PMBus®
Application Profile for
DC-DC Power Modules

Revision 1.0

6 Apr 2018

www.powerSIG.org

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REVISION HISTORY

REV	DATE	DESCRIPTION	EDITED BY
1.0	6 Apr 2018	First Release	Oleg Volfson, FLEX Jason Sekanina, ADI Robert V. White, Embedded Power Labs

Table of Contents

Table of Figures

No figures in this revision.

Table of Tables

1. Introduction

This application profile defines commonly used groups of PMBus® commands for isolated and non-isolated DC-DC power converter modules (hereafter referred as "modules") used in board mounted power applications. A module is a standalone self-contained device comprised of one or more control circuits, power stage components, and electrical/mechanical interface to allow an energy conversion from an input source to one or more outputs.

The application profile's goal is to enable re-use of software/firmware across devices in a power system. It's intended for a consistent experience in configuring, monitoring, and adjusting power modules from different vendors.

For more information, please see the System Management Interface Forum Web site: www.powerSIG.org.

1.1. Application Profile Scope

1.1.1. What Is Included

This application profile defines two levels of command requirements. Each successive level is a superset of its predecessor.

1.1.1.1. Level 1

Level 1 is focused on basic monitoring and status management. It's intended to serve as a starting point for commonality.

1.1.1.2. Level 2

Level 2 adds more complex configurable power management commands and storage while supporting all the commands included in Level 1.

1.1.2. What Is Not Included

The Application Profile is not a new specification – it defines subsets of commands and command options from the PMBus Specification that are relevant for modules. It does not attempt to define an internal functionality of a DC/DC module (e.g. topology, control loop) outside of those defined within the PMBus specification or a common basic functionality that is required for system level control and monitoring.

1.1.3. What Is Not Included in Revision 1.0

The first release of this profile is intended to be a starting point in understanding and defining commonality across module vendors from their existing (i.e. 'legacy') products. Because of this there are aspects not included that are expected to be in a future release:

1.1.3.1. Versioning Via APPLICATION_PROFILE_SUPPORT

This release does not require the APPLICATION_PROFILE_SUPPORT command. For this release application profile support information may be found via the manufacturer's device datasheet.

1.1.3.2. Common Memory Model

This specification recommends but doesn't require that configuration settings that are specific to the end user application to be kept in the User Store. More information on this can be found in the command profile descriptions for the STORE_USER_ALL and RESTORE_USER_ALL commands.

1.2. Application Profile Changes Since Last Revision

This is the initial release of this application profile. In future revisions a summary of the changes since the last revision will be shown in Appendix 1.

1.3. Where to Send Feedback and Comments

Please send all comments by email to: techquestions@smiforum.org.

2. Related Documents

2.1. Scope

There should be no conflicts between this document and any of the reference documents. A device complying with this application profile should have the application profile ("PMBus DC-DC Module Application Profile"), revision ("Revision 1.0"), and level (e.g. "Level 1") identified in its datasheet.

Referenced documents apply only to the extent of specific reference.

2.2. Applicable Documents

Applicable documents include information that is, by extension, part of this specification.

[A01] *PMBus™ Power System Management Protocol, Part I, General Requirements, Transport And Electrical Interface*, System Management Interface Forum, Revision 1.3.1, March 2015

[A02] *PMBus™ Power System Management Protocol, Part II, Command Language*, System Management Interface Forum, Revision 1.3.1, March 2015

[A03] *PMBus Power System Management Protocol, Part III, AVSBus*, System Management Interface Forum, Revision 1.3.1, March 2015

[A04] *System Management Bus (SMBus) Specification*, System Management Interface Forum, Version 3.0, 21 December 2014

[A05] *I²C-bus specification and user manual*, Revision 6, NXP Semiconductors, 4 April 2014

[A06] ISO/IEC 8859-1:1998*, 8-bit single-byte coded graphic character sets -- Part 1: Latin alphabet No. 1*, and all corrigenda, amendments published through the date of release of this specification.

