APPLICATION NOTE 308

Ericsson Power Modules

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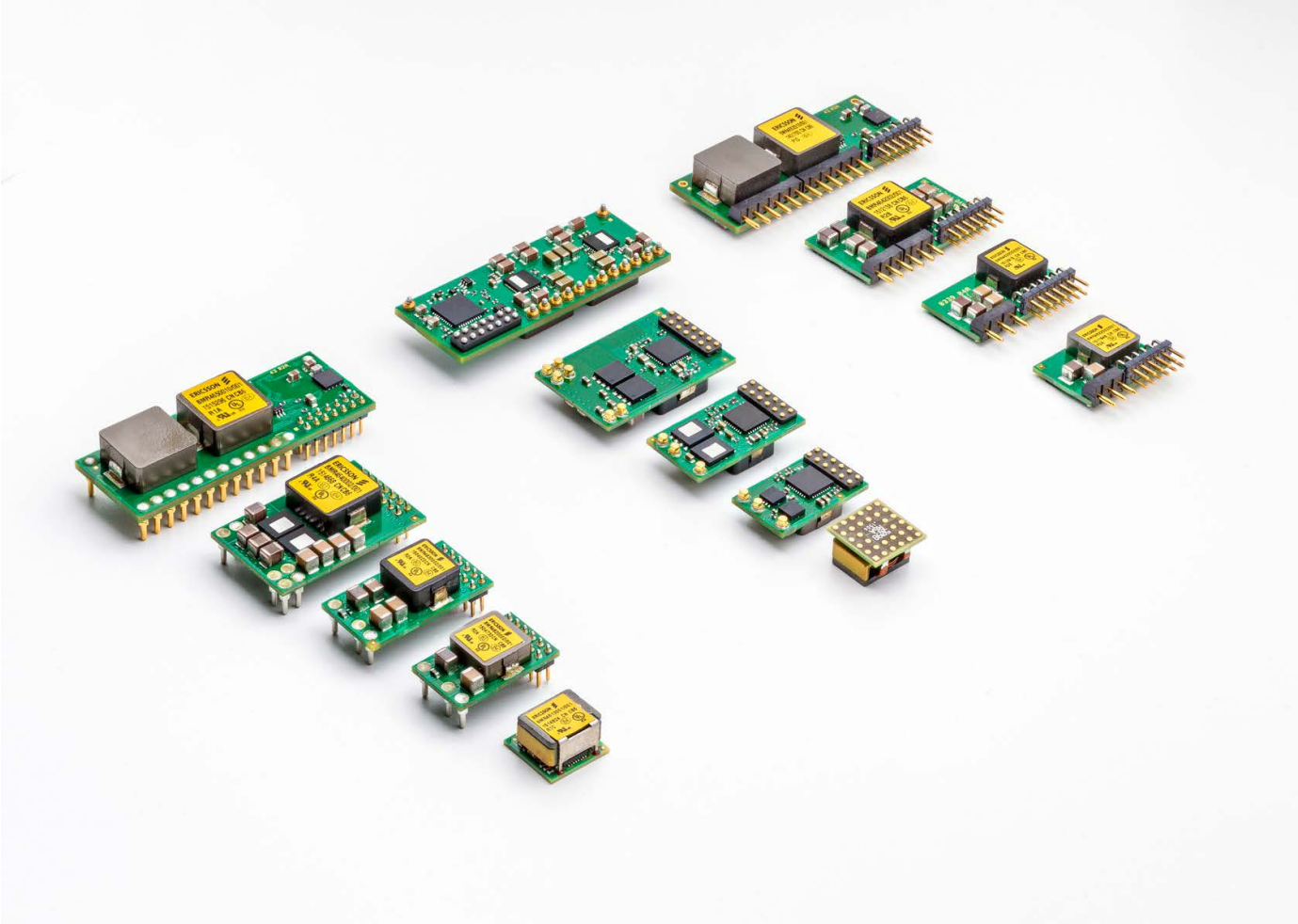

FAULT SPREADING - 3E POL REGULATORS

ABSTRACT

The 3E Digital products can be configured, controlled and monitored through a digital serial interface using the PMBus™ power management protocol.

This application note provides information on how to use the fault spreading function of the 3E POL regulators.

This application note applies to the following products:
BMR462
BMR463
BMR464
BMR465
BMR466
BMR467

INTRODUCTION

With the rising complexity and robustness requirements of many systems, the ability to monitor and control the power distribution has become increasingly more critical.

