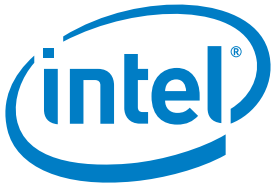

Intel® Enpirion® Power Solutions

Intel Enpirion Digital Power Configurator User Guide

User Guide

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1. Introduction

The EM21xx devices from the Intel® Enpirion® Power Solutions family of products contain a true digital controller and support the PMBus™ protocol, thus enabling the use of configuration, monitoring, and fault management during run-time. A PMBus host controller is connected to the EM21xx module via the PMBus pins.

To help the user configure, test and to fully optimize the full benefit of the EM21xx family, Intel developed an easy to use Graphical User Interface (GUI) entitled Intel Enpirion Digital Power Configurator. The purpose of this document is to describe the functionality of this GUI.

2. Intel Enpirion Digital Power Configurator

2.1 Overview

The Intel Enpirion Digital Power Configurator is a Graphical User Interface (hereafter referred to as the GUI) designed to guide the user through the entire design process when using Intel's Enpirion digital PowerSoCs. This manual provides instructions specifically for the EM21xx family.

The GUI supports the user in completing the following design steps in conjunction with using Intel's PMBus Communication Interface (EM2COMIF):

- Reviewing the preconfigured device settings
- Updating configurable settings in Volatile memory (using "Write Volatile") or in Non-Volatile Memory (using "Reprogram Configuration")
- Programming the system start-up and sequencing
- Setting up the protection features (i.e. the over-current protection and input/output voltage protection)
- Providing basic PMBus commands for operating with the EM21xx and monitoring the system status

EM21xx Evaluation Boards are available, and have been specifically developed to evaluate the performance of the EM21xx module. For more information, please see the specific EM21xx device's product page found at www.altera.com/enpirion.

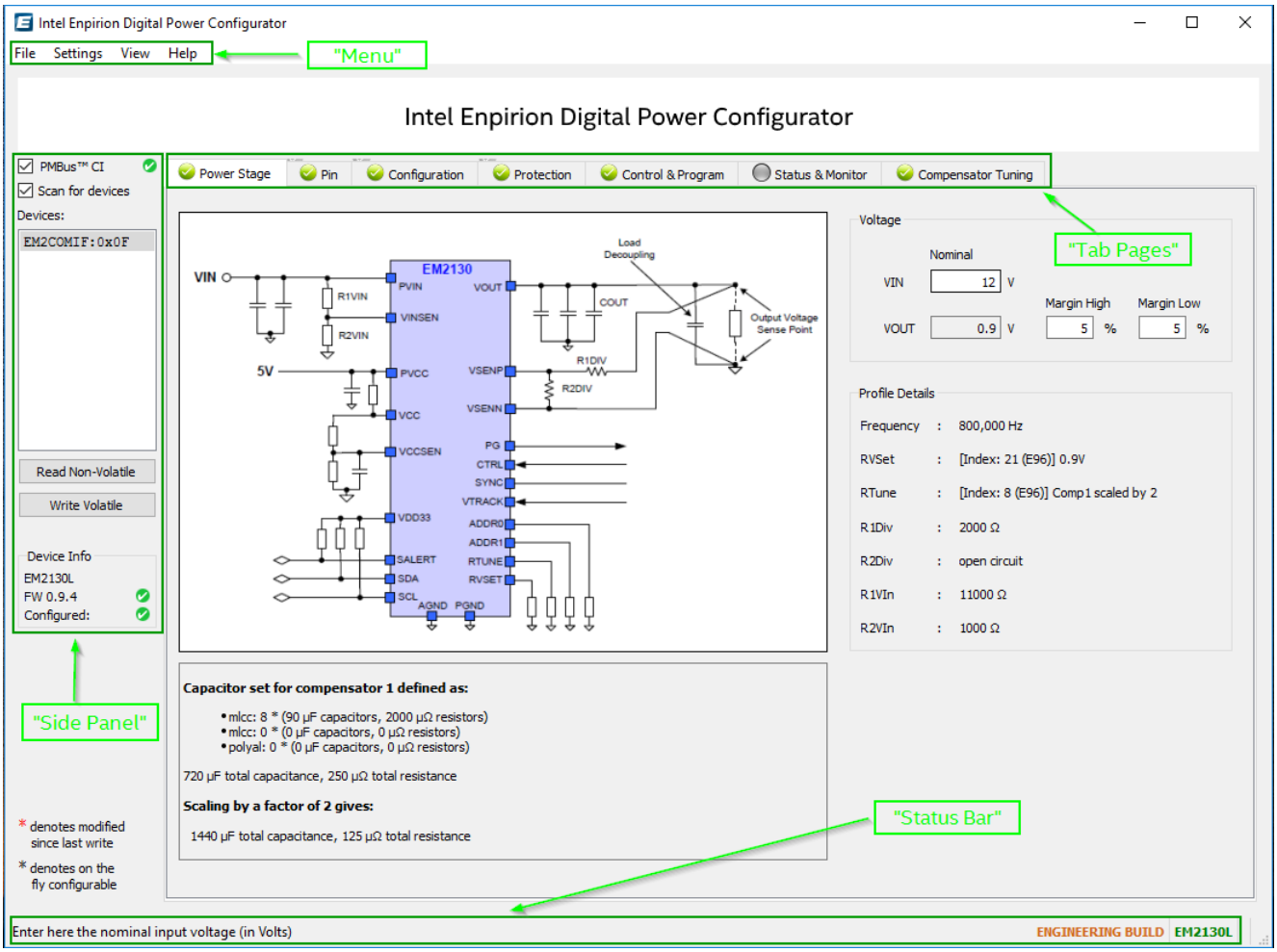


Figure 1: GUI Main Window, Showing An EM2130L Device Connected

Figure 1 provides an overview of the GUI main window, using an EM2130L device as an example. Points to note in Figure 1 are:

- A “Menu” at the top of the screen allows you to open and save project files, modify settings, modify the view and access help.
- A “Side Panel” shows the currently connected device(s).
- The configuration for the currently selected device is displayed as a set of “Tab Pages”. The user can progress from left to right to quickly view their configuration and test their device.
- A “Status Bar” at the bottom of the screen provides information on the currently selected field.

2.2 Communications

To allow easy communication between the GUI and the EM21xx Module, Intel offers a PMBus Communication Interface that allows communication via a USB socket on a Host PC. For more information, please see the specific EM21xx device's product page found at www.altera.com/enpirion.

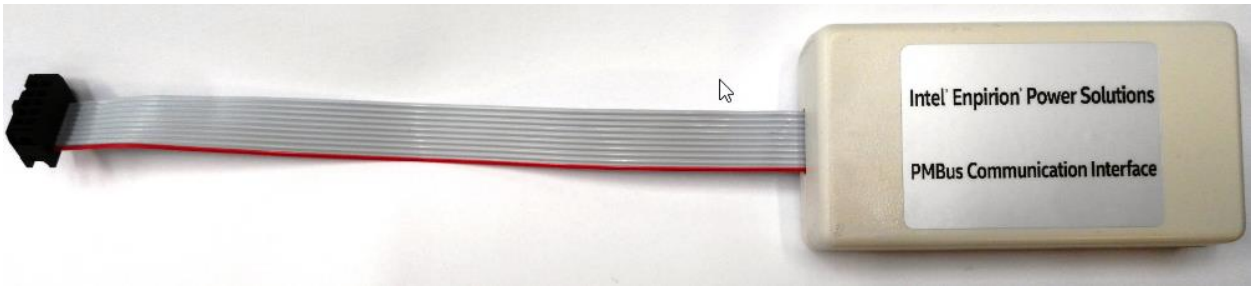


Figure 2: The PMBus Communication Interface (EM2COMIF)

3. GUI Main Features

This section outlines the main features of the GUI, and offers guidance on how to navigate these features.

3.1 Top Menu

The top level menu of the GUI allows the user to manage project files, to configure GUI settings, and to easily access documentation. A complete list of the features included in the top menu is provided in Table 1.

On start-up, the GUI provides the user with a set of default configuration parameters for the system. The user can change these configuration parameters as needed and save them to project files. Project files contain all the information used in the GUI. Projects files are managed via the "File" menu item in the menu bar.

Table 1: Top Menu of Intel Enpirion Power Configurator

Menu	Parameter	Function/Comments
File	Open	Load a project file into the GUI view.
	Save	Save the GUI view to the current project file.
	Save As	Save the GUI view to a named project file.
	Exit	Exit the GUI.
Settings	Monitoring	Select the "Status & Monitor" tab, averaging value.
	I2C Speed	Select I^2C clock frequency. Default frequency is 100 kHz.
View	Banner	Display or hide the GUI banner.
Help	User Guide	Open the GUI user guide.
	Show License	Displays the user license terms for using the GUI and evaluation kit.
	About	Displays the GUI version and licenses used by the GUI itself.

3.2 Side Panel

The Side Panel provides information on the status of the PMBus Communication Interface (CI) and the devices connected to it. Scanning of any PMBus devices connected to the user's computer is enabled by checking the box next to the "PMBus CI" field. All detected devices will appear in the "Devices" list box, which is formatted as: *<PMBus CI Name>:<PMBus Address>*.

Select the EM21xx device to be configured by clicking on the entry. When the EM21xx is powered up and selected, a "Device Info" box will appear immediately below the "Write Volatile" button, listing the information about the currently selected device as shown in Figure 3.

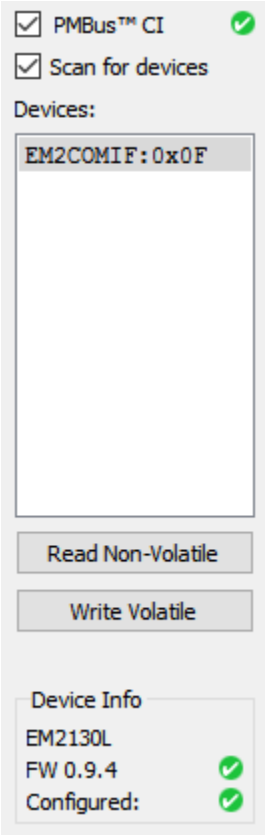


Figure 3: The Side Panel (Showing an EM2130L Connected)

Points to note in Figure 3 are:

- The "PMBus CI" checkbox is enabled. This has enabled the PMBus communication interface.
- The "Scan for devices" checkbox is enabled. The GUI will continue searching for new devices.
- The "Devices" list box shows all connected devices. In the example shown in Figure 3, there is one PMBus CI called "EM2COMIF" and it has one device connected to it using PMBus address "0x0F".
- The "Read Non-Volatile" button allows you to read the device configuration into the GUI view.
- The "Write Volatile" button allows you to write (lost on power reset) the GUI view to the device configuration.

