MPLAB® Harmony Integrated Software Framework

Advanced and Easy-to-Use Embedded Software Solution

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Simplify and Scale Your Design With MPLAB Harmony v3

MPLAB® Harmony 3 is an extension of the MPLAB development ecosystem that simplifies the development of embedded firmware for our 32-bit SAM and PIC32 microcontrollers (MCUs) and SAM microprocessors (MPUs). It includes an easy-to-use Graphical User Interface (GUI) for selecting, managing, configuring and generating starter code for application development.

This software development framework allows for maximum reuse and reduces a design's time to market. It includes examples for simple device support as well as for complex networking and Internet-ready applications, motor control, graphics, USB host and device applications, cryptography, capacitive touch and other smart, connected and secure designs.

MPLAB Harmony v3 provides you with easy access to simplified peripheral libraries, device drivers and modular software downloads to speed up the software development for your MCU or MPU. You can generate the code for your project with MPLAB Code Configurator (MCC) for seamless integration into your MPLAB Harmony project.

MPLAB Harmony v3 Improvements

In addition to supporting SAM, PIC32M and PIC32C MCUs, SAM MPUs and other devices, MPLAB Harmony's modular structure offers multiple development options. You can use its configurable, pre-written libraries to implement code in your project, which reduces your design risk and speeds up your development time.

Simplified Peripheral Libraries

MPLAB Harmony v3 provides substantial simplifications in the lowest layers, particularly in the Peripheral Libraries (PLIBs). These PLIBs use actual C language functions instead of inline functions or macros, which allows them to be used independently from drivers or other components in MPLAB Harmony. These libraries provide direct access to peripherals on the device so you can update their configurations as needed.

Driver Usage Model Simplifications

MPLAB Harmony v3 drivers and system services provide powerful multi-instance, multi-client features like buffer queueing and RTOS and non-RTOS support. These drivers provide simple abstractions of the peripherals on which the middleware, and potentially your applications, are built.

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 you want to perform bare-metal development (without RTOS support) or use another supported real-time operating system, simply select your preference from the available RTOS configuration options. It also supports Arm® Mbed™ OS, Microsoft® Azure® RTOS and other popular RTOSes.

Extensive Middleware

MPLAB Harmony v3 provides an extensive selection of middleware for a variety of applications. When used in conjunction with the provided application examples, this middleware will speed up your development. Options include MPLAB Harmony Graphics Suite (MHGS), TCP IPv4 and IPv6 stacks with many Internet protocols, USB host and device stacks, a crypto library and more. The easy-to-use Q Spin configuration tool is available for motor control applications. Additional middleware is available for aerospace applications, Wi-Fi® connectivity, bootloaders that support different peripherals and core architectures, crypto libraries for security-enabled devices, touch and machine learning algorithms. Class B libraries are also available for various MCUs and MPUs.

Modular Downloads and Installation

MPLAB Harmony v3 provides a download manager that allows you to select only the modules you would like to use. Modules are kept in GIT repositories that are publicly hosted on GitHub and Gitee and can be cloned to your local workstation to make them available for use in your projects.

Generate Your Code With MPLAB Code Configurator

MPLAB Code Configurator (MCC) is a free graphical programming environment that generates seamless, easy-to-understand C code to insert into your project. Featuring an intuitive interface, it enables and configures a rich set of peripherals and functions specific to your application. It supports our 8-bit, 16-bit and 32-bit devices, which include our PIC®, AVR® and SAM MCUs and dsPIC® Digital Signal Controllers (DSCs). The integrated MCC content manager tool provides content management and versioning at an individual component level.

MCC consists of three content types: MCC Melody, MCC Classic and MPLAB Harmony. It offers application libraries and system and peripheral drivers for the development of embedded software.

