

Product Manual
J87132B-2

Select Code 169-792-100
Comcode 107940108
Issue 3
March 1998

Lucent Technologies
140-Volt, 140-Ampere, 60-Hertz
Ferroresonant Rectifier

Notice:

Every effort was made to ensure that the information in this document was complete and accurate at the time of printing. However, information is subject to change.

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1 Introduction

General

This product manual (Select Code 169-792-100) describes Lucent Technologies J87132B-2 140-volt, 140-ampere, 60-hertz rectifier, which is shown in Figure 1-1. The manual covers rectifier technology, features and specifications, engineering information, installation and testing, operation and maintenance.

The J87132B-2 rectifier is a UL-listed rectifier designed to convert commercial 208, 240, or 480 volts ac input power at 60 hertz into a highly regulated and filtered, low-noise, 140-volt dc output for telecommunications equipment loads. In most telecommunications applications, the output of the rectifier system is electrically connected in parallel with the batteries. The rectifiers provide both the power to the telephone equipment through the plant distribution and the charging and float current to the batteries. In the event of a commercial power failure, the batteries supply the required dc power to the telephone equipment. This transition needs no switching because of the parallel connection of the rectifiers and batteries.

Applications

The J87132B-2 rectifier is intended for use with the Galaxy Controller (J85501F-1) and as part of the 415B Battery Plant.

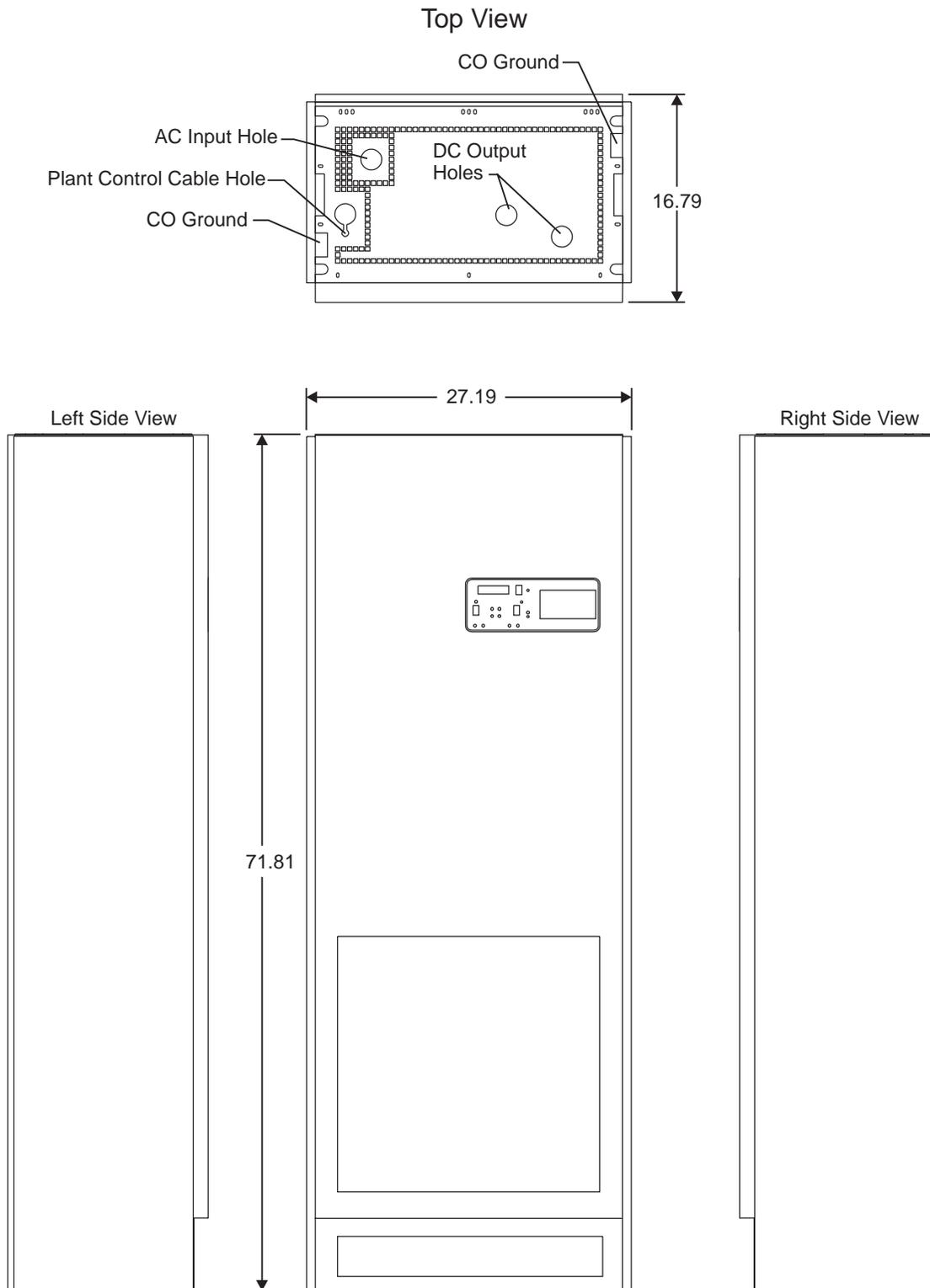


Figure 1-1: J87132B-2 140V/140A Ferroresonant Rectifier

Technical Support

Technical support for Lucent Technologies equipment is available to customers around the world.

***USA, Canada,
Puerto Rico, and
the US Virgin
Islands***

On a post-sale basis, **during the Product Warranty period**, our Technical Support telephone number 1-800-CAL RTAC (1-800-225-7822) provides coverage during normal business hours. Product Specialists are available to answer your technical questions and assist in troubleshooting problems. For out-of-hours EMERGENCIES, the 800 number will put you in touch with a Regional Technical Assistance Center Engineer via our 24 hour a day, 7 day per week Help Desk.

When Technical Support is required in **the Post-Warranty Period**, the service may be billable unless you hold an extended warranty or contractual agreement.

***Central and
South America,
Europe, Middle
East, Africa, and
Asia Pacific
Region***

If you need product technical support, contact your local Field Support/Regional Technical Assistance Center or contact your sales representative who will be happy to discuss your specific needs.

Product Repair and Return

Repair and return service for Lucent Technologies equipment is available to customers around the world.

***USA, Canada,
Puerto Rico, and
the US Virgin
Islands***

For information on returning of products for repair, customers may call 1-800-255-1402 for assistance.

***Central and
South America,
Europe, Middle
East, Africa, and
Asia Pacific
Region***

If you need to return a product for repair, your sales representative will be happy to discuss your individual situation.

Customer Service

For customer service, any other product or service information, or for additional copies of this manual or other Lucent Technologies documents, call 1-800-THE-1PWR (1-800-843-1797). Specify the select code number for manuals, or drawing number for drawings. Contact your regional customer service organization or sales representative for information regarding spare parts.

2 *Rectifier Description*

Application in a 415B Battery Plant

The J87132B-2 rectifier is part of the 415B Battery Plant, which is diagrammed in Figure 2-1. The subsystems of the 415B Battery Plant are described below.

415B Battery Plant Subsystems

AC Input connects the commercial and/or standby ac power sources to the rectifiers within the plant and provides overcurrent protection.

Rectifiers convert an ac source voltage into the dc voltage level required to charge and float the batteries and to power the using equipment.

Controller provides the local and remote control, monitor, and diagnostic functions required to administer the battery plant. This is part of the Control and Distribution Bay.

Batteries provide energy storage for an uninterrupted power feed to the using equipment during loss of ac input or rectifier failure.

DC Distribution provides overcurrent protection, connection points for the using equipment, and bus bars to interconnect the rectifiers, batteries, plant shunt, and dc distribution.

Secondary Distribution provides additional overcurrent protection near the using equipment.

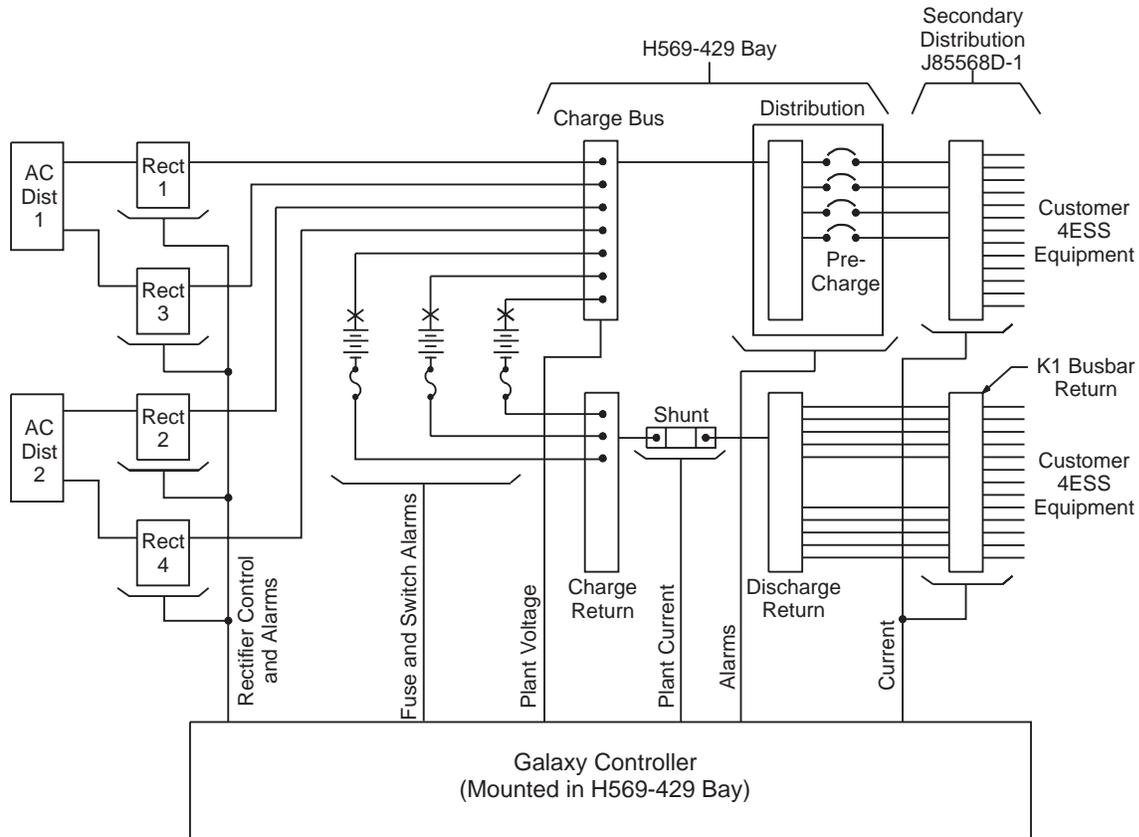


Figure 2-1: Block Diagram of the 415B Battery Plant

Technology

The J87132B-2 rectifier utilizes the electronically controlled closed loop ferroresonant technology developed at Lucent Technologies Bell Laboratories. This technology provides efficiency, space savings, serviceability, and a design of excellent output regulation in spite of load, commercial line voltage, and input frequency variations over the specified ranges.

The advantages of ferroresonant technology include:

- Eliminates internal switching transients typically associated with older technologies.
- Reduces noise and transients from the commercial ac source. As the interface between commercial power and telephone equipment, the ferroresonant rectifier significantly attenuates noise and lightning surges from commercial lines.

- Introduces virtually no noise into closely coupled telephone lines. This is because of the low harmonic content of the input current waveshape.
- Produces highly efficient power conversion.

Other benefits of the J87132B-2 140-ampere rectifier are:

- **High reliability** – all components in the rectifier meet Lucent Technologies' strict specifications and reliability standards. The rectifier uses an extremely efficient free-convection cooling system that keeps components operating at temperatures well below the recommended maximum, resulting in high reliability.
- **Easier maintenance** – all circuits for power control, alarms, voltage regulation, current limiting, restart, plant interface, and remote monitoring/control are mounted on replaceable circuit modules. Front access to the circuit modules simplifies replacement or adjustment, if required.

Features

The J87132B-2 140-volt, 140-ampere, 60-hertz rectifier has the following standard features:

Output Current Walk-in

This circuit controls the time required for the rectifier to reach its rated output voltage after it is turned on. Initially the output voltage is about 80 percent of normal, and is gradually increased to the required value in approximately 10 seconds. As the output voltage “walks-in”, output current does too. This feature minimizes the starting surge on the customer's power source, which is especially useful when the source is more limited, such as with an emergency generator set.

Selective High Voltage Shutdown (HVSD)

If the battery voltage goes too high, the controller signals all of the parallel rectifiers; any of these rectifiers having a high voltage condition and delivering at least 10 percent of its rated output current will shut off. The remaining rectifiers are permitted to continue in operation.

Internal Selective High Voltage Shutdown (ISHVSD)

If the rectifier voltage exceeds the threshold, factory set at 160V, and the rectifier is delivering at least 10 percent of its rated output current, the internal high voltage shutdown circuit will cause the rectifier to shut down. The internal selective high voltage shutdown (ISHVSD) circuit can be deactivated and the

controller will furnish a selective high voltage shutdown. The internal selective high voltage shutdown circuit may also be used as a backup to the controller's selective high voltage shutdown (HVSD). The setting may be changed via DIP switches on the CM2 control board.

***Backup High
Voltage
Shutdown
(BUHVSD)***

This prevents damage to the rectifier and its loads in the event of a high battery voltage condition. Each rectifier senses its own output voltage and shuts down when this voltage exceeds a preset value. This circuit will operate if both the rectifier's internal selective high voltage shutdown and the battery plant's selective high voltage shutdown circuits fail to operate. The backup high voltage shutdown (BUHVSD) operates from an independent voltage source. The BUHVSD is factory set at 163V and may be changed via DIP switch settings on the CM2 control board.

***Output Current
Limit***

The rectifier provides a constant output voltage up to its rated output, at which point it provides constant current. When the output current tends to increase above the rated output, an operational amplifier output overrides the voltage-regulating signal and limits the output current of the rectifier. The current limit is less than 170 amperes down to 122 volts.

***Backup Current
Limit***

In addition to the electronic output current limit, the ferroresonant transformers are self-current-limiting between 125 and 175 percent of full load.

Fuse Alarms

The low-power control functions have fuses and alarms and will shut the rectifier down if a fuse or circuit breaker operates. The REG leads and the dc output filter capacitors are also protected by alarm fuses. When any of the fuses or the circuit breaker operates, the rectifier shuts down and FA (Fuse Alarm) and RFA (Rectifier Failure Alarm) LEDs light. An RFA signal is also generated.

Safety Interlocks

A series loop circuit path electrically interconnects the control circuit modules. If an open circuit is detected, it will prevent rectifier operation.

<i>Rectifier Test</i>	A rectifier test (NL/FL) switch is provided to automatically raise or lower the output voltage of the rectifier by 0.5 volt. This verifies proper operation by causing the rectifier current to go to either <i>no load</i> or <i>full load</i> when on battery.
<i>Restart Circuit</i>	The rectifier is compatible with the automatic restart features of the Galaxy Controller. If a rectifier shuts down due to a high voltage, the plant will try to restart it automatically according to the Galaxy restart algorithm.
<i>Output Volts Adjust</i>	Up and down pushbuttons provide capability for manually setting the float and equalize output voltages.
<i>Rectifier Failure Alarm</i>	A rectifier failure alarm (RFA) provides both a local visual indication of failure and a signal to the controller.
<i>Digital Meter</i>	A digital meter selectively displays: (1) the rectifier current, (2) the voltage output, or (3) the plant battery voltage. The default display is rectifier current.
<i>Rectifier Test Jacks</i>	The rectifier test jacks are provided for measuring the voltage at the rectifier's output.
<i>Plant Test Jacks</i>	The plant test jacks are provided for measuring the voltage at the Control and Distribution Bay.
<i>DC Output Circuit Breaker</i>	A dc output circuit breaker is provided to protect the rectifier from malfunction and overcurrent, and may be used to disconnect the rectifier from the battery. The breaker is located on the control panel. An Output circuit breaker alarm is issued and the RFA and FA LEDs light when the circuit breaker trips.
<i>Isolated Output Current Indication</i>	The rectifier provides an isolated 2- to 10-volt signal, corresponding to a range of no load to 125 percent load, which is used to indicate the rectifier drain on the controller.

