CAR2548FP

2500W
1U High 48V, Front-End Power Module

DETAILED SPECIFICATION

Revised 12/21/07

CHEROKEE INTERNATIONAL

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1. GENERAL

Cherokee's latest 2500W Front end is a high line input operating switch mode power supply module. It is part of the CAR family offered as a front-end (48V or 12V) or a -54V rectifier.

With an unprecedented power density of ~27W/in^3, the CAR2548 is designed for a maximum output power of 2500W (max 52A @ 48Vout) in a 1U package. Up to Four (4) units can be mounted together in a 1U high 19" shelf. Cherokee also offers the rack with a monitoring unit and a low voltage disconnects option.

<u>Features of the latest CAR2548 Front-end include:</u>
Constant Current Characteristic
Visual LED Indicators
Hot Plug-ability
Redundant Parallel Operation
Active Load Sharing (Single Wire)
Remote On/Off
Remote Sense (up to 0.50V compensation per leg)
No Minimum Load Requirements
Universal Input with PFC
I2C communication/ and PM Bus with microcontroller capability
Various control and monitoring features
Four (4) CAR2548 Modules per Rack (7.5kW N+1 Capability)

2. INPUT SPECIFICATIONS

Input Voltage
      Range: *180-264VAC
                               * Unit derates to 1000W from 180Vac to 140Vac

Input Frequency
      Range: 47-63Hz (ETSI 300132-1 recommendation)

Under-Voltage
      The power supply switches off when mains voltage goes beyond the specified range. When active, the green LED is switched OFF on the front panel to generate a specific alarm. Turn off ≤ 140Vac .

Maximum Input Current
      16A (full load, Vin = 180Vac)

Power Factor
0.99 typical at nominal line & full load

Efficiency
92% typical, at 48Vdc output, nominal load and 230Vac (including Oring mosfets).

Input Fuse
Two fuses (line & neutral) – 20A & 250Vac
Type 3AB Axial

Relative Harmonics (of input current)
According to IEC 1000-3-2. Limits for harmonic current emissions for class D equipment

Inrush Current

Max 50A peak (Measured at 25ºC for all line conditions typical duration 10ms)

Input Leakage Current
3mArms (250Vac & 60Hz)

Switching Frequency
400khz typical

Hold-up Time
16.8ms at 2500W (typical) nominal 48Vdc, An early warning signal is provided 2ms prior to loss of an AC cycle. Ride thru is 8.3ms typically

3. OUTPUT SPECIFICATIONS

Output Voltage
Nominal output: 48Vout (Floating Output)
Tolerance: ±0.1V
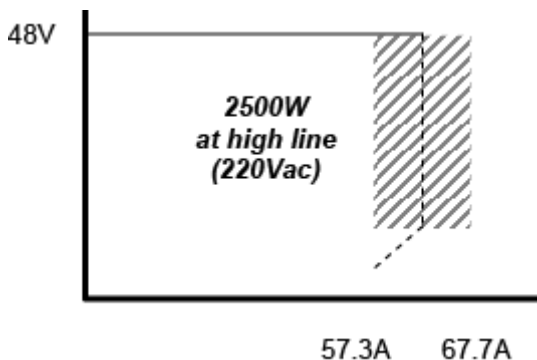Standby voltage: 3.3V (@ 1.0A) ± 5% or Optional 5V

Voltage Range
+43.2V to 52.8Vdc
For Vprog = (0 to 4.25V) ± 3%

Output Current
52A @ 48V
Minimum Load: 0A

Current Limit
Adjustable via I2C interface
Constant current characteristic

Output Power
2500W at high line operation (230Vac)

Line/Load/Temperature Regulation
$\leq \pm 2\%$ of Vnom for any combination of line, load & temperature.

Over-voltage Protection
Trip level: $\geq$ +59Vdc ± 1V
Reset condition by recycling the AC input or applying Remote ON/OFF

Dynamic Response

dIout/dt $\leq$ 1A/µs
Deviation $\leq$ 5% Vout (for a 50% step load)*
Recovery time 300us
* for system load conditions > 10% Iout max.

