



16-bit Embedded Control Solutions

PIC24 Microcontrollers • dsPIC® Digital Signal Controllers



Microchip's PIC24 Microcontrollers and dsPIC® Digital Signal Controllers

Microchip's PIC24 Microcontrollers (MCUs) and dsPIC® Digital Signal Controllers (DSCs) deliver more performance, low-power consumption, flexible peripherals and a complete development ecosystem of software and hardware tools to speed your development. With specialized offerings for motor control, digital power conversion, low-power security, advanced analog integration and functional safety, the 16-bit family offers a good balance between low cost, low power, high performance and robustness.

Microcontrollers for a Wide Range of Applications

Low-Power and General Embedded Applications – PIC24F MCUs

The PIC24F is a cost-effective, low-power family MCUs, featuring devices with eXtreme Low Power (XLP) technology, 16 MIPS performance and memory up to 1024 KB of Flash with a rich set of Core Independent Peripherals (CIPs). Our portfolio offers an upgrade in features and peripherals for applications that are pushing the boundaries of 8-bit MCU capabilities.

High Performance Embedded applications – dsPIC33 DSCs

The dsPIC33 Digital Signal Controllers (DSCs) accelerate Digital Signal Processor (DSP) performance for high-performance embedded applications. This family offers fast deterministic performance to address real-world design requirements. Offering up to 100 MIPS performance, the dsPIC33 family of DSCs is ideal for developing sophisticated real-time applications.

Motor Control Applications – dsPIC33 DSCs

The high-performance dsPIC33 DSCs feature a DSP engine for implementing high-efficiency, high-precision variable speed, constant torque PI control and Field Oriented Control (FOC) motor control. The dsPIC33 DSCs offer features such as:

- Dual independent cores offering performance up to 100 MIPS/core
- Integrated high-speed ADCs, Op-Amps, and Comparators for BoM cost reduction
- Up to 16 channel, high-resolution PWMs for two motor control and integrated PFC

Digital Power Conversion Applications – dsPIC33 DSCs

The high-performance dsPIC33 DSCs feature a DSP engine for very high-speed control loop execution in demanding power conversion applications. The dsPIC33 DSCs offer features like:

- Dual independent cores offering performance up to 100 MIPS/core, to separate time-critical control loops from housekeeping
- Tightly coupled PWM, high-speed ADCs, PGAs and CPU with fast and predictable interrupts
- High-resolution 250 pS PWMs with flexibility to control various power topologies
- Live update for real-time firmware upgrades in operating power supplies in servers with no downtime

With a high level of peripheral integration, the dsPIC33 family is ideal for industrial, automotive and consumer applications.

Robust and Safety Applications – PIC24 MCUs and dsPIC33 DSCs

The robust PIC24 MCUs and dsPIC33 DSCs feature dedicated peripherals and functions to help increase the reliability in safety-critical applications. These features facilitate to ensure end applications operate as intended, with safe shut down if any exception or issue occurs. With AEC Q100 qualification, the PIC24 MCUs and dsPIC33 DSCs offer 3V, 5V and up to 150°C operations.

Simplifying 16-bit Microcontroller Designs

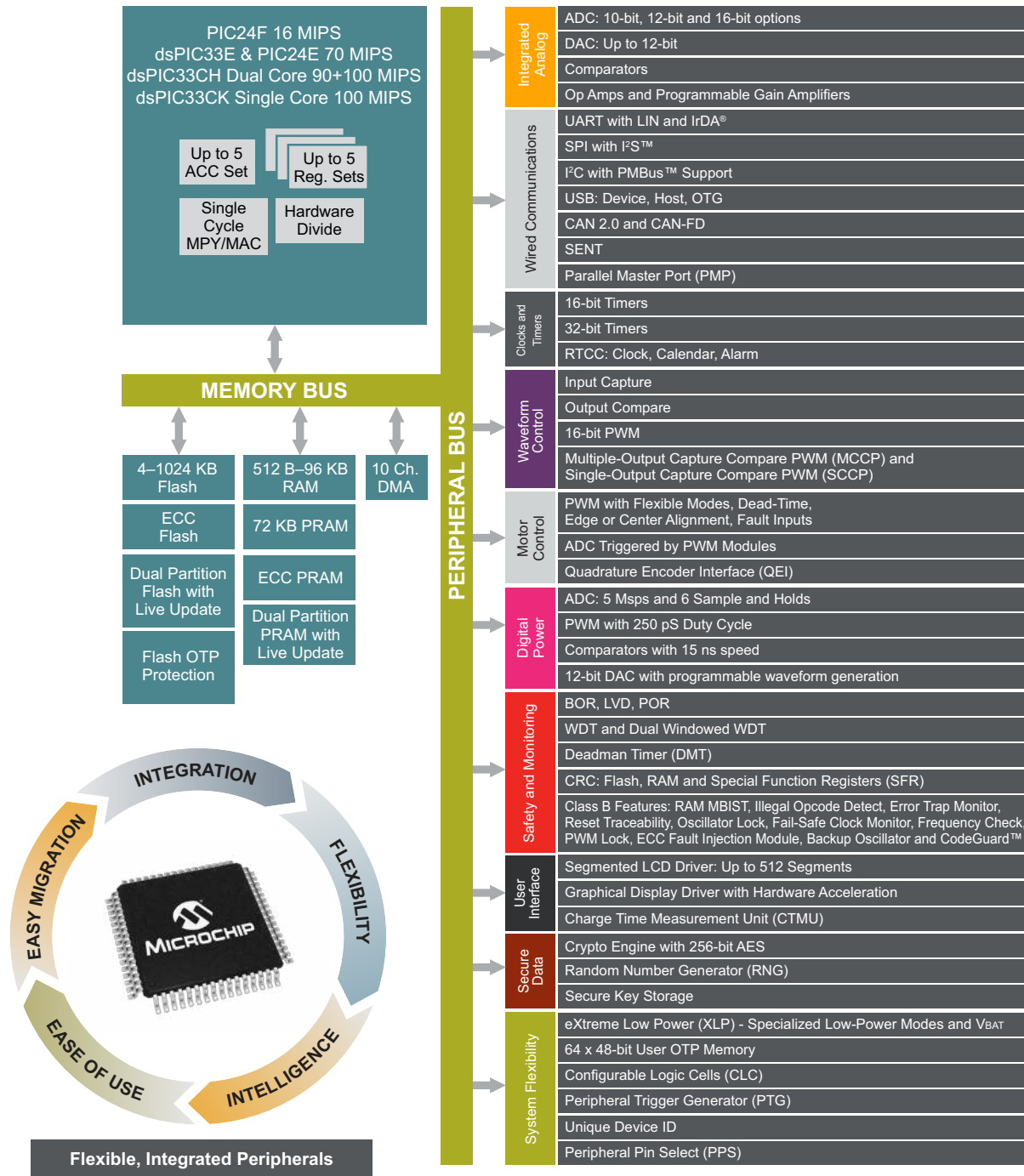
With a focus on reducing the time to market and minimizing the development risk, Microchip offers a complete ecosystem.