2.3. Reference Documents

Reference documents have background or supplementary information to this specification. They do not include requirements or specifications that are considered part of this document.

[R01] PMBus Application Note AN001, *Using The ZONE_READ and ZONE_WRITE Protocols*

[R02] PMBus™ Application Profile for DC-DC Point of Load Control ICs

[R03] PMBus™ Application Note AN002, Differences between PMBus Application Profile for DC-DC Point of Load ICs and PMBus Application Profile for DC-DC modules

3. Compliance

3.1. Principles for compliance

Compliant modules support commands defined in a relevant level of application profile and respond to these commands in a consistent manner, allowing re-use of application software and firmware.

3.1.1. Commands

To be compliant, <u>all</u> command options must be implemented in accordance with the given profile definition. All numeric commands shall be implemented in compliance with the Numeric Format defined in the Table 1 of this document.

3.1.2. Basic Functionality

Compliance around basic functionality is defined around aspects of monitoring, configuration & verification, testing, and responsiveness.

3.1.2.1. Monitoring

It is required that all levels of the modules complying to the profile provide monitoring functionality as defined in their respective profile level.

3.1.2.2. Configuration & Verification

Modules following level 2 of the profile are to support defined configuration commands along with their ability to be stored and verified. It is not required for modules to be able to be re-configured while enabled and operating (performing a power conversion).

3.1.2.3. Testing

It is incumbent on the device manufacturer to ensure compliance to this profile. It is incumbent on the users to verify compliance to a profile.

3.2. [RVW1][RVW2][RVW3]Bus Speed

. If a DC-DC converter module PMBus interface supports operation above 100 kHz, the device must support the CAPABILITY command.

System SMBus masters must support clock stretching.

3.3. SMBALERT#

The SMBALERT# signal is required for Level 1 and Level 2 of this application profile.

The SMBALERT# signal is described in the SMBus specification [A04].

3.4. Control Signal (CONTROL)

The control signal (CONTROL) is not required for compliance with this application profile. A pre-configuration of the ON_OFF_CONFIG command settings may be required to be compliant to this application profile (see section 3.1.1).

The control cignal and the ON_OFF_CONFIG command settings are described in the PMBus Specification [A01].

4. Commands

4.1. Command Handling Recommendations

4.1.1. Preserving Bit Settings

When changing command data that consist of discrete bit structures:

- Read the command data
- Modify only the data bits to be changed that are contained in this application profile
- Write the modified data back

This will prevent invalid data for bits not supported by this application profile.

4.1.2. Data Read Back and Validation

Due to a device's internal implementation, numerical values may be rounded such that the read back value won't be exactly what was initially written. This limitation means that configuration validation mechanisms may need to compare the read back value within a margin of resolution error (e.g. within 10 highest order bits).

The accuracy & resolution of data shall be given in the vendor's product literature, as referenced in PMBus Specification Part II Section 7.8 (Accuracy) and 7.9 (Resolution) [A02].

4.1.3. Alert Response Address (ARA)

Alert Response Address support is required for devices that support the Level 2 profile.

4.1.4. Address Resolution Protocol (ARP)

Address Resolution Protocol is not required for devices that support this application profile.

4.1.5. Group Command Protocol

Group Command Protocol is not required for devices that support this application profile.

4.1.6. ZONE_READ and ZONE_WRITE

ZONE_READ, ZONE_WRITE and associated commands are not required for devices that support this application profile.

4.2. Table of Commands

For some commands in this table use a bit mask to indicate the profile requirements for each individual bit whether it is only readable, readable and writable or optional. The legend for the mask is indicated in the notes immediately following the table.

