The D1U74T-W-2700-12-HBxC Series Power Converter Modules provide PMBus digital communications features that comply with CRPS-185 2700W specifications. This application note provides a basic overview of the PMBus features, including a list of supported commands. Refer to the referenced documentation for additional fine details as required.

Reference Documents:

- *Intel® PMBus Application Profile for AC/DC & DC/DC Server Power Supplies*; revision 1.31 (Reference Number: 451620)
- *Intel® CRPS-185 2700W* specifications
- *PMBus™ Power System Management Protocol Specification Part I – General Requirements, Transport And Electrical Interface*; Revision 1.2
- *PMBus™ Power System Management Protocol Specification Part II – Command Language*; Revision 1.2
- *Murata D1U74T-W-2700-12-HBxC Series Datasheet*

General PMBus Characteristics:

- PMBus Power Sourcing - Redundant Slave Device Power is sourced between adjoined power supply converter modules and makes it possible to communicate with a power supply that has lost input power. PMBus registers and other commands are possible after loss of input power if at least one adjoined redundant power supply installed is operating
- 100kbs maximum supported clock/data speed
- PEC (Packet Error Checking) is supported
- Linear Data Format, unless otherwise noted

Device Addressing Methods:

D1U74T-W-2700-12-HBxC contains two internal slave devices:

1. Secondary side micro-processor
2. IPMI compliant EEPROM

The address must be configured before communications between the system/host and power supply is possible. Address signal pins “A1” and “A0” are provided to configure the address as defined in the following table.

Slave Device Address Selection		
Slave Address (hex) PSU µP / IPMI FRU EEPROM	A1 Pin State	A0 Pin State
B0h / A0h	Low	Low
B2h / A2h	Low	High
B4h / A4h	High	Low
B6h / A6h	High	High

Supported Commands

Cmd Code	Page	Command	Transaction Type		Bit Name	Comments
03h	N/A	CLEAR_FAULTS	Send Byte			Clear all status bits in all PAGEs
05h	N/A	PAGE_PLUS_WRITE	Block Write			Used with STATUS_INPUT, STATUS_TEMPERATURE, STATUS_IOUT. Available page: 0 and 1
06h	N/A	PAGE_PLUS_READ	Block Write Block Read Process Call			Used with STATUS_INPUT, STATUS_TEMPERATURE, STATUS_IOUT, STATUS_WORD. Available page: 0 and 1
19h	N/A	CAPABILITY	Read Byte			This command provides a way for a host system to determine some key capabilities of a PMBus device. Always read 90h
1Ah	N/A	QUERY (used with any command)	Block Write Block Read Process Call			QUERY (used with any command)
1Bh	No Pg., 00h, 01h	SMBALERT_MASK	Reading: Block Write Block Read Process Call Writing: Write Word			Used with STATUS_INPUT, STATUS_TEMPERATURE, STATUS_IOUT
20h	N/A	VOUT_MODE	Read Byte			Single data byte sets the READ_VOUT sensor to linear mode data format and supplies N = -9 exponent for translation to volts. Always read 17h
30h	N/A	COEFFICIENT	Block Write Block Read Process Call			Used with READ_EIN
3Ah	N/A	FAN_CONFIG_1_2	Read Byte			Show the config of fan. Always read 90h
3Bh	N/A	FAN_COMMAND_1	Read Write Word			Manual fan override command fan speed value in Duty Cycle (0-100 in Linear data format)
46h	N/A	IOUT_OC_FAULT_LIMIT	Read Write Word			Sets the value of the output current, in Amperes, that causes an output overcurrent protection. In Linear Data format. (Allowable range: 1 - 330A (1-130A for low range input), Value must be higher or equal to IOUT_OC_WARN_LIMIT. Default value: 330A (130A for low range input)
4Ah	N/A	IOUT_OC_WARN_LIMIT	Read Write Word			Sets the value of the output current, in Amperes, that causes an output overcurrent warning. In Linear Data format. (Allowable range: 1 - 265A (1-110A for low range input), Value must be lower or equal to IOUT_OC_FAULT_LIMIT. Default value: 265A (110A for low range input)
51h	N/A	OT_WARN_LIMIT (Hot Spot)	Read Write Word			Set the temperature, in degrees Celsius, of the unit at which main output shutdown due to OTP. In the Linear Data format. (Allowable range: 0 to default value. Default value: 123C for D1U74T-W-2700-12-HB4C 136C for D1U74T-W-2700-12-HB3C
79h	No Pg., 00h, 01h	STATUS_WORD	Read Word	6	UNIT_OFF	Asserted when unit not providing power to the output for whatever reason
				5	VOUT_OV_F	Asserted when main output shutdown due to overvoltage fault has occurred. Refer to STATUS_VOUT for details
				4	IOUT_OC_F	Asserted when main output shutdown due to overcurrent fault has occurred. Refer to STATUS_IOUT for details
				3	VIN_UV_F	Asserted when main output shutdown due to input undervoltage fault has occurred. This bit will not be set before main output is normally startup
				2	TEMPERATURE_F_W	Asserted when an overtemperature fault or warning has occurred; Refer to STATUS_TEMPERATURE for details
				1	CML_F	Asserted when a communications, memory, or logic fault has occurred
				0	NONE_F_W	Other internal faults
				7	VOUT	Asserted when an output failure has occurred
				6	IOUT/POUT	Asserted when an output current / output power fault or warning has occurred; Refer to STATUS_IOUT for details
				5	INPUT	Asserted when an Input voltage/current/power fault or warning has occurred; Refer to STATUS_INPUT for details
				4	MFG_SPECIFIC_F_W	Manufacturer specific fault or warning has occurred
				3	POWER_GOOD#	Asserted when the POWER_GOOD signal is negated
				2	FANS	Asserted when a fan fault or warning has occurred; Refer to STATUS_FANS for details
7Ah	N/A	STATUS_VOUT	Read Byte	7	VOUT_OV_F	Asserted when main output shutdown due to overvoltage fault has occurred. Protection threshold: refer to data sheet.
				4	VOUT_UV_F	Asserted when main output shutdown due to undervoltage fault has occurred. Protection threshold: refer to data sheet.

