PMBus™ Application Profile for AC/DC Server Power Supplies

Revision 1.2

Revision History

Revision	Description	Date
1.1	Initial public release	
1.2	Changed title to target server power supplies Sections 7.1 and 11.3; Add SMBAlert and status bit persistence when event is persistent during clearing. Add OFF to the STATUS_WORD command Aligned accuracy stated in 6.1 text to table 2. Modified note in Table 4; section 7 to define a duration of AC voltage loss. Added description of addressing options to table in section 3. Deleted fall time requirements in section 4.5. Modified description of clock stretching requirements in section 4.3 Section 6.1; defined averaging period requirements as default. Intent is to allow custom MFR command to change this as long as the default falls into this range. Change VAC range to 100-127 and 200-240 for READ_PIN and READ_EIN sections. READ_EIN; change to define only direct formatting Section 6.2; added duration to READ_EIN reset section. Section 11; change Tallert_ac to UV Fault; instead of UV warning.	2012-04-16

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1 Overview

The PMBus™ features included in this specification are requirements for ac/dc silver box power supply for use in server systems. This specification is based on the PMBus specifications parts I and II, revision 1.2.

2 Related Documents

- *PMBus™ Power System Management Protocol Specification Part I – General Requirements, Transport and Electrical Interface; Revision 1.2*; Reference: http://pmbus.org/specs.html
- *PMBus™ Power System Management Protocol Specification Part II – Command Language; Revision 1.2*; Reference: http://pmbus.org/specs.html
- *System Management Bus (SMBus) Specification Version 2.0*; Reference: http://smbus.org/specs/

3 Addressing

The power supply PMBus device address locations are shown below. For redundant systems there are up to three signals to set the address location of the power supply once it is installed in the system; Address2, Address1, Address0. For non-redundant systems the power supply device address location should be B0h.

Addresses used:	Main addressing used for most server power supplies with two addressing pins				Additional addresses if three addressing pins are provided on the power supplies.			
System addressing Address2/Address1/ Address0	0/0/0	0/0/1	0/1/0	0/1/1	1/0/0	1/0/1	1/1/0	1/1/1
PMBus device read addresses [2]	B0h/B1h[1]	B2h/B3h	B4h/B5h	B6h/B7h	B8h/B9h	BAh/BBh	BCh/BDh	BEh/BFh

[1] Non-redundant power supplies will use the 0/0/0 address location

[2] The addressing method uses the 7 MSB bits to set the address and the LSB to define whether a device is reading or writing. The addresses defined above use 8 bits including the read/write bit.

4 Hardware

The device in the power supply shall be compatible with both SMBus 2.0 'high power' specification for I^2C V_{dd} based power and drive (for Vdd = 3.3V). This bus shall operate at 3.3V.

4.1 PMBus Power Sourcing

The circuits inside the power supply shall derive their power from the standby output. For redundant power supplies the device(s) shall be powered from the system side of the OR'ing device. The PMBus device shall be on whenever AC power is applied to the power supply or a parallel redundant power supply in the system.

4.2 Pull ups

Only weak pull-up resistors shall be on SCL or SDA inside the power supply. The main pull-up resistors are provided by the system and may be connected to 3.3V or 5V. For the system design, the main pull-ups shall be located external to the power supply and derive their power from the standby rail.

4.3 Data Speed

The PMBUS device in the power supply shall operate at the full 100 kbps SMBus speed and avoid using clock stretching as much as possible that can slow down the bus. For example, the power supply shall limit clock stretching while parsing a commands, servicing multiple internal interrupts, or NACK'ing a command. Unsupported commands may respond with a NACK but must always set the communication error status bit in STATUS_CML.

The PMBus device shall support SMBus cumulative clock low extend time (Tlow: sext) if < 25 ms. This requires the device to extend the clock time no more than 25 ms between START and STOP for any given message.

4.4 Bus Errors

The PMBus device shall support SMBus clock-low timeout (Ttimeout). This capability requires the device to abort any transaction and drop off the bus if it detects the clock being held low for >25 ms, and be able to respond to new transactions 10ms later.

