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

Microchip's 16-bit 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, making the PIC24F family ideal for low-power and space-constrained 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 14 channel, high-resolution PWMs for two motor control and integrated PFC

With functional safety features and operations up to 150°C, the dsPIC33 family is ideal for PMSM, ACIM and BLDC motor control in industrial, medical, automotive and consumer applications.

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 specialized peripheral integration, the dsPIC33 families are ideal for digital power conversion in industrial, medical, automotive and consumer applications.

Robust 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.

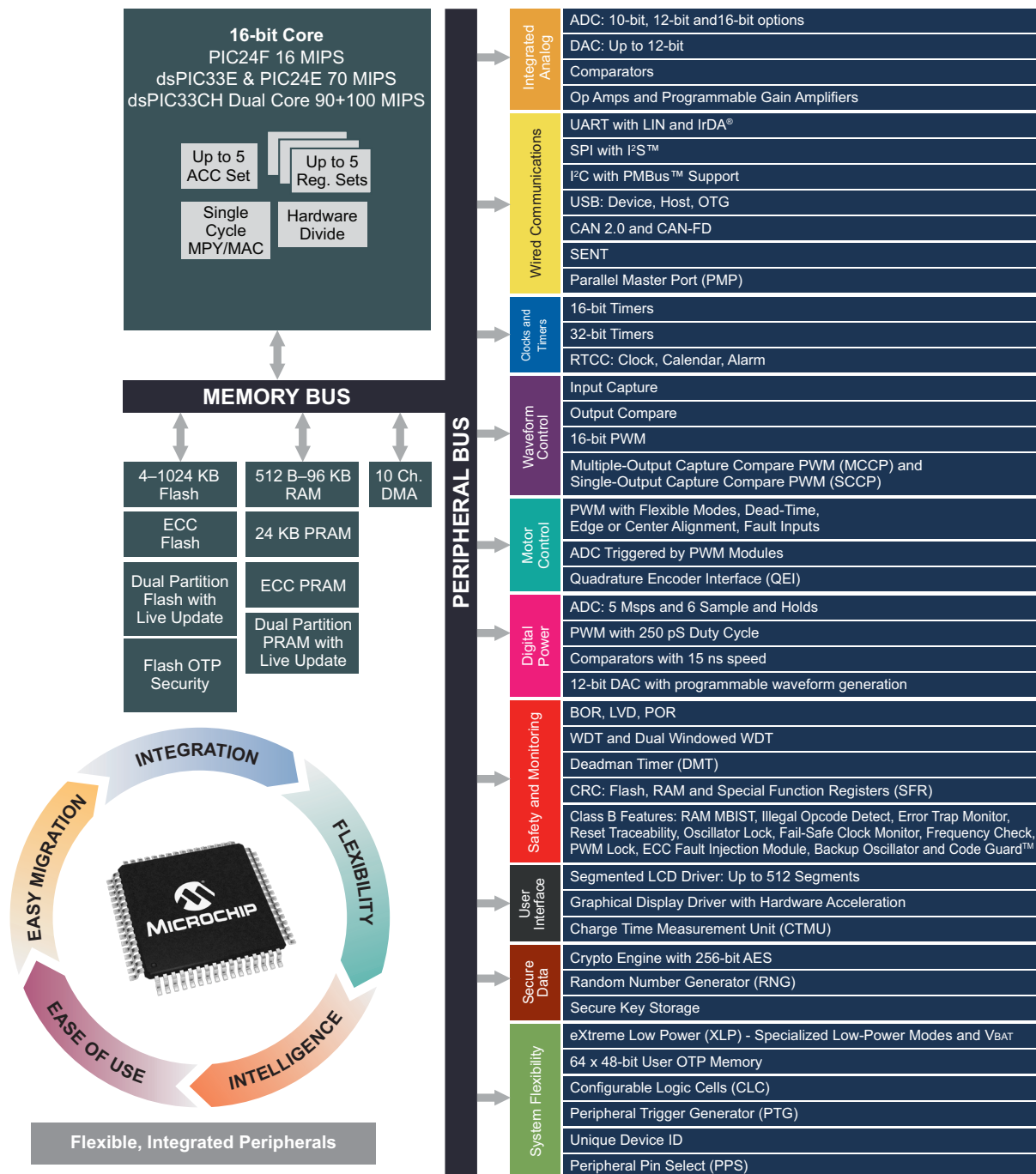## Simplifying 16-bit Microcontroller Designs

