

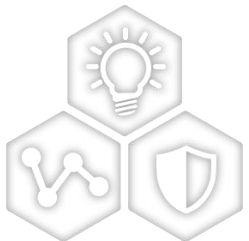


dsPIC33 Digital Signal Controllers



A Leading Provider of Smart, Connected and Secure Embedded Control Solutions

Development Tools



SMART | CONNECTED | SECURE

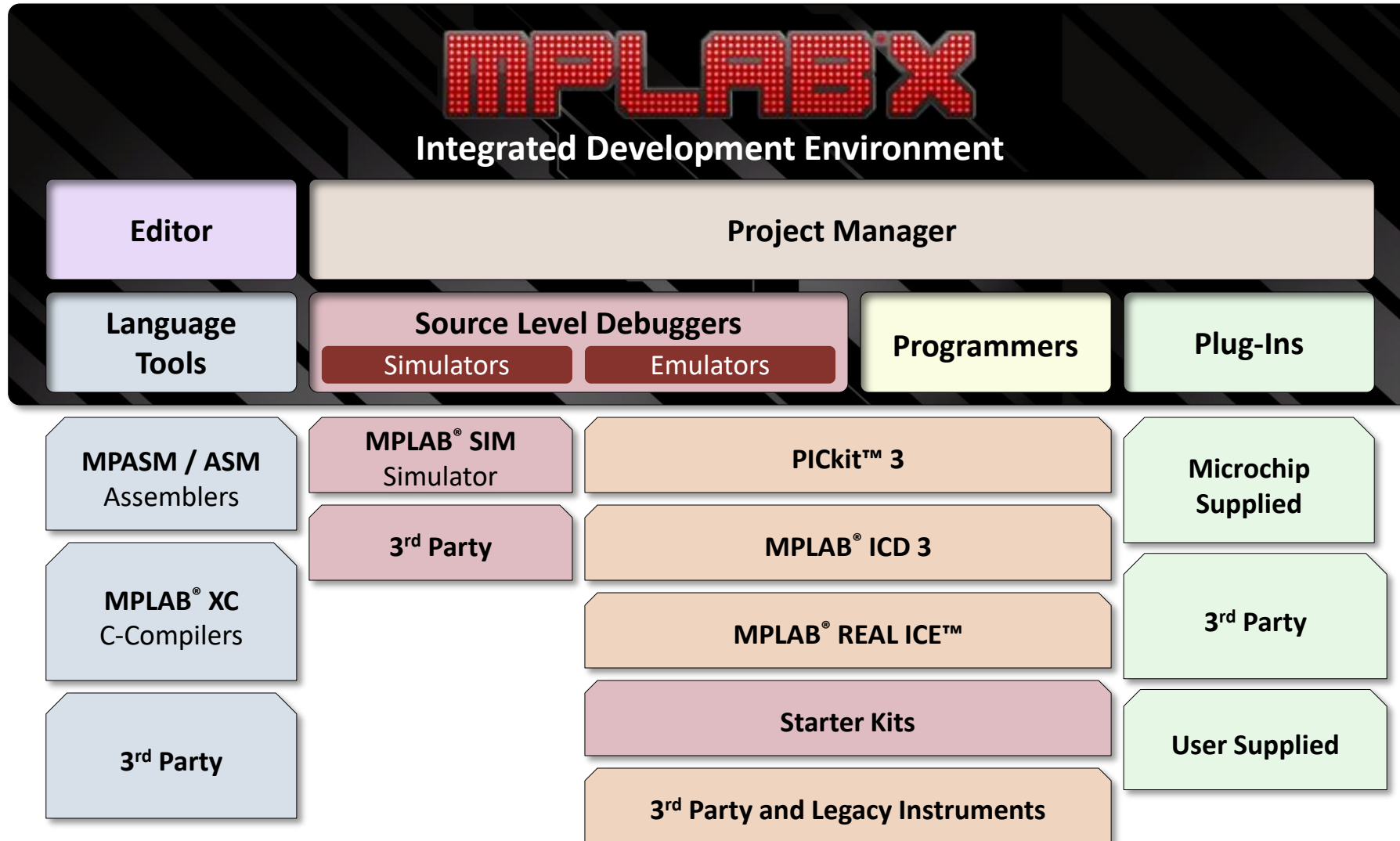


Power
Conversion

Andy Reiter
November 15, 2022

Introducing the MPLAB[®] X Ecosystem

MPLAB® X IDE Overview



MPLAB[®] XC Compilers

| Hi-Tech PICC Based | MPLAB C30 / GCC Based | MPLAB C32 / GCC Based | MPLAB C32 / GCC Based |
|---|---|---|---|
| MPLAB[®] XC8 <i>8-bit Compiler</i> | MPLAB[®] XC16 <i>16-bit Compiler</i> | MPLAB[®] XC32 <i>32-bit Compiler</i> | MPLAB[®] XC32++ <i>32-bit Compiler</i> |
| PIC10, PIC12 PIC16, PIC18 ATtiny | PIC24 dsPIC30 dsPIC33 | PIC32/SAMx | PIC32/SAMx |

| | |
|---------------------|--|
| Free | No cost, production worthy, optimizing compiler, community support |
| Standard | Entry level price, more optimization, access to priority support |
| Professional | Full price, whole program optimization, access to priority support |

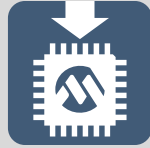
MPLAB X Ecosystem

Programmer/Debuggers

Microcontroller Design Environment



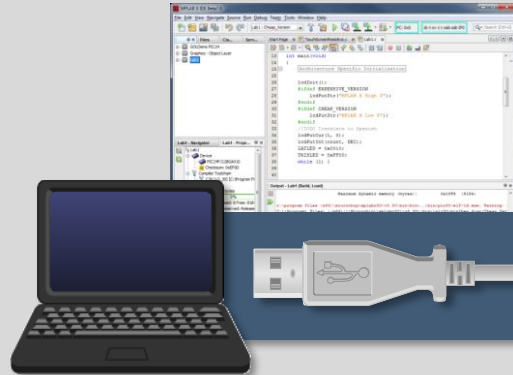
Integrated
Development
Environment



Programmer
Debugger



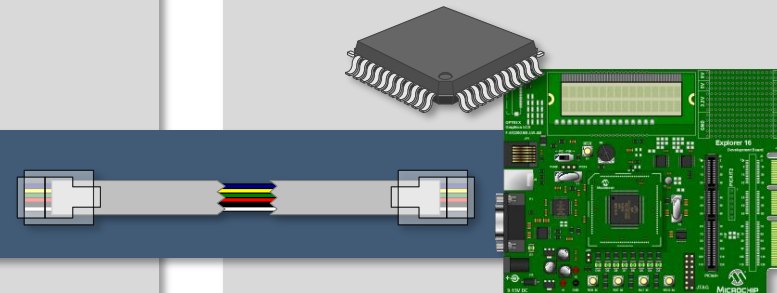
Target
Hardware



MPLAB® X IDE
C Compiler
C++ Compiler
MPASM Assembler



MPLAB ICE™
MPLAB ICD 4
MPLAB PICKIT™ 4



Curiosity Boards
Explorer 16
Starter Kits
Your Hardware...

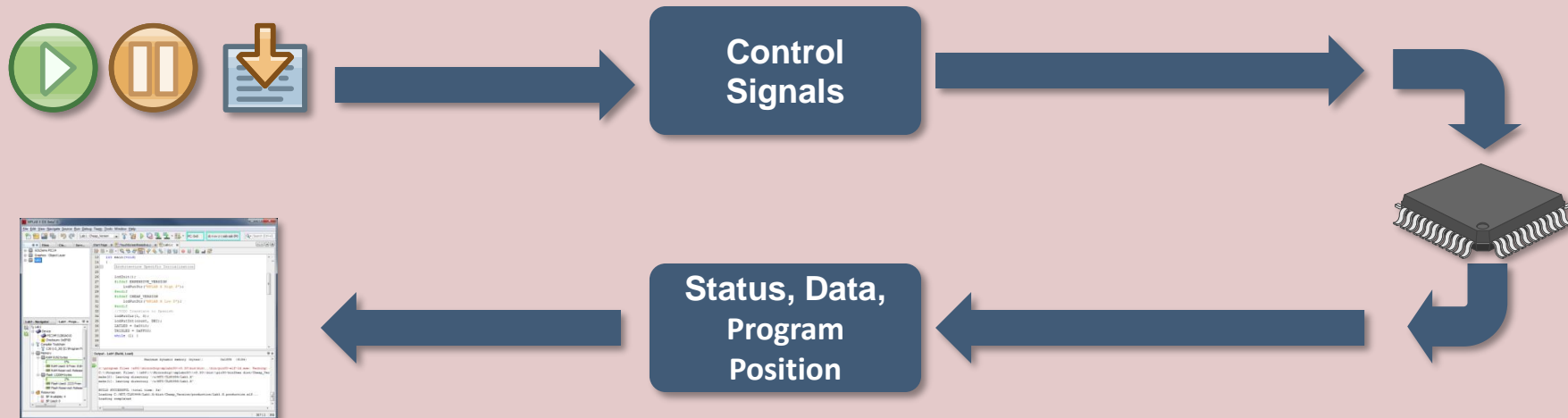
What is a Programmer/Debugger?