Cmd Code	Page	Command	Transaction Type	Bit #	Bit Name	Comments
7Bh	No Pg., 00h, 01h	STATUS_IOUT	Read Byte	7	IOUT_OC_F	Asserted when an output overcurrent fault has occurred. Protection threshold: refer to data sheet.
				5	IOUT_OC_W	Asserted when an output overcurrent warning has occurred. Warning threshold = IOUT_OC_WARN_LIMIT, recovery threshold = warning threshold – 2A
				1	POUT_OP_F	Asserted when Pout has exceeded limits Fault threshold = 3060W (1383W for low input range)
				0	POUT_OP_W	Asserted when an output overpower warning has occurred. Warning threshold = 3060W (1383W for low input range), recovery threshold = warning threshold – 50W
7Ch	No Pg., 00h, 01h	STATUS_INPUT	Read Byte	5	VIN_UV_W	Asserted when an input undervoltage warning has occurred. Warning threshold = 81V, recovery threshold = 85.5V
				4	VIN_UV_F	Asserted when main output shutdown due to input undervoltage fault has occurred. Protection threshold: refer to data sheet.
				3	VIN_UV_OFF (PSU_OFF)	Asserted when main output is OFF because of insufficient input voltage
				1	IIN_OC_W	Asserted when an input overcurrent warning has occurred. Warning threshold = 18A (17A for low input range), recovery threshold = warning threshold – 1A
				0	PIN_OP_W	Asserted when an input overpower warning has occurred. Warning threshold = 3240W (1530W for low input range), recovery threshold = warning threshold– 50W
7Dh	No Pg., 00h, 01h	STATUS_TEMPERATURE	Read Byte	7	TEMPERATURE_OT_F	Asserted when an input over temperature fault has occurred. For D1U74T-W-2700-12-HB4C, T1 threshold = 65C T2 threshold = 127C T3 threshold = 110C For D1U74T-W-2700-12-HB3C, T1 threshold = 60C T2 threshold = 140C T3 threshold = 110C
				6	TEMPERATURE_OT_W	Asserted when an input over temperature warning has occurred (For D1U74T-W-2700-12-HB4C): T1 threshold = 61C, recovery threshold = 58C T2 threshold = OT_WARN_LIMIT, T2 recovery threshold = 88C T3 threshold = 106C, recovery threshold = 78C For D1U74T-W-2700-12-HB3C T1 threshold = 56C, recovery threshold = 53C T2 threshold = OT_WARN_LIMIT, T2 recovery threshold = 90C T3 threshold = 106C, recovery threshold = 82C
7Eh	No Pg., 00h, 01h	STATUS_CML	Read Byte	7	CML_CMD_F	Asserted when an invalid or unsupported command is received
				6	CML_DATA_F	Asserted when invalid or unsupported data is received
				5	CML_PEC_F	Asserted when a packet error checking (PEC) failed has occurred
80h	N/A	STATUS_MFR	Read Byte	7	PFC_OV_F	Asserted when a PFC OV fault occurred.
				6	12VSB_OC_F	Asserted when 12Vsb output OC fault occurred
				5	12VSB_OV_F	Asserted when 12Vsb output OV fault occurred
				4	12VSB_UV_F	Asserted when 12Vsb output UV fault occurred
				3	PFC_UV_F	Asserted when a PFC UV fault occurred.
81h	00h	STATUS_FANS_1_2	Read Byte	7	FAN_1_F	Asserted when a fan fault has occurred.
				5	FAN_1_W	Asserted when a fan warning has occurred.
86h	N/A	READ_EIN	Block Read			
87h	N/A	READ_EOUT	Block Read			
88h	N/A	READ_VIN	Read Word			Linear data format
89h	N/A	READ_IIN	Read Word			
8Ah	N/A	READ_VCAP	Read Word			
8Bh	N/A	READ_VOUT	Read Word			Linear VOUT_MODE (N = -9) format
8Ch	N/A	READ_IOUT	Read Word			

