# ModusToolbox™ Power Conversion Configurator user guide

ModusToolbox™ Industrial MCU Technology Pack version 2.0.0

Power Conversion Configurator version 1.0.0

## About this document

### Scope and purpose

The Power Conversion Configurator is a tool included with the ModusToolbox™ software intended to generate data structures to configure middleware for provided power-supply design inputs. The tool provides a reference for estimating and demonstrating the typical behavior of a converter.

### Intended audience

This document helps application developers understand how to use the Power Conversion Configurator as part of creating a ModusToolbox™ application.

### Document conventions

| Convention | Explanation |
|---|---|
| **Bold** | Emphasizes heading levels, column headings, menus and sub-menus |
| *Italics* | Denotes file names and paths. |
| `Courier New` | Denotes APIs, functions, interrupt handlers, events, data types, error handlers, file/folder names, directories, command line inputs, code snippets |
| **File > Open** | Indicates that a cascading sub-menu opens when you select a menu item |

### Abbreviations and definitions

The following define the abbreviations and terms used in this document:

- ADC – analog-to-digital conversion
- Buck – A buck converter or step-down converter is a DC-to-DC converter that decreases voltage while increasing current from its input (supply) to its output (load).
- CMP – comparator
- Configurator – A GUI-based tool used to configure a resource.
- DAC – digital-to-analog conversion
- HS/LS – High/Low side
- ISR – interrupt service routine
- PCCM – Peak Current control mode
- PWM – pulse width modulation
- VCM – Voltage control mode

## Reference documents

Refer to the following documents for more information as needed:

- ModusToolbox™ tools package user guide
- Eclipse IDE for ModusToolbox™ user guide
- VS Code for ModusToolbox™ user guide
- Device Configurator user guide
- LCS Manager CLI user guide

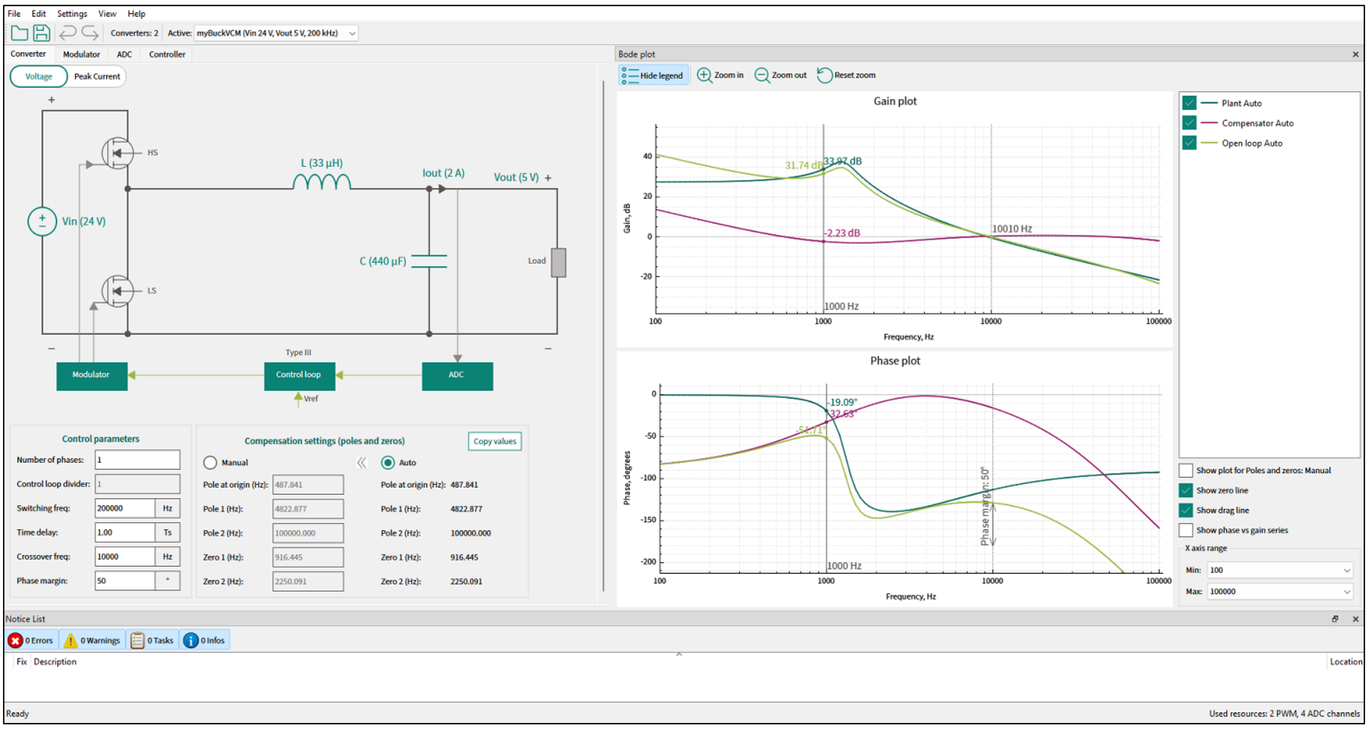
# Table of contents

# 1 Overview

The Power Conversion Configurator provides the capabilities to initially configure a buck topology. Various parameters such as input voltage, output voltage, output current, passive components, protection, and control parameters are easily configured in the user-friendly interface. Subsequently, the Configurator generates a basic schematic diagram, a Bode plot for user reference, and calculates the controller coefficient values to facilitate the execution of a control loop in firmware implementation.

