) technology, 16 MIPS performance and memory up to 1024 KB of Flash with rich set of Core Independent Peripherals (CIPs). Offering a step up in performance, memory and peripherals for applications that are pushing the envelope of 8-bit microcontroller capabilities, the PIC24F family is ideal for:

- Low-power applications
- Space-constrained applications
- Cost-sensitive applications

PIC24H and PIC24E Families

For more demanding applications, the PIC24H and PIC24E families offer up to 40 MIPS and 70 MIPS performance respectively, memory up to 512 KB of Flash and feature a robust peripheral set including fast and flexible PWMs, high-performance Analog-to-Digital Converter, op amp and CAN, which are optimized for real-time response. These families are ideally suited for:

- Automotive applications
- Functional safety applications
- Industrial applications

dsPIC33F and dsPIC33E Families

The dsPIC family of Digital Signal Controllers (DSCs) feature a Digital Signal Processor (DSP) engine, including a single-cycle 16 × 16 MAC and 40-bit accumulators, for enhanced math capabilities and implement high-speed precision control loops with the simplicity of a traditional microcontroller. The dsPIC33 DSCs offer up to 70 MIPS performance and include features for high-efficiency motor control, digital power supplies and other embedded control applications, including operation up to 150°C and support for both 3V and 5V applications. The dsPIC33 families are ideally suited for:

- Motor control applications
- Digital power applications
- Digital lighting applications
- Automotive applications
- Industrial applications
- High-performance applications

Simplifying 16-bit Microcontroller Designs

With focus on reducing the time to market and minimizing the development risks, Microchip offers a complete ecosystem around the PIC24 MCUs and dsPIC33 DSCs that simplifies the designs, including:

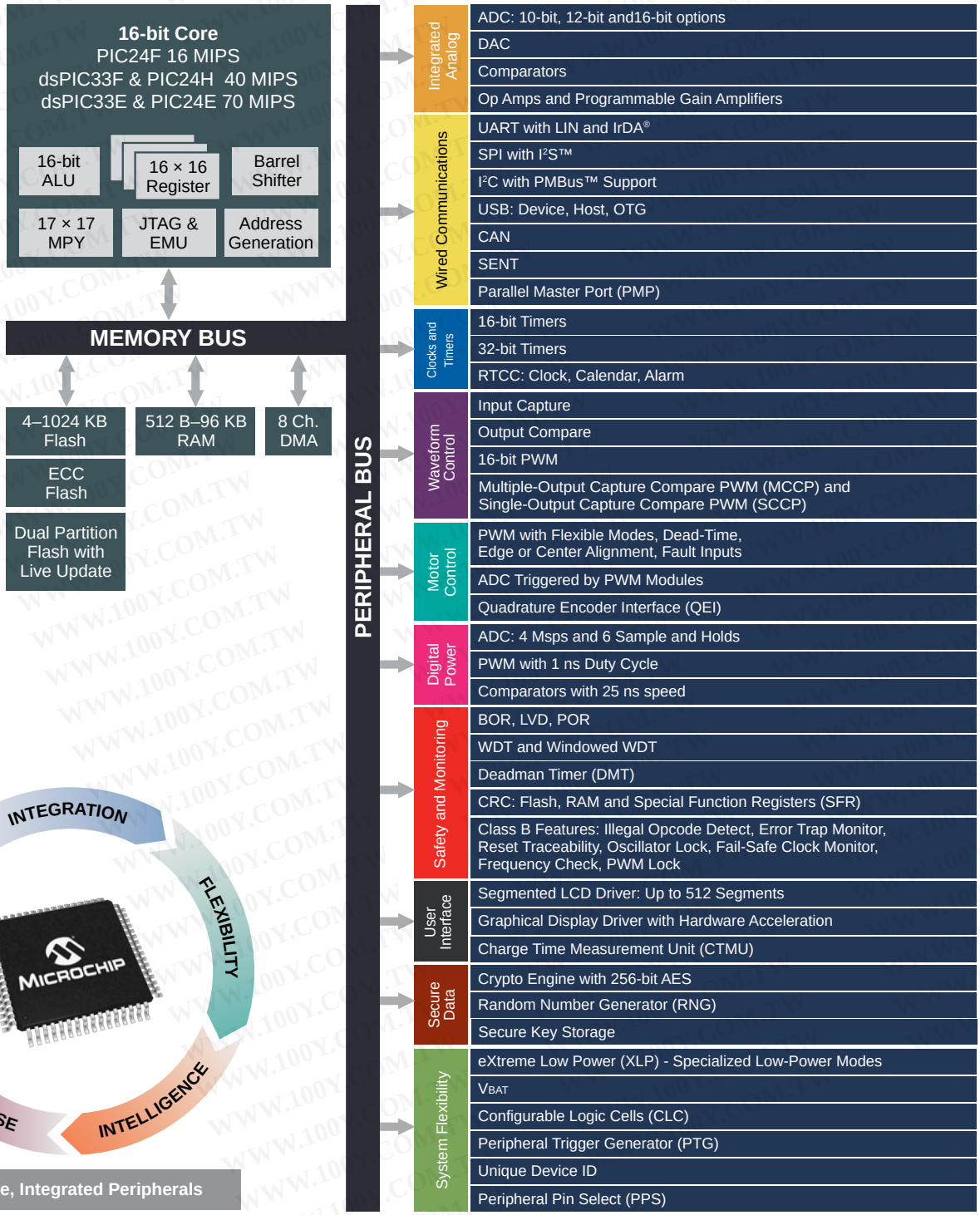
- MPLAB® X IDE and XC16 compilers
  - Single development platform across all 16-bit MCUs and DSCs
- MPLAB Code Configurator (MCC)
  - Free graphical programming environment
  - Generates easy-to-understand, production ready C code
- Microchip-tested software for quick time to market
  - USB, graphics, crypto, smart card, file I/O, Wi-Fi®, Class B safety stacks
  - Motor control and digital power software, models and tuning guides
  - DSP math library and digital filter design tools
- MPLAB Xpress cloud-based IDE
  - A quick start online development environment
  - Facilitates easy collaboration with capability to access project from anywhere
- Range of development boards
  - Cost-effective, rapid prototyping PIC24F-based Curiosity Development Boards
  - Ready-to-explore Starter Kits
  - Flexible and versatile Explorer 16/32 Development Board
  - Application-specific motor control and digital power development boards

All 16-bit families have the same instruction set, basic peripherals and common pin-outs and share the same development tool ecosystem enabling easy migration.

Flexible Integrated Peripherals

Microchip offers a rich set of high-performance peripherals that integrate seamlessly with customer applications and enable solution with reduced costs and time. The 16-bit family offers key communication and control peripherals like SPI, UART, CAN, I²C, PWM and Timers, as well as specialized peripherals for USB, graphics, motor control and digital power. With integrated analog peripherals, you can include analog functions such as high-performance ADCs, DACs and op amps into your applications, providing simple-to-use interfaces that ease analog design. In addition, core independent peripherals such as CLC, PTG and crypto enable higher levels of integration and flexibility.

