REF XDPP FBFB 50V Patch

XDPP1100 Firmware Patch

About this document

Scope and purpose

This document describes a custom firmware patch implementation for XDPP1100 Digital Power Controller to regulate an -48V to 50V FBFB Topology.

-48V to 50V FBFB implemented features are listed below:

- Modifying Transfomer Scaling - Modify the transformer scaling input to support boost mode.
- Efficiency table feature – input power and input current telemetry correction based on output power and efficiency;
- Current sharing feature – enable current sharing by controlling IMON resistor connection;
- Input voltage trim feature – changing voltage trim config based on regulation mode;

Intended audience

Power management engineers who wish implement these additional features.

Table of contents

1 FBFB -48V to 50V firmware

The custom N48V to 50V FBFB firmware is developed and combined into one single XDPP1100 patch. In case you are unfamiliar with XDPP1100 firmware projects, refer to “XDPP1100 Firmware Development Guide” and “XDPP1100 Firmware Examples Code”.

1.1 Patch usage

The N48V to 50V FBFB patch is delivered with a pre-built image, which the user can find */patch* folder. This image can be stored to XDPP1100 RAM or OTP via GUI. Upload ***/src/shasta_pmbus.****xlsx* to GUI to use FBFB Boost features through MFR PMBus commands.

Table 1 MFR PMBus commands

PMbus command name	PMBus address	Read / Write	Description
FAN_CONFIG_1_2	(0x3A)	Write / Read	The FAN_CONFIG_1_2 is used to configure up to two fans associated with one PMBus device.
FAN_COMMAND_1	(0x3B)	Write / Read	The FAN_COMMAND_1, FAN_COMMAND_2 commands are used to adjust the operation of up to four fans contained in the PMBus device or in the host system. For fans contained in the PMBus device, the host system may override the commanded values if needed to maintain proper system temperatures.
FAN_COMMAND_2	(0x3C)	Write /Read	The FAN_COMMAND_1, FAN_COMMAND_2 commands are used to adjust the operation of up to four fans contained in the PMBus device or in the host system. For fans contained in the PMBus device, the host system may override the commanded values if needed to maintain proper system temperatures.
MFR_VIN_TRIMMING_ACTIVE	(0xB1)	Write / Read	To set input voltage trim for active mode: [31:16] desired vin_pwl_slope in format u-2.14; [15:0] desired vin_trim in format s.6.4.
MFR_VIN_TRIMMING_STANDBY	(0xB2)	Write / Read	To set input voltage trim for standby mode: [31:16] desired vin_pwl_slope in format u-2.14; [15:0] desired vin_trim in format s.6.4.
MFR_ISHARE_THRESHOLD	(0xDA)	Write / Read	To set current sharing deadzone in linear11 format Amps units.
MFR_ADJ_TURN_RATIO	(0xE5)	Write/Read	To set the desired turn ratio in Linear 11 format with exponent -9.
MFR_ESTIMATE_EFFICIENCY	(0xED)	Read only	Read feedback of an estimated efficiency value in u0.8 format.

PMbus command name	PMBus address	Read / Write	Description
MFR_ADDED_DROOP_DURING_RAMP	(0xFC)	Write / Read	To set the additional droop resistor applies to loop during startup ramp. LINEAR11 with Binary point at 1 mOhm.

Attention: Perform features' enabling/disabling/config settings via respective PMBus commands only when XDPP1100 regulation is OFF to avoid unexpected artifacts.

1.2 Features

This section provides general overview of implemented boost features. For more details and code modification, refer to the section **2 "Advanced description and custom settings"**.

1.2.1 Modifying Transformer Scaling features

XDPP1100 digital power controller is designed to specifically support step-down, buck-kind of power topologies. As a result, the transformer scaling (primary-to-secondary turns ratio, expressed in Ns/Np) is limited from 0.0 to 1.0.

However, certain topologies that employs transformer for voltage and current scaling, such as -48V to 50Vdc conversion, may require transformer scaling such that Ns/Np = 5/3 = 1.67 which is out of the design limit.

