CP3000AC56TE Compact Power Line High Efficiency Rectifier

100-120/200-264V_{AC} input; Default Outputs: ±56V_{DC} @ 3000W, 5V_{DC} @ 3.75W

RoHS Compliant

The CP3000AC56TE Rectifier provides significant efficiency improvements in the Compact Power Line platform of Rectifiers. High density front-to-back airflow is designed for minimal space utilization and is highly expandable for future growth. The wide-input standard product is designed to be deployed internationally. The rectifier complements the CP2500DC56PE-FAL converter and is designed to proportionately current share with it, thus providing comprehensive solutions for systems connected either to commercial ac mains, or 48/60V_{DC} power plants common in telecom central offices. This rectifier is provided with many features including PoE isolation and dual-redundant I^2C communications busses that facilitate use in a broad range of applications.

Applications

- 48V_{DC} distributed power architectures
- Routers/Switches
- VoIP/Soft Switches
- LAN/WAN/MAN applications
- File servers
- Indoor wireless
- Telecommunications equipment
- Enterprise Networks
- SAN/NAS/iSCSI applications

Features

- Efficiency 95.6%
- Compact 1RU form factor with 28 W/in^3 density
- Constant power from 52 – 58V_{DC}
- 3000W from nominal 200 – 264V_{AC}
- 1200W from nominal 100 – 120V_{AC}
- Output voltage programmable from 42V – 58V_{DC}
- PMBus compliant dual I^2C serial busses
- Isolated +5V Aux
- Power factor correction (meets EN/IEC 61000-3-2 and EN 60555-2 requirements)
- Overvoltage, overload and overtemperature protection
- AC Input overvoltage and undervoltage protection
- Redundant, parallel operation with active load sharing
- Remote ON/OFF
- Proportional current share with the CP2500DC56PE-FAL
- Internally controlled Variable-speed fan
- Hot insertion/removal (hot plug)
- Two front panel LED indicators
- ANSI/UL* 62368-1 and CAN/CSA† C22.2 No. 62368-1 Recognized, DIN VDE‡ 0868-1/A11:2017 (EN62368-1:2014/A11:2017)
- CE mark meets 2006/95/EC directive§
- BSMI and KCC safety certifications
- RoHS 6 compliant

* UL is a registered trademark of Underwriters Laboratories, Inc.
† CSA is a registered trademark of Canadian Standards Association.
‡ VDE is a trademark of Verband Deutscher Elektrotechniker e.V.
§ This product is intended for integration into end-user equipment. All CE marking procedures of end-user equipment should be followed. (The CE mark is placed on selected products.)
** ISO is a registered trademark of the International Organization of Standards
* The PMBus name and logo are registered trademarks of the System Management Interface Forum (SMIF)

Absolute Maximum Ratings

Stresses in excess of the absolute maximum ratings can cause permanent damage to the device. These are absolute stress ratings only, functional operation of the device is not implied at these or any other conditions in excess of those given in the operations sections of the data sheet. Exposure to absolute maximum ratings for extended periods can adversely affect the device reliability.

Parameter	Symbol	Min	Max	Unit
Input Voltage: Continuous	V_{IN}	0	264	V_{AC}
Operating Ambient Temperature[1]	TA	-10	75	°C
Storage Temperature	Tstg	-40	85	°C
I/O Isolation voltage to Frame (100% factory Hi-Pot tested)			1500	V_{AC}

[1]See the derating guidelines under the Environmental Specifications section

Electrical Specifications

Unless otherwise indicated, specifications apply over all operating input voltage, Vo=56V_{DC}, resistive load, and temperature conditions

INPUT

Parameter	Symbol	Min	Typ	Max	Unit
Startup Input Voltage Low-line Operation High-line Operation	V_{IN}			90 185	V_{AC}
Operating Voltage Range Low-line Configuration High-line Configuration		90 185	100 – 120 200 - 240	140 264	
Input Voltage Swell (no damage)		264			
Input turn OFF		78	80	82	
Input turn ON		83	85	87	
Input Frequency	F_{IN}	47		66	Hz
Input protection fuse (314025 or 324025 .MX280 Series (pigtail type)			25		A
Input Current; At 90V_{AC}/1200W At 100V_{AC}/1200W At 110V_{AC}/1200W At 185V_{AC}/3000W At 200V_{AC}/3000W At 208V_{AC}/3000W	I_{IN}			15.4 13.8 12 18 16.5 15.9	A_{AC}
Inrush Transient (at 25°C, excluding X-Capacitor charging)	I_{IN}		25	30	A_{PK}
Idle Power (at 220V_{AC}) 56V OFF 56V ON @ I_o=0	P_{IN}		8.2 16		W
Input Leakage Current (264V_{AC}, 60Hz)	I_{IN}			2.0	mA
Power Factor (50 – 100% load)	PF	0.96	0.995		
Efficiency[2] (30 – 80% of FL, 240V_{AC} @ 25°C)	η	94.5	95.6		%
Holdup time (240V_{AC} output may decay from 56 to 40V_{DC}) FL (120V_{AC} output may decay from 56 to 40V_{DC}) FL	T		20 40		ms
Ride thru (tested at 115V @ 230V. (Complies to CISPR24)	T	1/2	1		cycle
Isolation (per EN62368) (consult factory for testing to this requirement) Input-Chassis/Signals Input - Output	V	1500 3000			V_{AC} V_{AC}

[2]See efficiency curve in the Characteristics Curves section.

Electrical Specifications (Continued)

56V_{DC} MAIN OUTPUT

Parameter	Symbol	Min	Typ	Max	Unit
Output Power @ low line input 100 – 120V_{AC} @ high line input 200 – 264V_{AC}	W	1200 3000			W_{DC}
Default Set point	V_{OUT}		56		V_{DC}
Overall regulation (line, load, temperature, aging)		-1		+1	%
Output Voltage Set Range - analog margining -Set by I^2C		44 42		58 58	V_{DC}
Output Current[3] - @ 1200W (100 – 120V_{AC}), 56V/52V @ 3000W (200 – 240V_{AC}), 56V/52V	I_{OUT}	1 1		21.4/23 53.5/57.7	A_{DC}
Current Share (> 50% FL)		-5		5	%FL
Proportional Current Share with the CP2500DC56PE-FAL (> 50% FL)			<7		%FL
Output Ripple (20MHz bandwidth, load > 1A) RMS (5Hz to 20MHz) Peak-to-Peak (5Hz to 20MHz) Psophometric Noise	V_{OUT}			100 300[4] 9[5]	mV_{rms} mV_{p-p} mV_{rms}
External Bulk Load Capacitance	C_{OUT}	0		5,000	µF
Turn-On (monotonic turn-ON from 30 – 100% of Vnom above 5°C) Delay Rise Time – PMBus mode Rise Time - RS-485 mode[6] Output Overshoot	 Time V_{OUT}		 5 100 5	 2	 s ms s %
Load Step Response ($I_{O,START}$ > 2.5A ; ramp 1A/µs) ΔI ΔV Response Time	 I_{OUT} V_{OUT} T		 2.5 2	 50 	 %FL V_{DC} ms
Overload - Power limit @ high line down to 52V_{DC} Power limit @ low line down to 52V_{DC} High line current limit if V_{out} > 41.5V_{DC} High line current limit if V_{out} < 41.5V_{DC} Low line current limit Output shutdown (commences as voltage decays below this level)	P_{OUT} P_{OUT} I_{OUT} I_{OUT} I_{OUT} V_{OUT}	3000 1200 58.3 36 24		 39	W_{DC} W_{DC} A_{DC} A_{DC} A_{DC} V_{DC}
System power up	Upon insertion the power supply will delay an overload shutdown for 20 seconds allowing for the insertion and startup of multiple modules within a system.				
Overvoltage - 200ms delayed shutdown Immediate shutdown Latched shutdown	V_{OUT}	> 65		< 65	V_{DC}
	Three restart attempts are implemented within a 1 minute window prior to a latched shutdown.				
Over-temperature warning (prior to commencement of shutdown) Shutdown (below the max device rating being protected) Restart attempt Hysteresis (below shutdown level)	Temp		5 20 10		°C
Power_OK signal[7] asserted when the output decays below 50V_{DC} asserted earlier (> 50V_{DC}) if AC input not present	V	49.25 51	50 52	50.75	V_{DC}
Isolation Output-Chassis (Standard, non-POE compliant) Output-Chassis/Signals (POE compliant per IEEE802.3)	V	500 2250			V_{DC} V_{DC}

[3] The unit regulates down to 0A_{DC} but may not meet all spec requirements below 1A_{DC}.

[4] 450mV_{p-p} max for V_{OUT} ≥ 56V_{DC}.

[5] Complies with ANSI TI.523-2001 section 4.9.2 emissions max limit of 20mV flat unweighted wideband noise limits

[6] Below -5°C, the rise time is approximately 5 minutes to protect the bulk capacitors.

[7] Internal protection circuits may override the Power_OK signal and may trigger an immediate shutdown.

Electrical Specifications (Continued)

$5V_{DC}$ Auxiliary output

Parameter	Symbol	Min	Typ	Max	Unit
Output Voltage Setpoint	V_{OUT}		5		V_{DC}
Overall Regulation (line, load, temperature, aging) – design goal		-3		+3	%
Output Current (regulates to 0A but may not meet all requirements)		0.005		0.75	A
Ripple and Noise (20mHz bandwidth)			50	100	mV_{p-p}
Load Step Response (ramp 0.5A/µs) ΔI ΔV;(0.375 – 0.75A) Response Time	 I_{OUT} V_{OUT} T		 0.375 0.1 2		 A V_{DC} ms
Over-voltage Clamp				6	V_{DC}
Over-current Limit		110		175	%FL
Isolation from the main output STD / POE compliant		500 / 2250			V_{DC}
Isolation from frame ground		50			V_{DC}

General Specifications

Parameter	Min	Typ	Max	Units	Notes
Reliability		450,000		Hours	Full load, 25°C ; MTBF per SR232 Reliability protection for electronic equipment, issue 2,
Service Life		10		Years	Full load, excluding fans
Unpacked Weight		2.18/4.8		Kgs/Lbs	
Packed Weight		2.45/5.4		Kgs/Lbs	
Heat Dissipation	125 Watts or 426 BTUs @ 80% load, 170 Watts or 580 BTUs @ 100% load				

Feature Specifications

Unless otherwise indicated, specifications apply over all operating input voltage, resistive load, and temperature conditions. Signals are referenced to Logic_GRD unless noted otherwise. Fault, PFW, OTW, SMBAlert#, and Power capacity need to be pulled HI through external pull-up resistors. See Feature Descriptions for additional information.

