# dsPIC33
# Digital Signal Controllers

MICROCHIP

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

SMART | CONNECTED | SECURE

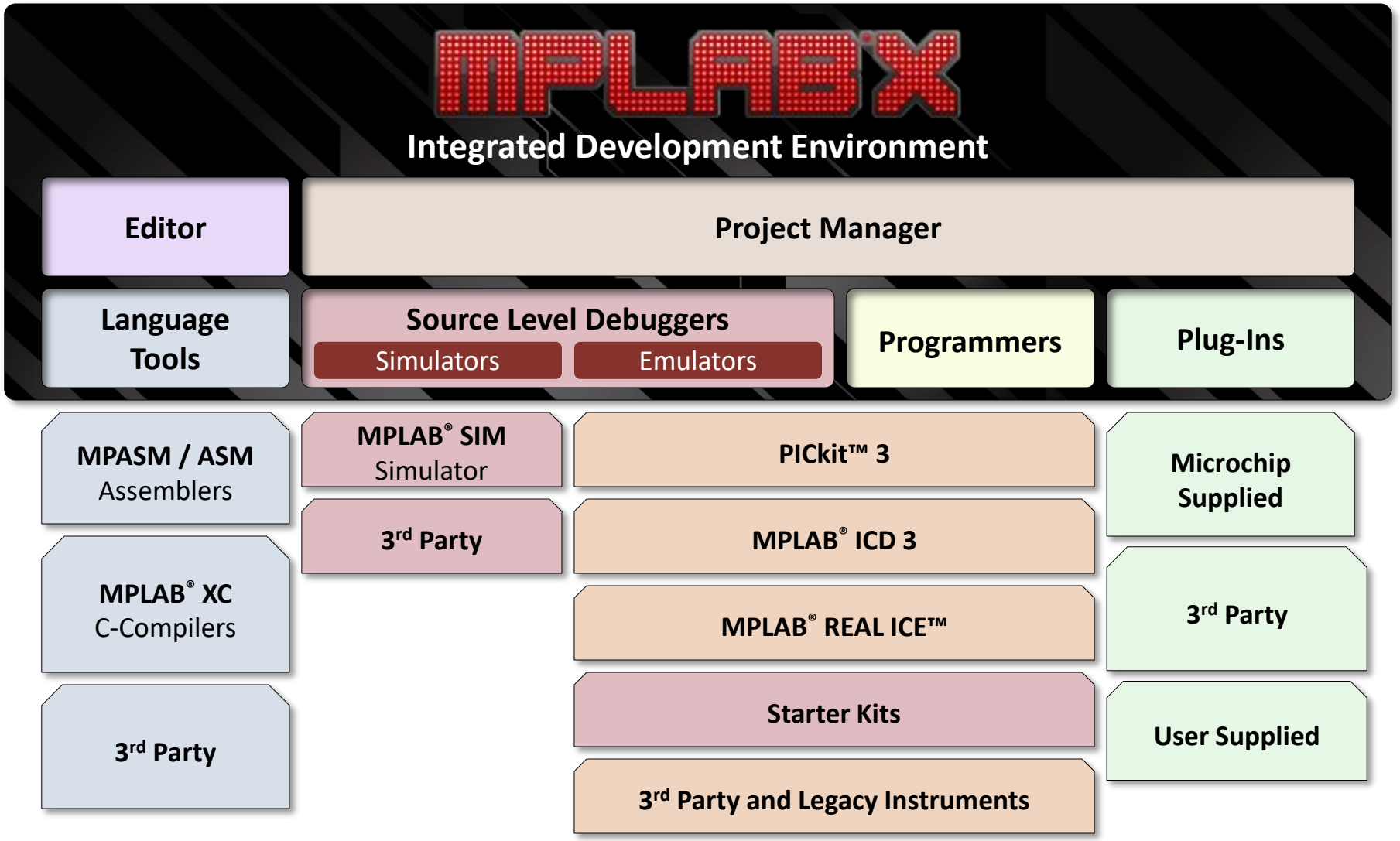
Power Conversion

**Andreas Reiter**

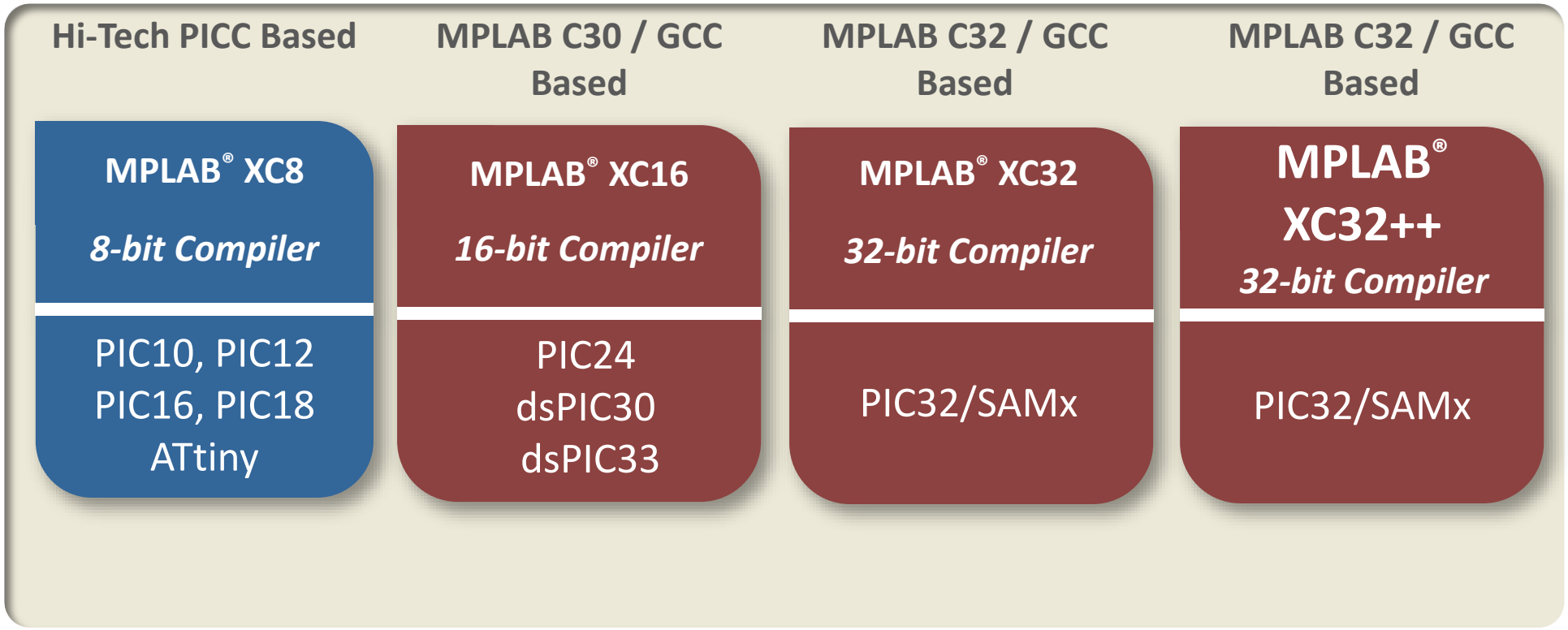
November 15, 2022

# Introducing the MPLAB® X Ecosystem

# MPLAB® X IDE Overview



# MPLAB® XC Compilers




| | |
|---|---|
| **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**

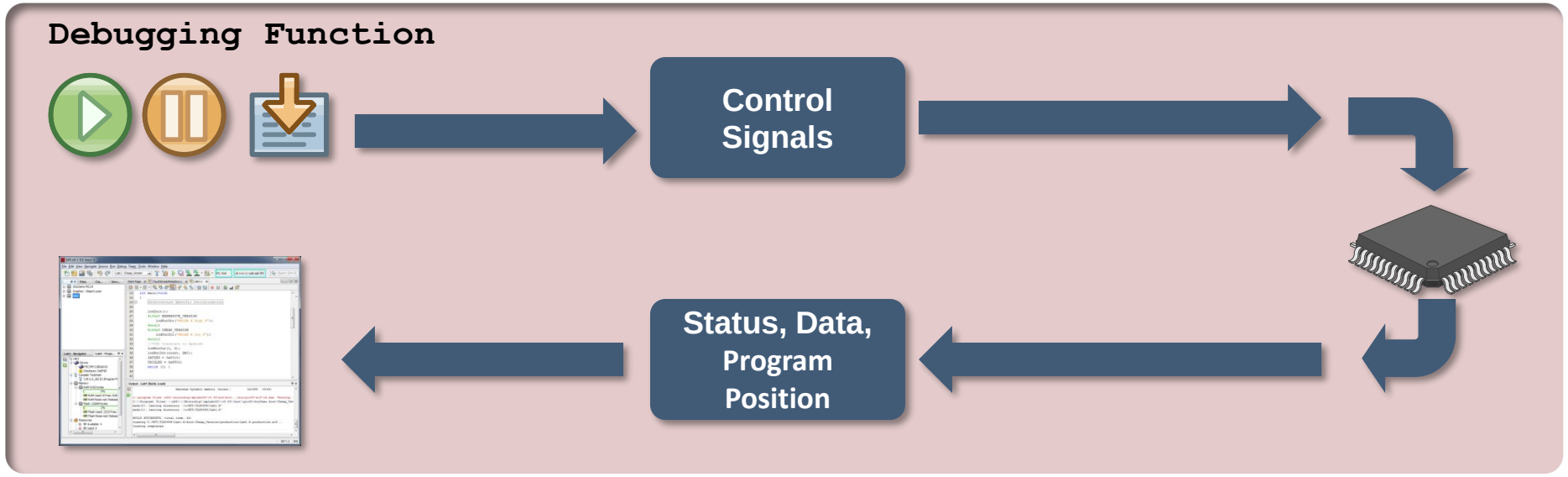

MPLAB® X IDE
C Compiler
C++ Compiler
MPASM Assembler

MPLAB ICE™
MPLAB ICD 4
MPLAB PICkit™ 4

Curiosity Boards
Explorer 16
Starter Kits
Your Hardware…

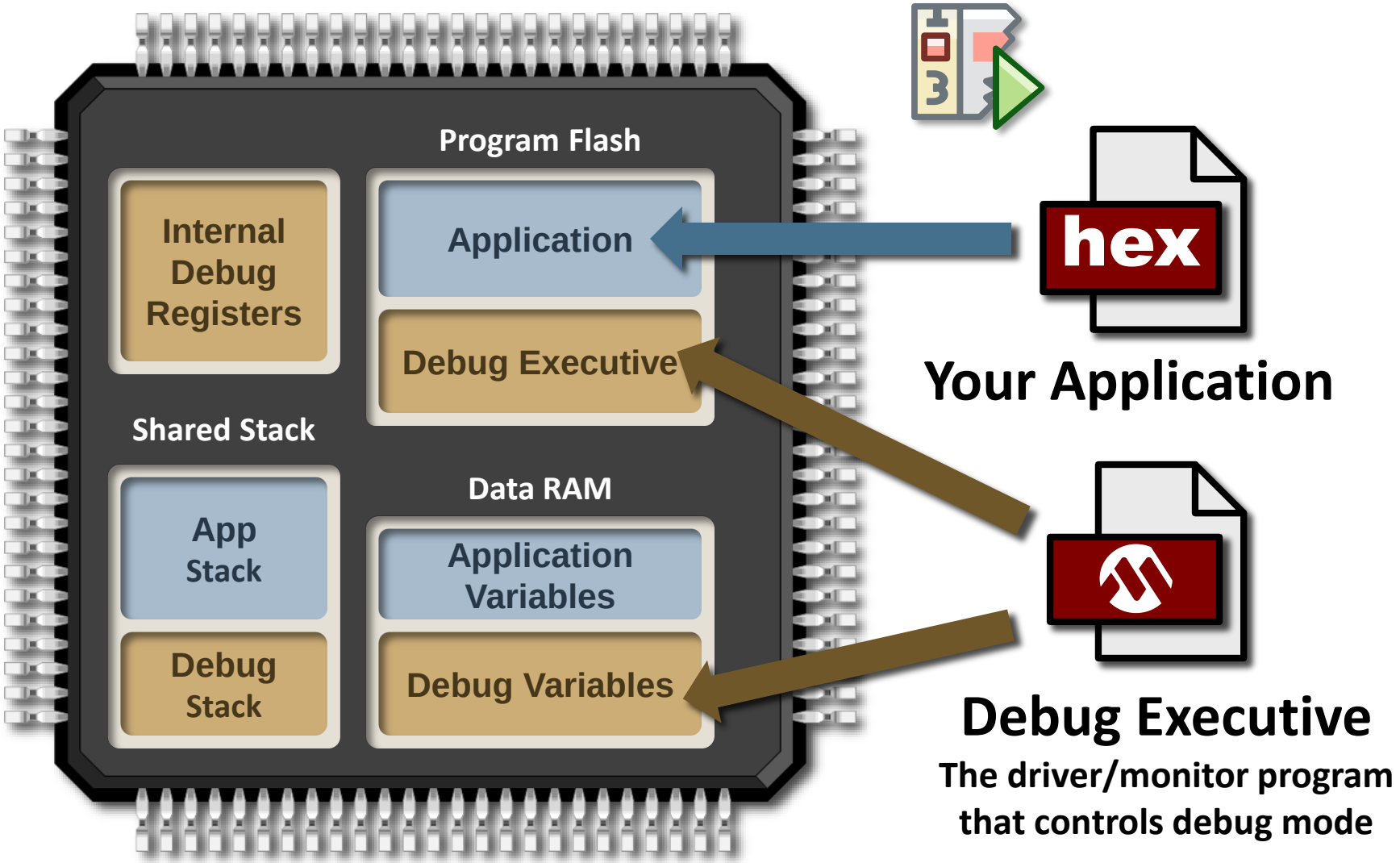
# What is a Programmer/Debugger?





# Debug Executive

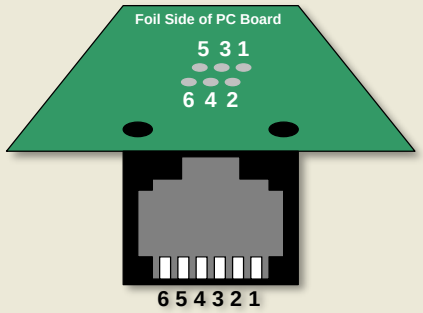
## Inserted to support In-Circuit Debugging



# Debugger Connection to Target

## 6-pin RJ-11 or ICSP™ Header

### ICSP™ Connections



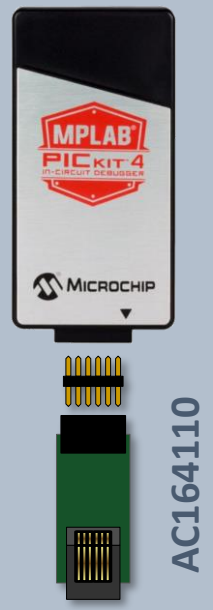