Programming Function

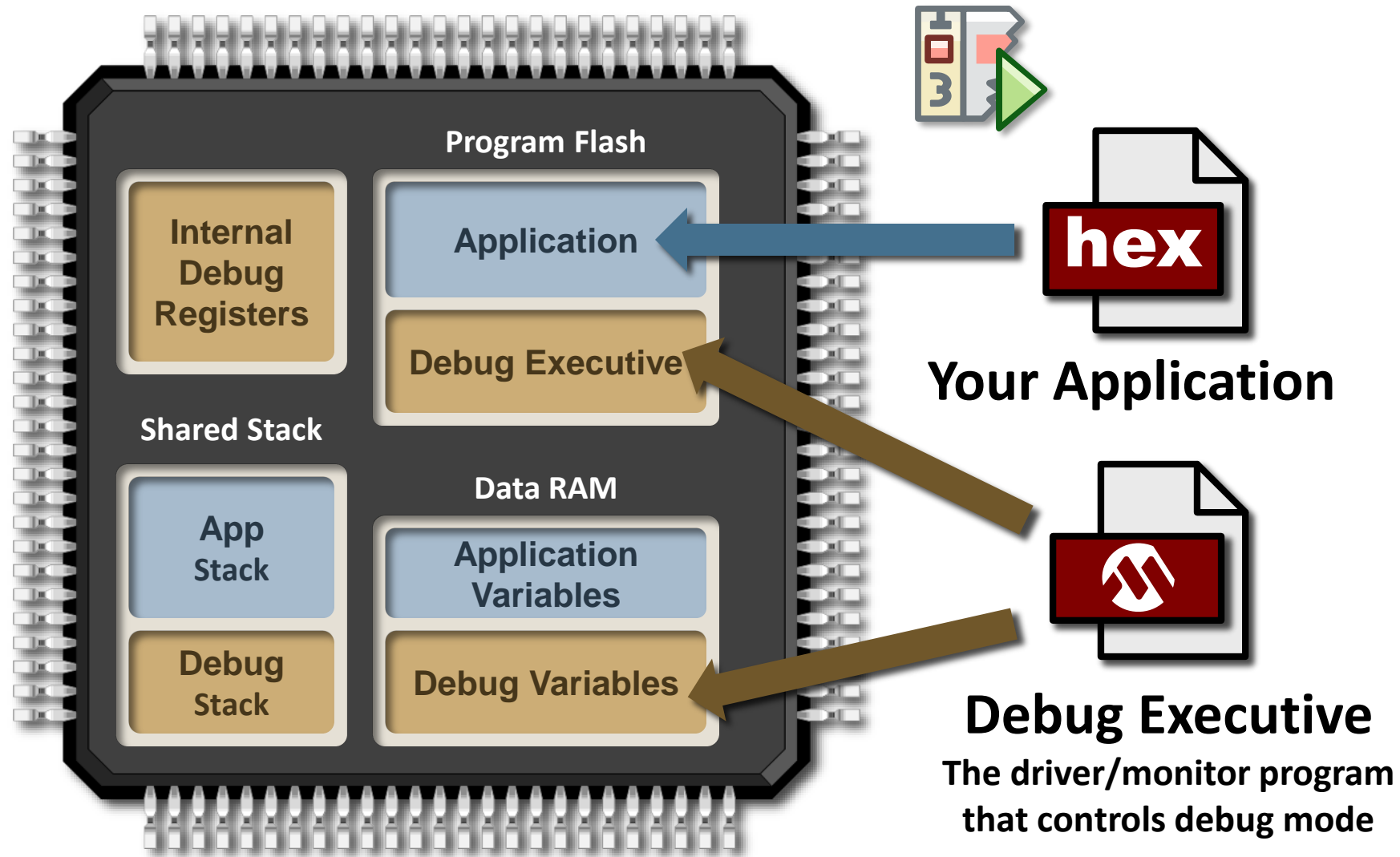


Debugging Function



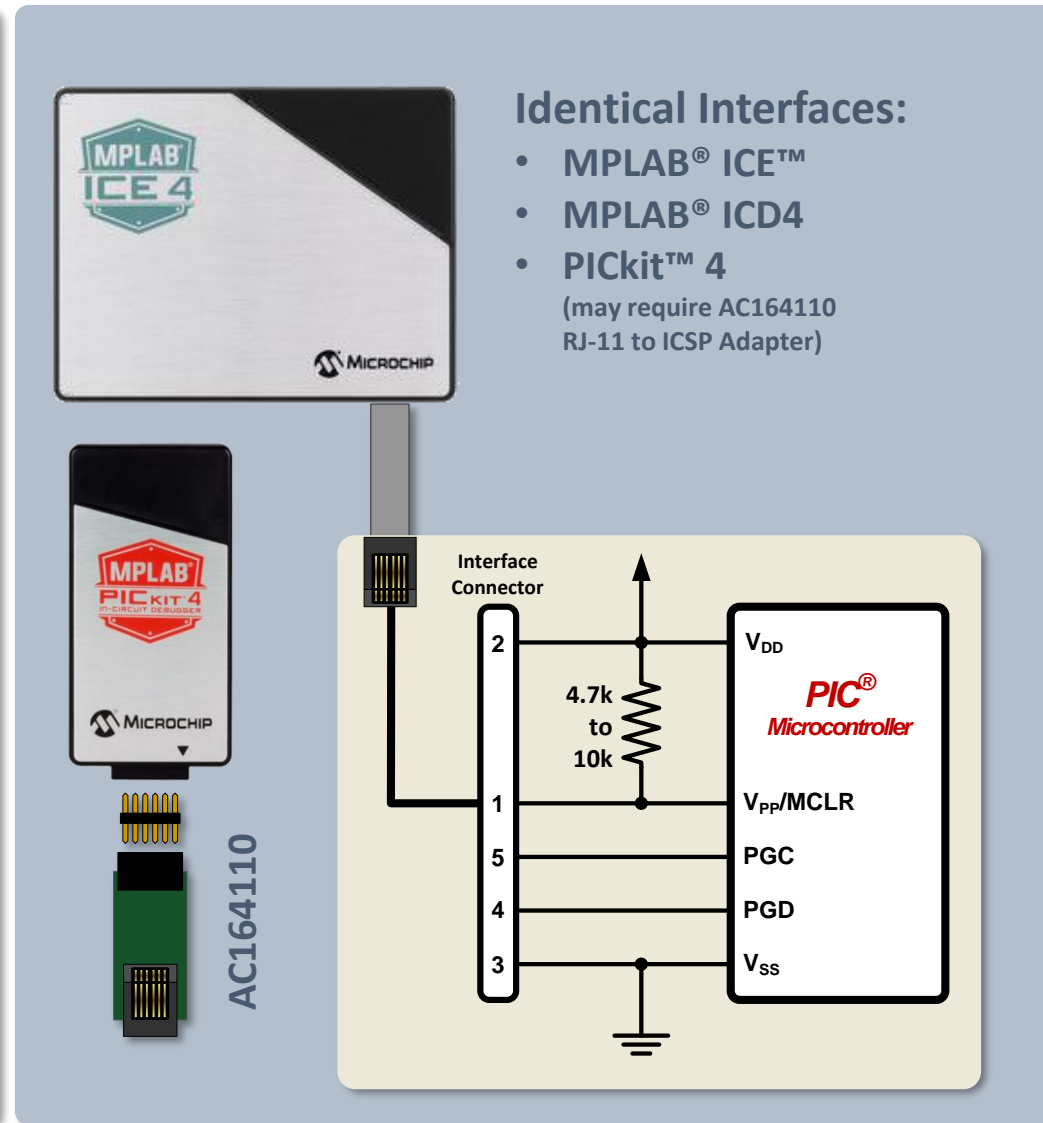
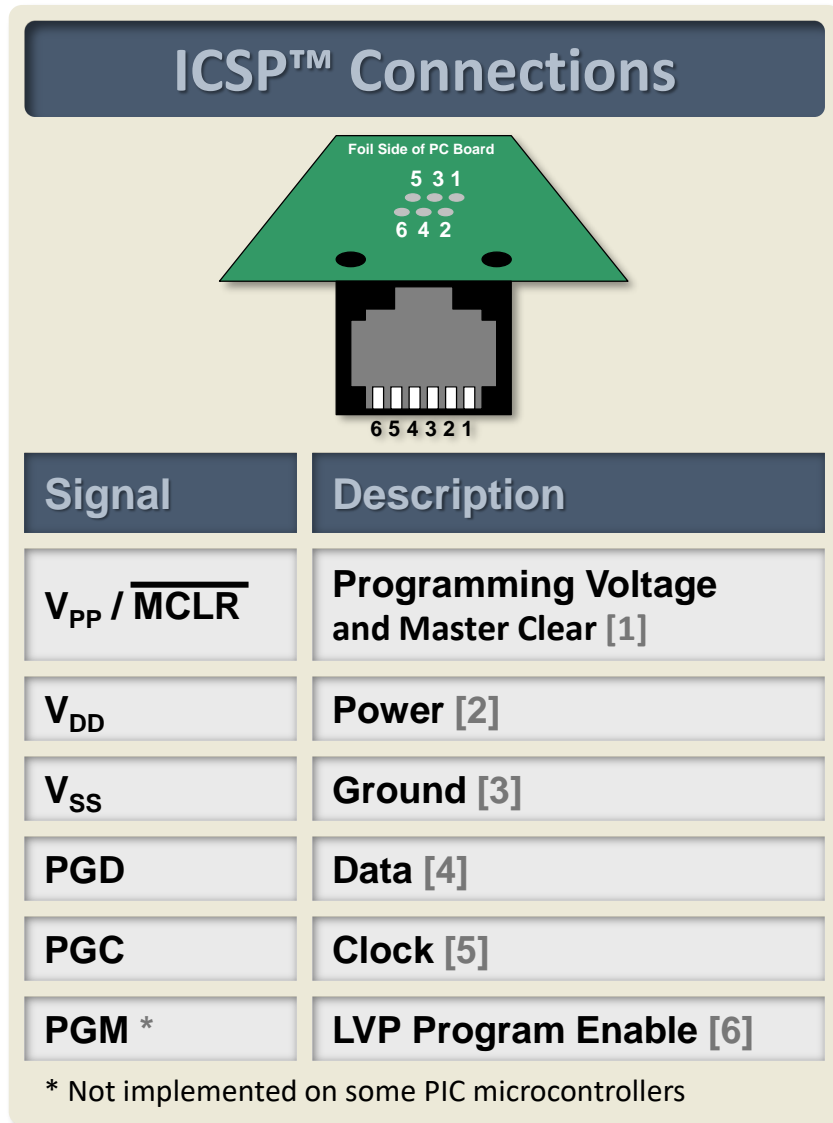
Debug Executive

Inserted to support In-Circuit Debugging



Debugger Connection to Target

6-pin RJ-11 or ICSP™ Header



Default Debugging Features

- **Target voltage of 1.20V to 5.5V**
 - Wide target voltage supports a variety of devices
- **Program voltages:**
 - 2.3V to 5.0V - Low voltage and high voltage program entry modes
 - 1.2V to 2.3V - Low voltage program entry mode only
- **Portable USB-powered and RoHS-compliant**
 - Powered by a high-speed USB 2.0, no external power required
 - CE and RoHS-compliant
- **8-pin single in-line header**
 - Supports advanced interfaces such as 4-wire JTAG and Serial Wire Debug with streaming Data Gateway
- **Compatibility**
 - Backward compatible for demo boards, headers and target systems using 2-wire JTAG and ICSP
- **Field-upgradeable through an MPLAB X IDE firmware download**
 - Add new device support and features by installing the latest version of MPLAB X IDE, which is available as a free download at www.microchip.com/mplabx
- **Debugging Features**
 - Hard- and software break points
 - Instruction Stopwatch

MPLAB® PICkit™ 4 In-Circuit Debugger



PG164140 – PICkit™ 4 Debug Express

- Matches silicon clocking speed
 - Programs as fast as the device will allow
- Can supply up to 50mA of power to the target
 - Can be powered from the target to program in the field
- Power from Target
 - Option to be self-powered from the target (2.7V to 5.5V)
- Programmer-to-Go (PTG) support
 - SD card slot to holds program data
 - Press on the logo to program the target
- Cost effective
 - Features and performance at a fraction of the cost of comparable debugger/programmers

MPLAB® ICD 4 In-Circuit Debugger

Microchip Standard Connectivity Plus JTAG



DV164045 – MPLAB® ICD 4

- **Full-Speed Real-Time Emulation**
 - Designed to support high-speed processors running at maximum speeds
 - High-Speed Programming
 - Quick firmware reload for fast debugging/in-circuit re-programming
 - Includes programmable adjustment of debugging speed for optimized programming
 - Test Interface Module
- **Ruggedized Interface**
 - Protection circuitries are added to the probe drivers to guard from power surges from the target
 - VDD and VPP voltage monitors protect against overvoltage conditions/all lines have over-current protection
 - Safely power up to 1A with an optional power supply
- **Compatibility**
 - Supports all MPLAB ICD 3 headers
- **Cost Effective**
 - Features and performance at a fraction of the cost of comparable emulator systems
- **Debugging Features**
 - Supports multiple breakpoints, stopwatch and source code file debugging
 - Selectable pull-up/pull-down option to the target interface in MPLAB X IDE's editor for quick program modification/debug

MPLAB® ICE 4 In-Circuit Debugger/Emulator



- **Variety of connectivity features to debug and program:**
 - SuperSpeed USB 3.0 host PC interface with USB speed of 5 Gbps
 - High-speed USB 2.0 host PC interface
 - Ethernet connectivity with speeds up to 100 Mbps
 - Wired/DHCP/APIAP IP addressing
 - Static IP addressing
 - Wi-Fi Access Point Connectivity (Wi-Fi-AP)
 - Connects with SSID of the unit
 - Connection to Wi-Fi using Wireless Station Mode (Wi-Fi-STA)
 - Connects to your home/office network
 - Uses network SSID, security type with username and password

DV244140 – MPLAB® ICE4

MPLAB® ICE 4 In-Circuit Debugger/Emulator



DV244140 – MPLAB® ICE4

- **Contains professional-grade safety features to enhance productivity:**
 - Powered by 9V DC wall mount power supply
 - Can safely power up to 1A of power to a target application
 - Ruggedized with protection circuitries to the probe drivers to guard from voltage transients from the target
 - VDD and Vpp voltage monitors protect against overvoltage conditions and all lines have overcurrent protection
 - RED tested and CE and RoHS compliant
- **Target Device Interfaces**
 - MPLAB ICE 4 in-circuit emulator JTAG adapter for SAM MCUs
 - MPLAB ICE 4 in-circuit emulator ICSP™ programming capability adapter board for AVR MCUs
 - MPLAB ICE 4 in-circuit emulator ICSP programming capability adapter board for PIC MCUs and dsPIC Digital Signal Controllers (DSCs)
 - MPLAB ICE 4 in-circuit emulator Arm® Cortex®-M trace adapter board for SAM MCUs
 - MPLAB ICE 4 in-circuit emulator PIC32 trace adapter board for PIC32M MCUs
 - The MPLAB ICE 4 in-circuit emulator connects to targets using a high-speed 40-pin rugged edge rate cable assembly.