*Note: The equations used in this tool are approximations. Real-world application conditions (PCB properties, components used, layout routing, cooling, etc.) may impact results.*

*Note: The software was tested with PSOC Control C3M3 Dual Buck Evaluation Kit (24 V DC input voltage).*




## 1.1 Supported middleware

The Power Conversion middleware uses configuration setups developed in the Power Conversion Configurator GUI or with external applications.

| Name | Version | Link |
|---|---|---|
| Power Conversion Middleware (`mtb-pwrconv`) | 1.0 | https://github.com/Infineon/mtb-pwrconv |

# 2 Launch the Power Conversion Configurator

There are several ways to launch the Power Conversion Configurator, and those ways depend on the application, and how you use the various tools.

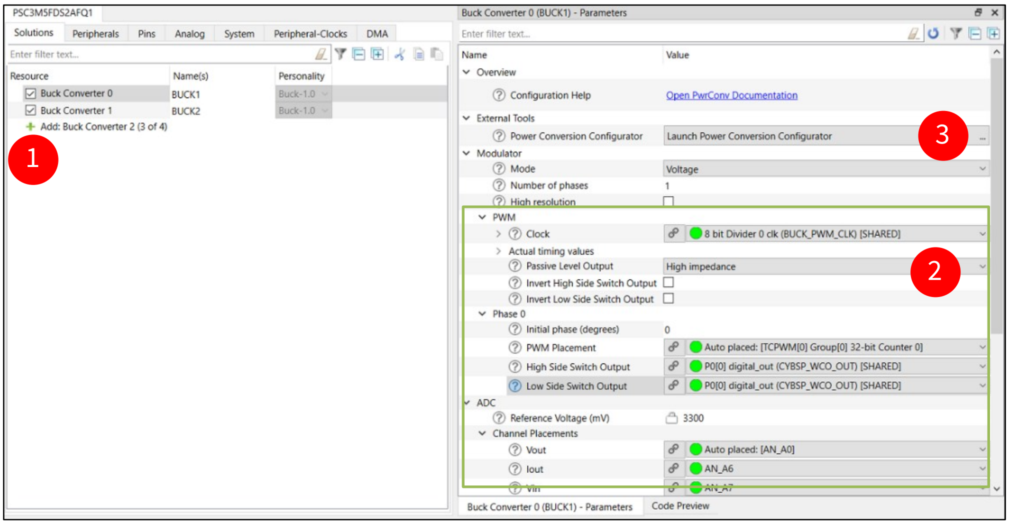
*Note: After you create a new project, at first use the Library Manager to add the* `mtb-pwrconv` *library and use the Device Configurator to add a Buck Converter. Further, you can open the Power Conversion Configurator in any below-described way.*

## 2.1 From the Device Configurator

You can launch the Power Conversion Configurator by using the Device Configurator. The Device Configurator displays information based on the *design.modus* file. When you open the Power Conversion Configurator from the Device Configurator, information about the device and the application is passed to the Power Conversion Configurator. When you save changes in the Power Conversion Configurator, it updates the *design.modus* file and generates code.

Launch the Device Configurator. (For details, refer to the Device Configurator user guide.)

On the **Solutions** tab:




1. Add a **Buck Converter**.
2. Configure the hardware parameters.
3. On the **Parameters** pane, click the **Launch Power Conversion Configurator** button.
4. For multiple solutions (up to 4): select a respective solution and do step 3.

## 2.2 make command

As described in the ModusToolbox™ tools package user guide " ModusToolbox™ build system" chapter, you can run numerous `make` commands in the application directory, such as launching the Power Conversion Configurator. Create a ModusToolbox™ application, navigate to the application directory, and type the following command in the appropriate bash terminal window:

```
make power-conversion-configurator
```

This command opens the Power Conversion Configurator GUI for the specific application in which you are working.

## 2.3 VS Code and Eclipse

VS Code and Eclipse have tools to launch the Power Conversion Configurator from within an open application. Refer to the applicable user guide for more details:

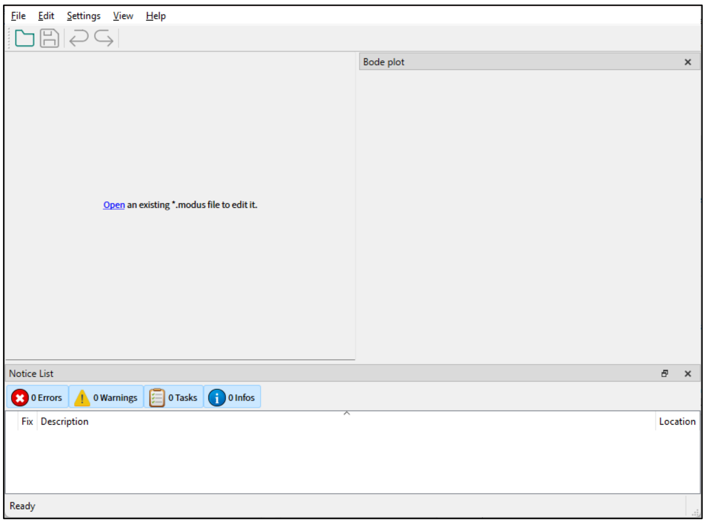
- VS Code for ModusToolbox™ user guide
- Eclipse IDE for ModusToolbox™ user guide