With a focus on reducing the time to market and minimizing the development risk, Microchip offers a complete ecosystem.
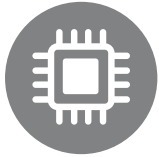
- MPLAB® X IDE and XC16 compilers
  - Single platform across all 16-bit MCUs and DSCs
- MPLAB Code Configurator (MCC)
  - Enables prototyping in minutes
- MPLAB Xpress cloud-based IDE
  - Quickstart online development environment
- Microchip-tested software for quick time to market
  - USB, graphics, 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

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

16-bit Core
PIC24F 16 MIPS
dsPIC33E & PIC24E 70 MIPS
dsPIC33CH Dual Core 90+100 MIPS

Up to 5 ACC Set
Up to 5 Reg. Sets
Single Cycle MPY/MAC
Hardware Divide

MEMORY BUS

4–1024 KB Flash
ECC Flash
Dual Partition Flash with Live Update
Flash OTP Security

512 B–96 KB RAM
24 KB PRAM
ECC PRAM
Dual Partition PRAM with Live Update

10 Ch. DMA

PERIPHERAL BUS

Integrated Analog
- ADC: 10-bit, 12-bit and16-bit options
- DAC: Up to 12-bit
- Comparators
- Op Amps and Programmable Gain Amplifiers

Wired Communications
- UART with LIN and IrDA®
- SPI with I²S™
- I²C with PMBus™ Support
- USB: Device, Host, OTG
- CAN 2.0 and CAN-FD
- SENT
- Parallel Master Port (PMP)

Clocks and Timers
- 16-bit Timers
- 32-bit Timers
- RTCC: Clock, Calendar, Alarm

Waveform Control
- Input Capture
- Output Compare
- 16-bit PWM
- Multiple-Output Capture Compare PWM (MCCP) and Single-Output Capture Compare PWM (SCCP)

Motor Control
- PWM with Flexible Modes, Dead-Time, Edge or Center Alignment, Fault Inputs
- ADC Triggered by PWM Modules
- Quadrature Encoder Interface (QEI)

Digital Power
- ADC: 5 Msps and 6 Sample and Holds
- PWM with 250 pS Duty Cycle
- Comparators with 15 ns speed
- 12-bit DAC with programmable waveform generation

Safety and Monitoring
- BOR, LVD, POR
- WDT and Dual Windowed WDT
- Deadman Timer (DMT)
- CRC: Flash, RAM and Special Function Registers (SFR)
- Class B Features: RAM MBIST, Illegal Opcode Detect, Error Trap Monitor, Reset Traceability, Oscillator Lock, Fail-Safe Clock Monitor, Frequency Check, PWM Lock, ECC Fault Injection Module, Backup Oscillator and Code Guard™

User Interface
- Segmented LCD Driver: Up to 512 Segments
- Graphical Display Driver with Hardware Acceleration
- Charge Time Measurement Unit (CTMU)

Secure Data
- Crypto Engine with 256-bit AES
- Random Number Generator (RNG)
- Secure Key Storage

System Flexibility
- eXtreme Low Power (XLP) - Specialized Low-Power Modes and VBAT
- 64 x 48-bit User OTP Memory
- Configurable Logic Cells (CLC)
- Peripheral Trigger Generator (PTG)
- Unique Device ID
- Peripheral Pin Select (PPS)

INTEGRATION — FLEXIBILITY — INTELLIGENCE — EASE OF USE — EASY MIGRATION

Flexible, Integrated Peripherals

dsPIC33CH Dual Core Digital Signal Controllers

Microchip's new dsPIC33CH DSCs offer two dsPIC cores in a single chip with advanced peripherals facilitating complex digital power, motor control and other high performance applications. With dual independent cores, dsPIC33CH family simplifies the firmware development. www.microchip.com/dsPIC33CH

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

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, CAN-FD LIN, SENT and USB are integrated onto our 16-bit devices with supporting free software libraries.

