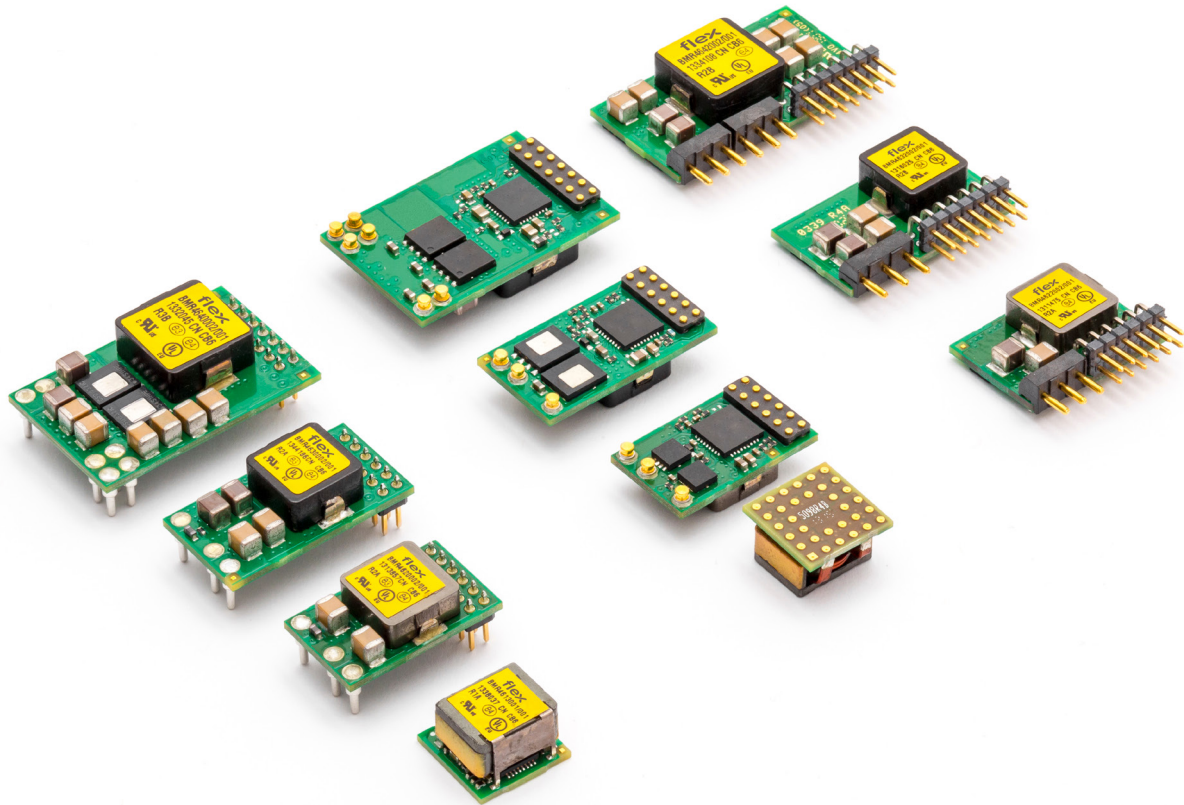


Application Note 302

Flex Power Modules



PMBus Command Set – 3E Series Power Modules

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Abstract

This document, used in conjunction with the PMBus specifications and the Technical Specifications for each product, provides a detailed description of each PMBus command available in the 3E Series modules. For each available command, the applicable products are identified, a brief description of the command's function is given, and the details of the command data needed to program the device are provided.

Introduction

Flex's 3E Series modules are designed with state-of-the-art digital controllers. This provides the user with superior electrical performance and a broad capability to configure, control and monitor the products in the engineering lab, in the factory, and in the field. This capability is provided by the use of the open-standard PMBus™ digital power management protocol.

The PMBus protocol was created by the System Management Interface Forum (SMIF) and Power Management Bus (PMBus) Implementers Forum to standardize communication with a wide range of power conversion devices. The resulting PMBus standard is written in two parts. The first, "Specification Part I – General Requirements Transport and Electrical Interface", specifies the transport including the physical layer, addressing, and packet structure. The second, "Specification Part II – Command Language", specifies the command language to be used when communicating with PMBus compliant devices. The PMBus specifications are freely available at the PMBus Web site:

<http://www.pmbus.org>

This app note is split into two chapters. The first chapter details commands for the 3E Series non-isolated POL modules. These modules feature the Group Command Bus (GCB) – an inter-device communication bus that provides additional features such as digital current sharing, sequencing, and fault management.

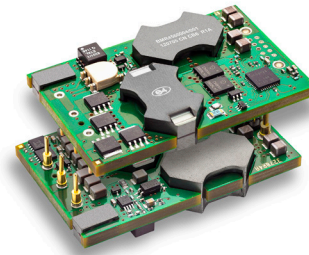
The second chapter is for the 3E Series isolated modules. These modules offer many similar commands as the non-isolated modules, and provide a number of input enable options.

For recently released products, the PMBus command information can be found in the product's Technical Specification.

3E Portfolio

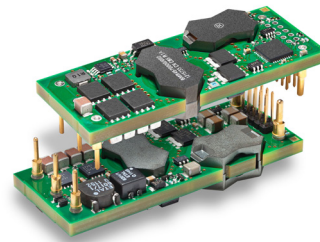
BMR 456 SERIES 39 A

Digitally controlled 3E Isolated DC/DC
Advanced Bus Converter
Efficiency, typ. 96%
Input voltage range, 36-75 V
Output power 468 W
Size (LxWxH): 57.9 x 36.8 x 11.3 mm
(2.28 x 1.45 x 0.445 inch)



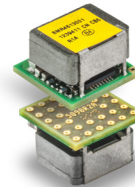
BMR 457 SERIES 25 A

Digitally controlled 3E Isolated DC/DC
Advanced Bus Converter (Isolated DC/DC Converter)
Efficiency, typ. 95.5%
Input voltage range, 36-75 V
Output power 300 W
Size (LxWxH): 58.4 x 22.7 x 10.2 mm
(2.30 x 0.89 x 0.40 inch)



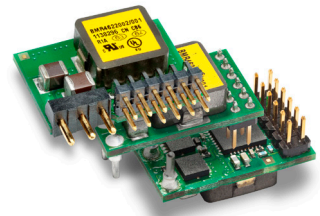
BMR 461 SERIES 6/12/18 A

Digitally controlled 3E POL regulator
Efficiency, typ. 96%
Input voltage range, 4.5-14 V
Output power up to 60 W
Size (LxWxH): 12.2 x 12.2 x 8.0 mm
(0.48 x 0.48 x 0.315 inch)



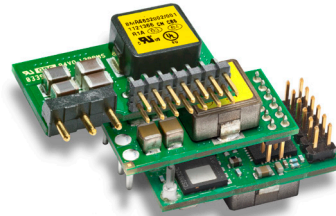
BMR 462 SERIES 12 A

Digitally controlled 3E POL regulator
Efficiency, typ. 97.1%
Input voltage range, 4.5-14 V
Output power 60 W
Size (LxWxH): 21.0 x 12.7 x 8.2 mm
(0.83 x 0.50 x 0.32 inch)



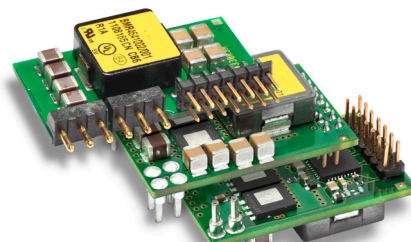
BMR 463 SERIES 20/25 A

Digitally controlled 3E POL regulator
Efficiency, typ. 97.1%
Input voltage range, 4.5-14 V
Output power up to 82.5 W
Size (LxWxH): 25.6 x 13.8 x 8.2 mm



BMR 464 SERIES 40/50 A

Digitally controlled 3E POL regulator
Efficiency, typ. 97.2%
Input voltage range, 4.5-14 V
Output power up to 165 W
Size (LxWxH): 30.8 x 20.0 x 8.2 mm



More Information on PMBus

Forum Websites

The System Management Interface Forum (SMIF)

<http://www.powersig.org/>

The System Management Interface Forum (SMIF) supports the rapid advancement of an efficient and compatible technology base that promotes power management and systems technology implementations. The SMIF provides a membership path for any company or individual to be active participants in any or all of the various working groups established by the implementer forums.

Power Management Bus Implementers Forum (PMBUS-IF)

<http://pmbus.org/>

The PMBus-IF supports the advancement and early adoption of the PMBus protocol for power management. This website offers recent PMBus specification documents, PMBus articles, as well as upcoming PMBus presentations and seminars, PMBus Document Review Board (DRB) meeting notes, and other PMBus related news.

PMBus – Power System Management Bus Protocol Documents

These specification documents may be obtained from the PMBus-IF website described above. These are

required reading for complete understanding of the PMBus implementation. This application note will not re-address all of the details contained within the two PMBus Specification documents.

Specification Part I – General Requirements Transport And Electrical Interface

Includes the general requirements, defines the transport and electrical interface and timing requirements of hardwired signals.

Specification Part II – Command Language

Describes the operation of commands, data formats, fault management and defines the command language used with the PMBus.

SMBus – System Management Bus Documents

System Management Bus Specification, Version 2.0, August 3, 2000

This specification specifies the version of the SMBus on which Revision 1.2 of the PMBus Specification is based. This specification is freely available from the System Management Interface Forum Web site at:

<http://www.smbus.org/specs/>

Data Formats

The devices in this app note make use of a few standardized numerical formats, along with custom data formats.

The numeric formats are as follows:

- > Linear Data Format - 16-bit floating point format using an 11-bit mantissa and 5-bit exponent
- > V_{out} Linear Data Format - A floating point format that uses a 16-bit unsigned mantissa within for the commands value, and a 'global' 5-bit exponent in the VOUT_MODE command.
- > Signed V_{out} Linear Data Format - A floating point

format that uses a 16-bit two's complement mantissa within for the commands value, and a 'global' 5-bit exponent in the VOUT_MODE command.

- > Direct Format - This is a master-processed floating point format that uses custom coefficient values written in the command documentation.

A detailed walkthrough of the above formats is provided in AN304, as well as in sections 7 and 8 of the PMBus Specification Part II.

The custom data formats vary depending on the command, and are detailed in the command description.

Chapter 1: PMBus Commands for 3E Series Non-Isolated Modules

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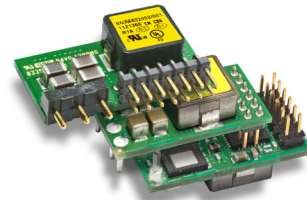
BMR 461 SERIES 6/12/18 A
Digitally controlled 3E POL regulator
Efficiency, typ. 96%
Input voltage range, 4.5-14 V
Output power up to 60 W
Size (LxWxH): 12.2 x 12.2 x 8.0 mm



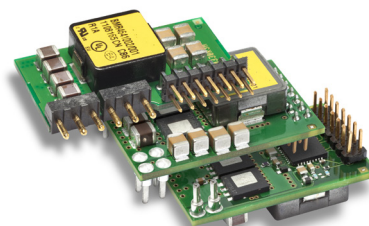
BMR 462 SERIES 12 A
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Efficiency, typ. 97.1%
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Output power 60 W
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BMR 463 SERIES 20/25 A
Digitally controlled 3E POL regulator
Efficiency, typ. 97.1%
Input voltage range, 4.5-14 V
Output power up to 82.5 W
Size (LxWxH): 25.6 x 13.8 x 8.2 mm



BMR 464 SERIES 40/50 A
Digitally controlled 3E POL regulator
Efficiency, typ. 97.2%
Input voltage range, 4.5-14 V
Output power up to 165 W
Size (LxWxH): 30.8 x 20.0 x 8.2 mm



Applicability

This document applies to the BMR450 regulator, the BMR451 regulator, and all members of the BMR46x family of regulators.

Most PMBus commands have the same data format and effect for these regulators. However, there are some exceptions.

For example, a command may be available for the BMR450 and BMR451 regulators but not the BMR46x regulators. In other cases the same command code may have different meanings and effects depending on the specific model. The details of these differences are listed with each PMBus command described in this document.

PMBus Command Description

Each available PMBus command is described below in the following format:

PMBUS_COMMAND_NAME

Applies To: <list of converters that support this command>

Command Code: <in hex>

Type: <SMBus transfer type>

Data Length In Bytes: <number>

Data Format: <PMBus data format>

Factory Value: <in hex and (decimal)>

Units: <data units>

Reference: <reference to related command or application note>

Definition: <brief description of command's operation>

Memory, Configuration Management, And Security

Power On Configuration

When operating, the 3E regulators maintain configuration information, such as the output voltage setting, in RAM in the controller IC. When the regulator is initially powered on, the RAM is loaded in the order specified by the PMBus specifications.

First, the controller IC will check the pin-strap settings and load the appropriate settings into RAM. Then the controller will copy the saved configuration information from the non-volatile memory to RAM. If the values retrieved from the non-volatile memory are different than the values set by pin-strapping, the pin-strapped values are overwritten.

At this point the regulator is operating as programmed and ready to accept an enable signal from the CTRL pin and start receiving commands from the PMBus.

A detailed description of each product's initialization

sequence at power on is provided in the product's Technical Specification.

Pin Strap Settings

The BMR450, BMR451, and BMR46x regulators offer the user additional flexibility through the use of pin-strapping. For example, the output voltage might be set by attaching a fixed resistor from a specified pin to ground. The descriptions of some PMBus commands refer to the pin-strap settings. These settings are different in the BMR450/BMR451 and BMR46x products as described below.

Pin-strapping The BMR450 and BMR451 3E Regulators

The BMR450 and BMR451 regulators feature the FLEX pin. The FLEX pin can be used to either set the output voltage or for frequency synchronization. How to configure the FLEX pin is given below in the description of the POLA_VADJ_CONFIG and USER_CONFIG commands.

Additional information is given in the Technical Specifications of these products.

Pin-strapping the BMR46x 3E Regulators

The BMR46x regulators allow the output voltage to be set by connecting a fixed resistor between the VSET and PREF pins. The details are given in the Technical Specification for these products.

Non-Volatile Memory

BMR450 and BMR451

The BMR450 and BMR451 3E regulators have one non-volatile memory bank called the DEFAULT_STORE. Settings for any PMBus command supported by the BMR450 and BMR451 can be saved here. When the regulator is powered on, the settings saved in the DEFAULT_STORE will be loaded into the controller IC RAM.

The STORE_DEFAULT_ALL PMBus command is used to save the current contents of the device RAM to the DEFAULT_STORE. To move the settings into RAM on command, the RESTORE_DEFAULT_ALL command is used.

Saving to the DEFAULT_STORE is only allowed if the device is at the Security Level 3, which is set by sending the PRIVATE_PASSWORD command with the password already saved in the DEFAULT_STORE.

Note that saving customized settings to the DEFAULT_STORE overwrites the values set at the Flex factory. Once these values have been overwritten, the regulator cannot be restored to the same settings as when it came from the factory.

BMR461 and BMR462-464

The BMR461 and BMR462-464 regulators have two non-volatile memory banks: USER_STORE and DEFAULT_STORE. The DEFAULT_STORE is reserved for Flex's use. It contains all of the settings programmed into the regulator at the time of manufacture. This allows a regulator to be restored to "factory condition" with the RESTORE_DEFAULT_ALL command.

The USER_STORE is made available to customers to store their customized settings. For example, when a 3E regulator is installed on a circuit board with its load, the output voltage and output voltage trim values may be adjusted by automatic test equipment (ATE). These values can be permanently saved with the STORE_USER_ALL command. The settings saved in the USER_STORE can also be copied to the regulator's RAM with the RESTORE_USER_ALL command.

At initialization of BMR462-464 the settings in USER_STORE will override the settings in DEFAULT_STORE. For BMR461 the DEFAULT_STORE settings are not used at initialization, only the values in USER_STORE are loaded. See each product's Technical Specification

for more details on the initialization procedure.

Protecting Commands Against Changes

BMR461

Individual commands can be protected against changes with the USER_CONF command. The data for the USER_CONF command is a bitvector of 256 bits (32 bytes) - one for each command code. Bit 0, the least significant bit, corresponds to PMBus command code 0x00.

Additionally, commands can be globally protected from writes by using the WRITE_PROTECT command.

Setting the bit corresponding to a given PMBus command code to 0 in the regulator's non-volatile memory (USER_STORE for the BMR461) allows the command to be written with new data ("unprotected"). Setting the bit to 1 prevents the regulator from accepting a new value for that command.

This command protection is in place regardless of the regulator's security level. In order to change the USER_CONF command settings, the regulator must be at the appropriate Security Level (Level 1 for the BMR461 regulator, read back with the SECURITY_LEVEL command). Once the USER_CONF command has been written to the regulator, it must be saved in the non-volatile memory using the STORE_USER_ALL command.

BMR462-464

Individual commands can be protected against changes with the UNPROTECT command. The data for the UNPROTECT command is a bitvector of 256 bits (32 bytes) - one for each PMBus command code. Bit 0, the least significant bit, corresponds to PMBus command code 0x00.

Setting the bit corresponding to a given PMBus command code to 1 in the regulator's non-volatile memory (USER_STORE for the BMR46x and DEFAULT_STORE for the BMR450 and BMR451) allows the command to be written with new data ("unprotected"). Setting the bit to 0 prevents the regulator from accepting a new value for that command.

This command protection is in place regardless of the regulator's security level. In order to change the UNPROTECT command settings, the regulator must be at the appropriate Security Level (Level 2 for the BMR462-464 regulators, read-back with the SECURITY_LEVEL command). Once the UNPROTECT command has been written to the regulator, it must be saved in the non-volatile memory via the STORE_USER_ALL command.

Passwords And Security Levels

As mentioned above, the 3E regulators have different security levels that are accessed by the use of passwords.

BMR450 and BMR451

The BMR450 and BMR451 have Security Levels available to the user: Level 0 and Level 3.

In Level 0 the regulator is protected against all changes (read only mode). The only command that will be accepted for writing is the PRIVATE_PASSWORD command with the password that matches the one stored in the DEFAULT_STORE.

Writing the PRIVATE_PASSWORD command with the password that matches the one already stored in the DEFAULT_STORE sets the regulator to Security Level 3. At this level the device is unprotected. A new PRIVATE_PASSWORD can be written and changes can be made to the UNPROTECT command settings.

To exit Security Level 3 to Security Level 0, write the PUBLIC_PASSWORD with a value that does not match the PUBLIC_PASSWORD in the DEFAULT_STORE.

For both the PUBLIC_PASSWORD and PRIVATE_PASSWORD commands, a value of 0 (0x00000000 for the PUBLIC_PASSWORD and 0x00000000000000000000 for the PRIVATE_PASSWORD) is a special case. If the Security Level is 3 and the given password is 0, then writing the password command with a non-zero value will set the password to that value. Also, if the Security Level is 3, and then a password command is written with the zero value, the password is set to zero.

This means to change the password it must first be set to 0, then to the new value, and then saved into the DEFAULT_STORE with the STORE_DEFAULT_ALL command.

BMR461

The BMR461 has both a USER_STORE and a DEFAULT_STORE. However, the DEFAULT_STORE is reserved for Flex's use to store factory settings. Security Level 2, needed to change the DEFAULT_STORE, is protected and not available.

The BMR461 regulators have available Security Levels 0 and 1 - where the current level can be read with the SECURITY_LEVEL command. Additionally, the PMBus-standard WRITE_PROTECT command is available to globally protect from any writes without a password.

When the regulator is at Security Level 0, changes to protection of individual commands by USER_CONF can not be made. At Security Level 1 USER_CONF can be changed.

To transition from Security Level 0 (default) to Security Level 1 a password must be written to USER_PASSWD that matches the password previously written to

USER_LOCK. The default value of USER_LOCK is 0x0000.

In summary, the following sequence can be used to protect individual commands:

1. Enter the default password by writing 0x0000 to USER_PASSWD. After correct password is entered, SECURITY_LEVEL will read back 0x01 instead of default 0x00.
2. If desired, define a new password by writing it to the USER_LOCK command.
3. Define which commands should be locked by using the 256 bit command USER_CONF. Setting bit X to '1' will write protect the PMBus command with code X.
4. Send command STORE_USER_ALL to save new password and protection settings.
5. Cycle input voltage.

BMR462-464

The BMR462-464 regulators have both a USER_STORE and a DEFAULT_STORE. However, the DEFAULT_STORE is reserved for Flex's use to store factory settings. Security Level 3, needed to access the DEFAULT_STORE, is not available in the BMR46x regulators.

The BMR462-464 regulators have available Security Levels 0, 1, and 2.

In Level 0 the regulator is protected against all changes (read only mode). Writing the PUBLIC_PASSWORD with the public password already in the USER_STORE sets the regulator to Security Level 1. Writing the PRIVATE_PASSWORD with the private password already in the USER_STORE set the regulator to Security Level 2.

When the regulator is at Security Level 1, write access is granted to commands for which the UNPROTECT bit is set in both the USER_STORE and the DEFAULT_STORE. The regulator can be taken back to Security Level 0 by writing the PUBLIC_PASSWORD command with a password that does not match the password in the USER_STORE.

Security Level 2 is intended for the user of the BMR46x regulators. Write access is granted for all commands for which the UNPROTECT bit is set in both the USER_STORE and DEFAULT_STORE. To prevent changes made at Security Level 1 from being saved, the UNPROTECT bit for the STORE_USER_ALL and RESTORE_DEFAULT_ALL commands should be cleared. The regulator can be taken back to Security Level 0 by writing the PUBLIC_PASSWORD command with a password that does not match the password in

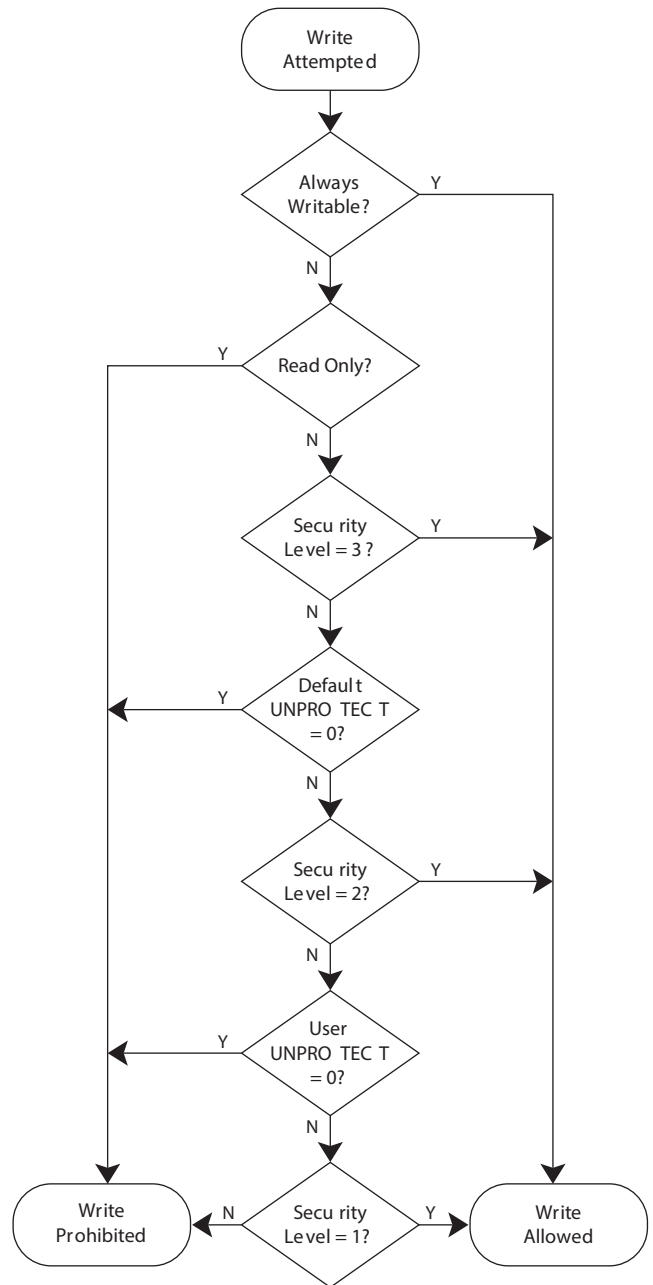
the USER_STORE.

