EXCELSYS FC1500 SERIES

PMBus™TM Communication

FLEXICHARGE by Advanced Energy

The Power Management Bus (PMBus™) is an open standard which defines a means of communication for power conversion devices. It defines a full set of commands and data structures required by power control and management components.

AT A GLANCE

Input Voltage

100 to 240 Vac

HV Output Voltage

0 to 1000 Vdc

Output Power

2300 W Total (2450 W Peak)
1500 W on Cap Charger (1650 W Peak)
800 W Max on Modular

Cooling

Fan cooled

Dimensions

322 x 144.9 x 105.9 mm
12.68 x 5.7 x 4.17 inch

Certifications

Medical

- IEC60601-1 3rd edition
  IEC60601-1-2 4th edition (EMC)
- 2 x MOPP
- Dual fused

PMBus™ SPECIFICATIONS

Introduction

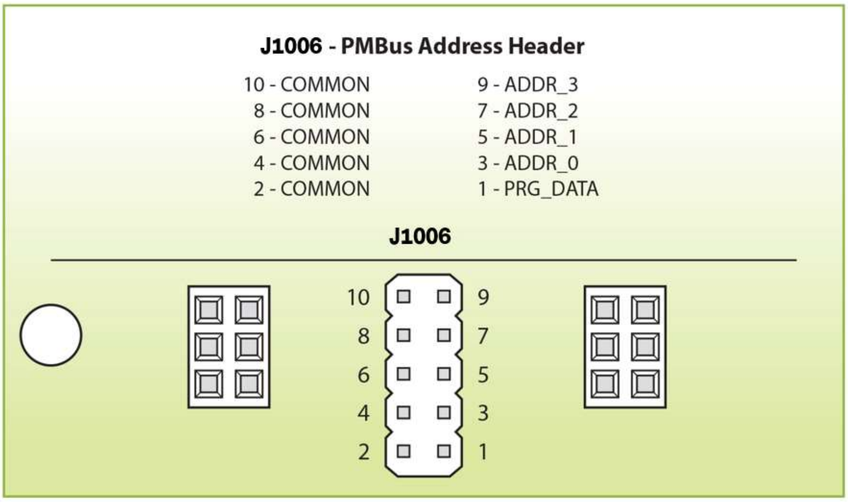
The Flexicharge series PMBus™ interface facilitates the communication of operating parameters such as output voltage, output current and internal temperature with other PMBus™ enabled devices. It also facilitates the remote adjustment of parameters such as output voltage level, current limit and enable status.

For more information about PMBus™, please see the System Management Interface Forum website www.PowerSIG.org.

Signal Connectors

J1006 - PMBus™ Addressing

J1006 is used to set the PMBus™ address of the system.



The PMBus™ standard utilizes 7 bits for addressing. These 7 bits form what is referred to as a secondary address. This is the hardware address of the PMBus™ device and is independent of the direction of data transfer.

During any read or write operation, a direction bit is appended by the main device to the 7-bit secondary address to indicate the direction of data transfer: 1 = READ operation; 0 = WRITE operation.

Sometimes PMBus™/I2C vendors will include the direction bit in the address leading to a separate READ ADDRESS and WRITE ADDRESS. In this convention, the WRITE ADDRESS can be calculated as (SECONDARY ADDRESS * 2) and the READ ADDRESS can be calculated as ((SECONDARY ADDRESS * 2) +1).

The Flexicharge Series PMBus™ interface allows the user to modify the lower 4 bits of the secondary address, leading to a fixed part of the address and a variable part of the address. The fixed part of the secondary address consists of the 3 most significant bits A6, A5, and A4 and always equals 101.

The variable part of the address consists of the 4 least significant bits A3, A2, A1 and A0 and these bits can be modified by the placement of jumpers on the corresponding 4 pin headers on connector J1006.

PMBus™ SPECIFICATIONS

A6	A5	A4	A3	A2	A1	A0
1	0	1	A3*	A2*	A1*	A0*

Secondary Address Structure

*Determined by the position of the jumper link. Jumper in = logic 1; Jumper out = logic 0.

