

## CAR1248TN series rectifier

Input: 90Vac to 264Vac; Output: -54Vdc @ 1200W



### Applications

- -48Vdc distributed power architectures
- Cellular Base Stations
- Blade Servers
- Network Equipment
- Network Attached Storage
- Telecom Access Nodes
- Routers/Switches
- Broadband Switches
- ATE Equipment

### Description

The CAR1248TN series of rectifiers provide highly efficient isolated -54Vdc power from worldwide input mains in a compact density of 19W/in<sup>3</sup> within a 1U industry standard form factor.

The high-density, front-to-back airflow is designed for minimal space utilization and is highly expandable for future growth. I<sup>2</sup>C communications offers remote control and monitoring capabilities.

### Features

- Universal input with PFC
- Constant power characteristic
- 3 front panel LEDs: 1-input;2-output; 3 - fault
- Remote ON/OFF control of the -54Vdc output
- Remote sense on the -54Vdc output
- No minimum load requirements
- Redundant parallel operation
- Active load sharing (single wire)
- Hot Plug-ability
- Efficiency: typically 91% @ 50% load
- Auto recoverable OC & OT protection
- Operating temperature: 0 - 70°C (de-rated above 50°C)
- Digital status & control: I<sup>2</sup>C serial bus
- EN/IEC/UL60950-1 2<sup>nd</sup> edition; UL, CSA and VDE
- EMI: class A FCC docket 20780 part 15, EN55022
- Meets EN6100 immunity and transient standards
- Shock & vibration: NEBS GR-63-CORE, level 3

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## 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	Device	Symbol	Min	Max	Unit
Input Voltage: Continuous	All	$V_{IN}$	0	264	$V_{ac}$
Operating Ambient Temperature		$T_A$	-10	70 <sup>1</sup>	°C
Storage Temperature		$T_{stg}$	-40	85	°C
I/O Isolation voltage to Frame (100% factory Hi-Pot tested)				1500	$V_{ac}$

## Electrical Specifications

Unless otherwise indicated, specifications apply over all operating input voltage, load, and temperature conditions.

INPUT						
Parameter	Device	Symbol	Min	Typ	Max	Unit
Operational Range	All	$V_{IN}$	90	110/230	264	$V_{ac}$
Frequency Range		$F_{IN}$	47	50/60	63	Hz
Main Output Turn_OFF		$V_{IN}$	70		80	$V_{ac}$
Maximum Input Current ( $V_O = V_{O, set}$ , $I_O = I_{O, max}$ )		$I_{IN}$			7.9 12.75	$A_{ac}$
Cold Start Inrush Current (Excluding x-caps, 25°C, <10ms, per ETSI 300-132)		$I_{IN}$			40	$A_{peak}$
Efficiency ( $T_{amb} = 25^\circ C$ , $V_{out} = -54V_{dc}$ , $I_O = I_{O, max}$ )		$\eta$			90 85	%
Power Factor ( $V_{in} = 230V_{ac}$ , $I_O = I_{O, max}$ )		PF		0.99		
Holdup time ( $V_{out} = -54V_{dc}$ , $T_{amb} = 25^\circ C$ , $I_O = I_{O, max}$ )		T			16.7 20	ms
Early warning prior to loss of DC output below regulation					2	ms
Ride through		T			8.3	ms
Leakage Current ( $V_{in} = 250V_{ac}$ , $F_{in} = 60Hz$ )		$I_{IN}$			3	$mA_{rms}$
Isolation				3000		$V_{ac}$
				1500		$V_{ac}$
				500		$V_{dc}$

-54V <sub>dc</sub> MAIN OUTPUT							
Parameter	Device	Symbol	Min	Typ	Max	Unit	
Output Power	All	W	0	-	1200	W	
High Line Operation			0	-	1000	W	
Low Line Operation							
Set point		$V_{out}$		-53.9	-54.00	-54.1	$V_{dc}$
Overall regulation (load, temperature, aging)				-3		+3	%
Ripple and noise <sup>2</sup>						540	$mV_{p-p}$
						32	dBrnc
Turn-ON overshoot						+3	%