PIC24 and dsPIC33 Family Block Diagram



eXtreme Low Power (XLP) Solutions

Microchip's XLP devices bring 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 including USB, touch, crypto and LCD drivers, XLP products can help extend the life of your battery-powered application. www.microchip.com/XLP

Low-Power Core Independent Peripherals

Smartly interconnected CIPs function with near zero latency. By taking load off the CPU, low-power CIPs can perform extremely complex tasks, such as cryptography and event monitoring. This allows the CPU to be in low power mode to save energy or perform additional tasks, therefore eliminating the need to migrate to complex and expensive MCUs. Significant BOM cost savings can also be realized by replacing external discrete components with these integrated peripherals. www.microchip.com/16bitCIP

Secure Data

Embedded applications in the internet-connected world demand secure data and long battery life. PIC® MCUs ensure data integrity without sacrificing power consumption through an integrated hardware crypto engine, random number generator for unique key creation and secure key storage for applications such as IoT sensor nodes and access control systems. www.microchip.com/lowpowercrypto

Driving Displays and Touch

For applications that need compelling and intuitive user interfaces, our portfolio includes devices with integrated low-power segmented LCD drivers or colorful graphical display drivers with hardware acceleration. Additionally, Microchip offers a broad portfolio of touch solutions for resistive and projected capacitive applications that make it easy for you to integrate touch-sensing interfaces. These hardware peripherals are supported by free software libraries to quickly integrate the touch and display functions into your application with a single MCU.
www.microchip.com/graphics www.microchip.com/LCD www.microchip.com/touch

Easy Connectivity

Whether you are considering adding wired or wireless connectivity to your application, Microchip supports a wide variety of communication protocols. It's easy to couple the PIC24 or dsPIC33 devices with Microchip's certified Bluetooth®, Wi-Fi and LoRa® modules. Peripherals for CAN, LIN, SENT and USB are integrated onto our 16-bit devices with supporting free software libraries. www.microchip.com/connectivity

Advanced Motor Control

The dsPIC33 motor control families feature a high-performance core with specialized motor control peripherals. The devices are supported with free software libraries and motor control algorithms. Our flexible motor control development boards support a wide variety of motors and help reduce development time.
www.microchip.com/motor

Efficiency for Digital Power and Lighting

The dsPIC33 "GS" DSC family is optimized for high performance on advanced algorithms for improved efficiency over widely varying load conditions. These devices feature dedicated peripherals such as fast ADCs and PWMs for digital power conversion and LED or HID lighting applications. www.microchip.com/power

System Level Integration

PIC24 MCUs and dsPIC33 DSCs operate up to 5V for increased noise immunity and robustness. Additionally, some devices are rated for operation up to 125°C or 150°C ambient temperature for the most extreme automotive and industrial applications, including AEC-Q100 Grade 0 qualification. For safety-critical applications, the products include memory integrity check and error correction, backup oscillators and fault detection. The certified Class B software stack helps to simplify regulatory compliance.
www.microchip.com/hightemp www.microchip.com/16bitFunctionalSafety

PIC24F MCUs with eXtreme Low Power

eXtreme Low Power (XLP) Technology

Today's connected applications must consume little power, and in extreme cases, last for over 20 years on a single battery. Microchip's XLP technology offers the industry's lowest Run and Sleep currents, ideal for a variety of applications including portable/wearable devices, remote controls, asset tracking, energy monitoring, security systems and IoT sensor nodes.

- Low sleep currents with flexible wake-up sources
  - Sleep current down to 10 nA
  - Brown-Out Reset (BOR) down to 45 nA
  - Real-time clock down to 300 nA
- Battery-friendly features
  - Enable battery lifetime greater than 20 years
  - Low-power supervisors for safe operation (BOR, WDT)
- V_{BAT} battery back-up
  - Automatic switch-over upon loss of V_{DD}
  - Maintains Real-Time Clock/Calendar (RTCC) and two user registers
  - Powered separately from 1.8–3.6V source (coin cell)
- Efficient instruction set; 90% single-cycle instruction
  - Active mode current as low as 150 µA/MHz

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 you to select the target device, battery type, the application's operating conditions and model the active and power-down times for your application. Learn more at www.microchip.com/BatteryLifeEstimator.

Application Notes

- **AN1861:** *Bluetooth Smart Communication Using Microchip's RN4020 Module and 16-bit PIC® MCU*
- **AN1556:** *Blood Pressure Meter Design Using Microchip's PIC24F Microcontroller and Analog Devices*
- **AN1416:** *Low Power Design Guide: A Single Source for Low Power Consumption from the Viewpoint of the MCU*
- **AN1267:** eXtreme Low Power *(XLP) PIC Microcontrollers: An Introduction to Microchip's Low-Power Devices*

Development Tools

LCD Explorer XLP Development Board (DM240314)

This board showcases the PIC24FJ128GA310 family with segmented LCD driver. The board operates from two AAA batteries and includes circuitry for V_{BAT} battery back-up from a coin cell battery.

Explorer 16/32 Development Board (DM240001-2)

This board is a modular development system supporting PIC24F XLP microcontrollers, providing a perfect platform to prototype applications using several expansion possibilities through its wide ecosystem support.

PIC24F Curiosity Development Board (DM240004)

This is a cost-effective, fully integrated, feature-rich, rapid prototyping board, featuring a PIC24FJ128GA204 XLP MCU. The board serves as a perfect platform to harness the power of 16-bit low-power PIC24F MCUs.

PIC32MM Curiosity Development Board (DM320101)

This board features the new XLP PIC32MM "GPL" family (PIC32MM0064GPL036) of low-cost MCUs and is a simple and easy-to-use platform that facilitates quick evaluation, experimentation and application prototyping.

Featured XLP Products

Product	Flash (KB)	Pin Count	Sleep (nA)	WDT (nA)	SOSC/RTCC (nA)	Active (µA/MHz)	Features
PIC24FJ64GB004	32–64	28/44	20	200	500	250	USB
PIC24FJ128GB204	64–128	28/44	18	240	300	178	Crypto, USB, V_{BAT}
PIC24FJ128GA310	64–128	64/100	10	270	400	150	LCD, V_{BAT}
PIC24FJ128GC010	64–128	64/100	75	270	350	178	Adv. Analog, LCD, USB, V_{BAT}
PIC24FJ256GA705	64–256	28/44/48	190	220	400	190	High integration
PIC24FJ256BG412	64–256	64/100/121	70	100	175	155	LCD, USB, V_{BAT}, Crypto
PIC24FJ1024GB610	128–1024	64/100	190	220	300	190	Large memory, USB
PIC32MM0064GPL064	16–64	20/28/36/40	440	80	400	280	High performance

PIC MCUs with Core Independent Peripherals

Core Independent Peripherals (CIPs)

Smartly interconnected CIPs function with near zero latency. By offloading the CPU, low-power CIPs can perform extremely complex tasks, such as cryptography and event monitoring. This allows the CPU to be in low power mode to save energy or perform additional tasks, therefore eliminating the need to migrate to complex and expensive MCUs. Significant BOM cost savings can also be realized by replacing external discrete components with these integrated peripherals.