This feature implements a new PMBus MFR command 0xB1 MFR_ADJ_TURN_RATIO in which the new turns ratio can be filled in. Take note that the default PMBus command 0xCE MFR_TRANSFORMER_SCALE must be set to 1.0.

Figure 1 show an example of write 1.67 ratio using the XDPP1100 GUI.

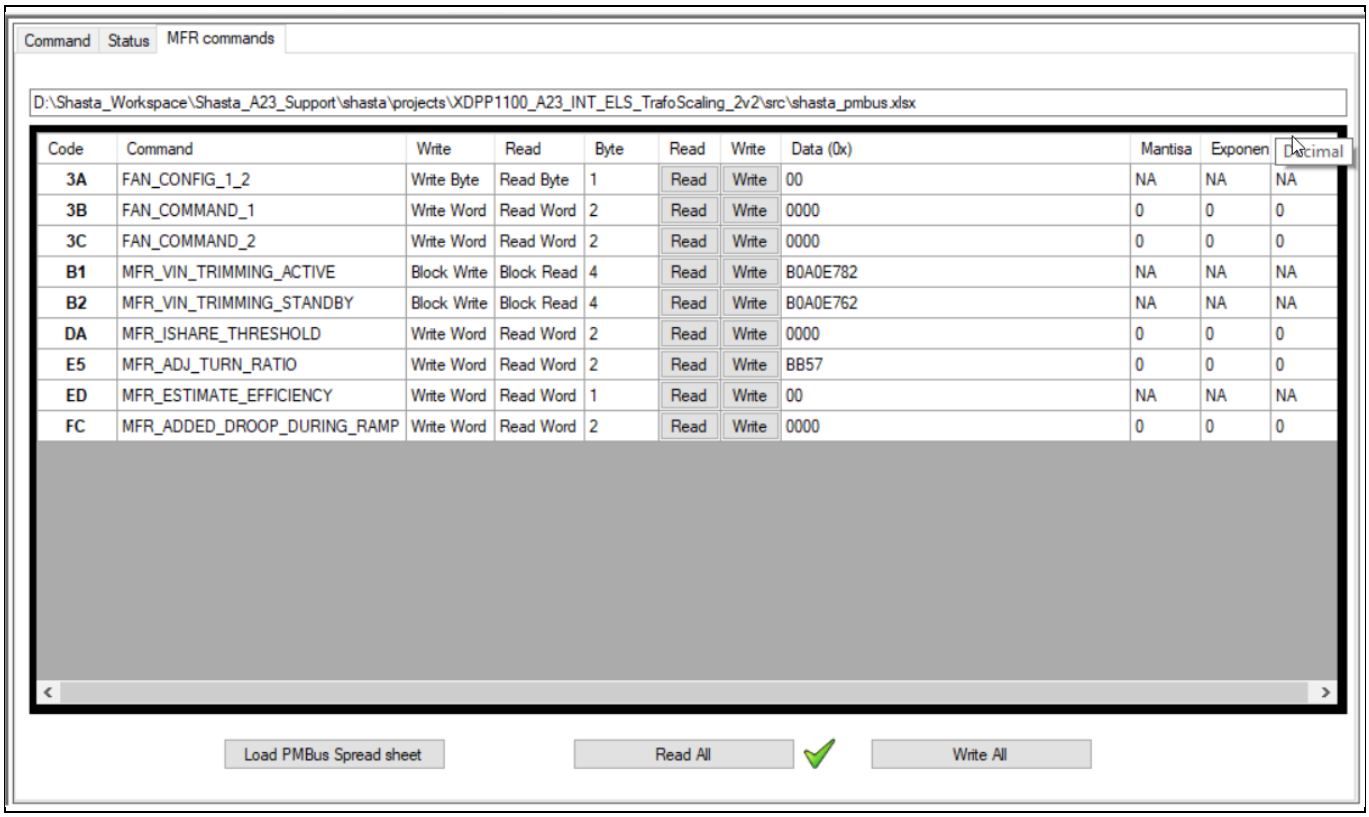

Figure 1 XDPP1100 GUI PMBus MFR Command 0xE5

1.2.2 Efficiency table feature

This feature allows to improve a measurement accuracy of the input current/power telemetry based on pre-programmed power efficiencies for different ranges.