Parameter	Symbol	Min	Typ	Max	Unit
Remote ON (should be connected to Logic_GRD) 56V output OFF	V_{OUT}	1.4	—	5	V_{DC}
56V output ON	V_{OUT}	0	—	0.8	V_{DC}
Margining (through adjusting Vcontrol)		44		58	V_{DC}
Voltage control range	Vcontrol	0		3.3	V_{DC}
Programmed output voltage range	V_{OUT}	42		58	V_{DC}
Voltage adjustment resolution (8-bit A/D)	Vcontrol		3.3		mV_{DC}
Output configured to $56V_{DC}$	Vcontrol	3.0		3. 3	V_{DC}
Output configured to $44V_{DC}$	Vcontrol	0		0.1	V_{DC}
INTERRUPT [short pin controls $56V_{DC}$ output -] referenced to V_{OUT}(-)					
56V output OFF	Vcontrol	1.4	—	5	V_{DC}
56V output ON	Vcontrol	0	—	0.8	V_{DC}
Module Present [Resistor connected to Logic_GRD internally]			500		Ω
Write protect enabled	V	1	—	5	V_{DC}
Write protect disabled	V	0	—	0.8	V_{DC}
Over Temperature Warning (OTW) Logic HI (temperature normal)	V	$0.7V_{DD}$	—	12	V_{DC}
Sink current	I	—	—	5	mA
Logic LO (temperature is too high)	V	0	—	0.4	V_{DC}

Feature Specifications (Continued)

Parameter	Symbol	Min	Typ	Max	Unit
Fault Logic HI (No fault is present)	V	$0.7V_{DD}$	—	12	V_{DC}
Sink current	I	—	—	5	mA
Logic LO (Fault is present)	V	0	—	0.4	V_{DC}
SMBAlert# (Alert#_0, Alert#_1) Logic HI (No Alert - normal)	V	$0.7V_{DD}$	—	12	V_{DC}
Sink current	I	—	—	5	mA
Logic LO (Alert is set)	V	0	—	0.4	V_{DC}
Power Capacity Logic HI	V	$0.7V_{DD}$	—	12	V_{DC}
Logic LO	V	0	—	0.4	V_{DC}
Reset Logic HI	V	$0.7V_{DD}$	—	12	V_{DC}
Logic LO	V	0	—	0.4	V_{DC}
Protocol select Logic HI - Analog/PMBus™ mode	V_{IH}	2.7	—	3.5	V_{DC}
Logic LO – DSP reprogram mode	V_{IL}	0	—	0.4	V_{DC}
Power_OK Logic HI	V	$0.7V_{DD}$	—	12	V_{DC}
Logic LO	V	0	—	0.4	V_{DC}

Digital Interface Specifications

Parameter	Conditions	Symbol	Min	Typ	Max	Unit
PMBus Signal Interface Characteristics						
Input Logic High Voltage (CLK, DATA)		V	1.5		3.6	V_{DC}
Input Logic Low Voltage (CLK, DATA)		V	0		0.8	V_{DC}
Input high sourced current (CLK, DATA)		I	0		10	µA
Output Low sink Voltage (CLK, DATA, SMBALERT#)	I_{OUT}=3.5mA	V			0.4	V_{DC}
Output Low sink current (CLK, DATA, SMBALERT#)		I	3.5			mA
Output High open drain leakage current (CLK,DATA, SMBALERT#)	V_{OUT}=3.6V	I	0		10	µA
PMBus Operating frequency range	Slave Mode	FPMB	10		400	kHz
Measurement System Characteristics						
Clock stretching		$T_{stretch}$			25	ms
I_{OUT} measurement range	Direct	I_{rng}	0		50[8]	A_{DC}
I_{OUT} measurement accuracy 25°C		$I_{out(acc)}$	-2.5		+2.5	% of FL
V_{OUT} measurement range	Direct	$V_{out(rng)}$	0		70	V_{DC}
V_{OUT} measurement accuracy		$V_{out(acc)}$	-2		+2	%
Temp measurement range	Direct	$Temp_{(rng)}$	0		150	°C
Temp measurement accuracy[9]		$Temp_{(acc)}$	-5		+5	%
V_{IN} measurement range	Direct	$V_{in(rng)}$	0		320	V_{AC}
V_{IN} measurement accuracy		$V_{in(acc)}$	-1.5		+1.5	%
P_{IN} measurement range	Direct	$P_{in(rng)}$	0		3000	W_{in}
P_{IN} measurement accuracy[10]		$P_{in(acc)}$	-3.5		+3.5	%
Fan Speed measurement range	Direct		0		30k	RPM
Fan Speed measurement accuracy			-10		10	%
Fan speed control range	Direct		0		100	%
Device Addressing						
Unit address [reference: V_{OUT} (-)]	Module 1	$V_{unitadr}$	2.3	2.477	3.3	V_{DC}
	Module 2	$V_{unitadr}$	1.6	1.925	2.2	V_{DC}
	Module 3	$V_{unitadr}$	0.9	1.243	1.5	V_{DC}
	Module 4	$V_{unitadr}$	0	0.654	0.8	V_{DC}
Shelf address [reference: V_{OUT} (-)]	Shelf 1	$V_{shelfadr}$	3.0	3.3	3.45	V_{DC}
	Shelf 2	$V_{shelfadr}$	2.7	2.86	2.97	V_{DC}
	Shelf 3	$V_{shelfadr}$	2.18	2.4	2.56	V_{DC}
	Shelf 4	$V_{shelfadr}$	1.73	1.96	2.14	V_{DC}
	Shelf 5	$V_{shelfadr}$	1.29	1.50	1.70	V_{DC}
	Shelf 6	$V_{shelfadr}$	0.84	1.10	1.25	V_{DC}
	Shelf 7	$V_{shelfadr}$	0.30	0.60	0.80	V_{DC}
	Shelf 8	$V_{shelfadr}$	0	0.01	0.25	V_{DC}

[8] Load levels higher than 50A will be read as 50A.

[9] Temperature accuracy reduces non-linearly with decreasing temperature

[10] Below 100W input power measurement accuracy reduces significantly

Environmental Specifications

Parameter	Min	Typ	Max	Units	Notes
Ambient Temperature	-40[11]		45[12]	°C	Air inlet from sea level to 5,000 feet.
Storage Temperature	-40		85	°C	
Operating Altitude			1524/5000	m / ft	
Non-operating Altitude			8200/30k	m / ft	
Power Derating with Temperature			2.0	%/°C	55°C to 75°C[13]
Power Derating with Altitude			2.0	°C/305 m °C/1000 ft	Above 1524/5000 m/ft; 3962/13000 m/ft max
Acoustic noise		55		dbA	Full load
Over Temperature Protection		125/110		°C	Shutdown / restart [internally measured points]
Humidity Operating Storage	 5 5		 95 95	 % %	Relative humidity, non-condensing
Shock and Vibration	Meets IPC 9592 Class II, Section 5 requirements				

[11]Designed to start and work at an ambient as low as -40°C, but may not meet operational limits until above -5°C

[12]Design target is to issue a OTW signal approximately 5°C below shutdown at full load, and shut down at ≥ 55°C, data to be taken at 240V_{AC}

[13]The maximum operational ambient is reduced in Europe in order to meet certain power cord maximum ratings of 70°C. The maximum operational ambient where 70°C rated power cords are utilized is reduced to 60°C until testing demonstrates that a higher level is acceptable.

EMC

Parameter	Criteria	Standard	Level	Criteria[14]	Test
AC input	Conducted emissions	EN55032, FCC Docket 20780 part 15, subpart J EN61000-3-2 Meets Telcordia GR1089-CORE by a 3dB margin	A		0.15 – 30MHz 0 – 2 KHz
	Radiated emissions	EN55032	A		30 – 10000MHz
AC Input Immunity	Line sags and interruptions	EN61000-4-11		A	-30%, 10ms
				B	-60%, 100ms
				B	-100%, 5sec
		Output will stay above 40V_{DC} @ full load Sag must be higher than 80Vrms.		A A	25% line sag for 2 seconds 1 cycle interruption
	Lightning surge	EN61000-4-5, Level 4, 1.2/50µs – error free		A	4kV, common mode
				A	2kV, differential mode
		ANSI C62.41 - level A3		B	6kV, common & differential
	Fast transients	EN61000-4-4, Level 3		A	5/50ns, 2kV (common mode)
Enclosure immunity	Conducted RF fields	EN61000-4-6, Level 3	A		130dBµV, 0.15-80MHz, 80% AM
	Radiated RF fields	EN61000-4-3, Level 3	A		10V/m, 80-1000MHz, 80% AM
		ENV 50140	A		
	ESD	EN61000-4-2, Level 4	B		8kV contact, 15kV air

[14] Criteria A: Normal performance Within limits. Criteria B: Temporary loss of function or degradation of performance which ceases after the disturbance ceases, and from which the equipment under test recovers its normal performance, without operator intervention.

Characteristics Curves

The following figures provide typical characteristics for the CP3000AC56TE rectifier and 25°C

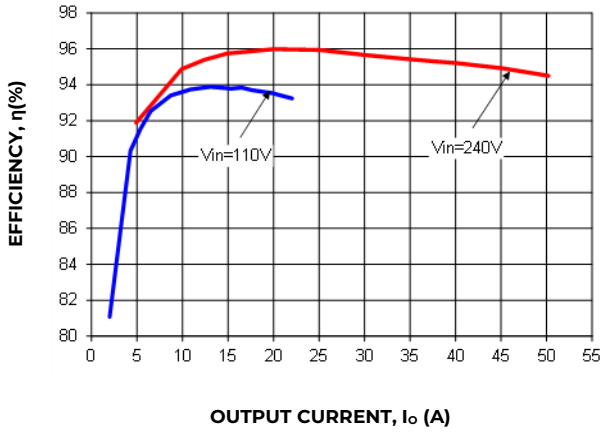


Figure 1. Rectifier Efficiency versus Output Current.

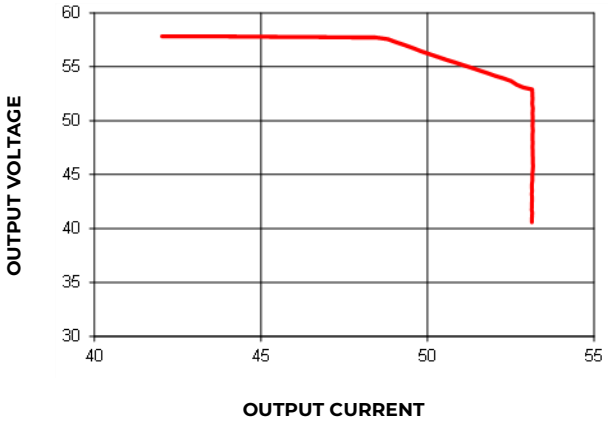


Figure 2. 56V_{DC} output: Power limit, Current limit and shutdown profile at V_{IN} = 185V_{AC}

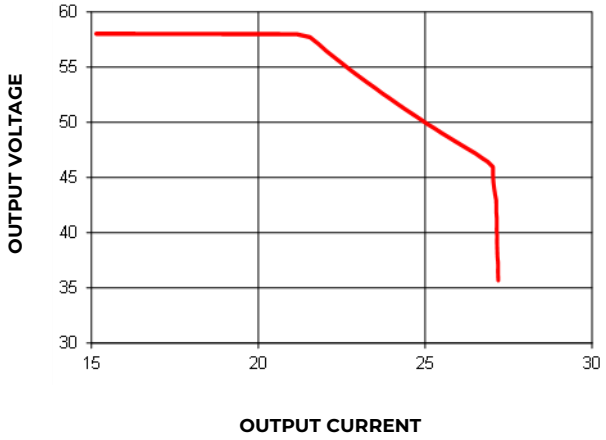


Figure 3. 56V_{DC} output: Power limit, Current limit and shutdown profile at V_{IN} = 90V_{AC}.

