REV.	DATE	CHANGE DESCRIPTION	CONTACT FOR FURTHER INFORMATION
0.1	11-10-2017	- Initial Release - Integrated documentation of UDP, RS485, and CAN protocol specification	Franz de Rama

73-95x-0001 iHP
Communications Protocol Definition

Rev. 0.1

TABLE OF CONTENTS

1. OVERVIEW 4
2. UDP MESSAGE STRUCTURE 5
2.1. COMMAND MESSAGE 5
2.2. RESPONSE MESSAGE....7
2.3. ERROR MESSAGE 9
3. RS485 MESSAGE STRUCTURE 10
3.1. COMMAND MESSAGE 10
3.2. RESPONSE MESSAGE....12
3.3. ERROR MESSAGE 14
4. CAN MESSAGE STRUCTURE 15
4.1. MESSAGE ID FORMAT....15
4.2. COMMAND MESSAGE 16
4.3. RESPONSE MESSAGE....17
4.4. ERROR MESSAGE 18
5. SUPPLEMENTAL INFORMATION 19
5.1. INTERNAL DEVICE ADDRESS....19
5.2. ERROR CODES....20
5.3. TIMING 20
APPENDIX A SUPPORTED COMMAND CODES 21

1. OVERVIEW

This document defines the protocol of the different communication interfaces provided by the iHP to allow configuration and monitoring.

iHP supports various interfaces for configuration and monitoring, which includes Ethernet, RS485, and CAN. Systems should not use several interfaces in parallel as this may produce unexpected results.

The protocols described in this document utilize the standard communication method of their respective interfaces to handle messages on a command/response basis.

Commands are based on PMBus specification, although some changes have been made to better fit the requirements of the iHP.

2. UDP MESSAGE STRUCTURE

The iHP protocol sits on the *Data* section of the UDP message packet, as seen on Figure 1.

UDP message packet should be taken cared of by the programming language used, via its network sockets library, and the developer just needs to format the data to be included based on the iHP UDP protocol as defined in this section.

Bit	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
0	Source IPv4 Address																															
32	Destination IPv4 Address																															
64	Zeroes								Protocol								UDP Length															
96	Source Port																Destination Port															
128	Length																Checksum															
160+	Data (iHP UDP Message Protocol)																															

Figure 1: UDP Packet Structure

2.1. Command Message

Each message can only contain a single command.

The commands are loosely based on the PMBus standard but modified for this product. Additional data has been added on the packet in order to parse the message. In particular the data length must be specified as there is no boundary information provided by the underlying protocol for variable length data, and the use of transaction oriented commands, such as PAGE, are not supported and instead replaced with direct addressing.

In addition, packet error checking (PEC) is not included in the protocol as this is already covered by the UDP checksum.

The format for an individual command is as follows:

Byte	Bit	Parameter	Definition
1st Byte	7 . . 0	Message ID	- 32-bit Message ID - This message ID is ignored by the iHP but is echoed back in the UDP response to indicate that this message has been received and processed.
2nd Byte	7 . . 0		
3rd Byte	7 . . 0		
4th Byte	7 . . 0		

5th Byte	7	Type	*Reserved for future use.* Value should be **one**.
	6	Reserved	*Reserved for future use.* Value should be **zero**.
	5	Split Type	*Reserved for future use.* Value should be **one**.
	4 3 2 1	Reserved	*Reserved for future use.* Values should be **zero**.
	0	No. of Commands	'1' indicates that a command code is included with this message. '0' indicates that this message is just a "ping" request meant to check if an iHP is available on the specified IP address
6th Byte	7 6 5	Reserved	*Unused for UDP interface*
	4 3 2 1 0	Internal Device Address	- Refers to the address of the device to communicate. - Refer to Section 5.1 for a list of available device addresses
7th Byte	7	Reserved	*Reserved for future use.*
	6	Operation	'1' = READ '0' = WRITE
	5 4 3 2 1 0	Command Data Length	A 6-bit value indicating the length of the data included in this message starting from 9th Byte.
8th Byte	7 . . 0	Command Code	- Command Code. - Refer to Appendix A for the command codes supported by the different devices.
9th Byte	7 . . 0	Command Data1	
Nth Byte	7 . . 0	Command Data N	

2.2. Response Message

All valid requests received by the iHP will be responded to. This includes READ, WRITE, and/or BLANK messages meant to check if the iHP is available.

Byte	Bit	Parameter	Definition
1st Byte	7 . . 0	Message ID	- A 32 bit Message ID. - This ID matches the Message ID given on the Command Message Request.
2nd Byte	7 . . 0		
3rd Byte	7 . . 0		
4th Byte	7 . . 0		
5th Byte	7	Reserved	*Reserved for future use.* Value should be **zero**.
	6	Error Bit	'0' indicates no error
	5	Final Bit	*Reserved for future use.* Value should be **one**.
	4	Reserved	*Reserved for future use.* Value should be **zero**.
	3		
	2		
	1		
	0	No. of Response	'1' indicates that a command response is included with this message. '0' indicates that the message is an acknowledgement receipt of a BLANK message.
6th Byte	7	Error Code	0 indicates a normal response, see next section for errors.
	6		
	5		
	4		
	3	Reserved	*Reserved for future use.* Value should be zero.
	2		
	1		
	0		
7th Byte	7	Reserved	*Unused for UDP protocol*
	6		
	5		
	4	Internal Device Address	Selects the internal device to address, Refer to section 5.1 for a list of available device addresses.
	3		
	2		
	1		
	0		

8th Byte	7	Reserved	Reserved for future expansion, should be 0
	6	Reserved	Reserved for future expansion, should be 0
	5.0	Response Data Length	A 6-bit value indicating the length of the data included in this message starting from 10th Byte.
9th Byte	7.0	Command Code	User Command code for Module, ISOCOMM, or PFC. Please refer to Appendix A.
10th Byte	7.0	Response Data1	
Nth Byte	7.0	Response Data N	

2.3. Error Message

If something goes wrong that prevents the iHP from processing the message, an Error Code will be sent.

The message still follows the protocol, but only contains the error code as its data.

Details of the error code can be found on section 2.3.1.

Byte	Bit	Parameter	Definition
1st Byte	7 . . 0	Message ID	- A 32 bit Message ID. - This ID matches the Message ID given on the Command Message Request.
2st Byte	7 . . 0		
3rd Byte	7 . . 0		
4th Byte	7 . . 0		
5th Byte	7	Reserved	*Reserved for future use.* Value should be zero.
	6	Error Bit	Always '1' to indicate an error.
	5	Reserved	*Reserved for future use.* Value should be zero.
	4		
	3		
	2		
	1		
	0	Data Length	Length of the
6th byte	7 . . 4	Error Code	A non-zero value indicates an error code, zero is reserved for normal responses
	3 . . 0	Command Sequence ID	This number indicates the command that is being responded to. Each command received in a message is given a sequence number (starting from 0), together with the message sequence number this can identify the command being responded to.

3. RS485 MESSAGE STRUCTURE

Unlike UDP, RS485 does not specify any communications protocol and so data are transmitted as raw. The iHP RS485 protocol in this section defines how these raw data should be formatted.

3.1. Command Message

Each message can only contain a single command.

The format for an individual command is as follows:

Byte	Bit	Parameter	Definition
1st Byte	7 . . 0	Message ID	- 32-bit Message ID - This message ID is ignored by the iHP but is echoed back in the UDP response to indicate that this message has been received and processed.
2nd Byte	7 . . 0		
3rd Byte	7 . . 0		
4th Byte	7 . . 0		
5th Byte	7	Type	*Reserved for future use.* Value should be **one**.
	6	Reserved	*Reserved for future use.* Value should be **zero**.
	5	Split Type	*Reserved for future use.* Value should be **one**.
	4	Reserved	*Reserved for future use.* Values should be **zero**.
	3		
	2		
	1		
	0	No. of Commands	'1' indicates that a command code is included with this message. '0' indicates that this message is just a "ping" request meant to check if an iHP is available on the specified IP address
6th Byte	7	iHP Rack Address	- A 3-bit value indicating the address of the iHP Rack, as configured on iHP's WEB Tool.
	6		
	5		
	4	Internal Device Address	- Refers to the address of the device to communicate. - Refer to section 5.1 for a list of available device addresses.
	3		
	2		
	1		
	0		

7th Byte	7	Reserved	*Reserved for future use.*
	6	Operation	'1' = READ '0' = WRITE
	5 4 3 2 1 0	Command Data Length	A 6-bit value indicating the length of the data included in this message starting from 9th Byte.
8th Byte	7 . . 0	Command Code	- Command Code. - Refer to Appendix A for the command codes supported by the different devices.
9th Byte	7 . . 0	Command Data1	
Nth Byte	7 . . 0	Command Data N	

3.2. Response Message

All valid requests received by the iHP will be responded to. This includes READ, WRITE, and/or BLANK messages meant to check if the iHP is available.

Below shows how the response message is formatted:

Byte	Bit	Parameter	Definition
1st Byte	7 . . 0	Message ID	- A 32 bit Message ID. - This ID matches the Message ID given on the Command Message Request.
2nd Byte	7 . . 0		
3rd Byte	7 . . 0		
4th Byte	7 . . 0		
5th Byte	7	Reserved	*Reserved for future use.* Value should be **zero**.
	6	Error Bit	'0' indicates no error
	5	Final Bit	*Reserved for future use.* Value should be **one**.
	4	Reserved	*Reserved for future use.* Value should be **zero**.
	3		
	2		
	1		
	0	No. of Response	'1' indicates that a command response is included with this message. '0' indicates that the message is an acknowledgement receipt of a BLANK message.
6th Byte	7	Error Code	0 indicates a normal response, see next section for errors.
	6		
	5		
	4		
	3	Reserved	*Reserved for future use.* Value should be zero.
	2		
	1		
	0		
7th Byte	7	iHP Rack Address	- A 3-bit value indicating the address of the iHP, as configured on iHP's WEB Tool.
	6		
	5		
	4	Internal Device Address	Selects the internal device address to use. See section 5.1 for a list of device addresses available.
	3		
	2		
	1		
	0		

8th Byte	7	Reserved	Reserved for future expansion, should be 0
	6	Reserved	Reserved for future expansion, should be 0
	5.0	Response Data Length	A 6-bit value indicating the length of the data included in this message starting from 10th Byte.
9th Byte	7.0	Command Code	User Command code for Module, ISOCOMM, or PFC. Please refer to Appendix A.
10th Byte	7.0	Response Data1	
Nth Byte	7.0	Response Data N	

3.3. Error Message

If something goes wrong that prevents the iHP from processing the message, an Error Code will be sent.

The message still follows the protocol, but only contains the error code as its data.

Details of the error code can be found on section 2.3.1.

Byte	Bit	Parameter	Definition
1st Byte	7 . . 0	Message ID	- A 32 bit Message ID. - This ID matches the Message ID given on the Command Message Request.
2st Byte	7 . . 0		
3rd Byte	7 . . 0		
4th Byte	7 . . 0		
5th Byte	7	Reserved	*Reserved for future use.* Value should be zero.
	6	Error Bit	Always ‘1’ to indicate an error.
	5	Reserved	*Reserved for future use.* Value should be zero.
	4		
	3		
	2		
	1		
	0	Data Length	Length of the
6th byte	7 . . 4	Error Code	A non-zero value indicates an error code, zero is reserved for normal responses
	3 . . 0	Command Sequence ID	This number indicates the command that is being responded to. Each command received in a message is given a sequence number (starting from 0), together with the message sequence number this can identify the command being responded to.