<sup>1</sup> Derated above 50°C at 2.5%/°C

<sup>2</sup> Measured across a 10 $\mu$ f electrolytic and a 0.1 $\mu$ f ceramic capacitors in parallel. 20MHz bandwidth

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-54V <sub>dc</sub> MAIN OUTPUT (continued)							
Parameter	Device	Symbol	Min	Typ	Max	Unit	
Turn-ON delay	All	T			2	sec	
Remote ON/OFF delay time					40	ms	
Turn-ON rise time (10 – 90% of V <sub>out</sub> )					50	ms	
Transient response 50% step [10%-60%, 50% - 100%] (di/dt – 1A/μs, recovery 300μs)			V <sub>out</sub>	-5		+5	%V <sub>out</sub>
Programmable range (hardware & software)				-42		-58	V <sub>dc</sub>
Overvoltage protection, latched (reset by cycling OFF/ON via hardware or software)			I <sub>out</sub>	-58	-59	-60	V <sub>dc</sub>
Output current V <sub>in</sub> – high line V <sub>in</sub> – low line				0		22.2 18.5	A <sub>dc</sub>
Power/Current limit V <sub>in</sub> – high line V <sub>in</sub> – low line			P <sub>out</sub>			1200 1000	W
Power limit down to -48Vdc							
Current limit below -48Vdc, Hiccup (programmable level)			I <sub>out</sub>	113		130	% of FL
Active current share			I <sub>out</sub>	-10		+10	% of FL

Environmental, Reliability					
Parameter	Min	Typ	Max	Units	Notes
Ambient Temperature					
Operating	-10 <sup>3</sup>		50	°C	Air inlet from sea level to 5,000 feet. 7400 ft 51°C to 70°C
Altitude Operating			2250	m	
Power Derating			2.5	%/°C	
Storage	-40		85	°C	30,000 ft
Altitude non-operating			8200	m	
Over Temperature Protection		120 / 110		°C	Shutdown / Restart
Humidity					
Operating	30		95	%	Relative humidity, non-condensing
Storage	10		95	%	
Shock and Vibration acceleration			6	Grms	NEBS GR-63-CORE, Level 3, 20 -2000Hz, minimum 30 minutes
Earthquake Rating	4			Zone	NEBS GR-63-CORE, all floors, Seismic Zone 4 Designed and tested to meet NEBS specifications.
MTBF		100,000 200,000		Hrs	Full load, 50°C ambient, per Bellcore RPP Demonstrated

<sup>3</sup> The unit will start up at -40°C but is not guaranteed to meet specification limits until it is within the operating ambient range.

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EMC				
Parameter	Criteria	Standard	Level	Test
AC input	Conducted emissions	EN55022, FCC Docket 20780 part 15, subpart J	A	0.15 – 30MHz
	Radiated emissions**	EN55022	A	30 – 10000MHz
	Voltage dips	EN61000-4-11	A	-30%, 10ms
			B	-60%, 100ms
			B	-100%, 5sec
	Voltage surge	EN61000-4-5	A	4kV, 1.2/50μs, common mode
A			2kV, 1.2/50μs, differential mode	
immunity	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

\*\* Radiated emissions compliance is contingent upon the final system configuration.

## Status and Control

### Signal Definitions

All signals and outputs are referenced to Output return. These include 'Vstb return' and 'Signal return'.

### Input Signals

**Voltage programming ( $V_{prog}$ ):** An analog voltage on this signal can vary the output voltage from -42Vdc to -58Vdc. The equation of this signal is:

$$V_{out} = 20 \times (V_{prog} - 2.1) < V_{prog} < 2.9$$

If  $V_{prog}$  is  $\geq 4V$ , or left open the programming signal is ignored and the unit output is set at the setpoint of -54Vdc.

**Load share (Ishare):** Single wire analog signal between power supplies connected in parallel. The Ishare pins should be tied together for power supplies. No resistors or capacitors should get connected to this pin.

**Remote ON/OFF:** Controls the presence of the main -54Vdc output voltage. This is an open collector, TTL level control signal. This signal needs to be pulled HI externally through a resistor. Maximum collector voltage is 12Vdc, maximum sink current is 1mA. Logic 1 turns ON the -54Vdc output, while a Logic 0 turns OFF the -54Vdc output.