Turn on/off Delay Time

Mains on delay time $\leq$ 2s
Remote on delay time $\leq$ 40ms
Remote off delay time $\leq$ 40ms

Turn-on Rise Time

$\leq$ 50ms

Ripple and Noise

Complies with ETS300 132-2
32 dBnrc (measured without external battery)
Narrow band noise/Wideband noise (25 Hz - 20 kHz)
$\pm$ 1% (pk-pk) @ 20MHz with 0.1µF ceramic and 10µF electrolytic caps at the output

4. SIGNALS AND CONTROLS

For specific signal protocol please contact factory.
All digital signals are referenced to the -Vout Return (alarm return).
Chassis ground is floating.

Output Voltage Programming

Analog input signal - voltage determining the front-end output voltage.
Vout = Vprog*10/3+44.3V
Vout = 43.2V + 3.3 x (Vprog - .0.364)V where 0.364<3.27V the output voltage goes from 43.2Vdc to 52.8Vdc.

Output Current Monitoring

Analog output signal.
Voltage proportional to the front-end output current (0.1V/Amp) ± 250mV.

Load Share/Paralleling

Analog signal. Single wire connection.
Ishare bus voltage at full load: 5V for a single supply.
Unit will load share within ±5% of full load.

Remote Power ON-OFF

TTL compatible. Open collector (High) for normal operation.
Sink curent: 1mA. Max collector voltage: 12Vdc
Logic 1 (TTL High) or open enables unit (ON); Logic 0 (TTL Low) or short shuts unit down (OFF).
Cycling this signal resets the over-voltage protection memory.

AC OK

TTL compatible. Open collector (High) for normal operation.
Sink curent: 4mA. Max collector voltage: 12Vdc
AC OK indicates that AC is applied within the specified input range for the front-end.

DC OK

TTL compatible. Open collector (High) for normal operation.
Sink curent: 4mA. Max collector voltage: 12Vdc

Over Temperature Warning

TTL compatible. Open collector (High) for normal operation.
Sink curent: 4mA. Max collector voltage: 12Vdc
In the event of an over temperature condition, the unit protects itself by providing a low warning signal for 10 seconds (typical) and then shutting off. Auto restart after the condition is cleared.

Fault Signal

TTL compatible. Open collector (High) for normal operation.
Sink curent: 4mA. Max collector voltage: 12Vdc
The signal indicates that a failure has been detected in the unit (OTP, OVP, AC Fail or No Input).

Alarm Return Signal

All signals are referenced to the -Vout Return.

PS Present

Digital signal delivered to the backplane when the module is present and is strapped to the return inside the module. When a module is inserted into a specific slot within the accompanying shelf/backplane, the PS Present signal indicates that a module is present via and active low signal. Typically an external pull resistor is required at the system level to detect a missing module when the application calls for an accompanying rack /backplane.

Module Enable (Short Pin)

Power supply will turn on when pin engages. It is required to tie the Mating Connector pin to the Output Return if you are not using a rack/backplane arrangement.

Hot Swap

Unit is equipped with internal Or-ring mosfets in the Vout leg and designed for hot swap operation.

LEDs

AC OK (Green for OK)
DC OK (Green for OK)
Fault (Amber for fault)

test condition:			LEDs Indicators			Monitoring Signals			
			AC OK	**DC OK**	**FAULT**	**FAULT**	**DC OK**	**AC OK**	**TEMP OK**
1	normal operation unit		green	green	off	low	low	low	high
2	low/no AC		off	off	red	high	high	high	high
3	ovp		green	off	red	high	high	low	high
4	over current		green	off	red	high	high	low	high
5	thermo alarm		green	green	red	high	low	low	low
NOTE:		Test condition # 2 had two modules plug in. One module running and the other module with no AC							

Digital Functions/Features

Serial Number/Part Number – module information read-back (EEPROM)
Voltage programming (programmable within stated operating range)
AC Good
DC Good
Fault
Thermal warning
Remote ON/OFF
Fan speed control
Digital Voltage programming
Digital Iout monitoring
Programmable current limit

5. I2C Serial Communication w/ Microcontroller (Option)

The I2C interface incorporated within the CAR2548FP modules includes facilities to monitor various operating parameters within the unit and transmits these on demand over an industry standard I2C Serial bus. I2C operation will over-ride analog signal operation when this option is selected.