## 2.4 Standalone executable

You can launch the Power Conversion Configurator by running its executable as appropriate for your operating system (for example, double-click it or select it using the Windows **Start** menu). By default, the Configurator is installed here:

> *<install_dir>/ModusToolbox/packs/ModusToolbox-Industrial-MCU-Pack/tools/power-conversion-configurator*

When launched this way, the Power Conversion Configurator opens blank. Open an existing **.modus* file that is already supporting the solution personality information.




See Menus for more information.

# 3 Quick start

This section provides a simple workflow for how to use the Power Conversion Configurator.

1. Create a project for a PSOC™ Control BSP using the Project Creator.
2. If the `mtb-pwrconv` library is not present in the project, use the Library Manager to add it.
3. Use the Device Configurator to add a Buck Converter on the **Solutions** tab and configure the hardware.
4. Launch the Power Conversion Configurator.
5. Configure the parameters as required.
6. Save the configuration. See Code generation.
7. Open the Device Configurator and configure peripherals if required.
8. Use the generated structures from *cycfg_pwrconv.h* and *cycfg_pwrconv.c* files as input parameters for functions in your application.

# 4 Code generation

The Power Conversion Configurator relevant firmware will appear in the *cycfg_pwrconv.h* and *cycfg_pwrconv.c* files. The generated files are located in the *GeneratedSource* folder next to the **.modus* file, which contains the user configuration.

# 5 GUI description

The Power Conversion Configurator GUI contains menus, toolbar, and tabs to configure the power converter settings and a Notice List to provide indications.

## 5.1 Menus

### 5.1.1 File

- **Open…** – Opens the folder with the configuration file.
- **Close** – Closes the configuration file.
- **Save** – Saves the existing configuration.
- **Open in System Explorer** – Opens your computer's file explorer tool to the folder that contains the **.modus* file.
- Recent files – Shows recent files that you can open directly.
- **Exit** – Closes the configurator.

### 5.1.2 Edit

- **Undo** – Undoes the last action or sequence of actions.
- **Redo** – Redoes the last undone action or sequence of undone actions.
- **Converters** – Displays the available converters.

### 5.1.3 Settings

- **Local Content** – Select this to toggle between the online and LCS mode, and read the local copy of the manifest file installed from the LCS Manager. Refer to the LCS Manager CLI user guide for more details.
- **Proxy settings…** – Opens a dialog to specify direct or manual proxy settings.

### 5.1.4 View

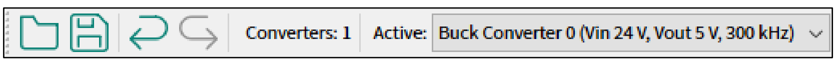
- **Notice List** – Shows/hides Notice List.
- **Bode plot** – Shows/hides the dock window with the bode plot.
- **Toolbar** – Shows/hides the toolbar.
- **Reset View** – Resets the view to the default.

### 5.1.5 Help

- **View Help** – Opens this document.
- **About Power Conversion Configurator** – Opens the About box for version information, with links to open https://www.infineon.com and the current session log files of the application and hardware configuration server.

## 5.2 Toolbar

The toolbar contains common commands from the File and Edit menus. Use the check box under the **View** menu to show or hide the toolbar.



The number of available converters depends on the configuration. The user can select a converter to configure by selecting it from the dropdown menu.

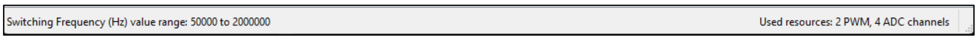
## 5.3 Notice List

The **Notice List** pane combines notices (errors, warnings, tasks, and notes) from many places in the configuration into a centralized list. If a notice shows a location, you can double-click that entry to display the parameter causing the error or warning.

For more information, refer to the Device Configurator user guide.

## 5.4 Status bar

The **Status bar** displays various input field ranges, etc. On the right side – MCU hardware resources reserved across all instantiated converters. On the left side – currently-edited parameter's name, units, and range.




