iMP series

I²C Protocol

Descriptions

This iMP Protocol is compliant with the PMBus Power System Management Protocol Specification Part I Revision 1.0, and the PMBus Power System Management Protocol Specification Part II Revision 1.0. Note that the PMBus is based on the System Management Bus (SMBus) Specification.

For supplementary information regarding the PMBus and SMBus specifications, these documents will be referred to, and are considered part of this protocol:

Ref#1 PMBus™ Power System Management Protocol Specification, Part I – General Requirements, Transport And Electrical Interface, Revision 1.0
www.powerSIG.org

Ref#2 PMBus™ Power System Management Protocol Specification, Part II – Command Language, Revision 1.0
www.powerSIG.org

Ref#3 System Management Bus Specification, Revision 1.1
www.sbs-forum.org

Ref#4 System Management Bus (SMBus) Specification, Version 2.0
www.sbs-forum.org

Ref#5 Astec PIC16F87xA I²C Bootloader Interfacing

Ref#6 Astec iMP Module UART Bootloader Interfacing

Ref#7 Astec iMP Case I²C Protocol Revision 16 - 20070130

ARTESYN™
EMBEDDED TECHNOLOGIES

SMBus Compliance

Packet Error Checking [Ref#4, 5.4]

Packet Error Checking (PEC) is optional in SMBus. This version of the protocol does not implement PEC.

Ack/Nack [Ref#4, 5.4.1.1]

This version of the protocol does not issue a Nack in any case of errors above the data link layer. Communication reliability can be achieved though read-back and/or through fault flags.

Bus Protocols [Ref#4, 5.5]

This protocol supports all SMBus bus protocols except the Quick Command and the Host Notify Protocol. Shown below are excerpts from the System Management Bus (SMBus) Specification, Version 2.0 document for easy reference (figure numbers are with reference to the said document).

Figure 5-3: Send byte protocol

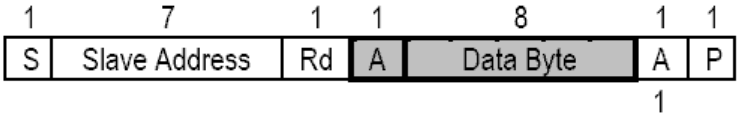


Figure 5-5: Receive byte protocol

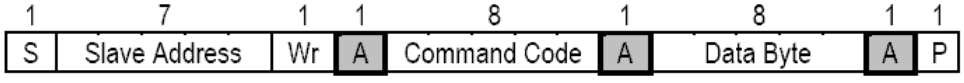


Figure 5-7: Write byte protocol

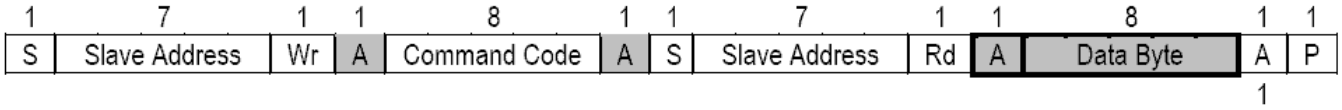


Figure 5-11: Read Byte Protocol

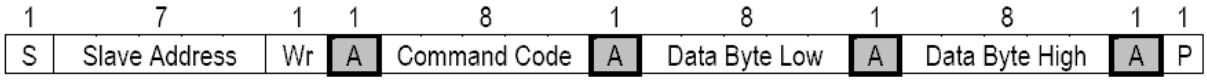
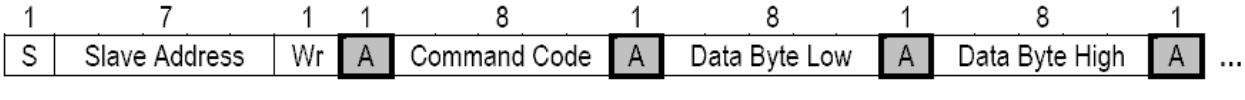


Figure 5-8: Write Word Protocol

Figure 5-13: Read word protocol



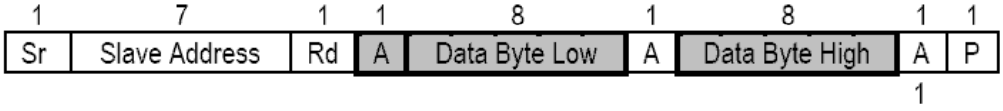


Figure 5-15: Process Call

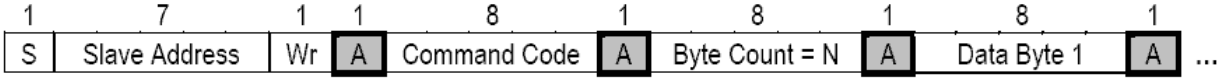


Figure 5-17: Block Write

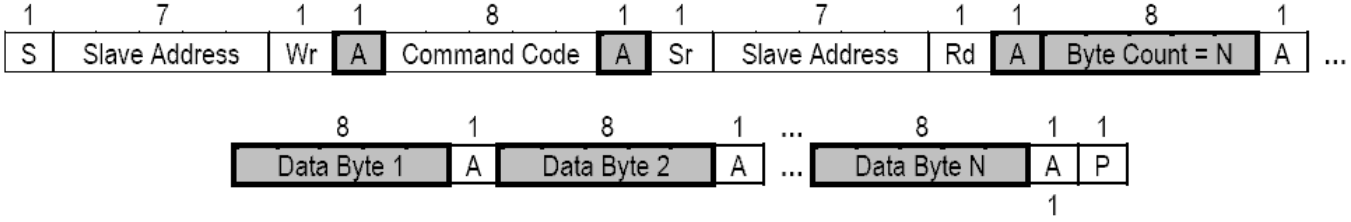


Figure 5-19: Block Read

Addressing [Ref#4, 5.6]

This protocol's addressing system is not dynamic, and is based only on the three input signals A0, A1, and A2. The iMP valid addresses are:

A2	A1	A0	MCU Address	EEPROM Address
0	0	0	30h	A0h
0	0	1	32h	A2h
0	1	0	34h	A4h
0	1	1	36h	A6h
1	0	0	38h	A8h
1	0	1	3Ah	AAh
1	1	0	3Ch	ACh
1	1	1	3Eh	AEh

This protocol also supports the General Call address (00h) for write operation only [Ref#3, 7.2].