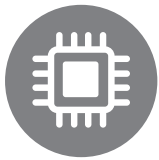
- MPLAB® X IDE and XC16 compilers
 - Single platform across all 16-bit MCUs and DSCs
- MPLAB Code Configurator (MCC)
 - Enables prototyping in minutes
- Microchip-tested software for quick time to market
 - Bootloader, RTOS, USB, graphics, crypto, file I/O, Wi-Fi®, Class B safety stacks and DSP math libraries
- motorBench® development suite
 - Simplifies motor control designs
- Digital power design suite
 - Simplifies digital power designs
- Range of development boards
 - Cost-effective, rapid prototyping curiosity boards
 - Versatile explorer 16/32 development board
 - Motor control and digital power boards

Flexible Integrated Peripherals

Microchip offers a rich set of peripherals that help customers differentiate their end designs with real-time control and simple communication with other devices. The 16-bit family offers key communication and control peripherals like USB, SPI, UART, CAN-FD, I²C, PWM and Timers, as well as specialized peripherals for graphics, motor control and digital power. Integrated analog peripherals like high-performance ADCs, DACs, PGAs and op amps, simplify analog designs and reduce BoM cost. In addition, core independent peripherals such as CLC, PTG and cryptographic accelerators enable higher levels of integration and flexibility. With dedicated peripherals and features enabling functional safety, the 16-bit family is ideal for robust and safety critical applications. To get a quick view into the 16-bit family, visit www.microchip.com/16bitquickreference.

PIC24 and dsPIC33 Family Block Diagram





dsPIC33C Single Core and Dual Core Digital Signal Controllers

Motor control, digital power, safety-critical and high-performance embedded applications come with an array of design challenges. The high-performance 100 MIPS dsPIC33C family of DSCs featuring a Digital Signal Processing (DSP) engine, offers fast deterministic performance to address real-world design challenges. The dsPIC33CH family features dual independent cores to simplify and speed up the firmware development whereas, the dsPIC33CK family offers a cost-effective single-core option with the same high-performance core and peripherals. www.microchip.com/dsPIC33C



Precision Motor Control

The dsPIC33 motor control families feature a high-performance core with specialized motor control peripherals. The devices are supported with motor-tuning development tools, 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 Conversion

Intelligent power supply implementations solve problems in a wide range of applications, with power solutions implementing the most advanced digital control topologies. In such advanced designs, the digital controller integrate ADCs, digital control algorithms, and PWM generators to close the loop with firmware. The dsPIC33 DSCs are optimized for high performance on advanced algorithms for improved efficiency over widely varying load conditions. These devices feature dedicated peripherals such as fast ADCs, PGAs and PWMs for digital power conversion applications. www.microchip.com/power



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/lowpower



Driving Displays

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. These hardware peripherals are supported by free software libraries to quickly integrate the display functions into your application with a single MCU. www.microchip.com/graphics www.microchip.com/LCD



Smart Connected Secure

Microchip provides total system solutions for smart, connected and secure designs. These designs can leverage everything from our smart PIC24 MCUs and dsPIC33 DSCs with integrated analog, certified wired and wireless connectivity and state-of-the-art security solutions along with ready-to-use software and tools, partnerships with the largest cloud computing companies and world-class support. www.microchip.com/PIC-IoT



Robust and Safety

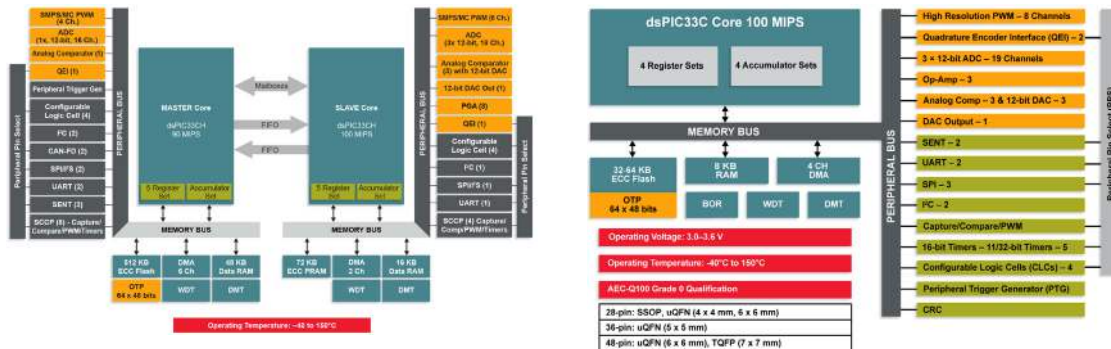
PIC24 MCUs and dsPIC33 DSCs operate up to 5V for increased noise immunity and robustness. Additionally, most of the devices are rated for operation up to 125°C or 150°C ambient temperature for the most extreme automotive and industrial applications, including AEC-Q100 Grade 0 qualification. Several hardware peripherals and functions have been integrated into PIC24 and dsPIC33 devices to help increase the reliability and redundancy for these applications. Offering a comprehensive ecosystem, Microchip's safety solution facilitates functional safety compliance of end applications. www.microchip.com/16bitFunctionalSafety

dsPIC33C Digital Signal Controllers

Scalable Dual- and Single-Core dsPIC33C Family

The dual-core dsPIC33CH DSCs have one core that is designed to function as master while the other is designed as a slave. The slave core can be used for executing dedicated, time-critical control code while the master core is busy running the user interface, system monitoring, and communications functions that are customized for your end application. The dsPIC33CH DSCs facilitate independent code development for each core by separate software teams and later enables seamless integration when the cores are brought together in one chip. If your design doesn't require the dual cores, the cost-effective, single-core dsPIC33CK family of DSCs offers the same high-performance core and peripherals as the dsPIC33CH family.