A turn OFF command either through this signal or firmware commanded would turn OFF the -54V output.

**Enable:** This is a short signal pin that controls the presence of the -54Vdc 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.

**Write protect (WP):** This signal protects the contents of the external EEPROM. When left open the EEPROM is write

protected. A LO permits writing to the EEPROM. This signal is pulled HI internally by the power supply.

### Output signals

**Output current monitor (Imon):** A voltage level proportional to the output current is present on this pin. The signal level is 0. 2V per amp  $\pm 0.25V$ .

**AC OK:** TTL compatible open collector. Maximum sink current 20mA, max voltage is 12Vdc. A (HI) on this signal indicates that the input voltage is present within limits.

**DC OK:** TTL compatible, open collector. Maximum sink current 20mA, max voltage is 12Vdc. A (HI) on this signal indicates that the output voltage is present.

**Over temp warning:** TTL compatible, open collector. Maximum sink current 20mA, max voltage is 12Vdc. A (HI) on this signal indicates that temperatures are normal.

If an over temperature should occur, this signal would delay pulling LO for approximately 10 seconds. The unit would restart if internal temperatures recover within normal operational levels.

**Fault:** TTL compatible, open collector. Maximum sink current 20mA, max voltage is 12Vdc. A (HI) on this signal indicates that no faults are present.

This signal activates for OTP, OVP, or AC fault.

**PS Present:** Connected to 'output return'. Its intent is to indicate to the system that a power supply is present. This signal may need to be pulled HI externally through a resistor.

**Interrupt:** A TTL compatible status signal, representing the SMBusAlert# feature of the i<sup>2</sup>C protocol in the power supply. This signal needs to be pulled HI externally through a resistor. Maximum sink current  $\leq 4mA$  and the pull up resistor should be tied to  $<5Vdc$ . Open collector (HI) on this signal indicates that no Interrupt has been triggered.

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## Serial Bus Communications – CAR1248TN

The I<sup>2</sup>C interface facilitates the monitoring and control of various operating parameters within the unit and transmits these on demand over an industry standard I<sup>2</sup>C Serial bus.

All signals are referenced to ‘Signal Return’.

**Device addressing:** The microcontroller (MCU) and the EEPROM have the following addresses:

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

**Address lines (A2, A1, A0):** Up to eight (8) modules to be addressed on a single I<sup>2</sup>C bus. The pins are pulled HI internal to the power supply. For a logic LO connect to ‘Output Return’

**Serial Clock (SCL):** Host generated, this signal needs to be pulled up externally ensuring that rise and fall time timing and the maximum sink current is in compliance to the I<sup>2</sup>C specification.

**Serial Data (SDA):** This is a bi-directional line that needs to be pulled up externally ensuring that rise and fall time timing and the maximum sink current is in compliance to the I<sup>2</sup>C specification.

### Command code:

All registers are 16 bits, written as LSB followed by MSB. All A/D’s are 10 bit (1024 steps). All constants can be fine-tuned to compensate for manufacturing tolerances;

Name	CMD	Access	Default /Name	Bits	Constant
Vout	00	R	-54		0.102
Iout	01	R	-		0.042
Temperature	02	R	-		0.005
ON/OFF	03	R/W	1 – OFF, 0 – ON		
Ilimit	04	R/W	25		0.042
Vset	05	R/W	-54		0.094
Vprog	06	R	Vout= 20 x Vprog		
OT trip	07	R/W	120		0.005
OT recover	08	R/W	110		0.005
DC_OK_HI	09	R/W	55.6		0.102
DC_OK_LO	0A	R/W	52.4		0.102
STATUS	0B	R	Input	0	1-normal
			AC_OK	1	
			DC_OK	2	
			OT	3	
			Fault	4	
			Intrpt	5	
			OV	6	
DC_INT	7				
Firmware	0C	R			
EEPROM	0D-7C	R/W			

**Vout [00]:** Output voltage read back, returns the voltage on the anode side of the or’ing function, data LSB followed by MSB.