| Signal | Description |
|---|---|
| $V_{PP}$ / $\overline{MCLR}$ | Programming Voltage and Master Clear [1] |
| $V_{DD}$ | Power [2] |
| $V_{SS}$ | Ground [3] |
| PGD | Data [4] |
| PGC | Clock [5] |
| PGM * | LVP Program Enable [6] |

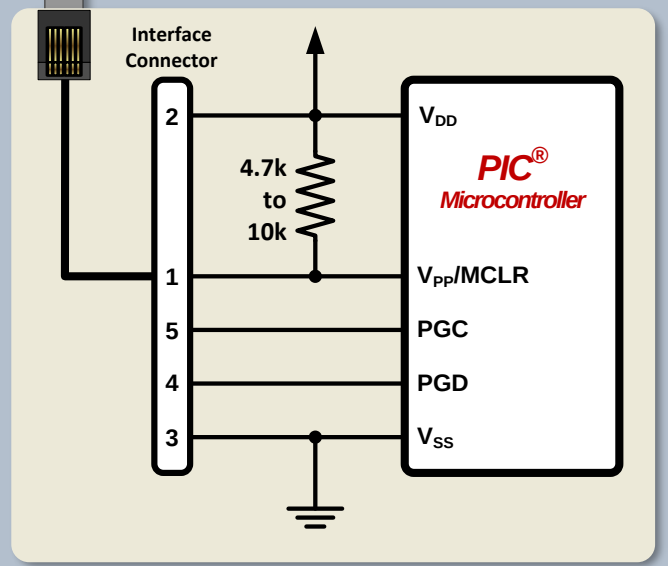
* Not implemented on some PIC microcontrollers


### Identical Interfaces:

- MPLAB® ICE™
- MPLAB® ICD4
- PICkit™ 4

(may require AC164110 RJ-11 to ICSP Adapter)






MICROCHIP

# 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


DV244140 – MPLAB® ICE4

- **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

# 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**

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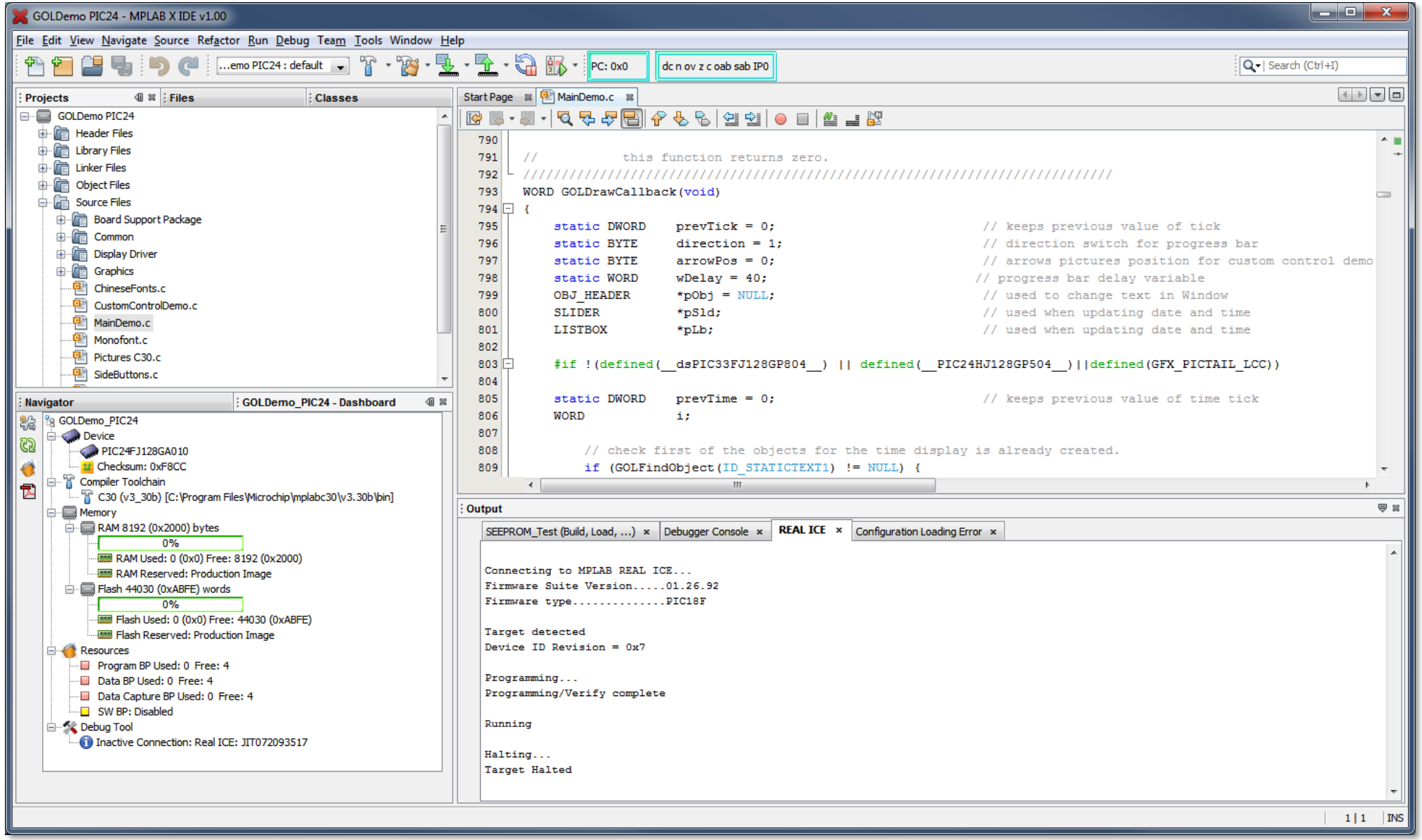
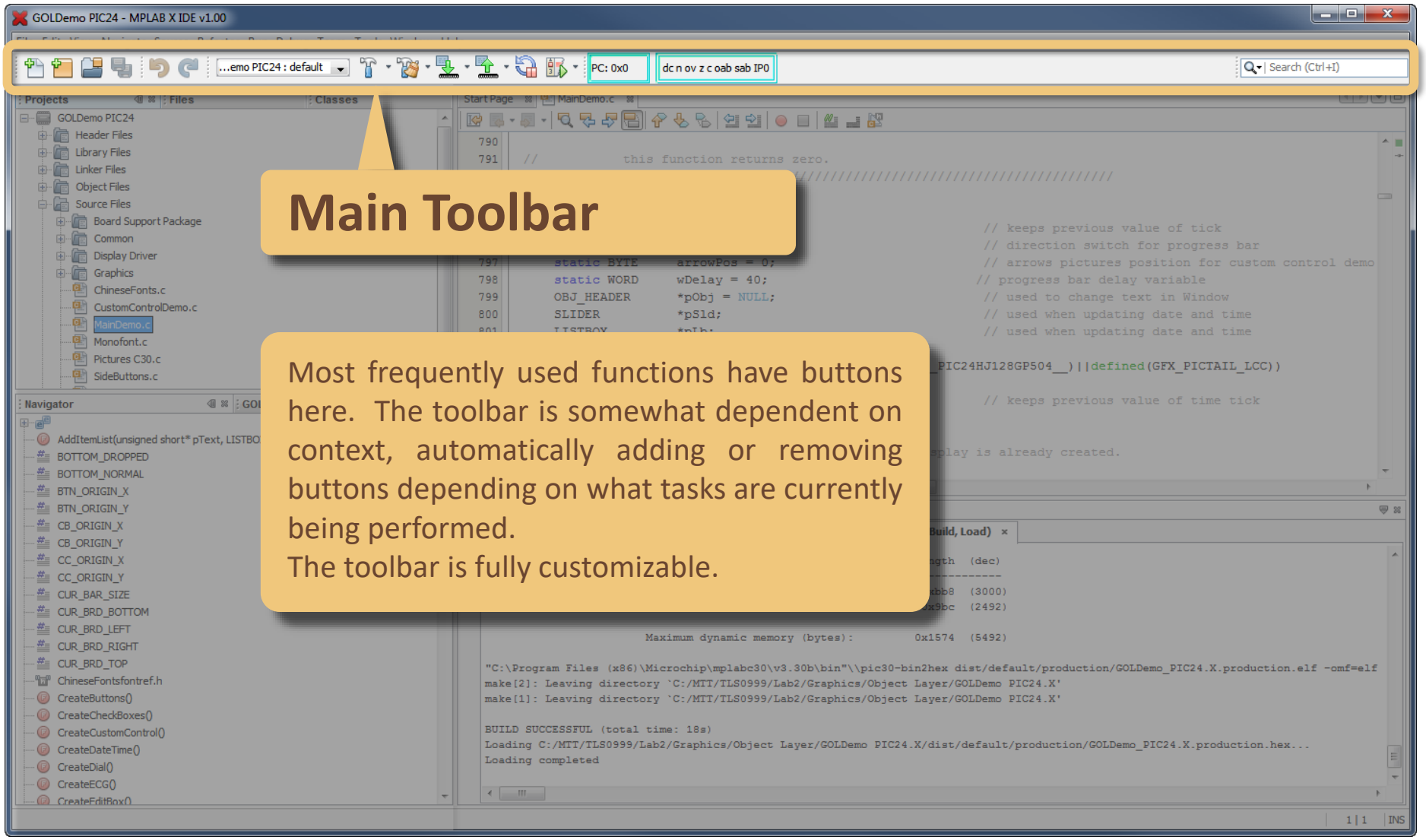
# MPLAB® X IDE

