VERTIV™

Rectifier Module

User Manual (UM1R123000), Revision K

Specification Number: 1R123000, 1R123300
Model Number: R12-3000, R12-3300

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ADMONISHMENTS USED IN THIS DOCUMENT

DANGER! Warns of a hazard the reader ***will*** be exposed to that will ***likely*** result in death or serious injury if not avoided. (ANSI, OSHA)

WARNING! Warns of a potential hazard the reader ***may*** be exposed to that ***could*** result in death or serious injury if not avoided. This admonition is not used for situations that pose a risk only to equipment, software, data, or service. (ANSI)

CAUTION! Warns of a potential hazard the reader ***may*** be exposed to that ***could*** result in minor or moderate injury if not avoided. (ANSI, OSHA) This admonition is not used for situations that pose a risk only to equipment, data, or service, even if such use appears to be permitted in some of the applicable standards. (OSHA)

ALERT! Alerts the reader to an action that ***must be avoided*** in order to protect equipment, software, data, or service. (ISO)

ALERT! Alerts the reader to an action that ***must be performed*** in order to prevent equipment damage, software corruption, data loss, or service interruption. (ISO)

FIRE SAFETY! Informs the reader of fire safety information, reminders, precautions, or policies, or of the locations of fire-fighting and fire-safety equipment. (ISO)

SAFETY! Informs the reader of general safety information, reminders, precautions, or policies not related to a particular source of hazard or to fire safety. (ISO, ANSI, OSHA)

IMPORTANT SAFETY INSTRUCTIONS

General Safety

DANGER! YOU MUST FOLLOW APPROVED SAFETY PROCEDURES.
Performing the following procedures may expose you to hazards. These procedures should be performed by qualified technicians familiar with the hazards associated with this type of equipment. These hazards may include shock, energy, and/or burns. To avoid these hazards:

a) The tasks should be performed in the order indicated.

b) Remove watches, rings, and other metal objects.

c) Prior to contacting any uninsulated surface or termination, use a voltmeter to verify that no voltage or the expected voltage is present. Check for voltage with both AC and DC voltmeters prior to making contact.

d) Wear eye protection.

e) Use certified and well maintained insulated tools. Use double insulated tools appropriately rated for the work to be performed.

Voltages

AC Input Voltages

DANGER! This system operates from AC input voltage capable of producing fatal electrical shock.

DC Output and Battery Voltages

DANGER! This system produces DC power and may have a battery source connected to it. Although the DC voltage is not hazardously high, the rectifiers and/or battery can deliver large amounts of current. Exercise extreme caution not to inadvertently contact or have any tool inadvertently contact an output terminal or battery terminal or exposed wire connected to an output terminal or battery terminal. NEVER allow a metal object, such as a tool, to contact more than one termination or battery terminal at a time, or to simultaneously contact a termination or battery terminal and a grounded object. Even a momentary short circuit can cause sparking, explosion, and injury.

Hazardous Voltage

DANGER! HAZARD OF ELECTRICAL SHOCK.
More than one disconnect may be required to de-energize the system before servicing.

Handling Equipment Containing Static Sensitive Components

ALERT! Installation or removal of equipment containing static sensitive components requires careful handling. Before handling any equipment containing static sensitive components, read and follow the instructions contained on the Static Warning Page.

STATIC WARNING

This equipment contains static sensitive components. The warnings listed below must be observed to prevent damage to these components. Disregarding any of these warnings may result in personal injury or damage to the equipment.

1. Strictly adhere to the procedures provided in this document.
2. Before touching any equipment containing static sensitive components, discharge all static electricity from yourself by wearing a wrist strap grounded through a one megohm resistor. Some wrist straps have a built-in one megohm resistor; no external resistor is necessary. Read and follow wrist strap manufacturer's instructions outlining use of a specific wrist strap.
3. Do not touch traces or components on equipment containing static sensitive components. Handle equipment containing static sensitive components only by the edges that do not have connector pads.
4. After removing equipment containing static sensitive components, place the equipment only on static dissipative surfaces such as conductive foam or ESD bag. Do not use ordinary Styrofoam™ or ordinary plastic.
5. Store and ship equipment containing static sensitive components only in static shielding containers.
6. If necessary to repair equipment containing static sensitive components, wear an appropriately grounded wrist strap, work on a conductive surface, use a grounded soldering iron, and use grounded test equipment.

INTRODUCTION

Overview

The rectifier provides load power during normal operating conditions. The rectifier is rated at its maximum output power. This means that, within the normal operating ambient temperature range and input voltage range, the maximum available output power is a constant 3000 W or 3300 W (depending on model). Within these ranges, the rectifier operates in one of three modes, depending upon load demands. Transition between modes is completely automatic. If ambient temperature rises above or input voltage falls below acceptable values, the rectifier continues to operate but at derated output power levels.

- Constant Voltage Mode: For any initial output voltage setting from 12.0 VDC to 13.2 VDC, output voltage remains constant regardless of load. This is the normal operating condition, in which loads are supplied. The rectifier operates in the constant voltage mode unless load increases to the point where the product of load current and output voltage is approximately 3000 W or 3300 W (depending on model).
- Constant Power Mode: As load increases above approximately 3000 W or 3300 W (depending on model) (non-adjustable), output current continues to increase, but output voltage decreases as required to maintain constant output power. The rectifier operates in the constant power mode unless load continues to increase to the point where the current limit setting is reached.
- Constant Current Mode: If load increases to the current limit setting, output voltage decreases linearly to maintain output current at the current limit setting.