The fault spreading functionality of the Ericsson 3E Digital POL regulators enables synchronized shutdown of a complete system of regulators in case of a fault in any POL, as well as automatic sequenced restart when fault is cleared. Complexity, cost and board space is saved when this functionality is managed by the regulators themselves, rather than using a dedicated controller.

The fault spreading function differs somewhat between products due to evolvement and improvement of functionality. Make sure the correct information from this document is applied.

In this application note the Ericsson Power Designer software is referenced. The software is available for download at www.digitalpowerdesigner.com.

CONTENTS

FAULT SPREADING OPERATION

Overview

The Ericsson 3E digital POL products can be configured to broadcast a fault event on the GCB bus. When a non-destructive fault occurs and a device is configured to shut down on a fault, the device will shut down and broadcast the fault event on the GCB bus. Other devices on the same GCB bus will shut down together if configured to do so, and will attempt to re-start in their prescribed sequencing order if configured to do so.

Introducing the GCB (Group Communication Bus)

The Ericsson 3E digital POL products have a dedicated single wire serial bus (GCB bus) to synchronize and communicate real-time events. This is an internal bus, such that it is only connected across modules and not the PMBus system host. GCB addresses are assigned on a rail level, i.e. devices within the same current sharing group share the same GCB address. Addressing rails across the GCB is done with a 5 bit GCB ID, yielding a theoretical total of 32 rails that can be shared with a single GCB bus. For reliable operation GCB signal integrity has to be maintained. It is especially critical when using multiple devices on the bus spread on a large board area as they might create a large capacitive load slowing the signals down. The GCB signal rise time has to be maintained to meet the criteria described by the rise time equation in the product's Technical Specification.
During GCB events, all devices will receive messages; however, only those devices configured to respond will do so. Multiple current sharing groups and power rails can communicate over the same GCB bus.

Fault Spreading Shutdown Response

The Ericsson 3E digital POL products can be operated with two different fault spreading shutdown response:

1. Immediate shutdown. A rail will respond to a fault event on the GCB bus by an immediate shutdown of its output voltage.

2. Sequenced shutdown. A rail will respond to a fault event on the GCB bus by a sequenced shutdown according to its position in a configured power-up sequence. This mode of operation requires that GCB based sequencing is configured (see AN310).
Note! Sequenced shutdown is not supported for BMR465/BMR467 devices operating in parallel configuration (current sharing).

A group of rails configured for both GCB based sequencing and fault spreading should all use the same fault spreading shutdown response - immediate shutdown or sequenced shutdown.

Immediate Shutdown Example

A fault spreading group of three rails is configured for immediate shutdown. Figure 1 shows how output voltages shut down in the case where Rail 1 faults. Rails 2 and 3 shut down in immediate response to a fault event sent from Rail 1. The delay t_{SPREAD} is a propergation delay that is occuring due to internal time delays of each device, needed to send and respond to GCB fault events. t_{SPREAD} depends on the products used and will typically vary in the range 2-10 ms.

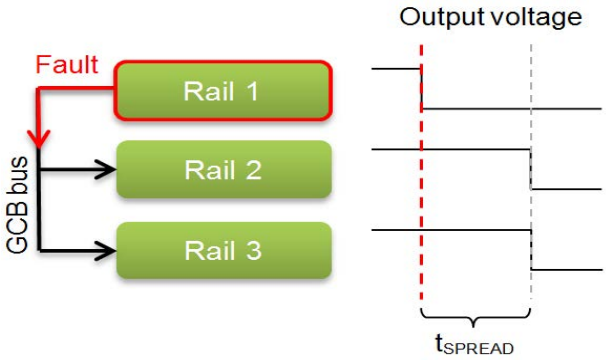

Figure 1. Operation of fault spreading example - immediate shutdown.

Sequenced Shutdown Example

A group of five rails is configured for GCB based sequencing with the power-up order Rail 1 -> Rail 2 -> Rail 3 -> Rail 4 -> Rail 5. For simplicity it is assumed that the sequencing timing between each rail, t_{SEQ} (delay + ramp time, see AN310), is the same for all rails. Figure 2 shows how output voltages shut down in the case where Rail 3 faults. As seen the rails will sequence down in both directions from the failed rail, based on the configured power-up order. The delay t_{SPREAD} before sequencing starts is due to internal time delays of each device, needed to send and respond to GCB fault events. t_{SPREAD} depends on the products used and will typically vary in the range 2-10 ms.