Available MPLAB Harmony Application Examples

- Audio supported on SAM E70 Xplained Ultra Evaluation Kit, PIC32 Audio Codec Daughter Board and SAM G55 Curiosity Development Board
- Bluetooth® Low Energy, Bluetooth audio and SPP
- CAN FD
- Graphics
- TCP/IP
- USB
- Crypto

Operating System Abstraction Layer (OSAL)

- OSAL interface with FreeRTOS support enabled by default
- OSAL implementation to support applications without an RTOS
- Arm Mbed OS support
- Microsoft Azure RTOS (previously known as Thread-X RTOS) support

Middleware/Software Libraries

- Graphics
- Crypto
- TCP/IP
- File systems
- System services
- Bluetooth
- Math
- Bootloader

Device Support Software

- Audio codecs
- Ethernet Media Access Controller (MAC)
- Ethernet PHY interface (KSZ8061, LAN8740 and MIIM)
- SPI, UART, high-speed USB host and device
- Peripheral Libraries (PLIBs) for supported devices

Device Family	MPLAB® X IDE	bsp	dev_packs	core	csp
PIC32C MC[1]	Yes	Yes	Yes	Yes	Yes
PIC32 MK	Yes	Yes	Yes	Yes	Yes
PIC32 MX	Yes	Yes	Yes	Yes	Yes
PIC32 MZ EF	Yes	Yes	Yes	Yes	Yes
PIC32 MZ DA	Yes	Yes	Yes	Yes	Yes
PIC32 MZ W1[1]	Yes	Yes	Yes	Yes	Yes
PIC32AK	Yes	Yes	Yes	Yes	Yes
SAM9X60	Yes	Yes	Yes	Yes	Yes
SAMA5D2	Yes	Yes	Yes	Yes	Yes
SAM C20/C21	Yes	Yes	Yes	Yes	Yes
SAM D9/10/11	Yes	Yes	Yes	Yes	Yes
SAM D20/D21/DA1	Yes	Yes	Yes	Yes	Yes
SAM D5x/E5x	Yes	Yes	Yes	Yes	Yes
SAM G55	Yes	Yes	Yes	Yes	Yes
SAM L10/L11	Yes	Yes	Yes	Yes	Yes
SAM L21/L22	Yes	Yes	Yes	Yes	Yes
SAM RH71	Yes	Yes	Yes	Yes	Yes
SAM S70/E70/V70/V71	Yes	Yes	Yes	Yes	Yes
WFI32[1]	Yes	Yes	Yes	Yes	Yes

[1] Beta Release

Software Development Tools

- MPLAB X IDE
- MPLAB XC32++ Compiler
- MPLAB Code Configurator (MCC) Plug-in
- Graphics design, configuration and driver tools
- Board Support Packages (BSPs) for PIC® and SAM boards

Third-Party Software

- Security: wolfSSL, wolfCrypt, wolfSSH and wolfMQTT
- FreeRTOS, Microsoft Azure RTOS, Arm Mbed OS, Micrium OS
- Supports project export capability to IAR Embedded Workbench®

MPLAB Code Configurator Block Diagram

Application Layer

MPLAB Harmony content provides code examples to support application development. These application examples are available on GitHub and are organized by device families and application areas. Demo examples include graphics, aerospace, motor control, USB, Ethernet and more.

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 using MCC to implement simple device configuration by generating initialization functions for the device and peripherals

Peripheral Libraries Layer (PLIBs)

