flex.

Power Modules
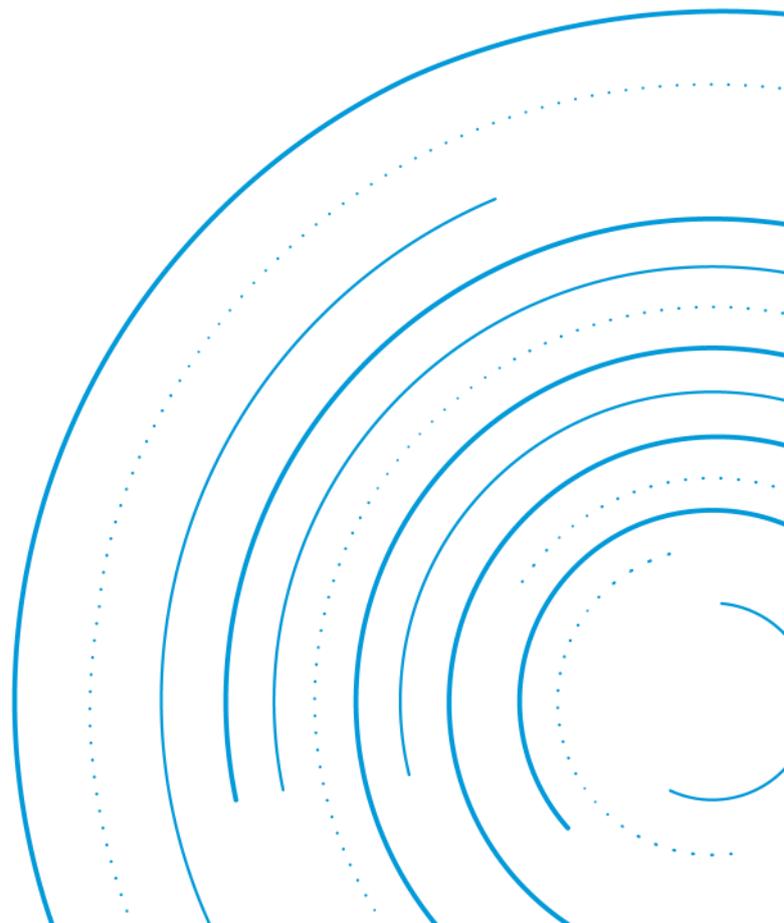
In-system programming guide for digital Point of Load regulators

Abstract

This application note provides information on communicating with Flex Power Modules' digital Point of Load regulators while they are already placed "in-system". Specifically, we discuss what changes are available while the power output is enabled, referred to as "Operation Changes".

Additionally, we guide the reader through designing your power system to support in-system configuration updates allowing you to potentially configure parts without the need of ordering pre-configured products or using a contract manufacturer.

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Introduction

This application note provides general information on how to change the configuration of digital DC/DC converters with real time updates and saved re-configurations, while they are already placed "in-system". These changes will involve memory management which will vary based on specific modules. The basics are covered in this note, but the technical documentation of specific modules should also be reviewed, and of course, your local FAE can always provide direct support.

This guide assumes that your host controller can communicate via PMBus (more information on this topic in AN304 – Microcontroller Programming). Additionally, before diving into the details of configuration & memory, let's first review the PMBus memory model, as understanding it helps to understand how in-system programming affects the product.

Review of the PMBus memory model

PMBus devices work by having multiple layers of 'non-volatile' storage, where its contents along with the PMBus commands written after startup determine the state of the 'RAM', a volatile store that is used in determining the actual output voltage, fault limits, compensation, etc.

In the diagram below, the User Store and Default Store are both non-volatile storages, and after startup certain values may be changed while the product is enabled, which we will refer to as 'Operational Changes'.
Additionally, in certain scenarios you may want to update the contents of the User Store after the product is already mounted in the system, which we will refer to as 'Configuration Updates'
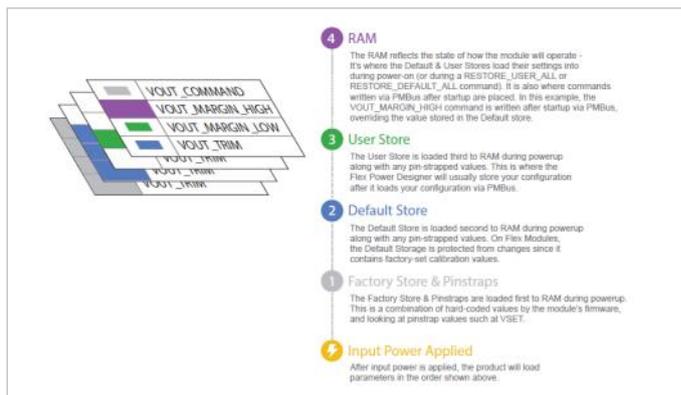

Figure 1: Memory model of PMBus compliant device

0 Input power applied

After input power is applied, the product will load all parameters in the order shown below.