Optional SMBus Signals [Ref#4, Appendix A]

This protocol does not use any of the Optional SMBus signals.

PMBus Compliance

Command Error [Ref#1, 4.1]

This protocol does not support NACKing the command code or data bytes as they are being received. For any command error, the **CML fault** bit in the **STATUS_BYTE [Ref#1, 17.1]** register is set. The **STATUS_CML** register is not supported however. To see the detailed description of the fault, the **CASE_FAULT_BYTE** (Manufacturer Specific) register must be read. It contains the **Command Error** and the **Command Disabled** flags which describes the kind of communication error encountered.

Control Signal [Ref#1, 9.3]

The control signal in the iMP Power Supply unit is replaced by two signals, the **INHIBIT_ENABLE_0** and the **INHIBIT_ENABLE_1** signals. The logic of these signals are controlled by the **ON_OFF_CONFIG [Ref#2, 12.2]** register bit1 (this bit is originally the **Control Pin Polarity** flag, in this protocol however this is the **Global Inhibit** Flag). Depending on the value of this bit, the logic of these signals are described below:

INHIBIT_ENABLE_0	INHIBIT_ENABLE_1	GLOBAL INHIBIT = TRUE	GLOBAL INHIBIT=FALSE
0	0	Modules ON	Modules OFF
0	1	Modules OFF	Modules ON
1	0	Modules ON	Modules OFF
1	1	Modules ON	Modules OFF

Parameter Reading [Ref#2, 5.4.2]

Due to the complexity of the internal communication system of the power supply, not all parameters that can be written is readable. This is specially the case for commands targeted to an individual module, including the PMBus standard commands **TON_DELAY, VOUT_COMMAND,** and **IOUT_OC_FAULT_LIMIT**. Since the **Page [Ref#2, 11.10]** may change, the previous parameter may not be applicable anymore.

Memory Model [Ref#2, 6]

There are four types of memory locations from which the configuration of the PSU can be defined. They are the Operating Memory, the User Configuration Memory, the Factory Default Configuration Memory, and the Firmware Default Configuration Memory locations.

Operating Memory (R/W, Volatile)

The settings that are used by the PSU are stored in a volatile memory location called Operating Memory. This memory location is the working memory of the PSU. Upon start-up, previously defined settings are loaded into the Operating Memory from either of three non-volatile memory locations (see succeeding items below). Configuration commands only affect this memory area. Although the contents of this memory space are not saved at turn-off, they can be saved in either the User or Factory Default Configuration Memory locations using the commands **STORE_DEFAULT_ALL, RESTORE_DEFAULT_ALL, STORE_USER_ALL,** and **RESTORE_USER_ALL.**

User Configuration Memory (R/W, Non-volatile)

This memory location contains the main configuration setup that will be loaded at the *Operating Memory* every time the PSU is powered. If any error is detected on this storage area, the **User Configuration Error** flag is set in the **CASE_FAULT_BYTE,** and the **CML fault** bit in the **STATUS_BYTE** register is set. This memory location is non-volatile.

Factory Default Configuration Memory (R/W, Non-volatile)

This memory location contains the factory configuration setup that will only be loaded at the *Operating Memory* if an error on the User Configuration Memory is detected upon power-up. If any error is detected on this storage area, the **Default Configuration Error** flag is set in the **CASE_FAULT_BYTE,** and the **CML fault** bit in the **STATUS_BYTE** register is set. This memory location is non-volatile.

Firmware Default Configuration Memory (Read-Only, Non-volatile)

This memory location is embedded on the firmware and is only loaded at the Operating Memory if both the User Configuration Memory and the Default Configuration Memory encountered errors upon power-up. This memory location is non-volatile.

Data Formats [Ref#2, 7]

This protocol will use only the **Direct Data Format** for all parameters except for the Case Temperature related parameters, which use a manufacturer-specific data format that has a resolution of 0.25 degrees Celsius. Refer to each parameter's associated commands for the details on the data format. Access to the coefficients is not supported as the data format is fixed and already described in the specifications. This format is also applicable to the **Output Voltage Related Parameters [Ref#2, 8]**. Shown below is an excerpt from the PMBus™ Power System Management Protocol Specification, Part II – Command Language, Revision 1.0 document for easy reference (section numbers are with reference to the said document).

7.2. DIRECT Data Format

DIRECT format data is a two byte, two's complement binary integer. DIRECT format data may be used with any command that sends or reads a parametric value.

If a PMBus device uses DIRECT form data, this shall be clearly described in the product literature.

7.2.1. Interpreting Received Values

The host system uses the following equation to convert the value received from the PMBus device into a reading of volts, amperes, degrees Celsius or other units as appropriate:

$$Y = (mX + b) \bullet 10^{R}$$

Where:

Y, is the calculated value in the appropriate units (A, V, °C, etc.);

m, the slope coefficient, is a two byte, two's complement integer;

X, a two byte two's complement integer received from the PMBus device;

b, the offset, is a two byte, two's complement integer; and

R, the exponent, is a two byte, two's complement integer.