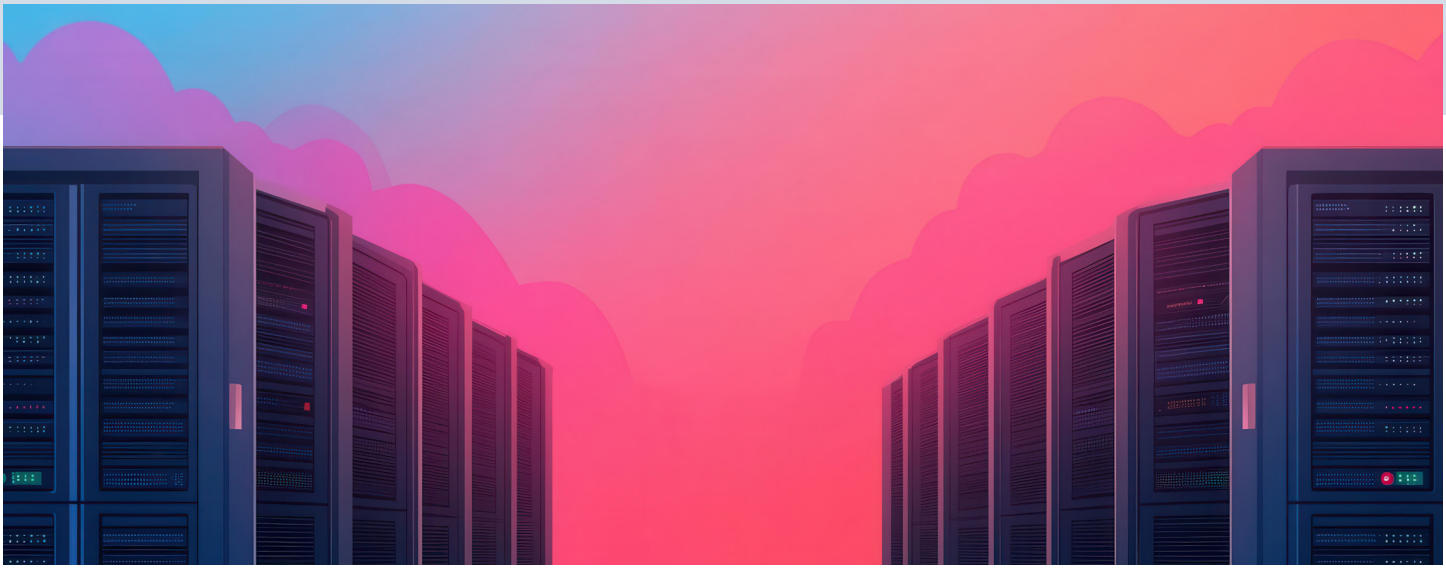
- Provides functional interface to peripheral modules
- Models the hardware peripheral modules available on Microchip MCUs by breaking each peripheral down into a set of individual features

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

Device Driver Layer

- Provides abstracted interface to peripherals
- Abstracts 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
- Provides code blocking feature that blocks the execution of code in a multi-threading environment until the next thread achieves a given state.



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.

USB Device Stack Features

- Support for different USB device classes
- Support for multiple class instances (even of the same class) in a composite device
- Thread-safe operation when used in an RTOS-based application
- Support for multiple configurations at different speeds
- Support for multiple USB peripherals
- Support for full and high-speed USB operation

USB Host Stack Features

The USB Host Stack allows you to develop an embedded USB host application that supports a variety of USB device classes.

- Hub support allows multiple USB devices to be supported in an application
- Thread-safe operation when used in an RTOS-based application
- Support for multi-configuration and composite USB devices

Human Machine Interface

Microchip Graphics Suite

Microchip Graphics Suite simplifies the creation of advanced graphics content by automatically generating code. It features a free, scalable and modular graphics stack and a variety of tools and utilities for use with PIC32 and SAM MCUs and SAM MPUs. Its easy-to-use GUI works within MPLAB X IDE, and it is tightly integrated into MCC for better performance when developing code and using the debug features.

Graphics Library

The Graphics Library provides the building blocks to simplify the creation of aesthetically pleasing user interfaces. It is also responsible for managing the interface after it is implemented.