## 5.5 Logging

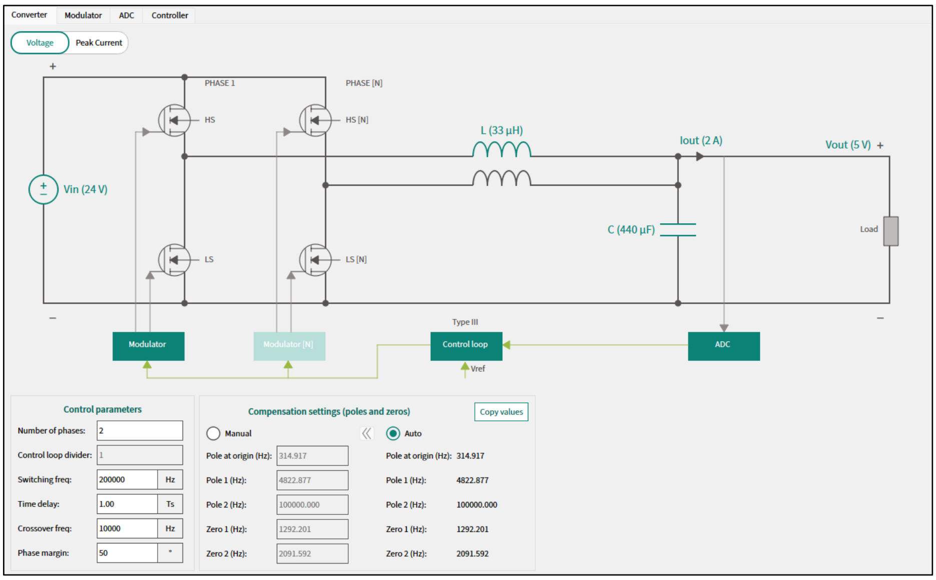
The configurator automatically generates a log for each session. The file location differs for each operating system and can be found in the **About** dialog.

# 6 Tabs/Parameter configuration

- Converter tab
- Modulator tab
- ADC tab
- Controller tab
- Bode plot

## 6.1 Converter tab

The **Converter** tab performs configuration of the general converter parameters.




### 6.1.1 Control mode

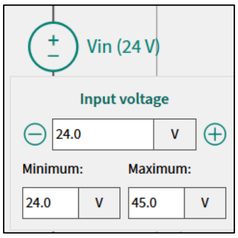
There are two control modes for the buck converter to regulate the output voltage:

- **Voltage** – Regulates the output voltage by using only the output voltage itself.
- **Peak Current** – Regulates the output voltage by using the output voltage and high-side switch current as control parameters.

### 6.1.2 Schematic diagram parameters

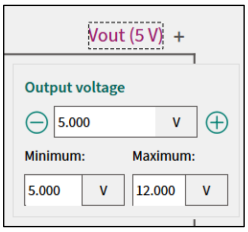
Click the green items on the schematic diagram to edit correspondent parameters: Vin (42V), L (33µH), Iout 2A, Vout (12V), C(440µF).

#### 6.1.2.1 Input Voltage (Vin)



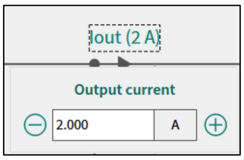
| Parameter | Description | Range | Default |
|---|---|---|---|
| **Input voltage** | Converter input voltage | 9-800 V | 24 V |
| **Minimum** | Minimum possible value of converter input voltage | 9-800 V | 20 V |
| **Maximum** | Maximum possible value of converter input voltage | 9-800 V | 28 V |

### 6.1.2.2 Output Voltage (Vout)



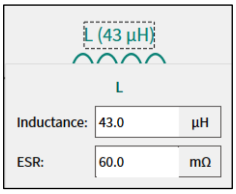

| Parameter | Description | Range | Default |
|---|---|---|---|
| **Output voltage** | Target converter output voltage | 2.5-240 V | 5 V |
| **Minimum** | Minimum possible value of converter output voltage | 2.5-240 V | 4 V |
| **Maximum** | Maximum possible value of converter output voltage | 2.5-240 V | 6 V |

### 6.1.2.3 Output Current (Iout)



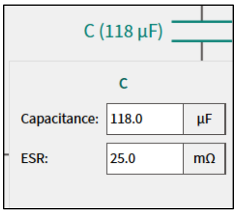

| Parameter | Description | Range | Default |
|---|---|---|---|
| **Output current** | Target converter output current | 0.1-20 A | 2 A |

### 6.1.2.4 Inductance (L)




| Parameter | Description | Range | Default |
|---|---|---|---|
| **Inductance** | Inductance value | 0.1 - 1000000 µH | 33.0 µH |
| **ESR** | Equivalent series resistance of inductor | 0.1 - 1000000 mΩ | 30 mΩ |

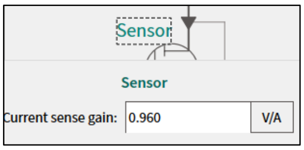
#### 6.1.2.5 Capacitance (C)




| Parameter | Description | Range | Default |
|---|---|---|---|
| **Capacitance** | Capacitance value | 0.1 - 1000000 µF | 440 µF |
| **ESR** | Equivalent series resistance of capacitor | 0.1 - 1000000 mΩ | 75 mΩ |

#### 6.1.2.1 Sensor

The sensor parameters are available only in **PCCM**.




| Parameter | Description | Range | Default |
|---|---|---|---|
| **Current sense gain** | Equivalent transducer gain to transform current to voltage (e.g. shunt resistance in ohms) | 0.001 - 100 V/A | 1 V/A |

### 6.1.3 Control parameters

The **Control parameters** group provides options to enter the required values.

| Parameter | Description | Range | Default |
|---|---|---|---|
| **Number of phases** | Number of converter interleaving phases | 1 - 4 | 1 |
| **Control loop divider**<br>Note: Read only for the current release. | Fast control loop frequency divider | 1 - 255 | 1 |
| **Switching freq** | Target switching frequency of power switch operation | 50000 - 2000000 Hz | 200000Hz |
| **Time delay** | Time expressed in fraction of PWM period to account for the inherent delay introduced by digital implementation: from analog sensing to duty cycle update. Such a delay is compensated in phase margin determination. | 0 - 10.0 | 1.0 |
| **Crossover freq*** | Target crossover frequency | 2000 - 200000 Hz | 10000 Hz |
| **Phase margin*** | Target phase margin | 10 - 90 | 50 |

* The maximum valid values for the **Crossover frequency** and **Phase margin** depend on the entered parameters. They display in the respective parameter tooltip.

