User's Guide
SLUUBL0–January 2017

Using the Fusion Digital Power™ Designer for TPS536xx VR13 Multiphase Power Solutions

The TPS536xx family of devices are Intel™ fully SVID compliant VR13.0 step down controllers with built-in Non Volatile Memory (NVM). TPS536xx family supports PMBus™ communication for voltage, current, power and temperature telemetry as well as fault conditions to the system controller. All programmable parameters can be configured via PMBus and can be stored in NVM as the new default values. This User's Guide describes the primary programmable parameters, telemetric data and fault reporting available via the Fusion Digital Power™ Designer ("Fusion GUI").

Contents

List of Figures

List of Tables

Trademarks

Fusion Digital Power is a trademark of Texas Instruments.
Intel is a trademark of Intel Corporation.
PMBus is a trademark of SMIF, Inc..

1 Fusion GUI Installation

1.1 Download and Install the Software

1. Click here to access the Fusion Digital Power home page
2. It is highly recommended that you enable alerts to be notified when a new version of the Fusion Digital Power Designer is available. Scroll down to the *Order Now* panel and click on the *Alert Me* button.
3. To download the latest version, in the *Order Now* panel click on the *Download* button.
4. Once download is complete, navigate to the downloaded install file on your hard drive and double-click on it to begin the installation process
5. Follow the installation instructions. When completed, the Fusion Design Online Icon appears on your desktop.

1.2 Initiate Fusion Digital Online

1. Connect the Fusion GUI USB Interface adaptor to the computer using a USB to Mini USB adaptor and then to the board containing the TPS536xx device via the 10-pin I/O port.

Figure 1. USB Interface Adaptor

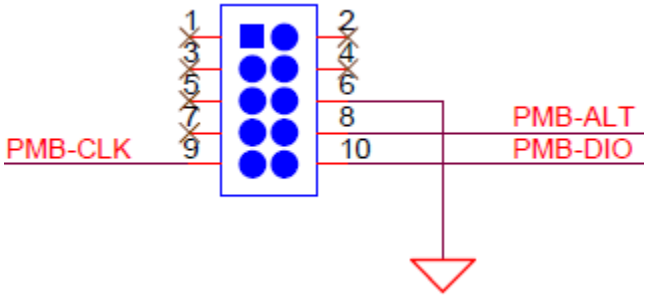

Figure 2. PMBus Connections to TI USB Interface Adaptor

2. Click on the Fusion Design Online Icon. The first time the Fusion GUI is initiated, the Device Scanning Options will pop up

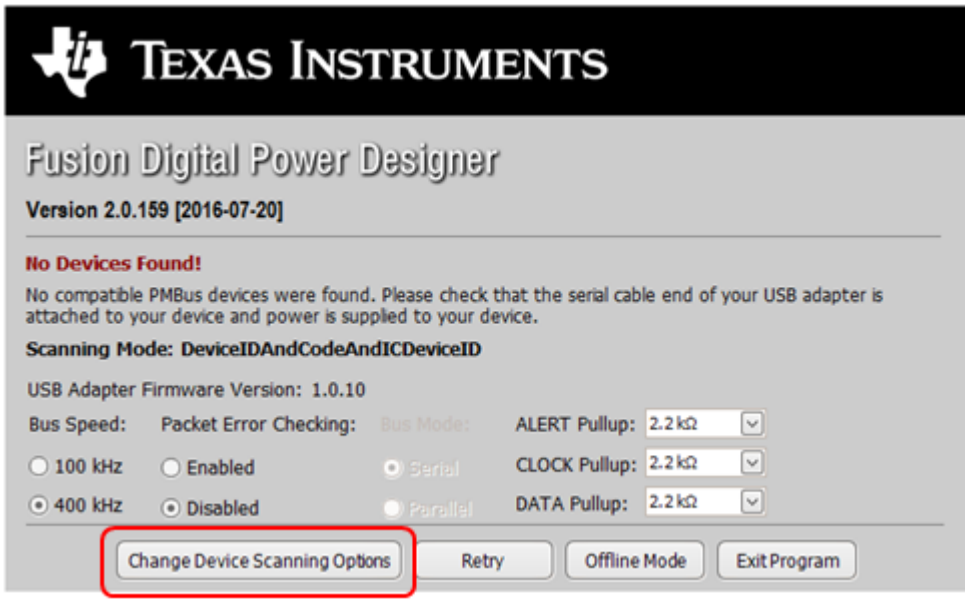

Figure 3. Device Scanning Options

3. Click **Change Device Scanning Options**. The **Device Scan Editor** table appears:

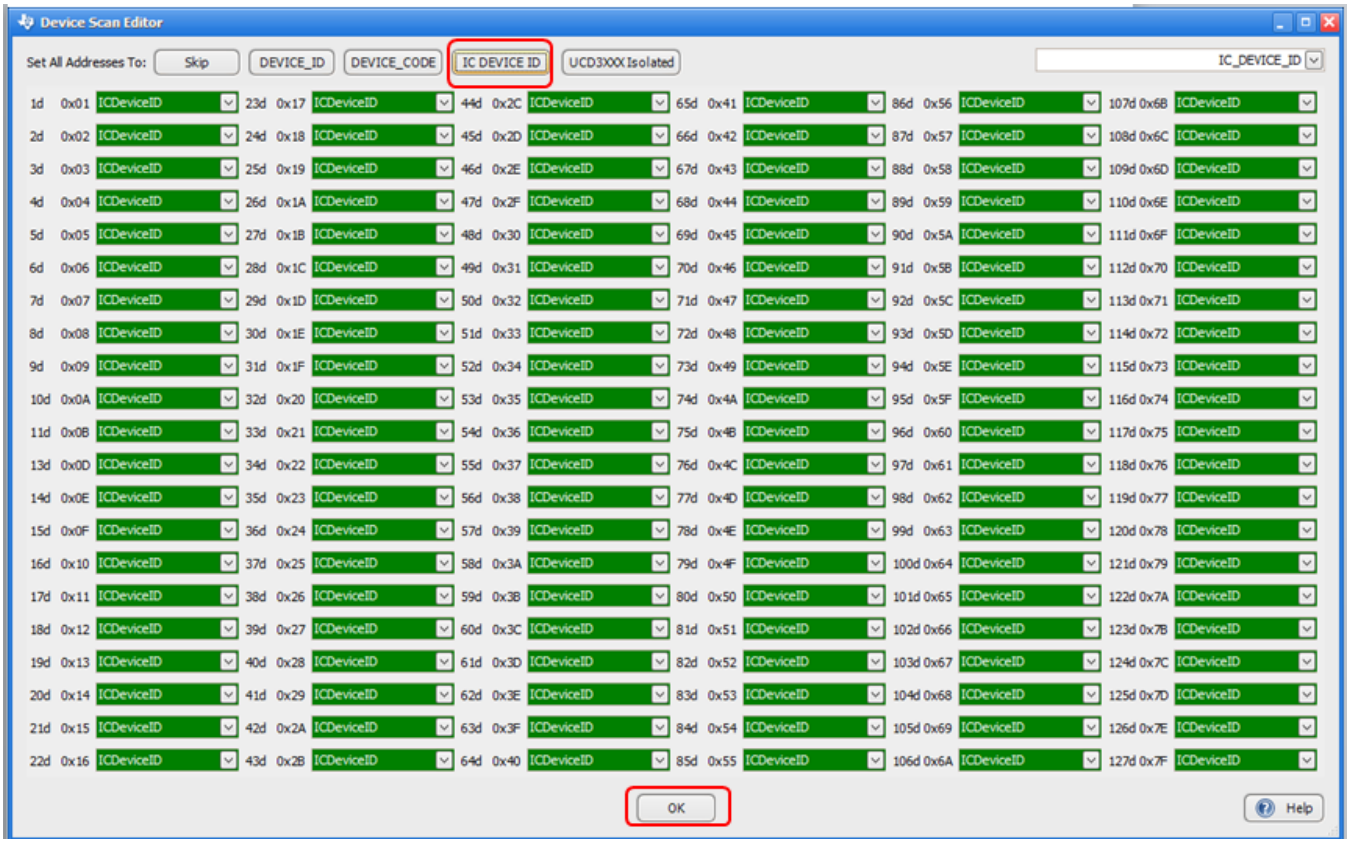

Figure 4. Device Scan Editor

4. Select **IC_DEVICE_ID**
5. Click OK
6. The application returns to the previous panel.
7. Click **Retry**

2 Configure Page

After one or more devices have been detected, the Fusion Digital Power GUI displays the **Configure** page.

The **Configure** page is where all user-accessible parameters can be viewed and modified. It is composed of several tabs each of which contain specific groupings of these parameters. Any changes to the settings must be written to RAM to take effect. In order to maintain these changes after V3P3 has been powered down, they must be stored to NVM.

2.1 Applying and Saving Settings to the Controller

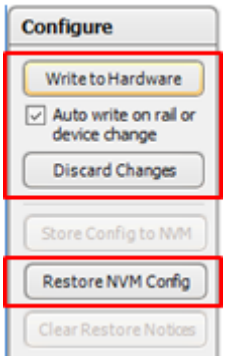

Figure 5. Register Write Panel

- When a selection is changed from what is currently in RAM, **Write to Hardware** becomes viewable. Select **Write to Hardware** to write the new setting to the device RAM.
- To undo any changes before **Write to Hardware** is selected, click on **Discard Changes**.
- If the wants to discard changes written to RAM, select **Restore NVM Config** to reload the NVM settings into RAM.
- When a change is made to a value stored in RAM, the **Store Config to NVM** becomes available. Select **Store Config to NVM** to write these changes to NVM so they are not lost when V3P3 is powered down.

