COMMUNICATION MANUAL

DC-DC PEC Series

CRPS Front End Power Supplies

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1. FRU REQUIREMENTS

1.1 OVERVIEW

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

1.2 RELATED DOCUMENTS

Power Management Bus Power System Management Protocol Specification Part I – General Requirements, Transport and Electrical Interface; Revision 1.2.
Power Management Bus Power System Management Protocol Specification Part II – Command Language; Revision 1.2.
SMBus 2.0.

1.3 HARDWARE CONNECTING

The device in the power supply shall be compatible with both SMBus 2.0 'high power' specification for I2C Vdd based power and drive (for Vdd = 3.3 V). This bus shall operate at 3.3 V.
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 Power Management Bus device shall be on whenever DC power is applied to the power supply or a parallel redundant power supply in the system. 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 3.3Vsb. For the system design, the main pull-ups shall be located external to the power supply and derive their power from the standby rail.
300ns maximum fall time with a 400pF capacitive load and 2.7Kohm pull up to 3.3V.
10ns minimum fall time with a 20pF capacitive load and 2.7Kohm pull up to 3.3V.
The power supply shall not load the SMBus if it has no input power.

1.4 DATA SPEED

The POWER MANAGEMENT BUS device in the power supply shall operate at the full 100 kbps SMBus speed and avoid using clock stretching that can slow down the bus. For example, the power supply can clock stretch while parsing a command or a power supply servicing multiple internal interrupts or NACK may require some use of clock stretching.
The Power Management Bus device shall support SMBus cumulative clock low extend time (Tlow:sext) if < 25msec. This requires the device to extend the clock time no more than 25msec between START and STOP for any given message.

1.5 BUS ERROR

The Power Management Bus 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 >25ms, 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.

1.6 FRU DATA FORMAT

For identification of the power supply an internal 256x8 bit EEPROM with Power Management Bus interface is used.

The information in the EEPROM follows the IPMI (Platform Management FRU Information Storage Definition) guidelines Document Revision 1.1 from November 15, 1999.

1.7 COMMUNICATION ADDRESS

Four pins will be allocated for the FRU and Power Management Bus information on the Power Supply connector. One pin is the serial clock (SCL). The second pin is used for serial data (SDA). Two pins are for address lines A0-A1 to indicate to the power supply's EEPROM and MCU. which position the power supply is located in the system. The SCL and SDA signals are pulled up by system, the address lines are also pulled up by system.

A1 LOGICAL VOLTAGE	A0 LOGICAL VOLTAGE	PSU ADDRESS	FRU ADDRESS
0	0	0xB0	0xA0
0	1	0xB2	0xA2
1	0	0xB4	0xA4
1	1	0xB6	0xA6

2. POWER MANAGEMENT BUS CONTENT

2.1 POWER MANAGEMENT BUS COMMAND TABLE

Via the Power Management Bus the computer system can communicate with the power supply to access currents, voltages, fan control and speed and temperatures. The communication follows the Power System Management Protocol Specification. (Power Management Bus 1.2). As soon as DC Power is connected to the PSU the Power Management Bus functionality must be available.
Following Table shows mandatory Power Management Bus commands to be supported by the PSU.

Command Code	Command Name	SMBus Transaction Type:		Number Of Data Bytes	Comment
		Writing Data	Reading Data		
00h	PAGE	Write Byte	Read Byte	1	
01h	OPERATION	Write Byte	Read Byte	1	0x80 ON; 0x00 OFF Default: 0x00
02h	ON_OFF_CONFIG	Write Byte	Read Byte	1	
03h	CLEAR_FAULTS	Send Byte	N/A	0	
05h	PAGE_PLUS_WRITE	Block Write	N/A	Variable	
06h	PAGE_PLUS_READ	N/A	Block Write – Block Read	Variable	
19h	CAPABILITY	N/A	Read Byte	1	0xB0
1Ah	QUERY	N/A	Block Write – Block Read	1	
1Bh	SMBALERT_MASK	Write Word	Block Write – Block Read	2	
20h	VOUT_MODE		Read Byte	1	0x17 (n=-9)
21h	VOUT_COMMAND	Write Word	Read Word	2	
30h	COEFFICIENTS	N/A	Block Write – Block Read	5	Use for Ein/Eout
31h	POUT_MAX	N/A	Read Word	2	
3Ah	FAN_CONFIG_1_2	Write Byte	Read Byte	1	Default is RPM
3Bh	FAN_COMMAND_1	Write Word	Read Word	2	
4Ah	IOUT_OC_WARN_LIMIT		Read Word	2	
51h	OT_WARN_LIMIT		Read Word	2	
5Dh	IIN_OC_WARN_LIMIT		Read Word	2	
6Ah	POUT_OP_WARN_LIMIT		Read Word	2	
6Bh	PIN_OP_WARN_LIMIT		Read Word	2	

78h	STATUS_BYTE	Write Byte	Read Byte	1	
Bit 6	OFF				
Bit 5	VOUT_OV_FAULT				
Bit 4	IOUT_OC				
Bit 3	VIN_UV				
Bit 2	TEMPERATURE				
Bit 1	CML				
Bit 0	NON OF THE ABOVE				
79h	STATUS_WORD	Write Word	Read Word	2	
Bit 7(H)	VOUT				
Bit 6	IOUT/POUT				
Bit 5	INPUT				
Bit 3	POWER_GOOD#				
Bit 2	FANS				
Bit 6(L)	OFF				
Bit 5	VOUT_OV_FAULT				
Bit 4	IOUT_OC_FAULT				
Bit 3	VIN_UV_FAULT				
Bit 2	TEMPERATURE				
Bit 1	CML				
Bit 0	NON OF THE ABOVE				
7Ah	STATUS_VOUT	Write Byte	Read Byte	1	
Bit 7	VOUT_OV_FAULT				
Bit 4	VOUT_UV_FAULT				
7Bh	STATUS_IOUT	Write Byte	Read Byte	1	
Bit 7	Iout OC fault				
Bit 5	Iout OC warning				
Bit 1	Pout OP fault				
Bit 0	Pout OP warning				
7Ch	STATUS_INPUT	Write Byte	Read Byte	1	
Bit 5	Vin UV warning				
Bit 4	Vin UV fault				
Bit 3	Unit off for insufficient input				
Bit 1	Iin over current warning				
Bit 0	Pin over power warning				
7Dh	STATUS_TEMPERATURE	Write Byte	Read Byte	1	
Bit 7	OT fault				
Bit 6	OT warning				
7Eh	STATUS_CML	Write Byte	Read Byte	1	
Bit 7	Invalid COMMAND				
Bit 6	Invalid DATA				
Bit 5	PEC Failed				
81h	STATUS_FANS_1_2	Write Byte	Read Byte	1	
Bit 7	Fan 1 fault				
Bit 5	Fan 1 warning				