Cmd Code	Page	Command	Transaction Type	Bit #	Bit Name	Comments
	N/A	READ_TEMPERATURE_1	Read Word			Linear data format; Ambient Temperature
8Eh	N/A	READ_TEMPERATURE_2	Read Word			Linear data format; Secondary Hotspot temperature
8Fh	N/A	READ_TEMPERATURE_3	Read Word			Linear data format; PFC Hotspot temperature
90h	N/A	READ_FAN_SPEED_1	Read Word			Linear data format
96h	N/A	READ_POUT	Read Word			
97h	N/A	READ_PIN	Read Word			Linear data format
98h	N/A	PMBUS_REVISION	Read Byte			Reading of the PMBus revision to which the power supply is compliant. Always read 22h
99h	N/A	MFR_ID	Block Read			Manufacture's ID (ASCII code): Murata-PS
9Ah	N/A	MFR_MODEL	Block Read			Manufacture's Model Number (ASCII code): D1U74T-W-2700-12-HBxC
9Bh	N/A	MFR_REVISION	Block Read			Manufacturer's model revision (ASCII code). XXXX-YYYY-0000 XXXX - Primary FW version/revision, YYYY- Secondary FW version/revision
9Ch	N/A	MFR_LOCATION	Block Read/Write			Identify the location that manufactured the unit (ASCII code 16 bytes max)
9Dh	N/A	MFR_DATE	Block Read/Write			Identify the unit's date of manufacture (ASCII code: YYWW, e.g. 1535, 15-> year, 35 -> week)
9Eh	N/A	MFR_SERIAL	Block Read/Write			Serial Number: SSYYWWRR**** MPS 12-digit serial number
9Fh	N/A	APP_PROFILE_SUPPORT	Read Byte			Always read 05h
A0h	N/A	MFR_VIN_MIN	Read Word			Linear data format; Minimum rated value of the input voltage = 90V (AC input) / 180V (DC input).
A1h	N/A	MFR_VIN_MAX	Read Word			Linear data format; Maximum rated value of the input voltage = 264V (AC input) / 300V (DC input).
A2h	N/A	MFR_IIN_MAX	Read Word			Linear data format; Maximum rated value of the input current = 18 Amps (High line AC or DC input) / 17 Amps (Low line AC input).
A3h	N/A	MFR_PIN_MAX	Read Word			Linear data format; Maximum rated value of the input power = 3240W (High line AC or DC input) / 1530 W (Low line AC input).
A4h	N/A	MFR_VOUT_MIN	Read Word			Minimum rated value of the output voltage = 11.59V. Linear (N = -9) supplied by command VOUT_MODE.
A5h	N/A	MFR_VOUT_MAX	Read Word			Maximum rated value of the output voltage = 12.81V. Linear (N = -9) supplied by command VOUT_MODE.
A6h	N/A	MFR_IOUT_MAX	Read Word			Linear data format; Maximum rated value of the output current = 225A (High line AC or DC input) / 100A (Low line AC input).
A7h	N/A	MFR_POUT_MAX	Read Word			Maximum rated value of the output power = 2700W (High line AC or DC input) / 1200W (Low line AC input).
A8h	N/A	MFR_TAMBIENT_MAX	Read Word			Maximum ambient temperature: 55degC for D1U74T-W-2700-12-HB4C, 50degC for D1U74T-W-2700-12-HB3C.
A9h	N/A	MFR_TAMBIENT_MIN	Read Word			Linear data format; Minimum ambient temperature: 0degC.
AAh	N/A	MFR_EFFICIENCY_LL	Block Read			Linear data format; Retrieves information about the efficiency of the device while operating at a low line condition. Vin =115V, LP = 240W, Leff = 92%, MP = 600W, Meff = 94%, HP = 1200W, Heff = 90%.
ABh	N/A	MFR_EFFICIENCY_HL	Block Read			Linear data format; Retrieves information about the efficiency of the device while operating at a high line condition. Vin =230V, LP = 540W, Leff = 94%, MP = 1350W, Meff = 96%, HP = 2700W, Heff = 91%.
C0h	N/A	MFR_MAX_TEMP_1	Read Word			Linear data format; Maximum rated temperature (Ambient): 61degC for D1U74T-W-2700-12-HB4C, 56degC for D1U74T-W-2700-12-HB3C.

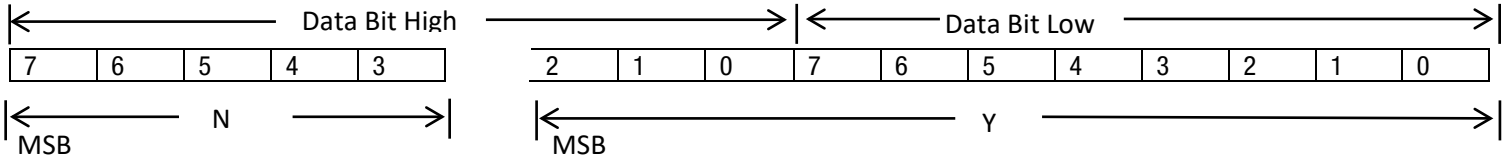
Cmd Code	Page	Command	Transaction Type	Bit #	Bit Name	Comments
C1h	N/A	MFR_MAX_TEMP_2	Read Word			Linear data format; Maximum rated temperature (hot-spot sec): 123degC for D1U74T-W-2700-12-HB4C, 136degC for D1U74T-W-2700-12-HB3C.
C2h	N/A	MFR_MAX_TEMP_3	Read Word			Linear data format; Maximum rated temperature (hot-spot primary): 106C for D1U74T-W-2700-12-HB4C, 106C for D1U74T-W-2700-12-HB3C.
D0	N/A	MFR_COLD_REDUNDANCY_CONFIG	Read/Write Byte			
D1h-D3h		RESERVED	RESERVED			
D4h	N/A	MFR_HW_COMPATIBILITY	Read Word			
D5h	N/A	MFR_FWUPLOAD_CAPABILITY	Read Byte			
D6h	N/A	MFR_FWUPLOAD_MODE	Read/Write Byte			
D7h	N/A	MFR_FWUPLOAD	Block Write (size = block size from image header)			
D8h	N/A	MFR_FWUPLOAD_STATUS	Read Word			
D9h	N/A	MFR_FW_REVISION	Block Read (3 bytes)			
DBh	N/A	MFR_FRU_PROTECTION	Read/Write Byte			
DCh	N/A	MFR_BLACKBOX	Block Read (237 byes)			
DDh	N/A	MFR_REAL_TIME_BLACK_BOX	Block Write/Read (4 bytes)			
DEh	N/A	MFR_SYSTEM_BLACK_BOX	Block Write/Read (40 bytes)			
DFh	N/A	MFR_BLACK_BOX_CONFIG	Read/Write Byte			
E0h	N/A	MFR_CLEAR_BLACK_BOX	Send Byte			
E8h - EFh		MFR_SPECIFIC COMMANDS				
F0h	N/A	MFR_PWOK_WARNING_TIME	Read/Write Word			PWOK warning time 1 to 255 in 1ms step Default value: 1ms
F1h	N/A	MFR_MAX_IOUT_CAPABILITY	Block Read			
F6 - FEh		MFR_SPECIFIC COMMANDS				

Linear Data Format

(Link back to front page)

Telemetry sensor and output voltage readings follow linear format defined by PMBus Power System Mgt Protocol Specification – Part II – Revision 1.2 (summarized below).

