SLP0712TE Series Power Supply

90 - 264V_{ac} input; 12V_{dc} output; 750W Output Power, 3.3 V_{dc} or 5.0V_{dc}/2A Auxiliary Output

Description

The SLP0712TE Series are low power 750W AC/DC power supplies in a high density 1RU x 1RU standard profile. The SLP series provides 80+ Platinum efficiency isolated power from the AC input mains. The SLP unique feature is the 1 RU x 1 RU design approach where OEMs can configure 2 units in either a 2RU width or 2RU height. The industry standard PMBus compliant I^2C communication's bus offers a full range of control and monitoring capabilities. The SMBAlert signal pin automatically alerts customers of any state change within the power supply.

Applications

- 12V_{dc} distributed power architectures
- Mid-End Servers
- Blade Servers
- Network Equipment
- Network Attached Storage
- Storage Area Networks
- Routers/Switches
- Enterprise Networks
- Advanced workstations

Options

- Reverse Airflow

Features

- 1 RU x 1RU form factor (1.52" x 11.81" x 1.57")
- 80Plus Platinum Efficiency - 94% typical @ 50% load
- 12V_{dc} Regulation: set point ±0.3%, overall ±3%
- 12V_{dc} programmable via PMBus between 10.8 – 13.2V_{dc}
- Turn-On overshoot: within regulation
- Active current share on 12V
- Remote sense on the 12V output
- Hot insertion/removal (hot plug)
- Standby voltage 3.3V_{dc} or 5.0 V_{dc} @ 2A
- 3.3V_{dc} or 5.0 V_{dc} Regulation: ± 5%
- Hardware recoverable latched 12V_{dc} overvoltage
- Auto recoverable overload & over temperature
- Firmware adjustable overload set point of 12V output
- Operating temperature: -10C to 65°C
- Digital status & control: PMBus serial bus
- Conducted EMI - meets CISPR32 (EN55032) and FCC Class A requirements
- UL and cUL approved to UL/CSA62368-1, TUV (EN62368-1), CE Mark (for LVD) and CB Report available
- Compliant to RoHS Directive 2011/65/EU and amended Directive (EU) 2015/863(-Z versions)
- Compliant to REACH Directive (EC) No 1907/2006

See footnotes on page 13

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Technical Specifications

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}	90	264	V_{ac}
Operating Ambient Temperature	T_A	-10[1]	65[2]	°C
Storage Temperature	T_{STG}	-40	85	°C
I/O Isolation voltage (100% factory Hi-Pot tested)			3000	V_{ac}
Humidity (non-condensing)		5	95	%
Altitude			5000	m

[1] Designed to start at an ambient down to -40°C; meet spec after □ 30 min warm up period, may not meet operational limits below -10°C.

[2] Derating guidelines shown in Figure 13-14.

Electrical Specifications

Parameter	Symbol	Min	Typ	Max	Unit
Operational Range	V_{IN}	90	115/230	264	V_{ac}
Frequency Range (ETSI 300-132-1 recommendation)	F_{IN}	47	50/60	63	Hz
Main Output Turn OFF	V_{IN}	75		85	V_{ac}
Main Output Turn ON	V_{IN}	80		90	V_{ac}
Hysteresis between turn OFF and turn ON		5			
Efficiency (T_A=25°C, V_O= 12V) V_{IN} = 230V, fan power externally) 100% load 50% load 20% load	η		 93.1 94 .2 91.5		%
Maximum Input Current (V_O= $V_{O,\ set}$, I_O=$I_{O,\ max}$) V_{IN}=100V_{AC} V_{IN}= 180V_{AC}	I_{IN}			 9 5	A_{ac}
Cold Start Inrush Current (Excluding x-caps, 25°C, <10ms,per ETSI 300-132)	I_{IN}			40	A_{PEAK}
Power Factor (V_{IN}=115/230V_{ac}), I_O= 50% $I_{O,\ max}$ I_O= 100% $I_{O,\ max}$	PF		 0.96 0.98		
Holdup time (V_{out}≥ 10.8V , T_{amb} = 25°C, I_O =80% load) V_{IN} = 90-230V_{ac}	T_H		12		ms
Early warning prior to output falling below regulation	T_W	2			
Ride through	T_R		10		
Leakage Current (V_{IN}= 250V_{ac}, F_{IN} = 60Hz)	I_{IN}			3	mA_{RMS}
Isolation Input to Output Input to Frame Output to Frame		 3000 2121 100			 V_{ac} V_{dc} V_{dc}

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Technical Specifications (continued)

Electrical Specifications (continued)

Parameter	Symbol	Min	Typ	Max	Unit
Output Power 100 – 264 V_{ac} V_{ac} < 100V_{ac}	W	 0 0	-	 750 700	W
Set point	V_O	11.94	12.00	12.06	V_{dc}
Overall regulation (load, temperature)		-1		+1	%
Ripple and noise (V_{out} =12.0V)		-		150	mV_{P-P}
Turn-ON overshoot				+3	%
Turn-ON delay	T			2	sec
Remote ON/OFF delay time				40	ms
Turn-ON rise time (10 – 90% of V_{out})				50	ms
Transient response 50% step [10%-60%, 50% - 100%] (dI/dt – 1A/µs, recovery 300µs)	V_O	-5		+5	$\%V_O$
Programmable range (PMBus only)		10.8		13.2	V_{dc}
Overvoltage protection, latched (recovery by cycling OFF/ON via hardware or PMBUs)		13.8	14.8	15.8	V_{dc}
Output current 100 ≥ V_{IN} ≥ 264 90 ≥ V_{IN} > 100	I_O	0		62.5 58.3	A_{dc}
Current limit, Hiccup (programmable level)		110		130	% of FL
Active current share		-5		+5	% of FL

Auxiliary/Standby Output Specifications

Parameter	Symbol	Min	Typ	Max	Unit
Set point	V_O		3.3 or 5.0		V_{dc}
Overall regulation (load, temperature, aging)	V_O	-5		+5	%
Ripple and noise (with 0.1uF ceramic capacitor at output)				100	mV_{P-P}
Output current	I_O	0		2	A_{dc}
Overload protection -		110		150	% of FL

General Specifications

Parameter	Symbol		Typ.		Unit
Calculated Reliability based on Telcordia SR-332 Issue 3: Method I Case 3(V_{IN}=230V_{ac}, Io = 62.5A, T_A = 40°C, internal fan, 90% confidence)	FIT MTBF		630.6 1,585,846		10^9/Hours Hours
Weight			765.7 27.0		g oz.

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Technical Specifications (continued)

Environmental Specifications

Parameter		Min	Typ	Max	Units
Ambient Inlet Temperature Rating Normal airflow (See Outline Drawing and Derating) Reverse airflow	 $T_{A, Normal}$ $T_{A, Reverse}$	 -10[1] -10[1]		 65[2] 65[2]	 °C °C
Storage Temperature		-40		85	°C
Operating Altitude (By Design)				5000	m (Ft)
Power Derating with Altitude Above 2250 m (7382ft)				2.0	°C/301m (1000ft)
Acoustic noise Full load Half load			 55 45		dbA
Over Temperature Protection (Internally Measured Points)			125/110		°C
Humidity Relative humidity, non-condensing Operating Storage		 30 10		 95 95	 %

[1] Designed to start at an ambient down to -40°C; meet spec after □ 30 min warm up period, may not meet operational limits below -10°C.

[2] Derating guidelines yet to be published

EMC Compliance

Parameter	Criteria	Standard	Level/ Criteria	Test
AC input	Conducted emissions	CISPR32 (EN55032), FCC part 15	A*	0.15 – 30MHz
	Radiated emissions	CISPR32 (EN55032) to comply with system enclosure	A*	30 – 1000MHz
AC input immunity	Voltage dips	EN61000-4-11	B	-30%, 10ms
			B	-60%, 100ms
			B	-100%, 5sec
	Voltage surge	EN61000-4-5	A	2kV, 1.2/50µs, common mode 4kV***, 1.2/50µs, common mode
			A	2kV, 1.2/50µs, differential mode
	Fast transients	EN61000-4-4	B	5/50ns, 2kV (common mode)
Enclosure immunity	Conducted RF fields	EN61000-4-6	A	130dBµV, 0.15-80MHz, 80% AM
	Radiated RF fields	EN61000-4-3	A	10V/m, 80-1000MHz, 80% AM
		ENV 50140	A	
	ESD	EN61000-4-2	B	4kV contact, 8kV air

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Technical Specifications (continued)