Bit 3	Fan1 speed overridden				
86h	READ_EIN	N/A	Block Read	6	DIRECT Data Format
87h	READ_EOUT	N/A	Block Read	6	DIRECT Data Format
88h	READ_VIN	N/A	Read Word	2	Linear
89h	READ_IIN	N/A	Read Word	2	Linear
8Bh	READ_VOUT	N/A	Read Word	2	Linear16
8Ch	READ_IOUT	N/A	Read Word	2	Linear
8Dh	READ_TEMPERATURE_1	N/A	Read Word	2	Ambient
8Eh	READ_TEMPERATURE_2	N/A	Read Word	2	SR Hotspot
8Fh	READ_TEMPERATURE_3	N/A	Read Word	2	PFC Hotspot
90h	READ_FAN_SPEED_1	N/A	Read Word	2	In RPM
96h	READ_POUT	N/A	Read Word	2	Linear
97h	READ_PIN	N/A	Read Word	2	Linear
98h	POWER MANAGEMENT BUS_REVISION	N/A	Read Byte	1	1.3
99h	MFR_ID	Block Write	Block Read	Variable (8)	"bel"
9Ah	MFR_MODEL	Block Write	Block Read	Variable (16)	"XXXXXXXXXXXXXXXX"
9Bh	MFR_REVISION	Block Write	Block Read	Variable (3)	"RXX"
9Ch	MFR_LOCATION	Block Write	Block Read	Variable (8)	"SHENZHEN"
9Dh	MFR_DATE	Block Write	Block Read	Variable (8)	"YYYYMMDD"
9Eh	MFR_SERIAL	Block Write	Block Read	Variable (14)	Serial Number
9Fh	APP_PROFILE_SUPPORT	N/A	Block Read	Variable (2)	Power Management Bus 1.2
A0h	MFR_VIN_MIN	N/A	Read Word	2	36V
A1h	MFR_VIN_MAX	N/A	Read Word	2	72V
A2h	MFR_IIN_MAX	N/A	Read Word	2	
A3h	MFR_PIN_MAX	N/A	Read Word	2	
A4h	MFR_VOUT_MIN	N/A	Read Word	2	11.4V
A5h	MFR_VOUT_MAX	N/A	Read Word	2	12.6V
A6h	MFR_IOUT_MAX	N/A	Read Word	2	
A7h	MFR_POUT_MAX	N/A	Read Word	2	
A8h	MFR_TAMBIENT_MAX	N/A	Read Word	2	
A9h	MFR_TAMBIENT_MIN	N/A	Read Word	2	
AAh	MFR_EFFICIENCY_LL	N/A	Block Read	14	At 20%/50%/100%
ABh	MFR_EFFICIENCY_HL	N/A	Block Read	14	At 20%/50%/100%
B0h	POWER MANAGEMENT BUS_MFR_ CALIBRATION_0xB0	Block Write	Block Read	Variable	
C0h	MFR_MAX_TEMP_1	N/A	Read Word	2	
C1h	MFR_MAX_TEMP_2	N/A	Read Word	2	
C2h	MFR_MAX_TEMP_3	N/A	Read Word	2	
D0h	MFR_COLD_ REDUNDANCY_CONFIG	Write Byte	Read Byte	1	
D4h	MFR_HW_COMPATIBILITY	N/A	Read Word	2	
D5h	MFR_FWUPLOAD_CAPABILITY	N/A	Read Byte	1	
D6h	MFR_FWUPLOAD_MODE	Write Byte	Read Byte	1	
D7h	MFR_FWUPLOAD	Block Write	N/A		
D8h	MFR_FWUPLOAD_STATUS	N/A	Read Word	21	

D9h	MFR_FW_REVISION	N/A	Block Read	3	
DCh	MFR_BLACK_BOX	N/A	Block Read	237	
DDh	MFR_REAL_TIME	Block Write	Block Read	4	
DEh	MFR_SYSTEM_BLACK_BOX	Block Write	Block Read	40	
DFh	MFR_BLACKBOX_CONFIG	Write Byte	Read Byte	1	
E0h	MFR_CLEAR_BLACKBOX	Send Byte	N/A	1	

Table 1. Supported Power Management Bus Command

Note: Write protocol must include PEC (Packet Error Checking).

2.2 STATUS COMMANDS

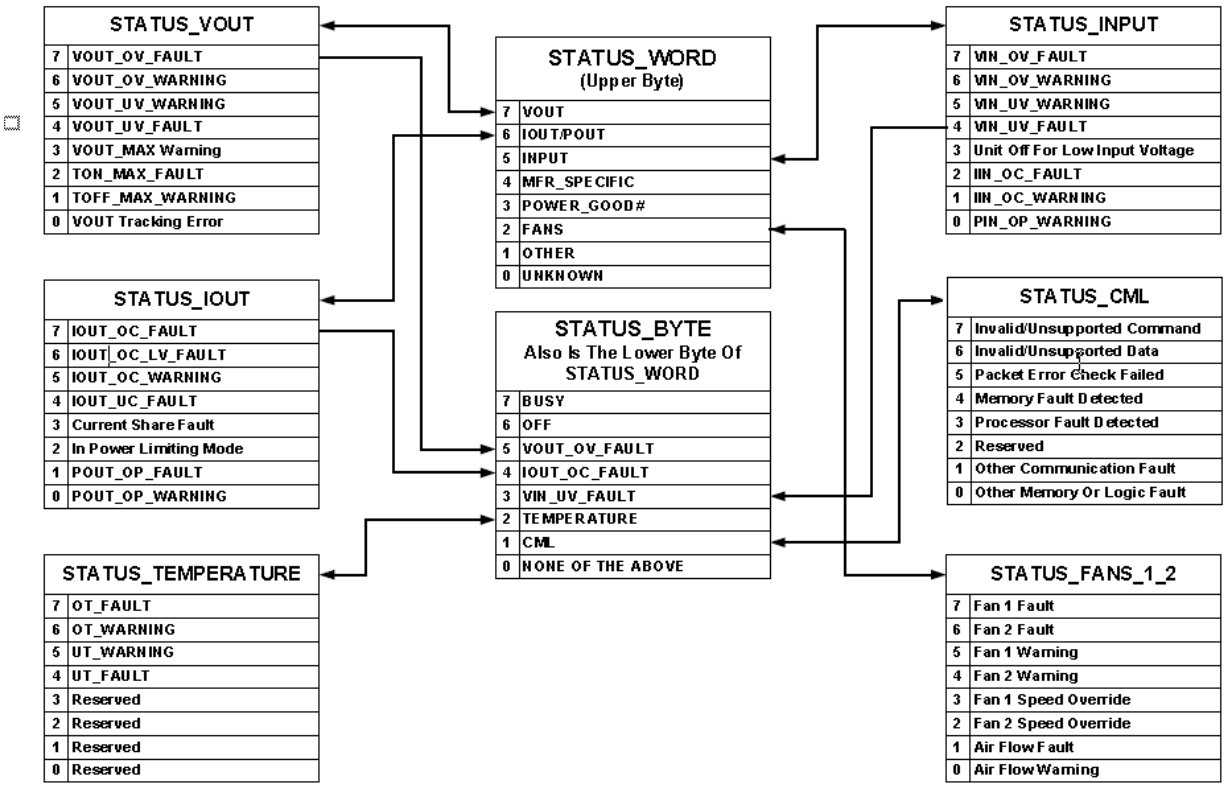


Figure 1. Summary of The Status Registers

The following Power Management Bus STATUS commands shall be supported. All STATUS commands stated in Table 7.1 Supporting PAGE instances shall support the PAGE_PLUS_WRITE and PAGE_PLUUS_READ commands since they are used by both the BMC and ME. The BMC and ME refer to the two instances of the commands accessed via the PAGE_PLUS_WRITE and PAGE_ PLUS_READ commands. 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

The STATUS commands that are supported with the PAGE_PLUS_READ and PAGEE_PLUS_W RITE commands shall still support direct access of the base STATUS_XXX commands using the read word, write word, read byte, and write byte protocols.