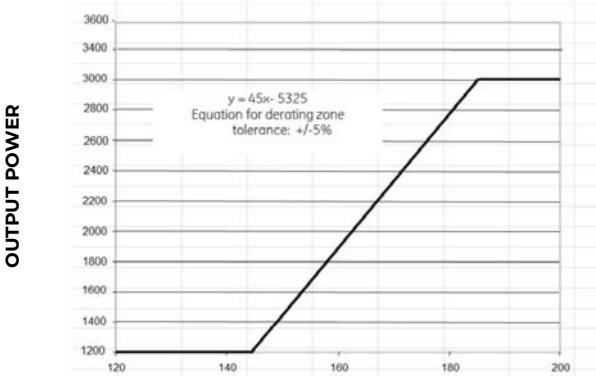


Figure 4. 56V_{DC} output: Output power derating based on input voltage.

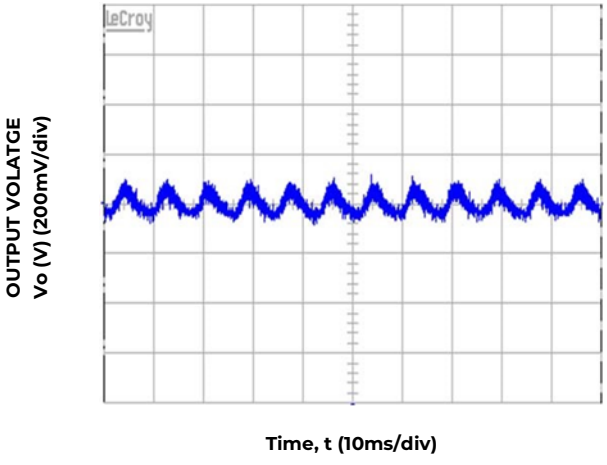


Figure 5. 56V_{DC} output ripple and noise, full load, V_{IN} = 185V_{AC}.

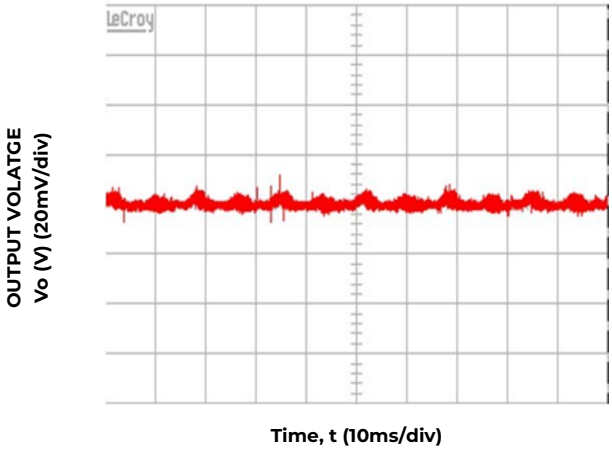


Figure 6. 5V_{DC} output ripple and noise, all full load,V_{IN} = 185V_{AC}.

Characteristics Curves (Continued)

The following figures provide typical characteristics for the CP3000AC56TE rectifier and 25°C

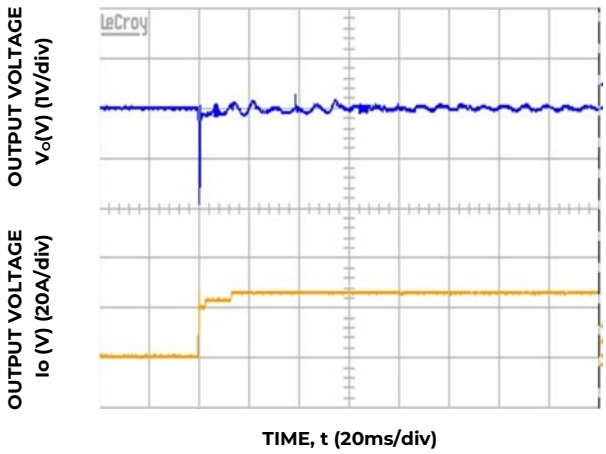


Figure 7. Transient response 56V_{DC} load step 2.5 – 27.2A, V_{IN} = 185V_{AC}.

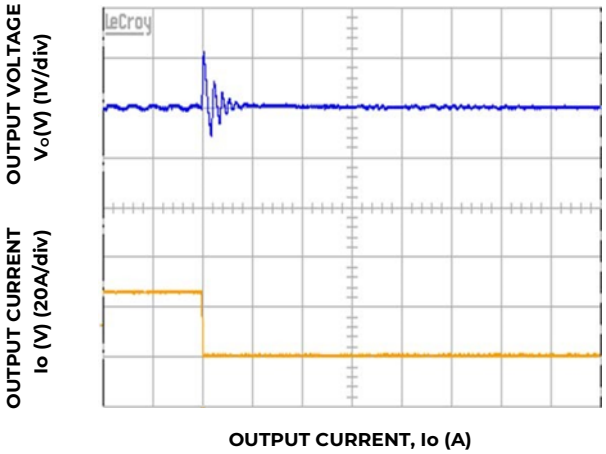


Figure 8. Transient response 56V_{DC} load step 27.2 – 2.5A, V_{IN} = 185V_{AC}.

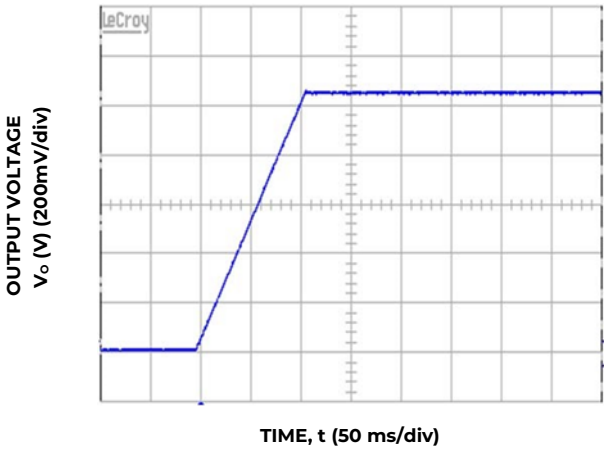


Figure 9. 56V_{DC} soft start, no-load & full load, VIN=185V_{AC} - I²C mode.

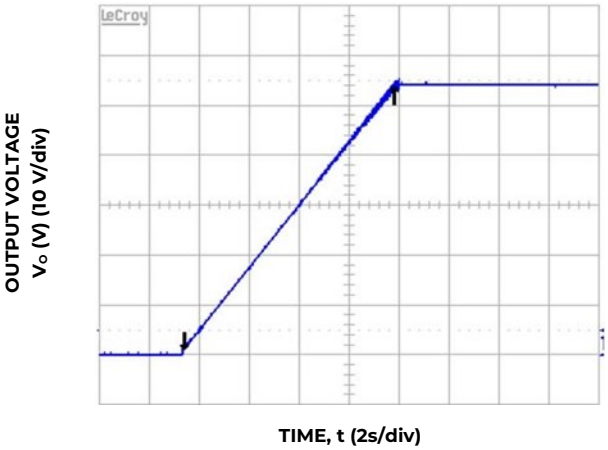


Figure 10. 56V_{DC} soft start, full load, V_{IN} = 185V_{AC} - RS485 mode.

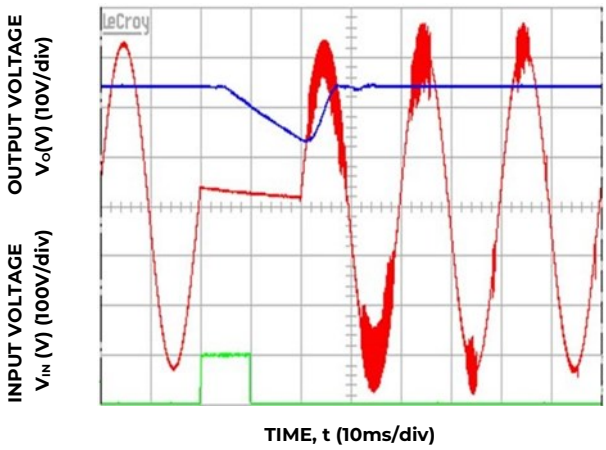


Figure 11. Ride through missing 1 cycle, full load, V_{IN} = 230V_{AC}

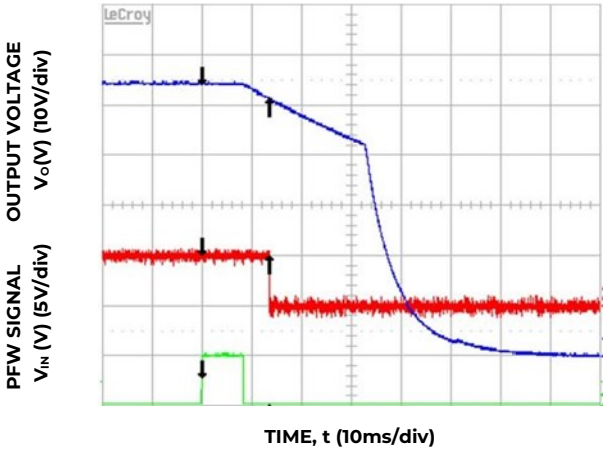
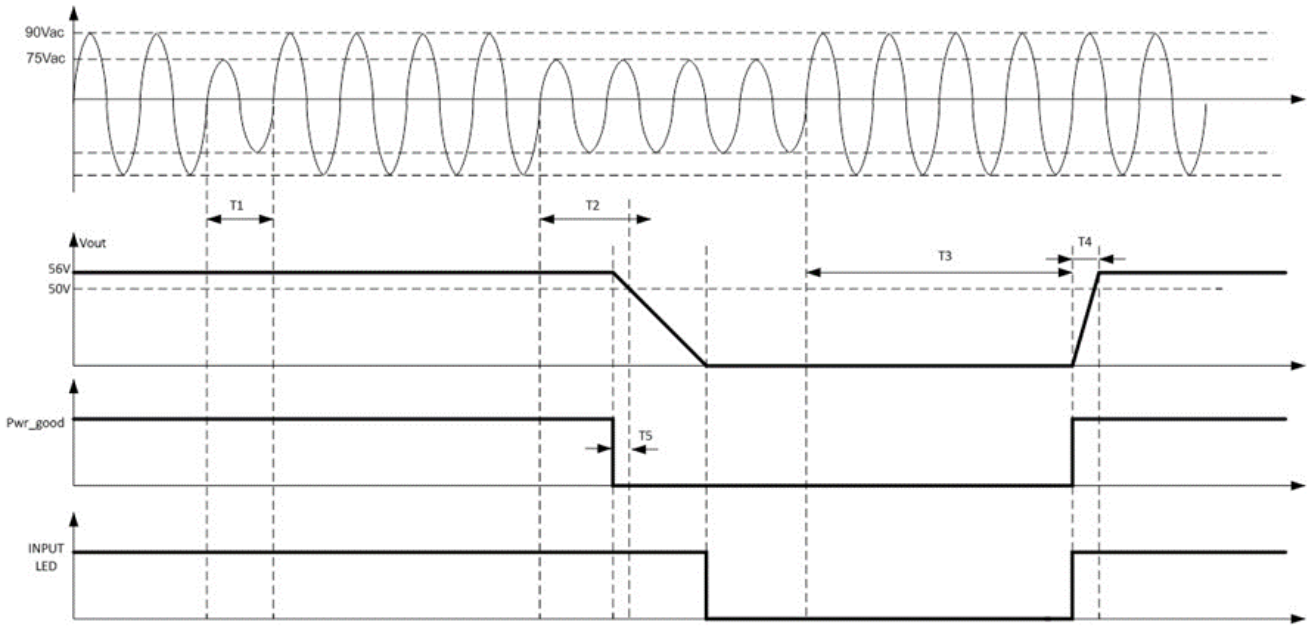


Figure 12. PFW alarmed 19.6ms prior to Vo < 40V, output load: 38A, V_{IN} = 185V_{AC}.