For both the PUBLIC_PASSWORD and PRIVATE_PASSWORD commands, a value of 0 (0x00000000 for the PUBLIC_PASSWORD and 0x00000000000000000000 for the PRIVATE_PASSWORD) is a special case.

If the regulator is at Security Level 1 or 2, and a PUBLIC_PASSWORD or PRIVATE_PASSWORD command is sent with a password equal to 0, the password is set to 0. Once a password is set to 0, it can be set to a new value by writing a non-zero value.

This means to change a password it must first be set to 0, then to the new value, and then saved to the USER_STORE with the STORE_USER_ALL command.

Figure 1. Password and security levels for BMR462-464.



PMBus Commands

Control Commands

OPERATION

Applies To: BMR450, BMR451, BMR46x

Command Code: 0x01

Type: R/W Byte - Protectable

Data Length In Bytes: 1

Data Format: Custom

Factory Value: N/A

Units: N/A

Reference: Section 12.1 - PMBus Spec Part II

Definition: The OPERATION command is used, in conjunction with the hardwired CTRL pin, to turn the regulator output on and off. It also used to set the margin state (margin high, margin low, no margin) of the output voltage.

For the non-isolated modules only, the OPERATION command is also a monitorable command. This means the value read back from OPERATION reflects the actual operating state of the module. This also means that the readback is 'volatile', meaning that if one writes a value to OPERATION, there is no guarantee that the device's readback will be the same value as what was sent.

Note: All margin settings are "Act on Fault" type. "Ignore Fault" settings are ignored and "Act on Fault" is used.

A simplified version of the OPERATION values are shown in Table 1 below. Please refer to Section 12.1 of the PMBus Spec Part II for a complete table:

Table 1: OPERATION command states

Value	Definition
0x00	Disable Immediately
0x60	Disable w/ Soft Off
0x80	Enable, No Margin
0x96 & 0x98	Enable, Margin Low (Act on Fault)
0xA6 & 0xA8	Enable, Margin High (Act on Fault)

ON_OFF_CONFIG

Applies To: BMR450, BMR451, BMR46x

Command Code: 0x02

Type: R/W Byte - Protectable

Data Length In Bytes: 1

Data Format: Custom

Factory Value: 0x17

Units: N/A

Reference: Section 12.2 - PMBus Spec Part II

Definition: Configures the interpretation and coordination of the OPERATION command and the CTRL pin.

Input Commands

VIN_ON

Applies To: BMR461

Command Code: 0x35

Type: R/W Word - Protectable

Data Length In Bytes: 2

Data Format: Section 7.1 - PMBus Spec Part II - Linear Data Format

Factory Value: 4.35 V

Units: Volts (V)

Reference: Section 14.5 - PMBus Spec Part II

Definition: Sets the threshold of input voltage above which enabling of the output voltage is possible. There is a hysteresis to this function, see VIN_OFF.

VIN_OFF

Applies To: BMR461

Command Code: 0x36

Type: R/W Word - Protectable

Data Length In Bytes: 2

Data Format: Section 7.1 - PMBus Spec Part II - Linear Data Format

Factory Value: 3.8 V

Units: Volts (V)

Reference: Section 14.6 - PMBus Spec Part II

Definition: Sets the threshold of input voltage below which the output voltage is always disabled.

Output Commands

VOUT_MODE

Applies To: BMR450, BMR451, BMR46x

Command Code: 0x20

Type: Read Byte

Data Length In Bytes: 1

Data Format: Mode + Exponent Format

Factory Value:

BMR461: 0x14 (Linear Mode, Exponent = -12)

Other: 0x13 (Linear Mode, Exponent = -13)

Units: N/A

Reference: Section 8 - PMBus Spec Part II

Definition: Preset to define the data format of the output voltage related commands (example: VOUT_COMMAND).

VOUT_COMMAND

Applies To: BMR450, BMR451, BMR46x

Command Code: 0x21

Type: R/W Word - Protectable

Data Length In Bytes: 2

Data Format: Section 8.3.1 - PMBus Spec Part II - VOUT linear mode

Factory Value: Pin-strap setting value (FLEX pin on BMR450 and BMR451; VSET pin on the BMR46x)

Units: Volts (V)

Reference: Section 8 - PMBus Spec Part II - VOUT_MODE

Definition: Sets the nominal value of the output voltage. The output voltage will be set to:

$$\text{Output Voltage} = \text{VOUT_COMMAND} \times 2^{\text{Exponent}}$$

For example, sending the VOUT_COMMAND command with the data bytes of 0x5000 will set the output to approximately 2.50 V (VOUT_MODE = 0x13; Exponent = -13):

$$\begin{aligned}\text{Output Voltage} &= \text{VOUT_COMMAND} \times 2^{-13} \\ &= 0x5000 \times (122.07 \times 10^{-6}) \\ &= 20,480 \times (122.07 \times 10^{-6}) \\ &= 2.500\end{aligned}$$

Please note there are limiting functions for the maximum output voltage that can be set using VOUT_COMMAND. Furthermore the VOUT_MODE exponent will vary depending on the part used (e.g. BMR461 is -12). See Technical Specification of each product for more details.

VOUT_TRIM

Applies To: BMR450, BMR451, BMR46x

Command Code: 0x22

Type: R/W Word - Protectable

Data Length In Bytes: 2

Data Format: Signed VOUT linear mode (see definition)

Factory Value: 0x0000

Units: Volts (V)

Reference: Section 13.3 - PMBus Spec Part II - VOUT_MODE

Definition: Sets output voltage trim value. The two bytes are formatted as a two's complement binary mantissa, used in conjunction with the exponent set in VOUT_MODE.

VOUT_CAL_OFFSET

Applies To: BMR450, BMR451, BMR46x

Command Code: 0x23

Type: R/W Word - Protectable

Data Length In Bytes: 2

Data Format: Signed VOUT linear mode (see definition)

Factory Value: Individually calibrated at the factory

Units: Volts (V)

Reference: Section 13.4 - PMBus Spec Part II - VOUT_MODE

Definition: Sets the output voltage calibration offset (same function as VOUT_TRIM). The two bytes are formatted as a two's complement binary mantissa, used in conjunction with the exponent set in VOUT_MODE.

Note: This command was previously known as VOUT_CAL.

VOUT_MAX

Applies To: BMR450, BMR451, BMR46x

Command Code: 0x24

Type: R/W Word - Protectable

Data Length In Bytes: 2

Data Format: Section 8.3.1 - PMBus Spec Part II - VOUT Linear Mode

Factory Value: $1.10 \times \text{VOUT_COMMAND}$

Units: Volts (V)

Reference: Section 13.5 - PMBus Spec Part II - VOUT_MODE

Definition: Sets the maximum possible value setting of the output voltage. For BMR450, BMR451 and BMR462-464 the maximum VOUT_MAX setting is 110% of the output voltage pin-strap setting.

VOUT_MARGIN_HIGH

Applies To: BMR450, BMR451, BMR46x

Command Code: 0x25

Type: R/W Word - Protectable

Data Length In Bytes: 2

Data Format: Section 8.3.1 - PMBus Spec Part II - VOUT Linear Mode

Factory Value: $1.05 \times \text{VOUT_COMMAND}$

Units: Volts (V)

Reference: Section 13.6 - PMBus Spec Part II - VOUT_MODE

Definition: Sets the value of the output voltage during the margin high operation state. To change the operation to output margin high, please refer to the OPERATION command.

VOUT_MARGIN_LOW

Applies To: BMR450, BMR451, BMR46x

Command Code: 0x26

Type: R/W Word - Protectable

Data Length In Bytes: 2

Data Format: Section 8.3.1 - PMBus Spec Part II - VOUT Linear Mode

Factory Value: $0.95 \times \text{VOUT_COMMAND}$

Units: Volts (V)

Reference: Section 13.7 - PMBus Spec Part II - VOUT_MODE

Definition: Sets the value of the output voltage during the margin low operation state. To change the operation to output margin low, please refer to the OPERATION command.

VOUT_TRANSITION_RATE

Applies To: BMR450, BMR451, BMR46x

Command Code: 0x27

Type: R/W Word - Protectable

Data Length In Bytes: 2

Data Format: Section 7.1 - PMBus Spec Part II - Linear Data Format

Factory Value:

BMR461: 0.1 V/ms

Other: 1 V/ms

Units: Volts (V)/ms

Reference: Section 13.8 - PMBus Spec Part II

Definition: Sets the output voltage transition rate during margin or other change of VOUT.

VOUT_DROOP

Applies To: BMR450, BMR451, BMR46x
Command Code: 0x28
Type: R/W Word - Protectable
Data Length In Bytes: 2
Data Format: Section 7.1 - PMBus Spec Part II - Linear Data Format
Factory Value: 0x0000
Units: mV/A
Reference: AN307, Parallel Operation with Load Sharing and Section 13.9 - PMBus Spec Part II
Definition: Sets the effective load line (V/I slope) of the output voltage.

MAX_DUTY

Applies To: BMR450, BMR451, BMR462-464
Command Code: 0x32
Type: R/W Word - Protectable
Data Length In Bytes: 2
Data Format: Section 7.1 - PMBus Spec Part II - Linear Data Format
Factory Value: 0xEAF8 (95)
Units: %
Reference: Section 14.3 - PMBus Spec Part II
Definition: Sets the maximum allowable duty cycle of the switching frequency.
Note: MAX_DUTY should not be used to set the output voltage of the device. VOUT_COMMAND is the proper method to set the output voltage.

FREQUENCY_SWITCH

Applies To: BMR450, BMR451, BMR46x
Command Code: 0x33
Type: R/W Word - Protectable
Data Length In Bytes: 2
Data Format: Section 7.1 - PMBus Spec Part II - Linear Data Format
Factory Value:
BMR461: 600 kHz
Other: 320 kHz
Units: kHz
Reference: Section 14.4 - PMBus Spec Part II
Definition: Sets the switching frequency. See each product's Technical Specification for applicable range. For BMR450, BMR451 and BMR462-464 the frequency is defined by:

$$F_{SWITCH} = \frac{8 \text{ MHz}}{N}; 6 \leq N \leq 40$$

INTERLEAVE

Applies To: BMR450, BMR451, BMR46x
Command Code: 0x37
Type: R/W Word - Protectable
Data Length In Bytes: 2
Data Format: Custom (See Table 2)
Factory Value: 0x0000.
Units: N/A
Reference: Section 14.7 - PMBus Spec Part II
Definition: Configures the phase offset of a device that is sharing a common SYNC clock with other devices.

Note that for Flex devices, a value of 0 for the Number in Group field is interpreted as 16, to allow for phase spreading groups of up to 16 devices.

For BMR462-464 the value of INTERLEAVE is not strictly adhered to when used in devices of a current sharing rail. For current sharing rails, INTERLEAVE is used to set the initial phase of the rail. The current share devices then automatically distribute their phase relative to the INTERLEAVE setting. Refer to AN307 for the phase control rules of a current shared rail.

For BMR461, writing an INTERLEAVE value of 0x0000 makes the phase offset controlled by the set PMBus address. See Technical specification for details.

Refer to application note AN307 for details on synchronization and phase spreading using the INTERLEAVE command.

Table 2. INTERLEAVE command data specification

Bits	Purpose	Value	Description
15:12	Reserved	0	Reserved
11:8	Group Number	0 to 15	Sets a number to a group of interleaved rails
7:4	Number in Group	16, 1 to 15 (0 = 16)	Sets the number of rails in the group A value of 0 is interpreted as 16
3:0	Position in Group	0 to 15	Sets position of the device's rail within the group

IOUT_CAL_GAIN

Applies To: BMR450, BMR451, BMR46x

Command Code: 0x38

Type: R/W Word - Protectable

Data Length In Bytes: 2

Data Format: Section 7.1 - PMBus Spec Part II - Linear Data Format

Factory Value: Individually calibrated at the factory

Units: mΩ

Reference: Section 14.8 - PMBus Spec Part I

Definition: This command tells the controller IC the value of the resistance used to monitor the output current. It is recommended that this value not be changed.

IOUT_CAL_OFFSET

Applies To: BMR450, BMR451, BMR46x

Command Code: 0x39

Type: R/W Word - Protectable

Data Length In Bytes: 2

Data Format: Section 7.1 - PMBus Spec Part II - Linear Data Format

Factory Value: Factory Individually calibrated at factory

Units: Amperes (A)

Reference: Section 14.9 - PMBus Spec Part II

Definition: For current sense calibration, this command provides the controller with the value of the offset correction to be applied to the measured output current. It is recommended not to change this value.

Fault Limit Commands**POWER_GOOD_ON**

Applies To: BMR450, BMR451, BMR46x

Command Code: 0x5E

Type: R/W Word - Protectable

Data Length In Bytes: 2

Data Format: Section 8.3.1 - PMBus Spec Part II - VOUT Linear Mode

Factory Value: $0.9 \times VOUT_COMMAND$

Units: Volts (V)

Reference: Section 15.32.1 - PMBus Spec Part II

Definition: Sets the voltage threshold for Power-Good indication. Power-Good asserts when the output voltage exceeds POWER_GOOD_ON and de-asserts when the output voltage is less than POWER_GOOD_OFF for BMR461, or less than VOUT_UV_FAULT_LIMIT for the other products.

POWER_GOOD_OFF

Applies To: BMR461

Command Code: 0x5F

Type: R/W Word - Protectable

Data Length In Bytes: 2

Data Format: Section 8.3.1 - PMBus Spec Part II - VOUT Linear Mode

Factory Value: $0.85 \times VOUT_COMMAND$

Units: Volts (V)

Reference: Section 15.32.2 - PMBus Spec Part II

Definition: Sets the voltage threshold for de-assertion of Power-Good indication.

VOUT_OV_FAULT_LIMIT

Applies To: BMR450, BMR451, BMR46x

Command Code: 0x40

Type: R/W Word - Protectable

Data Length In Bytes: 2

Data Format: Section 8.3.1 - PMBus Spec Part II - VOUT Linear Mode

Factory Value: $1.15 \times VOUT_COMMAND$

Units: Volts (V)

Reference: Section 15.2 - PMBus Spec Part II

Definition: Sets the output overvoltage fault threshold.

VOUT_UV_FAULT_LIMIT

Applies To: BMR450, BMR451, BMR46x
Command Code: 0x44
Type: R/W Word - Protectable
Data Length In Bytes: 2
Data Format: Section 8.3.1 - PMBus Spec Part II - VOUT Linear Mode
Factory Value: $0.85 \times \text{VOUT_COMMAND}$
Units: Volts (V)
Reference: Section 15.6 - PMBus Spec Part II
Definition: Sets the output undervoltage fault threshold.

IOUT_OC_FAULT_LIMIT

Applies To: BMR450, BMR451, BMR46x
Command Code: 0x46
Type: R/W Word - Protectable
Data Length In Bytes: 2
Data Format: Section 7.1 - PMBus Spec Part II - Linear Data Format
Factory Value: Model dependent
Units: Amperes (A)
Reference: Section 15.8 - PMBus Spec Part II
Definition: Sets the output overcurrent fault threshold. In BMR450, BMR451 and BMR462-464, this command sets a threshold for the peak output current. For limiting the average output current, please see the IOUT_AVG_OC_FAULT_LIMIT command.

IOUT_AVG_OC_FAULT_LIMIT

Applies To: BMR450, BMR451, BMR462-464
Command Code: 0xE7
Type: R/W Word - Protectable
Data Length In Bytes: 2
Data Format: Section 7.1 - PMBus Spec Part II - Linear Data Format
Factory Value: Model dependent
Units: Amperes (A)
Reference:
Definition: This command sets the average output current overcurrent fault threshold. Shares the fault bit operation and OC fault response with IOUT_OC_FAULT_LIMIT.

IOUT_UC_FAULT_LIMIT

Applies To: BMR450, BMR451, BMR462-464
Command Code: 0x4B
Type: R/W Word - Protectable
Data Length In Bytes: 2
Data Format: Section 7.1 - PMBus Spec Part II - Linear Data Format
Factory Value: Model dependent.
Units: Amperes (A)
Reference: Section 15.13 - PMBus Spec Part II
Definition: This command sets the peak limit when the converter's synchronous rectifier output is sinking current from the load (undercurrent operation). For limiting the average output sink current, please see the IOUT_AVG_UC_FAULT_LIMIT command.

IOUT_AVG_UC_FAULT_LIMIT

Applies To: BMR450, BMR451, BMR462-464
Command Code: 0xE8
Type: R/W Word - Protectable
Data Length In Bytes: 2
Data Format: Section 7.1 - PMBus Spec Part II - Linear Data Format
Factory Value: Model dependent
Units: Amperes (A)
Reference:
Definition: This command sets the average output sink current (undercurrent) fault threshold. Shares the fault bit operation and UC fault response with IOUT_UC_FAULT_LIMIT.

OT_FAULT_LIMIT

Applies To: BMR450, BMR451, BMR46x
Command Code: 0x4F
Type: R/W Word - Protectable
Data Length In Bytes: 2
Data Format: Section 7.1 - PMBus Spec Part II - Linear Data Format
Factory Value: Model dependent.
Units: °C
Reference: Section 15.17 - PMBus Spec Part II
Definition: Sets the over-temperature fault threshold.

OT_WARN_LIMIT

Applies To: BMR450, BMR451, BMR46x
Command Code: 0x51
Type: R/W Word - Protectable
Data Length In Bytes: 2
Data Format: Section 7.1 - PMBus Spec Part II - Linear Data Format
Factory Value: Model dependent.
Units: °C
Reference: Section 15.19 - PMBus Spec Part II
Definition: Sets the over-temperature warning threshold. Also used as the hysteresis threshold for OT faults.

UT_WARN_LIMIT

Applies To: BMR450, BMR451, BMR462-464
Command Code: 0x52
Type: R/W Word - Protectable
Data Length In Bytes: 2
Data Format: Section 7.1 - PMBus Spec Part II - Linear Data Format
Factory Value: -50 °C
Units: °C
Reference: Section 15.20 - PMBus Spec Part II
Definition: Sets the undertemperature warning threshold. Also used as the hysteresis threshold for UT faults.

UT_FAULT_LIMIT

Applies To: BMR450, BMR451, BMR462-464
Command Code: 0x53
Type: R/W Word - Protectable
Data Length In Bytes: 2
Data Format: Section 7.1 - PMBus Spec Part II - Linear Data Format
Factory Value: -55 °C
Units: °C
Reference: Section 15.21 - PMBus Spec Part II
Definition: Sets the undertemperature fault threshold.

VIN_OV_FAULT_LIMIT

Applies To: BMR450, BMR451, BMR46x
Command Code: 0x55
Type: R/W Word - Protectable
Data Length In Bytes: 2
Data Format: Section 7.1 - PMBus Spec Part II - Linear Data Format
Factory Value: Model dependent.
Units: Volts (V)
Reference: Section 15.23 - PMBus Spec Part II
Definition: Sets the VIN overvoltage fault threshold.

VIN_OV_WARN_LIMIT

Applies To: BMR450, BMR451, BMR462-464
Command Code: 0x57
Type: R/W Word - Protectable
Data Length In Bytes: 2
Data Format: Section 7.1 - PMBus Spec Part II - Linear Data Format
Factory Value: Model dependent.
Units: Volts (V)
Reference: Section 15.25 - PMBus Spec Part II
Definition: Sets the VIN overvoltage warning threshold.

VIN_UV_WARN_LIMIT

Applies To: BMR450, BMR451, BMR462-464
Command Code: 0x58
Type: R/W Word - Protectable
Data Length In Bytes: 2
Data Format: Section 7.1 - PMBus Spec Part II - Linear Data Format
Factory Value: Model dependent.
Units: Volts (V)
Reference: Section 15.26 - PMBus Spec Part II
Definition: Sets the VIN undervoltage warning threshold.
If a VIN_UV_FAULT occurs, the input voltage must rise above VIN_UV_WARN_LIMIT to clear the fault. If product is enabled, VIN_UV_WARN_LIMIT sets the input voltage level at which the output voltage is turned on.

VIN_UV_FAULT_LIMIT

Applies To: BMR450, BMR451, BMR46x
Command Code: 0x59
Type: R/W Word - Protectable
Data Length In Bytes: 2
Data Format: Section 7.1 - PMBus Spec Part II - Linear Data Format
Factory Value: Model dependent.
Units: Volts (V)
Reference: Section 15.27 - PMBus Spec Part II
Definition: Sets the VIN undervoltage fault threshold.

TON_MAX_FAULT_LIMIT

Applies To: BMR461
Command Code: 0x62
Type: R/W Word - Protectable
Data Length In Bytes: 2
Data Format: Section 7.1 - PMBus Spec Part II - Linear Data Format
Factory Value: 500 ms
Units: ms
Reference: Section 16.3 - PMBus Spec Part II
Definition: Sets an upper limit on how long the product can attempt to power up the output.

Fault Response Commands

All 3E POL regulators' fault responses, including current faults, are defined by Table 3. If a device is used in a current sharing rail, the device will not attempt a retry until the entire current share rail attempts a retry following a disable event.

Table 3. Fault response command functions and data format

Bits	Description	Value	Meaning
7:6	Response: For all modes set by bits [7:6], the device: > Pulls SALERT low > Sets the related fault bit in the status registers. Fault bits are only cleared by the CLEAR_FAULTS command.	00	Continuous operation. (Ignore fault)
		01	Delay, Disable and Retry The delay time is specified by bits [2:0] and the delay time unit is specified for that particular fault. If the fault condition is still present at the end of the delay time, the unit retries according to the setting in bits [5:3].
		10	Disable and Retry according to the setting in bits [5:3].
		11	The device's output is disabled while the fault is present. Operation resumes and the output is enabled when the fault condition no longer exists.
5:3	Retry Setting	000	No Retry. The output remains disabled.
		001 to 110	The PMBus device attempts to restart the number of times set by these bits. The minimum number is 1 and the maximum number is 6. If the device fails to restart in the allowed number of retries, it disables the output and remains disabled. The time between the start of each attempt to retry is set by the value in bits [2:0] along with the delay time unit specified for that particular fault.
		111	The PMBus device attempts retry continuously until it is commanded to disable (by the Enable pin or OPERATION command), input power is removed, or another fault condition causes the unit to shut down.
2:0	Retry Time and Delay Time	000 to 111	This time count is used for both the amount of time between retry attempts and for the amount of time a rail is to delay its response after a fault is detected. The retry time and delay time units are in the individual response command descriptions.