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 SMBBALERT_MASK command is used to define which status event control the SMBAlert# signal. Default values for these mask bits are shown in the table below.

POWER MANAGEMENT BUS COMMAND	BIT LOCATION	PSU STATE WHEN BIT IS ASSERTED ('1')	INSTANCES NO PAGE'ING2 PAGE 00H = BMC PAGE 01H = ME	SMBALERT_MASK DEFAULTS FOR EACH OF THE THREE INSTANCES (NO PAGE, PAGE 00H, PAGE 01H) 0 = CAUSES ASSERTION OF SMBALERT# 1 = DOES NOT CAUSE ASSERTION OF SMBALERT#
STATUS_WORD			No PAGE, 00h, 01h	
OFF	6 (lower)	OFF		NA
IOUT_OC_FAULT	4 (lower)	Refer to STATUS_IOUT		NA
VIN_UV_FAULT	3 (lower)	Refer to STATUS_INPUT		NA
TEMPERATURE	2 (lower)	Refer to STATUS_TEMPERATURE		NA
CML	1 (lower)	ON		NA
VOUT	7 (upper)	Refer to STATUS_VOUT		NA
IOUT/POUT	6 (upper)	Refer to STATUS_IOUT		NA
INPUT	5 (upper)	Refer to STATUS_INPUT		NA
FANS	2 (upper)	Refer to STATUS_FANS		NA
STATUS_VOUT			No PAGE'ing	
VOUT_OV_FAULT	7	OFF		1, 1, 1
VOUT_UV_FAULT	4	OFF		1, 1, 1
STATUS_IOUT			No PAGE'ing, 00h,01h	
IOUT_OC_FAULT	7	OFF		1, 1, 0
IOUT_OC_WARNING	5	ON		1, 1, 0
POUT_OP_FAULT	1	OFF		1, 1, 1
POUT_OP_WARNING	0	ON		1, 1, 1
STATUS_INPUT			No PAGE'ing, 00h,01h	
VIN_UV_WARNING	5	ON		1, 1, 0
VIN_UV_FAULT 1	4	OFF		1, 1, 0
Unit off for low input voltage	3	OFF		1, 1, 1
IIN_OC_WARNING	1	ON		1, 1, 1
PIN_OP_WARNING	0	ON		1, 1, 1
STATUS_TEMPERATURE			No PAGE'ing, 00h,01h	
OT_FAULT	7	OFF		1, 1, 0
OT_WARNING	6	ON		1, 1, 0
STATUS_FANS_1_2			No PAGE'ing	
Fan 1 fault3	7	OFF		1, 1, 1
Fan 1 warning3	5	ON		1, 1, 1

Table 2. Power Management Bus STATUS Commands Summary

1. The Vin Fault bit in STATUS_INPUT shall get asserted if the input power has dropped below the PSU's operating range for any duration of time; even if the PSU continues to operate normally through a momentary input dropout event.
2. 'No PAGE' is the standard STATUS_ commands accessed directly without using the PAGE_PLUS commands.
3. All fans in the PSU shall be OR'ed into a single fan status bit for fault and warning conditions.

2.3 POWER MANAGEMENT BUS TEMPERATURE READ COMMANDS

The following temperature read commands as documented by the Power Management Bus Specification Part II version 1.2 should be supported.
READ_TEMPERATURE_1(8Dh), should provide the PSU inlet temperature.
READ_TEMPERATURE_2(8Eh), should provide the temperature of the SR heat sink in the PSU.
READ_TEMPERATURE_3(8Fh), should provide the temperature of the PFC heat sink in the PSU.

2.4 PAGE (00h)

Setting a PAGE value of FFh is used to clear all status bits in all PAGEs with the CLEAR_FAULT command.

2.5 OPERATION (01h)

The OPERTION command is used to configure the operational state of the converter, in conjunction with input from the CONTROL pin. The OPERATION command is used to turn the Power Management Bus device output on and off.
Bit [7] controls whether the Power Management Bus device output is on or off.
If Bit [7] is cleared (equals 0) then the output is off. If Bit [7] is set (equals 1), then the output is on.

2.6 ON_OFF_CONFIG (02h)

The ON_OFF_CONFIG command configures the combination of CONTROL pin input and serial bus commands needed to turn the unit on and off. This includes how the unit responds when power is applied.
The default response for any Power Management Bus device is specified by the device manufacturer. The details of the ON_OFF_CONFIG data byte are shown in Table 14.1.
Example conditions:
If bit [4] is cleared, then the unit powers up and operates any time bias power is available regardless of the setting of bits [3:0].
If bit [4] is set, bit [3] is set, and bit [2] is cleared, then the unit is turned on and off only by commands received over the serial bus.
If bit [4] is set, bit [3] is cleared, and bit [2] is set, then the unit is turned on and off only by the CONTROL pin.
If bit [4] is set, bit [3] is set, and bit [2] is set, then the unit is turned on and off only when both the commands received over the serial bus AND the CONTROL pin are commanding the device to be on. If either a command from the serial bus OR the CONTROL pin commands the unit to be off, the unit turns off.

BIT NUMBER	PURPOSE	BIT VALUE	MEANING
[7:5]		000	Reserved for Future Use
4	Sets the default to either operate any time power is present or for the on/off to be controlled by CONTROL pin and serial bus commands	0	Unit powers up any time power is present regardless of state of the CONTROL pin
		1	Unit does not power up until commanded by the CONTROL pin and OPERATION command (as programmed in bits [3:0]).
3	Controls how the unit responds to commands received via the serial bus	0	Unit ignores the on/off portion of the OPERATION command from serial bus
		1	To start, the unit requires that that the on/off portion of the OPERATION command is instructing the unit to run. Depending on bit [2], the unit may also require the CONTROL pin to be asserted for the unit to start and energize the output.
2	Controls how the unit responds to the CONTROL pin	0	Unit ignores the CONTROL pin (on/off controlled only the OPERATION command)
		1	Unit requires the CONTROL pin to be asserted to start the unit. Depending on bit [3], the OPERATION command may also be required to instruct the device to start before the output is energized.
1	Polarity of the CONTROL pin	0	Active low (Pull pin low to start the unit)
		1	Active high (Pull high to start the unit)
0	CONTROL pin action when commanding the unit to turn off	0	Use the programmed turn off delay and fall time
		1	Turn off the output and stop transferring energy to the output as fast as possible. The device's product literature shall specify whether or not the device sinks current to decrease the output voltage fall time.

Table 3. ON_OFF_CONFIG Data Byte

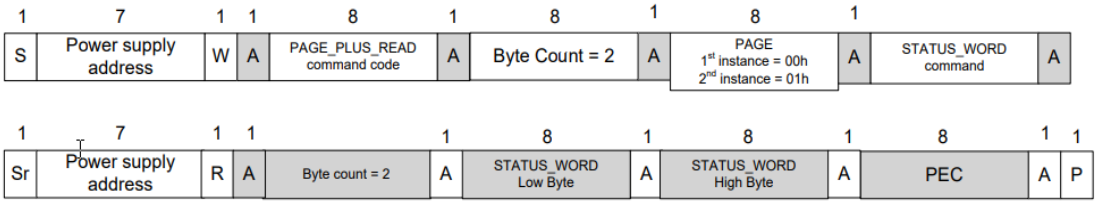
2.7 CLEAR_FAULTS COMMAND (03h)

The CLEAR_FAULTS command is used to clear any fault bits that have been set. This command clears all bits in all status registers simultaneously. At the same time, the device negates (clears, releases) its SMBALERT# signal output if the device is asserting the SMBALERT# signal.