To reflect more accurate readings on the input current telemetry, the following equation is used:

$$Iin_{est} = \frac{Iout * Vout}{Vin} = \frac{Pout}{Vin}$$

$$Iin_{est_{adj}} = Iin_{est} * \frac{1}{eff}$$

where *Efficiency LUT value* is selected from the Efficiency Look-Up Table based on the output current and the input voltage current ranges of operation.

In the default project, the following Efficiency Look-Up Table is programmed:

Table 2 Efficiency LUT Example (decimal)

Vin\Pout	50W	100W	150W	350W	550W	750W
36Vdc	0.871	0.921	0.938	0.963	0.966	0.963
48Vdc	0.817	0.892	0.917	0.945	0.953	0.952
60Vdc	0.766	0.863	0.898	0.931	0.943	0.945
72Vdc	0.724	0.836	0.879	0.92	0.934	0.938

The values in the table above can be represented as an unsigned U0.8 where:

Table 3 U0.8 Representation

Format	DEC	HEX
Bit Length	8 bits	
LSB Weight	2^(-8) = 0.00390625	
Min Value	0	0x00
Max Value	255 * LSB Weight = 0.99609375	0xFF

Using U0.8 representation, the efficiency LUT can be represented as following:

Table 4 Efficiency LUT in U0.8 Representation

Vin\Pout	50W	100W	150W	350W	550W	750W
36Vdc	223	236	240	247	247	247
48Vdc	209	228	235	242	244	244
60Vdc	196	221	230	238	241	242
70Vdc	185	214	225	236	239	240

The input current/power correction happens every frequency iteration.

Efficiency Look-Up Table hysteresis 1 V and 0.75 A for the input voltage for the output current respectively.

Reporting efficiency figure to the user can then be implemented via custom PMBus MFR command. In this example patch, 0xED slot is chosen.