The device must recognize SMBus START and STOP conditions on ANY clock interval. (These are requirements of the SMBus specifications, but are often missed in first-time hardware designs.) The device must not hang due to 'runt clocks', 'runt data', or other out-of-spec bus timing. This is defined as signals, logic-level glitches, setup, or hold times that are shorter than the minimums specified by the SMBus specification. The device is not required to operate normally, but must return to normal operation once 'in spec' clock and data timing is again received. Note if the device 'misses' a clock from the master due to noise or other bus errors, the device must continue to accept 'in spec' clocks and re-synch with the master on the next START or STOP condition.

4.5 Additional SMBus Hardware Requirements

The power supply shall not load the SMBus if it has no input power (SCL & SDA lines should go to High-Z).

5 New PAGE_PLUS_WRITE / PAGE_PLUS_READ Commands (05h/06h)

The new PAGE_PLUS_WRITE and PAGE_PLUS_READ commands are used with the STATUS_WORD, STATUS_INPUT, STATUS_TEMPERATURE, STATUS_IOUT, and STATUS_CML to create two instances of the same command. Each instance is set by the same events but cleared by their own master in the system. The instances at PAGE 00h are controlled by the system BMC and the instances at PAGE 01h are controlled by the system ME.

6 Sensors

The following PMBus commands shall be supported for the purpose of monitoring current, power and temperature. All sensors shall continue providing real time data as long as the PMBus device is powered. This means in standby mode the main output(s) of the power supply shall be zero amps and zero volts. Sensors shall meet requirements from 100VAC to 127VAC and from 200VAC to 240VAC. They shall be tested down to 10% load.

Table 1 Current / Power / Temperature Monitoring PMBus Commands

PMBus command	Description
READ_EIN	New input energy counter; described below. Will be added to PMBus rev 1.2 spec. Uses direct format for the power accumulator; unsigned integer value for the sample count.
READ_PIN	Input power meter based on PMBus rev 1.1 spec. Uses Linear formatting.
READ_IOUT	Output current in amps for the total 12V current. The other outputs are not sensed. Uses linear format.
READ_TEMPERATURE_1	Returns the temperature in °C of the inlet temperature. Based on PMBus rev 1.1 spec. Uses linear format.
READ_TEMPERATURE_2	Returns the temperature in °C of the hot spot temperature. Based on PMBus rev 1.1 spec. Uses linear format.

6.1 READ_PIN (97h)

The power supply shall provide input power data in watts. The data shall be reported using the PMBus linear format. The data shall be the average input power or filtered input power. If a simple average is used to provide average input power, the default minimum averaging duration shall be 2 seconds. If filtering is used; the default maximum filter bandwidth shall be 0.5 Hz. The minimum accuracy shall be +/-5% over 200W to 100% load range; +/-10W over 10% to 200W load range. The accuracy shall be tested by polling with the READ_PIN command at a rate ranging from 1 sample / second to 10 samples / second.

Table 2 READ_PIN Requirements Summary

<table>
<tr><th></th><th>MIN</th><th>MAX</th><th>Description</th></tr>
<tr><td>Format</td><td colspan="2">PMBus linear format</td><td>PMBus data format; refer to PMBus specification for details</td></tr>
<tr><td>Default averaging period</td><td>2 sec</td><td>10 sec</td><td rowspan="2">The AC input power shall be averaged using a simple averaging method of a filtering method. This defines the default max/min period for simple averaging and the bandwidth range if the filter method is used.</td></tr>
<tr><td>Default filtering bandwidth</td><td>0.1 Hz</td><td>0.5 Hz</td></tr>
<tr><td>Accuracy

(10% to 200W load)</td><td>+/- 10W</td><td></td><td>The input power data shall meet these accuracy requirements over 100-127VAC and 200-240VAC and under the defined system polling rate.</td></tr>
</table>

	MIN	MAX	Description
Accuracy (200W to 100% load)	+/- 5%		
System polling rate	1 sample/ sec	10 samples / sec	The power supply shall be polled over this range of rates while testing accuracy.

Resetting READ_PIN

The READ_PIN power value should reset to 0W when in standby mode or when AC power is lost.

6.2 READ_EIN (86h)

The new READ_EIN command is used to allow the system to apply its own input power filtering. This will allow the system to get faster input power data while preventing aliasing. The command returns an accumulated power value and an associated sample count of number of accumulated power values. This allows the system to calculate its own average power value each time the system polls the power supply.