Thus the CAR2548TN is equipped which either analog, I2C or PMBus means of control and monitoring.

Electrical Interface
Address lines (A0, A1 &A2)
These external address lines allow up to four (4) CAR2548FP modules to be addressed on a single I2C bus.
Serial Clock
This line is clocked by the processor that controls the I2C serial bus. It should be tied to a +3.3V supply via a pull up resistor. Max bus frequency is 100kHz.
Serial Data
This line is a bi-directional data line. It should be tied to a +3.3V supply via a pull up resistor.

NOTE: CAR2548FP supports 3.3V and 5V bus voltages.

Microprocessor (uP) Design Feature
The following information represents a summary of the basic functions provided by the microprocessor (P/N PIC16F873A).

General Functions:

Analog Sensing – Output Voltage Sensing (Anode of Oring Device), Current Monitor, and Temperature.

Analog/PWM Control - External Voltage Programming, I2C Voltage Programming, I2C Current Limit Programming, Fan Speed Control, Constant Power Control

Digital Reporting – Line sense, ACOK, DCOK, TEMP_OK, FAULT, Interrupt, OVSD (maybe)

Digital Control – ON/OFF

EEPROM – Internal to IC (1K, 128 bytes)

Communications – SDA, SCL, Addressing (8 unique addresses)

Programming (Factory setting only) – PGC, PGD, MCLR

I2C Iprogram / IPWM (RC1/CCP2) – The user can set the current limit point through the duty cycle at RC1/CCP2 so that its average value (IPWM) is related to ILIMIT by the follow relationship:

$$ILIMIT = 10 \times IPWM \qquad = 50 \times DCCP2 \text{ (CCP2 Duty Cycle)}$$

FANPWM (RC7) – Use a slow sequence (<TBD kHz) of 1's and 0's as a pseudo-PWM output to control the fan speed. The duty cycle should be a function of TS.

Formula to derive $D = 0.1 \times TS + 0.4$

Temp	TS	D (Duty Cycle)	Avg FANPWM	Fan Volt
36C	4V	0.8	4V	12V
86C	2V	0.6	3V	9V

Constant Power Control – Besides the I2C current the uP will also set the current limit point (ILIMIT) basing on the VASENSE reading to create a constant power characteristic on the output from 48 – 58V. The **LOWER** value between this constant power current limit and the I2C current limit will be used to set the DCCP2 and thus the ILIMIT point. Accuracy TBD.

$$ILIMIT = 10 \times IPWM \qquad = 50 \times DCCP2 \text{ (CCP2 Duty Cycle)}$$

Digital Reporting/Control

-LINE_SENSE (RA4) – Input from external hardware
        No Low Line Operation
        Lo = 180 – 264Vac range

ACOK (RB4) – Input from external hardware
> Hi = AC OK
> Lo = AC not OK

DCOK (RC5) – Input from external hardware
> Hi = DC OK
> Lo = DC not OK

OTEMP (RC6) – Output signal to indicate that there is an over-temperature condition by comparing the voltage from TS against a certain thresholds.

The default values correspond to about 120C of turn off and 110C of recovery.

> Hi = TEMP too high
> Lo = TEMP OK

Programmable (Internal) DCOK (DCOK_INT) –

This is an optional user programmable DCOK internal to the uP in addition to the hardware DCOK.

Default values: DCOKLO = 307 (1.5V at VASENSE)
              DCOKHI = 717 (3V at VASENSE)

FAULT (RB3) – Output signal that indicates whether there is a fault due to over-temperature, over-voltage or internal DCOK conditions.