Note: Output Voltage readings are also expressed in linear VOUT_MODE format as detailed below.



The Relationship between Y, N and the "real world" value is:

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

where, as described above:

X is the "real world" value;
Y is an 11 bit, two's compliment integer; and
N is a 5 bit, two's compliment integer.

V-OUT MODE (Command Code 20h) PROTOCOL and Returned results:

Link back to CMD_20 list
Output voltage returned readings are expressed in Linear VOUT MODE format as shown in the 2-steps described below.
Refer to PMBus Power System Mgt Protocol Specification – Part II – Revision 1.2 for additional details as needed

Step #1:

Read VOUT_MODE (Command 20h) to determine the exponent and format as follows:

MODE DEFINITION			RETURNED RESULTS				
Mode	**Bits (7:5)**	**Bits (4:0) (Parameter)**	**Command Code (Hex)**	**Command Name**	**Value**	**Bit#**	**Value**
Linear (Default)	000b	Five bit 2's complement exponent for the mantissa delivered as the data bits for an output voltage command Bits 4:0 returned = 10111b = N = -9 (Default)	20	VOUT_MODE	17h	Bit 7	0
						Bit 6	0
						Bit 5	0
						Bit 4	1
						Bit 3	0
						Bit 2	1
						Bit 1	1
						Bit 0	1

Step #:

Convert the high and low data bytes, known as the mantissa into real world voltage:

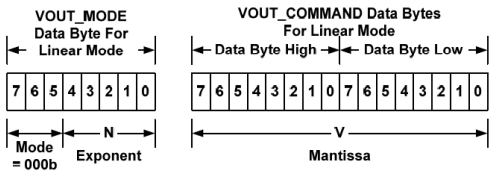


Figure 6. Linear Format Data Bytes

The Mode bits are set to 000b.
The Voltage, in volts, is calculated from the equation:

$$Voltage = V \cdot 2^N$$

Where:
Voltage is the parameter of interest in volts;
V is a 16 bit unsigned binary integer; and
N is a 5 bit two's complement binary integer.

Additional Details

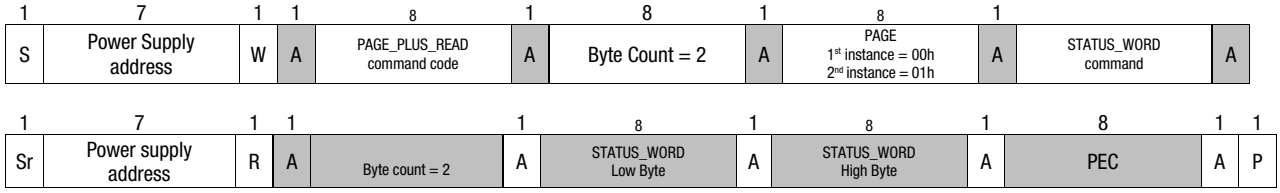
The following section describes the returned results from the above command list.

PAGE_PLUS_WRITE / PAGE_PLUS_READ commands (05h/06h)

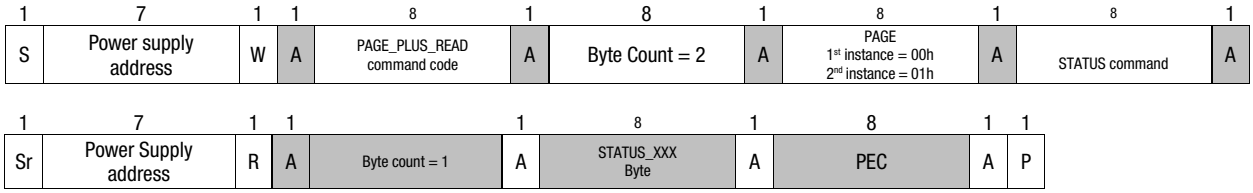
Link Back to Command List

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

Reading STATUS_WORD
Block Write – Block Read Process Call with PEC

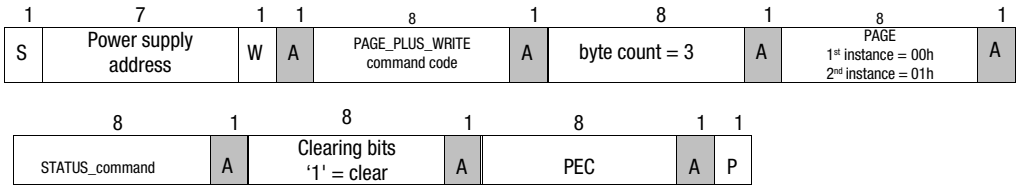


Reading STATUS_TEMPERATURE, STATUS_IOUT, STATUS_INPUT, STATUS_CML
Block Write – Block Read Process Call with PEC



Reading STATUS commands with PAGE_PLUS_READ

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



STATUS_WORD cannot be cleared directly It is clearedbased on lower-level status commands

Figure 4 Clearing STATUS Commands Using PAGE_PLUS_WRITE

Sensors

The following PMBus commands are supported for the purpose of monitoring current, voltage, and power. All sensors continue providing real time data as long as the PMBus device is powered. This means in standby mode the main output(s) of the PSU shall be zero amps and zero volts. Sensors shall meet requirementsfrom 100VAC to 127VAC and from 200VAC to 240VAC (or -36VDC to -75VDC for DC input power supplies). They shall be tested down to 5% load.