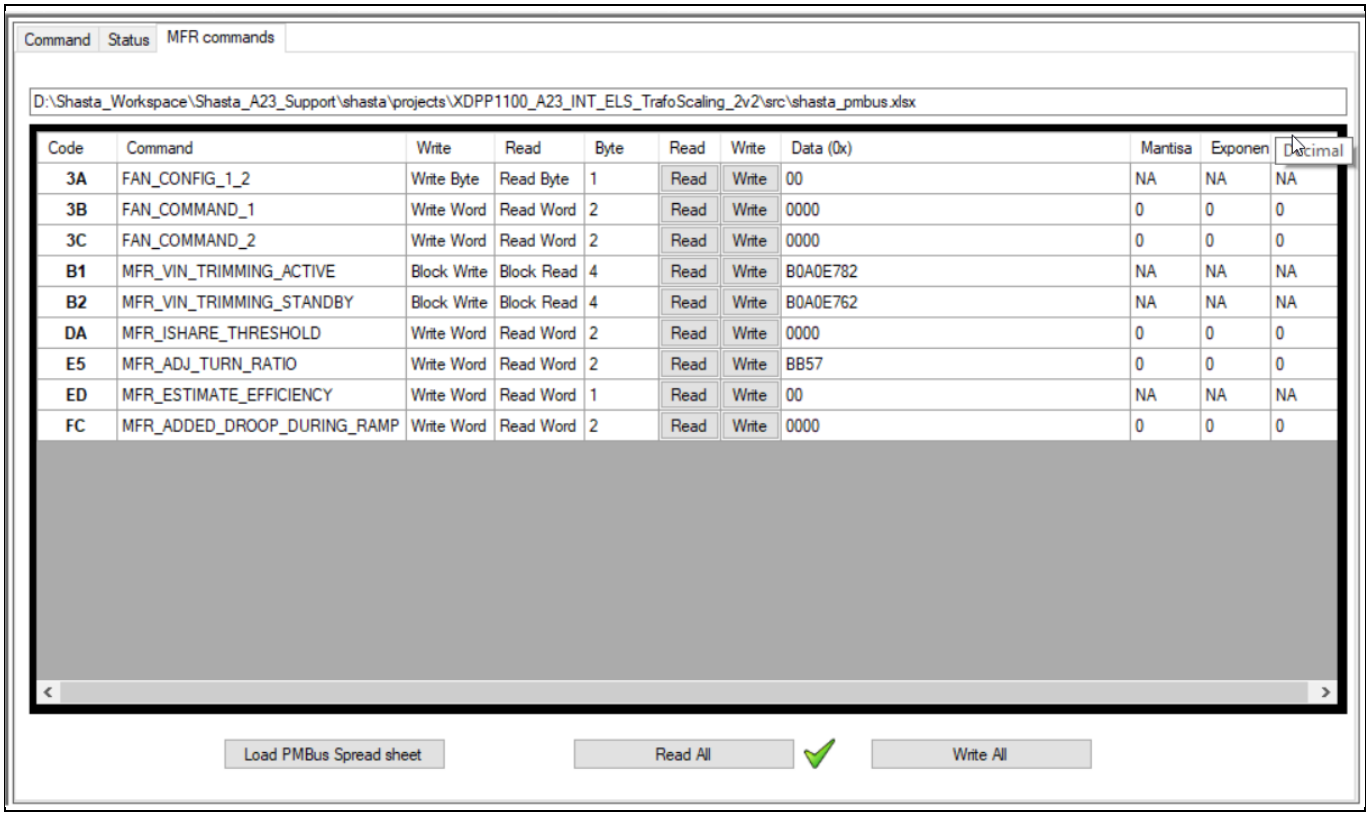

Figure 2 XDPP1100 GUI PMBus MFR Command 0xED

1.2.3 Current sharing feature

Refer to XDPP1100 datasheet for "*Current Share*" feature clarification.

In this patch, (0xDA) MFR_ISHARE_THRESHOLD command was added to set a custom current sharing deadzone in linear11 format in Amps units. MFR_ISHARE_THRESHOLD default value is 0. The active current sharing feature is disabled if MFR_ISHARE_THRESHOLD is 0.

Usually, the worst condition of the current sharing feature is the startup ramp for parallel converters. The added droop helps current balancing during the startup. The PMBus command (0xFC) MFR_ADDED_DROOP_DURING_RAMP defines the additional droop resistor which applies to loop during startup ramp. The added droop will be removed when Vout reached to target.