2.8 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, STATUS_VOUT, 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. Below are the protocols used to read and clear the STATUS_ commands using the PAGE_PLUS_WRITE and PAGE_PLUS_READ commands.

Reading STATUS_WORD
Block Write – Block Read Process Call with PEC



Reading STATUS_TEMPERATURE, STATUS_IOUT, STATUS_INPUT, STATUS_CML
Block Write – Block Read Process Call with PEC

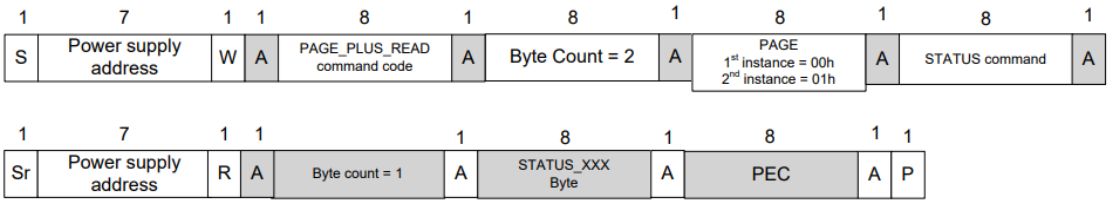


Figure 2. Reading STATUS commands with PAGE_PLUS_READ

Clearing STATUS commands (write '1' to clear a bit) STATUS_TEMPERATURE, STATUS_IOUT, STATUS_INPUT, STATUS_CML Block Write with PEC

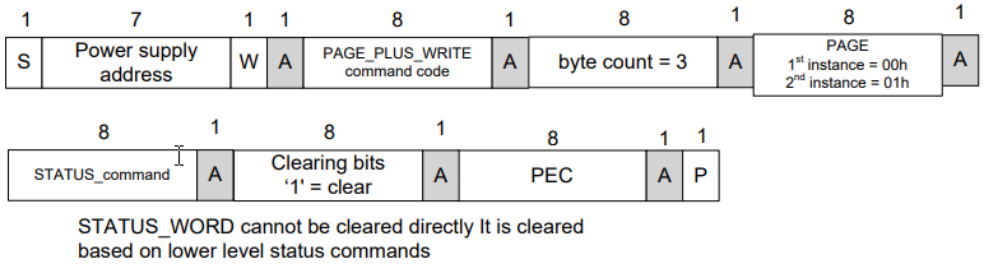


Figure 3. Clearing STATUS commands using PAGE_PLUS_WRITE

2.9 CAPABILITY (19h)

This command provides a way for a host system to determine some key capabilities of a Power Management Bus device. There is one data byte formatted as shown in Table 12.2. This command is read only.

BITS	DESCRIPTION	VALUE	MEANING
7	Packet Error Checking	0	Packet Error Checking not supported
		1	Packet Error Checking is supported
6:5	Maximum Bus Speed	00	Maximum supported bus speed is 100 kHz
		01	Maximum supported bus speed is 400 kHz
		10	Reserved
		11	Reserved
4	SMBALERT#	0	The device does not have a SMBALERT# pin and does not support the SMBus Alert Response protocol
		1	The device does have a SMBALERT# pin and does support the SMBus Alert Response protocol
3:0	Reserved	X	Reserved

Table 4. CAPABILITY COMMAND Data Byte Format

2.10 QUERY (1Ah)

The QUERY command is used to ask a Power Management Bus device if it supports a given command, and if so, what data formats it supports for that command. This command uses the Block Write-Block Read Process Call described in the SMBus specification.

BITS	VALUE	MEANING
7	1	Command is supported
	0	Command is not supported
6	1	Command is supported for write
	0	Command is not supported for write
5	1	Command is supported for read
	0	Command is not supported for read
4:2	000	Linear Data Format used
	001	16 bit signed number
	010	Reserved
	011	Direct Mode Format used
	100	8 bit unsigned number
	101	VID Mode Format used
	110	Manufacturer specific format used
	111	Command does not return numeric data. This is also used for commands that return blocks of data.
1:0	XX	Reserved for future use

Table 5. QUERY Command Returned Data Byte Format

If bit [7] is zero, then the rest of the bits are “don’t care”.

2.11 SMBALERT_MASK (1Bh)

This allows the system to mask events from asserting the SMBAlert# signal and to read back this information from the PSU. 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. It is not supported for masking the Non-PAGE'd STATUS_ commands. Below are the protocols.

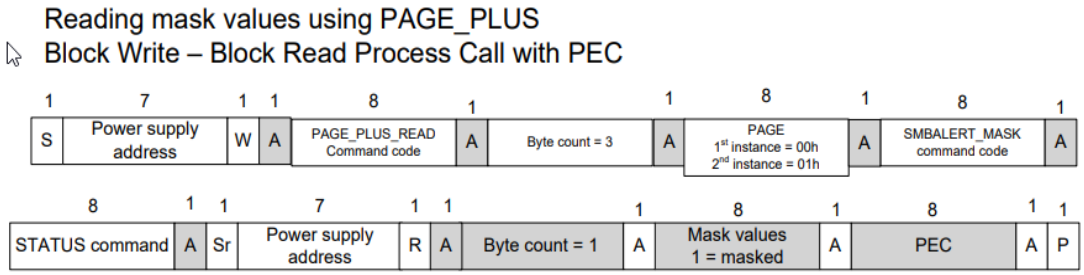


Figure 4. PAGE_PLUS_READ command.

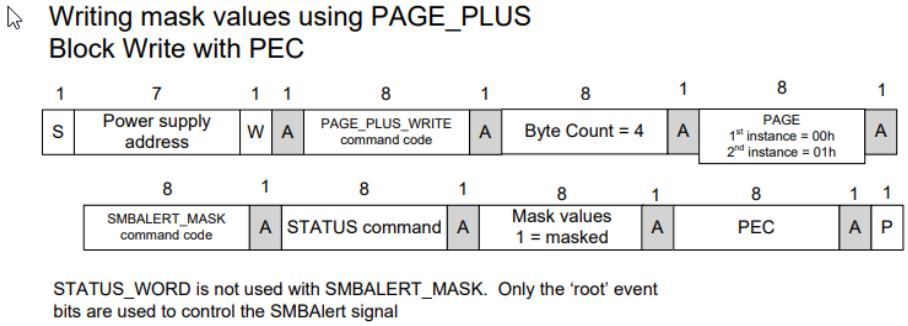


Figure 5. PAGE_PLUS_WRITE command.

2.12 COEFFICIENT (30h)

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

COMMAND	COEFFICIENTS SUPPORT	M	B	R
READ_EIN	Yes	01h	00h	00h
READ_EOUT	Yes	01h	00h	00h

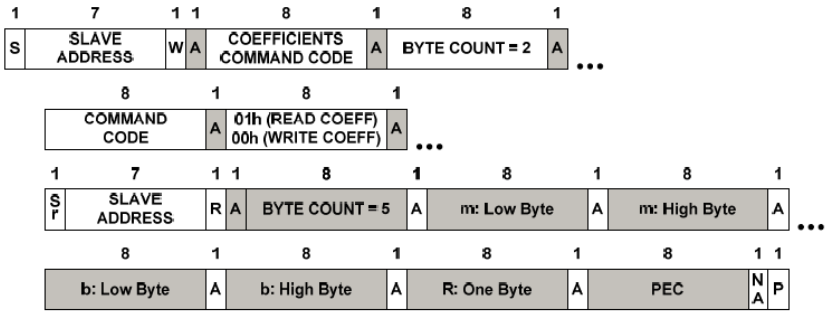


Figure 6. Retrieving Coefficients Using PEC

2.13 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).