<i>Man Alarm</i>	Indicates that either the rectifier has been turned off or has lost power.
<i>Remote Sense Leads</i>	Permits the rectifier to provide accurate regulation at the Control and Distribution Bay rather than at the output terminals of the rectifier.
<i>Transfer (TR)</i>	Allows for shutdown of the rectifier, e.g., by the controller's efficiency algorithm or by a rectifier sequence controller.
<i>Phase Alarm</i>	An alarm will be issued when any one of the input phase voltages has decreased approximately 35 percent from the nominal value. A phase alarm will shut down the rectifier. The rectifier will automatically restart when the phase voltage is restored.
<i>AC Fail Alarm</i>	If all phases are lost, an alarm will be issued. The phase fail alarm will not be issued. The rectifier will automatically restart when the input voltage is restored within normal limits.
<i>Unbalance Alarm</i>	If severe unbalance develops between the two ferroresonant transformers, an alarm is issued and the rectifier shuts down. The rectifier fail circuit is energized to deliver this alarm, with a 3-second delay to allow for transient disturbances such as from initial turn-on. The alarm is latching and indicates a failure in the rectifier via the RFA LED.
<i>Additional Fusing</i>	Each output filter capacitor is fused. An associated alarm fuse is located on the CM1 circuit module.
<i>Battery Equalize Charge</i>	The 140-ampere rectifier, in association with the Galaxy Controller, allows the batteries to be charged at a higher voltage than float voltage to equalize the individual voltages of the cells in the string. The equalize voltage is factory set to 158 volts.
<i>Equalize</i>	An Equalize LED is provided to indicate when the rectifier is placed in the equalize mode of operation.

Power Switch As part of the digital meter board, a Power On/Off switch is provided for manually turning the rectifier on and off.

Local Float/Equalize As part of the digital meter board, the rectifier can be put into the equalize mode by positioning the Float/Equalize switch to the Equalize position. Local equalize can be disabled via a switch setting on the CM2 control board.

Dynamic Response For any step load change of 10 to 90 percent, or 90 to 10 percent, the sense point voltage will remain within ± 5 percent of its setting and return and remain in the $\pm 1/2$ percent band within 300 milliseconds.

EMC (Electromagnetic Compatibility) The J87132B-2 rectifier complies with FCC Docket 20780, Part 15, Subpart J, as required for Class A applications. In addition, the rectifier meets all specified operating characteristics when subjected to electric fields up to 6 volts per meter over a frequency range of 20 to 1000 MHz. The unit does not shut down when subjected to electric fields up to 10 volts per meter over the same frequency range.

Circuit Modules The rectifier's signal processing and control circuitry are located on replaceable circuit modules or packs. (See Section 8, *Spare Parts and Replacement Procedures*, for ordering information.) All modules are accessible by opening the rectifier door. Figure 5-6 shows the location of the modules and other features of the rectifier.

CM1 (329B) The CM1 (329B Fuse Board) protects the control circuits from faults in the rectifier power train. It contains alarm fuses and sense resistors.

CM2 (208G) The CM2 (208G Control Board) contains the following circuits:

- local power supplies
- part of the restart feature
- feedback regulator
- unbalance shutdown
- walk-in feature
- fuse alarm

- backup high voltage shutdown
- electronic current limit
- remote shutdown
- output current isolation circuit
- manual on/off
- phase monitor
- RFA test
- rectifier portion of plant selective high voltage shutdown
- internal selective high voltage shutdown

CM3 (323E) The CM3 (323E Display Board) controls the Digital Output Meter and all controls and indicators on the rectifier control panel. The meter displays the rectifier's current, voltage, or the plant battery voltage, depending on the position of the selector switch.

CM5 and CM6 (ED83156-30 G4) CM5 and CM6 (ED83156-30 G4) connect between CM2 and Q1 and Q2 triacs to provide turn-on and turn-off transient protection.

CM7 (425C, D, F) CM7 (425C, D, F) is a transformer board that contains a step-down transformer for CM2 bias and phase sense circuitry. It also contains a relay to drive the ac contactor.

CM8 (868A) CM8 is a bleeder resistor board. It contains resistors that discharge output capacitors when the rectifier is powered off.

Alarm and Control Flow

The J87132B-2 140-volt, 140-ampere, 60-hertz rectifier described in this manual is self-controlled and self-protected. Short circuits and overloads are handled automatically. Various monitoring and alarm signals are generated by the rectifier and sent to the Galaxy Controller for processing and subsequent action. The resulting action may be local or remote alarm indications or control signals fed back to the rectifier.

Refer to the Galaxy Controller Product Manual for a description of rectifier signal processing and resultant action. See Figure 2-2 for a typical signal flow between a rectifier and the Galaxy Controller. Note that in the rectifier the control signals and alarms enter and leave via circuit modules. These modules are

where the rectifier alarm signals are generated and where control signals are either received or generated. This is also the type of design used by the Galaxy Controller, where replaceable circuit modules give flexibility to battery plant design.

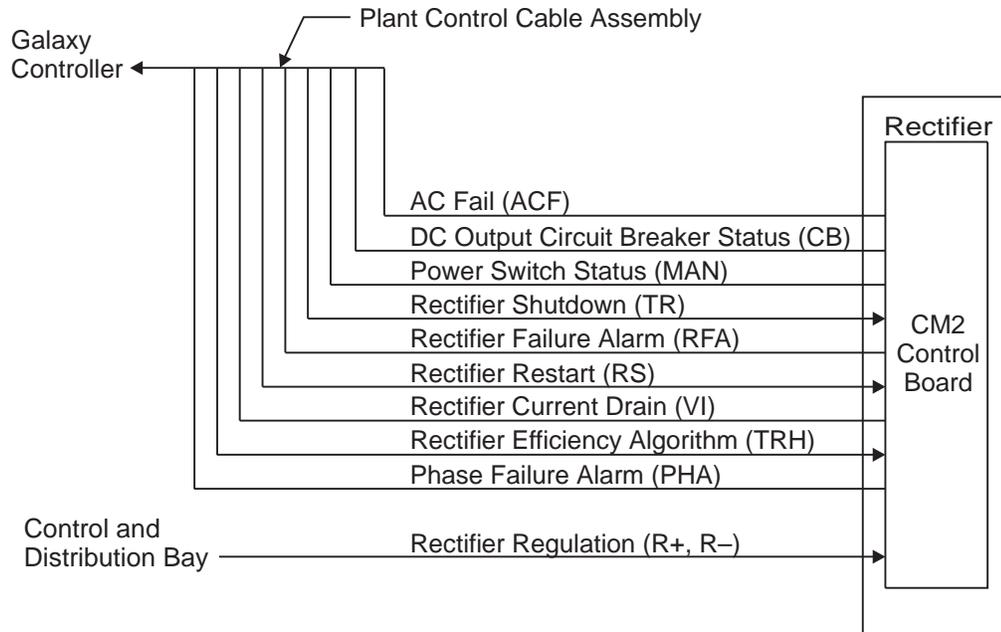


Figure 2-2: Signal Flow Between Rectifier and Galaxy Controller

Specifications

Table 2-A lists the electrical and physical specifications of the J87132B-2 rectifier.

Table 2-A: Electrical and Physical Specifications of the J87132B-2 Rectifier

Characteristics	Details
Heat dissipation	7,500 BTU/hour (2,200 Watts) at full load 152 volts dc
Relative humidity, operating	10 to 95% (non-condensing)
Temperature, normal operation	40° F to 100° F (5° C to 35.5° C)
Temperature, short-term operating	35° F to 120° F (1.5° C to 48.8° C) for not more than 72 consecutive hours, but not more than 15 days cumulative in one year.
Altitude, operating	Sea level to 10,000 feet (3,048 meters)
Audible noise	Less than 65 dBA at a point 5 feet (1.52 meters) above floor and 2 feet (0.61 meters) in front of rectifier

Table 2-A: Electrical and Physical Specifications of the J87132B-2 Rectifier

Characteristics	Details
Earthquake	Meets Zone 4 per Bellcore TR-EOP-000063 (Issue 3)
Input voltage	J87132B-2 List 1: 208 Vac (184-220) J87132B-2 List 2: 240 Vac (212-254) J87132B-2 List 3: 480 Vac (424-508)
Input frequency	60 hertz nominal (57-63 hertz)
Input current drain at full load (per line)	J87132B-2 List 1: 67 amperes typical, 76 amperes maximum J87132B-2 List 2: 60 amperes typical, 65 amperes maximum J87132B-2 List 3: 30 amperes typical, 33 amperes maximum
Power factor	Greater than 0.9 from half load to full load Minimum power factor at full load 0.94
Rated output	140 amperes at 151.9 volts dc, all input conditions Rated power at 152 volts dc, minimum input conditions 20 amperes at 155-175 volts dc (initial battery charging), all input conditions
Output current	0-140 amperes
Output voltage	140 through 175 volts dc (175 volts maximum at no load)
Output ripple	For standard filter on battery: 613 millivolts (RMS) measured on a battery rated four times the rectifier capacity
Output electrical noise	Less than 87 dB _{rnf} at battery terminals with a 1680 ampere-hour battery
Regulation on battery	±0.5 percent for line, load, frequency, and temperature variations specified above
Regulation off battery	±2 percent for line, load, frequency, and temperature variations specified above
Efficiency	Greater than 92% at full load, 90% at half load
Dimensions	26.00 inches (660.4 mm) wide 16.25 inches (412.8 mm) deep 71.56 inches (1,817.6 mm) high
Weight	1,330 pounds (603.3 kilograms)

3 *Ordering Information*

Ordering the J87132B-2 Rectifier

Refer to the H569-429 drawing for ordering information for the J87132B-2 rectifier. The information is also given in the H569-429 Control and Distribution Bay product manual (Select Code 167-792-120).

Documentation References

The following documents provide engineering, ordering, and installation information for the J87132B-2 Rectifier.

**Table 3-B: Documentation References for the J87132B-2
140Vdc, 140A, 60Hz Ferroresonant Rectifier**

Assembly Drawing	J87132B-2
Wiring Diagram	T-83325-30
Schematic Drawing	SD-83325-01
Product Manual Select Code	169-792-100

4 *Safety*

Please read this section carefully before installing, maintaining, or repairing the J87132B-2 rectifier.

Admonishments

Always take precautions to protect personal safety as well as the equipment when working on power systems. Throughout this manual, admonishments relating to personal safety are labeled **DANGER** or **Warning**. Those relating to equipment damage are labeled **Caution**. Please read all admonishments carefully and follow safety instructions and warnings.

Safety Statements

- For use only in restricted access areas (dedicated equipment rooms, equipment closets, or the like) in accordance with articles 110-16, 110-17, and 110-18 of the U.S. National Electric Code (NEC), ANSI/NFPA No. 70, and pursuant to applicable local codes.
- This equipment must not be installed over combustible surfaces.
- This equipment is to be used in controlled environments (an area where the humidity is maintained at levels that can not cause condensation on the equipment, the contaminating dust is controlled, and the steady-state ambient temperature is within the range specified).
- This equipment has been evaluated for use in a continuous ambient temperature of up to 35 degrees Celsius.
- AC branch circuits to this equipment must be protected with either fuses or circuit breakers sized as required by the National Electric Code (NEC)

and/or local codes. The size of the 480V input overcurrent protector used must not exceed 50A; the size of the 280/240V input overcurrent protector should not exceed 100A. Refer to the equipment ratings to assure rating of equipment will not exceed 80% of the value of the protector chosen.

- An accessible ac disconnect/protection device to remove ac power from the equipment in the event of an emergency must be provided.
- For installations in the United States, UL-listed compression connectors should be used to terminate UL-listed field-wired conductors where required. For all installations, the appropriate connector should be applied only to the correct size conductor as specified by the connector manufacturer using only the connector manufacturer's recommended tooling or tooling approved for that connector.
- If the proper connector for the country of installation is not provided, obtain appropriate connectors and follow manufacturer's and all local requirements for proper connections. All national and local rules and regulations are to be followed when making field connections.
- Torque electrical connections to the values specified on labels or in the product documentation.

Precautions

When working on or using this type of equipment, follow these precautions:

- This unit must be installed, serviced, and operated only by skilled and qualified personnel who have the necessary knowledge and practical experience with electrical equipment and who understand the hazards that can arise when working on this type of equipment.
- Because of the hazardous voltages supplied to and within the equipment, make sure the equipment, all associated framework, and the cable rack are properly grounded per local job instructions before turning on any power to the rectifier.
- For equipment connected to batteries, disconnecting the AC alone will not necessarily remove power to the equipment. Make sure the equipment is not also powered by the batteries or the batteries are not connected to the output of the equipment.

- AC voltage may be present in the unit even when the Power switch is in the **Off** position.
- Hazardous DC energy (from batteries and rectifier output) and voltages up to 600 volts are present in the unit. Use a voltmeter to insure no voltage, or the expected voltage, is present before contacting any uninsulated conductor surface. Follow the procedures in the order given to minimize dangerous encounters with these voltages. Exercise extreme caution when working near the battery busbars.
- The circuitry on the circuit boards within the unit is referenced to the non-ground side of the hazardous dc output voltage. Therefore, these circuits will also be at hazardous voltage with respect to ground (earth ground and equipment frame). If the boards must be serviced or removed, disconnect all connectors to the boards first (even before removing plastic covers), taking care not to touch any bare circuits. Replace all plastic covers before attaching connectors.
- DC capacitors may be charged even with power disconnected from the rectifier. If filter capacitor fuses have blown, capacitors will be charged. Always check all of the dc capacitor terminals (observe polarity) with a voltmeter before performing this procedure, and discharge capacitors safely, if necessary.



Wait at least 5 minutes after shutting down ac and circuit breaker (CB1) before working on capacitors or associated buswork.

- Batteries may be connected in parallel with the output of the rectifiers. Turning off the rectifiers will not necessarily remove power from the bus. Battery voltage may still be present on one side of the output DC circuit breaker even with the circuit breaker off. Make sure the battery power is also disconnected and/or follow safety procedures while working on any equipment that contains hazardous energy/voltage.
- Use only properly insulated tools.
- Remove all metallic objects (key chains, glasses, rings, watches, or any other jewelry).
- Wear safety glasses.
- Test circuits before touching.

- Lock out and tag any circuit breakers/fuses when possible to prevent accidental turn on.
- Be aware of potential hazards in the area you are working before entering the equipment.
- Identify exposed hazardous electrical potentials on connectors, wiring, etc. (note the condition of these circuits, especially any wiring).
- Use care when removing or replacing any covers - avoid contacting any circuits.
- Use gloves when handling thermally hot components inside the rectifier. Transformers are very hot after sustained operation.

Warning Statements and Safety Symbols

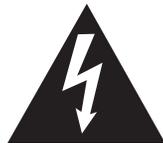
The symbols may sometimes be accompanied by some type of statement. For example, "Hazardous voltage/energy inside. Risk of injury. This unit must be accessed only by qualified personnel."



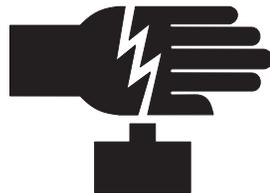
This symbol identifies the need to refer to the equipment instructions for important information.



This symbol (or equivalent) is used to identify the presence of hazardous ac mains voltage.