Feature Specifications

Parameter	symbol	Min	Typ	Max	Units
Remote ON/OFF (Needs to be pulled HI via an external resistor)					
Logic High (Module ON)	I_{IH}		—	20	µA
	V_{IH}	2.0	—	12	V_{dc}
Logic Low (Module OFF)	I_{IL}	—	—	4	mA
	V_{IL}	0	—	0.8	V_{dc}
Enable [short pin controlling presence of the 12V_{dc} output]					
12V output OFF	V_I	2.0	—	12	V_{dc}
12V output ON	V_I	0	—	0.8	V_{dc}
Fault (Needs to be pulled HI via an external resistor)					
Logic High (No fault is present)	I_{OH}		—	20	µA
	V_{OH}	2.0	—	12	V_{dc}
Logic Low (Fault is present)	I_{OL}	—	—	4	mA
	V_{OL}	0	—	0.4	V_{dc}
PS Present (Needs to be pulled HI via an external resistor)					
Logic High (Power supply is not plugged in)					
Logic Low (Power supply is present)	V_{IL}	0	¾	0.1	Vdc
SMBSMBAlert (Interrupt) (Needs to be pulled HI via an external resistor)					
Logic High (No Alert - normal)	I_{OH}		—	20	µA
	V_{OH}	2.0	—	12	V_{dc}
Logic Low (Alert is set)	I_{OL}	—	—	4	mA
	V_{OL}	0	—	0.4	V_{dc}

Digital Interface Specifications

Parameter	Cond.	Symbol	Min	Max	Unit
PMBus Signal Interface Characteristics					
Input Logic High Voltage (CLK, DATA)		V_{IH}	0.7VDD	3.6	V
Input Logic Low Voltage (CLK, DATA)		V_{IL}	0	0.8	V
Input high sourced current (CLK, DATA)		I_{IH}	0	10	µA
Output Low sink Voltage (CLK, DATA, SMBSMBALERT)	I_O=5mA	V_{OL}		0.4	V
Output Low sink current (CLK, DATA, SMBSMBALERT)		I_{OL}	5		mA
Output High open drain leakage current (CLK,DATA, SMBSMBALERT)	V_O=3.6V	I_{OH}	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	Linear	I_{RNG}	0	242	A
I_{OUT} measurement accuracy 25°C		I_{OUT}	-3	+3	% of Full Load
V_{OUT} measurement range	Linear	$V_{OUT(rng)}$	0	14	V
V_{OUT} measurement accuracy		$V_{OUT(acc)}$	-5	+5	%
Temp measurement range	Linear	$T_{(rng)}$	0	125	°C
Temp measurement accuracy[2]		$T_{(acc)}$	-5	+5	%
I_{IN} measurement range	Linear	$I_{IN(rng)}$	0	18	A_{rms}
I_{IN} measurement accuracy		$I_{IN(acc)}$	-6	+6	% of Full Load
V_{IN} measurement range	Linear	$V_{IN(rng)}$	0	300	V_{rms}
V_{IN} measurement accuracy		$V_{IN(acc)}$	-5	+5	%
P_{IN} measurement range	Linear	$P_{N(rng)}$	0	3000	W
P_{IN} measurement accuracy		$P_{IN(acc)}$	-6	+6	% of Full Load
Fan Speed measurement range	Linear		0	30k	RPM
Fan Speed measurement accuracy			-10	10	%
Fan speed control range	number		0	100	%

See footnotes on page 13

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Technical Specifications (continued)

Characteristic Curves

The following figures provide typical characteristics for SLP0712 power supply

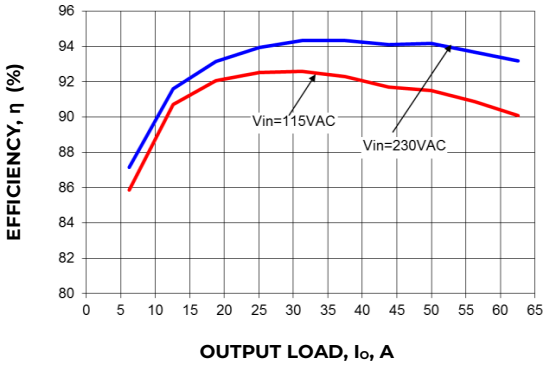

Figure 1. Power Supply Efficiency versus Output Current.

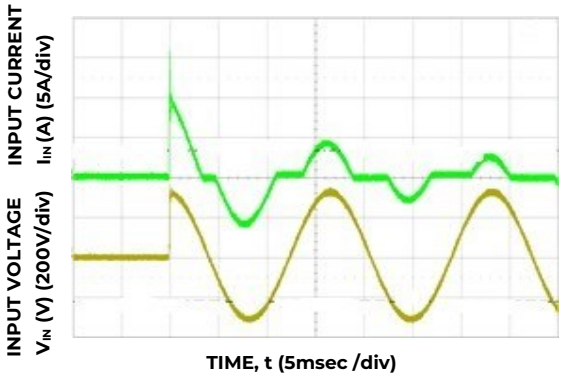

Figure 2. Inrush Current (V_{IN} = 230V_{ac}, 100% load)

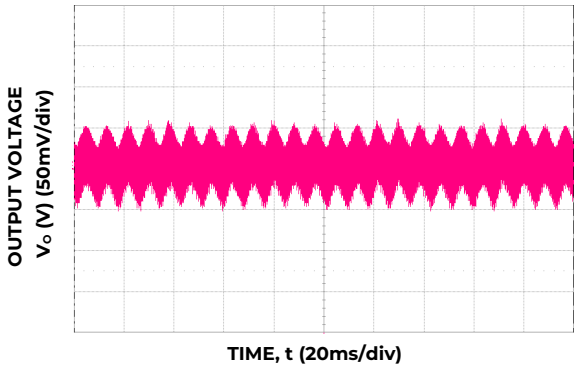

Figure 3. Typical 12V output ripple and noise (V_{IN} = 230V_{ac}, 100% load).

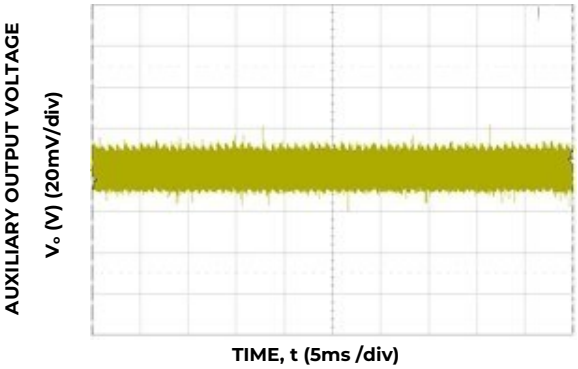

Figure 4. Typical auxiliary 3.3V output ripple and noise (V_{IN} = 230V_{ac}, 100% load).

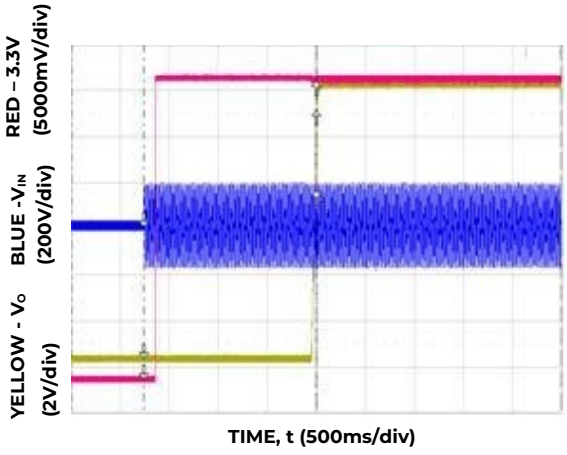

Figure 5. Typical Start-up (V_{IN} = 230V_{ac}).

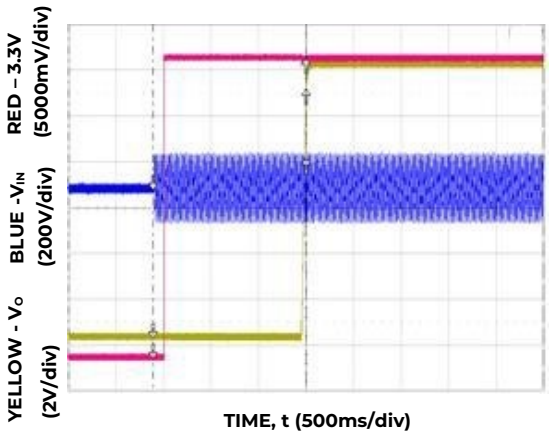

Figure 6. Typical Start-up (V_{IN} = 150V_{ac})

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Technical Specifications (continued)

Characteristic Curves (continued)