- The information presented in the "Device Info" screen shows the details of this device. This shows us the device type, the firmware version and the device configuration state. Tooltips will appear if you hover over the icons to explain further.

We can summarize the icons used in the "Device Info" box in Table 2. Similar information is also present in the icon's tooltip.

Table 2: Device Information, Icons Used, And Icon Meaning

Field	Icon	Device Information Fields
Firmware		Supported firmware version.
		Firmware version is not supported. Download an updated GUI or contact Intel for support.
Configuration		Non-volatile memory of the device is configured.
		Non-volatile memory of the device is configured, but the device has been re-configured via the volatile memory.
		Unknown configuration of volatile memory or configuration data was not programmed during the current GUI session.

3.3 Tab Pages

The following tabs are implemented in the GUI:

- "**Power Stage**" tab: Informs the user on device details such as nominal V_{IN}, nominal V_{OUT}, and V_{OUT} margin values. It also displays components of the power stage such as capacitors related to RTUNE, switching frequency, input and output voltage divider values, and detected RVSET & RTUNE values.
- "**Pin**" tab: RVSET and RTUNE tables and PMBus address value tables.
- "**Configuration**" tab: Configuration of parameters for sequencing and startup.
- "**Protection**" tab: Setting of protection features including fault condition warning and fault levels.
- "**Control & Program**" tab: Download of configuration into non-volatile memory (NVM), generation of programming file for manufacturing, and PMBus command access.
- "**Status & Monitor**" tab: Status and monitoring functions to monitor voltage, current, and temperatures. Also allows some basic device control for experimentation.
- "**Compensator Tuning**" tab: Allows tuning of the compensation loop using RTUNE and separation of the Steady State and Transient loops for Bode Plot Measurements.

A status icon is displayed alongside the tab name. This indicates the overall status of all the fields in that tab. More information is contained in the Tab Descriptions section.

3.4 Feedback and Validation

The GUI tracks all configuration value changes. Feedback is given to the user on a "field change" as follows:

- *Italics* – the project file value is different; project "Save" will save the project and remove this notification.

Figure 4: Example Field Change Display - Italics

- (*) – the device value is different; "Write Volatile" will update the device and remove this notification.

Figure 5: Example Field Change Display – (*)

Feedback is given to the user on the "field status" as follows:

- **WARNING** – the field background color will be amber and the field tooltip will contain the warning message.
- **ERROR** – the field background color will be red and the field tooltip will contain the error message.

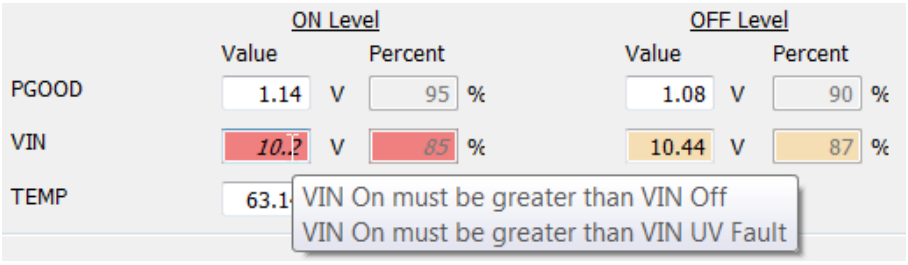


Figure 6: Example Field Status Display – "WARNING" and "ERROR"

Figure 6 shows an example field change status for "WARNING" and "ERROR." The "WARNING" field status is shown via amber-colored fields under the "OFF Level" section shown in Figure 6. The "ERROR" field status is shown via red-colored fields under the "ON Level" section shown in Figure 6.

The status of all fields on a tab page is used to create an overall "tab status" as follows:

- A "green check mark" indicates that all the fields in the tab page are in a valid state.
- A "amber warning" indicates that some fields in the tab page are in a warning state.
- A "red x" indicates that some fields in the tab page are in an error state.

Figure 7 shows an example of the overall tab status in the GUI.

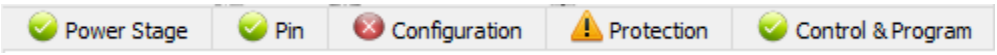


Figure 7: Example Overall Tab Status Display

3.5 Configuration Testing and Programming

The GUI allows the device to be configured Volatile (temporary) or Non-Volatile (permanent) memory as outlined below:

- **Volatile** memory using the "Write Volatile" button located on the side panel, shown in Figure 8:
  - This writes configuration directly into the device registers
  - This configuration is lost when the power is reset
  - There is no limit to the number of times this can be done
  - As this is a temporary change, it is ideal for evaluating a configuration

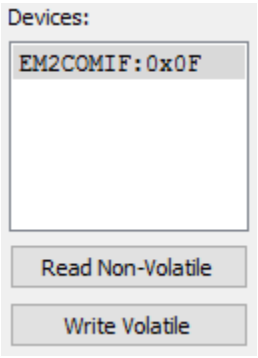


Figure 8: "Write Volatile" Button

- **Non-Volatile** memory using the "Program" and "Re-Program" buttons located on the "Control & Program" tab:
  - This writes configuration to the device OTP (One Time Programmable) storage
  - This configuration is retained on power reset
  - As this is a permanent change and storage is limited, it should be used sparingly

Figure 9 shows an example display for configuring an EM21xx device using Non-Volatile memory.

CAUTION: *The device can be re-configured using Non-Volatile memory fully a total of 3 times or re-configured partially until all storage is used. The display example in Figure 9 shows that the example device has only used 11% of the available Non-Volatile memory.*

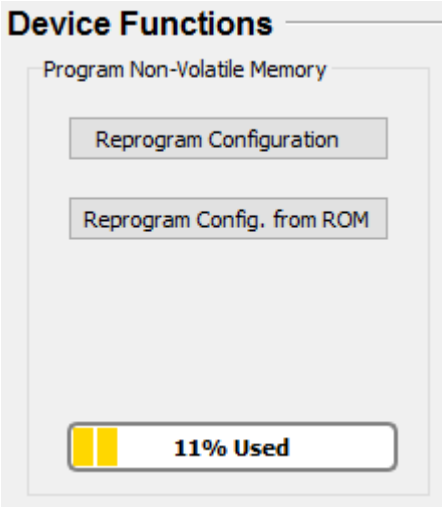


Figure 9: Example Display For Configuring An EM21xx Device Via Non-Volatile Memory

Note that users will not be allowed to write a configuration to your device if your project has configuration errors - these must be corrected first.

4. Tab Descriptions

The tab pages of the GUI are specifically designed to guide the user through the complete configuration process of an EM21xx device. The design flow can be followed by proceeding through the tabs from the left to the right. This section provides detailed explanations of the individual tabs found within the GUI.

4.1 The "Power Stage" Tab

The "Power Stage" tab is used as a reference link between the actual physical components of the user's power stage and the EM21xx. There are only four input fields on this tab and all other parameters displayed are read only information values. Table 3 provides more details about the four input fields found on the "Power Stage" tab.

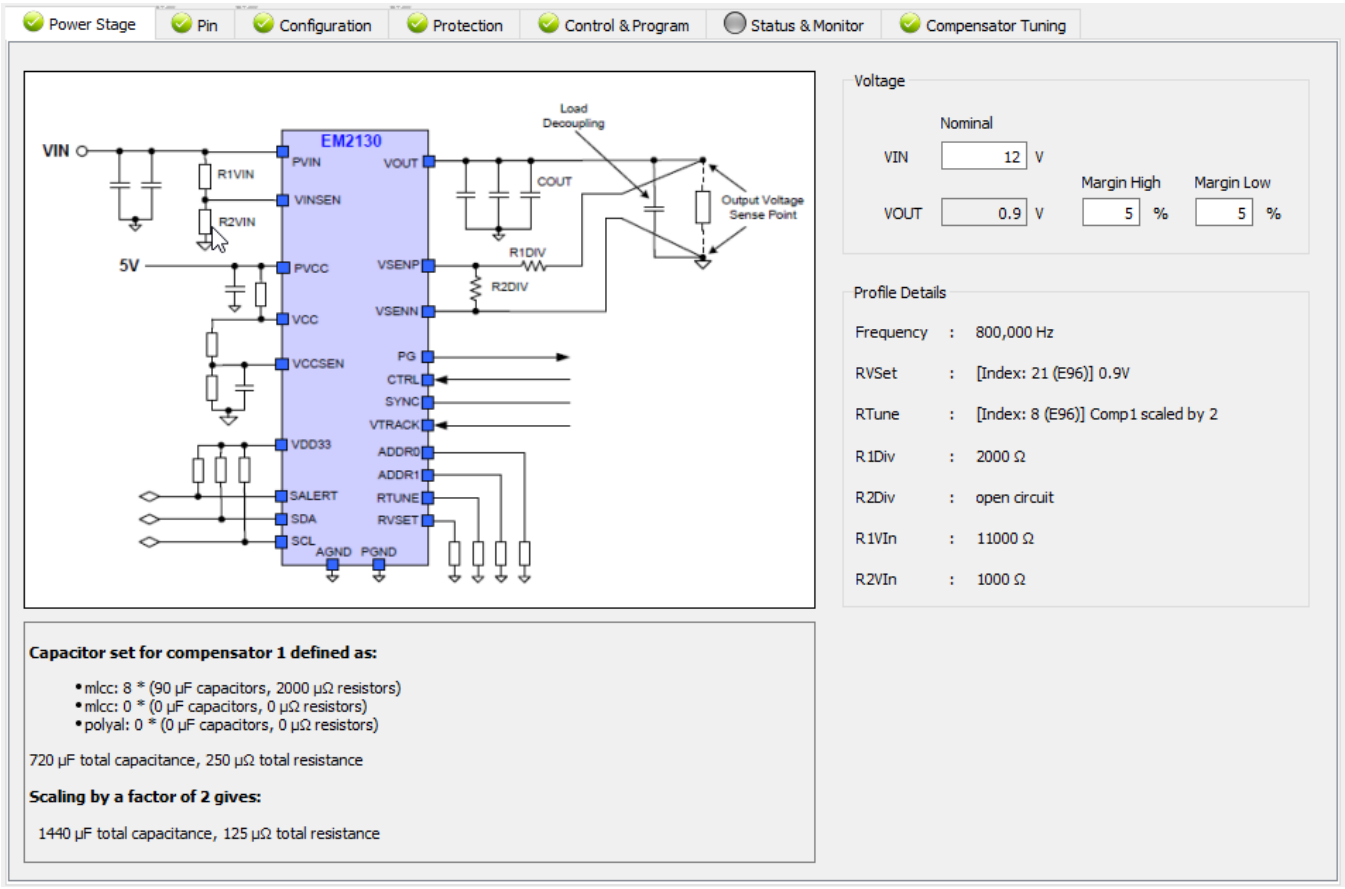


Figure 10: The "Power Stage" Tab (With An EM2130L Connected)

Table 3: Overview Of Input Fields On The "Power Stage" Tab

Input Field	Description
VIN	User set nominal VIN value . Related values on the protection tab can be scaled automatically if set as % of this.
VOUT	User set VOUT value or read-back value based on RVSET (if enabled). Related values on the protection tab can be scaled automatically if set as % of this.
VOUT Margin High	The percentage to add to VOUT when VOUT_MARGIN_HIGH in effect.
VOUT Margin Low	The percentage to subtract from VOUT when VOUT_MARGIN_LOW in effect.