Functional Safety and Robust Usages

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, fault detection and a range of other features enabling functional safety. The certified Class B software stack helps to simplify regulatory compliance. www.microchip.com/hightemp   www.microchip.com/16bitFunctionalSafety

dsPIC33CH Dual Core Family - Design Separately and Integrate Seamlessly

System developers designing high-end embedded control applications can benefit from a new Digital Signal Controller (DSC) with two dsPIC cores in a single chip. The dsPIC33CH has a master and a slave core. The slave core can execute dedicated, time-critical control code while the master core is busy running the user interface and system functions, customized for an end application.

The dsPIC33CH is designed to facilitate independent code development for each core by separate design teams and allows seamless integration when they are brought together in one chip. The dsPIC33CH family is optimized for high-performance digital power, motor control and other applications implementing sophisticated algorithms.

Wireless Power	Server Power Supply	Motor Control	Automotive	Industrial	Medical
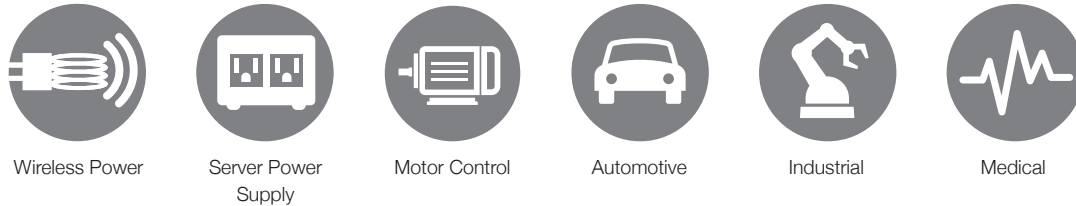
What's New?

- Simplified firmware development with dual independent cores
- Dual cores and peripheral sets facilitate robust systems and improve functional safety
- First dsPIC33 with CAN-FD 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
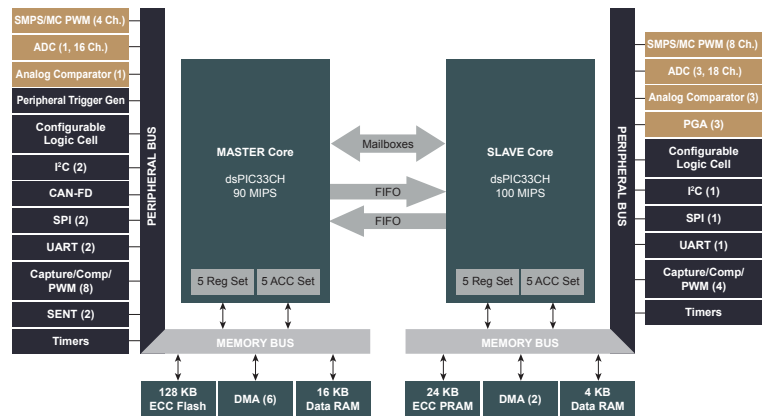
Operating Temperature: –40 to 125°C

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)

dsPIC33CH Motor Control PIM (MA330039) for MCLV-2, MCHV-3 Boards

dsPIC33CH General Purpose PIM (MA330040) for Explorer 16/32 Boards

16-bit 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 dsPIC33CH DSCs with up to 100 MIPS 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
  - 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
- Features enabling functional safety for safety critical applications

Software and Application Notes

Motor Type	Algorithm	App Note
Stepper Motor	Closed-Loop Microstepping	AN1307
BLDC, PMSM and IPMSM	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/ PRAM (KB)	RAM (KB)	DMA Ch.	IC/OC/PWM/ MCCP/SCCP	MC PWM	QEI	Int. Op Amps/PGAs	ADC Modules/ Channels	UART
dsPIC33CH128MP508	3.3	90+100	28/36/48/64	64–128/24	16 +4	8	12	12 ch	2	3	4/18 ch	3
dsPIC33EP512GM710	3.3	70	44/64100/121	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

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 www.embeddedcodesource.com

Motor Control Library for dsPIC33
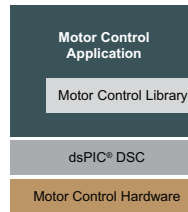
This library contains function blocks optimized for the dsPIC33 DSCs. All functions have input(s) and output(s), but do not access any of the DSC peripherals. The user's motor control application interfaces to the DSC peripherals while using function calls into this library to perform a majority of the time-critical operations.