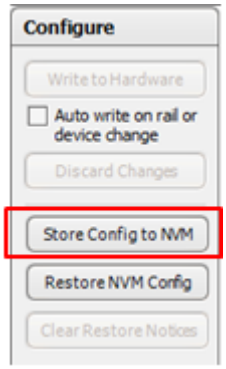

Figure 6. Store Config to NVM

Throughout this document the terms “pages”, “tabs”, “panels”, “drop-down lists”, “value boxes” and “radio buttons” are used. An example of each one of these elements on the **Configure** page is briefly described here:

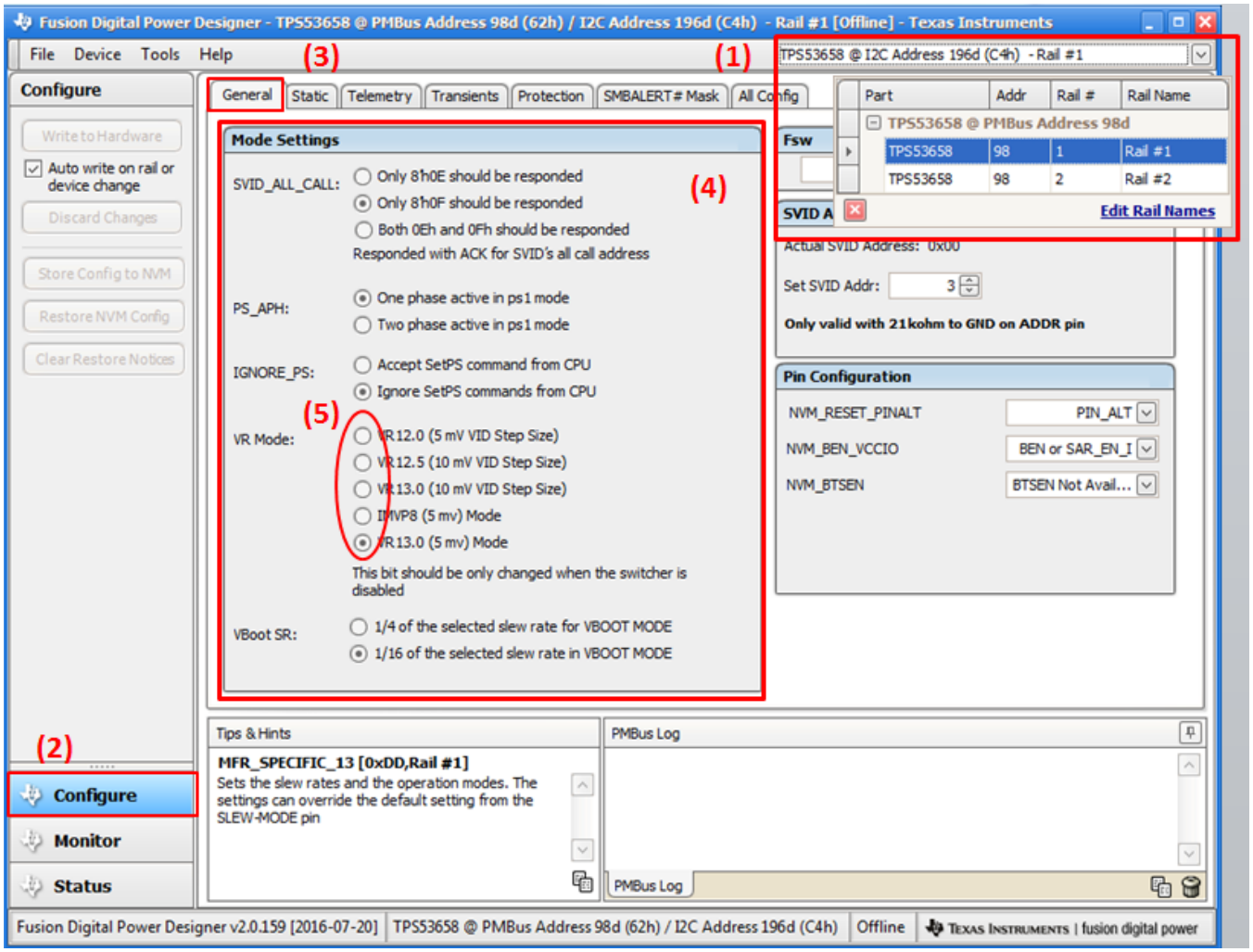

Figure 7. Configure Page

1. Part/Rail drop-down list. Each rail for all TPS536xx parts detected on the bus can be selected here. This list is used to determine which rail is being controlled/monitored via the GUI.
2. There are 4 pages that separate the main functions of the GUI:
   - **Configure**: This is a collection of tabs used to view and change all user-accessible parameters.
   - **Monitor**: This page displays all voltage, current, power and temperature telemetric data in real time. VR status and faults are also summarized here.
   - **Status**: This is a complete list of all Status Registers.
   - **Security**: This page displays the list of registers which will be write-protected when security is enabled.
3. **General** tab. This tab within the **Configure** page displays basic configuration settings for the controller, not specific to any particular category of settings. The General tab and all others are described in more detail below.
4. **Mode Settings** is an example of a panel. Each panel groups related controls together for finer categorization. These panels will be described in more detail below.
5. Radio buttons are used to allow choices of specific behavioral settings. In this case, they are used to select one of five VR Modes.

2.2 General Tab

The **General** tab contains many of the basic functional settings for the device.

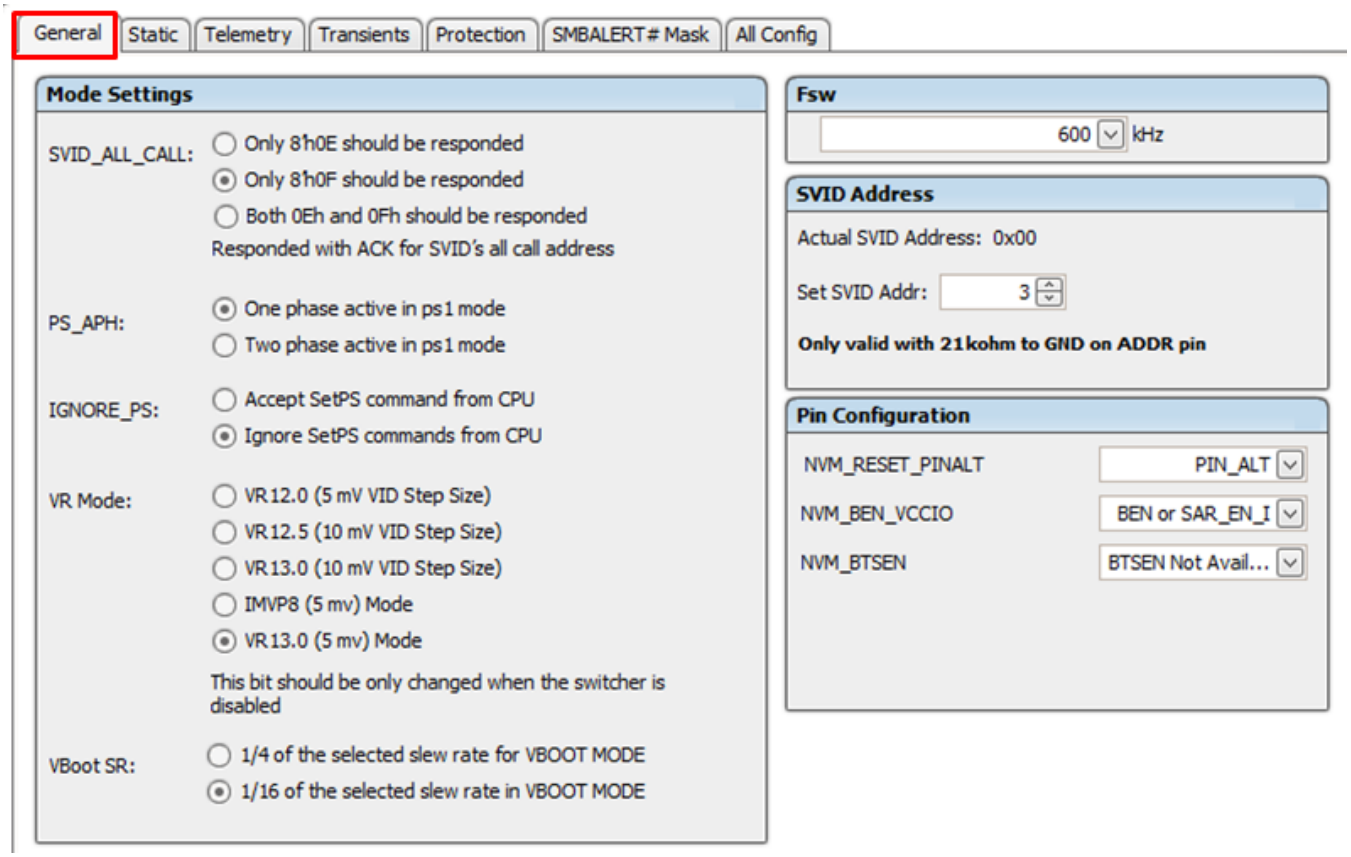

Figure 8. General Tab

2.2.1 Mode Settings

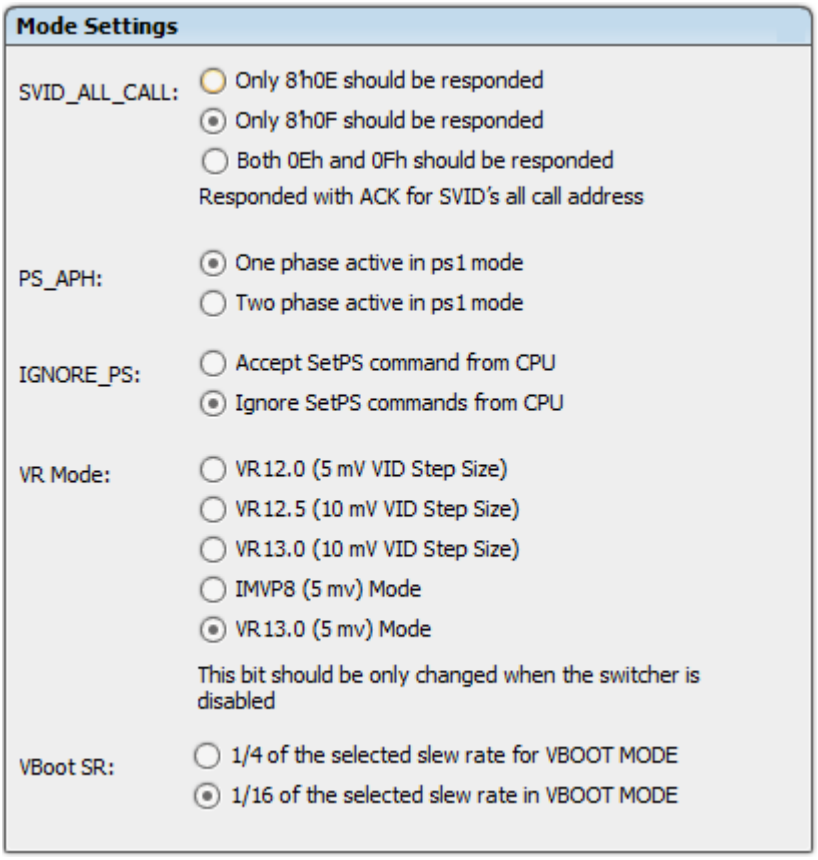

Figure 9. MFR_SPECIFIC_13 Settings Panel

These are the settings defined by the MFR_SPECIFIC_13 register

2.2.2 F_{sw}

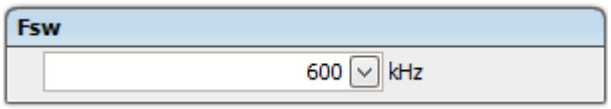

Figure 10. Switching Frequency Panel

- Switching frequency: 15 settings from 300kHz to 1000kHz

2.2.3 SVID Address

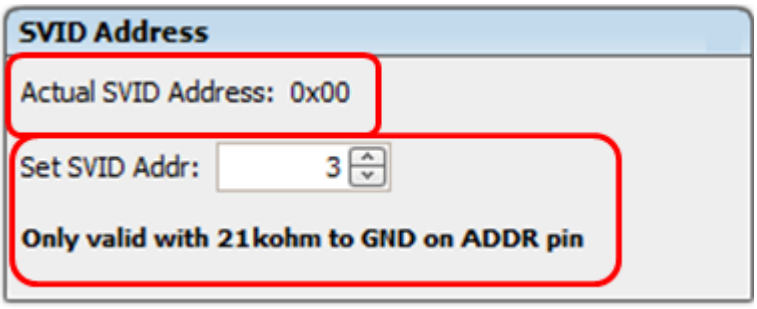

Figure 11. Set SVID Address Panel

- **Actual SVID Address**: Shows the actual address detected (set via ADDR pin resistor to ground).
- **Set SVID Addr**: Allows the user to set the SVID Address via an NVM register. This selection is only valid if the ADDR pin resistor to ground = 21 kΩ.