7.2.2. Sending A Value

To send a value, the host must use the equation in Section 7.2.1 solved for X:

$$X = \frac{1}{m}(Y \bullet 10^{-R} - b)$$

Where:

X is the two byte two's complement integer to be sent to the unit that is most closely equivalent to the decimal value calculated from m, Y, R and b;

m, the slope coefficient, is the decimal value equivalent to the two byte, two's complement integer retrieved from the PMBus device;

Y, a decimal value, in units such as amperes or volts, to be converted for transmission;

b, the offset, is the decimal value equivalent to the two byte, two's complement integer retrieved from the PMBus device; and

R, the exponent, is the decimal value equivalent to the one byte, two's complement integer retrieved from the PMBus device.

Status Registers [Ref#2, 10.3]

This protocol will use only the **STATUS_BYTE** register. In conjunction with this, there is also a **CASE_FAULT_BYTE** (Manufacturer Specific), a **MODULE_COMMUNICATION_ERROR_BYTE** (Manufacturer Specific), and a **CASE_STATUS_BYTE** (Manufacturer Specific) register. Only the **CASE_STATUS_BYTE** register is real-time, since the others requires the **CLEAR_FAULTS** command to reset the flags.

Supported PMBus Standard Registers

Listed below are the PMBus standard registers that are supported by the PSU. Details are described in the PMBus™ Power System Management Protocol Specification, Part II – Command Language, Revision 1.0 document, but excerpts are shown for easy reference (table numbers are with reference to the said document).

STATUS_BYTE [Ref#2, 17.1]

Table 9. STATUS BYTE Message Contents

Bit Number	Status Bit Name	Meaning
7	BUSY	The device is busy.
6	OFF	This bit is asserted if the unit is not providing power to the output, regardless of the reason, including simply not being enable.
5	VOUT_OV	An output overvoltage fault has occurred.
4	IOUT_OC	An output overcurrent fault has occurred.
3	VIN_UV	An input undervoltage fault has occurred.
2	TEMPERATURE	A temperature fault or warning has occurred.
1	CML	A communications, memory or logic fault has occurred.
0	OTHER	A fault or warning not listed in bits [7:1] has occurred.

This device uses the PMBus standard STATUS_BYTE register and all applicable flags. This register reflects all the other faults such that:

a. Any Module Over Voltage Protection fault sets the STATUS_BYTE **VOUT_OV** Flag
b. Any Module Over Current Protection fault sets the STATUS_BYTE **IOUT_OC** Flag
c. Any Module Over Temperature Protection fault, Case Over Temperature Protection fault, Case Over Temperature Protection warning, or Primary Over Temperature Protection warning, sets the STATUS_BYTE **TEMPERATURE** Flag
d. Calling a Disabled Command, Command Errors, Fault in the Default or User Memory Locations, or errors in any of the smart module internal UART communication buses, sets the STATUS_BYTE **CML** Flag
e. Any module UVP condition, module system fault, or an Over Power Limit Protection fault sets the STATUS_BYTE **OTHER** Flag
f. The following commands will set the **BUSY** flag while the command operation is ongoing:

   i. VOUT_COMMAND
   ii. IOUT_OC_FAULT_LIMIT
   iii. TON_DELAY
   iv. EXTRACT_MODULE_VERSION

v. **EXTRACT_MODULE_CONFIG_BYTES**
vi. **IOUT_SENSOR_CALIBRATION**
vii. **OVP_LIMIT_PERCENT**
viii. **UVP_LIMIT_PERCENT**
ix. **MODULE_OTP_LIMIT**
x. **MODULE_CONFIG_FLAGS**
xi. **LOAD_PREDEFINED_SETTING**
xii. **MODULE_VSCALE_CALIBRATION**
xiii. **DIRECT_MODULE_ACCESS**

g. The same commands in item f above will be temporarily disabled while the **BUSY** flag is set, along with these commands:

i. **READ_MODULE_VERSION**
ii. **READ_MODULE_CONFIG_BYTES**
iii. **READ_DIRECT_MODULE_ACCESS_REPLY**

WRITE_PROTECT [Ref#2, 11.1]

Table 5. WRITE_PROTECT Command Data Byte

Bits	Value	Meaning
7	1	Disable all writes except for the WRITE_PROTECT command.
	0	Enable writes as permitted in bits [6:n].
6	1	Disable all writes except for the WRITE_PROTECT, OPERATION and PAGE commands.
	0	Enable all writes as permitted in bits [5:n].
5	1	Disable all writes except for those permitted in bits [7:6] and the ON_OFF_CONFIG and VOUT_COMMAND commands.
	0	Enable all writes as permitted in bits [4:n]..
4	X	Reserved.
3	X	Reserved.
2	X	Reserved.
1	X	Reserved.
0	1	Disable all writes except those permitted in bits [7:1].
	0	Enable writes for all supported commands.

This device uses the PMBus standard WRITE_PROTECT register and all applicable flags.

ON_OFF_CONFIG [Ref#2, 12.2]

Table 7. ON_OFF_CONFIG Data Byte

Bit Number	Purpose	Bit Value	Meaning
[7:5]		N/A	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 the state of the CONTROL pin.
		1	Unit does not power up until commanded by the CONTROL pin and OPERATION command (as programmed in bits [2:0]).
3	Controls how the unit responds commands received via the serial bus	0	Unit ignores the on/off portion of the OPERATION command from the serial bus.
		1	Unit responds to the on/off portion of the OPERATION command. Depending on bit [1], the CONTROL pin may also be required to instruct the device to start before the output is energized.
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 the bit [2], 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 (Section 16.5) and fall time (Section 16.6)
		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.

This device uses the PMBus standard ON_OFF_CONFIG register and all applicable flags except for **bit 0**. The **Control Pin Polarity** flag is used as the **Global Inhibit** flag instead.