Specifications

DC Output Ratings

NOTE! *The current limit and output voltage level can be set by the User through the controller.*

- Voltage: Nominal +12 VDC, negative ground. Output voltage is adjustable from +12.0 VDC to +13.2 VDC via the associated controller. Factory default voltage is set to +12.3 VDC.
- Output Power and Current:
  a) R12-3000: 3000 W (250 A) @ 208 VAC / 220 VAC / 230 VAC / 277 VAC input and +12 VDC output.
  b) R12-3300: 3300 W (275 A) @ 208 VAC / 220 VAC / 230 VAC / 277 VAC input and +12 VDC output.
- Output Characteristics: Refer to **Figure 1** or **Figure 2** for a graph of output voltage vs. output current.

Figure 1: *Output Voltage vs. Output Current (R12-3000)*

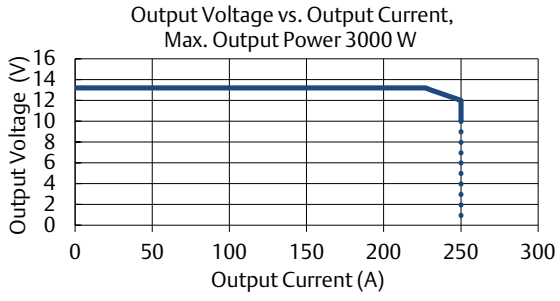
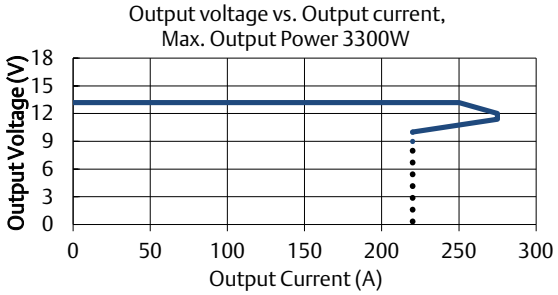
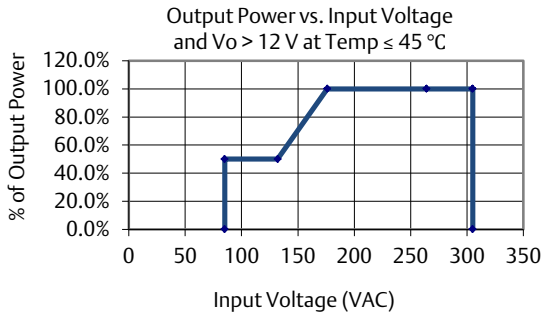


Figure 2: *Output Voltage vs. Output Current (R12-3300)*



- Power Derating Based on Input Voltage: The rectifier power varies with changes in input voltage and output voltage. It uses an advanced power limitation method. The lower input threshold is 85 VAC. The rectifier can provide its maximum rated power (3000 W or 3300 W, depending on model) as long as the input voltage is within the range of 176 VAC to 305 VAC. Below 176 VAC, and down to 85 VAC, the rectifier will continue to operate normally but will be in a power derating mode. The relationship between the output power and input voltage is illustrated in **Figure 3**.

Figure 3: *Power Derating Based on Input Voltage*



- Power Derating Based on Temperature: The rectifier delivers full power when operating at an ambient temperature of +45 °C (+113 °F) or below. Each rectifier continuously monitors the ambient temperature surrounding the power conversion circuit. If this temperature for any reason (such as a high ambient temperature) increases above approximately +45 °C (+113 °F), the rectifier will not shut down. Rather, the rectifier limits its maximum output power to maintain the temperature of the power conversion circuit within design parameters. Operation between +45 °C (+113 °C) and +75 °C (+167 °F) will result in output power being decreased. Full power capability is restored when the temperature decreases to below approximately +45 °C (+113 °F). Refer to **Figure 4** to view the relationship between the output power and the ambient temperature.

  Other power rating values are as follows (refer to **Figure 4**):

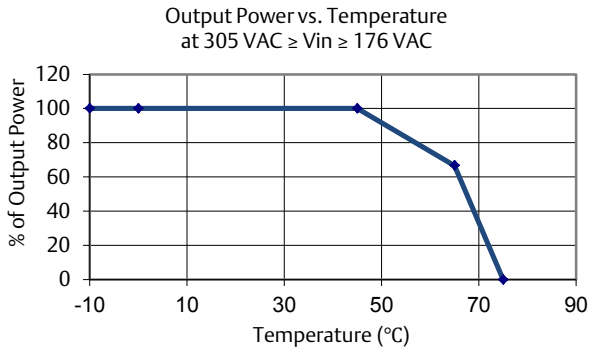
  a) At an ambient temperature of +55 °C (+131 °F), the power delivered by the rectifier is 2500 W.

  b) At an ambient temperature of +65 °C (+149 °F), the power delivered by the rectifier is 2000 W.

WARNING! The rectifier is rated for continuous operation at full output power up to +45 °C (+113 °F). Operation between +45 °C (+113 °F) and +75 °C (+167 °F) will result in output power decrease. Operation above +75 °C (+167 °F) is considered abnormal and should be used on a temporary[1] basis only.

[1] Temporary Operation at Abnormal Temperature: Temporary operation is defined as a period of not more than eight consecutive hours per day, and a total of not more than 15 days in a year. (This refers to a total of 120 hours in any given year, but no more than 15 occurrences in that one-year period.)

Figure 4: *Power Derating Based on Temperature*



NOTE! *3000 W or 3300 W (depending on model) @ +45 °C (+113 °F) and 176 VAC < Vin < 305 VAC.*

- Regulation:

  a) Static: Steady state regulation is ±1% as controlled within the rectifier for any and all combinations of load from no load to full load, input voltage, and input frequency at a constant ambient temperature. The associated system controller may provide improved regulation.

  b) Dynamic Load: Response time ≤1000 us and overshot ≤ 5% for load changes at 50% - 25% - 50% and 50% - 75% - 50% at rated output voltage and current

  For any step load change within the range of 10% to 90% of full load within 1000 microseconds, per Telcordia GR-947-CORE, the maximum voltage transient will not exceed 5% of the initial steady state voltage within 250±10 microseconds. Recovery to within ±1% of the initial steady state voltage does not exceed 4 milliseconds.