2.2.4 Pin Configuration

2.2.4.1 NVM_RESET_PINALT

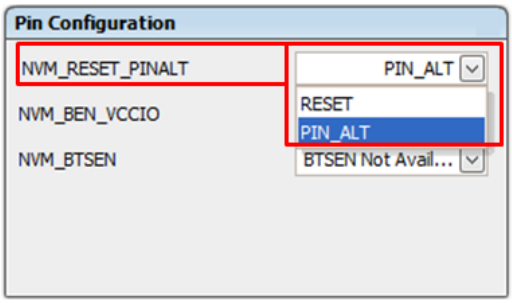

Figure 12. NVM_RESET_PINALT Drop-Down List

NVM_RESET_PINALT: Selects function of PINALT#_ RESET# pin as either:

- **PINALT#:** Input power alert flag
- **RESET#:** Boot voltage reset

2.2.4.2 NVM_BEN_VCCIO

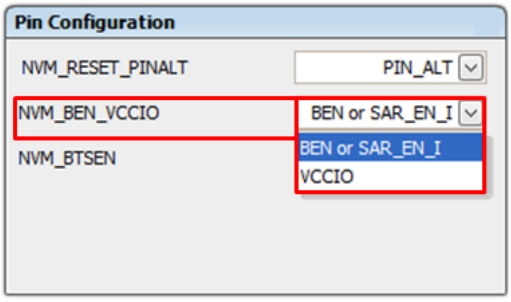

Figure 13. NVM_BEN_VCCIO Drop-Down List

NVM_BEN_VCCIO: Configures BEN_VCCIO pin as either:

- **BEN (SAR_EN):** Active high enable for Rail 2
- **VCCIO:** Input to monitor VCCIO and its UV fault conditions

2.2.4.3 NVM_BTSEN

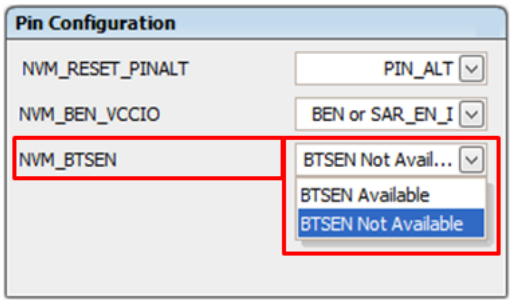

Figure 14. NVM_BTSEN Drop-Down List

- **NVM_BTSEN:** Selects whether or not BTSEN signal will be used to report temperature of Rail 2.

2.3 Static Tab

This tab contains the settings which are not specifically intended to affect transient performance.

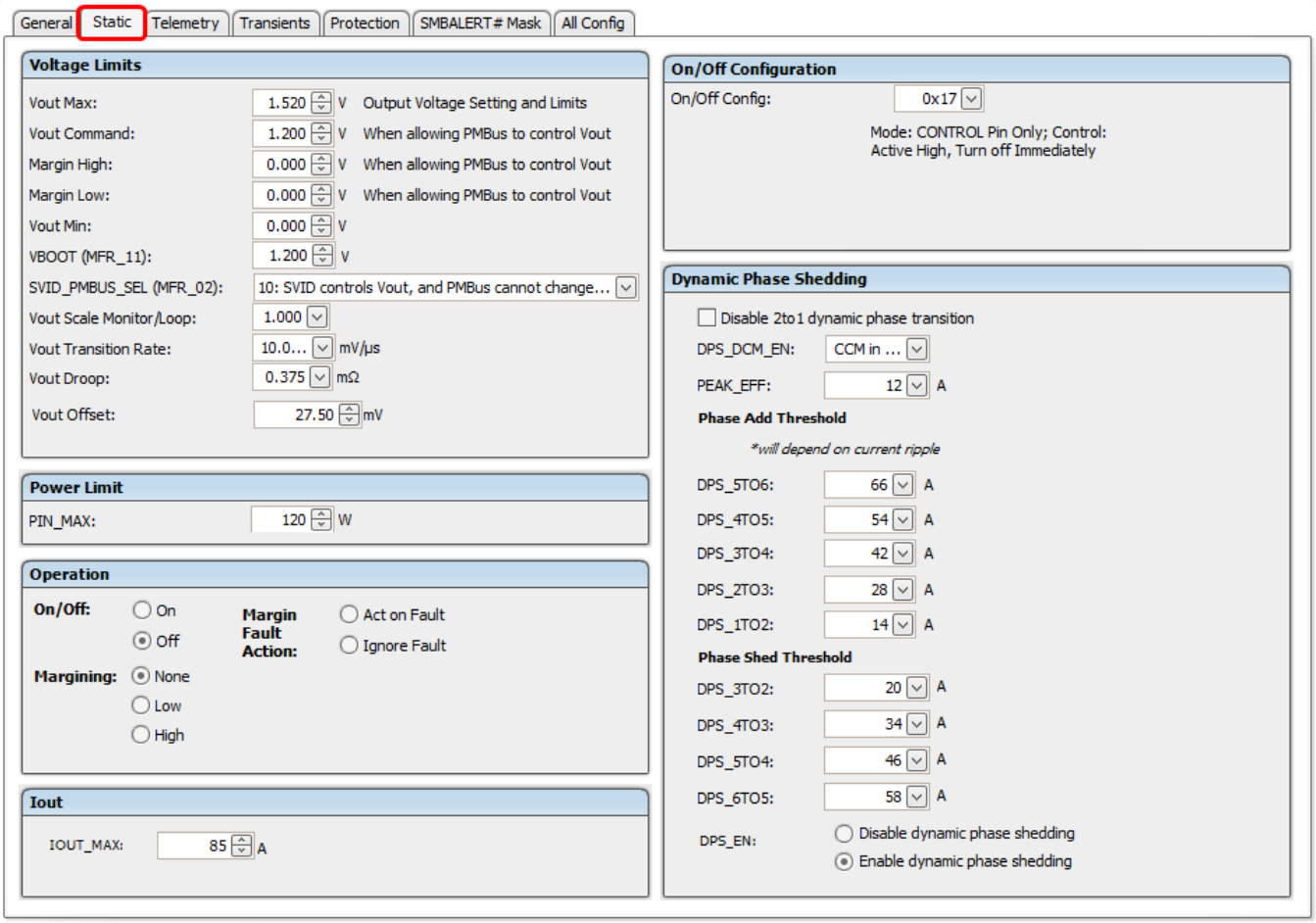

Figure 15. Static Tab

2.3.1 Voltage Limits

- **Vout Max:** The highest allowable value of V_{OUT}.
- **Vout Command:** Output voltage setting.
- **Margin High:** V_{OUT} set voltage when Margining High is selected in the Operation panel.
- **Margin Low:** V_{OUT} set voltage when Margining Low is selected in the Operation panel.
- **Vout Min:** The lowest allowable value of V_{OUT}.
- **Vboot:** Boot voltage.
- **SVID_PMBUS_SEL:** Selects whether output voltage is controlled by SVID or by PMBus.
- **Vout Scale Monitor/Loop:** Select either 1.000 output voltage scaling or 1.125 scaling.
  - 1.125 is used if the output is gained up to 1.125 × VSP via an external voltage divider.
  - 1.000 is used when no up-scaling is performed via an external voltage divider.
- **Vout Transition Rate:** Pull-down menu with values from 0.3125 mV/uS up to 40 mV/us to control the slew rate of the output.
- **Vout Droop:** Pull-down menu to set the DC Load Line. There are 64 values from 0.000 to 3.000mΩ for Rail 1, and 16 values ranging from 0.000 to 0.875 for Rail 2.
- **Vout Offset:** DC voltage offset applied to the output.

2.3.2 Power Limit

- **PIN_MAX:** Input power sensor scaling value (34 W - 510 W)

2.3.3 Operation

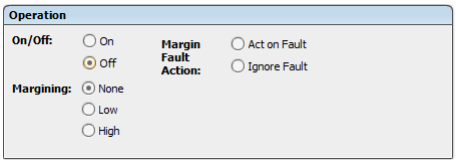

Figure 16. Operation Panel

- **On/Off:** Enables/Disables controller if *Act on ON_OFF* bit is selected in ON_OFF_CONFIG (02h) register. (See On/OFF Configuration description below)
- **Margining:** Choose Low, High, or No Margining.
- **Margin Fault Action:** Behavior of the controller if output violates margin voltages.

2.3.4 Iout

Figure 17. Iout Value Box

- **IOUT_MAX:** Maximum output current, from 0 A to 255 A.