PIC24FJ256GA705 Family

The PIC24F "GA7" family is our newest member of PIC24F family with XLP specifications and offers the lowest-cost 256 KB Flash memory 16-bit MCUs. These devices enable extremely cost-effective designs for Internet of Things (IoT), portable medical devices and industrial control applications by facilitating developers to cut power consumption, cost and space. The PIC24 "GA7" family features CIPs such as CLC, MCCP and DMA, which allow you to accomplish tasks in hardware while freeing up the CPU to do other tasks or to go to sleep. The new MCUs also feature a robust peripheral set including 12-bit, 200 ksps ADC and range of communication peripherals. For more information visit www.microchip.com/PIC24FJ256GA705.

Migrating to Low-Power 32-bit Families: PIC32MM

Some PIC24 customers are looking to migrate to low-power 32-bit platforms for various reasons including performance, library or tool-chain support. Within the PIC MCU ecosystem, the PIC32MM family is our lowest-power and most cost-effective family of 32-bit PIC32 microcontrollers with XLP specifications. This new family bridges the gap between our popular PIC24F XLP and PIC32MX families.

For applications demanding long battery life and smaller form factors, the PIC32MM devices offer sleep modes down to 440 nA and packages as small as 4 × 4 mm. The PIC32MM is the first in the PIC32 portfolio to introduce Microchip's unique Core Independent Peripherals. Designed to offload the CPU and lower power consumption, these peripherals include a 12-bit ADC, comparators, RTCC, WDT, Configurable Logic Cells, flexible PWMs and timer modules as well as Multiple Output Capture Compare PWMs (MCCPs). With low-power and small-form-factor packages, the PIC32MM is a good fit for various applications, including IoT sensor nodes, connected thermostats and other environmental monitoring devices. The flexible MCCP module helps enable low-cost BLDC motor control applications. The PIC32MM devices are supported by Microchip's MPLAB Code Configurator (MCC), MPLAB Xpress Cloud-Based IDE and the PIC32MM Curiosity Developent Board (DM320101) to help simplify designs. For more information, please visit www.microchip.com/PIC32MM.

Application Notes

- **AN2133**: *Extending PIC MCU Capabilities Using CLC*
- **AN2152:** *Applications of the Peripheral Trigger Generator (PTG)*
- **TB3152:** *MCCP: Extending the Functionality for Low-Cost Motor Control Applications*
- *Migrating to the PIC32MM Microcontroller Family*

16-bit PIC MCU Peripheral Integration Quick Reference Guide

Looking for a quick way to see which families support which peripherals? Download the 16-bit PIC MCU Peripheral Integration Quick Reference Guide. To download, please visit www.microchip.com/16bitquickreference.

Featured Products with CIPs

Product	Core	Flash (KB)	Pin Count	Core Independent Peripherals									
				Crypto Engine	LCD	MCCP	SCCP	IC/ OC	DMA	RTCC	CLC	Comp.	CRC
PIC24FJ128GB204	16-bit PIC24F	64–128	28/44	✓				✓	✓	✓			✓
PIC24FJ256GB412	16-bit PIC24F	64–256	64/100/121	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
PIC24FJ256GA705	16-bit PIC24F	64–256	28/44/48			✓		✓	✓	✓	✓	✓	✓
PIC24FJ1024GB610	16-bit PIC24F	128–1024	64/100			✓	✓	✓	✓	✓	✓	✓	✓
PIC32MM0064GPL036	32-bit PIC32MM	16–64	20/28/36/40			✓	✓		✓	✓	✓	✓	✓

Hardware Crypto Engine for Secure Data

Hardware Crypto Engine

For IoT applications, protecting embedded data and extending battery life are a necessity. Microchip's PIC24F "GB2" and "GB4" families offer an integrated hardware crypto engine along with XLP performance. These devices also features a True Random Number Generator (RNG) and secure key management for data protection. For connectivity, both families integrate USB and UART with ISO7816 support, facilitating smart card applications. The "GB4" family offers a direct drive LCD module with up to 512 segments.

Key Features

Cryptographic Engine

- AES engine with 128, 192 or 256-bit key
- DES/Triple DES (TDES) engine
- Encryption, decryption and authentication
- RNG for key generation/OTP memory for secure key storage
- Secure RAM for key storage with self destruction on external tamper detection
- Once written, keys cannot be read or overwritten
- CIP – offloads CPU to save power and headroom

eXtreme Low Power Technology

- 18 nA deep sleep, 155 µA/MHz Run
- Enables data integrity at low power
- V_{BAT} allows the device to transition to a backup battery

Connection to USB or Wireless Protocols

- Integrated USB 2.0 device, host, OTG
- Easy connection to certified modules for Wi-Fi, zigbee®, Sub-GHz and Bluetooth Low Energy

Human Interface

- Direct drive segmented LCD with up to 512 segments
- mTouch® capacitive touch sensing capability

Low Profile and Small Footprint

- QFN and uQFN packages

You can add crypto functions in software to any PIC24/dsPIC33 device using the free software found in the Microchip Libraries for Applications (MLA) available at www.microchip.com/MLA.

Application Note

- **AN1861:** *Bluetooth Smart Communication Using Microchip's RN4020 Module and 16-bit PIC Microcontroller*

Target Applications

Industrial

- Access control systems
- Security cameras
- POS terminals
- Smart card readers
- Heat/gas meters
- IoT sensor nodes

Computer

- PC peripherals
- Printers
- Portable accessories

Medical/Fitness

- Wearable fitness
- Handheld devices

Development Tools

PIC24 XLP Bluetooth LE IoT Demo

This demo showcases data security using the integrated crypto engine available on PIC24FJ128GB204 and communicating over Bluetooth LE to an Android™ tablet using the RN4020 to demonstrate basic command and control similar to a simple IoT sensor node. For further details visit: www.microchip.com/PIC24IoTdemo.

PIC24F Curiosity Development Board (DM240004)

This board is a cost-effective, fully integrated, feature-rich, rapid prototyping platform featuring the PIC24FJ128GA204 XLP MCU with an integrated crypto engine for data encryption/decryption and authentication.

Explorer 16/32 Development Board (DM240001-2)

Get the board and choose from a wide variety of PIMs such as:

- PIC24FJ128GB204 Plug-in Module (MA240036)
- PIC24FJ256GB410 Plug-in Module (MA240038)

Featured Products

Product	Flash (KB)	Pins	Crypto Engine	Key Storage	RNG	Tamper Detection	Other Features
PIC24FJ128GB204	64–128	28–44	AES, DES, 3DES	Secure OTP	TRNG	–	USB 2.0 OTG, UART with ISO7816, XLP
PIC24FJ256GB412	64–256	64–121	AES, DES, 3DES	Secure OTP and RAM	TRNG	External physical tamper detect	USB 2.0 OTG, UART with ISO7816, LCD, Dual Partition Flash with Live Update, XLP

Display and Touch

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

Segmented LCD Displays

The PIC24 "GA3", "GC" and "GB4" families feature integrated segmented display drivers with up to 512 segments. Key advantages include:

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

Graphical Displays

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

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

Touch Buttons: Keys and Sliders

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

- Longer battery life with eXtreme Low Power MCUs
- Sensing through metal, plastic or glass
- High noise immunity and low emissions
- Free mTouch sensing solutions software library is available as part of legacy MLA software

Development Tools

LCD Explorer XLP Development Board (DM240314)

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

PIC24FJ256DA210 Development Kit (DV164039)

This kit bundles the PIC24FJ-256DA210 Development Board (DM240312), a 3.2" Truly 240 × 320 TFT Display Board (AC164127-4), three Graphics Display Prototype Boards (AC164139), the MPLAB ICD 3 Debugger (DV164035) and also includes a USB cable and accessories.