# IDE Layout



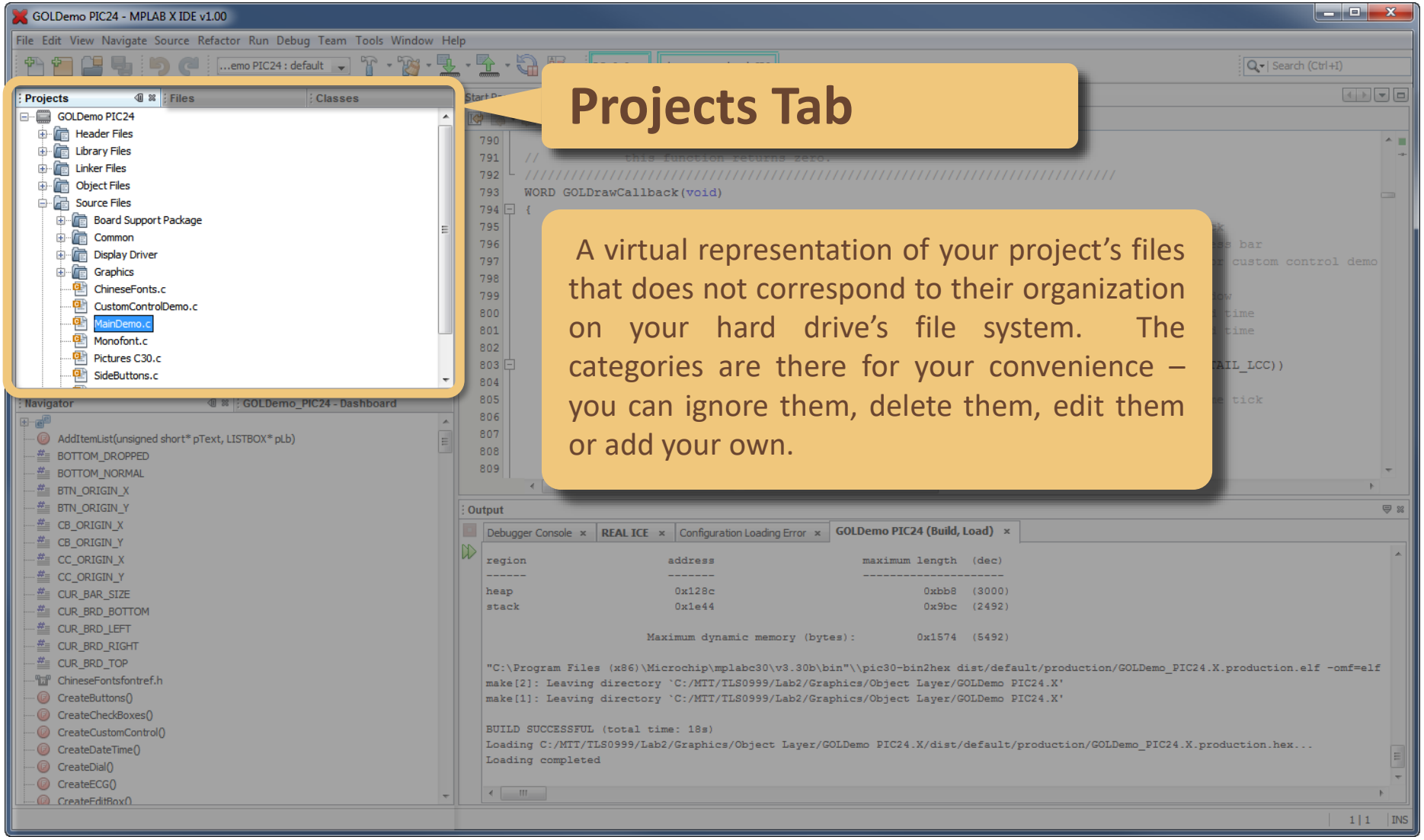
# IDE Layout

## Main Toolbar



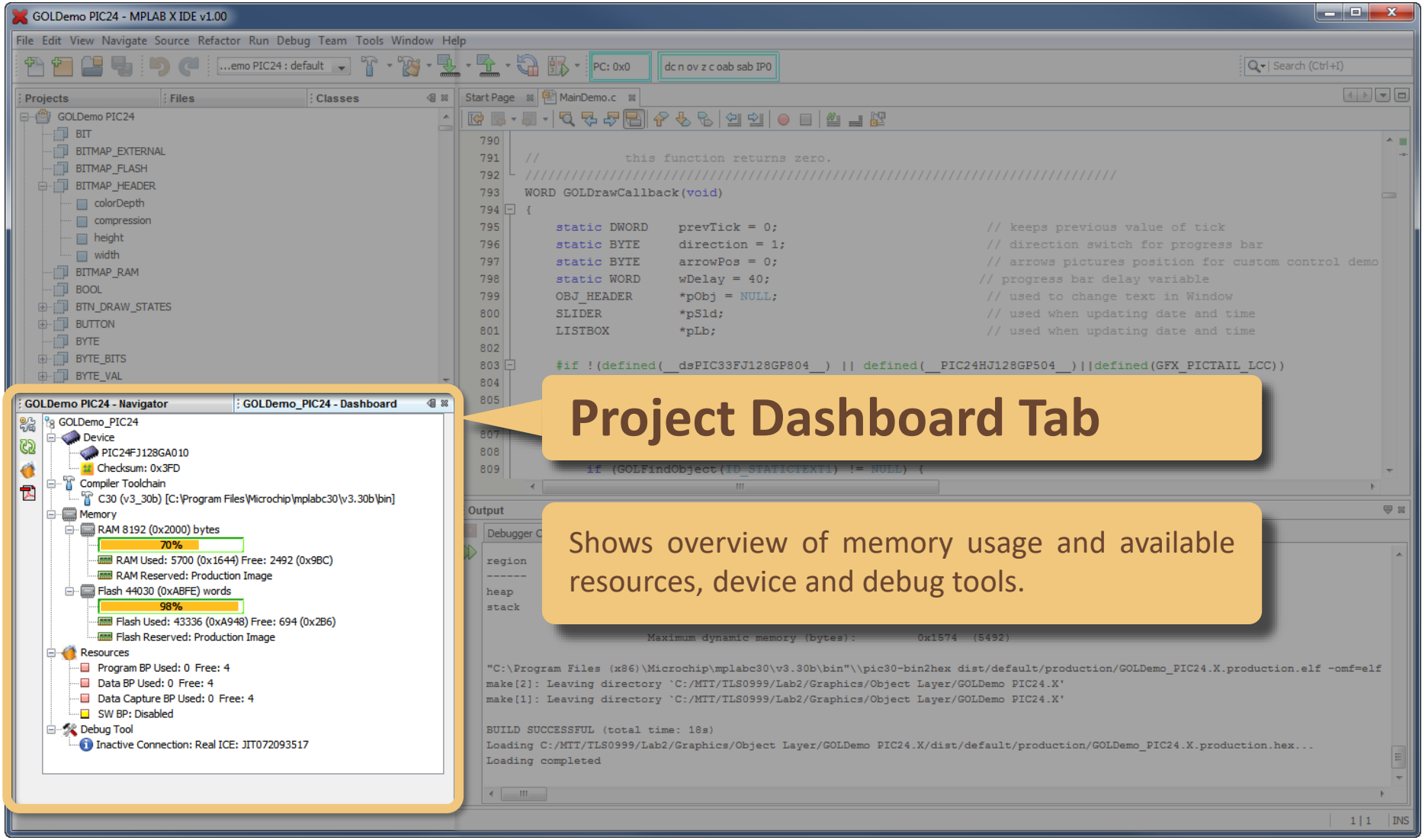
# IDE Layout

## Projects Tab (Project Tree)



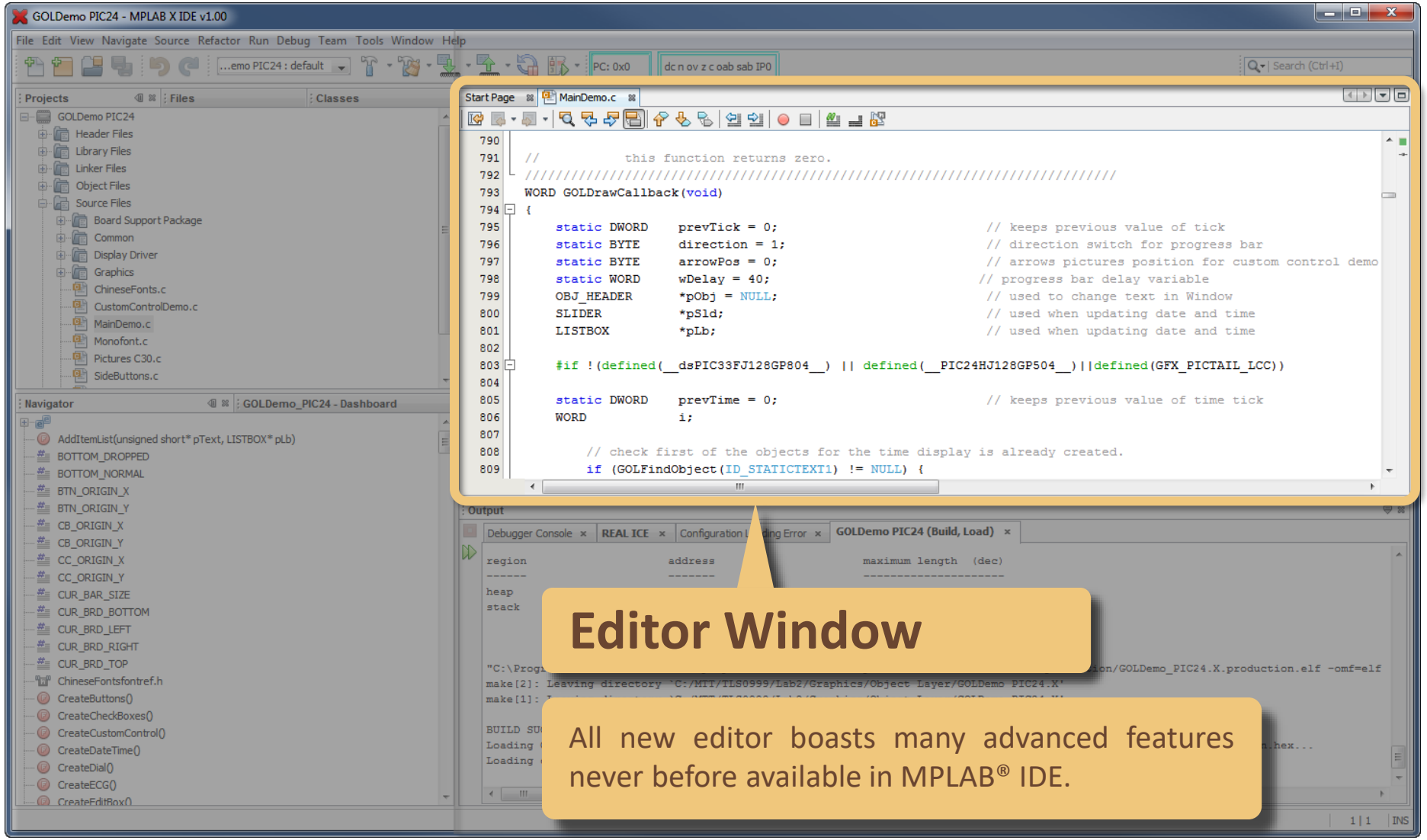
# IDE Layout

## Project Dashboard Tab



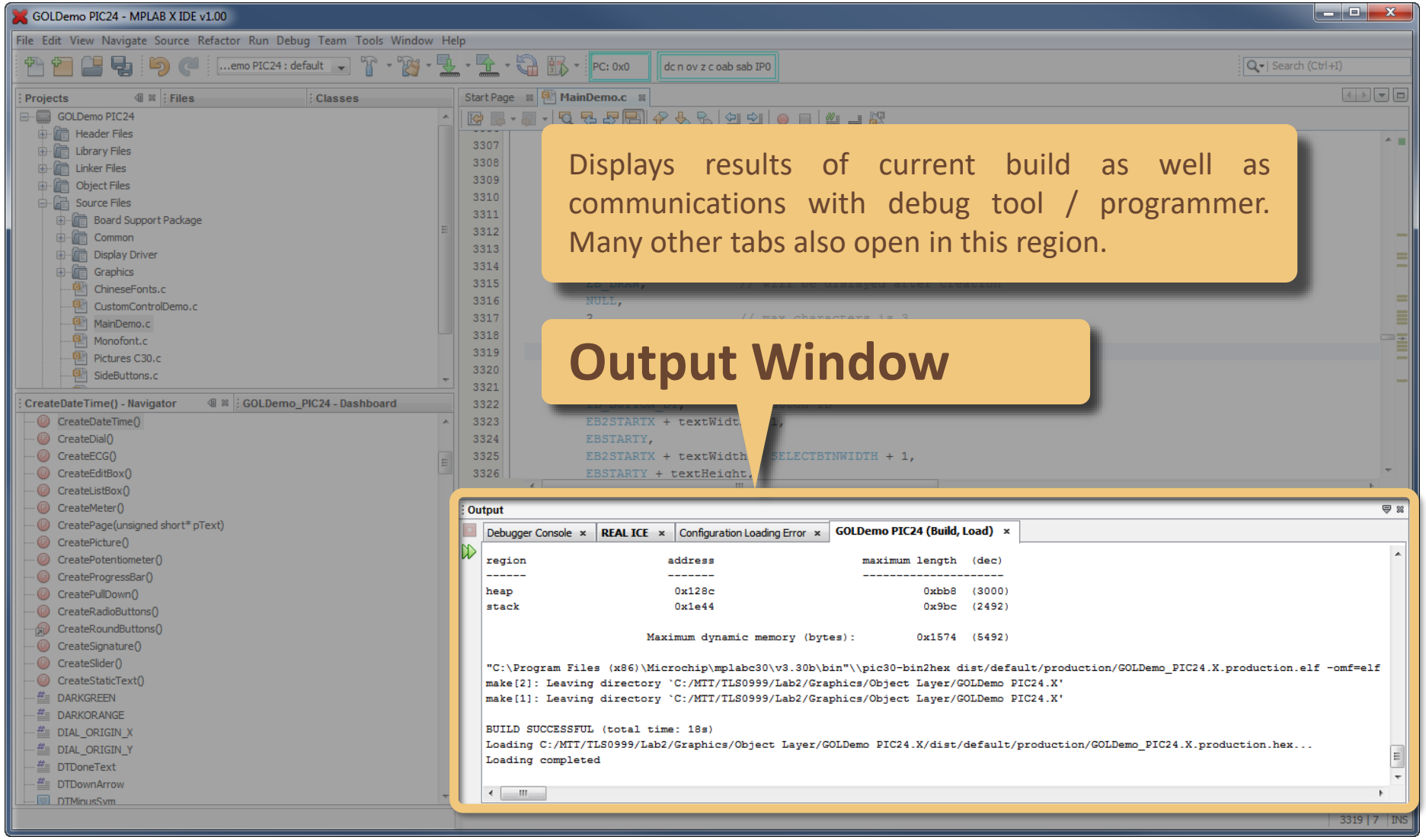