2.3.5 On/Off Configuration

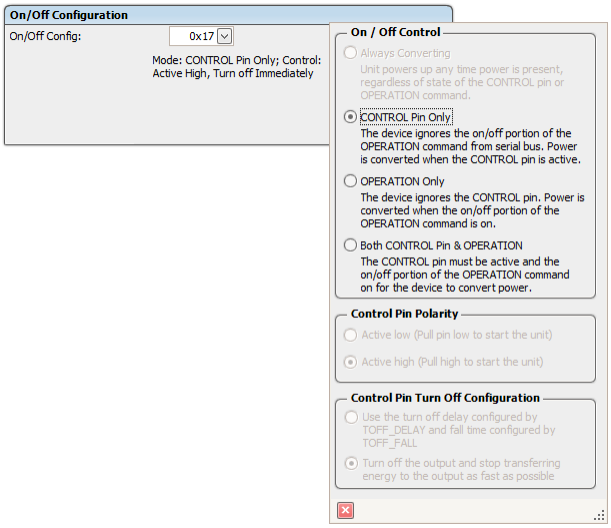

Figure 18. On/Off Configuration Panel

- **CONTROL pin Only:** The outputs are enabled/disabled via the active high ENB_A or ENB_B (control pin). The *Act on ON_OFF* bit (OPERATION[7]) is ignored.
- **OPERATION Only:** The outputs ignore the active high ENB_A or ENB_B (control pin) and are enabled/disabled only by the *Act on ON_OFF* bit (OPERATION[7]).
- **Both CONTROL Pin and OPERATION:** The outputs can be enabled and disabled by either the active high ENB_A or ENB_B (control pin) or the *Act on ON_OFF* bit (OPERATION[7]).
- *Greyed-out* settings are not selectable and are for information only.

2.3.6 Dynamic Phase Shedding

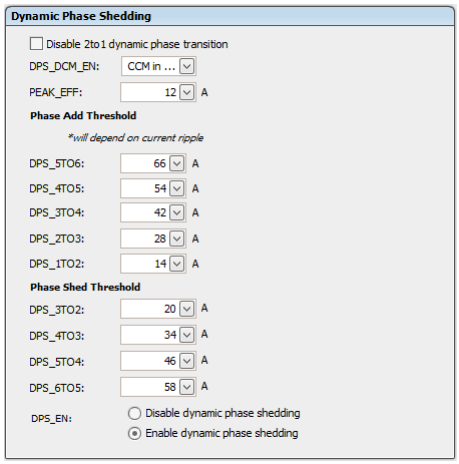

Figure 19. DPS Panel

- **Disable 2 to 1 dynamic phase transition:** Check to enable single-phase operation during normal operation (single-phase operation continues to occur in PS2 Mode).
- **DPS_DCM_EN:** Use this pull-down list to choose either CCM or DCM during single-phase operation.
- **PEAK_EFF:** Pull-down to select 12 A, 14 A, 16 A or 18 A to set the phase shedding offset between phases which results in the highest efficiency for the application.
- **DPS_PH# TO PH#+1:** Pull-down list of four current levels at which phase addition occurs. These values will scale by default based on the PEAK_EFF setting.
- **DPS_PH# TO PH#-1:** Pull-down list of four current levels at which phase shedding occurs.
- **DPS_EN:** Radio buttons to select whether phase shedding (and adding) is Disabled or Enabled.

2.4 Telemetry Tab

This tab contains the settings which affect the IIN and IMON telemetry data

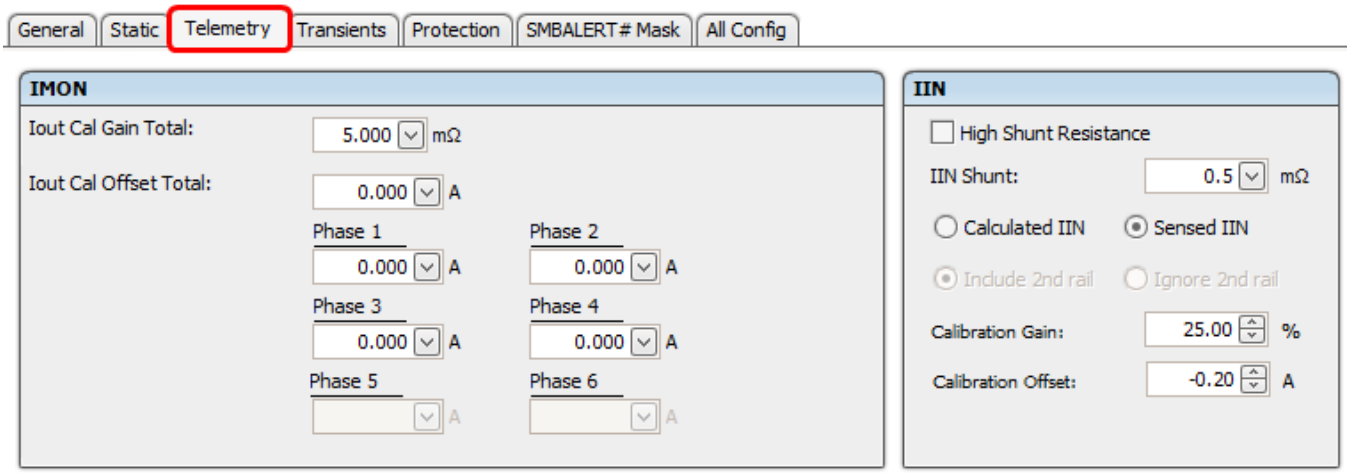

Figure 20. Telemetry Tab

2.4.1 Imon Calibration

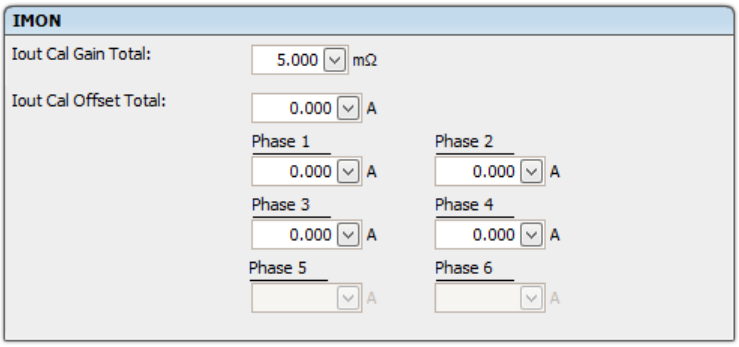

Figure 21. Imon Panel

- **Iout Cal Gain Total:** Pull-down list of 32 gain settings from 4.766 to 5.250. Gain is set as a ratio of 5 mV/A ($I_{OUT\_REPORTED} = I_{OUT} \times 5.000\ m\Omega \div$ gain setting). Gain can be adjusted from (5.000 mΩ ÷ 5.250 mΩ) to (5.000mΩ ÷ 4.766 mΩ).
- **Iout Cal Offset Total:** Offset applied to total current output value. Pull-down list with 32 settings from –3.750 A to +4.000 A
- **Iout Cal Offset Per Phase:** Offset applied to individual phase current output value. Pull-down list with 16 settings from –0.875 A to +1.000 A

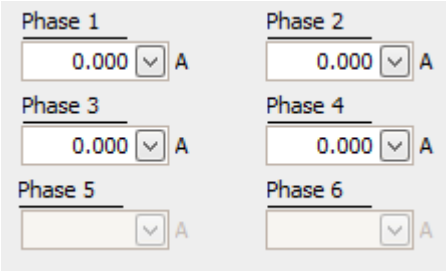

Figure 22. Per-Phase Iout Calibration Drop-Down Lists

2.4.2 IIN

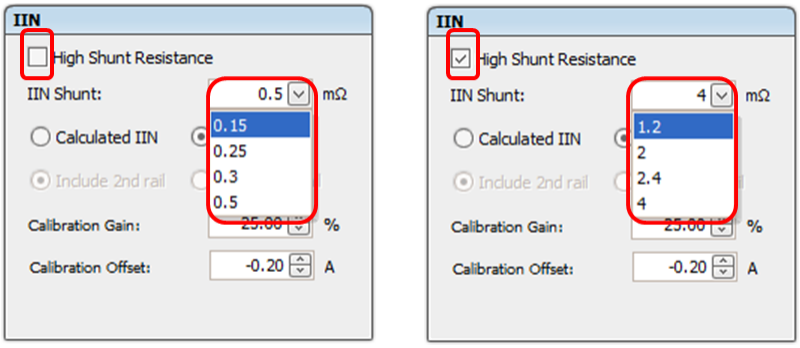

Figure 23. I_{IN} Shunt Selection Panel

- **High Shunt Resistance:** The selection box provides a high or low I_{IN} Shunt Resistance selection range. When unchecked, the selection box displays four values from 0.15 mΩ to 0.5 mΩ. When checked, the box displays four values from 1.2 mΩ to 4.0 mΩ.
- **Calculated IIN or Sensed IIN:** These radio buttons allow the user to select between reported I_{IN} which is sensed across an inductor/shunt resistor or a calculated I_{IN} . This calculated value reports I_{IN} based on the real-time measured values of V_{IN}, V_{OUT}, I_{OUT} and a fixed value of efficiency (95% for Rail 1, 92% for Rail 2).

2.5 Transient Tab

This tab contains the settings intended to affect the transient performance of the controller

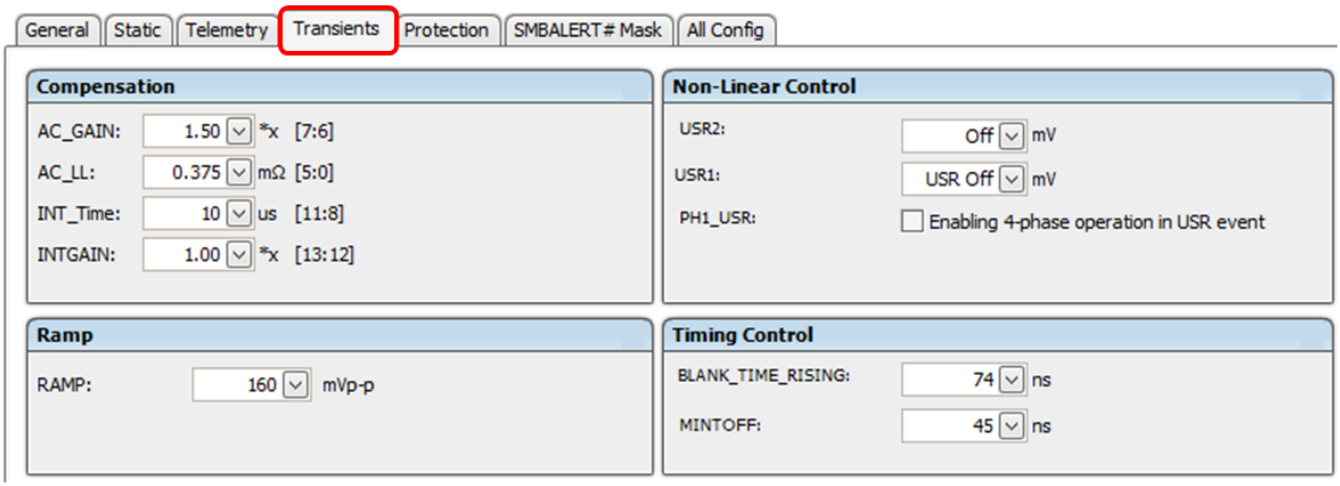

Figure 24. Transient Tab

2.5.1 Compensation

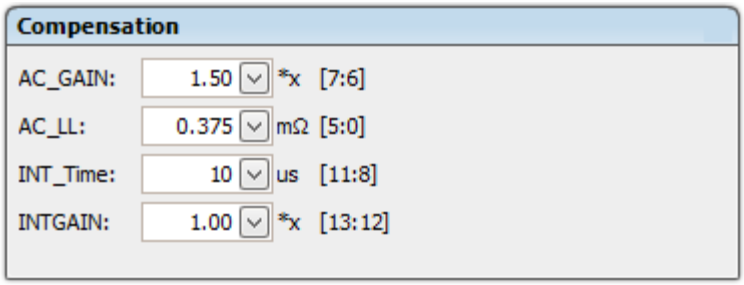

Figure 25. Compensation Panel

- **AC_GAIN:** Pull-down list has four settings: 0.5, 1.0, 1.5, 2.0.
- **AC_LL:** Pull-down list with 61 settings for AC Load Line, from 0.375 mΩ to 3.125 mΩ
- **INT_Time:** Dynamic Integration Time Constant. Pull-down list with 15 settings from 1.0 us to 40 us
- **INTGAIN:** Integrator Gain. Pull-down list with four settings: 0.50, 0.66, 1.0, 2.0