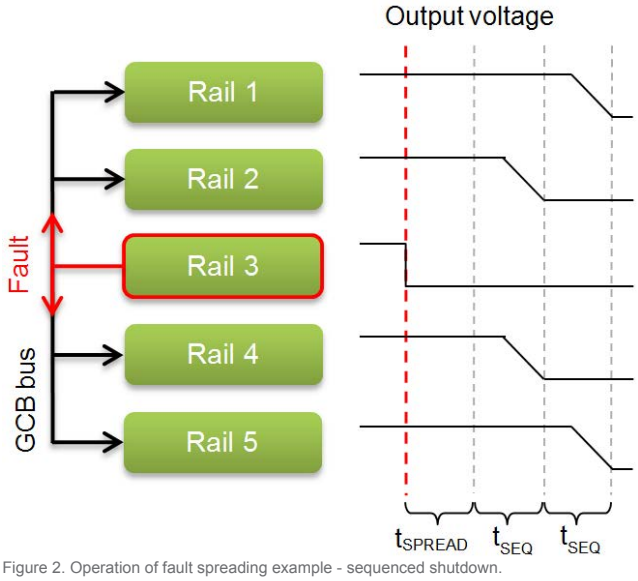

Figure 2. Operation of fault spreading example - sequenced shutdown.

Fault Spreading Recovery

Note! Fault spreading recovery is not fully supported for phase spreading groups that include BMR465/BMR467 based rails. See chapter Configuration of Fault Spreading.

Rails not using GCB based Sequencing

A rail not configured for GCB based sequencing, responding to a GCB fault spreading event, will restart according to the faulting rail's fault response setting for the fault type that occured. Thus, a restart event is broadcasted on the GCB bus by the faulting device if it is configured for restart.

Example - Rails not using GCB based Sequencing

This example is illustrated by the oscilloscope capture in Figure 3. Rail 1 is configured to restart automatically after an over current fault (MFR_IOUT_OC_FAULT_RESPONSE = 0xBF). When an over current fault occurs for Rail 1, it broadcasts a fault event on the GCB bus. Rail 2 receives the fault event and shuts down (immediately).

The faulting Rail 1 is configured for restart and when it is about to restart it will broadcast a restart event on the GCB bus. Since Rail 2 is configured to respond to fault events from Rail 1, it will also respond to the restart event from Rail 1 and make a restart attempt of its output voltage. Note that the over current fault response setting for Rail 2 has no impact on if Rail 2 will restart or not in this case, since it is controlled by restart event from Rail 1.

Due to internal time delays of devices, needed to send and respond to GCB events, Rail 2 will restart at a later point in time compared to Rail 1 (both rails have the same ramp-up settings).

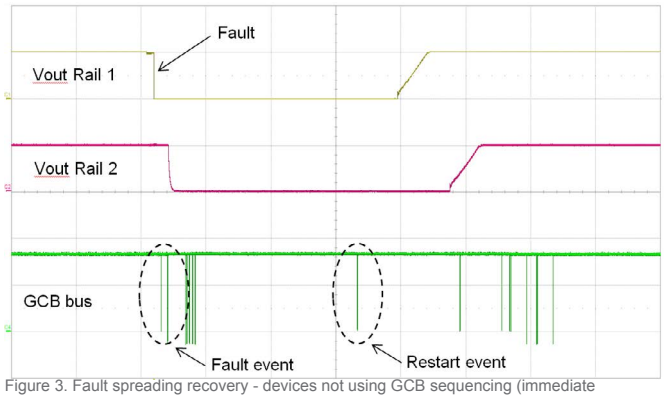

Figure 3. Fault spreading recovery - devices not using GCB sequencing (immediate shutdown). 20 ms/div.

Rails using GCB based Sequencing

Rails configured for GCB based sequencing and fault spreading will restart output voltages according to the configured power-up sequence if the fault response setting of the faulting rail is set to restart (retry). This applies regardless of which rail in the sequence order faulted and broadcasted the fault event. This also applies regardless of immediate or sequenced shutdown response of the configured fault spreading.

Example - Rails using GCB based Sequencing

This example is illustrated by the oscilloscope capture in Figure 4. A GCB sequencing group with power-up order Rail 1 -> Rail 2 -> Rail 3. Rails are configured for fault spreading with sequenced shutdown. Rail 3 is configured to restart automatically after an over current fault (MFR_IOUT_OC_FAULT_RESPONSE = 0xBF).

When an over current fault occurs for Rail 3, it sends a fault event on the GCB bus. Rails 1 and 2 receive the fault event and shut down in sequence (in direction from the faulting Rail 3). Since Rail 3 is configured for restart it will broadcast a restart event on the GCB bus. This event will trigger Rail 1, being the first rail in the power-up sequence, to restart. GCB sequencing will then follow with Rails 2 and 3 also ramping up.