1 Factory Store & Pin-straps

The Factory Store & Pin-straps are loaded first to RAM during powerup. This is a combination of hard-coded values by the module's firmware and looking at pin-strap values such as VSET.

2 Default Store

The Default Store is loaded second to RAM during powerup along with any pin-strapped values. On Flex Modules devices, the Default Storage is protected from changes since it contains factory-set calibration values.

3 User Store

The User Store is loaded third to RAM during powerup along with any pin-strapped values. This is where the Flex Power Designer will usually store your configuration after it loads your configuration via PMBus.

4 RAM

The RAM reflects the state of how the module will operate. It is where the Default & User Stores load their settings into during power-on (or during a RESTORE_USER_ALL or RESTORE_DEFAULT_ALL command). It is also where commands written via PMBus after startup are placed.

Operational changes

Operational changes refer to changing how the product works while it is enabled but does not involve storing changes to the non-volatile storage. A very common scenario is changing the output voltage while the product is enabled.

Changing Vout while enabled

For a product that is not using current sharing, you may change the voltage just by setting VOUT_COMMAND to the new value, provided the new value still falls within your fault and warning thresholds.

The upper limit that you can set VOUT_COMMAND or the margin commands to is dependent on the highest-allowed value of VOUT_MAX (which may be determined from the VSET resistor setting) or the value currently set as the VOUT_OV_FAULT_LIMIT/ VOUT_OV_WARN_LIMIT.

Changing Vout while current sharing

When current sharing, it is not advisable to directly change VOUT_COMMAND while all units in the current sharing group are enabled. There are two approaches depending on the product:

One unit can handle the current load

Disable all but one unit and make the changes. When all changes are made, re-enable all units.

Two or more units must be enabled

This approach makes use of the VOUT_MARGIN_HIGH / VOUT_MARGIN_LOW commands. The steps are a bit different depending on the product:

1.   While enabled and operating with load, write the desired voltage of either VOUT_MARGIN_LOW (Vout shall be lower) or VOUT_MARGIN_HIGH (Vout shall be higher) to all units.

2.   Change OPERATION to the appropriate margin state. For Margin Low, you set OPERATION to 0x98, and for Margin High it will be 0xA8. If available, this may be done via the margin pin.
     A)   If the product has Group Communication Bus (GCB), simply set OPERATION in the master phase to the desired value. While in margin state, you may update the value of VOUT_COMMAND across all phases to the updated value. Then you can change your state via the OPERATION command back to be enabled (nominal, 0x88) to the master phase

or ---

     B)   Send OPERATION with the desired value as a group command.

or ---

     C)   Send OPERATION with the desired value as a General Call (Global Broadcast).

In (B) and (C) we recommend using PEC (Packet Error Checking) to make sure all units react in the same way. It is also important to set VOUT_TRANSITION_RATE to an appropriate number.

Other changes while enabled

For any other operational changes that need to be performed while enabled, please contact a Flex Power Modules FAE for assistance. Much of what can be done is product specific due to variations in how the digital controller's firmware works, and depends on how the controller is operating when the command is sent (i.e., whether the product is currently handling a transient response, fault, etc.).

Configuration updates

Configuration updates are where a product's configuration needs to change and be stored in non-volatile memory after the product has already been inserted in-system. Configuration updates help facilitate design changes and streamlines your production process by leveraging 'off the-shelf' products without using a separate programmer. To safely support configuration updates, we recommend the following:

1) Design for system-driven enable: Design the power system such that the products may be enabled via PMBus or have its control pin driven by the host controller.

2) If the product does not support flash programming while in operation, the system must be disabled.

3) Use delays on appropriate commands, notably storage related commands: When issuing STORE or RESTORE commands, a delay is needed afterwards before sending any other commands. This is to account for time to write to the non-volatile flash memory. Specific times for the storage commands, as well as other commands, are included in AN302 – PMBus Command Set or the Technical Specification of the product.

4) Perform a power-cycle after configuration: Certain commands will not take effect until after the input power is cycled.

In-system configuration steps for products without support for flash programming while in operation

To update or reconfigure a product that does not support flash programming while in operation, follow these steps:

1) Disable the output voltage either via PMBus disable (only applicable for products which have volatile OPERATION register) or control pin.

2) Issue commands following one of the 'Configuration' templates in Table 1, depending on whether your intent is to modify your existing configuration or completely reconfigure the product.

3) Power-cycle the product if required, otherwise re-enable the product's output.