Timing Diagram

Response to input fluctuations



T1 – ride through time – 0.5 to 1.0 cycles [10 – 20ms] V_{OUT} remains within regulation

T2 – hold up time - 20ms V_{OUT} stays above 40V_{DC} under all loading conditions

T3 – delay time – 5ms from when the time AC returns within regulation to when the output starts rising

T4 – rise time - 100ms – typical to within regulation (except in RS485 mode)

T5 – Pwr_good warning – 0.5ms – minimum warning before V_{OUT} falls below 50V_{DC}.

AC OK LED: Blinking when AC input fails Below approx, 430AC when bias power is available

Control and status

The Rectifier provides two means for monitor/control: analog, or PMBus™,

Details of analog control and the PMBus™ based protocol are provided in this data sheet.

Signal Reference

Unless otherwise noted, all signals are referenced to Logic_GRD. See the Signal Definitions Table at the end of this document for further description of all the signals.

Logic_GRD is isolated from the main output of the power supply for PMBus communications. Communications and the 5V standby output are not connected to main power return (Vout(-)) and can be tied to the system digital ground point selected by the user.

Logic_GRD is capacitively coupled to Frame_GRD inside the power supply. The maximum voltage differential between Logic_GRD and Frame_GRD should be less than 100V_{DC}.

Control Signals

Remote ON: Controls the main 56V_{DC} output when either analog control or PMBus protocols are selected, as configured by the Protocol pin. This pin must be pulled low to turn **ON** the rectifier. The rectifier will turn **OFF** if either the **Remote ON** or the **INTERLOCK** pin is released. Remote ON ia referenced to Logic_GRD

INTERLOCK: This is a shorter pin utilized for hot-plug applications to ensure that the rectifier turns **OFF** before the power pins are disengaged. It also ensures that the rectifier turns **ON** only after the power pins have been engaged. Must be connected to V_OUT (-) for the rectifier to be ON.

Margining: The 56V_{DC} output can be adjusted between 44–58V_{DC} by a control voltage on the Margin pin. This control voltage can be generated either from an external voltage source, or by forming a voltage divider between 3.3V and Logic_GRD, as shown in Fig. 13. The power supply includes the high side pull-up 10kΩ resistor to 3.3V_{DC}. Connecting a resistor between the margin pin and Logic_GRD will complete the divider. An open circuit, or a voltage level > 3.0V_{DC}, on this pin sets the main output to the factory default setting of 56V_{DC}.

Hardware margining is only effective until software commanded output voltage changes are not executed. Software commanded output voltage settings permanently override the hardware margin setting until power to the internal controller is interrupted, for example if input power or bias power is recycled.

The controller always restarts into its default configuration, programmed to set the output as instructed by the margin pin. Subsequent software commanded settings permanently override the margin pin. Adding a resistor between margin and Vout(-) is an ideal way of changing the factory set point of the rectifier to whatever voltage level is desired by the user.

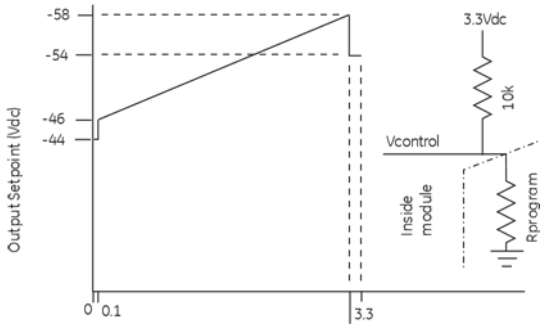


Figure 13. Diagram showing how output can be margined using Vcontrol adjustment.

Module Present Signal: This signal has dual functionality. It can be used to alert the system when a rectifier is inserted. A 500Ω resistor is present in series between this signal and Logic_GRD. An external pull-up should not raise the voltage on the pin above 0.25V_{DC}. When the voltage on this pin exceeds 1V_{DC}, the write_protect feature of the EEPROM is enabled.

8V_INT: Single wire connection between modules, Provides bias to the DSP of an unpowered module.

Reset: This is a PCA9541 multiplexer function utilized during PMBus communications. If momentarily grounded (Logic_GRD), the multiplexer would reset itself.

Unit Address: Each module has an internal 10kΩ resistor pulled up between unit_address and 3.3V_{DC}. A resistor between unit_address and Vout(-) sets the appropriate unit address.

			I²C address	
Rectifier	**Resistor Value**	**Vprog**	**A1**	**A0**
1	30K	2.477	0	0
2	14K	1.925	0	1
3	6K	1.243	1	0
4	2.5K	0.654	1	1

Shelf Address: A voltage between the shelf address pin and Vout(-), configures up to 8 different shelves. Since PMBus addressing is limited to a maximum of 8 modules, the shelf address is decoded into either shelf 0 or shelf 1.

Shelf_address	1	2	3	4
Maximum voltage	3.45	2.97	2.56	2.14
Nominal voltage	3.30	2.86	2.4	1.96
Minimum voltage	3.00	2.60	2.18	1.73
Address bit- A2	0	1	0	1

Shelf_address	5	6	7	8
Maximum voltage	1.70	1.25	0.80	0.25
Nominal voltage	1.50	1.10	0.60	0.01
Minimum voltage	1.29	0.84	0.30	0
Address bit- A2	0	1	0	1

Status Signals

Power Capacity: A HI on this pin indicates that the rectifier delivers high line rated output power; a LO indicates that the rectifier is connected to low line configured for 1200W operation.

Power_OK: This signal is HI when the main output is within regulation and goes LO for the duration listed in this data sheet prior to the output decaying below the listed voltage level.

Fault: This signal goes LO for any failure that requires rectifier replacement. These faults may be due to:

- Fan failure
- Over-temperature warning
- Over-temperature shutdown
- Over-voltage shutdown
- Internal Rectifier Fault

Digital Feature Descriptions

PMBus™ compliance: The power supply is fully compliant to the Power Management Bus (PMBus™) rev1.2 requirements with the following exceptions:

The power supply continuously updates its STATUS and ALARM registers to the latest state in order to capture the 'present' state of the power supply. There are a number of indicators, such as those indicating a communications fault (PEC error, data error) that do not get cleared until specifically instructed by the host controller sending a clear_faults command. A 'bit' indicator notifies the user if the STATUS and ALARM registers changed since the last 'read' by the host controller.

For example, if a voltage surge causes a momentary shutdown for over voltage the power supply will automatically restart if the 'auto_restart' feature is invoked. During the momentary shutdown the power supply issues an Alert# indicating to the system controller that a status change has occurred. If the system controller reads back the STATUS and ALARM registers while the power supply is shut down it will get the correct fault condition. However, inquiry of the state of the power supply after the restart event would indicate that the power supply is functioning correctly. The STATUS and ALARM indicators did not freeze at the original shutdown state and so the reason for the original Alert# is erased. The restart 'bit' would be set to indicate that an event has occurred.

The power supply also clears the STATUS and ALARM registers after a successful read back of the information in these registers, with the exception of communications error alarms. This automated process improves communications efficiency since the host controller does not have to issue another clear_faults command to clear these registers.

Dual, redundant buses: Two independent I²C lines provide true communications bus redundancy and allow two independent controllers to sequentially control the power supply. For example, a short or an open connection in one of the I²C lines does not affect communications capability on the other I²C line. Failure of a 'master' controller does not affect the power supplies and the second 'master' can take over control at any time.

Using the PCA9541 multiplexer: Transition between the two I²C lines is provided by the industry standard PCA9541 I²C master selector multiplexer. Option 01 of the device code is supplied which, upon start-up, connects channel 0 to the power supply. In this fashion applications using only a single I²C line can immediately start talking across the bus without first requiring to reconfigure the multiplexer.

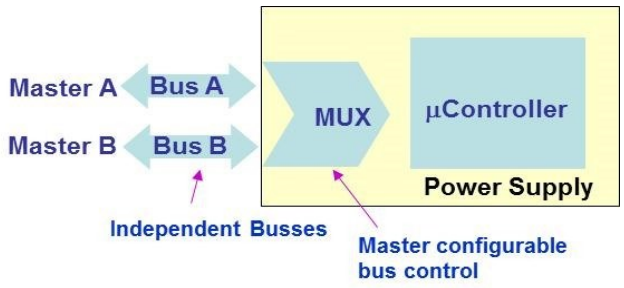


Figure 14. Diagram showing conceptual representation of the dual I²C bus system.

Control can be taken over at any time by a specific 'master' even during data transmission to the other 'master'. The 'master' needs to be able to handle incomplete transmissions in the multi-master environment in case switching should commence in the middle of data transmission.

Master/Slave: The 'host controller' is always the MASTER. Power supplies are always SLAVES. SLAVES cannot initiate communications or toggle the Clock. SLAVES also must respond expeditiously at the command of the MASTER as required by the clock pulses generated by the MASTER.

Clock stretching: The 'slave' µController inside the power supply may initiate clock stretching if it is busy and it desires to delay the initiation of any further communications. During the clock stretch the 'slave' may keep the clock LO until it is ready to receive further instructions from the host controller. The maximum clock stretch interval is 25ms.

The host controller needs to recognize this clock stretching, and refrain from issuing the next clock signal, until the clock line is released, or it needs to delay the next clock pulse beyond the clock stretch interval of the power supply.

Note that clock stretching can only be performed after completion of transmission of the 9th ACK bit, the exception being the START command.

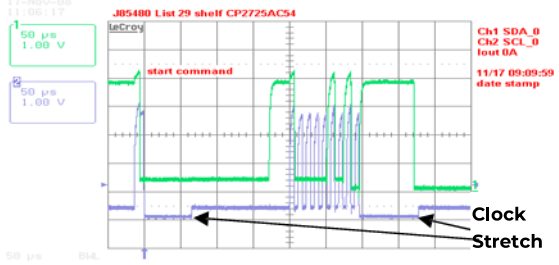


Figure 15. Example waveforms showing clock stretching.

Communications speed: Both 100kHz and 400kHz clock rates are supported. The power supplies default to the 100kHz clock rate.

Packet Error Checking: The power supply will not respond to commands without the trailing PEC. The integrity of communications is compromised if packet error correction is not employed. There are many functional features, including turning OFF the main output, that require validation to ensure that the correct command is executed.

PEC is a CRC-8 error-checking byte, based on the polynomial $C(x) = x^8 + x^2 + x + 1$, in compliance with PMBus™ requirements. The calculation is based in all message bytes, including the originating write address and command bytes preceding read instructions. The PEC is appended to the message by the device that supplied the last byte.

SMBusAlert#: The power supply can issue SMBAlert# driven from either its internal micro controller (µC) or from the PCA9541 I²C bus master selector. That is, the SMBAlert# signal of the internal µC funnels through the PCA9541 master selector that buffers the SMBAlert# signal and splits the signal to the two SMBAlert# signal pins exiting the power supply. In addition, the PCA9541 signals its own SMBAlert# request to either of the two SMBAlert# signals when required.