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.

Motors

You can use your own motor or purchase one of these:
- AC300020: 24V BLDC Motor
- AC300022: 24V BLDC Motor with Shaft Encoder
- AC300023: 220V, AC Induction Motor
- AC300024: 220V, AC Servo Motor with Encoder

Hardware Development Boards

Motor Control Starter Kit (MCSK) (DM330015)
This starter kit is based on the dsPIC33FJ16MC102 and it includes a USB interfaced debugger/programmer, a complete drive circuit, an on-board BLDC motor and a switch with LED indicators for speed control.
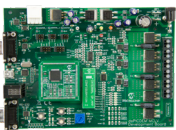
dsPICDEM™ MCLV-2 Development Board (DM330021-2)
This board provides a cost-effective method of evaluating sensored or sensorless BLDC motor and PMSM control applications. It supports PIMs with dsPIC33 DSCs and on-chip op amps found on certain DSCs or the external op amps on the development board. A dsPIC33EP256MC506 PIM (MA330031) is included.

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. The rated continuous output is 6.5 A (RMS) or, 2 kVA when running from a 208V to 230V single-phase input voltage. It includes a Power Factor Correction (PFC) circuitry.

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. The dsPIC33 DSC Signal Board supports both 3.3V and 5V operated devices. The Motor Control 10–24V Driver Board (Dual/Single) supports current up to 10A.
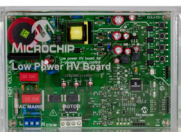
Low-Power High-Voltage Motor Control Reference Design (LPHV-MC-BOARD)
This cost-effective high voltage reference design board is targeted to control ACIM, PMSM and BLDC Motors in sensored or sensorless operations. The board is ideally designed to demonstrate the capabilities and efficiency of high voltage motor control operations at a low power of up to 150W.

16-bit 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 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 and software workload
- Live update features
  - Update all of the firmware in an operating power supply while maintaining continuous regulation
- Maximum analog integration including high-speed ADCs, DACs with waveform generation, comparators and PGAs
- 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
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 CSCI 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 Compare	UART/I²C/SPI	CAN/CAN-FD*
dsPIC33CH128MP508	80	128/24	16 +4	8/8	12	18 × 12-bit, 5 S/H	3	4	3/3/3	1*
dsPIC33EP128GS808	80	128	8	4/4	16	22 × 12-bit, 5 S/H	2	4	2/2/3	2
dsPIC33EP64GS506	64	64	8	4/4	10	22 × 12-bit, 5 S/H	2	4	2/2/2	0
dsPIC33EP32GS504	44	32	4	4/4	10	19 × 12-bit, 5 S/H	2	4	2/2/2	0
dsPIC33EP32GS202	28	32	2	1/1	6	12 × 12-bit, 3 S/H	2	2	1/1/1	0

Reference Designs

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 power supply can be firmware updated (including the compensator algorithm) with zero down time to the system it is powering while the power supply is running.

Platinum Rated 720 W 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.
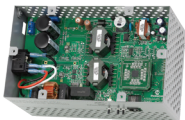
Digital Power Interleaved PFC Reference Design

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).
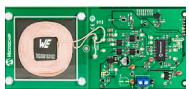
15W Wireless Power Demonstration Board

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 and includes status LEDs and LEDs for power level indication.

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.

dsPIC33CH Curiosity Development Board (DM330028)

This cost-effective board is a development platform for the dsPIC33CH128MP508 dual core DSCs. The configurable test circuit can be operated in buck, boost or buck-boost modes, using either voltage mode or peak current mode control. The board also includes a configurable SMPS load step transient generator.

dsPIC33EP128GS808 Development Board (DM330026)
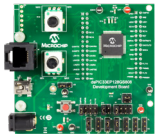
This board operates on a standalone basis or interfaces with CAN/LIN/J2602 PICtail™ (Plus) Board. The board contains single order RC filters to emulate power supply functionality in open or closed loop mode. The power supply transient behavior can also be simulated on the board.