Table 3 READ_EIN Requirements Summary

	MIN	MAX	Description
Format	PMBus Direct format m = 01h, R = 00h, b = 00h		PMBus data format; refer to PMBus specification for details.
P_{sample} averaging period	= 4 AC cycles		Period instantaneous AC power is averaged over to calculate P_{sample}.
[P_{accum} / N] Accuracy (10% to 200W load)	+/-10W		The calculated input power data shall meet these accuracy requirements over 100-127VAC and 200-240VAC and under the defined system polling rate.
[P_{accum} / N] Accuracy (200W to 100% load)	+/-5%		
System polling rate	1 sample / sec	10 samples / sec	The power supply shall be polled over this range of rates while testing accuracy.

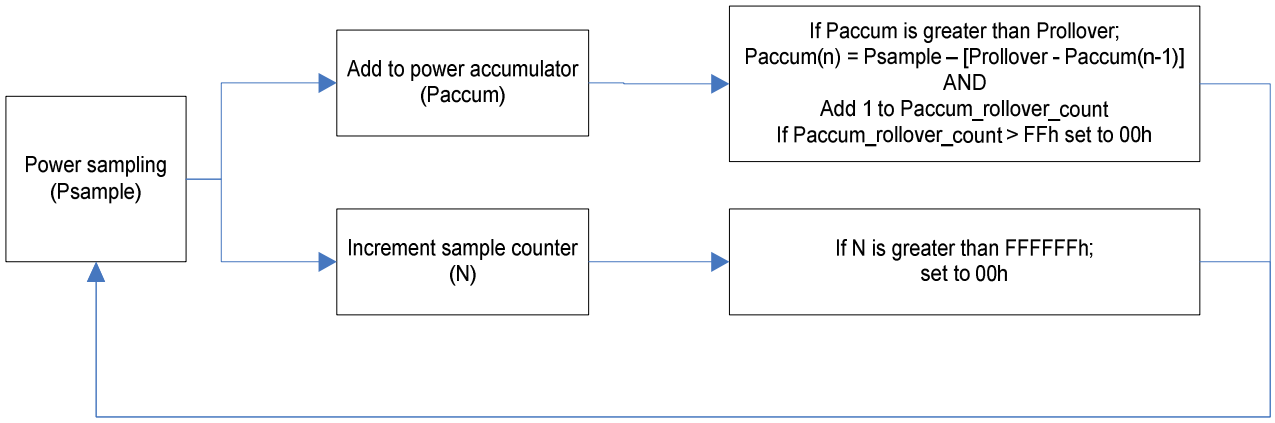
READ_EIN Format

The READ_EIN command shall use the PMBus direct format to report the accumulated power value and the sample count. The PMBus coefficients m, R, and b shall be fixed values and the power supply shall report these values using the PMBus COEFFICIENT command. The coefficient m shall be set to 01h, coefficient R shall be set to 00h, and coefficient b shall be set to 00h.

READ_EIN Accumulators

The accumulated power data shall be the sum of input power values averaged over 4 AC cycles. The value shall automatically roll-over when the 15 bit maximum value is reached (> 7FFFh). The sample count should increment 1 for each accumulated power value. The system shall calculate average power by dividing the accumulated power value by the sample count. The system must sample READ_EIN faster than the roll-over period to get an accurate power calculation. If the system sees a smaller value than the previous sampled data; then the system must account for the roll-over by adding 7FFFh to the present value. Below is a block diagram depicting the READ_EIN accumulator function in the power supply.

Note: When the power supply responds to the system requesting READ_EIN data; the data in the sample count must always be in alignment with the number of samples accumulated in the power accumulator.



Psample: …….. The sampled power value in direct format

Paccum: …….. 2 bytes in direct format.

The accumulated power values made up of Psample(0) + Psample(1) + … + Psample(n)

N: …….. 3 byte unsigned integer value. The number of accumulated power values summed in Paccum

Prollover: …….. The max value of Paccum before a rollover will occur

Paccum_rollover_count: 1 byte unsigned integer counting the number of times Paccum rolls over.

Once this reaches FFh; it will automatically get reset to 00h

Figure 1 READ_EIN Power Supply Functional Diagram

Resetting READ_EIN

The READ_EIN power accumulator, roll-over counter, and sample count should keep the latest value when the power supply is put into standby mode. The power accumulator, roll-over counter and sample count should reset to 00 when AC power is lost long enough to cause the power supply to shutdown.