- Filtering:

  a) Voice Band Noise: Peak-peak voltage is ≤120 mV at 0 MHZ to 20 MHZ and normal output voltage.

AC Input Ratings

- Voltage: Nominal 208 VAC / 220 VAC / 230 VAC / 277 VAC, single phase, 3-wire, 50 Hz / 60 Hz, with an operating range of 200 VAC to 277 VAC. Acceptable input frequency range is 45 Hz to 65 Hz.

  Permitted Variation: 85 VAC to 305 VAC.

- Harmonic Content (ITHD): Meets EN61000-3-2.

  ≤5% from 50% to 100% of rated output current at (208 VAC, 220 VAC, 230 VAC, and 277 VAC), 50 Hz, 12 VDC, and 25 °C.

- Inrush Current: Peak does not exceed 1.5 times of the peak value of the maximum steady-state input current at full load.

- Typical Input Data: 50 Hz Input

  a) Refer to **Table 1** or **Table 3**.

  b) Maximum Input Current: Refer to **Table 2** or **Table 4**.

- Typical Input Data: 60 Hz Input

  a) Refer to **Table 5** or **Table 7**.

  b) Maximum Input Current: Refer to **Table 6** or **Table 8**.

Table 1: *Typical Input Data, 50Hz Input (R12-3000)*

Nominal Input Voltage	Percent of Full Load	Input Current (Amperes)	Input VA	Input Watts	Power Factor	Efficiency %	Heat Dissipation BTU/Hr
208	0	0.43	88.7	31.3	+0.3552	--	106.79
	25	3.23	669.3	649.2	+0.9699	92.30	170.58
	50	7.73	1597.0	1581.7	+0.9904	94.49	297.58
	75	10.83	2231.5	2218.5	+0.9942	94.24	436.26
	100	13.99	2876.6	2863.6	+0.9950	93.72	613.28
	110	15.55	3207.5	3190.3	+0.9955	93.43	715.50
240	0	0.48	114.5	32.5	+0.2841	--	110.88
	25	2.83	680.9	647.5	+0.9511	92.42	167.39
	50	6.68	1601.5	1578.5	+0.9857	94.67	287.10
	75	9.33	2233.5	2213.2	+0.9909	94.52	413.68
	100	12.02	2872.9	2854.8	+0.9936	94.10	575.13
	110	13.39	3197.3	3179.2	+0.9944	93.79	673.13
277	0	0.50	138.5	34.07	+0.246	--	118.26
	25	2.76	764.50	730.10	+0.955	93.30	166.77
	50	5.3	1468.2	1435.90	+0.978	95.00	244.60
	75	7.84	2170.88	2147.00	+0.989	95.18	352.63
	100	10.43	2890.12	2867.00	+0.992	94.89	500.05
	110	11.48	3180.08	3161.00	+0.994	94.62	579.45

NOTE! *System output is initially adjusted to 12 volts DC as measured at the system sense points at 50% of full load and nominal input. "Percent of Full Load" refers to percent of 227.3 amperes.*

Table 2: *Maximum Input Current, 50Hz Input (R12-3000)*

Nominal Input Voltage	Input Voltage	Input Current (Amperes)
208/240/277	176	18.54

NOTE! *At 100% of full load with output adjusted to 13.2 volts DC as measured at the module mounting assembly output terminals.*

Table 3: *Typical Input Data, 50Hz Input (R12-3300)*

Nominal Input Voltage	Percent of Full Load	Input Current (Amperes)	Input VA	Input Watts	Power Factor	Efficiency %	Heat Dissipation BTU/Hr
208	0	0.40	83.2	36.7	+0.4405	--	125.15
	25	4.31	895.6	886.2	+0.9895	93.32	202.16
	50	8.44	1754.6	1747.5	+0.9960	94.40	334.10
	75	12.62	2635.0	2630.3	+0.9982	94.09	530.32
	100	17.02	3535.9	3532.9	+0.9991	93.20	819.75
	110	17.34	3597.3	3594.3	+0.9992	93.10	846.74
240	0	0.45	107.8	35.5	+0.3289	--	121.03
	25	3.75	899.7	884.2	+0.9828	93.59	193.41
	50	7.32	1755.5	1743.7	+0.9933	94.79	309.99
	75	11.02	2632.3	2623.0	+0.9965	94.39	502.19
	100	14.69	3525.9	3518.9	+0.9980	93.59	769.88
	110	14.81	3553.5	3545.9	+0.9979	93.44	794.04
277	0	0.50	138.3	29.9	+0.2162	--	102.02
	25	3.27	906.1	882.2	+0.9736	93.80	186.81
	50	6.37	1763.3	1740.2	+0.9869	94.83	307.12
	75	9.52	2636.0	2616.3	+0.9925	94.44	496.54
	100	12.73	3521.6	3506.4	+0.9957	93.69	755.51
	110	13.03	3603.2	3588.5	+0.9959	93.56	789.01

NOTE! *System output is initially adjusted to 12 volts DC as measured at the system sense points at 50% of full load and nominal input. "Percent of Full Load" refers to percent of 275 amperes.*

Table 4: *Maximum Input Current, 50Hz Input (R12-3300)*

Nominal Input Voltage	Input Voltage	Input Current (Amperes)
208/240/277	176	20.22