### 6.1.4 Compensation settings (poles and zeros)

The **Compensation settings (poles and zeros)** are the characteristic of the transfer function of the converter's control system. They can be either calculated automatically or set manually. The compensator type may be

Type III (**VCM**) or Type II (**PCCM**). The number of poles and zeros aligns correspondingly with the selected Control mode.

| Parameter | Range | Default |
|---|---|---|
| **Pole at origin (Hz)** | 0 - 1e+09 | 487.841 |
| **Pole 1 (Hz)** | 0 - 1e+09 | 4822.877 |
| **Pole 2 (Hz)** (**VCM** only) | 0 - 1e+09 | 100000.000 |
| **Zero 1 (Hz)** | 0 - 1e+09 | 916.445 |
| **Zero 2 (Hz)** (**VCM only**) | 0 - 1e+09 | 2250.091 |

Copy values – Click this button to copy the compensation settings values.

You can use them in your custom code example for **VCM**:

```
#define Pole0 487.841
#define Pole1 4822.877
#define Pole2 100000.000
#define Zero1 916.445
#define Zero2 2250.091
```

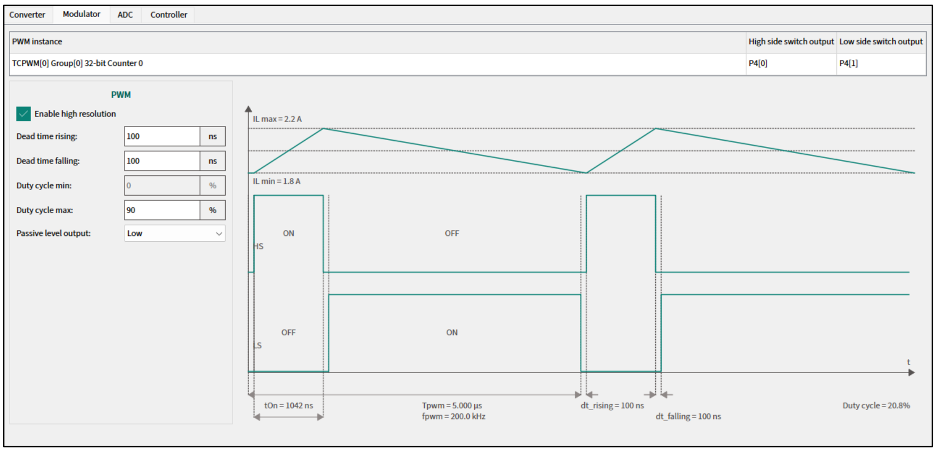
or **PCCM**:

```
#define Pole0 24659.727
#define Pole1 4822.877
#define Zero1 882.364
```

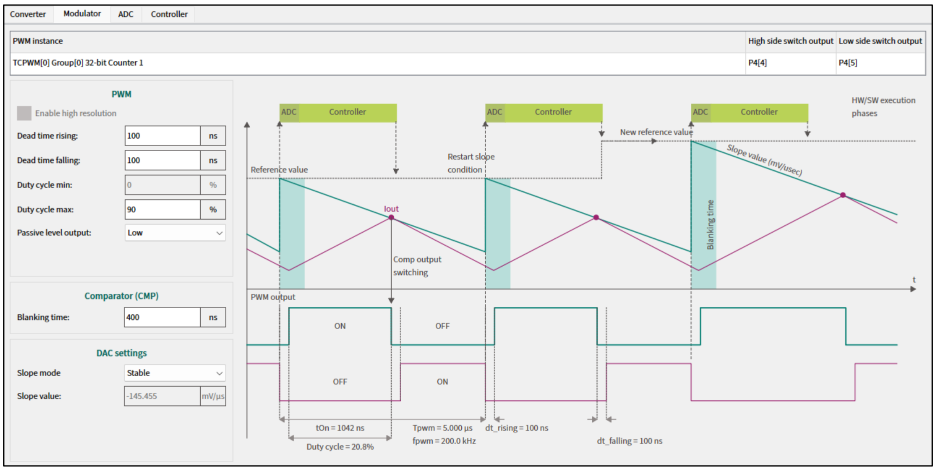
## 6.2 Modulator tab

The **Modulator** tab defines the configuration for high-level parameters of PWM instances.

### Voltage



### Peak Current




## 6.2.1 PMW instance table

The **PWM instance** table displays information about allocated PWM resources.

- **High/Low side switch output** – Corresponding assigned pins.