2.5.2 Ramp

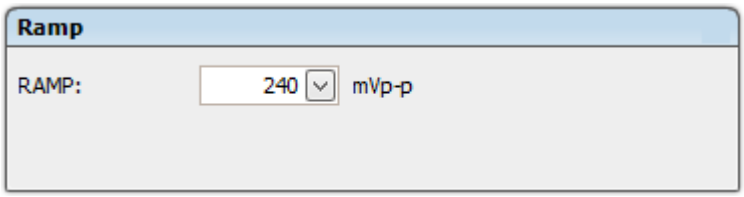

Figure 26. Ramp Panel

- **Ramp:** Pull-down list with 8 Ramp values from 40 mV to 320 mV

2.5.3 Non-Linear Control

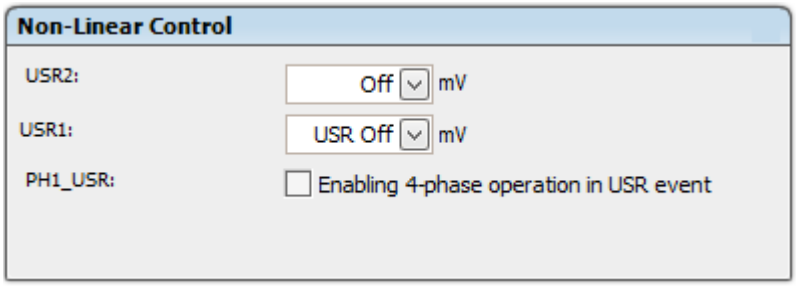

Figure 27. Non-Linear Control Panel

- **USR2:** Higher USR voltage range. Pull-down list of 7 Values ranging from 140 mV to 380 mV or disabled with **USR2 OFF** setting. All available phases are active when USR2 is triggered.
- **USR1:** Lower USR voltage range. Pull-down list of 7 Values ranging from 90 mV to 270 mV or disabled with **USR1 OFF** setting.
- **PH1_USR:** This selection (Rail 1 only) enables 4-phase operation if USR1 is triggered. Unchecked limits USR1 to 3-phases.

2.5.4 Timing Control

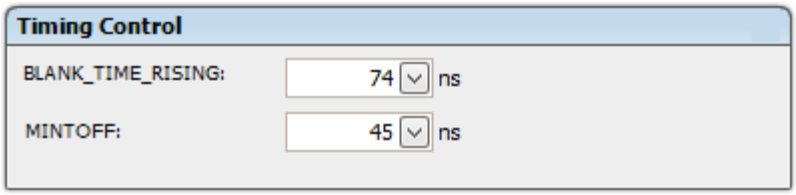

Figure 28. Timing Control Panel

- **BLANK_TIME_RISING:** Pull-down list with eight values for blanking time ranging from 56 ns to 98 ns.
- **MINTOFF:** Pull-down list with four values for the minimum off time ($t_{OFF(min)}$) of 45 ns, 60 ns, 75 ns, 90 ns.

2.6 Protection Tab

This tab contains the settings for over-temperature and input and output current and voltage protection.

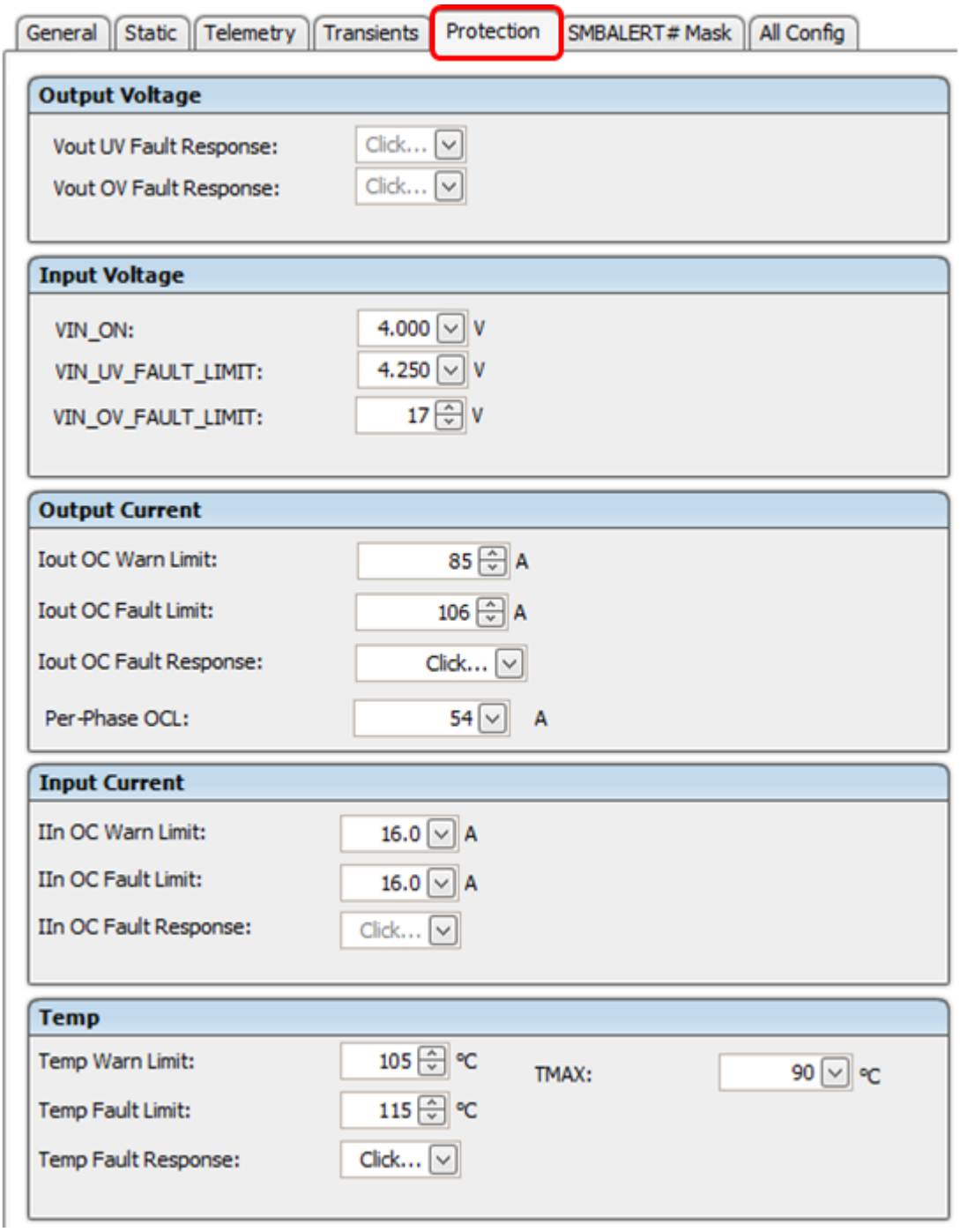

Figure 29. Protection Tab

2.6.1 Output Voltage

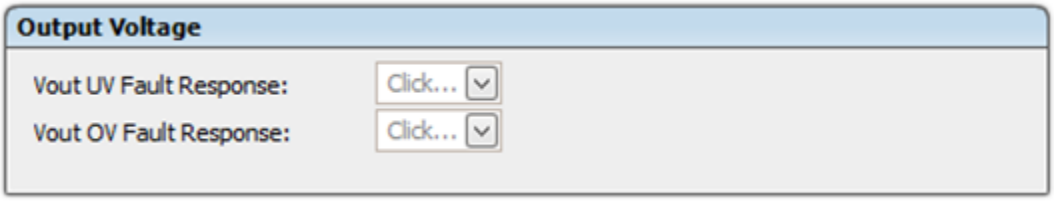

Figure 30. Output Voltage Panel

- **Vout UV Fault Response:** Lists the behavior settings for the UV condition. Modifications are not allowed. For information only.
- **Vout OV Fault Response:** Lists the behavior settings for and OV condition. Modifications are not allowed. For information only.

2.6.2 Input Voltage

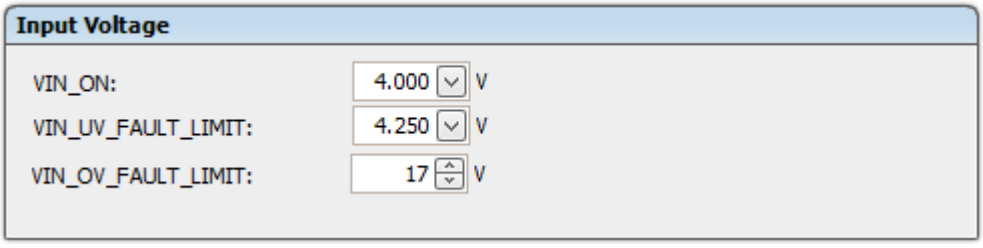

Figure 31. Input Voltage Panel

- **VIN_ON:** P12V Undervoltage lockout (UVLO) OK threshold.
- **VIN_UV_FAULT_LIMIT:** P12V Undervoltage lockout (UVLO) Fault threshold.
- **VIN_OV_FAULT_LIMIT:** P12V Overvoltage (OV) Fault threshold.