NOTE! *At 100% of full load with output adjusted to 13.2 volts DC as measured at the module mounting assembly output terminals.*

Table 5: *Typical Input Data, 60Hz Input (R12-3000)*

Nominal Input Voltage	Percent of Full Load	Input Current (Amperes)	Input VA	Input Watts	Power Factor	Efficiency %	Heat Dissipation BTU/Hr
208	0	0.50	103.5	31.4	+0.3046	--	107.13
	25	3.26	678.8	648.1	+0.9549	92.18	172.99
	50	7.73	1602.9	1581.3	+0.9865	94.46	298.70
	75	10.80	2235.8	2218.1	+0.9921	94.27	433.45
	100	13.93	2879.9	2862.5	+0.9940	93.79	606.56
	110	15.53	3207.2	3189.4	+0.9944	93.47	710.39
240	0	0.56	134.3	31.8	+0.2371	--	108.50
	25	2.86	687.5	647.3	+0.9416	92.35	168.93
	50	6.70	1606.2	1578.2	+0.9826	94.66	287.70
	75	9.35	2237.1	2212.3	+0.9892	94.51	414.66
	100	12.04	2875.4	2854.4	+0.9927	94.08	576.98
	110	13.40	3199.2	3178.9	+0.9936	93.80	672.86
277	0	.50	138.5	38.01	+0.204	--	129.61
	25	2.81	779.53	731.20	+0.938	93.10	172.05
	50	5.34	1478.37	1435.50	+0.971	94.95	247.07
	75	7.88	2181.91	2147.00	+0.984	95.10	358.94
	100	10.46	2898.99	2870.00	+0.990	94.73	515.81
	110	11.52	3190.72	3162.99	+0.991	94.55	587.99

NOTE! *System output is initially adjusted to 12 volts DC as measured at the system sense points at 50% of full load and nominal input. "Percent of Full Load" refers to percent of 227.3 amperes.*

Table 6: *Maximum Input Current, 60Hz Input (R12-3000)*

Nominal Input Voltage	Input Voltage	Input Current (Amperes)
208/240/277	176	18.53

NOTE! *At 100% of full load with output adjusted to 13.2 volts DC as measured at the module mounting assembly output terminals.*

Table 7: *Typical Input Data, 60Hz Input (R12-3300)*

Nominal Input Voltage	Percent of Full Load	Input Current (Amperes)	Input VA	Input Watts	Power Factor	Efficiency %	Heat Dissipation BTU/Hr
208	0	0.48	99.7	36.3	+0.3642	--	123.99
	25	4.33	899.7	886.4	+0.9852	93.35	201.04
	50	8.45	1756.9	1747.2	+0.9945	94.58	322.95
	75	12.70	2636.5	2630.7	+0.9978	94.09	530.26
	100	16.96	3535.8	3531.8	+0.9988	93.23	815.84
	110	17.40	3626.0	3621.8	+0.9989	93.11	851.80
240	0	0.55	132.0	36.1	+0.2738	--	123.30
	25	3.79	908.5	884.3	+0.9734	93.52	195.54
	50	7.32	1759.9	1743.2	+0.9905	94.82	308.27
	75	11.00	2635.1	2622.2	+0.9951	94.39	501.63
	100	14.69	3527.4	3517.8	+0.9973	93.60	768.09
	110	15.06	3613.0	3603.4	+0.9973	93.51	798.10
277	0	0.61	168.4	33.1	+0.1963	--	112.86
	25	3.32	914.0	882.4	+0.9654	93.75	188.32
	50	6.40	1773.9	1740.9	+0.9814	94.87	305.08
	75	9.53	2643.9	2616.5	+0.9896	94.46	494.34
	100	12.75	3528.4	3506.9	+0.9939	93.68	756.24
	110	13.04	3607.2	3586.1	+0.9942	93.61	781.57

NOTE! *System output is initially adjusted to 12 volts DC as measured at the system sense points at 50% of full load and nominal input. "Percent of Full Load" refers to percent of 275 amperes.*

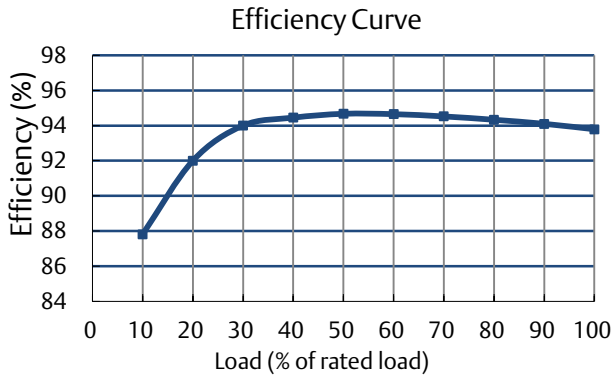
Table 8: *Maximum Input Current, 60Hz Input (R12-3300)*

Nominal Input Voltage	Input Voltage	Input Current (Amperes)
208/240/277	176	20.24

NOTE! *At 100% of full load with output adjusted to 13.2 volts DC as measured at the module mounting assembly output terminals.*

- Typical Efficiency Curve: See **Figure 5**.

Figure 5: *Typical Efficiency Curve (at 240 VAC input, 50 Hz, 25 °C)*



Environmental Ratings

- Operating Ambient Temperature Range:

  a) +45 °C (+113 °F) to +75 °C (+167 °F) with derating output.

  b) -10 °C (14 °F) to +45 °C (+113 °F) with full power performance.