> Hi = FAULT
> Lo = No FAULT

INT (RB0/INT) – Output interrupt signal to be triggered by changing state of ACOK, DCOK, TEMP_OK or -OVP going Lo. Interrupt timing from ACOK and DCOK should be minimized per the uP's capability.

> Hi = No Interrupt
> Lo = Interrupt

–OVSD (RA3/AN3, Maybe) – Input from external hardware

> Hi = No OV shutdown
> Lo = Shutdown due to OV

-ON/OFF (RB5) – Output to control output on and off by user's input from I2C. The off status from either this signal or the analog Remote On/Off will override the on conditions of one another.

> Hi = Output Off
> Lo = Output On

EEPROM – UP has 1K bytes of memory available. A separate EEPROM IC will provide another 1K bytes of memory with write protect feature. Minimum information to be included in the external EEPROM: model number, revision, date code, serial number and TBD.

I2C Communications – SDA (RC4) and SCL (RC3) lines should have no pull-up resistors and no more than 47pF of filtering capacitor. A0 (RC0), A1 (RB1) & A2 (RB2) are for setting 8 possible addresses by the user.

Device Addresses:

Device	Address	Address Bit Assignments (Most to Least Significant)							
uP	Bx	1	0	1	1	A2	A1	A0	R/W
EEPROM	Ax	1	0	1	0	A2	A1	A0	R/W

Access: R = Read Only; R/W = Read/Write

Source Parameter	Input Source	Register/Bit Location	Access	Comments
VASENSE	RA0	0X00	R	
IMON1	RA2	0X01	R	
TS	RA5	0X02	R	
-ON/OFF	RB5	0X03	R/W	
IPWM	CCP2	0X04	R/W	
VPWM	CCP1	0X05	R/W	
VPROG_EXT	RA1	0X06	R	
OTEMP TRIP THRESHOLD		0X07	R/W	
OTEMP RECOVERY THRESHOLD		0X08	R/W	
DCOKHI		0X09	R/W	
DCOKLO		0X0A	R/W	
-LINE_SENSE	RA4	0X0B.0	R	1 = Low Line
ACOK	RC5	0X0B.1	R	1 = ACOK
DCOK	RC6	0X0B.2	R	1 = DCOK
OTEMP	RC6	0X0B.3	R	-OTEMP reported at 0X0B.3 (1 = No OTEMP)
FAULT	RB3	0X0B.4	R	-FAULT reported at 0X0B.4 (1 = No FAULT)
INT	RB0	0X0B.5	R	1 = No Interrupt
-OVSD	RA3	0X0B.6	R	1 = No OVSD
DCOK_INT		0X0B.7	R	1 = Internal DCOK
EEPROM IN MICRO-P		0X0D – 0X8C	R/W	
Firmware Revision		0X0C	R	
EEPROM			R/W	

Programming – MCLR, PGC and PGD are for factory programming of uP and not for user's access.

6. PMBUS Product Requirements

Product communicates using the same signals I2C.
The PMBUS interface incorporated within the CAR2548FP modules includes facilities to monitor various operating parameters within the unit and transmits these on demand over an industry standard PMBUS Serial bus. PMBUS operation will over-ride analog signal operation when this option is selected.

Thus the CAR2548FP is equipped which either analog, I2C or PMBus means of control and monitoring.