The address lines for A3, A2, A1 and A0 default to logic 0 (jumper out) (default secondary address = 1010000 =0x50). The placement of a jumper on a header pulls the corresponding address line to a logic 1. The full list of available addresses is therefore as follows:

A6	A5	A4	A3	A2	A1	A0	Secondary Address	Write Address	Read Address
1	0	1	0	0	0	0	0x50	0xA0	0xA1
1	0	1	0	0	0	1	0x51	0xA2	0xA3
1	0	1	0	0	1	0	0x52	0xA4	0xA5
1	0	1	0	0	1	1	0x53	0xA6	0xA7
1	0	1	0	1	0	0	0x54	0xA8	0xA9
1	0	1	0	1	0	1	0x55	0xAA	0xAB
1	0	1	0	1	1	0	0x56	0xAC	0xAD
1	0	1	0	1	1	1	0x57	0xAE	0xAF
1	0	1	1	0	0	0	0x58	0xB0	0xB1
1	0	1	1	0	0	1	0x59	0xB2	0xB3
1	0	1	1	0	1	0	0x5A	0xB4	0xB5
1	0	1	1	0	1	1	0x5B	0xB6	0xB7
1	0	1	1	1	0	0	0x5C	0xB8	0xB9
1	0	1	1	1	0	1	0x5D	0xBA	0xBB
1	0	1	1	1	1	0	0x5E	0xBC	0xBD
1	0	1	1	1	1	1	Reserved	Reserved	Reserved

Available Address Space

PMBus™ SPECIFICATIONS

Parallel Operation

If multiple Flexicharge units are to be used in parallel on the same bus then each unit will need to be assigned a unique address through the fitting of one or more jumpers according to Table 2 above. In total, 15 unique addresses are available which limits the maximum possible number of devices on a single bus to 15 (the highest address is reserved). The buses of all devices must then be paralleled. To do this, simply connect all required PMBus™ signals (i.e. SDA, SCL, CONTROL (if required) & COMMON) in parallel.

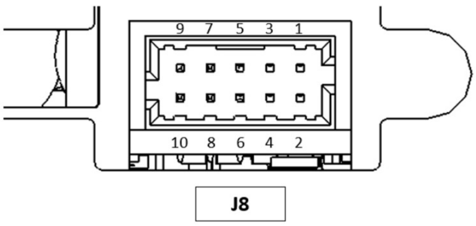
General Call Address (Global Broadcast)

Along with the unique Secondary Address, the Flexicharge will also respond to the General Call address (0x00). This can be used when it is desirable to issue the same write command to multiple devices on the bus simultaneously e.g.:

- Enable or disable parallel FC1500 units simultaneously.
- Adjust the output voltages of parallel FC1500 units simultaneously.

Note that it is not possible to use the General Call address with read commands as this would cause multiple secondary responses to clash. Read requests to the General Call address will therefore not be acknowledged.

J8 – PMBus™ Communication



J8 Connector		
Pin	Name	Function
1	Common	Common ground
2	SCL	Communications port
3	LV Global EN	External global enable and disable of modules
4	SDA	Communications port
5	LV Global PG	Power Good signal for all modules
6	LV AC Fail	Primary fault status in which the modules must turn off
7	LV OTP	Warning that shutdown may occur due to over temperature
8	HV AC Fail	Primary fault status in which the cap charger output must turn off
9	Fan Fail	Primary fault status in which the fan fault has occurred must turn off
10	+5V Aux	5V, 3W Auxiliary output_B

PMBus™ SPECIFICATIONS

Global Signal Connector

SDA - Serial Data Line - (Pin 4 of J8)

This is the data line over which all serial communication takes place. This pin must be connected to the PMBus™ SDA line. This is an open collector pin which should be pulled up to 5V by the PMBus™ host device.

SCL - Serial Clock Line - (Pin 2 of J8)

This is the clock line which synchronizes all serial communication over the PMBus™. This pin must be connected to the PMBus™ SCL line. The CoolX Series PMBus™ interface is designed to operate with a PMBus™ clock frequency of 100 kHz. This is an open collector pin which should be pulled up to 5V by the PMBus™ host device.

LV Global EN - (Pin 3 of J8)

This analogue input can be used to enable or disable the main output voltage. This pin is pulled up to 5 V internally. The default operation (jumper J1006 pins 2/1 not fitted) is that logic high means the output is enabled. Pulling the pin to 0 V will disable the output. If the jumper is fitted then the logic is reversed i.e., the pin must be pulled to 0 V to enable the output voltage.

COMMON - Signal GND - (Pin 1 of J8)

This should be connected to GND or Signal Return of the PMBus™ Host device. Note that this is at the same potential as the Auxiliary output ground terminal.

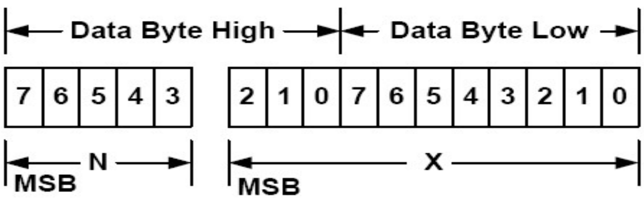
PMBus™ Communication

PMBus™ Linear Format

The Flexicharge Series PMBus™ interface utilizes the linear data format defined in the PMBus™ Specification to represent voltage, current and temperature readings. This format presents real world units (Amps, Volts, Degrees) to the host system in a manner which is less computationally difficult for the host system than the alternative direct system.