4.1.1 Capacitor Section

The displayed capacitor selection is based on the RTUNE index detected if a module is detected; otherwise the capacitor selection is based upon the project file loaded. Upon the detection of a module, the user is given the option to update the GUI view based on the detected device.

NOTE: Before reading the device configuration into your GUI view, you may wish to save your existing configuration first as a project file. This will ensure you do not lose any edits you may have made.

You can press the "Read Non-Volatile" button at any time, to read the device stored configuration into your GUI view.

4.1.2 "Switching Frequency"

To help balance the ratio between minimum size and maximum efficiency, the EM21xxL and EM21xxH operate at two different switching frequencies. EM21xxL devices are designed to support output voltages less than or equal to 1.325V, and operate at a switching frequency of 800 kHz. EM21xxH devices are designed to support output voltages greater than 1.325V, and operate at a switching frequency of 1.33 MHz. Please see the specific EM21xx device's product datasheet available at www.altera.com/enpirion for more information.

4.1.3 "RVSET"

RVSET allows the output voltage to be set using an externally connected resistor. Upon power up, the EM21xx detects the attached resistor and displays the corresponding RVSET Index and related V_{OUT} value. In the default configuration, RVSET is enabled.

When RVSET is set to "Enabled", V_{OUT} is read-only as it has been chosen based on the external resistor. When RVSET is set to "Disabled", V_{OUT} is editable. Please see the specific EM21xx device's product datasheet available at www.altera.com/enpirion for more information.

4.1.4 "RTUNE"

RTUNE allows the compensation to be optimized using an externally connected resistor. Upon power up, the EM21xx detects the attached resistor and displays the corresponding RTUNE Index and related compensator. In the default configuration, RTUNE is enabled.

When RTUNE is set to "Enabled", the compensator is chosen based on the external resistor. When RTUNE is set to "Disabled", the compensator is as defined in the project file. Please see the specific EM21xx device's product datasheet available at www.altera.com/enpirion for more information.

4.1.5 "Feedback Divider" and "VIN Divider"

For both the input (R1VIn, R2VIn) and output (R1Div, R2Div), the component values to be used are displayed and should be chosen as recommended in the specific EM21xx device datasheet in order to meet the maximum range for the input and output voltage.

The GUI ensures that the dividers are sufficient to cover the sense ranges as specified.

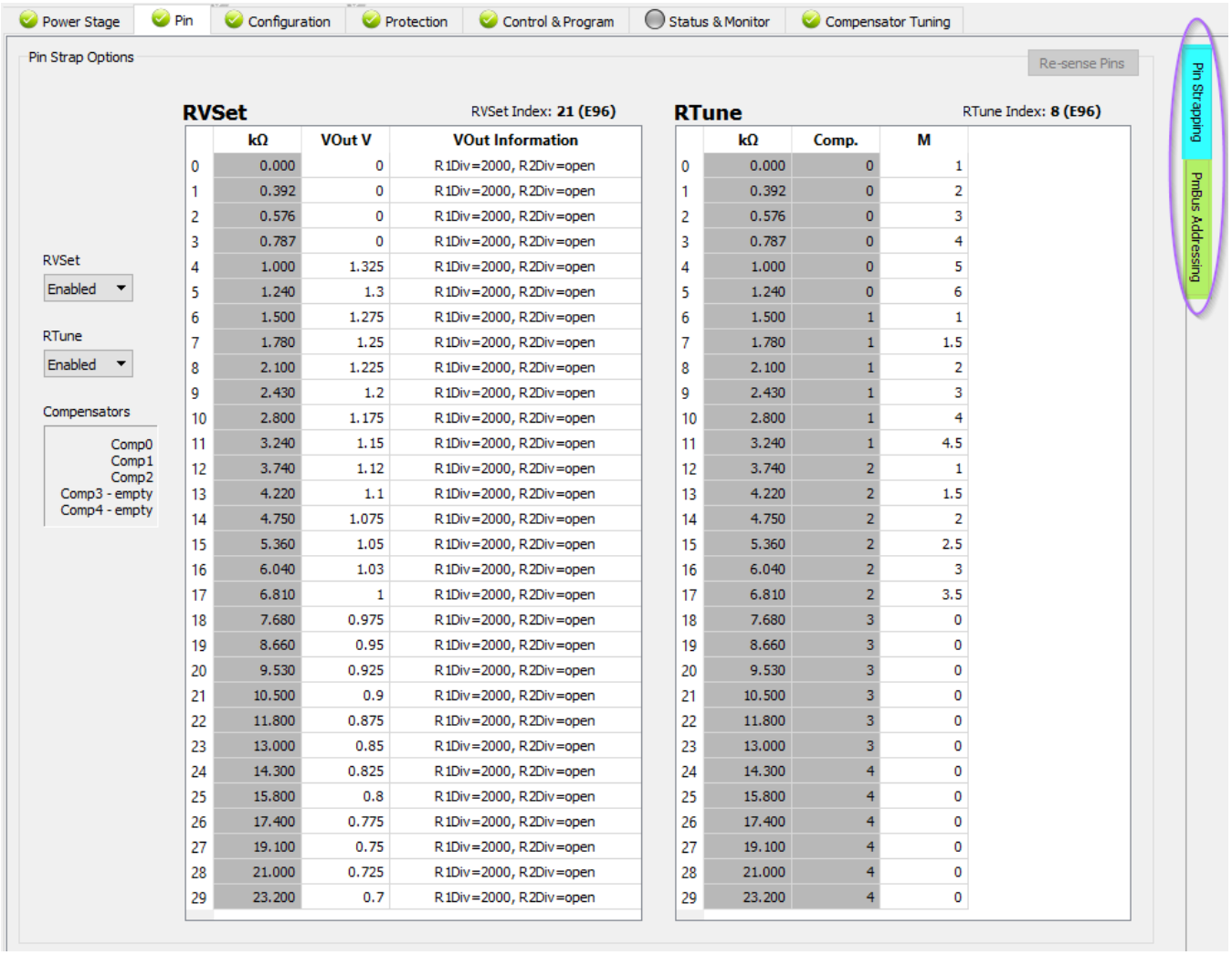
4.2 The "Pin" Tab

Each EM21xx device can support the selection of multiple output voltages and compensators directly through pin-strapping, which eliminates the need to use the PMBus interface. The RVSET input allows the output voltage to be selected and the RTUNE input allows the compensator to be selected.

The "Pin" tab has two embedded tabs.

- "Pin Strapping" which configures the EM21xx RVSET and RTUNE features.
- "PMBus Addressing" which provides information on how a PMBus address is configured.

These embedded tab selectors are highlighted in Figure 11.



	kΩ	VOut V	VOut Information
0	0.000	0	R1Div=2000, R2Div=open
1	0.392	0	R1Div=2000, R2Div=open
2	0.576	0	R1Div=2000, R2Div=open
3	0.787	0	R1Div=2000, R2Div=open
4	1.000	1.325	R1Div=2000, R2Div=open
5	1.240	1.3	R1Div=2000, R2Div=open
6	1.500	1.275	R1Div=2000, R2Div=open
7	1.780	1.25	R1Div=2000, R2Div=open
8	2.100	1.225	R1Div=2000, R2Div=open
9	2.430	1.2	R1Div=2000, R2Div=open
10	2.800	1.175	R1Div=2000, R2Div=open
11	3.240	1.15	R1Div=2000, R2Div=open
12	3.740	1.12	R1Div=2000, R2Div=open
13	4.220	1.1	R1Div=2000, R2Div=open
14	4.750	1.075	R1Div=2000, R2Div=open
15	5.360	1.05	R1Div=2000, R2Div=open
16	6.040	1.03	R1Div=2000, R2Div=open
17	6.810	1	R1Div=2000, R2Div=open
18	7.680	0.975	R1Div=2000, R2Div=open
19	8.660	0.95	R1Div=2000, R2Div=open
20	9.530	0.925	R1Div=2000, R2Div=open
21	10.500	0.9	R1Div=2000, R2Div=open
22	11.800	0.875	R1Div=2000, R2Div=open
23	13.000	0.85	R1Div=2000, R2Div=open
24	14.300	0.825	R1Div=2000, R2Div=open
25	15.800	0.8	R1Div=2000, R2Div=open
26	17.400	0.775	R1Div=2000, R2Div=open
27	19.100	0.75	R1Div=2000, R2Div=open
28	21.000	0.725	R1Div=2000, R2Div=open
29	23.200	0.7	R1Div=2000, R2Div=open

	kΩ	Comp.	M
0	0.000	0	1
1	0.392	0	2
2	0.576	0	3
3	0.787	0	4
4	1.000	0	5
5	1.240	0	6
6	1.500	1	1
7	1.780	1	1.5
8	2.100	1	2
9	2.430	1	3
10	2.800	1	4
11	3.240	1	4.5
12	3.740	2	1
13	4.220	2	1.5
14	4.750	2	2
15	5.360	2	2.5
16	6.040	2	3
17	6.810	2	3.5
18	7.680	3	0
19	8.660	3	0
20	9.530	3	0
21	10.500	3	0
22	11.800	3	0
23	13.000	3	0
24	14.300	4	0
25	15.800	4	0
26	17.400	4	0
27	19.100	4	0
28	21.000	4	0
29	23.200	4	0