Non-supported commands: Non supported commands are flagged by setting the appropriate STATUS bit and issuing an SMBAlert# to the 'host' controller.

Data out-of-range: The power supply validates data settings and sets the data out-of-range bit and SMBAlert# if the data is not within acceptable range.

SMBAlert# triggered by the µC: The µC driven SMBAlert# signal informs the 'master/host' controller that either a STATE or ALARM change has occurred. Normally this signal is HI. The signal will change to its LO level if the power supply has changed states and the signal will be latched LO until the power supply receives a 'clear' instruction as outlined below. If the alarm state is still present after the 'clear_faults' command has been received, then the signal will revert back into its LO level again and will latch until a subsequent 'clear' signal is received from the host controller.

The signal will be triggered for any state change, including the following conditions;

- V_{IN} under or over voltage
- V_{OUT} under or over voltage
- I_{OUT} over current
- Over Temperature warning or fault
- Fan Failure
- Communication error
- PEC error
- Invalid command
- Internal faults

The power supply will clear the SMBusAlert# signal (release the signal to its HI state) upon the following events:

- Completion of a 'read_status' instruction
- Receiving a CLEAR_FAULTS command
- The main output recycled (turned OFF and then ON) via the REMOTE ON signal pin
- The main output recycled (turned OFF and then ON) by the OPERATION command

SMBAlert# triggered by the PCA9541: If clearing the Alert# signal via the clear_faults or read back fails, then reading back the Alert# status of the PCA9541 will be necessary followed by clearing of the PCA9541 Alert#.

The PCA9541 can issue an Alert# even when single bus operation is selected where the bus master selector has not been used or addressed. This may occur because the default state of the PCA9541/01 integrated circuit issues Alert# to both I²C lines for all possible transitioning states of the device. For example, a RESET caused by a glitch would cause the Alert# to be active.

If the PCA9541 is not going to be used in a specific application (such as when only a single I²C line is utilized), it is imperative that interrupts from the PCA9541 are de-activated by the host controller. To de-activate the interrupt registers the PCA9541 the 'master' needs to address the PCA9541 in the 'write' mode, the interrupt enable (IE) register needs to be accessed and the interrupt masks have to be set to HI '1'. (Note: do not mask bit 0 which transmits Alert# from the power supply). This command setting the interrupt enable register of the PCA9541 is shown below;

Start	Unit Address								ACK
1	7	6	5	4	3	2	1	0	1
S	1	1	1	0	A2	A1	A0	0	A

Command Code	ACK	IE Register	Stop
8	1	8	
0x00	A	0x0E	P

There are two independent interrupt enable (IE) registers, one for each controller channel (I^2C-0 and I^2C-1). The interrupt register of each channel needs to be configured independently. That is, channel I^2C-0 cannot configure the IE register of I^2C-1 or vise-versa.

This command has to be initiated to the PC9541 only once after application of power to the device. However, every time a restart occurs the PCA9541 has to be reconfigured since its default state is to issue Alert# for changes to its internal status.

If the application did not configure the interrupt enable register the Alert# line can be cleared (de-activated), if it has been activated by the PCA9541, by reading back the data from the interrupt status registers (Istat).

Refer to the PCA9541 data sheet for further information on how to communicate to the PCA9541 multiplexer.

Please note that the PCA9541 does not support Packet Error Checking (PEC).

Re-initialization: The I^2C code is programmed to re-initialize if no activity is detected on the bus for 5 seconds. Re- initialization is designed to guarantee that the I^2C µController does not hang up the bus. Although this rate is longer than the timing requirements specified in the SMBus specification, It had to be extended in order to ensure that a re-initialization would not occur under normal transmission rates. During the few µseconds required to accomplish re-initialization the I^2C µController may not recognize a command sent to it. (i.e. a start condition).

Global broadcast: This is a powerful command because it can instruct all power supplies to respond simultaneously in one command. But it does have a serious disadvantage. Only a single power supply needs to pull down the ninth acknowledge bit. To be certain that each power supply responded to the global instruction, a READ instruction should be executed to each power supply to verify that the command properly executed. The GLOBAL BROADCAST command should only be executed for write instructions to slave devices.

Note: The PCA9541 I^2C master selector does not respond to the GLOBAL BROADCAST command.

Read back delay: The power supply issues the SMBAlert # notification as soon as the first state change occurred. During an event a number of different states can be transitioned to before the final event occurs. If a read back is implemented rapidly by the host a successive SMBAlert# could be triggered by the transitioning state of the power supply. In order to avoid successive SMBAlert# s and read back and also to avoid reading a transitioning state, it is prudent to wait more than 2 seconds after the receipt of an SMBAlert# before executing a read back. This delay will ensure that only the final state of the power supply is captured.

Successive read backs: Successive read backs to the power supply should not be attempted at intervals faster than every one second. This time interval is sufficient for the internal processors to update their data base so that successive reads provide fresh data.

Device ID: Address bits A2, A1, A0 set the specific address of the power supply. The least significant bit x (LSB) of the address byte configures write [0] or read [1] events. In a **write** command the system instructs the power supply. In a **read** command information is being accessed from the power supply

	Address Bit							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
PCA9541	1	1	1	0	A2	A1	A0	R/W
Micro controller	1	0	0	0	A2	A1	A0	R/W
External EEPROM	1	0	1	0	A2	A1	A0	R/W
Global Broadcast	0	0	0	0	0	0	0	0
	MSB							LSB

The **Global Broadcast** instruction executes a simultaneous **write** instruction to all power supplies. A **read** instruction cannot be accessed globally. The three programmable address bits are the same for all I^2C accessible devices within the power supply.

PMBus™ Commands

Standard instruction: Up to two bytes of data may follow an instruction depending on the required data content. Analog data is always transmitted as LSB followed by MSB. PEC is mandatory and includes the address and data fields.

1	8		1	8	1
S	Slave address	Wr	A	Command Code	A

8	1	8	1	8	1	1
Low data byte	A	High data byte	A	PEC	A	P

Master to Slave Slave to Master

SMBUS annotations; S – Start , Wr – Write, Sr – re-Start, Rd – Read, A – Acknowledge, NA – not-acknowledged, P – Stop

Direct mode data format: The Direct Mode data format is supported, where y = [mX + b] x 10^R . In the equation, y is the data value from the controller and x is the 'real' value either being set or returned, except for V_{IN} and Fan speed , x is the data value from the controller and y is the 'real' value.

For example, to set the output voltage to 50.45V_{DC}, Multiply the desired set point by the m constant, 50.45 x 400 = 20,180. Convert this binary number to its hex equivalent: 20,180b = 0x4ED4. The result is sent LSB=0xD4 first, then MSB=0x4E.

The constants are

Function	Operation	m	b	R
Output voltage Output voltage shutdown	Write / read	400	0	0
Output Current	read	5	0	0
Temperature	read	1	0	0
Input Voltage	read	1	75	0
Input Power	read	1	0	0
Fan Speed setting (%)	read	1	0	0
Fan speed in RPM	read	100	0	0

PMBus™ Command set:

Command	Hex Code	Data Field	Function
Operation	01	1	Output ON/OFF
Clear_Faults	03	0	Clear Status
Vout_command	21	2	Set Vout
Vout_OV_fault_limit	40	2	Set OV fault limit
Read_status	D0	10	Read Status, Vout, Iout, T
LEDs test ON	D2	0	Test LEDs
LEDs test OFF	D3	0	
Service_LED_ON	D4	0	Service LED
Service_LED_OFF	D5	0	
Enable_write	D6	0	Enable EEPROM write
Disable_write	D7	0	Disable EEPROM write
Inhibit_restart	D8	0	Latch upon failure
Auto_restart	D9	0	Hiccup
Isolation_test	DA	0	Perform isolation test
Read_input_string	DC	2	Read Vin and Pin
Read_firmware_rev	DD	3	Firmware revisions
Read_run_timer	DE	3	Accumulated ON state
Fan_speed_set	DF	3	Fan speed control
Fan_normal_speed	E0	0	Stop fan control
Read_fan_speed	E1	4	Fan control & speed
Stretch_LO_25ms	E2	0	Production test feature

Command Descriptions

Operation (01h) : By default the Power supply is turned **ON** at power up as long as REMOTE ON is active LO. The Operation command is used to turn the Power Supply ON or OFF via the PMBus. The data byte below follows the OPERATION command.

FUNCTION	DATA BYTE
Unit ON	0x80
Unit OFF	0x00

To **RESET** the power supply cycle the power supply OFF, wait at least 2 seconds, and then turn back ON. All alarms and shutdowns are cleared during a restart.

Clear_faults (03h): This command clears information bits in the STATUS registers, these include:

- Isolation OK
- Isolation test failed
- Restarted OK
- Invalid command
- Invalid data
- PEC error

Vout_Command (21h) : This command is used to change the output voltage of the power supply. Changing the output voltage should be performed simultaneously to all power supplies operating in parallel using the Global Address (Broadcast) feature. If only a single power supply is instructed to change its output, it may attempt to source all the required power which can cause either a power limit or shutdown condition.

Software programming of output voltage overrides the set point voltage configured during power_up. The program no longer looks at the 'margin pin' and will not respond to any hardware voltage setting. The default state cannot be accessed any longer unless power is removed from the DSP.

To properly hot-plug a power supply into a live backplane, the system generated voltage should get re-configured into either the factory adjusted firmware level or the voltage level reconfigured by the margin pin. Otherwise, the voltage state of the plugged in power supply could be significantly different than the powered system.

Voltage margin range: $42V_{DC}$ – 58 V_{DC}.

A voltage programming example: The task: set the output voltage to $50.45V_{DC}$

The constants for voltage programming are: m = 400, b and R = 0. Multiply the desired set point by the m constant, 50.45 x 400 = 20,180. Convert this binary number to its hex equivalent: 20,180b = 4ED4h. Transmit the data LSB first, followed by MSB, 0 x D44Eh.

Vout_OV_fault_limit (40h) : This command sets the Output Overvoltage Shutdown level.

Manufacturer-Specific PMBus™ Commands

Many of the manufacturer-specific commands read back more than two bytes. If more than two bytes of data are returned, the standard SMBus™ Block read is utilized. In this process, the Master issues a Write command followed by the data transfer from the power supply. The first byte of the Block Read data field sends back in hex format the number of data bytes, exclusive of the PEC number, that follows. Analog data is always transmitted LSB followed by MSB. A No-ack following the PEC byte signifies that the transmission is complete and is being terminated by the 'host'.

Read_status (D0h) : This 'manufacturer specific' command is the basic read back returning STATUS and ALARM register data, output voltage, output current, and internal temperature data in a single read.

1	8		1	8	1
S	Slave address	Wr	A	Command Code	A

1	8		1	8	1
Sr	Slave address	Rd	A	Byte count = 9	A

8	1	8	1	8	1
Status-2	A	Status-1	A	Alarm-2	A

8	1	8	1	8	1
Alarm-1	A	Voltage LSB	A	Voltage MSB	A

8	1	8	1	8	1	1
Current	A	Temperature	A	PEC	NA	P

Status and alarm registers

The content and partitioning of these registers is significantly different than the standard register set in the PMBus™ specification. More information is provided by these registers and they are accessed rapidly, at once, using the 'multi parameter' read back scheme of this document. There are a total of four registers. All errors, 0 – normal, 1 – alarm.

