



MPLAB® Harmony Integrated Software Framework

Industry's Most Advanced and Easy-to-Use
Embedded Software Solution



Applications

Device Drivers

Middleware

**Peripheral
Libraries**

3RD Party Software

Introducing MPLAB Harmony v3

MPLAB Harmony v3 is an extension of the MPLAB ecosystem for creating embedded firmware solutions for PIC32 and SAM microcontrollers and microprocessors providing a unified software development framework. It enables development of robust, interoperable, RTOS-friendly applications with quick and extensive support for third-party software integration. The software development format allows for maximum re-use and reduces time-to-market. MPLAB Harmony v3 provides access to highly-simplified peripheral libraries, simplified device drivers and modular software downloads which remove much of the development work from configuring your MCU or MPU. MPLAB Harmony v3 features an improved MPLAB Harmony Configurator (MHC), now with a modular download manager, that provides a graphical way to select and configure all MPLAB Harmony components, including middleware, system services and peripherals with ease.

MPLAB Harmony v3 Improvements

In addition to SAM microcontrollers and microprocessor support, MPLAB Harmony v3 is a significant upgrade from MPLAB Harmony v2 versions in a number of ways.

Simplified Peripheral Libraries

MPLAB Harmony v3 provides substantial simplifications in the lowest layers, particularly the Peripheral Libraries (PLIBs). MPLAB Harmony v3 PLIBs use actual C language functions, instead of inline functions or macros and they are much simpler, making them more useful on their own and making them similar to the peripheral libraries provided by the popular MPLAB Code Configurator (MCC) tool.

Driver Usage Model Simplifications

MPLAB Harmony v3 drivers and system services provide the same powerful multi-instance, multi-client features like buffer queueing and RTOS (and non-RTOS) support as they did in MPLAB Harmony v2, but they have been redesigned and reimplemented to use the new PLIBs and in many cases the usage models have been simplified to focus on fundamental features. Additionally, some drivers and services now provide blocking-style interfaces to give a more traditional development experience. However, simplified drivers and services doesn't mean that MPLAB Harmony v3 is incompatible with MPLAB Harmony v2, as the updated drivers and system services provide the same hardware abstractions they provided for MPLAB Harmony v2 (either natively or via API adapter components).

FreeRTOS By Default

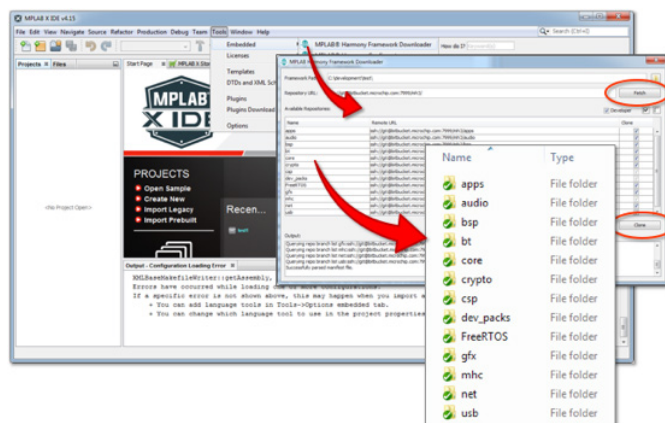
To simplify application development and improve interoperability when using blocking functions, FreeRTOS is enabled by default whenever MPLAB Harmony v3 drivers, system services, or middleware are used. If bare-metal development (without RTOS support) or use of another supported real-time operating system is desired, simply select the desired option from the available RTOS configuration options.

No Middleware Changes!

MPLAB Harmony v3 provides the same great middleware that MPLAB Harmony v2 provided, such as the MPLAB Harmony Graphics Suite (MHGS), TCP IPv4 and IPv6 stacks with numerous Internet protocols, USB Host and Device stacks, Crypto library and more. This means that MPLAB Harmony v3 can support the same applications that MPLAB Harmony v2 supports with just a few mouse clicks.