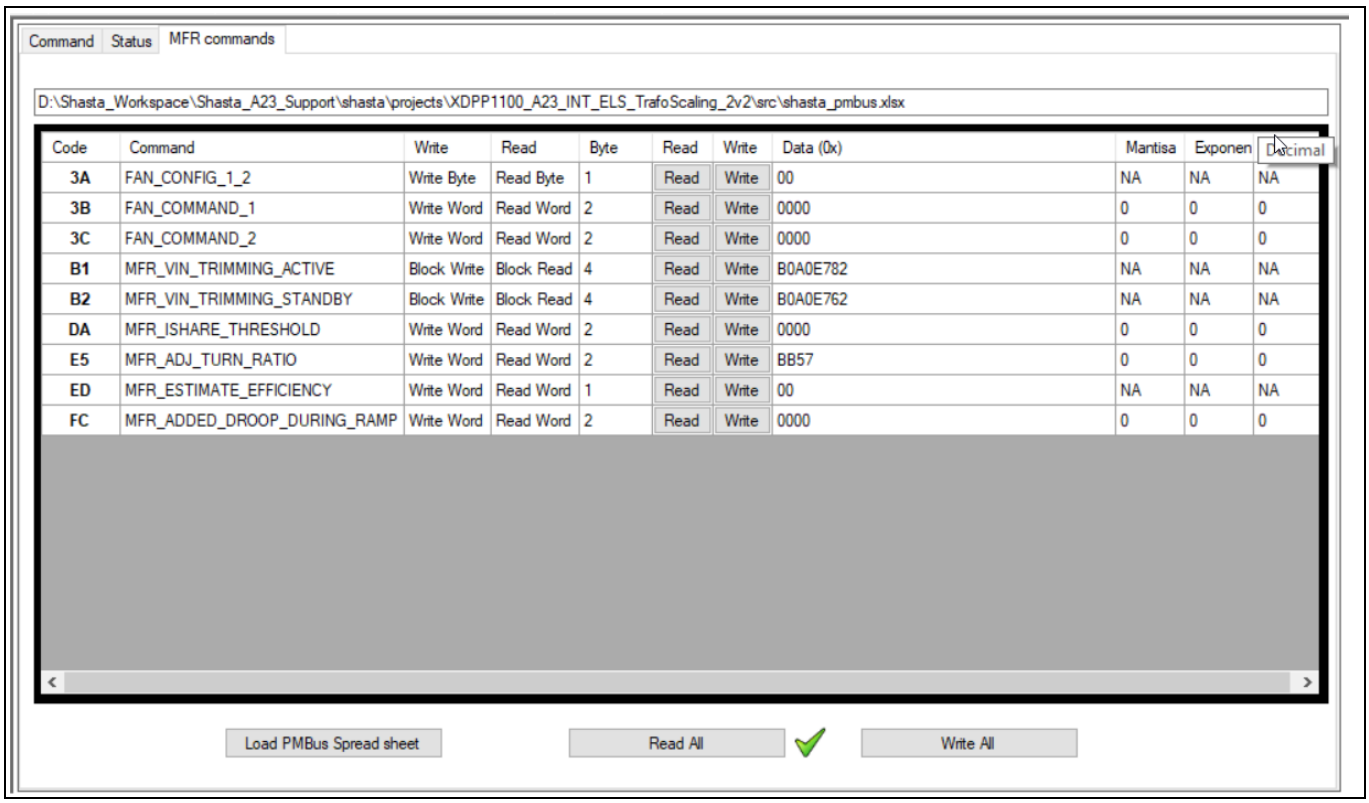

Figure 3 XDPP1100 GUI PMBus MFR Command 0xDA, 0xFC

1.2.4 Input voltage trim feature

This feature allows to have different input voltage trim settings (vin_trim and vin_pwl_slope) for standby and active regulation modes. Input voltage trip is applied only when the input voltage is sensed at PRISEN pin and when tlm_vin_src_sel = 3 (TS ADC Vin).

Use MFR_VIN_TRIMMING_ACTIVE and MFR_VIN_TRIMMING_STANDBY commands to set desired input voltage trim settings for active and standby modes accordingly. Default value is 0.

MFR_VIN_TRIMMING_ACTIVE and MFR_VIN_TRIMMING_STANDBY are 32 bits commands each, where:

- [31:16] vin_pwl_slope in format u-2.14;
- [15:0] vin_trim in format s.6.4.

Feature example

If the user wants to use 0.15625 as the VIN slope, then its register value vin_pwl_slope (u-2.14 format) will be

$$\frac{0.15625}{2^{-14}} = 2560 \text{ or } '0xA00'$$

Now, covert gotten value into linear11 format with exponent '-10' to get '**0xB0A0**'.