The first of the configuration tells the Power Management Bus device whether or not a fan associated with position 1 (or 2) is installed. Any combination of fan installation is permitted.

The second part of the configuration tells the device whether the fan speed commands are in RPM or PWM duty cycle (in percent). These settings do not have to be the same for Fan 1 and Fan 2.

The third part of the configuration data tells the Power Management Bus device the number of tachometer pulses per revolution each fan provides. This information is needed for commanding and reporting fan speed in RPM. Two bits are provided for each fan. These settings do not have to be the same for Fan 1 and Fan 2. The binary values of these bits map to pulses per revolution as follows:

- 00b = 1 pulse per revolution,
- 01b = 2 pulses per revolution,
- 10b = 3 pulses per revolution,
- 11b = 4 pulses per revolution.

This command has one data byte formatted as follows:

BITS	VALUE	MEANING
7	1	Fan in position 1
6	0	Fan 1 commanded in Duty Cycle
5:4	00b-11b	Fan 1 Tachometer Pulses Per Revolution
3	0	No fan in position 2
2	Not used	
1:0	Not used	

Table 6. FAN_CONFIG_1_2 Command

2.14 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 PSU fan speed below what the PSU minimum speed of the thermal requirement.

The default control mode of fan is RPM.

2.15 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 Power Management Bus linear format.

2.16 POWER MANAGEMENT BUS_REVISION (98h)

This is a correction to the table in the Power Management Bus part II specification regarding the POWER MANAGEMENT BUS_REVISION command.

BITS [7:4]	PART I REVISION	BITS [3:0]	PART II REVISION
0000	1.0	0000	1.0
0001	1.1	0001	1.1
0010	1.2	0010	1.2
0011	1.3	0011	1.3

Table 7. Power Management Bus_Revision Command

2.17 MFR-EFFIENCY_LL (AAh)

The MFR_EFFICIENCY_LL command sets or retrieves information about the efficiency of the device while operating at a low line condition. Not including the PEC byte, if used, and the byte count byte, there are fourteen data bytes as described below. The efficiency is specified at one input voltage and three data points consisting of output power and the efficiency at that output power. The three power ratings are typically referred as low, medium and high output power and are transmitted in that order. For example, the low, medium and high output power might correspond to 20%, 50% and 100% of the rated output power. The exact values of the output power are specified is left to the Power Management Bus device manufacturer. Each value (voltage, power or efficiency) is transmitted as two bytes in linear format.

BYTE NUMBER	BYTE ORDER	DESCRIPTION
0	Low Byte	The input voltage, in volts, at which the low line efficiency data is applicable. Note that byte 0 is the first data byte transmitted as part of the block transfer.
1	High Byte	
2	Low Byte	Power, in watts, at which the low power efficiency is specified
3	High Byte	
4	Low Byte	The efficiency, in percent, at the specified low power.
5	High Byte	
6	Low Byte	Power, in watts, at which the medium power efficiency is specified
7	High Byte	
8	Low Byte	The efficiency, in percent, at the specified medium power.
9	High Byte	
10	Low Byte	Power, in watts, at which the high power efficiency is specified
11	High Byte	
12	Low Byte	The efficiency, in percent, at the specified high power. Note that byte 13 is the last data byte transmitted as part of the block transfer.

Table 8. MFR_EFFICIENCY_LL

2.18 MFR-EFFIENCY_HL (ABh)

The MFR_EFFICIENCY_HL command sets or retrieves information about the efficiency of the device while operating at a high line condition. Not including the PEC byte, if used, and the byte count byte, there are fourteen data bytes as described below. The efficiency is specified at one input voltage and three data points consisting of output power and the efficiency at that output power. The three power ratings are typically referred as low, medium and high output power and are transmitted in that order. For example, the low, medium and high output power might correspond to 20%, 50% and 100% of the rated output power. The exact values of the output power is specified is left to the Power Management Bus device manufacturer. Each value (voltage, power or efficiency) is transmitted as two bytes in linear format.

BYTE NUMBER	BYTE ORDER	DESCRIPTION
0	Low Byte	The input voltage, in volts, at which the high line efficiency data is applicable. Note that byte 0 is the first data byte transmitted as part of the block transfer.
1	High Byte	
2	Low Byte	Power, in watts, at which the low power efficiency is specified
3	High Byte	
4	Low Byte	The efficiency, in percent, at the specified low power.
5	High Byte	
6	Low Byte	Power in watts, at which the medium power efficiency is specified
7	High Byte	
8	Low Byte	The efficiency, in percent, at the specified medium power.
9	High Byte	
10	Low Byte	Power, in watts, at which the high power efficiency is specified
11	High Byte	
12	Low Byte	The efficiency, in percent, at the specified high power. Note that byte 13 is the last data byte transmitted as part of the block transfer.

Table 9. MFR_EFFICIENCY_HL

2.19 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 PSU.

	MIN	MAX	DESCRIPTION
Format	Power Management Bus Direct format m = 01h, R = 00h, b = 00h		Power Management Bus data format; refer to Power Management Bus specification for details.
Psample averaging period	4 AC cycles		Period instantaneous input power is averaged over to calculate Psample.
READ_EIN update period	80/66.7ms (50/60Hz)		Period at which the power accumulator and sample counter are updated
Range of System polling period	1 sec	100 ms	The PSU shall be polled over this range of rates while testing accuracy.

IMPORTANT:

The PSU READ_EIN update period MUST always be less than the system polling period. To make sure the PSU is compatible with all possible system polling periods; the PSU must update the READ_EIN power accumulator and sample counter at a period less than 100msec (required period is 4 AC cycles 80/67msec).

Table 10. READ_EIN Requirements Summary

2.20 READ EOUT (87h)

The new READ_EOUT command is used to allow the system to apply its own output power filtering. This will allow the system to get faster output 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 PSU.

	MIN	MAX	DESCRIPTION
Format	Power Management Bus Direct format m = 01h, R = 00h, b = 00h		Power Management Bus data format; refer to Power Management Bus specification for details.
Psample averaging period	Nominal 50msec		Period instantaneous input power is averaged over to calculate Psample.
Sampling period	Nominal 50msec		Period at which the power accumulator and sample counter are updated
System polling rate	1 sample /s	10 samples /s	The PSU shall be polled over this range of rates while testing accuracy.

Table 11. READ_EOUT Requirements Summary

2.21 READ_EIN & READ_EOUT FORMATS

The READ_EIN and READ_EOUT commands shall use the Power Management Bus direct format to report an accumulated power value and the sample count. The Power Management Bus coefficients m, R, and b shall be fixed values and the PSU shall report these values using the Power Management Bus 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 and READ_EOUT shall use the SMBus Block Read with PEC protocol in the below format.