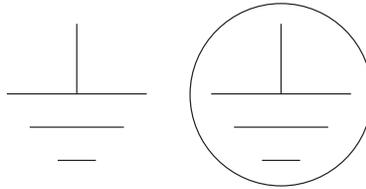
This symbol is used to identify the presence of hazardous ac or dc voltages. It may also be used to warn of hazardous energy levels.



This symbol identifies the presence of rectifier and battery voltages. The symbol may sometimes be accompanied by some type of statement. For example, "Battery voltage present. Risk of injury due to high voltage. Avoid contacting conductors with uninsulated metal objects. Follow safety precautions."



This symbol is used to identify the presence of a hot surface. It may also be accompanied by a statement explaining the hazard. A symbol like this with a lightning bolt through the hand also means that the part is or could be at hazardous voltage levels.



These symbols (and/or the word “gnd”, “ground”, or the equivalent) are used to identify the safety earth ground or bonding point for the equipment. Make sure the associated

framework and cable rack are properly grounded, per local job instructions, before turning on any rectifier.

5 *Installation and Testing*

Installation Preparation

Please read Section 4, *Safety*, carefully before installing the J87132B-2 rectifier.

Location The J87132B-2 rectifier and associated equipment should conform to the specific plans of each battery plant installation. Where limiting dimensions or tolerances are not specified, locate the equipment within such limits of the specified dimensions to assure satisfactory functioning and workmanlike appearance of the equipment.

In a side-by-side lineup of rectifiers, the rectifier cabinet door, when opened, will project approximately 25 inches (635 mm) into the front aisle space. To prevent interfering with or obscuring an adjacent rectifier, the rectifier door should not protrude outside the 26-inch-wide (660.4 mm) cabinet profile.

Floor Mounting For secure fastening when installing the rectifier directly on the building's permanent floor, use the four floor anchors chosen for proper use in the regional area. Shim cabinets to satisfy plumbing requirements.

Heat Dissipation The maximum heat load exhausted to the environment by each rectifier is 2,200 watts or 7,500 BTU/hr. The rectifier is designed for free convective cooling, where cooler air enters the cabinet through perforations in the front door and is exhausted through perforations in the top cover. A minimum of 26 inches in front and 12 inches above the rectifier must be free of obstructions to allow the door to swing free and provide for proper ventilation.

See “Specifications” in Section 2 for more information on the environment in which this rectifier may be installed.

Caution

Do not block rectifier ventilation openings or damage may result due to overheating.

Installation Material Provided

- Input ac lugs:
 - (3) List 1 or 2 WP91412 L53 for 2-gauge wire
 - (3) List 3 WP91412 L2 for 6-gauge wire
 - (See Figure 5-1 and Table 5-A for sizing equivalent lugs.)
- Input ac ground lug:
 - (1) List 1 or 2 WP91412 L108 for 6-gauge wire
 - (1) List 3 WP91412 L52 for 8-gauge wire
 - (See Figure 5-1 and Table 5-A for sizing equivalent lugs.)
- Input ac lug mounting hardware ac conduit reducing washers:
 - Hole provided 1.75 in diameter, 1.25 to 1.00 and 1.25 to 0.50 conduit size
- Output dc mounting hardware
- Central Office Ground lug:
 - (1) WP91412 L54 2-gauge AWG Class B
 - or
 - (1) WP91412 L8 2-gauge AWG Flex
 - (See Figure 5-1 and Table 5-A for sizing equivalent lugs.)
- Central Office Ground hardware
- Mounting plates:
 - (2) plates for side-to-side and back-to-back
 - (See Figure 5-2.)
- Rectifier hole-locating template
- (3) Spare alarm fuses
- (2) Plant control cables for Control and Distribution Bay

Installation Material Required but Not Provided

- Input ac conduit fittings:
 - Hole provided in rectifier for 1.25 conduit, reducing washers (1.25 to 1.00 and 1.25 to 0.50) provided
 - (See Figure 5-2 for location.)
- Input ac cable:
 - 4-wire cable (3-wire with ground conductor) rated minimum 90° C
 - (See Figure 5-2 for location.)

- DC output cable: One 4/0 cable at each of the positive and negative outputs rated minimum 90° C are required. The 4/0 cable is connected to the Control and Distribution Bay.
- Material handling equipment to unload rectifiers at site, remove rectifiers from shipping containers, and set up rectifiers into final positions
- Common electrician's hand tools, including jeweler's screwdriver, electrical tape, and wire cutters and strippers, 6 AWG to 4/0
- Proper crimping tools and dies for connectors (The connectors (lugs), which are specified in Table 5-A, are to be installed with compression tools according to WP91412 specifications.)
- Common mechanic's hand tools, including flat-blade screwdriver (0.30-inch blade width), socket and torque wrenches for 3/8-inch bolts, channel-lock pliers for ac conduit tightening, hammer, and crowbar (for uncrating)
- Drill with 3/4-inch bit to bore holes for floor anchors
- Lifting eye bolts; (4) 5/8-11 threaded holes provided (lifting with all four is required)
- DMM (Digital Multimeter), Fluke® 8060A or equivalent
- DC dummy loads (152 volts, 150 amperes minimum)
- DC output lugs for cable ends at battery
- Cable rack and associated hardware

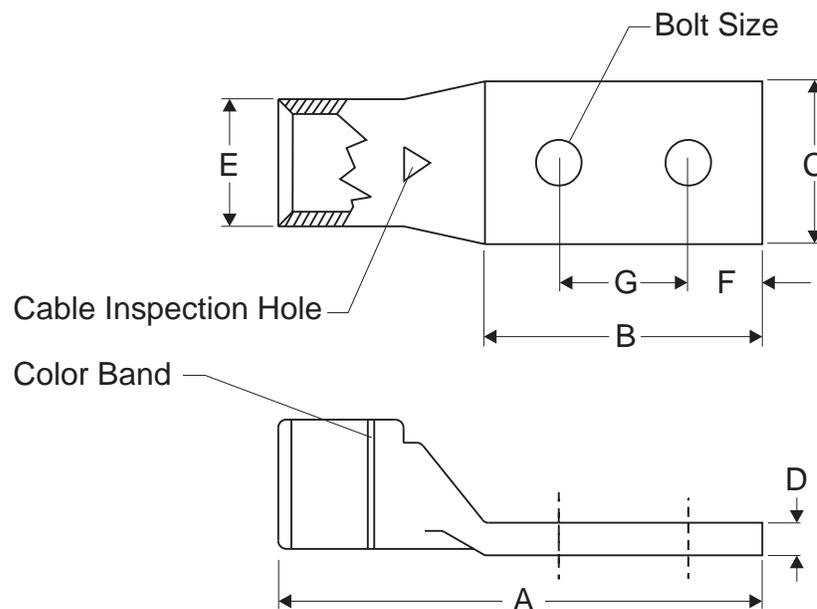


Figure 5-1: Sizing Equivalent Lugs

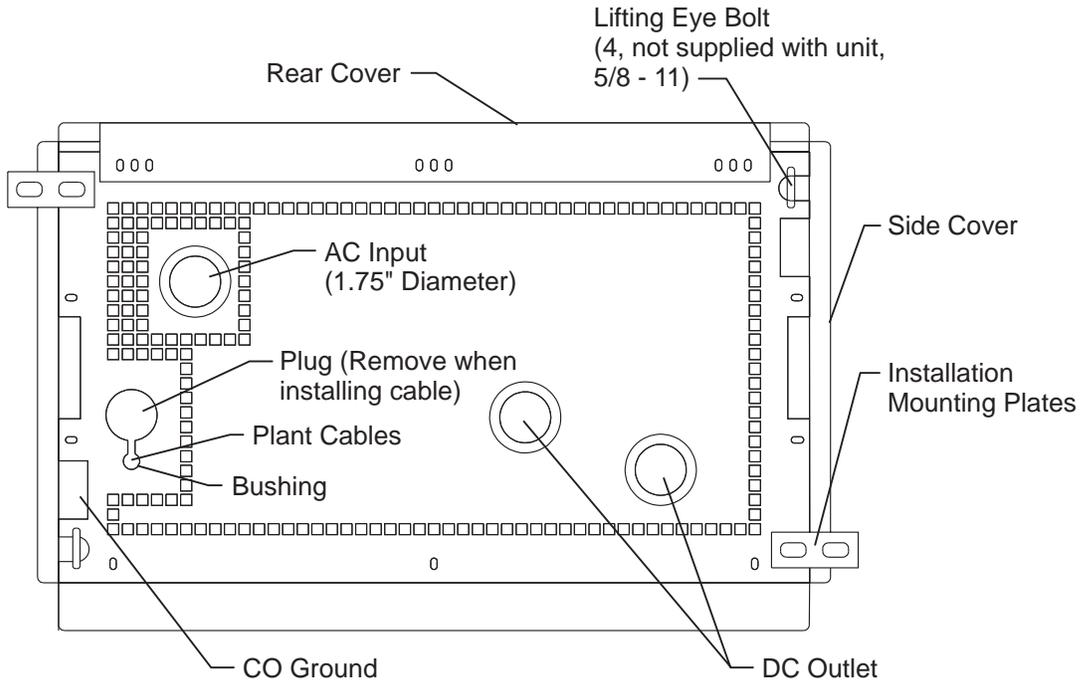


Figure 5-2: Rectifier Top View

Table 5-A: Equivalent Lugs

Type	List	Wire	Part #	Crimp Die		Bolt	A	B	C	D	E	F	G	Note
				No.	Color									
AC Wire Ground	1 or 2	2	WP91412 L53	33	Brown	0.25	1.37	0.56	0.59	0.12	0.41	0.25	--	--
		6	WP91412 L2	24	Blue	#10	1.69	1.06	1.41	1.06	0.25	1.22	0.63	--
AC Wire Ground	3	6	WP91412 L108	24	Blue	#10	1.16	0.51	0.44	0.11	0.28	0.22	--	--
		8	WP91412 L52	21	Red	#10	1.69	1.06	1.41	1.08	0.25	1.22	0.63	--
DC Wire	All	4/0 Flex	WP91412 L27	62	Yellow	0.38	3.19	1.81	1.09	0.19	0.77	0.38	1.00	1
CO Ground	All	2 Class B	WP91412 L54	33	Brown	0.25	2.00	1.19	0.59	0.13	0.41	0.25	0.63	2
		2 Flex	WP91412 L8	37	Green	0.25	2.06	1.19	0.67	0.13	0.46	0.25	0.63	2

Note 1: 1- 4/0 per polarity is the minimum wire size which should be run to the rectifier, considering ampacity. If voltage drop or cable rack heating due to I^2R losses are considered, larger cable may be required. Flex stranding is used in KS-24194 L2-type wire.

Note 2: For CO grounds larger than 2 gauge, use adapter 846377798. EIM89NJ0003 may be useful when sizing this lead.

Installation

Installing or Adding a Rectifier

This section defines the procedure that must be followed to install an additional rectifier to a battery plant. Since the procedure assumes that the rectifier is being added to an operating plant, it is important to perform the tasks in the sequence given to minimize the installer's exposure to hazardous voltages and high current capacities.

This procedure is also appropriate for a new plant.

Note

Before beginning this procedure, read all paragraphs on "Installation Preparation" at the beginning of this section.

DANGER

Use insulated tools when working on electrically *energized* parts.

DANGER

AC voltages in excess of 600V to ground and dc voltages of 175V are present. Follow the procedures in the order they are listed to minimize risk of encounters with these voltages.

DANGER

Before contacting any uninsulated conductor surfaces, always use a voltmeter to ensure that no voltage, or the expected voltage, is present.

Warning

Thermally hot surfaces are located inside the rectifier. Use gloves when handling hot components.

Unpacking and Handling

Warning

The rectifier weighs 1,330 pounds (603 kg). Use appropriate material handling equipment to ensure personal safety and equipment protection.

The rectifier is shipped on its back in a wooden crate. The crate's pallet is designed to be moved by a forklift truck. The crated rectifier weighs 1,600 pounds (727 kg) and measures 82" L (2082 mm) by 36" W (914 mm) by 30" H (726 mm).

Move the crated rectifier to a convenient area for uncrating and follow the steps listed below.

CAREFULLY:

1. Remove any shipping bands.
2. Pry off top, then sides of crate.

IMPORTANT:

3. Inspect exposed exterior of rectifier for shipping damage.
4. With the rectifier lying on its back, open its front door and visually inspect for shipping damage.
5. If material is damaged, contact the shipping company and process a claim form.
6. Remove the parts package from inside the rectifier.
7. Verify that the station main ac voltage agrees with the List option furnished.
 - J87132B-2 List 1 208 Vac
 - J87132B-2 List 2 240 Vac
 - J87132B-2 List 3 480 Vac
8. Using the lifting eye bolts and appropriate material handling equipment, raise the rectifier from the pallet and set it on the floor in its upright vertical position. **All four lifting eye bolts must be used.**

Note

Follow steps in sequence.

Locating and Anchoring Rectifiers

See Figure 5-3.

1. From site drawing information, locate the exact position specified for the installation of the rectifier.

DANGER

Use eye protection devices when drilling holes for floor anchors.

2. Using the template found in the service kit provided with each rectifier, drill holes for a minimum of two diagonally placed floor anchors. (In Zone 3 or Zone 4 earthquake areas, drill all four holes).
3. Set anchors and assemble tie down rods and couplings.
4. Using appropriate material handling equipment, move the rectifier into place, level, shim as necessary, and anchor rectifier with bolts and washers.

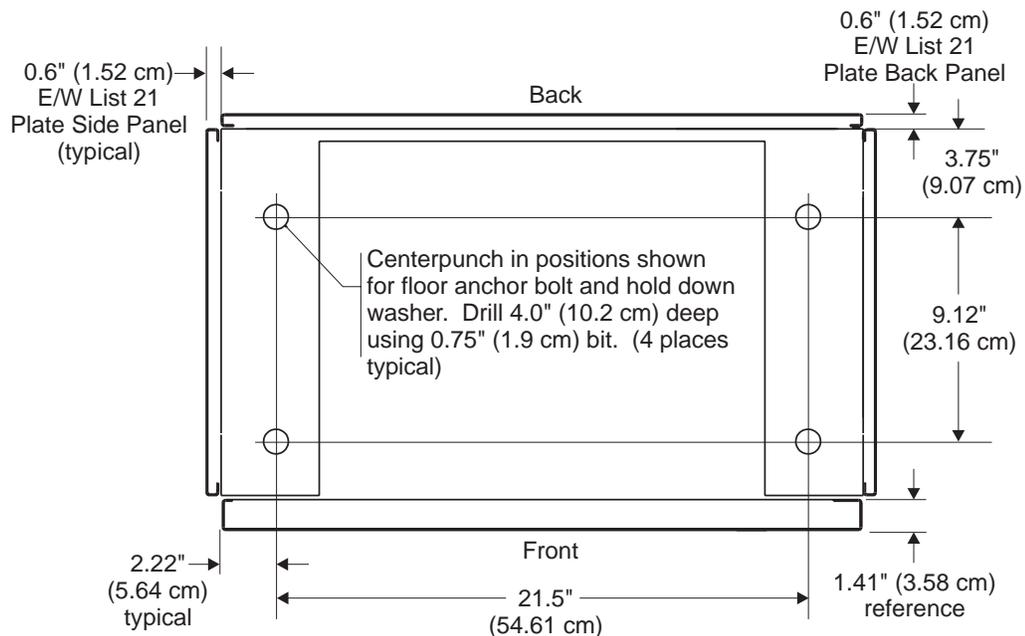


Figure 5-3: Rectifier Footprint

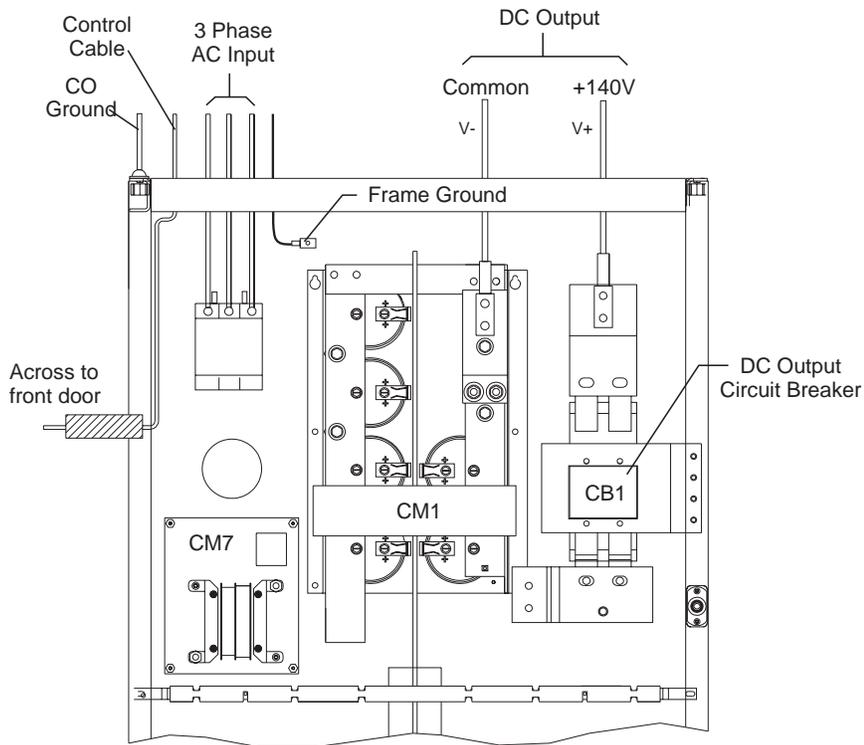


Figure 5-4: Installation of AC and DC Power Cables

**Installation of
AC Power to
Rectifier**

See Figures 5-2 and 5-4.