Modular Downloads and Installation

No more gigabyte downloads! MPLAB Harmony v3 provides a download manager that allows users to select only the modules in which they are interested. Modules are kept in GIT repositories (publicly hosted on GitHub) and cloned to the local workstation to make them available for use in user projects.

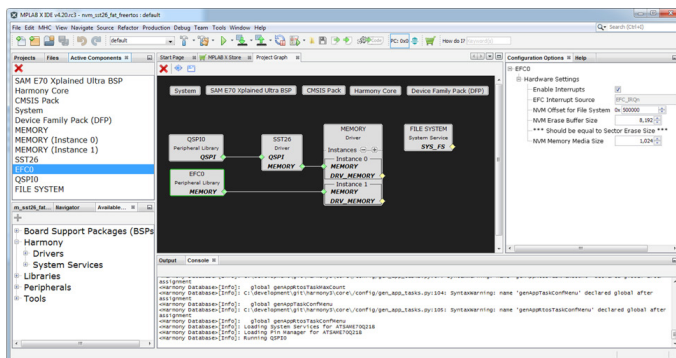


MPLAB Harmony Configurator

The MPLAB Harmony Configurator (MHC) seamlessly integrates with the MPLAB X Integrated Development Environment (IDE) or operates standalone to support third-party tool chains. The MHC Graphical User Interface (GUI) framework provides content distribution, code configuration, code generation, and GUI extension capabilities for MPLAB Harmony library modules and chip support packages. The MHC provides an easy setup and configuration experience with your chosen SAM or PIC32 microcontroller. It offers a simple graphical representation of the selected MCU or MPU and allows firmware developers to quickly initialize clock frequencies, IO pin settings and peripherals. The MHC tool now provides an editable Project Graph view that makes selecting and connecting the desired firmware building blocks much quicker and easier to visualize.

Highlights of MHC

- Available as standalone Graphical User Interface (GUI) tool or as a plug-in to MPLAB X IDE
- Enables selection, downloading and configuration of code you need for a given application
- Convenient way to create project and generate software code
- Starter code for unlimited user applications
- Graphical DMA Manager (new)
- Graphical Memory Protection Unit manager (new)
- Enables seamless integration of supported third-party RTOS or software libraries into your application with the click of a mouse.



- System Configuration Graph
- Python Configuration Data (Heonfig)
- MPLAB & Standalone
- Intuitive Resource Management

Applications

- Audio: Supported on SAM E70 XULT plus WM8904
- Bluetooth® Low Energy, Bluetooth audio and SPP
- CAN-FD applications
- Graphics applications
- TCP/IP applications and utilities
- USB applications
- Crypto

Operating System Abstraction Layer (OSAL)

- OSAL interface with FreeRTOS support (now enabled by default)
- OSAL implementation to support usage without an RTOS
- Micrium µC/OS support in production
- Express Logic Thread-X RTOS Support (planned)

Middleware/Software Libraries

- Graphics
- Crypto
- TCP/IP
- File systems
- System services
- Bluetooth
- DSP/Math – not in beta
- Bootloader – not in beta

Device Support Software:

- Audio Codecs
- EEPROM using I²C
- EEPROM using SPI
- Ethernet media access controller
- Ethernet PHY interface (KSZ8061, LAN8740 and MIIM)
- SPI, UART, high-speed USB Host and Device
- Peripheral Libraries (PLIB) for supported devices

Device Family	MPLAB® X IDE	at91bootstrap	bsp	dev_packs	core	csp
SAMA5D2		✓	✓	✓	✓	✓
SAMS70/E70/V70/V71	✓		✓	✓	✓	✓
SAMG55						
SAMD5x/E5x	✓		✓	✓	✓	✓
SAMD20/D21	✓		✓	✓	✓	✓
SAMC20/C21	✓		✓	✓	✓	✓
SAML21/L22						
SAML10/L11	✓		✓	✓	✓	✓
PIC32MZ DA	✓		✓	✓	✓	✓
PIC32MK	✓		✓	✓	✓	✓
PIC32MZ EF	✓		✓	✓	✓	✓
PIC32MX	✓		✓	✓	✓	✓

https://github.com/Microchip-MPLAB-Harmony/Microchip-MPLAB-Harmony.github.io/wiki/device_support