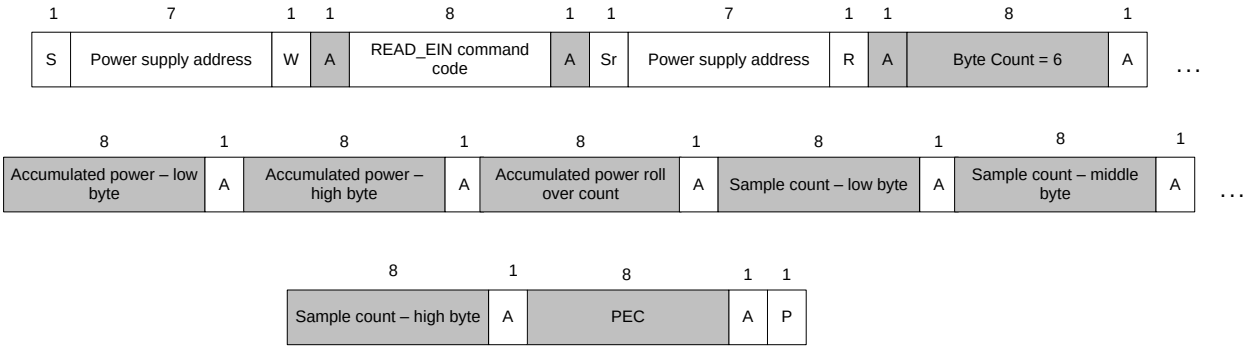


Figure 7. READ_EIN Command

The accumulated power data shall be the sum of input power values averaged over 4 AC cycles (or over 50ms for READ_EOUT). 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 and READ_EOUT faster than the roll-over period to get an accurate power calculation. Below is a block diagram depicting the accumulator function in the PSU.

IMPORTANT NOTE:

When the PSU responds to the system requesting READ_EIN or READ_EOUT data; the data in the sample count must always alignment with the number of samples accumulated in the power accumulator. To achieve this power accumulator, power rollover counter, and sample counter shall be loaded into a READ_EIN and READ_EOUT register at the same time.

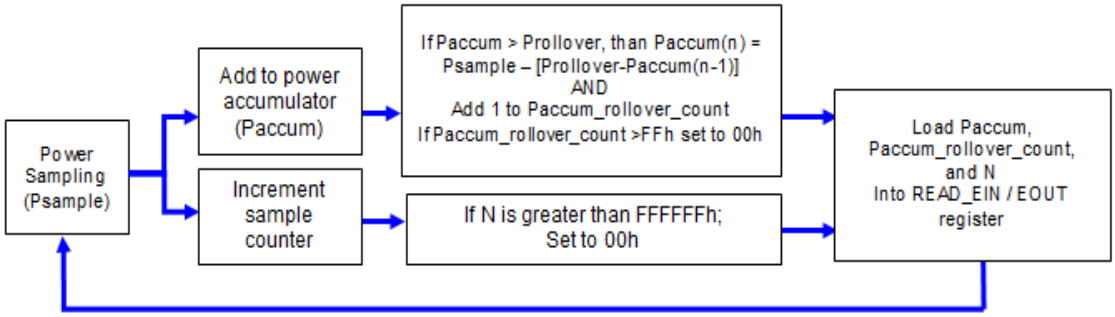


Figure 8. READ_EIN PSU Functional Diagram

Psample:	The sampled power value in linear or direct format
Paccum:	2 bytes in Power Management Bus linear or 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

2.22 POWER SUPPLY ACCURACY

For the following Power Management Bus commands a minimum preciseness/accuracy for voltage, current and power readings and settings must be follow below table: Power Power Management Bus Accuracy: (For the DC input voltage:48 Vdc); The maximum deviation for the ambient temperature is +4°C;

	<20% of Max. Load	**20%~100% of Max. Load**	
Pin	**±10W or**±8%	±5%	
Iin	**±0.3A or**±8%	**±0.3A or**±5%	
	<20% of Max. Load	**20%~50% of Max. Load**	**50%~100% of Max. Load**
Iout	±5% or ±1A	±3%	±2%
Pout	±5% or ±10W	±3%	±2%
	0%~20% of Max. Load	**20%~50% of Max. Load**	**50%~100% of Max. Load**
Vout	±3%	±3%	±3%
Vin	±5%	±5%	±5%

Table 12 B. Power Management Bus Accuracy for DC-DC Models

Preferred data format is the “Linear Data Format” as specified by Power Management Bus Specification Part II version 1.2.

2.23 LINEAR DATA FORMAT

The Linear Data Format is typically used for commanding and reporting the parameters such as (but not only) the following:

- Output Current,
- Input Voltage,
- Input Current,
- Operating Temperatures,
- Time (durations), and Energy Storage Capacitor Voltage.

The Linear Data Format is a two byte value with:

- An 11 bit, two’s complement mantissa and,
- A 5 bit, two’s complement exponent (scaling factor),

The format of the two data bytes is illustrated in Figure 5.1 as show below.

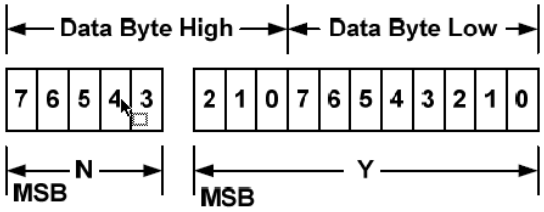


Figure 9. Linear Data Format Data Bytes

The relation between *Y*, *N* and the “real world” value is:

$X = Y \cdot 2^{N}$

Where, as described above:
X is the “real world” value;
Y is an 11 bit, two’s complement integer; and
N is a 5 bit, two’s complement integer.

Devices that use the linear format must accept and be able to process any value of *N*.

2.24 VOUT_MODE (20h)

The data byte for the VOUT_MODE command is one byte that consists of a three bit Mode and a five bit exponent. The three bit Mode shall be set to indicate the LINEAR mode for output voltage related commands. The five bit Exponent shall be set to indicate the value of the five bit two's complement exponent for the mantissa delivered as the data bytes for an output voltage related command.

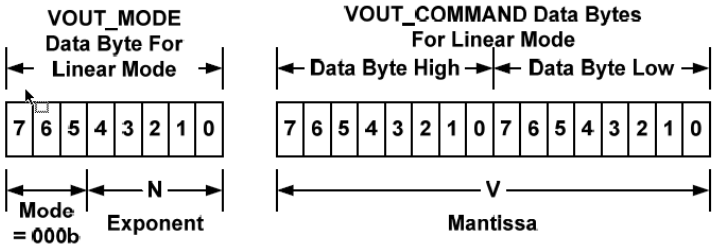


Figure 10. Linear Format Data Bytes

The voltage, in volts, is calculated from the equation Voltage = $V \cdot 2^N$, where:

- V is a 16 bit unsigned binary integer
- N is a 5 bit two's complement binary integer

Sending the VOUT_MODE command with the address set for writing is not supported. If the system sends a VOUT_MODE command for a write, the power supply shall reject the command, and set the Invalid/Unsupported Data bit in the STATUS_CML register.

3. COLD REDUNDANCY

3.1 OVERVIEW

Below is a block diagram showing the Cold Redundancy architecture. When the power subsystem is in Cold Redundant mode; only the needed power supply to support the best power delivery efficiency are ON. Any additional power supplies; including the redundant power supply, is in Cold Standby state.
Each power supply has an additional signal that is dedicated to supporting Cold Redundancy; CR_BUS. This signal is a common bus between all power supplies in the system. CR_BUS is asserted (pulled low) when there is a fault in any power supply OR the power supplies output voltage falls below the Vfault threshold. Asserting the CR_BUS signal causes all power supplies in Cold Standby state to power ON.