Graphics Library Key Features

- Provides a simple but powerful user experience
- Can be customized to meet the specific requirements of an application
- Lightweight and flexible to minimize resource consumption
- Easily extensible to meet future design needs
- Display Manager for automatic generation of display drivers
- Graphics Composer Design Tool
- Multiple modern widgets with support for touch gestures
- Multi-lingual font package

Display Manager

This rapid prototyping tool automatically generates drivers for your chosen display. It offers display controller timing simulation and active area management. It supports Low-Cost Controller-less graphics (LCC) and GLCD, LCDC, S1D13517, SSD1926 and OT- M2201A display controllers. 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 a SAM9x60 FGX2D Graphics Processor Unit (GPU) and uses minimal to no CPU resources.

maXTouch® Technology Driver and Touch Systems Services

The MPLAB Harmony maXTouch technology driver, integrated Peripheral Touch Controller (PTC) and Touch System Services provide a high-level interface to the touch controller. The driver provides application routines to read the touch input data from a touchscreen. The integrated PTC touch driver supports the development of a low-cost, integrated touch solution.

The Touch System Services provide a simple interface to manage the touchscreen drivers. MHGC is designed to automatically configure the Touch System Services and the Message System Services based on your request for touchscreen input. This library includes a convenient C language interface and provides a low-level abstraction of the Device Control System Service Library that is available on PIC32 MCUs.

Digital Audio and Bluetooth

Bluetooth Audio Package

This complete software package enables audio playback with remote control in a Bluetooth application. It includes a 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).

We offer MP3 (SW320022-1 HPM), ACC (SW320025-1 HPM) decoder libraries that are designed and optimized for all PIC32 devices and that integrate seamlessly with MPLAB Harmony v3.

Free Audio Decoder Libraries

We also offer decoder libraries, including FLAC, OPUS, SPEEX, WAVE and ADPCM, that are available with MPLAB Harmony v3.

USB Audio Device Libraries

The MPLAB Harmony USB audio device libraries feature routines to implement USB audio class 1.0 and USB audio class 2.0 applications. The libraries offer various services that abstract USB specification details to simplify implementation and enable the USB audio device to communicate with the host.

USB Audio Host Client Driver Library

This library allows USB host applications to support and interact with USB audio class 1.0 devices. It offers the following features:

- Support for USB audio class 1.0 with multiple streaming interfaces
- Multi-client operation
- RTOS ready
- Event driver non-clocking application interaction model
- Queuing of read and write data transfers

Universal Audio Decoder

The universal audio decoder application runs in USB host mode and supports the 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 GUI with touchscreen support is designed using the SEGGER emWin graphics library. The GUI provides options to select the media file type (SD card/Flash drive) and manage functions like volume controls, random selection/shuffling of tracks and viewing a playlist with a progress bar/seek bar.

FreeRTOS

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

WolfSSL

The wolfSSL Embedded SSL Library is a lightweight SSL/TLS library written in ANSI C that targets embedded, RTOS and resource-constrained environments. The wolfMQTT library is a client implementation of the Message Queuing Telemetry Transport (MQTT) protocol that is written in C for embedded use. It supports SSL/TLS via the wolfSSL Library. This multi-platform, space-conscious and extensible library supports all packet types and Quality of Service (QoS) levels 0–2.

MPLAB Harmony v3 Documentation

Documentation, which includes readme and release notes, can be downloaded with each MPLAB Harmony repository but is also distributed online for easy access as follows:

- MPLAB Harmony Web Page: This should be your starting point to find links to the documentation and resources you need to start your application development. Also, refer to the MPLAB Harmony Help File/Release Notes in the “Documentation” area on this page to get the latest information on updates to MPLAB Harmony and solutions from our third-party partners.
- MPLAB Harmony v3 GitHub Wiki: This area includes instructional materials that will introduce you to each repository and explain what it is, how it works and why and how to use it. These materials include:
  - Getting started and other introductory tutorials
  - General development guides
  - General training materials
  - Links to other resources
- MPLAB Harmony GitHub Pages: In these pages, you’ll find reference materials that provide limited introductory material on different concepts but not exhaustive details. For example, you may read a general explanation about the mechanics of the I^2C interface, but not how a library controls it. If you are totally unfamiliar with a topic, the documentation will guide you to other instructional materials.