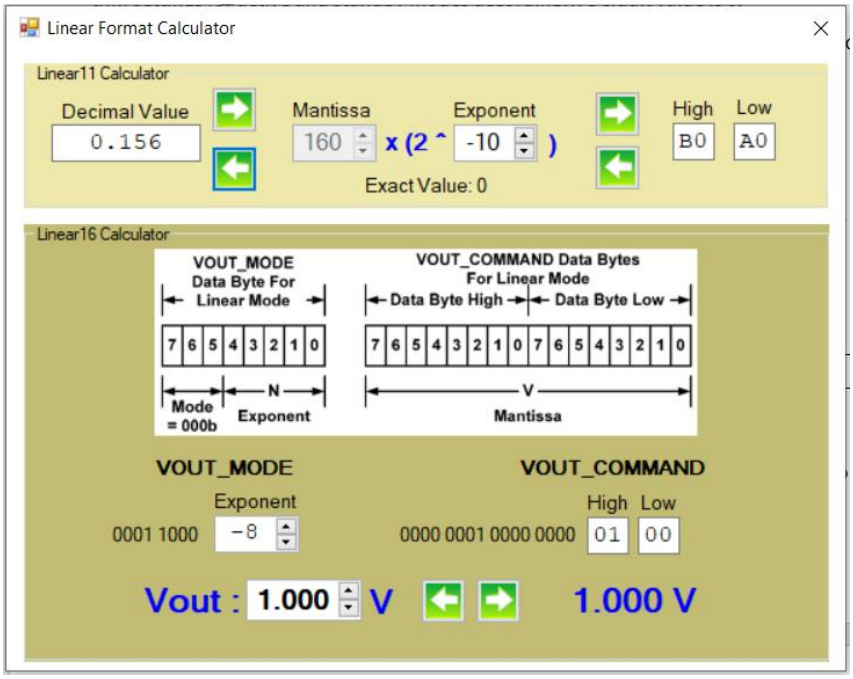

Figure 4 Linear11 calculator for 0.15625

If the user wants to use -7.875 as the VIN offset, then its register value vin_trim (s6.4 format) will be

$$\frac{-7.875}{2^{-4}} = -126 \text{ or } '0x382'$$

Now, covert gotten value into linear11 format with exponent '-4' to get '***0xE782***'.

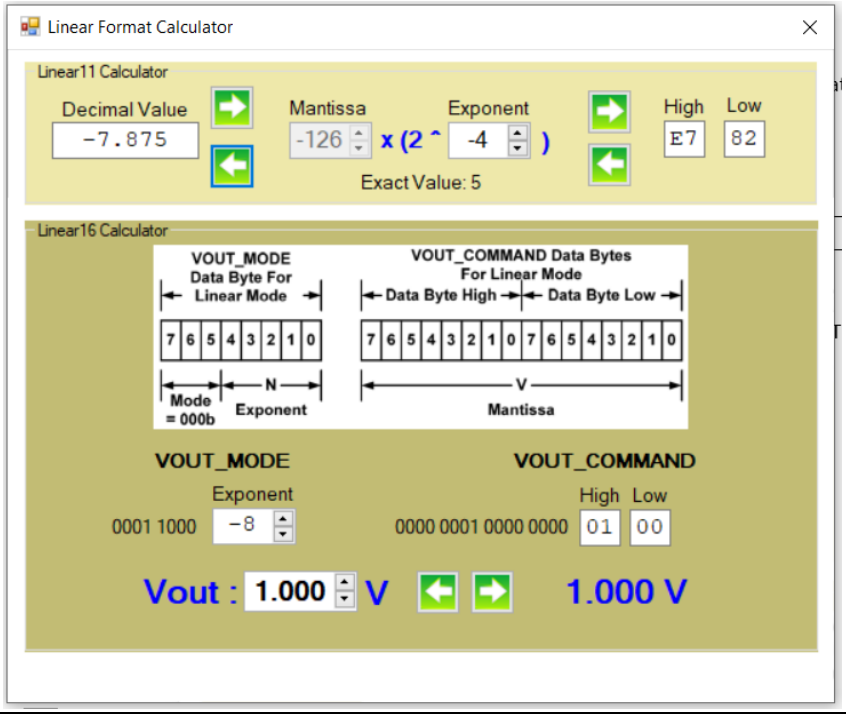

Figure 5 Linear11 calculator for -7.875

Put together gotten values into one '0x**B0A0***E782*' and set it into MFR_VIN_TRIMMING_ACTIVE or MFR_VIN_TRIMMING_STANBY.