Note: The delay time is the time between restart attempts.

For BMR461 the Retry/Delay time is 100 ms/LSB.

For BMR462-464 normally the Retry time = 8.2 ms/LSB and Delay time = 10 ms/LSB, except for OT_FAULT_RESPONSE and UT_FAULT_RESPONSE where Retry time = 32 ms/LSB and Delay time = 80 ms/LSB.

However for BMR463-464 in current sharing operation the Retry time instead becomes approximately 8.2 ms/LSB + configured TON_DELAY + 20 ms.

VOUT_OV_FAULT_RESPONSE

Applies To: BMR450, BMR451, BMR46x

Command Code: 0x41

Type: R/W Byte - Protectable

Data Length In Bytes: 1

Data Format: Section 10.5.1 - Custom (PMBus Spec Part II)

Factory Value: 0xBF (Retry always, max delay)

Units: ms

Reference: Section 15.3 - PMBus Spec Part II

Definition: Configures the output overvoltage fault response. Note that the two most significant bits can be written as 01 or 00. However, upon an overvoltage fault, these two bits will be set to 1:0 (i.e. bits (7:6) = 1:0). Thus an overvoltage fault cannot be set to be ignored.

VOUT_UV_FAULT_RESPONSE

Applies To: BMR450, BMR451, BMR46x
Command Code: 0x45
Type: R/W Byte - Protectable
Data Length In Bytes: 1
Data Format: Section 10.5.1 - Custom (PMBus Spec Part II)
Factory Value: 0xBF (Retry always, max delay)
Units: ms
Reference: Section 15.7 - PMBus Spec Part II
Definition: Configures the output undervoltage fault response.

IOUT_OC_FAULT_RESPONSE

Applies To: BMR461
Command Code: 0x47
Type: R/W Byte - Protectable
Data Length In Bytes: 1
Data Format: Section 10.5.1 - Custom (PMBus Spec Part II)
Factory Value: 0xBF (Retry always, max delay)
Units: ms
Reference: Section 15.9 - PMBus Spec Part II
Definition: Configures the output overcurrent fault response.
Note: The delay time is the time between restart attempts.

MFR_IOUT_OC_FAULT_RESPONSE

Applies To: BMR450, BMR451, BMR462-464
Command Code: 0xE5
Type: R/W Byte - Protectable
Data Length In Bytes: 1
Data Format: Section 10.5.1 - Custom (PMBus Spec Part II)
Factory Value: 0xBF (Retry always, max delay)
Units: ms
Reference: Section 15.3 - PMBus Spec Part II
Definition: Configures the output overcurrent fault response. The command format is the same as the PMBus standard responses for voltage and temperature faults except that it sets the overcurrent status bit.
Note: The delay time is the time between restart attempts.

MFR_IOUT_UC_FAULT_RESPONSE

Applies To: BMR450, BMR451, BMR462-464
Command Code: 0xE6
Type: R/W Byte - Protectable
Data Length In Bytes: 1
Data Format: Section 10.5.1 - Custom (PMBus Spec Part II)
Factory Value: 0xBF (Retry always, max delay)
Units: ms
Reference: Section 15.7 - PMBus Spec Part II
Definition: Configures the output undercurrent fault response. The command format is the same as the PMBus standard responses for voltage and temperature faults except that it sets the undercurrent status bit.
Note: The delay time is the time between restart attempts.

OT_FAULT_RESPONSE

Applies To: BMR450, BMR451, BMR46x
Command Code: 0x50
Type: R/W Byte - Protectable
Data Length In Bytes: 1
Data Format: Section 10.5.1 - Custom (PMBus Spec Part II)
Factory Value: 0xBF (Retry always, max delay)
Units: ms
Reference: Section 15.18 - PMBus Spec Part II
Definition: Configures the over-temperature fault response.
Note: The delay time is the time between restart attempts.

UT_FAULT_RESPONSE

Applies To: BMR450, BMR451, BMR462-464
Command Code: 0x54
Type: R/W Byte - Protectable
Data Length In Bytes: 1
Data Format: Section 10.5.1 - Custom (PMBus Spec Part II)
Factory Value: 0xBF (Retry always, max delay)
Units: ms
Reference: Section 15.22 - PMBus Spec Part II
Definition: Configures the undertemperature fault response.
Note: The delay time is the time between restart attempts.

VIN_OV_FAULT_RESPONSE

Applies To: BMR450, BMR451, BMR46x
Command Code: 0x56
Type: R/W Byte - Protectable
Data Length In Bytes: 1
Data Format: Section 10.5.1 - Custom (PMBus Spec Part II)
Factory Value: 0xBF (Retry always, max delay)
Units: ms
Reference: Section 15.24 - PMBus Spec Part II
Definition: Configures the VIN overvoltage fault response.
Note: The delay time is the time between restart attempts

VIN_UV_FAULT_RESPONSE

Applies To: BMR450, BMR451, BMR46x
Command Code: 0x5A
Type: R/W Byte - Protectable
Data Length In Bytes: 1
Data Format: Section 10.5.1 - Custom (PMBus Spec Part II)
Factory Value: 0xBF (Retry always, max delay)
Units: ms
Reference: Section 15.28 - PMBus Spec Part II
Definition: Configures the VIN undervoltage fault response.
Note: The delay time is the time between restart attempts

TON_MAX_FAULT_RESPONSE

Applies To: BMR461
Command Code: 0x63
Type: R/W Byte - Protectable
Data Length In Bytes: 1
Data Format: Section 10.5.1 - Custom (PMBus Spec Part II)
Factory Value: 0xBF (Retry always, max delay)
Units: ms
Reference: Section 16.4 - PMBus Spec Part II
Definition: Configures the response for fault protection configured by TON_MAX_FAULT_LIMIT.

OVUV_CONFIG

Applies To: BMR450, BMR451, BMR462-464

Command Code: 0xD8

Type: R/W Byte - Protectable

Data Length In Bytes: 1

Data Format: Custom (See Table 4)

Factory Value:

MR450, BMR451: 0x80

BMR462-464: 0x8F (Sets the output to turn on the synchronous rectifier as a crowbar when an overvoltage fault is detected.)

Table 4. OV And UV Fault Detection Feature Configuration.

Bits	Purpose	Value	Description
7	Controls how an OV fault response shutdown sets the output driver state	0	An OV fault does not enable the low-side power device
		1	An OV fault enables the low-side power device
6:4	Reserved	0	
3:0	Defines the number of consecutive limit violations required for an OV or UV fault	N	N+1 consecutive OV or UV violations initiate a fault response

Time Setting Commands

TON_DELAY

Applies To: BMR450, BMR451, BMR46x

Command Code: 0x60

Type: R/W Word - Protectable

Data Length In Bytes: 2

Data Format: Section 7.1 - PMBus Spec Part II - Linear Data Format

Factory Value: 10 ms

Units: ms

Reference: Section 16.1 - PMBus Spec Part II

Definition: Sets the delay time from ENABLE to start of the rise of the output voltage.

TON_RISE

Applies To: BMR450, BMR451, BMR46x

Command Code: 0x61

Type: R/W Word - Protectable

Data Length In Bytes: 2

Data Format: Section 7.1 - PMBus Spec Part II - Linear Data Format

Factory Value: 10 ms

Units: ms

Reference: Section 16.2 - PMBus Spec Part II

Definition: Sets the rise time of the output voltage after ENABLE and TON_DELAY.

TOFF_DELAY

Applies To: BMR450, BMR451, BMR46x

Command Code: 0x64

Type: R/W Word - Protectable

Data Length In Bytes: 2

Data Format: Section 7.1 - PMBus Spec Part II - Linear Data Format

Factory Value: 10 ms

Units: ms

Reference: Section 16.5 - PMBus Spec Part II

Definition: Sets the delay time from DISABLE to start of the fall of the output voltage.

TOFF_FALL

Applies To: BMR450, BMR451, BMR46x

Command Code: 0x65

Type: R/W Word - Protectable

Data Length In Bytes: 2

Data Format: Section 7.1 - PMBus Spec Part II - Linear Data Format

Factory Value: 10 ms

Units: ms

Reference: Section 16.6 - PMBus Spec Part II

Definition: Sets the fall time of the output voltage after DISABLE and TOFF_DELAY.

POWER_GOOD_DELAY

Applies To: BMR450, BMR451, BMR462-464

Command Code: 0xD4

Type: R/W Word - Protectable

Data Length In Bytes: 2

Data Format: Section 7.1 - PMBus Spec Part II - Linear Data Format

Factory Value: 10 ms

Units: ms

Reference:

Definition: Sets the delay time between the output voltage exceeding the power good threshold (set by the POWER_GOOD_ON command) and clearing the POWER_GOOD# bit in STATUS_WORD (note that if the POWER_GOOD# bit is set, then power is not good). The POWER_GOOD_DELAY time can range from 0 ms to 500 ms in steps of 125 ns. A 1 ms minimum configured value is recommended to adequately debounce the detection of a power good condition.

Status Commands

CLEAR_FAULTS

Applies To: BMR450, BMR451, BMR46x
Command Code: 0x03
Type: Send Byte
Data Length In Bytes: 0
Data Format: N/A
Factory Value: N/A
Units: N/A
Reference: Section 15.1 - PMBus Spec Part II
Definition: Clears fault indications.

STATUS_BYTE

Applies To: BMR450, BMR451, BMR46x
Command Code: 0x78
Type: Read Byte
Data Length In Bytes: 1
Data Format: Custom
Factory Value: N/A
Units: N/A
Reference: Section 17.1 - PMBus Spec Part II
Definition: Returns an abbreviated status for fast reads.

STATUS_WORD

Applies To: BMR450, BMR451, BMR46x
Command Code: 0x79
Type: Read Word
Data Length In Bytes: 2
Data Format: Custom
Factory Value: N/A
Units: N/A
Reference: Section 17.2 - PMBus Spec Part II
Definition: Returns the general status information used to indicate subsequent status to be read for more detail.

STATUS_VOUT

Applies To: BMR450, BMR451, BMR46x
Command Code: 0x7A
Type: Read Byte
Data Length In Bytes: 1
Data Format: Custom
Factory Value: N/A
Units: N/A
Reference: Section 17.3 - PMBus Spec Part II
Definition: Returns the output voltage related status.

STATUS_IOUT

Applies To: BMR450, BMR451, BMR46x
Command Code: 0x7B
Type: Read Byte
Data Length In Bytes: 1
Data Format: Custom
Factory Value: N/A
Units: N/A
Reference: Section 17.4 - PMBus Spec Part II
Definition: Returns the output current related status.

STATUS_INPUT

Applies To: BMR450, BMR451, BMR46x
Command Code: 0x7C
Type: Read Byte
Data Length In Bytes: 1
Data Format: Custom
Factory Value: N/A
Units: N/A
Reference: Section 17.5 - PMBus Spec Part II
Definition: Returns specific status specific to the input.

STATUS_TEMPERATURE

Applies To: BMR450, BMR451, BMR46x
Command Code: 0x7D
Type: Read Byte
Data Length In Bytes: 1
Data Format: Custom
Factory Value: N/A
Units: N/A
Reference: Section 17.6 - PMBus Spec Part II
Definition: Returns the temperature specific status.

STATUS_CML

Applies To: BMR450, BMR451, BMR46x
Command Code: 0x7E
Type: Read Byte
Data Length In Bytes: 1
Data Format: Custom
Factory Value: N/A
Units: N/A
Reference: Section 17.7 - PMBus Spec Part II
Definition: Returns the Communication, Logic and Memory specific status.

STATUS_MFR_SPECIFIC

Applies To: BMR46x
Command Code: 0x80
Type: Read Byte
Data Length In Bytes: 1
Data Format: Custom (See Table 3)
Factory Value: N/A
Units: N/A
Reference: Section 17.9 - PMBus Spec Part II
Definition: Returns manufacturer specific status information. See table 5.

Table 5. STATUS_MFR_SPECIFIC data byte specification

Bit	Fault meaning
7	Reserved
6	Reserved
5	Reserved
4	Reserved
3	CLOCK_FAIL ¹
2	Reserved
1	Reserved
0	Reserved

Note 1: The controller firmware monitors the switching period. If this period is longer than expected, the CLOCK_FAIL bit is set. If the regulator is configured to operate from an external switching frequency clock through the FLEX (BMR450 and BMR451) or SYNC (BMR46x) pin, then the controller will switch over to the internal clock and keep the regulator switching.

Monitor Commands

READ_VIN

Applies To: BMR450, BMR451, BMR46x

Command Code: 0x88

Type: Read Word

Data Length In Bytes: 2

Data Format: Section 7.1 - PMBus Spec Part II - Linear Data Format

Factory Value: N/A

Units: Volts (V)

Reference: Section 18.1 - PMBus Spec Part II

Definition: Returns the measured value of the input voltage.

BMR462-464:

If the regulator is not enabled, and has been put into low power standby mode with the USER_CONFIG command, input voltage information is not available and the regulator will NACK (Not ACKnowledge) this command.

READ_VOUT

Applies To: BMR450, BMR451, BMR46x

Command Code: 0x8B

Type: Read Word

Data Length In Bytes: 2

Data Format: Section 8.3.1 - PMBus Spec Part II - VOUT Linear Mode

Factory Value: N/A

Units: Volts (V)

Reference: Section 18.4 - PMBus Spec Part II

Definition: Returns the measured value of the output voltage.

BMR462-464:

If the regulator is not enabled, and has been put into low power standby mode with the USER_CONFIG command, output voltage information is not available and the regulator will NACK (Not ACKnowledge) this command.

READ_IOUT

Applies To: BMR450, BMR451, BMR46x

Command Code: 0x8C

Type: Read Word

Data Length In Bytes: 2

Data Format: Section 7.1 - PMBus Spec Part II - Linear Data Format

Factory Value: N/A

Units: Amperes (A)

Reference: Section 18.5 - PMBus Spec Part II

Definition: Returns the measured value of the output current.

BMR462-464:

If the regulator is not enabled, and has been put into low power standby mode with the USER_CONFIG command, output current information is not available and the regulator will NACK (Not ACKnowledge) this command.

READ_TEMPERATURE_1

Applies To: BMR450, BMR451, BMR46x

Command Code: 0x8D

Type: Read Word

Data Length In Bytes: 2

Data Format: Section 7.1 - PMBus Spec Part II - Linear Data Format

Factory Value: N/A

Units: °C

Reference: Section 18.6 - PMBus Spec Part II

Definition: Returns the measured value of the regulator's internal temperature.

BMR462-464:

If the regulator is not enabled, and has been put into low power standby mode with the USER_CONFIG command, internal temperature information is not available and the regulator will NACK (Not ACKnowledge) this command.

READ_DUTY_CYCLE

Applies To: BMR450, BMR451, BMR46x

Command Code: 0x94

Type: Read Word

Data Length In Bytes: 2

Data Format: Section 7.1 - PMBus Spec Part II - Linear Data Format

Factory Value: N/A

Units: %

Reference: Section 18.9 - PMBus Spec Part II

Definition: Returns the measured value of the duty cycle.
BMR462-464:

If the regulator is not enabled, and has been put into low power standby mode with the USER_CONFIG command, duty cycle information is not available and the regulator will NACK (Not ACKnowledge) this command.

READ_FREQUENCY

Applies To: BMR450, BMR451, BMR46x

Command Code: 0x95

Type: Read Word

Data Length In Bytes: 2

Data Format: Section 7.1 - PMBus Spec Part II - Linear Data Format

Factory Value: N/A

Units: kHz

Reference: Section 18.10 - PMBus Spec Part II

Definition: Returns the measured value of the switching frequency.

BMR462-464:

If the regulator is not enabled, and has been put into low power standby mode with the USER_CONFIG command, switching frequency information is not available and the regulator will NACK (Not ACKnowledge) this command.

SNAPSHOT_CONTROL

Applies To: BMR462-464

Command Code: 0xF3

Type: R/W Byte

Data Length In Bytes: 1

Data Format: Custom

Factory Value: N/A

Units: N/A

Definition: Used to save a set of current information about the operation of the regulator (see the SNAPSHOT command description below). Sending the SNAPSHOT_CONTROL command with the data byte equal to 0x01 copies the last snapshot stored in FLASH to RAM for reading via the SNAPSHOT command. Writing the SNAPSHOT_CONTROL command with the data byte equal to 0x02 causes the current SNAPSHOT values to be stored in set location in flash memory. Any other data values (0x00, 0x03-0xFF) are ignored.

Command Code: 0xEA

Type: Block Read

Data Length In Bytes: 32

Data Format: Custom (See Table 6)

Factory Value: N/A

Units: N/A

Definition: The SNAPSHOT command by itself is a 32-byte read-back of parametric and status values. See table 6.

Guide to using the Snapshot Feature

The snapshot feature allows monitoring and status data to be stored away to flash either during a fault condition or via a system-defined time via the SNAPSHOT_CONTROL command:

- 1) In order to use the snapshot feature, it must first be enabled. This is done by setting bit 1 (Snapshot Enable) in MISC_CONFIG to 1 (Enable).
- 2) Now by default snapshot is continuously updated in RAM and can be read using the SNAPSHOT command.
- 3) When a fault occurs, the latest snapshot in RAM is stored to Flash. After this, one can bring readback the snapshot stored in Flash by writing a 0x01 to the SNAPSHOT_CONTROL command, then reading SNAPSHOT. NOTE: It is advised that this step be performed while the device's operation is disabled, or when snapshot is temporarily disabled (via MISC_CONFIG).

SNAPSHOT

Applies To: BMR462-464

Table 6. SNAPSHOT command data byte specification

Bit number	Value	Format
31:22	Reserved	0x00
21	Manufacturer Specific Status Byte	Byte
20	STATUS_CML byte	Byte
19	STATUS_TEMPERATURE byte	Byte
18	STATUS_VIN byte	Byte
17	STATUS_IOUT byte	Byte
16	STATUS_VOUT byte	Byte
15:14	Switching Frequency	Linear Data Format
13:12	Reserved	N/A
11:10	Internal Temperature	Linear Data Format
9:8	Duty Cycle	Linear Data Format
7:6	Peak Current	Linear Data Format
5:4	Load Current	Linear Data Format
3:2	Output Voltage	VOUT Linear Format
1:0	Input Voltage	Linear Data Format

Identification Commands

CAPABILITY

Applies To: BMR461

Command Code: 0x19

Type: Read Byte (Read Only)

Data Length In Bytes: 1

Data Format: Hex

Factory Value: 0xA0

Units: N/A

Reference: Section 11.12 - PMBus Spec Part II

Definition: Returns the key PMBus capabilities of the product.

PMBUS_REVISION

Applies To: BMR450, BMR451, BMR46x

Command Code: 0x98

Type: Read Byte (Read Only)

Data Length In Bytes: 1

Data Format: Hex

Factory Value: The PMBus revision implemented in this unit.

Units: N/A

Reference: Section 22.1 - PMBus Spec Part II

Definition: Returns the revision of the PMBus implemented in the device.

IC_DEVICE_ID

Applies To: BMR461

Command Code: 0xAD

Type: Block Read (Read Only)

Data Length In Bytes: 16

Data Format: ASCII

Factory Value: ID of the controller IC.

Units: N/A

Reference: N/A

Definition: Returns the 16-byte (character) device identifier string.

IC_DEVICE_REV

Applies To: BMR461

Command Code: 0xAE

Type: Block Read (Read Only)

Data Length In Bytes: 16

Data Format: ASCII
Factory Value: Revision of the controller IC.
Units: N/A
Reference: N/A
Definition: Returns the 16-byte (character) device revision string.

DEVICE_ID

Applies To: BMR462-464
Command Code: 0xE4
Type: Block Read (Read Only)
Data Length In Bytes: 16
Data Format: ASCII
Factory Value: The part number, die revision and firmware revision of the controller IC.
Units: N/A
Reference: N/A
Definition: Returns the 16-byte (character) device identifier string.

MFR_ID

Applies To: BMR450, BMR451, BMR46x
Command Code: 0x99
Type: Block R/W (Read Only)
Data Length In Bytes:
BMR461: 8
Others: 22
Data Format: ASCII
Factory Value: FPM or Flex
NOTE: May be EPM or Ericsson on some custom devices
Units: N/A
Reference: Section 22.2 - PMBus Spec Part II
Definition: This command returns the name of the regulator manufacturer, Flex.

MFR_MODEL

Applies To: BMR450, BMR451, BMR46x
Command Code: 0x9A
Type: Block R/W (Read Only)
Data Length In Bytes:
BMR450/451: 18
BMR462-464: 14
BMR461: 13
Data Format: ASCII
Factory Value: Flex model number
Units: N/A
Reference: Section 22.2.2 - PMBus Spec Part II
Definition: This command returns the model number of the regulator.

MFR_REVISION

Applies To: BMR450, BMR451, BMR46x
Command Code: 0x9B
Type: Block R/W (Read Only)

Data Length In Bytes:
BMR 450/451: 22
BMR 462-464: 24
BMR461: 7
Data Format: ASCII
Factory Value: Flex product revision number
Units: N/A
Reference: Section 22.2.3 - PMBus Spec Part II
Definition: This command returns the name of the configuration file used at the factory to program the device.

MFR_LOCATION

Applies To: BMR450, BMR451, BMR46x
Command Code: 0x9C
Type: Block R/W - Protectable
Data Length In Bytes:
BMR461: 8
Others: 7
Data Format: ASCII
Factory Value: Typically EAB/SEC
Units: N/A
Reference: Section 22.2.4 - PMBus Spec Part II
Definition: This command returns Flex's identification for the location where the regulator was manufactured.

MFR_DATE

Applies To: BMR450, BMR451, BMR46x
Command Code: 0x9D
Type: Block R/W - Protectable
Data Length In Bytes:
BMR461: 6
Others: 10
Data Format: ASCII
Factory Value: Manufacturing date code formatted as YYMMDD or YYYY-MM-DD.
Units: N/A
Reference: Section 22.2.5 - PMBus Spec Part II
Definition: This command returns the date the regulator was manufactured.

MFR_SERIAL

Applies To: BMR450, BMR451, BMR46x
Command Code: 0x9E
Type: Block R/W - Protectable
Data Length In Bytes: 13
Data Format: ASCII
Factory Value: Flex serial number
Units: N/A
Reference: Section 22.2.6 - PMBus Spec Part II
Definition: This command returns a string of 13 characters and numbers that provides a unique identification of the regulator.

USER_DATA_00

Applies To: BMR462-464
Command Code: 0xB0
Type: Block R/W - Protectable

Data Length In Bytes: Up to 32

Data Format: ASCII

Factory Value: null

Units: N/A

Reference: Section 23 - PMBus Spec Part II

Definition: Sets a user defined data. The maximum number of bytes that can be stored is 32.

Other Configuration Commands

ADAPTIVE_MODE

Applies To: BMR461

Command Code: 0xD0

Type: R/W Word - Protectable

Data Length In Bytes: 2

Data Format: Custom

Factory Value: 0x024B

Definition: Configures options for DLC (Dynamic Loop Compensation) calibration. The data field is defined in Table 7.