4. CAN MESSAGE STRUCTURE

CAN is a multi-master broadcast serial bus standard for connecting different devices.

Each node in a CAN is able to send and receive messages, but not simultaneously. A message consists primarily of an Identifier, which represents the priority of the message, and up to eight data bytes.

It features automatic priority-based bus arbitration. This means that a CAN message transmitted with a highest priority (most dominant ID) will succeed and the node transmitting with a lower priority message will sense this, backs off and wait.

Bit rates up to 1 Mbit/s are possible at network lengths below 40 m. Decreasing the bit rate allows longer network distances (e.g., 500 m at 125 kbit/s).

iHP protocol sits on the *Data Bytes* of the standard CANBus v2.0A frame as shown below, with 11-bit ID field and up to 1Mbit/sec data rate

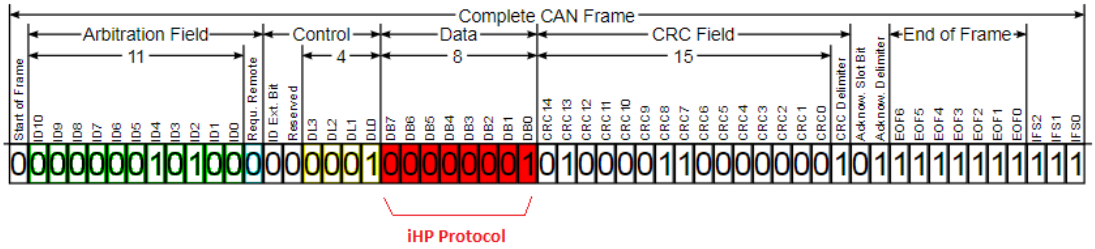

Figure 2: Standard CANBus v2.0A message frame

4.1. Message ID Format

Diagram below shows the Message ID format for the iHP, :

ID10	ID9	ID8	ID7	ID6	ID5	ID4	ID3	ID2	ID1	ID0
Rack Address			Reserved			Internal Device Address				

- ***Rack Address*** indicates the External Address assigned to the rack. This address is configured using the iHP's built-in WEB Tool.
- ***Node address*** indicates the device for which the message is intended to (*See section 5.1 for a list of device addresses available*).

4.2. Command Message

Each message can only contain one command and up to 5 command data bytes.

For commands which need to send more than 5 bytes of data, the "Final" bit must be utilized in order to send up to 255 bytes in chunks of 5 data bytes. The iHP will take care of assembling the data.

Packet error checking (PEC) is not included as this is already covered by the CAN hardware as seen on the standard CANBus v2.0A message frame above (Figure 2).

The format for the command message is as follows:

Byte	Bit	Parameter	Definition
1st Byte	7 . . 0	Command Code	- 8-bit Command Code. - Refer to Appendix A for the command codes supported by the different devices.
2nd Byte	7	Final	'1' indicates that this is the final message. '0' indicates that a succeeding packet is expected and should be a part of this message.
	6	Operation	'0' = READ '1' = WRITE
	5	Reserved	*Reserved for future use.* Value should be zero.
	4		
	3		
	2		
	1		
	0		
3rd Byte	7 . . 0	Data Length	*Length of the command data*
4th Byte	7 . . 0	Command Data1	
Nth Byte	7 . . 0	Command Data N	

4.3. Response Message

In contrast to UDP and RS485, CAN interface only responds to READ requests.

Below shows how the CAN response message is formatted:

Byte	Bit	Parameter	Definition
1st Byte	7 . . 0	Command Code	- 8-bit Command Code. - Refer to Appendix A for the command codes supported by the different devices.
2nd Byte	7	Final	'1' indicates that this is the final message. '0' indicates that a succeeding packet is expected and should be a part of this message.
	6	Operation	'0' = READ
	5	Reserved	*Reserved for future use.* Value should be zero.
	4		
	3		
	2		
	1		
	0		
3rd Byte	7 . . 0	Data Length	*- Length of the response data* *- End System should be able to assemble the data if and when the response data length is greater than 5. Multiple reply messages will be sent by the iHP in chunks of 5 data bytes until completion.*
4th Byte	7 . . 0	Response Data1	
Nth Byte	7 . . 0	Response N	

4.4. Error Message

If something goes wrong that prevents the iHP from processing the message, an Error Code will be sent.

The message still follows the protocol, but only contains the error code as its data.

Details of the error code can be found on section 2.3.1.

Byte	Bit	Parameter	Definition
1st Byte	7 . . 0	Command Code	- 8-bit Command Code. - Refer to Appendix A for the command codes supported by the different devices.
2nd Byte	7	Final	'1' indicates that this is the final message. '0' indicates that a succeeding packet is expected and should be a part of this message.
	6	Operation	'0' = READ '1' = WRITE
	5	Reserved	*Reserved for future use.* Value should be zero.
	4		
	3		
	2		
	1		
	0		
3rd Byte	7 . . 0	Data Length	*- Length of the error data; usually '1', since it only sends the error code.*
4th Byte	7 . . 0	Error Code	

5. SUPPLEMENTAL INFORMATION

5.1. Internal Device Address

Table below lists the addresses of the different devices inside iHP Rack.

Device	Address
COMMS	0x00
PFC1	0x07
PFC2	0x08
Module1	0x10
Module2	0x11
Module3	0x12
Module4	0x13
Module5	0x14
Module6	0x15
Module7	0x16
Module8	0x17
Group1	0x18
Group2	0x19
Group3	0x1A
Group4	0x1B
Group5	0x1C
Group6	0x1D
Group7	0x1E

5.2. Error Codes

Table below lists the codes emitted by iHP when it encounters an error.

Value	Code	Description
0	ERR_SUCCESS	Success / No Error
1	ERR_RACK_NOT_EXISTING	No iHP Rack available on the specified address
2	ERR_DEVICE_NOT_EXISTING	Invalid / No devices existing on the specified device address
3	ERR_UNSUPPORTED_CMD	Unsupported command code
4	ERR_OPERATION_INVALID	Operation not supported – that command is not valid for reading/writing (depending on what operation was issued)
5	ERR_LENGTH_INVALID	The length given is invalid for the command code
6	ERR_DATA_INVALID	The data provided doesn't match what was expected
7	ERR_WRITE_PROTECT	The command is valid but the data is write protected
8	ERR_PROTOCOL_INVALID	There was an error parsing the command.
9 … 15	…	*Reserved for future use*

5.3. Timing

If all Modules are in digital mode, User can send one command every 20msec.

If at least one Module is in analog mode, User can send one command every 55msec.

APPENDIX A SUPPORTED COMMAND CODES

B.1 PFC Supported Commands

<table>
<tr><th>Command Code</th><th>Name</th><th>Definition</th></tr>
<tr><td>03h</td><td>CLEAR_FAULTS</td><td>Standard PMBUS command
To remove the warning or fault bits set in the status register, User need to send CLEAR_FAULT command.</td></tr>
<tr><td>10h</td><td>WRITE_PROTECT</td><td>Standard PMBUS command
Command used to Enable or Disable writing to the Module PMBUS Registers.
This will prevent accidental writing to the Module.
Data: 80h – Disable all write except to the
WRITE_PROTECT command.
Data: 00h – Enable writes to all commands.</td></tr>
<tr><td>78h</td><td>STATUS_BYTE</td><td>Standard PMBUS STATUS Register.
Returns one byte of information with the summary of the most critical faults.
Please see below Listing of STATUS_BYTE supported Bits:
<table>
<tr><th>Bit #</th><th>Status Bit Name</th><th>Supported</th></tr>
<tr><td>7</td><td>BUSY</td><td>No</td></tr>
<tr><td>6</td><td>OFF</td><td>Yes</td></tr>
<tr><td>5</td><td>VOUT_OV_FAULT</td><td>Yes</td></tr>
<tr><td>4</td><td>IOUT_OC_FAULT</td><td>No</td></tr>
<tr><td>3</td><td>VIN_UV_FAULT</td><td>Yes</td></tr>
<tr><td>2</td><td>TEMPERATURE</td><td>Yes</td></tr>
<tr><td>1</td><td>CML</td><td>Yes</td></tr>
<tr><td>0</td><td>NONE OF THE ABOVE</td><td>No</td></tr>
</table></td></tr>
<tr><td>79h</td><td>STATUS_WORD</td><td>Standard PMBUS STATUS Register.
Returns two byte of information with the summary of the unit’s faults condition. Based on the information, User can get more information by reading the appropriate status registers.
The low byte of the STATUS_WORD is the same register as the STATUS_BYTE command.
Please see below Listing of STATUS_WORD supported Bits:
LOW BYTE</td></tr>
</table>

<table>
<tr>
<td></td>
<td></td>
<td>Please refer to Command Code 0x78h STATUS_BYTE
HIGH BYTE
<table>
<tr><th>Bit #</th><th>Status Bit Name</th><th>Supported</th></tr>
<tr><td>7</td><td>VOUT</td><td>Yes</td></tr>
<tr><td>6</td><td>IOUT/POUT</td><td>Yes</td></tr>
<tr><td>5</td><td>INPUT</td><td>Yes</td></tr>
<tr><td>4</td><td>MFR_SPECIFIC</td><td>Yes</td></tr>
<tr><td>3</td><td>POWER_GOOD#</td><td>Yes</td></tr>
<tr><td>2</td><td>FANS</td><td>No</td></tr>
<tr><td>1</td><td>OTHER</td><td>No</td></tr>
<tr><td>0</td><td>UNKNOWN</td><td>No</td></tr>
</table></td>
</tr>
<tr>
<td>7Ah</td>
<td>STATUS_VOUT</td>
<td>Standard PMBUS STATUS Register.
Command returns one data byte with contents as follows:
<table>
<tr><th>Bit #</th><th>Status Bit Name</th><th>Supported</th></tr>
<tr><td>7</td><td>VOUT Overvoltage Fault</td><td>Yes</td></tr>
<tr><td>6</td><td>VOUT Overvoltage Warning</td><td>Yes</td></tr>
<tr><td>5</td><td>VOUT Undervoltage Warning</td><td>Yes</td></tr>
<tr><td>4</td><td>VOUT Undervoltage Fault</td><td>Yes</td></tr>
<tr><td>3</td><td>VOUT Max Warning</td><td>No</td></tr>
<tr><td>2</td><td>TON Max Fault</td><td>No</td></tr>
<tr><td>1</td><td>TON Max Warning</td><td>No</td></tr>
<tr><td>0</td><td>VOUT Tracking Error</td><td>No</td></tr>
</table></td>
</tr>
<tr>
<td>7Ch</td>
<td>STATUS_INPUT</td>
<td>Standard PMBUS STATUS Register.
Command returns one data byte with contents as follows:
<table>
<tr><th>Bit #</th><th>Status Bit Name</th><th>Supported</th></tr>
<tr><td>7</td><td>VIN Overvoltage Fault</td><td>Yes</td></tr>
<tr><td>6</td><td>VIN Overvoltage Warning</td><td>Yes</td></tr>
<tr><td>5</td><td>VIN Undervoltage Warning</td><td>Yes</td></tr>
</table></td>
</tr>
</table>