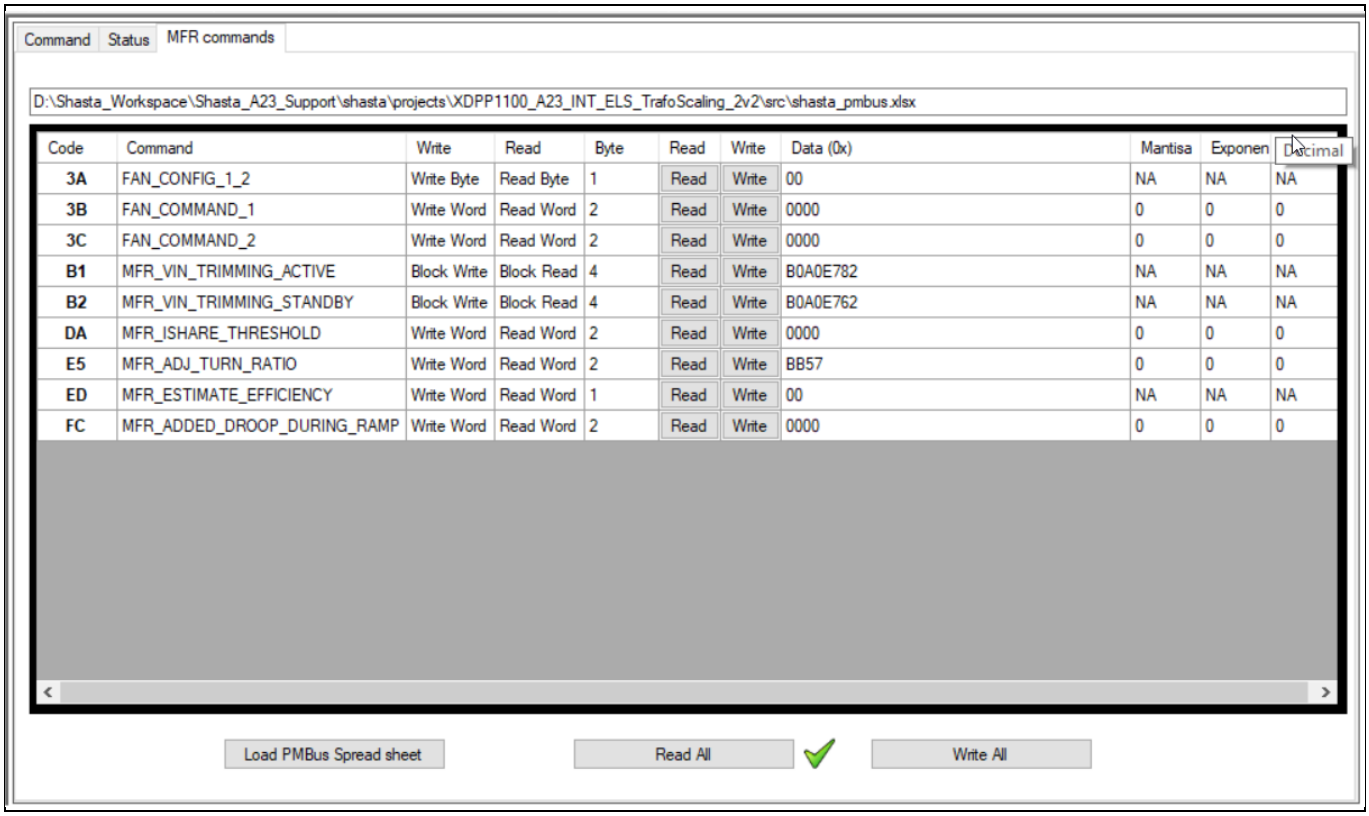

Figure 6 XDPP1100 GUI PMBus MFR Command 0xB1, 0xB2

2 Advanced description and custom settings

This section shows where, what and how the user can modify each described feature.

Table 5 Project Blocks

Filename	Description and Properties
user_app.c/h	User entry point
add_on_features.c/h	Settings initialization and current share feature
regulation_state_machine_callbacks.c/h	State machine callback
pmbus_mfr_autogen.c/h	PMBus generated commands
pmbus_mfr_specific_handlers.c/h	PMBus commands' handlers
transformer_scaling.c/h	Transformer Scale implementation for boost
input_current_correction.c/h	input current telemetry correction implementation
efficiency_table.h	Efficiency table implementation
vin_trim.c/h	Input voltage trim implementation

2.1 Features Implementation

Each feature implementation can be found per sections below.