Note that the over current fault response setting for Rail 1 and 2 has no impact on if these rails will restart or not in this case, since they are controlled by restart event from Rail 3.

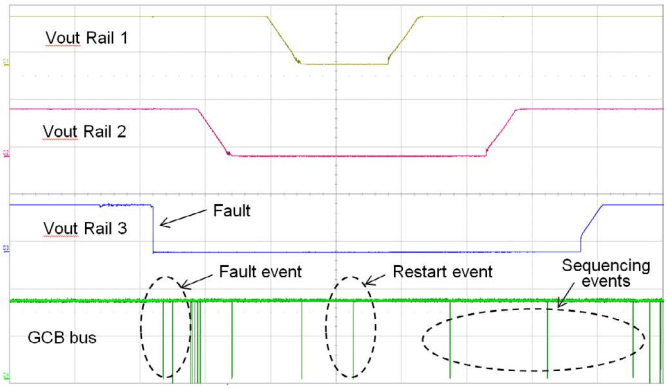

Figure 4. Fault spreading recovery - devices using GCB sequencing (sequenced shutdown). 20 ms/div.

Fault Indication

In a fault spreading group only the rail that faulted and initiated the shutdown will report a fault via its status registers (e.g. PMBus commands STATUS_BYTE and STATUS_WORD). Rails shutting down only due to a received GCB fault event do not report any fault.

CONFIGURATION OF FAULT SPREADING

Configuration of a fault spreading group including only BMR462-464/BMR466

Fault spreading is configured by the following PMBus commands. An example is shown in Table 1.

GCB_CONFIG

Each rail in the fault spreading group must have its unique GCB ID set by bits [4:0]. Further, GCB TX Inhibit bit [5] must be set to 0. If Ericsson Power Designer is used to create a configuration, these settings are made automatically.

GCB_GROUP

Defines which rails' fault events should be responded to. Setting bit #0 to 1 means fault events from rail with GCB ID = 0 will be responded to. Setting bit #1 means fault events from rail with GCB ID = 1 will be responded to, and so on. Multiple bits can be set so a device would respond to faults of multiple rails.

USER_CONFIG

Bit [8] selects response to immediate shutdown (bit=1) or sequenced shutdown (bit=0). If sequenced shutdown is selected, a GCB based sequencing must be configured by the command SEQUENCE and other related commands, see AN310 for details. A group of rails configured for both fault spreading and GCB based sequencing should all use the same shutdown response (immediate or sequenced).

	GCB TX	GCB ID	Shutdown Response	Response to Fault Events
Setting	Do not inhibit		Immediate	Each rail will respond to fault events from the other two rails
	GCB_CONFIG[5]	GCB_CONFIG[4:0]	USER_CONFIG[8]	GCB_GROUP
Rail 1 - BMR463	0	0b00000 (ID = 0)	1	0x0006 (bits #1 and #2 set)
Rail 2 - BMR464	0	0b00001 (ID = 1)	1	0x0005 (bits #0 and #2 set)
Rail 3 - BMR466	0	0b00010 (ID = 2)	1	0x0003 (bits #0 and #1 set)

Table 1. Fault spreading configuration example with BMR462-464/BMR466 products.

Configuration of a fault spreading group including only BMR465/BMR467

Fault spreading is configured by the following PMBus commands. An example is shown in Table 2.

GCB_CONFIG

Each rail in the fault spreading group must have its unique GCB ID set by bits [12:8]. If Ericsson Power Designer is used to create a configuration, this setting is made automatically.

GCB_GROUP

Bits [4:0] defines a Fault Spreading Group ID (0-31) and controls which rails' fault events should be responded to. A rail with a certain Fault Spreading Group ID set will respond to fault events from other rails which has the same Fault Spreading Group ID set.

Note! Rails configured for GCB based sequencing will always respond to each others fault events, regardless of the Fault Spreading Group ID setting.

Bit [5] selects response to immediate shutdown (bit=1) or sequenced shutdown (bit=0). If sequenced shutdown is selected, a GCB based sequencing must be configured by the command SEQUENCE and other related commands, see AN310 for details. A group of rails configured for both fault spreading and GCB based sequencing should all use the same shutdown response (immediate or sequenced).