OPERATION [Ref#2, 12.1]

Table 6. OPERATION Data Byte Contents

Bits [7:6]	Bits [5:6]	Bits [3:2]	Bits [1:0]	Unit On or Off	Margin State
00	XX	XX	XX	Immediate Off (No Sequencing)	N/A
01	XX	XX	XX	Soft Off (With Sequencing)	N/A
10	00	XX	XX	On	Off
10	01	01	XX	On	Margin Low (Ignore Fault)
10	01	10	XX	On	Margin Low (Act On Fault)
10	10	01	XX	On	Margin High (Ignore Fault)
10	10	10	XX	On	Margin High (Act On Fault)

This device uses only **bit 7** of the PMBus standard OPERATION register. The other flags are disregarded.

Manufacturer Specific Registers

PSU_CONFIG

This register is stored in a non-volatile memory (User or Default Configuration Memory), and contains different configuration flags that controls the fan speed, external EEPROM access, and start-up state.

BIT	FLAG	R/W	DESCRIPTION
0	Fan Alarm Disabled	R/W	If this flag is set, fan fault detection is disabled (useful for PSU without fans).
1	Fan Off at Standby	R/W	At standby, fans operate at quiet mode by default. If this flag is set, the fans are turned off at standby mode instead.
2	Fan Direction Reversed	R/W	Fan speed is based on the hottest temperature reading, and reaches the maximum at 50 degrees Celsius. If this flag is set, reverse fan air flow is assumed and fan speed reaches the maximum at 40 degrees Celsius.
3	Full Speed Override*	R/W	If this flag is set, fan speed is set to maximum.
4	Half Speed Override*	R/W	If this flag is set, fan PWM duty is set to half.
5	Fan Voltage Override*	R Only	If this flag is set, fan speed is set according to a requested fan voltage. This flag can be controlled only by use of the **VFAN_1** command.
6	FRU EEPROM Write Enabled	R/W	If this flag is set, external write to the FRU EEPROM is allowed.
7	Startup Operation Mode On	R/W	If this flag is set, the initial value of the **OPERATION** register is set to ON mode.

Note * - These fan overrides work in conjunction with the default temperature-based fan control. Whichever results to the highest fan speed will take control of the fans.

ACTIVE_SLOTS

This register contains the configuration of the module slots. The eight bits refer to the eight module slots. If a bit is set, then the corresponding slot contains a module (smart or otherwise). This register is stored in a non-volatile memory (User or Default Configuration Memory).

SMART_MODULES

This register contains the configuration of the smart modules. The eight bits refer to the eight module slots. If a bit is set, then the corresponding slot contains a smart module. This register is stored in a non-volatile memory (User or Default Configuration Memory).

PSU_SETUP

This register contains flags regarding the current status of the PSU configuration access.

BIT	FLAG	R/W	DESCRIPTION
0	Configuration Data Status 0	R Only	These flags determine the state of the Operating Memory 11 - User Configuration Data was loaded 10 - Default Configuration Data was loaded 01 - Firmware Default Configuration Data was loaded 00 - Configuration Data in the Operating Memory was Updated
1	Configuration Data Status 1	R Only	

CASE_STATUS_BYTE

This register contains flags about the current status of the PSU. Note that the flags here represents the real-time status, and therefore does not require a separate command to be reset.

BIT	FLAG	R/W	DESCRIPTION
0	Inhibit_Enable_0	R Only	These flags mirrors the Control Signal Input state.
1	Inhibit_Enable_1	R Only	
2	AC Ok	R Only	This flag reflects the state of the AC input.
3	Bulk Ok	R Only	This flag reflects the state of the Bulk voltage.
4	Global DC Ok	R Only	This flag reflects the state of all module outputs.
5	Fan1 Ok	R Only	This flag reflects the state of the PSU Fan1.
6	Fan2 Ok	R Only	This flag reflects the state of the PSU Fan2.
7	PS ON	R Only	This flag reflects the state of the PSU operation.

CASE_FAULT_BYTE

This register contains Case fault flags, and must be reset using the **CLEAR_FAULTS** command.

BIT	FLAG	R/W	DESCRIPTION
0	Case OTP	R Only	Case Over Temperature Limit was reached.
1	Case OTW	R Only	Case Temperature near the Over Temperature Limit.
2	Primary OTW	R Only	Primary Over Temperature Warning Limit was reached.
3	Over Power Fault	R Only	Smart module Power Limit was reached.
4	User Config Error	R Only	User Configuration Memory Data Corrupted.
5	Default Config Error	R Only	Default Configuration Memory Data Corrupted.
6	Disabled Command	R Only	Disabled Command was called by host.
7	Command Error	R Only	General Command error detected.

MODULE_COMMUNICATION_ERROR_BYTE

This register contains fault flags regarding the internal UART-based module communication bus. The eight bits refer to the eight module slots. If a bit is set, then the attempted communication with the installed module in the corresponding slot failed. These flags must be reset using the **CLEAR_FAULTS** command.

MODULE_STATUS_FLAGS

This register contains status and fault flags with respect to the module referenced by the current Page. Note that the flags here represents the real-time status, and therefore does not require a separate command to be reset.

BIT	FLAG	R/W	DESCRIPTION
0	Output Enabled	R Only	This flag reflects the state of the module's operation.
1	UVP Fault	R Only	Module Under voltage condition exists.
2	DC Ok	R Only	Module's output is not within regulation.
3	OCP Fault	R Only	Module Over current fault exists.
4	OTP Fault	R Only	Module Over Temperature condition exists.
5	OTP Warning	R Only	Module's Temperature is near the Temperature Limit.
6	OVP Fault	R Only	Module Over voltage fault detected.
7	System Fault	R Only	General module fault detected.

MODULE_POWER_VOLTAGE_RANGE_CODE

This register is stored in the non-volatile memory of the module referenced by the Page, and contains information regarding the rated power of the said module as well as the voltage range of the output.