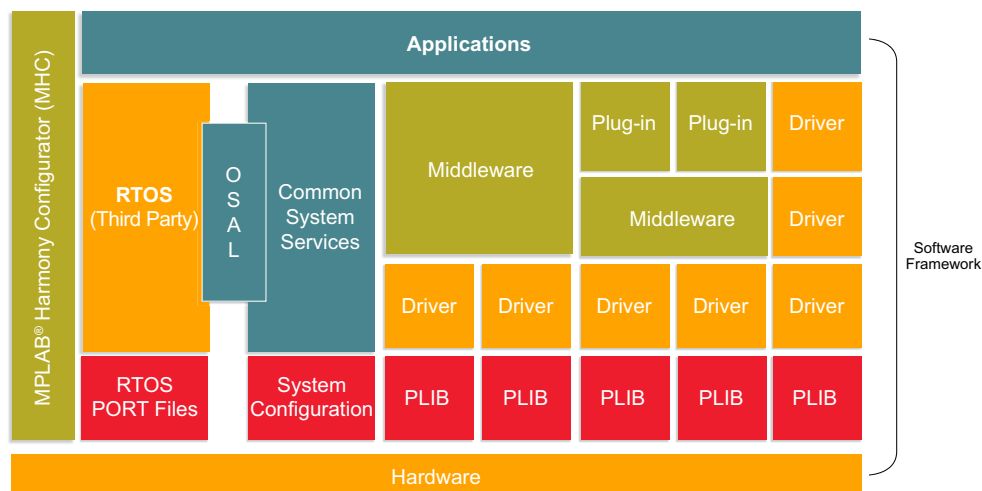
Software Development Tools

- MPLAB X IDE
- MPLAB XC32++ Compiler
- MPLAB Harmony Configurator (MHC) Plug-in
- Graphics design, configuration and driver tools
- Board support packages for PIC® and SAM boards

Third-Party Software

- Security: wolfSSL, wolfCrypt, wolfSSH and wolfMQTT
- FreeRTOS, Micrium OS and Express Logic
- Support project export capability to IAR embedded workbench

MPLAB Harmony Block Diagram



Application Layer

- Implements desired overall behavior
- Abstracted hardware access
- Allows for easy port across SAM and PIC32 devices

Common System Services

- Provides common functionality to avoid duplication and conflicts
- Eliminates complex interactions and interdependencies between modules
- OSAL provides OS compatibility (FreeRTOS, bare-metal, easily ported to others)
- Manages shared resources
- Supports low-level configuration and board support Package (H3 splits BSP into hardware config and config "template" for Software settings)

Peripheral Libraries Layer (PLIBs)

- Provide functional interface to peripheral capabilities
- Implements device-specific features

Middleware Layer

- Eases implementation of libraries and protocols (USB, TCP/IP, digital audio, graphics)
- Provides a highly-abstracted Application Program Interface (API)
- Libraries are thread-safe and RTOS-ready
- Built-on drivers, PLIBs, system services

Device Driver Layer

- Provides highly abstracted interface to peripherals
- Controls access to the peripherals
- Manages multiple hardware instances and software clients with select drivers
- Manages peripheral state and operation
- Accesses hardware directly or via PLIB
- Supports blocking or non-blocking code

Connectivity

TCP/IP AND Wi-Fi®

The MPLAB Harmony TCP/IP Stack provides a foundation for embedded network applications by handling most of the interaction required between the physical network port and your application. It includes modules for several commonly used application layers, including HTTP for serving web pages, SMTP for sending e-mails, SNMP for providing status and control, Telnet, TFTP and much more.

- Dual stack with IPv4 and/or IPv6 support
- Fully dynamic
- Easy RTOS integration
- Multiple interfaces (Ethernet and/or Wi-Fi)

USB

The USB Device Stack provides you with a framework to design and develop a wide variety of USB devices. A choice of full-speed only or full-speed and high-speed USB operations are available.