MPLAB® ICE 4 In-Circuit Debugger/Emulator



DV244140 – MPLAB® ICE4

- **Advanced Trace Capabilities**
 - Data capture/native trace
 - SPI trace (currently supported on 16-bit PIC devices)
 - Port trace (currently supported on 16-bit PIC devices)
 - PIC32 iFlowtrace™ 1.0/iFlowtrace 2.0
 - ARM ITM/SWO
- **Power Debugging Capabilities (Currently Only Supported on AVR and SAM MCUs)**
 - Can correlate to code by capturing power data and corresponding PC values
 - Can identify power profiles
 - Can determine functions which take the most power
 - Can Interface to MPLAB Data Visualizer
- **Power Monitoring (Supported on All Devices)**
 - Can monitor power of the full system or component
 - Contains two channels with different resolutions
 - CI/CD Support
- **MPLAB ICE 4 in-circuit emulator hardware tool can be used for continuous integration/continuous delivery over Ethernet using hardware in the loop**
- **Can use CI/CD wizard to set up for Jenkins and Docker on the latest version of MPLAB X IDE v6.00**
- **Data Gateway Interfaces**
- **USART**
- **Power**
- **SPI (support coming soon)**
- **I2C (support coming soon)**
- **Comprehensive Debug Functionality**
- **Supports multiple breakpoints, stopwatch and source code file debugging**
- **Selectable pull-up/pull-down option to the target interface**

MPLAB® ICE 4 In-Circuit Debugger/Emulator



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MPLAB® ICE 4 In-Circuit Debugger/Emulator

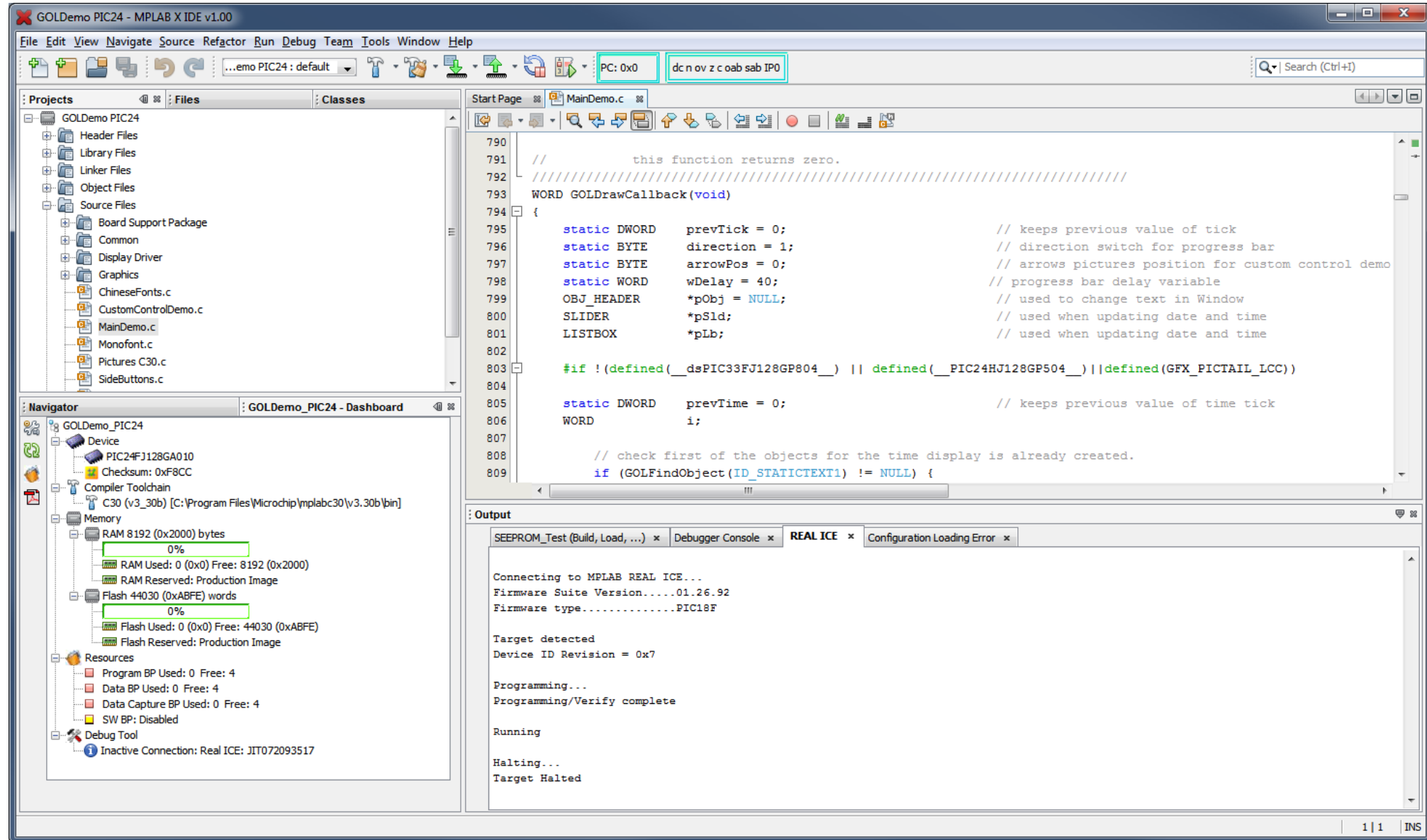


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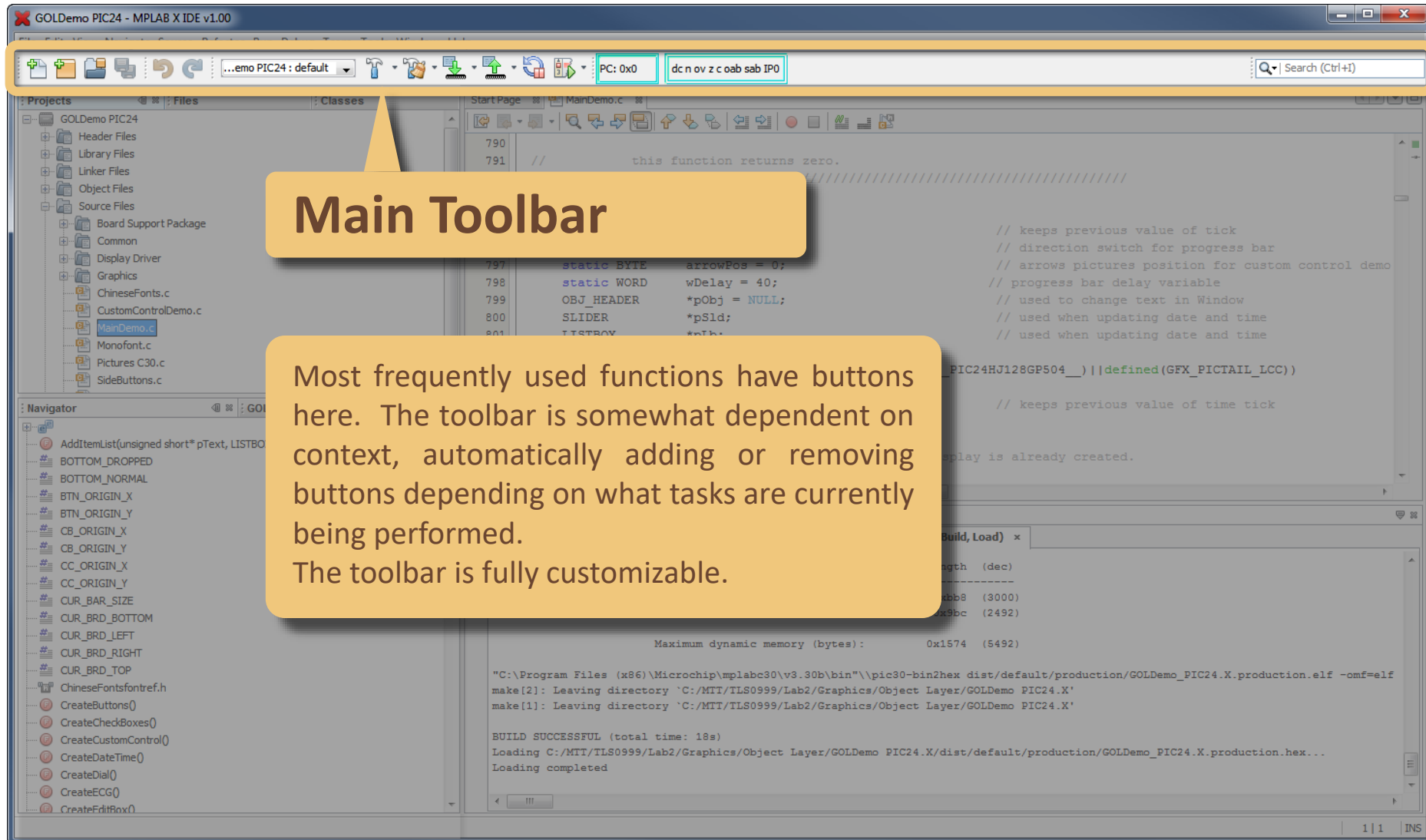
MPLAB® X IDE