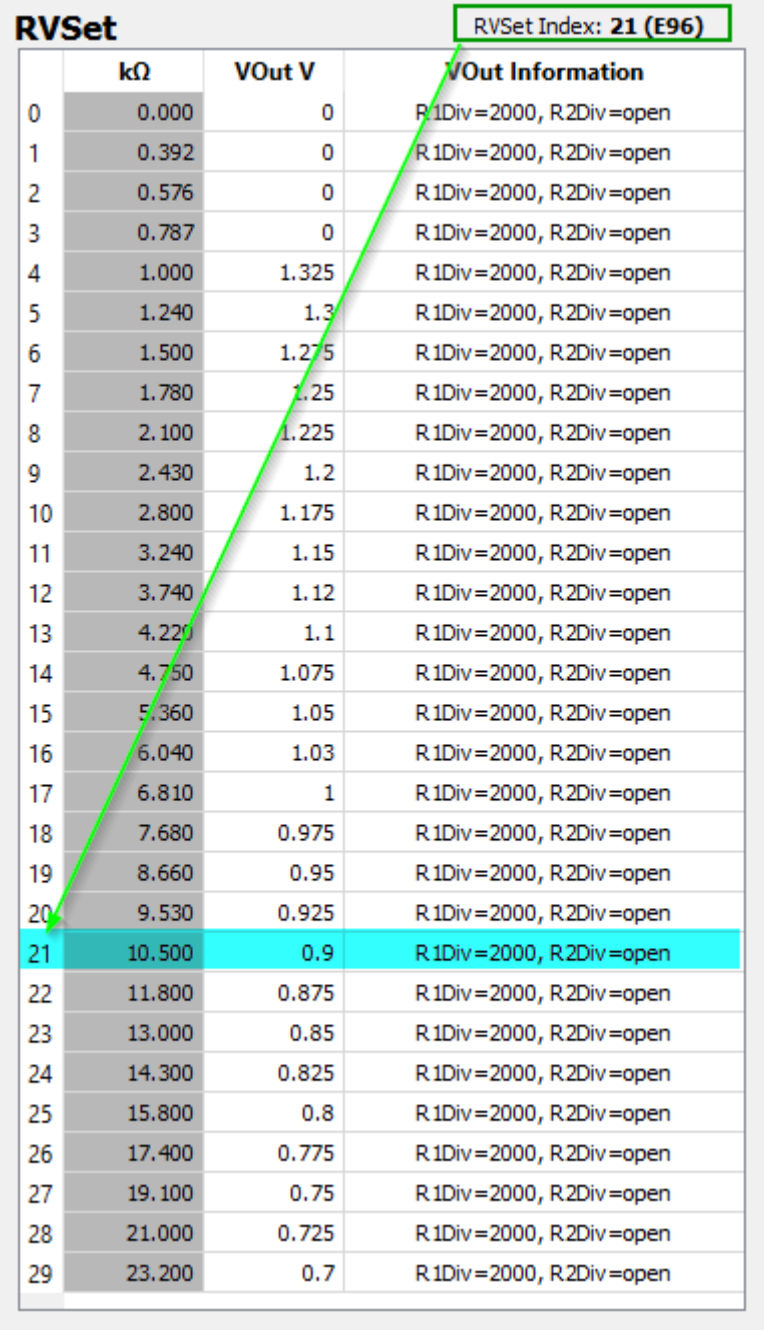
Figure 11: The "Pin" Tab

Some additional points to note about Figure 11:

- The "RVSet" combo box turns on/off RVSET feature.
- The "RTune" combo box turns on/off RTUNE feature.
- The Compensators list box shows a summary of compensators available and whether or not they are programmed.

4.2.1 RVSET

RVSET allows the output voltage to be set using an externally connected resistor. When the device starts, it detects the resistor value attached to the RVSET pin and, if the RVSET feature is "Enabled", sets the output voltage based on the configuration in the RVSET table shown in Figure 12.



RVSet

RVSet Index: **21 (E96)**

	kΩ	VOut V	VOut Information
0	0.000	0	R1Div=2000, R2Div=open
1	0.392	0	R1Div=2000, R2Div=open
2	0.576	0	R1Div=2000, R2Div=open
3	0.787	0	R1Div=2000, R2Div=open
4	1.000	1.325	R1Div=2000, R2Div=open
5	1.240	1.3	R1Div=2000, R2Div=open
6	1.500	1.275	R1Div=2000, R2Div=open
7	1.780	1.25	R1Div=2000, R2Div=open
8	2.100	1.225	R1Div=2000, R2Div=open
9	2.430	1.2	R1Div=2000, R2Div=open
10	2.800	1.175	R1Div=2000, R2Div=open
11	3.240	1.15	R1Div=2000, R2Div=open
12	3.740	1.12	R1Div=2000, R2Div=open
13	4.220	1.1	R1Div=2000, R2Div=open
14	4.750	1.075	R1Div=2000, R2Div=open
15	5.360	1.05	R1Div=2000, R2Div=open
16	6.040	1.03	R1Div=2000, R2Div=open
17	6.810	1	R1Div=2000, R2Div=open
18	7.680	0.975	R1Div=2000, R2Div=open
19	8.660	0.95	R1Div=2000, R2Div=open
20	9.530	0.925	R1Div=2000, R2Div=open
21	10.500	0.9	R1Div=2000, R2Div=open
22	11.800	0.875	R1Div=2000, R2Div=open
23	13.000	0.85	R1Div=2000, R2Div=open
24	14.300	0.825	R1Div=2000, R2Div=open
25	15.800	0.8	R1Div=2000, R2Div=open
26	17.400	0.775	R1Div=2000, R2Div=open
27	19.100	0.75	R1Div=2000, R2Div=open
28	21.000	0.725	R1Div=2000, R2Div=open
29	23.200	0.7	R1Div=2000, R2Div=open

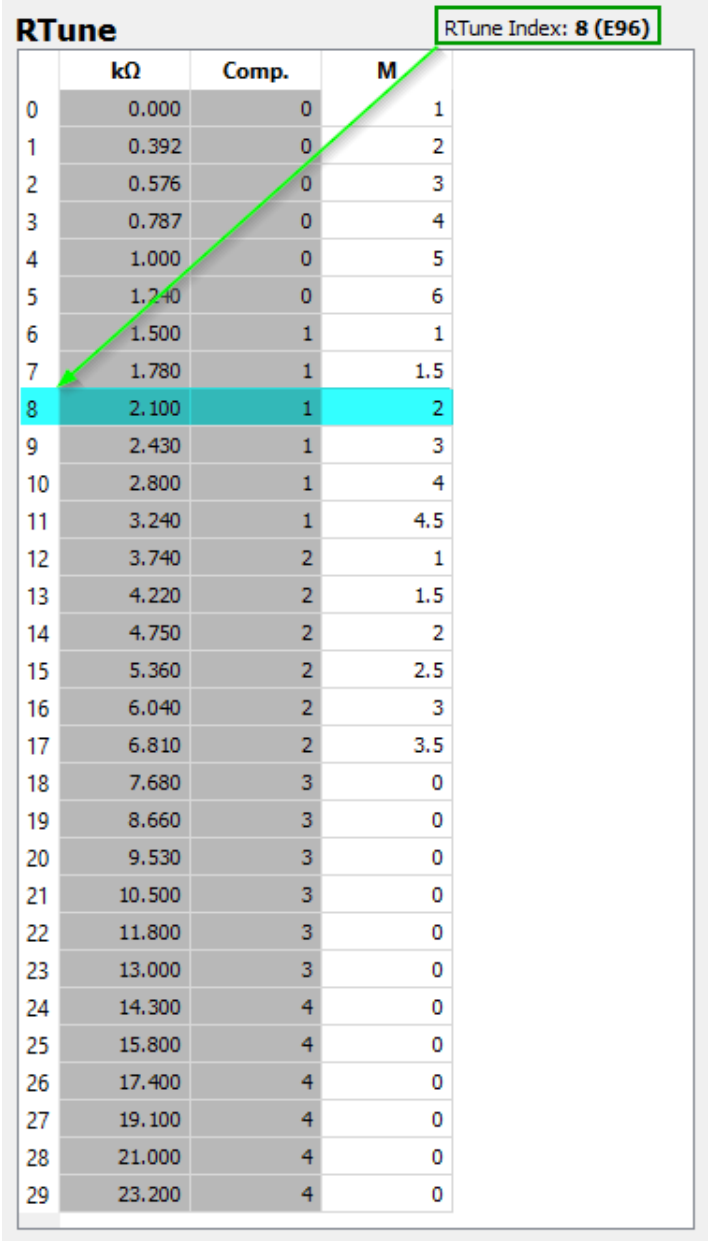
Figure 12: RVSET Table

The RVSET feature is turned on/off using the RVSET combo box on the “Pin” tab:

- Enabled – V_{OUT} is chosen from RVSET table based on sensing of the RVSET pin external resistor.
- Disabled – V_{OUT} can be configured on the “Power Stage” tab.

4.2.2 RTUNE

RTUNE allows the correct transient compensator output capacitance to be used via an externally connected resistor. When the EM21xx starts, it detects the resistor value attached to the RTUNE pin and, if the RTUNE feature is "Enabled", uses the selected compensator scaled by the corresponding capacitance multiplier "M" as shown in Figure 13.



	kΩ	Comp.	M
0	0.000	0	1
1	0.392	0	2
2	0.576	0	3
3	0.787	0	4
4	1.000	0	5
5	1.240	0	6
6	1.500	1	1
7	1.780	1	1.5
8	2.100	1	2
9	2.430	1	3
10	2.800	1	4
11	3.240	1	4.5
12	3.740	2	1
13	4.220	2	1.5
14	4.750	2	2
15	5.360	2	2.5
16	6.040	2	3
17	6.810	2	3.5
18	7.680	3	0
19	8.660	3	0
20	9.530	3	0
21	10.500	3	0
22	11.800	3	0
23	13.000	3	0
24	14.300	4	0
25	15.800	4	0
26	17.400	4	0
27	19.100	4	0
28	21.000	4	0
29	23.200	4	0

Figure 13: RTUNE Table

The RTUNE feature is turned on/off using the RTUNE combo box on the "Pin" tab:

- Enabled – The compensator and capacitance multiplier used are based on RTUNE pin external resistor.
- Disabled – The compensator and capacitance multiplier used are based on "Compensator Tuning" tab.

4.2.3 PMBus Address Selection

This tab is read only and is provided for information purposes only. This information, shown in Figure 14 and Figure 15, can also be found in the specific EM21xx device's datasheet, available at www.altera.com/enpirion.