Modifying and adding settings to an existing configuration	Clearing the existing configuration and reconfiguration
## Step 1: ## Disable the output ## Refresh User Store (clearing unsaved RAM values) SET address=20 01 WRITE_BYTE 00 #Disable via OPERATION #(0x01) command **16 SEND_BYTE #RESTORE_USER_ALL** DELAY 100 #100ms delay after store/restore ## Step 2. Modify Configuration. ## Insert commands to be added ## or modified in the User Store here. ## Step 3. Store the updated settings and ## Re-enable 15 SEND_BYTE #STORE_USER_ALL DELAY 100 #100ms delay after store/restore 01 WRITE_BYTE 80 #Enable via OPERATION (0x01) command	##Step 1. Disable the output ## and clear the User Store. ## SET address=20 01 WRITE_BYTE 00 #Disable via OPERATION #(0x01) command **12 SEND_BYTE #RESTORE_DEFAULT_ALL** DELAY 100 #100ms delay after store/restore ## Step 2. Reconfiguration. ## Insert all commands to be added ## in the User Store here. ## Step 3. Store the updated settings and ## Re-enable 15 SEND_BYTE #STORE_USER_ALL DELAY 100 #100ms delay after store/restore 01 WRITE_BYTE 80 #Enable via OPERATION (0x01) command

Table 1: Command template

Table 1 describes the command templates to modify configuration or clear and reconfigure the product, assuming the unit has address 20h. These are formatted in the SMBS format and may be used with the Flex Power Modules 'SMBus Tool'. If using an earlier-generation product without a user store, please contact a Flex Power Modules FAE for more information.

As bolded in **Table 1**, the actual difference between modifying versus reconfiguring a product just depends on whether RESTORE_USER_ALL or RESTORE_DEFAULT_ALL is used before issuing new commands to be stored. Generally, you may want to just modify an existing configuration if you are changing just a few commands. However, if you

need to reset certain commands back to their default values, reconfiguration must be done. This is due to a limitation on most products where the firmware currently doesn't support the RESTORE_DEFAULT_CODE command.

Using Flex Power Designer to help with operational changes & in-system configuration updates

One of the common issues when using your host controller is knowing how exactly commands should be communicated across the bus. It is recommended that you read [AN304 (Microcontroller Programming for Digital Products)](#) for more information. In addition, [Flex Power Designer's](#) "Export to SMBS file" feature exports to the SMBus tool (SMBS) format. This format includes PMBus command codes and arranges data bytes in the correct order to be sent consecutively on the bus.

The example shown earlier in [Table 1](#) follows the SMBS format, and a full specification of the format is included with the Flex Power Designer installation. To export your project to the format, open your project and then in the File menu click on Export -> Export to SMBS Configuration File, as shown in Figure 2 below
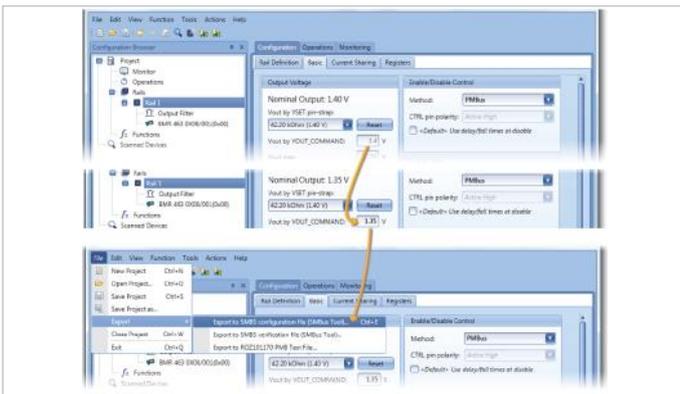

Figure 2: Example of making a single change to a new project then exporting it as an SMBS file
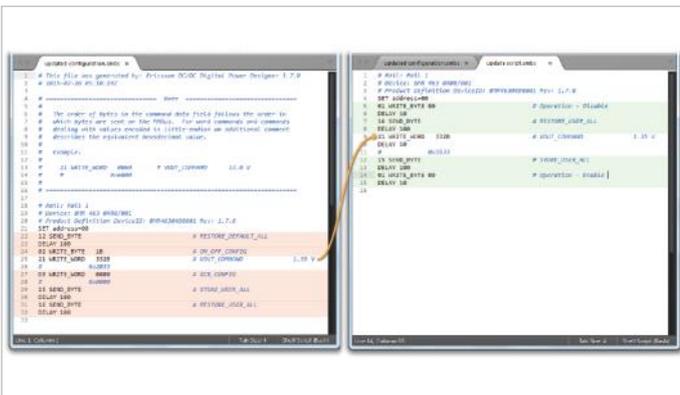

Figure 3: Modifying an SMBS file exported from Flex Power Designer to function as an update

After saving the file, open it in a text editor and look for the product address you want to reconfigure. If you are planning to only modify an existing configuration with a subset of changes, you will want to extract only the commands related to the update.