6.2.1 COEFFICIENT (30h)

The power supply shall support the PMBus COEFFICIENT command. The system shall use this to read the values of m, b, and R used to determine READ_EIN accumulated power values.

The values of m, b, and R shall be set to:

m = 01h

b = 00h

R = 00h

7 Status Commands

The following PMBus STATUS commands shall be supported. All STATUS commands except the STATUS_FAN_1_2 command shall be accessed with the new PAGE_PLUS command since they are used by both the BMC and ME. The (BMC) and (ME) refer to the two instances of the command accessed via the PAGE_PLUS command. The status bits shall assert whenever the event driving the status bit is present. Once a bit is asserted it shall stay asserted until cleared using one of the methods shown in section 7.1. A summary of the supported STATUS commands are shown below.

STATUS_FAN_1_2 command is only accessed by the system BMC. It uses the standard read byte protocol to read status and write byte protocol to clear bits.

The STATUS events are also used to control the SMBAlert# signal. The new SMBALERT_MASK command is used to define which status event controls the SMBAlert# signal. Default values for these mask bits are shown in the table below.

Table 4 PMBus STATUS Commands Summary

PMBus command	Power supply state when bit is asserted ('1')	PAGEs 00h = BMC 01h = ME	SMBALERT_MASK default 0 = causes assertion of SMBAlert# 1 = does not cause assertion of SMBAlert#
STATUS_WORD		00h, 01h	
OFF	OFF		1
IOUT_OC_FAULT	Refer to STATUS_IOUT		1
TEMPERATURE	Refer to STATUS_TEMPERATURE		1

PMBus command	Power supply state when bit is asserted ('1')	PAGEs 00h = BMC 01h = ME	SMBALERT_MASK default 0 = causes assertion of SMBAlert# 1 = does not cause assertion of SMBAlert#
VIN_UV_FAULT	Refer to STATUS_INPUT		1
CML	ON		1
VOUT	OFF		1
IOUT/POUT	Refer to STATUS_IOUT)		1
INPUT	Refer to STATUS_INPUT)		1
FANS	Refer to STATUS_FANS)		1
STATUS_IOUT		00h, 01h	
Iout OC fault	OFF		1
Iout OC warning	ON		1
Pout OP fault	OFF		1
Pout OP warning	ON		1
STATUS_INPUT		00h, 01h	
Vin UV warning	ON		1
Vin UV fault [1]	OFF		Page 00h = 1 Page 01h = 0
Unit off for insufficient input	OFF		1
Iin over current warning	ON		1
Pin over power warning	ON		1
STATUS_TEMPERATURE		00h, 01h	1
OT fault	OFF		1
OT warning	ON		Page 00h = 1 Page 01h = 0
STATUS_FANS_1_2		NA	1
Fan 1 fault	OFF		1
Fan 1 warning	ON		1

1. The Vin Fault bit in STATUS_INPUT shall get asserted if the AC input has dropped to 0VAC for > 2msec. Even if the power supply continues to operate normally through a < 20 ms AC dropout; this bit shall get asserted.

7.1 Resetting of Status Bits

The STATUS_ commands shall be reset only by the below methods. If the event is still present that caused the assertion of the status bit; the bit shall stay asserted when attempting to clear.

- Writing a '1' to any given bit location shall reset only that bit of the command.
- Sending a CLEAR_FAULTS command to the power supply shall reset all STATUS_ bits to '0'
- Cycling AC power OFF then ON shall reset all STATUS_ bits to '0'.
- Systems with redundant power supplies where only one of the supplies cycle AC power OFF/ON; the power cycled power supply shall reset the STATUS_ bits to '0' only when powered back ON. If the power supply is kept OFF, the STATUS_ bits shall not be reset.
- Cycling the PSON# signal from de-asserted to asserted shall reset the STATUS_ bits to '0'. The bits shall be reset only on the assertion of PSON#; not the de-assertion.

8 Default Limits for Warning and Faults

Warning limits shall be set with enough margin to guarantee that no false warnings will occur if the power supply operates within the specified requirements, but before the power supply shuts down. Fault limits shall be set at limits equal to or greater than the level at which the power supply shuts down. The system does not set any of the warning or fault limits.