PMBUS Product Requirements:
I.   Interoperability with I2C (as called stated in Appendix B of SMB v2.0)
   a. Power supply must operate either in standard I2C mode or PMBus protocol based by auto-sensing command structure.
   b. PMBus frequency must be support 400kHz
   c. AC Specifications (must comply as stated in Table 2 – of Section 5.2.6 of PMB v1.1X2)
   d. DC Specifications (must comply with High Power DC Specifications of Section 3.1.3 SMBus v2.0)
II.   Signals and Controls
   a. 7 bit addressing (DO NOT use reserved Addresses in Appendix B of SMB v2.0)
      • Device must also respond to Global Broadcast address of 00h
   b. /SMBALERT (Active low)
      • Output pin (use INTERRUPT pin as I2C)
   c. WP – Write Protect of Memory (Section 3.1.3 SMB v2.0)
   d. Protocol Select (Active High)
      • High on signal means to communicate using I2C
      • Low on signal means to communicate in PMBUS
III. Functionality
   a. Device is always a slave mode (Never contends to be master)
   b. Reporting of device Fault condition using SMBALERT (Interrupt mechanism to communicated with host Appendix A of SMB v2.0)
   c. Self Power ON
IV.   Protocol/ Command Structures Supported
   a. Block Write- Block Read Process Call (Section 5.5.8 SMB v2.0)
   b. Group Command Protocol (Section 5.2.3 PMB v1.1X2)
   c. Direct Mode supported for all command/data transfers (Section 7.2 PMB v1.1X2)
V.   Control and Monitoring Commands
   a. VOUT_MODE
      • READ ONLY command that states we operate at "DIRECT MODE"

b. VOUT_COMMAND
- Input control command with program the power supply's Vout.

c. COEFFICIENTS COMMAND
- used in conjunction with "DIRECT MODE"

d. CLEAR_FAULTS
- Clears fault status register

e. VOUT_OV_FAULT_LIMIT
- Vout Over Voltage

f. VOUT_UV_FAULT_LIMIT
- Vout under voltage

g. IOUT_OC_FAULT_LIMIT
- Iout over current

h. IOUT_UC_FAULT_LIMIT
- Iout under current

i. IIN_OC_FAULT_LIMIT
- Input Current Over Current

j. POWER_GOOD_ON
- Vout at which the DC good signal should be asserted

k. POWER_GOOD_OFF
- Vout at which the DC good signal should be negated

l. OT_FAULT_LIMIT
- Over temperature point , in degrees Celsius, OT should be asserted

m. STATUS_BYTE
- Status register reporting

n. STATUS_WORD
- Status register reporting

o. STATUS_CML
- Status register reporting

p. READ_VIN
- Host performs Read ONLY Vin

q. READ_VOUT
- Host performs Read ONLY Vout

r. READ_IOUT
- Host performs Read ONLY Output Current

s. READ_TEMPERATURE
- Host performs Read ONLY Temperature

t. READ_FAN_SPEED
- Host performs Read ONLY Fan Speed

u. READ_POUT
- Host performs Read ONLY Output Power

VI. MFR Specific Commands Supported
- Manufacturer's rating of product.
  b. PMBUS_REVISION
  c. INVENTORY INFORMATION
  d. MFR_ID
  e. MFR_MODEL
  f. MFR_REVISION
  g. MFR_LOCATION
  h. MFR_DATE
  i. MFR_SERIAL
  j. MFR_VIN_MIN
  k. MFR_VIN_MAX
  l. MFR_IIN_MAX
  m. MFR_PIN_MAX
  n. MFR_VOUT_MIN
  o. MFR_VOUT_MAX
  p. MFR_IOUT_MAX
  q. MFR_POUT_MAX
  r. MFR_TAMBIENT_MAX
  s. MFR_TAMBIENT_MIN
VII. Other Misc. Commands
  a. CAPABILITY
- Host performs READ ONLY of key capabilities
  b. QUERY
- Host queries to see support for a command

7. SAFETY ASPECTS

Applicable Standards
IEC 950 (per EN 60950)
CSA C22.2-950
UL 1950
CE Mark (LVD)

Input Fuse
20A

Isolation
Insulation test voltage:
Input – ground: 1500Vac
Output – ground: 100Vdc
Input – Output: 3000Vac