<table>
<tr><td></td><td></td><td>
<table>
<tr><td>4</td><td>VIN Undervoltage Fault</td><td>Yes</td></tr>
<tr><td>3</td><td>Unit is Off for Insufficient Input Voltage</td><td>No</td></tr>
<tr><td>2</td><td>IIN Overcurrent Fault</td><td>No</td></tr>
<tr><td>1</td><td>IIN Overcurrent Warning</td><td>No</td></tr>
<tr><td>0</td><td>PIN Overpower Warning</td><td>No</td></tr>
</table>
</td></tr>
<tr><td>7Dh</td><td>STATUS_TEMPERATURE</td><td>Standard PMBUS STATUS Register.
Command returns one data byte with contents as follows:
<table>
<tr><th>Bit #</th><th>Status Bit Name</th><th>Supported</th></tr>
<tr><td>7</td><td>OT_FAULT</td><td>Yes</td></tr>
<tr><td>6</td><td>OT_WARNING</td><td>Yes</td></tr>
<tr><td>5</td><td>UT_WARNING</td><td>No</td></tr>
<tr><td>4</td><td>UT_FAULT</td><td>No</td></tr>
<tr><td>3</td><td>Reserved</td><td>No</td></tr>
<tr><td>2</td><td>Reserved</td><td>No</td></tr>
<tr><td>1</td><td>Reserved</td><td>No</td></tr>
<tr><td>0</td><td>Reserved</td><td>No</td></tr>
</table>
</td></tr>
<tr><td>7Eh</td><td>STATUS_CML</td><td>Standard PMBUS STATUS Register.
Command returns one data byte with contents as follows:
<table>
<tr><th>Bit #</th><th>Status Bit Name</th><th>Supported</th></tr>
<tr><td>7</td><td>Invalid Or Unsupported Command Received</td><td>Yes</td></tr>
<tr><td>6</td><td>Invalid Or Unsupported Data Received</td><td>Yes</td></tr>
<tr><td>5</td><td>Packet Error Check Failed</td><td>Yes</td></tr>
<tr><td>4</td><td>Memory Fault Detected</td><td>Yes</td></tr>
<tr><td>3</td><td>Processor Fault Detected</td><td>No</td></tr>
<tr><td>2</td><td>Reserved</td><td>No</td></tr>
</table>
</td></tr>
</table>

<table>
<tr><td></td><td></td><td>
<table>
<tr><td>1</td><td>A communication fault other than the ones listed in this table has
occurred</td><td>No</td></tr>
<tr><td>0</td><td>Other Memory Or Logic Fault has occurred.</td><td>No</td></tr>
</table>
</td></tr>
<tr><td>80h</td><td>STATUS_MFR_SPECIFIC</td><td>Standard PMBUS STATUS Register.
Command returns one data byte with contents as follows:
<table>
<tr><th>Bit #</th><th>Status Bit Name</th><th>Supported</th></tr>
<tr><td>7</td><td>RAIL3 Fault</td><td>Yes</td></tr>
<tr><td>6</td><td>RAIL2 Fault</td><td>Yes</td></tr>
<tr><td>5</td><td>RAIL1 Fault</td><td>Yes</td></tr>
<tr><td>4</td><td>Reserved</td><td>No</td></tr>
<tr><td>3</td><td>Reserved</td><td>No</td></tr>
<tr><td>2</td><td>Reserved</td><td>No</td></tr>
<tr><td>1</td><td>Reserved</td><td>No</td></tr>
<tr><td>0</td><td>BULK OVP/DVP</td><td>Yes</td></tr>
</table>
</td></tr>
<tr><td>99h</td><td>MFR_ID</td><td>Standard PMBUS command.
Command to return back the manufacturer’s name.</td></tr>
<tr><td>9Ah</td><td>MFR_MODEL</td><td>Standard PMBUS command.
Command to return back the manufacturer’s model number</td></tr>
<tr><td>E0h</td><td>FW_PRI_VERSION</td><td>Manufacture specific command.
Command to return back the SW version of the device.</td></tr>
<tr><td>E9h</td><td>MFR_STATUS_01</td><td>PMBUS Command for Summary of PFC present status.

This PMBUS command has 3 indexes. Each index contains 2 bytes of data.

Index 00 “Input Status”
<table>
<tr><th>Bit</th><th>Bit Name</th></tr>
<tr><td>Bit15</td><td>Reserved</td></tr>
<tr><td>Bit14</td><td>Reserved</td></tr>
<tr><td>Bit13</td><td>Reserved</td></tr>
<tr><td>Bit12</td><td>Reserved</td></tr>
<tr><td>Bit11</td><td>Vin3OVP</td></tr>
</table>
</td></tr>
</table>

Bit10	Vin2OVP
Bit9	Vin1OVP
Bit8	Vin3UVP
Bit7	Vin2UVP
Bit6	Vin1UVP
Bit5	AUX
Bit4	Relay
Bit3	Supply
Bit2	PSON
Bit1	Address
Bit0	BulkOK

Index 01 “PFC Status”

Bit	Bit Name
Bit15	Reserved
Bit14	Reserved
Bit13	Reserved
Bit12	Reserved
Bit11	Reserved
Bit10	Reserved
Bit9	Reserved
Bit8	OPW
Bit7	OCW
Bit6	OVW
Bit5	Other
Bit4	SCKT
Bit3	OCP
Bit2	UVP
Bit1	OVP
Bit0	OutOK

Index 02 “VBUS Status”

Bit	Bit Name
Bit15	Reserved

		Bit14	Reserved
		Bit13	Reserved
		Bit12	Reserved
		Bit11	Differential Voltage Protection Rail3
		Bit10	Differential Voltage Protection Rail2
		Bit9	Differential Voltage Protection Rail1
		Bit8	Bulk Short Circuit3
		Bit7	Bulk Short Circuit2
		Bit6	Bulk Short Circuit1
		Bit5	Bulk Under Voltage Protection Rail3
		Bit4	Bulk Under Voltage Protection Rail2
		Bit3	Bulk Under Voltage Protection Rail1
		Bit2	Bulk Over Voltage Protection Rail3
		Bit1	Bulk Over Voltage Protection Rail2
		Bit0	Bulk Over Voltage Protection Rail1

PFC Command Data Classifications

Command Code	Command Name	Transaction Type	# of Bytes	Data Format	Write Protection
03h	CLEAR_FAULTS	Send Byte	0	N/A	Basic
10h	WRITE_PROTECT	Read/Write Byte	1	Bitmapped	N/A
78h	STATUS_BYTE	Read Byte	1	Bitmapped	N/A
79h	STATUS_WORD	Read Word	2	Bitmapped	N/A
7Ah	STATUS_VOUT	Read Byte	1	Bitmapped	Basic
7Ch	STATUS_INPUT	Read Byte	1	Bitmapped	Basic
7Dh	STATUS_TEMPERATURE	Read Byte	1	Bitmapped	Basic
7Eh	STATUS_CML	Read Byte	1	Bitmapped	Basic
80h	STATUS_MFR_SPECIFIC	Read Byte	1	Bitmapped	Basic
99h	MFR_ID	Block Read	7	ASCII	N/A
9Ah	MFR_MODEL	Block Read	15	ASCII	N/A
E0h	FW_PRI_VERSION	Block Read	8	ASCII	N/A

E9h	MFR_STATUS_01	Block Read	2 bytes per index	Bitmapped	N/A

Note:

24kW iHP Rack is composed of 2 boards of 12kW PFC.
In PFC PMBUS Commands,

- IOUT refers to the Output current of the PFC in which the command is addressed.
- VOUT refers to the Output voltage of the PFC in which the command is addressed.
- VIN refers to the Input Voltage of the PFC in which the command is addressed.
- IIN refers to the Input Current of the PFC in which the command is addressed.

B.2 MODULE PMBUS Command

To convert Linear Data Format to "real world value", please refer to appendix B.4

To convert Direct Data Format to "real world value", please refer to appendix B.5

MODULE Command Definition

Command Code	Command Name	Definition
01h	OPERATION	Standard PMBUS STATUS Register. Command used to Turn-off or Turn-on the module. Bit6 = 0 and Bit 7 = 1 : Module is ON Bit6 = 0 and Bit 7 = 0 : Module is OFF Bit 0 to Bit 5 : Don't Care User Configurable.
03h	CLEAR_FAULTS	Standard PMBUS command To remove the warning or fault bits set in the status register, User need to send CLEAR_FAULT command. This command will only clear the status registers fault.
10h	WRITE_PROTECT	Standard PMBUS command Command used to Enable or Disable writing to the Module PMBUS Registers. This will prevent accidental writing to the Module. Data: 80h – Disable all write except to the WRITE_PROTECT command. Data: 40h – Disable all write except to the WRITE_PROTECT and OPERATION command.

		Data: 00h – Enable writes to all commands.
24h	VOUT_MAX	Read maximum output voltage of the Module. Automatically Set to 120% of Nominal Rating. Refer to Module Command data classification for Data Format
31h	POUT_MAX	Read Module's rated power Refer to Module Command data classification for Data Format
40h	MFR_REG	Manufacturer register. Do not access.
41h	VOUT_OV_FAULT_RESPONSE	Standard PMBUS STATUS Register. Read Module Response during over-voltage fault condition Fix Data: 80h – Device Latch.
42h	MFR_REG	Manufacturer register. Do not access.
43h	MFR_REG	Manufacturer register. Do not access.
44h	MFR_REG	Manufacturer register. Do not access.
45h	VOUT_UV_FAULT_RESPONSE	Standard PMBUS STATUS Register. Read Module Response during under-voltage fault condition Fix Data: 80h – Device Latch
46h	MFR_REG	Manufacturer register. Do not access.
47h	MFR_REG	Manufacturer register. Do not access.
48h	OV_FAULT_LIMIT_MULTIPLIER	Data is used to compute for the tracking over voltage protection (OVP) of the module Refer to Module Command data classification for Data Format. During Digital Voltage Source (DVS), Analog Current Source (ACS), and Digital Current Source (DCS). OVP Level = VREF + (Nominal Voltage * (OVP Multiplier-1))

		During AVS, this PMBUS Register is not functional. Data Range: 120% to 130% If user commands outside the set range, 0x7Eh STATUS_CML will be asserted with invalid data fault. User Configurable. This parameter will be override by BRICK OVP Level if target TRACKING OVP Level is higher than BRICK OVP Level. Please refer to iHP Manual for the setting of the BRICK OVP level.
49h	OV_WARN_LIMIT_MULTIPLIER	Data is used to compute for the over voltage warning (OVW) level of the module Refer to Module Command data classification for Data Format. During Digital Voltage Source (DVS), Analog Current Source (ACS), and Digital Current Source (DCS). OVW Level = VREF + (Nominal Voltage * (OVP Multiplier-1)) During Analog Voltage Source (AVS), this PMBUS Register is not functional. Data Range: 105% to 125% If user command outside the set range, 0x7Eh STATUS_CML will be asserted with invalid data fault User Configurable.
4Ah	MFR_REG	Manufacturer register. Do not access.
4Bh	UV_FAULT_LIMIT_MULTIPLIER	Data is used to compute for the under voltage protection (UVP) level of the module Refer to Module Command data classification for Data Format. Under Voltage Protection is functional during Digital Programming Voltage Source (DVS)