Software and Application 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. It is available at www.microchip.com/MLA.

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

Visual Graphics Display Designer (SW500190)

Visual Graphics Display Designer (VGDD) by VirtualFab is a powerful visual design tool that provides a quick and easy way of creating Graphical User Interface (GUI) screens. This development environment fully utilizes the Microchip graphics library in MLA as well as Microchip's graphics development boards.

Application Notes

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

Connectivity for PIC24 and dsPIC DSC Families


Connectivity

Whether the application demands wired or wireless connectivity, PIC24 MCUs and dsPIC33 DSCs support a wide variety of communication protocols. These 16-bit devices include a wide range of integrated wired communication peripherals such as CAN, LIN, SENT and USB. It is also easy to couple the devices with Microchip's Bluetooth, Wi-Fi and LoRa modules for wireless connectivity.

Integrated Wired Communication

CAN

Numerous dsPIC DSCs and PIC24 MCUs include an integrated CAN peripheral which is ideal for applications requiring robust and high-speed communication supporting:

- CAN 2.0B compliance
- Vector CANbedded™ and osCAN™ development solutions

SENT

The dsPIC33EV family features SENT for point-to-point transmission of sensor values in automotive applications. Development tools to enable this connectivity in your designs include:

- dsPIC33EV 5V CAN-LIN Starter Kit (DM330018) supporting CAN, LIN and SENT interfaces
- CAN/LIN PICtail™ Plus Daughter Board (AC164130-2) for Explorer 16/32 Development Board

PMBus™

The PMBus protocol standard operates over an I^2C physical later to enable easy digital management of power supplies. The latest dsPIC33 "GS" family supports the PMBus protocol along with many other dsPIC DSCs and PIC24 MCUs. A PMBus stack is available for free for use with dsPIC DSCs.

LIN

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

IrDA®

The IrDA standard is an inexpensive method for providing wireless point-to-point communication. Microchip's free IrDA stack is available through Application Note AN1071 for 16-bit MCUs with integrated IrDA support.

USB

There are several PIC24 MCU and dsPIC DSC families with integrated USB which include support for device, host and On-The-GO (OTG) functionality. Development tools include:

- dsPIC DSC USB Starter Kit (DM330012)
- Explorer 16/32 Development Board (DM240001-3)
- Several USB processor plug-in modules

Microchip's free USB stack framework includes USB software libraries with a comprehensive set of host and device drivers including Human Interface Device (HID), Mass Storage Device (MSD), CDC, PHDC, custom, audio, printer and demo code including thumb drive bootloader and printer host.

Wireless Communication

Microchip offers a wide range of wireless modules for Wi-Fi, Bluetooth, Bluetooth Low Enery (BLE), LoRa and various personal area networks. These modules allow quick and seamless addition of wireless connectivity to the applications. The certified modules allow you to bypass costly, time-consuming RF design and regulatory certifications to get your designs to market faster. For wireless sensors and battery-operated applications, the PIC24F XLP MCUs are ideal companions to Microchip's BLE and LoRa modules, creating low-power wireless networks. Together these devices make it easy to add internet connection to your applications.

- AN1861: Bluetooth Smart Communication Using Microchip's RN4020 and PIC24F XLP MCU

PIC24 MCUs and dsPIC33 DSCs support a range of wired and wireless communication protocols. Many of these communication libraries, such as USB and Wi-Fi, are integrated into the Microchip Libraries for Applications (MLA) and can be downloaded at www.microchip.com/MLA.

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
- 5V, 70 MIPS dsPIC DSC core for harsh environments
- High-performance on-chip op amps
- Integrated, high-speed ADC
- Algorithms and application notes for
  - BLDC, PMSM, ACIM
  - Sensorless control
  - Field-oriented control
  - Certified class B safety software
- Dual motor control with FOC control for each motor
- Multiple package options, ranging from 28 to 144 pins
- Scalable motor control tools with low- and high-voltage options
- Motor control PWM: up to 14 outputs
  - Up to seven duty cycle generators
  - Independent or complementary mode
  - Programmable dead time settings
  - Edge- or center-aligned PWMs
  - Manual output override control, up to 10 fault inputs
  - ADC samples triggered by PWM module
- Quadrature Encoder Interface (QEI) module
  - Up to two modules
  - Phase A, Phase B and index pulse input
- High current sink/source

Software and Application Notes

Motor Type	Algorithm	App Note
Stepper Motor	Closed-Loop Microstepping	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	Operating Voltage (V)	MIPS	Pins	Flash (KB)	RAM (KB)	DMA Ch.	Input Capture	Output Compare/ Std. PWM	MC PWM	QEI	Internal Op Amps	ADC 10/ 12-bit 1.1/ 0.5 MSPS	UART
dsPIC33EP512GM710	3.3	70	100/121	128–512	16–48	4	8	8	12 ch	2	4	2/49 ch	4
dsPIC33EP512GM706	3.3	70	64	128–512	16–48	4	8	8	12 ch	2	4	2/30 ch	4
dsPIC33EP512GM604	3.3	70	44	128–512	16–48	4	8	8	12 ch	2	4	2/18 ch	4
dsPIC33EP512MC506	3.3	70	64	32–512	4–48	4	4	4	6 ch	1	3	1/16 ch	2
dsPIC33EP512MC504	3.3	70	44	32–512	4–48	4	4	4	6 ch	1	3	1/9 ch	2
dsPIC33EP512MC502	3.3	70	28	32–512	4–48	4	4	4	6 ch	1	3	1/6 ch	2
dsPIC33EV256MC106	5	70	64	32–256	4–16	4	4	4	6 ch	0	4	1/36 ch	2
dsPIC33EV256MC104	5	70	44	32–256	4–16	4	4	4	6 ch	0	4	1/24 ch	2
dsPIC33EV256MC102	5	70	28	32–256	4–16	4	4	4	6 ch	0	3	1/11 ch	2

Development with Simulink®

Microchip offers a rapid prototyping solution that allows compiling and flashing a Simulink model of a motor control system into a dsPIC DSC with a single push of a button. The Simulink blocksets and models are supported by Microchip's devices and development boards for a complete hardware and software motor control solution. Together this will make prototyping your next motor control design easier. Follow these steps to simplify your motor control development.

1. Have MPLAB X IDE and Simulink tools on your computer
2. Build your Simulink model using Microchip's Simulink tools
3. Generate code using the Simulink embedded code generator and MATLAB plug-in for MPLAB X IDE
4. Compile the MPLAB X IDE project and load code onto target motor control development board
5. Connect your board to your motor
6. Run your code to spin the motor

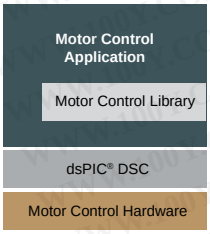
For further information, visit www.microchip.com/simplified.