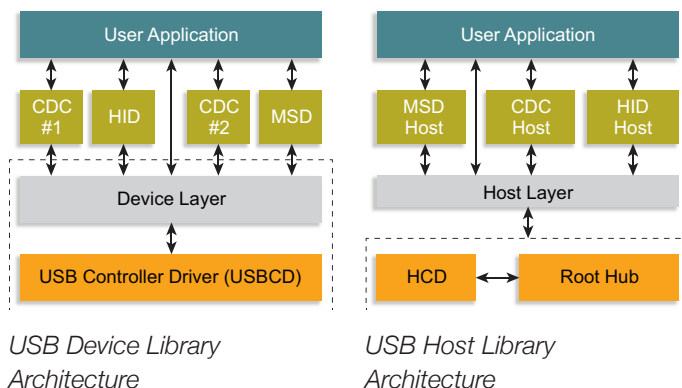
USB Device Stack Features

- Support for different USB device classes (CDC, audio, HID, MSD and generic)
- Support for multiple class instances (even of the same class) in a composite device
- Features thread safe operation when used in an RTOS based application
- Support for multiple configurations at different speeds
- Supports multiple USB peripherals

USB Host Stack Features

The USB Host Stack allows development of an embedded USB Host application that supports a variety of USB Device classes.

- Supports CDC, MSD, HID and Hub device classes
- Hub support allows multiple USB devices to be supported in an application.
- Features thread safe operation when used in an RTOS based application
- Support for multi-configuration and composite USB devices
- Support for VID/PID and class, subclass and protocol devices
- Concise API simplifies application development
- Support for high-speed USB devices



Bluetooth Basic Stack Library

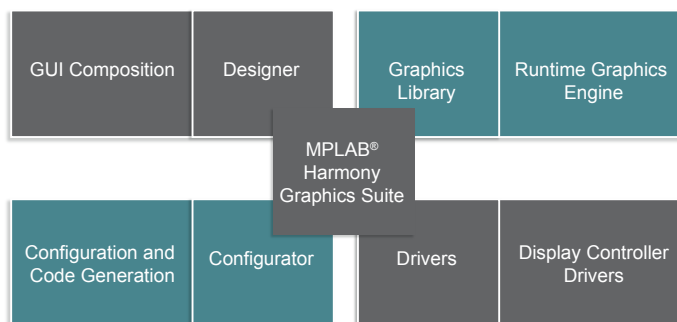
MPLAB Harmony offers Bluetooth Basic stack supporting the data transfer and includes Bluetooth Low Energy (BLE) and Serial Port Profile (SPP) Data demonstrations for free.

Human Machine Interface

MPLAB Harmony Graphics Composer Suite

The MPLAB Harmony Graphics Composer Suite (MHGS) features a free, modular graphics stack, various tools, and utilities for use with Microchip's SAM microcontrollers and microprocessors. The MHGS provides an easy to use GUI that works within the MPLAB X Integrated Development Environment (IDE). This is tightly integrated for better performance with MPLAB Harmony Configurator (MHC) for code development and other integrated debug features. The suite simplifies creation of advanced graphics content by facilitating automatic code generation to reduce the development time.

Graphics Library Features



- 24-bit color (32-bit with alpha channel) and multi-layer support
- Display Manager for automatic generation of display drivers
- Graphics Composer Design Tool
- Graphics Library
- Multiple modern widgets with support for touch gestures
- Multi-lingual font package
- Run-time graphic widget motion
- Run-Length Encoding (RLE) image compression