The default value is -54Vdc

Example; readback 0211h, convert into its decimal equivalent and then multiply by the constant,  
Vout = 529 x 0.102 = 54Vdc

**Iout [01]:** Output current read back, data LSB followed by MSB.

Example; readback 021Fh, convert into its decimal equivalent and multiply by the constant, Iout=543 x 0.042 = 22.8A

**Temperature [02]:** Temperature read back, data LSB followed by MSB.

Example; readback 037Bh, convert into its decimal equivalent and multiply by the constant, temp = 891 x 0.005 = 4.36. In the table below this corresponds to 25°C

Data	Temp °C	Data	Temp °C	Data	Temp °C
4.83	-5	3.71	45	1.7	95
4.78	0	3.51	50	1.54	100
4.72	5	3.3	55	1.4	105
4.65	10	3.09	60	1.26	110
4.56	15	2.88	65	1.14	115
4.46	20	2.67	70	1.03	120
4.35	25	2.46	75	0.93	125
4.21	30	2.25	80	0.84	130
4.06	35	2.06	85		
3.89	40	1.88	90		

**ON/OFF [03]:** A logic ‘1’ turns OFF the -54V output of the power supply.

**Ilimit [04]:** This feature lowers the current limit from the default values of 0253h (595), corresponding to 25A at high line and 01EFh (495) corresponding to 20.8A at low line.

The delivered output current cannot exceed the maximum power capacity of the unit. At high line the power supply is limited to 1200W, thus, at -48Vdc the output current is limited to 25A.

Example: At high line, reduce the current limit to 20A.

Compute the data to be sent to the controller;  
20 / 0.042 = 476. The hex equivalent of this decimal data is 01DCh. The data should be sent across the bus as LSB [DC] followed by MSB [01].

**Vset [05]:** Changes the output voltage via i2c, if the Vprog hardware signal is > 4Vdc. If the Vprog pin voltage level is < 4Vdc, this command is ignored.

The output voltage setting must be between -42 – -58Vdc.

The default value is 023Eh, corresponding to -54Vdc.

Example; set the output to 48Vdc. Compute the data to be sent to the controller; 48 / 0.094 = 510. The hex equivalent of this decimal data is 01FEh. The data should be sent across the bus as LSB [FE] followed by MSB [01].

**Vprog [06]:** Reads back the hardware configured analog voltage program value via i2c.

The value of Vprog can range from 2.1V to 2.8V.

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Example: set the output to 44Vdc. From the equation determine that  $V_{prog} = 2.2$ . The 10bit D/A is set for the range of 0 – 5Vdc, therefore with a resolution of 1024 bits each bit is 0.00488V. So the corresponding value to enter is  $2.2/0.00488 = 451$  decimal. This corresponds to 01C3h. The data should be sent across the bus as LSB [C3] followed by MSB [01].

**OT trip[07] and OT recover[08];** Configures the OT shutdown and recovery levels. The default values are;

OT trip: 120°C corresponds to 1.03/0.005 = D3h

OT recover: 110°C that corresponds to 1.26/0.00488 = 0102h

Example: Change the recovery temperature to 100°C. In the look up table above the corresponding level is 1.54. Divide by the conversion ration,  $1.54/0.00488 = 315$  dec. Converting to its hex equivalent yields 013B hex. The data should be sent across the bus as LSB [3B] followed by MSB [01].

**DC\_OK\_HI[09] and DC\_OK\_LO[0A];** Changes the DC\_OK signal comparator level. The default values are;

DC\_OK\_HI: 0221h, corresponding to 55.6V

DC\_OK\_LO: 0201h, corresponding to 52.4V

Example: Change the upper level of comparison to 55V. Determine the corresponding register value setting;  $55/0.102 = 539$ dec. This is equivalent to 021Bh. The data should be sent across the bus as LSB [1B] followed by MSB [02].

**STATUS [0B];** All read backs are two bytes and so read back two bytes but ignore the MSB.

**Firmware [0C];** Reads back the latest firmware revision.

**MCUeeprom [0D – 7C];** 125 bytes of information may be stored in the EEPROM section of the micro controller starting

from register location 0Dh. Each byte of data needs to be stored into its specific register location, one byte at a time.