Simulink Tools

- Motor Control Library Blockset
  - Simulation blocks and code generation for motor control algorithms.
- 16-bit Device Blocks for Simulink
  - Code generation blocks for dsPIC33 peripherals
- PMSM Simulink Motor Model
  - Used to simulate PMSMs in Simulink

Software Library

Motor Control Library for dsPIC33F/dsPIC33E



This library contains function blocks that are optimized for the dsPIC33F and dsPIC33E DSC families. All functions in this Motor Control Library have input(s) and output(s), but do not access any of the DSC peripherals. The library functions are designed to be used within an application framework for realizing an efficient and flexible way of implementing a motor control application.

motorBench™ Development Suite

The motorBench Development Suite is an advanced GUI-based software development tool for motor control capable of performing accurate measurement of critical motor parameters and automatic tuning of feedback control gains for dsPIC33EP DSCs. For information, visit www.microchip.com/motorBench.

Motors

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

- AC300020: 24V BLDC Motor
- AC300022: 24V BLDC Motor with Shaft Encoder
- AC300023: 220V, AC Induction Motor

Hardware Development Boards

Motor Control Starter Kit (MCSK) (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, an on-board BLDC motor, a user-configurable switch and an mTouch sensing slider with LED indicators for speed control.

dsPICDEM™ MCLV-2 Development Board (DM330021-2)

This board provides a cost-effective method of evaluating and developing sensored or sensorless BLDC motor and PMSM control applications. It supports Microchip's 100-pin PIM with dsPIC33E or dsPIC33F DSCs and internal, on-chip op amps found on certain dsPIC DSCs or the external op amps found on the MCLV-2 board. A dsPIC33EP256MC506 Internal Op Amp PIM (MA330031) is included. The board is capable of controlling motors rated up to 48V and 15A, with multiple communication channels.

dsPICDEM MCHV-2 Development System (DM330023-2)

This high-voltage development system is targeted to control BLDC motors, PMSM and AC Induction Motors (ACIM) in sensor or sensorless operation. The rated continuous output current from the inverter is 6.5 A (RMS), allowing up to approximately 2 kVA output when running from a 208V to 230V single-phase input voltage.

Low-Voltage Motor Control Development Bundle (DV330100)

This bundle provides a cost-effective method of evaluating and developing dual/single motor control to drive BLDC motors or PMSMs concurrently or one of each. The dsPIC DSC Signal Board supports both 3.3V and 5V operated devices for various applications and frequently used human interface features along with the communication ports. The Motor Control 10–24V Driver Board (Dual/Single) supports currents up to 10A.

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
- High-resolution PWMs for digital power
  - 1 ns for duty cycle, phase shift, period and dead time
  - Flexibility to control numerous power topologies
- Live update features
  - Update all of the firmware in an operating power supply while maintaining continuous regulation
- Very fast ADCs optimized for digital power applications
- Complete reference designs and algorithms including:
  - 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
- Broad range of package sizes and types
  - 18–100 pins, as small as 4 × 4 mm
  - Robust packages to ease IPC-9592B qualification

Software and Application Notes

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

Featured Digital Power Products

Product	Pins	Flash (KB)	RAM (Bytes)	IC/OC	PS PWM	ADC	Analog Amps	Analog Compare	UART/I²C/SPI	CAN
dsPIC33EP128GS808	80	128	8	4/4	16	22 × 12-bit, 5 S/H	2	4	2/2/3	2
dsPIC33FJ64GS610	100	64	9 K	4/4	18	24 × 10-bit, 6 S/H	0	4	2/2/2	1
dsPIC33EP64GS506	64	64	8 K	4/4	10	22 × 12-bit, 5 S/H	2	4	2/2/2	0
dsPIC33FJ16GS504	44	16	2 K	2/2	8	12 × 10-bit, 6 S/H	0	4	1/1/1	0
dsPIC33EP32GS504	44	32	4 K	4/4	10	19 × 12-bit, 5 S/H	2	4	2/2/2	0
dsPIC33FJ09GS302	28/36	9	1 K	1/1	6	8 × 10-bit, 3 S/H	0	2	1/1/1	0
dsPIC33EP64GS502	28	64	8 K	4/4	10	12 × 12-bit, 5 S/H	2	4	2/2/2	0
dsPIC33EP32GS202	28	16	2 K	1/1	6	12 × 12-bit, 3 S/H	2	2	1/1/1	0
dsPIC33FJ06GS001	18/20	6	256	0/0	4	6 × 10-bit, 2 S/H	0	2	0/1/0	0

Digital Power and Lighting Development Solutions

Reference Designs

Platinum Rated 720W AC/DC Reference Design

This reference design demonstrates the flexibility of dsPIC DSCs 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.

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

This reference design provides an easy method to evaluate the power and features of the SMPS dsPIC DSCs for IPFC applications. It features a universal input voltage range and produces a single high-voltage DC output up to 350W with low Total Harmonid Distortion (THD) of the input current.

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

This reference design demonstrates how digital power techniques applied to UPS applications enable easy modifications through software and allow for the use of smaller magnetics, higher efficiency and reduction in audible and electrical noise via a purer sine-wave output, USB communication and reduce cost.

Grid Connected Solar Micro Inverter Reference Design

This reference design demonstrates maximum power point tracking for PV panel voltages between 20–45V DC and has a maximum output power of 215 W. High efficiency is achieved by implementing a novel interleaved active-clamp flyback topology with Zero Voltage Switching (ZVS).

Development Boards

MPLAB Starter Kit for Digital Power (DM330017-2)

This kit uses the dsPIC33EP64GS502 DSC to implement a buck converter and a boost converter. Each can drive its on-board MOSFET controlled resistive load or an external load. The board has an LCD for showing voltage, current, temperature and fault conditions, and an integrated programmer/debugger.

Tools and Libraries

Digital Compensator Design Tool (DCDT)

Use this free MPLAB X IDE plug-in to calculate optimum compensator coefficients for maximum performance, with support for five common compensator types. Use this plug-in to analyze system response as well as stability.

SMPS Compensator Library

This library includes optimized functions for the dsPIC33 family of DSCs implementing common compensator algorithms such as 2P2Z, 3P3Z and PID to realize an efficient way of implementing the control of an SMPS application.

The above tools can be downloaded from www.microchip.com/dsPIC33EP-GS.