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)

The Digital Compensator Design Tool (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

Design Examples and Reference Designs

Royalty-free application-specific hardware and software designs to reduce time to market
- Starter kits/Development boards/EVBs
- Reference designs and application notes

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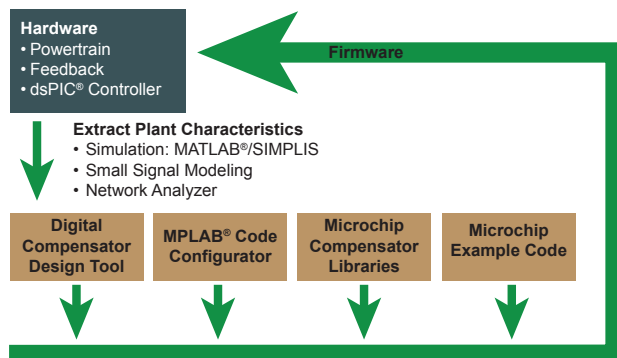- Algorithms such as PID, 2P2Z and 3P3Z
- Fixed point and trigger update
- Context registers on "GS" and "MP" family devices

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

Simplified SMPS Design Flow

Hardware
- Powertrain
- Feedback
- dsPIC® Controller

Firmware

Extract Plant Characteristics
- Simulation: MATLAB®/SIMPLIS
- Small Signal Modeling
- Network Analyzer

Digital Compensator Design Tool | **MPLAB® Code Configurator** | **Microchip Compensator Libraries** | **Microchip Example Code**

PIC24F and PIC32MM MCUs with eXtreme Low Power

eXtreme Low Power (XLP) Technology - PIC24F and PIC32MM 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 µA/MHz

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. Learn more at www.microchip.com/BatteryLifeEstimator.

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

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.

PIC32MM Curiosity Board (DM320101) and PIC32MM USB Curiosity Board (DM320107)
The boards feature the new XLP PIC32MM "GPL" or "GPM" family of low-cost MCUs. The boards offer 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
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
PIC32MM0256GPM064	64–256	28/36/48/64	650	220	1100	316	High-performance, 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
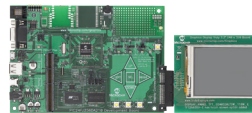
Development Tools

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
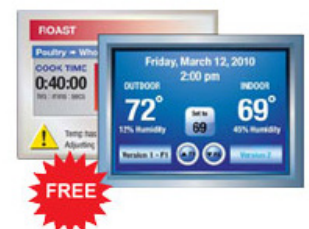
Visual Graphics Display Designer (SW500190)

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*

Connectivity for PIC24 and dsPIC33 DSC Families

Connectivity

Whether an 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 2.0, CAN-FD, LIN, SENT and USB. It is also easy to couple the devices with Microchip's Bluetooth, Wi-Fi and LoRa modules for wireless connectivity and Ethernet, EtherCAT controllers for wired connectivity.

Integrated Wired Communication

CAN 2.0 and CAN-FD

Numerous dsPIC33 DSCs and PIC24 MCUs include an integrated CAN and CAN-FD peripherals which are ideal for applications requiring robust and high-speed communication supporting:
- CAN 2.0B and CAN-FD 1.0 compliance
- Vector CANbedded™ and osCAN™ development solutions

SENT

The dsPIC33 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
- dsPIC33CH Curiosity Board (DM330028)
- CAN/LIN PICtail Plus Daughter Board (AC164130-2) for Explorer 16/32 Development Board

PMBus™

The PMBus protocol standard operates over an I²C physical later to enable easy digital management of power supplies. The latest dsPIC33 "GS" and dsPIC33CH "MP" families support the PMBus protocol along with many other dsPIC33 DSCs and PIC24 MCUs. A PMBus stack is available for free for use with dsPIC33 DSCs.

EtherCAT

EtherCAT enables an application to include a real-time, robust communication based on industrial Ethernet technology that offers flexibility and stability. Microchip's EtherCAT slave controllers integrate seamlessly with PIC24 MCUs and dsPIC33 DSCs to deliver solutions that increase system efficiency and reduce cost.