The following figures provide typical characteristics for SLP0712 power supply

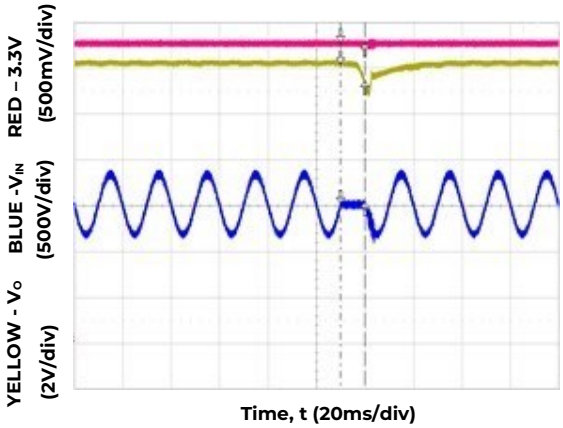

Figure 7. Ride Through at full load, V_{IN} = 230V_{ac}, V_o = 12V_{dc},

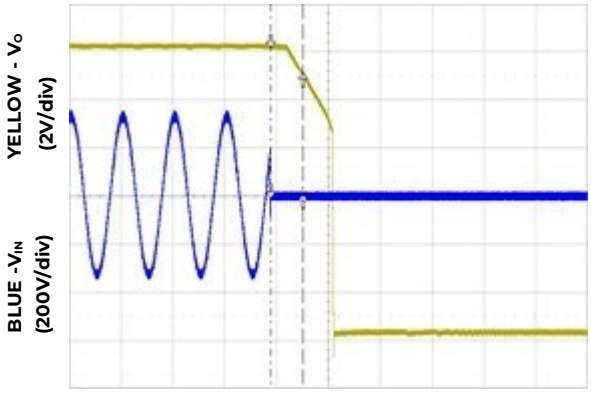

Figure 8. Hold up at 50A load, V_{IN} = 230V_{ac}, V_o = 12V_{dc}

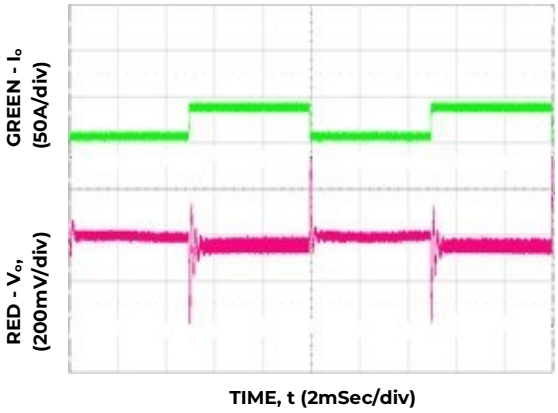

Figure 9. 10%-60%-10% Load Transient, Slew Rate = 1A/uS, V_{IN} = 230V_{ac}, V_o = 12V_{dc}

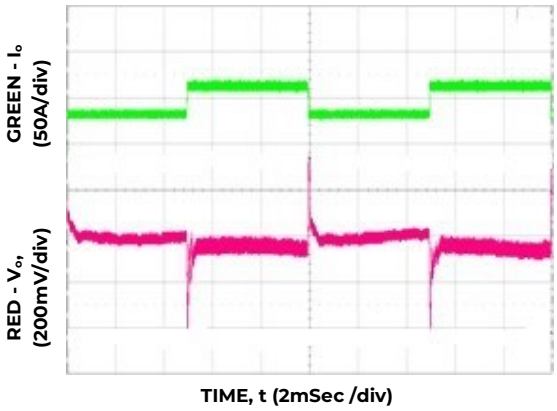

Figure 10. 50%-100%-50% Load Transient, Slew Rate = 1A/ uS, V_{IN} = 230V_{ac}, V_o = 12V_{dc}

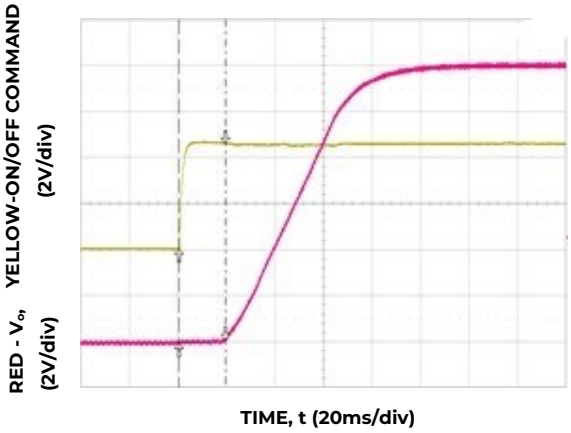

Figure 11. 12V_{dc} Turn-on delay upon inception of ON/ OFF command, V_{in} = 230V

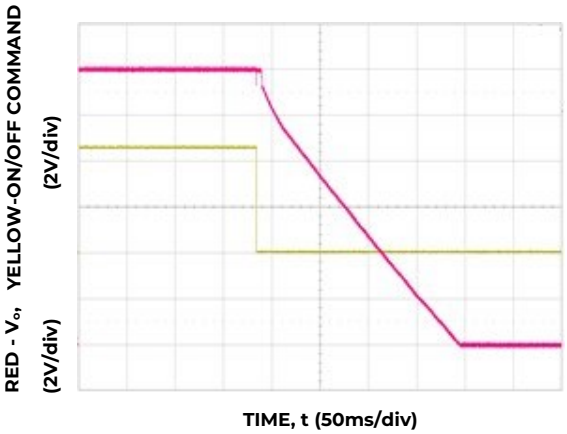

Figure 12. 12V_{dc} Turn-off delay upon inception of ON/OFF command, V_{in} = 230V

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Characteristic Curves (continued)

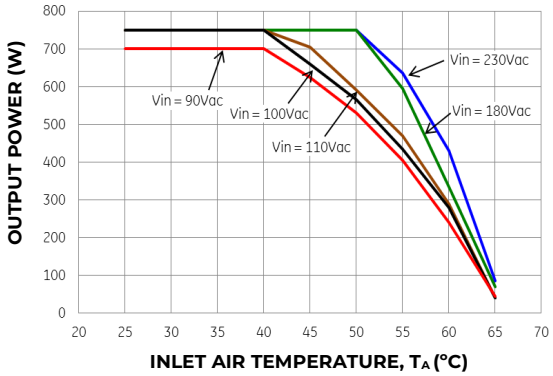

Figure 13. Derating output current versus ambient temperature (Normal airflow direction)

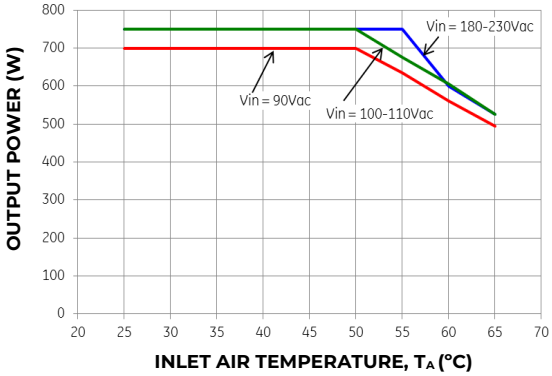

Figure 14. Derating output current versus ambient temperature (Reverse airflow direction)

Safety Considerations

The SLP0712 power supply is intended for inclusion in other equipment and the installer must ensure that it is in compliance with all the requirements of the end application. This product is only for inclusion by professional installers within other equipment and must not be operated as a stand- alone product. The power supply meets Class 1, IEC62368-1, EN62368-1, with the appliable national deviations which approved by TUV and UL (Recognized Component) C-UL (Canadian Approval by UL).

Auxiliary/Standby Output

The SLP0712 Auxiliary/Standby Output will always deliver output power when ac is provided. The output includes output ORing to insure reliable hot swap operation. The Auxiliary/ Standby Output can be connected in parallel, when multiple SLP0712 are used in a system. However, the outputs will not load share, so the total Auxiliary/Standby Output load should not exceed the capacity of a single SLP0712.

Control and Status

Control Hierarchy: Some features, such as remote on/ off, can be controlled both through hardware and firmware. Default control is given to hardware signal.

Analog Controls: Details of analog controls are provided in this data sheet under Signal Definitions.

Common Ground: All signals and outputs are referenced to Output return, V_o(-).

Control Signals

Load share (Ishare): This is a single wire analog signal that is generated and acted upon automatically by power supplies connected in parallel. Ishare pins should be connected to each other for power supplies, if active current share among the power supplies is desired. No resistors or capacitors should get connected to this pin.

Remote ON/OFF: Controls the presence of the main $12V_{dc}$ output voltage. This is an open collector signal that needs to be pulled HI externally through a resistor.

A turn OFF command either through this signal (Remote ON/OFF) or firmware commanded would turn OFF the 12V output.

Interlock: This is a short signal pin that controls the presence of the $12V_{dc}$ main output. This pin should be connected to 'output return' on the system side of the output connector. The purpose of this pin is to ensure that the output turns ON after engagement of the power blades and turns OFF prior to disengagement of the power blades.

Status Signals

Fault: A TTL compatible open drain status signal representing whether a Fault occurred. High = no Fault, L_o=Fault present. This signal needs to be pulled HI externally through a resistor. An internal pull up resistor shall be included in the layout.

This signal activates for OTP, OVP, OCP, AC fault or No output.

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Technical Specifications (continued)

Status Signals (continued)

PS Present: This pin is connected to 'output return' within the power supply. Its intent is to indicate to the system that a power supply is present. An internal pull up resistor shall be included in the layout.

Power Fail Warning (PFW): A TTL compatible open drain status signal indicating an imminent output failure, ~2ms before output voltage falls to 10.8V. High= normal, L_o=PFW occurred. This signal needs to be pulled HI externally through a resistor. An internal pull up resistor shall be included in the layout.