Enabling power supplies to maintain best efficiency is achieved by looking at the Load Share bus voltage and comparing it to a programmed voltage level via a Power Management Bus command.
Whenever there is no Cold Redundant active power supply on the Cold Redundancy bus driving a HIGH level on the bus all power supplies are ON no matter their defined Cold Redundant roll (active or Cold Standby). This guarantees that incorrect programming of the Cold Redundancy states of the power supply will never cause the power subsystem to shut down or become over loaded. The default state of the power subsystem is all power supplies ON. There needs to be at least one power supply in Cold Redundant Active state or Standard Redundant state to allow the Cold Standby state power supplies to go into Cold Standby state.

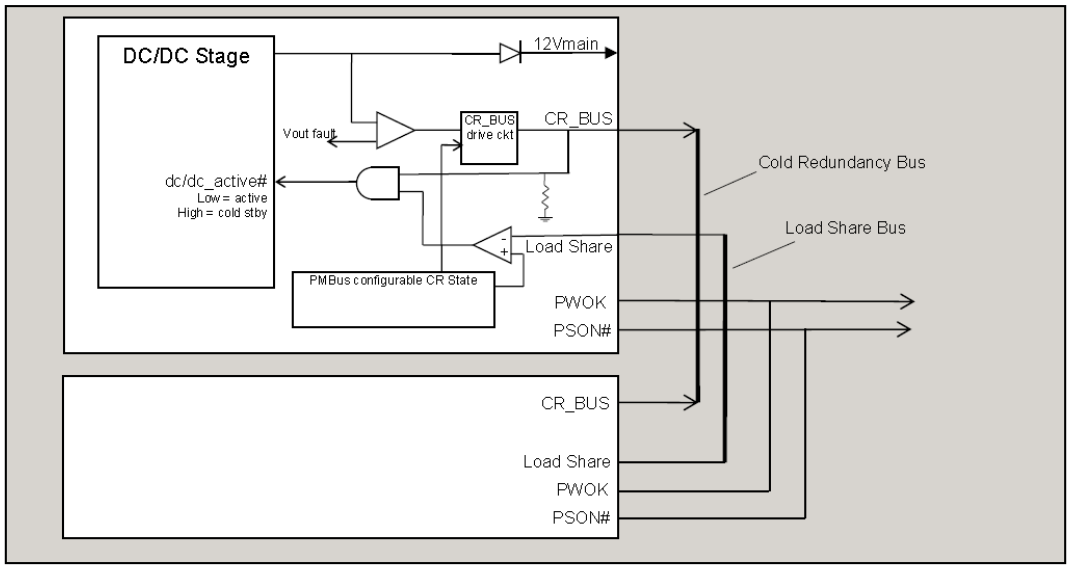


Figure 11. Cold Redundancy 1+1 Functional Block Diagram

CR_BUS	LOAD SHARE	DC/DC_ACTIVE#	COLD STANDBY POWER SUPPLY STATE(S)
High	< VCR_ON	High	Cold Standby
Low	< VCR_ON	Low	Active
High	> VCR_ON	Low	Active
Low	> VCR_ON	Low	Active

Table 13. Logic Matrix for Cold Standby Power Supplies

3.2 POWERING ON COLD STANDBY SUPPLIES TO MAINTAIN BEST EFFICIENCY

Power supplies in Cold Standby state shall monitor the shared voltage level of the load share signal to sense when it needs to power on. Depending upon which position (1, 2, or 3) the system defines that power supply to be in the cold standby configuration; will slightly change the load share threshold that the power supply shall power on at.

	Enable Threshold for VCR_ON_EN	Disable Threshold for VCR_ON_DIS	CR_BUS De-asserted / Asserted States
Standard Redundancy	N/A; Ignore dc/dc_ active# signal; power supply is always ON		OK = Tri-state Fault = Low
Cold Redundant Active	NA; Ignore dc/dc_ active# signal; power supply is always ON		OK = High Fault = Low
Cold Standby 1 (02h)	3.2V (40% of max)	90% x (3.2V x 1/2) = 1.44V	OK = Tri-state Fault = Low
Cold Standby 2 (03h)	5.0V (62% of max)	90% x (5.0V x 2/3) = 3.01V	OK = Tri-state Fault = Low
Cold Standby 3 (04h)	6.7V (84% of max)	90% x (6.7V x 3/4) = 4.52V	OK = Tri-state Fault = Low

Table 14. Example Load Share Threshold for Activating Supplies

Notes:
Maximum load share voltage = 8.0V at 100% of rated output power
These are example load share bus threshold; for any power supply these shall be customized to maintain the best efficiency curve that specific model.

3.3 POWERING ON COLD STANDBY SUPPLIES DURING A FAULT OR OVER CURRENT CONDITION

When an active power supply asserts its CR_BUS signal (pulling it low), all parallel power supplies in cold standby mode shall power on within 100µsec.

3.4 COLD REDUNDANCY SMBUS COMMANDS

The Power Management Bus manufacturer specific command MFR_SPECIFIC_00 is used to configure the operating state of the power supply related to cold redundancy. We will call the command Cold_Redundancy_Config (D0h). Below is the definition of the values used with the Read-Write Byte SMBus protocol with PEC.

VALUE	STATE	DESCRIPTION
00h	Standard Redundancy (default power on state)	Turns the power supply ON into standard redundant load sharing more. The power supply's CR_BUS signal shall be in Tri-state but still pull the bus low if a fault occurs to activate any power supplies still in Cold Standby state.
01h	Cold Redundant Active	Defines this power supply to be the one that is always ON in a cold redundancy configuration.
02h	Cold Standby 1 [1]	Defines the power supply that is first to turn on in a cold redundant configuration as the load increases.
03h	Cold Standby 2 [1]	Defines the power supply that is second to turn on in a cold redundant configuration as the load increases.
04h	Cold Standby 3 [1]	Defines the power supply that is third to turn on in a cold redundant configuration as the load increases.

[1] When the CR_BUS transitions from a high to a low state; each PSU programmed to be in Cold Standby state shall be put into Standard Redundancy mode (Cold_redundancy_Config = 00h). For the power supplies to enter Cold Redundancy mode the system must re-program the power supplies using the Cold_Redundancy_Config command.

Table 15. Cold_Redundancy_Config (D0h)

3.5 COLD REDUNDANT SIGNALS

There is an additional signal defined supporting Cold Redundancy. This is connected to a bus shared between the power supplies; the CR_BUS.

4. BLACK BOX

4.1 BLACK BOX FUNCTION DESCRIPTION

This specification defines the requirements for power supplies with Power Management Bus capability to store Power Management Bus and other data into non-volatile memory inside the power supply. The data shall be saved to non-volatile memory upon a critical failure that caused the power supply to shutdown. The data can be accessed via the Power Management Bus interface by applying power to the 12Vstby pins. No DC power need to be applied to the power supply.

4.2 WHEN DATA IS SAVED TO THE BLACK BOX?

Data is saved to the Black Box for the following fault events:

- General fault
- Over voltage on output
- Over current on output
- Loss of DC input
- Input voltage fault
- Fan failure
- Over temperature

4.3 BLACK BOX EVENTS

There are two types of data saved in the black box:

1) System Tracking Data.
2) Power supply event data.

System tracking data is saved to the Black Box whenever the system powers ON or when a power supply is added to the system.

4.4 BLACK BOX PROCESS

- System writes system tracking data to the power supply RAM at power ON.
- System writes the real time clock data to the PSU RAM once every ~5 minutes.
- Power supply tracks number of PSON and AC power cycles in EEPROM.
- Power supply tracks ON time in EEPROM
- Power supply loads warning and fault event counter data from EEPROM into RAM
- Upon a warning event; the PSU shall increment the associated counter in RAM.
- Upon and fault event the PSU shall increment the associated counter in RAM
- Upon a fault event that causes the PSU to shut down all event data in the PSU's RAM is saved to event data location N in the power supply's EEPROM. This data includes the real time clock, number of AC & PSON power cycles, PSU ON time, warning event counters and fault event counters.