LIN

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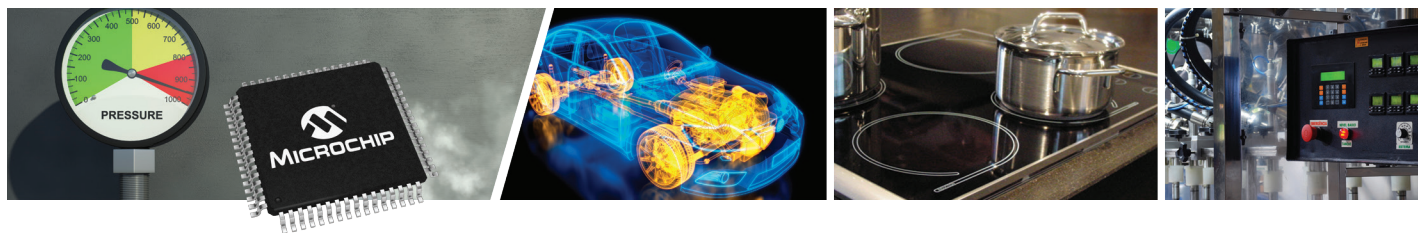
USB

There are several PIC24 MCU and dsPIC33 DSC families with integrated USB, supporting device, host and On-The-GO (OTG) functionality. Development tools include:
- dsPIC33E 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. 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. These communication libraries, such as USB and Wi-Fi, are integrated into the Microchip Libraries for Applications (MLA) www.microchip.com/MLA.

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.

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

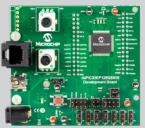## Extreme Temperatures and AEC-Q100 Qualification

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

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 3/4 In-Circuit Debugger, MPLAB REAL ICE™ In-Circuit Emulator or MPLAB PM3 device programmer. 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™ 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.
	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.
	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.
	PIC32MM USB Curiosity Development Board	DM320107	The PIC32MM USB Curiosity Development Board features the new eXtreme Low Power (XLP), PIC32MM "GPM" family of low cost microcontrollers. This board is a simple and easy to use platform that facilitates quick PIC32MM GPM evaluation, experimentation and prototyping.
	dsPIC33CH Curiosity Development Board	DM330028	The dsPIC33CH Curiosity board is a development and demo platform for the dsPIC33CH128MP508 family of dual core high performance DSCs. The board features an integrated programmer/debugger and mikroBUS interfaces. The configurable Switch Mode Power Supply (SMPS) test circuit on the board can be operated in buck, boost or buck-boost modes. It includes a configurable load step transient generator.
	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.
	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.
	dsPIC33EP128GS808 Development Board	DM330026	The dsPIC33EP128GS808 Development Board can operate in standalone mode or can be interfaced with CAN/LIN/J2602 PICtail™ (Plus) Daughter Board. The standalone mode serves to explore the peripherals. The board features single order RC filters to emulate power supply functions. While interfacing with the PICtail™ (Plus) Daughter Board, the board can be used for dual channel CAN/LIN communication, without using the Explorer 16/32 board.

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 • AN2601 describes Live Update support for online firmware updates in time-critical applications requiring no downtime • 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 AN2601
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 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. • 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
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	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

Microchip's Development Ecosystem

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.

- Intuitive interface for quick start development
- Automated configuration of peripherals and functions
- Minimized reliance upon product datasheet

- Integrated software libraries: USB
- Reduces overall design effort and time
- Accelerates generation of production ready code

MCC supports click boards™

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 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.