	GCB ID	Shutdown Response	Response to Fault Events
Settings		Immediate	Each rail will respond to fault events from the other two rails (all rails assigned to Fault Spreading Group with ID=2).
	GCB_CONFIG[12:8]	GCB_GROUP[5]	GCB_GROUP[4:0]
Rail 1 - BMR465	0b00000 (ID = 0)	1	0b00010 (Fault Spreading Group ID = 2)
Rail 2 - BMR465	0b00001 (ID = 1)	1	0b00010 (Fault Spreading Group ID = 2)
Rail 3 - BMR467	0b00010 (ID = 2)	1	0b00010 (Fault Spreading Group ID = 2)

Table 2. Fault spreading configuration example with BMR465/BMR467 products.

Configuration of a fault spreading group including both BMR462-464/BMR466 and BMR465/BMR467

When mixing the two type of products an additional command LEGACY_FAULT_GROUP must be configured for the BMR465/BMR467 devices in order to respond to faults events from BMR462-464/BMR466:

LEGACY_FAULT_GROUP
Defines which rails' fault events should be responded to. Setting bit #0 means fault events from rail with GCB ID = 0 will be responded to. Setting bit #1 means fault events from rail with GCB ID = 1 will be responded to, and so on.

An example is shown in Table 3. For example Rail 4 has bits in LEGACY_FAULT_GROUP corresponding to GCB IDs 0 and 1 set in order to respond to faults from Rail 1 and Rail 2, and GCB_GROUP[4:0] set to same Fault Spreading Group ID as Rail 3 in order to respond to faults from Rail 3.

	GCB TX	GCB ID		Shutdown Response		Response to Fault Events		
Setting	Do not inhibit			Sequenced		Each rail will respond to fault events from the other three rails.		
	GCB_CONFIG[5]	GCB_CONFIG[4:0]	GCB_CONFIG[12:8]	USER_CONFIG[8]	GCB_GROUP[5]	GCB_GROUP	LEGACY_FAULT_GROUP	GCB_GROUP[4:0]
Rail 1 - BMR463	0	0b00000 (ID = 0)	-	0	-	0x000E (bits #1, #2, #3 set)	-	-
Rail 2 - BMR464	0	0b00001 (ID = 1)	-	0	-	0x000D (bits #0, #2, #3 set)	-	-
Rail 3 - BMR465	-	-	0b00010 (ID = 2)	-	0	-	0x0003 (bits #0, #1 set)	0b00010 (Spreading ID = 2)
Rail 4 - BMR465	-	-	0b00011 (ID = 3)	-	0	-	0x0003 (bits #0, #1 set)	0b00010 (Spreading ID = 2)

Table 3. Fault spreading configuration example with BMR462-464/BMR466 products mixed with BMR465/BMR467 products.

Disabling Fault Spreading

For BMR462-464/BMR466 products fault spreading is disabled by setting GCB_GROUP = 0x0000, which is the default setting.

For BMR465/BMR467 products fault spreading is disabled by setting LEGACY_FAULT_GROUP = 0x0000 and GCB_GROUP[5] = 0 (sequenced shutdown set), which are the default setting.

Note! BMR465/BMR467 rails being part of the same GCB based sequencing group will always respond to each others fault events, thus fault spreading between these rails cannot be disabled.

Configuration of Fault Spreading Recovery

Control of restart is made by the individual FAULT_RESPONSE_x commands for each fault type. Refer to the Technical Specification of the product or AN302.

For sequenced restart, GCB based sequencing must be configured, see AN310 for details.

Note! Fault spreading recovery is not fully supported for BMR465/BMR467 rails. Therefore it is recommended to use latched fault response (Disable, No retry; FAULT_RESPONSE_x = 0x80) for all rails in fault spreading groups that include BMR465/BMR467 rails.

Parallel Rails

Fault spreading is supported also for devices operating in parallel configuration (current sharing rails). Each device in the parallel rail must have the same settings for the PMBus commands related to fault spreading (see above). See AN307 for further details.

Note! BMR465/BMR467 parallel rails do not support sequenced shutdown.

Note! BMR465/BMR467 rails cannot be operated on the same GCB bus as parallel rails of DLC variants of BMR463-464/BMR466 (see Ordering Information in each product's Technical Specification). Thus these type of rails cannot be part of the same fault spreading group.

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Formed in the late seventies, Ericsson Power Modules is a division of Ericsson AB 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 700 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.

Ericsson AB, Power Modules
SE-164 80 Stockholm, Sweden
Telephone: +46 10 716 9620

Power Modules – Americas
Telephone: +1-972-583-5254
+1-972-583-6910

Power Modules – Asia/Pacific
Telephone: +852-2590-2453

Power Modules – Japan
Telephone: +81 80 3363 67

Ericsson AB, Power Modules
SE-164 80 Stockholm, Sweden
Telephone +46 10 716 9620
www.ericsson.com/powermodules

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