The data returned consists of the following:
- An 11-bit, two's complement mantissa.
- A 5-bit, two's complement exponent (scaling factor).

These combine to form a two-byte word as follows:



Linear Format Data Structure

PMBus™ SPECIFICATIONS

Linear Format Decoding

To understand the decoding of the linear format data to obtain the real-world measurement, we will work through an example of an output current measurement:

Sample Data:
- Returned Byte 1 = 0xDB
- Returned Byte 2 = 0x12

The first step is to extract the exponent data:

- 0xDB12 in binary format = 1101101100010010.
- Exponent bits = 11011
- 11011 converted from two's complement = -5.

The exponent in this example is therefore -5. The second step is to extract the mantissa data:

- 0xDB12 converted to binary = 1101101100010010
- Mantissa bits = 01100010010
- 01100010010 converted from two's complement = 786.

The Mantissa in this example is therefore 786.

The final step is simply to calculate the real-world value using the two figures obtained above and the equation:

$$Y = X * (2^{N})$$

Where:
- Y = The real-world value to be calculated e.g., output current (in Amps) in this example.
- X = The Mantissa obtained above e.g. 786 in this example.
- N = The Exponent obtained above e.g. -5 in this example.

$Iout = 786 * (2^{-5}) = 24.56$ Amps

The exact same process is used to calculate temperature readings.

PMBus™ Extended Linear Format

The extended linear format works in the same way as the linear format detailed above however, all 16 bits are allocated as mantissa bits which allows for extended precision (and/or range) which is useful when measuring output voltage. For this reason, commands which relate to output voltage will tend to use the extended format. Since the exponent is not available within the returned data, the exponent must be queried by the system by issuing the VOUT_MODE command which will return the exponent. Using VOUT_MODE to obtain the exponent is explained later in this section.

Packet Error Checking (PEC)

SMBus version 1.1 introduced a Packet Error Checking mechanism to improve communication reliability and robustness. PEC in CoolX is supported as per the SMBus specification but is optional.
To use PEC, simply request one extra byte for read transactions or write one extra byte for write transactions. The extra byte will be the checksum byte which is a Cyclic Redundancy Check (CRC) checksum. The polynomial used for the CRC calculation in SMBus/PMBus™ is X8 + X2 + X + 1 (CRC-8).
There are many online resources providing source code and lookup tables for calculation of the CRC-8 checksum.

PMBus™ SPECIFICATIONS

Supported Commands

The full list of commands currently supported by the FC1500 PMBus™ interface is as follows:

Monitoring Commands	Control Commands	Identification Commands	Calibration Commands
VOUT_MODE	PAGE	MFR_ID	IOUT_CAL_GAIN
READ_VOUT	OPERATION	MFR_MODEL	IOUT_CAL_OFFSET
MFR_READ_ALL_VOUT*	VOUT_COMMAND	MODULE_ID	VOUT_SCALE_LOOP
READ_IOUT	ILIMIT_TRIM*		VOUT_CAL_OFFSET
MFR_READ_ALL_IOUT*	ON_OFF_CONFIG		MFR_ITRIM_CAL_GAIN*
READ_TEMP1	STORE_USER_ALL		MFR_ITRIM_CAL_OFFSET*
MFR_READ_ALL_TEMP1*	RESTORE_DEFAULT_ALL		VOUT_SCALE_MONITOR
MFR_SPECIFIC_STATUS*	CLEAR_FAULTS		MFR_VOUT_OFFSET_MONITOR*
STATUS_WORD	MFR_SPEC_PLIMIT		MFR_EOC_CAL
MFR_READ_ALL_STATUS_WORD*	MFR_PMBus™_STANDBY*		MFR_CS_USER_CAL*
READ_VIN			MFR_VPEAK_USER_CAL*
READ_FIN*			
READ_FAN_SPEED_1			
MFR_READ_VPROG*			
STATUS_CML			

- These commands are manufacturer specific

Commands can return either: a BYTE, a WORD, a BLOCK (multiple bytes including a byte count) or nothing at all as indicated in the descriptions below.