IDE Layout



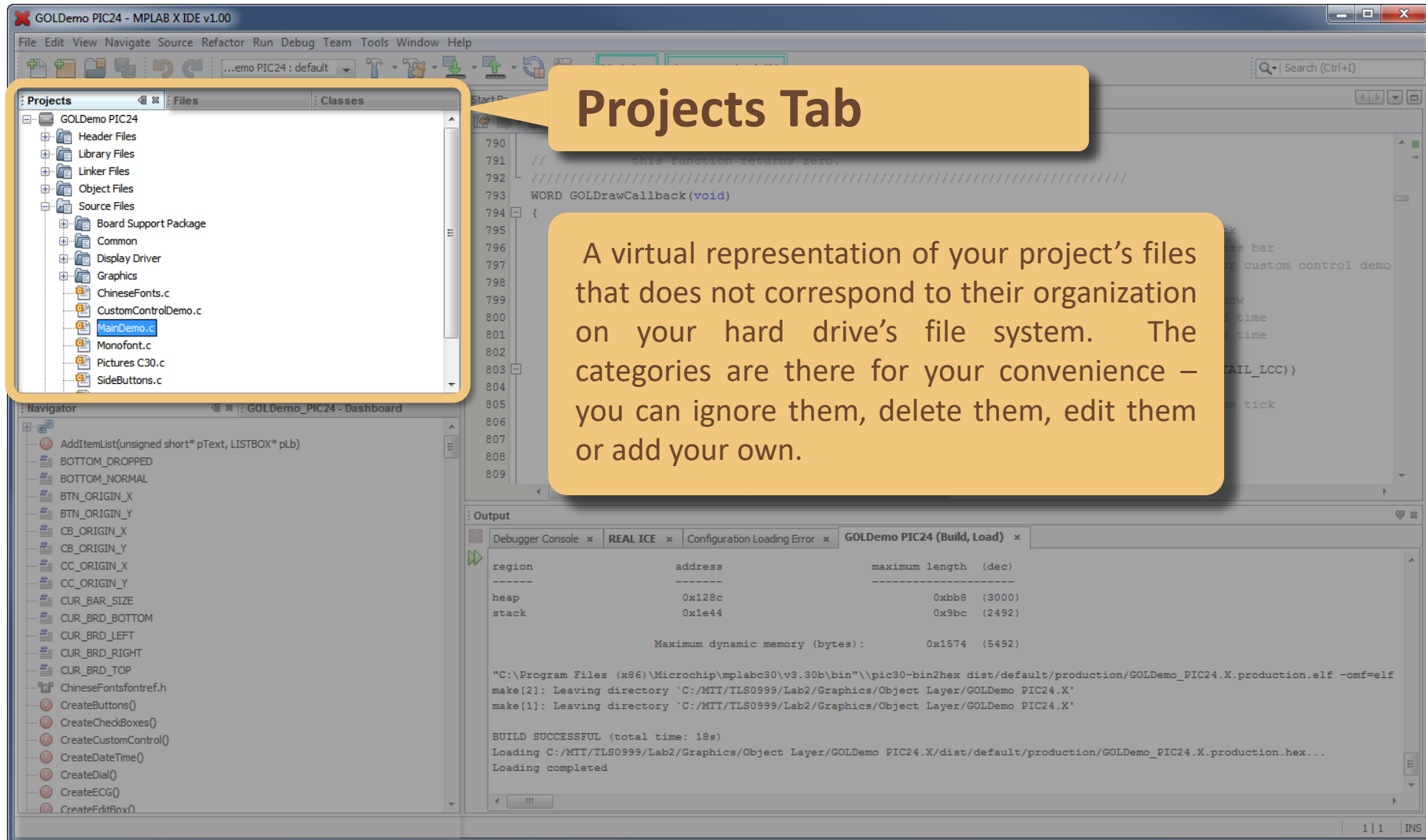
IDE Layout

Main Toolbar



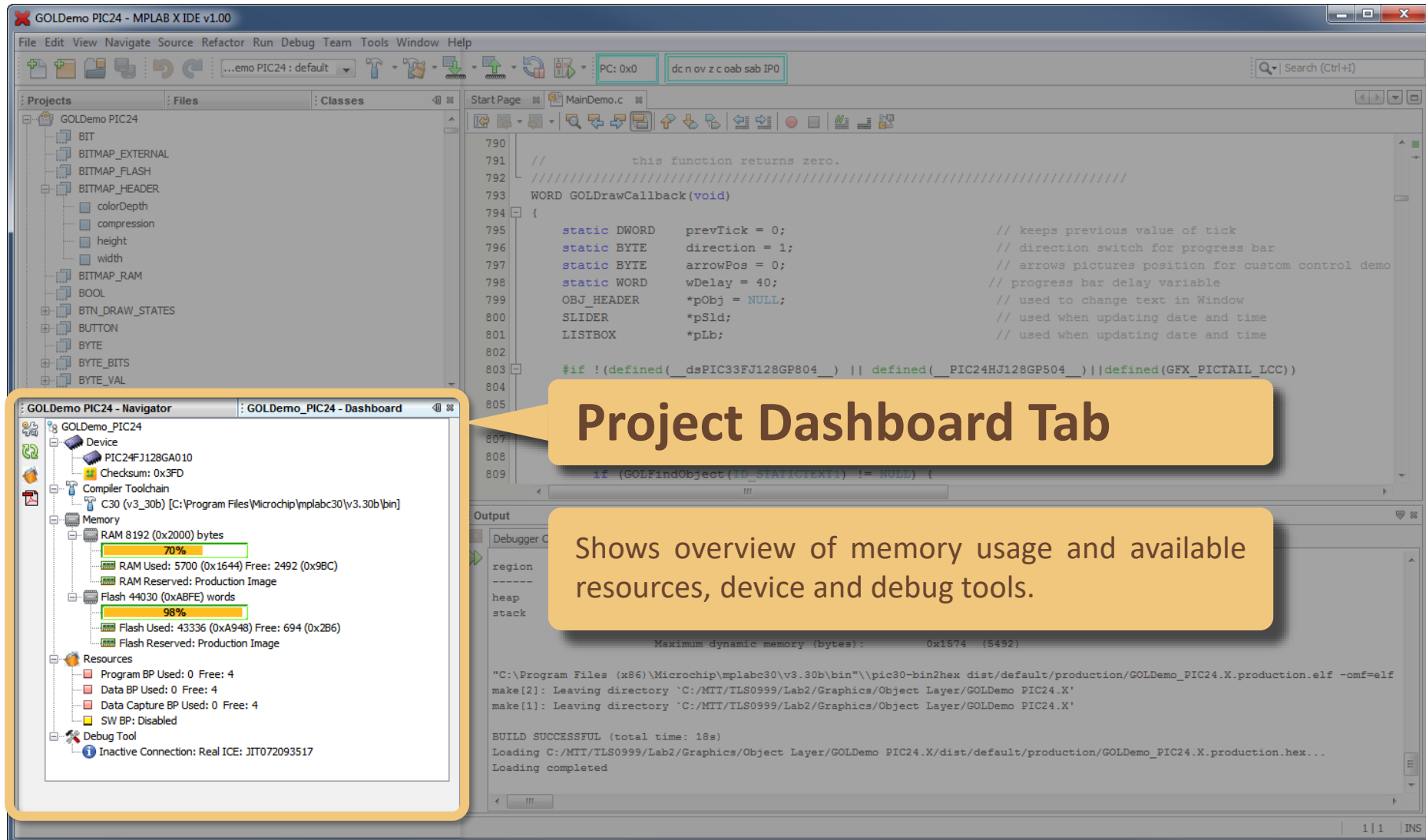
IDE Layout

Projects Tab (Project Tree)