## External EEPROM

A separate EEPROM, with its own i2c address and with write\_protect capability, provides 128 bytes of memory. This is a standard i2c compliant generic EEPROM with a single byte for its memory location. Standard i2c command structure applies.

The following FRU\_ID information is stored in this EEPROM

Start Location	Length	Value	Description
00h	7		Serial number, ascii
07h	1	20h	space
08h	4		Date code [YYWW] ascii
0Ch	1	20h	space
0Dh	17		Code <b>CAR1248TNBXX201A</b> ascii
1Eh	1	20h	space
1Fh	1		Revision

## LEDs

Three LEDs are located on the front faceplate. The AC\_OK LED provides visual indication of the INPUT signal function. When the LED is ON GREEN the power supply input is within normal design limits.

When the DC\_OK LED is GREEN the DC output is present.

When the FAULT\_LED is RED then a fault condition exists and the power supply may not provide output power. The table below further defines these states:

## Alarm Table

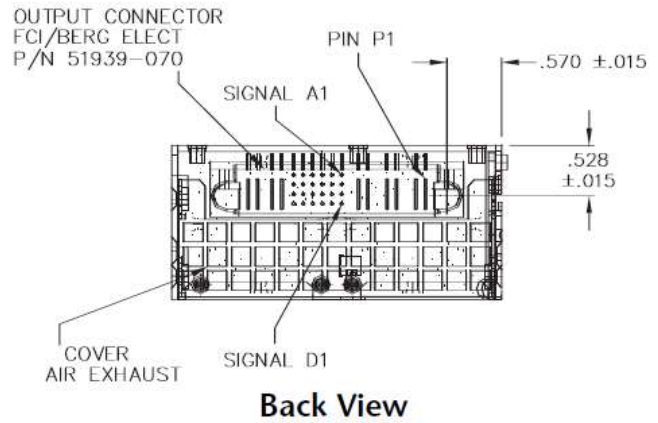
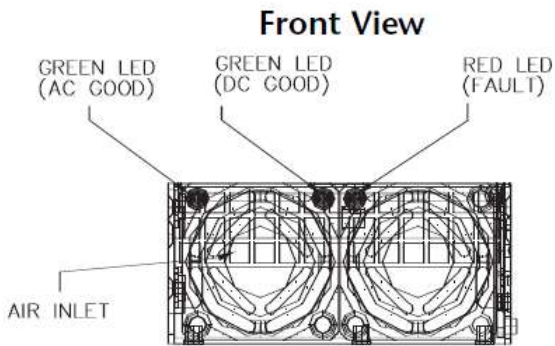
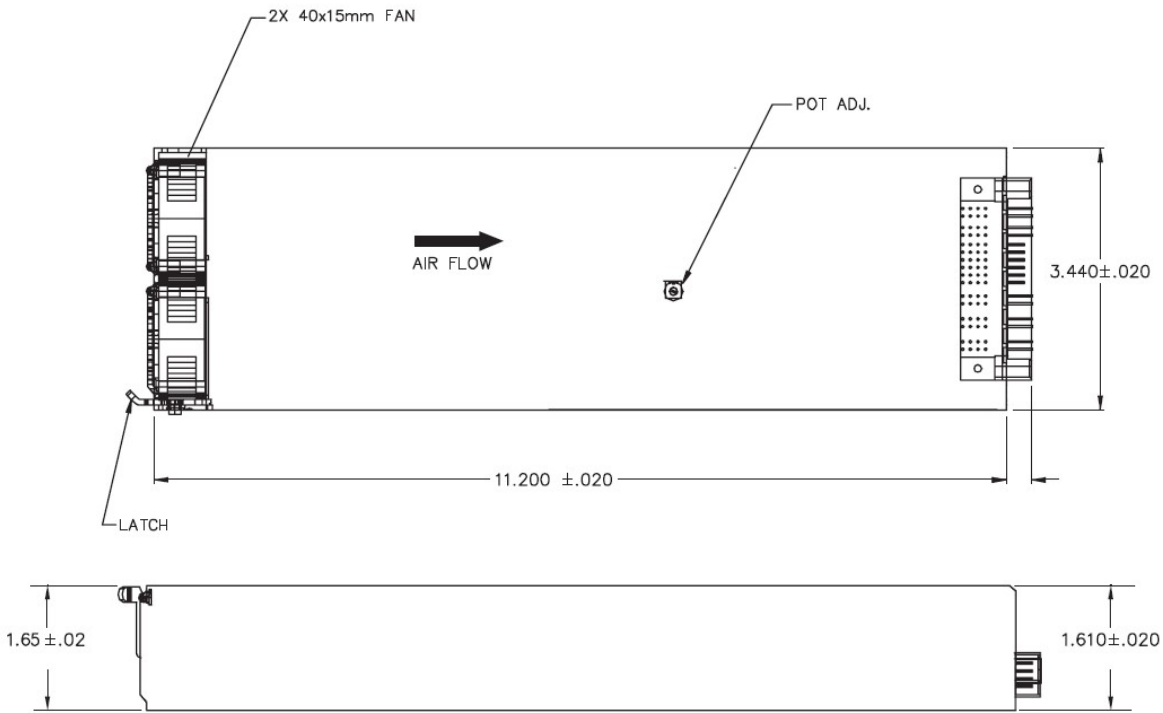
Test Condition	LED Indicator			Monitoring Signals			
	AC OK	DC OK	FAULT	FAULT	DC OK	AC OK	TEMP OK
1 Normal Operation	Green	Green	OFF	High	High	High	High
2 Low or NO INPUT	OFF	OFF	OFF	High	Low	Low	High
3 OVP	Green	OFF	Red	Low	Low	High	High
4 Over Current	Green	OFF	Red	High	Low	High	High
5 Over Temp Fault	Green	OFF	Red	Low	Low	High	Low