Table 1. Commands in each profile

Command Code	Command Name	Numeric Format	Level 1 Profile	Level 2 Profile
00h	PAGE		Only required for multi-page devices	Only required for multi-page devices

Command Code	Command Name	Numeric Format	Level 1 Profile	Level 2 Profile
01h	OPERATION		WXXX_XXXX	WWWW_XXXX
02h	ON_OFF_CONFIG		XXXX_WXXX	XXXX_WXXW
03h	CLEAR_FAULTS		W	W
11h	STORE_DEFAULT_ALL			W
12h	RESTORE_DEFAULT_ALL			W
15h	STORE_USER_ALL			W
16h	RESTORE_USER_ALL			W
19h	CAPABILITY		Only required for bus speed > 100kHz	Only required for bus speed > 100kHz
20h	VOUT_MODE	(Linear Mode)	RRRR_RRRR	RRRR_RRRR
21h	VOUT_COMMAND	uL16		W
25h	VOUT_MARGIN_HIGH	uL16		W
26h	VOUT_MARGIN_LOW	uL16		W
40h	VOUT_OV_FAULT_LIMIT	uL16		W
44h	VOUT_UV_FAULT_LIMIT	uL16		W
46h	IOUT_OC_FAULT_LIMIT	L11		W
51h	OT_WARN_LIMIT	L11		W
60h	TON_DELAY	L11		W
61h	TON_RISE	L11		W
64h	TOFF_DELAY	L11		W
65h	TOFF_FALL	L11		W
78h	STATUS_BYTE (STATUS_WORD Low Byte)		XRRR_XRRX	XRRR_XRRX
79h	STATUS_WORD (Only High Byte shown)		RRXX_RXXX	RRXX_RXXX
7Ah	STATUS_VOUT		RXXR_XXXX	RXXR_XXXX

Command Code	Command Name	Numeric Format	Level 1 Profile	Level 2 Profile
7Dh	STATUS_TEMPERATURE			RRXX_XXXX
7Eh	STATUS_CML			RRRR_XXRX
8Bh	READ_VOUT	uL16	R	R
8Ch	READ_IOUT	L11	R	R
8Dh	READ_TEMPERATURE_1	L11		R
98h	PMBUS_REVISION		R	R
99h	MFR_ID			R

Notes

R = Read Only bit. The corresponding function must be implemented.

W = Readable and Writable bit. The corresponding function must be implemented and controllable using this bit.

X = Optional bit. Therefore it must not be required to be changable for application profile compliance.

uL16 = Unsigned VOUT_MODE Format

sL16 = Signed VOUT_MODE Format

L11 = Linear Data Format

Blank cells in the table indicate that the listed command is not included in that profile level.

4.3. Command Profile Descriptions

4.3.1. PAGE

Multi-page devices may require page commands to communicate the commands in this profile. Implementation must be compliant to the PMBus Specification Part II [A02]. The command is not required for non-paged devices.

4.3.2. OPERATION

OPERATION Command Bit [7] (ON/OFF State) is required for devices that are compliant with Level 2 of this application profile.

OPERATION Command Bits [6:4] (Turn Off Behavior [6], Voltage Command Source [5:4]) are required for devices with Level 2 of this application profile.

The remaining bits are optional and therefore must not be required to be changeable for application profile compliance.

NOTE: For this revision there is no requirement on whether the changes applied to the OPERATION command are executed in a non-volatile or volatile fashion.

4.3.3. ON_OFF_CONFIG

ON_OFF_CONFIG Command Bit [3] (Serial Bus control) is required for devices that are compliant with Level 2 of this application profile.

ON_OFF_CONFIG Command Bit [0] (Control pin action) is required for devices with Level 2 of this application profile.

The remaining bits are optional and therefore must not be required to be changable for application profile compliance.

4.3.4. CLEAR_FAULTS

This command is required for devices that are compliant with this application profile.

4.3.5. STORE_DEFAULT_ALL

This command is an alternate requirement for modules which are compliant with Level 2 of this application profile, but do not support the STORE_USER_ALL command. If writing STORE_USER_ALL is NACK'd (indicating that STORE_USER_ALL and RESTORE_USER_ALL are not supported), then STORE_DEFAULT_ALL and RESTORE_DEFAULT_ALL must be supported in Level 2 modules.