1. Disconnect ac power from ac distribution service panel to be used to supply ac power to the rectifier.
2. Install circuit breaker in ac distribution service panel. Leave circuit breaker in **Off** position or leave fuse out.
3. The following circuit breakers (or equivalent breakers or fuses) are recommended:
 - 480V_{in} - 50A, KS-22089 L606
 - 208/240V_{in} - 100A, KS-22089 L610
4. Install branch circuit conductors at panel board and route conductors to rectifier.

Caution

Use the proper crimping tool and die for connector being crimped to prevent damage to equipment.

5. Install crimp connectors onto phase leads and ac equipment ground lead as required.
6. Secure phase leads and frame ground lead in rectifier. Install ground lead first. Torque as follows:
 - a. Torque phase connections to 50 in-lbs for Lists 1 and 2 and 30 in-lbs for List 3.
 - b. Torque central office ground connections to 65 in-lbs.
 - c. Torque ac frame ground to 30 in-lbs.
7. Verify that the branch circuit breaker in the panel board is off or fuses are removed. Reenergize ac distribution service panel. Tag branch circuit breaker to inform others not to close the breaker.

***Installation of DC
Power Cables***

See Figures 5-2 and 5-4.

1. Turn DC Output circuit breaker CB1 to **Off**.
2. Measure the lengths of cable required to run the positive circuit (circuit breaker) from the rectifier to its termination on the charge bus, and to run the negative return from the rectifier to its termination on the charge ground bus.
3. Cut cables to length and install crimp connectors.

Caution

Use proper crimping tool and die for connector being crimped to prevent damage to the equipment.

4. Tape or otherwise insulate the connectors on the end of each cable that does not terminate in the rectifier.

DANGER

Plant bus bars are *energized* (+150Vdc). Remove all jewelry and use insulated tools.

5. Lay-up each negative return cable in cable rack.
6. Thread the rectifier return lead ends of cables through the rectifier and terminate connectors on the negative ground

bus bar in the rectifier. Torque connections to 240 in-lbs (see Figure 5-4).

7. One at a time, remove tape or insulation from connector at other end of cable and terminate on plant charge ground bus bar.
8. Lay-up ungrounded (*energized*) positive output cables in cable rack.
9. Thread rectifier ends of cables through rectifier and terminate connectors on positive bus bar in rectifier. Torque to 240 in-lbs (see Figure 5-4).

Warning

Avoid arc or sparks. Before making contact of connectors to bus bar in next step, use Digital Multimeter to measure true open circuit between each connector and known battery plant ground.

10. One at a time, remove tape or insulation from connector. Terminate connector on positive (*energized*) charge bus bar.

Installation of Supplemental Rectifier Grounding

Install supplemental rectifier grounding on top of rectifier (see Figure 5-2). The ground conductor is usually terminated on the central office ground bus. Torque to 65 in-lbs.

Installing Two Plant Control Cable Assemblies

This section describes the procedures for installing the Plant Control and Voltage Sense Cable Assemblies between the Control and Distribution Bay and the rectifier (see Figure 5-5). There are two control cables, one carrying voltages less than 60 volts to the controller, and another carrying the voltages above 100 volts to the Control and Distribution Bay.

The Plant Control Cable Assembly is factory assembled with a 34-pin connector on one end and a 40-pin connector on the other end. The 40-pin end terminates on the controller, and the 34-pin end terminates on connector **P202** of the **CM2** control board in the rectifier.

The Plant Voltage Sense Cable Assembly is factory assembled with a 6-pin mini-molex connector on each end. One end terminates on the BNF2 alarm board in the H569-429 Control and Distribution Bay, and the other end terminates on **P208** of **CM2** in the rectifier.

1. Route the cables from the plant controller chassis via the cable racks to the rectifier, then through the holes provided (see Figure 5-2).
2. Terminate the 34-pin connector on **P202** of **CM2**, terminate the 6-pin connector on **P208** of **CM2**, and dress the cable (using the strain relief bushings and cable ties provided) inside the rectifier, allowing for the front door to be opened and closed without putting stress on the cable. After securing the cable, disconnect the cables from **P202** and **P208**.
3. Determine the number to be assigned to the rectifier in the rectifier lineup, that is 1, 2, 3, etc.

Caution

<p>Remove the REG fuse associated with the subject rectifier. Plug the cable with the 40-pin connector into the Galaxy Controller connector assigned to the rectifier number designated in Step 3. Plug the cable with the 6-pin connector into the connector on the BNF2 assigned to the rectifier designated in Step 3.</p>

4. Dress and tie down the cable to afford stress relief at the connector. The grounding terminal ring must be straight (not bent out from door) so that the control cables with spiral wrap do not interfere with the plastic ac cover.

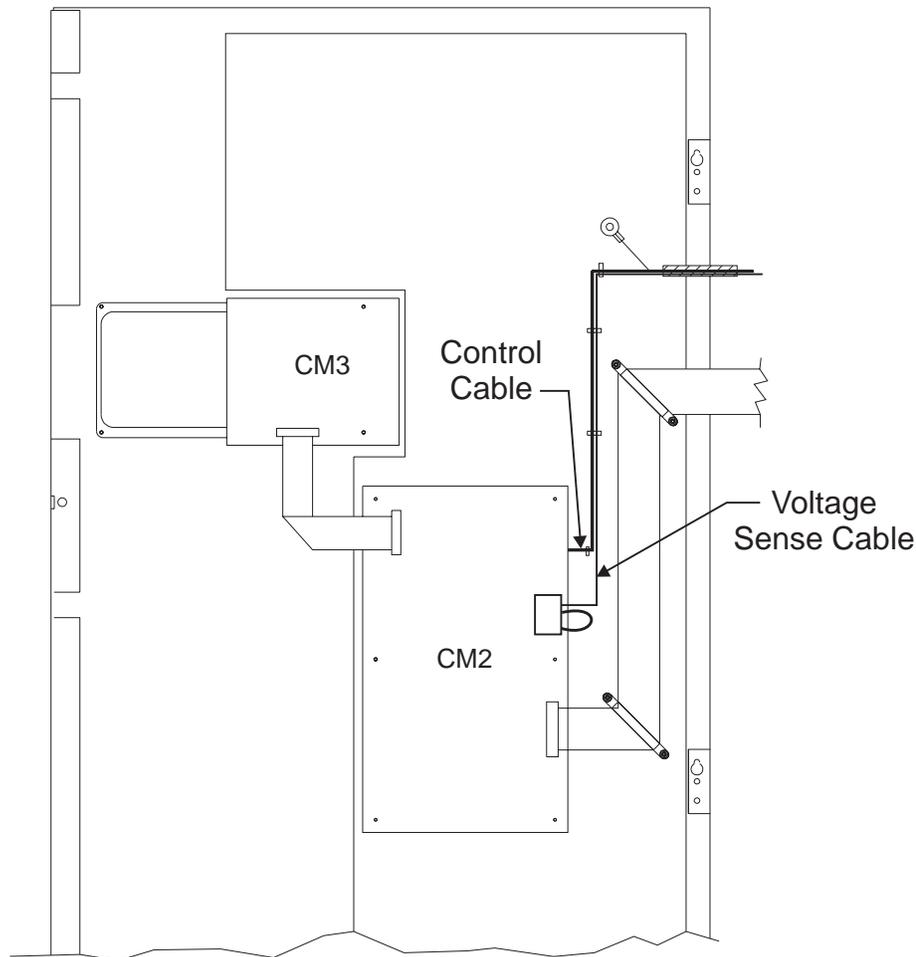


Figure 5-5: Plant Control Cable Assembly between Controller and Rectifier

Initial Startup and Checkout

The procedures in this section are for testing rectifiers in a newly installed battery plant as well as for testing rectifiers being added to an existing plant. If the plant to which the rectifier is being connected has never been operational, consult the plant and controller product manuals for their installation test procedures. **The rectifier installation test must be performed at the proper time after plant and controller tests have been completed.**

Electrical Testing for Rectifiers

The following procedures can be used to verify that the rectifiers are working after initial installation, subsequent addition, or replacement of a rectifier. For troubleshooting and diagnostics, refer to the paragraph on “Diagnostics and Troubleshooting” in Section 7, *Maintenance*. Those unfamiliar with the function of

rectifier controls and indicators should read Section 6, *Operating Controls and Displays*.

DANGER

Voltages in excess of 600 volts are present in the rectifier. Exercise extreme care to avoid contact with exposed terminals.

AC voltage is present even when the Power switch is in the **Off** position.

Before turning on any rectifier, be sure that the associated framework and cable rack are properly grounded according to local job instructions.

The rectifier output filter capacitors stay charged for long periods of time. Check that they have discharged adequately before contacting any exposed terminals inside the rectifier. Do not work on the rectifier until capacitors have discharged below 50Vdc.

The rectifier digital meter stays lit until output filter capacitors have discharged to approximately 30Vdc.

Warning

Do not operate the **DC Output** circuit breaker (**CB1**) to **On** until told to do so.

Preparation The following information covers initial settings of equipment and meter, and the test connections necessary before beginning the test.

Caution

Be sure that connections to circuit packs are not made or removed with voltages present. Before disconnecting a cable from a circuit pack, operate the **Power** switch to **Off** and remove the ac input voltage by turning off the breaker in the ac distribution panel. If the remote sense cable is connected, remove the associated REG fuse from the plant control panel, and then disconnect the remote sense cable. The **DC Output** circuit breaker should then be turned **Off**. Now, circuit packs can be disconnected or connected. After reconnecting all circuit packs, restore the ac, operate the **Power** switch to **On**, and verify that the digital meter reads approximately the battery voltage with switch **S1** set to the **Rect V** position, indicating that the filter capacitors are charged.

Note: The rectifier may shut down, generating a rectifier fail alarm. If the rectifier does shut down, monitor the **Rect V** voltage. When the **Rect V** voltage reaches 140V to 150V, turn the circuit breaker **On**.

If rectifier does not shut down, wait 10 seconds and close the **DC Output** circuit breaker. If complete plant connections are to be restored, operate the **Power** switch to **Off**, reconnect the remote sense cables, and then install the associated REG fuse.

Failure to follow this procedure could result in damage to the circuit boards.

Verify that the ac supply and rectifier controls are set as follows:

Controls	Position/Status
Associated ac circuit breaker	Off and locked out
Rectifier Power switch	Off
Rectifier DC Output circuit breaker	Off
Output Volts Adjust	Fully down
Plant control connector (P202) and remote sense cable (P208) mounted on inside of front panel door on CM2 control board	Disconnected
REG fuse in Control and Distribution Bay	Removed

Refer to the documentation for the H569-429 Control and Distribution Bay. Perform all the preliminary checks on the plant up to the point where the rectifier tests are called for. If a battery is present and connected to the charge and charge-return bus bars, use the digital multimeter on the dc volts scale to verify that battery voltage is present between the rectifier output charge terminal and ground.

Figure 5-6 shows the location of the circuit packs in the J87132B-2 rectifier. Figure 5-7 is a replication of the DIP Switch Settings label that is located inside the front door of the rectifier.

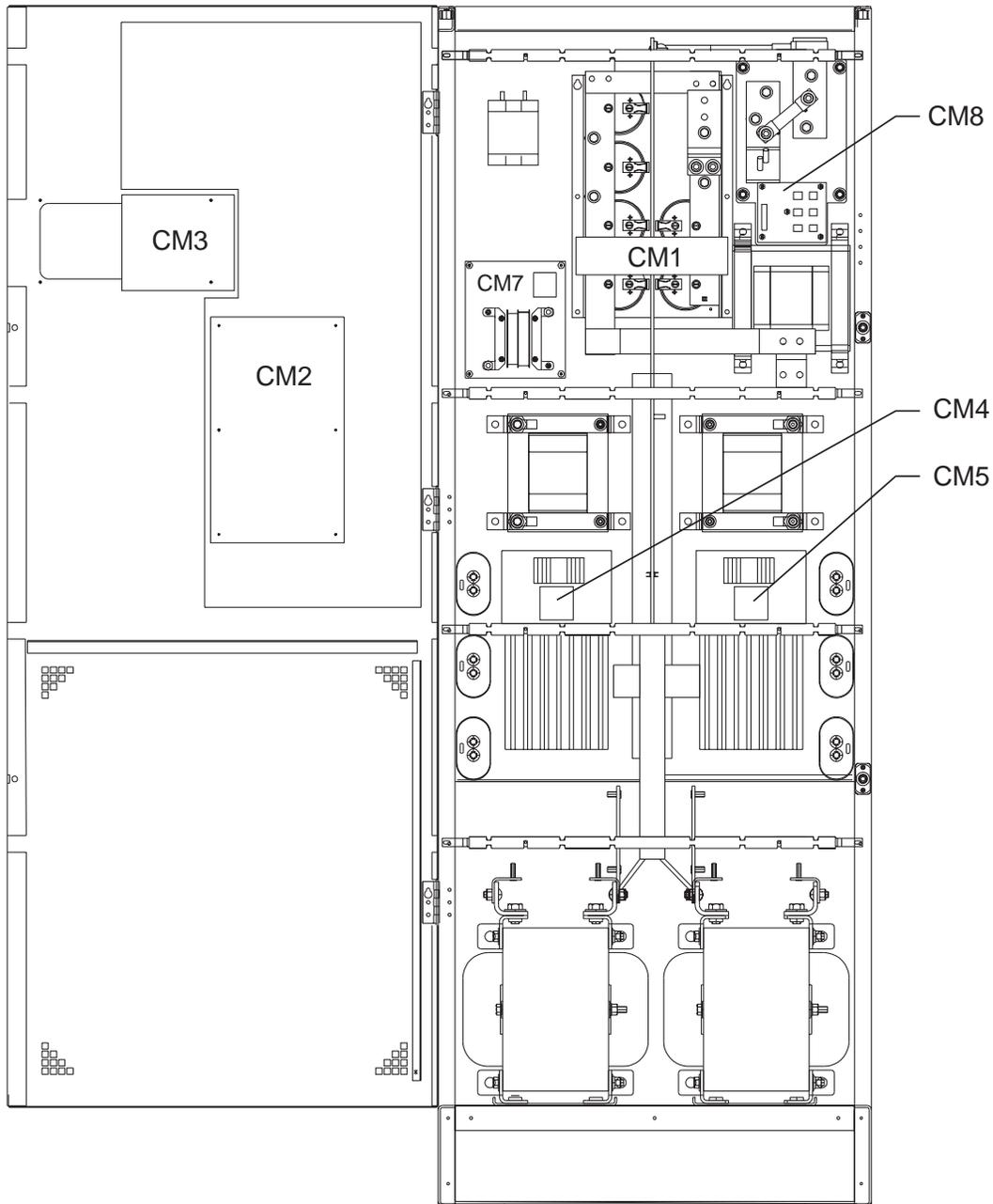


Figure 5-6: Location of Circuit Packs in the Rectifier

DIP SWITCH SETTINGS						
BOARD	SWITCH	FUNCTION	FIELD ADJ	FACTORY SETTING	OPTION (SWITCH SETTING)	
CM2	S203.1	BUHVSD LEVEL ADJ	YES	0	SEE TABLE A	
	S203.2	BUHVSD LEVEL ADJ	YES	0	SEE TABLE A	
	S203.3	BUHVSD LEVEL ADJ	YES	0	SEE TABLE A	
	S203.4	BUHVSD LEVEL ADJ	YES	0	SEE TABLE A	
	S205.1	ISHVSD LEVEL ADJ	YES	1	SEE TABLE B	
	S205.2	ISHVSD LEVEL ADJ	YES	1	SEE TABLE B	
	S205.3	LOCAL EQUALIZE DISABLE	YES	1	ENABLE: SET TO 0	
	S205.4	METER ON WITH UNIT OFF	NO	1	1=METER OFF WITH UNIT OFF	
S205.5	METER CALIBRATE	YES	0	1=ALLOWS CALIBRATION OF FRONT METER PANEL		
S205.6	FACTORY TEST	NO	0			
S205.7	FACTORY TEST	NO	0			
S205.8	FACTORY TEST	NO	0			