dsPIC33C – 100 MIPS		Dual-Core	Single-Core
		dsPIC33CH Family Up to 512 KB Flash	dsPIC33CK Family Up to 256 KB Flash
Digital Power	Motor Control	Digital Power	Motor Control



These products offer fast deterministic performance to address real-world design requirements such as high energy efficiency across variable load conditions in a power supply or controlling the precise speed and rotation of a motor. The dsPIC33C devices are optimized for high-performance digital power, motor control and other high-performance embedded applications implementing sophisticated algorithms. This includes applications such as wireless power, server power supplies, drones, automotive sensors and digital power solutions for electric vehicles (EVs).

dsPIC33C DSC Advantages

- Simplified firmware development with dual independent cores
- Dual cores and peripheral sets facilitate robust systems and improve functional safety
- Up to two CAN-FDs for robust communication with increased bandwidth
- Maximum analog integration including high-speed ADCs, DACs with waveform generation, analog comparators and PGAs
- Live Update of firmware for high-availability systems, especially important for power supplies
- Single core option with same high performance with dsPIC33CK family

Dual Core Use Cases

	Slave Core	Master Core
Digital Power	Closes control loop in firmware by running latency-critical compensator algorithms	Runs PMBus stack and system-level functions
Motor Control	Provides speed and torque control by executing time-sensitive control algorithms	Runs functional safety routines, CAN-FD stack and other system-level function
High Performance Embedded	Accelerates math intensive functions such as DSP filtering of sensor inputs	Facilitates reliability and fault tolerance for safety critical applications

Development Tools



dsPIC33CH Curiosity Development Board (DM330028-2)



dsPIC33CK Curiosity Development Board (DM330030)



dsPIC33C Digital Power Starter Kit (DM330017-3)



dsPIC33 Motor Control Products

- High-performance dsPIC33 DSC core with DSP instructions for precise control
 - Variable speed with constant torque using PI controllers
 - Field oriented control (FOC) for greater efficiency
- Dual core and single core dsPIC33C DSCs with up to 100 MIPS/core performance
 - Slave core provides speed and torque control by executing time-sensitive motor control algorithms
 - Master core runs functional safety routines, CAN-FD stack or other system-level functions
 - Design different functions separately and integrate them seamlessly
- High-performance on-chip op-amps and comparators
- High-speed ADCs enabling simultaneous sampling
- Algorithms and application notes for
 - BLDC, PMSM, IPMSM, ACIM
 - Sensorless control
 - Field-oriented control
- Dual motor control with FOC control for each motor
- Multiple package options, ranging from 28 to 144 pins
- Low- and high-voltage motor control tools
- Motor control PWM: up to 16 outputs
 - Up to eight 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) modules
 - Phase A, Phase B and index pulse input
- High current sink/source
- Features enabling functional safety for compliance

Software and Application Notes

Motor Type	Algorithm	App Note
Stepper Motor	Closed-Loop Microstepping	AN1307
	Sensored	AN957
BLDC, PMSM and IPMSM	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
	Sensorless Dual-Shunt FOC with SMO and PFC	AN1208
	Sensorless Field-Oriented Control of Permanent Magnet Synchronous Motor (Surface and Interior) for Appliances with Angle-Tracking Phase-Locked Loop Estimator	TB3220
	Open-Loop V/F	AN984
AC Induction Motor	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/PRAM (KB)	RAM (KB)	DMA Ch.	IC/OC/PWM/MCCP/SCCP	MC PWM	QEI	Int. Op Amps/PGAs	ADC Modules/Channels	UART
dsPIC33EP512GM710	3.3	70	44/64/100/121	128-512	16-48	4	8	12 ch	2	4	2/49 ch	4
dsPIC33EP512MC506	3.3	70	28/44/64	32-512	4-48	4	4	6 ch	1	3	1/16 ch	2
dsPIC33EV256GM106	5	70	28/36/48/64	32-256	4-16	4	4	6 ch	0	4	1/36 ch	2
dsPIC33CH512MP508	3.3	90+100	28/36/48/64/80	64-512/24-72	16+48	8	12	12 ch	2	3	3+1/18+16 ch	3
dsPIC33CK256MP508	3.3	100	28/36/48/64/80	32-256	8-24	4	9	16 ch	2	3	3/24 ch	4

Motor Control Development Solutions

Model-based Development with Simulink® and X2C

Microchip offers a rapid prototyping solution that allows compiling and flashing a simulation based model of a PMSM motor control system into a dsPIC33 DSC with a single push of a button using Simulink and X2C platforms. Microchip's dsPIC33EP devices are supported with block-sets for both Matlab/Simulink and X2C/COS.