In addition to the resources listed above, the MPLAB Harmony area on GitHub also provides the following information:

- List of supported devices
- Links to repositories
- Repository-specific wikis

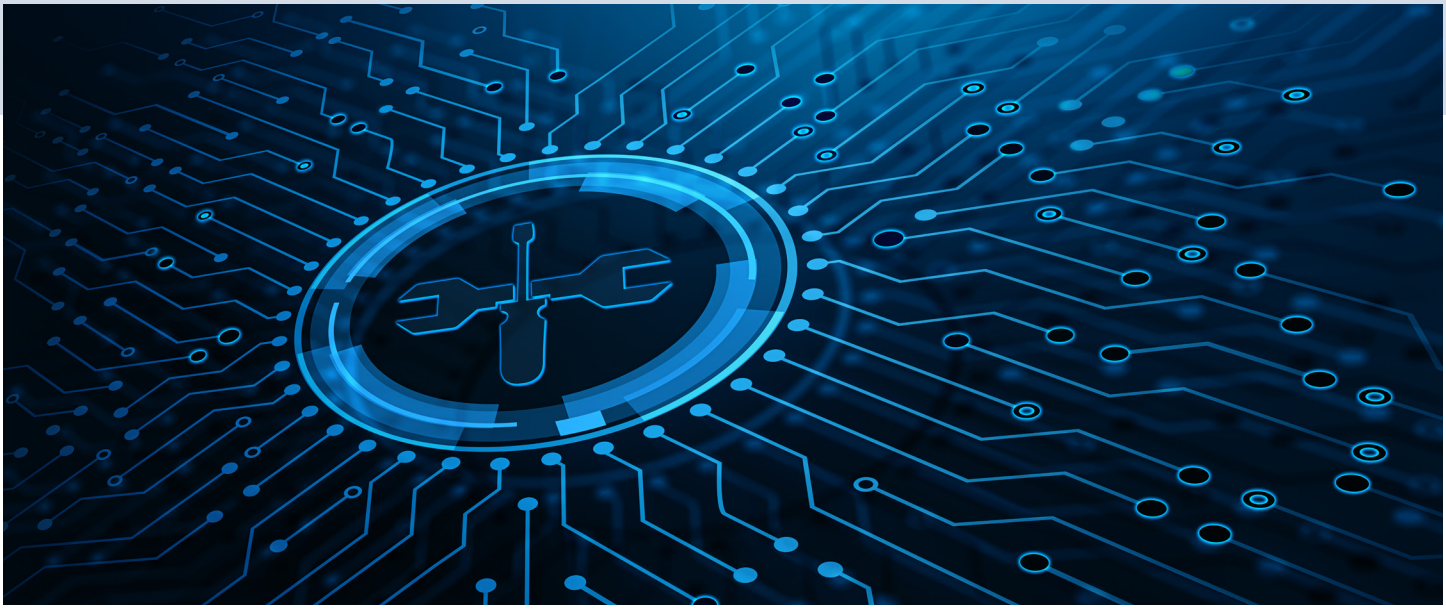
MPLAB Harmony Board Support Packages (BSP)

A BSP provides the code and configuration resources necessary to support board-specific hardware. To enhance board support capabilities, MCC can be used for Microchip device configuration and easy setup of memory controllers.

BSPs for one or a combination of the development tools listed below 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.

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
	SAM C21 Xplained Pro Evaluation Kit	ATSAMC21-XPRO
	SAM D21 Xplained Pro Evaluation Kit	ATSAMD21-XPRO
PIC32A MCU	Curiosity Platform Development Board	EV74H48A
	PIC32AK1216GC41064 General Purpose (GP) DIM	EV25Z08A
	Curiosity Platform Development Board and PIC32AK1216GC41064 GP DIM Bundle	BN61G23A

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	



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 available at www.microchip.com/harmony.

Microchip Technology Inc. | 2355 W. Chandler Blvd. | Chandler AZ, 85224-6199 | microchip.com

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