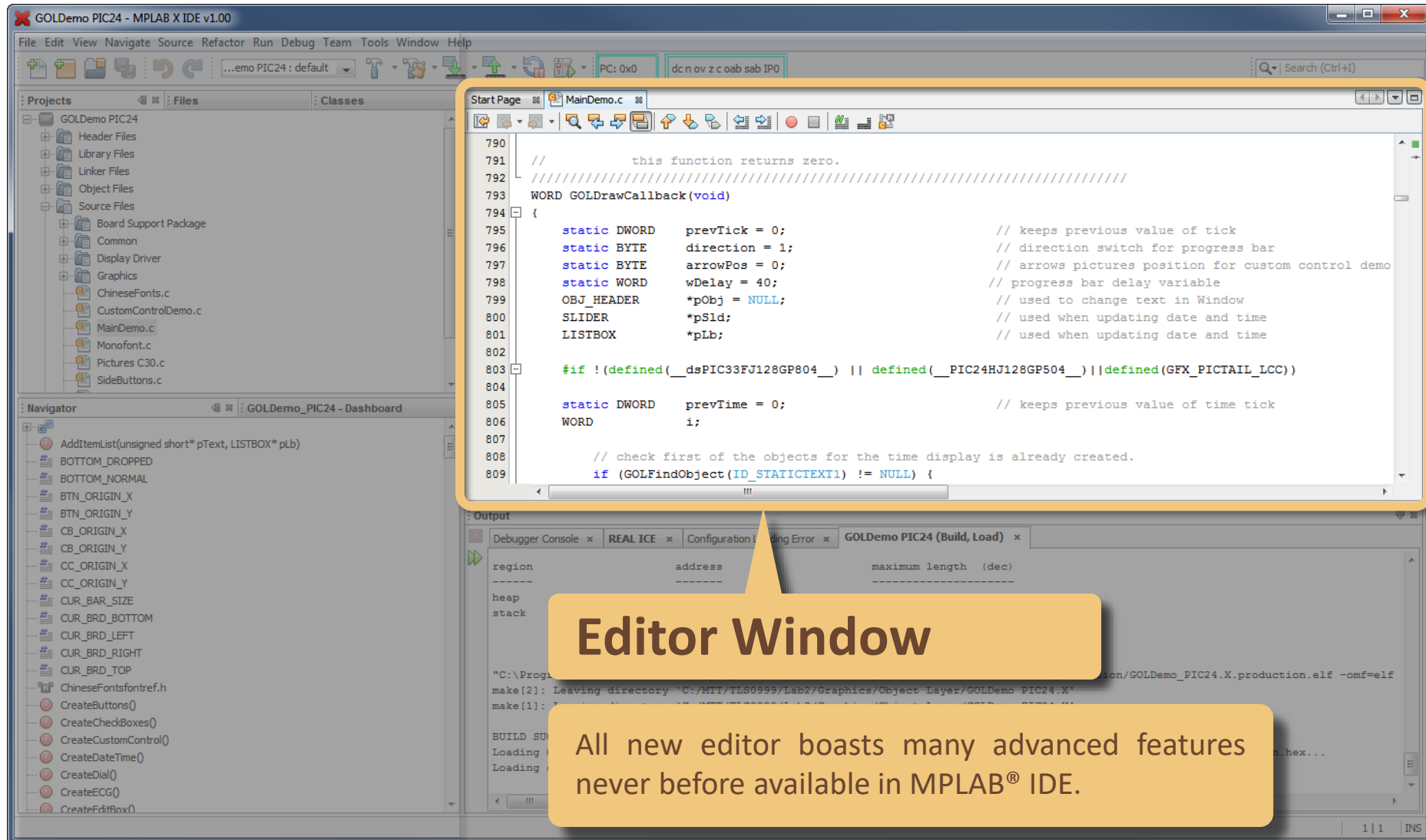
IDE Layout

Project Dashboard Tab



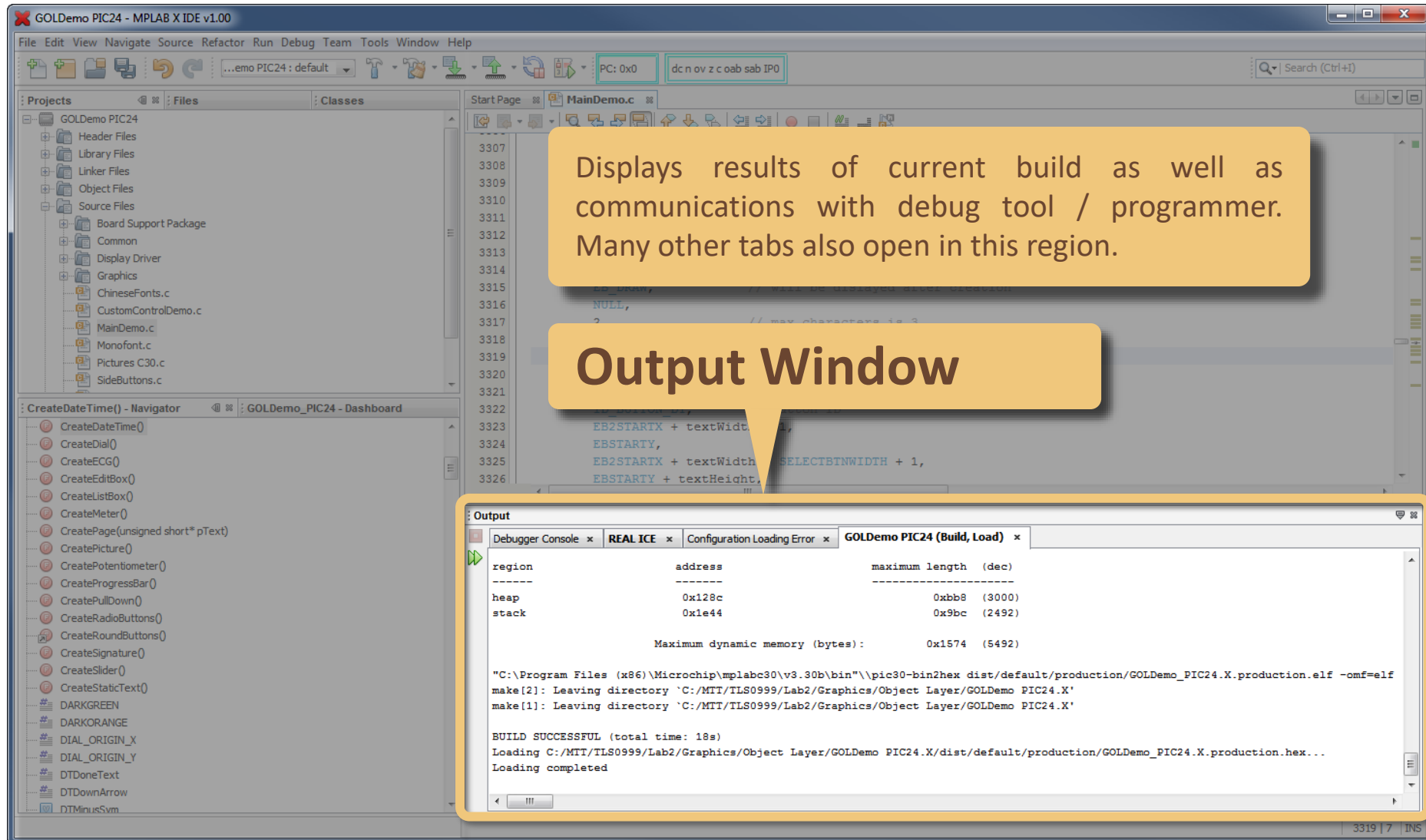
IDE Layout

Editor



IDE Layout

Output Window



MPLAB® Code Generators

Microchip Code Generator Standard Tools



8-/16-bit Software Framework

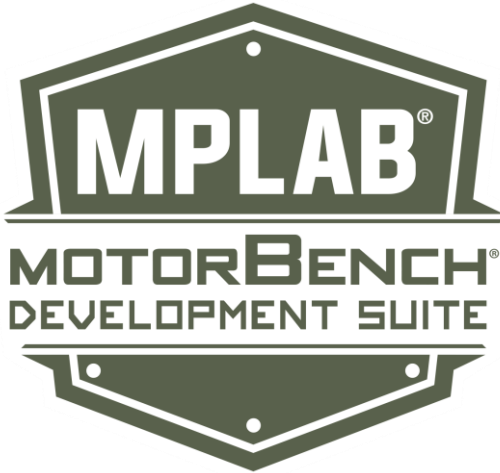


32-bit Software Framework



8-/16-/32-bit Device Configurator

Vertical Application Code Generator Tools



Motor Control Configuration



Standard Device Configuration

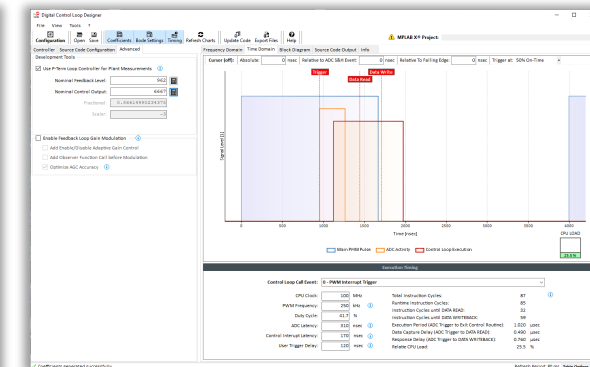
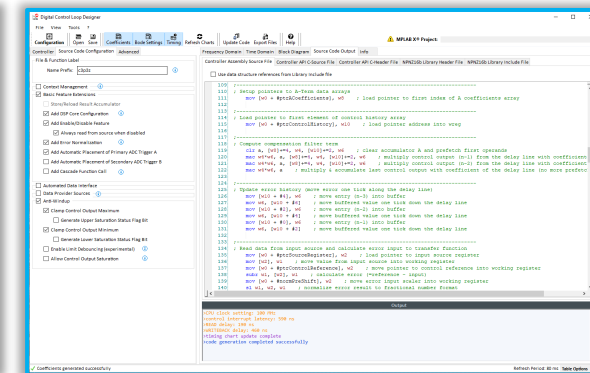


Power Supply Configuration
(independent)