Graphics Library



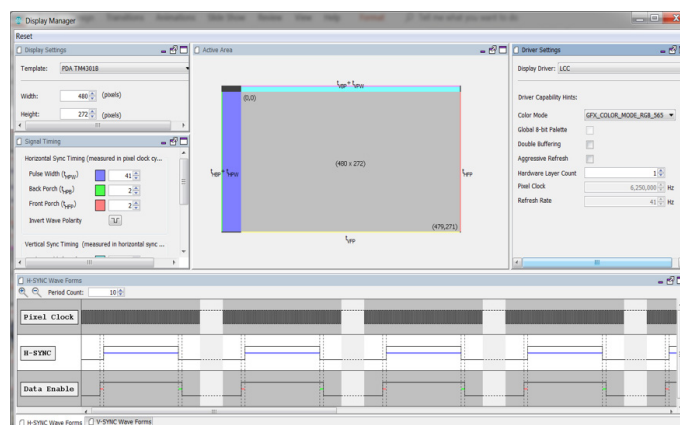
The library provides the building blocks to ease the development of aesthetically pleasing user interfaces and is responsible for managing the interface once created.

Key Features

- Provides a simple but powerful user experience
- Customizable to the needs of the application
- Light and flexible with regards to resource consumption
- Easily extensible to meet future design needs

Display Manager

A rapid prototyping tool that automatically generates drivers for your chosen display. It offers simulation of display controller timing and active area management. The tool supports both Low-Cost Controller-less graphics (LCC) and display controllers that include GLCD, S1D13517, SSD1926, and OT-M2201A. It can also be easily configured to incorporate a custom display driver.



GPU Driver Library

The GPU Library provides full functionality for the PIC32MZ 2D Graphics Processing Unit (GPU), which includes lines, rectangles, bit block transfers (blits), transparency, and binary raster operations (ROP2). The library provides the APIs for drawing accelerated raster graphics onto memory buffers with the aid of GPU and used little to no CPU resources.

maXTouch® Driver and Touch Systems Services

The MPLAB Harmony maXTouch Driver provides a high-level interface to the touch controller device. The driver provides application routines to read the touch input data from the touch screen.

The Touch System Service provides a simple interface to manage the touchscreen drivers. The MPLAB Harmony Graphics Composer is designed to automatically configure the Touch System Service and the Message System Service based on your request for touch screen input. This library provides a low-level abstraction of the Device Control System Service Library that is available on the Microchip family of PIC32 microcontrollers with a convenient C language interface.

Digital Audio and Bluetooth

Bluetooth Audio Package

This complete software package enables audio playback with remote control in a Bluetooth application. It includes Bluetooth Audio SBC decoder and features Bluetooth audio products and profiles such as Serial Port Profile (SPP), Advanced Audio Distribution Profile (A2DP), Audio Video Remote Control Profile (AVRCP), Audio Video Distribution Transport Protocol (AVDTP) and Audio Video Control Transport Protocol (AVCTP).

Microchip offers MP3 (SW320022-1 HPM), ACC (SW320025-1 HPM) decoder libraries that are designed and optimized for all PIC32 devices and seamlessly integrates with MPLAB Harmony Software Framework.

Free Audio Decoder Libraries

Microchip also offers decoder libraries that are available with the free download of MPLAB Harmony Framework. These include FLAC, OPUS, SPEEX, WAVE and ADPCM.

USB Audio Device Libraries

The MPLAB Harmony USB Audio device libraries feature routines to implement a USB Audio class 1.0 and USB audio class 2.0. The libraries offer various services to the USB audio device to communicate with the host by abstracting USB specification details and simplifying the implementation.

USB Audio Host Client Driver Library

It allows USB Host applications to support and interact with USB audio class 1.0 devices with the following features:

- Supports USB Audio class 1.0 with multiple streaming interfaces
- Designed to support multi-client operation
- RTOS ready
- Features an event driver non-clocking application interaction model
- Supports queuing of read and write data transfers

Universal Audio Decoder

The universal audio decoder application runs in USB host mode and supports FAT32 file system to play audio files from the mass storage device. The application supports WAVE, MP3, AAC, WMA, ADPCM and Speex formats

emWin Media Player: This application demonstrates the creation of an audio player that plays WAVE files from an SD card and from a USB Flash drive. The graphical user interface (GUI) with touch screen support is designed using SEGGER emWin graphics library. The GUI provides options to select media file type (SD card/flash drive), volume controls, random selection/shuffling of tracks and playlist view with progress bar/seek bar.