# IDE Layout

## Editor



# IDE Layout

## Output Window



# MPLAB® Code Generators

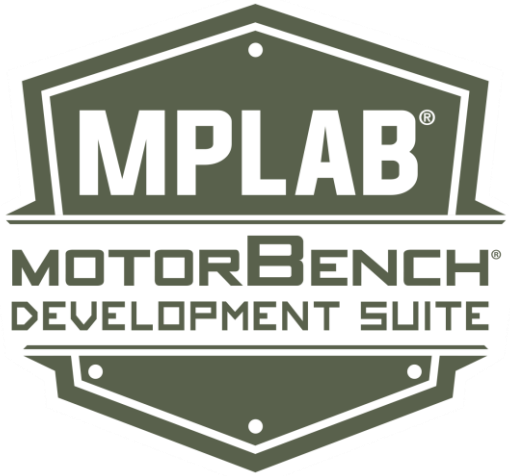
# Microchip Code Generator Standard Tools


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

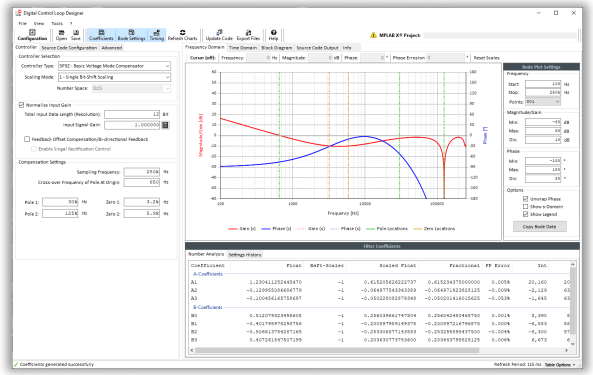

Power Supply Configuration (independent)