Monitoring Commands

VOUT_MODE (0x20)

Protocol: Read Byte
Data Format: Unsigned binary integer
Default Value: N/A

To interpret the extended linear mode readings returned by a module in response to output voltage related commands, the system needs to know the 5-bit exponent which is being used to generate the linear mode data. The VOUT_MODE command will return a byte value which contains the exponent for the selected (paged) output. The byte can be interpreted as follows:

PMBus™ SPECIFICATIONS

Mode	Bits [7:5]	Bits [4:0]
Linear	000	5-bit exponent which applies to voltage commands

Example: If the exponent is -8, VOUT_MODE will return 0b00011000 = 0x18

READ_VOUT (0x8B)

Protocol: Read Word
Data Format: Extended Linear Format
Default Value: N/A

The READ_VOUT command is used to return the output voltage measurement of the selected (paged) output. The data will be formatted in the Extended Linear format using the exponent which can be found using the VOUT_MODE command.

Example:
- Exponent: -8
- Data Returned: Byte 0 = 0x80; Byte 1 = 0x18;
- 0x1880 = 0d6272

$$V_{out} = \frac{6272}{\frac{1}{2^{-8}}} = 24.50V$$

MFR_READ_ALL_VOUT (0xFB)

Protocol: Read Block
Data Format: Extended Linear Format
Default Value: N/A

This manufacturer specific command is closely related to the READ_VOUT command. Where the READ_VOUT command returns the 2-byte extended linear Vout value for the currently paged module, this command returns the Vout data for all modules in one operation. The data is returned in the following format:

PMBus™ SPECIFICATIONS

Byte Number	Description
0	Block size
1	Slot 1 Vout low byte
2	Slot 1 Vout high byte
3	Slot 2 Vout low byte
4	Slot 2 Vout high byte
5	Slot 3 Vout low byte
6	Slot 3 Vout high byte
7	Slot 4 Vout low byte
8	Slot 4 Vout high byte
9	Slot 5 Vout low byte
10	Slot 5 Vout high byte
11	HV Output Vout low byte
12	HV Output Vout high byte

For decoding of the low-bye and high-byte pairs from the extended linear format, please refer to "READ_VOUT".

READ_IOUT (0x8C)

Protocol: Read Word
Data Format: Linear Format
Default Value: N/A

The READ_IOUT command is used to return the output current measurement of the selected (paged) output. The data will be formatted in the Linear format.
Example:

- Data Returned: Byte 0 = 0x62; Byte 1 = 0xD8;
- 0xD862 = 0b1101100001100010
- Exponent = 11011 = -5
- Mantissa = 00001100010 = 98

$$I_{out} = \frac{98}{\frac{1}{2^{-5}}} = 3.06A$$

PMBus™ SPECIFICATIONS

MFR_READ_ALL_IOUT (0xFC)

Protocol: Read Block
Data Format: Extended Linear Format
Default Value: N/A

This manufacturer specific command is closely related to the READ_IOUT command. Where the READ_IOUT command returns the 2-byte linear Iout value for the currently paged module, this command returns the Iout data for all modules in one operation. The data is returned in the following format:

Byte Number	Description
0	Block size
1	Slot 1 Iout low byte
2	Slot 1 Iout high byte
3	Slot 2 Iout low byte
4	Slot 2 Iout high byte
5	Slot 3 Iout low byte
6	Slot 3 Iout high byte
7	Slot 4 Iout low byte
8	Slot 4 Iout high byte
9	Slot 5 Iout low byte
10	Slot 5 Iout high byte
11	HV Output Iout low byte
12	HV Output Iout high byte

For decoding of the low-bye and high-byte pairs from the linear format, please refer to “READ_IOUT”.

READ_TEMPERATURE_1 (0x8D)

Protocol: Read Word
Data Format: Linear Format
Default Value: N/A

The READ_TEMPERATURE_1 command is used to return the temperature of the temperature sensor of the currently paged module in degrees Celsius e.g. The data will be formatted in the Linear11 format.
Example:

- Data Returned: Byte 0 = 0x2D; Byte 1 = 0x00
- 0x002D = 0b0000000000101101
- Exponent = 00000 = 0
- Mantissa = 00000101101

PMBus™ SPECIFICATIONS

The mantissa Most Significant Bit (MSB) is 0 (positive number) therefore we can just use the decimal value directly = 45. (If the MSB is 1 then this represents a negative temperature, and we must convert the mantissa from 2's complement representation).

$$\text{Temperature} = \frac{45}{\frac{1}{2^0}} = 45°\text{C}.$$

MFR_READ_ALL_TEMP1 (0xFD)

Protocol: Read Block
Data Format: Extended Linear Format
Default Value: N/A

This manufacturer specific command is closely related to the READ_TEMPERATURE_1 command. Where the TEMPERATURE_1 command returns the 2-byte linear temperature for the currently paged module, this command returns the temperature data for all modules in one operation. The data is returned in the following format:

Byte Number	Description
0	Block size
1	Slot 1 Temperature low byte
2	Slot 1 Temperature high byte
3	Slot 2 Temperature low byte
4	Slot 2 Temperature high byte
5	Slot 3 Temperature low byte
6	Slot 3 Temperature high byte
7	Slot 4 Temperature low byte
8	Slot 4 Temperature high byte
9	Slot 5 Temperature low byte
10	Slot 5 Temperature high byte
11	HV Output Temperature low byte
12	HV Output Temperature high byte

For decoding of the low-bye and high-byte pairs from the Linear11 format, please refer to "READ_TEMPERATURE_1".

PMBus™ SPECIFICATIONS

STATUS_MFR_SPECIFIC (0x80)

Protocol: Read Byte
Data Format: Unsigned binary integer
Default Value: N/A

The STATUS_MFR_SPECIFIC command is used to check the status of multiple parameters which can affect the output of the cap charger module The data returned will be one byte:

B7	B6	B5	B4	B3	B2	B1	B0
REN	INH	OVP	LAT	INT	OTP	PRI	EN

- EN: Enable input state
- PRI: Primary fault state
- OTP: OTP warning state
- INT: Interlock switch state
- LAT: Hardware Latch state
- OVP: Overvoltage Protection state
- INH: Inhibit input state
- REN: Remote Enable (PMBus™) state

STATUS_WORD (0x79)

Protocol: Read Word
Data Format: Unsigned binary integer
Default Value: N/A

The STATUS_WORD command is used to check for the presence of fault conditions such as OTP (Over Temperature Protection), PG (Power Good) or Communication, Logic, Memory faults (CML). The data returned will be two bytes:

B7	B6	B5	B4	B3	B2	B1	B0
X	X	X	X	X	OTP	CML*	X

Low Byte (Byte 0) Structure

B7	B6	B5	B4	B3	B2	B1	B0
X	X	X	X	X	PG**	X	X

High Byte (Byte 1) Structure

*When the CML bit is set, the actual CML fault which has occurred can be determined through use of the STATUS_CML command.

** The PG bit represents the Power Good status of the currently paged module:

0 = PG Bad; 1 = PG Good;

PMBus™ SPECIFICATIONS

MFR_READ_ALL_STATUS_WORDS (0xFE)

Protocol: Read Block
Data Format: Extended Linear Format
Default Value: N/A

This manufacturer specific command is closely related to the STATUS_WORD command. Where the STATUS_WORD command returns the 2-byte status word for the currently paged module, this command returns the status words for all modules in one operation. The data is returned in the following format:

Byte Number	Description
0	Block size
1	Slot 1 STATUS_WORD Low Byte
2	Slot 1 STATUS_WORD High Byte
3	Slot 2 STATUS_WORD Low Byte
4	Slot 2 STATUS_WORD High Byte
5	Slot 3 STATUS_WORD Low Byte
6	Slot 3 STATUS_WORD High Byte
7	Slot 4 STATUS_WORD Low Byte
8	Slot 4 STATUS_WORD High Byte
9	Slot 5 STATUS_WORD Low Byte
10	Slot 5 STATUS_WORD High Byte
11	HV Output STATUS_WORD Low Byte
12	HV Output STATUS_WORD High Byte

For decoding of the status words, please refer to “STATUS_WORD”.

READ_VIN (0x88)

Protocol: Read Word
Data Format: Linear Format
Default Value: N/A

The READ_VIN command is used to return the input voltage measurement. The data will be formatted in the Linear format.

PMBus™ SPECIFICATIONS

READ_FIN [Manufacturer Specific] (0xD5)

Protocol: Read Word
Data Format: Linear Format
Default Value: N/A

The READ_FIN command is used to return the input frequency measurement. The data will be formatted in the Linear format.

READ_FAN_SPEED_1

Protocol: Read Word
Data Format: Linear Format
Default Value: N/A

The READ_FAN_SPEED_1 command is used to return the fan speed in units of RPM (Revolutions Per Minute). The data will be formatted in the Linear format.

MFR_READ_VPROG

Protocol: Read Word
Data Format: Extended Linear Format
Default Value: N/A

The MFR_READ_VPROG command is used to return the output voltage which is currently commanded by the voltage which is present on the USER_VPROG pin. The data will be formatted in the Linear format.