Status-2

Bit	Title	Description
7	PEC Error	Mismatch between computed and transmitted PEC. The instruction has not been executed. Clear_Flags resets this register.
6	Will Restart	Restart after a shutdown = 1
5	Invalid Instruction	The instruction is not supported. An ALERT# will be issued. Clear_Flags resets this register.
4	Power Capacity	High line power capacity = 1
3	Isolation test failed	Information only to system controller
2	Restarted ok	Informs HOST that a successful RESTART occurred clearing the status and alarm registers
1	Data out of range	Flag appears until the data value is within range. A clear_flags command does not reset this register until the data is within normal range.
0	Enable pin HI	State of the ENABLE pin, HI = 1 = OFF

Isolation test failed: The 'system controller' has to determine that sufficient capacity exists in the system to take a power supply 'off line' in order to test its isolation capability. Since the power supply cannot determine whether sufficient redundancy is available, the results of this test are provided, but the 'internal fault' flag is not set.

Status-1

Bit	Title	Description
7	spare	
6	Isolation test OK	Isolation test completed successfully.
5	Internal fault	The power supply is faulty
4	Shutdown	
3	Service LED ON	ON = 1
2	External fault	the power supply is functioning OK
1	LEDs flashing	LEDs tested test ON = 1
0	Output ON	ON = 1

Alarm-2

Bit	Title	Description
7	Fan Fault	
6	No primary	No primary detected
5	Primary OT	Primary section OT
4	DC/DC OT	DC/DC section OT
3	Output voltage lower than bus	Internal regulation failure
2	Thermal sensor failed	Internal failure of a temperature sensing circuit
1	5V out_of_limits	Either OVP or OCP occurred
0	Power Delivery	A power delivery fault occurred

Power Delivery: The power supply compares its internal sourced current to the current requested by the current share pin. If the difference is > 10A, a fault is issued.

Alarm-1

Bit	Title	Description
7	Unit in power limit	An overload condition that results in constant power
6	Primary fault	Indicates either primary failure or INPUT not present. Used in conjunction with bit-0 and Status_1 bits 2 and 5 to assess the fault.
5	Over temp. shutdown	One of the over_temperature sensors tripped the supply
4	Over temp warning	Temperature is too high, close to shutdown
3	In over current	Shutdown is triggered by low output voltage < $39V_{DC}$.
2	Over voltage shutdown	
1	Vout out_of_limits	Indication the output is not within design limits. This condition may or may not cause an output shutdown.
0	Vin out_of_limits	The input voltage is outside design limits

LEDS test ON (D2h) : Will turn-ON simultaneously the two front panel LEDs of the Power supply sequentially 7 seconds ON and 2 seconds OFF until instructed to turn OFF. The intent of this function is to provide visual identification of the power supply being talked to and also to visually verify that the LEDs operate and driven properly by the micro controller.

LEDS test OFF (D3h) : Will turn-OFF simultaneously the two front panel LEDs of the Power supply.

Enable write (D6h) : This command enables write permissions into the upper ¼ of memory locations for the external EEPROM. A write into these locations is normally disabled until commanded through I^2C to permit writing into the protected area. A delay of about 10ms is required from the time the instruction is requested to the time that the power supply actually completes the instruction.

See the FRU-ID section for further information of content written into the EEPROM at the factory.

Disable write (D7h) : This command disables write permissions into the upper ¼ of memory locations for the external EEPROM.

Unit in Power Limit or in Current Limit: When output voltage is > $36V_{DC}$ the Output LED will continue blinking.

When output voltage is < $36V_{DC}$, if the unit is in the RESTART mode, it goes into a hiccup. When the unit is ON the output LED is ON, when the unit is OFF the output LED is OFF. When the unit is in latched shutdown the output LED is OFF.

Inhibit_restart (D8h) : The **Inhibit-restart** command directs the power supply to remain latched off for over_voltage, over_temperature and over_current. The command needs to be sent to the power supply only once. The power supply will remember the INHIBIT instruction as long as internal bias is active.

Restart after a lachoff: To restart after a latch_off either of four restart mechanisms are available. The hardware pin **Enable** may be turned OFF and then ON**.** The unit may be commanded to restart via I^2C through the Operation command by first turning OFF

then turning ON . The third way to restart is to remove and reinsert the unit. The fourth way is to turn OFF and then turn ON ac power to the unit. The fifth way is by changing firmware from **latch off** to **restart.** Each of these commands must keep the power supply in the OFF state for at least 2 seconds, with the exception of changing to **restart**. A successful restart shall clear all alarm registers, set the **restarted successful** bit of the **Status_2** register.

A power system that is comprised of a number of power supplies could have difficulty restarting after a shutdown event because of the non-synchronized behavior of the individual power supplies. Implementing the latch-off mechanism permits a synchronized restart that guarantees the simultaneous restart of the entire system.

A synchronous restart can be implemented by;

1. Issuing a GLOBAL OFF and then ON command to all power supplies,
2. Toggling Off and then ON the REMOTE ON signal
3. Removing and reapplying input commercial power to the entire system.

The power supplies should be turned OFF for at least 20 – 30 seconds in order to discharge all internal bias supplies and reset the soft start circuitry of the individual power supplies.

Auto_restart (D9h) : Auto-restart is the default configuration for overvoltage, overcurrent and overtemperature shutdowns.

However, overvoltage has a unique limitation. An overvoltage shutdown is followed by three attempted restarts, each restart delayed 1 second, within a 1 minute window. If within the 1 minute window three attempted restarts failed, the unit will latch OFF. If within the 1 minute less than 3 shutdowns occurred then the count for latch OFF resets and the 1 minute window starts all over again.

This command resets the power supply into the default auto- restart configuration.

Isolation test (DAh): This command verifies functioning of output OR'ing. At least two paralleled power supplies are required. The host should verify that N+1 redundancy is established. If N+1 redundancy is not established the test can fail. Only one power supply should be tested at a time.

Verifying test completion should be delayed for approximately 30 seconds to allow the power supply sufficient time to properly execute the test.

Failure of the isolation test is not considered a power supply FAULT because the N+1 redundancy requirement cannot be verified. The user must determine whether a true isolation fault indeed exists.

Read input string (DCh) : Reads back the input voltage and input power consumed by the power supply. In order to improve the resolution of the input voltage reading the data is shifted by 75V.

1	7	1	1	8	1
S	Slave address	Wr	A	Command Code 0xDC	A

1	1	7	1	1
A	Sr	Slave Address	Rd	A

8	1	8	1
Byte Count = 4	A	Voltage	A

8	1	8	1	8	1	1
Power - LSB	A	Power - MSB	A	PEC	No-ack	P

Read_firmware_rev [0 x DD]: Reads back the firmware revision of all three µC in the power supply.

1	7	1	1	8	1
S	Slave address	Wr	A	Command Code 0xDD	A

1	1	7	1	1	8	1
A	Sr	Slave Address	Rd	A	Byte Count = 4	A

8	1	8	1
Primary micro revision	A	DSP revision	A

8	1	8	1	1
I²C Micro revision	A	PEC	No-ack	P

For example; the read returns one byte for each device (i.e. 0 x 002114h). The sequence is primary micro, DSP, and I²C micro. 0x00 in the first byte indicates that revision information for the primary micro is not supported. The number 21 for the DSP indicates revision 2.1, and the number 14 for the I²C micro indicates revision 1.4.

Read_run_timer [0 x DE]: This command reads back the recorded operational ON state of the power supply in hours. The operational ON state is accumulated from the time the power supply is initially programmed at the factory. The power supply is in the operational ON state both when in standby and when it delivers main output power. Recorded capacity is approximately 10 years of operational state.

1	7	1	1	8	1
S	Slave address	Wr	A	Command Code 0xDE	A

1	7	1	1	8	1
Sr	Slave Address	Rd	A	Byte count = 4	A

8	1	8	1	8	1
Time - LSB	A	Time	A	Time - MSB	A

8	1	1
PEC	No-ack	P

Fan_speed_set (DFh) : This command instructs the power supply to increase the speed of the fan. The transmitted data byte represents the hex equivalent of the duty cycle in percentage, i.e. 100% = 0 x 64h. The command can only increase fan speed, it cannot instruct the power supply to reduce the fan speed below what the power supply requires for internal control.

Fan_normal_speed (E0h): This command returns fan control to the power supply. It does not require a trailing data byte.

Read_Fan_speed (E1h) : Returns the commanded fan speed in percent and the measured fan speed in RPM from the individual fans. Up to 3 fans are supported. If a fan does not exist (units may contain from 1 to 3 fans), or if the command is not supported the unit return 0x00.

1	8	1	8	1
S	Slave address	Wr	A	Command 0xE1	A

1	8	1	8	1
Sr	Slave address	Rd	A	Byte count = 5	A

8	1	8	1	8	1	8	1
Adjustment %	A	Fan-1	A	Fan-2	A	Fan-3	A

8	1	1
PEC	NA	P

Stretch_LO_25ms (E2h) : Command used for production test of the clock stretch feature.

None supported commands or invalid data: The power supply notifies the MASTER if a non-supported command has been sent or invalid data has been received. Notification is implemented by setting the appropriate STATUS and ALARM registers and setting the SMBAlert# flag.

Fault Management

The power supply records faults in the STATUS and ALARM registers above and notifies the MASTER controller as described in the **Alarm Notification** section of the non- conforming event.

The STATUS and ALARM registers are continuously updated with the latest event registered by the rectifier monitoring circuits. A host responding to an SMBusALERT# signal may receive a different state of the rectifier if the state has changed from the time the SMBusALERT# has been triggered by the rectifier.

The power supply differentiates between **internal faults** that are within the power supply and **external faults** that the power supply protects itself from, such as overload or input voltage out of limits. The FAULT LED, FAULT PIN or I^2C alarm is not asserted for EXTERNAL FAULTS. Every attempt is made to annunciate External Faults. Some of these annunciations can be observed by looking at the input LEDs. These fault categorizations are predictive in nature and therefore there is a likelihood that a categorization may not have been made correctly.

Input voltage out of range: The Input LED will continue blinking as long as sufficient power is available to power the LED. If the input voltage is completely gone the Input LED is OFF.

State Change Definition

A **state_change** is an indication that an event has occurred that the MASTER should be aware of. The following events shall trigger a **state_change**;

- Initial power-up of the system when AC gets turned ON .This is the indication from the rectifier that it has been turned ON. Note that the master needs to read the status of each power supply to reset the system_interrupt. If the power supply is back-biased through the 8V_INT or the 5VSTB it will not issue an SMBALERT# when AC power is turned back ON.
- Whenever the power supply gets hot-plugged into a working system. This is the indicator to the system (MASTER) that a new power supply is on line.
- Any changes in the bit patterns of the STATUS and ALARM registers are a STATUS change which triggers the SMBALERT# flag. Note that a host-issued command such as CLEAR_FAULTS will not trigger an SMB

Hot plug procedures

Careful system control is recommended when hot plugging a power supply into a live system. It takes about 15 seconds for a power supply to configure its address on the bus based on the analog voltage levels present on the backplane. If communications are not stopped during this interval, multiple power supplies may respond to specific instructions because the address of the hot plugged power supply always defaults to xxxx000 (depending on which device is being addressed within the power supply) until the power supply configures its address.