## 6.2.2 PWM

The **PMW** settings parameters are applied to all PWM instances. The diagram on the right side illustrates the control loop operation replotted for **VCM** and **PCCM**. At the bottom, the dynamically-replotted PWM ON/OFF scheme for the HS and LS switches depending on the time scale with marked PWM period, Duty cycle, and dead times. The time change of the inductance current is on the top of the scheme. In PCCM, the slope generator curve, ADC and Controller blocks present the control loop operation.

| Parameter | Description | Range | |
|---|---|---|---|
| **Enable high resolution** | Enables the PWM High resolution mode | True/False | **VCM** – True<br>**PCCM** – False (Read-only) |
| **Dead time rising** | Dead time delay for HS | 1-1e+09 ns | 100 ns |
| **Dead time falling** | Dead time delay for LS | 1-1e+09 ns | 100 ns |
| **Duty cycle min** | Minimum modulation duty cycle | Read-only | 0% |
| **Duty cycle max** | Maximum modulation duty cycle | 1-100% | 90% |
| **Passive level output** | Behavior of PWM outputs with passive PWM | Low<br>High<br>High impedance | Low |

### 6.2.2.1 Comparator (CMP)

The **Comparator (CMP)** group is available only in **PCCM**.

| Parameter | Description | Range | Default |
|---|---|---|---|
| **Blanking time** | The time period when input is ignored to avoid switching transient | 0-1000 ns | 400 ns |

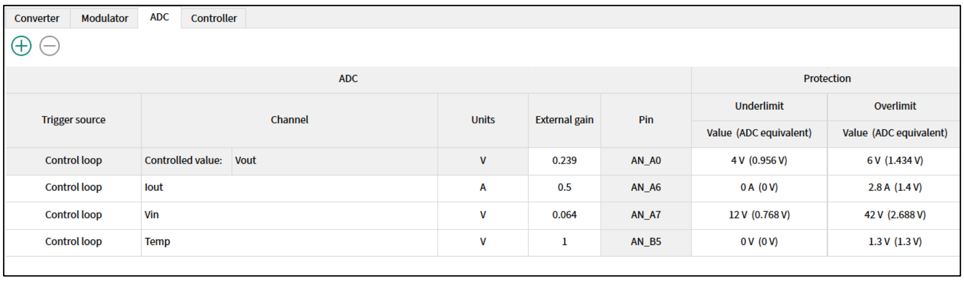
### 6.2.2.2 DAC settings

The **DAC settings** group is available only in **PCCM**.

| Parameter | Description | Range | Default |
|---|---|---|---|
| **Slope mode** | Added by DAC current compensation slope | Stable (HW-based)<br>Responsive (HW-based)<br>Custom (editable) | Stable |
| **Slope value** | The decrease rate of the comparator reference voltage; active in custom Slope mode | -3300-0 mV/µs | -151.515 mV/µsec |

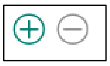
## 6.3 ADC tab

The **ADC** tab provides the options to configure ADC channels and protection settings in the respective parts.




### 6.3.1 Toolbar

The ADC tab toolbar contains **Add** and **Remove** channel buttons. The **Remove** button is active only for the last channel on the list.



### 6.3.2 ADC channels table

**ADC** group:

- **Trigger source** – The ISR trigger priority. The options from the dropdown menu: **Control loop** or **Scheduled**. For details, see the middleware documentation: https://github.com/Infineon/mtb-pwrconv
- **Channel** – The channel name is auto-set or custom.

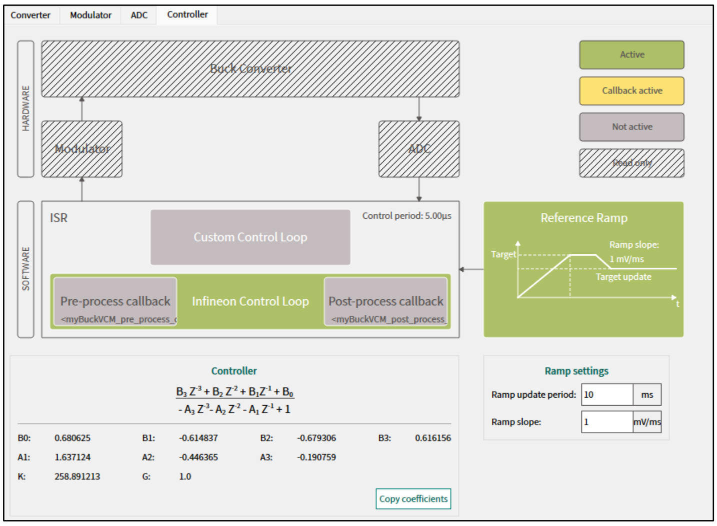
  The first channel configuration is mandatory for the **Infineon control loop**. The controlled output parameter – **Vout**, and the channel name is defined accordingly.
- **Units** – The units of the respective channel. You can select from the dropdown menu: **V** (volts), **A** (amperes), **°** (degrees), or **Custom**.
- **External gain** – The resulting factor of the signal conditioning on the electrical quantity: either attenuation or amplification. The value range is 0.001 - 100.
- **Pin** – Displays the pin assigned to the channel. The pin assignment can be changed from the Device Configurator.