Robust 3V Operation

With operating voltages as low as 1.8V and up to 3.6V, PIC24 MCUs and dsPIC33 DSCs ensure robust operation such as:

- POR/BOR/Watchdog Timer (WDT)
- Support for temperatures up to 150°C
- AEC-Q100 Grade 0 qualification for automotive applications

Enhanced Robustness with 5V Operation

Microchip's PIC24 MCU and dsPIC33 DSC portfolios include families that operate up to 5V for increased noise immunity and robustness. Devices with 5V operation provide more dynamic range for signals and improved sensitivity. The 5V devices include additional features to ensure robust operation such as:

- Backup system oscillator
- Windowed watchdog timer (WWDT)
- PWM with fault detection
- Support for temperatures up to 150°C
- AEC-Q100 Grade 0 qualification for automotive applications

Families with 5V Operation	Flash	Pins
dsPIC33 "EV" DSC Family	32–256 KB	28–64
PIC24F "KM" and "KA" MCU Family	8–32 KB	20–44

Extreme Temperatures and AEC-Q100 Qualification

A variety of devices are also rated for operation up to 125°C or 150°C ambient temperature for the most extreme automotive and industrial applications, including AEC-Q100 Grade 0 qualification. Some target applications require operation in extreme environmental conditions. PIC24 MCUs and dsPIC33 DSCs have options for standard (85°C), extended temperature (125°C) and even high temperature up to 150°C.

For automotive applications, our products support AEC-Q100 Grade 0 level qualification for 150°C support, especially helpful for under-the-hood systems. Fore more information, visit www.microchip.com/hightemp.

Temperature Ranges	Range	Part Number Suffix
Standard	–40 to 85°C	-I
Extended	–40 to 125°C	-E
High	–40 to 150°C	-H

Safety Critical Applications and Class B Certification

PIC24 MCUs and dsPIC33 DSCs include integrated safety features to ease implementation of IEC 60730 compliance for Class B safety.

The CRC provides a memory integrity check and devices also include memory error correction. In addition, dsPIC33 devices with Error-Correcting Code (ECC) include 2-bit error detection and single-bit error correction for enhanced reliability, completely transparent and real-time implementation.

The memory also has read/write protection capability to protect sections of memory from code flow changes or interrupt vectors. You can establish zones that have different permissions, and you can define secure areas that should not be entered without the proper permissions.

Products include a backup system oscillator for system redundancy as well as clock-fail detection. A windowed watchdog timer will detect and reset the MCU in event of code execution error, with a dedicated clock source independent of the system clock. A Dead-Man Timer (DMT), clocked from the main system clock, is useful for detecting and recovering software malfunctions. The PWMs include fault detection features and the CPU includes trap instructions and illegal opcode detection.

The UL and VDE certified Class B software stack helps to simplify IEC 60730 regulatory compliance. This library routines integrate into the MCU application to test and verify the critical functionalities without affecting the end application. For more information, visit www.microchip.com/16bitfunctionalsafety.

Robust Package Options for IPC-9592B

Some dsPIC33 "GS" devices are available with robust package options to help with operation in extremely noisy environments. These packages make it easier to achieve IPC-9592B qualification. Options include a 28-pin µQFN (4 × 4 mm) or 28-pin µQFN (6 × 6 mm). These package options are designed to withstand temperature cycling as defined in IPC-9592B with over 700 cycles of –40°C/+125°C on thick high-layer count PCBs.

Development and Evaluation Tools

A variety of hardware development boards are available for the PIC24 and dsPIC33 products, enabling you to shorten your design cycle and quickly develop prototypes. These boards are designed to allow easy connectivity to an MPLAB ICD 3 In-Circuit Debugger, MPLAB REAL ICE In-Circuit Emulator or MPLAB PM3 device programmer. Several boards also include integrated debugger and programmers. When combined with the MPLAB X IDE and the MPLAB XC16 Compiler, these development boards and starter kits allow you to quickly gain knowledge and experience using Microchip's 16-bit MCU and dsPIC DSC products.

Photo	Tool	Part Number	Description
	**Explorer 16/32 Development Board**	DM240001-2 (stand-alone board) DM240001-3 (board with PIMs and cables)	The new Explorer 16/32 Development Board is a modular development system supporting PIC24, dsPIC33 and PIC32 devices. The board comes with several new features including an integrated programmer/debugger, on-board USB communication and USB-to-serial communication bridge. The board's wide ecosystem includes mikroBUS™, Pmod and PICtail™ Plus interfaces that support Click™ boards, Pmod boards and PICtail Plus daughter cards. Full documentation is available at www.microchip.com/Explorer1632.
	**PIC24F Curiosity Development Board**	DM240004	The PIC24F Curiosity Development Board is a cost-effective, fully integrated, feature-rich, rapid prototyping platform featuring the PIC24FJ128GA204 XLP MCU. The board serves as the perfect platform to harness the power of 16-bit PIC24 MCUs.
	**PIC32MM Curiosity Development Board**	DM320101	The PIC32MM Curisoity Development Board features the XLP PIC32MM "GPL" family (PIC32MM0064GPL036) of low-cost MCUs. This board is a simple and easy-to-use platform that facilitates quick evaluation, experimentation and prototyping. The board also includes an integrated programmer/debugger and offers seamless integration with MPLAB® X IDE and MPLAB Code Configurator for easy set up and development.
	**Intelligent Analog PIC24 Starter Kit**	DM240015	This starter kit features the PIC24FJ128GC010 family with advanced integrated analog peripherals. The board includes an analog header, allowing clean signals to be accessed for easy prototyping. The board also includes sensors for light, touch and temperature as well as USB, potentiometer, microphone and headphone interface. Comprehensive demos are included as well as integrated programmer and debugger.
	**LCD Explorer XLP Development Board**	DM240314	This development board supports 100-pin PIC® MCUs with eight common segmented LCD drivers. It ships with the PIC24FJ128GA310 and other families can be evaluated with different processor PIMs. In addition to the display, the board includes a PICtail Plus connector for daughter cards. It can be powered from USB, battery or 9V power supply, and includes V_{BAT} battery back-up.
	**dsPIC33EV 5V CAN-LIN Starter Kit**	DM330018	This USB-powered starter kit features the dsPIC33EV256GM106 with connections for CAN, LIN and SENT, as well as integrated programmer and debugger.
	**dsPIC33E USB Starter Kit**	DM330012	This starter kit includes integrated programmer and debugger and expansion capability with the Multimedia Expansion Board or I/O Expansion Board. It comes with preloaded demonstration software to allow you to explore the features of the dsPIC33E DSC family including USB communication.
	**Motor Control Starter Kit**	DM330015	This board includes a small 3-phase BLDC motor driven by dsPIC33FJ16MC102 motor control device and integrated programmer and debugger, powered by 9V power supply. This is a low-cost way to evaluate the motor control features on the dsPIC33 family and comes with full source code based on Application Note AN1160: *Sensorless BLCD Control with Back-EMF Filtering Using a Majority Function*.
	**Digital Power Starter Kit**	DM330017-2	This board includes the dsPIC33EP64GS502 digital power conversion device to implement a DC/DC synchronous buck converter power stage and boost converter power stage. Each power stage includes a MOSFET controlled 5 W resistive load. The board includes a display for voltage, current, temperature and fault conditions and integrated programmer and debugger, all powered by 9V power supply.
	**Graphics PIC24FJ256DA210 Development Board**	DM240312	This graphics development board is for developing colorful graphics displays with the PIC24FJ256DA210 family. The board includes touch pads, USB and a PICtail Plus connector for daughter cards. Match this board with your desired display size; it easily connects to the 3.2" Truly TFT Display (AC164127-4) or 4.3" Powertip TFT Display (AC164127-6) or Display Prototype Board (AC164139).