SWITCH	163	166	169	172	175	178	182	185
S203.1	0	1	0	0	0	1	0	0
S203.2	0	0	1	0	0	0	1	0
S203.3	0	0	0	1	0	0	0	1
S203.4	0	0	0	0	1	1	1	1

SWITCH	FUNCTION	160V	163V	166V	DISABLE
S205.1	ISHVSD	1	0	1	0
S205.2	ISHVSD	1	1	0	0

EQUALIZE MODE AUTOMATICALLY DISABLES ISHVSD

NOTE: SEE PRODUCT MANUAL FOR DETAILED EXPLANATION OF SWITCH SETTINGS.

BUHVSD - BACK UP HIGH VOLTAGE SHUTDOWN
 ISHVSD - INTERNAL SELECTIVE HIGH VOLTAGE SHUTDOWN

WARNING: ADJUSTMENT OF NON-FIELD ADJUSTABLE SWITCH SETTINGS MAY RESULT IN DAMAGE TO THE RECTIFIER.

CONNECTION IDENTIFICATION	LIST CONFIGURATION	SIZE	TORQUE IN.-LB.	TORQUE Nm
OUTPUT DC	ALL	3/8-16	240	30
C.O. GROUND	ALL	1/4-20	65	8
A.C.E.G	ALL	10-32	30	4

SPARE FUSE
 REPLACEMENT FUSE F1,F2,F3,F4 AND F5 FOR THE CIRCUIT MODULE CM1 ARE RATED FOR .18A AND 160VDC.
 WP-90247 , L-101, COMCODE 40771573

OPEN OFF CLOSED ON

847839420

Figure 5-7: DIP Switch Settings (Label Inside Front Door of the Rectifier)

Test Procedures

The following steps are for the actual test procedures. The procedures are:

- Startup
- Internal Tests
- Test Completion - Adjusting Rectifier to Float Voltage

Note

Deactivate the efficiency algorithm before performing these procedures. See instructions in the Galaxy Controller product manual.

- Startup**
1. Program DIP switches for the required rectifier application as shown in the switch setting chart displayed inside the front door of the rectifier. (See Figure 5-7.)

Note

The Galaxy Controller provides the rectifier with a High Voltage Shutdown (HVSD) signal. Verify that the rectifier's Internal Selective High Voltage Shutdown (ISHSD) circuit has been factory set to 160 volts. If not, close switch positions S205.1 and S205.2 of S205 on the CM2 circuit module according to Figure 5-7. Also, verify that the BUHVSD is factory set to 163 volts. If not, adjust to 163 volts according to Figure 5-7.

2. Turn on the ac supply to the rectifier at the ac distribution.
3. Set the digital test multimeter to measure 200Vdc, and connect it to the rectifier side of CB1 and dc output return bus.
4. Operate the **Power** switch to **On**. The rectifier should start. The digital test multimeter should indicate between 140 and 150 volts. (If the rectifier does not start, refer to "Diagnostics and Troubleshooting" in Section 7, *Maintenance*.)

- Internal Tests**
1. Adjust **Output Volts Adjust** up until the rectifier shuts down from BUHVSD (factory set at 163V).
 2. Turn rectifier **Power** switch to **Off**.
 3. Adjust **Output Voltage Adjust** down (approximately 150 volts).
 4. To bring the rectifier into service:

Note

The following tests are performed **ON BATTERY**.

- a. Turn the rectifier **Power** switch to **On**. The green **Power** LED must light. Wait ten seconds.

- b. Hold the meter selector switch in the **Rect V** position. Adjust output float voltage (**Output Volts Adjust** pushbutton) until the digital meter reads approximately battery voltage, typically 151.9 volts.

Caution

Do not turn on CB1 until Step 10. Be sure and follow turn-on procedure.

- c. Turn the Power switch to **Off**.
5. At the rectifier, connect the control cable connector **J202 to P202**, and **J208 to P208**, of CM2.
6. Turn the rectifier **Power** switch to **On**.
7. Close the rectifier front door and secure the locking screws.
8. Adjust the rectifier to float voltage (151.9V).
9. Enable efficiency algorithm at controller (see Galaxy Controller product manual).
10. After ten seconds, turn the rectifier **Power** switch to **Off**, and within five seconds turn the **DC Output** circuit breaker (**CB1**) to **On**. Replace REG fuse at Control and Distribution Bay and turn the rectifier **Power** switch to **On**.

Note

If no load is present, connect a load box across the charge and charge return bus bars. For test load connection and removal, see the paragraph on "Test Load Connection and Removal" in Section 7, *Maintenance*.

11. Adjust **Rectifier Output Volts** up to 151.9 volts. Adjust load to provide between 14 and 50 amperes.
12. Connect the test meter to the **Plant** jacks on the rectifier control panel. Hold the meter selector (**S1**) switch in the **Plt V** position. The digital display should agree with the digital test meter within ± 0.1 volt. If not, refer to Section 7, "Calibrate CM3 Digital Meter."

13. Observe the amperes reading on the rectifier's digital meter. Operate the **Rect Test** switch to the **NL** position. The output amperes should decrease.
14. Operate the **Rect Test** switch to the **FL** position. The output current should increase.
15. Connect a digital test meter across the source side of the output circuit breaker and the rectifier ground bus. Hold the **Rect V-Amps-Batt V** switch in the **Rect V** position. The digital display should agree with the digital test meter within ± 0.1 volt. Release the switch. If the displays do not agree, refer to Section 7, "Calibrate CM3 Digital Meter."

Note

Neither calibration nor adjustment is feasible unless the test meter has an accuracy of ± 0.02 percent or better. If calibration is indicated, refer to the paragraph on "Diagnostics and Troubleshooting" in Section 7, *Maintenance*.

Note

The F101, F102, F103, F104, and F105 alarm fuses are located inside the rectifier on the CM1 control module (see Figure 5-6).

16. Insert a blown fuse into the fuse holder **F101** on the rectifier CM1 control module. Note that the rectifier shuts down and the **RFA** and **FA** alarm indicators on the rectifier light.
17. Restart the rectifier by cycling the rectifier **Off**, then **On**.
18. Repeat Steps (16) and (17) for the **F102** alarm fuse located on CM1.
19. Repeat Steps (16) and (17) for the **F103** alarm fuse located on CM1.
20. Repeat Steps (16) and (17) for the **F104** alarm fuse located on CM1.
21. Repeat Steps (16) and (17) for the **F105** alarm fuse located on CM1.

22. The following additional tests must be performed:
 - a. Check that the Galaxy Controller has been configured to recognize the J87132B-2 140A rectifier.
 - b. Verify the isolated current measuring circuit (see “Isolated Current Measuring Circuit” in Section 7, *Maintenance*).
 - c. Verify the current limiting adjustment (see “Current Limit Circuit” in Section 7, *Maintenance*).

***Test Completion
- Adjusting
Rectifiers to
Float Voltage***

1. Measure the battery voltage by holding the meter selector (**S1**) switch in the **Plt V** position.

Note

The rectifiers must be on line with plant cables connected and REG fuses in place.

2. If the battery voltage is not 151.9 ± 0.1 volt, perform the following:
 - a. If the voltage is too high, adjust **Output Volts Adjust down** on the rectifier with the highest output current.
 - b. If the voltage is too low, adjust **Output Volts Adjust up** on the rectifier with the lowest output current.
 - c. Check the battery voltage and repeat the steps above until the battery voltage is within the required tolerance of the desired float voltage.
3. If all rectifiers are not carrying some load current (between 5 percent and 95 percent of rated load):

Note

Rectifiers are not required to share load current equally.

- a. Turn off all spare rectifiers, but leave enough rectifiers on to handle the load current.
- b. Adjust **Output Volts Adjust up** on rectifiers carrying less than 5 percent rated load until they carry more than 5 percent rated load.

- c. Adjust **Output Volts Adjust down** on rectifiers carrying more than 95 percent rated load until they carry less than 95 percent rated load.
- d. Repeat from Step 2 (battery voltage check and adjustment) until all rectifiers are carrying between 5 and 95 percent rated load and the battery voltage is within the required tolerance of the desired float voltage.
- e. Turn on one of the spare rectifiers, and turn off one of the previously loaded rectifiers (same number of rectifiers on), and repeat parts (b) through (d). Repeat this procedure for each spare rectifier that has not been adjusted.
- f. Upon completion, turn all rectifiers **On**.

Initial Battery Charge Procedure

The rectifier described in this manual is capable of supplying a new battery string with its initial charge. Since the voltage levels recommended by battery manufacturers for initial battery charging are considerably above the normal plant voltage, neither the battery nor the rectifier used to supply its initial charge should be connected to the rest of the plant during this procedure. One rectifier should be sufficient to supply the charge. However, the high voltage shutdown levels must be raised to accomplish the initial charge. The following procedures describe how to raise the high voltage shutdown levels.

AC Supply and Rectifier Controls

Operate the ac supply and rectifier controls as follows:

Controls	Position/Status
Rectifier Power Switch	Off
Rectifier DC Output Circuit Breaker	Off
Float/Equalize	Float
Output Volts Adjust	Minimum Setting
Plant control connector (P202) located on CM2	Disconnected
Plant remote voltage sense connector (P208) located on CM2	Connected
REG Fuse	Removed

1. To disable the Internal Selective High Voltage Shutdown (ISHVSD), see switch table located inside rectifier door.
2. To shift the Backup High Voltage Shutdown (BUHVSD) level upward, see the switch table located inside the rectifier door.

After these temporary modifications have been made, perform the following steps.

1. Close the front rectifier panel.
 - a. Turn the rectifier **Power** switch **On**. The green **Power** LED must light. Wait 10 seconds.
 - b. Hold the meter selector switch in the **Rect V** position. Adjust **Float Voltage** up until the digital meter reads approximately battery voltage, typically 151.9 volts.

Caution

Do not turn on CB1 until Step 6. Be sure and follow turn-on procedure.

- c. Turn the power switch **Off**.

Note

Check that the REG fuse is not installed.

2. At the rectifier, connect the control cable connector **J202** to **P202** of CM2.
3. At the Control and Distribution Bay, install the REG fuse associated with the rectifier that is being placed in service.
4. Turn the rectifier **Power** switch **On**.

Caution

In the following step, DO NOT set the rectifier output voltage to exceed 175 volts or damage to the unit may result.

5. Adjust the **Output Volts Adjust** to obtain the desired initial charge voltage (within the limits specified in the preceding caution).

6. After completion of the initial charge procedure, operate the rectifier **Power** switch to **Off**, remove REG fuse, and turn the **DC Output** circuit breaker (**CB1**) **Off**. Restore the original switch setting configuration for ISHVSD and BUHVSD on the **CM2** board to the factory default settings of 160 and 163 volts, respectively. Refer to the switch setting label located inside the front door on the rectifier.

Restore Rectifier to Float Service

To restore the rectifier to float service:

1. With the rectifier turned off, adjust the **Output Volts Adjust** to its minimum setting.
2. Reinstall the REG fuse in the Control and Distribution Bay.
3. To restore the rectifier to float service, follow the procedure entitled “Test Completion - Adjusting Rectifiers to Float Voltage” in the paragraph on “Test Procedures” earlier in this section.

Disconnecting a Rectifier

The procedure for disconnecting a rectifier from an operating plant is the first part of the task of replacing a rectifier.

Note

Before performing this procedure, personnel should be familiar with “Initial Startup and Checkout” procedures.

It is extremely important to perform the steps of this procedure in the order given to minimize the installer's exposure to hazardous voltages and high current capacities.

DANGER

AC voltages up to 600 volts to ground, and dc voltages of 175 volts with high current capacities, may be present in the equipment. Follow the procedures in the order given to minimize dangerous encounters with these voltages.

Procedure

1. At the rectifier control panel, operate the **Power** switch to the **Off** position. Remove REG fuse. Operate the **DC**

Output circuit breaker (**CB1**) to the **Off** position. Remove REG fuses associated with the rectifier remote sense leads.

2. At the ac distribution service panel, open the circuit breakers that are supplying the rectifier with ac power. Tag and lock out the circuit breaker and instruct all personnel to leave circuit deenergized.
3. Disconnect the plant cable assemblies from the rectifier **CM2** control board at connectors **P202** and **P208**. The cable assemblies must be removed from the cable tie anchors to permit their withdrawal through the conductor opening in the cabinet. The cable tie anchors, while providing a secure physical support of the cable assembly, protect the cable assemblies from undesirable abrasion and bending.

DANGER

Before contacting any uninsulated conductor surfaces, always use a voltmeter to ensure that no voltage, or the expected voltage, is present.

Use insulated tools when working on electrically *energized* parts.

Exercise extreme caution when working near the battery bus bars.

Rectifier output filter capacitors stay charged for several minutes. Check that they have discharged to below 50 volts before contacting any exposed terminals inside the rectifier.

The front panel meter remains lit until the voltage reaches about 30 volts.

Caution

Use care when performing the following procedures or damage to the equipment may result.

4. The rectifier output filter capacitor must be completely discharged. Verify by connecting a DMM directly to the capacitor bus bars inside the rectifier. It will take several

minutes to completely discharge the capacitors after the **DC Output** circuit breaker (**CB1**) is turned **Off** (Step 1).

5. One at a time, disconnect the battery plant end of the dc output and output return conductors from the battery plant **CHG** and **CHG GRD** bus bars. Insulate the connector ends and label the conductors for easy identification when reconnecting.
6. One at a time, disconnect the dc output conductors from the rectifier *energized* and *return* bus bars. Insulate the connector ends and label the conductors for easy identification when reconnecting.
7. One at a time, disconnect the ac input conductors from their terminations and the ac equipment ground (green) conductor from the **FRAME GRD** in the cabinet. Insulate the connector ends and label the conductors for easy identification when reconnecting.
8. Unfasten the ac conduit that is structurally attached to the rectifier. Displace the disconnected conduit to the side, and, if necessary, tie the conduit to an adjacent structure to prevent interference with the rectifier removal.