2.6.3 Output Current

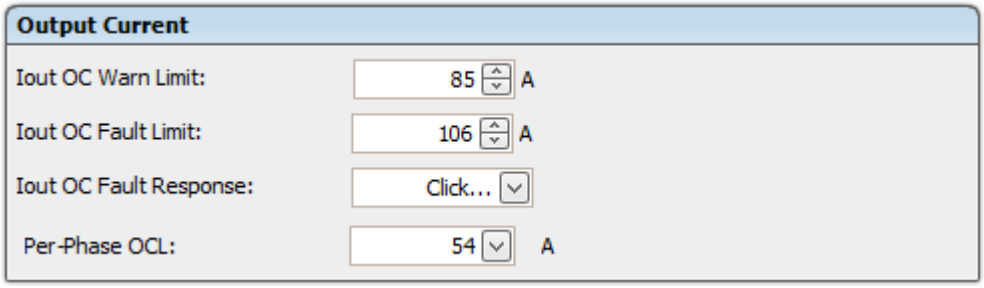

Figure 32. Output Current Panel

- **Iout OC Warn Limit:** Output over-current Warning Limit.
- **Iout OC Fault Limit:** Output over-current Fault limit. Can be changed here temporarily but will automatically be set to 25% above the OC Warning Limit stored in NVM after V3P3 is powered down or after an NVM write.
- **Iout OC Fault Response:** Settings for behavior of controller when output over-current limit is reached. See descriptions in Figure 33

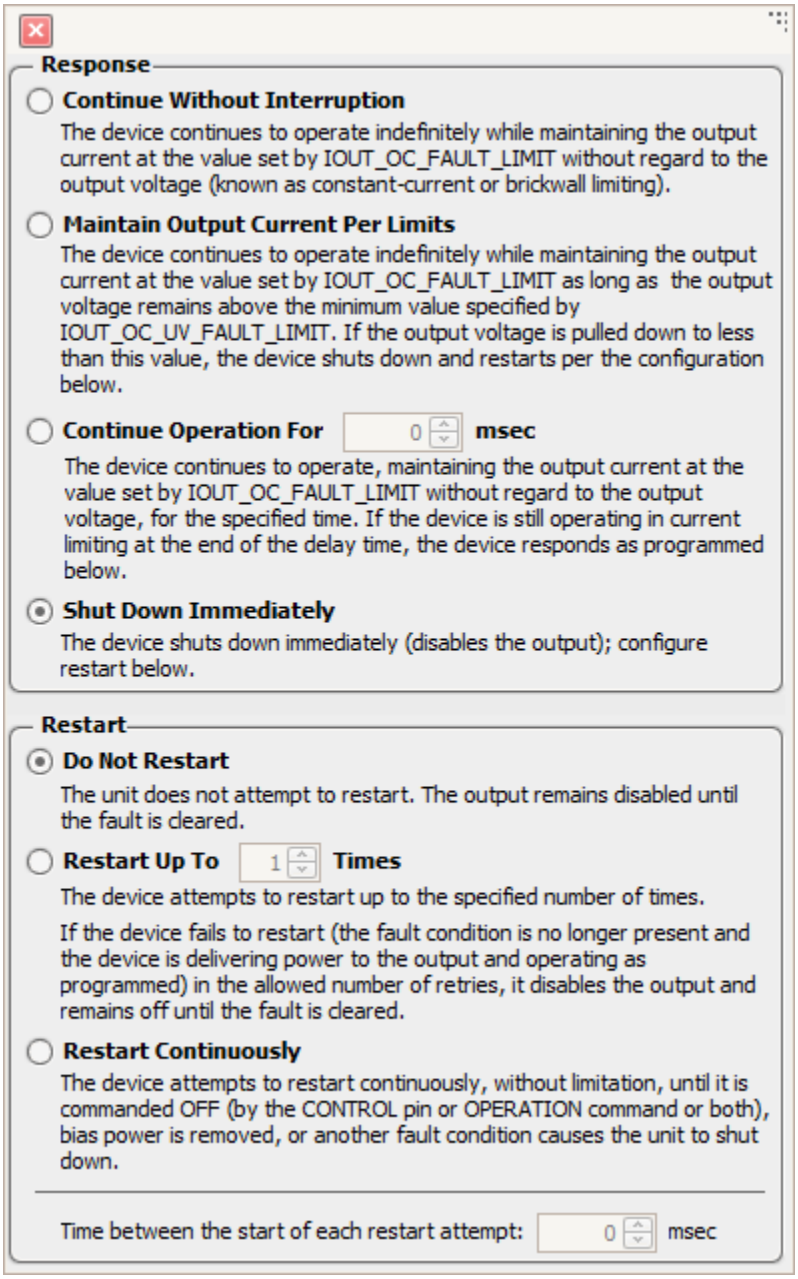

Figure 33. Iout Fault Response Panel

2.6.4 Input Current

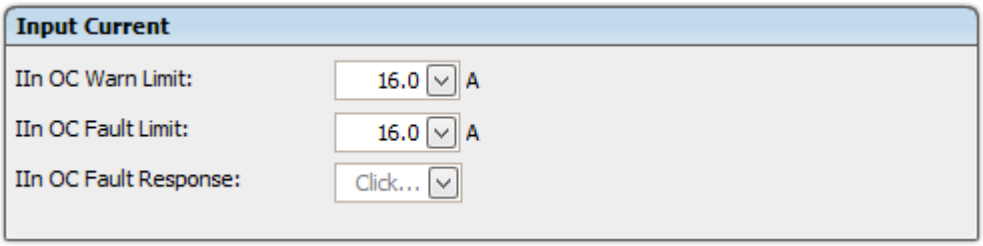

Figure 34. Input Current Panel

- **IIn OC Warn Limit:** Input over-current Warning Limit. Eight values from 8 A to 63.5 A.
- **IIn OC Fault Limit:** Input over-current Fault Limit. Eight values from 8 A to 63.5 A.
- **IInOC Fault Response:** Settings for behavior of controller when input over-current limit is reached. Values are not selectable but are for inspection only. See descriptions below:

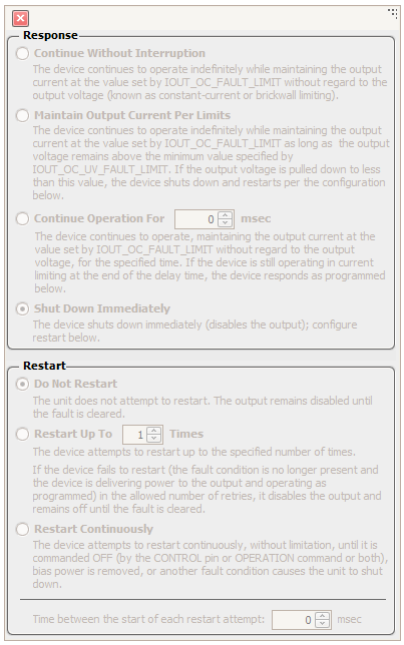

Figure 35. IIN Fault Response Panel

2.6.5 Temp

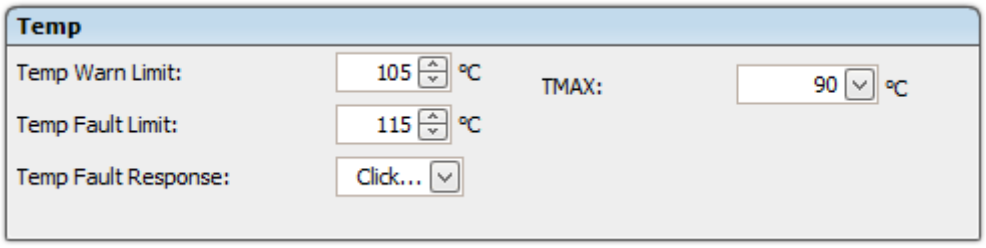

Figure 36. Temperature Panel

- **Temp OC Warn Limit:** Temperature sensor Warning Limit. Temperatures up to 255°C.
- **Temp OC Fault Limit:** Temperature sensor Fault Limit. Temperatures up to 255°C.

- **Temp Fault Response:** Settings for behavior of controller when Over Temperature Limit is reached. See descriptions in Figure 37
- **TMAX:** Sets the value in SVID Temp Max register (common for both rails). Eight values from 90°C to 125°C.

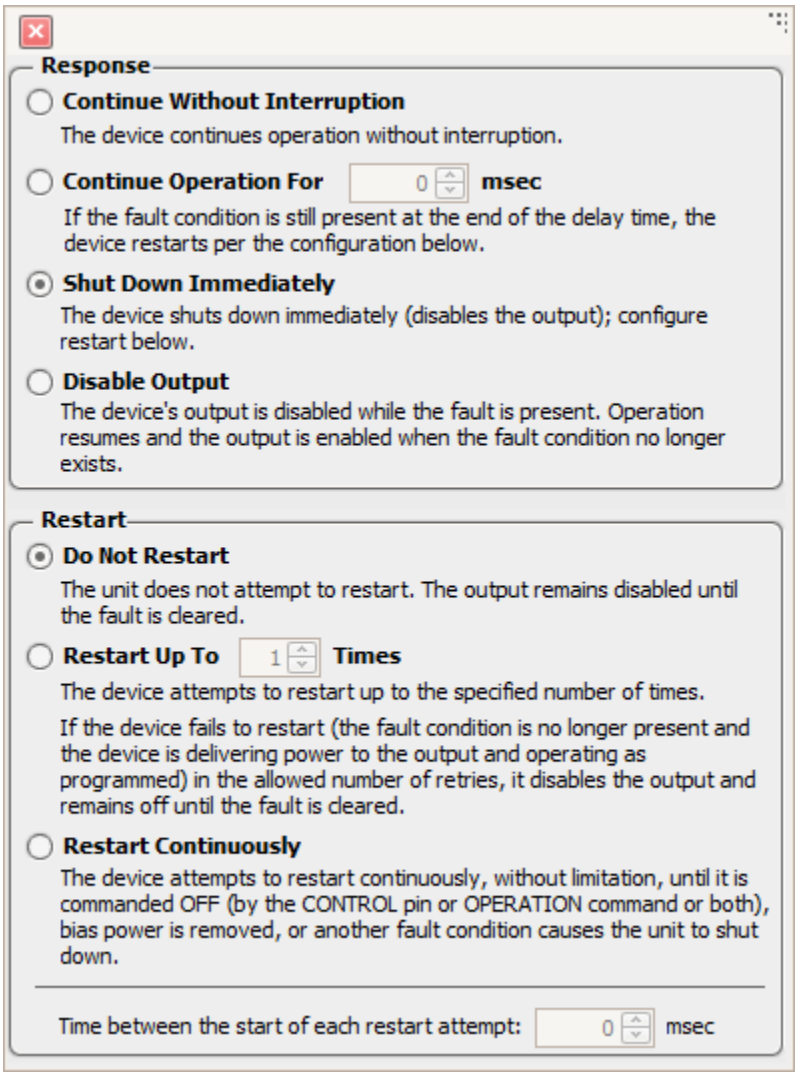

Figure 37. Temperature Fault Response Panel

2.7 SMBALERT# Mask Tab

This tab contains the all maskable **SMBALERT#** commands. Each alert can be individually selected and masked.