		UVP Level = VREF – (Nominal Voltage * (1-UVP Multiplier)) Data Range: 80% to 90% This function will be disable when the VREF is set to less than or equal to 10% of the nominal. If user command outside the set range, 0x7Eh STATUS_CML will be asserted with invalid data fault User Configurable.
4Ch	UV_WARN_LIMIT_MULTIPLIER	Data is used to compute for the under voltage warning (UVW) level of the module Refer to Module Command data classification for Data Format. Under Voltage Warning is functional during Digital Voltage Source (DVS) UVW Level = VREF – (Nominal Voltage *(1- UVP Multiplier)) Data Range: 85% to 95% This function will be disable when the VREF is set to less than or equal to 10% of the nominal. If user command outside the set range, 0x7Eh STATUS_CML will be asserted with invalid data fault User Configurable.
4Dh	OC_FAULT_LIMIT_MULTIPLIER	Data is used to compute for the Over Current Protection (OCP) level of the module Refer to Module Command data classification for Data Format. Digital Voltage Source and Analog Voltage Source Latch type OC level = (Io nominal)*(OC_FAULT_LIMIT_MULTIPLIER) CC type OC level = (Io nominal)*(OC_FAULT_LIMIT_MULTIPLIER) Data Range: 50% to 105% Digital Current Source and Analog Current Source

		OC_FAULT_LIMIT_MULTIPLIER is not functional during this operation.
4Eh	MFR_REG	Manufacturer register. Do not access.
4Fh	OT_FAULT_LIMIT	Over Temperature Protection level of the Module for TEMP1. Refer to Module Command data classification for Data Format. Fix data varies per module series.
50h	OT_FAULT_RESPONSE	Standard PMBUS STATUS Register. Read Module Response during over temperature fault condition Fix Data: B8h – Device Shuts down Unit attempt to restart continuously, when required condition is met, until commanded OFF, bias power is removed, or another fault condition shuts the module down.
51h	OT_WARN_LIMIT	Over Temperature Warning level of the Module for TEMP1. Refer to Module Command data classification for Data Format. Fix data varies per module series.
52h	OC_RESPONSE_TYPE	Command to read/write Over-current Protection Type Applicable only during Voltage Source configuration. Data 00h - CC Type Protection Data 01h - Latch Type Protection User Configurable.
53h	MFR_REG	Manufacturer register. Do not access.
54h	MFR_REG	Manufacturer register. Do not access.
5Eh	POWER_GOOD_ON	Command to read the output voltage level (DVS) where POWER_GOOD signal is asserted. Refer to Module Command data classification for Data Format.

<table>
<tr><td></td><td></td><td>During Digital Programming Voltage Source,
Vo @ Power Good ON = VREF * POWER_GOOD_ON
This PMBUS command is not functional during DCS, AVS and ACS.</td></tr>
<tr><td>5Fh</td><td>POWER_GOOD_OFF</td><td>Command to read the output voltage level (DVS) where POWER_GOOD signal is de-asserted.
Refer to Module Command data classification for Data Format.

During Digital Voltage Source,
Vo @ Power Good OFF = VREF * POWER_GOOD_OFF

This PMBUS command is not functional during APVS and APCS.</td></tr>
<tr><td>61h</td><td>MFR_REG</td><td>Manufacturer register.
Do not access.</td></tr>
<tr><td>62h</td><td>MFR_REG</td><td>Manufacturer register.
Do not access.</td></tr>
<tr><td>63h</td><td>MFR_REG</td><td>Manufacturer register.
Do not access.</td></tr>
<tr><td>6Ah</td><td>MFR_REG</td><td>Manufacturer register.
Do not access.</td></tr>
<tr><td>78h</td><td>STATUS_BYTE</td><td>Standard PMBUS STATUS Register.
Returns one byte of information with the summary of the most critical Module faults.
Please see below Listing of STATUS_BYTE supported Bits:

<table>
<tr><th>Bit #</th><th>Status Bit Name</th><th>Supported</th></tr>
<tr><td>7</td><td>BUSY</td><td>No</td></tr>
<tr><td>6</td><td>OFF</td><td>Yes</td></tr>
<tr><td>5</td><td>VOUT_OV_FAULT</td><td>Yes</td></tr>
<tr><td>4</td><td>IOUT_OC_FAULT</td><td>Yes</td></tr>
<tr><td>3</td><td>VIN_UV_FAULT</td><td>No</td></tr>
<tr><td>2</td><td>TEMPERATURE</td><td>Yes</td></tr>
</table>
</td></tr>
</table>

<table>
<tr><td></td><td></td><td>
<table>
<tr><td>1</td><td>CML</td><td>Yes</td></tr>
<tr><td>0</td><td>NONE OF THE ABOVE</td><td>Yes</td></tr>
</table>
</td></tr>
<tr><td>79h</td><td>STATUS_WORD</td><td>
Standard PMBUS STATUS Register.

Returns two byte of information with the summary of the Module’s faults condition. Based on the information, User can get more information by reading the appropriate status registers.

The low byte of the STATUS_WORD is the same register as the STATUS_BYTE command.

Please see below Listing of STATUS_WORD supported Bits:

LOW BYTE

Please refer to Module Command Code 0x78h STATUS_BYTE

HIGH BYTE
<table>
<tr><th>Bit #</th><th>Status Bit Name</th><th>Supported</th></tr>
<tr><td>7</td><td>VOUT</td><td>Yes</td></tr>
<tr><td>6</td><td>IOUT/POUT</td><td>Yes</td></tr>
<tr><td>5</td><td>INPUT</td><td>Yes</td></tr>
<tr><td>4</td><td>MFR_SPECIFIC</td><td>Yes</td></tr>
<tr><td>3</td><td>POWER_GOOD#</td><td>Yes</td></tr>
<tr><td>2</td><td>FANS</td><td>No</td></tr>
<tr><td>1</td><td>OTHER</td><td>No</td></tr>
<tr><td>0</td><td>UNKNOWN</td><td>No</td></tr>
</table>
</td></tr>
<tr><td>7Ah</td><td>STATUS_VOUT</td><td>
Standard PMBUS STATUS Register.

Command returns one data byte with contents as follows:
<table>
<tr><th>Bit #</th><th>Status Bit Name</th><th>Supported</th></tr>
<tr><td>7</td><td>VOUT Overvoltage Fault</td><td>Yes</td></tr>
<tr><td>6</td><td>VOUT Overvoltage Warning</td><td>Yes</td></tr>
<tr><td>5</td><td>VOUT Undervoltage Warning</td><td>Yes</td></tr>
<tr><td>4</td><td>VOUT Undervoltage Fault</td><td>Yes</td></tr>
<tr><td>3</td><td>VOUT Max Warning</td><td>No</td></tr>
</table>
</td></tr>
</table>

2	TON Max Fault	No
1	TON Max Warning	No
0	VOUT Tracking Error	No

7Bh — STATUS_IOUT

Standard PMBUS STATUS Register.

Command returns one data byte with contents as follows:

Bit #	Status Bit Name	Supported
7	IOUT Overcurrent Fault	Yes
6	IOUT Overcurrent and Low Voltage Shutdwown Fault	No
5	IOUT_OC_WARNING	Yes
4	IOUT_UC_FAULT	No
3	Current Share Fault	No
2	In Power Limiting Mode	No
1	POUT_OP_FAULT	No
0	POUT_OP_WARNING	No

7Ch — STATUS_INPUT

Standard PMBUS STATUS Register.

Command returns one data byte with contents as follows:

Bit #	Status Bit Name	Supported
7	VIN Overvoltage Fault	No
6	VIN Overvoltage Warning	No
5	VIN Undervoltage Warning	No
4	VIN Undervoltage Fault	No
3	Unit is Off for Insufficient Input Voltage	No
2	IIN Overcurrent Fault	Yes
1	IIN Overcurrent Warning	Yes
0	PIN Overpower Warning	No

Bit 1 and 2 will be asserted when Module Primary Over

<table>
<tr><td></td><td></td><td>Current fault is triggered.</td></tr>
<tr><td>7Dh</td><td>STATUS_TEMPERATURE</td><td>Standard PMBUS STATUS Register.
Command returns one data byte with contents as follows:
<table>
<tr><th>Bit #</th><th>Status Bit Name</th><th>Supported</th></tr>
<tr><td>7</td><td>OT_FAULT</td><td>Yes</td></tr>
<tr><td>6</td><td>OT_WARNING</td><td>Yes</td></tr>
<tr><td>5</td><td>UT_WARNING</td><td>No</td></tr>
<tr><td>4</td><td>UT_FAULT</td><td>No</td></tr>
<tr><td>3</td><td>Reserved</td><td>No</td></tr>
<tr><td>2</td><td>Reserved</td><td>No</td></tr>
<tr><td>1</td><td>Reserved</td><td>No</td></tr>
<tr><td>0</td><td>Reserved</td><td>No</td></tr>
</table></td></tr>
<tr><td>7Eh</td><td>STATUS_CML</td><td>Standard PMBUS STATUS Register.
Command returns one data byte with contents as follows:
<table>
<tr><th>Bit #</th><th>Status Bit Name</th><th>Supported</th></tr>
<tr><td>7</td><td>Invalid Or Unsupported Command Received</td><td>Yes</td></tr>
<tr><td>6</td><td>Invalid Or Unsupported Data Received</td><td>Yes</td></tr>
<tr><td>5</td><td>Packet Error Check Failed</td><td>Yes</td></tr>
<tr><td>4</td><td>Memory Fault Detected</td><td>Yes</td></tr>
<tr><td>3</td><td>Processor Fault Detected</td><td>No</td></tr>
<tr><td>2</td><td>Reserved</td><td>No</td></tr>
<tr><td>1</td><td>A communication fault other than the ones listed in this table has
occurred</td><td>No</td></tr>
<tr><td>0</td><td>Other Memory Or Logic Fault has occurred.</td><td>No</td></tr>
</table></td></tr>
<tr><td>80h</td><td>STATUS_MFR_SPECIFIC</td><td>Standard PMBUS STATUS Register.
Command returns one data byte with contents as follows:</td></tr>
</table>