Address selection using external resistors

ADDR0 \ ADDR1	0.000k	0.680k	1.2k	1.8k	2.7k	3.9k	4.7k	5.6k
0.000k	0x40	0x10	0x20	0x30	0x40	0x50	0x60	0x70
0.680k	*0x01	0x11	0x21	0x31	0x41	0x51	*0x61	0x71
1.2k	*0x02	0x12	0x22	0x32	0x42	0x52	0x62	0x72
1.8k	*0x03	0x13	0x23	0x33	0x43	0x53	0x63	0x73
2.7k	*0x04	0x14	0x24	0x34	0x44	0x54	0x64	0x74
3.9k	*0x05	0x15	0x25	0x35	0x45	0x55	0x65	0x75
4.7k	*0x06	0x16	0x26	0x36	0x46	0x56	0x66	0x76
5.6k	*0x07	0x17	0x27	*0x37	0x47	0x57	0x67	0x77
6.8k	*0x08	0x18	*0x28	0x38	0x48	0x58	0x68	*0x78
8.2k	0x09	0x19	0x29	0x39	0x49	0x59	0x69	*0x79
10.0k	0x0A	0x1A	0x2A	0x3A	0x4A	0x5A	0x6A	*0x7A
12.0k	0x0B	0x1B	0x2B	0x3B	0x4B	0x5B	0x6B	*0x7B
15.0k	*0x0C	0x1C	0x2C	0x3C	0x4C	0x5C	0x6C	*0x7C
18.0k	0x0D	0x1D	0x2D	0x3D	0x4D	0x5D	0x6D	*0x7D
22.0k	0x0E	0x1E	0x2E	0x3E	0x4E	0x5E	0x6E	*0x7E
27.0k	0x0F	0x1F	0x2F	0x3F	0x4F	0x5F	0x6F	*0x7F

*Reserved by standards

Figure 14: PMBus Address Selection Using Exernal Resistors

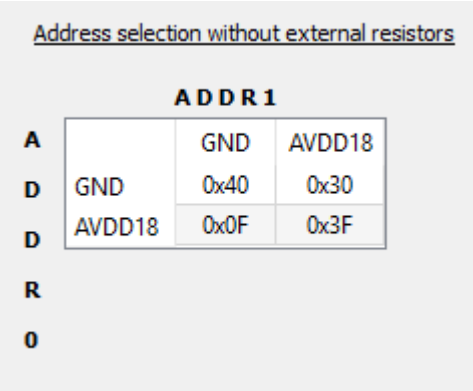


Figure 15: PMBus Address Selection Without External Resistors

4.3 The "Configuration" Tab

The "Configuration" tab consists of two sections: a sequencing section and a miscellaneous section.

4.3.1 The "Sequencing" Section

The "Sequencing" section handles all parameters relevant for the power sequencing of the device (i.e. system startup and shutdown sequences) as shown in Figure 16. The user can select the startup condition, the target output voltage after ramp up, and the timing values as described in the PMBus standard. For a complete list of all the configurable parameters, refer to Table 4.

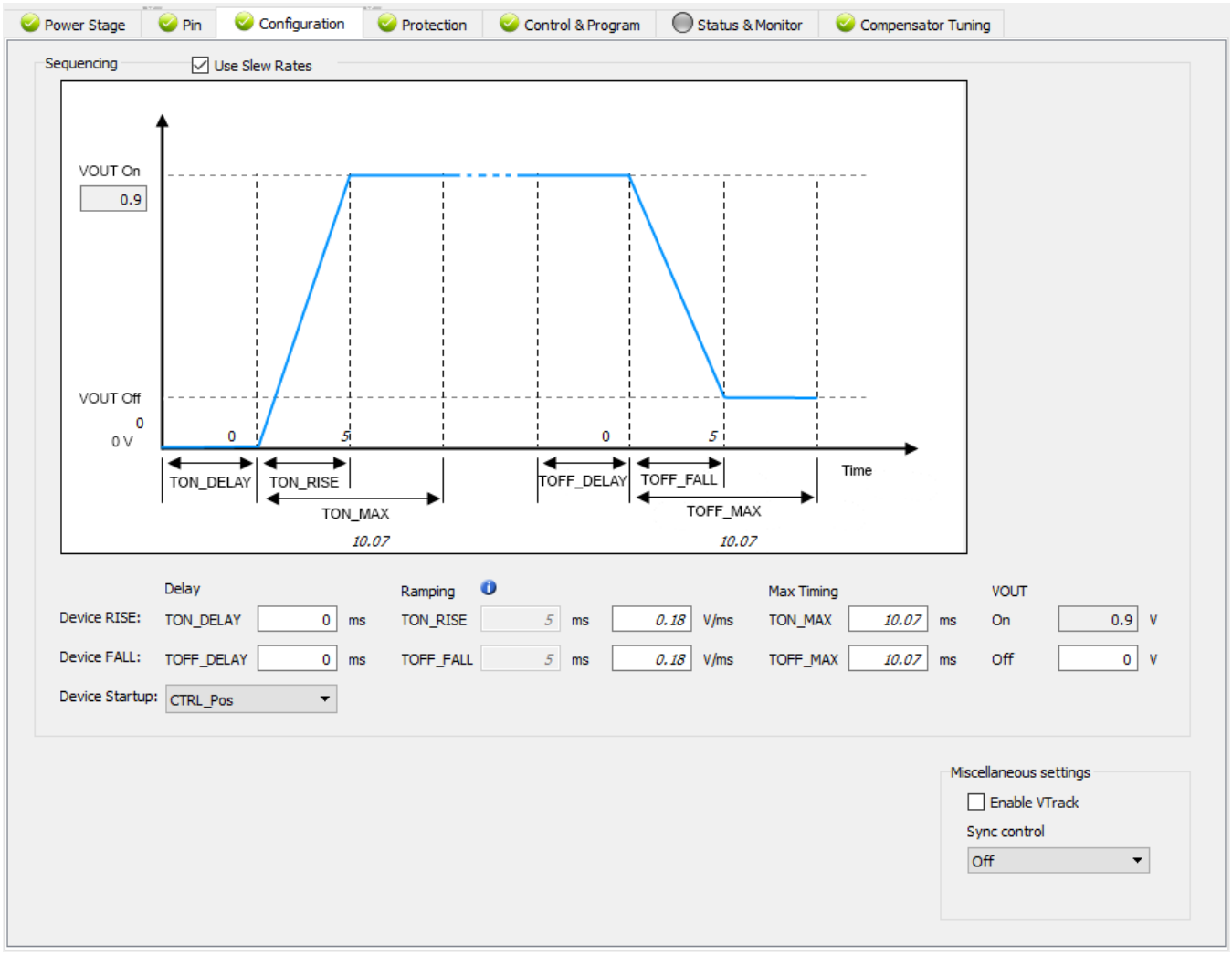


Figure 16: The "Configuration" Tab

Table 4: "Configuration" Tab Functions

Section	Parameter	Function/Comments
Sequencing	Device Startup	PMBus compliant startup sequence: ▪ Operation CMD: Device turn on/off controlled by PMBus. Operation command only. ▪ CTRL_Pos: Device turn on/off controlled by CONTROL pin only, upon detection of a LOW to HIGH transition of the signal at the control pin. ▪ CTRL_Neg: Device turn on/off controlled by CONTROL pin only, upon detection of a HIGH to LOW transition of the signal at the control pin. ▪ CMD & CTRL_Pos: Device turn on/off controlled by reception of the positive edge of the signal at the CONTROL pin and reception of the PMBus operation command. ▪ CMD & CTRL_Neg: Device turn on/off controlled by reception of the negative edge of the signal at the CONTROL pin and reception of the PMBus operation command.
	Device RISE: TON_DELAY	Time sequence for voltage ramp up.
	Device RISE: TON_RISE	
	Device RISE: TON_MAX	
	Device FALL: TOFF_DELAY	Time sequence for power down.
	Device FALL: TOFF_FALL	
	Device FALL: TOFF_MAX	
	VOUT On	Nominal value of output voltage in ON state.
	VOUT Off	Nominal value of output voltage in OFF state if a soft turn off is used; an example is turning off into pre-bias level.
	Use Slew Rates	If "Use Slew Rates" has been checked, the ramping parameters TON_RISE and TOFF_FALL can be set as a voltage slew rate in V/ms.

4.3.2 The "Miscellaneous" Section

In the "Miscellaneous" section, the user can enable or disable the VTRACK feature. In the default EM21xx configuration, VTRACK is off. It can be enabled through the GUI or a separate

manufacturer specific PMBus command MFR_PIN_CONFIG (0xE7). For more information, please refer to the specific EM21xx device's datasheet, available at www.altera.com/enpirion.

The "Miscellaneous" section also allows the user to enable or disable the SYNC functionality. If enabled, the ability to configure the Sync pin to be an input or an output is also available on this tab. In the event that SYNC is an input, the Sync pin can also be configured to synchronize to the rising or falling edge of the incoming signal, as shown in Figure 17.

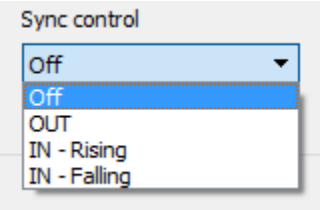


Figure 17: Sync Control

In the default configuration for the EM21xx modules, the SYNC functionality is off. It can be enabled through the GUI or a separate Manufacturer specific PMBus command MFR_PIN_CONFIG (0xE7). For more information, please refer to the specific EM21xx device's datasheet, available at www.altera.com/enpirion.

4.4 The "Protection" Tab

The "Protection" tab is used to configure all warning and fault-relevant options of the EM21xx. The power-good on/off levels can also be configured in the "POWER OK" section of this tab.