# MPLAB® PowerSmart™

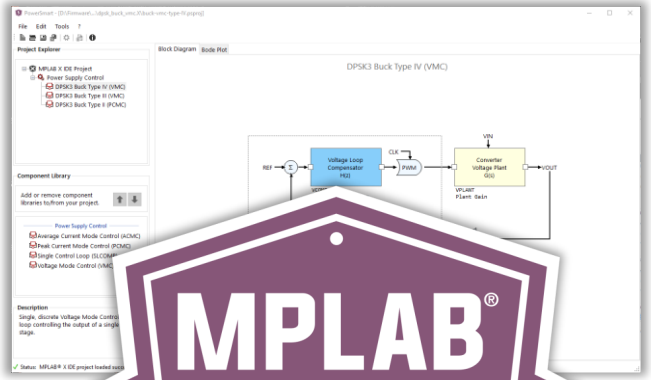
# MPLAB® PowerSmart™ Development Suite

## The comprehensive Digital Power Supply design eco-system

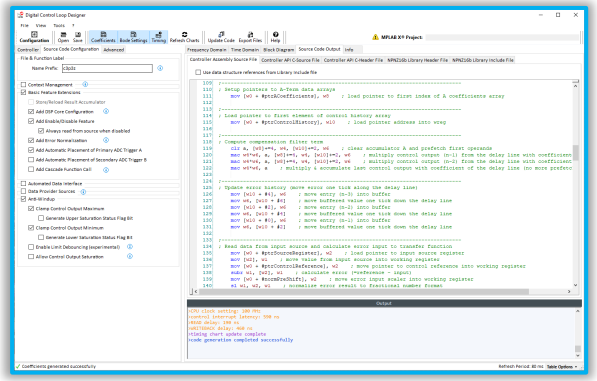
Circuit Simulation

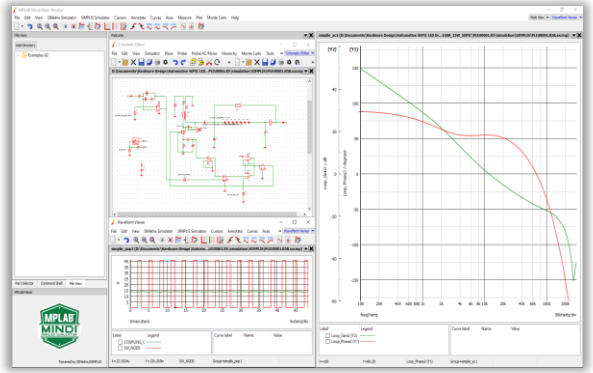


Control System Modeling

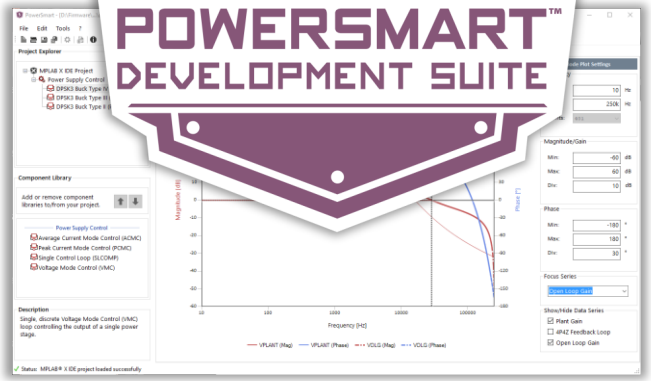


Code Generation

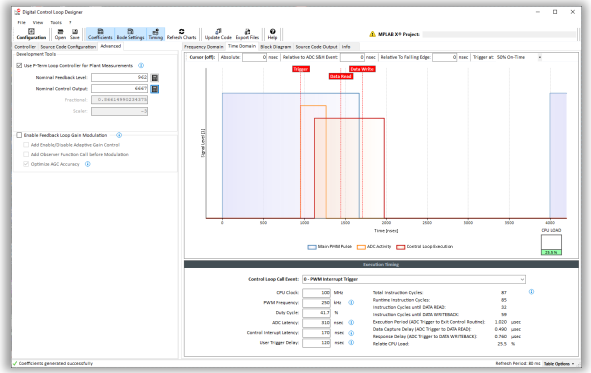




Time/Frequency Domain Analysis



Model Validation



Implementation Analysis

https://www.microchip.com/powersmart

# MPLAB® PowerSmart™ Development Suite

## Junction between Circuit Design & Simulation and X IDE

GNU Octave

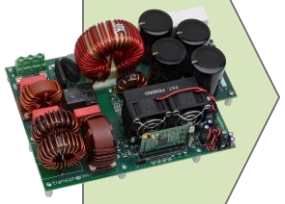
MATLAB

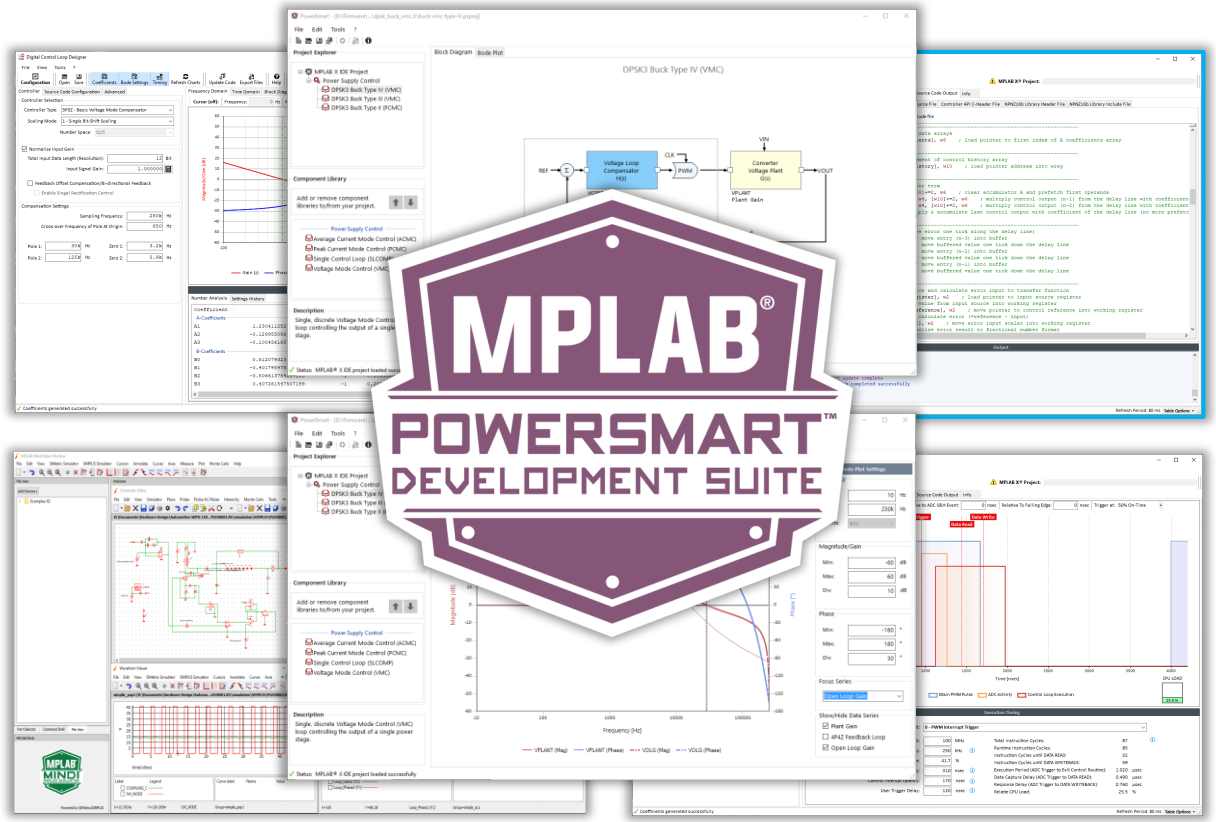
Scilab

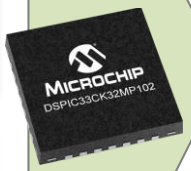
plexim PLECS

PSIM

LTspice®






MPLAB® X IDE

MPLAB® CODE CONFIGURATOR

MPLAB® XC COMPILER

MPLAB® ANALYSIS TOOL SUITE