1. Load MPLAB X IDE with the X2C Plug in, or the MATLAB Plug in and Simulink tools on your computer
2. Build your Simulink/X2C model
3. Generate code for dsPIC33 using the MATLAB or X2C code generator plugins for MPLAB X
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 on Simulink tools, visit www.microchip.com/simplified. To download SCILAB X2C for free, visit https://www.microchip.com/Scilab_XCOS_X2C

Aircon and Refrigerator Reference Designs

Our solutions help to develop a cost-effective design using a dsPIC33 Motor Control Digital Signal Controller. The design works with a wide variety of motors and implement advanced control techniques for achieving high energy efficiency and extending motor's lifespan.



www.microchip.com/refrigerator www.microchip.com/aircon

Hardware Development Boards



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

This board provides a cost-effective method of evaluating sensed or sensorless BLDC motor and PMSM control applications. It supports PIMs with dsPIC33 DSCs.



dsPICDEM MCHV-3 Development System (DM330023-3)

This high-voltage development system is targeted to control BLDC motors, PMSM and AC Induction Motors (ACIM) in sensor or sensorless operation. It includes a Power Factor Correction (PFC) circuitry.



dsPICDEM MCSM Development Board (DM330022-1)

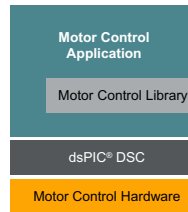
This board is targeted to control both unipolar and bipolar stepper motors in open-loop or closed-loop (current control) mode. The hardware is designed in such a way that no hardware changes are necessary for 8-, 6- or 4-wire stepper motors in either bipolar or unipolar configurations



Low-Power High-Voltage Motor Control Reference Design (LPHV-MC-BOARD)

This cost-effective high voltage reference design board is targeted to efficiently control ACIM, PMSM and BLDC Motors in sensed or sensorless operations at a low power of up to 150W.

Motor Control Library for dsPIC33



This library is a collection of optimized functions designed to be used in developing 3-phase Motor Control applications on the dsPIC Digital Signal Controllers. All functions have input(s) and output(s), but do not access any of the DSC peripherals. The user's motor control application

interfaces to the DSC peripherals while using function calls into this library to perform a majority of the time-critical operations.

Advanced FOC Feature

Microchip provides source code and implementation examples for advanced FOC features to solve application challenges and improve reliability by supporting algorithms like:

- Field weakening
- Wind milling
- Initial Position Detection
- Stall detection and recovery
- Maximum Torque Per Ampere (MTPA)
- Soft stop
- Voltage, Torque and DC bus compensation
- Over modulation
- Angle Tracking Phase Locked Loop (AT-PLL) estimator

Visit www.microchip.com/Advanced-FOC to learn more.

motorBench® Development Suite

The motorBench Development Suite is an advanced GUI-based software development tool for FOC motor control capable of performing accurate measurement of critical motor parameters and automatic tuning of feedback control gains for dsPIC33 DSCs. For information, visit www.microchip.com/motorBench.



dsPIC33 Digital Power Conversion 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
- Dual core and Single core dsPIC33C DSCs with up to 100 MIPS performance
 - Slave core implements control loop executing latency critical compensator algorithms
 - Master core runs PMBus stack and system-level functions
 - Design different functions separately and integrate them seamlessly
- High-resolution PWMs for digital power
 - 250 ps for duty cycle, phase shift, period and dead time for high switching frequency designs
 - Flexibility to control numerous power topologies
 - Configurable PWM Control Inputs for hardware response to external events that reduces control latency
- Live update features
 - Update all of the firmware without downtime
- Maximum analog integration including high-speed ADCs, DACs with waveform generation, comparators and PGAs
- 18–100 pins and packages as small as 4 × 4 mm
 - Robust packages to ease IPC-9592B qualification

Software and Application Notes

Application Solution	AN #	Description
Online Firmware Updates in Timing-Critical Applications	AN2601	Many applications require live firmware update feature with no downtime. This application note discusses how Live Update feature can be realized using Microchip's new 16-bit dsPIC33 and PIC24F controllers and associated compiler tools and Easy Bootloader library.
Power Factor Correction in Power Conversion Applications Using the dsPIC® DSC	AN1106	This application note focuses on the 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 pros and cons, applications. It also explained to guides you to select an appropriate topology for a given application, while providing useful information.
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 dsPIC DSC.
Digital Power Interleaved PFC	AN1278	The application note describes the design of a Digital Power Interleaved PFC (IPFC) using a dsPIC DSC.
Quarter Brick DC-DC Reference Design	AN1335	This application note describes the design of Quarter Brick DC-DC Reference Design using dsPIC DSC.
DC-DC LLC Resonant Converter	AN1336	This application note describes the design of DC-DC LLC Resonant Converter using dsPIC DSC.
Grid Connected Solar Microinverter	AN1338	This application note describes the design of Grid Connected Solar Microinverter Reference Design using dsPIC 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 CSC1 Platinum Specifications, as well as provides a variety of additional, application-specific features and functions.
Getting Started with Dual Core	AN2721	This application note explains how to develop and debug an application using Microchip's new dsPIC33CH Dual Core DSCs offering Master and Slave Cores with their dedicated sub-system and peripherals.

Featured Digital Power Products

Product	Pins	Flash/PRAM (KB)	RAM (KB)	IC/OC/MCCP/SCCP	PS PWM	ADC	Analog Amps	Analog Comparator	UART/I ² C/SPI	CAN/CAN-FD*
dsPIC33EP128GS808	28/44/48/64/80	128	8	4/4	16	22 × 12-bit, 5 S/H	2	4	2/2/3	2
dsPIC33CH512MP508	48/64/80	512/72	16 +48	8+4	8+4	18 × 12-bit, 5 S/H	3	4	3/3/3	2*
dsPIC33CK256MP508	28/36/48/64/80	256	24	9	16	24 × 12-bit	3	4	2/2/3	1*

Digital Power Development Solutions

Reference Designs



15W Wireless Power Demonstration Board

This demo board based on the dsPIC33 DSC, is compatible with Qi medium power receivers. The development board enables a system efficiency of about 80% at full load.



Microchip 15W Multi-Coil Wireless Power Transmitter

The Three Coil Wireless Power Transmitter is based on the dsPIC33CH128MP506 device and implements a fixed frequency power control topology. The transmitter includes CAN for ease of integration into the automotive environment. The transmitter also enables the implementation of NFC.



200W Wireless Power Reference Design

The 200W Wireless Power reference design implements a proprietary protocol developed from several years of R&D and granted U.S. patents in the field of wireless power. The 200W solution is ideal for applications such as power tools, vacuum robots, industrial slip rings, small electric vehicles and drones.