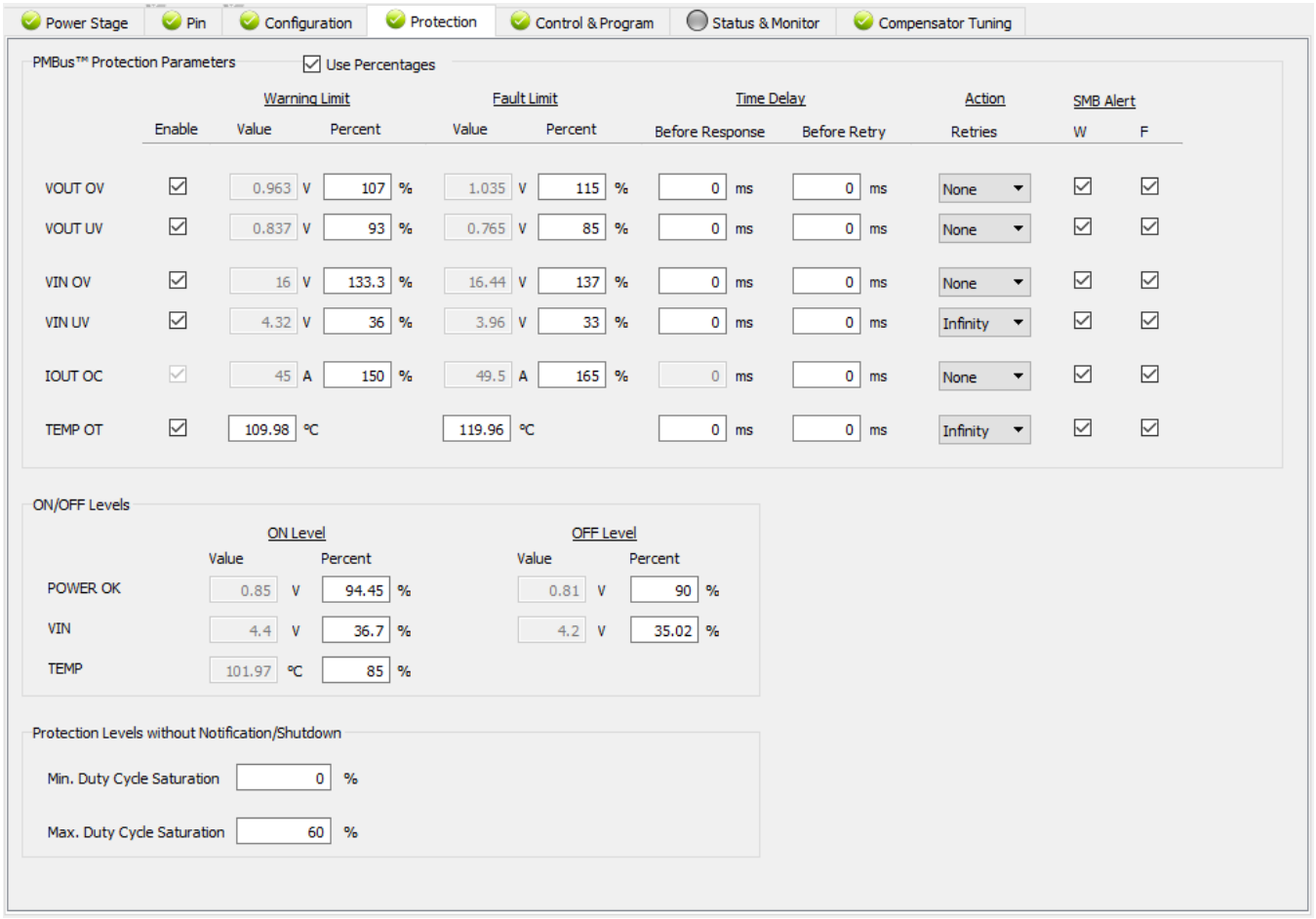


Figure 18: The "Protection" Tab

As shown in Figure 18, this tab is organized as a matrix with one row for each supervised parameter in which the user can configure the warning level, the fault level, the number of retries, and the delay times according to the PMBus specification and device-specific options. The delay times consist of two elements:

- "Before Response" defines the time between the detection of a fault and when the device reacts to the fault.
- "Before Retry" defines the time between turning off the output in response to a fault and attempting to turn it on again (if configured for retries).

This tab also configures protection features that are not related to the PMBus specification (e.g. duty cycle limits). Refer to Table 5 for a brief description of "Protection" tab functions.

Table 5: "Protection" Tab Functions

Section	Parameter	Function/Comments
PMBus Protection Parameters	VOUT OV / VOUT UV	Output over / under-voltage.
	VIN OV / VIN UV	Input over / under-voltage.
	IOUT OC	Output over-current.
	TEMP OT	Over-temperature.
	Use Percentages	If "Use Percentages" is checked, the "PMBus Protection Parameters" and "POWER OK" thresholds can be set as a percentage of the nominal values entered on the "Power Stage" tab.
POWER OK	ON Level	Output voltage threshold at which the POK pin is pulled high. POWER OK is pulled high if the output voltage rises above the "ON Level" threshold.
	OFF Level	Output voltage threshold at which the POK pin is pulled low. POWER OK is pulled low if the output voltage falls below the "OFF Level" threshold.
VIN	ON Level	Input voltage threshold at which the output is enabled. The output voltage will behave as programmed in the Sequencing section of the Configuration Tab.
	OFF Level	Input voltage threshold at which the output is disabled. The output voltage will behave as programmed in the Sequencing section of the Configuration Tab. NOTE: If the falling Slew rate of V_{IN} is very rapid, a V_{IN} UV fault condition will be deemed to have occurred resulting in the fault functionality over riding the VIN OFF Level operation.
Temp	On Level	If the temperature measurements exceed the programmed fault over-temperature level, the output is disabled. The output voltage will behave as programmed in the Sequencing section of the Configuration Tab. If the configured retries response to a temperature response is other than none, then when the sensed temperature falls below this level the output will be enabled. The output voltage will behave as programmed in the Sequencing section of the Configuration Tab.

Section	Parameter	Function/Comments
Protection Levels without Notification/ Shutdown	Min. Duty Cycle Saturation	Minimum PWM duty cycle in % (the device will not generate duty cycles lower than this limit).
	Max. Duty Cycle Saturation	Maximum PWM duty cycle in % (the device will not generate duty cycles greater than this limit).

The enable column is used to enable or disable individual protection features. Note that disabling a protection feature also disables the setting of the respective PMBus status bits.

Warning and fault limits for each parameter can be expressed as an absolute value or as a percentage with respect to the nominal value of the parameter set in the "Power Stage" tab. The type of notation used is selected by means of the "Use Percentages" check box. As an example, if the nominal value of the output voltage in the "Power Stage" tab is set to V_{OUT} = 1.20V, setting a warning limit for the output voltage over-voltage (VOUT OV) to 1.35V in percentage notation means writing the value VOUT OV (%)= (1.35/1.2)*100=112.5% in the VOUT OV – "Warning Limit" field.

Whenever a warning or a fault limit is changed in one of the two possible entry fields, depending on the notation chosen, its corresponding value in the other notation will be automatically updated. When using percentage notation, an absolute value is also adapted when its nominal value in the "Power Stage" tab is changed. The GUI dynamically validates new parameter values; see the GUI Main Features section for more information about physical validation and logical validation.

Fault conditions are triggered by dedicated hardware in the EM21xx digital controller. In order to prevent the system from shutting down due to noise triggering a fault event, a delay can be implemented for each fault event. The user can configure the delay of the fault handler in ms in the "Delay" field. The delay function can be used to increase the noise immunity of the digital controller.

CAUTION: *For overcurrent events, the programming of "Delay before Response" is not allowed. Disabling overcurrent fault protection is also not allowed.*

If a fault is detected, the EM21xx will wait for the programmed delay time and check again for the fault condition. If the fault condition still exists, the device will shut down. Maximum delay values for each fault event are provided in the device datasheet.

The number of attempts to restart after a fault event can also be programmed by entering the number of retries in the "Retries" field. Up to six restart attempts can be set, or a continuous attempt to restart can be programmed by setting "Retries" to "Infinity."

For All Fault events other than temperature faults, the device will respond with a“High-Z” response in which it will turn off both FETs, resulting in a high impedance condition for the output.

For a temperature fault, the module will respond with a “Soft-off” response, which uses the ramp down sequence to turn off the converter rather than an immediate power off.

"Fault" and "Warning" events can be reported to a host via the PMBus signal SMBALERT. Enabling warning and fault reporting through SMBALERT is done by checking the “W” (warn) and “F” (fault) checkboxes of the “SMB Alert” section.

4.5 The “Control & Program” Tab

The “Control & Program” tab enables programming of the module after the design process has been finished or a project file has been loaded. Prior to using any of the programming functions, see the Configuration Testing and Programming section regarding the important differences between configuring the volatile memory of the module and programming its non-volatile memory.

Configuration parameters can be stored in a ROM file for expediting the programming process of multiple modules in production. To do so, click the “Export Model Configuration” button in the “Utilities” section. A complete list of the features provided in the “Control & Program” tab are shown in Figure 19 and described in Table 6.

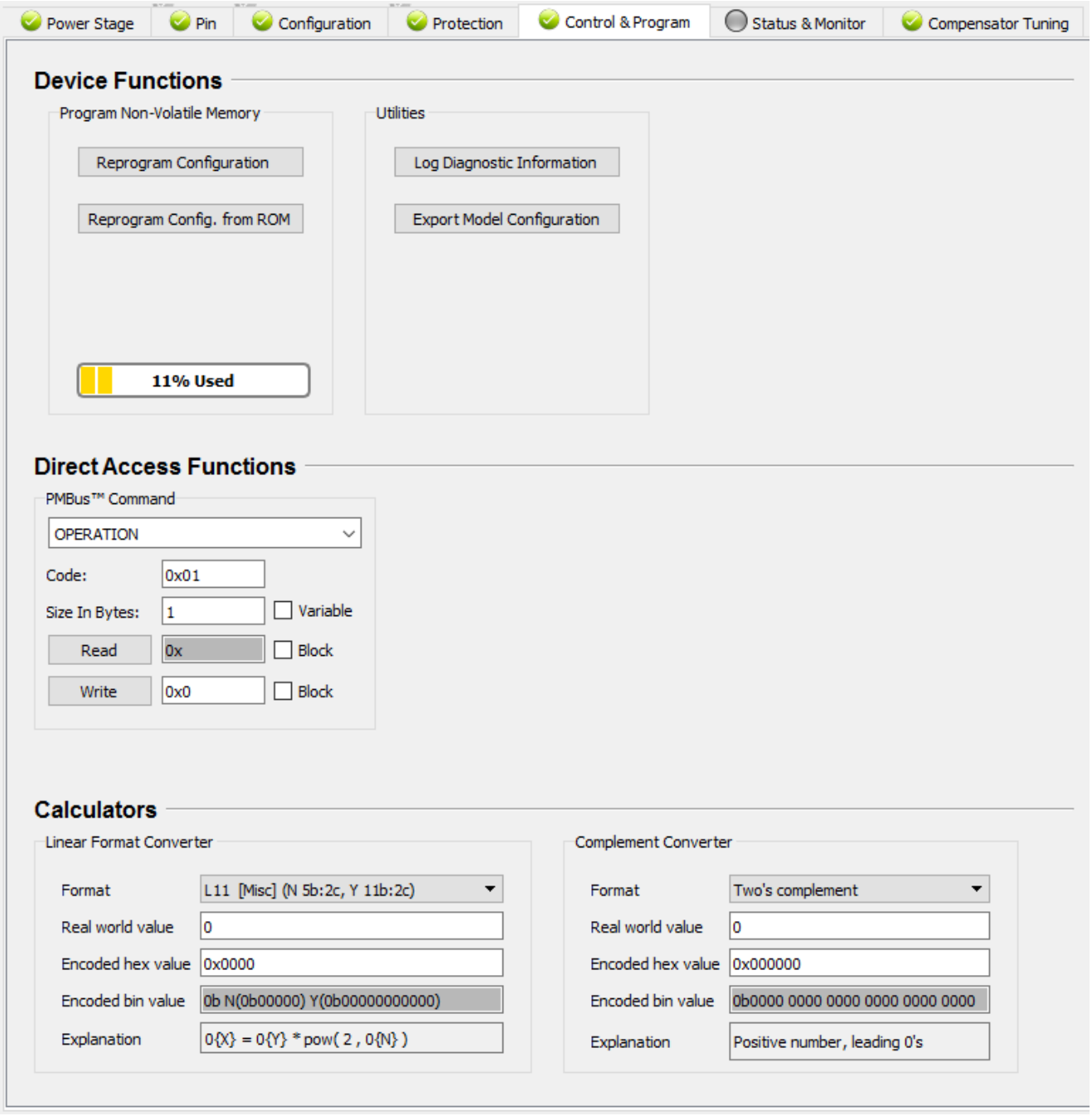


Figure 19: The "Control & Program" Tab

Table 6: "Control & Program" Functions

Section	Parameter	Function/Comments
Program Non-Volatile Memory	Reprogram Configuration	Store current configuration parameters to your devices NVM. ***IMPORTANT:*** *THREE-time full programming only!*
	Reprogram Configuration from ROM	Loads configuration parameters from a ROM file and then stores them to your devices NVM. ***IMPORTANT:*** *THREE-time full programming only!*
	Percentage Used Icon	Displays the amount of NVM used as a percentage of the total NVM.
Utilities	Log Diagnostic Information	Log additional diagnostic information into the log file. The log file can be used to help troubleshoot problems.
	Export Model Configuration	Save your current configuration parameters to a ROM file for programming of the EM21xx.