Visual Indicators

AC OK (Bicolor Green/Red)

DC OK (Bicolor Green/Red)

Operating Condition		LED Indicator AC OK	LED Indicator DC OK	FAULT Signal
1	Normal Operation	Green	Green	High
2	Low or High INPUT	Red	OFF	High
3	NO INPUT	OFF	OFF	High
4	OVP	Green	Red	Low
5	Over Current Fault	Green	Blinking	Low
6	Over Temp Fault	Green	Blinking	Pulsing

Blinking and pulsing: 0.5 second intervals. 0.5 seconds ON and 0.5 seconds OFF

Design Features

Serial Bus Communications

The I²C interface facilitates the monitoring and control of various operating parameters within the unit and transmits these on demand over an industry standard I²C Serial bus.

All signals are referenced to 'SGND'.

Pull-up resistors: The clock, data, and SMBAlert lines do not have any internal pull-up resistors inside the rectifier. The customer is responsible for ensuring that the transmission impedance of the communications lines complies with I²C and SMBus standards.

Serial Clock (SCL): The clock pulses on this line are generated by the host that initiates communications across the I²C Serial bus. This signal needs to be pulled HI externally through a resistor as necessary to ensure that rise and fall time timing and the maximum sink current is in compliance to the I²C/SMBus specifications.

Serial Data (SDA): This line is a bi-directional data line. This signal needs to be pulled HI externally through a resistor as necessary to ensure that rise and fall time timing and the maximum sink current is in compliance to the I²C /SMBus specifications.

Digital Feature Descriptions

PMBus™ compliance: The rectifier is fully compliant to the Power Management Bus (PMBus™) rev1.2 requirements. This Specification can be obtained from www.pmbus.org.

'Manufacturer Specific' commands are used to support additional instructions that are not in the PMBus™ specification.

All communication over the PMBus interface must support the Packet Error Checking (PEC) scheme. The PMBus master must generate the correct PEC byte for all transactions, and check the PEC byte returned by the rectifier.

The SMBAlert response protocol (ARA) whereby the PMBus Master can inquire who activated the SMBAlert signal is also supported. This feature is described in more detail later on.

Non-volatile memory is used to store configuration settings. Not all settings programmed into the device are automatically saved into this non-volatile memory. Only those specifically identified as capable of being stored can be saved. (see the Table of Commands for which command parameters can be saved to non-volatile storage).

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

If a non-supported read is requested the rectifier will return 0x00h for data.

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

Master/Slave: The 'host controller' is always the MASTER. Rectifiers 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.

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Technical Specifications (continued)

Digital Feature Descriptions (continued)

Clock stretching: The 'slave' µController inside the rectifier 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 L_O 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 rectifier. Note that clock stretching can only be performed after completion of transmission of the 9th ACK bit, the exception being the START command.

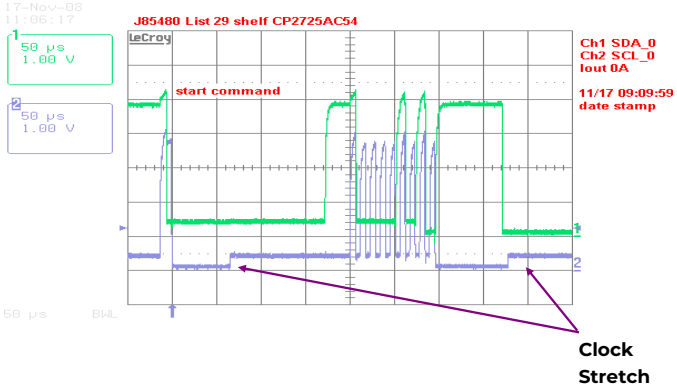

Figure 15. Example waveforms showing clock stretching.

I²C Bus Lock-Up detection: The device will abort any transaction and drop off the bus if it detects the bus being held low for more than 35ms.

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

Packet Error Checking (PEC): The rectifier 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 desired 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.

SMBAlert: 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 it's LO level if the rectifier has changed states and the signal will be latched L_O until the rectifier receives a 'clear_faults' instruction.

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
- SMBAlert is asserted during power up to notify the master that a new rectifier has been added to the bus.

The rectifier will clear the SMBAlert signal (release the signal to its HI state) upon the following events:

- Receiving a CLEAR_FAULTS command
- Bias power to the processor is recycled

The rectifier will re-assert the Alert line if the internal state of the rectifier has changed, even if that information cannot be reported by the status registers until a clear_faults is issued by the host. If the Alert asserts, the host should respond by issuing a clear_faults to retire the alert line (this action also provides the ability to change the status registers). This action triggers another Alert assertion because the status registers changed states to report the latest state of the rectifier. The host is now able to read the latest reported status register information and issue a clear_faults to retire the Alert signal.

Re-initialization: The I²C 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 I²C 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 I²C µController may not recognize a command sent to it. (i.e. a start condition).

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Digital Feature Descriptions (continued)

Read back delay: The rectifier 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 rectifier. 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 a SMBAlert before executing a read back. This delay will ensure that only the final state of the rectifier is captured.

Successive read backs: Successive read backs to the rectifier 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.

Global Broadcast: This is a powerful command because it instructs all rectifiers to respond simultaneously. A read instruction should never be accessed globally. The rectifier should issue an 'invalid command' state if a 'read' is attempted globally.

For example, changing the 'system' output voltage requires the global broadcast so that all paralleled rectifiers change their output simultaneously. This command can also turn OFF the 'main' output or turn ON the 'main' output of all rectifiers simultaneously. Unfortunately, this command does have a side effect. Only a single rectifier needs to pull down the ninth acknowledge bit. To be certain that each rectifier responded to the global instruction, a READ instruction should be executed to each rectifier to verify that the command properly executed. The GLOBAL BROADCAST command should only be executed for write instructions to slave devices.

Alert Response Address (ARA): This feature enables the 'master' to rapidly determine which 'slave' rectifier triggered the SMBAlert signal without having to poll each rectifier one at a time. During normal operation the rectifier activates (pulls down L_O) the SMBAlert signal line indicating that it needs attention when a 'state' change occurs.

The master can determine who pulled the 'alert' line by sending out the alert- response-address, address 12b, with a 'read' instruction. If the rectifier triggered the 'alert' it should respond back with its address. The instruction takes the form below;

1	8		1	8	1	8	1	1
S	ARA address	Rd	A	My address	A	PEC	A	P

If during the ARA response multiple rectifiers send out their addresses, then the actual address received by the master is the lowest address from the combinations of those rectifiers that responded.

The 'my address' field contains the address of the rectifier in the 7 most significant bits (msb) of the byte. The lsb of the byte is a don't care, it could be a 0 or a 1. For more information refer to the SMBus specification The µC does not have the ability to listen to the actual address that is sent over the bus, if multiple 'slaves' respond simultaneously, and therefore it does not clear its SMBAlert line. The host should read the status of the rectifier whose address was actually sent across the bus. Reading either the read_status [0 x D0] or status_word [0 x 79] would clear the SMBAlert line of the rectifier that was addressed. The rectifier will not re-assert the SMBAlert line unless the status states actually changed.

If the SMBAlert line is still asserted, the host should send out an ARA request again and find out who else asserted SMBAlert. This process needs to continue until the SMBAlert is released which is a clear indication that all rectifiers that asserted SMBAlert have had their status states read back.

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

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Technical Specifications (continued)

PMBus™ Commands (continued)

Standard READ: Up to two bytes of data may follow a READ request 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	7	1	1	8	1
S	Slave address	Wr	A	Command Code	A

1	7	1	1	8	1
Sr	Slave Address	Rd	A	LSB	A

8	1	8	1	1
MSB	A	PEC	NA	P

Block communications: When writing or reading more than two bytes of data at a time BLOCK instructions for WRITE and READ commands are used instead of the Standard Instructions above to write or read any number of bytes greater than two.

Block write format:

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

8	1	8	1	8		1
Byte count = N	A	Data 1	A	Data 2		A

8	1	8	1	8	1	1
.....	A	Data N	A	PEC	A	P

Block read format:

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

1	7	1	1
Sr	Slave Address	Rd	A

8	1	8	1	8		1
Byte count = N	A	Data 1	A	Data 2		A

8	1	8	1	8	1	1
.....	A	Data N	A	PEC	NA	P

Linear Data Format: The definition is identical to Part II of the PMBus Specification. All standard PMBus values, with the exception of output voltage related functions, are represented by the linear format described below. Output voltage functions are represented by a 16 bit mantissa. Output voltage has a E=9 constant exponent.

The Linear Data Format is a two byte value with an 11-bit,two's complement mantissa and a 5-bit, two's complement exponent or scaling factor, its format is shown below.

	Data Byte High								Data Byte Low							
Bit	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0
	Exponent (E)					Mantissa (M)										

The relationship between the Mantissa, Exponent, and Actual Value (V) is given by the following equation:

$$V = M * 2^{E}$$

Where: V is the value, M is the 11-bit, two's complement

mantissa, E is the 5-bit, two's complement exponent.

Standard features

Supported features that are not readable: The commands below are supported at the described setting but they cannot be read back through the command set.