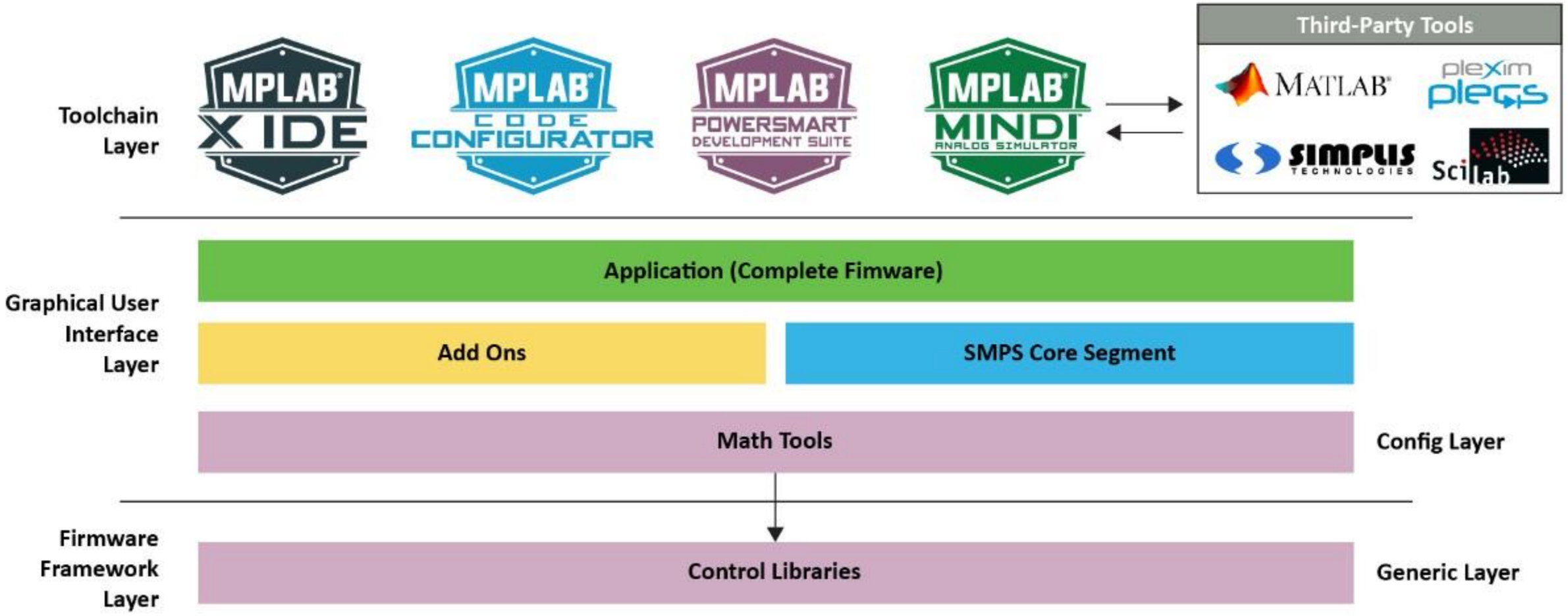
MPLAB® CODE COVERAGE

MPLAB® MINDI™ ANALOG SIMULATOR

SIMetrix / SIMPLIS

https://www.microchip.com/powersmart

# PowerSmart™ Eco System

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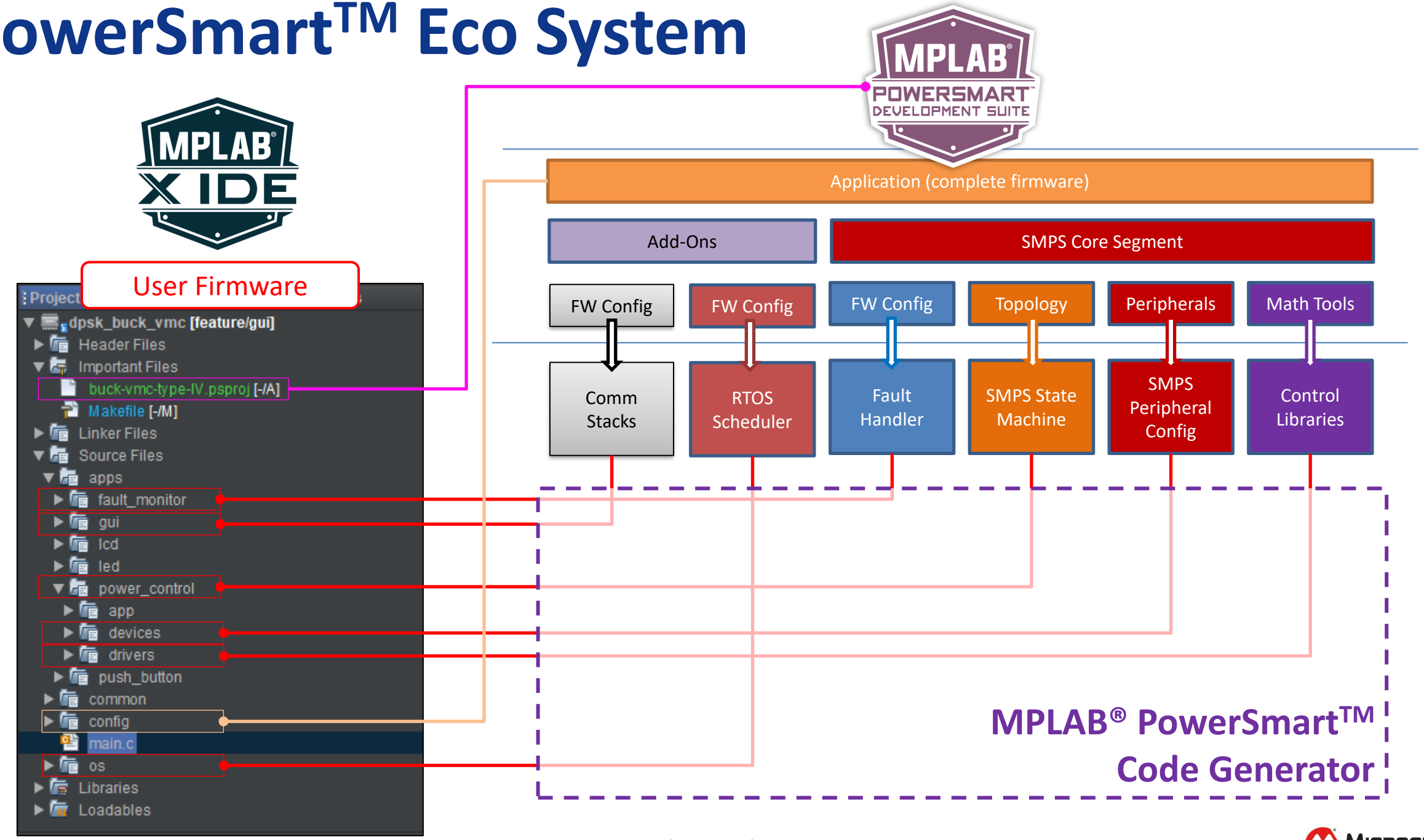
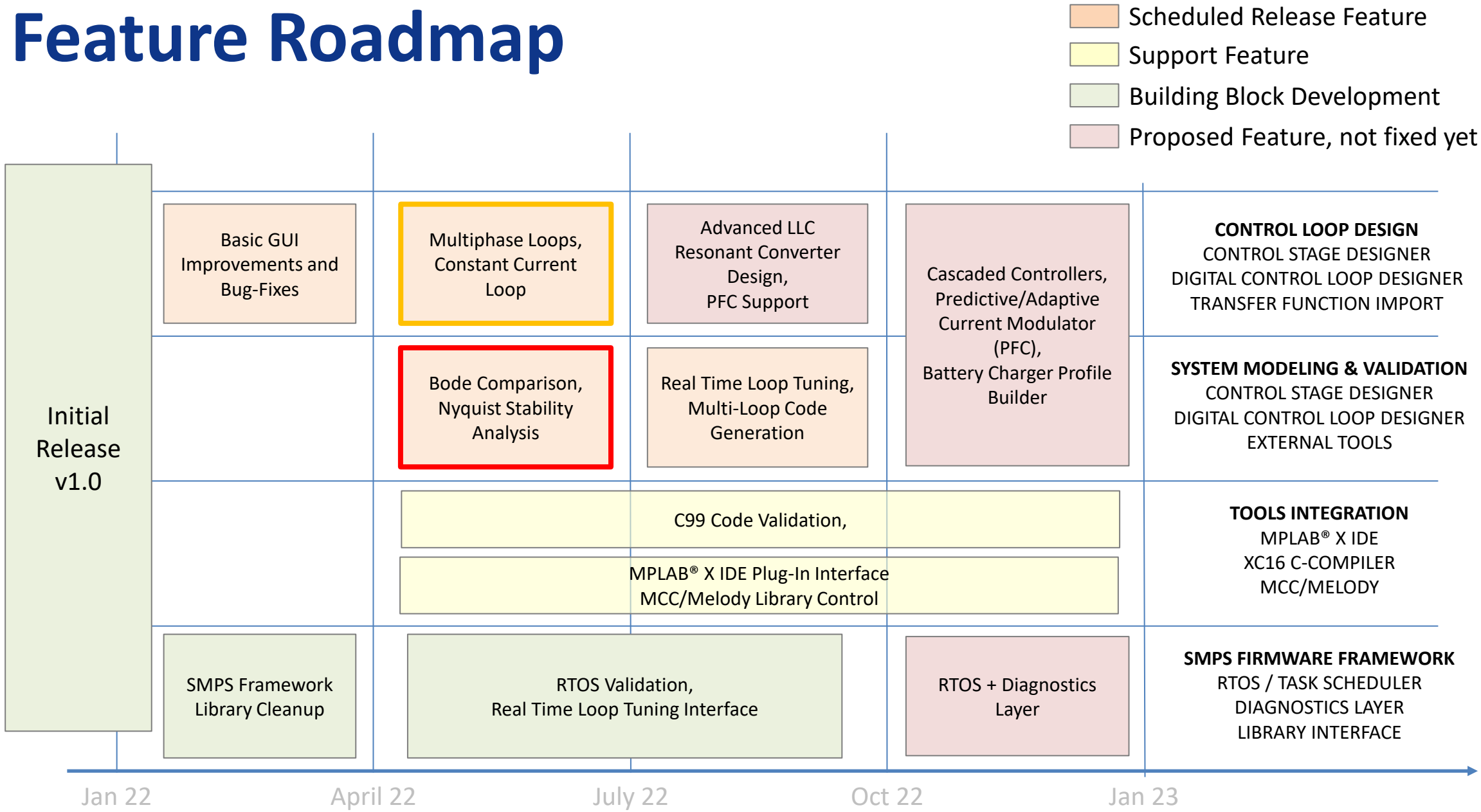


# Feature Roadmap




# MPLAB® PowerSmart™ v1.0 Digital Control Library Designer

## MPLAB® PowerSmart™ Development Suite

# Digital Control Library Designer

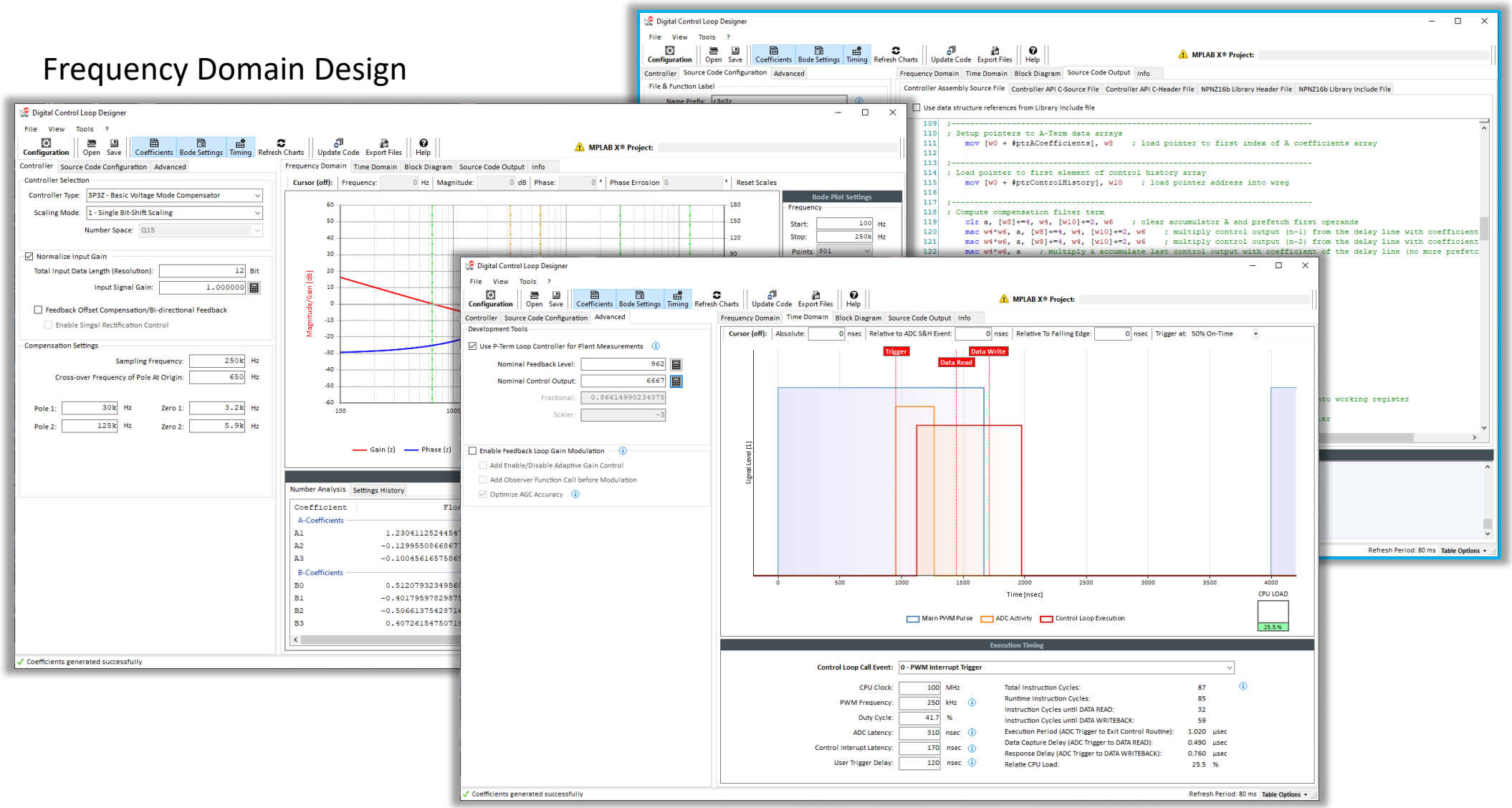
- **Key Features**
  - Supports z-Domain Compensation Filters from 1st to 6th Order
  - Fixed-Point and Floating-Point DSP Library Support
  - Graphic Loop Adjustment
  - Transfer Function Import/Export
  - Built-In Number Resolution Analysis and Optimization
  - Graphic Execution Timing Analysis
  -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