BIT	FLAG	R/W	DESCRIPTION
3-0	Voltage Range	R Only	These bits describe the range of the module's output voltage. 0000 – 2V to 5.5V 0001 – 6V to 12V 0010 – 14V to 20V 0011 – 24V to 36V 0100 – 42V to 60V 0101 – 5V (Fixed) 0110 – 2V to 6V 0111 – 12V to 15V 1000 – 24V to 28V
7-4	Power	R Only	These bits describe the rated power of the module. 0000 – 210W 0001 – 360W 0010 – 144W 0011 – 600W 0100 – 750W 0101 – 1500W

MODULE_CONFIG_FLAGS

This register is stored in the non-volatile memory of the module referenced by the Page, and contains different configuration flags that control certain module operation.

BIT	FLAG	R/W	DESCRIPTION
0	Inhibit High-Asserted	R/W	If this flag is set, the module output is disabled if the inhibit signal is high.
1	Fold Back OCP Mode	R/W	If this flag is set, the module's OCP mode is Fold Back, else the OCP mode is Constant Current.
2	UART Mode	R Only	This is always set.

HARDWARE_CODE

This register is stored in the non-volatile memory of the iMP case, and contains detailed information regarding the hardware model.

BIT	FLAG	R/W	DESCRIPTION
3-0	Model Option	R Only	0000 – (Unused) 0001 – Medicals 0010 – External Fan 0011 – Reverse Fan 0100 – IEC Option
7-4	Model Code	R Only	0000 – (Unused) 0001 – iMP1 0010 – iVS1 0011 – (Reserved) 0100 – iMP4 0101 – (Reserved) 0110 – iVS6 0111 – (Reserved) 1000 – iMP8 1001 – iVS8 1010 – iVS8H

Supported PMBus Standard Commands

Notes: **CONFIG** means that this command can update a Case Configuration data that can be stored in a non-volatile memory location.

MCONFIG means that this command can update a Module Configuration data.

Listed below are the standard commands supported by the PSU. Command details are described in the PMBus™ Power System Management Protocol Specification, Part II – Command Language, Revision 1.0 document (items in square brackets points to the section) but a summary excerpt is shown for easy reference (the table number is with reference to the said document).

WRITE_PROTECT [Ref#2, 11.1]

The WRITE_PROTECT command can be used to control access to the PSU. Upon power-up, all commands are read-only (as applicable) except for this one. The Write Protection Setting can be updated then to:

1. Lock the serial access by disabling all write commands even the WRITE_PROTECT command
2. Allow only the WRITE_PROTECT, OPERATION and PAGE write commands.
3. Allow only the WRITE_PROTECT, OPERATION, PAGE, ON_OFF_CONFIG and VOUT write commands.
4. Allow only the ON_OFF_CONFIG, VOUT and the WRITE_PROTECT write commands.
5. Lock the serial access only for the ON_OFF_CONFIG and VOUT write commands.

RESTORE_DEFAULT_ALL [Ref#2, 11.3] – CONFIG

This command will restore the contents of the Default Configuration Memory location to the Operating Memory.

STORE_USER_ALL [Ref#2, 11.6] – CONFIG

This command will store the contents of the Operating Memory in the User Configuration Memory location.

RESTORE_USER_ALL [Ref#2, 11.7] – CONFIG

This command will restore the contents of the User Configuration Memory location to the Operating Memory.

PAGE [Ref#2, 11.10]

Valid Range: 0 to 7

The iMP PSU can support up to eight different outputs. An internal register serves as an index that can be used by many commands to distinguish between the Modules. This is the Page register which can be accessed through the Page command. The valid values for the Page register are from zero to seven (0 to 7). At power-up, this value is zero.

OPERATION [Ref#2, 12.1]

This command can be used to turn the unit on and off (if enabled in the ON_OFF_CONFIG register). Only bit 7 (0 = OFF, 1 = ON) is used by the PSU since Sequencing and Margining are not supported through this protocol. At power-up, the initial value of this register is controlled by the **Startup Operation Mode On** flag of the **PSU_CONFIG** register (bit 7).

ON_OFF_CONFIG [Ref#2, 12.2] – CONFIG

This command can be used to set how the PSU will be turned on, by enabling the OPERATION command or the Control Signals (**INHIBIT_ENABLE_0** and **INHIBIT_ENABLE_1)**, or both. The Control Signal polarity (**Global Inhibit Flag** is this case) can also be set here. The **ON_OFF_CONFIG** flag for turn off delay and fall time (bit 0) is disregarded.

VOUT_MODE [Ref#2, 13.1]

This command can be used to read the data format used by the PSU for output voltage related commands. Though the format is fixed (Direct Format), this command was supported for compliance purposes.

VOUT_COMMAND [Ref#2, 13.2] - MCONFIG

Direct Data Format: m = 1, b = 0, R = -2 (10mV resolution)
Valid Range: (Refer to the module documentation)

This command is used to update the voltage of the output module referenced by the current **Page.**

VFAN_1 [Ref#2, 14.10] - CONFIG

Direct Data Format: m = 1, b = 0, R = -2 (10mV resolution)
Valid Range: 6.5 to 12 V, 0 V to disable

This command will set the **Fan Override** flag in the **PSU_CONFIG** register and overrides the PSU fan control with the requested fan voltage (only if this fan voltage is greater than the expected voltage of the fan control logic, which is based on the temperature data). If the parameter is zero, the **Fan Override** flag is disabled.

CLEAR_FAULTS [Ref#2, 15.1]

This command is used to clear the fault flags set in the **STATUS_BYTE**, **CASE_FAULT_BYTE**, and **MODULE_COMMUNICATION_ERROR_BYTE**. Note that if the fault condition still exists, the associated flag will be set again. This command will only affect the flags and not the fault condition itself.