Table 7. ADAPTIVE_MODE command data byte specification

Bits	Purpose	Value	Description
15:13	Reserved	0	N/A
12	Calibrate at first enable only	0	Calibrate after each ramp-up (if enabled)
		1	Calibrate only once after first ramp-up after input voltage is applied.
11:10	Reserved	0	N/A
9	Calibrate after ramp-up	0	Do not calibrate after ramp-up
		1	Calibrate after ramp-up
8	Calibrate continuously	0	Continuous calibration disabled.
		1	Calibrate continuously after ramp-up or during operation if ramp-up already completed.
7	Reserved	0	N/A
6	Update FLC	0	Do not update
		1	Update power stage resonant frequency FLC in COMP_MODEL[15:0] after calibration (LC double pole frequency).
5	Update FZ	0	Do not update
		1	Update ESR zero frequency (FZ) in COMP_MODEL[31:16] after calibration.

Bits	Purpose	Value	Description
4	Update ZLC	0	Do not update
		1	Update LC damping factor (ZLC) in COMP_MODEL[47:32] after calibration.
3	Reset gains	0	Do not reset
		1	Gain values reset to stored values when output is disabled.
2	Write flash after next calibration	0	Do not write flash
		1	Execute a STORE_USER_ALL after the next calibration. The bit is cleared before the STORE_USER_ALL command is executed.
1	Recalculate fast gains	0	Do not recalculate
		1	Recalculate new fast gains based on COMP_MODEL parameters.
0	Use fast gains	0	Do not enable fast gains
		1	Enable fast gains after successful calibration and gain calculation.

FEEDBACK_EFFORT

Applies To: BMR461
 Command Code: 0xD3
 Type: R/W Word - Protectable
 Data Length In Bytes: 2
 Data Format: Section 7.1 - PMBus Spec Part II - Linear Data Format
 Factory Value: 0.5
 Definition: Controls the amount of effort the feedback loops use to achieve the set output. Proportional to the open loop gain of the system. Value should be in the range 0.1 to 0.9.

ZETAP

Applies To: BMR461
 Command Code: 0xE8
 Type: R/W Word - Protectable
 Data Length In Bytes: 2
 Data Format: Section 7.1 - PMBus Spec Part II - Linear Data Format
 Factory Value: 1.5
 Definition: Compensation setting that corresponds to the damping ratio of the closed loop system.

TEST_MODE

Applies To: BMR461
 Command Code: 0xD9
 Type: R/W Word - Protectable
 Data Length In Bytes: 2
 Data Format: Custom
 Factory Value: 0x0002
 Definition: Control of various test modes.

LOOP_CONFIG

Applies To: BMR461
 Command Code: 0xD5
 Type: R/W Word - Protectable
 Data Length In Bytes: 2
 Data Format: Custom
 Factory Value: 0x0100
 Definition: Configures options for DLC (Dynamic Loop Compensation). The data field is defined in Table 8.

Table 8. LOOP_CONFIG command data byte specification.

Bits	Purpose	Value	Description
15:10	Reserved	0	N/A
9	Use stored gain values	0	Use calculated gain values.
		1	Use stored NLSS gain values instead of calculated.
8	Enable PID mode	0	Disable integral term in the control loop.
		1	Enable integral term in the control loop.
7	Reserved	0	N/A
6	Enable variable gate drive	0	Disable variable gate drive.
		1	Enable gate drive voltage lookup table as a function of load current.
5	Reserved	0	N/A
4	Enable Adaptive Gate Drive (AGD)	0	Disable adaptive gate drive.
		1	Adaptive gate drive to adjust the delay between commanding the gate drive FETs on and them actually being on.
3	Enable negative duty	0	Disable negative duty.
		1	Enables negative duty cycles (body diode "braking").
2:0	Reserved	0	N/A

COMP_MODEL

Applies To: BMR461

Command Code: 0xDB

Type: Block R/W - Protectable

Data Length In Bytes: 6

Data Format: Custom

Factory Value: 0xB2CDB2009207:

LC damping factor = 0.7

ESR zero frequency = 0.5 x Fsw

Power stage resonant frequency = 0.031677 x Fsw

Units: N/A

Definition: Compensation model used by the device. Allows manual setting of power stage FLC, FZ and ZLC values, and readout of DLC calibration result. The data field is defined in Table 9.

See Technical Specification of product for more details.

Table 9. COMP_MODEL command data specification

Byte	Purpose	Definition
5	LC damping factor	LC damping factor.
4		
3	ESR zero frequency	Power stage ESR zero frequency.
2		
1	Power stage resonant frequency	Power stage resonant frequency (LC double-pole) as a fraction of the switching frequency F_{sw} . If compensation calibration is enabled, this value will be overwritten and may be read out to see the calibration result. See Technical Specification of product for more details.
0		

Table 10. STRAP_DISABLE data byte specification

STRAP_DISABLE

Applies To: BMR461

Command Code: 0xDC

Type: R/W Word - Protectable

Data Length In Bytes: 2

Data Format: Custom

Factory Value: 0x5A00

Definition: Indicates present pin-strap control. When a bit is set the corresponding pin-strap or automatic control is disabled, thus the parameter is overridden by a written PMBus command. The data field is defined in Table 10.

DEADTIME_GCTRL

Applies To: BMR461

Command Code: 0xE7

Type: Block R/W

Data Length In Bytes: 19

Data Format: Custom

Factory Value:

0x00000F0C0A08050500000F000800030007000A

Definition: Configures several manufacturer-level features such as deadtimes and gate drive. This value is set at the factory and should not be changed.

Note. This command initiates a flash write of the internal ConfigPage. Upon sending the command the product will briefly stop responding to PMBus commands while the flash write and a reboot are carried out. Note that since a reboot is carried out, all changes in RAM will be lost. The command should only be used when the device output is disabled.

Bit	PMBus Command
14	COMP_MODEL
13	VOUT_MAX
12	IOUT_CAL_GAIN
11	FREQUENCY_SWITCH
9	IOUT_OC_FAULT_LIMIT
8	VOUT_MARGIN_LOW
7	VOUT_MARGIN_HIGH
6	POWER_GOOD_OFF
5	POWER_GOOD_ON
3	VOUT_UV_FAULT_LIMIT
1	VOUT_OV_FAULT_LIMIT
0	VOUT_COMMAND

MFR_CONFIG

Applies To: BMR450, BMR451, BMR462-464

Command Code: 0xD0

Type: R/W Word - Protectable

Data Length In Bytes: 2

Data Format: Custom

Factory Value: Model dependent.

Definition: Configures several manufacturer-level features.

The data field is defined in Tables 11 and 12.

Table 11. MFR_CONFIG command data byte specification for the BMR450 and BMR451

Bits	Purpose	Value	Description
15:11	Current Sense Blanking Delay	D	Sets the delay, D, in 32 ns steps
10:8	Current Sense Fault Count	C	Sets the number of consecutive OC or UC violations required for a fault to 2C+1.

Bits	Purpose	Value	Description
7:6	Reserved	0	N/A
5:4	Current Sense Control	00	Current sense uses GND-referenced, down-slope sense
		01	Current sense uses output voltage referenced, down-slope sensing
		10	Current sense uses output voltage referenced, up-slope sensing
		11	Current sense uses VOUT-referenced, up/down slope selected by the nominal duty cycle
3:1	Reserved	0	N/A
0	SYNC Pin Output Control (when FLEX pin is configured as SYNC pin in POLA_VADJ_CONFIG)	0	SYNC is open-drain
		1	SYNC is push-pull

Table 12 MFR_CONFIG specification for the BMR462-464.

Bits	Purpose	Value	Description
15:11	Current Sense Blanking Delay	D	Sets the delay, D, in 32 ns steps
10:8	Current Sense Fault Count	C	Sets the number of consecutive OC or UC violations required for a fault to $2C+1$.
7:6	Reserved	0	N/A

Bits	Purpose	Value	Description
5:4	Current Sense Control	00	Current sense uses GND-referenced, down-slope sense
		01	Current sense uses output voltage referenced, down-slope sensing
		10	Current sense uses output voltage referenced, up-slope sensing
		11	Reserved
3	NLR During Ramp	0	Wait for power good (PG)
		1	Always on
2	Alternate Ramp Control	0	Alternate Ramp Disabled
		1	Alternate Ramp Enabled
1	PG Pin Output Control	0	PG is open-drain
		1	PG is push-pull
0	SYNC Pin Output Control	0	SYNC is open-drain
		1	SYNC is push-pull

USER_CONFIG

Applies To: BMR450, BMR451, BMR462-464

Command Code: 0xD1

Type: R/W Word - Protectable

Data Length In Bytes: 2

Data Format: Custom

Factory Value: Model dependent.

Units: N/A

Reference: N/A

Definition: Configures several user-level features. The data field is defined Table 13 and 14.

Table 13. USER_CONFIG specification for the BMR450 and BMR451.

Bits	Purpose	Value	Description
15:12	Reserved	–	Reserved

Bits	Purpose	Value	Description
11	SYNC Time-out Enable (when FLEX pin is configured as SYNC pin in POLA_VADJ_CONFIG)	0	SYNC output remains on after device is disabled
		1	SYNC turns off 500ms after device is disabled
10	Reserved	–	Reserved
9	PID Feed-Forward Control	0	PID Coefficients are corrected for VDD variation
		1	PID Coefficients are not corrected for VDD variations
8	Fault Spreading Control	0	Received faults are ignored
		1	Received faults cause a shut-down
7	SMBus Master Clock Rate	0	Operate at 100 kHz in master mode
		1	Operate at 400 kHz in master mode
6	SYNC Utilization Control (when FLEX pin is configured as SYNC pin in POLA_VADJ_CONFIG)	0	Auto-configure using the SYNC pin and FREQUENCY_SWITCH parameter
		1	Switch using the SYNC input
5	SYNC Output Control (when FLEX pin is configured as SYNC pin in POLA_VADJ_CONFIG)	0	Configure the SYNC pin as an input-only
		1	Drive the switch clock out of SYNC when using the internal oscillator
4	SMBus Transmit Inhibit	0	SMBus master transmissions are allowed
		1	SMBus master transmissions are not allowed
3	SMBus Timeout Inhibit	0	SMBus Idle and Fault timeouts are enabled
		1	SMBus Idle and Fault timeouts are inhibited
2	OFF low-side control	0	The low-side drive is off when device is disabled
		1	The low-side drive is on when device is disabled
1:0	Standby Mode	00	Enter low-power mode when device is disabled. No READ_xxxx data is available in this mode.
		01	Monitor for faults when device is disabled. READ_xxxx data is available.
		10	Reserved
		11	Monitor for faults using pulsed mode. READ_xxxx data is available.

Table 14. USER_CONFIG specification for the BMR462-464.

Bits	Purpose	Value	Description
15:14	Minimum Duty Cycle	N	Sets the minimum duty cycle $((N+1)/(2^8))$ during a ramp when "Minimum Duty Cycle" (Bit 13) is enabled. For example, if Minimum Duty Cycle input N is set to 3, the minimum duty cycle is $(3+1)/(2^8) = (1/64)$.
13	Minimum Duty Cycle	0	Minimum Duty Cycle is Disabled
		1	Minimum Duty Cycle is Enabled
12	Alternate Ramp Down	0	Output follows TOFF_FALL ramp time
		1	Output is set to high impedance/open mode during ramp down until VOUT_UV threshold is reached.
11	SYNC Time-out Enable	0	SYNC output remains on after device is disabled
		1	SYNC turns off 500 ms after device is disabled
10	Reserved	0	Reserved
9	PID Feed-Forward Control	0	PID Coefficients are corrected for VDD variation
		1	PID Coefficients are not corrected for VDD variations
8	Fault Spreading Mode	0	If sequencing is disabled, this device will ignore faults from other devices. If sequencing is enabled, the devices will sequence down from the failed device outward.
		1	Faults received from any device selected by the GCB_GROUP command will cause this device to shut down immediately.
7	Reserved	0	Reserved
6	SYNC Input Mode	0	Auto-configure using the SYNC pin and FREQUENCY_SWITCH parameter
		1	Switch using the SYNC input
5	SYNC Output Control	0	Configure the SYNC pin as an input-only
		1	Drive the switch clock out of SYNC when using the internal oscillator
4:3	Reserved	0	Reserved
2	OFF Low-side Control	0	The low-side drive is off when device is disabled
		1	The low-side drive is on when device is disabled

Bits	Purpose	Value	Description
1:0	Standby Mode	00	Enter low-power mode when device is disabled (no READ_xxxx data available). Note that if the Precise Ramp-Up Delay bit is cleared in MISC_CONFIG, monitoring will still be active and power consumption is affected.
		01	Monitor for faults when device is disabled (READ_xxxx data available)
		10	Reserved
		11	Monitor for faults using pulsed mode. (READ_xxxx data available upon read command)

MISC_CONFIG

Applies To: BMR462-464

Command Code: 0xE9

Type: R/W Word – Protectable

Data Length In Bytes: 2

Data Format: Custom

Factory Value: 0x0000

Definition: This command sets a few options pertaining to ramp timing accuracy and current-driven control. The format of this command is shown in Table 15.

Table 15. MISC_CONFIG command data specification

Bits	Purpose	Value	Description
15	Broadcast Margin (see GCB_CONFIG)	0	Disabled
		1	Enabled
14	Broadcast Enable (see GCB_CONFIG)	0	Disabled
		1	Enabled
13	Phase Enable Select	0	Use PH_EN pin to add/drop current-share phases.
		1	Use PHASE_CONTROL command to add/drop phases.
12:9	Reserved	0	Reserved
8	IOUT blanking delay and IOUT_OMEGA_OFFSET calibration calculations. (Not supported for variants with DLC)	0	Disabled
		1	Enabled
7	Precise Ramp-Up Delay (Not supported for variants with DLC)	0	Monitor mode enabled creating a more accurate delay time. This mode also enables certain circuits that may affect standby power. NOTE: This timing mode only applies to enable via CTRL pin, not PMBus.
		1	Normal, low standby power, delay operation

6	Diode Emulation	0	Disabled
		1	Enabled, enter diode emulation at low current loads to improve efficiency
5:3	Reserved	0	
2	Minimum GL Pulse (Pulse Skip Control)	0	Disabled
		1	Enabled, limited to 10% × 1/Fswitch minimum during diode emulation
1	Snapshot	0	Disabled
		1	Enabled
0	Adaptive Frequency (Not supported for variants with DLC).	0	Disabled, Switching frequency is fixed
		1	Enabled

PID_TAPS

Applies To: BMR450, BMR451, BMR462-464

Command Code: 0xD5

Type: Block R/W - Protectable

Data Length In Bytes: 9

Data Format: Custom

Factory Value: Model dependent

Units: N/A

Reference: TP022, Control Loop Design

Definition: Configures the linear control loop filter coefficients. The PID algorithm implements the following Z-domain function in below equation:

$$\frac{A + Bz^{-1} + Cz^{-2}}{1 - z^{-12}}$$

Table 16. PID_TAPS command data specification.

The coefficients A , B , and C are represented using a pseudo-floating point format similar to the output voltage related parameters (with the addition of a sign bit), defined as:

$$(-1)^S \times 2^E \times M$$

where M is a two-byte unsigned mantissa, S is a sign-bit, and E is a 7-bit two's-complement signed integer. The 9-byte data field is defined in Table 16. S is stored as the MSB of the E byte.

Note: Data bytes are transmitted on the PMBus in the order of Byte 0 through Byte 8.

Byte	Purpose	Definition
8	Tap C - E	Coefficient C exponent + S
7	Tap C - M [15:8]	Coefficient C mantissa, high-byte
6	Tap C - M [7:0]	Coefficient C mantissa, low-byte
5	Tap B - E	Coefficient B exponent + S
4	Tap B - M [15:8]	Coefficient B mantissa, high-byte
3	Tap B - M [7:0]	Coefficient B mantissa, low-byte
2	Tap A - E	Coefficient A exponent + S
1	Tap A - M [15:8]	Coefficient A mantissa, high-byte
0	Tap A - M [7:0]	Coefficient A mantissa, low-byte

PID_TAPS Command - BMR450 And BMR451

The PID_TAPS command data is only read at startup. Changes made while the regulator is operating will not take effect until the regulator is powered off and restarted.

PID_TAPS Command - BMR462-464 without DLC

The data for this command is read only at startup. Changes made while the regulator is operating will not take effect until the regulator is powered off and restarted.

If data has been written to the PID_TAPS_CALC command, the data in the PID_TAPS_CALC command is used to compensate the control loop and the PID_TAPS data is ignored. Description of the PID_TAPS_CALC command is shown in table 17.

PID_TAPS Command - BMR463-464 with DLC

See each product's Technical Specification for details on how the PID_TAPS command is used when there is DLC support.

PID_TAPS_CALC

Applies To: BMR462-464 variants without DLC

Command Code: 0xF2

Type: Block R/W – Protectable

Data Length In Bytes: 9

Data Format: Custom (See PID_TAPS above)

Factory Value: Model dependent

Units: N/A

Reference: TP022, Control Loop Design

Definition: The user may store customized values of the PID_TAPS settings (see the PID_TAPS command above) using this command

Data written to PID_TAPS_CALC takes effect immediately if the PID Feed-Forward Control bit of the USER_CONFIG command is set. This means that the loop compensation can be changed while the regulator is operating. Great care must be taken when changing the compensation while the regulator is operating to avoid introducing unstable operation.

If the data written to the PID_TAPS_CALC command is saved in the USER_STORE memory, on power up, the PID_TAPS_CALC data will be used to compensate the control loop and any data saved for the PID_TAPS command will be ignored.

AUTO_COMP_CONFIG

Applies To: BMR463-464 with DLC

Command Code: 0xBC

Type: R/W Byte – Protectable

Data Length In Bytes: 1

Data Format: Custom

Factory Value: 0x49

Definition: Configures the DLC (Dynamic Loop compensation) function. See each product's Technical Specification for details. The format of this command is shown in Table 17.

Table 17. AUTO_COMP_CONFIG command data specification

Bits	Purpose	Value	Description
7:4	Scaling of DLC result	G	Scale the gain of the DLC results by a factor of $(G+1)*10\%$, where G is a integer value 0,1..9. G = 0 yields lowest jitter; G = 9 yields tightest transient response.
3	Power Good assertion	0	Use the power good delay time specified in POWER_GOOD_DELAY.
		1	Assert the Power Good signal after the DLC algorithm has completed.
2	DLC result store	0	DLC results are not stored in RAM after completed algorithm, which means the DLC algorithm will be performed after each new ramp-up.
		1	DLC results are stored in RAM after completed algorithm, which means the DLC algorithm will only be performed after first ramp-up after input voltage is applied.

1:0	DLC mode	00	DLC algorithm disabled. Compensation parameters stored in command PID_TAPS will be used.
		01	Algorithm performed once after ramp. DLC algorithm is performed once after ramp-up of output voltage.
		10	Repeat algorithm every ~1 second. DLC algorithm is performed repeatedly, with ~1 second intervals. This mode can not be used for current sharing groups.
		11	Repeat algorithm every ~1 minute. DLC algorithm is performed repeatedly, with ~1 minute intervals. This mode can not be used for current sharing groups.

POLA_VADJ_CONFIG

Applies To: BMR450, BMR451

Command Code: 0xD6

Type: R/W Word - Protectable

Data Length In Bytes: 1

Data Format: Custom

Factory Value: Pin-strap setting value (V0)

Units: N/A

Reference: N/A

Definition: Configures the Device's voltage pin-straps to either conform to the POLA standard or to follow Flex's method. The command format is shown in Table 18.

Table 18. POLA_VADJ_CONFIG command data specification

Byte	Purpose	Value	Description
15:0	POLA Config	0x00	The output voltage is set to 5.0V. It can be adjusted through the VOUT_COMMAND PMBus command. The FLEX pin is configured as a SYNC pin in auto-detect mode. On power up, the controller will check the FLEX pin for an external clock. If one is found, the controller will synchronize with it. If no external clock is detected on the FLEX pin at power up, the controller reverts to either its nominal frequency of 400 kHz or the value set by the FREQUENCY_SWITCH command.
		0x01	This puts the converter output voltage settings into the POLA Mode. In this mode the output voltage, maximum output voltage, and output voltage fault limits are set by connecting a resistor from the FLEX pin to GND. Refer to the product Technical specifications for details. These values may be overridden by the use of the appropriate PMBus commands.
		0x02	This puts the converter output voltage settings into the POLA Mode. In this mode the output voltage, maximum output voltage, and output voltage fault limits are set by connecting a resistor from the FLEX pin to GND. Refer to the product Technical specifications for details. These values may be overridden by the use of the appropriate PMBus commands. This is the same as sending data 0x01.

NLR_CONFIG

Applies To: BMR450, BMR451, BMR462-464

Command Code: 0xD7

Type: Block R/W - Protectable

Data Length In Bytes:

BMR450/451: 2

BMR46x: 4

Data Format: Product dependent (For the BMR450 and BMR451, See Table 19. For the BMR462-464, see Table 20.

Factory Value:

Units: N/A

Reference: AN306, NLR Configuration

Definition: Configures the non-linear response (NLR) control parameters.

Table 19. NLR_CONFIG command data specification for the BMR450 and BMR451.

Bits	Purpose	Value	Description
15	Controls the NLR enable	0	The NLR feature is disabled
		1	The NLR feature is enabled
14:12	Sets the high-side (control FET) NLR threshold	HT	Sets the high-side comparator threshold to approximately $0.005 \times (HT+1) \times V_{out}$
11	Controls the outer NLR comparators	0	The outer NLR comparators are disabled
		1	The outer NLR comparators are enabled
10:8	Sets the low-side (sync FET) NLR threshold	LT	Sets the low-side comparator threshold to approximately $0.005 \times (LT+1) \times V_{out}$
7:6	Sets the maximum high-side correction time	HC	Sets the maximum high-side correction time to $T_{sw} \times ((2 \times HC) + 1) / 64$
5:4	Sets the maximum low-side correction time	LC	Sets the maximum low-side correction time to $T_{sw} \times ((2 \times LC) + 1) / 64$
3:0	NLR Blanking time control	B	Adds to the NLR blanking time by $B \times T_{sw} / 64$

Table 20. NLR_CONFIG command data specification for the BMR462-464

Bits	Purpose	Value	Description
31:30	Outer threshold multiplier. This is set such that the outer load/unload thresholds are a multiple of their respective inner threshold values: Load-Outer = mult * LI Unload-Outer = mult * UI	00	2x multiplier
		01	3x multiplier
		10	4x multiplier
		11	Outer Threshold Disabled
29:27	NLR threshold: Load-Inner		Sets the inner comparator threshold for a loading event to approximately $0.005 \times (LI + 1) \times V_{OUT}$

Bits	Purpose	Value	Description
26:24	NLR threshold: Unload-Inner	UI	Sets the inner comparator threshold for an unloading event to approximately $0.005 \times (UI+1) \times V_{OUT}$
23:20	Max time: Load-Outer threshold correction time	LOT	Sets the outer threshold, maximum correction time for a loading event to $LOT \times T_{sw}/64$ (s)
19:16	Max time: Load-Inner threshold correction time	LIT	Sets the inner threshold, maximum correction time for a loading event to $LIT \times T_{sw}/64$ (s)
15:12	Max time: Unload-Outer threshold correction time	UOT	Sets the outer threshold, maximum correction time for an unloading event = $UOT \times T_{sw}/64$ (s)
11:8	Max time: Unload-Inner threshold correction time	UIT	Sets the inner threshold, maximum correction time for an unloading event = $UIT \times T_{sw}/64$ (s)
7:4	Load Blanking time control	LB	Sets the NLR blanking time for a loading event as described in Table 21.
3:0	Unload Blanking time control	UB	Sets the NLR blanking time for an unloading event as described in Table 21.