- Temperature Coefficient: 0.02% per degrees Celsius.
- Storage Ambient Temperature Range: -40 °C (-40 °F) to +85 °C (+185 °F).
- Relative Humidity: This rectifier is capable of operating in an ambient relative humidity range of 0% to 95%, non-condensing.
- Altitude: 2000 m (6560 ft) at full power (power limited for heights above 2000 m).
- Surge Protection: Compliance with EN61000-4-5 (4 kV Line to Line, 4 kV Line to Earth). Capable of withstanding surges per ANSI/IEEE C 62.41 1999 Category B3 across the input terminals.

NOTE! *This level of protection is a widely used standard for telecommunications and data center power equipment. As with all such equipment, it is the end user's responsibility to provide an adequately sized surge suppression device at the commercial power service entrance of the building that reduces all incoming surges to levels below the classes/categories stated for the equipment.*

- Ventilation Requirements: The rectifier is fan cooled and utilizes front to back forced ventilation. A rectifier must be mounted so ventilating openings are not blocked and temperature of the air entering the rectifier does not exceed the operating ambient temperature range stated above.
- Single Rectifier Audible Noise: At 25 °C ≤ 60 dB(A) with fan. Measurement made at 0.6 m distance in front of rectifier and at same horizontal line of the middle of rectifier.
- High Voltage Category: II.
- Power Distribution System: TN/TT/IT.

NOTE! *The rectifier is recommended to be used in an environment with Pollution of Degree 2 or less. Pollution Degree 2 applies where there is only non-conductive pollution that might temporarily become conductive due to occasional condensation (such as the office environment).*

- EMI/RFI Suppression: Rectifiers operating in an approved module mounting assembly conform to the requirements of FCC rules Part 15, Subpart A, Class A for radiated and conducted emissions limits.

Compliance Information

- EMC: ETSI EN 300 386, FCC CFR 47 Part 15 class A, Telcordia GR-3160, EN 55022/EN 55024.
- EMI Load Range: 5% to 100%.
- Safety: IEC 60950, EN 60950,UL 60950-1.

WARNING! This is a class A product. In a domestic environment, this product may cause radio interference in which case the User may be required to take adequate measures.

Standard Features

- Type of Power Conversion Circuit: High frequency.
- Constant Voltage Mode: For any initial output voltage setting from 12.0 VDC to 13.2 VDC, output voltage remains constant regardless of load. This is the normal operating condition, in which loads are supplied. The rectifier operates in the constant voltage mode unless load increases to the point where the product of load current and output voltage is approximately 3000 W or 3300 W (depending on model).
- Constant Power Mode: As load increases above approximately 3000 W or 3300 W (depending on model) (non-adjustable), output current continues to increase, but output voltage decreases as required to maintain constant output power. The rectifier operates in the constant power mode unless load continues to increase to the point where the current limit setting is reached.
- Constant Current Mode: If load increases to the current limit setting, output voltage decreases linearly to maintain output current at the current limit setting.
- Input Protection:
  a) Input Over/Under Voltage Protection: The rectifier shuts down at low or high voltage input; based on the following voltage levels:
     1. Low Voltage Disable Point: 80 V, ±5 V; hysteresis is at least 15 VAC for restart.
     2. High Voltage Disable Point: 310 V, ±4 V; hysteresis is at least 10 VAC for restart.

  b) Between 132 V and 176 V the output power will be derated linearly based on the input voltage as follows:
     1. At input voltage of 85 V with output >12 V, max output power is 1500 W.
     2. At input voltage of 132 V with output >12 V, max output power is 1500 W (R12-3000) or 1650 W (R12-3300).
     3. At input voltage of 150 V with output >12 V, max output power is 2114 W (R12-3000).
     4. At input voltage of 176 V and output >12 V, max output power is 3000 W (R12-3000) or 3300 W (R12-3300).

c) AC Input Fuse: 280 V / 25 A.

- Output Protection:

  a) Current Limiting: The rectifier has a current limit function. The current limit point can be set between the range of 0 A to 250 A (R12-3000) or 0 A to 275 A (R12-3300), adjustable via the controller. Refer to "Rectifier Current Limit" on page 20. The current limit accuracy is ±10 A when the output voltage ranges from 12 V to 13.2 V.

  b) High Voltage Shutdown:

     1. Adjustable Control: If rectifier output voltage exceeds an adjustable preset value and the rectifier is delivering more than 10% of its rated current, the rectifier shuts down. (Adjustable from 13 VDC to 13.6 VDC via the controller. The restart hysteresis is 0.5 V ±0.2 V.)

        The rectifier then restarts and a HVSD restart timer starts (time value configurable via the controller, factory default is 5 minutes). If output voltage again exceeds the high voltage shutdown value before the HVSD restart timer expires, the rectifier shuts down and locks out. Manual restart is then required (by turning power to the rectifier off or by removing the rectifier, waiting until the LEDs on the rectifier extinguish, then turning power to the rectifier on or re-inserting the rectifier). If the rectifier does not experience a high voltage condition before the HVSD restart timer expires, the restart circuit is reset.

        If two or more rectifiers are paralleled, only the rectifier causing the high voltage condition shuts down.

     2. Backup: If rectifier output voltage exceeds 14 V ±0.5 V (non-adjustable) and the rectifier is delivering more than 10% of its rated current, the rectifier shuts down. The rectifier then restarts and a HVSD restart timer starts (time value configurable via the controller, factory default is 5 minutes). If output voltage again exceeds the high voltage shutdown value before the HVSD restart timer expires, the rectifier shuts down and locks out. Manual restart is then required (by turning power to the rectifier off or by removing the rectifier, waiting until the LEDs on the rectifier extinguish, then turning power to the rectifier on or re-inserting the rectifier).

- Over-Temperature Protection: The rectifier provides over temperature protection by derating output power and recovers automatically.

- Active Load Sharing: The rectifier uses advanced digital active load sharing technology that maintains balancing to within 3% of rated current.