MPLAB Xpress: Cloud-Based IDE

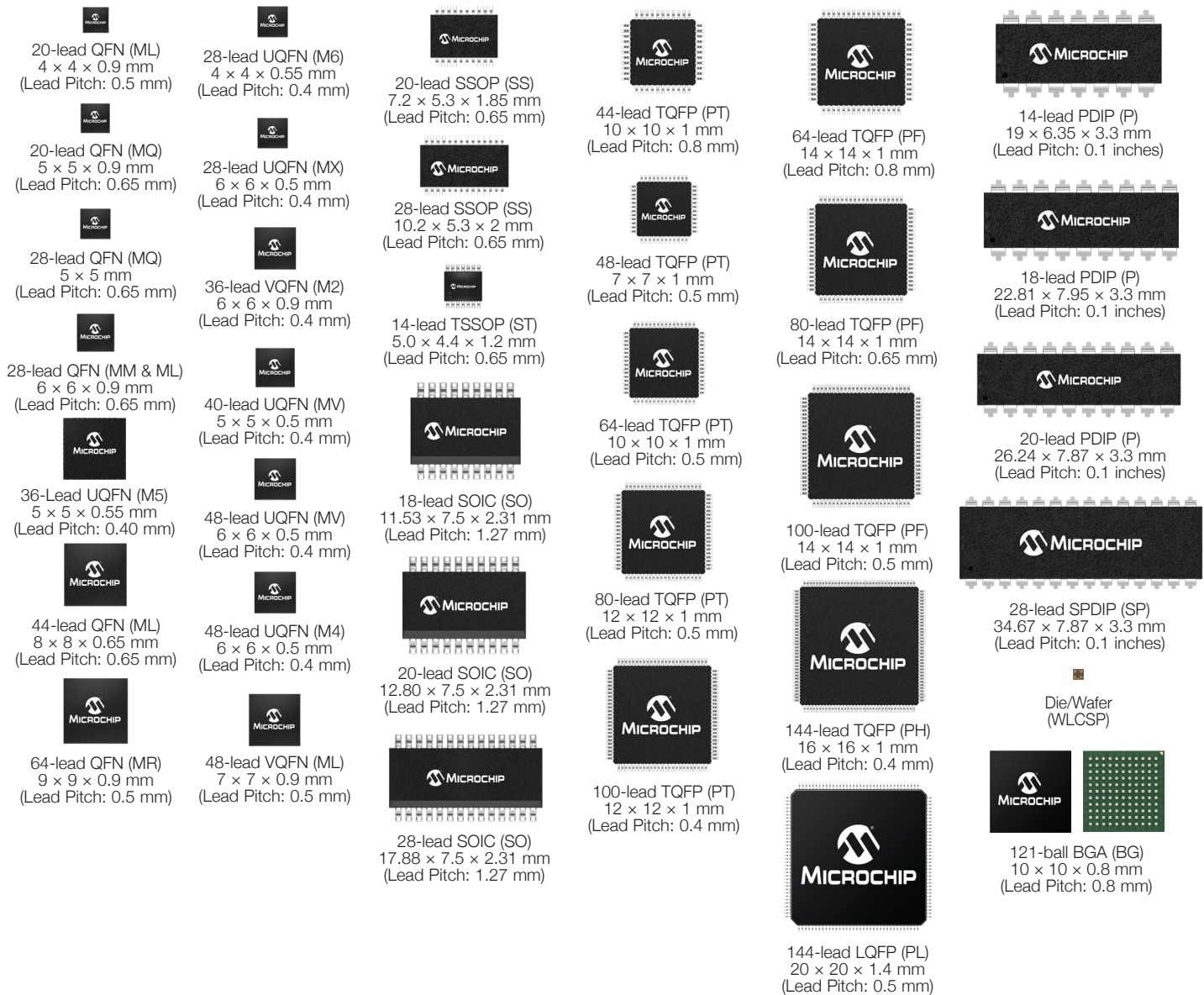MPLAB Xpress Cloud-Based IDE is a free online development environment that contains the most popular features of our award-winning MPLAB X IDE. MPLAB Xpress is a perfect starting point for new users and allows you to transition between the two environments.

- Integrated MPLAB Code Configuratorand XC16 Compiler
- Library of Microchip-validated code examples
- MPLAB Xpress Community to share code and ideas
- Supports PICkit™ 3

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	64–128 24 (PRAM for Slave Core)
SRAM (KB)	0.5–96	1–16	4–53	0.25–30	2–53	16 4 (Slave Core RAM)
DMA	✓	✓	✓	✓	✓	✓
Operating Voltage	3V and 5V	3V	3V	3V	3V and 5V	3V
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	Up to 4, 12-bit @ 3.5 Msps
DAC	✓	✓	✓	✓	✓	✓
Comparators	✓	✓	✓	✓	✓	✓
Op Amps and PGAs	✓	–	✓	–	✓	✓
Wired Communications						
UART with LIN and IrDA®	✓	✓	✓	✓	✓	✓
SPI and I²C	✓	✓	✓	✓	✓	✓
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)	✓	✓	✓	✓	✓	✓

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)

36-Lead UQFN (M5)
5 × 5 × 0.55 mm
(Lead Pitch: 0.40 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)

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