4.5 RELATED COMMAND OF BLACK BOX

The following command set will be used for Black Box function via the Host System. The commands and protocol used by the Host System and shall be implemented by the microcontroller are defined by this document.

COMMAND CODE	COMMAND NAME	SMBUS TRANSACTION TYPE	NUMBER OF DATA BYTES	REMARK
DCh	MFR_BLACK_BOX	Read only (7)	237	Read the data of the Black box.
DDh	MFR_REAL_TIME	Read/Write (6/7)	4	Read/Write the data of MFR real time.
DEh	MFR_SYSTEM_BLACK_BOX	Read/Write (6/7)	40	Read/Write the data of MFR system black box.
DFh	MFR_BLACKBOX_CONFIG	Read/Write (2/3)	1	Read/Write the data of MFR black box configure.
E0h	MFR_CLEAR_BLACKBOX	Write only (1)	1	Send one byte to clear all data of black box.

1) Command Name: MFR_BLACKBOX

Format: Read Block with PEC (237 bytes)

Code: DCh

	ITEM	NUMBER OF BYTES	DESCRIPTION
System Tracking Data	System top assembly number	10	The system will write its Intel part number for the system top assembly to the power supply when it is powered ON. This is 9 ASCI characters.
	System serial number	10	The system shall write the system serial number to the power supply when it is powered ON. This include the serial number and date code.
	Motherboard assembly number	10	The system will write the motherboard Intel part number for the assembly to the power supply when it is powered ON. This is 9 ASCI characters.
	Motherboard serial number	10	The system shall write the motherboard's serial number to the power supply when it is powered ON. This includes the serial number and date code.
	Present total PSU ON time	3	Total on time of the power supply with PSON asserted in minutes. LSB = 1 minute.
	Present number of DC power cycles	2	Total number of times the power supply powered OFF then back ON due to loss of DC power. This is only counted when the power supply's PSON# signal is asserted. This counter shall stay at FFFFh once the max is reached.
	Present number of PSON power cycles	2	Total number of times the power supply is powered OFF then back ON due to the PSON# signal de-asserting. This is only counted when DC power is present to the power supply. This counter shall stay at FFFFh once the max is reached.
Power supply event data (N)		38	Most recent occurrence of saved black box data
Time Stamp			The power supply shall track these time and power cycle counters in RAM. When a black box event occurs, the data is saved into the Black Box.
	Power supply total power on time	3	Total on time of the power supply in minutes. LSB = 1 minute.
	Real Time Clock Data from System (reserved for future use)	4	This time stamp does not need to generated by the power supply. The system rights a real time clock value periodically to the power supply using the MFR_REAL_TIME command. Format is based on IPMI 2.0. Time is an unsigned 32-bit value representing the local time as the number of seconds from 00:00:00, January 1, 1970. This format is sufficient to maintain time stamping with 1-second resolution past the year 2100. This is based on a long standing UNIX-based standard for time keeping, which represents time as the number of seconds from 00:00:00, January 1, 1970 GMT. Similar time formats are used in ANSI C.
	Number of DC power cycles	2	Number of times the power supply powered OFF then back ON due to loss of DC power at the time of the event. This is only counted when the power supply's PSON# signal is asserted.

	Number of PSON power cycles	2	Number of times the power supply is powered OFF then back ON due to the PSON# signal de-asserting at the time of the event. This is only counted when DC power is present to the power supply.
Power Management Bus			The power supply shall save these Power Management Bus values into the Black Box when a black box event occurs. Fast events may be missed due to the filtering effects of the Power Management Bus sensors.
	STATUS_WORD	2	
	STATUS_IOUT	1	
	STATUS_INPUT	1	
	STATUS_TEMPERTATURE	1	
	STATUS_FAN_1_2	1	
	READ_VIN	2	
	READ_IIN	2	
	READ_IOUT	2	
	READ_TEMPERATURE_1	2	
	READ_TEMPERATURE_2	2	
	READ_FAN_SPEED_1	2	
	READ_PIN	2	
	READ_VOUT	2	
Event Counters			The power supply shall track the total number for each of the following events. These values shall be saved to the black box when a black box event occurs. Once a value has reached 15, it shall stay at 15 and not reset.
	AC shutdown due to under voltage on input	Lower ½	The power supply shall save a count of these critical events to non-volatile memory each time they occur. The counters will increment each time the associated STATUS bit is asserted.
	Thermal shutdown	Upper ½	
	Over current or over power shutdown on output	Lower ½	
	General failure shutdown	Upper ½	
	Fan failure shutdown	Lower ½	
	Shutdown due to over voltage on output	Upper ½	
	Input voltage warning; no shutdown	Lower ½	The power supply shall save into RAM a count of these warning events. Events are count only at the initial assertion of the event/bit. If the event persists without clearing the bit the counter will not be incremented. When the power supply shuts down it shall save these warning event counters to non-volatile memory. The counters will increment each time the associated STATUS bit is asserted.
	Thermal warning; no shutdown	Upper ½	
	Output current power warning; no shutdown	Lower ½	
	Fan slow warning; no shutdown	Upper ½	
Power supply event data (N-1)		38	
Power supply event data (N-2)		38	
Power supply event data (N-3)		38	
Power supply event data (N-4)		38	

2) Name: MFR_REAL_TIME_BLACK_BOX

Format: Write/Read Block with PEC (4 bytes)

Code: DDh

The system shall use this command to periodically write the real time clock data to the power supply.

Format is based on IPMI 2.0. Time is an unsigned 32-bit value representing the local time as the number of seconds from 00:00:00, January 1, 1970. This format is sufficient to maintain time stamping with 1-second resolution past the year 2100. This is based on a long standing UNIX-based standard for time keeping, which represents time as the number of seconds from 00:00:00, January 1, 1970 GMT. Similar time formats are used in ANSIC.

3) Name: MFR_SYSTEM_BLACK_BOX

Format: Write/Read Block with PEC (40 bytes). Low byte first.

Code: DEh

The system uses this command to write the following data to the PSU.

1)

Item	Bytes	
System top assembly number	1-10	Low bytes
System serial number	11-20	
Motherboard assembly number	21-30	
Motherboard serial number	31-40	High bytes

4) Name: MFR_BLACKBOX_CONFIG

Format: Read/Write Byte with PEC

Code: DFh

BIT	VALUE	DESCRIPTION
0	0 = disable black box function 1 = enable black box function	Writing a 1 enables the power supply with black box function. Writing a 0 disables the power supply black box function. The state of MFR_BLACKBOX_CONFIG shall be saved in non-volatile memory so that it is not lost during power cycling. Intel shall receive the power supply with the black box function enabled; bit 0 = '1'.
1-7		Reserved

5) Name: MFR_CLEAR_BLACKBOX

Format: Send Byte with PEC

Code: E0h

The MFR_CLEAR_BLACKBOX command is used to clear all black box records simultaneously.

This command is write only. There is no data byte for this command.

4.6 HARDWARE REQUIREMENTS

The SMBus interface shall be used to access the Black Box data. It may be accessed when the power supply is ON or in standby mode. It also may be accessed when no DC power is applied, and power is only applied at the standby output pins by an external source (12Vstby).