9 Faults and Error Checking

The power supply shall support PEC per the SMBus 2.0 specification.

9.1 Packet Error Checking

The power supply shall support packet error checking to support error checking and handling.

10 Capability and Inventory Reporting

The follow commands shall be supported for discovery of the power supplies (PSU) capabilities.

Table 5 PMBus PSU Capability & Inventory Commands Summary

PMBus command	Value	Description
CAPABILITY	PEC = supported Bus speed = 100 kHz SMBAlert# = supported	Defines the power supplies PEC support, bus speed, and support of SMBAlert#
QUERY	Linear formats for all but READ_EIN which is Direct	Used to determine if the power supply supports a specific command
PMBUS_REVISION	0010 0010	Used to verify the PMBUS_REVISION the power supply is based on. This shall be set to revision 1.2.
MFR_TEMP1_MAX	Trip threshold for the ambient temperature sensor (TEMP1) to assert SMBAlert#	Defines the maximum inlet temperature to generate a warning condition in the STATUS_TEMPERATURE command.
MFR_TEMP2_MAX	Trip threshold for the hot spot temperature sensor (TEMP2) to assert SMBAlert#	Defines the maximum hotspot temperature to generate a warning condition in the STATUS_TEMPERATURE command.
MFR_IOUT_MAX	Rated output current using the linear format	Defines the maximum rated output current on the 12V rail.
APP_PROFILE_SUPPORT	04h	Defines that the power supply supports this application profile.

11 SMBAlert#

The SMBAlert# signal may be asserted by the power supply for any of the supported STATUS events. The events that control SMBAlert# can be masked using the SMBALERT_MASK command. Default masking is shown in section 7.

By default the SMBAlert# signal is asserted for the following cases.

1. AC input voltage drops below the fault threshold of the power supply for > 2ms
2. Thermal sensor on a hot spot inside the power supply has exceeded its warning temperature.

Table 6 Power Supply SMBAlert# Timing Requirements

Item	Description	PMBus command	MIN	MAX

T_{alert_ac}	Timing from input voltage dropping to 0VAC to SMBAlert# going low	STATUS_INPUT UV Fault		2 ms
T_{over_temp}	Hot spot temp > warning threshold	STATUS_TEMPERATURE Over temp warning		1 sec
$T_{smbalert\_shutdown}$	Minimum time power supply must continue to operate within voltage regulation limits and PWOK asserted after the SMBAlert# signal has been asserted due to an over temperature event.	NA	TBD	
$T_{max\_warning}$	Hot spot temperature inside the power supply that causes SMBAlert# to assert.	MFR_TEMP2_MAX	Tmax_continuous	Tshutdown

11.1 SMBALERT_MASK (1Bh)

This allows the system to mask events from asserting the SMBAlert# signal and to read back this information from the power supply. SMBALERT_MASK command can be used with any of the supported STATUS events. The events are masked from asserting SMBAlert# by writing a '1' to the associated STATUS bits. The SMBALERT_MASK command is used in conjunction with the PAGE_PLUS command and STATUS_ commands. Below are the protocols.

11.2 Alert Response Address (ARA)

The power supply shall not support ARA. After asserting the SMBAlert# signal the power supply shall keep its address at it standard address; not change to 18h.

11.3 Setting and Resetting the SMBAlert# signal

The SMBAlert# signal shall be asserted whenever any un-masked event has occurred. This is a level detected event. Whenever the event is present SMBAlert# shall be asserted. If the SMBAlert# signal is cleared; it shall stay asserted if the event is still present.

The SMBAlert# signal shall be cleared and re-armed by the following methods.

- Clearing STATUS bits causing the asserted SMBAlert# signal.
- Power cycling with PSON or with AC power

12 Fan Speed Control

The power supply shall support the PMBus commands to allow the system to control and monitor the power supply's fan.

12.1 FAN_CONFIG_1_2 (3Ah)

The FAN_CONFIG_1_2 command is used to define the presence of a fan and the method it is controlled (by duty cycle or RPM).