Vienna 3-Phase Power Factor Correction (PFC) Reference Design (SICPFC/REF5)

This reference design based on the dsPIC33CH dual-core digital signal controller, showcases solutions for Hybrid Electric Vehicle/Electric Vehicle (HEV/EV) charger and high-power switch mode power supply applications. It achieves 98.5% efficiency at 20 kW output power and is capable of operating up to 30 kW.



750W AC/DC Reference Design

This Reference Design demonstrates a semi-bridgeless PFC topology followed by a peak current controlled zero-voltage switching full-bridge (ZVS FB) converter with digital slope compensation to achieve very high conversion efficiencies. This design showcases live update of firmware.



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.



200W DC/DC LLC Resonant Converter Reference Design

This reference design operates over a wide input voltage range (350–420 VDC) while maintaining high-voltage isolation between the primary and secondary sides. High efficiency is achieved through Zero Voltage Switching (ZVS) on the half-bridge converter and Zero Current Switching (ZCS) on the synchronous rectifier.



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 Harmonic Distortion (THD) of the input current.



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

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



dsPIC33C Digital Power Starter Kit (DM330017-3)

The starter kit is intended to introduce and demonstrate the capabilities and features of Microchip's latest dsPIC33C family of devices targeted for digital power applications. The dsPIC33C Digital Power Starter Kit features the on-board dsPIC33CK256MP505 single-core DSC, SMPS power stages, loads, LCD display, USB/UART bridge and programmer/debugger, which eliminates the need for any additional hardware.



Digital Power Development Board (DM330029)

The Digital Power Development Board is a demonstration board that offers a flexible measurement and evaluation platform for all compatible Microchip dsPIC33's Digital Power Plug-In Modules (DP PIMs). The DP PIMs can be inserted into the mating socket in the middle of the Digital Power Development Board. All pins of the DP PIM are accessible via test loops or pin headers



Digital Power Plug-In Modules (DP PIMs)

Microchip's DP PIMs feature different device families, from dsPIC33E to dsPIC33CK and dsPIC33CH DSCs. These devices have different CPU performance levels as well as peripheral features and functions. These DP PIMs have the same functional card edge connector pinout to support seamless migration between device families. The DP PIMs plug into a range of digital power development boards and reference designs.



Low Voltage PFC Development Kit (DV330101)

Low Voltage Power Factor Correction (LVPFC) Development Kit offers safe voltage levels at moderate power while designing algorithms on a boost power factor correction topology. These algorithms can be applied on real systems under development with minimal changes.

Microchip's Digital Power Design Suite

Microchip's digital power design suite includes the Digital Compensation Design Tool (DCDT), MPLAB Code Configurator (MCC), SMPS Compensator Libraries and Design Examples. The suite offers tools and required guidance for a complete designs.

Digital Compensator Design Tool (DCDT)

DCDT helps power supply designers by simplifying the compensator coefficients calculations and analyzing the performance. This topology independent GUI offers advantages such as

- Analyzing plant and feedback transfer functions
- Designing controller (PID, 2P2Z, 3P3Z, etc.)
- Migrating analog Type II, Type III to digital control
- Analyzing loop gain and tuning controller
- Generating coefficients and exporting to MPLAB X IDE

SMPS Compensator Library

The Compensator library includes optimized functions for the dsPIC33 DSCs that facilitate implementing common compensator algorithms and realize an efficient SMPS application design. The library supports

- Algorithms such as PID, 2P2Z and 3P3Z
- Fixed point and trigger update
- Context registers on "GS" and "MP" family devices

MPLAB Code Configurator

MCC is a graphical programming environment that generates seamless, easy-to-understand device configuration code. It offers advantages such as

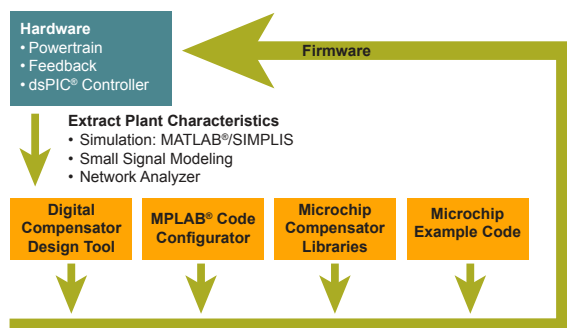
- Intuitive interface for quick start and easy configuration
- Reduces overall design effort
- Minimizes references to product datasheet

Design Examples and Reference Designs

Royalty-free application-specific hardware and software

- Starter kits/Development boards/EVBs
- Reference designs and application notes

Simplified SMPS Design Flow



PIC24F MCUs with eXtreme Low Power



eXtreme Low Power (XLP) Technology - PIC24F MCUs

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 offer 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
- 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)
 - Powered separately from 1.8–3.6V source (coin cell)
- Efficient instruction set; 90% single-cycle instruction
 - Active mode current as low as 150 μ A/MHz

Migrating from 8-bit to 16-bit Microcontroller Families

Are your next design requirements increasing, requiring more performance, more Flash, more RAM or faster peripherals than are available on the PIC18 microcontroller (MCU) that you used in your original design? You can easily extend your application with more functionality by migrating to a PIC24 MCU. Created as a powerful extension to Microchip's PIC18 MCU portfolio, the PIC24F architecture gives you an even greater range of options for computational power and rich peripheral sets making it easy to scale up or scale down your MCU if you are running out of or have an excess of resources in your application. www.microchip.com/migration

Development Tools



PIC24F Curiosity Board (DM240004) and PIC24FJ256GA7 Curiosity Board (DM240016)

These are cost-effective, fully integrated, rapid prototyping boards, featuring PIC24FJ128GA204 or PIC24FJ-256GA705 XLP MCUs. The boards serve as a perfect platform to harness the power of low-power PIC24F MCUs.



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.