STATUS_CML (0x7E)

Data Format: Unsigned binary integer
Default Value: N/A

The STATUS_CML command is used to check for the presence of Communication, Logic or Memory faults (CML). The data returned will be a single byte containing the following supported bit-fields:

B7	B6	B5	B4	B3	B2	B1	B0
Invalid Command	Invalid Data	PEC Fault	X	X	X	Other CML Fault	X

Status CML Byte Structure

PMBus™ SPECIFICATIONS

Control Commands

PAGE (0x00)
Protocol: Read/Write Byte
Data Format: Unsigned binary integer
Default Value: 0x01

As there is only one physical PMBus™ address within a CoolX system which is shared amongst all of the fitted modules' outputs, the PAGE command is used to select which of the modules subsequent commands are to be applied to.

For example, to perform monitoring or control operations on the Module in slot 1, the PAGE command should be issued with a data byte of 1 prior to the issuing of any further commands. The page shall remain selected until another Page command is received. When read, this command shall return the currently selected page number.

The available page numbers are as follows:

Page	Selection
0	System
1	Slot 1 Module
2	Slot 2 Module
3	Slot 3 Module
4	Slot 4 Module
5	Slot 5 Module
6	Cap Charger Module

OPERATION (0x01)

Protocol: Read/Write Byte
Data Format: Unsigned binary integer
Default Value: 0x80

The OPERATION command is used to enable or disable the main output. The upper bit (bit 7) is set to 0 to disable the output and is set to 1 to enable the output. The other seven bits are ignored so for example, the following data bytes can be used to enable/disable the main output.

When read, this command shall return the last OPERATION command sent to the Flexicharge.
- Enable output = 0x80
- Disable output = 0x00

EN: 1 = Output Enabled; 0 = Output Disabled
X: Don't care

B7	B6	B5	B4	B3	B2	B1	B0
EN	X	X	X	X	X	X	X

PMBus™ SPECIFICATIONS

VOUT_COMMAND (0x21)

Protocol: Read/Write Word
Data Format: Extended Linear
Default Value: N/A

The VOUT_COMMAND command is used to explicitly set the output voltage to the commanded value. The data will be formatted in the Extended Linear format using the exponent which can be found using the VOUT_MODE command.

Example:
- Exponent = -8; Commanded Vout = 36.00V

$$\frac{36}{2^{-8}} = 0d9216 = 0x2400$$

- Byte 0 = 0x00; Byte 1 = 0x24

ILIMIT_TRIM (0xD1)

Protocol: Read/Write Word
Data Format: Extended Linear
Default Value: N/A

The ILIMIT_TRIM command is used to explicitly set the current limit of the selected (paged) module to the commanded value. The data should be formatted in the Extended Linear format using the exponent which can be found using the VOUT_MODE command.

Example:
- Exponent = -8
- Commanded Ilimit = 3.00A

$$\frac{3}{2^{-8}} = 0d768 = 0x0300$$

- Byte 0 = 0x00; Byte 1 = 0x03

ON_OFF_CONFIG (0x02)

Protocol: Read/Write Byte
Data Format: Unsigned Binary Integer
Default Value: 0x00

The ON_OFF_CONFIG command configures/reads the combination of CONTROL pin input and serial bus commands needed to turn the unit on and off. This includes how the unit responds when power is applied. Bits 2 and 3 of this byte as supported as follows:

PMBus™ SPECIFICATIONS

B7	B6	B5	B4	B3	B2	B1	B0
X	X	X	X	OPERATION	CONTROL	X	X

CONTROL behaviour bit:
0: Unit ignores the CONTROL pin state (on/off controlled only by the operation command).
1: Unit requires the CONTROL pin to be asserted to enable the output. Depending on the OPERATION behaviour bit, the OPERATION command may also be required in order to enable the output.

OPERATION behaviour bit:
0: Unit ignores the OPERATION command (on/off controlled only by the CONTROL pin).
1: Unit requires the OPERATION state to be enabled to enable the output. Depending on the CONTROL behaviour bit, the CONTROL pin may also be required to be asserted in order enable the output.

STORE_USER_ALL (0x15)

Protocol: Send Byte
Data Format: N/A
Default Value: N/A

By default, all PMBus™ changes occur in volatile memory only and will revert to default values on the next system power up. The STORE_USER_ALL command instructs the device to copy the entire contents of the operating (volatile) memory into the non-volatile User Store memory. It is safe to issue the STORE_USER_ALL command at any time, even when the output is operational.

Note: The non-volatile memory has a rated endurance of 100,000 write cycles.

RESTORE_DEFAULT_ALL (0x12)

Protocol: Send Byte
Data Format: N/A
Default Value: N/A

The RESTORE_DEFAULT_ALL command instructs the device to copy the entire contents of the non-volatile Default Store memory into the volatile operating memory. This has the effect of restoring all operating parameters to their default values.