Table 21. NLR blanking time as a function of LB or UB

LB OR UB	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Tsw/64 UNITS	0	1	2	4	8	16	32	48	64	80	96	128	160	176	192	224

TEMPCO_CONFIG

Applies To: BMR450, BMR451, BMR462-464

Command Code: 0xDC

Type: R/W Byte - Protectable

Data Length In Bytes: 1

Data Format: Custom

Factory Value: Model Dependent

Definition: Configures the correction factor when performing temperature coefficient correction for current sense. This value is set at the factory and should not be changed.

IOUT_OMEGA_OFFSET

Applies To: BMR462-464 variants without DLC

Command Code: 0xBE

Type: R/W word - Protectable

Data Length In Bytes: 2

Data Format: Section 7.1 - PMBus Spec Part II - Linear Data Format

Factory Value: 0

Definition: Advanced correction offset for current sense. This value should not be changed.

INDUCTOR

Applies To: BMR462-464

Command Code: 0xD6

Type: R/W Word - Protectable

Data Length In Bytes: 2

Data Format: Custom

Factory Value: Model Dependent

Definition: Used by algorithms in the controller.

DEADTIME_CONFIG

Applies To: BMR450, BMR451, BMR462-464

Command Code: 0xDE

Type: R/W Word - Protectable

Data Length In Bytes: 2

Data Format: Custom

Factory Value: Model Dependent

Units: N/A

Reference:

Definition: Configures the deadtime optimization mode. Also sets the minimum deadtime value for the adaptive deadtime mode range. This value is set at the factory and should not be changed.

DEADTIME

Applies To: BMR450, BMR451, BMR462-464

Command Code: 0xDD

Type: R/W Word - Protectable

Data Length In Bytes: 2

Data Format: Custom – two 2's complement bytes

Factory Value: Model Dependent.

Units: ns

Reference:

Definition: Sets the non-overlap between PWM transitions. This value is set at the factory and should not be changed.

DEADTIME_MAX

Applies To: BMR462-464

Command Code: 0xBF

Type: R/W Byte - Protectable

Data Length In Bytes: 2

Data Format: Custom

Factory Value: Model Dependent

Units: N/A

Reference:

Definition: Sets the maximum deadtime value for the adaptive deadtime mode range. This value is set at the factory and should not be changed.

Group Commands

SEQUENCE

Applies To: BMR450, BMR451, BMR462-464

Command Code: 0xE0

Type: R/W Word - Protectable

Data Length In Bytes: 2

Data Format: Custom

Factory Value: 0x0000 (Sequencing disabled)

Units: N/A

Reference: AN310

SEQUENCE Command for the BMR450 and BMR451

Definition: The SEQUENCE command sets the serial interface address of the prequel and sequel devices when using group sequencing. The device will enable its output (using the programmed delay values) when its EN or OPERATION enable state, as defined by ON_OFF_CONFIG, is set and the prequel device has issued a Power Good event

on the serial bus. The device will disable its output (using the programmed delay values) when the sequel device has issued a Power Down event on the serial bus.

The data field is a two-byte value according to Table 22. The most-significant byte contains the serial interface address of the prequel device (left-justified). The least-significant byte contains the address of the sequel device. The unused least-significant bit of both addresses must be 0 (i.e., the data byte for the five bit address 0x21 would be 0x42). An address byte value of 0x00 for the prequel defines that device as the first device in a sequence. An address byte value of 0x00 for the sequel defines the device to be the last device in a sequence.

A SEQUENCE command value of 0x0000 disables device sequencing, unless defined by pin-straps. This command overrides the corresponding factory pinstrap settings.

SEQUENCE Command For The BMR462-464

Definition: The SEQUENCE command identifies the Rail GCB ID of the prequel and sequel rails when performing multi-rail sequencing. The device will enable its output (using the programmed delay values) when its EN or OPERATION enable state, as defined by ON_OFF_CONFIG, is set and the prequel device has issued a Power-Good event on the GCB bus. The device will disable its output (using the programmed delay values) when the sequel device has issued a Power-Down event on the GCB bus.

The data field is a two-byte value according to Table 23. The most-significant byte contains the 5-bit Rail GCB ID of the prequel device. The least-significant byte contains the 5-bit Rail GCB ID of the sequel device. The most significant bit of each byte contains the enable of the prequel or sequel mode.

NOTE: In order to disable prequel or sequel in the SEQUENCE command, the enable bit must be set to 0 AND the respective prequel or sequel bit must also be set to all 0's.

Table 22. SEQUENCE command data specification for the BMR450 and BMR451.

Bits	Purpose	Value	Description
15:9	Prequel Device	Varies	The 7 bit PMBus address of the prequel device in the sequencing order
8	Unused	0	Must be 0
7:1	Sequel Device	Varies	The 7 bit PMBus address of the sequel device in the sequencing order
0	Unused	0	Must be 0

Table 23. SEQUENCE command data specification for the BMR46x

Bits	Purpose	Value	Description
15	Prequel Enable	0	Disable, no prequel preceding this rail. NOTE: To disable, this bit must be set to 0 AND Prequel Rail GCB ID must be set to 0x00
		1	Enable, prequel to this rail is defined by bits 12:8
14:13	Reserved	0	Reserved
12:8	Prequel Rail GCB ID	0 to 31 (0x00 to 0x1F)	Set to the Rail GCB ID of the rail that should precede this device's rail in a sequence order.
7	Sequel Enable	0	Disable, no sequel following this rail. NOTE: To disable, this bit must be set to 0 AND Sequel Rail GCB ID must be set to 0x00
		1	Enable, sequel to this rail is defined by bits 4:0
6:5	Reserved	0	Reserved
4:0	Sequel Rail GCB ID	0 to 31 (0x00 to 0x1F)	Set to the Rail GCB ID of the rail that should follow this device's rail in a sequence order.

GCB_CONFIG

Applies To: BMR462-464

Command Code: 0xD3

Type: R/W Word - Protectable

Data Length In Bytes: 2

Data Format: Custom (See Table 24)

Factory Value: Lowest five bits of the converter's SMBus Address.

Units: N/A

Reference:

Definition: Configures the GCB bus

GCB_GROUP

Applies To: BMR462-464

Command Code: 0xE2

Type: Block R/W - Protectable

Data Length In Bytes: 4

Data Format: Custom

Factory Value: 0x00000000

Units: N/A

Reference:

Definition: This command sets which rail GCB IDs should be listened to for fault spreading information. The data sent is a 4-byte, 32-bit, bit vector where every bit represents a rail's GCB ID. A bit set to 1 indicates a device GCB ID to which the configured device will

respond upon receiving a fault spreading event. In this vector, bit 0 of byte 0 corresponds to the rail with GCB ID 0. Following through, Bit 7 of byte 3 corresponds to the rail with GCB ID 31.

Note: The device/rail's own GCB ID should not be set within the GCB_GROUP command for that device/rail.

All devices in a current share rail must shutdown for the rail to report a shutdown.

If fault spread mode is enabled in USER_CONFIG (Bit 8 set to 1), the device will immediately shut down if one of its GCB_GROUP members fail. The device/rail will attempt its configured restart only after all devices/rails within the GCB_GROUP have cleared their faults.

If fault spread mode is disabled in USER_CONFIG (Bit 8 cleared to 0) and sequencing is enabled, the device will perform a sequenced shutdown as defined by the SEQUENCE command setting. The rails/devices in a sequencing set only attempt their configured restart after all faults have cleared within the GCB_GROUP.

If fault spread mode is disabled and sequencing is also disabled, the device will ignore faults from other devices and stay enabled.

Table 24. GCB_CONFIG command data specification

Bits	Purpose	Value	Description
15:13	Reserved	0	Reserved
12:8	Broadcast Group	0 to 31	Group number used for broadcast events. (i.e. Broadcast Enable and Broadcast Margin) Set this number to the same value for all rails/devices that should respond to each other's broadcasted event. This function is enabled by the bits 15 and 14 in the MISC_CONFIG command.
7:6	Reserved	0	Reserved
5	GCB TX Inhibit	0	GCB Transmission Enabled
		1	GCB Transmission Inhibited
4:0	GCB ID	0 to 31	Sets the rail's GCB ID for sequencing and fault spreading. For the current-sharing applications, set this value the same as the ID value in ISHARE_CONFIG for all devices in the current sharing rail.

ISHARE_CONFIG

Applies To: BMR462-464

Command Code: 0xD2

Type: R/W Word - Protectable

Data Length In Bytes: 2

Data Format: Custom

Factory Value: 0x0000

Units: N/A

Reference: AN307, Parallel Operation with Load Sharing

Definition: Configures the device for current sharing communication over the GCB bus. The command format is described in Table 25.

Table 25. ISHARE_CONFIG command data specification

Bits	Purpose	Value	Description
15:8	IShare GCB ID	0 to 31 (0x00 to 0x1F)	Sets the current share rail's GCB ID for each device within a current share rail. Set to the same GCB ID as in GCB_CONFIG. This GCB ID is used for sequencing and fault spreading when used in a current share rail.
7:5	Number of Members	0 to 7	Number of devices in current share rail - 1. Example: 3 device current share rail, use $3 - 1 = 2$
4:2	Member Position	0 to 7	Position of device within current share rail
1	Reserved	0	Reserved
0	I-Share Control	1	Device is a member of a current share rail
		0	Device is not a member of a current share rail

PHASE_CONTROL

Applies To: BMR462-464

Command Code: 0xF0

Type: R/W Byte - Protectable

Data Length In Bytes: 1

Data Format: Custom

Factory Value: 0x00

Units: N/A

Reference: AN307, Parallel Operation with Load Sharing

Definition: This command controls the adding and shedding of phases when the device is set up for current sharing. Writing a data value equal to 0x01 causes the device to be active (supplying power to the load). Writing a data value equal to 0x00 disables the devices and stops power transfer to the load. Any other data value is ignored.

TRACK_CONFIG

Applies To: BMR462-464

Command Code: 0xE1

Type: R/W Byte - Protectable

Data Length In Bytes: 1

Data Format: Custom

Factory Value: 0x00

Units: N/A

Reference: AN310

Definition: Configures the voltage tracking modes of the device. The data field is described in Table 26.

Table 26. TRACK_CONFIG command data specification

Bits	Purpose	Value	Description
7	Enables Voltage Tracking	0	Tracking is disabled
		1	Tracking is enabled
6:3	Reserved	0	Reserved
2	Controls the tracking ratio	0	Output tracks 100% of VTRK
		1	Output tracks 50% of VTRK
1	Controls Upper Track Limit	0	Output is limited by target voltage
		1	Output is limited by VTRK pin
0	Controls ramp-up behavior	0	The output is not allowed to track VTRK down before power-good
		1	The output is allowed to track VTRK down before power-good

Supervisory Commands

See section Memory, Configuration Management and Security above for more details on below commands.

STORE_DEFAULT_ALL

Applies To: BMR450, BMR451, BMR46x

Command Code: 0x11

Type: Send Byte

Data Length In Bytes: 0

Data Format: N/A

Factory Value: N/A

Units: N/A

Reference: Section 11.2 - PMBus Spec Part II

Definition: Stores, at the DEFAULT level, all PMBus values that were written since the last restore command. To add to the DEFAULT store, perform a RESTORE_DEFAULT_ALL, write commands to be added, then STORE_DEFAULT_ALL. After a STORE_DEFAULT_ALL command a delay according to Technical Specification is required before issuing another PMBus command.

RESTORE_DEFAULT_ALL

Applies To: BMR450, BMR451, BMR46x

Command Code: 0x12

Type: Send Byte

Data Length In Bytes: 0

Data Format: N/A

Factory Value: N/A

Units: N/A

Reference: Section 11.3 - PMBus Spec Part I

Definition: Restores PMBus settings that were stored using STORE_DEFAULT_ALL. This command is automatically performed at power up. The security level is changed to level 1 following this command. After a RESTORE_DEFAULT_ALL command a delay according to Technical Specification is required before issuing another PMBus command.

STORE_USER_ALL

Applies To: BMR46x

Command Code: 0x15

Type: Send Byte

Data Length In Bytes: 0

Data Format: N/A

Factory Value: N/A

Units: N/A

Reference: Section 11.6 - PMBus Spec Part I

Definition: Stores, at the USER level, all PMBus values that were changed since the last restore command. To add to the USER store, perform a RESTORE_USER_ALL, write commands to be added, then STORE_USER_ALL. After a STORE_USER_ALL command a delay according to Technical Specification is required before issuing another PMBus command.

RESTORE_USER_ALL

Applies To: BMR46x

Command Code: 0x16

Type: Send Byte

Data Length In Bytes: 0

Data Format: N/A

Factory Value: N/A

Units: N/A

Reference: Section 11.7 - PMBus Spec Part I

Definition: Restores PMBus settings that were stored using STORE_USER_ALL. This command is automatically performed at power up. The values restored will overwrite the values previously loaded by the RESTORE_DEFAULT_ALL command. The security level is changed to Level 1 following this command. After a RESTORE_USER_ALL command a delay according to Technical Specification is required before issuing another PMBus command.

BLANK_PARAMS

Applies To: BMR462-464

Command Code: 0xEB

Type: Block R/W

Data Length In Bytes: 16

Data Format: Custom

Factory Value: N/A

Units: N/A

Definition: Returns a 16-byte string which indicates which parameter values were either retrieved by the last RESTORE operation or have been written since that time. Reading BLANK_PARAMS immediately after a restore operation allows the user to determine which parameters are stored in that store. A one indicates the parameter is not present in the store and has not been written since the RESTORE operation.

PRIVATE_PASSWORD

Applies To: BMR462-464

Command Code: 0xFB

Type: Block R/W

Data Length In Bytes: 9

Data Format: Custom

Factory Value: Product dependent

Units: N/A

Reference:

Definition: Sets the private password string for the USER_STORE. Password strings have the same format as the MFR_ID parameters.

PUBLIC_PASSWORD

Applies To: BMR450, BMR451, BMR462-464

Command Code: 0xFC

Type: Block R/W

Data Length In Bytes: 4

Data Format: Custom

Factory Value: 0x0000

Units: N/A

Reference:

Definition: Sets the public password string.

UNPROTECT

Applies To: BMR450, BMR451, BMR462-464

Command Code: 0xFD

Type: Block R/W
Data Length In Bytes: 32
Data Format: Custom
Factory Value: Model dependent
Units: N/A
Reference:

Definition: Sets a 256-bit (32-byte) parameter which identifies which commands are to be protected against write-access at lower security levels. Each bit in this parameter corresponds to a command according to the command's code. The command with a code of 0x00 (PAGE) is protected by the least-significant bit of the least-significant byte, followed by the command with a code of 0x01 and so forth. Note that all possible commands have a corresponding bit regardless of whether they are protectable or supported by the device. Clearing a command's UNPROTECT bit indicates that write-access to that command is only allowed if the device's security level has been raised to an appropriate level.

Although the UNPROTECT command is writeable at any security level, it only takes effect when it is stored in the Default or User store (storing in the Default store requires a security level of 3, and storing in the User store requires a security level of 2 or higher).

SECURITY_LEVEL

Applies To: BMR450, BMR451, BMR462-464
Command Code: 0xFA
Type: Read Byte
Data Length In Bytes: 1
Data Format: Hex
Factory Value: 0x01
Units: N/A
Reference:
Definition: This command returns the current security level of the 3E regulator.

SECURITY_LEVEL

Applies To: BMR461
Command Code: 0xE6
Type: Read Byte
Data Length In Bytes: 1
Data Format: Hex
Factory Value: 0x00
Units: N/A
Reference:
Definition: This command returns the current security level. The levels are defined according to:

0x00 = Level 0 = PMBus command protections can not be changed.
0x01 = Level 1 = PMBus command protections for user memory can be changed using USER_CONF command.
0x02 = Level 2 = PMBus command protections for default/ manufacturer memory can be changed using MANUF_CONF command.

MANUF_CONF

Applies To: BMR461

Command Code: 0xE0
Type: Block R/W
Data Length In Bytes: 32
Data Format: Custom
Factory Value: 0x00...00
Units: N/A
Reference:

Definition: Sets a 256-bit (32-byte) parameter which identifies which commands are to be protected against write-access in the DEFAULT non-volatile memory (NVM). Each bit in this parameter corresponds to a command according to the command's code. The command with a code of 0x00 is protected by the least-significant bit of the least-significant byte, followed by the command with a code of 0x01 and so forth. Note that all possible commands have a corresponding bit regardless of whether they are protectable or supported by the device. Setting a command's MANUF_CONF bit indicates that command is protected against write-access.

MANUF_LOCK

Applies To: BMR461
Command Code: 0xE1
Type: R/W Word
Data Length In Bytes: 2
Data Format: Hex
Factory Value: 0x0000
Units: N/A
Reference:
Definition: Stores a 2-byte password to be used for changing from security Level 1 to security Level 2. This command is read back as all zeroes.

MANUF_PASSWD

Applies To: BMR461
Command Code: 0xE2
Type: R/W Word
Data Length In Bytes: 2
Data Format: Hex
Factory Value: N/A
Units: N/A
Reference:
Definition: Used to enter User password to change from security Level 1 to security Level 2. This command is read back as all zeroes.

USER_CONF

Applies To: BMR461
Command Code: 0xE3
Type: Block R/W
Data Length In Bytes: 32

Reference documents

Flex Technical Specifications

BMR450 3E POL Regulators,
Document number EN/LZT 146 400

BMR451 3E POL Regulators,
Document number EN/LZT 146 401

BMR461 3E POL Regulators,
Document number 1/287 01 - BMR 461

BMR462 3E POL Regulators,
Document number EN/LZT 146 436

BMR463 3E POL Regulators,
Document number EN/LZT 146 434

BMR464 3E POL Regulators,
Document number EN/LZT 146 435

Quick Reference Table

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OPERATION	0x01	12
ON_OFF_CONFIG	0x02	12
CLEAR_FAULTS	0x03	21
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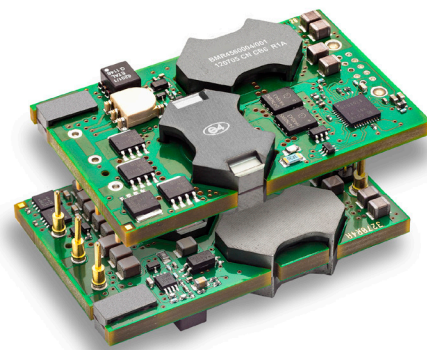
Chapter 2: PMBus Commands for 3E Series Isolated Modules

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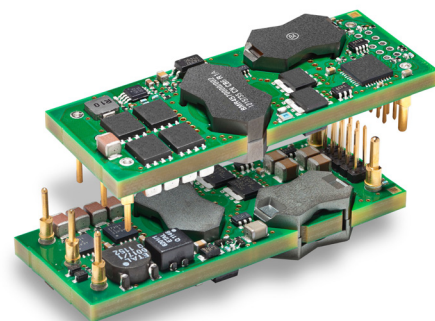
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BMR 456 SERIES 39 A
Digitally controlled 3E Isolated DC/DC
Advanced Bus Converter
Efficiency, typ. 96%
Input voltage range, 36-75 V
Output power 468 W
Size (LxWxH): 57.9 x 36.8 x 11.3 mm
(2.28 x 1.45 x 0.445 inch)



BMR 457 SERIES 25 A
Digitally controlled 3E Isolated DC/DC
Advanced Bus Converter (Isolated DC/DC Converter)
Efficiency, typ. 95.5%
Input voltage range, 36-75 V
Output power 300 W
Size (LxWxH): 58.4 x 22.7 x 10.2 mm
(2.30 x 0.89 x 0.40 inch)



Applicability

This chapter applies to both the BMR453/454 modules and BMR456/457 modules. The BMR456 and BMR457 are the latest generation of 3E isolated modules made for the PMBus 1.2 specification. The BMR453 and BMR454 modules are first-generation modules made for the PMBus 1.1 specification.

Most PMBus commands have the same data format and effect. However there are differences in

supported commands between the BMR453/454 versus the BMR456/457, which will be noted in the descriptions and the “Applies To” sections. There may also be some minor differences where a command has a certain range of allowed values and defaults for the BMR456, and a different range of allowed values and defaults for the BMR457. Any such differences will be described in the document.

PMBus Command Description

Each available PMBus command is described below in the following format:

PMBUS_COMMAND_NAME

Applies To: <list of converters that support this command>

Command Code: <in hex>

Type: <SMBus transfer type>

Data Length In Bytes: <number>

Data Format: <PMBus data format>

Factory Value: <in hex, (decimal), or ascii>

Units: <data units>

Reference: <reference to related command or application note>

Definition: <brief description of command’s operation>

Memory, Configuration Management, And Security

Power On Configuration

When operating, the 3E series modules maintain configuration information, such as the output voltage setting, in RAM in the controller IC. When the module is initially powered on, the RAM is loaded in the order specified by the PMBus specification.

First, the controller will copy in any factory settings in the non-volatile Default Store. Then any saved configuration information that from the non-volatile User Store is copied to RAM. The User Store settings will override the factory defaults as long as the settings are not factory protected.

At this point the module is operating as programmed and ready to accept an enable signal (via RC, CTRL pins or PMBus) and start receiving commands from the PMBus.

Non-Volatile Memory

The Non-Volatile memory setup is different between the BMR453/454 and the BMR456/457, as explained below.

BMR453/454

The BMR453/454 modules contain only one non-volatile memory bank: the DEFAULT_STORE. The DEFAULT_STORE is pre-loaded with default configuration settings by Flex, which can be overwritten by first issuing a RESTORE_DEFAULT_ALL command, writing new settings, then storing them with a STORE_DEFAULT_ALL command.

Please note that some command settings are protected from changes, as noted in the PMBus Commands section.

BMR456/457

The BMR456/457 modules have two non-volatile memory banks: USER_STORE and DEFAULT_STORE. The DEFAULT_STORE is reserved for Flex's use. It contains all of the settings programmed into the module at the time of manufacture. This allows a BMR46x regulator to be restored to "factory condition" with the RESTORE_DEFAULT_ALL command.

The USER_STORE is made available to customers to store their customized settings. For example, when a module is installed on a circuit board with its load, the output voltage and output voltage trim values may be adjusted by automatic test equipment (ATE). These values can be permanently saved with the STORE_USER_ALL command. The settings saved in the USER_STORE can also be copied to the module's RAM with the RESTORE_USER_ALL command.

Command Protection

The 3E series isolated modules offer command write protection via the WRITE_PROTECT command. This is a password-less protection mechanism to prevent random bus traffic from writing new settings to the device. More information on the WRITE_PROTECT command may be found in Section 11.1 in the PMBus Specification Part II.

PMBus Commands

Control Commands

OPERATION

Applies To: BMR453, BMR454, BMR456, BMR457

Command Code: 0x01

Type: R/W Byte

Data Length In Bytes: 1

Data Format: Custom

Factory Value: 0x80 (Enabled)

Units: N/A

Reference: The OPERATION command is used, in conjunction with the hardwired RC or CTRL pin, to turn the module output on and off. It also used to set the margin state (margin high, margin low, no margin) of the output voltage.