		Bitmap: Bit7: Asserted when Memory Error occur Bit6: Reserved Bit5: Asserted when DSP supply goes below regulation Bit4: Reserved Bit3: Asserted when module primary current imbalance occur Bit2: Asserted when module primary over current occur Bit1: Reserved Bit0: Asserted when internal CAN communication fault occur.
8Bh	READ_VOUT	Module Output Voltage reporting Refer to Module Command data classification for Data Format.
8Ch	READ_IOUT	Module Output Current reporting Refer to Module Command data classification for Data Format.
8Dh	READ_TEMPERATURE_1	Module power device temperature reporting Refer to Module Command data classification for Data Format.
8Eh	MFR_REG	Manufacturer register. Do not access.
8Fh	READ_TEMPERATURE_3	Module Transformer temperature reporting Refer to Module Command data classification for Data Format.
96h	Read_POUT	Module Output Power reporting Refer to Module Command data classification for Data Format. .
99h	MFR_ID	Standard PMBUS command Command to indicate the manufacturer's Identification. Fix data: "ARTESYN"
9Ah	MFR_MODEL	Standard PMBUS command Command to indicate the manufacturer's model number. Data : Varies per module series
9Bh	MFR_REVISION	Standard PMBUS command Command to indicate the module revision number Data : Varies per module series

9Ch	MFR_LOCATION	Standard PMBUS command Command to indicate the manufacturer's location. Fix data: "PHILIPPINES"
9Dh	MFR_DATE	Standard PMBUS command Command to indicate the Module's Manufacturing Date. Data format: "YYMMDD"
9Eh	MFR_SERIAL	Standard PMBUS command Module's serial number. Command to indicate the
A4h	MFR_VOUT_MIN	Standard PMBUS command Minimum Output voltage that can be set in the Module. Refer to Module Command data classification for Data Format.
A5h	MFR_VOUT_MAX	Standard PMBUS command Maximum Output voltage that can be set in the Module. Refer to Module Command data classification for Data Format.
A6h	MFR_IOUT_MAX	Standard PMBUS command Maximum Output current that can be set in the Module. Refer to Module Command data classification for Data Format.
A7h	MFR_POUT_MAX	Standard PMBUS command Maximum Output Power that can be delivery by the Module the Module. Refer to Module Command data classification for Data Format.
B0h	FRU_DATA	Command to return FRU data of the Module.
B1h	VREF	Module voltage reference. Refer to Module Command data classification for Data Format. Command have different function in each Module operation (D3h) Digital Voltage Source - User Configurable. User can change output voltage using this command from 5% of nominal Vout to 120% of nominal Vout.

		- The Module will enter to standby mode when user writes 0V to this register. Analog Voltage Source - Read Only - Automatically set to Module Nominal Output Voltage - Not functional during this operation. Digital/Analog Current Source - User Configurable. User can change output voltage using this command from 5% of nominal Vout to 100% of nominal Vout. - Clamp Voltage during Current Source operation
B2h	IREF	Module current reference. Refer to Module Command data classification for Data Format. Digital Current Source - User Configurable. User can change output current using this command from 0A to Nominal output current. - The Module will enter to standby mode when user writes 0A to this register. Analog Current Source - Read Only - Automatically set to 0A. - Not functional during this operation. Digital/Analog Voltage Source - Read only. - Latch type Fault: Fix to 120% of nominal output current. Not functional. - CC Type Fault: IREF= (Io nominal)*(OC_FAULT_LIMIT_MULTIPLIER) PMBUS command 4Dh OC_FAULT_LIMIT_MULTIPLIER

B3h	MFR_REG	Manufacturer register. Do not access.
B5h	SET_VOLTAGE_RISE_SETTING	Command used to read the voltage rise time during Module's Digital Voltage Source (DVS) operation. Data Range: 00h – 0Fh Data 0x02h: 50ms (+/- 5ms) Data 0x03h: 70ms (+/- 5ms) Data 0x04h: 80ms (+/- 5ms) Data 0x05h: 90ms (+/- 5ms) Data 0x06h: 100ms (+/- 5ms) Data 0x07h: 110ms (+/- 5ms) Data 0x08h: 120ms (+/- 5ms) Data 0x09h: 130ms (+/- 5ms) Data 0x0Ah: 140ms (+/- 5ms) Data 0x0Bh: 150ms (+/- 5ms) Data 0x0Ch: 175ms (+/- 10ms) Data 0x0Dh: 200ms (+/- 10ms) Data 0x0Eh: 225ms (+/- 10ms) Data 0x0Fh: 250ms (+/- 10ms) Send Command to Module Read only. User Configurable To configure use ISOCOMM PMBUS Command B5h to change Module B5h.
B6h	SET_CURRENT_RISE_ SETTING	Command used to read the current rise time during Module's Digital Current Source (DCS) operation. Data Range: 00h – 0Fh Data 0x00h: 7.2ms Data 0x01h: 100ms (+/- 10ms) Data 0x02h: 125ms (+/- 10ms) Data 0x03h: 150ms (+/- 10ms) Data 0x04h: 175ms (+/- 10ms)

		Data 0x05h: 200ms (+/- 10ms) Data 0x06h: 225ms (+/- 10ms) Data 0x07h: 250ms (+/- 10ms) Data 0x08h: 300ms (+/- 10ms) Data 0x09h: 350ms (+/- 10ms) Data 0x0Ah: 400ms (+/- 10ms) Data 0x0Bh: 450ms (+/- 10ms) Data 0x0Ch: 500ms (+/- 10ms) Data 0x0Dh: 700ms (+/- 50ms) Data 0x0Eh: 900ms (+/- 50ms) Data 0x0Fh: 1250ms (+/- 50ms) Send Command to Module Read only. User Configurable To configure use ISOCOMM PMBUS Command B6h to change Module B6h.
B7h	SET_IO_ACTIVE_LEVEL_LOGIC	Command used to set the logic of SYS_M_FAULT#, SYS_M_ENABLE#, and SYS_M_INHIBIT signals. Bitmap: Bit7: Reserved Bit6: Reserved Bit5: Reserved Bit4: Reserved Bit3: Reserved Bit2: Data: 1 – SYS_M_FAULT# Logic High means Module is at Fault. Data: 0 – SYS_M_FAULT# Logic Low means Module is at Fault. Bit1: Data: 1 – Module will turn-off if SYS_M_INHIBIT is Logic High Data: 0 –Module will turn-off if SYS_M_INHIBIT is Logic Low. Bit0: Data: 1 – Module will turn-on if SYS_M_ENABLE# is

		Logic High Data: 0 –Module will turn-on if SYS_M_ENABLE# is Logic Low. Please refer to Section 3.2.1.1 Module's J1 Signal for the recommended external circuitry for SYS_M_ENABLE#, SYS_M_FAULT#, and SYS_M_INHIBIT signal User Configurable
B8h	SET_MODULE_LOAD_TYPE	Command to read Module compensation Data: 01h – Resistive load compensation Data: 02h - Capacitive load compensation Data: 04h - LED load compensation User Configurable To configure use ISOCOMM PMBUS Command B8h to change Module B8h.
B9h	MFR_REG	Manufacturer register. Do not access.
BAh	ANALOG_FILTER_ENABLE	To enable or disable heavy filtering of IPROG signal during ACS or VPROG signal during AVS. Bit2 to7: Reserved/Unused Bit1: Data "1" ACS Heavy Filter Data "0" Bit0: Data"1" AVS operation and modules in parallel. Sharing enable Data"0" AVS operation and modules stand-alone Waveshape enable.
BBh	MFR_REG	Manufacturer register. Do not access.
D0h	SHUTDOWN_CAUSE	Status that indicate the cause of Module shutdown

		Bitmap: Bit 4-6: Reserved/Unused Bit3: Config Inhibit Status : Module inhibit status during Module Configuration change. Bit 2: Module is ON (1), Module is OFF (0) Bit 1: Module Auto Recoverable Fault Assert Bit Due to: 1) OT Fault, 2) COMM Fault, 3) Invalid Programming (PGM) Range and 4) Output Short Circuit Bit 0: Module Latch Type Fault Assert Bit Due to: 1) Over-voltage Fault, 2) Under-voltage Fault, 3) Over-current Fault, 4) Primary Over-current Fault, 5) Rail Imbalance Fault, and 6) Supply_MON Fault
D3h	MODULE_CONFIG	Command to Read Module Configuration Mode Bitmap: Bit 7-4: Reserved/Unused Bit 6: Reserved Bit 5: Reserved Bit 4: Reserved/Unused Bit 3: Source Selection Data 1: Current Source Mode Data 0: Voltage Source Mode Bit 2: Reserved/Unused Bit 1: Select Analog or Digital Control Data 1: Analog Control

		Data 0: Digital Control Bit 0: Current Sensing Data 1: External Shunt Data 0: Internal Shunt Bit 5 data should be data 0 all the time. Send Command to Module Read only. User Configurable To configure use ISOCOMM PMBUS Command D3h to change Module configuration D3h.
D4h	MFR_REG	Manufacturer register. Do not access.
D5h	MFR_REG	Manufacturer register. Do not access.
D7h	MFR_REG	Manufacturer register. Do not access.
E1h	FW_SEC_VERSION	Command to read Module Software version
E2h	MFR_REG	Manufacturer register. Do not access.
E3h	MFR_REG	Manufacturer register. Do not access.
E4h	MFR_REG	Manufacturer register. Do not access.
E5h	OPTN_TIME_TOTAL	Command to read the total time when the Module is turn-on and the output is operational. This will reset when the iHP Rack is turn-off.
E6h	OPTN_TIME_PRESENT	Command to read the total time when the Module is turn-on and the output is operational. This will reset when the module enters to standby mode.
E7h	HISTORY_DATA	Command to read the Module History Data.
E8h	HISTORY_CLEAR	Command to clear History Data
E9h	CALIBRATION_DATE	Command to read the last calibration date.

		Data representation: YYMMDD YY – Year MM - Month DD – Day
EDh	MFR_REG	Manufacturer register. Do not access.
F6h	MFR_REG	Manufacturer register. Do not access.
F7h	MFR_REG	Manufacturer register. Do not access.
F9H	MFR_REG	Manufacturer register. Do not access.
FAh	MFR_REG	Manufacturer register. Do not access.
FBh	MFR_REG	Manufacturer register. Do not access.