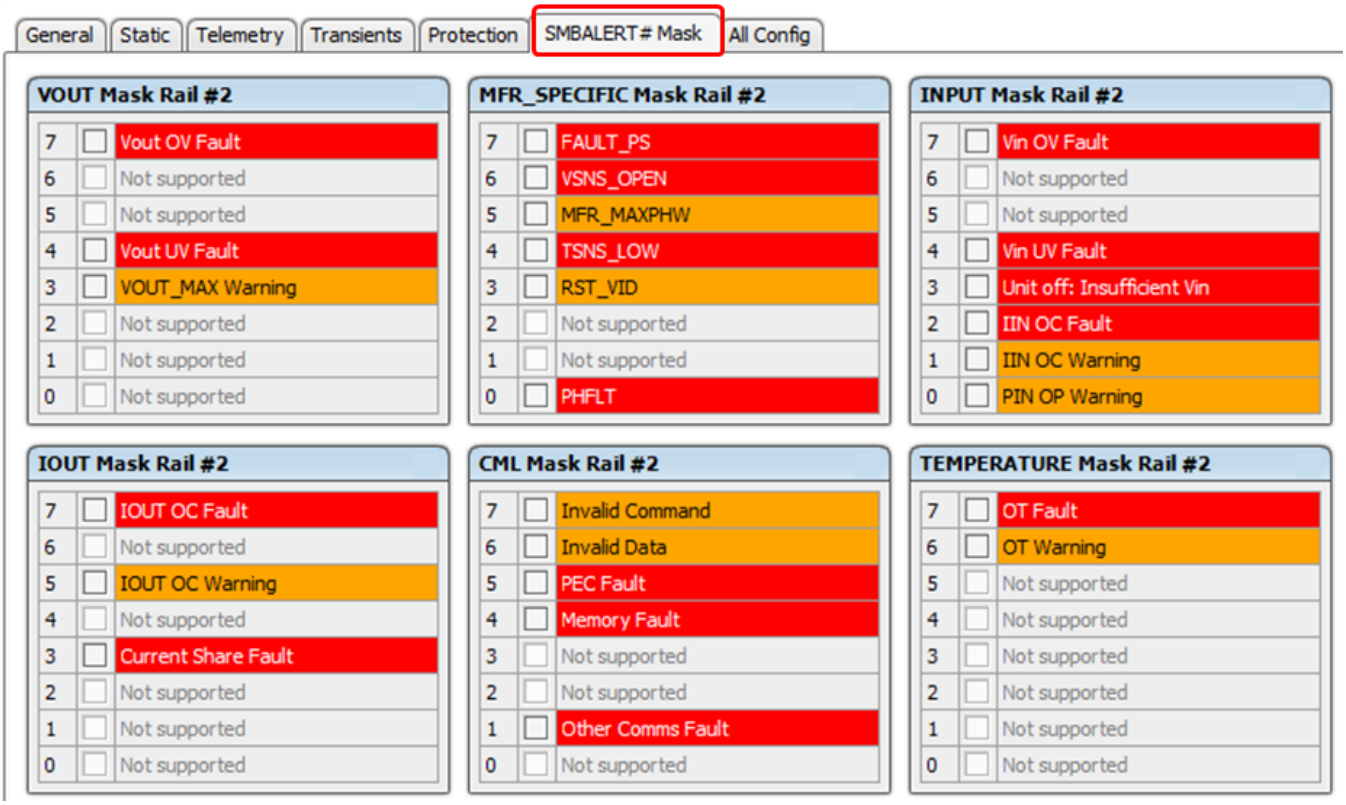

Figure 38. SMBALERT# Mask Tab

2.8 All Config Tab

This tab contains the all available settings including some not available on the main tabs. All settings here are grouped by register. Figure 39 is shown here for reference only.

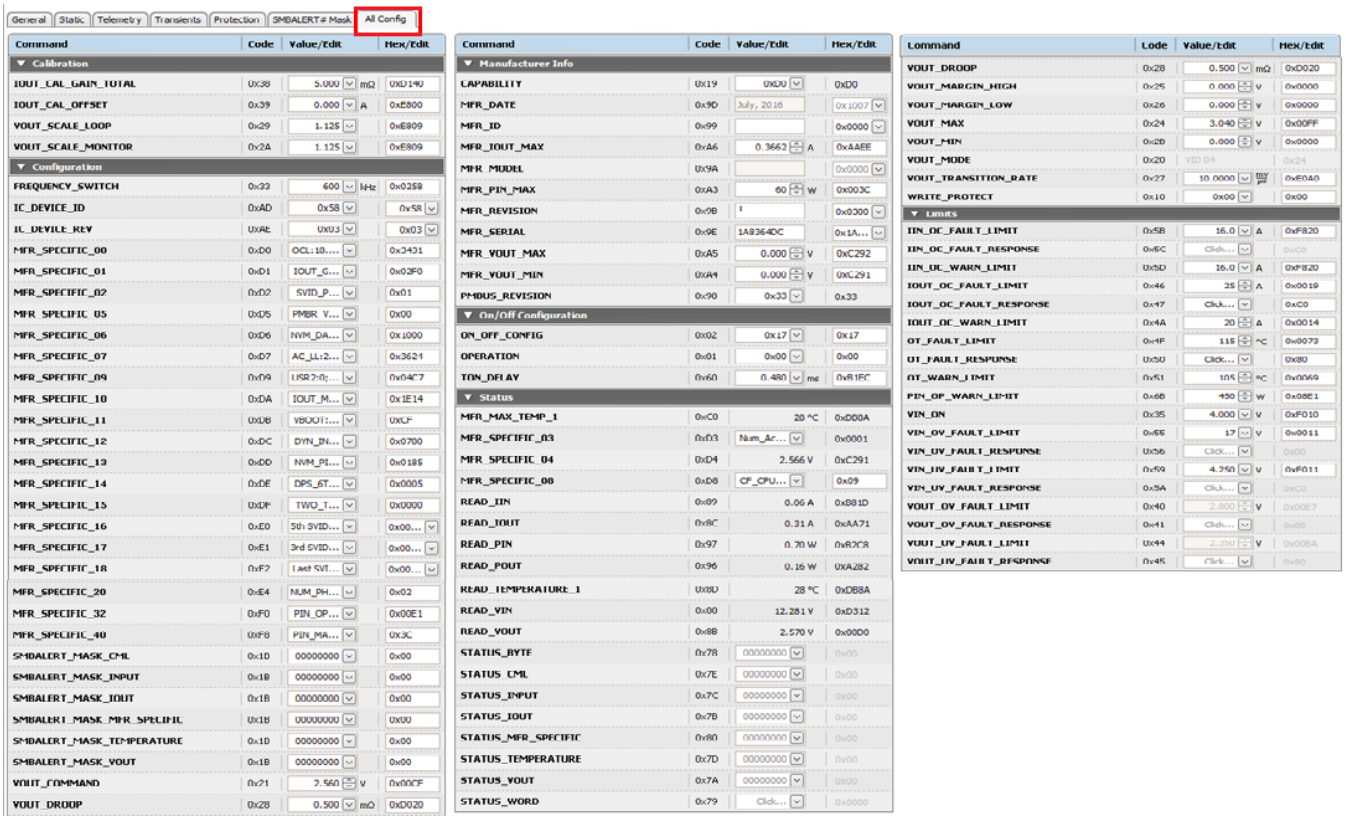

Figure 39. All Config Tab

3 PMBus GUI Monitor Page

Figure 40. Monitor Page Selection

The Monitor Page allows the user to view all of the real-time telemetry on one screen. Refer to Figure 41 for key features of the Monitor Page.