DIP Switch Settings

Functions **208G Board (CM2):**

S205.1 - S205.2 permit the internal selective high-voltage shutdown (ISHVSD) level to be adjusted.

S203.1 - S203.4 sets the level of the backup high voltage shutdown (BUHVSD)

6 *Operating Controls and Displays*

Rectifier Operation

The following information provides a functional description of those components to be visually observed and manually operated during normal rectifier operation.

Front Panel Controls and Indicators

The controls and indicators located on the rectifier front panel function as follows. See Figure 6-1.

- **Power Switch:** Rectifiers have a standard on and off switch. When the switch is in the **Off** position, the rectifier is off and cannot be turned on by the plant controller. When in the **On** position, the Galaxy Controller can remotely turn the rectifier on or off to satisfy the plant load current requirements.
- **Power On Indicator:** This green LED indicates that the rectifier is on.
- **Output Meter and Control Switch:** The meter will display either the output current of the rectifier when the switch is in the center position, the rectifier output voltage when in the up position, or the plant voltage when in the down position. The center position is the default, and the voltage reading is observed when the switch is held up or down. The accuracy of this meter in the various positions is as follows:

Meter Position	Accuracy
Rect V	±0.1 volt
Plt V	±0.1 volt
Amps	±2.5% of meter reading ±2 amperes

Note

With the remote sense cable disconnected, or the REG fuse removed, the plant voltage display reads an erroneous voltage that should be disregarded. Plant voltage is displayed only when the remote sense cable is connected to the rectifier and the REG fuse is installed.

- **PHA** (Phase Alarm) Indicator: This red LED provides visual indication of unacceptable ac input voltage levels or loss of an input phase.
- **RFA** (Rectifier Failure Alarm) Indicator: This red LED provides visual indication of a rectifier shutdown because of a blown fuse, an internal unbalance, or an external or internal high voltage.
- **FA** (Fuse Alarm) Indicator: This red LED provides visual indication of a blown rectifier sense fuse (F102 and F104 alarm fuses on CM1), dc output filter capacitor alarm fuse (F101 on CM1), blown auxiliary bias fuse (F103 and F105), or tripping of the rectifier's output circuit breaker.

Capacitor Fuse (F1 through F6): Each output filter capacitor is protected by its own fuse. If any capacitor fuse operates, the **F101** alarm fuse located on CM1 will open and generate an **RFA** Alarm (Rectifier Failure Alarm) and light the FA and RFA LEDs.

Sense Fuses (F102, F104): These fuses protect voltage sense leads to the rectifier control and regulation circuits. The fuses are located inside the rectifier on the CM1 circuit module and correspond to +V and -V on earlier Lineage[®] 2000 rectifiers.

- **ACF** (AC Fail) Alarm Indicator: This red LED is lit if the ac fails. It will only light if the battery voltage is present when the ac fails.
- **EQ** (Equalize) Indicator: This yellow LED provides a visual indication that the rectifier is in the equalize mode.
- **FLT/EQ** Switch: When the switch is set to **FLT**, manual adjustment of float voltage may be performed. When the switch is set to **EQ**, manual adjustment of equalize voltage may be performed if not disabled by S205 on CM2. This switch provides local control of equalize function and **should not** be used when connected to a Galaxy controller.

- **Raise Voltage/Lower Voltage:** Provides a manual pushbutton adjustment of rectifier output voltage.
- **Rect Test Switch:** The switch tests the rectifier regulation by simulating a full load or no load condition on the output (**FL** or **NL** position). When in the center position, the rectifier is in the normal operating state. May also be used to check current limit; it is also used in calibrating digital meter.
- **Rect Test Points:** These jacks are used to measure the rectifier's terminal voltage.
- **Plant Test Points:** These test points are used to measure the output voltage at the points where the remote sense leads are connected, and are accurate only when the remote sense leads are connected.
- **FLT Indicator:** Indicates that the rectifier is in its normal operating mode.

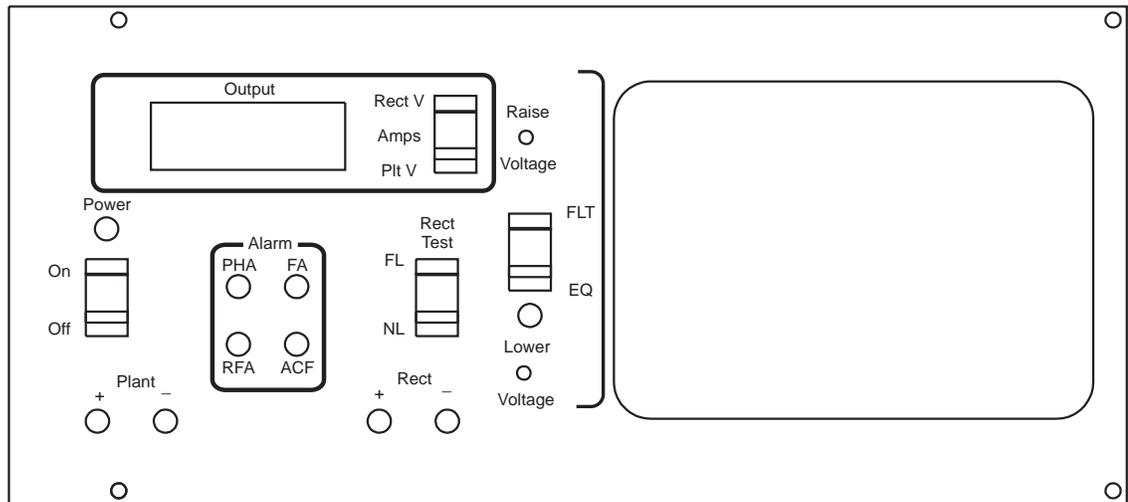


Figure 6-1: J87132B-2 Rectifier Control Panel

***DC Output
Circuit Breaker
(CB1)***

The **DC Output** circuit breaker (**CB1**) is located on the front panel. The circuit breaker protects the rectifier from malfunction and overcurrent conditions. It may also be used to electrically disconnect the battery from the rectifier for test purposes. When the circuit breaker is operated to the trip position (midway between **On** and **Off**) by an overcurrent condition, an alarm is transmitted to the power plant controller and the **RFA** LED is lit. If the circuit breaker is manually turned off, no alarm is transmitted.

Caution

If an incorrect procedure for operating CB1 is used, output filter fuses may operate.
--

The proper procedure to close **CB1** is as follows:

1. Remove REG fuse at the Control and Distribution Bay.
2. Place the **Power** switch to **On**. The green LED, if provided, must turn on. Wait 10 seconds.
3. Place the **Rect V-Amps-Plt V** switch in the **Rect V** position. Adjust to the float voltage in the **Rect V** position.
4. Place the power switch to the **Off** position.
5. Immediately (within 5 seconds) place the dc output breaker to **On**.
6. Install REG fuse at Control and Distribution Bay.
7. Place the **Power** switch to **On**.

***Front Panel
Conditions***

Table 6-A lists possible front panel conditions and describes their significance. These pages may be copied and kept with the rectifier or by service personnel.

Table 6-A: Front Panel Conditions

Front Panel Condition	Description
Power On LED On Output Meter Lit	Rectifier operating normally
Power Switch On Power On LED Off	Rectifier turned off by plant controller or AC Power Loss without battery connected
Power Switch On Power On LED Off/PHA LED On	Unacceptable AC Input source, either too low or loss of phase
Power Switch On Power On LED Off/FA and RFA LEDs On	Blown fuse inside the Rectifier or tripped Circuit Breaker
Power Switch On Power On LED Off/RFA LED On	Rectifier shut down due to high voltage or an internal unbalance
Power Switch On Power On LED On/EQ LED On	Rectifier placed in Equalize by controller
Power Switch On Power On LED Off/CB1 Tripped (Handle Midway Between On and Off) RFA and FA LEDs On	Rectifier's output breaker tripped
Power Switch On, FLT/EQ Switch on EQ, Power LED On, Equalize LED On	Rectifier placed in Equalize by front panel
Power Switch On Power On LED On/CB1 Off	Rectifier's output breaker manually turned Off
Power Switch Off	Rectifier manually turned Off
Note: When power is removed from the rectifier, the LEDs may be lit until the rectifier dc output voltage reaches about 30 volts.	

7 *Maintenance*

Introduction

Please read Section 4, *Safety*, carefully before troubleshooting or maintaining the J87132B-2 rectifier.

This section provides comprehensive diagnostic and troubleshooting information for the rectifier described in this manual. Those unfamiliar with the function of rectifier controls and indicators should read Section 6, *Operating Controls and Displays*.

Test Load Connection and Removal

The following procedures are used to connect (and disconnect) a test load when called for in a test or other procedure. The steps **MUST** be followed in order. Refer to the rectifier control panel in Figure 6-1, if necessary, during performance of the procedure.

DANGER

Plant bus bars are *energized* (150Vdc) with high current capability. Remove all jewelry.

DANGER

Use insulated tools when working on electrically *energized* parts.

Note

Test load connections are made on the internal bus of the rectifiers; to isolate the rectifier from the battery and plant bus, the rectifier **DC Output** circuit breaker (**CB1**) must be left off and REG fuse removed while the test load is connected before the circuit breaker. The control cables must be disconnected from the 208G board or the rectifier output voltage may be unstable.

1. At the ac distribution panel, remove ac power to the rectifier. Lock out circuit breakers for safety reasons.
2. Turn rectifier **DC Output** circuit breaker (**CB1**) off.

Warning

The rectifier output filter capacitors stay charged for several minutes after removal of power. Check voltage across capacitors and do not work inside rectifier until they are completely discharged. The digital meter stays lit until filter capacitors discharge below 30Vdc.

Caution

Support the CM2 control board with your hands when disconnecting the cable or damage to CM2 may result.

Caution

Do NOT disconnect the plant controller cable connector **J202** or plant voltage sense cable J208 from the CM2 control board by pulling the cable.

3. Remove REG fuse, then disconnect the plant controller cable connector **J202** and plant voltage sense cable **J208** from the **CM2** control board by first unlatching, then pulling the cable header connector.
4. Connect the test load between the input bus to **CB1** (bolted joint on bus attached to lower part of **CB1**) and any convenient point on the ground bus anywhere in the plant.

5. Reconnect the ac input to the rectifier to perform the tests under load. **Leave rectifier dc output circuit breaker (CB1) off.**

Note

The regulation off battery and with the control cable disconnect at the rectifier will be $\pm 2\%$.

6. When the tests under load are completed, remove the ac input to the rectifier, and then remove the test load connections. Reconnect the plant control cable connector **J202** and plant voltage sense cable **J208** to **CM2** and install REG fuse.
7. To reconnect the rectifier to the plant, restore ac power to the rectifier, and then restore the rectifier to service.

Note

The procedure for restoring the rectifier to service is described in the paragraph "Restore Rectifier to Service."

Preparation for Testing

Voltages required for the operation of the ac contactor control relays and the ac contactor are derived from the ac input voltage. They do not depend on plant battery voltage for power. All other circuitry is powered by a redundant bias supply derived from both the ac supply and the plant battery.

Remote sensing occurs with the REG fuse installed and connector installed on 208G circuit pack. Internal sensing occurs with this connector disconnected or the REG fuse removed.

The digital meter on the front panel is used to measure output current, output voltage, or battery voltage. The accuracy for each meter position is as follows:

Meter Position	Accuracy
Rect V	± 0.1 volt
Plt V	± 0.1 volt
Amps	$\pm 2.5\%$ of meter reading ± 2 amperes

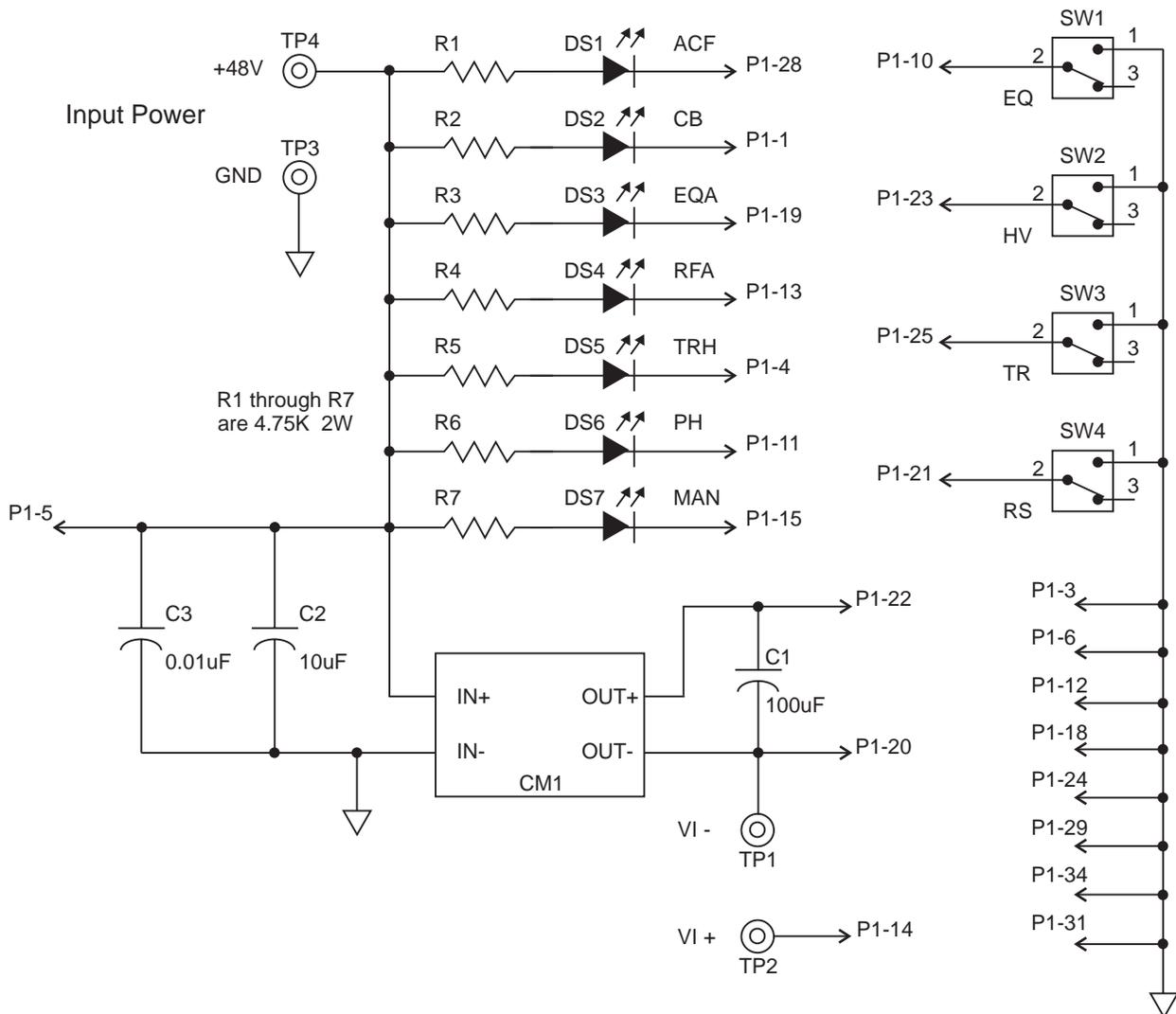


Figure 7-1: Battery Plant Simulator Test Set Schematic Used with CM2 Control Board

Required Test Equipment

Depending upon the tests to be performed, one or more of the following may be required.