Table 7 FAN_CONFIG_1_2 Command

Bits	Value	Meaning
7	1	Fan in position 1
6	0	Fan 1 commanded in Duty Cycle
5:4	Not used	
3	0	No fan in position 2
2	Not used	
1:0	Not used	

12.2 FAN_COMMAND_1 (3Bh)

The system may increase the power supplies fan speed through using the FAN_COMMAND_1 command. This command can only increase the power supplies fan speed; it cannot decrease the power supply fan speed below what the power supply commands.

The control is configured to be duty cycle controlled using the linear format of the PMBus protocol.

The exponent N is fixed to a value of 0 (N = 0).

12.3 READ_FAN_SPEED_1 (90h)

The system will read the fan speed by using the READ_FAN_SPEED_1 command. This data shall return the fan speed in the PMBus linear format.

13 Summary of Required PMBus Commands

Table 8 PMBus Commands Summary (Romley Platform)

Code	Pages	Command	SMBus Transaction Type Status bit mapping
03h	NA	CLEAR_FAULTS	Send Byte w/PEC
05h	NA	PAGE_PLUS_WRITE	Block Write w/PEC Used with STATUS_INPUT, STATUS_TEMPERATURE, STATUS_IOUT

Code	Pages	Command	SMBus Transaction Type Status bit mapping
06h	NA	PAGE_PLUS_READ	Write Block Read Block Process Call w/PEC Used with STATUS_INPUT, STATUS_TEMPERATURE, STATUS_IOUT, STATUS_WORD
19h	NA	CAPABILITY	Read Byte w/PEC
1Ah	NA	QUERY	Block Write Block Read Process Call w/ PEC
1Bh	NA	SMBALERT_MASK	Reading: Write Block Read Block Process Call w/PEC Writing: Write Word Used with STATUS_INPUT, STATUS_TEMPERATURE, STATUS_IOUT
30h	NA	COEFFICIENT	Block Write Block Read Process Call w/PEC
3Ah	NA	FAN_CONFIG_1_2	
3Bh	NA	FAN_COMMAND_1	
79h	00h, 01h	STATUS_WORD	Read Word w/PEC
(Low) 4		IOUT_OC	Indeterminate (Use STATUS_IOUT)
2		TEMPERATURE	Indeterminate (Use STATUS_TEMPERATURE)
3		VIN_UV	Indeterminate (Use STATUS_INPUT)
1		CML	
(High) 7		VOUT	Failure
6		IOUT/POUT	Indeterminate (Use STATUS_IOUT)
5		INPUT	Indeterminate (Use STATUS_INPUT)
2		FANS	Indeterminate (Use STATUS_FANS)
7Bh	00h, 01h	STATUS_IOUT	Read Byte w/PEC
7		Iout OC fault	Failure
5		Iout OC warning	Pedictive failure
1		Pout OP fault	Failure
0		Pout OP warning	Pedictive failure

Code	Pages	Command	SMBus Transaction Type Status bit mapping
7Ch	00h, 01h	STATUS_INPUT	Read Byte w/PEC
5		Vin UV warning	Predictive failure
4		Vin UV fault	AC Loss
3		Unit off for insufficient input	AC Loss
1		Iin over current warning	Predictive failure
0		Pin over power warning	Predicitve failure
7Dh	00h, 01h	STATUS_TEMPERATURE	Read Byte w/PEC
7		OT fault	Fault
6		OT warning	Predicitve fault
81h	00h	STATUS_FANS_1_2	Read Byte w/PEC
7		Fan 1 fault	Failure
6		Fan 2 fault	Failure
5		Fan 1 warning	Pedictive failure
4		Fan 2 warning	Predicitive failure
86h	NA	READ_EIN	Block Read w/ PEC
8Ch	NA	READ_IOUT	Read Word w/PEC
8Dh	NA	READ_TEMPERATURE_1 (Ambient)	Read Word w/PEC
8Eh	NA	READ_TEMPERATURE_2 (Hot Spot)	Read Word w/PEC
90h	NA	READ_FAN_SPEED_1	Read Word w/PEC
98h	NA	PMBUS_REVISION	Read Byte w/PEC
9Fh	NA	APP_PROFILE_SUPPORT	Read Byte w/PEC
A6h	NA	MFR_IOUT_MAX	Read Word w/PEC
C0h	NA	MFR_MAX_TEMP_1 (Ambient)	Read Word w/PEC
C1h	NA	MFR_MAX_TEMP_2 (hot Spot)	Read Word w/PEC