FreeRTOS

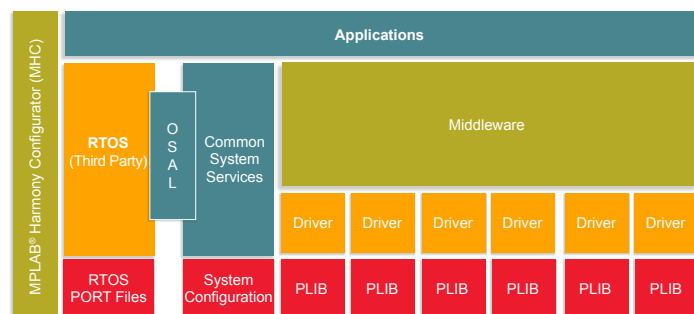
FreeRTOS is a small-footprint, portable, preemptive and open-source RTOS.

WolfSSL

The wolfSSL, Embedded SSL Library, is a light weight SSL/TLS library written in ANSI C and targeted for embedded, RTOS and resource-constrained environments. This is primarily because of its small size, speed and feature set. The wolfMQTT library is a client implementation of the Message Queuing Telemetry Transport (MQTT) written in C for embedded use. It supports SSL/TLS via the wolfSSL library. It was built from the ground up to be multi-platform, space conscience and extensible. It supports all packet types and all Quality of Service (QoS) levels 0-2. This implementation is based on the MQTT v3.1.1 specification.

Harmony v3 Documentation

Documentation for MPLAB Harmony 3, while still downloaded with each repository, is distributed and easy to access online. The www.microchip.com/harmony is the main entry point. GitHub Wiki pages provide instructional information. GitHub (web) pages publish reference material. Each repository has readme and release notes files to explain what the repository contains and to direct readers to other material.



The Documentation is Categorized as

- Instructional material, similar to textbooks and tutorials, introduce readers to content, explain what it is, how it works, and why and how to use it.
- Reference material is effectively the “programmer’s dictionary”. It provides limited introductory material, but explains the mechanics of the interface. Introductory material is just enough to help readers who are already familiar with the type of content, but not this specific content (ex. readers who understand the I²C bus, but not how this library controls it). It directs readers who are totally unfamiliar with the content to other instructional material. In addition to the above material GitHub also has information about release notes, devices supported, read me files and repository information.

MPLAB Harmony Board Support Packages (BSP)

For MPLAB Harmony 3, BSPs have been split into 2: BSPs and templates.

- BSPs provide configuration of settings related to hardware located on or connected to development boards.
- Templates provide configuration settings related to configuration of software components commonly desired when using specific development boards.

Main Harmony 3

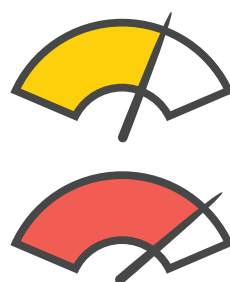
microchip-mplab-harmony.github.io

- Introductory material
- General development guides
- General training material
- Links to other resources

Module-Specific WiKi

microchip-mplab-harmony.github.io/gfx

- Introductory material
- Development guides, training material and references to other resources
- Module-specific version of main pages site



MPLAB Harmony

Board Support Packages (BSP)

A Board Support Package provides code and configuration items necessary to support board-specific hardware. A BSP may contain custom library code supporting on-board LEDs and switches as well as appropriate configuration settings to configure drivers and libraries that support available hardware on the selected board. Everything that is contained within a BSP can be either used or replaced by application-specific items if desired.