Command	Comments
ON_OFF_CONFIG (0x02)	Both the CNTL pin, and the OPERATION command, enabling or disabling the output, are supported. Other options are not supported.
Capability (0x19)	400KHz, SMBALERT
PMBus revision (0x98)	1.2

Status and Alarm registers: The registers are updated with the latest operational state of the rectifier. For example, whether the output is ON or OFF is continuously updated with the latest state of the rectifier. However, alarm information is maintained until a clear_faults command is received from the host. For example, the shutdown or OC_fault bits stay in their alarmed state until the host clears the registers.

A clear_faults clears all registers. If a fault still persists after the clear_faults is commanded, the register bit annunciating the fault is reset again.

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Technical Specifications (continued)

PMBus Addressing

Hardware setting: Two signal pins, ADDR0 and ADDR1 configure the address of the power supply. Note that the ground reference for addressing is V_o(-).

Internally each power supply has a 10kΩ pull up resistor between the ADDR0/ADDR1 pin and 3.3V. The resistance between the ADDR pin and V_o(-) shall determine the values for A3-A0. The nominal resistor and corresponding voltage value for each position is tabulated below

Firmware setting:

Resistor Value, ADDR0	Nominal voltage	A1	A0
open	3.3V	0	0
20K	2.20V	0	1
4.99K	1.10V	1	0
Short to Vo(-)	0V	1	1

		Address	
Resistor Value, ADDR1	Nominal voltage	A3	A2
open	3.3V	0	0
20K	2.20V	0	1
4.99K	1.10V	1	0
Short to Vo(-)	0V	1	1

Bit	7	6	5	4	3	2	1
µC	1	1	0	A3	A2	A1	A0
Broadcast	0	0	0	0	0	0	0

Footnotes

* 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.

** ISO is a registered trademark of the International Organization of Standards

[2] Temperature accuracy decreases non-linearly with decreasing temperature

[3] Yes – indicates that the data can be changed by the user

[4] Only latched (0xC0) or hiccup (0xF8) are supported

[5] Only latched (0x80) or restart (0xC0) are supported

[6] Recovery set at 90V

[7] Recovery set at 86V

PMBus™ Command set:

Command	Hex Code	Data Field	Non-Volatile Memory Storage[3] / Default
Operation	0x01	1	Yes/80
Clear_Faults	0x03	-	
Write _Protect	0x10	1	Yes/00
Restore_default_all	0x12	-	
Restore_user_all	0x16	-	
Store_user_code	0x17	1	yes
Restore_user_code	0x18	1	
Vout_mode	0x20	1	
Vout_command	0x21	2	yes
Vin_ON	0x35	2	
Vin_OFF	0x36	2	
Fan_config_1	0x3A	1	Yes /90
Fan_command_1	0x3B	2	
Vout_OV_fault_limit	0x40	2	Yes / 14.8
Vout_OV_fault_response	0x41	1	No / 80
Vout_OV_warn_limit	0x42	2	Yes / 13.8
Vout_UV_warn_limit	0x43	2	Yes / 10.8
Vout_UV_fault_limit	0x44	2	Yes /10.0
Vout_UV_fault_response	0x45	1	No / C0
Iout_OC_fault_limit	0x46	2	Yes / 68
Iout_OC_fault_response[4]	0x47	1	Yes / F8
Iout_OC_LV_fault_limit	0x48	2	Yes/7
Iout_OC_warn_limit	0x4A	2	Yes / 62.5
OT_fault_limit	0x4F	2	Yes/TBD
OT_fault_response[5]	0x50	1	Yes / C0
OT_warn_limit	0x51	2	Yes/TBD
Vin_OV_fault_limit	0x55	2	No/ 275
Vin_OV_fault_response	0x56	1	No/ C0
Vin_OV_warn_limit	0x57	2	Yes / 265
Vin_UV_warn_limit[6]	0x58	2	Yes / 87.5
Vin_UV_fault_limit[7]	0x59	2	No / 80
Vin_UV_fault_response	0x5A	1	No/ C0
Status_byte	0x78	1	
Status_word (+ byte)	0x79	1	
Status_Vout	0x7A	1	
Status_Iout	0x7B	1	
Status_Input	0x7C	1	
Status_temperature	0x7D	1	
Status_CML	0x7E	1	
Status_fans_1	0x81	1	
Read_Vin	0x88	2	
Read_Iin	0x89	2	
Read_Vout	0x8B	2	
Read_Iout	0x8C	2	
Read_temp_PFC	0x8D	2	
Read_temp_dc_pri	0x8E	2	
Read_temp_dc_sec	0x8F	2	
Read_fan_speed_1	0x90	2	
Read_Pin	0x97	2	
Mfr_ID	0x99	6	

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Technical Specifications (continued)

PMBus™ Command set: (continued)

Command	Hex Code	Data Field	Non-Volatile Memory Storage[3] / Default
Mfr_model	0x9A	16	
Mfr_revision	0x9B	8	
Mfr_serial	0x9E	16	
Status_summary	0xD0	12	
Status_unit	0xD1	2	
Status_alarm	0xD2	4	
Read_fan_speed	0XD3	7	
Read_input	0xD4	5	
Read_firmware_rev	0xD5	7	
Read_run_timer	0xD6	4	
Status_bus	0xD7	1	
EEPROM Record	0xD9	128	yes
Read_temp_exhaust	0xDA	2	
Read_ temp_inlet	0xDB	2	
Reserved for factory use	0XDC		
Reserved for factory use	0XDD		
Reserved for factory use	0XDE		
Test_Function	0xDF	1	

Command Descriptions

Operation (0x01) : Turns the 12V output ON or OFF. The default state is ON at power up. Only the following data bytes are supported:

FUNCTION	DATA BYTE
Unit ON	0x80
Unit OFF	0x00

To RESET the rectifier using this command, command the rectifier OFF, wait at least 2 seconds, and then command the rectifier back ON. All alarms and shutdowns are cleared during a restart.

Clear_faults (0x03): Clears all STATUS and FAULT registers and resets the SMBAlert line of the I^2C side in control. The I^2C side not in control cannot clear registers in the rectifier. This command is always executable.

If a fault still persists after the issuance of the clear_faults command, the specific registers indicating the fault first clears but then get set again to indicate that the unit is still in the fault state.

WRITE_PROTECT register (0x10): Used to control writing to the PMBus device. The intent of this command is to provide protection against accidental changes. All supported commands may have their parameters read, regardless of the write_protect settings. The contents of this register cannot be stored into non-volatile memory using the Store_user_code command. The default setting of this register is enable_all_writes, write_protect 0x00h. The write_protect command must always be accepted.

FUNCTION	DATA BYTE
Enable all writes	00
Disable all writes except write_protect	80
Disable all writes except write_protect and OPERATION	40

Restore_default_all (0x12): Restores all operating register values and responses to the factory default parameters set in the rectifier. The factory default cannot be changed.

Restore_default_code (0x14): Restore only a specific register parameter into the operating register section of the rectifier.

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Technical Specifications (continued)

Command Descriptions (continued)

Store_user_code (0x17): Changes the user default setting of a single register. In this fashion some protection is offered to ensure that only those registers that are desired to be changed are in fact changed.

Restore_user_code (0x18): Restores the user default setting of a single register.

Vout_mode (0x20): This is a 'read only' register. The upper three bits specify the supported data format, in this case Linear mode. The lower five bits specify the exponent of the data in two's complement binary format for output voltage related commands, such as Vout_command.

These commands have a 16 bit mantissa. The exponent is fixed by the rectifier and is returned by this command

Mode	Bits [7:5]	Bits [4:0] (Parameter)
Linear	000b	xxxxxb

Vout_Command (0x21) : Used to dynamically change the output voltage of the rectifier. This command can also be used to change the factory programmed default set point of the rectifier by executing a store-user instruction that changes the user default firmware set point.

The default set point can be overridden by the Vprog signal pin which is designed to override the firmware based default setting during turn ON.

In parallel operation, changing the output voltage should be performed simultaneously to all rectifiers using the Global Address (Broadcast) feature. If only a single rectifier 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.

Vin_ON (0x35): This is a 'read only' register that informs the controller at what input voltage level the rectifier turns ON. The default value is tabulated in the data section. The value is contingent on whether the rectifier operates in the low_line or high_line mode.

Vin_OFF (0x36): This is a 'read only' register that informs the controller at what input voltage level the rectifier turns OFF. The default value is tabulated in the data section. The value is contingent on whether the rectifier operates in the low_line or high_line mode.

Fan_config_1 (0x3A) : This command requires that the fan speed be commanded by duty cycle. The tachometer pulse per revolution is not used. Default is duty cycle control.

Fan_command_1 (0x3B): This command instructs the rectifier to increase the speed of the fan above what is internally required. The transmitted data byte represents the hex equivalent of duty cycle in percentage, i.e. 100% = 0 x 64h.

The command can increase or decrease fan speed, as long the resultant speed is not below the internally required speed. An incorrect value will result in a 'data error'.

Sending 00h tells the rectifier to revert back to its internal control.

Vout_OV_fault_limit (0x40): Sets the value at which the main output voltage will shut down. The default OV_fault value is set at 14.8V_{dc}. This level can be permanently changed and stored in non-volatile memory.

Vout_OV_fault_response (0x41): This is a 'read only' register. The only allowable state is a latched state after three retry attempts.