A simplified version of the OPERATION values are shown in Table 1 below. Please refer to Section 12.1 of the PMBus Spec Part II for a complete table:

Table 1: OPERATION command states.

Value	Definition
0x00	Disable Immediately
0x60	Disable w/ Soft Off
0x80	Enable, No Margin
0x96	Enable, Margin Low (Ignore Fault)
0x98	Enable, Margin Low (Act on Fault)
0xA6	Enable, Margin High (Ignore Fault)
0xA8	Enable, Margin High (Act on Fault)

ON_OFF_CONFIG

Applies To: BMR453, BMR454, BMR456, BMR457

Command Code: 0x02

Type: R/W Byte

Data Length In Bytes: 1

Data Format: Custom

Factory Value: Varies depending on model, typically 0x1B
(Use Operation Command, Ignore secondary-side control)

Units: N/A

Reference: Section 12.2 - PMBus Spec Part II

Definition: Configures the interpretation and coordination of the OPERATION command and the secondary-side CTRL pin. ON_OFF_CONFIG is dependent on the configuration of MFR_MULTI_PIN_CONFIG. Please refer to the MFR_MULTI_PIN_CONFIG for more options of the CTRL pin, MFR_REMOTE_CTRL for configuration of the primary-side RC pin, and Appendix 1 for a detailed explanation of enable control methods.

Input Commands

VIN_ON

Applies To: BMR453, BMR454, BMR456, BMR457

Command Code: 0x35

Type: R/W Word

Data Length In Bytes: 2

Data Format: Section 7.1 - PMBus Spec Part II - Linear Data Format

Factory Value: Varies depending on module model standard (ETSI vs. ANSI)

Units: N/A

Reference: Section 14.5 – PMBus Spec Part II

Definition: Sets the input voltage at which the module should start power conversion.

VIN_OFF

Applies To: BMR453, BMR454, BMR456, BMR457

Command Code: 0x36

Type: R/W Word

Data Length In Bytes: 2

Data Format: Section 7.1 - PMBus Spec Part II - Linear Data Format

Factory Value: Varies depending on module model standard (ETSI vs. ANSI)

Units: N/A

Reference: Section 14.6 – PMBus Spec Part II

Definition: Sets the input voltage at which the module, once operation has started, should stop power conversion.

Output Commands

VOUT_MODE

Applies To: BMR453, BMR454, BMR456, BMR457

Command Code: 0x20

Type: Read Byte (Protected - Read Only)

Data Length In Bytes: 1

Data Format: Mode + Exponent Format

Factory Value: 0x15 (Linear Mode, Exponent = -11)

Units: N/A

Reference: Section 8 - PMBus Spec Part II

Definition: Preset to define the data format of the output voltage related commands (example: VOUT_COMMAND).

VOUT_COMMAND

Applies To: BMR453, BMR454, BMR456, BMR457

Command Code: 0x21

Type: R/W Word

Data Length In Bytes: 2

Data Format: Section 8.3.1 - PMBus Spec Part II - VOUT linear mode

Factory Value: 0x6000 (12 Volts)

Units: Volts (V)

Reference: Section 8 - PMBus Spec Part II - VOUT_MODE

Definition: Sets the nominal value of the output voltage. The output voltage will be set to:

$$\text{Output Voltage} = \text{VOUT_COMMAND} \times 2^{-11}$$

For example, sending the VOUT_COMMAND command with the data bytes of 0x1400 will set the output to approximately 10.0 V:

$$\begin{aligned} \text{Output Voltage} &= \text{VOUT_COMMAND} \times 2^{-11} \\ &= 0x5000 \times (488.28 \times 10^{-6}) \\ &= 20,480 \times (488.28 \times 10^{-6}) \\ &= 10.0 \text{ V} \end{aligned}$$

Please note that the output voltage cannot be set greater than the voltage set by the VOUT_MAX command.

VOUT_TRIM

Applies To: BMR453, BMR454, BMR456, BMR457

Command Code: 0x22

Type: R/W Word

Data Length In Bytes: 2

Data Format: Signed VOUT linear mode (see definition)

Factory Value: 0x0000 (0 Volts)

Units: Volts (V)

Reference: Section 13.3 - PMBus Spec Part II -

VOUT_MODE

Definition: Sets output voltage trim value. The two bytes are formatted as a two's complement binary mantissa, used in conjunction with the exponent set in VOUT_MODE.

VOUT_CAL_OFFSET

Applies To: BMR453, BMR454, BMR456, BMR457
Command Code: 0x23
Type: R/W Word (Protected - Read Only)
Data Length In Bytes: 2
Data Format: Signed VOUT linear mode (see definition)
Factory Value: Individually calibrated at the factory
Units: Volts (V)
Reference: Section 13.4 - PMBus Spec Part II - VOUT_MODE
Definition: Sets the output voltage calibration offset (same function as VOUT_TRIM). The two bytes are formatted as a two's complement binary mantissa, used in conjunction with the exponent set in VOUT_MODE.
NOTE: This command was previously known as VOUT_CAL and VOUT_GAIN.

VOUT_MAX

Applies To: BMR453, BMR454, BMR456, BMR457
Command Code: 0x24
Type: R/W Word
Data Length In Bytes: 2
Data Format: Section 8.3.1 - PMBus Spec Part II - VOUT Linear Mode
Factory Value: 0x7100 (14.125 Volts)
Units: Volts (V)
Reference: Section 13.5 - PMBus Spec Part II - VOUT_MODE
Definition: Sets the maximum possible value setting of the output voltage.

VOUT_MARGIN_HIGH

Applies To: BMR453, BMR454, BMR456, BMR457
Command Code: 0x25
Type: R/W Word
Data Length In Bytes: 2
Data Format: Section 8.3.1 - PMBus Spec Part II - VOUT Linear Mode
Factory Value: 0x6999 (13.2 Volts)
Units: Volts (V)
Reference: Section 13.6 - PMBus Spec Part II - VOUT_MODE
Definition: Sets the value of the output voltage during the margin high operation state. To change the operation to output margin high, please refer to the OPERATION command.

VOUT_MARGIN_LOW

Applies To: BMR453, BMR454, BMR456, BMR457
Command Code: 0x26
Type: R/W Word
Data Length In Bytes: 2
Data Format: Section 8.3.1 - PMBus Spec Part II - VOUT Linear Mode
Factory Value: 0x5666 (10.8 Volts)
Units: Volts (V)
Reference: Section 13.7 - PMBus Spec Part II - VOUT_MODE
Definition: Sets the value of the output voltage during the margin low operation state. To change the operation to output margin low, please refer to the OPERATION command.

VOUT_TRANSITION_RATE

Applies To: BMR453, BMR454, BMR456, BMR457
Command Code: 0x27
Type: R/W Word
Data Length In Bytes: 2
Data Format: Section 7.1 - PMBus Spec Part II - Linear Data Format
Factory Value: 0x9B02 (0.094 V/ms)
Units: Volts (V)/ms
Reference: Section 13.8 - PMBus Spec Part II
Definition: Sets the output voltage transition rate during margin or other change of VOUT.

VOUT_SCALE_LOOP

Applies To: BMR453, BMR454, BMR456, BMR457
Command Code: 0x29
Type: R/W Word (Protected - Read Only)
Data Length In Bytes: 2
Data Format: BMR453/454: Section 7.1 - PMBus Spec Part II - Linear Data Format
BMR456/457: Section 7.2 – PMBus Spec Part II – DIRECT Data Format
Factory Value: Calibrated value determined by Flex
Units: BMR453/454: Dimensionless scalar value
BMR456/457: Dimensionless Integer, where coefficients are m=1, R=0, b=0
Reference: Section 13.10 & Section 9.1 – PMBus Spec Part II
Definition: This is a value set by Flex during production to set the ratio between the measured output voltage using a resistor divider and the actual output voltage used in the control loop to compare against the commanded output voltage. Please read Section 9.1 of the PMBus Spec Part II for a detailed overview.

VOUT_SCALE_MONITOR

Applies To: BMR453, BMR454, BMR456, BMR457
Command Code: 0x2A
Type: R/W Word (Protected - Read Only)
Data Length In Bytes: 2
Data Format: BMR453/454: Section 7.1 - PMBus Spec Part II - Linear Data Format
BMR456/457: Section 7.2 – PMBus Spec Part II – DIRECT Data Format
Factory Value: Calibrated value determined by Flex
Units: BMR453/454: Dimensionless scalar value
BMR456/457: Dimensionless Integer, where coefficients are m=1, R=0, b=0
Reference: Section 13.10 & Section 9.1 – PMBus Spec Part II
Definition: This is a value set by Flex during production to set the ratio between the measured output voltage using a resistor divider and the actual monitored voltage. Please read Section 9.1 of the PMBus Spec Part II for a detailed overview.

MAX_DUTY

Applies To: BMR453, BMR454, BMR456, BMR457
Command Code: 0x32
Type: R/W Word
Data Length In Bytes: 2
Data Format: Section 7.1 - PMBus Spec Part II - Linear Data Format
Factory Value: 0xEB18 (99%)
Units: %
Reference: Section 14.3 - PMBus Spec Part II
Definition: Sets the maximum allowable duty cycle of the switching frequency.
NOTE: MAX_DUTY should not be used to set the output voltage of the device. VOUT_COMMAND is the proper method to set the output voltage.

FREQUENCY_SWITCH

Applies To: BMR453, BMR454, BMR456, BMR457
Command Code: 0x33
Type: R/W Word
Data Length In Bytes: 2
Data Format: BMR453/454: Section 7.1 - PMBus Spec Part II - Linear Data Format
BMR456/457: Section 7.2 – PMBus Spec Part II – DIRECT Data Format
Factory Value: Varies depending on model. Typically it is between 140 - 180 kHz
Units: BMR453/454: kHz.
BMR456/457: kHz, coefficients are m=1, R=0, b=0.
Allowed range is 80-230kHz.
Reference: Section 14.4 - PMBus Spec Part II
Definition: Sets the switching frequency.

IOUT_CAL_GAIN

Applies To: BMR453, BMR454, BMR456, BMR457
Command Code: 0x38
Type: R/W Word (Protected - Read Only)
Data Length In Bytes: 2
Data Format: BMR453/454: Section 7.1 - PMBus Spec Part II - Linear Data Format
BMR456/457: Section 7.2 – PMBus Spec Part II – DIRECT Data Format
Factory Value: Individually calibrated at the factory
Units: BMR453/454: milli-ohms (mΩ).
BMR456/457: milli-ohms (mΩ), where coefficients are m=1, R=0, b=0.
Reference: Section 14.8 - PMBus Spec Part I
Definition: This command tells the controller IC the value of the resistance used to monitor the output current. It is recommended that this value not be changed.
NOTE: This command was formerly known as IOUT_SCALE.

IOUT_CAL_OFFSET

Applies To: BMR453, BMR454, BMR456, BMR457
Command Code: 0x39
Type: R/W Word (Protected - Read Only)
Data Length In Bytes: 2
Data Format: BMR453/454: Section 7.1 - PMBus Spec Part II - Linear Data Format
BMR456/457: Section 7.2 – PMBus Spec Part II – DIRECT Data Format
Factory Value: Individually calibrated at factory
Units: BMR453/454: Amperes (A)
BMR456/457: Integer units of 0.125 Amperes (A), where coefficients are m=1, R=0, b=0.
Reference: Section 14.9 - PMBus Spec Part II
Definition: When calibrating the current sense circuit, this command provides the controller IC with the value the offset correction to be applied to the measured output current. It is recommended that this value not be changed.

Fault Limit Commands

POWER_GOOD_ON

Applies To: BMR453, BMR454, BMR456, BMR457
Command Code: 0x5E
Type: R/W Word
Data Length In Bytes: 2
Data Format: Section 8.3.1 - PMBus Spec Part II - VOUT Linear Mode
Factory Value: Varies depending on model (typically 8 Volts)
Units: Volts (V)
Reference: Section 15.32.1 - PMBus Spec Part II
Definition: Sets the voltage threshold for Power-Good indication. Power-Good asserts when the output voltage exceeds POWER_GOOD_ON and de-asserts when the output voltage is less than VOUT_UV_FAULT_LIMIT.

POWER_GOOD_OFF

Applies To: BMR453, BMR454, BMR456, BMR457
Command Code: 0x5F
Type: R/W Word
Data Length In Bytes: 2
Data Format: Section 8.3.1 - PMBus Spec Part II - VOUT Linear Mode
Factory Value: Varies depending on model (typically 5 Volts)
Units: Volts (V)
Reference: Section 15.32.2 - PMBus Spec Part II
Definition: Sets the voltage threshold for Power-Good indication to disable. Power-Good asserts when the output voltage.

VOUT_OV_FAULT_LIMIT

Applies To: BMR453, BMR454, BMR456, BMR457
Command Code: 0x40
Type: R/W Word
Data Length In Bytes: 2
Data Format: Section 8.3.1 - PMBus Spec Part II - VOUT Linear Mode
Factory Value: Varies depending on model
Units: Volts (V)
Reference: Section 15.2 - PMBus Spec Part II
Definition: Sets the output overvoltage fault threshold.

VOUT_OV_WARN_LIMIT

Applies To: BMR453, BMR454, BMR456, BMR457
Command Code: 0x42
Type: R/W Word
Data Length In Bytes: 2
Data Format: Section 8.3.1 - PMBus Spec Part II - VOUT Linear Mode
Factory Value: Varies depending on model
Units: Volts (V)
Reference: Section 15.4 - PMBus Spec Part II
Definition: Sets the output overvoltage warning threshold.

VOUT_UV_FAULT_LIMIT

Applies To: BMR453, BMR454, BMR456, BMR457
Command Code: 0x44
Type: R/W Word
Data Length In Bytes: 2
Data Format: Section 8.3.1 - PMBus Spec Part II - VOUT Linear Mode.
Factory Value: 0x0000 (0 Volts)
Units: Volts (V)
Reference: Section 15.6 - PMBus Spec Part II
Definition: Sets the output undervoltage fault threshold

VOUT_UV_WARN_LIMIT

Applies To: BMR453, BMR454, BMR456, BMR457
Command Code: 0x43
Type: R/W Word
Data Length In Bytes: 2
Data Format: Section 8.3.1 - PMBus Spec Part II - VOUT Linear Mode
Factory Value: 0x0000 (0 Volts)
Units: Volts (V)
Reference: Section 15.5 - PMBus Spec Part II
Definition: Sets the output overvoltage warning threshold.

IOUT_OC_FAULT_LIMIT

Applies To: BMR453, BMR454, BMR456, BMR457
Command Code: 0x46
Type: R/W Word
Data Length In Bytes: 2
Data Format: Section 7.1 - PMBus Spec Part II - Linear Data Format
Factory Value: Varies depending on model
Units: Amperes (A)
Reference: Section 15.8 - PMBus Spec Part II
Definition: Sets the current value that will trigger an overcurrent fault condition if the output current exceeds this set value. The fault condition will be handled as set by the IOUT_OC_FAULT_RESPONSE command.

IOUT_OC_WARN_LIMIT

Applies To: BMR453, BMR454, BMR456, BMR457
Command Code: 0x4A
Type: R/W Word
Data Length In Bytes: 2
Data Format: Section 7.1 - PMBus Spec Part II - Linear Data Format
Factory Value: Varies depending on model
Units: Amperes (A)
Reference: Section 15.12 - PMBus Spec Part II
Definition: Sets the current value that will trigger an overcurrent warning condition if the output current exceeds this set value.

IOUT_OC_LV_FAULT_LIMIT

Applies To: BMR453, BMR454, BMR456, BMR457
Command Code: 0x48
Type: R/W Word
Data Length In Bytes: 2
Data Format: Section 8.3.1 – PMBus Spec Part II – VOUT Linear Mode
Factory Value: Varies depending on model
Units: Volts (V)
Reference: Section 15.10 – PMBus Spec Part II
Definition: Sets the voltage threshold in which during an output current event, the response will be to operate in a constant current mode unless the output voltage is pulled below the voltage threshold set with this command.

OT_FAULT_LIMIT

Applies To: BMR453, BMR454, BMR456, BMR457
Command Code: 0x4F
Type: R/W Word
Data Length In Bytes: 2
Data Format: Section 7.1 - PMBus Spec Part II - Linear Data Format
Factory Value: 0x007D or 0xE8E8 (both mean 125 °C)
Units: °C
Reference: Section 15.17 - PMBus Spec Part II
Definition: Sets the over-temperature fault threshold.

OT_WARN_LIMIT

Applies To: BMR453, BMR454, BMR456, BMR457
Command Code: 0x51
Type: R/W Word
Data Length In Bytes: 2
Data Format: Section 7.1 - PMBus Spec Part II - Linear Data Format
Factory Value: 0x0073 or 0xEB98 (both are 115 °C)
Units: °C
Reference: Section 15.19 - PMBus Spec Part II
Definition: Sets the over-temperature warning threshold.

UT_FAULT_LIMIT

Applies To: BMR453, BMR454, BMR456, BMR457
Command Code: 0x53
Type: R/W Word
Data Length In Bytes: 2
Data Format: Section 7.1 - PMBus Spec Part II - Linear Data Format
Factory Value: 0x07CE or 0xE4E0 (both are -50 °C)
Units: °C
Reference: Section 15.21 - PMBus Spec Part II
Definition: Sets the undertemperature fault threshold.

UT_WARN_LIMIT

Applies To: BMR453, BMR454, BMR456, BMR457
Command Code: 0x52
Type: R/W Word
Data Length In Bytes: 2
Data Format: Section 7.1 - PMBus Spec Part II - Linear Data Format
Factory Value: 0x07D8 or 0xE580 (both are -40 °C)
Units: °C
Reference: Section 15.20 - PMBus Spec Part II
Definition: Sets the under-temperature warning threshold.

VIN_OV_FAULT_LIMIT

Applies To: BMR453, BMR454, BMR456, BMR457
Command Code: 0x55
Type: R/W Word - Protectable
Data Length In Bytes: 2
Data Format: Section 7.1 - PMBus Spec Part II - Linear Data Format
Factory Value: 0x0055 or 0xEAA8 (both are 85 Volts)
Units: Volts (V)
Reference: Section 15.23 - PMBus Spec Part II
Definition: Sets the VIN overvoltage fault threshold.

VIN_OV_WARN_LIMIT

Applies To: BMR453, BMR454, BMR456, BMR457
Command Code: 0x57
Type: R/W Word
Data Length In Bytes: 2
Data Format: Section 7.1 - PMBus Spec Part II - Linear Data Format
Factory Value: 0x0050 or 0xEA80 (both are 80 Volts)
Units: Volts (V)
Reference: Section 15.25 - PMBus Spec Part II
Definition: Sets the VIN overvoltage warning threshold.

VIN_UV_WARN_LIMIT

Applies To: BMR453, BMR454, BMR456, BMR457
Command Code: 0x58
Type: R/W Word
Data Length In Bytes: 2
Data Format: Section 7.1 - PMBus Spec Part II - Linear Data Format
Factory Value: 0x0000 (0 Volts)
Units: Volts (V)
Reference: Section 15.26 - PMBus Spec Part II
Definition: Sets the VIN undervoltage warning threshold. If a VIN_UV_FAULT occurs, the input voltage must rise above VIN_UV_WARN_LIMIT to clear the fault. If product is enabled, VIN_UV_WARN_LIMIT sets the input voltage level at which the output voltage is turned on.

VIN_UV_FAULT_LIMIT

Applies To: BMR453, BMR454, BMR456, BMR457
Command Code: 0x59
Type: R/W Word - Protectable
Data Length In Bytes: 2
Data Format: Section 7.1 - PMBus Spec Part II -
Linear Data Format
Factory Value: 0x0000 (0 Volts)
Units: Volts (V)
Reference: Section 15.27 - PMBus Spec Part II
Definition: Sets the VIN undervoltage fault threshold.

TON_MAX_FAULT_LIMIT

Applies To: BMR453, BMR454, BMR456, BMR457
Command Code: 0x62
Type: R/W Word
Data Length In Bytes: 2
Data Format: BMR453/454: Section 7.1 - PMBus Spec
Part II - Linear Data Format
BMR456/457: Section 7.2 - PMBus Spec
Part II - DIRECT Data Format
Factory Value: 0x000F (15 ms)
Units: BMR453/454: Time in milliseconds (ms)
BMR456/457: Time in milliseconds (ms), where
coefficients are m=1, R=0, b=0
Reference: Section 16.3 - PMBus Spec Part II
Definition: Sets an upper time limit of how long the
module can try to power up without reaching the
undervoltage fault limit. A value of zero milliseconds
means that there is no limit.

TOFF_MAX_WARN_LIMIT

Applies To: BMR453, BMR454, BMR456, BMR457
Command Code: 0x66
Type: R/W Word
Data Length In Bytes: 2
Data Format: BMR453/454: Section 7.1 - PMBus Spec
Part II - Linear Data Format
BMR456/457: Section 7.2 - PMBus Spec
Part II - DIRECT Data Format
Factory Value: 0x000F (15 ms)
Units: BMR453/454: Time in milliseconds (ms)
BMR456/457: Time in milliseconds (ms), where
coefficients are m=1, R=0, b=0
Reference: Section 16.7 - PMBus Spec Part II
Description: Sets a time limit on how long the module
can power down without reaching 12.5% of the output
voltage the device was operating at when the unit is
turned off. If the voltage is still higher, fault-bits are set
in STATUS_BYTE, STATUS_WORD, and STATUS_VOUT
as described in Section 16.7 of PMBus Spec Part II.

Table 2

Bits	Description	Value	Meaning
7:6	Response: For all modes set by bits [7:6], the device: <ul style="list-style-type: none"> > Pulls SALERT low > Sets the related fault bit in the status registers. Fault bits are only cleared by the CLEAR_FAULTS command. 	00	Continuous operation. (Ignore fault)
		01	Delay, Disable and Retry The delay time is specified by bits [2:0] and the delay time unit is specified for that particular fault. If the fault condition is still present at the end of the delay time, the unit retries according to the setting in bits [5:3].
		10	Disable and Retry according to the setting in bits [5:3].
		11	The device's output is disabled while the fault is present. Operation resumes and the output is enabled when the fault condition no longer exists.
5:3	Retry Setting	000	No Retry. The output remains disabled.
		001 to 110	The device attempts to restart the number of times set by these bits. The minimum number is 1 and the maximum number is 6. If the device fails to restart in the allowed number of retries, it disables the output and remains disabled. The time between the start of each attempt to retry is set by the value in bits [2:0] along with the delay time unit specified for that particular fault.
		111	The device attempts retry continuously until it is commanded to disable (by the Enable pin or OPERATION command), input power is removed, or another fault condition causes the unit to shut down.
2:0	Retry Time and Delay Time	000 to 111	This time count is used for both the amount of time between retry attempts and for the amount of time a rail is to delay its response after a fault is detected. The retry time and delay time units are in the individual response command descriptions.

Fault Response Commands

The 3E series module fault responses for V_{out} , V_{in} , Temperature and Timing responses are defined by Table 2 below. Output Current fault responses are handled slightly differently and described in Table 2 below.