Software Libraries and Tools

Software libraries, code examples and application notes are available to support the PIC24 MCUs and dsPIC33 DSCs. The table below includes some of the most popular software libraries and tools that help you jump start your application development.

Software	Description	Location
16-bit CPU Self-Test Library	The 16-bit CPU Self-Test Library allows you to verify during run-time, that all CPU core features are functioning correctly.	www.microchip.com/libraries
Bootloaders	Several application notes and code examples exist to help with your bootloader applications. • Easy Bootloader for PIC24 and dsPIC33 (EZBL) software library and example projects for UART and I²C • AN1094 describes UART-based bootloader with command line interface for dsPIC30F, dsPIC33F and PIC24FJ and PIC24H • AN1157 describes PIC24F family and includes a GUI for quick programming • CE417 code example for dsPIC33EP with aux Flash • USB bootloader included in the MLA USB stack	www.microchip.com/ezbl AN1094 AN1157 CE417
Class B Safety Software Library	Microchip has developed a library of low-level software routines that simplify meeting IEC 60730 requirements for Class B safety. Includes CPU register test, program counter test, variable memory test, Flash memory test and clock test. Certified by VBE.	www.microchip.com/16bitfunctionalsafety AN1778
Code Examples	Hundreds of code examples to help you set-up peripherals and functions, sorted by product family: • PIC24E and dsPIC33E code examples = CE4XX • PIC24F code examples = CE3XX • PIC24H code examples = CE2XX • dsPIC33F code examples = CE1XX • dsPIC30 code examples = CE0XX	www.microchip.com/codeexamples
Data EEPROM Emulation	For devices that do not have on-chip EEPROM, this algorithm increases endurance when emulating EEPROM with an on-chip Flash memory.	AN1095
Digital Filter Design	The Digital Filter Design Tool makes designing and analyzing FIR and IIR filters easy. When the user enters frequency specifications, the tool automatically generates the filter code and coefficients. Graphical output windows provide the desired filter's characteristics.	www.microchip.com/SW300001
Digital Power	Several software libraries and tools are available for digital power applications. • Includes Digital Power Compensator Libraries, optimized for dsPIC33 "GS" devices • Digital Compensator Design Tool (DCDT) helps calculate compensator coefficients for maximum performance • PMBus™ stack implements the PMBus protocol over I²C communication interface	www.microchip.com/dcdt www.microchip.com/power
dsPICworks Data Analysis	dsPICworks Data Analysis allows you to evaluate and analyze DSP algorithms in both time and frequency domains. Includes signal generation and DSP functions such as FFT or DCT.	www.microchip.com/SW300021
Embedded Code Source	Embedded Code Source is a collection of code, tools and utilities from Microchip and third party developers to help speed your design.	www.embeddedcodesource.com
Fixed Point Math Library for PIC24 MCUs and dsPIC® DSCs	This software library provides a set of speed-optimized functions for the most common digital signal processing applications. The I/Q math library includes over 65 general-purpose functions composed of 28 functions support Q15 math and 37 functions supporting Q16 math.	www.microchip.com/libraries
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 XC16 Compiler. It contains advanced single- and double-precision floating-point arithmetic and trigonometric functions from the standard C header file <math.h>.	www.microchip.com/libraries
Motor Control	This library includes the Motor Control Library for 3-phase control as well as MATLAB Simulink® Blockset and motor models, tuning guides, application notes and code examples.	www.microchip.com/motor
motorBench™ Development Suite	This tool identifies the electrical and mechanical parameters of a motor and then automatically tunes the current and speed control loops. Version 1.0 works with: • Low-voltage development board (MCLV-2; DM330021-2) • Permanent magnet synchronous motor (AC300022) Lookout for future releases supporting additional development baords and motors.	www.microchip.com/motorBench
Microchip Libraries for Applications (MLA)	MLA includes source code, drivers, demos, documentation and utilities. All PIC24 MCUs and dsPIC33 DSCs are supported. • USB – including device, host and OTG support • Graphics – including pre-made graphics objects, fonts, languages, images and display drivers • File I/O Memory Disk Drive – share portable memory devices between embedded system and PC • Crypto Software – including AES, DES, 3DES, MD5, SHA-1, SHA-2 • Smart Card • MiWi™ Wireless Networking Protocol • TCP/IP for Wi-Fi® Legacy versions of MLA are archived and also include support for TCP/IP with Ethernet, touch or accessory framework for Android™.	www.microchip.com/mla
XLP Battery Life Estimator	This library 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.	www.microchip.com/xlp

MPLAB X IDE

Universal and Integrated Tool Set

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

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 IDE is flexible and friendly enough for new users.

Open-Source Platform

Based on the NetBeans™ Platform, MPLAB X IDE supports a host of free software components and plug-ins from the NetBeans community for high-performance application development customized to your needs.

Cross-Platform

You can run your favorite toolset and develop your next embedded application on Windows®, Linux® or Mac OS® X.

MPLAB Xpress: Cloud-Based IDE

MPLAB Xpress Cloud-Based IDE is a free online development environment that contains the most popular features of our award-winning MPLAB X IDE. This simplified and distilled application is a faithful reproduction of our desktop-based program, which allows you to easily transition between the two environments. MPLAB Xpress is a perfect starting point for new users of PIC MCUs—no downloads, no machine configuration and no waiting to get started on your system development. To learn further and start using the IDE in your designs, visit www.microchip.com/Xpress.

- MPLAB Code Configurator: GUI-based code generation
- Library of Microchip-validated code examples to get you started
- Integrated MPLAB XC 16 Compiler
- MPLAB Xpress Community to share code, ideas, and knowledge
- Support for PICkit™ 3
- Supporting all PIC24F and dsPIC33EP devices

MPLAB Code Configurator (MCC)

The MPLAB Code Configurator is a free graphical programming environment that generates seamless, easy-to-understand C code that is inserted into your project. Using an intuitive interface it enables and configures a rich set of peripherals and functions. It is integrated into MPLAB X IDE to provide a powerful and easy-to-use development platform. MCC supports 8-, 16- and 32-bit PIC MCUs, including PIC24 and dsPIC33 families. New products are supported in every release. MCC offers a simple graphical representation of the selected microcontroller allowing designers to quickly configure the peripherals and pins. MCC generates function and peripheral drivers in seamless easy-to-understand C code for flexibility and portability. MCC supports independent library, device and module development. Devices, off-chip peripherals and libraries can now be independently developed and added to MCC at any point of time during product design cycle based on the need and facilitates easy upgradability. For more information, please visit www.microchip.com/mcc.

MPLAB XC16 Compiler for PIC24 MCUs and dsPIC DSCs

The MPLAB XC16 Compiler includes a complete ANSI C standard library, including string manipulation, dynamic memory allocation, data conversion, timekeeping and math libraries with a 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 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 powerful code generation tool.