MPLAB® PowerSmart™

The comprehensive Digital Power Supply design eco-system

Code Generation

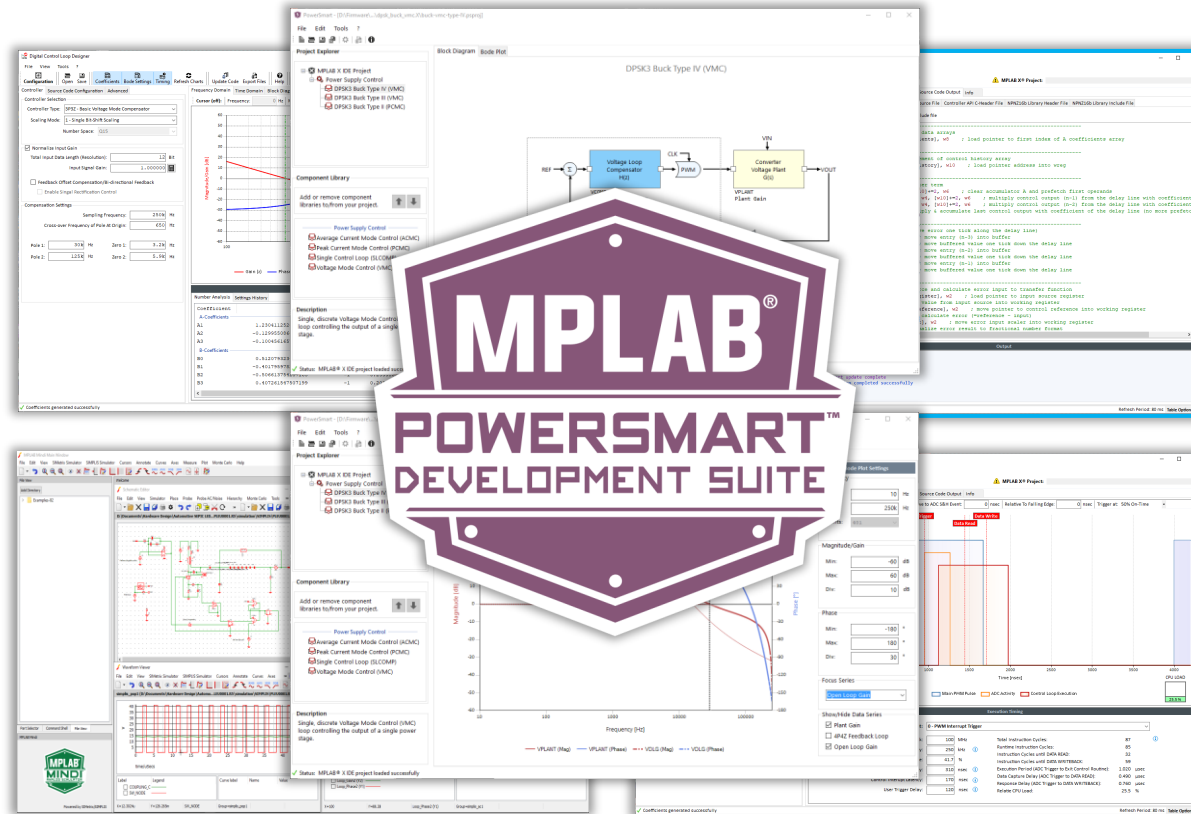


Implementation Analysis

MCU16 Digital Power Applications

MPLAB® PowerSmart™ Development Suite

Junction between Circuit Design & Simulation and X IDE

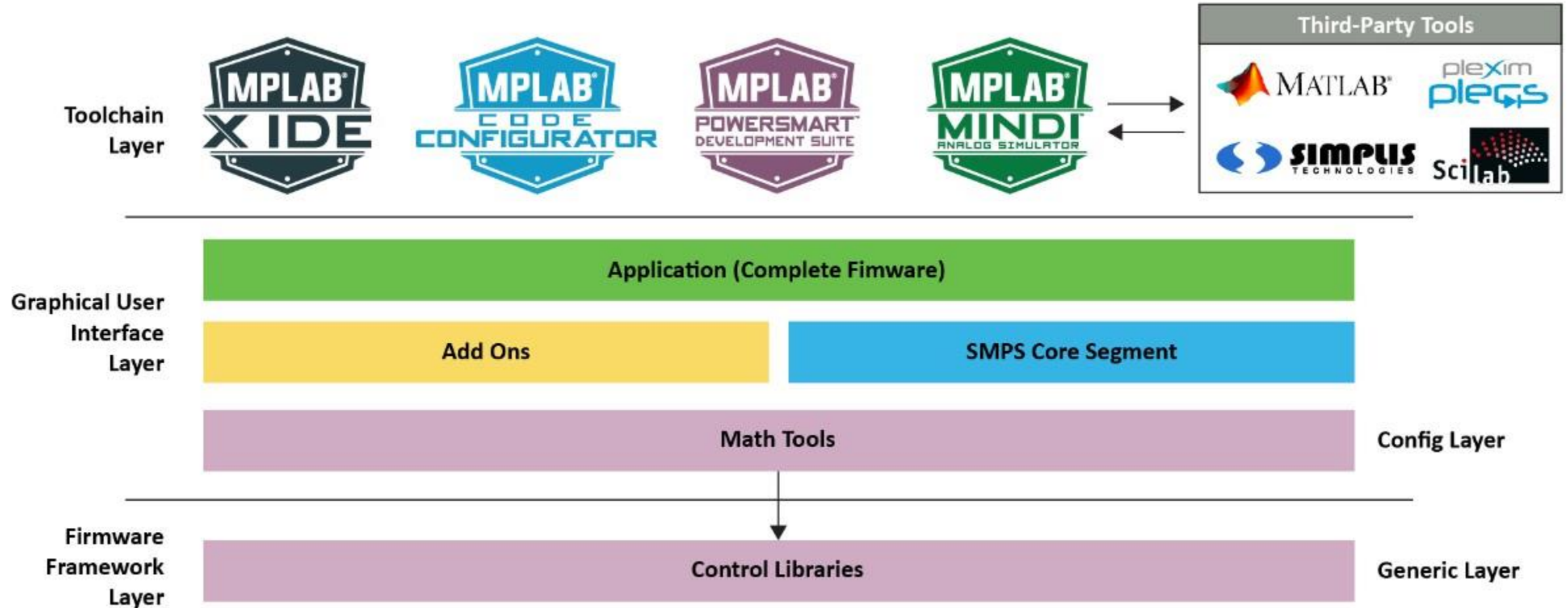


<https://www.microchip.com/powersmart>

MCU16 Digital Power Applications



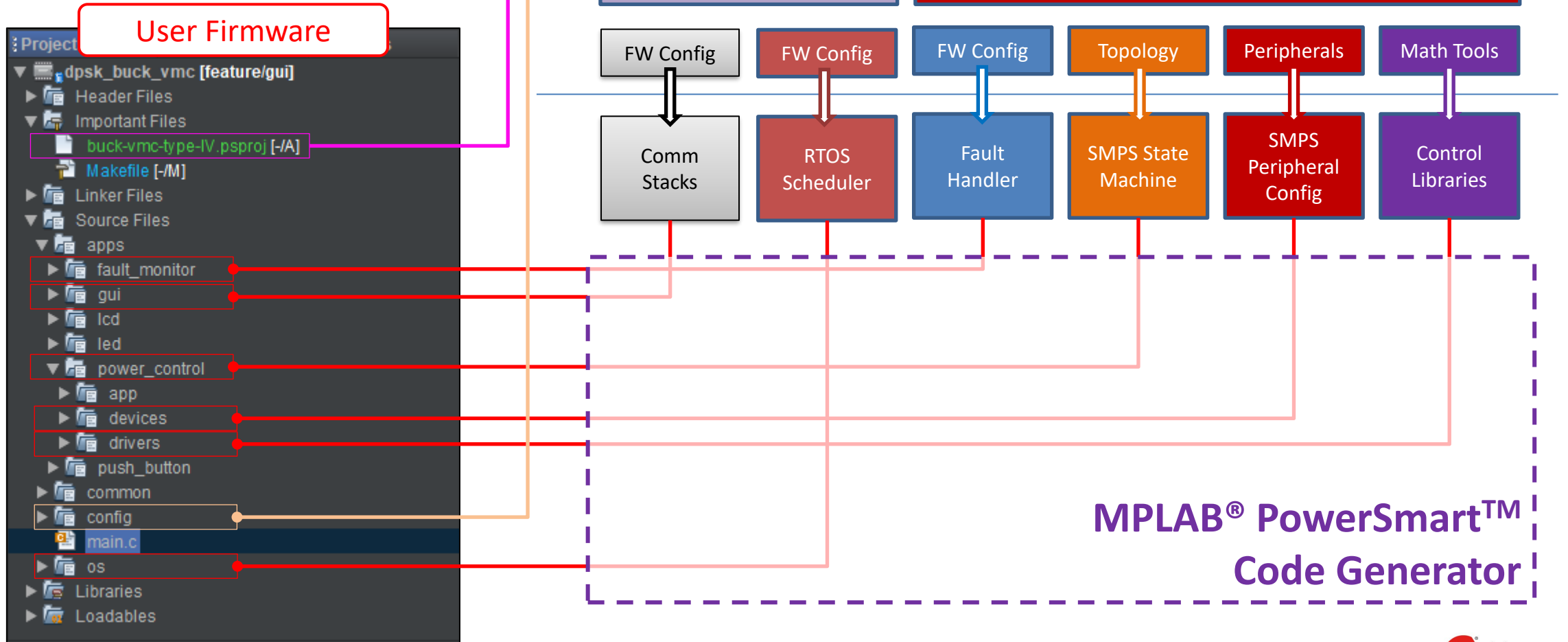
PowerSmart™ Eco System



<https://www.microchip.com/powersmart>

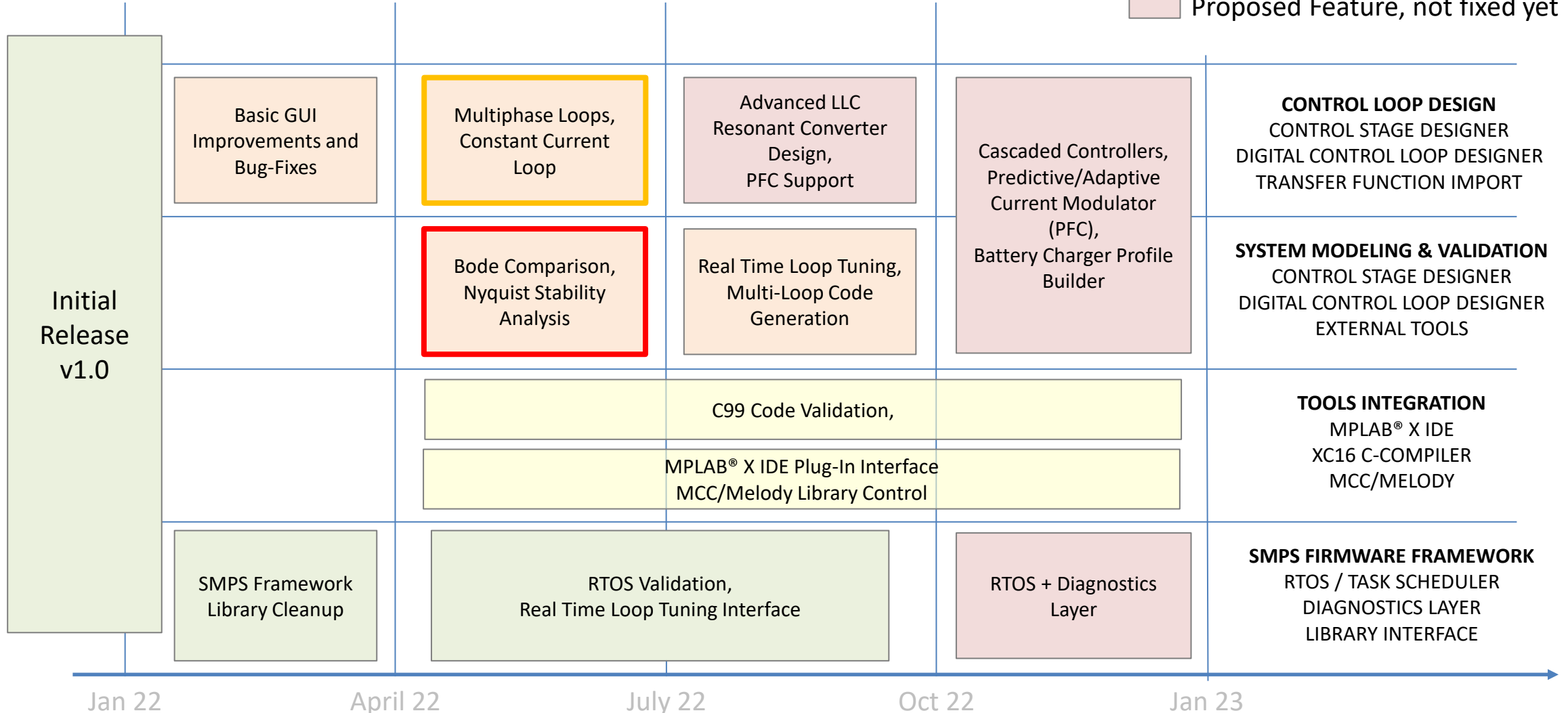
MCU16 Digital Power Applications

PowerSmart™ Eco System



Feature Roadmap

- Scheduled Release Feature
- Support Feature
- Building Block Development
- Proposed Feature, not fixed yet





MPLAB[®] PowerSmart[™] v1.0 Digital Control Library Designer

MPLAB[®] PowerSmart[™] Development Suite

Digital Control Library Designer

- **Key Features**

- Supports z-Domain Compensation Filters from 1st to 6th Order
- Fixed-Point and Floating-Point DSP Library Support
- Graphic Loop Adjustment
- Transfer Function Import/Export
- Built-In Number Resolution Analysis and Optimization
- Graphic Execution Timing Analysis
- ANSI C/DSP Assembly Code Generation

- **Special Features**

- **Advanced Control Options**

- PS-DCLD provides code generator options injecting code into the real-time high-speed loop allowing advanced control algorithms manipulative access to the compensation filter computation as well as data provider sources to track and monitor internal processing data at runtime.

- **System Design Options**

- PS-DCLD offers alternative feedback loops enabling power supply plant measurements supporting power plant model verification and/or directly deriving essential, unknown plant transfer function information through bench tests using vector network analyzers.

- **MPLAB® X Support**

- PS-DCLD was developed as control library generator for Microchip dsPIC33 product families. To allow the code generator derive project settings like C include directories and selected device part number, each controller project is tightly coupled to a user-specified MPLAB® X project. For most convenient use, PS-DCLD can be opened from the MPLAB® X project manager context menu when the project file is included in the related MPLAB® X project.

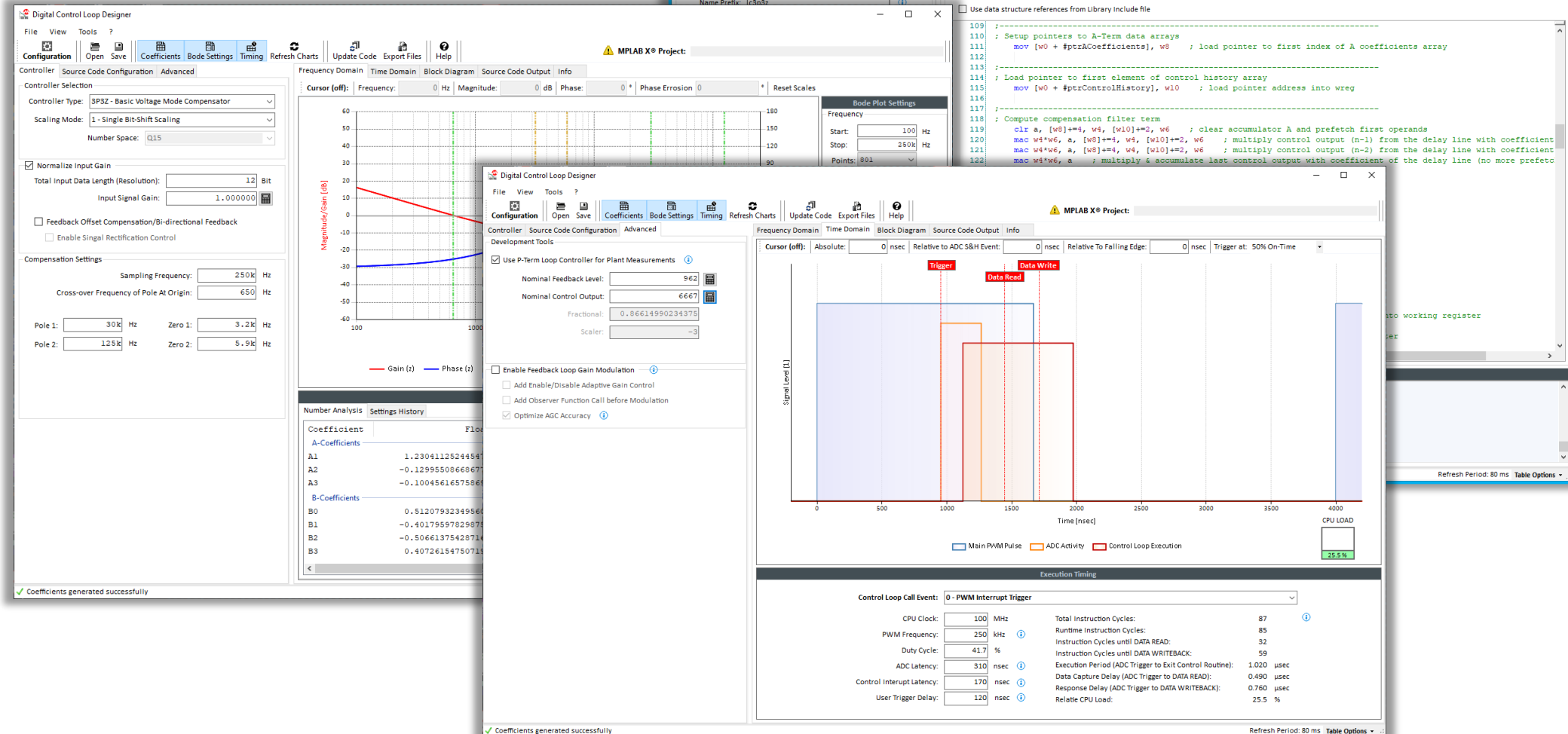
- **Data Export**

- Export of s-Domain and z-Domain Transfer Function (Bode Plot Data) copies the bode plot data table into the clipboard as tab-separated text table with column headers. This data can directly be pasted into external applications such as MS Excel.