Table 2. V_{out} , V_{in} , Temperature, and timing fault response command functions and data format

Table 3. Output current fault response command functions and data format

Bits	Description	Value	Meaning
7:6	<p>Response:</p> <p>For all modes set by bits [7:6], the device:</p> <ul style="list-style-type: none"> > Pulls SALERT low > Sets the related fault bit in the status registers. Fault bits are only cleared by the CLEAR_FAULTS command. 	00	The device continues to operate indefinitely while maintaining the output current at the value set by IOUT_OC_FAULT_LIMIT without regard to the output voltage (known as constant-current or brickwall limiting).
		01	The device continues to operate indefinitely while maintaining the output current at the value set by IOUT_OC_FAULT_LIMIT as long as the output voltage remains above the minimum value specified by IOUT_OC_LV_FAULT_LIMIT. If the output voltage is pulled down to less than that value, then the device shuts down and responds according to the Retry setting in bits [5:3].
		10	The device continues to operate, maintaining the output current at the value set by IOUT_OC_FAULT_LIMIT without regard to the output voltage, for the delay time set by bits [2:0] and the delay time units specified in IOUT_OC_FAULT_RESPONSE. If the device is still operating in current limiting at the end of the delay time, the device responds as programmed by the Retry Setting in bits [5:3].
		11	The device's output is disabled while the fault is present. Operation resumes and the output is enabled when the fault condition no longer exists.
5:3	Retry Setting	000	No Retry. The output remains disabled.
		001 to 110	The device attempts to restart the number of times set by these bits. The minimum number is 1 and the maximum number is 6. If the device fails to restart in the allowed number of retries, it disables the output and remains disabled. The time between the start of each attempt to retry is set by the value in bits [2:0] along with the delay time unit specified for that particular fault.
		111	The device attempts retry continuously until it is commanded to disable (by the Enable pin or OPERATION command), input power is removed, or another fault condition causes the unit to shut down.
2:0	Retry Time and Delay Time	000 to 111	This time count is used for both the amount of time between retry attempts and for the amount of time a rail is to delay its response after a fault is detected. The retry time and delay time units are in the individual response command descriptions.

VOUT_OV_FAULT_RESPONSE

Applies To: BMR453, BMR454, BMR456, BMR457
Command Code: 0x41
Type: R/W Byte
Data Length In Bytes: 1
Data Format: Section 10.5.1 - Custom (PMBus Spec Part II)
Factory Value: BMR 453/454: 0x80 (Disable upon fault)
BMR 456/457: 0xC0 (Disable upon fault, resume when fault clears)
Units: Delay = 10 ms/LSB
Reference: Section 15.3 - PMBus Spec Part II
Definition: Configures the output overvoltage fault response.

VOUT_UV_FAULT_RESPONSE

Applies To: BMR453, BMR454, BMR456, BMR457
Command Code: 0x45
Type: R/W Byte
Data Length In Bytes: 1
Data Format: Section 10.5.1 - Custom (PMBus Spec Part II)
Factory Value: BMR 453/454: 0x00 (Ignore fault)
BMR 456/457: 0xC0 (Disable upon fault, resume when fault clears)
Units: Delay = 10 ms/LSB
Reference: Section 15.7 - PMBus Spec Part II
Definition: Configures the output undervoltage fault response.

IOUT_OC_FAULT_RESPONSE

Applies To: BMR453, BMR454, BMR456, BMR457
Command Code: 0x47
Type: R/W Byte
Data Length In Bytes: 1
Data Format: Section 10.5.1 – Custom (PMBus Spec Part II)
Factory Value: 0x7B (Continue as long as above IOUT_OC_LV_LIMIT, otherwise retry continuously with a 20ms delay)
Units: Delay = 10 ms/LSB
Reference: Section 15.9 – PMBus Spec Part II
Definition: Configures the output overcurrent fault response.

OT_FAULT_RESPONSE

Applies To: BMR453, BMR454, BMR456, BMR457
Command Code: 0x50
Type: R/W Byte
Data Length In Bytes: 1
Data Format: Section 10.5.1 - Custom (PMBus Spec Part II)
Factory Value: 0xC8 (Disable upon fault, resume when fault clears, retry once)
Units: Exponential delay units such that Delay = $2^n * 1$ second. (e.g. if bits 2:0 are set to 100, n equals 4, and the delay is $2^4 * 1$ second, or 16 seconds)
Reference: Section 15.18 - PMBus Spec Part II
Definition: Configures the over-temperature fault response.
NOTE: The delay time is the time between restart attempts.

UT_FAULT_RESPONSE

Applies To: BMR453, BMR454, BMR456, BMR457
Command Code: 0x54
Type: R/W Byte
Data Length In Bytes: 1
Data Format: Section 10.5.1 - Custom (PMBus Spec Part II)
Factory Value: 0x00 (Faults ignored)
Units: Exponential delay units such that Delay = $2^n * 1$ second. (e.g. if bits 2:0 are set to 100, n equals 4, and the delay is $2^4 * 1$ second, or 16 seconds)
Reference: Section 15.22 - PMBus Spec Part II
Definition: Configures the under-temperature fault response.
NOTE: The delay time is the time between restart attempts.

VIN_OV_FAULT_RESPONSE

Applies To: BMR453, BMR454, BMR456, BMR457
Command Code: 0x56
Type: R/W Byte
Data Length In Bytes: 1
Data Format: Section 10.5.1 - Custom (PMBus Spec Part II)
Factory Value: 0x00 (Ignore fault)
Units: Delay = 10 ms/LSB
Reference: Section 15.24 - PMBus Spec Part II
Definition: Configures the VIN overvoltage fault response.
NOTE: The delay time is the time between restart attempts.

VIN_UV_FAULT_RESPONSE

Applies To: BMR453, BMR454, BMR456, BMR457
Command Code: 0x5A
Type: R/W Byte
Data Length In Bytes: 1
Data Format: Section 10.5.1 - Custom (PMBus Spec Part II)
Factory Value: 0xC0 (Disable upon fault, resume when fault clears)
Units: Delay = 10 ms/LSB
Reference: Section 15.28 - PMBus Spec Part II
Definition: Configures the VIN undervoltage fault response.
NOTE: The delay time is the time between restart attempts.

TON_MAX_FAULT_RESPONSE

Applies To: BMR453, BMR454, BMR456, BMR457
Command Code: 0x63
Type: R/W Byte
Data Length In Bytes: 1
Data Format: Section 10.5.1 – PMBus Spec Part II
Factory Value: 0x00
Units: Delay = 10ms / LSB
Reference: Section 16.4 – PMBus Spec Part II
Description: Sets the response when the output can't power up above the undervoltage fault limit within the time set by TON_MAX_FAULT_LIMIT.

Time Setting Commands

TON_DELAY

Applies To: BMR453, BMR454, BMR456, BMR457
Command Code: 0x60
Type: R/W Word
Data Length In Bytes: 2
Data Format: BMR453/454: Section 7.1 - PMBus Spec Part II - Linear Data Format
BMR456/457: Section 7.2 – PMBus Spec Part II – DIRECT Data Format
Factory Value: BMR 453/454: 0xE280 (40 ms) BMR 456/457: 0x0000 (0 ms)
Units: BMR453/454: Time in milliseconds (ms)
BMR456/457: Time in milliseconds (ms), where coefficients are m=1, R=0, b=0
Reference: Section 16.7 – PMBus Spec Part II
Definition: Sets the delay time from ENABLE to start of the rise of the output voltage.

TON_RISE

Applies To: BMR453, BMR454, BMR456, BMR457
Command Code: 0x61
Type: R/W Word
Data Length In Bytes: 2
Data Format: BMR453/454: Section 7.1 - PMBus Spec Part II - Linear Data Format
BMR456/457: Section 7.2 – PMBus Spec Part II – DIRECT Data Format
Factory Value: 0x000A or 0xD280 (both mean 10 ms)
Units: BMR453/454: Time in milliseconds (ms)
BMR456/457: Time in milliseconds (ms), where coefficients are m=1, R=0, b=0
Reference: Section 16.2 - PMBus Spec Part II
Definition: Sets the rise time of the output voltage after ENABLE and TON_DELAY.

TOFF_DELAY

Applies To: BMR453, BMR454, BMR456, BMR457
Command Code: 0x64
Type: R/W Word
Data Length In Bytes: 2
Data Format: BMR453/454: Section 7.1 - PMBus Spec Part II - Linear Data Format
BMR456/457: Section 7.2 – PMBus Spec Part II – DIRECT Data Format
Factory Value: 0x0005 or 0xCA80 (both mean 5 ms)
Units: BMR453/454: Time in milliseconds (ms)
BMR456/457: Time in milliseconds (ms), where coefficients are m=1, R=0, b=0
Reference: Section 16.5 - PMBus Spec Part II
Definition: Sets the delay time from DISABLE to start of the fall of the output voltage.

TOFF_FALL

Applies To: BMR453, BMR454, BMR456, BMR457
Command Code: 0x65
Type: R/W Word
Data Length In Bytes: 2
Data Format: BMR453/454: Section 7.1 - PMBus Spec Part II - Linear Data Format
BMR456/457: Section 7.2 – PMBus Spec Part II – DIRECT Data Format
Factory Value: 0x000A or 0xD280 (both mean 10 ms)
Units: BMR453/454: Time in milliseconds (ms)
BMR456/457: Time in milliseconds (ms), where coefficients are m=1, R=0, b=0
Reference: Section 16.6 - PMBus Spec Part II
Definition: Sets the fall time of the output voltage after DISABLE and TOFF_DELAY.

Status Commands

The status commands are used to see whether any faults have occurred, as well as seeing if the device is operating. Faults may be cleared via the CLEAR_FAULTS command. One the BMR456/457, the faults may also be cleared individually by writing to the desired status command.

CLEAR_FAULTS

Applies To: BMR453, BMR454, BMR456, BMR457
Command Code: 0x03
Type: Send Byte
Data Length In Bytes: 0
Data Format: N/A
Factory Value: N/A
Units: N/A
Reference: Section 15.1 - PMBus Spec Part II
Definition: Clears fault indications.

STATUS_BYTE

Applies To: BMR453, BMR454, BMR456, BMR457
Command Code: 0x78
Type: BMR453/454: Read Byte
BMR456/457: R/W Byte
Data Length In Bytes: 1
Data Format: Custom
Factory Value: 0x00
Units: N/A
Reference: Section 17.1 - PMBus Spec Part II
Definition: Returns an abbreviated status for fast reads.

STATUS_WORD

Applies To: BMR453, BMR454, BMR456, BMR457
Command Code: 0x79
Type: BMR453/454: Read Word
BMR456/457: R/W Word
Data Length In Bytes: 2
Data Format: Custom
Factory Value: 0x0000
Units: N/A
Reference: Section 17.2 - PMBus Spec Part II
Definition: Returns the general status information used to indicate subsequent status to be read for more detail.

STATUS_VOUT

Applies To: BMR453, BMR454, BMR456, BMR457
Command Code: 0x7A
Type: BMR453/454: Read Byte
BMR456/457: R/W Byte
Data Length In Bytes: 1
Data Format: Custom
Factory Value: 0x00
Units: N/A
Reference: Section 17.3 - PMBus Spec Part II
Definition: Returns the output voltage related status.

STATUS_IOUT

Applies To: BMR453, BMR454, BMR456, BMR457
Command Code: 0x7B
Type: BMR453/454: Read Byte
BMR456/457: R/W Byte
Data Length In Bytes: 1
Data Format: Custom
Factory Value: 0x00
Units: N/A
Reference: Section 17.4 - PMBus Spec Part II
Definition: Returns the output current related status.

STATUS_INPUT

Applies To: BMR453, BMR454, BMR456, BMR457
Command Code: 0x7C
Type: BMR453/454: Read Byte
BMR456/457: R/W Byte
Data Length In Bytes: 1
Data Format: Custom
Factory Value: 0x00
Units: N/A
Reference: Section 17.5 - PMBus Spec Part II
Definition: Returns specific status specific to the input.

STATUS_TEMPERATURE

Applies To: BMR453, BMR454, BMR456, BMR457
Command Code: 0x7D
Type: BMR453/454: Read Byte
BMR456/457: R/W Byte
Data Length In Bytes: 1
Data Format: Custom
Factory Value: 0x00
Units: N/A
Reference: Section 17.6 - PMBus Spec Part II
Definition: Returns the temperature specific status.

STATUS_CML

Applies To: BMR453, BMR454, BMR456, BMR457
Command Code: 0x7E
Type: BMR453/454: Read Byte
BMR456/457: R/W Byte
Data Length In Bytes: 1
Data Format: Custom
Factory Value: 0x00
Units: N/A
Reference: Section 17.7 - PMBus Spec Part II
Definition: Returns the Communication, Logic and Memory specific status.

Monitor Commands

READ_VIN

Applies To: BMR453, BMR454, BMR456, BMR457
Command Code: 0x88
Type: Read Word
Data Length In Bytes: 2
Data Format: Section 7.1 - PMBus Spec Part II - Linear Data Format
Factory Value: N/A
Units: Volts (V)
Reference: Section 18.1 - PMBus Spec Part II
Definition: Returns the measured value of the input voltage.

READ_VOUT

Applies To: BMR453, BMR454, BMR456, BMR457
Command Code: 0x8B
Type: Read Word
Data Length In Bytes: 2
Data Format: Section 8.3.1 - PMBus Spec Part II - VOUT Linear Mode
Factory Value: N/A
Units: Volts (V)
Reference: Section 18.4 - PMBus Spec Part II
Definition: Returns the measured value of the output voltage.

READ_IOUT

Applies To: BMR453, BMR454, BMR456, BMR457
Command Code: 0x8C
Type: Read Word
Data Length In Bytes: 2
Data Format: Section 7.1 - PMBus Spec Part II - Linear Data Format
Factory Value: N/A
Units: Amperes (A)
Reference: Section 18.5 - PMBus Spec Part II
Definition: Returns the measured value of the output current.

READ_TEMPERATURE_1

Applies To: BMR453, BMR454, BMR456, BMR457
Command Code: 0x8D
Type: Read Word
Data Length In Bytes: 2
Data Format: Section 7.1 - PMBus Spec Part II - Linear Data Format
Factory Value: N/A
Units: °C
Reference: Section 18.6 - PMBus Spec Part II
Definition: Returns the measured value of the module's internal temperature sensor.

READ_TEMPERATURE_2

Applies To: BMR453, BMR454, BMR456
Command Code: 0x8E
Type: Read Word
Data Length In Bytes: 2
Data Format: Section 7.1 - PMBus Spec Part II - Linear Data Format
Factory Value: N/A
Units: °C
Reference: Section 18.6 - PMBus Spec Part II
Definition: Returns the measured value of the module's external module temperature sensor.

READ_DUTY_CYCLE

Applies To: BMR453, BMR454, BMR456, BMR457
Command Code: 0x94
Type: Read Word
Data Length In Bytes: 2
Data Format: Section 7.1 - PMBus Spec Part II - Linear Data Format
Factory Value: N/A
Units: %
Reference: Section 18.9 - PMBus Spec Part II
Definition: Returns the measured value of the duty cycle.

READ_FREQUENCY

Applies To: BMR453, BMR454, BMR456, BMR457
Command Code: 0x95
Type: Read Word
Data Length In Bytes: 2
Data Format: BMR453/454: Section 7.1 - PMBus Spec Part II - Linear Data Format
BMR456/457: Section 7.2 - PMBus Spec Part II - DIRECT Data Format
Factory Value: N/A
Units: BMR453/454: kHz
BMR456/457: kHz, where coefficients are $m=1$, $R=0$, $b=0$.
Reference: Section 18.10 - PMBus Spec Part II
Definition: Returns the measured value of the switching frequency.

Identification Commands

CAPABILITY

Applies To: BMR453, BMR454, BMR456, BMR457
Command Code: 0x19
Type: Read Byte
Data Length In Bytes: 1
Data Format: Custom
Factory Value: 0xB0
Units: N/A
Reference: Section 11.12 - PMBus Spec Part II
Definition: This read-only command reports on the device's basic pmbus-level abilities. For the BMR456/457's default value of 0xB0, it means the device is capable of Packet Error checking (PEC), a maximum bus speed of 400kHz, and has an SALERT# pin used for fault notification.
NOTE: On the BMR453/454, the SALERT# pin operates in push-pull mode instead of open-drain.

PMBUS_REVISION

Applies To: BMR453, BMR454, BMR456, BMR457
Command Code: 0x98
Type: Read Byte (Read Only)
Data Length In Bytes: 1
Data Format: Hex
Factory Value: The PMBus revision implemented in this unit.
Units: N/A
Reference: Section 22.1 - PMBus Spec Part II
Definition: Returns the revision of the PMBus implemented in the device.

MFR_ID

Applies To: BMR453, BMR454, BMR456, BMR457
Command Code: 0x99
Type: Block R/W (Protected - Read Only)
Data Length In Bytes: 12
Data Format: ASCII
Factory Value: Flex
Units: N/A
Reference: Section 22.2 - PMBus Spec Part II
Definition: This command returns the name of the module manufacturer, Flex.

MFR_MODEL

Applies To: BMR453, BMR454, BMR456, BMR457
Command Code: 0x9A
Type: Block R/W (Protected - Read Only)
Data Length In Bytes: 20
Data Format: ASCII
Factory Value: Flex model number
Units: N/A
Reference: Section 22.2.2 - PMBus Spec Part II
Definition: This command returns the model number of the module.

MFR_REVISION

Applies To: BMR453, BMR454, BMR456, BMR457
Command Code: 0x9B
Type: Block R/W (Protected - Read Only)
Data Length In Bytes: 12
Data Format: ASCII
Factory Value: Flex product revision number
Units: N/A
Reference: Section 22.2.3 - PMBus Spec Part II
Definition: This command returns the name of the configuration file used at the factory to program the device.

MFR_LOCATION

Applies To: BMR453, BMR454, BMR456, BMR457
Command Code: 0x9C
Type: Block R/W (Protected - Read Only)
Data Length In Bytes: 12
Data Format: ASCII
Factory Value: Typically EAB/SEC
Units: N/A
Reference: Section 22.2.4 - PMBus Spec Part II
Definition: This command returns Flex's identification for the location where the module was manufactured.

MFR_DATE

Applies To: BMR453, BMR454, BMR456, BMR457
Command Code: 0x9D
Type: Block R/W (Protected - Read Only)
Data Length In Bytes: 12
Data Format: ASCII
Factory Value: Manufacturing date code formatted as YYYY-MM-DD
Units: N/A
Reference: Section 22.2.5 - PMBus Spec Part II
Definition: This command returns the date the module was manufactured.

MFR_SERIAL

Applies To: BMR453, BMR454, BMR456, BMR457
Command Code: 0x9E
Type: Block R/W (Protected - Read Only)
Data Length In Bytes: 20
Data Format: ASCII
Factory Value: Flex serial number
Units: N/A
Reference: Section 22.2.6 - PMBus Spec Part II
Definition: This command returns a string of 20 characters and numbers that provides a unique identification of the module.

USER_DATA_00

Applies To: BMR453, BMR454, BMR456, BMR457
Command Code: 0xB0
Type: Block R/W
Data Length In Bytes: Up to 16
Data Format: ASCII
Factory Value: null
Units: N/A
Reference: Section 23 - PMBus Spec Part II
Definition: Sets user defined data. The maximum number of bytes that can be stored is 16. This command is recommended for the user to keep any of their own model tracking/serial information.

Other Configuration Commands

MFR_PGOOD_POLARITY

Applies To: BMR453, BMR454, BMR456, BMR457
Command Code: 0xD0
Type: R/W Byte
Data Length In Bytes: 1
Data Format: Custom (see Table Below)
Factory Value: 0x00
Units: N/A
Reference:

Definition: Sets the polarity of the Power Good pin, see table 4 below:

Table 4. MFR_PGOOD_POLARITY command data.

Value	State	Description
0x00	Active Low	Power Good will output a low state.
0x01	Active High	Power Good will output a high state.

MFR_SELECT_TEMPERATURE_SENSOR

Applies To: BMR453, BMR454, BMR456, BMR457
Command Code: 0xDC
Type: R/W Byte
Data Length In Bytes: 1
Data Format: Custom (see Table Below)
Factory Value: BMR456: 0x01, BMR457: 0x00
Units: N/A
Reference:
Definition: Selects between an internal or external temperature sensor, see table 5 below:

Table 5. MFR_SELECT_TEMPERATURE_SENSOR command data.

Value	State	Description
0x00	Internal	Use internal temperature sensor.
0x01	External	Use external temperature sensor on the module.

MFR_TEMP_OFFSET_INT

Applies To: BMR456, BMR457
Command Code: 0xE1
Type: R/W Word
Data Length In Bytes: 2
Data Format: Section 7.2 – PMBus Spec Part II – DIRECT Data Format
Factory Value: Determined by calibration
Units: Increments of 0.1 °C
Reference:
Definition: Sets temperature offset for the internal temperature sensor.

MFR_REMOTE_TEMP_CAL

Applies To: BMR453, BMR454, BMR456, BMR457

Command Code: 0xE2

Type: R/W Block

Data Length In Bytes: 4

Data Format: Custom

Factory Value: Determined by calibration

Units: N/A

Reference:

Definition: Sets the calibration offset and slope for the external temperature sensor. This works by using the equation $T = \text{Slope} * V + \text{Offset}$, where T is the read temperature (in degrees celsius), V is the output voltage of the external sensor, and Slope / Offset are values defined in table 6.

Table 6. MFR_REMOTE_TEMP_CAL command data.

Byte	Purpose	Description
3:2	Slope	Sets the slope to the above equation as a 16-bit integer.
1:0	Offset	Sets the offset to the above equation as a 16-bit integer.

MFR_REMOTE_CTRL

Applies To: BMR453, BMR454, BMR456, BMR457

Command Code: 0xE3

Type: R/W Byte

Data Length In Bytes: 1

Data Format: Custom

Factory Value: 0x15

Units: N/A

Reference:

Definition: Sets configuration of the remote control feature. The remote control feature enables the ability to either use a mechanical switch or a signal (See table 7 below). This command also works with ON_OFF_CONFIG.

Table 7. MFR_REMOTE_CTRL command data.

NOTE: For BMR453/454, after application of input supply, a PMBus command (of any sort) must be sent to the module before secondary side CTRL pin is functional.

Bits	Purpose	Value	Description
5:7	Reserved	000	Reserved
4	Primary RC's relationship with ON_OFF_CONFIG (Operation command and Secondary-side CTRL pin)	0	Primary RC Pin's Enable output is OR'ed with the Enable output resulting from ON_OFF_CONFIG's configuration. For more information please see Appendix 1.
		1	Primary RC Pin's Enable output is AND'ed with the Enable output resulting from ON_OFF_CONFIG's configuration. For more information please see Appendix 1.
3	Reserved	0	Reserved
2	Primary RC Pin Enable	0	RC Pin is Disabled and not used
		1	RC Pin is Enabled
1	Primary RC Pin Polarity	0	Active Low Pin Polarity
		1	Active High Pin Polarity
0	Turn-off Action	0	RC pin disable will trigger a Soft-Off Shutdown using the times set in TOFF_FALL and TOFF_DELAY
		1	RC pin disable will trigger an immediate off

MFR_VOUT_ANALOG_SCALE

Applies To: BMR453, BMR454
Command Code: 0xE8
Type: R/W Word
Data Length In Bytes: 2
Data Format: Section 7.1 - PMBus Spec Part II - Linear Data Format
Factory Value: N/A
Units:
Reference:
Definition: This sets the scale factor for the voltage on the "PG SYNC" multi-function pin when it is used in either the tracking or external reference modes (see MFR_MULTI_PIN_CONFIG for more info).