Note that this command restores to volatile memory so any previous changes which have been made permanent with the STORE_USER_ALL command will be reinstated on the next power on. If it is desired to permanently reset the device to factory defaults, then the RESTORE_DEFAULT_ALL command should be followed by the STORE_USER_ALL command.

It is safe to issue the RESTORE_DEFAULT_ALL command at any time, even when the output is operational.

PMBus™ SPECIFICATIONS

CLEAR_FAULTS (0x03)

Protocol: Send Byte
Data Format: N/A
Default Value: N/A

The CLEAR_FAULTS command is used to clear any fault bits that have been set. This command clears al bits in all status registers simultaneously. If the fault is still present when the bit is cleared, then the fault bit shall immediately be set again.

MFR_SPEC_PLIMIT (0xDA)

Protocol: Read/Write Word
Data Format: Linear Format
Default Value: 0x0000 = 0.00

The MFR_SPEC_PLIMIT command is used to set/check the power limit of the cap charger output in units of watts. The data should be formatted in the Linear format. Note that the minimum level which can be set = 850W

PMBus™ STANDBY (0xD4)

Protocol: Read/Write Byte
Data Format: Unsigned binary integer
Default Value: 0

There are two possible behaviours in response to a global disable command i.e. OPERATION=0 with PAGE=0. The default behaviour is to simply disable all of the module outputs. This facilitates a very quick response to an enable command (<10ms typ.) at the expense of standby power consumption.

In applications where standby power is more critical than response time, the global disable behaviour can be modified to also shut down all primary sub-systems to minimize power consumption (Deep Standby Mode). The response time to enable commands in this mode will be up to 1 second. Note that this command enables/disables the deep standby option only. The OPERATION command must still be used to enter/exit standby modes.

The upper bit (bit 7) is set to 0 to disable Deep standby Mode and is set to 1 to enable Deep Standby Mode. The other seven bits are ignored so for example, the following data bytes can be used to enable/disable the Deep Standby Mode. Note if the page is 0 then the operation will be applied to all modules simultaneously.

- Enable output = 0x80
- Disable output = 0x00

EN: 1 = Output Enabled; 0 = Output Disabled; X: Don't care

B7	B6	B5	B4	B3	B2	B1	B0
EN	X	X	X	X	X	X	X

PMBus™ SPECIFICATIONS

Identification Commands

MFR_ID (0x99)

Protocol: Read Block
Data Format: IEC/ISO 8859-1
Default Value: "Excelsys"

The MFR_ID command is used to return a text string which identifies the manufacturer of the system. As per the Read Block protocol, the first byte returned will be an integer representing the number of characters contained within the string.

MFR_MODEL (0x9A)

Protocol: Read Block
Data Format: IEC/ISO 8859-1
Default Value: "FC15"

The MFR_MODEL command is used to return a text string which identifies the model number/name of the system. As per the Read Block protocol, the first byte returned will be an integer representing the number of characters contained within the string.

MODULE_ID [Manufacturer Specific] (0xD0)

Protocol: Read Byte
Data Format: Unsigned binary integer
Default Value: N/A

The MODULE_ID command is used to return a code representing the model type of the selected (paged) CoolMod. Some of the ID codes in the CoolX family are as follows:

- CmA CoolMod = 0x20
- CmB CoolMod = 0x40
- CmC CoolMod = 0x60
- CmD CoolMod = 0x80
- CmA-W01 CoolMod = 0x22
- CmB-W01 CoolMod = 0x42
- CmC-W01 CoolMod = 0x62
- CmD-W01 CoolMod = 0x82

PMBus™ SPECIFICATIONS

Calibration Commands

IOUT_CAL_GAIN (0x38)

Protocol: Read/Write Word
Data Format: Linear Format
Default Value: 0xBA00 = 1.00

The IOUT_CAL_GAIN command is used to set/check the ratio of the voltage at the current sense pins to the actual current in Amperes. This is typically used to compensate for unit-to-unit gain variations errors in the current sensing circuit.

This command may be used in conjunction with the IOUT_CAL_OFFSET command to calibrate the device's current sensing circuit in order to achieve greater current measurement accuracy. The data should be formatted in the Linear format.

IOUT_CAL_OFFSET (0x39)

Protocol: Read/Write Word
Data Format: Linear Format
Default Value: 0x00

The IOUT_CAL_OFFSET command is used to set/check the offset of the measured current to the actual current in Amperes. This is typically used to compensate for offset errors in the current sensing circuit.

This command may be used in conjunction with the IOUT_CAL_GAIN command to calibrate the device's current sensing circuit in order to achieve greater current measurement accuracy. The data should be formatted in the Linear format.