**Protection** group:

- **Underlimit**/**Overlimit** – The protection from the under/over crossing ADC range.
- **Value (ADC equivalent)** – Represents the voltage of the native electrical quantity at the MCU pin after conditioning. The maximum supported ADC value is 3.3 V and the minimum – 0V.

## 6.4 Controller tab

In the **Controller** tab, the Power Conversion Configurator configures the controller and displays calculated controller coefficients values.




### 6.4.1 Block diagram

The block diagram illustrates the hardware and software components for the power converter operation. There are several categories of the blocks as shown in the diagram's legend on the right side:

- **Active** – clickable option, turned on
- **Callback active** – clickable option, turned on
- **Not active** – clickable option, turned off
- **Read only** – not clickable, illustrative only.

| Parameter | Description | Default |
|---|---|---|
| **Control period** | The time required for 1 switching cycle. | 5.00µs |
| **Custom Control Loop** | Disables default Infineon control loop and enables custom implementation | Disabled |
| **Infineon control loop** | Enables default control loop implementation | Enabled |
| **Pre-process callback** | Executes a user-defined pre-processing callback function before execution of control loop ISR. The callback name is displayed below. Click it to enter a custom name. | Disabled |
| **Post-process callback** | Executes a user-defined post-processing callback function after execution of control loop ISR. The callback name is displayed below. Click it to enter a custom name. | Disabled |

### 6.4.2 Controller

The **Controller** section displays the formula used in the controller and correspondent coefficient values. The compensator type can be either Type III (**VCM**) or Type II (**PCCM**).

| Parameter | Range |
|---|---|
| **B0** | Coefficient for Type II and Type III compensator |
| **B1** | Coefficient for Type II and Type III compensator |

**Tabs/Parameter configuration**

| Parameter | Range |
|---|---|
| **B2** | Coefficient for Type II and Type III compensator |
| **B3** | Coefficient for Type III compensator |
| **A1** | Coefficient for Type II and Type III compensator |
| **A2** | Coefficient for Type II and Type III compensator |
| **A3** | Coefficient for Type III compensator |
| **K** | Digital controller gain.<br>Scales the controller output to consider PWM, ADC and pre-ADC scaling gain |
| **G** | Value fixed to default |

*Note: Default values for these coefficients are calculated depending on the control mode:* ***Voltage*** *or* ***Peak Current*** *(see the examples below).*

- **Copy coefficients** – Click this button to copy the controller coefficients.

You can use them in your custom code example for **VCM**:

```
#define B0 0.680625
#define B1 -0.614837
#define B2 -0.679306
#define B3 0.616156
#define A1 1.637124
#define A2 -0.446365
#define A3 -0.190759
#define K 258.891213
#define G 1.0
```

or **PCCM**:

```
#define B0 1.915586
#define B1 0.052375
#define B2 -1.863211
#define A1 1.859155
#define A2 -0.859155
#define K 1.046025
#define G 1.0
```

### 6.4.3 Ramp

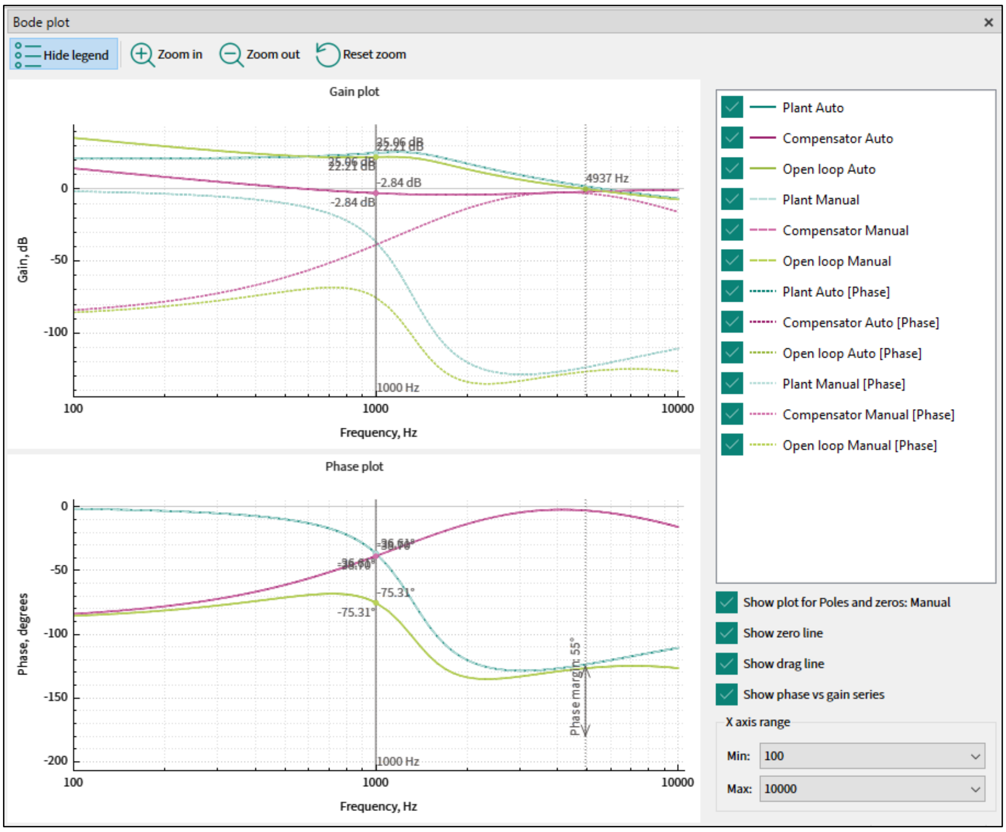
The **Reference Ramp** diagram next to the ISR component illustrates the Target update depending on the **Ramp update period** and **Ramp slope**.