2.1.1 Modifying Transformer Scaling features

Uncomment **#define transformer_scaling** in transformer_scaling.h to build patch with this feature.

In transformer_scaling.c the function patch_Telemetry_change_scales () is created to replace the ROM Telemetry_change_scales () function.

The PMBus MFR handler for command 0xB1 MFR_ADJ_TURN_RATIO is declared in pmbus_mfr_specific_handlers.c to change the transformer scale for boost.

In add_on_features_init (), initialize program to replace ROM function of Telemetry_change_scales () to patch_ Telemetry_change_scales ().

Table 6 Additions/Modifications

Filename	Function and/or Variable Name
transformer_scaling.c/h	patch_Telemetry_change_scales ()
pmbus_mfr_specific_handlers.c/h	PMBUS_HANDLE_MFR_ADJ_TURN_RATIO ()
add_on_features.c/h	add_on_features_init ()

2.1.2 Efficiency table feature

Uncomment **#define input_current_correction_en** in input_current_correction.h to build patch with this feature.

The values in the table above can be represented as an unsigned U0.8 where:

Table 7 U0.8 Representation

Format	DEC	HEX
Bit Length	8 bits	

Format	DEC	HEX
LSB Weight	2^(-8) = 0.00390625	
Min Value	0	0x00
Max Value	255 * LSB Weight = 0.99609375	0xFF

Using U0.8 representation, the efficiency LUT can be represented as following:

Table 8 Efficiency LUT in U0.8 Representation

Vin\Pout	50W	100W	150W	350W	550W	750W
36Vdc	223	236	240	247	247	247
48Vdc	209	228	235	242	244	244
60Vdc	196	221	230	238	241	242
70Vdc	185	214	225	236	239	240

Refer to */src/user_app/efficiency_table.h* to set a custom Efficiency Look-Up Table in u0.8 format.

Refer to */src/user_app/add_on_features.c* to set custom Efficiency Look-Up Table hysteresis for the input voltage and the output current.

Note: Do not change Efficiency Look-Up Table size. Hysteresis function is hardcoded and is only appropriate for the same Efficiency Look-Up Table size as per default.

Table 9 Feature Additions/Modifications

Filename	Function and/or Variable Name
input_current_correction.c/h	calculate_i() calculate_j() input_current_correction() patch_Telemetry_Sample()
efficiency_table.h	efficiency_table[][]
add_on_features.c	add_on_features_init ()

2.1.3 Current sharing feature

Uncomment **#define enable_ishare** in add_on_features.h to build patch with this feature.

Refer to */src/user_app/add_on_features.c/h* to get more details about active current sharing implementation.

Table 10 Feature Additions/Modifications

Filename	Function and/or Variable Name
add_on_features.c/h	added_droop_disable() added_droop_enable() remove_added_droop_irq_callback() enable_ishare() disable_ishare() patch_Regulation_Shutdown_Sequence()
regulation_state_machine_callbacks.c/h	regulation_sm_callbacks_init ()

Filename	Function and/or Variable Name
	TON_RISE_ENABLE () AT_SHUTDOWN () TON_RISE_VID_REACHED ()

2.1.4 Input voltage trim feature

Uncomment **#define vin_trim_feature_en** in vin_trim.h to build patch with this feature.

Refer to */src/user_app/vin_trim.c/h* to get more details about the input voltage trim implementation.

Table 11 Feature Additions/Modifications

Filename	Function and/or Variable Name
vin_trim.c/h	Update_Vin_Trim () PMBUS_HANDLE_MFR_FLEX_VIN_TRIMMING_ACTIVE () PMBUS_HANDLE_MFR_FLEX_VIN_TRIMMING_STANDBY ()
regulation_state_machine_callbacks.c/h	regulation_sm_callbacks_init () TON_RISE_ENABLE () AT_SHUTDOWN () AT_TARGET_ENABLE ()

Reference

[1] XDPP1100 Firmware Development Guide.

[2] XDPP1100 Firmware Examples Code.

[3] XDPP1100 N48V to 50V patch and config guide

Revision history

Document version	Date of release	Description of changes
V1.0	13-12-2021	First Release

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