Current Power/Temperature Monitoring PMBus Commands	
PMBus Command	**Description**
READ_EIN	New input energy counter described below. Added to PMBus rev 1.2 spec. Uses direct format forthe power accumulator; unsigned integer value for the sample count.
READ_PIN	Input power meter based on PMBus rev 1.1 spec. Uses Linear formatting.
READ_IOUT	Output current in amps for the total 12V current. The other outputs are not sensed. Linear format.
READ_EOUT	New output energy counter described below. Added to PMBus rev 1.2 spec. Direct format for the power accumulator; unsigned integer value for the sample count.
READ_TEMPERATURE_1	Returns the temperature in °C of the inlet temperature. Based on PMBus rev 1.1 spec. Linear format.
READ_TEMPERATURE_2	Returns the temperature in °C of the hot spot temperature. Based on PMBus rev 1.1 spec. Linear format.
READ_TEMPERATURE_3	Returns the temperature in °C of the primary heatsink temperature. Based on PMBus rev 1.1 spec. Linear format.

Sensor Functionality in Different PSU States and Configurations

The functionality of READ_EIN and READ_EOUT in different PSU configurations is stated in the below table. The PSU must continue incrementing the sample counter even if AC power is not present to the PSU but the PMBus device in the PSU is powered from the other power supplies in parallel.

READ_EIN & READ_EOUT Functioning in differing states

Number of PSUs in system	**One PSU state (PSU_1)**	**Rest of PSU states (PSU_n)**	**PSU_1 Power Accumulator**	**PSU_1 Sample counter**
1 or more	ON & AC present	All ON & AC present	New power values continue to add tothe power accumulator based on loading condition	Sample counter increments every sample period
1 or more	*Stby & AC present*	*All ON & AC present*	*New power values continue to add tothe power accumulator based on loading condition*	*Sample counter increments every sample period*
1 or more	OFF & no AC present	All OFF & no AC present	Reset power accumulator values to 00when AC power is re-applied	Reset sample counter to 00 whenAC power is re-applied
2 or more	AC power not present	Rest of PSUs in standby mode & ACpresent	Continue adding 0W to accumulatorevery sample period	Incrementing sample counterevery sample period
2 or more	AC power not present	Rest of PSUs ON &AC present	Continue adding 0W to accumulatorevery sample period	Incrementing sample counterevery sample period

READ_PIN, READ_IOUT, and READ_TEMPERTURE shall continue to report accurate values when the PSU isin standby mode or when it has no AC power but is in parallel with another PSU(s) with AC power and standby power present.

READ_PIN (97h)

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The power supply shall provide input power data in watts. The data shall be reported using the PMBus linear format. The data shall be the average input power or filtered input power. If a simple average is used to provideaverage input power, the minimum averaging duration shall be 2 seconds. If filtering is used; the maximum filterbandwidth shall be 0.5 Hz. The accuracy shall be tested by polling with the READ_PIN command at a rate ranging from one sample/second to 10 samples/second.

READ_PIN Requirements Summary			
	Min.	**Max.**	**Description**
Format	PMBus linear format		PMBus data format; refer to PMBus specification for details
Averaging period	2 seconds	10 seconds	The AC input power shall be averaged using a simple averaging method of a filtering method. This defines the max/min period for simple averaging and the bandwidth range if the filter method is used.
Filtering bandwidth	0.1 Hz	0.5 Hz	
Accuracy (300W – Max load)	+/-2%		The input power data shall meet these accuracy requirements over 100-240VAC and under the defined system polling rate.
Accuracy (150W - 300W load)	+/-3%		
Accuracy (40W – 150W load)	+/-5W		
System polling rate	1 sample/ second	10 samples / second	The power supply shall be polled over this range of rates while testing accuracy.

READ_IOUT (8Ch)

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The power supply shall provide output current data in amperes. The data shall be reported using the PMBus linear format. The data shall be the average output current or filtered output current. If a simple average is used to provide average output current, the minimum averaging duration shall be 2 seconds. If filtering is used; the maximum filter bandwidth shall be 0.5 Hz .The minimum accuracy is specified in the table below. The accuracy shall be tested by polling with the READ_IOUT command at a rate ranging from 1 sample/second to 10 samples/second.

READ_IOUT Requirements Summary			
	Min.	**Max.**	**Description**
Format	PMBus linear format		PMBus data format; refer to PMBus specification fordetails.
Averaging period	2 seconds	10 seconds	The output current shall be averaged using a simple averaging method of a filtering method. This defines themax/min period for simple averaging and the bandwidth range if the filter method is used.
Filtering bandwidth	0.1 Hz	0.5 Hz	
Accuracy (300W – Max load)	+/-2%		The output current data shall meet these accuracy requirements over 100-240VAC and under the definedsystem polling rate.
Accuracy (150W - 300W load)	+/-3%		
Accuracy (40W – 150W load)	+/- 1A		
System polling rate	1 sample/ second	10 samples / second	The power supply shall be polled over this range of rateswhile testing accuracy.