Note: Test condition #2 has 2 modules working in parallel. One module is running and the other has no AC.

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## Outline Drawing



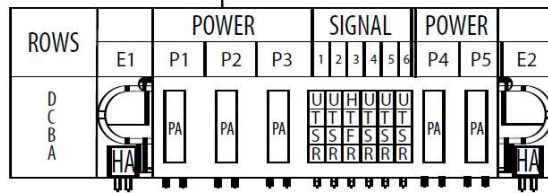
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Connector

FCI Berg P/N: 51939-070

Mating connector: FCI Berg P/N: 51915-050



Pin	Function	Pin	Function	Pin	Function	Pin	Function
A1	n/c	B1	Fault	C1	ISHARE	D1	VProg
A2	n/c	B2	I Monitor (IMON)	C2	N/C	D2	OVP Test Point
A3	Signal Return	B3	Enable: "0" -ON "1" -OFF	C3	Over Temp Warning	D3	Remote ON/OFF
A4	Write Protect (WP)	B4	PS Present	C4	I <sup>2</sup> C Address (A0)	D4	DC OK
A5	Remote Sense (+)	B5	SDA (I <sup>2</sup> C bus)	C5	I <sup>2</sup> C Address (A1)	D5	AC OK
A6	Remote Sense (-)	B6	SCL (I <sup>2</sup> C bus)	C6	I <sup>2</sup> C Address (A2)	D6	Interrupt
P1	Line	P2	Neutral	P3	Chassis		
P4	+Vout	P5	Output Return				



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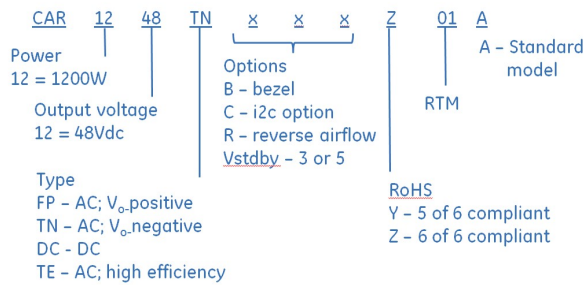
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## Ordering Information

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

PRODUCT	DESCRIPTION	PART NUMBER
1200W Front-End	-54Vout Front-End, i2c communications	CAR1248TNXXXZ01A
1200W Front-End	-54Vout Front-End, w/bezel, i2c communications	CAR1248TNBXXZ01A

### PART NUMBER DEFINITION GUIDE EXAMPLE



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