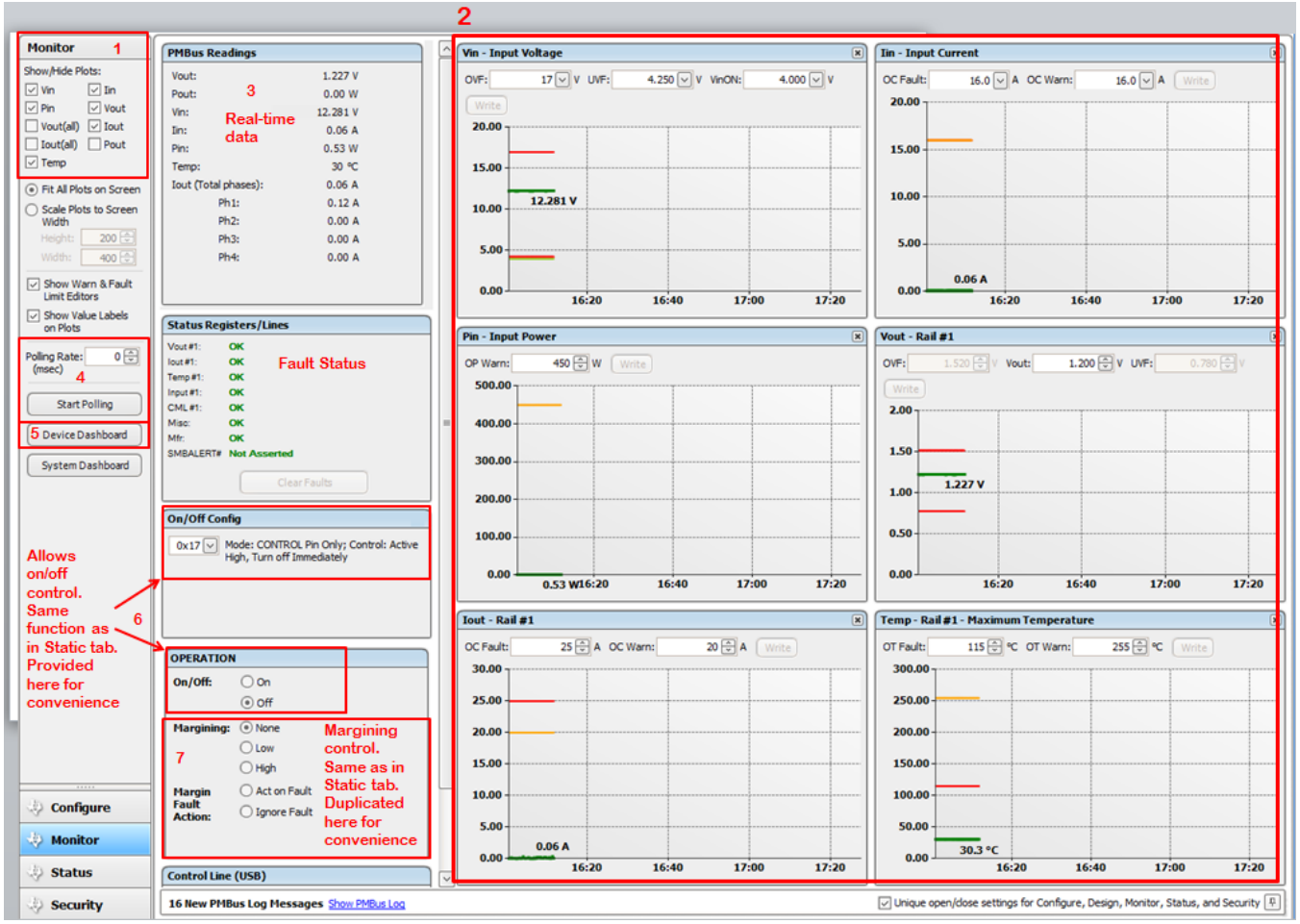

Figure 41. Monitor Page

1. **Plot Selection/Configuration:** This section of the page allows the user to select which graphs to display. Options include V_{IN}, I_{IN}, P_{IN}, V_{OUT}, I_{OUT}, P_{OUT}, and Temperature. Additionally, the user can select whether the plots are scaled to fit the screen or to a specific size. The user can also select whether or not the real-time value is displayed on the graph and if the warning and fault limit values will be visible in the chart.
2. **Plot display region:** All plots selected above will display here.
3. **PMBus Readings:** This section displays the real-time PMBus telemetry values. This includes V_{IN}, I_{IN}, P_{IN}, V_{OUT}, I_{OUT}, P_{OUT}, and Temperature.
4. **Polling Options:** This section allows the user to select whether the GUI is actively polling the device

for PMBus telemetry values (Start Polling, Stop Polling). The PMBus polling update rate can also be changed.

5. **Device and System Dashboard:** Allows the user to access the Device and System Dashboards.
6. **On/Off Config and Operation:** Same as the On/Off Config in the Operation panel of the Static Tab on the Configuration Page (see Figure 18). It is provided here again to allow the user to control this function right from the Monitor page.
7. **Margining:** Same as the Margin settings in the Operation panel of the Static Tab on the Configuration Page (see Figure 16). It is provided here again to allow the user to control this function right from the Monitor page

4 Status page

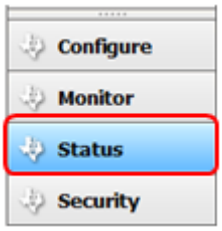

Figure 42. Status Page Selection

The Status page shows the status of each fault bit.

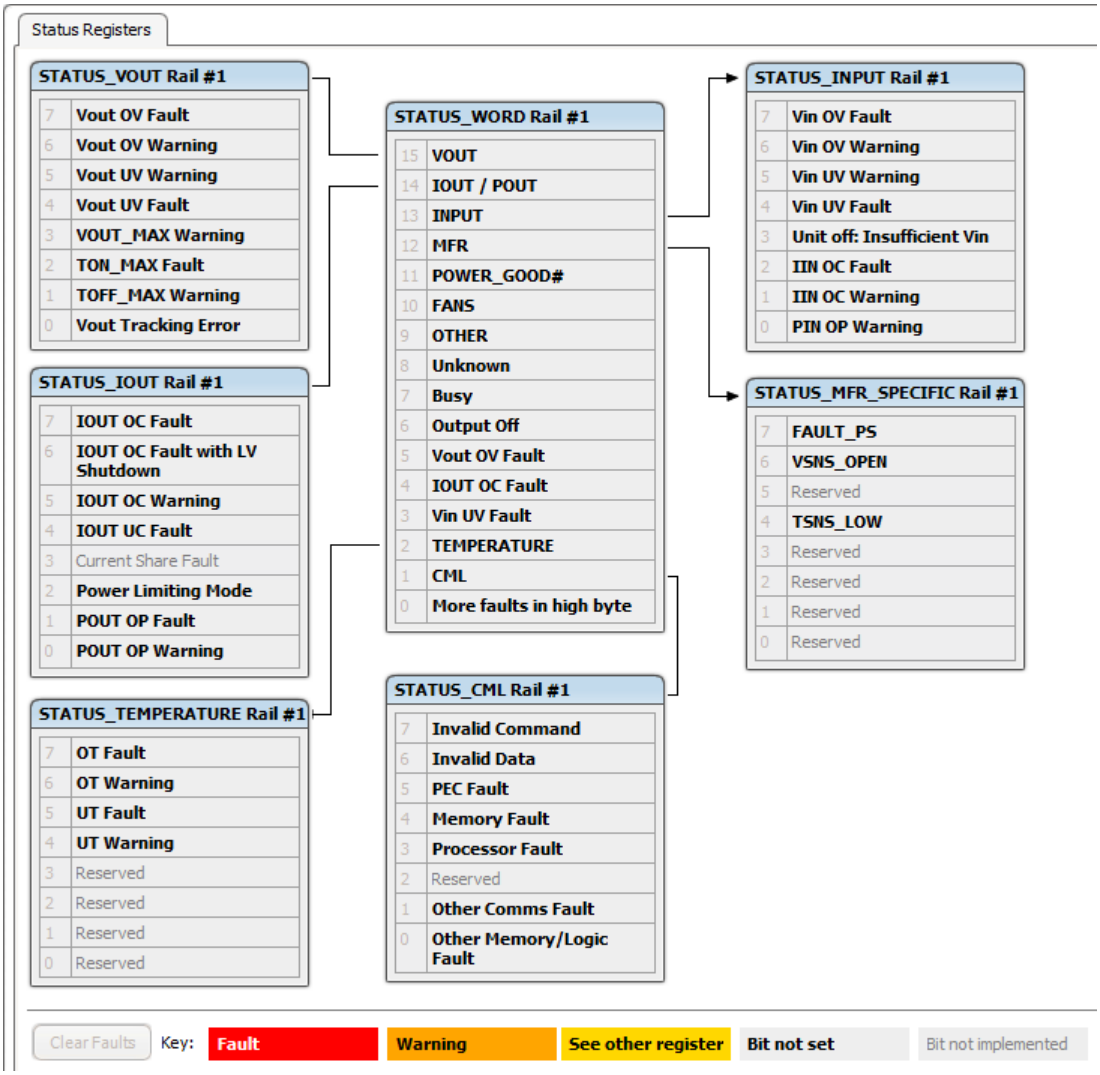

Figure 43. Status Page

5 Security Page

Figure 44. Security Page Selection

The Security page contains the full list of commands that can be write-protected when security is enabled.

IMPORTANT NOTICE FOR TI DESIGN INFORMATION AND RESOURCES

Texas Instruments Incorporated ('TI") technical, application or other design advice, services or information, including, but not limited to, reference designs and materials relating to evaluation modules, (collectively, "TI Resources") are intended to assist designers who are developing applications that incorporate TI products; by downloading, accessing or using any particular TI Resource in any way, you (individually or, if you are acting on behalf of a company, your company) agree to use it solely for this purpose and subject to the terms of this Notice.

TI's provision of TI Resources does not expand or otherwise alter TI's applicable published warranties or warranty disclaimers for TI products, and no additional obligations or liabilities arise from TI providing such TI Resources. TI reserves the right to make corrections, enhancements, improvements and other changes to its TI Resources.

You understand and agree that you remain responsible for using your independent analysis, evaluation and judgment in designing your applications and that you have full and exclusive responsibility to assure the safety of your applications and compliance of your applications (and of all TI products used in or for your applications) with all applicable regulations, laws and other applicable requirements. You represent that, with respect to your applications, you have all the necessary expertise to create and implement safeguards that (1) anticipate dangerous consequences of failures, (2) monitor failures and their consequences, and (3) lessen the likelihood of failures that might cause harm and take appropriate actions. You agree that prior to using or distributing any applications that include TI products, you will thoroughly test such applications and the functionality of such TI products as used in such applications. TI has not conducted any testing other than that specifically described in the published documentation for a particular TI Resource.

You are authorized to use, copy and modify any individual TI Resource only in connection with the development of applications that include the TI product(s) identified in such TI Resource. NO OTHER LICENSE, EXPRESS OR IMPLIED, BY ESTOPPEL OR OTHERWISE TO ANY OTHER TI INTELLECTUAL PROPERTY RIGHT, AND NO LICENSE TO ANY TECHNOLOGY OR INTELLECTUAL PROPERTY RIGHT OF TI OR ANY THIRD PARTY IS GRANTED HEREIN, including but not limited to any patent right, copyright, mask work right, or other intellectual property right relating to any combination, machine, or process in which TI products or services are used. Information regarding or referencing third-party products or services does not constitute a license to use such products or services, or a warranty or endorsement thereof. Use of TI Resources may require a license from a third party under the patents or other intellectual property of the third party, or a license from TI under the patents or other intellectual property of TI.

TI RESOURCES ARE PROVIDED "AS IS" AND WITH ALL FAULTS. TI DISCLAIMS ALL OTHER WARRANTIES OR REPRESENTATIONS, EXPRESS OR IMPLIED, REGARDING TI RESOURCES OR USE THEREOF, INCLUDING BUT NOT LIMITED TO ACCURACY OR COMPLETENESS, TITLE, ANY EPIDEMIC FAILURE WARRANTY AND ANY IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE, AND NON-INFRINGEMENT OF ANY THIRD PARTY INTELLECTUAL PROPERTY RIGHTS.

TI SHALL NOT BE LIABLE FOR AND SHALL NOT DEFEND OR INDEMNIFY YOU AGAINST ANY CLAIM, INCLUDING BUT NOT LIMITED TO ANY INFRINGEMENT CLAIM THAT RELATES TO OR IS BASED ON ANY COMBINATION OF PRODUCTS EVEN IF DESCRIBED IN TI RESOURCES OR OTHERWISE. IN NO EVENT SHALL TI BE LIABLE FOR ANY ACTUAL, DIRECT, SPECIAL, COLLATERAL, INDIRECT, PUNITIVE, INCIDENTAL, CONSEQUENTIAL OR EXEMPLARY DAMAGES IN CONNECTION WITH OR ARISING OUT OF TI RESOURCES OR USE THEREOF, AND REGARDLESS OF WHETHER TI HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES.

You agree to fully indemnify TI and its representatives against any damages, costs, losses, and/or liabilities arising out of your non-compliance with the terms and provisions of this Notice.

This Notice applies to TI Resources. Additional terms apply to the use and purchase of certain types of materials, TI products and services. These include; without limitation, TI's standard terms for semiconductor products http://www.ti.com/sc/docs/stdterms.htm), evaluation modules, and samples (http://www.ti.com/sc/docs/sampterms.htm).

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265