VOUT_SCALE_ LOOP (0x29)

Protocol: Read/Write Word
Data Format: Linear Format
Default Value: 0xBA00 = 1.00

The VOUT_SCALE_LOOP command is used to set/check the correction factor applied to the Vout command value. This is typically used to compensate for unit-to-unit gain variations in the voltage setting circuitry.
This command may be used in conjunction with the VOUT_CAL_OFFSET command to calibrate the device's voltage setting circuit in order to achieve greater voltage setting accuracy. The data should be formatted in the Linear format.

VOUT_CAL_OFFSET (0x23)

Protocol: Read/Write Word
Data Format: Extended Linear Format
Default Value: 0x00

The VOUT_CAL_OFFSET command is used to apply a fixed voltage offset to the output voltage command value in order to compensate for offset errors in the voltage setting circuitry. The data will be formatted in the Extended Linear format using the exponent which can be found using the VOUT_MODE command.

PMBus™ SPECIFICATIONS

MFR_ITRIM_CAL_GAIN (0xD6)

Protocol: Read/Write Word
Data Format: Linear Format
Default Value: 0xBA00 = 1.00

The MFR_ITRIM_CAL_GAIN command is used to set/check the correction factor applied to the Iout sensed value. This is typically used to compensate for unit-to-unit gain variations errors in the current sensing circuit. The data should be formatted in the Linear format.

MFR_ITRIM_CAL_OFFSET (0xD7)

Protocol: Read/Write Word
Data Format: Linear Format
Default Value: 0x0000 = 0.00

The MFR_ITRIM_CAL_OFFSET command is used to apply a fixed current offset to the output voltage command value in order to compensate for offset errors in the voltage setting circuitry. The data will be formatted in the Linear format.

VOUT_SCALE_MONITOR (0x2A)

Protocol: Read/Write Word
Data Format: Linear Format
Default Value: 0xBA00 = 1.00

The VOUT_SCALE_MONITOR command is used to set/check the ratio of the voltage at the voltage sense pins to the actual output voltage in Volts. This is typically used to compensate for unit-to-unit gain variations errors in the voltage sensing circuit. The data should be formatted in the Linear format.

MFR_VOUT_OFFSET_MONITOR (0xD3)

Protocol: Read/Write Word
Data Format: Linear Format
Default Value: 0x0000 = 0.00

The MFR_VOUT_OFFSET_MONITOR command is used to apply a fixed voltage offset to the output voltage monitor value in order to compensate for offset errors in the voltage sensing circuitry. The data will be formatted in the Extended Linear format using the exponent which can be found using the VOUT_MODE command.

MFR_EOC_CAL (0xF5)

Protocol: Read/Write Word
Data Format: Linear Format
Default Value: 0xB9FB = 0.99

The MFR_EOC_CAL command is used to set/check the level at which the End Of Charge (EOC) signal should assert as a percentage of the Vout setpoint. This is set to 0.99 by default which means that the EOC signal will assert when the output voltage exceeds 99% of the setpoint.
This command can be used to calibrate this setpoint or to change the level at which EOC should assert. The data should be formatted in the Linear format.

PMBus™ SPECIFICATIONS

MFR_CS_USER_CAL (0xF6)

Protocol: Read/Write Word
Data Format: Linear Format
Default Value: 0xBA00 = 1.00

The MFR_CS_USER_CAL command is used to set/check the correction factor applied to the CS_USER output signal. This is typically used to compensate for unit-to-unit gain variations in the DAC and amplifier circuit. The data should be formatted in the Linear format.

MFR_VPEAK_USER_CAL (0xF7)

Protocol: Read/Write Word
Data Format: Linear Format
Default Value: 0xBA00 = 1.00

The MFR_VPEAK_USER_CAL command is used to set/check the correction factor applied to the VPEAK_USER output signal. This is typically used to compensate for unit-to-unit gain variations in the DAC and amplifier circuit. The data should be formatted in the Linear format.

RECORDS OF REVISION AND CHANGES

Issue	Date	Description	Originators
1.0	09.20.2023	First Issue	J. Zhang

ABOUT ADVANCED ENERGY

Advanced Energy (AE) has devoted more than three decades to perfecting power for its global customers. AE designs and manufactures highly engineered, precision power conversion, measurement and control solutions for mission-critical applications and processes.

Our products enable customer innovation in complex applications for a wide range of industries including semiconductor equipment, industrial, manufacturing, telecommunications, data center computing, and medical. With deep applications know-how and responsive service and support across the globe, we build collaborative partnerships to meet rapid technological developments, propel growth for our customers, and innovate the future of power.

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