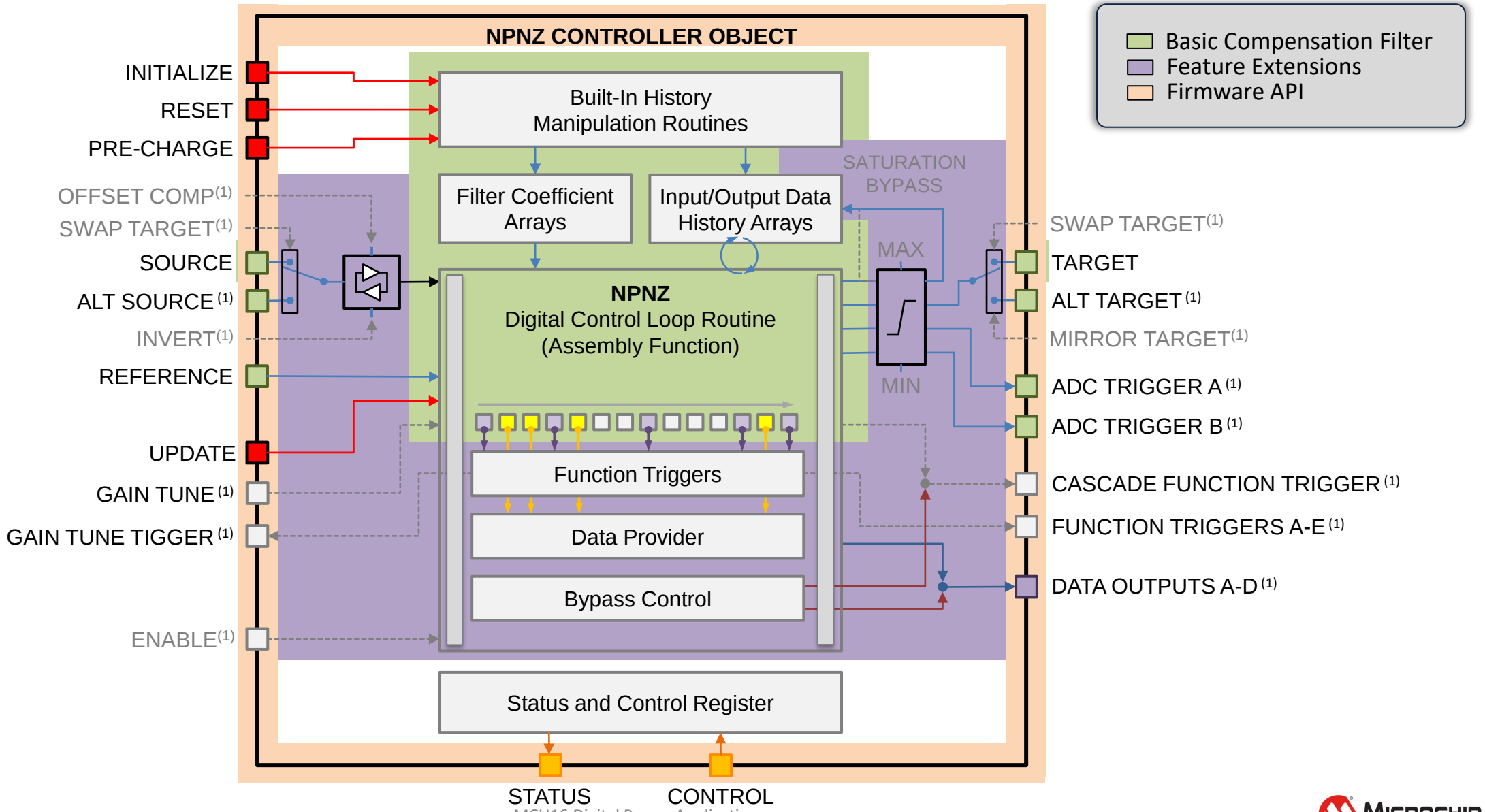
Code Generation

Frequency Domain Design

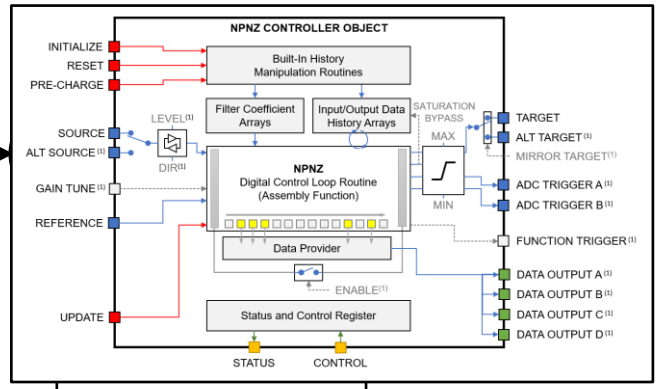



Implementation/Execution Analysis

# NPNZ Controller Block Diagram



# Using DCLD in Multi-Loop Systems




REF

input

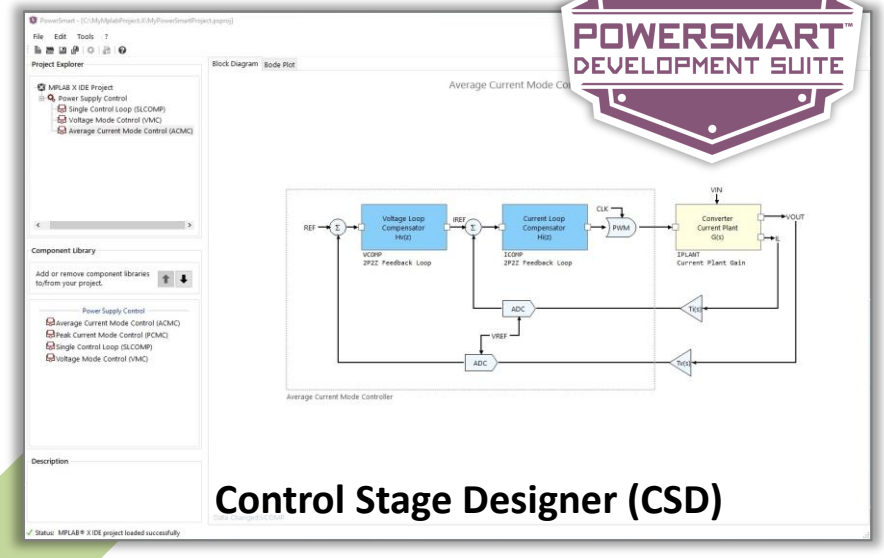
output

$V_{OUT}$

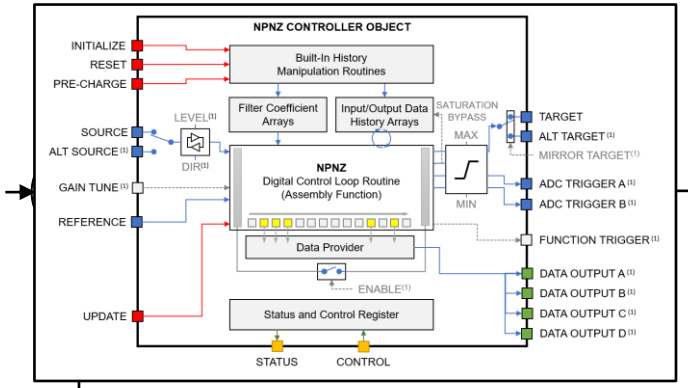
Voltage Divider

ADC

Voltage Loop



Control Stage Designer (CSD)




REF

input

output

PWM

$G_P(s)$ (Plant A)