An overvoltage shutdown is followed by three attempted restarts, each successive restart delayed 1 second. If within a 1 minute window three attempted restarts failed, the unit will latch OFF. If less than 3 shutdowns occur within the 1 minute window then the count for latch OFF resets and the 1 minute window starts all over again. This performance cannot be changed.

Restart after a latched state: Either of four restart mechanisms is available;

- The hardware pin ON/OFF may be cycled 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.

A successful restart clears all STATUS and ALARM registers.

A power system that is comprised of a number of rectifiers could have difficulty restarting after a shutdown event because of the non-synchronized behavior of the individual rectifiers.

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Technical Specifications (continued)

Command Descriptions (continued)

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;

- Issuing a GLOBAL OFF and then a GLOBAL ON command to all rectifiers
- Toggling Off and then ON the ON/OFF signal, if this signal is paralleled among the rectifiers.
- Removing and reapplying input commercial power to the entire system.

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

Vout_OV_warn_limit (0x42): Sets the value at which a warning will be issued that the output voltage is too high. The default OV_warn limit is set at 13.8V_{dc}. Exceeding the warning value will set the SMBAlert signal. This level can be permanently changed and stored in non-volatile memory.

Vout_UV_warn_limit (0x43): Sets the value at which a warning will be issued that the output voltage is too low. The default UV_warning limit is set at 10.8V_{dc}. Reduction below the warning value will set the SMBAlert signal. This level can be permanently changed and stored in non-volatile memory.

Vout_UV_fault_limit (0x44): Sets the value at which the rectifier will shut down if the output gets below this level. The default UV_fault limit is set at 10.0V_{dc}. This register is masked if the UV is caused by interruption of the input voltage to the rectifier. This level can be permanently changed and stored in non-volatile memory.

Vout_UV_fault_response (0x45): Sets the response if the output voltage falls below the UV_fault_limit. The default UV_fault_response is restart (0xC0). The only two allowable states are latched (0x80) and restart (0xC0). The default response state can be permanently changed and stored in non-volatile memory.

Iout_OC_fault_limit (0x46): Sets the value at which the rectifier will shut down at High Line. This level can be permanently changed and stored in non-volatile memory. The level for V_{in}<100V_{ac} is not adjustable, it is set at 45A.

Iout_OC_fault_response (0x47): Sets the response if the output overload exceeds the OC_Fault_limit value. The default OC_fault_response is hiccup (0xF8). The only two allowable states are latched (0xC0) or hiccup. The default response state can be permanently changed and stored in non-volatile memory. The response is the same for both low_line and high_line operations.

Iout_OC_warn_limit (0x4A): Sets the value at which the rectifier issues a warning that the output current is getting too close to the shutdown level at high line. This level can be permanently changed and stored in non-volatile memory.

The Low Line level is not adjustable, it is set at 62.5A.

OT_fault_limit (0x4F): Sets the value at which the rectifier responds to an OT event, sensed by the dc-sec sensor. The response is defined by the OT_fault_response register.

OT_fault_response (0x50): Sets the response if the output over temperature exceeds the OT_Fault_limit value. The default OT_fault_response is hiccup (0xC0). The only two allowable states are latched (0x80) or hiccup. The default response state can be permanently changed and stored in non-volatile memory.

OT_warn_limit (0x51): Sets the value at which the rectifier issues a warning when the dc-sec temperature sensor exceeds the warn limit.

Vin_OV_fault_limit (0x55): Sets the value at which the rectifier shuts down because the input voltage exceeds the allowable operational limit. The default Vin_OV_fault_limit is set at 275V_{ac}. This level can be permanently lowered and stored in non-volatile memory.

Vin_OV_fault_response (0x56): Sets the response if the input voltage level exceeds the Vin_OV_fault_limit value. The default Vin_OV_fault_response is restart (0xC0). The only two allowable states are latched (0x80) and restart (0xC0). The default response state can be permanently changed and stored in non-volatile memory.

Vin_UV_warn_limit (0x58): This is another warning flag indicating that the input voltage is decreasing dangerously close to the low input voltage shutdown level. The default UV_fault_limit is 87.5V_{ac}. This level can be permanently raised, but not lowered, and stored in non-volatile memory.

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Technical Specifications (continued)

Command Descriptions (continued)

Vin_UV_fault_limit (0x59): Sets the value at which the rectifier shuts down because the input voltage falls below the allowable operational limit.

The default Vin_UV_fault_limit is set at 80V_{ac}. This level can be permanently raised and stored in non-volatile memory.

Vin_UV_fault_response (0x5A): Sets the response if the input voltage level falls below the Vin_UV_fault_limit value. The default Vin_UV_fault_response is restart (0xC0). The only two allowable states are latched (0x80) and restart (0xC0). The default response state can be permanently changed and stored in non-volatile memory.

STATUS_BYTE (0x78): Returns one byte of information with a summary of the most critical device faults.

Bit Position	Flag	Default Value
7	Unit is busy	0
6	OUTPUT OFF	0
5	VOUT Overvoltage Fault	0
4	IOUT Overcurrent Fault	0
3	VIN Under voltage Fault	0
2	Temperature Fault or Warning	0
1	CML (Comm. Memory Fault)	0
0	None of the above	0

STATUS_WORD (0x79): Returns status byte as the low byte and the following high_byte.

Bit Position	Flag	Default Value
7	VOUT Fault or Warning	0
6	IOUT Fault or Warning	0
5	INPUT Fault or Warning	0
4	MFR SPECIFIC	0
3	POWER_GOOD# (is negated)	0
2	FAN Fault or Warning	0
1	OTHER	0
0	UNKNOWN Fault or Warning	0

STATUS_VOUT (0X7A): Returns one byte of information of output voltage related faults.

Bit Position	Flag	Default Value
7	VOUT OV Fault	0
6	VOUT_OV_WARNING	0
5	VOUT_UV_WARNING	0
4	VOUT UV Fault	0
3 - 0	X	0

STATUS_IOUT (0X7B): Returns one byte of information of output current related faults.

Bit Position	Flag	Default Value
7	IOUT OC Fault	0
6	IOUT OC LV Fault	0
5	IOUT OC Warning	0
4	X	0
3	CURRENT SHARE Fault	0
2	IN POWER LIMITING MODE	0
1 - 0	X	0

The OC Fault limit sets where current limit is set. The rectifier actually shuts down below the LV fault limit setting.

STATUS_INPUT (0X7C): Returns one byte of information of input voltage related faults.

Bit Position	Flag	Default Value
7	VIN_OV_Fault	0
6	VIN_OV_Warning	0
5	VIN_UV_ Warning	0
4	VIN_UV_Fault	0
3	Unit OFF for low input voltage	0
2	IIN_OC_Fault	0
1 - 0	X	0

STATUS_TEMPERATURE (0x7D): Returns one byte of information of temperature related faults.

Bit Position	Flag	Default Value
7	OT Fault	0
6	OT Warning	0
5 - 0	X	0

STATUS_CML (0X7E): Returns one byte of information of communication related faults.

Bit Position	Flag	Default Value
7	Invalid/Unsupported Command	0
6	Invalid/Unsupported Data	0
5	Packet Error Check Failed	0
4 - 2	X	0
1	Other Communication Fault	0
0	X	0

STATUS_fans_1 (0X81): Returns one byte of information of fan status.

Bit Position	Flag	Default Value
7	Fan 1 fault	0
6	X	0
5 - 4	X	0
3 - 2	Fan 1 speed overwritten	0
1 - 0	X	0

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Read back Descriptions

Single parameter read back: Functions can be read back one at a time using the read_word_protocol with PEC. A command is first sent out notifying the slave what function is to be read back followed by the data transfer.

Analog data is always transmitted LSB followed by MSB. A NA following the PEC byte signifies that the transmission is complete and is being terminated by the 'host'.

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

1	8		1
Sr	Slave address	Rd	A

8	1	8	1	8	1	1
LSB	A	MSB	A	PEC	No-Ack	P

Read back error: If the µC does not have sufficient time to retrieve the requested data, it has the option to return all FF's instead of incorrect data.

Read_fan_speed 1 (0x90): Reading the fan speed is in Direct Mode returning the RPM value of the fan.

Read_FRU_ID (0x99,0x9A,0x9B,0x9E): Returns FRU information. Must be executed one register at a time.

1	8		1	8	1
S	Slave address	Wr	A	Command 0x9x	A

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

8	1	8	1	8	1	8	1	1
Byte_1	A	Byte	A	Byte_x	A	PEC	No-Ack	P

Mfr_ID (0x99): Manufacturer in ASCII – 6 characters maximum,

OmniOn – Critical Power represented as, OmniOn-CP

Mfr_model (0x9A): Manufacturer model-number in ASCII – 16 characters, for this unit: SLP0712TExxxx

Mfr_revision (0x9B): Total 8 bytes, provides the product series number when the product was manufactured.

Mfr_serial (0x9E): Product serial number includes the manufacturing date, manufacturing location in up to 16 characters. For example:

13KZ51018193xxx, is decoded as;

13 – year of manufacture, 2013

KZ – manufacturing location, in this case Matamoros

51 – week of manufacture

018193xxx – serial #, mfr choice

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 rectifier. 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'.