- Hot Swappable: The rectifier is designed to be plug-and-play. The rectifier can be inserted or removed from a live DC power system with no damage. When the rectifier is plugged into the system, the system output voltage will remain within the specified regulation range.

- Cooling: Each rectifier contains two fans for front-to-back forced convection cooling.

  a) Fan Fault Protection: The rectifier shuts down and its alarm indicator (red) flashes if either fan fails. Fan failure is detected and reported to controller. The fans are not field replaceable.

  b) Fan Control: Fan speed is continuously variable. When input voltage is within normal range, the built-in processor adjusts fan speed according to the rectifier's internal temperature and output power. For example, a higher temperature or output power increases the fan speed. This feature can be disabled via the controller, allowing the fan to run at full speed regardless of temperature.

- Paralleling: Up to twenty-seven (27) rectifiers can be connected in parallel in one system.
- Communication Failure: The rectifier's protection indicator (yellow) flashes should it lose communication with the controller.
- Rectifier Output Current Imbalance:

  a) When the average current of all rectifier modules is greater than 20% of full rated current, and the difference between local rectifier current and average current is greater than 16% of full rated current, the yellow protection indicator will illuminate.

  b) When the average current of all rectifier modules is greater than 20% of full rated current, and local rectifier current is less than 2% of full rated current, then the red fault indicator will illuminate.

- Monitoring Function: The rectifier has a built-in advanced DSP (Digital Signal Processor) that monitors and controls the operation of the rectifier. The DSP also communicates with the associated controller in real time through the CAN bus. **Table 9** lists the different commands and information exchanged between the rectifier and the controller.

Table 9: Exchange of Information between Rectifier and Controller

Commands / Signals that can be Received by the Rectifier from the Controller	Information Gathered by the Controller from the Rectifier
• Turn On/Off • Current Walk-in On/Off • HVSD (High Voltage Shutdown) Voltage • Current Limit Adjustment • Output Voltage Setpoint	• Input Voltage • Output Voltage • Output Current • Current Limit Setting • Rectifier Temperature • HVSD Setting • On/Off Status • Fault Alarms, such as: HVSD Fan Fail • Protection Alarms, such as: Input Voltage Protection Inner DC Bus Voltage Protection High Temperature Protection • Thermal Derating • AC Derating • AC Fail • Imbalanced Output Current • Address • Code • Date • Software Version • Hardware Version

Mechanical Specifications

- Dimensions (H x W x D): 41.4 x 124 x 453.2 mm (1.6 x 4.9 x 17.8 inches)
- Weight: 3.0 kg (6.6 lbs) (R12-3000), 3.5 kg (7.7 lbs) (R12-3300).
- Local Controls: None.
- Local Status and Alarm Indicators: (See also **Table 10**.)
  a) Power (Green LED)
  b) Protection (Yellow LED)
  c) Alarm (Red LED)

OPERATION

AC Input Protection Device Requirements/Recommendations

Refer to the system documentation supplied with the system the rectifier is installed in.

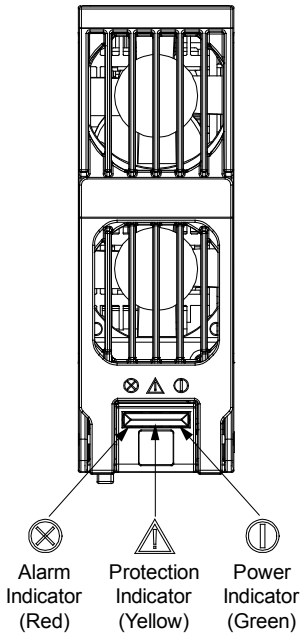
Local Indicators

Location and Identification: Refer to **Figure 6**.

Description: There are three (3) alarm and status indicators located on the rectifier's front panel. The functions of these indicators are as shown in **Table 10**.

NOTE! *AC voltage must be present at the rectifier input terminals.*

Figure 6: *Rectifier Local Indicators Locations*



Rectifier High Voltage Shutdown and Lockout Restart

Procedure

1. Turn the power to the rectifier off or remove the rectifier, wait 30 seconds or more (until the LEDs on the rectifier extinguish), then turn the power to the rectifier on or re-insert the rectifier.

Rectifier Current Limit

When setting total rectifier current limit, the set point to each rectifier is the total set point divided by the number of rectifiers. For example, if the system contains five rectifiers and the current limit is set to 150 amps then each rectifier has a current limit set point of 30 amps. If one or more rectifiers are removed or fail it will take several seconds for the individual set points to the remaining rectifiers to be reset. In the example given, if one rectifier is removed the current limit set point will drop to 120 amps (30 amps times four remaining rectifiers) until the controller can send updated set points to the remaining rectifiers. This takes a couple communication cycles (several seconds) after which each rectifier would have a new set point of 37.5 amps for a total of 150 amps. The total current limit of the rectifiers should not be set such that the loss of the redundant rectifiers will cause this temporary set point to drop below the actual maximum expected load.

Table 10: *Rectifier Local Indicators*

Indicator		Normal State	Alarm State	Alarm Cause
	Power (Green)	On	Off	No input voltage. Internal input fuse open.
			Flashing	The rectifier is being identified by the controller.
	Protection (Yellow)	Off	On	AC input under/over voltage. PFC over-voltage, under-voltage, or fault. Moderate load sharing imbalance. Rectifier not inserted into the slot completely. Rectifier is not in the position. Rectifier over-temperature protection.
			Flashing	Loss of communication with controller (the rectifier can provide power).
	Alarm (Red)	Off	On	Severe load sharing imbalance. Rectifier output disabled for any reason, including overvoltage shutdown. Rectifier addresses contradictory. DC failure.
			Flashing	One or both fans not operating (rectifier shuts down).