IOUT_OC_FAULT_LIMIT [Ref#2, 15.8] - MCONFIG

Direct Data Format: m = 1, b = 0, R = -2 (10mA resolution)
Valid Range: (Refer to the module documentation)

This command is used to set the relative maximum current of the output module referenced by the current **Page**. Refer to the associated module's documentation with regards to the pre-requisites of this command, as well as on the details of the affected output parameters.

OT_FAULT_LIMIT [Ref#2, 15.17] - CONFIG

Data Format: 0.25 degree Celsius resolution
Valid Range: 20 to 90 degree Celsius

This command is used to set the Over Temperature Limit of the Case. If the value is less than the current **OT_WARN_LIMIT**, it will also set **OT_WARN_LIMIT** to this value.

OT_WARN_LIMIT [Ref#2, 15.19] - CONFIG

Data Format: 0.25 degree Celsius resolution
Valid Range: 0 to current **OT_FAULT_LIMIT** value

This command is used to set the Over Temperature Warning Limit of the Case.

TON_DELAY [Ref#2, 16.1] – MCONFIG

Direct Data Format: m = 1, b = 0, R = 0 (1ms resolution)
Valid Range: 0 to 255 ms

This command will set the turn on delay of the output module referenced by the current **Page**.

STATUS_BYTE [Ref#2, 17.1]

This command is used to read the **STATUS_BYTE** of the PSU.

READ_VIN [Ref#2, 18.1]

Direct Data Format: m = 1, b = 0, R = -2 (10mV resolution)

This command returns the input AC RMS voltage of the PSU.

READ_IIN [Ref#2, 18.2]

Direct Data Format: m = 1, b = 0, R = -2 (10mA resolution)

This command returns the input current of the PSU.

READ_VOUT [Ref#2, 18.4]

Direct Data Format: m = 1, b = 0, R = -2 (10mV resolution)

This command returns the output voltage of the module referenced by the current **Page**.

READ_IOUT [Ref#2, 18.5]

Direct Data Format: m = 1, b = 0, R = -2 (10mA resolution)

This command returns the output current of the module referenced by the current **Page**.

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READ_TEMPERATURE_1 [Ref#2, 18.6]

Data Format: 0.25 degree Celsius resolution, 2's Complement

This command returns the temperature of the PSU Case.

READ_TEMPERATURE_2 [Ref#2, 18.6]

Direct Data Format: m = 1, b = 0, R = 0 (1 degree Celsius resolution)

This command returns the temperature of the PSU primary side.

READ_TEMPERATURE_3 [Ref#2, 18.6]

Direct Data Format: m = 1, b = 0, R = 0 (1 degree Celsius resolution)

This command returns the temperature of the module referenced by the current **Page**.

READ_FAN_SPEED_1 [Ref#2, 18.7]

Direct Data Format: m = 10, b = 0, R = 0 (10 RPM resolution)

This command returns the speed of the PSU Case fan1.

READ_FAN_SPEED_2 [Ref#2, 18.7]

Direct Data Format: m = 10, b = 0, R = 0 (10 RPM resolution)

This command returns the speed of the PSU Case fan2.

PMBus_REVISION [Ref#2, 22.1]

This command returns the PMBus revision for which this PSU is compliant.

Table 19. Command Summary

Command Code	Command Name	SMBus Transaction Type	Number Of Data Bytes	Reversed For Future Use	Reversed For Future Use
00h	PAGE	R/W Byte	1		
01h	OPERATION	R/W Byte	1		
02h	ON_OFF_CONFIG	R/W Byte	1		
03h	CLEAR_FAULTS	Send Byte	0		
10h	WRITE_PROTECT	R/W Byte	1		
11h	STORE_DEFAULT_ALL	Send Byte	0		
12h	RESTORE_DEFAULT_ALL	Write Byte	1		
15h	STORE_USER_ALL	Send Byte	0		
16h	RESTORE_USER_ALL	Write Byte	1		
20h	VOUT_MODE	R/W Byte	1		
21h	VOUT_COMMAND	R/W Word	2		
3Ah	VFAN_1	R/W Word	2		
46h	IOUT_OC_FAULT_LIMIT	R/W Word	2		
4Fh	OT_FAULT_LIMIT	R/W Word	2		
51h	OT_WARN_LIMIT	R/W Word	2		
60h	TON_DELAY	R/W Word	2		
78h	STATUS_BYTE	Read Byte	1		
88h	READ_VIN	Read Word	2		
89h	READ_IIN	Read Word	2		
8Bh	READ_VOUT	Read Word	2		
8Ch	READ_IOUT	Read Word	2		
8Dh	READ_TEMPERATURE_1	Read Word	2		
8Eh	READ_TEMPERATURE_2	Read Word	2		
8Fh	READ_TEMPERATURE_3	Read Word	2		
90h	READ_FAN SPEED_1	Read Word	2		
91h	READ_FAN SPEED_2	Read Word	2		
98h	PMBUS_REVISION	Read Byte	1		

Manufacturer Specific Commands

Notes: **CONFIG** means that this command can update a Case Configuration data that can be stored in a non-volatile memory location.
MCONFIG means that this command can update a Module Configuration data.

CASE_FIRMWARE_VERSION

Command Code:	D0h
Transaction Type:	Read Block
Data Bytes:	5
Data Format:	Byte1 is the Byte Count equal to 4 Byte2 is the Primary Firmware Version Byte3 is the Secondary Firmware Major Version in BCD Byte4 is the Secondary Firmware Minor Version in BCD Byte5 is the Secondary Firmware Version Branch in BCD

This command will return the Case Firmware Version information for both the Primary Microcontroller and Secondary Microcontroller Firmware.