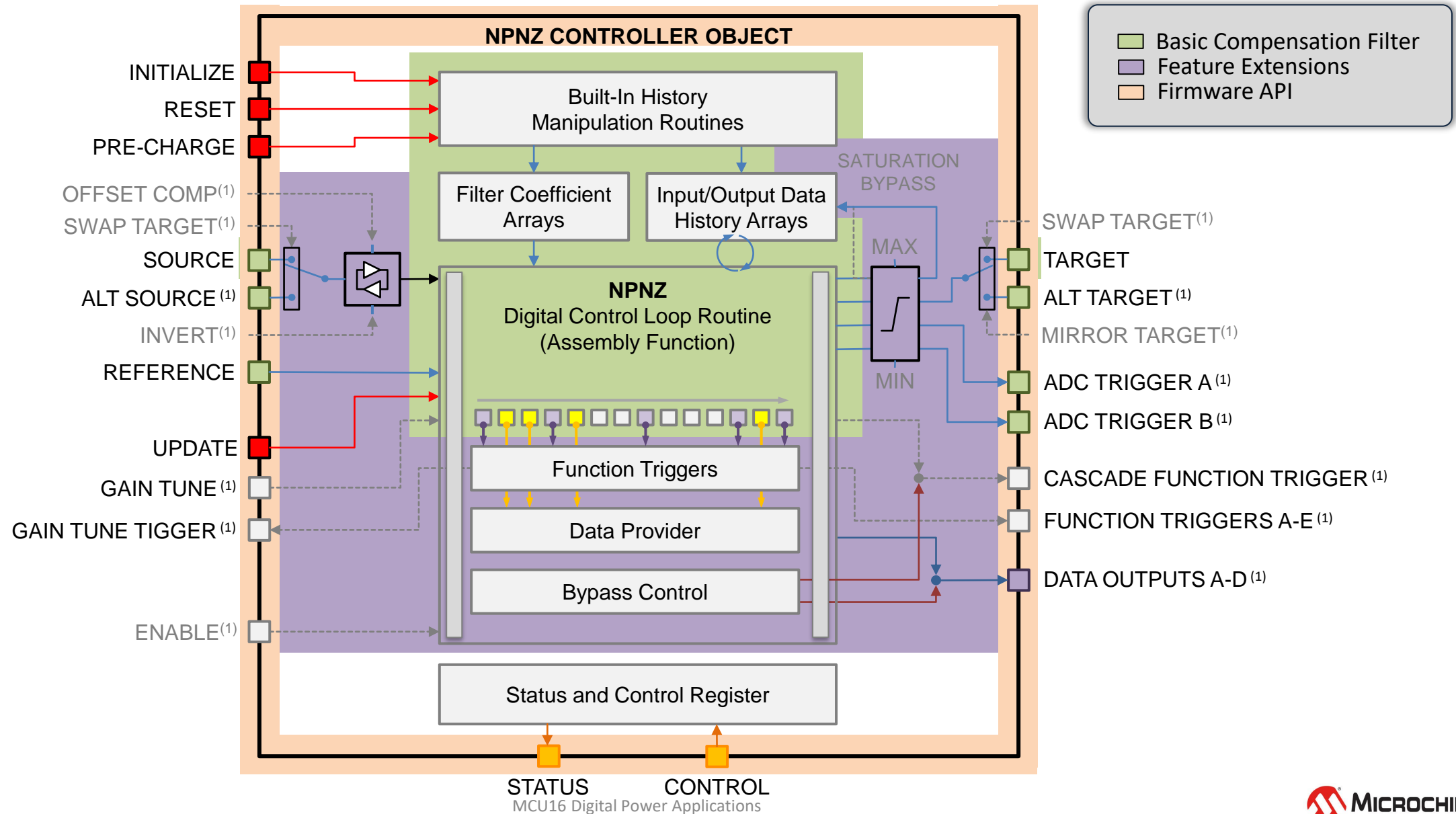
MPLAB® PowerSmart™ Digital Control Library Designer (DCLD)

Code Generation

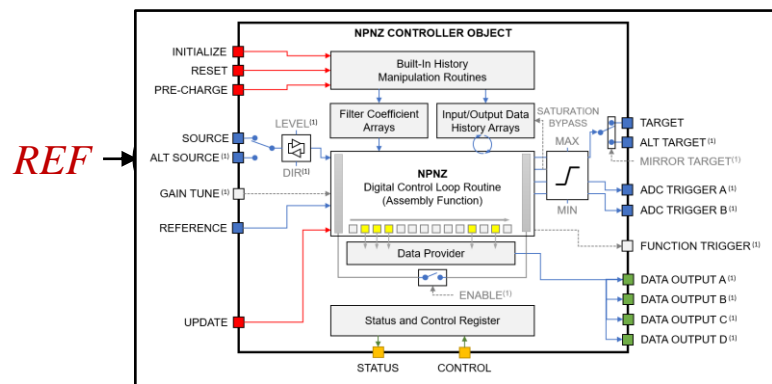
Frequency Domain Design



NPNZ Controller Block Diagram



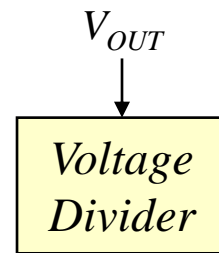
Using DCLD in Multi-Loop Systems



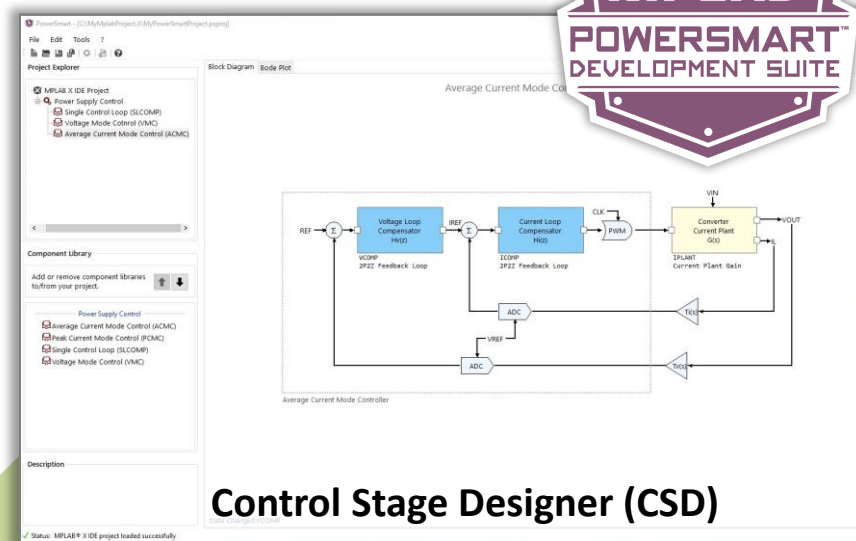
input

output

Voltage Loop

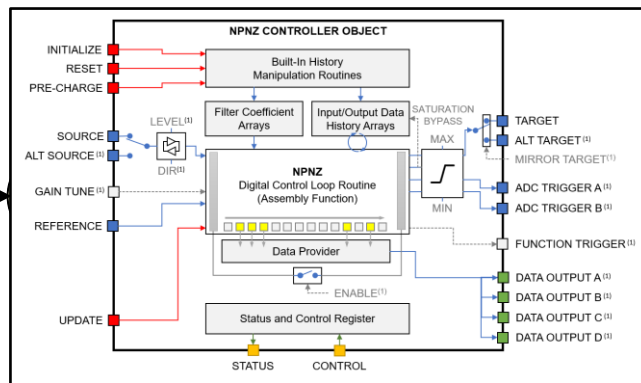


ADC



Control Stage Designer (CSD)

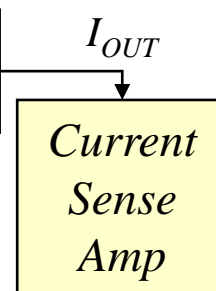
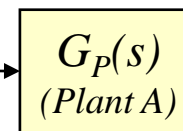
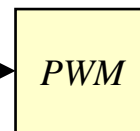
REF