8. EMC SPECIFICATIONS

Immunity

Port	Phenomena	Test	Criteria	Ref Standard
Enclosure	Conducted RF fields Immunity	130dBµV 0.15MHz - 80MHz (80% AM)	A	EN 61000-4-6
	Radiated RF fields Immunity	10V/m 80MHz - 1000MHz (80% AM)	A	EN 61000-4-3
			A	ENV 50140
	ESD	8KV air 4KV contact	B	EN 61000-4-2
AC input	Fast transients Common mode	(5/50ns) 2KV	B	EN 61000-4-4
	Voltage dips Voltage interr.	-30%, 10ms -60%, 100ms -100%, 5000ms > 95% 5 s	A B B	EN 61000-4-11
	Surge common mode differential mode	(1.2 / 50µs) 4KV 2KV	A	EN 61000-4-5

Emission (size dependent – per Engineering)

| Port	Frequency-range	Limits	Reference Standard
AC input (conducted)	0.15 – 30MHz	A/B (B) w/enclosures	EN 55022 FCC Docket 20780 Part 15, Subpart J Class B.
	0 – 2KHz	-	EN 61000-3-2
Enclosure (radiated)	30 - 230MHz 230 - 1000MHz	B	EN 55022

9. MECHANICAL SPECIFICATIONS

Dimensions
Height: 1.61" – (40.9mm) (fits in 1U rack in vertical installation)
Width: 4.00" – (101.6mm)
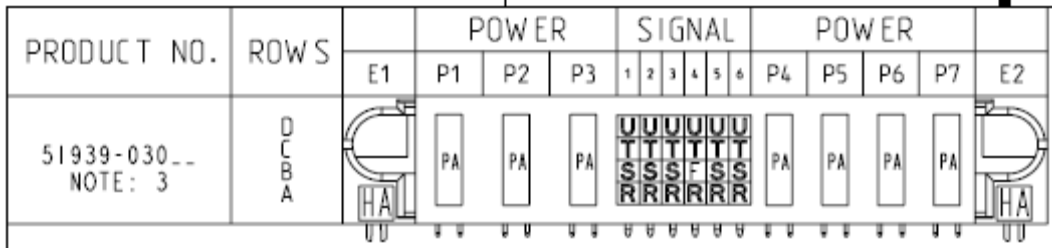Depth: 14.25" – (361mm)

Mounting
Hot plugging allowed. The PS is automatically locked when introduced into the rack. To remove, a small handle enables that user to unlock the unit and easily extract the unit.