READ_EIN (86h)

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

Requirements Summary			
	Min.	**Max.**	**Description**
Format	PMBus Direct format m = 01h, R = 00h, b = 00h		PMBus data format; refer to PMBus specification for details.
Psample averaging period	4 AC cycles		Period instantaneous input power is averaged over to calculate Psample.
READ_EIN update period	80/66.7ms (50/60Hz)		Period at which the power accumulator and sample counter are updated
Accuracy (300W – Max load)	+/-2%		The input power data shall meet these accuracy requirements over100-240VAC and under the defined system polling rate.
Accuracy (150W - 300W load)	+/-3%		
Accuracy (40W – 150W load)	+/-5W		
Range of System polling period	1 sec	100 ms	The PSU shall be polled over this range of rates while testing accuracy.
IMPORTANT: The PSU READ_EIN update period MUST always be less than the system polling period. To ensure the PSU is compatible with allpossible system polling periods; the PSU must update the READ_EIN power accumulator and sample counter at a period less than 100msec (required period is 4 AC cycles 80/67msec).			

READ_EOUT (87h)

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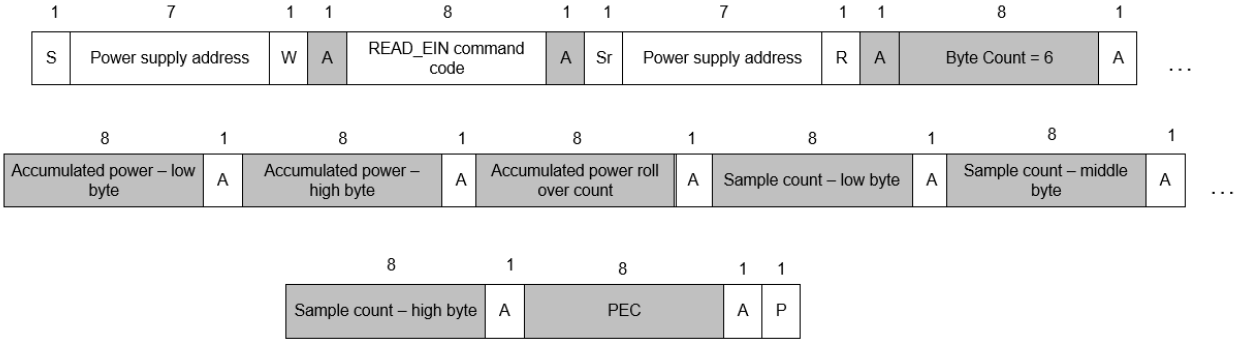
The new READ_EOUT command is used to allow the system to apply its own output power filtering. This will allow the system to get faster output power data while preventing aliasing. The command returns an accumulatedpower value and an associated sample count of number of accumulated power values. This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

READ_EOUT Requirements Summary			
	Min.	**Max.**	**Description**
Format	PMBus Direct format m = 01h, R = 00h, b = 00h		PMBus data format; refer to PMBus specification for details.
Psample averaging period	Nominal 8msec		Period instantaneous input power is averaged over to calculate Psample.
Sampling period	Nominal 8msec		Period at which the power accumulator and sample counter areupdated
[Paccum / N] Accuracy(5% to 100% load)	±2%		The calculated output power data shall meet these accuracy requirements over 100-240VAC and under the defined system pollingrate.
System polling rate	1 sample /s	10 samples /s	The PSU shall be polled over this range of rates while testing accuracy.

READ_EIN & READ_EOUT Formats

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

READ_EIN and READ_EOUT shall use the SMBus Block Read with PEC protocol in the below format.



Cold Redundancy

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The following details are based on Intel's® CRPS-185 2700W specification.

The aim of the cold redundancy feature is to ensure the optimum number of power supplies are supporting the system load in 1+1, 2+2, and 3+1 redundant
configurations. PMBus manufacturer specific commands are required/used to enable, configure, and monitor this feature.

Architecture Overview:

Block diagrams below show the Cold Redundancy architecture in various redundant configurations.

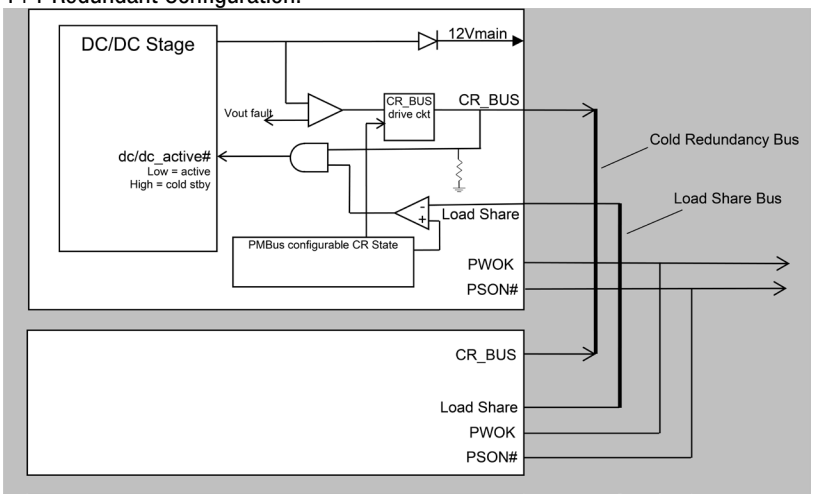
When the power subsystem is operating in Cold Redundant mode, only the needed power supply to support the best power delivery efficiency are ON. Any additional power supplies; including the redundant power supply, is in Cold Standby state.

Each power supply's CR signal pin needs to be connected to for the CR_BUS and is therefore a common bus between all power supplies sharing load in the system. CR_BUS is asserted (pulled low) when there is a fault in any power supply or the power supply's output voltage falls below the Vfault threshold. Asserting the CR_BUS signal causes all power supplies in Cold Standby state to power ON.