Module Command Data Classifications

Command	Command Name	Transaction Type	# of Bytes	Data Format	Multiplier	Data Unit	Write Protection
01h	OPERATION	Read/Write Byte	1	Bitmapped	N/A	N/A	Basic

03h	CLEAR_FAULTS	Send Byte	0	N/A	N/A	N/A	Basic
10h	WRITE_PROTECT	Read/Write Byte	1	Bitmapped	N/A	N/A	None
24h	VOUT_MAX	Read Word	3	DIRECT	10000	V	N/A
31h	POUT_MAX	Read Word	2	Linear	N/A	W	N/A
41h	VOUT_OV_FAULT_RESPONSE	Read Byte	1	Bitmapped	N/A	N/A	N/A
45h	VOUT_UV_FAULT_RESPONSE	Read Byte	1	Bitmapped	N/A	N/A	N/A
48h	OV_FAULT_LIMIT_MULTIPLIER	Block Read/Write Word	2	DIRECT	100	%	Basic
49h	OV_WARN_LIMIT_MULTIPLIER	Block Read/Write Word	2	DIRECT	100	%	Basic
4Bh	UV_FAULT_LIMIT_MULTIPLIER	Block Read/Write Word	2	DIRECT	100	%	Basic
4Ch	UV_WARN_LIMIT_MULTIPLIER	Block Read/Write Word	2	DIRECT	100	%	Basic
4Dh	OC_FAULT_LIMIT_MULTIPLIER	Block Read/Write	2	DIRECT	100	%	Basic
4Fh	OT_FAULT_LIMIT	Read Word	2	Linear	N/A	^{0}C	N/A
50h	OT_FAULT_RESPONSE	Read Byte	1	Bitmapped	N/A	N/A	N/A
51h	OT_WARN_LIMIT	Read Word	2	Linear	N/A	^{0}C	N/A
52h	OC_RESPONSE_TYPE	Read/Write Byte	1	Bitmapped	N/A	N/A	Basic
5Eh	POWER_GOOD_ON	Read Word	3	DIRECT	10000	V	N/A
5Fh	POWER_GOOD_OFF	Read Word	3	DIRECT	10000	V	N/A
78h	STATUS_BYTE	Read Byte	1	Bitmapped	N/A	N/A	N/A
79h	STATUS_WORD	Read Word	2	Bitmapped	N/A	N/A	N/A
7Ah	STATUS_VOUT	Read Byte	1	Bitmapped	N/A	N/A	N/A
7Bh	STATUS_IOUT	Read Byte	1	Bitmapped	N/A	N/A	N/A
7Ch	STATUS_INPUT	Read Byte	1	Bitmapped	N/A	N/A	N/A
7Dh	STATUS_TEMPERATURE	Read Byte	1	Bitmapped	N/A	N/A	N/A
7Eh	STATUS_CML	Read Byte	1	Bitmapped	N/A	N/A	N/A
80h	STATUS_MFR_SPECIFIC	Read Byte	1	Bitmapped	N/A	N/A	N/A
8Bh	READ_VOUT	Read Word	3	DIRECT	10000	V	N/A

8Ch	READ_IOUT	Read Word	3	DIRECT	10000	A	N/A
8Dh	READ_TEMPERATURE_1	Read Word	2	Linear	N/A	^{0}C	N/A
8Fh	READ_TEMPERATURE_3	Read Word	2	Linear	N/A	^{0}C	N/A
96h	READ_POUT	Read Word	2	Linear	N/A	W	N/A
99h	MFR_ID	Block Read	7	ASCII	N/A	N/A	N/A
9Ah	MFR_MODEL	Block Read	15	ASCII	N/A	N/A	N/A
9Bh	MFR_REVISION	Block Read	2	ASCII	N/A	N/A	N/A
9Ch	MFR_LOCATION	Block Read	6	ASCII	N/A	N/A	N/A
9Dh	MFR_DATE	Block Read	2	ASCII	N/A	N/A	N/A
9Eh	MFR_SERIAL	Block Read	13	ASCII	N/A	N/A	N/A
A4h	MFR_VOUT_MIN	Read Word	3	Direct	10000	V	N/A
A5h	MFR_VOUT_MAX	Read Word	3	Direct	10000	V	N/A
A6h	MFR_IOUT_MAX	Read Word	3	Direct	10000	A	N/A
A7h	MFR_POUT_MAX	Read Word	2	Linear	N/A	W	N/A
B1h	VREF	Read/Write Word	3	Direct	10000	V	Basic
B2h	IREF	Read/Write Word	3	Direct	10000	A	Basic
B5h	SET_VOLTAGE_RISE_SETTING	Block Read Word	2	Direct	1	N/A	N/A
B6h	SET_CURRENT_RISE_SETTING	Block Read Word	2	Direct	1	N/A	N/A
B7h	SET_IO_ACTIVE_LEVEL_LOGIC	Block Read/Write	2	Bitmapped	N/A	N/A	Basic
B8h	SET_MODULE_LOAD TYPE	Block Read Word	2	Bitmapped	N/A	N/A	N/A
BAh	ANALOG_FILTER_ENABLE	Read/Write Byte	1	Bitmapped	N/A	N/A	Basic
D0h	FAULT_CONFIG	Read Byte	1	Bitmapped	N/A	N/A	N/A
D3h	MODULE_CONFIG	Read Byte	1	Bitmapped	N/A	N/A	N/A
E1h	FW_SEC_VERSION	Block Read	8	ASCII	N/A	N/A	N/A
E5h	OPTN_TIME_TOTAL	Block Read	4	DIRECT	1	sec	N/A

E6h	OPTN_TIME_PRESENT	Block Read	4	DIRECT	1	sec	N/A
E7h	HISTORY_DATA	Block Read	4	varies	N/A	N/A	N/A
E8h	HISTORY_CLEAR	Send Byte	0	N/A	N/A	N/A	Factory Configuration
E9h	CALIBRATION_DATE	Block Read	6	ASCII	N/A	N/A	N/A

B.3 ISOCOMM PMBUS Command

To convert Linear Data Format to “real world value”, please refer to appendix B.4

To convert Direct Data Format to “real world value”, please refer to appendix B.5

ISOCOMM Command Definition

Command Code	Command Name	Definition

<table>
<tr><td>01h</td><td>OPERATION</td><td>Command used to Turn-off or Turn-on ALL modules.

Bit 7 = 1 : Module is ON
Bit 7 = 0 : Module is OFF
Bit 0 to Bit 6 : Don’t Care

User Configurable.</td></tr>
<tr><td>03h</td><td>CLEAR_FAULTS</td><td>Standard PMBUS command

To remove the warning or fault bits set in the status register, User need to send CLEAR_FAULT command</td></tr>
<tr><td>10h</td><td>WRITE_PROTECT</td><td>Standard PMBUS command

Command used to Enable or Disable writing to the ISOCOMM PMBUS Registers.

This will prevent accidental writing to the Module.

Data: 80h – Disable all write except to the WRITE_PROTECT command.
Data: 00h – Enable writes to all commands.</td></tr>
<tr><td>3Ah</td><td>FAN_CONFIG_1_2</td><td>Standard PMBUS STATUS Register.

Command returns one data byte with contents as follows:
<table>
<tr><th>Bit #</th><th>Status Bit Name</th><th>Fixed data</th></tr>
<tr><td>7</td><td>Data 1: Fan 1 is present.
Data 0: Fan 1 is not present.</td><td>1</td></tr>
<tr><td>6</td><td>Data 1: Fan 1 commanded in RPM
Data 0: Fan 1 commanded Duty Cycle</td><td>0</td></tr>
<tr><td>5</td><td>Fan 1 Tachometer pulses per revolution
00b – 1 pulse per revolution</td><td>0</td></tr>
<tr><td>4</td><td>01b – 2 pulse per revolution
10b – 3 pulse per revolution
11b - 4 pulse per revolution</td><td>1</td></tr>
<tr><td>3</td><td>Data 1: Fan 2 is present.
Data 0: Fan 2 is not present.</td><td>1</td></tr>
<tr><td>2</td><td>Data 1: Fan 2 commanded in RPM
Data 0: Fan 2 commanded Duty Cycle</td><td>0</td></tr>
<tr><td>1</td><td>Fan 2 Tachometer pulses per revolution
00b – 1 pulse per revolution</td><td>0</td></tr>
<tr><td>0</td><td>01b – 2 pulse per revolution</td><td>1</td></tr>
</table></td></tr>
</table>

<table>
<tr><td></td><td></td><td>
<table>
<tr><td></td><td>10b – 3 pulse per revolution
11b - 4 pulse per revolution</td><td></td></tr>
</table>
</td></tr>
<tr><td>3Dh</td><td>FAN_CONFIG_3_4</td><td>
Standard PMBUS STATUS Register.
Command returns one data byte with contents as follows:
<table>
<tr><th>Bit #</th><th>Status Bit Name</th><th>Fixed data</th></tr>
<tr><td>7</td><td>Data 1: Fan 3 is present.
Data 0: Fan 3 is not present.</td><td>1</td></tr>
<tr><td>6</td><td>Data 1: Fan 3 commanded in RPM
Data 0: Fan 3 commanded Duty Cycle</td><td>0</td></tr>
<tr><td>5</td><td rowspan="2">Fan 3 Tachometer pulses per revolution
00b – 1 pulse per revolution
01b – 2 pulse per revolution
10b – 3 pulse per revolution
11b - 4 pulse per revolution</td><td>0</td></tr>
<tr><td>4</td><td>1</td></tr>
<tr><td>3</td><td>Data 1: Fan 4 is present.
Data 0: Fan 4 is not present.</td><td>1</td></tr>
<tr><td>2</td><td>Data 1: Fan 4 commanded in RPM
Data 0: Fan 4 commanded Duty Cycle</td><td>0</td></tr>
<tr><td>1</td><td rowspan="2">Fan 4 Tachometer pulses per revolution
00b – 1 pulse per revolution
01b – 2 pulse per revolution
10b – 3 pulse per revolution
11b - 4 pulse per revolution</td><td>0</td></tr>
<tr><td>0</td><td>1</td></tr>
</table>
</td></tr>
<tr><td>78h</td><td>STATUS_BYTE</td><td>
Standard PMBUS STATUS Register.
Returns one byte of information with the summary of the most critical ISOCOMM faults.
Please see below Listing of STATUS_BYTE supported Bits:
<table>
<tr><th>Bit #</th><th>Status Bit Name</th><th>Supported</th></tr>
<tr><td>7</td><td>BUSY</td><td>No</td></tr>
<tr><td>6</td><td>OFF</td><td>No</td></tr>
</table>
</td></tr>
</table>

<table>
<tr><td></td><td></td><td>
<table>
<tr><td>5</td><td>VOUT_OV_FAULT</td><td>No</td></tr>
<tr><td>4</td><td>IOUT_OC_FAULT</td><td>No</td></tr>
<tr><td>3</td><td>VIN_UV_FAULT</td><td>No</td></tr>
<tr><td>2</td><td>TEMPERATURE</td><td>Yes</td></tr>
<tr><td>1</td><td>CML</td><td>Yes</td></tr>
<tr><td>0</td><td>NONE OF THE ABOVE</td><td>Yes</td></tr>
</table>
</td></tr>
<tr><td>79h</td><td>STATUS_WORD</td><td>
Standard PMBUS STATUS Register.

Returns two byte of information with the summary of the ISOCOMM’s faults condition. Based on the information, User can get more information by reading the appropriate status registers.

The low byte of the STATUS_WORD is the same register as the STATUS_BYTE command.

Please see below Listing of STATUS_WORD supported Bits:

LOW BYTE

Please refer to ISOCOMM Command Code 0x78h STATUS_BYTE

HIGH BYTE
<table>
<tr><th>Bit #</th><th>Status Bit Name</th><th>Supported</th></tr>
<tr><td>7</td><td>VOUT</td><td>No</td></tr>
<tr><td>6</td><td>IOUT/POUT</td><td>No</td></tr>
<tr><td>5</td><td>INPUT</td><td>No</td></tr>
<tr><td>4</td><td>MFR_SPECIFIC</td><td>Yes</td></tr>
<tr><td>3</td><td>POWER_GOOD#</td><td>No</td></tr>
<tr><td>2</td><td>FANS</td><td>Yes</td></tr>
<tr><td>1</td><td>OTHER</td><td>No</td></tr>
<tr><td>0</td><td>UNKNOWN</td><td>No</td></tr>
</table>
</td></tr>
<tr><td>7Dh</td><td>STATUS_TEMPERATURE</td><td>
Standard PMBUS STATUS Register.