Installing Rectifiers

Rectifiers can be inserted or removed with power applied (hot swappable).

WARNING! To prevent damage to the latching mechanism, ensure the handle is in the open position when installing or removing a rectifier. NEVER hold the handle in the closed position when installing a rectifier into a module mounting assembly.

CAUTION! This rectifier contains double pole fusing; parts of the equipment that remain energized might represent a hazard during servicing after operation of the fuse. If the rectifiers are connected to a 3-phase system, the neutral line should also have a fuse. All-pole circuit breaker should be provided if used in IT power system.

NOTE! *Electrical, fire, mechanical enclosures should be provided in the end-product.*

NOTE! *The rectifier locks into the module mounting assembly through a latch located on the underside of the module. The latch and module handle are interactive. Pushing the handle up into the module's front panel causes the latch to extend to the locking position. Clicking the handle to pop it out from the module's front panel causes the latch to retract.*

NOTE! *For safety, the unit rear connector output DC pins are disabled until "awakened" inside the module mounting assembly.*

Procedure

Refer **Figure 7** as this procedure is performed.

1. Unpack the rectifier.
2. Note the model number located on the front of the module. Ensure the correct module is being installed.
3. If present, remove the blank cover panel from the module mounting position into which a rectifier is to be installed.
4. Place the rectifier into an unoccupied mounting position without sliding it in completely.
5. Push the handle built into the rectifier's front cover in and release at the top center of the cover as shown in in **Figure 7**. This pops the handle forward out of the rectifier's front panel (this will also retract the latch mechanism located on the underside of the rectifier).
6. Push the rectifier completely into the module mounting assembly.
7. Push the handle into the front panel of the rectifier. This will lock the rectifier securely to the module mounting assembly.
8. Repeat the above steps for each rectifier being installed in the system.
9. After the rectifiers are physically installed in the module mounting assembly(s), they are ready for operation immediately after power is supplied to them.

10. Certain functions (i.e. rectifier current limit, rectifier addressing) may require adjustment when adding or replacing a rectifier. Refer to “Rectifier Current Limit” on page 20 and the power system documentation for instructions.

TROUBLESHOOTING AND REPAIR

Troubleshooting

Rectifier Current Sharing Imbalance

When multiple rectifiers are operating in parallel and the load is greater than 20%, if the current sharing imbalance among them is greater than 3%, check if the rectifier is properly seated in the module mounting assembly.

If the current sharing imbalance still persists following the verification suggested above, replace the rectifier exhibiting the current imbalance.

Rectifier Fault Symptoms and Troubleshooting

The fault indicators that can be displayed by the rectifier are as follows. Refer to **Table 11** for a list of possible causes and corrective actions.

- Power Indicator (Green) OFF
- Protection Indicator (Yellow) ON
- Protection Indicator (Yellow) Flashing
- Alarm Indicator (Red) ON
- Alarm Indicator (Red) Flashing