Mfr_Specific 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 either accessed rapidly, at once, using the 'multi parameter' read back scheme of this document, or in batches of two STATUS and two ALARM registers.

Status_summary (0xD0): 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. Internal temperature should return the temperature that is closest to a shutdown level.

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 = 11	A

8	1	8	1	8	1	8	1
Status-2	A	Status-1	A	Alarm-3	A	Alarm-2	A

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

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Technical Specifications (continued)

Manufacturer-Specific PMBus™ Commands (continued)

8	1	8	1
Current-LSB	A	Current-MSB	A

8	1	8	1
Temperature-LSB	A	Temperature-MSB	A

8	1	1
PEC	No-Ack	P

Status_unit(0xD1): This command returns the STATUS -2 and STATUS-1 register values using the standard 'read' format.

Bit Position	Flag	Default Value
7	PEC Error	0
6	OC [hiccup=1,latch=0]	1
5	Invalid_Instruction	0
4	Power_Capacity [HL = 1]	x
3	OR'ing Test Failed	0
2	n/a	0
1	Data_out_of_range	0
0	Remote ON/OFF [HI = 1]	x

Status-2

Oring fault: Triggered either by the host driven or'ing test or by the repetitive testing of this feature within the rectifier. A destructive fault would cause an internal shutdown. Success of the host driven test depends on power capacity capability which needs to be determined by the external processor. Thus a non-destructive or'ing fault does not trigger a shutdown.

Bit Position	Flag	Default Value
7	OT [Hiccup=1, latch=0]	1
6	OR'ing_Test_OK	0
5	Internal_Fault	0
4	Shutdown	0
2	External_Fault	0
1	LEDs_Test_ON	0
0	Output ON (ON = 1)	x

Status-1

Status_alarm (0xD2): This command returns the ALARM-3 - ALARM-1 register values.

Bit Position	Flag	Default Value
7	Interlock open	0
6	Fuse fail	0
5	PFC-DC communications fault	0
4	DC-i2c communications fault	0
3	AC monitor communications fault	0
2	x	0
1	x	0
0	Or'ing fault	0

Alaram-3

Bit Position	Flag	Default Value
7	FAN_Fault	0
6	No_Primary	0
5	Primary_OT	0
4	DC/DC_OT	0
3	Vo lower than BUS	0
2	Thermal sensor filed	0
1	Stby_out_of_limits	0
0	Power_Delivery	0

Alaram-2

Power Delivery: If the internal sourced current to the current share current is > 10A, a fault is issued.

Bit Position	Flag	Default Value
7	POWER LIMIT	0
6	PRIMARY Fault	0
5	OT_Shutdown	0
4	OT_Warning	0
3	IN OVERCURRENT	0
2	OV_Shutdown	0
1	VOUT_out_of_limits	0
0	VIN_out_of_limits	0

Alaram-1

Read_Fan_speed (0 x D3) : Returns the commanded speed in percent and the measured speed in RPM. If a fan does not exist, 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 = 6	A

8	1	8	1	8	1	8	1
Adj%-LSB	A	Adj%-MSB	A	Fan1-LSB	A	Fan1-MSB	A

8	1	8	1	8	1	1
Fan2-LSB	A	Fan2-MSB	A	PEC	No-Ack	P

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Technical Specifications (continued)

Manufacturer-Specific PMBus™ Commands (continued)

Read input string (0xD4): Reads back the input voltage and input power consumed by the rectifier.

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

1	1	7	1	1
A	Sr	Slave Address	Rd	A

8	1	8	1	8	1
Byte Count = 4	A	Voltage - LSB	A	Voltage - MSB	A

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

Read_firmware_rev [0 x D5]: Reads back the firmware revision of all three µC in the rectifier.

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 = 6	A

8	1	8	1
Primary major rev	A	Primary minor rev	A

8	1	8	1
Secondary major rev	A	Secondary minor rev	A

8	1	8	1	8	1	1
i²c major rev	A	i2c revision	A	PEC	No-ack	P

Read_run_timer [0 x D6]: This command reads back the recorded operational ON state of the rectifier in hours. The operational ON state is accumulated from the time the rectifier is initially programmed at the factory. The rectifier 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 = 3	A

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

8	1	1
PEC	No-ack	P

EEPROM record (0xD9): The µC contains 128 bytes of reserved EEPROM space for customer use. After the command code, the starting memory location must be entered followed by a block write, and terminated by the PEC number;

1	7	1	1	8	1
S	Slave address	Wr	A	Command Code 0xD9	A

8	1	8	1
Start location	A	Byte count	A

8	1		8	1
first_byte	A	.....	last - byte	A

8	1	1
PEC	A	P

To read contents from the EEPROM section

1	7	1	1	8	1
S	Slave address	Wr	A	Command 0xD9	A

8	1	8	1
Memory location	A	Byte count ≤ 32	A

1	7	1	1
Sr	Slave address	Rd	A

8	1		8	1
Byte 1	A	.....	Byte ≤ 32	A

8	1	1
PEC	No-ack	P

Bit	Function	State
7	25ms stretch for factory use	1= stretch ON
5 - 6	reserved	
4	Or'ing test	1=ON, 0=OFF
2 -3	reserved	
0	LED test	1=ON, 0=OFF

Test Function (0xDF)

LEDS test ON: Will turn-on simultaneously the front panel LEDs of the Rectifier 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 rectifier being talked to and also to visually verify that the LEDs operate and driven properly by the micro controller.

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Technical Specifications (continued)

Manufacturer-Specific PMBus™ Commands (continued)

LEDS test OFF: Will turn-off simultaneously the four front panel LEDs of the Rectifier.

OR'ing Test: This command verifies functioning of output OR'ing. At least two paralleled rectifiers 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 rectifier should be tested at a time.

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

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

General performance descriptions

Default state: Rectifiers are programmed in the default state to automatically restart after a shutdown has occurred. The default state can be reconfigured by changing non-volatile memory (Store_user_code).

Delayed overcurrent shutdown during startup: Rectifiers are programmed to stay in a constant current state for up to 20 seconds during power up. This delay has been introduced to permit the orderly application of input power to a subset of paralleled rectifiers during power up. If the overload persists beyond the 20 second delay, the rectifier will revert back into its programmed state of overload protection.

Unit in Power Limit or in Current Limit: When output voltage is > $7V_{dc}$ the Output LED will continue blinking. When output voltage is < $7V_{dc}$, if the unit is in the RESTART mode, it goes into 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.

Restart after a latch off: PMBus™ fault_response commands can be configured to direct the rectifier to remain latched off for over_voltage, over_temperature and over_current.

To restart after a latch off either of five restart mechanisms are available.

1. The hardware pin ON/OFF may be cycled OFF and then ON.
2. The unit may be commanded to restart via i^2c through the Operation command by cycling the output OFF followed by ON.
3. Remove and reinsert the unit.
4. Turn OFF and then turn ON AC power to the unit.
5. Changing firmware from latch off to restart.

Each of these commands must keep the rectifier 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 rectifiers could have difficulty restarting after a shutdown event because of the non-synchronized behavior of the individual rectifiers. 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 rectifiers,
2. Toggling Off and then ON the ON/OFF (ENABLE) signal
3. Removing and reapplying input commercial power to the entire system.

The rectifiers 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 rectifiers.

Auto_restart: Auto-restart is the default configuration for over-current and over-temperature shutdowns. These features are configured by the PMBus™ fault_response commands

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

Hot plug procedures

Careful system control is recommended when hot plugging a rectifier into a live system. It takes about 15 seconds for a rectifier 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 rectifiers may

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Hot plug procedures (continued)

respond to specific instructions because the address of the hot plugged rectifier always defaults to xxxx000 (depending on which device is being addressed within the rectifier) until the rectifier configures its address.

Failure Predictions

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

Fault Management

The rectifier recognizes that certain transitionary states can occur before a final state is reached. The STATUS and ALARM registers will not be frozen into a notification state until the final state is reached. Once a final state is reached the SMBAlert signal is set and the STATUS and ALARM registers will not get reinstated until a clear_faults is issued by the master. The only exception is that additional state changes may be added to the original list if further changes are noted.

The rectifier differentiates between internal faults that are within the rectifier and external faults that the rectifier 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 rectifier to reset the system_interrupt.
- Any changes in the bit pattern of either the PMBus standard STATUS or the mfr_specific STATUS registers should trigger the SMBAlert signal.

Another example of potential predictive failure mechanisms can be derived from information such as fan speed when multiple fans are used in the same rectifier. 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 rectifier out of service.