Command returns one data byte with contents as follows:

<table>
<tr><th>Bit #</th><th>Status Bit Name</th><th>Supported</th></tr>
<tr><td>7</td><td>OT_FAULT</td><td>Yes</td></tr>
<tr><td>6</td><td>OT_WARNING</td><td>Yes</td></tr>
</table>
</td></tr>
</table>

<table>
<tr><td></td><td></td><td>
<table>
<tr><td>5</td><td>UT_WARNING</td><td>No</td></tr>
<tr><td>4</td><td>UT_FAULT</td><td>No</td></tr>
<tr><td>3</td><td>Reserved</td><td>No</td></tr>
<tr><td>2</td><td>Reserved</td><td>No</td></tr>
<tr><td>1</td><td>Reserved</td><td>No</td></tr>
<tr><td>0</td><td>Reserved</td><td>No</td></tr>
</table>

ISOCOMM OTP protection is with reference to the internal ambient temperature of the iHP RACK (Front Panel Ambient Temperature).
</td></tr>
<tr><td>7Eh</td><td>STATUS_CML</td><td>Standard PMBUS STATUS Register.
Command returns one data byte with contents as follows:
<table>
<tr><th>Bit #</th><th>Status Bit Name</th><th>Supported</th></tr>
<tr><td>7</td><td>Invalid Or Unsupported Command Received</td><td>Yes</td></tr>
<tr><td>6</td><td>Invalid Or Unsupported Data Received</td><td>Yes</td></tr>
<tr><td>5</td><td>Packet Error Check Failed</td><td>No</td></tr>
<tr><td>4</td><td>Memory Fault Detected</td><td>No</td></tr>
<tr><td>3</td><td>Processor Fault Detected</td><td>No</td></tr>
<tr><td>2</td><td>Reserved</td><td>No</td></tr>
<tr><td>1</td><td>A communication fault other than the ones listed in this table has
occurred</td><td>No</td></tr>
<tr><td>0</td><td>Other Memory Or Logic Fault has occurred.</td><td>No</td></tr>
</table>
</td></tr>
<tr><td>80h</td><td>STATUS_MFR</td><td>Standard PMBUS STATUS Register.
Command returns a word data where the high byte is a copy of PFC’s STATUS_MFR and the low byte is defined as follows:</td></tr>
</table>

		<table><tr><th>Bit #</th><th>Status Bit Name</th><th>Supported</th></tr><tr><td>7</td><td>Reserved</td><td>No</td></tr><tr><td>6</td><td>Reserved</td><td>No</td></tr><tr><td>5</td><td>Reserved</td><td>No</td></tr><tr><td>4</td><td>GROUP mismatched</td><td>YES</td></tr><tr><td>3</td><td>Module Communication Error</td><td>YES</td></tr><tr><td>2</td><td>PFC Communication Error</td><td>YES</td></tr><tr><td>1</td><td>Module Synchronize Off</td><td>YES</td></tr><tr><td>0</td><td>5V Standby Error</td><td>YES</td></tr></table>
81h	STATUS_FAN_1_2	Standard PMBUS STATUS Register Command returns one data byte with contents as follows: <table><tr><th>Bit #</th><th>Status Bit Name</th><th>Supported</th></tr><tr><td>7</td><td>Fan 1 Fault</td><td>YES</td></tr><tr><td>6</td><td>Fan 2 Fault</td><td>YES</td></tr><tr><td>5</td><td>Fan 1 Warning</td><td>No</td></tr><tr><td>4</td><td>Fan 2 Warning</td><td>No</td></tr><tr><td>3</td><td>Fan 1 Speed Override</td><td>No</td></tr><tr><td>2</td><td>Fan 2 Speed Override</td><td>No</td></tr><tr><td>1</td><td>Air Flow Fault</td><td>No</td></tr><tr><td>0</td><td>Air Flow Warning</td><td>No</td></tr></table>
82h	STATUS_FAN_3_4	Standard PMBUS STATUS Register Command returns one data byte with contents as follows: <table><tr><th>Bit #</th><th>Status Bit Name</th><th>Supported</th></tr><tr><td>7</td><td>Fan 3 Fault</td><td>YES</td></tr></table>

		<table><tr><td>6</td><td>Fan 4 Fault</td><td>YES</td></tr><tr><td>5</td><td>Fan 3 Warning</td><td>No</td></tr><tr><td>4</td><td>Fan 4 Warning</td><td>No</td></tr><tr><td>3</td><td>Fan 3 Speed Override</td><td>No</td></tr><tr><td>2</td><td>Fan 4 Speed Override</td><td>No</td></tr><tr><td>1</td><td>Reserved</td><td>No</td></tr><tr><td>0</td><td>Reserved</td><td>No</td></tr></table>
8Dh	READ_TEMPERATURE_1	This command returns the highest temperature between PFC1 and PFC2. Refer to ISOCOMM Command data classification for Data Format
8Fh	READ_TEMPERATURE_2	This command returns the Internal Ambient Temperature of the iHP Rack. Temperature sensor of the Internal Ambient temperature is located on the Front panel. Refer to ISOCOMM Command data classification for Data Format
90h	READ_FAN1_SPEED	iHP RACK fan speed reporting in RPM for FAN1. Refer to ISOCOMM Command data classification for Data Format
91h	READ_FAN2_SPEED	iHP RACK fan speed reporting in RPM for FAN2. Refer to ISOCOMM Command data classification for Data Format
92h	READ_FAN3_SPEED	iHP RACK fan speed reporting in RPM for FAN3. Refer to ISOCOMM Command data classification for Data Format
93h	READ_FAN4_SPEED	iHP RACK fan speed reporting in RPM for FAN4. Refer to ISOCOMM Command data classification for Data Format
99h	MFR_ID	Standard PMBUS command Command to indicate the iHP RACK's manufacturer's Identification. Fix data: "ARTESYN"
9Ah	MFR_MODEL	Standard PMBUS command

		Command to indicate the iHP RACK's model number. Data : Varies per module series
9Bh	MFR_REVISION	Standard PMBUS command Command to indicate the iHP RACK's revision number Data : Varies per module series
9Ch	MFR_LOCATION	Standard PMBUS command Command to indicate the iHP RACK's manufacturer's location. Fix data: "PHILIPPINES"
9Dh	MFR_DATE	Standard PMBUS command Command to indicate the iHP RACK's Manufacturing Date.
9Eh	MFR_SERIAL	Standard PMBUS command Command to indicate the iHP RACK's serial number.
B0h	FRU_DATA	Command to return FRU data of the ISOCOMM
B5h	MODULE_VRISE_TIME	Command used to set the voltage rise time of the module during Module's Digital Programming Voltage Source (DPVS) operation. This command has 3 bytes of data to write <DATA1> <DATA2> <DATA3> Data1 indicates the module slot or Group number in which the setting will be implemented <data1> = "00" = Slot 1 module <data1> = "01" = Slot 2 module <data1> = "02" = Slot 3 module <data1> = "03" = Slot 4 module <data1> = "04" = Slot 5 module <data1> = "05" = Slot 6 module <data1> = "06" = Slot 7 module <data1> = "07" = Slot 8 module <data1> = "08" = GROUP1 module <data1> = "09" = GROUP2 module <data1> = "0A" = GROUP3 module <data1> = "0B" = GROUP4 module

		<data1> = “0C” = GROUP5 module <data1> = “0D” = GROUP6 module <data1> = “0E” = GROUP7 module Data2 and Data3 indicate the module rise time setting. Data “00 02” : 50ms (+/- 5ms) Data “00 03” : 70ms (+/- 5ms) Data “00 04” : 80ms (+/- 5ms) Data “00 05” : 90ms (+/- 5ms) Data “00 06” : 100ms (+/- 5ms) Data “00 07” : 110ms (+/- 5ms) Data “00 08” : 120ms (+/- 5ms) Data “00 09” : 130ms (+/- 5ms) Data “00 0A” : 140ms (+/- 5ms) Data “00 0B” : 150ms (+/- 5ms) Data “00 0C” : 175ms (+/- 10ms) Data “00 0D” : 200ms (+/- 10ms) Data “00 0E” : 225ms (+/- 10ms) Data “00 0F” : 250ms (+/- 10ms) After sending this PMBUS command, All modules will shut down and restart again.
B6h	MODULE_IRISE_TIME	Command used to set the current rise time of the module during Module’s Digital Programming Current Source (DPCS) operation. This command has 3 bytes of data to write <DATA1> <DATA2> <DATA3> Data1 indicates the module slot or Group number in which the setting will be implemented <data1> = “00” = Slot 1 module <data1> = “01” = Slot 2 module <data1> = “02” = Slot 3 module

		<data1> = “03” = Slot 4 module <data1> = “04” = Slot 5 module <data1> = “05” = Slot 6 module <data1> = “06” = Slot 7 module <data1> = “07” = Slot 8 module <data1> = “08” = GROUP1 module <data1> = “09” = GROUP2 module <data1> = “0A” = GROUP3 module <data1> = “0B” = GROUP4 module <data1> = “0C” = GROUP5 module <data1> = “0D” = GROUP6 module <data1> = “0E” = GROUP7 module Data2 and Data3 indicate the module rise time setting. Data “00 00” : 7.2ms Data “00 01” : 100ms (+/- 10ms) Data “00 02” : 125ms (+/- 10ms) Data “00 03” : 150ms (+/- 10ms) Data “00 04” : 175ms (+/- 10ms) Data “00 05” : 200ms (+/- 10ms) Data “00 06” : 225ms (+/- 10ms) Data “00 07” : 250ms (+/- 10ms) Data “00 08” : 300ms (+/- 10ms) Data “00 09” : 350ms (+/- 10ms) Data “00 0A” : 400ms (+/- 10ms) Data “00 0B” : 450ms (+/- 10ms) Data “00 0C” : 500ms (+/- 10ms) Data “00 0D” : 700ms (+/- 50ms) Data “00 0E” : 900ms (+/- 50ms) Data “00 0F” : 1250ms (+/- 50ms) After sending this PMBUS command, All modules will shut down and restart again.