- DMM (Digital Multimeter) Fluke® 8060A or equivalent meter having ± 0.02 percent accuracy on the dc scale
- Battery Plant Simulator Test Set, customer constructed, or equivalent (see **Note** below and Figure 7-1)
- DC Dummy Load Bank, 150-volt, with adjustment to provide a load of at least 10 to 12 percent of the rectifier's rating (see specific test procedure to determine ampere setting required)

- Jeweler's screwdriver for adjusting potentiometers

Note

The Battery Plant Simulator Test Set, listed above, is a convenient tool used to isolate communication troubles between the plant controller and the rectifier. It simulates the plant controller relative to receiving signals from, and sending signals to, the rectifier. If the rectifier works properly with the test set, the problem is either at the controller or in the interface wiring (plant cable). This BPSTS can be ordered from ITE (ITE-7102).

Simulated Plant-Rectifier Interface Tests Using Test Set

The following tests will verify that the rectifier responds properly to plant controller commands and outputs proper signals in return. It may be helpful to refer to the Schematic Drawing (SD-83325-01) during performance of the procedures.

DANGER

Voltages in excess of 600 volts are present in the rectifier. Extreme care should be exercised to avoid contact with exposed terminals or bus bars.

DANGER

AC voltage is present even when the **Power** switch is in the **Off** position.

DANGER

Before turning on any rectifier, be sure that the associated framework and cable rack are properly grounded per local job instructions.

Warning

Do not operate the **DC Output** circuit breaker to **On** (or turn an external charge circuit breaker on, or install an external charge fuse) until told to do so.

Warning

The rectifier output filter capacitors stay charged for several minutes. Check that they have discharged adequately before contacting any exposed terminals inside the rectifier. Do not work on the rectifier until capacitors have discharged below 50Vdc.

Preparation The following information covers initial settings of equipment and meter, and the test connections necessary before beginning the test.

Warning

Be sure that connections to circuit packs are not made or removed with voltages present. Before disconnecting a cable from a circuit pack, operate the **Power** switch to **Off**. If the control cable is connected, remove the associated REG fuse from the plant control panel and then disconnect the control cable. If complete plant connections are to be restored, operate the **Power** switch to **Off**, reconnect the control cable, and then install the associated REG fuse.

Note

For the following steps, refer to Figures 2-2 and 6-1 for location of rectifier controls, indicators, etc.

Warning

For safety, make measurements for current on CM1 at E101 and E102 at the shunt (+) and (-) test points. (See Figure 7-3).

Set the ac supply and rectifier controls as follows:

Controls	Position/Status
Associated ac circuit breaker or fuse at the ac service cabinet	Off or fuse is removed
Rectifier Power switch	Off

Controls	Position/Status
Rectifier DC Output circuit breaker	Off
Output Volts Adjust	Fully down
Plant control connector (J202) and remote sense connector (J208) mounted on inside of front panel door on CM2	Disconnected

Using the digital multimeter on the dc volts scale, make the following checks:

1. Verify that battery voltage is present between the rectifier charge terminal and ground.
2. With the associated REG fuse in the plant installed, check for battery voltage between terminals of REG connector of 208G circuit pack (J208). Check that Pin 3 is positive with respect to Pin 2.
3. Check for between 15 and 20 volts dc between terminals 17 and 16 (toward controller). Terminal 17 should be positive with respect to terminal 16.

Connections

Secure the Battery Plant Simulator Test Set (Figure 7-1), and support it at a convenient location near the rectifier. Make the connections as detailed in Table 7-A. Note that Table 7-A contains references to Figure 7-2.

Table 7-A: Test Set Connections

Step	Test Clip	Connection	See Figure
1	Red	E13 on CM2 (Positive side of capacitor C201)	7-2
2	Black	E22 on CM2 (Negative side of capacitor C202)	7-2

Connect **J202**, on the other end of the cable from the test set, to connector **P202** on the **CM2** control board (mounted on the inside of the front door).

Startup

1. Turn on the ac supply to the rectifier. Measure voltage at banana jacks TP4 and TP5 on test set. The voltage should be approximately 54V at TP4 (red) with respect to TP5 (black).
2. Set the digital multimeter to the 200-volts range, and connect it to the **Rect** jacks on the rectifier control panel (see Figure 6-1).
3. Adjust the test load so that when the rectifier is turned on it will deliver between 5 and 20 percent of full load.
4. Operate the power switch to **On**. The rectifier should start. The digital meter should indicate between 135 and 150 volts. The **MAN** LED on the test box should light and remain lit as long as the rectifier is turned on.

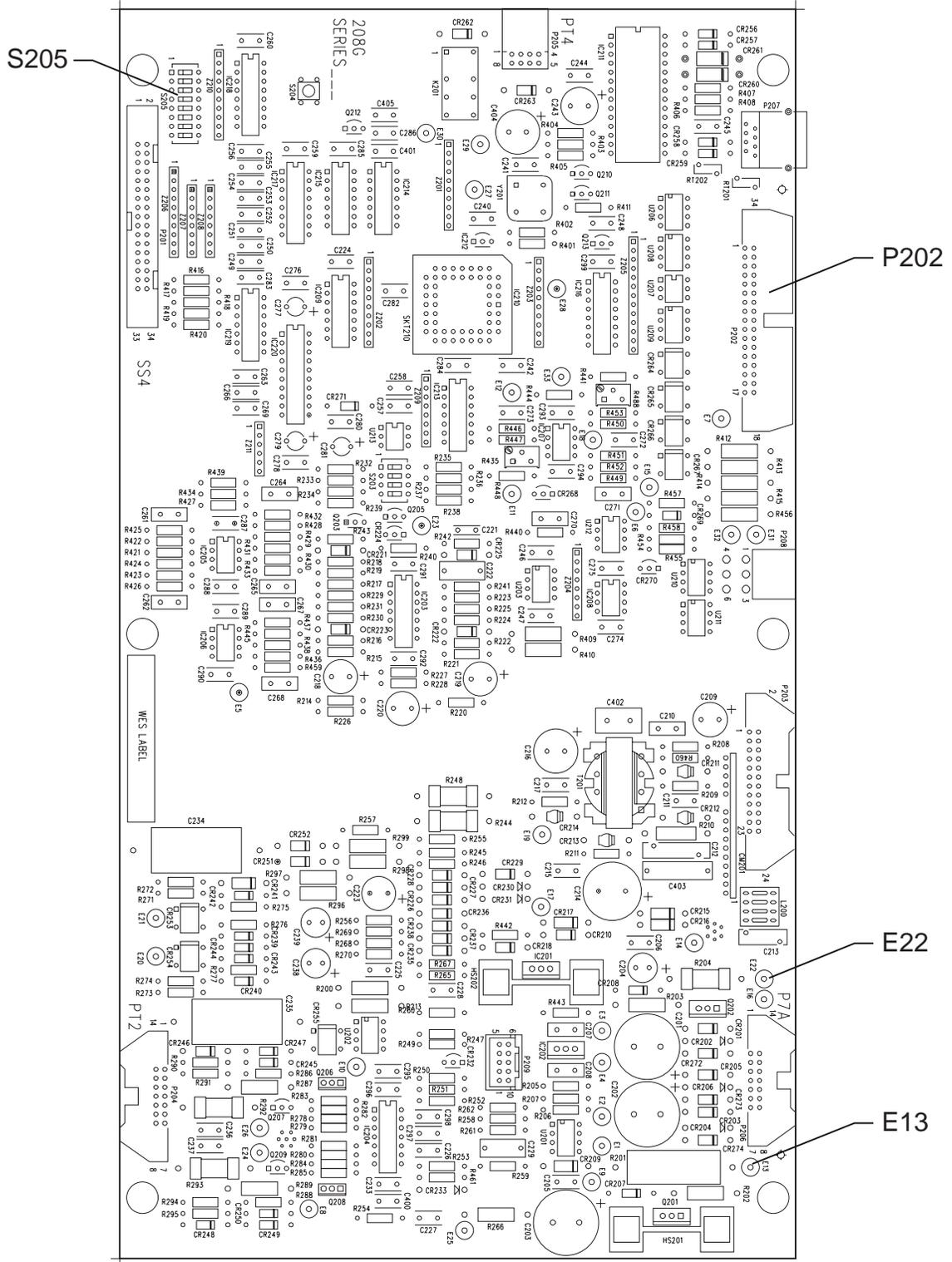


Figure 7-2: Partial Sketch of CM2 (208G) Control Board

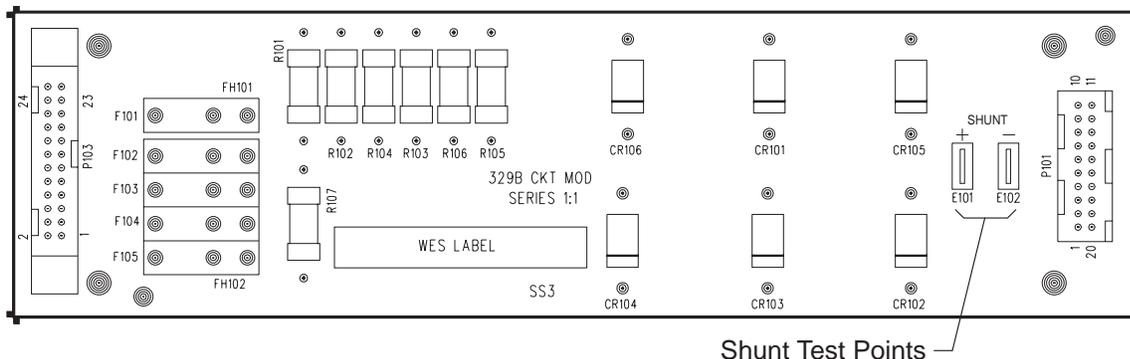


Figure 7-3: CM1 (329B) Fuse Board

Internal Tests

1. Disable the internal selective high voltage shutdown by opening **S205.1** and **S205.2** on **CM2** (see Figure 7-2). Then adjust the **Output Volts Adjust** until the rectifier shuts down.

Note

When the rectifier shuts down, the **RFA** LED on the front panel should light and the rectifier should shut down at 163 ± 2 volts. When this step is completed, restore the original conditions of **S205.1** and **S205.2**.

2. Adjust the **Output Volts Adjust** down, restart the rectifier, and adjust the voltage to 151.9 volts. The **RFA Alarm** LED on the rectifier and the **RFA** LED on the test box should go out. Restore internal selective high voltage shutdown to 160V (**S205.1** and **S205.2**).
3. Connect the test meter to the rectifier input conductor to **CB1** and **DC OUTPUT RETURN**. On the rectifier, hold the **Rect V - Amps - Plt V** switch in the **Rect V** position. The digital display should agree with the digital test meter within ± 0.1 volt. Release the switch.
4. Hold the same switch in the **Plt V** position. The digital display should agree with the digital test meter within ± 0.1 volt. If not, refer to the paragraph "Check Calibration of CM3 Digital Meter" in this section.
5. Hold the **Rect V - Amps - Plt V** switch in the **Rect V** position. Watch the digital test meter and operate the **Rect**

Test switch to **NL**. The voltage should drop between 0.3 and 0.6 volt.

6. Repeat Step 5 with the **Rect Test** switch in the **FL** position. The voltage should increase between 0.1 and 0.46 volt.
7. Turn off rectifier. Replace fuse on 329B fuse board with blown fuse. Turn on rectifier. Rectifier should shut down immediately and the **RFA** alarm, **FA** (fuse alarm), and the **RFA LED** on test set should light. (See Figure 7-3.) Turn off rectifier and replace blown fuse.
8. Restart the rectifier.
9. Repeat Steps 7 and 8 for the **F101**, **F103**, **F104**, and **F105** alarm fuses located on **CM1**.

Control Test

1. Press and hold the **TR** switch on the test box for 5 seconds. The rectifier should shut down and the **TRH LED** on the test box should light.
2. Release the switch. The rectifier should restart and the **TRH LED** should go out.
3. Reduce the load to zero.
4. Press the **HV** switch on the test box. The rectifier should continue to operate.

Note

<p>The following four tests involve the use of the test load. Refer to the paragraph on “Test Load Connection and Removal” earlier in this section for the procedure used for the test load connection and removal.</p>

HV Shutdown and Restart

1. Adjust the test load so that the rectifier delivers a minimum of 10 percent of its rated amperage (14 amperes).
2. Turn on the **HV** switch on the test box. After approximately 5 seconds, the rectifier should shut down and the **RFA Alarm LED** on the rectifier and the **RFA LED** on the test box should light.

3. Momentarily press the **RS** switch on the test box. The rectifier should restart and both **RFA** LEDs should go out.

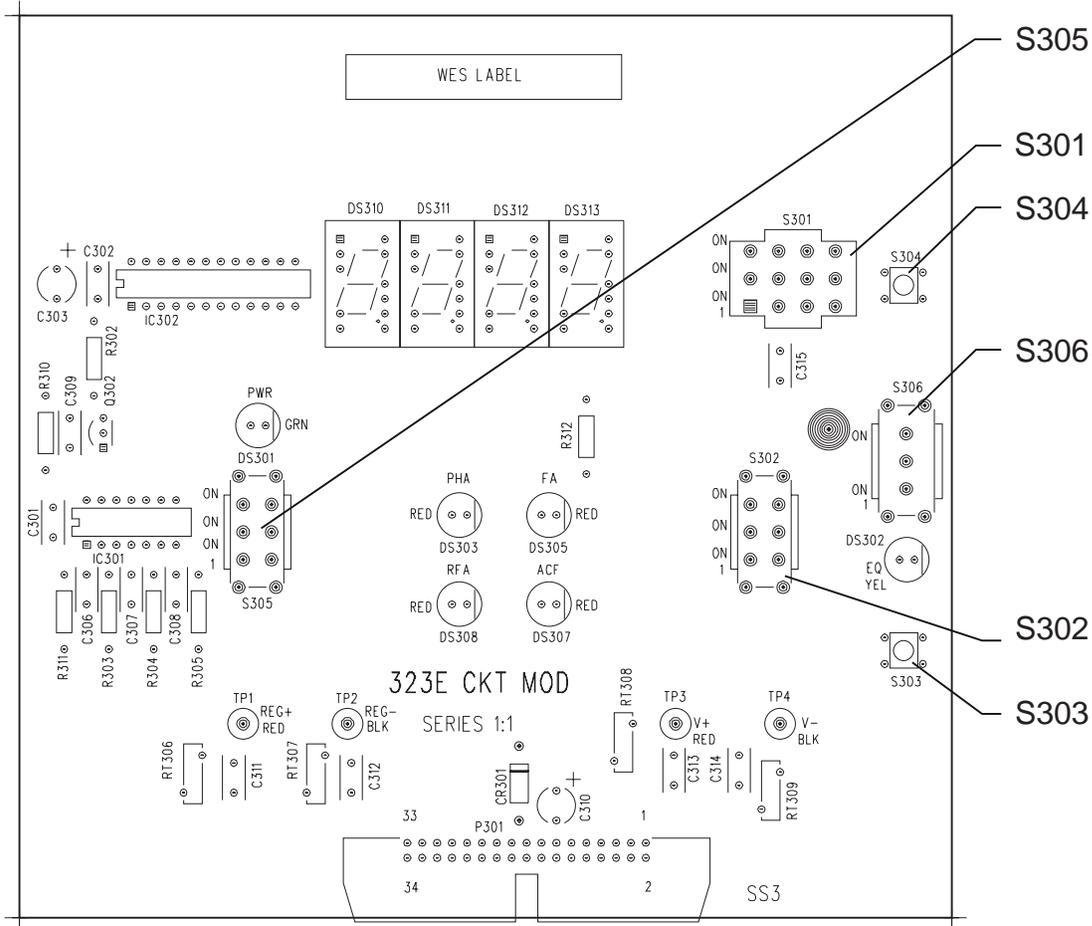


Figure 7-4: Partial Sketch of CM3 Digital Meter Board

Phase Failure Test

1. Increase the load to between 25 and 30 percent of the rectifier's rated amperage.
2. With the **Power** switch still in the **On** position, turn off the ac service and note that the rectifier has shut down and that the **MAN** LED on the test box is off.
3. Verify that no ac voltages are present on the input leads of the ac input contactor.
4. Disconnect one input lead of the ac input contactor (colored wire) or at the ac service panel, whichever is more convenient. Insulate the lead.