Information only alarms: The following alarms are for information only, they do not cause a shutdown

- Over temperature warning
- V_{out} out-of-limits
- Output voltage lower than bus
- Unit in Power Limit
- Thermal sensor failed
- Or'ing (Isolation) test failure
- Power delivery
- Standby out of limits
- Communication errors

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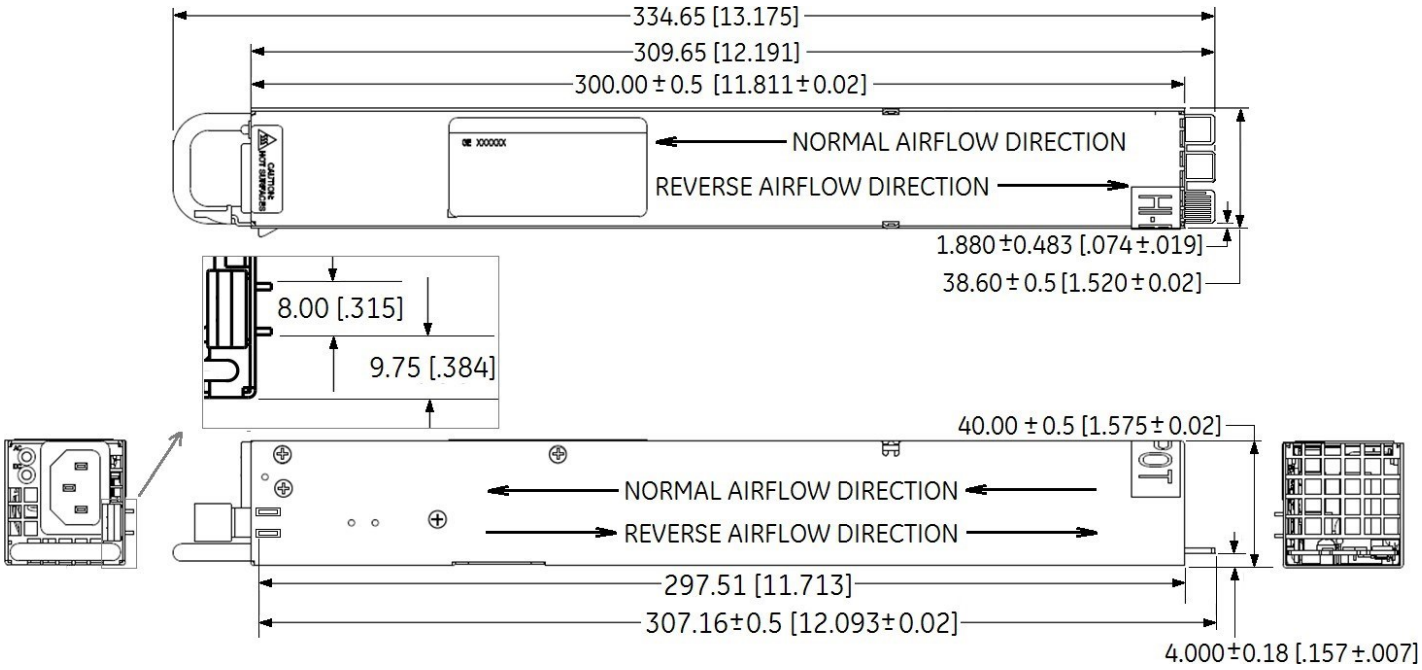
Technical Specifications (continued)

Outline Drawing

Dimensions are in millimeters and (inches).

Tolerances: x.x mm ± 0.5 mm (x.xx in. ± 0.02 in.) [unless otherwise indicated]

x.xx mm ±0.25 mm (x.xxx in ± 0.010 in.)



- H x W x L: 40.0mm [1.575”] x 38.6mm [1.520”] x 300mm [11.811”] (excluding handle, latch and connector)
- Connector:
  AC: IEC60320-C14
  DC: Edgecard Molex 45984, 4P/16S
- Default (normal) airflow: inlet on DC connector, exhaust at AC connector
- Reverse airflow: inlet at AC connector, exhaust at DC connector
- Handle/latch requirements
  Latch includes interlock with AC receptacle to prevent removal when AC cord is attached

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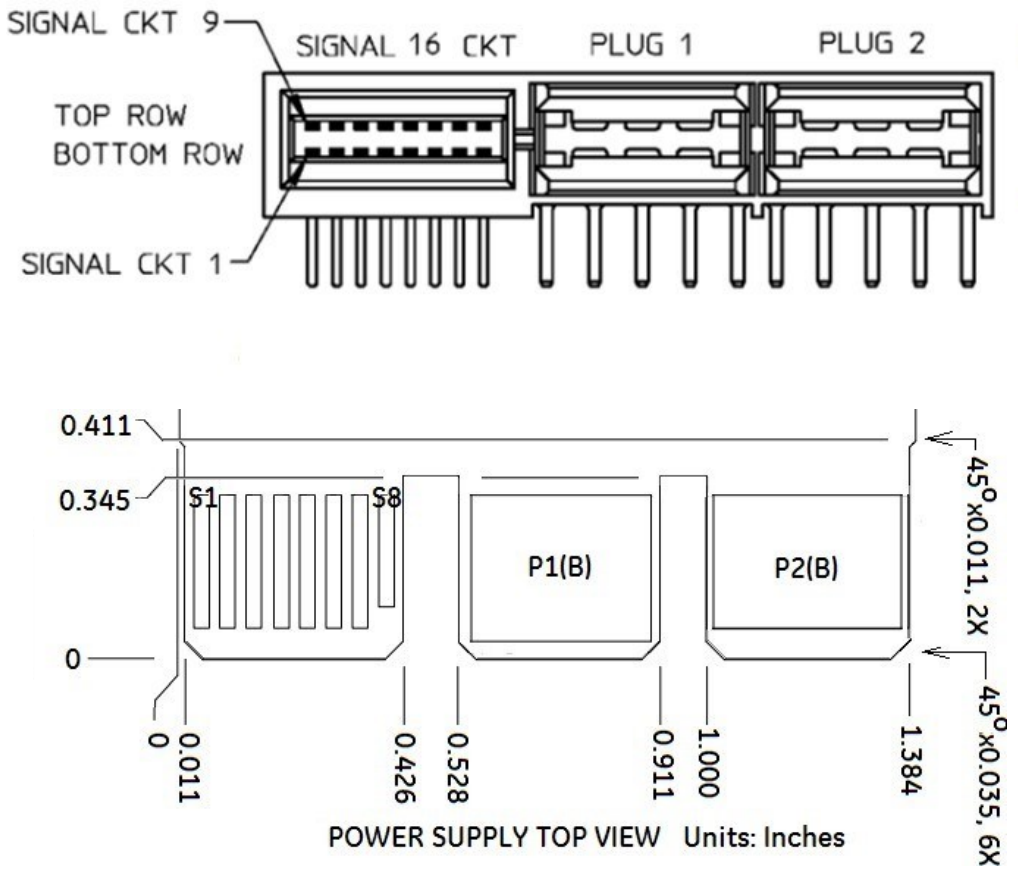
Technical Specifications (continued)

Connector Pin Assignments

Position	Function	Position	Function	Position	Function	Position	Function
S1	Sense +	S5	SDA	S9	Vstb	S13	PFW
S2	Sense -	S6	SCL	S10	Vstb	S14	PS Present
S3	IShare	S7	SGND	S11*	Interloc	S15	ADDR0
S4	SMBAlert	S8*	Remote On/Off	S12	FAULT	S16	ADDR1
P1 (B)	GND	P2 (B)*	V_o+	P1 (T)	GND	P2 (T)*	V_o+

* Short Pin length, engages last upon insertion.



Mating Connector Part Number

Molex 45984-4x2y, 1.27mm, 12.00mm Pitch, EXTreme LPHPower™ Receptacle Header, Right Angle, 4 Power Contacts, 16 Signal Contacts. x = 1 or 3. Y specific to pcb thickness mounting mating connector. Consult Molex web site for further information.

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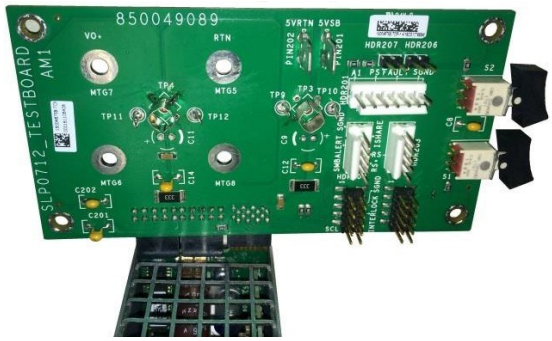
Technical Specifications (continued)

Ordering Information

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

PRODUCT CODE	AIRFLOW DIRECTION	STANDBY VOLTAGE	Ordering code
SLP0712TEXX3Z01A	NORMAL	3.3V	150034918
SLP0712TEXX5Z01A	NORMAL	5.0V	150034920
SLP0712TEXR3Z01A	REVERSE	3.3V	150034919
SLP0712TEXR5Z01A	REVERSE	5.0V	150034921

Accessories

Item	Description	Ordering code	Source
	Interface Card (for use with single power supply for bench testing only)	150048758	OmniOn

Contact Us

For more information, call us at
1-877-546-3243 (US)
1-972-244-9288 (Int'l)

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Change History (excludes grammar & clarifications)

Revision	Date	Description of the change
6.3	12/29/2021	Updated as per template
6.4	12/12/2023	Updated as per OmniOn template

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

omnionpower.com

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