Figure 3 illustrates this by taking the exported file from Figure 2 and modifying it to follow the update template shown in Table 1. In the example, the intent is to only introduce the modification of VOUT_COMMAND, and not alter the state of operational control, so the configuration update script is trimmed down to only introduce that change. Additionally, a time delay is introduced per-command as noted in the product's technical specification – this delay is already present when using the USB-PMBus dongle due to USB transmission delays but needs to be known when communicating in-system with the host controller. For convenience, [Appendix 1](#) provides a table of some known time delays between certain commands.

Product specific considerations

When communicating with products in-system, there are some product-specific considerations to be aware of. For additional information on command issues, consult the product's technical specification.

BMR461

Configuration updates & issuing RESTORE commands
The [BMR 461](#) has a known issue with how its RESTORE commands work where several command values (such as the operating voltage, etc.) will change to non-default value after issuing a RESTORE_USER_ALL or RESTORE_DEFAULT_ALL command. Due to that, it is recommended that either the BMR461 input power be cycled after a configuration update occurs before it is re-enabled, or one of the workarounds below is performed.

- If modifying an existing configuration, you can work around this issue by ensuring that the configuration update occurs before any other PMBus values are written after powerup. This allows you to avoid issuing the RESTORE_USER_ALL command beforehand. To do this safely requires that you are controlling the enable state via the enable pin, or can issue enable via the OPERATION command every time upon powerup.

- If reconfiguring without a power-cycle, another alternative is to retain then configure a value for all commands (i.e., your configuration as well as default values) – this workaround is what is performed by the Flex Power Designer and is also what will appear in its SMBS export file.

Due to a different data storing structure, this product's stored analog values (voltage, current and temperature) are not bit-by-bit identical between WRITE in data and READ out data. If the user wants to verify the data integrity, the value should be converted into decimal format domain with certain tolerance.

The digital values, for example protection responsiveness mode, is still bit-by-bit identical.

BMR462/463/464/466

VOUT_MAX delay
It is recommended that a 10ms delay is added after issuing the VOUT_MAX command. This is to provide the device firmware additional time to re-calculate default values dependent on this value (nominal/margin defaults, etc.)

Other products

Please refer to the product documentation.

Appendix 1

As mentioned earlier, there are specific delay times for products when communicating with them over PMBus, due to how the internal firmware works. Below are tables for delay timings for the products covered in this guide. Delay timings for other products may be found in their technical specification.

BMR456/BMR457		
Command name	**Delay time required after sending command**	**Comment**
Bus-free time required between any STOP and START condition on the bus:		
Any transaction	1.3 µs	This is a minimum required bus free time between commands.
STORE_DEFAULT_ALL STORE_USER_ALL RESTORE_DEFAULT_ALL RESTORE_USER_ALL	500 ms	This delay is required to allow the firmware to perform operations with the Non-volatile memory

BMR456/BMR457		
Command name	**Delay time required after sending command**	**Comment**
Bus-free time required between any STOP and START condition on the bus:		
Any transaction	1.3 µs	This is a minimum required bus free time between commands.
Delay times required between subsequent transaction ot the same device		
All Commands	2ms when reading 10ms when writing	This delay is required due to known limitations in the controller's firmware.
STORE_DEFAULT_ALL STORE_USER_ALL RESTORE_DEFAULT_ALL RESTORE_USER_ALL	500 ms	This delay is required due to known limitations in the controller's firmware.
VOUT_MAX	10 ms	This delay is required to allow the firmware time to recalculate default values dependent on VOUT_MAX

BMR461		
Command name	**Delay time required after sending command**	**Comment**
Bus-free time required between any STOP and START condition on the bus:		
Any transaction	1.3 μs	This is a minimum required bus free time between commands.
Delay times required between subsequent transaction to the same device		
STORE_DEFAULT_ALL STORE_USER_ALL DEADTIME_GCTRL	500 ms	This delay is required due to known limitations in the controller's firmware.
VOUT_MAX	10 ms	This delay is required to allow the firmware time to recalculate default values dependent on VOUT_MAX

flex. Power Modules

Flex Power Modules, a business line of Flex, is a leading manufacturer and solution provider of scalable DC/DC power converters primarily serving the data processing, communications, industrial and transportation markets. Offering a wide range of both isolated and non-isolated solutions, its digitally-enabled DC/DC converters include PMBus compatibility supported by the powerful Flex Power Designer.

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