input

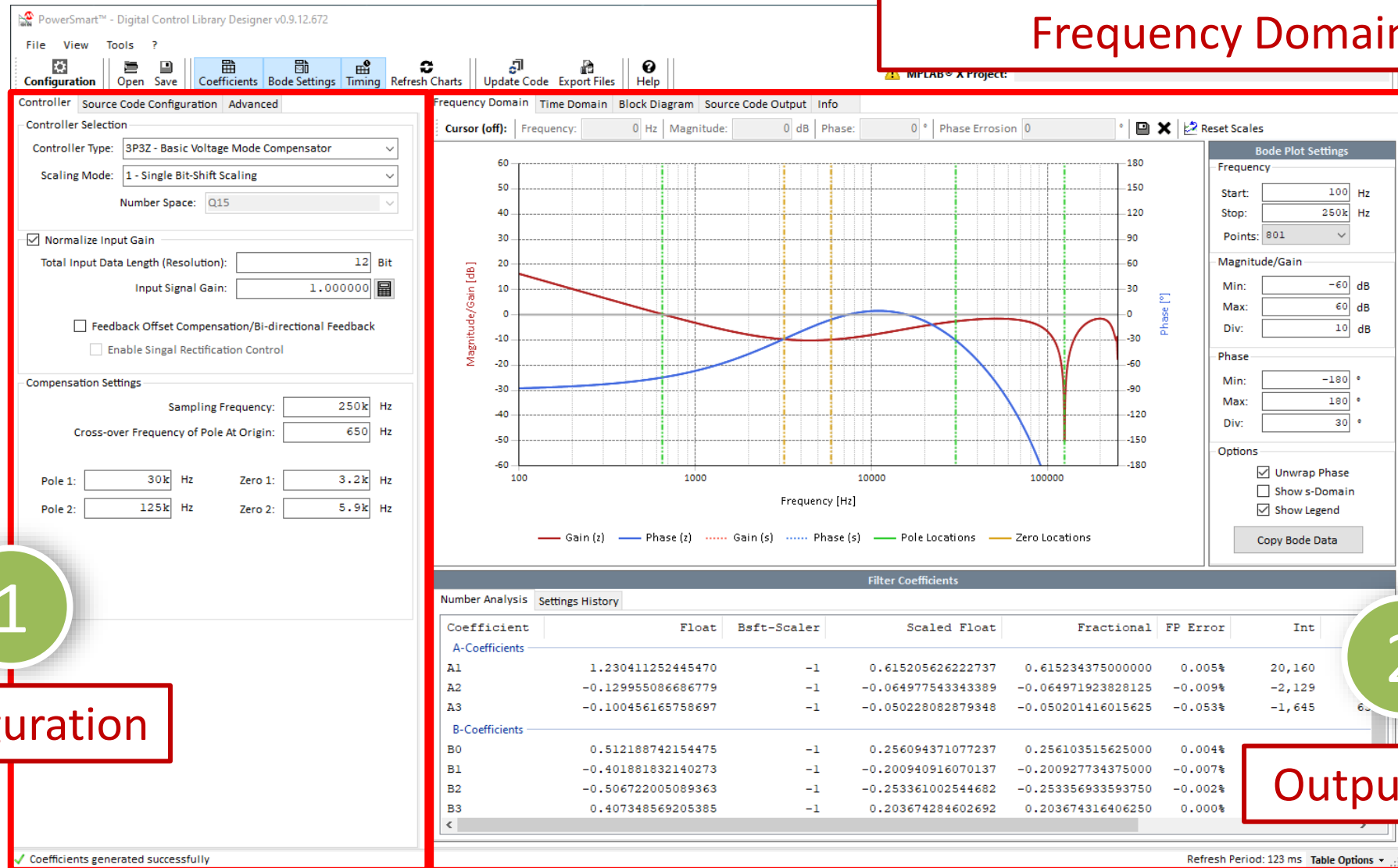
ADC

output



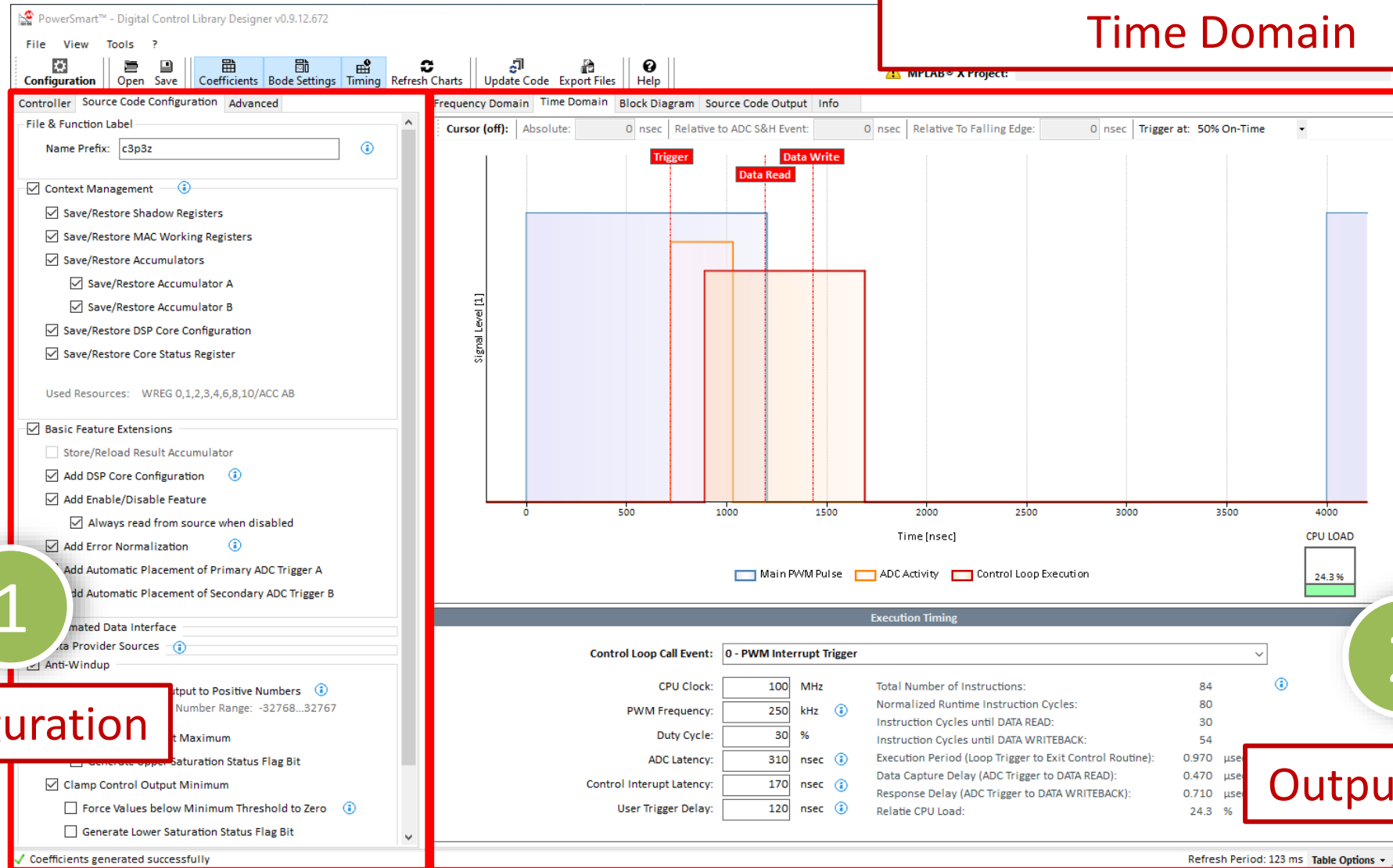
Current Loop

PowerSmart™ DCLD Main Window Overview



PowerSmart™ DCLD Main Window Overview

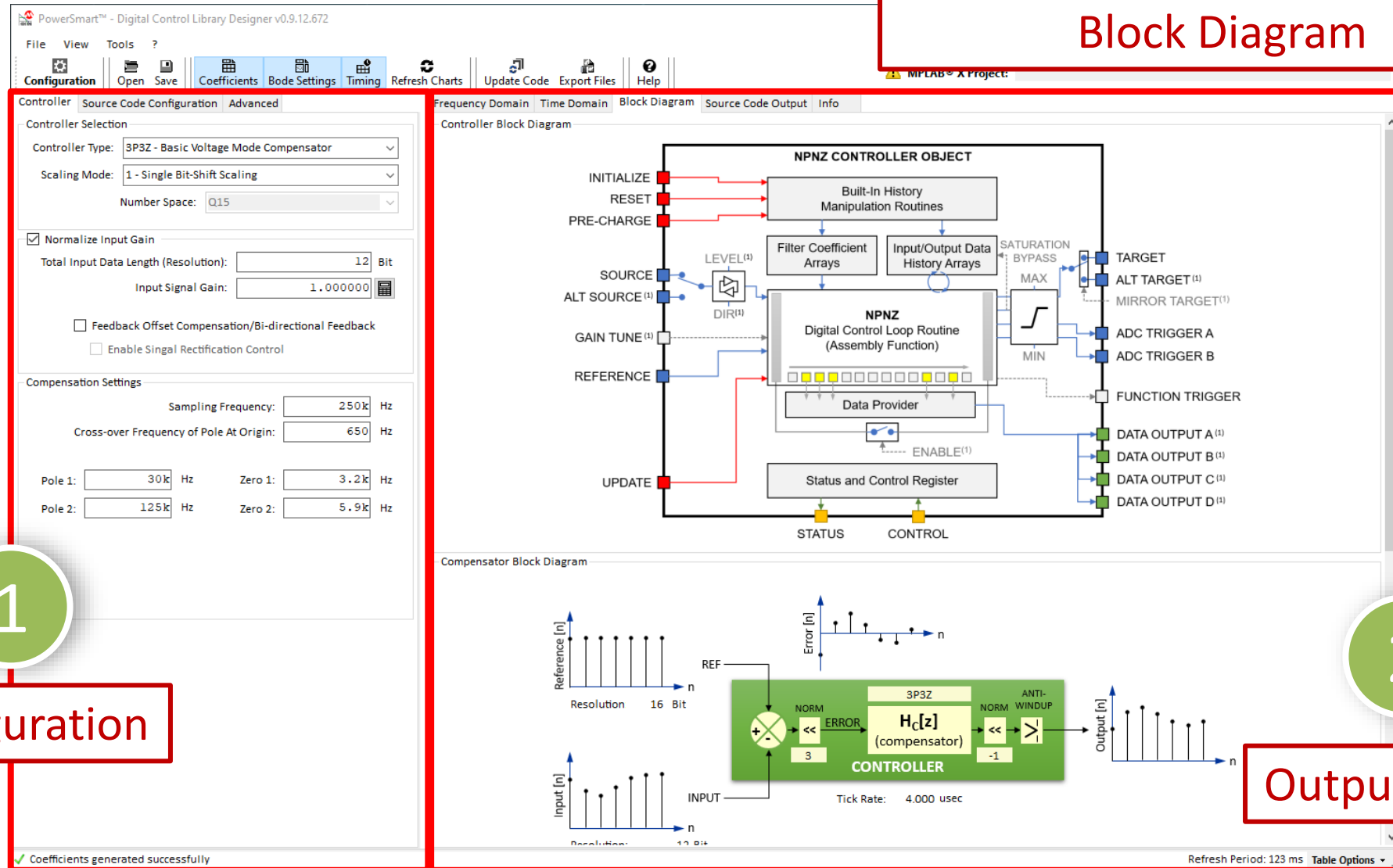
Time Domain



Output/Analysis

PowerSmart™ DCLD Main Window Overview

Block Diagram



1

Configuration

2

Output/Analysis

PowerSmart™ DCLD Main Window Overview

Code Generation

PowerSmart™ - Digital Control Library Designer v0.9.12.672

File View Tools ?

Configuration Open Save Coefficients Bode Settings Timing Refresh Charts Update Code Export Files Help

Controller Source Code Configuration Advanced

File & Function Label

Name Prefix: c3p3z

☒ Context Management

- ☒ Save/Restore Shadow Registers
- ☒ Save/Restore MAC Working Registers
- ☒ Save/Restore Accumulators
 - ☒ Save/Restore Accumulator A
 - ☒ Save/Restore Accumulator B
- ☒ Save/Restore DSP Core Configuration
- ☒ Save/Restore Core Status Register

Used Resources: WREG 0,1,2,3,4,6,8,10/ACC AB

☒ Basic Feature Extensions

- ☐ Store/Reload Result Accumulator
- ☒ Add DSP Core Configuration
- ☒ Add Enable/Disable Feature
 - ☒ Always read from source when disabled
- ☒ Add Error Normalization
- ☐ Add Automatic Placement of Primary ADC Trigger A
- ☐ Add Automatic Placement of Secondary ADC Trigger B

Automated Data Interface

Data Provider Sources

☒ Anti-Windup

Output to Positive Numbers

Number Range: -32768...32767

Maximum

☐ Generate Upper Saturation Status Flag Bit

☒ Clamp Control Output Minimum

☐ Force Values below Minimum Threshold to Zero

☐ Generate Lower Saturation Status Flag Bit

Coefficients generated successfully

Frequency Domain Time Domain Block Diagram Source Code Output Info

Assembly Source File API C-Source File API C-Header File NPNZ16b Library Header File NPNZ16b Library Include File Example Code

☐ Use data structure references from Library Include file

☐ Add file location in #include path

```
135
136
137 ; Configure DSP for fractional operation with normal saturation (Q1.31 format)
138 mov #0x00C0, w4 ; load default value of DSP core configuration enabling accumulator saturation and sign
139 mov w4, _CORCON ; load default configuration into CORCON register
140
141
142 ; Setup pointers to A-Term data arrays
143 mov [w0 + #ptrACoefficients], w8 ; load pointer to first index of A coefficients array
144
145
146 ; Load pointer to first element of control history array
147 mov [w0 + #ptrControlHistory], w10 ; load pointer address into working register
148
149
150 ; Compute compensation filter term
151 clr a, [w8]+4, w4, [w10]+2, w6 ; clear accumulator A and prefetch first operands
152 mac w4*w6, a, [w8]+4, w4, [w10]+2, w6 ; multiply control output (n-1) from the delay line with coefficient A1
153 mac w4*w6, a, [w8]+4, w4, [w10]+2, w6 ; multiply control output (n-2) from the delay line with coefficient A2
154 mac w4*w6, a ; multiply & accumulate last control output with coefficient of the delay line (no more
155
156
157 ; Update error history (move error one tick down the delay line)
158 mov [w10 + #4], w6 ; move entry (n-3) into buffer
159 mov w6, [w10 + #6] ; move buffered value one tick down the delay line
160 mov [w10 + #2], w6 ; move entry (n-2) into buffer
161 mov w6, [w10 + #4] ; move buffered value one tick down the delay line
162 mov [w10 + #0], w6 ; move entry (n-1) into buffer
163 mov w6, [w10 + #2] ; move buffered value one tick down the delay line
164
```

Output

>>DATA READ delay: 300 ns

>>WRITEBACK delay: 540 ns

>>timing chart update completed successfully (22 ms)

>>code generation completed successfully (251 ms)

>>update Bode plot data...

>>Bode plot data update complete (4 ms)

Refresh Period: 123 ms Table Options

Configuration

Output/Analysis

Thank you!

May the power be with you!