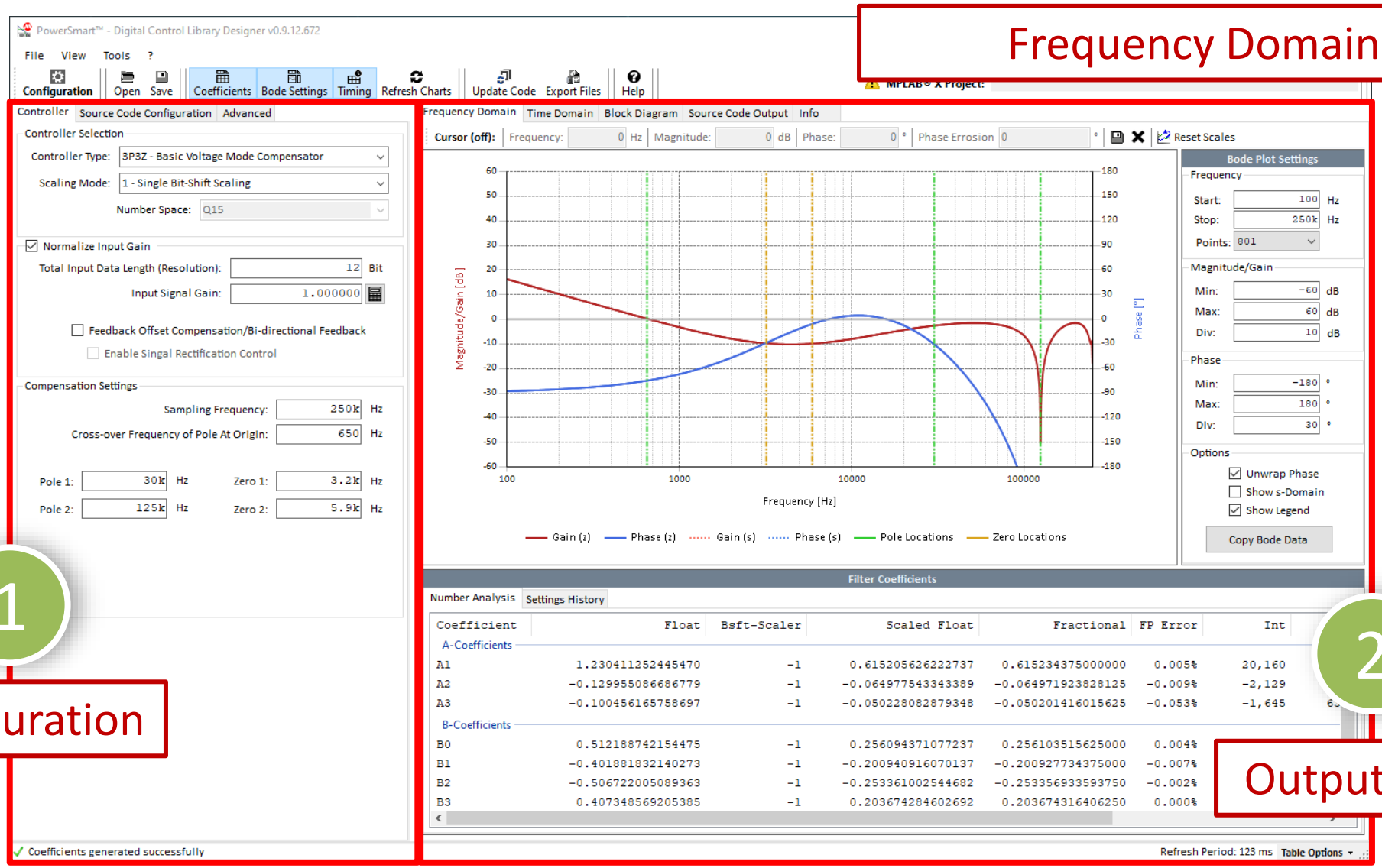
$I_{OUT}$

Current Sense Amp

ADC

Current Loop

# PowerSmart™ DCLD Main Window Overview




Frequency Domain

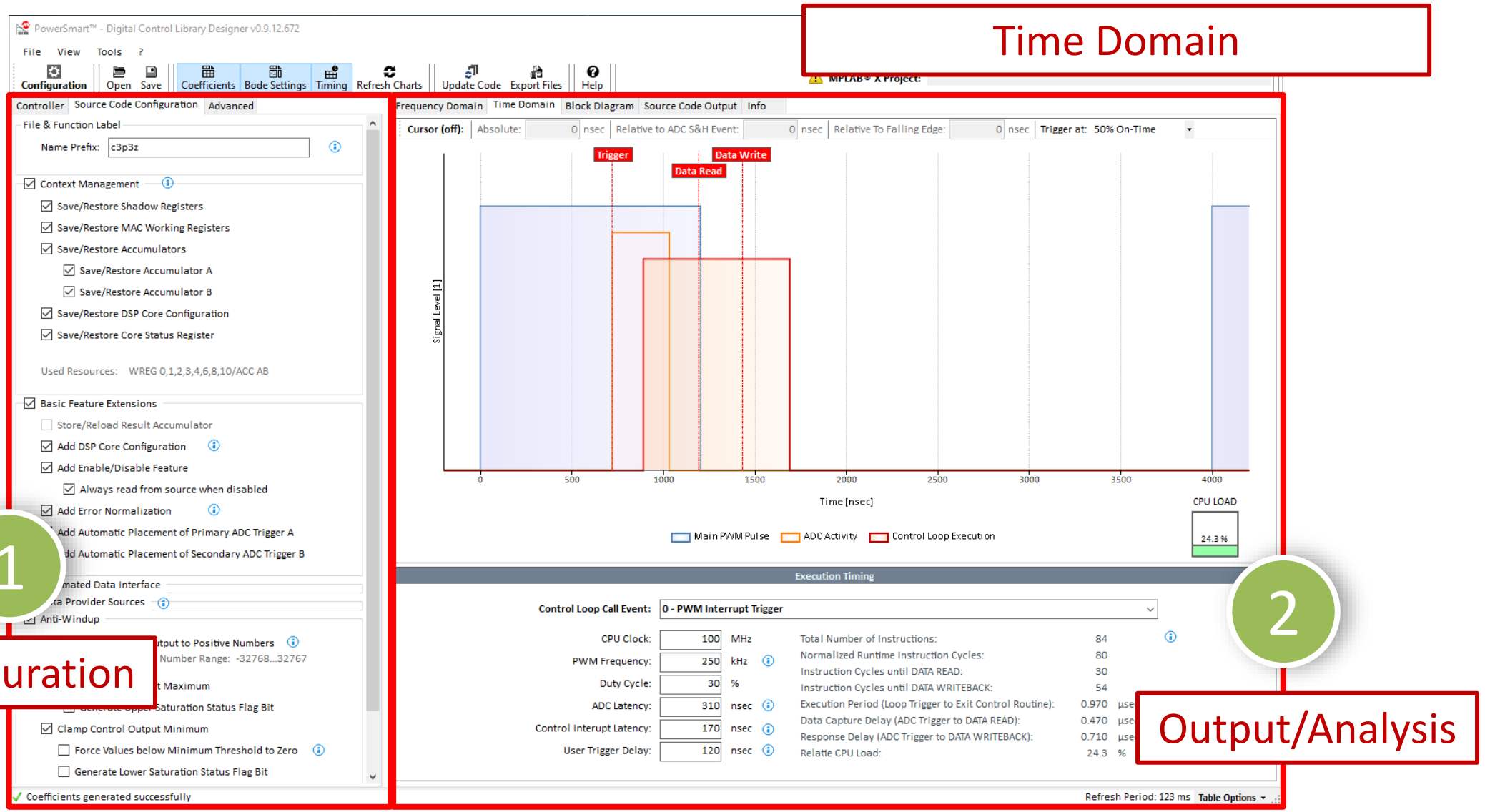
1

Configuration

2

Output/Analysis

# PowerSmart™ DCLD Main Window Overview



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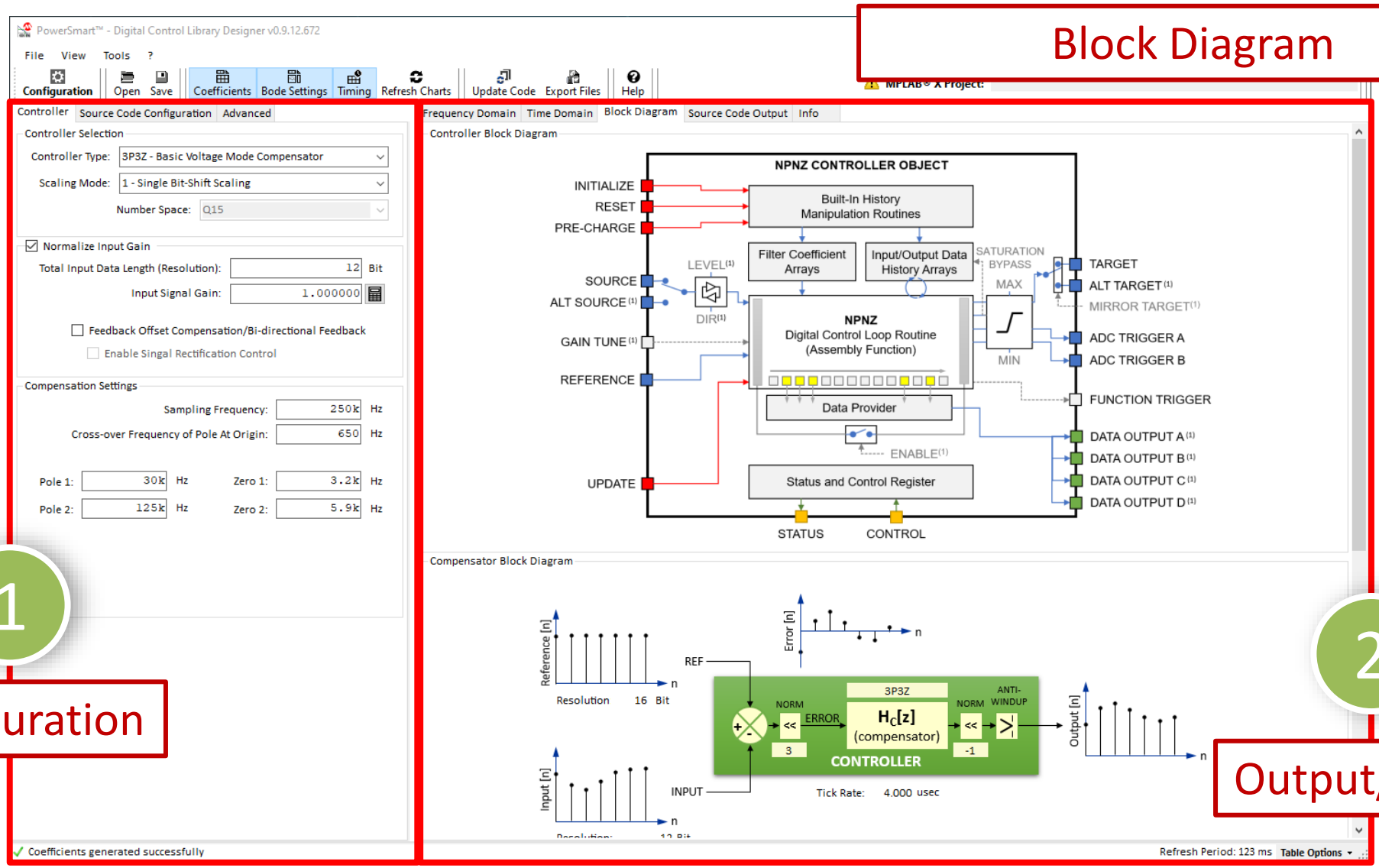



Block Diagram

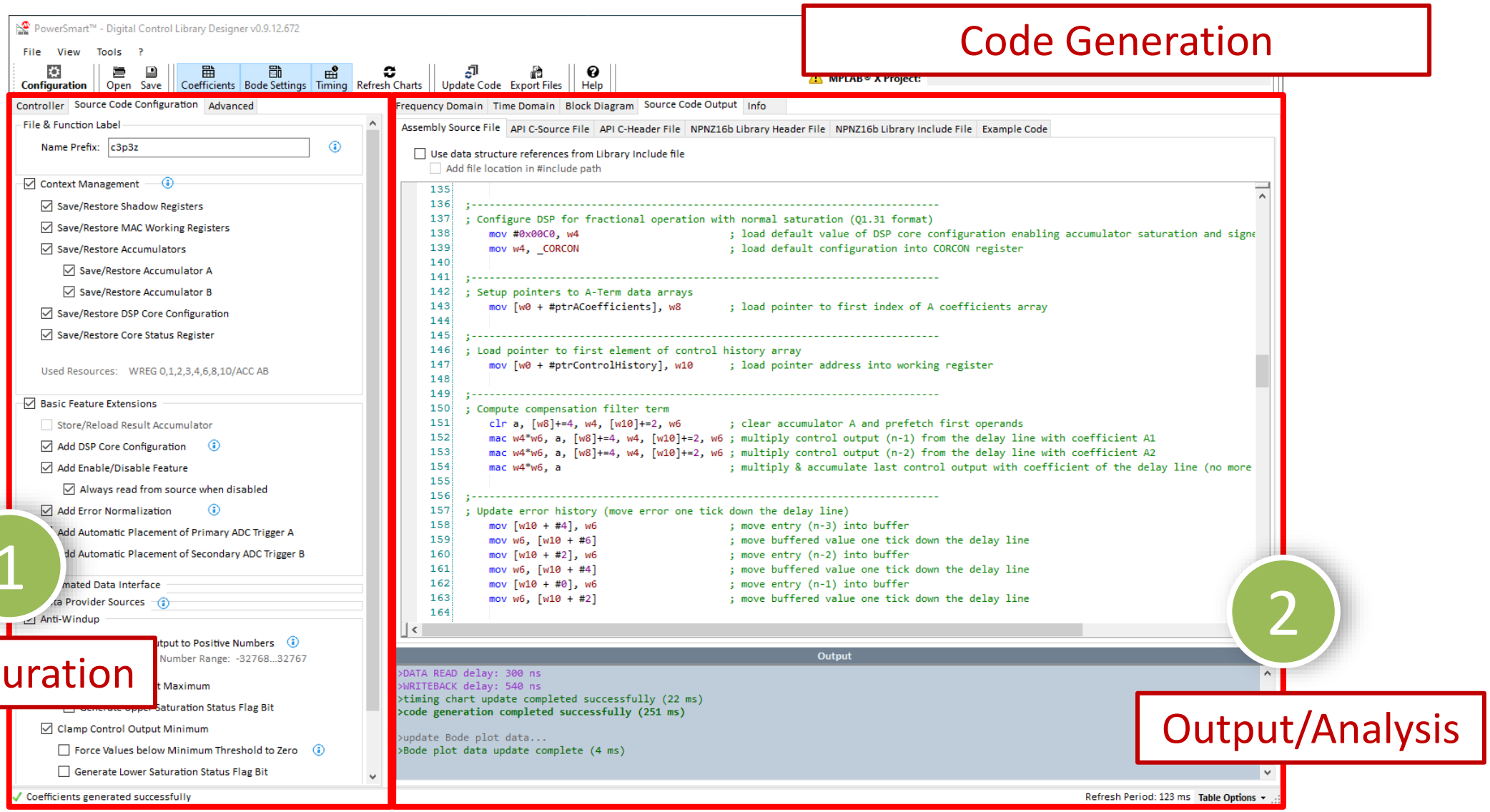
1

Configuration

2

Output/Analysis

# PowerSmart™ DCLD Main Window Overview



# Thank you!

May the power be with you!