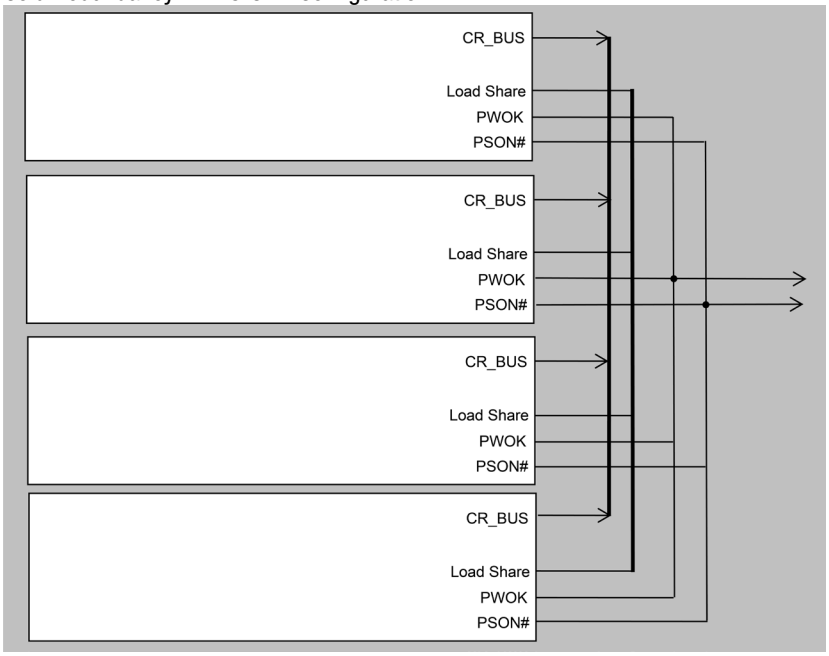
Enabling power supplies to maintain best efficiency is achieved by monitoring the Load Share bus voltage and comparing it to a programmed voltage level via a PMBus command.

Whenever there is no Cold Redundant active power supply on the Cold Redundancy bus driving the CR_BUS Logic high state, all power supplies turn on no matter their defined Cold Redundant roll (active or Cold Standby), ensuring incorrect programming of the Cold Redundancy states of the power supply will never cause thepower subsystem to shut-down or become over loaded. The default state of the power subsystem is all power supplies ON. There needs to be at least one power supply in Cold Redundant Active state or Standard Redundant state to allow the Cold Standby state power supplies to go into Cold Standby state.

1+1 Redundant Configuration:



Cold Redundancy 2+2 & 3+1 Configuration:



LOGIC MATRIX FOR COLD STANDBY POWER SUPPLIES			
CR_BUS	**Load Share**	**dc/dc_active#**	**Cold Standby Power Supply State(s)**
High	< V_{CR_ON}	High	Cold Standby
Low	< V_{CR_ON}	Low	Active
High	> V_{CR_ON}	Low	Active
Low	> V_{CR_ON}	Low	Active

Cold Standby Power Supply Operating State

A power supply is put into Cold Standby whenever PSON# is asserted, CR_ON# is de-asserted, and COLD_RED_CONFIG value is set to 02h, 03h, or 04h. In the cold standby mode the power supply must:

1. Power ON in < 100µsec when Cold_Red bus is driven LOW
2. Turn off its output OR'ing FET
3. Keep its internal output capacitor before the output OR'ing FET charged to not less than 12.6V
4. Keep PWOK asserted
5. Disconnect any output dummy loads to prevent discharging of the recharged output capacitor
6. Power off any internal fans
7. Pre-bias its voltage error amplifier to maximum duty cycle (preventing the loop compensation fromslowing up the turn on process)
8. Disable its output slow start circuit
9. Keep the PFC stage ON at lowest possible operating frequency and its output bulk capacitor charged
10. No PMBus fault or warning conditions reported via STATUS commands

Powering on Cold Standby Supplies to Maintain Best Efficiency

Power supplies in Cold Standby state shall monitor the shared voltage level of the load share signal to sense when it needs to power on. Depending upon which position (1, 2, or 3) the system defines that power supply to be in the cold standby configuration; will slightly change the load share threshold that the power supply shall power on at. The CR_BUS of any power supply may be in one of three different states; pulled low, pulled high, ortri-stated. In tri-state the CR_BUS is a high impedance to ground; only a high impedance resistor pulling the signal to ground.

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

Powering on Cold Standby supplies during a fault or over current condition

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

Cold Redundancy PMBus Commands

The PMBus manufacturer specific command MFR_SPECIFIC_00 is used to configure the operating state of the power supply related to cold redundancy. Command Cold_Redundancy_Config (D0h) includes the definition of the values used with the Read-Write Byte SMBus protocol with PEC.

The power supplies set up to be the cold standby power supplies; shall change to standard redundancy mode(D0h = 00h) whenever the CR_BUS is pulled low.