PIC-IoT WG / WA Development Board (AC164164/EV54Y39A)

The PIC-IoT WG and WA Development Boards combines a powerful PIC24FJ128GA705 MCU, an ATEC-C608A CryptoAuthentication™ secure element IC and the fully-certified ATWINC1510 Wi-Fi network controller - which provides the most simple and effective way to connect your embedded application to the Google Cloud/Amazon Web Services (AWS). To learn more, visit www.microchip.com/PIC-IoT

Application Notes

- AN3329: V_{BAT} Emulation Using PIC24F eXtreme Low-Power Microcontrollers

Featured XLP Products

Product	Flash (KB)	Pin Count	Sleep (nA)	WDT (nA)	SOSC/RTCC (nA)	Active (μ A/MHz)	Features
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



Display

Many 16-bit designs incorporate modern user interfaces to increase the usability and functionality of end products. More sophisticated displays 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 high-peripheral integration with low power.

Segmented LCD Displays

The Liquid Crystal Display (LCD) driver module generates the timing control to drive a Static or Multiplexed LCD panel and meets low power design requirements including driving the LCD display in sleep mode as well as software contrast control for boosting or dimming. 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 charge pump for contrast control even when powered from a low voltage battery
- Software contrast control for LCD using the internal biasing graphical displays

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

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*

Microchip provides total system solutions for smart, connected and secure designs. These designs can leverage everything from our smart PIC24 MCUs and dsPIC33 DSCs with integrated analog, certified wired and wireless connectivity and state-of-the-art security solutions along with ready-to-use software and tools, partnerships with the largest cloud computing companies and world-class support.

Secured System

As the attack surface of IoT devices continues to grow with clear acceleration, security can no longer be an afterthought. The PIC24 MCUs and dsPIC33 DSCs featuring various complementary protection schemes like Flash configurable as OTP + Code-Guard™ security, can be easily interfaced with Microchip's CryptoAuthentication devices to add security into your system.

Wireless Connectivity Solutions

With the massive growth of the Internet of Things, wireless connectivity has never been more important. Quickly incorporate connectivity to your designs with wireless ICs, modules, software and development kits that make connecting effortless for your customers.



Wi-Fi

- Pre-certified modules
- Popular cloud provider support
- Personal and enterprise security
- Extensive interoperability testing
- www.microchip.com/wifi

Bluetooth® Low Energy

- Low power enables long battery life
- Small form factor
- Interoperable with Bluetooth 5
- www.microchip.com/bluetooth

LoRa®

- Long range, up to 15 km
- Low power enables long battery life
- Global network and radio certification
- Certified LoRaWAN™ protocol stack
- www.microchip.com/LoRa

Wired Communication

EtherCAT®

- Microchip's EtherCAT slave controllers integrate seamlessly with PIC24 MCUs and dsPIC33 DSCs to add EtherCAT communication.
- www.microchip.com/EtherCAT



PMBus™

- The PMBus protocol supported on dsPIC33 "GS" and "MP" families, operates over an I²C physical layer. A PMBus stack is available for free for use with dsPIC33 DSCs.



USB

- There are several PIC24 MCU and dsPIC33 DSC families with integrated USB, supporting device, host and On-The-GO (OTG) functionality.
- Microchip's free USB stack framework includes libraries supporting Human Interface Device (HID), Mass Storage Device (MSD), CDC, PHDC, custom, audio, printer and demo code including thumb drive boot-loader and printer host.



CAN and CAN-FD

- Numerous dsPIC33 DSCs and PIC24 MCUs include an integrated CAN and CAN-FD peripherals
- CAN 2.0B and CAN-FD 1.0 compliance
- Vector CANbedded™ and osCAN™ development solutions



SENT and LIN

- The dsPIC33 family features SENT for point-to-point transmission of sensor values
- LIN support is integrated into products for low-cost, single-wire serial communication for automotive applications.

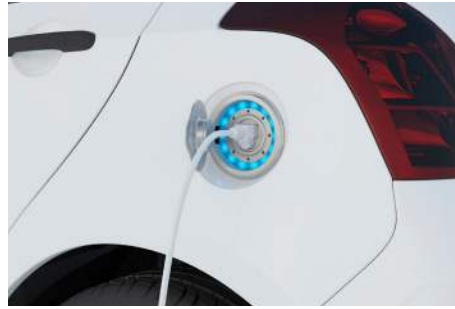
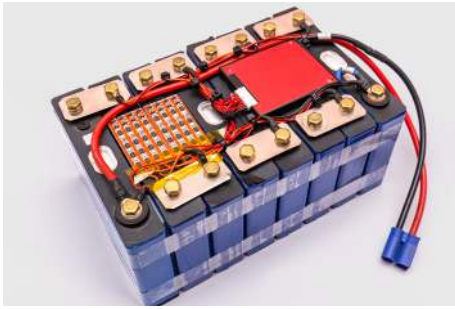


PIC-IoT WG/WA Development Boards

Connecting to Google and Amazon Cloud Platforms



The PIC-IoT WG and WA Development Boards combines a powerful PIC24FJ128GA705 MCU, an ATEC-C608A CryptoAuthentication secure element IC and the fully-certified ATWINC1510 Wi-Fi network controller - which provides the most simple and effective way to connect your embedded application to the Google Cloud / Amazon Web Services (AWS). To learn more, visit www.microchip.com/PIC-IoT



Functional Safety Ready



In today's automotive applications, ISO26262 has become a critical element of passenger safety, as electric and electronic content has rapidly grown within cars and now mobility solutions to a wider extent. To help customers achieve the desired Automotive Safety Integrity Level (ASIL) certification, Microchip's dsPIC33 family of Digital Signal Controllers (DSCs) is commonly used in digital-power and motor-control applications for the automotive market including DC/DC systems and On-Board Chargers (OBC), actuators and also sensors (position, pressure) for which ASIL requirements apply.

Select dsPIC33 DSCs are products that contains the "Functional Safety Ready" designation. It has been carefully selected as one that encompasses the latest features and support collateral available from Microchip, including integrated safety features, safety manuals, Failure Mode, effect, diagnostic analysis (FMEDA) reports and in some cases, diagnostic software.

Safety and Robustness Collateral

- Automotive-grade silicon (Q100 qualification, up to Grade 0)
- Functional Safety Diagnostic Firmware (with complete requirements mapping, static/dynamic analysis and test reports)
- Failure modes, Effects and Diagnostic Analysis report
- Functional Safety Manual
- MPLAB XC Functional Safety Certified Compilers
- MCAL Drivers for Autosar
- MPLAB Code Coverage tool to effectively test your code

These collaterals are available under NDA upon request from your local Microchip Sales office.