4.5.1 Reprogram Configuration

Press the "Reprogram Configuration" button to program your device with the current GUI configuration. The GUI will display a warning informing you that it is intending to write to persistent storage, as shown in Figure 21Figure 20.

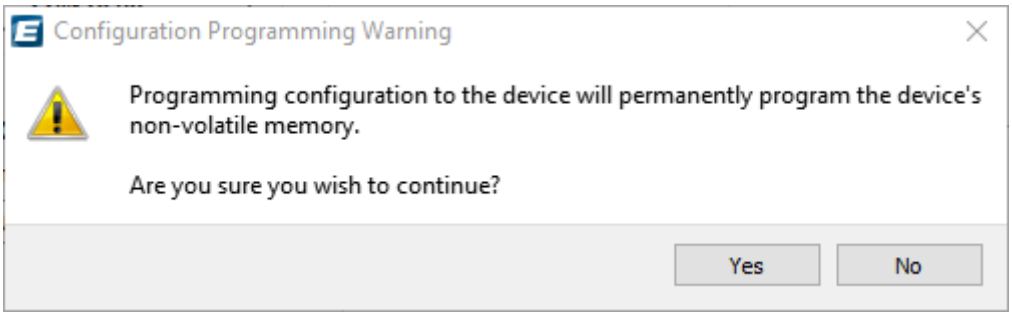


Figure 20: Configuration Programming Warning

If the user decides to continue (i.e. selected 'Yes' above), the GUI will tell the user the current percent of NVM free space and the percent of NVM space we will use to store this new configuration, shown in Figure 21.

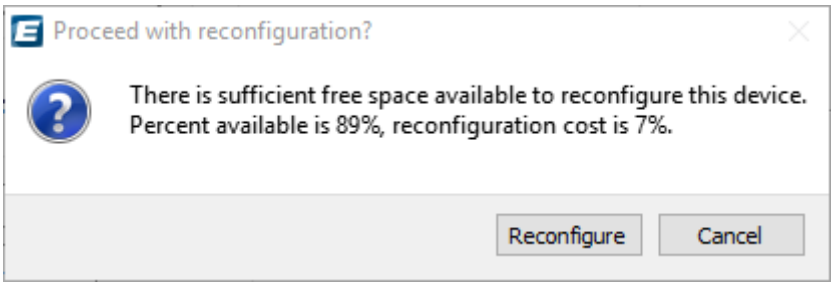


Figure 21: Proceed With Reconfiguration

4.6 The "Status & Monitor" Tab

This tab can be used to monitor system input and output signals, temperature, and faults. It also allows the user to modify the output voltage set-point. See Figure 22 for an overview of the tab and

Table 7 **Error! Reference source not found.**for a summary of the functions.

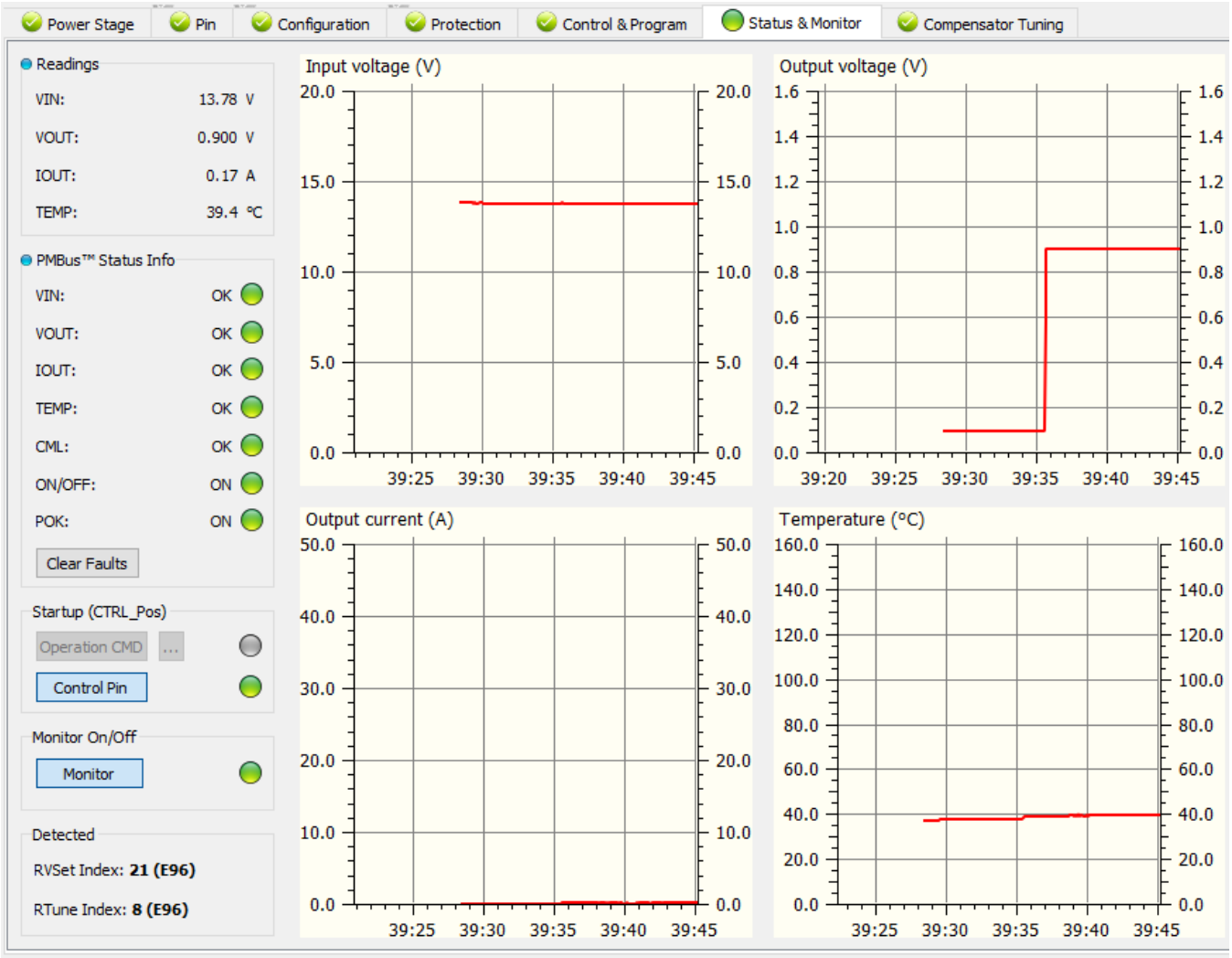


Figure 22: The "Status & Monitor" Tab

The "Readings" section of this tab shows real-time readings of all monitored parameters. The same information is shown over time in the four adjacent graphs. Readings plotted for input and output voltage, output current, and temperature can be averaged over 5, 10, 20, 50, or 100 samples by selecting the number of samples in the top menu: *Settings>Monitoring*, as shown in Figure 23. The default setting is 'no averaging'.

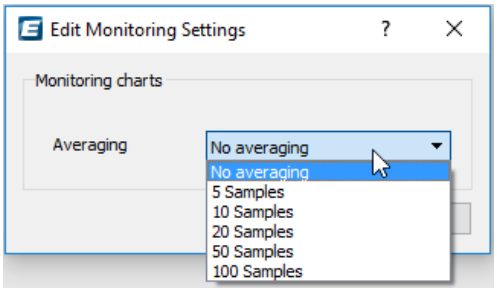


Figure 23: Monitoring Charts, Selecting Averaging

System warnings or faults available via PMBus are displayed in the “PMBus Status Info” section of this tab. If the status is "OK," no PMBus warning or fault has been detected. If there are warnings/faults, the “Clear faults” button can be used to clear all the faults by sending a PMBus CLEAR_FAULTS command. Note that according to the PMBus specification, a CLEAR_FAULTS command does not restart the system. It only clears the faults and warnings. To enable the output voltage again, an OFF/ON sequence **must be** executed. This can be done by clicking the “Operation CMD” button twice or through the Control pin if so configured.

The “Operation CMD” button toggles the operation mode of the system by sending an On/Off command. If the “Control Pin” toggle button is clicked, the GUI sets to high the control line of the PMBus CI connected to the control pin of the module. The action triggered by the control pin on the module is configured on the “Configuration” tab (see The “Configuration” Tab).

Monitoring functions can be disabled by clicking the “Monitor” button in the “Monitor On/Off” section. A virtual LED is used to display the status of the monitoring.

Table 7: "Status & Monitor" Functions

Section	Parameter	Function/Comments
Readings	VIN	Real-time value of input voltage.
	VOUT	Real-time value of output voltage.
	IOUT	Real-time value for output current.
	Temp	Real-time temperature.
PMBus Status Info	VIN	VIN under-voltage (UV) and over-voltage (OV).
	VOUT	VOUT under-voltage (UV) and over-voltage (OV).
	IOUT	IOUT over-current (OC).
	Temp	Over-temperature (OT).
	CML	Status of PMBus communication.
	ON/OFF	Status of the system (delivery of power to the load): ON/OFF.
	POK	Status of POWER OK signal: ON/OFF.
	Clear Faults (button)	Send CLEAR_FAULTS command to clear all PMBus faults and warnings.
Startup (Power on/off)	Operation CMD	Turn on or off via PMBus command.
	Control Pin	Toggle the control pin on the CI (instead of using the OPERATION command). If configured to use the control pin as an enable, it will start up; otherwise, this will be ignored.
Monitor On/Off	Monitor (button)	Turn on or off the monitoring functions.