The recommended procedure for hot plug is the following: The system controller should be told which power supply is to be removed. The controller turns the service LED ON, thus informing the installer that the identified power supply can be removed from the system. The system controller should then poll the module_present signal to verify when the power supply is re-inserted. It should time out for 15 seconds after this signal is verified. At the end of the time out all communications can resume.

Predictive Failures

Alarm warnings that do not cause a shutdown are indicators of potential future failures of the power supply. For example, if a thermal sensor failed, a warning is issued but an immediate shutdown of the power supply is not warranted.

Another example of potential predictive failure mechanisms can be derived from information such as fan speed when multiple fans are used in the same power supply. If the speed of the fans varies by more than 20% from each other, this is an indication of an impending fan wear out.

The goal is to identify problems early before a protective shutdown would occur that would take the power supply out of service.

External EEPROM

A 64k-bit EEPROM is provided across the I^2C bus. This EEPROM is used for both storing FRU_ID information and for providing a scratchpad memory function for customer use.

Functionally the EEPROM is equivalent to the ST M34D64 part that has its memory partitioned into a write protected upper ¼ of memory space and the lower ¾ section that cannot be protected. FRU_ID is written into the write protected portion of memory.

Write protect feature: Writing into the upper 1/4 of memory can be accomplished either by hardware or software.

The power supply pulls down the write_protect (Wp) pin to ground via a 500Ω resistor between the 'module_present' signal pin and Logic_GRD (see the Module Present Signal section of Input Signals). Writing into the upper ¼ of memory can be accomplished by pulling HI the module_present pin. An alternative, and the recommended approach, is to issue the Enable_write command via software.

Page implementation: The external EEPROM is partitioned into 32 byte pages. For a write operation only the starting address is required. The device automatically increments the memory address for each byte of additional data it receives. However, if the 32 byte limit is exceeded the device executes a wrap- around that will start rewriting from the first address specified. Thus byte 33 will replace the first byte written, byte 34 the second byte and so on. One needs to be careful therefore not to exceed the 32 byte page limitation of the device.

Table 1: FRU_ID

The upper quarter of memory starting from address 6144 shall be reserved for factory ID and factory data.

Memor Location Decimal	Memory Location (HEX)	Length (bytes)	Format	Static Value type	Description	Notes/Example
6144d	0x1800	12	ASCII	Fixed	OmniOn-energy - Product ID	CP3000AC56TE
6156d	0x180C	10	ASCII	Fixed	OmniOn-energy – Part Number	123456789x or C123456789
6166d	0x1816	6	ASCII	Variable	OmniOn-energy - Hardware revision	x:xxxx controlled by PDI series #
6172d	0x181C	6	ASCII	Variable	spare	
6178d	0x1822	14	ASCII	Variable	OmniOn-energy - Serial_No	01KZ51018193xx 01 .... Year of manufacture - 2001 KZ ... factory, in this case Matamoros 51 .. week of manufacture _____018193xx serial # mfg choice
6192d	0x1830	40	ASCII	Variable	OmniOn- Manufacturing location	"Matamoros, Tamps, Mexico"
6232d	0x1858	8	ASCII	Fixed	spare	
6240d	0x1860	2	HEX	Fixed	spare	
6242d	0x1862	158	ASCII	Fixed	Customer Information	See Table Below
6400d	0x1900	5	HEX	Fixed	M, B, & R for voltage read	M & B are 2 bytes each sent as MSB and then LSB. R is one byte. These are stored as two's complement. See the section on Direct Mode Constants Stored in the EEPROM for the constants stored in these fields
6405d	0x1905	5	HEX	Fixed	M, B, & R for current read	
6410d	0x190A	5	HEX	Fixed	M, B, & R temp read	
6415d	0x190F	5	HEX	Fixed	spare	
6420d	0x1914	5	HEX	Fixed	M, B, & R for voltage set	
6425d	0x1919	5	HEX	Fixed	M, B, & R for input voltage read	
6430d	0x191E	1	HEX	Variable	Validation CHKSUM	
6431d	9x191F	5	HEX	Fixed	M, B, & R for input power read	
6436d	0x1924	5	HEX	Fixed	M, B, & R for fan percent adjust	
6441d	0x1929	5	HEX	Fixed	M, B, & R for fan RPM read	
6446d	0 x 192E	5	HEX	Fixed	M, B, & R for converter input voltage read	

Notes:
SUM = the addition from location 0x1800 to location 0x19FF without including variable fields such as the Unix time stamp serial number and checksum locations. Chksum_value = 0xFF - (mask of SUM with 0x0000ff).
Write chksum_value byte to location 0x191E.

Table 2: FRU_ID ALU section

Data	Format	Location	Content	Description
Serial EEPROM format	binary	0	04	One byte format number. The only legal value for Power Supply EEPROM is: **0x04**.
Module Type	binary	1-4	07* 04* 01* 01*	Four byte field known as 'Hardware ID. This is an Agile field defined in Agile in the power supply part number's 'Page Two' information. **07040101** Before assembly, verify 'Hardware ID' per Agile.
Part number	ASCII	5 6 7 8 9 10 11 12 13 14 15-29	39* 30* 33* 37* 34* 39* 2d* 39* 30* 00* 00*	25 Bytes representation of Alcatel part number, in hex and terminated by NULL (0x00). Fill unused characters with NULL also. *Example: Part number is: **903749-90**

Data	Format	Location	Content	Description
Revision number	ASCII	30 31 32	41* 30* 37*	Three (3) byte representation of Assembly revision, in hex and terminated by NULL (0x00). Fill unused characters with NULL also. Example: Revision number is: **A07**. Before assembly, verify current rev. per Agile. ** The two revision fields defined in this specification are the programmed with the same data. This is a special case in this assembly where the fields are always identical. They should be updated together and always in synch.
Serial Number	ASCII	33 34 35 36 37 38 39 40 41 42-57	4B* 32* 36* 4B* 31* 32* 33* 34* 00* 00*	25 Bytes representation of Alcatel serial number, in hex and terminated by NULL (0x00). Fill unused characters with NULL also. *Example: Serial number is: K40K1234. NOTE: Follow procedure # 027045-00
Manufacturing Date	binary	58 59 60 61	4A* DC* 75* E9*	4 bytes of UNIX style date, seconds since January 1, 1970, converted to hex. *Example: unix time is 1255962089 (Oct,19 2009, 14:21:29)
Starting MAC address Range 1	binary	62-67	00	Not used. Set all characters to NULL.
Number of MACs in Range 1	binary	68-69	00	Not used. Set all characters to NULL.
Starting MAC address Range 2	binary	70-75	00	Not used. Set all characters to NULL.
Number of MACs in Range 2	binary	76-77	00	Not used. Set all characters to NULL
Starting MAC address Range 3	binary	78-83	00	Not used. Set all characters to NULL.
Number of MACs in Range 3	binary	84-85	00	Not used. Set all characters to NULL.
Starting MAC address range 4	binary	86-91	00	Not used. Set all characters to NULL.
Number of MACs in Range 4	binary	92-93	00	Not used. Set all characters to NULL.
Description	ASCII	94 95 96 97 98 99 100 101 102 103 104 105 106 107-125	4F* 53* 39* 39* 2D* 50* 53* 2D* 41* 2A* 41* 43* 00* 00*	32 bytes representation of EEPROM Description as defined in Agile system on 'page two' data for part number: 'EEPROM Description' field. Data in hex and terminated by NULL (0x00). Fill unused characters with NULL also. *Example: OS99-PS-A*AC Before assembly, verify EEPROM description per Agile.
FRU#	ASCII	126 127 128 129 130 131 132 133 134 135 136-150	39* 30* 33* 37* 34* 39* 2D* 39* 30* 00* 00*	25 Bytes representation of Alcatel Field Replaceable Unit part number, in hex and terminated by NULL (0x00). Fill unused characters with NULL also. *Example: Part number is: 903749-90 ** The two part number fields defined in this specification are the programmed with the same data. This is a special case in power supply where the fields are always identical. They should be updated together and always in synch.

Data	Format	Location	Content	Description
FRU Revision number	ASCII	151-153	41* 30* 37*	Three (3) byte representation of Assembly revision, in hex and terminated by NULL (0x00). Fill unused characters with NULL also. Example: Revision number is: A07. Before assembly, verify current rev. per Agile. ** The two revision fields defined in this specification are the programmed with the same data. This is a special case in this assembly where the fields are always identical. They should be updated together and always in synch.
Power Consumption	binary	154 155	0B* B8*	16 bit Power consumption of this module: Example: **3000 (for 3,000 watts).**
Variant	binary	156 157 158 159 160 161 162 163	00* 00* 00* 00* 00* 00* 00* E9*	8 byte field known as 'Variant'. This is an Agile field defined in Agile in the power supply part number's 'Page Two' information. *Example: 00000000000000E9 These bits are used internally to represent variations in hardware for a given module type (these changes are significant to software). At offset 163, eight bits will have a fixed value of 0xE9 to ensure differentiation from uninitialized EEPROM as this is a new field. The remaining bits shall assume any assigned meaning; their default value is 0. Before assembly, verify variant per Agile.
Reserved	any	164-205	00	Not used. Set all characters to NULL. This is reserved for future fields that require checksum protection
Checksum	binary	206-207	(Calculated at write time)	Two-byte value equal to the 16 bit checksum of the serial EEPROM contents including only bytes 0-205.
Manufacturing Process Control	binary	208-215	00	64 bit field to be used for Manufacturing test. No value required for initial programming. Set all bytes to NULL.
Unused	any	216-255	00	Future use for field that can change dynamically, Manufacturing will reserve starting 216 and incrementing, where as AOS Software will reserve starting 255 and decrementing. No value required for initial programming. Set all bytes to NULL.

Table 3: Alarm and LED state summary

	Test Condition	LED Indicator		Monitoring Signals		
		LED1 INPUT OK	Dual-Color LED2 DC OK / Fault	FAULT	Power_OK	OTW
1	Normal Operation	**Green**	**Green**	High	High	High
2	Out of range INPUT	**Blinking**	OFF	High	High[15]	High
3	No Input[16]	OFF	OFF	High	Low	High
4	OVP	**Green**	**Red**	Low	Low	High
5	Over Current	**Green**	**Blinking**	High	Low	High
6	Over Temp Warning	**Green**	**Green**	High	High	Low
7	Over Temp Fault	**Green**	**Red**	Low	Low	Low
8	Remote ON	**Green**	**Green**	High	High	High
9	Remote OFF	**Green**	OFF	High	Low	High

[15]The Power_OK signal will change states to Logic LO if the output section would get turned OFF because of an AC input out of range.

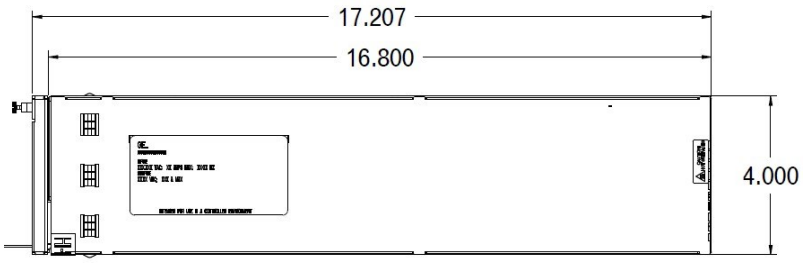
[16]Test condition #2 and #3 had 2 modules plugged in. One module is running and the other one is with no/low AC.