4.3.6. RESTORE_DEFAULT_ALL

This command is an alternate requirement for modules which are compliant with Level 2 of this application profile, but do not support the RESTORE_USER_ALL command. If writing STORE_USER_ALL is NACK'd (indicating that STORE_USER_ALL and RESTORE_USER_ALL are not supported), then STORE_DEFAULT_ALL and RESTORE_DEFAULT_ALL must be supported in Level 2 modules. If only one configuration memory store is available, some mechanism or command for reverting to a known safe configuration must be provided.

4.3.7. STORE_USER_ALL

This command is required for devices that are compliant with Level 2 of this application profile.

Devices that comply with Level 2 of this application profile must support memory commands. If writing STORE_USER_ALL is NACK'd (indicating that STORE_USER_ALL and RESTORE_USER_ALL are not supported) then STORE_DEFAULT_ALL and RESTORE_DEFAULT_ALL must be supported.

4.3.8. RESTORE_USER_ALL

This command is required for modules which are compliant with Level 2 of this application profile. If writing STORE_USER_ALL is NACK'd (indicating that STORE_USER_ALL and RESTORE_USER_ALL are not supported), then STORE_DEFAULT_ALL and RESTORE_DEFAULT_ALL must be supported.

4.3.9. CAPABILITY

This command is only required if the device supports bus speeds greater than 100 kHz (i.e. CAPABILITY Command Bits [6:5] are not equal to 00b.)

PEC support is required for devices with all levels of this Application Profile, regardless of whether CAPABILITY is supported.

If the CAPABILITY command is implemented, then it will be READ_ONLY, and used as follows:

- The CAPABILITY Command Bit [7] (Packet Error Correction) is required for devices with all levels of this application profile.
- The CAPABILITY Command Bits [6:5] (Maximum Bus Speed) is required for devices with all levels of this application profile.
- The CAPABILITY Command Bit [4] (SMBALERT#) is required for devices with all levels of this application profile. Since SMBALERT# is required for devices with Level 2, this bit shall be set to 1b for devices that support Level 2 of this application profile.
- The CAPABILITY Command Bit [3] (Numeric Format) isn't required for devices with all levels of this application profile.
- The CAPABILITY Command Bit [2] (AVSBus Support) isn't required for devices with all levels of this application profile.
- The remaining bits are optional and therefore must not be required to be changed for application profile compliance.

4.3.10. VOUT_MODE

VOUT_MODE Command Bits [7:0] are required (READ ONLY) for devices that comply with Level 2 of this application profile. The upper three mode bits [7:5] must be set to the Linear VOUT Mode format, and the lower five parameter bits [4:0] must include the Linear VOUT Mode exponent value.

4.3.11. VOUT_COMMAND

VOUT_COMMAND Command Bits [15:0] are required for devices compliant with Level 2 of this application profile.

4.3.12. VOUT_MARGIN_HIGH

This command is required for devices that are compliant with Level 2 of this application profile.

4.3.13. VOUT_MARGIN_LOW

This command is required for devices that are compliant with Level 2 of this application profile.

4.3.14. VOUT_OV_FAULT_LIMIT

This command is only required for devices with Level 2 of this application profile.

4.3.15. VOUT_UV_FAULT_LIMIT

This command is only required for devices with Level 2 of this application profile.

4.3.16. IOUT_OC_FAULT_LIMIT

This command is only required for devices with Level 2 of this application profile.

4.3.17. OT_WARN_LIMIT

This command is only required for devices with Level 2 of this application profile.

4.3.18. TON_DELAY

This command is only required for devices with Level 2 of this application profile.

4.3.19. TON_RISE

This command is only required for devices with Level 2 of this application profile.

4.3.20. TOFF_DELAY

This command is only required for devices with Level 2 of this application profile.

4.3.21. TOFF_FALL

This command is only required for devices with Level 2 of this application profile.