Compare 16-bit Families

Features	PIC24 Families			dsPIC® DSC Families		
	PIC24 "F"	PIC24 "H"	PIC24 "E"	dsPIC33 "F"	dsPIC33 "EP"	dsPIC33"EV"
Description	Low cost, lowest power, general purpose	High performance, general purpose	High performance, general purpose and motor control	16-bit DSCs: General Purpose	High performance and integrated op amps	5V operation, enhanced noise immunity and robustness in harsh environments
Performance, Pins and Memory						
MIPS	16 MIPS	40 MIPS	70 MIPS	50 MIPS	70 MIPS	70 MIPS
Pins	14–121	18–100	28–144	18–100	28–144	28–64
Flash Memory (KB)	4–1024	12–256	32–512	6–256	16–512	64–256
SRAM (KB)	0.5–96	1–16	4–53	0.25–30	2–53	8–16
DMA	✓	✓	✓	✓	✓	✓
Integrated Analog						
ADC	10-bit @ 500 ksps 12-bit @ 200 ksps 16-bit Delta-Sigma 12-bit @ 10 Msps	10-bit @ 1100 ksps 12-bit @ 500 ksps	10-bit @ 1100 ksps 12-bit @ 500 ksps	10-bit @ 1100 ksps 12-bit @ 500 ksps 10-bit @ 2 Msps	10-bit @ 1100 ksps 12-bit @ 500 ksps 12-bit @ 3.25 Msps	10-bit @ 1100 ksps 12-bit @ 500 ksps
DAC	✓	✓	✓	✓	✓	✓
Comparators	✓	✓	✓	✓	✓	✓
Op Amps and PGAs	✓	–	✓	–	✓	✓
Wired Communications						
UART with LIN and IrDA®	✓	✓	✓	✓	✓	✓
SPI	✓	✓	✓	✓	✓	✓
I²C	✓	✓	✓	✓	✓	✓
USB - Device, Host, OTG	✓	–	✓	–	✓	–
CAN	–	✓	✓	✓	✓	✓
SENT	–	–	✓	–	–	✓
Parallel Master Port (PMP)	✓	✓	✓	✓	✓	–
Clocks and Timers						
16-bit and 32-bit Timers	✓	✓	✓	✓	✓	✓
RTCC - Clock, Calendar, Alarm	✓	–	✓	✓	–	–
Waveform Control						
Input Capture	✓	✓	✓	✓	✓	✓
Output Compare	✓	✓	✓	✓	✓	✓
16-bit PWM	✓	✓	✓	✓	✓	✓
Multiple-Output Capture Compare PWM (MCCP) and Single-Outputs CCP (SCCP)	✓	–	–	–	–	–
Motor Control						
Motor Control PWM with Flexible Modes	✓	–	✓	✓	✓	✓
ADC Triggered by PWM Modules	✓	–	✓	✓	✓	✓
Quadrature Encoder Interface (QEI)	–	–	✓	✓	✓	–
Digital Power						
ADCs with Multi-Million sps	–	–	–	✓	✓	–
Power Conversion PWM with 1 ns Resolution	–	–	–	✓	✓	–
Comparators with 25 ns speed	–	–	–	✓	✓	–
Safety and Monitoring						
BOR, LVD, POR, WDT	✓	✓	✓	✓	✓	✓
Windowed WDT	–	✓	✓	✓	✓	✓
Deadman Timer (DMT)	–	–	–	–	–	✓
CRC - Flash, RAM and SFR	✓	✓	✓	✓	✓	–
Class B Features	✓	✓	✓	✓	✓	✓
User Interface						
Segmented LCD Driver	✓	–	–	–	–	–
Graphical Display Driver	✓	–	–	–	–	–
Charge Time Measurement Unit (CTMU)	✓	–	✓	✓	✓	✓
Secure Data						
Crypto Engine with AES-256	✓	–	–	–	–	–
Random Number Generator (RNG)	✓	–	–	–	–	–
Secure Key Storage	✓	–	–	–	–	–
System Flexibility						
eXtreme Low Power (XLP)	✓	–	–	–	–	–
V_{BAT}	✓	–	–	–	–	–
Configurable Logic Cells (CLC)	✓	–	–	–	–	–
Peripheral Trigger Generator (PTG)	–	–	✓	–	✓	–
Unique Device ID	✓	–	–	–	✓	–
Peripheral Pin Select (PPS)	✓	✓	✓	✓	✓	✓

16-bit Packages


20-lead QFN (ML)
4 × 4 × 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 × 0.9 mm
(Lead Pitch: 0.5 mm)


28-lead UQFN (M6)
4 × 4 × 0.55 mm
(Lead Pitch: 0.4 mm)


28-lead UQFN (MX)
6 × 6 × 0.5 mm
(Lead Pitch: 0.4 mm)


36-lead VQFN (M2)
6 × 6 × 0.9 mm
(Lead Pitch: 0.4 mm)


40-lead UQFN (MV)
5 × 5 × 0.5 mm
(Lead Pitch: 0.4 mm)


48-lead UQFN (MV)
6 × 6 × 0.5 mm
(Lead Pitch: 0.4 mm)

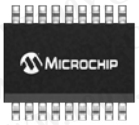

48-lead UQFN (M4)
6 × 6 × 0.5 mm
(Lead Pitch: 0.4 mm)

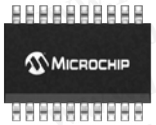

48-lead VQFN (ML)
7 × 7 × 0.9 mm
(Lead Pitch: 0.5 mm)

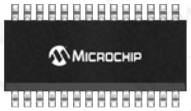

20-lead SSOP (SS)
7.2 × 5.3 × 1.85 mm
(Lead Pitch: 0.65 mm)


28-lead SSOP (SS)
10.2 × 5.3 × 2 mm
(Lead Pitch: 0.65 mm)


14-lead TSSOP (ST)
5.0 × 4.4 × 1.2 mm
(Lead Pitch: 0.65 mm)


18-lead SOIC (SO)
11.53 × 7.5 × 2.31 mm
(Lead Pitch: 1.27 mm)


20-lead SOIC (SO)
12.80 × 7.5 × 2.31 mm
(Lead Pitch: 1.27 mm)


28-lead SOIC (SO)
17.88 × 7.5 × 2.31 mm
(Lead Pitch: 1.27 mm)


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


48-lead TQFP (PT)
7 × 7 × 1 mm
(Lead Pitch: 0.5 mm)


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

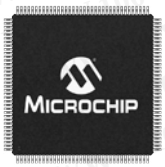

80-lead TQFP (PT)
12 × 12 × 1 mm
(Lead Pitch: 0.5 mm)


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

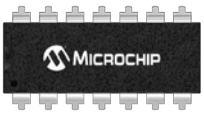

64-lead TQFP (PF)
14 × 14 × 1 mm
(Lead Pitch: 0.8 mm)

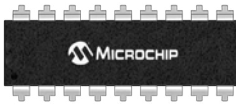

80-lead TQFP (PF)
14 × 14 × 1 mm
(Lead Pitch: 0.65 mm)

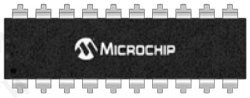

100-lead TQFP (PF)
14 × 14 × 1 mm
(Lead Pitch: 0.5 mm)


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

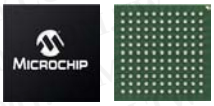

144-lead LQFP (PL)
20 × 20 × 1.4 mm
(Lead Pitch: 0.5 mm)


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)


Die/Wafer
(WLCSP)

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

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

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