Make your certification process easier and less risky with Microchip high-quality collateral.

Development Tools

Microchip offers a number of products that enable system-level compliance to functional safety. This means that they have integrated features, qualified test libraries, safety manuals, and FMEDA reports, depending on the standard and the level of safety they support. All these items make it easier to develop applications that conform to the functional safety standards, and thereby reduce the work and cost of the final product compliance. Microchip offers the MPLAB XC Compiler, ISO 26262 qualified up to ASIL D.

Third Party Support

- LDRA software technology
- TÜV SÜD

Applications

- On-Board Chargers (OBC)
- Battery Management Systems (BMS)
- Sensors (position, pressure)

Safety and Robustness Capabilities

The dsPIC33 family of DSCs provide the following features and capabilities for robust environments:

Hardware functional safety features including but not limited to:

- Memory: ECC, CRC, RAM BIST
- System: DMT, WDT/Windowed WDT, POR/BOR, MCLR
- Clocking: Redundant Oscillator, Fail Safe Clock Monitor (FSCM)
- CPU: Error Trap Monitors
- GPIO: ESD Protection, I/O Port Readback







Additional Information

- Some of these hardware features apply to Class B application applications.

www.microchip.com/16bitfunctionalsafety

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 4 In-Circuit Debugger, MPLAB REAL ICE™ In-Circuit Emulator, MPLAB PICKit™ 4 or TRACE32 debugger from Lauterbach. Many 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 DM240001-3	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 board™, 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.
	PIC24FJ256GA7 Curiosity Development Board	DM240016	The PIC24FJ256GA7 Curiosity Board is a cost-effective, fully integrated 16-bit development platform that enables easy and faster adoption of low-cost XLP 16-bit PIC24FJ256GA705 family of microcontrollers.
	PIC-IoT WG/WA Development Board	AC164164/ EV54Y39A	The PIC-IoT WG and WA Development Boards combines a powerful PIC24FJ128GA705 MCU, an ATECC608A CryptoAuthentication™ secure element IC and the fully-certified ATWINC1510 Wi-Fi network controller - which provides the most simple and effective way to connect your embedded application to the Google Cloud/ Amazon Web Services (AWS). To learn more, visit www.microchip.com/PIC-IoT
	dsPIC33CH/CK Curiosity Development Board	DM330028-2/ DM330030	The dsPIC33CH/CK Curiosity Development Board is a cost-effective development and demonstration platform for the dsPIC33CH/CK family of dual-core / single-core and high performance digital signal controllers. Designed to take full advantage of Microchip's MPLAB X IDE, the board includes an integrated programmer/debugger and requires no additional hardware, making it a perfect starting point to explore the dsPIC33CH/CK family.
	dsPIC33C Digital Power Starter Kit	DM330017-3	The starter kit is intended to introduce and demonstrate the capabilities and features of Microchip's latest dsPIC33C family of devices targeted for digital power applications. The dsPIC33C Digital Power Starter Kit features the on-board dsPIC33CK256MP505 single-core DSC, SMPS power stages, loads, LCD display, USB/UART bridge and programmer/debugger, which eliminates the need for any additional hardware.
	Digital Power Development Board	DM330029	The Digital Power Development Board is a demonstration board that offers a flexible measurement and evaluation platform for all compatible Microchip dsPIC33's Digital Power Plug-In Modules (DP PIMs). The DP PIMs can be inserted into the mating socket in the middle of the Digital Power Development Board. All pins of the DP PIM are accessible via test loops or pin headers.
	Digital Power Plug-In Modules	DP PIMs	Microchip's DP PIMs feature different device families, from dsPIC33E to dsPIC33CK and dsPIC33CH DSCs. These devices have different CPU performance levels as well as peripheral features and functions. These DP PIMs have the same functional card edge connector pinout to support seamless migration between device families. The DP PIMs plug into a range of digital power development boards and reference designs.
	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.
	Low Voltage PFC Development Kit	DV330101	Low Voltage Power Factor Correction (LVPFC) Development Kit offers safe voltage levels at moderate power while designing algorithms on a boost power factor correction topology. These algorithms can be applied on real systems under development with minimal changes.

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	The bootloader firmware resides within the memory to provide self-programming capability to the microcontroller. Developing custom bootloader code can be a complex and time-consuming process and to assist 16-bit developers with this, Microchip provides a 16-bit Bootloader. Using a simple GUI interface, developers can create bootloader firmware designed to suit their application needs.	www.microchip.com/16-bit-bootloader
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/16bitfunctionalsafetyAN1778
Code Examples	Hundreds of code examples to help you set-up peripherals and functions, sorted by product family: <ul style="list-style-type: none"> • 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 Power Design Suite	This suite includes ready to use, royalty free tools that simplify the intelligent digital power designs. It facilitates developing designs with high efficiency, optimum performance at a lower cost and significantly cuts down the time-to-market. <ul style="list-style-type: none"> • Digital Power Compensator Libraries, optimized for dsPIC33 DSCs • Digital Compensator Design Tool (DCDT) helps calculate compensator coefficients for maximum performance • PMBus™ stack implements the PMBus protocol over I²C communication interface • MPLAB Code Configurator (MCC), a graphical programming tool for peripheral configuration • A range of royalty-free, application specific hardware and software reference designs, code examples, Application notes and Development boards 	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
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
FreeRTOS	A market leading RTOS, professionally developed, strictly quality controlled, robust, supported and free to use in commercial products without any requirement to expose your proprietary source code. Supports PIC24 and dsPIC device families.	www.freertos.org
Functional Safety	To access our device-specific, safety-related content, such as the Failure Modes, Effects, and Diagnostic Analysis (FMEDA) and Functional Safety Manual.	www.microchip.com/16bitFunctionalSafety
Motor Control	This library includes the Motor Control Library for 3-phase control as well as MATLAB Simulink® and X2C Blockset and motor models, tuning guides, application notes and code examples.	www.microchip.com/motor
motorBench® Development Suite	The motorBench® Development Suite is a GUI-based software development tool for Field Oriented Control (FOC) of low-voltage motors (up to 48 volts and 10 amps), performing accurate measurement of critical motor parameters, automatic tuning of feedback control gains and generating source code for an MPLAB® X IDE project, utilizing the Motor Control Application Framework (MCAF).	www.microchip.com/motorBench
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/lowpower

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. It is compatible across Windows®, Linux® or Mac OS® X.