4.3.22. STATUS_BYTE

This command is required for devices with Level 1 or 2 of this application profile.

Bit	Name	Application Profile Support
7	Busy	Not required for compliance
6	OFF	Required (Read Only) for any level of profile
5	VOUT_OV_FAULT	Required (Read Only) for any level of profile
4	IOUT_OC_FAULT	Required (Read Only) for any level of profile
3	VIN_UV_FAULT	Not required for compliance
2	TEMPERATURE	Required (Read Only) for any level of profile
1	CML	Required (Read Only) for any level of profile
0	NONE_OF_THE_ABOVE	Not required for compliance

4.3.23. STATUS_WORD

This command is required for devices with Level 1 or 2 of this application profile.

Bit	Name	Application Profile Support
15	VOUT	Required (Read Only) for any level of profile
14	IOUT/POUT	Required (Read Only) for any level of profile
13	INPUT	Not required for compliance
12	MFR_SPECIFIC	Not required for compliance
11	PG_STATUS#	Required (Read Only) for any level of profile
10	FANS	Not required for compliance
9	OTHER	Not required for compliance
8	UNKNOWN	Not required for compliance
7:0	STATUS_BYTE Bits	See Section 4.3.22 above.

4.3.24. STATUS_VOUT

Bit	Name	Application Profile Support
7	VOUT_OV_FAULT	Required (Read Only) for any level of profile
6	VOUT_OV_WARNING	Not required for compliance
5	VOUT_UV_WARNING	Not required for compliance
4	VOUT_UV_FAULT	Required (Read Only) for any level 2 profile
3	VOUT_MAX_MIN	Not required for compliance
2	TON_MAX_FAULT	Not required for compliance
1	TOFF_MAX_WARNING	Not required for compliance

0	VOUT Tracking Error	Not required for compliance

4.3.25. STATUS_TEMPERATURE

Bit	Name	Application Profile Support
7	OT_FAULT	Required (Read Only) for level 2 of profile
6	OT_WARNING	Required (Read Only) for level 2 of profile
5	UT_WARNING	Not required for compliance
4	UT_FAULT	Not required for compliance
3	Reserved	Not required for compliance
2	Reserved	Not required for compliance
1	Reserved	Not required for compliance
0	Reserved	Not required for compliance

4.3.26. STATUS_CML

Bit	Name	Application Profile Support
7	Invalid or Unsupported Command Received	Required (Read Only) for level 2 of profile
6	Invalid or Unsupported Data Received	Required (Read Only) for level 2 of profile
5	Packet Error Check Failed	Required (Read Only) for level 2 of profile
4	Memory Fault Detected	Required (Read Only) for level 2 of profile
3	Processor Fault Detected	Not required for compliance
2	Reserved	Not required for compliance
1	Other Communication Fault	Required (Read Only) for level 2 of profile
0	Other Memory or Logic Fault	Not required for compliance

4.3.27. READ_VOUT

This command is required for devices with Level 1 or 2 of this application profile.

4.3.28. READ_IOUT

This command is required for devices with Level 1 or 2 of this application profile.

4.3.29. READ_TEMPERATURE_1

This command is only required for devices with Level 2 of this application profile.

4.3.30. PMBUS_REVISION

This command is required for devices with Level 1 or 2 of this application profile.

4.3.31. MFR_ID

This command is only required for devices with Level 2 of this application profile.

4.3.32. IC_DEVICE_ID

The IC_DEVICE_ID command is not required for this applications profile.

While MFR_ID is the preferred command for device discovery, when modules and discrete devices are utilized in the same power system, IC_DEVICE_ID may also be used in the device discovery process.

Appendix 1 - Summary of Changes

DISCLAIMER: The section is provided for reference only and for the convenience of the reader. No suggestion, statement or guarantee is made that the description of the changes listed below is sufficient to design a device compliant with this document.

This is the initial release of this document. There are no previous revisions against which changes can be identified. In future releases changes from the previous revision will be listed here.