ACTIVE_SLOTS - CONFIG

Command Code:	D2h
Transaction Type:	R/W Byte
Data Bytes:	1
Data Format:	See previous discussion on the **ACTIVE_SLOTS** register (Page 15)

This command will access the **ACTIVE_SLOTS** register.

SMART_MODULES - CONFIG

Command Code:	D3h
Transaction Type:	R/W Byte
Data Bytes:	1
Data Format:	See previous discussion on the **SMART_MODULES** register (Page 15)

This command will access the **SMART_MODULES** register.

MODULE_AUTO_DETECT - CONFIG

Command Code:	D4h
Transaction Type:	Send Byte
Data Bytes:	0

This command will initiate auto detection of the Smart Modules installed on the slots. This will automatically update the **SMART_MODULES** register, and set the appropriate flags in the **ACTIVE_SLOTS** register. Previously set flags in the **ACTIVE_SLOTS** register will remain set.

PSU_CONFIG - CONFIG

Command Code:	D5h
Transaction Type:	R/W Byte
Data Bytes:	1
Data Format:	See previous discussion on the **PSU_CONFIG** register (Page 15)

This command will access the **PSU_CONFIG** register.

PSU_SETUP

Command Code:	D6h
Transaction Type:	Read Byte
Data Bytes:	1
Data Format:	See previous discussion on the **PSU_SETUP** register (Page 16)

This command will return the **PSU_SETUP** register.

TOTAL_POWER

Command Code:	D7h
Transaction Type:	Read Word
Data Bytes:	2
Direct Data Format:	m = 1, b = 0, R = 0 (1W resolution)

This command will return the total input power of the PSU.

CASE_STATUS_BYTE

Command Code: D8h
Transaction Type: Read Byte
Data Bytes: 1
Data Format: See previous discussion on the **CASE_STATUS_BYTE** register (Page 16)

This command will return the **CASE_STATUS_BYTE**.

CASE_FAULT_BYTE

Command Code: D9h
Transaction Type: Read Byte
Data Bytes: 1
Data Format: See previous discussion on the **CASE_FAULT_BYTE** register (Page 16)

This command will return the **CASE_FAULT_BYTE**.

MODULE_COMMUNICATION_ERROR_BYTE

Command Code: DAh
Transaction Type: Read Byte
Data Bytes: 1
Data Format: See previous discussion on the **MODULE_COMMUNICATION_ERROR_BYTE** register (Page 17)

This command will return the **MODULE_COMMUNICATION_ERROR_BYTE**.

MODULE_STATUS_FLAGS

Command Code: DBh
Transaction Type: Read Byte
Data Bytes: 1
Data Format: See previous discussion on the **MODULE_STATUS_FLAGS** register (Page 17)

This command will return the **MODULE_STATUS_FLAGS** referenced by the current Page.

EXTRACT_MODULE_CONFIG_BYTES

Command Code:	DCh
Transaction Type:	Read/Write Word
Data Bytes:	2
Data Format:	Byte1 is the start address Byte2 is the number of bytes to read
Data Range:	for the address range, refer to the module documentation the number of bytes to read must be from 1 to 5.

This command will initiate reading of the configuration bytes from the module referenced by the current Page.

READ_MODULE_CONFIG_BYTES

Command Code:	DDh
Transaction Type:	Read Block
Data Bytes:	2 to 6 (including the Byte Count)
Data Format:	Byte1 is the Byte Count (succeeding bytes are the module configuration bytes)

This command will return the extracted configuration bytes of the module referenced by the current Page.

EXTRACT_MODULE_VERSION

Command Code:	DEh
Transaction Type:	Send Byte
Data Bytes:	0

This command will initiate reading of the version information from the module referenced by the current Page.

READ_MODULE_VERSION

Command Code:	DFh
Transaction Type:	Read Block
Data Bytes:	4 (including the Byte Count)
Data Format:	Byte1 is the Byte Count equal to 3 Byte2 is the Module Firmware Major Version Byte3 is the Module Firmware Minor Version Byte4 is the **MODULE_POWER_VOLTAGE_RANGE_CODE** (Page 17)

This command will return the extracted version information of the module referenced by the current Page.

IOUT_SENSOR_CALIBRATION - MCONFIG

Command Code:	E0h
Transaction Type:	Send Byte
Data Bytes:	0

This command will initiate calibration of the output current sensor, of the module referenced by the current Page. Refer to the associated module's documentation with regards to the pre-requisites of this command, as well as on the details of the affected output parameters.

OVP_LIMIT_PERCENT - MCONFIG

Command Code:	E1h
Transaction Type:	Write Byte
Data Bytes:	1
Data Format:	Parameter Byte is in 1% resolution
Data Range:	101 to 255 %

This command will update the Over Voltage Protection Limit of the module referenced by the current Page. The limit is in percentage of the output voltage setting.

UVP_LIMIT_PERCENT - MCONFIG

Command Code:	E2h
Transaction Type:	Write Byte
Data Bytes:	1
Data Format:	Parameter Byte is in 1% resolution
Data Range:	0 to 99 %

This command will update the Under Voltage Protection Limit of the module referenced by the current Page. The limit is in percentage of the output voltage setting.

MODULE_OTP_LIMIT - MCONFIG

Command Code:	E3h
Transaction Type:	Write Byte
Data Bytes:	1
Data Format:	Parameter Byte is in 1 degree Celsius resolution
Data Range:	0 to 255 degrees Celsius

This command will update the Over Temperature Protection Limit of the module referenced by the current Page.

MODULE_CONFIG_FLAGS - MCONFIG

Command Code:	E4h
Transaction Type:	Write Byte
Data Bytes:	1
Data Format:	See previous discussion on the **MODULE_CONFIG_FLAGS** (Page 18)

This command will update the **MODULE_CONFIG_FLAGS** of the module referenced by the current Page.