Figure 7: *Installing or Removing a Rectifier*

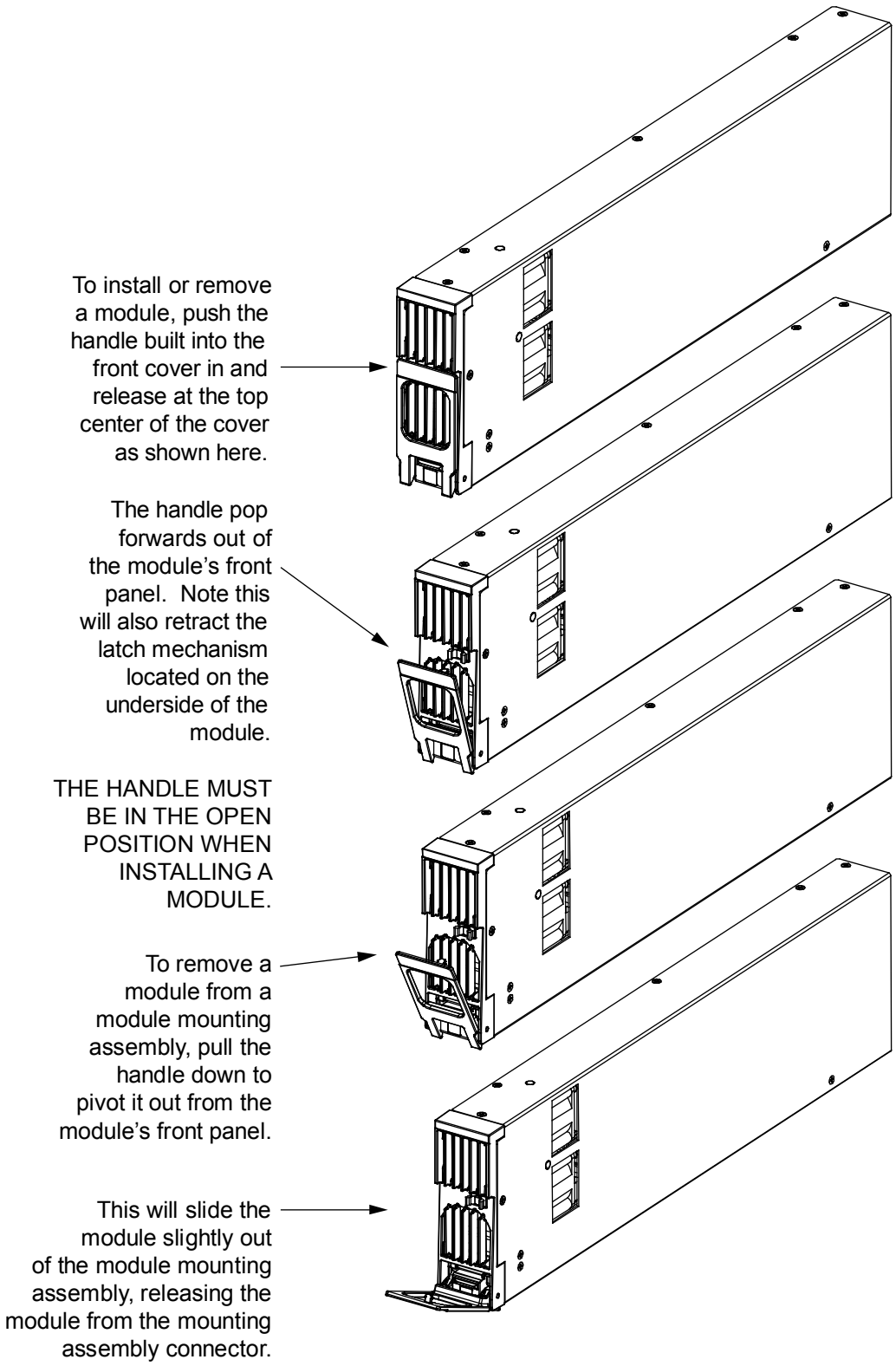


Table 11: *Rectifier Troubleshooting*

Symptom		Possible Cause(s)	Suggested Action(s)
	Power Indicator (Green) On	AC is on. 12 VDC is on.	No action required.
	Power Indicator (Green) Off	No input voltage.	Make sure there is input voltage.
		Internal input fuse open.	Replace the rectifier.
	Protection Indicator (Yellow) On	AC input under/over voltage.	Correct the AC input voltage to within the acceptable range.
		PFC over-voltage, under-voltage, or fault.	Change the failure rectifier position, if it still doesn't work, replace the rectifier.
		Moderate load sharing imbalance.	Check if the rectifier is properly seated in the module mounting assembly. If this does not correct the fault, replace the rectifier.
		Rectifier not inserted into the slot completely.	Remove and properly insert the rectifier.
		Rectifier is not in the position.	Check if the contacts of the module mounting assembly's mating socket is ok. Change the failure rectifier position, if it still doesn't work, change the rectifier.
		Rectifier over-temperature protection.	Fan rotor blocked: remove any object that may be blocking the fan. Ventilation blocked (inlet or outlet): remove any object that may be blocking the inlet or outlet. Ambient temperature too high or rectifier inlet too close to a heat source: lower the ambient temperature or relocate the heat source.
	Protection Indicator (Yellow) Flashing	Loss of communication with controller (the rectifier can provide power).	Check the communication cables. Remove and properly insert the rectifier and controller.
	Alarm Indicator (Red) On	Severe load sharing imbalance. Rectifier output disabled for any reason, including overvoltage shutdown.	Turn AC power to the rectifier off or remove the rectifier, wait 30 seconds or more (until the LEDs on the rectifier extinguish), then turn the AC power to the rectifier on or re-insert the rectifier. If rectifier fails to start, shuts down again, or load sharing imbalance persists; replace the rectifier.
		Rectifier addresses contradictory.	Replace the rectifier.
		DC failure.	Change the failure rectifier position ,if it still doesn't work, replace the rectifier.
	Alarm Indicator (Red) Flashing	One or both fans not operating (rectifier shuts down).	Replace the rectifier.

Replacement Procedures

Rectifier Replacement

Rectifiers can be inserted or removed with power applied (hot swappable).

DANGER! Take care when removing a rectifier that was in operation, as rectifier surfaces could be very hot.

WARNING! To prevent damage to the latching mechanism, ensure the handle is in the open position when installing or removing a rectifier. NEVER hold the handle in the closed position when installing a rectifier into a module mounting assembly.

NOTE! *The rectifier locks into the module mounting assembly through a latch located on the underside of the module. The latch and module handle are interactive. Pushing the handle up into the module's front panel causes the latch to extend to the locking position. Clicking the handle to pop it out from the module's front panel causes the latch to retract.*

Procedure

Refer **Figure 7** as this procedure is performed.

1. Performing this procedure may activate external alarms. Do one of the following. If possible, disable these alarms. If these alarms cannot be easily disabled, notify the appropriate personnel to disregard any alarms associated with this system while this procedure is performed.
2. Push the handle built into the rectifier's front cover in and release at the top center of the cover as shown in in **Figure 7**. This pops the handle forward out of the rectifier's front panel (this will also retract the latch mechanism located on the underside of the rectifier).
3. Pull the handle down to pivot it out from the module's front panel. As you pull the handle down, the module will slide out of the module mounting assembly, releasing the module from the mounting assembly connector.
4. Remove the rectifier from the module mounting assembly.
5. Place the replacement rectifier into the mounting position without sliding it in completely.
6. Push the handle built into the rectifier's front cover in and release at the top center of the cover as shown in in **Figure 7**. This pops the handle forward out of the rectifier's front panel (this will also retract the latch mechanism located on the underside of the rectifier).
7. Push the rectifier completely into the module mounting assembly.
8. Push the handle into the front panel of the rectifier. This will lock the rectifier securely to the module mounting assembly.
9. Certain functions (i.e. rectifier current limit, rectifier addressing) may require adjustment when adding or replacing a rectifier. Refer to "Rectifier Current Limit" on page 20 and the power system documentation for instructions.
10. After the rectifiers are physically installed in the module mounting assembly(s), they are ready for operation immediately after power is supplied to them. Verify that the rectifiers are operating normally.
11. Enable the external alarms, or notify appropriate personnel that this procedure is finished.

12. Ensure that there are no local or remote alarms active on the system.

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