Cold_Redundancy_Config (D0h)		
Value	**State**	**Description**
00h	Standard Redundancy (default power on state)	Turns the power supply ON into standard redundant load sharing more. The power supply's CR_BUS signal shall be in Tri-state but still pull the bus low if a fault occurs toactivate any power supplies still in Cold Standby state.
01h	Cold Redundant Active [1]	Defines this power supply to be the one that is always ON in a cold redundancyconfiguration.
02h	Cold Standby 1 [1]	Defines the power supply that is first to turn on in a cold redundant configuration as theload increases.
03h	Cold Standby 2 [1]	Defines the power supply that is second to turn on in a cold redundant configuration asthe load increases.
04h	Cold Standby 3 [1]	Defines the power supply that is third to turn on in a cold redundant configuration as theload increases.
05h	Always Standby [1]	Defines this power supply to be always in cold redundant configuration no matter whatthe load condition.
06h –– FFh	reserved	

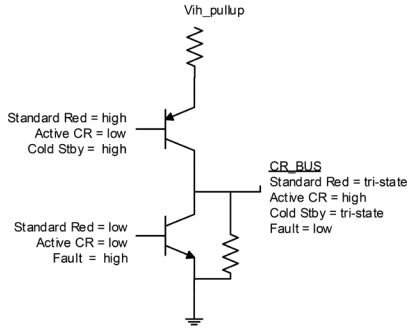
[1] When the CR_BUS transitions from a high to a low state; each PSU programmed to be in Cold Standby state shall be put into Standard Redundancy mode (Cold_redundancy_Config = 00h). For the power supplies to enterCold Redundancy mode the system must re-program the power supplies using the Cold_Redundancy_Config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

Cold Redundancy Bus (CR_BUS)

This is a tri-state output signal of the power supply used to communicate a fault or over current has occurred in one of the power supplies. This is used to power on all the power supplies in the system via the CR_BUS. Whenthe signal is pulled high it allows all power supplies in cold standby mode to go into cold standby state when the load is light enough. When the signal I left open on all power supplies it force them all cold standby power supplies ON.

Cold Redundant States			
Cold Redundant Config	**Operating State**	**PSU Fault State**	**CR_BUS**
Active	On	OK	High
Cold Standby 1,2,3	On	OK	Tri-state
Cold Standby 1,2,3	Cold Stby	OK	Tri-state
Always standby	Cold Stby	OK	Tri-state
Active	Off	Fault	Low
Cold Standby 1,2,3	On	Fault	Low
Cold Standby 1,2,3	Cold Stby	Fault	Low
Always standby	Cold Stby	Fault	Low

CR Signal / Bus Circuit Diagram



CR_BUS Signal Characteristics:		
Signal Type	custom	
	MIN	MAX
Logic level low (power supply ON)	0V	Vil_cr_bus
Logic level high (power supply OFF)	Vih_cr_bus	
Source current, Cold Red = high	Ioh_cr_bus	
Sink current, Cold_Red = low		Iol_cr_bus
Cold_Red fault delay		10 µs
Cold_Red turn on delay		100 µs

System BMC Requirements

The BMC uses the Cold_Redundancy_Config command to define/configure the power supply's roll in cold redundancy and to turn on/off cold redundancy.
The BMC schedules a rolling change for which PSU is the Active, Cold Stby1, Cold Stby 2, and Cold Stby 3 power supply. The allows for equal loading across power supply over their life.

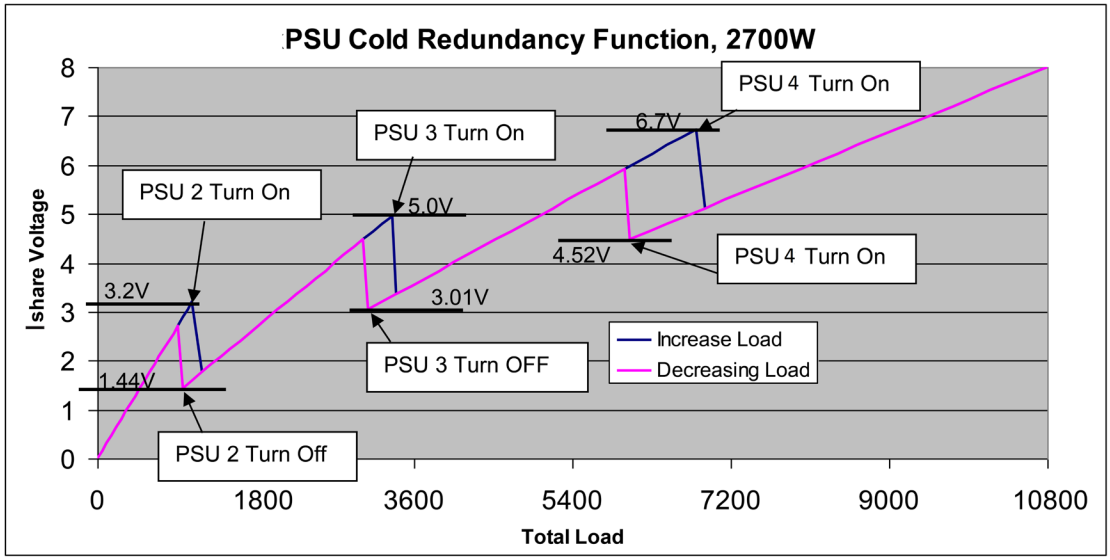
Events that trigger a re-configuration of the power supplies using the Cold_Redundancy_Config command:

- AC power ON
- PSON power ON
- Power Supply Failure
- Power supply inserted into system

Power Supply Turn On Function

Powering on and off of the cold standby power supplies is only controlled by each PSU sensing the Vshare bus. Once a power supply turns on after crossing the enable threshold; it lowers its threshold to the disable threshold. The system defines the 'position' of each power supply in the Cold Redundant operation. It will do this each time the system is powered on, a power supply fails, or a power supply is added to the system.

The system is relied upon to tell each power supply where it resides in the Cold Redundancy scheme. When the load ramps up and crosses the CR threshold module wake up time must be <3ms. When the load ramps down and crosses the CR threshold module go-to-sleep (sdby) time must be <5ms



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