Application	Development Tool	Part Number
Connectivity: USB, Ethernet, CAN, Wi-Fi®, Bluetooth SPP and Bluetooth® Low Energy	PIC32MX1/2/5 Starter Kit	DM320100
	PIC32 Bluetooth Starter Kit	DM320018
	PIC32 Ethernet Starter Kit	DM320004
	PIC32MK GP Development Kit	DM320106
	PIC32 Ethernet Starter Kit II	DM320004-2
	PIC32 XLP Starter Kit	DM320105
	PIC32 USB Starter Kit II	DM320003-2
	PIC32 USB Starter Kit III	DM320003-3
	PIC32MZ Curiosity Development Board	DM320104
	PIC32MZ with FPU, Embedded Connectivity Starter Kit	DM320007
	PIC32MZ with FPU and Crypto, Embedded Connectivity Starter Kit	DM320007-C
	PIC32 I/O Expansion Board	DM320002
	Explorer 16 Development Board	DM240001
	PIC32MX460 Plug-In Module (PIM)	MA320002
	PIC32MX450/470 PIM	MA320002-2
	PIC32MX795F PIM	MA320003
	PIC32MZ with FPU PIM	MA320019
	chipKIT® WF32 Wi-Fi Development Board	TDGL021
	WINC1500 Wi-Fi PICtail/PICtail Plus Daughter Board	AC164156
	chipKIT Wi-FIRE Development Board	TDGL021-2
	SAME54 Xplained Pro Evaluation Kit	ATSAME54-XPRO
	SAMC21 Xplained Pro Evaluation Kit	ATSAMC21-XPRO
	SAMD21 Xplained Pro Evaluation Kit	ATSAMD21-XPRO

Continued on page 10

Application	Development Tool	Part Number
Graphics and Touch	Multimedia Expansion Board II (MEB II)	DM320005-5
	Graphics Controller PICtail™ Plus Epson S1D13517	AC164127-7
	Graphics LCD Controller PICtail Plus SSD1926	AC164127-5
	Low-Cost Controllerless (LCC) Graphics Board	AC164144
	PIC32 GUI Development Board	DM320015
	Graphics Display Truly 3.2" 320 × 240 Board	AC164127-4
	Graphics Display Truly 5.7" 640 × 480 Board	AC164127-8
	Graphics Display Powertip 4.3" 480 × 272 Board	AC164127-6
	Graphics Display 5" WVGA PCAP Board	AC320005, AC320005-4 and AC320005-5
	PIC32MZ Embedded Graphics with Stacked DRAM (DA) Starter Kit	DM320010
	PIC32MZ Embedded Graphics with Stacked DRAM (DA) Starter Kit (Crypto)	DM320010-C
	PIC32MZ Embedded Graphics with External DRAM (DA) Starter Kit	DM320008
	PIC32MZ Embedded Graphics with External DRAM (DA) Starter Kit (Crypto)	DM320008-C
	SAMV71 Xplained Ultra Evaluation Kit	ATSAMV71-XULT
Digital Audio and Bluetooth	PIC32MX470 Curiosity Development Board	DM320103
	PIC32 Bluetooth Audio Development Kit	DV320032
	PIC32 Audio DAC Daughter Board	AC320032-2
	Audio codec daughter card-AK4642	AC320100
	PIC32MX270F512L Bluetooth PIM	MA320017
	PIC32MZ with FPU Bluetooth PIM	MA320018
	Audio codec daughter card-AK7755	AC327755
	BM64 Bluetooth Radio Daughter Board	AC320032-3
MPU	SAMA5D2 Xplained Ultra Kit	ATSAMA5D2C-XULT
	ATSAMA5D2-SOM1-EK1	

Board Support Packages (BSPs) for one or more combinations of the development tools listed above are offered with the MPLAB Harmony Software Framework. For a specific combination of BSPs and updates, please refer to the Board Support Packages document under the "Documentation" section at www.microchip.com/harmony.

MPLAB Harmony Resources



Download

Download MPLAB Harmony at www.microchip.com/harmony.



Support

User support is provided by forums at www.microchip.com/forums keyword: "harmony"



Self-Paced Training

www.microchip.com/developerhelp



Pricing

The basic framework is free. Select libraries may need to be purchased.



One-Stop Shop

License, resale and support (including select third-party solutions) all via www.microchip.com/harmony.

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:

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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
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Tel: 49-2129-3766-400

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Tel: 49-89-627-144-0

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Spain - Madrid
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UK - Wokingham
Tel: 44-118-921-5800

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China - Chengdu
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China - Chongqing
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