**Ramp settings**

| Parameter | Description | Range | Default |
|---|---|---|---|
| **Ramp update period** | Period required for ramp generator function execution | 1-50 ms | 1 ms |
| **Ramp slope** | Maximal speed of reference value change over time | 1-1000 mV/ms (or counts) | 1 mV/ms (or counts) |

## 6.5 Bode plot

The **Bode plot** is a set of graphs that allow assessing a given power conversion design. The graphs are **Gain plot** (magnitude) and **Phase plot** of a transfer function versus frequency. The gain expressed in decibels and phase in degrees are plotted versus frequency using semi-logarithmic axes. A plot set consists of the **Plant**, **Compensator**, and **Open loop** series.



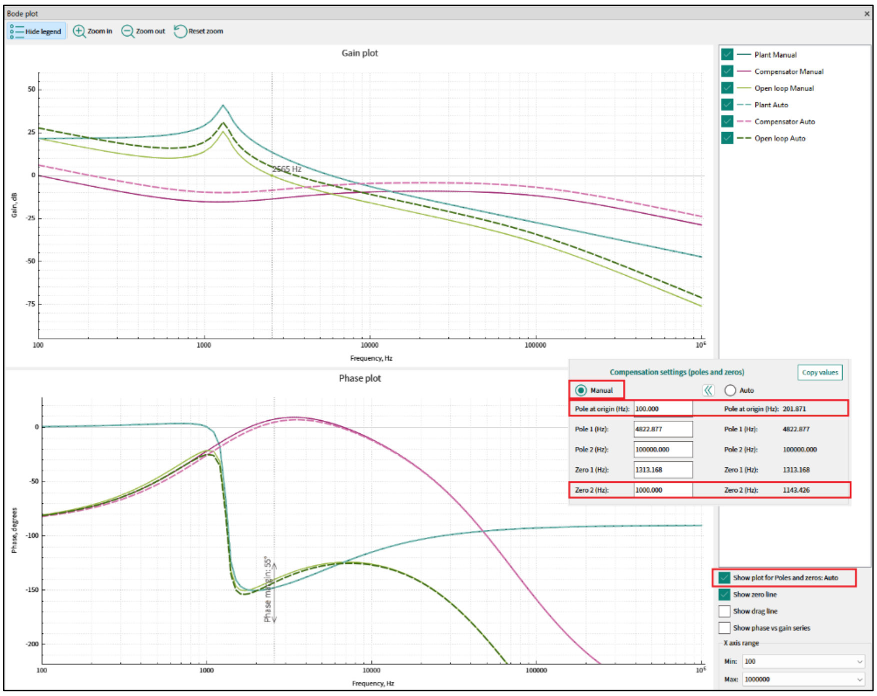

### 6.5.1 Toolbar


The **Bode plot** toolbar consists of the **Hide/Show legend**; **Zoom in**; **Zoom out**; **Reset zoom** commands.

You can also zoom or move a graph using the mouse. With additional modifiers, you can zoom only the **X** axis (**Shift + Wheel**) or **Y** axis (**Ctrl + Wheel**).

### 6.5.2 Legend

The **Legend** provides an explanation of displayed graph data and allows for the customization of this information. Select a respective option in the **Legend**, to display the various subsets of series.




The following options are available:

- **Show plot for poles and zeros** – Check this box to compare the output for the manual and auto compensation settings. If the respective manual and auto compensation settings values are not equal, the series will not overlap, and an alternative set with a dash line series can be clearly visible.
- **Show zero line** – Enable this option to reveal a vertical static line that indicates the **X** coordinate where the open loop series intersects with the 0 dB **Y** axis value, as well as the target Phase margin.
- **Show drag line** – Enable this option to display a vertical draggable line that presents the values of the bode plot series at their intersection with the line at a certain frequency. This line can be moved using the mouse or, if it is beyond the **X** axis range, to make it visible, double-click the chart area.
- **Show phase vs gain series** – Check this box to additionally showcase the phase series on the **Gain plot**. The label [**Phase**] will be included in the legend for differentiation.
- The **X-axis range** remains consistent for both the **Gain** and **Phase** plots and can be modified by selecting the desired min and max values from the dropdown menus. The widest available range spans from 100 Hz to 1 MHz. The Y-axis range adjusts dynamically to ensure the visualization of all series.

# 7 Version changes

This section lists and describes the changes for each version of this tool.

| Version | Change descriptions |
|---|---|
| 1.0 | New tool. |

# Revision history

| Revision | Date | Description |
|---|---|---|
| ** | 2024-11-28 | New document. |

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