Outline Drawing
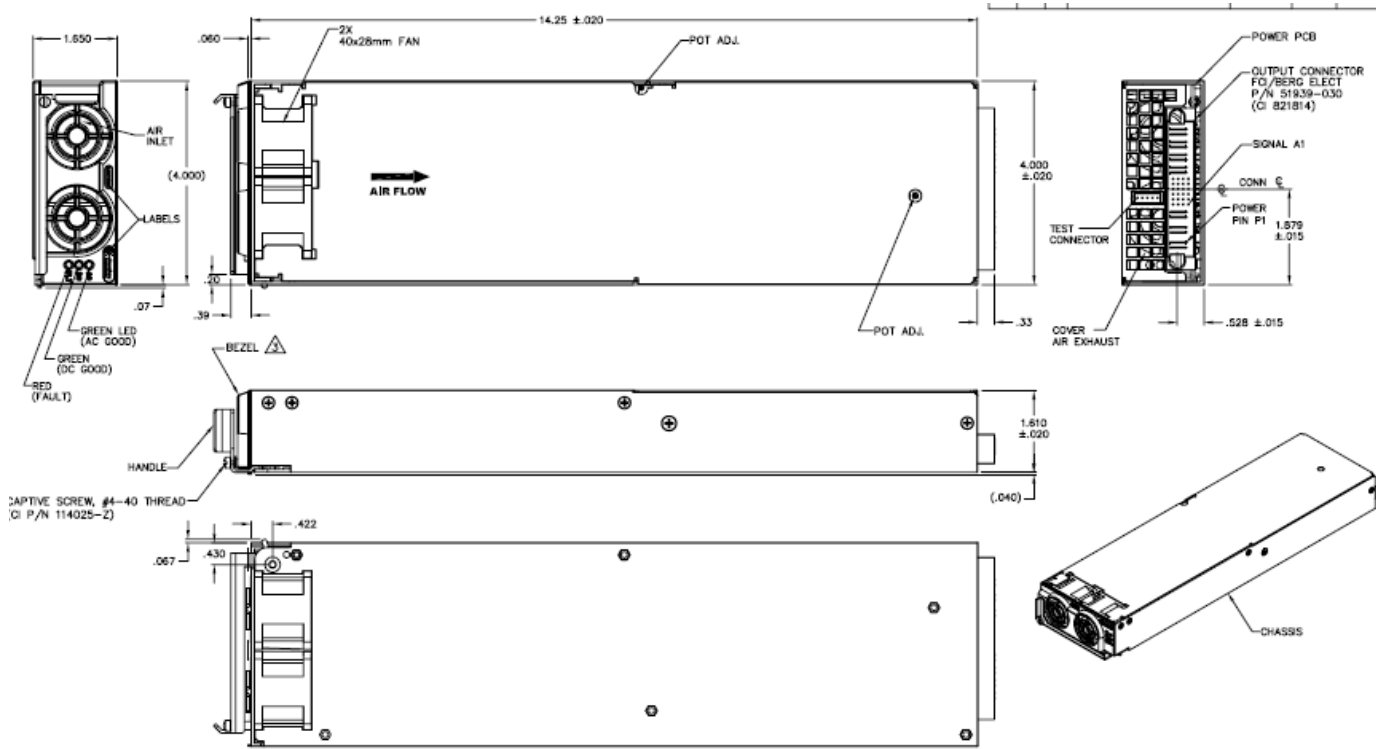
10. CONNECTIONS

FCI Berg P/N 51939-030
Mating connector 51939-015

A1	Vstb [3.3V]	C1	I Share	P1	Line
A2	Vstb [3.3V] Return	C2	Protocol Select	P2	Neutral
A3	Signal Return	C3	Temp Warning	P3	Chassis
A4	Write Protect	C4	I2C Address (A0)	P4	+Vout
A5	Remote Sense (+)	C5	I2C Address (A1)	P5	+Vout
A6	Remote Sense (-)	C6	I2C Address (A2)	P6	Output Return
				P7	Output Return
B1	Fault	D1	V Prog		
B2	I Monitor	D2	OVP Test Point		
B3	Module Enable	D3	Remote Power ON/OFF		
B4	PS Present	D4	DC OK		
B5	Serial Data Line	D5	AC OK		
B6	Serial Clock Line	D6	Interrupt		

11. ENVIRONMENTAL SPECIFICATIONS

Temperature

Operating ambient: -10°C to +70° C (startup -40° C, meet specified spec with 30min. warm period)
Active derating between: 51°C to +70°C @ 2.5%°C/W
Storage: -40°C to +85°C
Cooling: Horizontal airflow front to back with built in fan

Humidity

Operating relative humidity: 30 to 95 % non-condensing
Storage: 10 to 95 % non condensing

Altitude – Pressure Drop

Operating (up to 2250m):   700 – 1100mbar
Non-operating: 300 – 1100mbar

Vibration/Shock

Shock & Vibration: NEBS GR-63-CORE Level 3
Frequency Range: 20 – 2000Hz
Time duration: Minimum of 30 minutes
Acceleration: 6Grms

Telcordia GR-63-CORE, GR-487-CORE (NEBS shock and vibration, Seismic Zone 4)
Designed and tested to meet NEBS specifications.

MTBF

100,000 hrs at full load and 50°C per Bell core RPP
200,000 hrs at full load and 50°C – demonstrated

12.   PART NUMBER SELECTION

PRODUCT	DESCRIPTION	PART NUMBER
2500W Front-End	+48Vout Front-End	CAR2548FP-1A
2500W Front-End	+12Vout Front-End	CAR2512FP-1A
2500W Rectifier	-48Vout Rectifier with Face Plate	CAR2548TNB-1A
10 KW Rack	Rack for CAR2548TN – Holds 4 Units	ACE254RUW-1A