MFR_READ_VOUT_ANALOG_REF

Applies To: BMR453, BMR454
Command Code: 0xE9
Type: Read Word
Data Length In Bytes: 2
Data Format: Section 7.2 - PMBus Spec Part II – Vout Linear
Factory Value: N/A
Units: Volts
Reference:
Definition: Reads the voltage present on the "PG SYNC" multi-function when it is used in either the tracking or external reference modes (see MFR_MULTI_PIN_CONFIG for more info).

MFR_SET_DPWM_POLARITY

Applies To: BMR453, BMR454
Command Code: 0xF7
Type: R/W Byte (Protected - Read Only)
Data Length In Bytes: 1
Data Format: Custom
Factory Value: Varies depending on model.
Units: N/A
Reference:
Definition: Sets the polarity of the PWM drivers – the protected default is 0 for active high, but is set to 1 when the module uses active low driver ICs.

MFR_ILIM_SOFTSTART

Applies To: BMR453, BMR454, BMR456, BMR457
Command Code: 0xF8
Type: R/W Byte
Data Length In Bytes: 1
Data Format: Integer Value
Factory Value: 0x14 (20%)
Units: Percent (%)
Reference:
Definition: Sets the percentage of how much ILIM can increase beyond the user setting

MFR_MULTI_PIN_CONFIG

Applies To: BMR453, BMR454, BMR456, BMR457
Command Code: 0xF9
Type: R/W Byte
Data Length In Bytes: 1
Data Format: Custom
Factory Value: 0x04
Units: N/A
Reference:
Definition: There are two different command definitions, one for the BMR453/BMR454 and a separate definition for the BMR456/457.

Definition for BMR453/BMR454:

This command lets you configure the function of the "PG SYNC" pin, a multi-function pin that allows for either sync input/output, power good output, tracking input, or external-reference input. The following modes are available:

Table 8: MFR_MULTI_PIN_CONFIG Standalone Operation Modes for BMR453/454

Value	Mode	Description
0x62	Sync Input	"PG SYNC" pin acts as a sync input.
0xC2	Sync Output	"PG SYNC" pin acts as a sync output.
0x04	PG Output	"PG SYNC" pin acts as a Power Good output in push-pull mode.
0x10	Tracking	"PG SYNC" pin serves as a tracking voltage input, which in this case means that the module will 'track' the voltage whenever it is below the desired output voltage set via VOUT_COMMAND
0x08	External Reference	"PG SYNC" pin serves as an external reference input. In this state, the module will 'track' the external reference at all times regardless of the modules own output voltage settings.

NOTE: Please ensure that only one of the listed modes above is used. Any value set outside the ones listed will result in an unsupported configuration.

Definition for BMR456/BMR457:

This command lets you choose from a number of modes relating to how the device current-shares, asserts Power Good, and enables a secondary remote control via the CTRL pin. The standalone modes are listed below. The load-sharing modes are listed in the second table. The load-sharing method in the BMR456/BMR457 is a passive droop-based form of load sharing that works by introducing an output voltage dependency on the load current. More information on droop load sharing (DLS) can be found in the BMR456 and BMR457 technical specifications.

Please note that in any of these modes, the Primary RC is always active depending on its configuration in MFR_REMOTE_CTRL.

The CTRL Pin is available in two modes:

- > PMBus Control mode - The CTRL Pin internal pullup is disabled, and is used as a control pin as setup via the ON_OFF_CONFIG command.
- > Secondary RC mode - The CTRL Pin internal pullup is enabled, which allows for a 'Negative Logic' method of enabling the device just like the Primary RC pin. If using negative logic, ensure that ON_OFF_CONFIG has the pin setup for 'Active Low' polarity.

The PG pin may set into one of three modes:

- > Inactive – The PG Pin is not used. To determine whether the device is operating, one must instead read the PMBus command STATUS_BYTE.
- > Push-Pull – The PG Pin outputs Power Good as a Push-Pull signal, using the polarity as defined using MFR_PGOOD_POLARITY.
- > Push-Up – The PG Pin outputs Power Good such that when it is active, it will output High-Z, when it is inactive it will drive the output depending on the MFR_PGOOD_POLARITY setting.

Table 9: MFR_MULTI_PIN_CONFIG Standalone Operation Modes for BMR456/457

Value	PG Pin Mode	CTRL Pin Mode
0x00	Inactive	PMBus Control
0x01	Inactive	Secondary RC
0x04	Push-Pull	PMBus Control
0x05	Push-Pull	Secondary RC
0x24	Pull-Up	PMBus Control
0x25	Pull-Up	Secondary RC

NOTE: Bit 2 = 0 and bit 5 = 1 is a supported command combination, although bit 5 has no effect when bit 2 = 0.

Table 10: MFR_MULTI_PIN_CONFIG Droop Load Sharing Modes for BMR456/457

Value	PG Pin Mode	CTRL Pin Mode
0x82	Inactive	PMBus Control
0x83	Inactive	Secondary RC
0x86	Push-Pull	PMBus Control
0x87	Push-Pull	Secondary RC
0xA6	Pull-Up	PMBus Control
0xA7	Pull-Up	Secondary RC

NOTE: Please ensure that only one of the listed modes above is used. Any value set outside the ones listed will result in an unsupported configuration.

Supervisory Commands

WRITE_PROTECT

Applies To: BMR453, BMR454, BMR456, BMR457

Command Code: 0x10

Type: R/W Byte

Data Length In Bytes: 1

Data Format: Custom

Factory Value: 0x00

Units: N/A

Reference: Section 11.1 – PMBus Spec Part II

Definition: Sets whether the device is in a "Write Protect" mode that restricts PMBus Commands from being written. This is a useful precaution for scenarios where there are multiple masters or other traffic on the bus.

STORE_DEFAULT_ALL

Applies To: BMR453, BMR454, BMR456, BMR457

Command Code: 0x11

Type: Send Byte (Protected from use on BMR456 & BMR457)

Data Length In Bytes: 0

Data Format: N/A

Factory Value: N/A

Units: N/A

Reference: Section 11.2 - PMBus Spec Part II

Definition: Stores, at the DEFAULT level, all PMBus values that were written since the last restore command. To add to the DEFAULT store, perform a RESTORE_DEFAULT_ALL, write commands to be added, then STORE_DEFAULT_ALL. Note that any subsequent STORE commands sent should be sent after a 250ms delay.

RESTORE_DEFAULT_ALL

Applies To: BMR453, BMR454, BMR456, BMR457

Command Code: 0x12

Type: Send Byte

Data Length In Bytes: 0

Data Format: N/A

Factory Value: N/A

Units: N/A

Reference: Section 11.3 - PMBus Spec Part I

Definition: Restores PMBus settings that were stored using STORE_DEFAULT_ALL. This command is automatically performed at power up. The security level is changed to level 1 following this command. Wait 20 ms after a RESTORE_DEFAULT_ALL command before issuing another PMBus command.

STORE_USER_ALL

Applies To: BMR456, BMR457

Command Code: 0x15

Type: Send Byte

Data Length In Bytes: 0

Data Format: N/A

Factory Value: N/A

Units: N/A

Reference: Section 11.6 - PMBus Spec Part I

Definition: Stores, at the USER level, all PMBus values that were changed since the last restore command. To add to the USER store, perform a RESTORE_USER_ALL, write commands to be added, then STORE_USER_ALL. Note that any subsequent STORE commands sent should be sent after a 250ms delay.

RESTORE_USER_ALL

Applies To: BMR456, BMR457

Command Code: 0x16

Type: Send Byte

Data Length In Bytes: 0

Data Format: N/A

Factory Value: N/A

Units: N/A

Reference: Section 11.7 - PMBus Spec Part I

Definition: Restores PMBus settings that were stored using STORE_USER_ALL. This command is automatically performed at power up. The values restored will overwrite the values previously loaded by the RESTORE_DEFAULT_ALL command. The security level is changed to Level 1 following this command. Wait 20 ms after a RESTORE_USER_ALL command before issuing another PMBus command.

Reference documents

Flex Technical Specifications

BMR453 3E Isolated Module,
Document number EN/LZT 146 395

BMR 453 3E Stacked Isolated Module,
Document number EN/LZT 146 444

BMR 454 3E Isolated Module,
Document number EN/LZT 146 404

BMR 456 3E Isolated Module,
Document number 1/28701-FGC 101 1823

BMR 457 3E Isolated Module,
Document number 1/28701-FGC 101 1835

Quick Reference Table

PMBus Command	Command Code	AN302 Page
OPERATION	0x01	54
ON_OFF_CONFIG	0x02	55
CLEAR_FAULTS	0x02	64
WRITE_PROTECT	0x10	70
STORE_DEFAULT_ALL	0x11	70
RESTORE_DEFAULT_ALL	0x12	71
STORE_USER_ALL (BMR 456/457)	0x15	71
RESTORE_USER_ALL (BMR 456/457)	0x16	71
CAPABILITY	0x19	66
VOUT_MODE	0x20	55
VOUT_COMMAND	0x21	55
VOUT_TRIM	0x22	55
VOUT_CAL_OFFSET	0x23	56
VOUT_MAX	0x24	56
VOUT_MARGIN_HIGH	0x25	56
VOUT_MARGIN_LOW	0x26	56

PMBus Command	Command Code	AN302 Page
VOUT_TRANSITION_RATE	0x27	56
VOUT_SCALE_LOOP	0x29	57
VOUT_SCALE_MONITOR	0x2A	57
MAX_DUTY	0x32	57
FREQUENCY_SWITCH	0x33	57
VIN_ON	0x35	55
VIN_OFF	0x36	55
IOUT_CAL_GAIN	0x38	57

IOUT_CAL_OFFSET	0x39	57
VOUT_OV_FAULT_LIMIT	0x40	58
VOUT_OV_FAULT_RESPONSE	0x41	63
VOUT_OV_WARN_LIMIT	0x42	58
VOUT_UV_WARN_LIMIT	0x43	58
VOUT_UV_FAULT_LIMIT	0x44	58
VOUT_UV_FAULT_RESPONSE	0x45	63
IOUT_OC_FAULT_LIMIT	0x46	58
IOUT_OC_FAULT_RESPONSE	0x47	63
IOUT_OC_LV_FAULT_LIMIT	0x48	59
IOUT_OC_WARN_LIMIT	0x4A	58
OT_FAULT_LIMIT	0x4F	59
OT_FAULT_RESPONSE	0x50	63
OT_WARN_LIMIT	0x51	59
UT_WARN_LIMIT	0x52	59
UT_FAULT_LIMIT	0x53	59
UT_FAULT_RESPONSE	0x54	63
VIN_OV_FAULT_LIMIT	0x55	59

Appendix 1: Enable Control Methods For 3E Isolated Modules

The 3E series isolated modules offer a number of options to enable and disable the device. There are three enable control inputs on an isolated 3E series module:

1. The Primary RC Pin, which is setup with the MFR_REMOTE_CONTROL command.
2. The Second-Side CTRL pin, which can be configured into multiple modes as described in MFR_MULTI_PIN_CONFIG, and when used as an enable control input, the pin's polarity/turn-off operation is set with ON_OFF_CONFIG.
3. The OPERATION command sent via PMBus, which is configured via ON_OFF_CONFIG.

These three inputs can be used in different combinations depending on the settings in MFR_REMOTE_CONTROL and ON_OFF_CONFIG. The available input configurations are listed in the tables below, separated by product generation (BMR 453/454 vs. BMR 456/457).

In the tables below, the enable states (written as "On" in the table) do not reference the actual polarity setting of

the pin. Furthermore, for any ANDing and ORing options used in the table, the best way to visualize how this works is similar to logic gates, where the enable input represents a logic '1', and a disable input represents a logic '0'.

If you have two enable inputs ANDed together, this means enabling the device requires both inputs to be set to enable, and disabling the device only requires at least one input to be set to disable. If you have two enable inputs ORed together, this means that enabling the device requires at least one input set to enable, and disabling requires both inputs set to disable. For the ORed input scenarios on the BMR453/454, there are some exceptions in how the device disables as described in the enable configuration table.

NOTE: For BMR453/454, after application of input supply, a PMBus command (of any sort) must be sent to the module before secondary side CTRL pin is functional.

BMR453/454 Enable Configuration Table:

Enable Configuration	setup commands		inputs			output
	ON_OFF_CONFIG (02h)	MFR_REMOTE_CTRL (E3h)	PMBus (01h-Operation)	PriRC	SecRC	V _{out}
Enable always	00h	00h	xx	x	x	On
	10h	00h	xx	x	x	On
OPERATION Command only	18h	00h	On	x	x	On
	18h	00h	Soft-off	x	x	Soft-off
	18h	00h	Imm-off	x	x	Imm-off
Primary RC Only	00h	14h / 15h	x	On	x	On
	00h	14h	x	Off	x	Soft-Off
	00h	15h	x	Off	x	Imm-off
Secondary Side Only	14h/15h	00h	x	x	On	On
	14h	00h	x	x	Off	Soft-Off

Enable Configuration	setup commands		inputs			output
	ON_ OFF_ CONFIG (02h)	MFR_ REMOTE_ CTRL (E3h)	PMBus (01h- Operation)	PriRC	SecRC	V _{out}
- Immediate-off setup	15h	00h	x	x	Off	Imm-off
PMBus OPERATION Command ORed with Secondary Side CTRL Pin (mode not available)						
PMBus OPERATION command ANDed with Secondary Side CTRL Pin	1Ch/1Dh	00h	On	x	On	On
	1Ch/1Dh	00h	Soft-off	x	On	Soft-off
	1Ch/1Dh	00h	Imm-off	x	On	Imm-off
- Soft-off pin disable setup	1Ch	00h	On / Soft-off	x	Soft-off	Soft-off
	1Ch	00h	Imm-off	x	Soft-off	Whichever came first
- Immediate-off pin disable setup	1Dh	00h	On / Imm-off	x	Imm-off	Imm-off
	1Dh	00h	Soft-off	x	Imm-off	Whichever came first
PMBus OPERATION command ORed with Primary RC Pin – NOTE: There is an exception to the ORing rule such that the OPERATION command's off setting takes priority						
	18h	04h / 05h	x	On	x	On
	18h	04h / 05h	On	x	x	On
- Soft-off pin disable setup	18h	04h	Soft-off	Soft-off	x	Soft-off
	18h	04h	Imm-off	Soft-off	x	Imm-off (Operation command has priority)
- Immediate-off pin disable setup	18h	05h	Soft-off	Imm-off	x	Soft-off (Operation command has priority)
	18h	05h	Imm-off	Imm-off	x	Imm-off
PMBus OPERATION command ANDed with Primary RC Pin						
	18h	14h / 15h	On	On	x	On
	18h	14h / 15h	Soft-off	On	x	Soft-off
	18h	14h / 15h	Imm-off	On	x	Imm-off
- Soft-off pin disable setup	18h	14h	On / Soft-off	Soft-off	x	Soft-off
	18h	14h	Imm-off	Soft-off	x	Whichever came first
- Immediate-off pin disable setup	18h	15h	On / Imm-off	Imm-off	x	Imm-off

Enable Configuration	setup commands		inputs			output
	ON_ OFF_ CONFIG (02h)	MFR_ REMOTE_ CTRL (E3h)	PMBus (01h- Operation)	PriRC	SecRC	V _{out}
	18h	15h	Soft-off	Imm-off	x	Whichever came first
Primary RC Pin ORed with Secondary Side CTRL Pin – NOTE: There is an exception to the ORing rule in which the immediate-off setting takes priority in certain scenarios	14h / 15h	04h / 05h	x	x	On	On
	14h / 15h	04h / 05h	x	On	x	On
- Primary pin as soft-off, secondary as soft-off	14h	04h	x	Soft-off	Soft-off	Soft-off
- Primary pin as immediate-off, secondary as soft-off	14h	05h	x	Imm-off	Soft-off	Imm-off (Imm-off has priority)
- Primary pin as soft-off, secondary as immediate-off	15h	04h	x	Soft-off	Imm-Off	Imm-off (Imm-off has priority)
- Primary pin as immediate-off, secondary as immediate-off	15h	05h	x	Imm-off	Imm-Off	Imm-off
Primary RC Pin ANDed with Secondary Side CTRL Pin	14h / 15h	14h / 15h	x	On	On	On
- Primary pin as soft-off, secondary as soft-off	14h	14h	x	Soft-Off	On	Soft-off
	14h	14h	x	On	Soft-Off	Soft-off
	14h	14h	x	Soft-Off	Soft-Off	Soft-off
- Primary pin as immediate-off, secondary as soft-off	14h	15h	x	Imm-Off	On	Imm-Off
	14h	15h	x	On	Soft-Off	Soft-off
	14h	15h	x	Imm-Off	Soft-Off	Whichever came first
- Primary pin as soft-off, secondary as immediate-off	15h	14h	x	Soft-Off	On	Soft-off
	15h	14h	x	On	Imm-Off	Imm-Off
	15h	14h	x	Soft-Off	Imm-Off	Whichever came first
- Primary pin as immediate-off, secondary as immediate-off	15h	15h	x	Imm-Off	On	Imm-Off
	15h	15h	x	On	Imm-Off	Imm-Off
	15h	15h	x	Imm-Off	Imm-Off	Imm-Off
Primary RC ORed with both PMBus OPERATION command AND Secondary Side CTRL Pin	Please contact Flex for support on this configuration					
Primary RC Pin ANDed with PMBus OPERATION command AND Secondary Side CTRL Pin	Please contact Flex for support on this configuration					

BMR456/457 Enable Configuration Table:

Enable Configuration	setup commands		OPERATION (01h)	inputs		output V _{out}	
	ON_ OFF_ CONFIG (02h)	MFR_ REMOTE_ CTRL (E3h)		PriRC	SecRC		
Enable Always	00h	00h	x	x	x	On	
	10h	00h	x	x	x	On	
PMBus OPERATION Command Only	18h	00h	On	x	x	On	
	18h	00h	Soft-off	x	x	Soft-off	
	18h	00h	Imm-off	x	x	Imm-off	
Primary RC Pin Only	00h	14h / 15h	x	On	x	On	
	- Soft-off setup	00h	14h	x	Soft-off	x	Soft-off
	- Immediate-off setup	00h	15h	x	Imm-off	x	Imm-off
Secondary Side CTRL Pin Only	14h/15h	00h	x	x	On	On	
	- Soft-off setup	14h	00h	x	x	Soft-off	Soft-off
	- Immediate-off setup	15h	00h	x	x	Imm-off	Imm-off
PMBus OPERATION Command ORed with Secondary Side CTRL pin, (mode not available)							
PMBus OPERATION Command ANDed with Secondary Side CTRL Pin	1Ch/1Dh	00h	On	x	On	On	
	1Ch/1Dh	00h	Soft-off	x	On	Soft-off	
	1Ch/1Dh	00h	Imm-off	x	On	Imm-off	
	- Soft-off pin disable setup	1Ch	00h	On / Soft-off	x	Soft-off	Soft-off
	1Ch	00h	Imm-off	x	Soft-off	Whichever came first	
- Immediate-off pin disable setup	1Dh	00h	On / Imm-off	x	Imm-off	Imm-off	
	1Dh	00h	Soft-off	x	Imm-off	Whichever came first	
PMBus OPERATION Command ORed with Primary RC Pin	18h	04h / 05h	x	On	x	On	
	18h	04h / 05h	On	x	x	On	
	- Soft-off pin disable setup	18h	04h	Soft-off	Soft-off	x	Soft-off
	18h	04h	Imm-off	Soft-off	x	Whichever came last	
	- Immediate-off pin disable setup	18h	05h	Soft-off	Imm-off	x	Whichever came last
	18h	05h	Imm-off	Imm-off	x	Imm-off	

Enable Configuration	setup commands		OPERATION (01h)	inputs		output V _{out}	
	ON_ OFF_ CONFIG (02h)	MFR_ REMOTE_ CTRL (E3h)		PriRC	SecRC		
PMBus OPERATION command ANDed with Primary RC Pin							
		18h	14h / 15h	On	On	x	On
		18h	14h / 15h	Soft-off	On	x	Soft-off
		18h	14h / 15h	Imm-off	On	x	Imm-off
	- Soft-off pin disable setup	18h	14h	On / Soft-off	Soft-off	x	Soft-off
		18h	14h	Imm-off	Soft-off	x	Whichever came first
	- Immediate-off pin disable setup	18h	15h	On / Imm-off	Imm-off	x	Imm-off
	18h	15h	Soft-off	Imm-off	x	Whichever came first	
Primary RC Pin ORed with Secondary Side CTRL Pin							
		14h / 15h	04h / 05h	x	x	On	On
		14h / 15h	04h / 05h	x	On	x	On
	- Primary pin as soft-off, secondary as soft-off	14h	04h	x	Soft-off	Soft-off	Soft-off
	- Primary pin as immediate-off, secondary as soft-off	14h	05h	x	Imm-off	Soft-off	Whichever came last
	- Primary pin as soft-off, secondary as immediate-off	15h	04h	x	Soft-off	Imm-Off	Whichever came last
	- Primary pin as immediate-off, secondary as immediate-off	15h	05h	x	Imm-off	Imm-Off	Imm-off
Primary RC Pin ANDed with Secondary Side CTRL Pin							
		14h / 15h	14h / 15h	x	On	On	On
	- Primary pin as soft-off, secondary as soft-off	14h	14h	x	Soft-Off	On	Soft-off
		14h	14h	x	On	Soft-Off	Soft-off
		14h	14h	x	Soft-Off	Soft-Off	Soft-off
	- Primary pin as immediate-off, secondary as soft-off	14h	15h	x	Imm-Off	On	Imm-Off
		14h	15h	x	On	Soft-Off	Soft-off
		14h	15h	x	Imm-Off	Soft-Off	Whichever came first
	- Primary pin as soft-off, secondary as immediate-off	15h	14h	x	Soft-Off	On	Soft-off
		15h	14h	x	On	Imm-Off	Imm-Off
	15h	14h	x	Soft-Off	Imm-Off	Whichever came first	

Enable Configuration	setup commands		OPERATION (01h)	inputs		output
	ON_ OFF_ CONFIG (02h)	MFR_ REMOTE_ CTRL (E3h)		PriRC	SecRC	V _{out}
- Primary pin as immediate-off, secondary as immediate-off	15h	15h	x	Imm-Off	On	Imm-Off
	15h	15h	x	On	Imm-Off	Imm-Off
	15h	15h	x	Imm-Off	Imm-Off	Imm-Off
Primary RC Pin ORed with both PMBus OPERATION command AND Secondary Side CTRL Pin	Please contact Flex for support on this configuration					
Primary RC Pin ANDED with both PMBus OPERATION command AND Secondary Side CTRL Pin	Please contact Flex for support on this configuration					

Formed in the late seventies, Flex Power Modules is a division of Flex that primarily designs and manufactures isolated DC/DC converters and non-isolated voltage products such as point-of-load units ranging in output power from 1 W to 860 W. The products are aimed at (but not limited to) the new generation of ICT (information and communication technology) equipment where systems' architects are designing boards for optimized control and reduced power consumption.

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