CAh	READ_VIN1	iHP RACK Input Voltage reporting (Vac) for Line1 Refer to ISOCOMM Command data classification for Data Format
CBh	READ_VIN2	iHP RACK Input Voltage reporting (Vac) for Line2 Refer to ISOCOMM Command data classification for Data Format
CCh	READ_VIN3	iHP RACK Input Voltage reporting (Vac) for Line3 Refer to ISOCOMM Command data classification for Data Format
CDh	READ_IIN1	iHP RACK Input Current reporting (Vac) for Line1 Refer to ISOCOMM Command data classification for Data Format
CEh	READ_IIN2	iHP RACK Input Current reporting (Vac) for Line2 Refer to ISOCOMM Command data classification for Data Format
CFh	READ_IIN3	iHP RACK Input Voltage reporting (Vac) for Line3 Refer to ISOCOMM Command data classification for Data Format
D3h	MODULE_CONFIG	Command used to set the current rise time of the module during Module's Digital Programming Current Source (DPCS) operation. This command has 2 bytes of data to write <DATA1> <DATA2> Data1 indicates the module slot or Group number in which the setting will be implemented <data1> = "00" = Slot 1 module <data1> = "01" = Slot 2 module <data1> = "02" = Slot 3 module <data1> = "03" = Slot 4 module <data1> = "04" = Slot 5 module <data1> = "05" = Slot 6 module <data1> = "06" = Slot 7 module <data1> = "07" = Slot 8 module

		<data1> = “08” = GROUP1 module <data1> = “09” = GROUP2 module <data1> = “0A” = GROUP3 module <data1> = “0B” = GROUP4 module <data1> = “0C” = GROUP5 module <data1> = “0D” = GROUP6 module <data1> = “0E” = GROUP7 module Data2 indicate the module configuration setting. Bitmap: Bit 7-4: Reserved/Unused Bit 6: Reserved/Unused Bit 5: Reserved/Unused Bit 4: Reserved/Unused Bit 3: Source Selection Data 1: Current Source Mode Data 0: Voltage Source Mode Bit 2: Reserved/Unused Bit 1: Select Analog or Digital Control Data 1: Analog Control Data 0: Digital Control Bit 0: Current Sensing Data 1: External Shunt Data 0: Internal Shunt Bit 5 data should be data 0 all the time. After sending this PMBUS command, All modules will shut down and restart again.
D6h	MODULE_DETECTION	Command to indicate module present in the iHP RACK Data Bit0 : Asserted when module is present in slot1 Data Bit1 : Asserted when module is present in slot2

		Data Bit2 : Asserted when module is present in slot3 Data Bit3 : Asserted when module is present in slot4 Data Bit4 : Asserted when module is present in slot5 Data Bit5 : Asserted when module is present in slot6 Data Bit6 : Asserted when module is present in slot7 Data Bit7 : Asserted when module is present in slot8
D7h	MODULE_SAVE	Command used to Save below Module Configuration. - 48h, 49h, 4Bh, 4Ch, 4Dh, 4Eh, 52h, 53h, 54h, B4h B5h, B6h, B7h, B8h, B9h, Bah, D3h, F9h, FAh This command have indicates the module slot or Group number in which the setting will be implemented data = “00” = Slot 1 module data = “01” = Slot 2 module data = “02” = Slot 3 module data = “03” = Slot 4 module data = “04” = Slot 5 module data = “05” = Slot 6 module data = “06” = Slot 7 module data = “07” = Slot 8 module data = “08” = GROUP1 module data = “09” = GROUP2 module data = “0A” = GROUP3 module data = “0B” = GROUP4 module data = “0C” = GROUP5 module data = “0D” = GROUP6 module data = “0E” = GROUP7 module After sending this PMBUS command, All modules will shut down and restart again.
DFh	GROUP_CONFIG	This command returns the group configuration of the rack. - The first byte is the length of the data (which also happens to be the number of groups available). - 2nd byte = GROUP1, 3rd byte = GROUP2, ... 8th byte =

		GROUP7. - Each byte is bitmapped (Bit0 = Module1, Bit1 = Module2, ... Bit7 = Module8) Asserted bits are the modules which belong to that group.
E1h	FW_VERSION	Command to indicate the software version of the ISOCOMM

ISOCOMM Command Data Classifications

Command	Command Name	Transaction Type	# of Bytes	Data Format	Multiplier	Data Unit	Write Protection
01h	OPERATION	Read/Write Byte	1	Bitmapped	N/A	N/A	Basic
03h	CLEAR_FAULTS	Send Byte	0	N/A	N/A	N/A	Basic
10h	WRITE_PROTECT	Read/Write Byte	1	Bitmapped	N/A	N/A	N/A
3Ah	FAN_CONFIG_1_2	Read Byte	1	Bitmapped	N/A	N/A	N/A
3Dh	FAN_CONFIG_3_4	Read Byte	1	Bitmapped	N/A	N/A	N/A
78h	STATUS_BYTE	Read Byte	1	Bitmapped	N/A	N/A	N/A
79h	STATUS_WORD	Read Byte	2	Bitmapped	N/A	N/A	N/A
7Dh	STATUS_TEMPERATURE	Read Byte	1	Bitmapped	N/A	N/A	N/A
7Eh	STATUS_CML	Read Byte	1	Bitmapped	N/A	N/A	N/A
80h	STATUS_MFR	Read Byte	2	Bitmapped	N/A	N/A	N/A
81h	STATUS_FAN_1_2	Read Byte	1	Bitmapped	N/A	N/A	N/A
82h	STATUS_FAN_3_4	Read Byte	1	Bitmapped	N/A	N/A	N/A
8Dh	READ_TEMPERATURE_1	Read Byte	2	Linear	N/A	^0C	N/A

8Fh	READ_TEMPERATURE_2	Read Byte	2	Linear	N/A	^{0}C	N/A
90h	READ_FAN1_SPEED	Read Byte	2	Linear	N/A	RPM	N/A
91h	READ_FAN2_SPEED	Read Byte	2	Linear	N/A	RPM	N/A
92h	READ_FAN3_SPEED	Read Byte	2	Linear	N/A	RPM	N/A
93h	READ_FAN4_SPEED	Read Byte	2	Linear	N/A	RPM	N/A
99h	MFR_ID	Block Read	7	ASCII	N/A	N/A	N/A
9Ah	MFR_MODEL	Block Read	12	ASCII	N/A	N/A	N/A
9Bh	MFR_REVISION	Block Read	2	ASCII	N/A	N/A	N/A
9Ch	MFR_LOCATION	Block Read	1	ASCII	N/A	N/A	Factory Config
9Dh	MFR_DATE	Block Read	2	ASCII	N/A	N/A	Factory Config
9Eh	MFR_SERIAL	Block Read	13	ASCII	N/A	N/A	Factory Config
B0h	FRU_DATA	Block Read	256	ASCII	N/A	N/A	Factory Config
B5h	MODULE_VRISE_TIME	Block Write	3	Bitmapped	N/A	N/A	Basic
B6h	MODULE_IRISE_TIME	Block Write	3	Bitmapped	N/A	N/A	Basic
CAh	READ_VIN1	Read Word	2	Direct	10	V	N/A
CBh	READ_VIN2	Read Word	2	Direct	10	V	N/A
CCh	READ_VIN3	Read Word	2	Direct	10	V	N/A
CDh	READ_IIN1	Read Word	2	Direct	100	A	N/A
CEh	READ_IIN2	Read Word	2	Direct	100	A	N/A
CFh	READ_IIN3	Read Word	2	Direct	100	A	N/A
D3h	MODULE_CONFIG	Write Word	2	Bitmapped	N/A	N/A	Basic
D6h	MODULE_DETECTION	Read Byte	1	Bitmapped	N/A	N/A	Basic
D7h	MODULE_SAVE	Write Byte	1	Bitmapped	N/A	N/A	Basic
DFh	GROUP_CONFIG	Read Byte	8	Bitmapped	N/A	N/A	N/A
E1h	FW_VERSION	Read Byte	8	ASCII	N/A	N/A	N/A

B.4 Data Format: Linear

Data Format Linear is one of the PMBUS Data Format used in iHP units. Please refer to Appendix B.1, B.2, and B.3 for the PMBUS Commands that uses Linear Data Format.

Linear data format follows the equation:

$X = Y \times 2^N$

Where: X = real world data
Y = transmitted value / mantissa
N = exponent

Convert Real World Data to Linear Data Format

The following steps show how to convert from real world data (any integer in decimal format) to its corresponding
linear data format:

1. Solve for N using below formula

$$N = \frac{\ln\left(\frac{X}{Y_{max}}\right)}{\ln(2)}$$

Where: $Y_{max} = 2^{n-1}$

n = number of bits of mantissa = 11

Note: Roundup N to the nearest integer

Ex. X = 6000rpm

$$N = \frac{\ln\left(\frac{X}{Y_{max}}\right)}{\ln(2)} = \frac{\ln\left(\frac{6000}{1024}\right)}{\ln(2)} = 2.55$$

N = 3

2. Solve for Y

$$X = Y \times 2^N$$
$$Y = X \times 2^{-N}$$

Ex. X = 6000rpm, N = 3

$$Y = X \times 2^{-N}$$
$$Y = 6000 \times 2^{-3}$$

Y = 750

3. Convert N and Y from decimal format to binary format and combine or concatenate them in the following format :

   aaaaaBBBBBBBBBBB
   Where: a = binary format of N
   B = binary format of Y

   Ex. N = 3, Y = 750

   Binary Format of N = 3: 00011_2
   Binary Format of Y = 750: 01011101110_2
   Linear Data Format in Binary = 0001101011101110_2

4. Convert the concatenated data in binary format to hexadecimal format. The data in hexadecimal format is now the equivalent linear data format of the real world data.

Ex. Linear Data Format in Binary = 0001101011101110_2
Linear Data Format in Hex = 1AEE hex

Convert Linear Data Format to Real World Data
The following steps show how to convert from linear data format to its corresponding real world data:

1. Convert data from hexadecimal format to binary format.

   Ex. Linear Data Format in Hex = 1AEE hex
   Linear Data Format in Binary = 0001101011101110 2

2. Separate the exponent N from the mantissa Y.

   Ex. Linear Data Format in Binary = 0001101011101110 2

   aaaaaBBBBBBBBBBB

   where: a = binary format of exponent N

   B = binary format of mantissa Y

   0001101011101110_2

   Binary format of exponent **N = 00011_2**
   Binary format of mantissa **Y = 01011101110_2**

3. Convert exponent N from binary format to its corresponding decimal format.

Ex. N = 00011 $_2$
N = 3

4. Convert mantissa Y from binary format to its corresponding decimal format.

Ex. Y = 01011101110 $_2$
Y = 750

5. Solve for the real world data X using below equation.

$$X = Y \times 2^N$$
$$X = 750 \times 2^3$$

$$\boldsymbol{X = 6000}$$

B.5 Data Format: Direct

One of the PMBUS Data Format used in iHP units. Please refer to Appendix B.1, B.2, and B.3 for the PMBUS Commands that uses Direct Data Format.

In order to convert the data in to "real word" value, user needs to determine the # of bytes and the multiplier.

The relationship between Y, N, and the "real word" value is:

$$Y = X * N$$

Where:

X is the "real word" value

Y is the data read from the device in decimal.

N is a the multiplier

Example 1:

Module PMBUS Command 8Bh (READ_VOUT)

# of byte = 3 Byte

Multiplier = N = 10000

PMBUS COMMAND 8Bh returns a data of 0757B0h

Convert 0757B0h to decimal = 481200

$$Y = X * N$$

$$481200 = X * 10000$$

$$X = 48.12\ V$$

Example 2

Module PMBUS Command 8Ch (READ_IOUT)

# of byte = 3 Byte

Multiplier = N = 10000

PMBUS COMMAND 8Bh returns a data of 098968h

Convert 098968h to decimal = 625000

$$Y = X * N$$

$$625000 = X * 10000$$

$$X = 62.5A$$

Example 3

Module PMBUS Command 48h (OV_FAULT_LIMIT_MULTIPLIER)

# of byte = 2 Byte

Multiplier = N = 100

PMBUS COMMAND 48h returns a data of 2EE0h

Convert 2EE0h to decimal = 12000

$$Y = X * N$$

$$12000 = X * 100$$

$$X = 120\%$$