Table 4: Signal Definitions

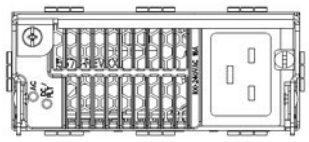
All hardware alarm signals (Fault, Power_OK, OTW, Power Capacity) are open drain FETs. These signals need to be pulled HI to either 3.3V or 5V. Maximum sink current 5mA. An active LO signal (< 0.4V_{DC}) state. All signals are referenced to Logic_GRD unless otherwise stated.

Function	Label	Type	Description
Main output control	Remote ON	Input	When shorted to Logic_GRD the main output is ON in Analog or PMBus mode.
Output power above 50Vdc	Power_OK	Output	An open drain FET; Changes to LO 0.5ms before the output decays below 50V_{DC}.
I²C Interrupt	Alert#_0/Alert#_1	Output	This signal is pulled to 3.3V via a 10kΩ resistor. Active LO.
Rectifier Fault	Fault	Output	An open drain FET; normally HI, changes to LO.
Module Present	MOD_PRES	Output	Short pin, see Status and Control description for further information on this signal.
Main output control	INTERRUPT	Input	Short pin, controls main output during hot-insertion and extraction. Ref: Vout (-)
Margining	Margin	Input	Changes the default set point of the main output.
Over-Temperature Warning	OTW	Output	Open drain FET; normally HI, changes to LO 5°C prior to thermal shutdown.
Power Capacity	POWER_CAP	Output	Open drain FET; HI indicates 3000W operation and LO indicates 1200W operation.
Rectifier address	Unit_addr	Input	Voltage level addressing of Rectifiers within a single shelf. Ref: Vout (-).
Shelf Address	Shelf_addr	Input	Voltage level addressing of Rectifiers within multiple shelves. Ref: Vout (-).
Back bias	8V_INT	Bi-direct	Used to back bias the DSP from operating Rectifiers. Ref: Vout (-).
Mux Reset	Reset	Input	Resets the internal PCA9541 multiplexer
Standby power	5VA	Output	5V at 0.75A provided for external use
Current Share	Ishare	Bi-direct	A single wire active-current-share interconnect between modules Ref: Vout (-).
I²C Line 0	SCL_0	Input	PMBus line 0.
I²C Line 0	SDA_0	Bi-direct	PMBus line 0.
I²C Line 1	SCL_1	Input	PMBus line 1.
I²C Line 1	SDA_1	Bi-direct	PMBus line 1.
SMBALERT# Line 0	ALERT#_0	Output	PMBus line 0 interrupt
SMBALERT# Line 1	ALERT#_1	Output	PMBus line 1 interrupt

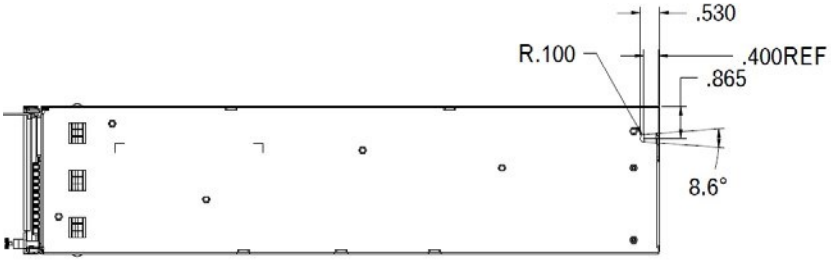
Mechanical outline



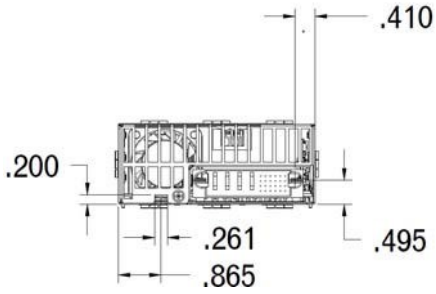
Top view



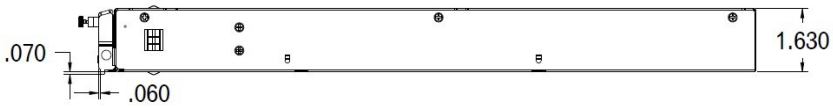
Front View



Bottom view



Rear view



Side view

All dimensions ± 0.020

Input Connector:

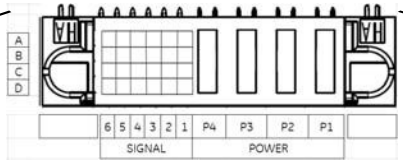
IEC320, C20 type

Mating connector:

TYCO P/N: 1-6450162-4 or FCI Berg P/N: 51915-409LF

Output Connector:

TYCO P/N: 3-6450332-4 or FCI Berg P/N: 51939-820LF



	SIGNAL						OUTPUT POWER			
	6	5	4	3	2	1	P4	P3	P2	P1
A	SCL_0	SDA_0	Power_OK	LOGIC_GRD	N/C	UNIT_ADDR				
B	MOD_PRE	OTW	Alert#_0	Alert#_1	N/C	8V_INT	V_OUT	V_OUT	V_OUT	V_OUT
C	SCL_1	Margin	Reset	Remote ON	Ishare	N/C	(-)	(-)	(+)	(+)
D	SDA_1	Fault	5VA	Power_Cap	Interlock	SHELF_ADDR				

Notes: 1. Connector is viewed from the rear of the front end
2. Signal pins columns 1 and 2 are referenced to Vout(-), the rest are referenced to Logic_GRD
3. Last to make first to break short pin

Ordering Information

Please contact your OmniOn Power Sales Representative for pricing, availability and optional features.

Item	Description	Ordering code
CP3000AC56TEPZ-FAL	3000W output power capacity, $5V_{DC}$ @ 0.75A, RoHS 6/6,	150035390
AC input cord strain relief		450037250

APPENDIX

The information requested to be included inside the packaging: 3/16/2022

Alcatel-Lucent Enterprise Resource Information

Additional product documentation, software, and training resources can be accessed at the locations listed below:

De la documentation supplémentaire sur les produits, des logiciels et des ressources de formation sont accessibles aux emplacements indiqués ci-dessous:

Documentation and Software
Business Portal: myportal.al-enterprise.com
Training and Certification
Knowledge Hub: enterprise-education.csod.com
Email: education-services@al-enterprise.com

Service & Support Contact Information
North America: 1-800-995-2696
Latin America: 1-877-919-9526
EMEA: +800-00200100 (Toll Free) or
+1-650-385-2193
Asia Pacific: +65-6240-8484
Other International: 1-818-878-4507
Web: myportal.al-enterprise.com

ALE USA, Inc.
26801 West Agoura Rd.
Calabasas, CA 91301
www.al-enterprise.com

033346-10 Rev. C

Safety Instructions

Instructions de sécurité
Veuillez lire ce chapitre avant d'installer l'équipement. Afin d'utiliser l'équipement en toute sécurité et de manière efficace, observez les recommandations de ce manuel et respectez les consignes de sécurité lors de son utilisation. Suivez les instructions d'installation et respectez tous les avertissements et mesures de sécurité signalés sur le produit.

• Des modifications apportées et non approuvées par le constructeur rendent cet équipement inopérable.
• Il est recommandé de suivre les consignes de sécurité des zones sensibles aux ondes électromagnétiques (hôpitaux...).
• N'exposez pas cet équipement à des conditions difficiles (pluie, air marin, poussière, etc.). Cet appareil est conçu pour une utilisation dans un local sec uniquement.
• Pour éviter tout court-circuit, ne laissez pas la broche de l'appareil entrer en contact avec un objet métallique étranger.
• Vérifiez le bon état de l'appareil, de ses câbles et de ses accessoires avant chaque utilisation. N'utilisez pas l'appareil s'il présente des traces visibles d'endommagement.
• Assurez-vous que la prise secteur est installée à proximité de l'équipement et facilement accessible. Si vous constatez la moindre anomalie, débranchez-le immédiatement de la prise AC.
• Cet équipement doit être connecté à la source d'alimentation conformément à la étiquette de notation.

APPENDIX (Continued)

产品说明书附件
SUPPLEMENT TO PRODUCT INSTRUCTIONS

这个文件涉及的是在中华人民共和国境内进口或销售的电子信息产品
Include this document with all Electronic Information Products imported or sold in the People's Republic of China

部件名称 (Parts)	有毒有害物质或元素 (Hazardous Substance)					
	铅 (Pb)	汞 (Hg)	镉 (Cd)	六价铬 (Cr^{6+})	多溴联苯 (PBB)	多溴二苯醚 (PBDE)
电路模块 (Circuit Modules)	×	○	○	○	○	○
电缆及电缆组件 (Cables & Cable Assemblies)	×	○	○	○	○	○
金属部件 (Metal Parts)	×	○	○	○	○	○
塑料和聚合物部件 (Plastic and Polymeric parts)	○	○	○	○	○	○
可插拔模块 (Pluggable Modules)	×	○	○	○	○	○
对于交付时集成了电池的电子信息产品 For electronic information products delivered with integrated functional batteries:						
电池 (Batteries)	○	○	○	○	○	○

本表格依据 SJ/T：11364-2014 的规定编制。

○：表示此部件使用的所有同类材料中此种有毒或有害物质的含量均低于 GB/T 26572-2011 规定的限制要求。

○：indicates the toxic or hazardous substance content of the part (at the homogenous material level) is lower than the threshold defined by Requirements for Concentration Limits for Toxic or hazardous Substances in Electronic Information Products(GB/T 26572-2011) issued by Chinese Ministry of Information Industry ("Not Contained" toxic or hazardous substances).

X: 表示此部件使用的至少一种同类材料中，此种有毒或有害物质的含量高于 GB/T 26572-2011 规定的限制要求。

X: indicates the toxic or hazardous substance content of the part (at the homogenous material level) is over the threshold defined by standard of GB/T 26572-2011("Contained"toxic or hazardous substances). Suppliers can explain the technical cause of "X" according to actual situation.

对销售之日的所售产品，本表显示，阿尔卡特朗讯公司供应链的电子信息产品可能包含这些物质。注意：在所售产品中可能会也可能不会含有所有所列的部件。

This table shows where these substances may be found in the supply chain of Alcatel-Lucent electronic information products, as of the date of sale of the enclosed product. Note that some of the component types listed above may or may not be a part of the enclosed product.

除非另外特别的标注，此标志为针对所涉及产品的环保使用期标志. 某些零部件会有一个不同的环保使用期（例如，电池单元模块）贴在其产品上.
此环保使用期限只适用于产品是在产品手册中所规定的条件下工作.

The Environment- Friendly Use Period (EFUP) for all enclosed products and their parts are per the symbol shown here, unless otherwise marked. Certain parts may have a different EFUP (for example, battery modules) and so are marked to reflect such. The Environment- Friendly Use Period is valid only when the product is operated under the conditions defined in the product manual.

Change History (excludes grammar & clarifications)

Revision	Date	Description of the change
1.1	03/11/2022	Initial Release
1.2	03/15/2022	CHINA ROHS AND RESOURCE INFORMATION CARD has been added to the power supply's packaging
1.3	12/18/2023	Updated as per OmniOn template

OmniOn Power Inc.
601 Shiloh Rd.
Plano, TX USA

omnionpower.com

Mouser Electronics

Authorized Distributor

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