MPLAB Code Configurator (MCC)

MPLAB Code Configurator is a free graphical programming environment that generates seamless, easy-to-understand C code. It is incorporated into MPLAB X IDE to provide a powerful and easy-to-use development platform. Supporting 8-, 16- and 32-bit PIC MCUs, including PIC24, dsPIC33 and PIC32MM families, MCC can be used to jumpstart your next design.



- Free graphical programming environment
- Intuitive interface for quick start development
- Automated configuration of peripherals & functions
- Minimized reliance upon product datasheet
- Reduces overall design effort & time
- From Novice to Expert...
- Accelerates generation of production ready code
- Reduces overall design effort and time
- Accelerates generation of production ready code
- Integrated software libraries:
 - IoT
 - USB
 - Bootloader
 - EEPROM Emulation
 - CryptoAuthentication
 - Development Board Support

MCC supports Click board™

To help you bring your ideas to life even faster, MCC supports quick-start software libraries for MikroElektronika click boards to prototype your design without the stress and hassle of low level code development and validation.

Range of Click Boards Supported

- Sensors and Mixed Signal
- Human Machine Interface
- Storage
- Wired and Wireless Communication

Three Easy Ways to Get MCC

Install the MPLAB X IDE plugin

Use MPLAB Xpress IDE

Manually install the MPLAB X IDE plugin

MPLAB XC16 Compiler for PIC24 MCUs and dsPIC DSCs

The MPLAB XC16 Compiler includes a complete ANSI C standard library with 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.



Emulators and Debuggers

- MPLAB PICkit 4 In-Circuit Debugger (PG164140)
- MPLAB Snap In-Circuit Debugger (PG164100)
- MPLAB ICD 4 In-Circuit Debugger (DV164045)
- Trace32 dsPIC33 debugger

Features	PIC24 Families			dsPIC [®] DSC Families		
	PIC24 "F"	PIC24 "H"	PIC24 "E"	dsPIC33 "F"	dsPIC33 "E"	dsPIC33 "C"
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, enhanced noise immunity and robustness	High-performance, up to two cores, advanced MC and DP
Performance, Pins and Memory						
MIPS	16 MIPS	40 MIPS	70 MIPS	50 MIPS	70 MIPS	100 MIPS
Pins	14–121	18–100	28–144	18–100	28–144	28–80
Flash Memory (KB)	4–1024	12–256	32–512	6–256	16–512	32 KB to 512 KB Flash
SRAM (KB)	0.5–96	1–16	4–53	0.25–30	2–53	RAM: 8 KB to 48 KB
DMA	✓	✓	✓	✓	✓	✓
Operating Voltage	3V and 5V	3V	3V	3V	3V and 5V	3V
Integrated Analog						
ADC	10-bit @ 500 ksp/s 12-bit @ 200 ksp/s 16-bit Delta-Sigma 12-bit @ 10 Msps	10-bit @ 1100 ksp/s 12-bit @ 500 ksp/s	10-bit @ 1100 ksp/s 12-bit @ 500 ksp/s	10-bit @ 1100 ksp/s 12-bit @ 500 ksp/s 10-bit @ 2 Msps	10-bit @ 1100 ksp/s 12-bit @ 500 ksp/s 12-bit @ 3.25 Msps	Up to 4, 12-bit @ 3.5 Msps
DAC	✓	✓	✓	✓	✓	✓
Comparators	✓	✓	✓	✓	✓	✓
Op Amps and PGAs	✓	–	✓	–	✓	✓
Wired Communications						
UART with LIN and IrDA [®]	✓	✓	✓	✓	✓	✓
SPI and I ² C	✓	✓	✓	✓	✓	✓
USB - Device, Host, OTG	✓	–	✓	–	✓	–
CAN and CAN-FD	–	✓	✓	✓	✓	✓
SENT	–	–	✓	–	✓	✓
Clocks and Timers						
16-bit and 32-bit Timers	✓	✓	✓	✓	✓	✓
RTCC - Clock, Calendar, Alarm	✓	–	✓	✓	–	–
Waveform Control						
Input Capture and 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/ 250 pS Resolution	–	–	–	✓	✓	✓
Comparators with 25 nS/15 nS speed	–	–	–	✓	✓	✓
Safety and Monitoring						
BOR, LVD, POR, WDT	✓	✓	✓	✓	✓	✓
Windowed WDT	–	✓	✓	✓	✓	✓
Deadman Timer (DMT)	–	–	–	–	✓	✓
CRC - Flash, RAM and SFR	✓	✓	✓	✓	✓	✓
Functional Safety 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



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

Microchip Quick Web Links

16-bit MCUs and DSCs Home Page
www.microchip.com/16bit
16-bit PIC MCU Peripheral Integration
Quick Reference Guide
www.microchip.com/16bitquickreference
16-bit Core Independent Peripherals
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Support

Microchip is committed to supporting its customers in developing products faster and more efficiently. We maintain a worldwide network of field applications engineers and technical support ready to provide product and system assistance. For more information, please visit www.microchip.com:

- Technical Support: www.microchip.com/support
- Evaluation samples of any Microchip device: www.microchip.com/sample
- Knowledge base and peer help: www.microchip.com/forums
- Sales and Global Distribution: www.microchip.com/sales

Training

If additional training interests you, Microchip offers several resources including in-depth technical training and reference material, self-paced tutorials and significant online resources.

- Overview of Technical Training Resources: www.microchip.com/training
- MASTERS Conferences: www.microchip.com/masters
- Developer Help Website: www.microchip.com/developerhelp
- Technical Training Centers: www.microchip.com/seminars

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Tel: 45-4485-5910

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