LOAD_PREDEFINED_SETTING - MCONFIG

Command Code:	E5h
Transaction Type:	Write Byte
Data Bytes:	1
Data Format:	Parameter Byte is the index to the pre-defined setting stored in the module
Data Range:	Refer to the module documentation for valid stored settings index

This command will load an indexed pre-defined setting stored in the module referenced by the current Page.

MODULE_VSCALE_CALIBRATION - MCONFIG

Command Code:	E6h
Transaction Type:	Write Word
Data Bytes:	2
Direct Data Format:	m = 1, b = 0, R = -2 (10mV resolution)
Data Range:	0.01 to 655.35 Volts

This command will initiate calibration of the Voltage Scale parameter of the module referenced by the current Page. The Voltage Scale parameter is the factor used in the calculation of the sensed output voltage. The module will adjust the Voltage Scale parameter such that the calculated output voltage will be the same as the commanded voltage. This operation requires that the module output is enabled and that the commanded voltage is the same as the measured output voltage of the module.

MODULE_OPERATIONS

Command Code: E7h
Transaction Type: Read/Write Word
Data Bytes: 2
Data Format: Byte1 is the Operation Type
Byte2 is the Operation Parameter (Write) or Operation Reply (Read)

This command will forward to the module referenced by the current Page an Operation Request. Note that the case will not perform any verification if the request is valid or not. The details of the supported operations depends on the module. Please review module documentation for this. An I²C Read with the said command code will return two bytes wherein Byte1 is the latest Operation type received, and Byte 2 is reply of the module (a value of FFh means there is no reply yet). Note that there is significant delay from issuing the Module Operations command to the time of the module's reply. A fixed delay may be used or a repeated poll for the reply may be implemented.

Commonly supported Module Operations:

TYPE	DESCRIPTION	PARAMETER	REPLY	DETAILS
00h	Output Off	Delay (ms)	AAh	Clears the module software On/Off control flag which disables the output of the module
01h	Output On	Delay (ms)	55h	Sets the module software On/Off control flag which enables the output of the module
02h	Read On/Off Status	(N/A)	AAh/55h	Extracts the status of the module software On/Off control flag (AAh = Off, 55h = On)
03h	FW Branch	(N/A)	Branch	Extracts the firmware version branch of the module (00h = main, else it is a Modification branch)

PSU_MONITOR

Command Code: E9h
Transaction Type: Read Block
Data Bytes: 17 (including the Byte Count)
Data Format: Byte1 is the Byte Count equal to 16
(for the succeeding bytes, refer to the previous discussions on the formats of the individual reply data as referenced by the associated commands)

This command will return all the commonly monitored Case data. All the individual data here can be read using separate commands, and has the same formats.

Reply Format:

REPLY TYPE	DESCRIPTION	REFERENCE COMMAND
1	Byte Count = 16	
2	STATUS_BYTE	**STATUS_BYTE [Ref#2, 17.1]**
3	CASE_STATUS_BYTE	**CASE_STATUS_BYTE**
4-5	Input Voltage	**READ_VIN [Ref#2, 18.1]**
6-7	Input Current	**READ_IIN [Ref#2, 18.2]**
8-9	TOTAL_POWER	**TOTAL_POWER**
10-11	PSU Case Temperature	**READ_TEMPERATURE_1 [Ref#2, 18.6]**
12-13	PSU Case Primary Temperature	**READ_TEMPERATURE_2 [Ref#2, 18.6]**
14-15	Fan1 Speed	**READ_FAN_SPEED_1 [Ref#2, 18.7]**
16-17	Fan2 Speed	**READ_FAN_SPEED_2 [Ref#2, 18.7]**

MODULE_MONITOR

Command Code: EAh
Transaction Type: Read Block
Data Bytes: 8 (including the Byte Count)
Data Format: Byte1 is the Byte Count equal to 7
(for the succeeding bytes, refer to the previous discussions on the formats of the individual reply data as referenced by the associated commands)

This command will return all the commonly monitored data of the module referenced by the Page. All the individual data here can be read using separate commands, and has the same formats.

Reply Format:

REPLY TYPE	DESCRIPTION	REFERENCE COMMAND
1	Byte Count = 7	
2-3	Output Voltage	**READ_VOUT [Ref#2, 18.4]**
4-5	Output Current	**READ_IOUT [Ref#2, 18.5]**
6-7	Module Temperature	**READ_TEMPERATURE_3 [Ref#2, 18.6]**
8	MODULE_STATUS_FLAGS	**MODULE_STATUS_FLAGS**

OVER_POWER_LIMITS

Command Code:	EBh
Transaction Type:	Read/Write Block
Data Bytes:	5 (including the Byte Count)
Data Format:	Byte1 is the Byte Count equal to 4 Byte2 is the least significant byte of the Low Line Power Limit Byte3 is the most significant byte of the Low Line Power Limit Byte4 is the least significant byte of the High Line Power Limit Byte5 is the most significant byte of the High Line Power Limit
Data Range:	0 to 65536 Watts

This command will access the power limit settings for both low-line and high-line input voltage operations.

OUTPUT_INDEX

Command Code:	ECh
Transaction Type:	Read/Write Word
Data Bytes:	2
Data Format:	Byte1 is the Output Index Byte2 is the Smart Modules flags

This command will access the Output Index register. This register will determine the output of the modules in which the case will communicate with, and is zero (referring to the first output) at start-up. The second byte refers to the new smart modules flags (see **SMART_MODULES**, page 15) applicable to this output index value, since the new output index may not be applicable to some of the installed modules (a value of 2 is not applicable to dual-output modules). If the output index is set to zero, the second byte is disregarded since the **SMART_MODULES** register will be used instead.

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