4.6.1 Using PMBus Operation Commands In The “Status & Monitor” Tab

Next to the “Operation CMD” button is a “…” button, shown in Figure 24, which allows the user to perform On, Off and Margin PMBus OPERATION commands directly.

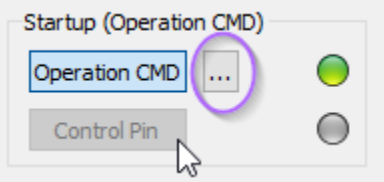


Figure 24: Opening Advanced OPERATION Command Dialog

This will open the following dialog, shown in Figure 25, which allows you to select the specific PMBus OPERATION command code to be sent.

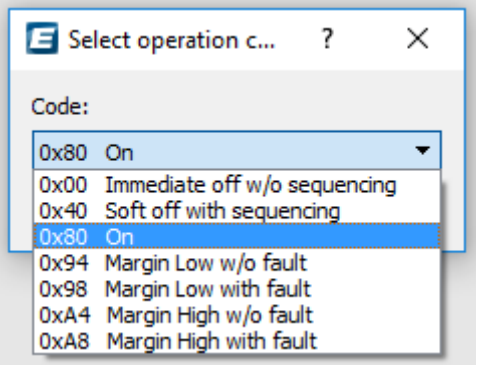


Figure 25: Selecting The OPERATION Command Code To Be Sent

Table 8 gives the explanation of these PMBus OPERATION command codes.

Table 8: PMBus OPERATION Command Codes

Section	Parameter	Function/Comments
Code Bits [7:0]	0x00	The device will turn off the PWM outputs immediately .
	0x40	The device will turn off the PWM outputs in a controlled manner as programmed on the Configuration Tab.
	0x80	The device will turn on in a controlled manner as programmed on the Configuration Tab.
	0x94	The device will change to the programmed Margin low level and ignore programmed V_{OUT} UVLO level. Margin Levels programmed in Configuration Tab.
	0x98	The device will change to the programmed Margin low level but obey programmed V_{OUT} UVLO level. Margin Levels programmed in Configuration Tab.
	0xA4	The device will change to the programmed Margin High level and ignore programmed V_{OUT} OVLO level. Margin Levels programmed in Configuration Tab.
	0xA8	The device will change to the programmed Margin High level but obey programmed V_{OUT} OVLO level. Margin Levels programmed in Configuration Tab.

4.7 The "Compensation Tuning" Tab

The "Compensation Tuning" tab enables the user to optimize (tune) the loop compensation of the module based on the type and amount of capacitance used based on preconfigured compensators, as shown in Figure 26.

NOTE: *To vary RTUNE using the GUI, you will need to perform a "Write Volatile" first (this button is located on the Side Panel).*

After doing this and for this tab only, any changes made while a module is connected will now be applied immediately without pressing "Write Volatile" again. This allows the user to select the desired compensator and then scale RTUNE easily while they view the results of the transient compensation on their scope.

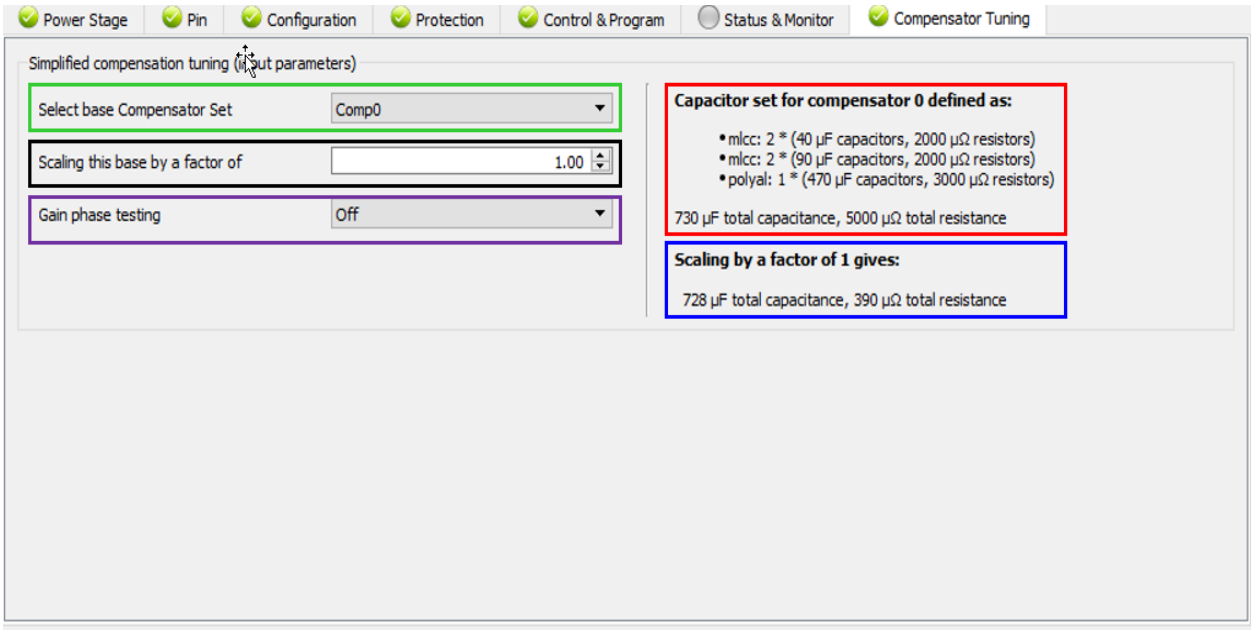


Figure 26: The "Compensation Tuning" Tab

4.7.1 Compensator Selected

This section, circled in green in Figure 26, allows the user to select which compensator to use.

- Compensator 0 is designed for a mix of ceramic and low ESR Polymer Aluminum.
- Compensator 1 is designed for an all ceramic solution.
- Compensators 2, 3 & 4 are blank.

For further detail and more updated information on all five compensator options please refer to the device datasheet.

4.7.2 RTUNE Scaling

This section, circled in black in Figure 26 allows the user to directly apply the RTUNE scaling parameter. Its default is 1.

4.7.3 Selected Compensators Minimum Capacitance (RTUNE = 1)

This section is circled in red in Figure 26. For the selected compensator, the minimum total capacitance to be used will be listed here (RTUNE = 1).

4.7.4 Minimum Total capacitance with RTUNE >1

This section, circled in blue in Figure 26, gives the total capacitance scaled with RTUNE. For an RTUNE scalar value of 1, it will be the same as the compensator minimum. As the RTUNE scalar value is increased, the total capacitance will also increase.

4.7.5 Gain Phase Testing

The digital controller within a EM21xx module contains two control loops, a steady state loop and a transient loop to maximize performance, giving a low B/W minimizing noise during steady state operation and high B/W during a transient event.

In order to be able to successfully measure the response of both loops, they must be measured independently. To accomplish this, the “Gain Phase testing” selection drop down box has been created. During normal operation the selected option is “Off” as circled in purple in Figure 26.

Measuring the Gain Phase can be accomplished by the following steps:

- Ensure that the appropriate compensator is selected.
- Ensure RTUNE is equal to 1 and the Gain Phase option is equal to “Off.”
- Perform a “Write to Chip.”

The user can now select “Steady State” from the Gain Phase testing drop down box and perform a Gain Phase measurement. This procedure can be performed to measure either steady state or transient by selecting the appropriate loop to measure from the Gain Phase testing drop down box and performing a Gain Phase measurement.

If the RTUNE scaler is greater than one, then the Scaling base may also be changed to the appropriate value to give the transient loop measurement. The steady state loop is not modified by RTUNE so there will be no difference in the measure Gain Phase response with varying RTUNE.

5. Logging Diagnostics Information

The GUI enables users to log diagnostics information to facilitate root cause analysis if any issues are encountered while using the GUI. To capture all details in this log file, perform the following steps:

1. Go to the "Control & Program" tab.
2. Click the "Log diagnostic Information" button in the "Utilities" section as shown in Figure 27. This will create a detailed log file that is automatically saved in the *log* folder of the GUI.

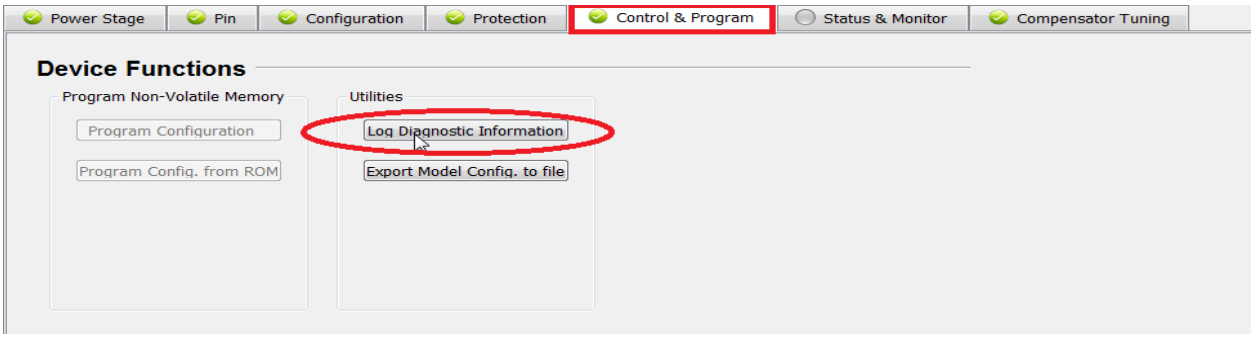


Figure 27: Log Diagnostic Information

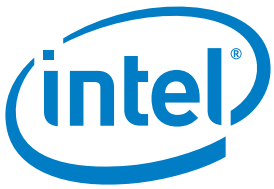
3. Open the log folder by clicking the "Yes" button of the dialog box that appears on the screen after clicking the "Log diagnostic Information" button and select the "DPCEGui.log" file in the log folder.

NOTE: Each time a new session of the GUI is started, log information is saved in the "DPCEGui.log" file while log files related to previous sessions are renamed to "DPCEGui.log_i", where i=1 to 10. Therefore, a maximum of 10 log files from 10 previous sessions of the GUI are available in the log folder.

6. Definition of Acronyms

Table 9: Definition of Acronyms

Term	Description
CI	PMBus Communication Interface Board
DCR	DC Resistance
ESR	Equivalent Series Resistance
NVM	Non Volatile Memory
PID	Proportional-Integral-Derivative
SCR	Sub-cycle Response (asynchronous transient response)



7. Revision History

Revision Number	Description	Revision Date
001	Initial release.	March 2017