5. Again verify that there is no ac voltage from the disconnected lead, then tape the lead.
6. Turn on the ac. The rectifier should not restart. The display and alarm outputs to the test box may blink.
7. Turn off the ac and reconnect the ac input lead.
8. Turn on the ac. The rectifier should restart. On the test box only the **PWR** and **MAN** LEDs should light.
9. Repeat for the other two phases.

Completion of Test

1. Reduce the load to zero.
2. Operate the **Power** switch to **Off**.
3. Disconnect and remove the Battery Plant Simulator Test Set and the DMM (Digital Multimeter).
4. To remove the test load, follow the procedure described in the paragraph on "Test Load Connection and Removal" earlier in this section.
5. If the reason for performing the rectifier tests was just to affirm the operation of the rectifier, and was not part of total plant testing, restore the rectifier to service by following the procedures described in "Restore Rectifier to Service" later in this section. If this is part of total plant testing, leave the plant control cable disconnected until directed to reconnect it as part of another plant procedure.

Diagnostics and Troubleshooting

Possible problems that may occur with the rectifier subsystem are:

1. Rectifier will not start. No indication on front panel.
2. Rectifier tries to start but gives an **RFA** alarm.
3. Rectifier starts but gives **FA** and **RFA** alarms
4. Rectifier starts but gives an **RFA** alarm.

5. Rectifier does not shut down at no load but may shut down at 10% load or more.
6. Rectifier will not start; ac is present, digital meter is on, **PWR** switch is on.
7. Rectifier gives a **PHA** alarm (Phase Alarm).
8. Rectifier goes to high voltage at turn-on.
9. Rectifier attempts to start but immediately gives an **RFA** alarm.
10. Rectifier gives an **RFA** alarm at certain loads.
11. Control panel digital meter does not light and rectifier is on.
12. Battery voltage (**Pit V** position), as read on the digital meter, does not agree with the actual battery voltage measured across **Rect+** and **Rect-** jacks.

Table 7-B lists these problems, probable causes, and corrective actions. Refer to SD-83325-01 when troubleshooting this rectifier.

Table 7-B: Troubleshooting

Problem	Probable Cause	Corrective Action
1. Rectifier will not start. No indication on the front panel.	a. No ac input to rectifier. b. Board improperly installed.	a. Check for ac input voltage to rectifier. b. Check boards.
2. Rectifier tries to start but gives an RFA alarm.	a. CM2 (control board) is defective. b. CM3 (digital meter board) is defective. c. CM1 (fuse board) is defective. d. Ribbon cable may be defective.	a. Check for ac voltage on secondary of T3 . See SD. b. Boards interlock may not be connected properly. Check ribbon cables. c. Check for +27Vdc ($\pm 5V$) across C201. If not present, but ac is present on all secondaries of T3 , check the connections E29 through E32 . If the connection is ok, replace CM2 . d. Check wiring associated with coil of K1 and contacts 4-7 of K2 .
3. Rectifier starts but gives FA and RFA alarms.	a. Fuse(s) blown. b. Circuit breaker is tripped.	a. Check alarm fuses on CM1 . If F1 has operated, check filter capacitor fuses F1-F6. b. Check circuit breaker.

Table 7-B: Troubleshooting

Problem	Probable Cause	Corrective Action
4. Rectifier starts but gives an RFA alarm.	<ul style="list-style-type: none"> a. CM2 is defective. b. CM3 is defective. c. Open or shorted triac. 	<ul style="list-style-type: none"> a. Measure output voltage while rectifier is “walking in.” If the output voltage exceeds 175 volts, the rectifier is shutting down due to high output voltage. See Probable Causes associated with Problem 6. b. Replace CM2. c. Replace CM3. d. If voltage does not go high, but still gives an RFA, check triac.
5. Rectifier does not shut down at no load but may shut down at 10% load or more.	<ul style="list-style-type: none"> a. Shorted triac. b. Open triac. c. Winding 13 or 14 of T1 or T2 is open. 	<ul style="list-style-type: none"> a. Replace triacs (see SD). b. Check wiring associated with windings 13 or 14 or T1 or T2.
6. Rectifier will not start; ac is present, digital meter is on, PWR switch is on.	<ul style="list-style-type: none"> a. Input contactor coil may be open. 	<ul style="list-style-type: none"> a. Check input contactor coil. If it is open, replace the contactor.
7. Rectifier gives a PHA alarm (Phase Alarm).	<ul style="list-style-type: none"> a. One of the phase voltages is too low under a load condition. b. One of the phase voltages coming into CM2 is too low. c. CM2 is defective. 	<ul style="list-style-type: none"> a. Check connections and voltage. b. Verify that the voltages across C9, C10, and C11 on CM2 are equal ± 2 volts. c. Replace CM2.

Table 7-B: Troubleshooting

Problem	Probable Cause	Corrective Action
<p>Warning: This test should be performed only if a high voltage shutdown problem is suspected.</p> <p>8. Rectifier goes to high voltage at turn-on.</p>	<p>a. Output Volts Adjust is set too high.</p> <p>b. CM2 is defective.</p>	<p>a. On the rectifier control panel (see Figure 6-1), hold the meter selector switch (S1) in the Rect V position. While observing the display, adjust the Output Volts Adjust until the rectifier shuts down. Note at what voltage this occurs.</p> <p>b. If the rectifier did not shut down between 160 and 175Vdc, CM2 is probably defective. Replace CM2. Restore rectifier to service.</p> <p>c. If the rectifier did shut down within the limits specified, adjust Output Volts Adjust down. Operate the rectifier Power switch to Off then back to On. (Rectifier restarts.)</p> <p>d. Restore rectifier to service.</p>
<p>9. Rectifier attempts to start but immediately gives an RFA alarm.</p>	<p>a. CM1 is defective.</p> <p>b. JT2 cable is defective.</p>	<p>a. Check fuses.</p> <p>b. Check JT2 cable.</p>

Table 7-B: Troubleshooting

Problem	Probable Cause	Corrective Action
10. Rectifier gives an RFA alarm at certain loads.	a. CM2 is defective. b. Defect in control and alarm leads from the fuses to CM2 .	a. Replace CM2 . Verify that the rectifier is on and delivering at least 2-1/2% of its rated output current (if not connected to the batteries). See Problem 7. b. Restore rectifier to service. c. Check alarm leads. d. Check for +27 Vdc ($\pm 5V$) across C201 on CM2 .
11. Control panel digital meter does not light and rectifier is on.	a. Defective wiring to CM3 . b. CM3 is defective.	a. Check wiring to CM3 ; check connectors J1B and J3A for proper insertion. b. Replace CM3
12. Battery voltage (Plt V position), as read on the digital meter, does not agree with the actual battery voltage measured across Rect+ and Rect- jacks.		a. Adjust the digital meter as follows: – Connect a universal digital multimeter (± 0.02 percent or better) such as a Fluke 8060A or equivalent to the Rect jacks on the rectifier control panel. Observe polarity. – Refer to “Calibrate CM3 Digital Meter” for calibration procedure.

**Replace CM2
Control Board**

The following procedure is used to replace the **CM2** control board:

1. Operate the rectifier **Power** switch to the **Off** position.
2. At the plant Control and Distribution Bay, remove the REG fuse associated with the rectifier.
3. Operate the rectifier **DC Output** circuit breaker to the **Off** position.
4. At the ac service cabinet supplying power to the rectifier, remove the input fuse assigned to the rectifier or operate the circuit breaker to the **Off** position. **Tag and lock out circuit breaker.**
5. At the rectifier, loosen the locking screws and open the front door of the rectifier.
6. Locate the **CM2** control board.

Caution

Support the **CM2** control board and **CM3** digital meter board with your hands while connecting and disconnecting cables or damage to the board may result.

Warning

Do NOT disconnect the plant controller cable connector **J202** or remote sense connector **J208** from the **CM2** board by pulling the cable.

7. Disconnect the plant controller connector **J202** and remote sense connector **J208** from **CM2** by unlatching the connector locking ears and then pulling the cable header connector.
8. Disconnect the connecting cables from **CM2**.
9. Remove **CM2** from the six support standoffs by using a small pair of needle nose pliers to push in the latches on each standoff.

10. Position the new **CM2** over the six standoffs. Verify that each latch snaps and locks into place.
11. Reconnect all cables to **CM2**.
12. If the rectifier is to be tested, refer to the paragraph on “Prepare Rectifier for Test” later in this section to prepare the rectifier for testing.
13. If the rectifier is to be restored to service, refer to the paragraph on “Calibrate CM3 Digital Meter” later in this section to check the calibration of the digital meter if there is an indication that the meter is defective. Also refer to paragraphs on “Isolated Current Measurement Circuit” and “Current Limit Circuit” to check calibration of these circuits.

**Restore Rectifier
to Service**

1. Check the ac supply and rectifier controls as follows:

Controls	Position/Status
Associated ac circuit breaker (or fuse) at the ac service cabinet	Off or fuse is removed
Rectifier Power switch	Off
Rectifier DC Output circuit breaker	Off
Rectifier REG fuse at the plant controller panel	REG fuse removed

2. If before the rectifier voltage was turned off it was NOT at the desired float voltage, adjust the **Output Volts Adjust** fully down.
3. At the ac service cabinet, install the ac fuse or operate the ac input circuit breaker to the **On** position.

Warning

The rectifier **DC Output** circuit breaker must be operated to the **On** position within 5 seconds after the rectifier **Power** switch is operated to the **Off** position. If not, the **Power** switch should be turned back **On** and the step repeated.

4. Operate the rectifier **Power** switch to the **On** position for about 10 seconds, and then back to the **Off** position. Quickly operate the rectifier **DC Output** circuit breaker to the **On** position.
5. At the rectifier, connect the plant controller cable connector **J202** and remote sense connector **J208**.
6. Install the REG fuse associated with the rectifier that is being restored to service (at Control and Distribution Bay).
7. Operate the rectifier **Power** switch to the **On** position.
8. Wait approximately 10 seconds.
9. Close the rectifier front door and secure the locking screws.
10. Adjust the rectifier as specified in the paragraph on “Test Procedures” in Section 5, *Installation and Testing*.
11. Enable the efficiency algorithm at controller (see controller product manual).

**Clear RFA
(Rectifier Failure
Alarm)**

Note

An FA (Fuse Alarm) may be present with the RFA (Rectifier Failure Alarm); see “Clear FA (Fuse Alarm).”

1. Observe and record the status of the fuses in the plant controller fuse panel.
2. If any of the following fuses are blown, replace them with one of the same type and rating: **F1, F2, F3, F4, F5, or F6** filter capacitor fuses or **F101, F102, F103, F104, or F105** alarm fuses located on **CM1**.
3. Operate the rectifier **Power** switch to the **Off** position and then back to the **On** position.

4. If the rectifier started, the minor alarm retired, and the rectifier **RFA** and **FA** LEDs extinguished, then the **RFA** problem has been cleared. Otherwise, continue with the following procedures.
5. Observe and record the rectifier output voltage.
6. If the rectifier output voltage is greater than the plant float voltage, use the following procedures:
 - a. Adjust **Output Volts Adjust down** to lower the output voltage to the correct value.
 - b. If the rectifier **Output Volts Adjust** can be used to adjust the voltage to the correct level, the **RFA** problem has been cleared.
7. If the rectifier output voltage is less than the plant voltage and/or all rectifiers shut down, use the following procedures:
 - a. If **CM2** has not been replaced, then replace it as described in the paragraph “Replace **CM2** Control Board” earlier in this section.
 - b. If the rectifier started, the minor alarm retired, and the rectifier **RFA** and **FA** LEDs extinguished, then the **RFA** problem has been cleared. Otherwise, continue with the following procedures:
 - c. If replacing **CM2** does not clear the problem, then the outputs from **T1** and **T2** are probably unbalanced. Try the following:
 - Check the wiring to the triacs.
 - Check for defective triacs. Replace if defective.

Clear FA (Fuse Alarm)

1. Check to see if **DC Output** circuit breaker (**CB1**) is tripped. If so, turn the **Power** switch to **Off** and then back to **On** again. After ten seconds, turn **CB1** back on.
2. If **CB1** did not trip, check alarm fuses **F102**, **F103**, **F104**, and **F105** located on **CM1**. These fuses are accessible by opening the front door of the rectifier and are located on **CM1** near the output filter capacitor.

3. If the **F102, F103, F104, or F105** alarm fuse is blown, check for possible trouble and replace the fuse.
4. If the **F1, F2, F3, F4, F5, F6, or F101** alarm fuse on **CM1** is blown, check for a shorted output capacitor. Replace capacitor and fuse if necessary.

***Prepare Rectifier
for Test***

1. Observe and record the rectifier output voltage.
2. Operate the rectifier **Power** switch to the **Off** position.
3. Operate the rectifier **DC Output** circuit breaker to the **Off** position.
4. At the Control and Distribution Bay, remove the REG fuse associated with the rectifier.
5. At the ac service cabinet supplying power to the rectifier, remove the input fuse assigned to the rectifier or operate the circuit breaker to the **Off** position.
6. At the rectifier, loosen the locking screws and open the front door.
7. Locate the **CM2** control board.

Caution

Support the **CM2** control board with your hands when disconnecting the cable leads or damage to the control board may result.

Warning

Do NOT disconnect the plant controller cable connector **J208** from the **CM2** control board by pulling the cable.

8. Disconnect the plant voltage sense cable connector **J208** from **CM2** by first unlatching, then pulling the cable header connector.
9. At the ac service cabinet supplying power to the rectifier, insert the input fuse assigned to the rectifier or operate the circuit breaker to the **On** position.

10. If the rectifier is to be tested *off battery*, operate the rectifier **Power** switch to the **On** position, and wait approximately 30 seconds for the voltage to stabilize. The rectifier is now ready to be tested off battery.
11. If the rectifier is to be tested *on battery*, use the following procedures:
 - a. Verify that the rectifier **Power** switch is operated to the **Off** position.
 - b. Operate the rectifier **Power** switch to the **On** position for 10 seconds, then back to **Off**, and then quickly close the **DC Output** circuit breaker (**CB1**). The circuit breaker must be closed within 5 seconds after the **Power** is turned to **Off**. If not, the **Power** switch should be turned back to **On** and the step repeated.
 - c. At the rectifier, connect the plant voltage sense cable connector **J202** to **CM2**.
 - d. Insert associated REG fuse at Control and Distribution Bay.
 - e. Operate the rectifier **Power** switch to the **On** position to start rectifier
 - f. Enable the efficiency algorithm at the controller (see controller product manual).

***Check
Calibration of
CM3 Digital
Meter***

1. Verify that the following conditions are met:
 - Rectifier **Power** switch must be in the **On** position.
 - Plant Connector **J202** must be connected.
 - Rectifier REG leads must be connected (**J208**).
 - Rectifier must be connected to a battery.
2. Connect a DMM (Digital Multimeter) to the rectifier REG test points.
3. Set the meter selector switch (S1) to the **Plt V** position.
4. Observe and record the voltage values on the DMM and the **CM3** meter (the rectifier meter display).
5. Set the meter selector switch **S1** to the **Amps** position.

6. Disconnect the DMM from the rectifier REG test points.
7. If the rectifier **CM3** meter is not within ± 0.1 volts of the value indicated on the DMM, then go to Step 1 in the next paragraph on “Calibrate CM3 Digital Meter” to calibrate the CM3 digital meter and repeat the procedures.
8. Connect a DMM (Digital Multimeter) to the rectifier output terminals.
9. Press and hold the meter selector switch (**S1**) in the **Rect V** position.
10. Observe and record the voltage values on the DMM and the **CM3** meter (the rectifier meter display).
11. Release the meter selector switch (**S1**). Switch should automatically return to the **Amps** (center) position.
12. If the rectifier **CM3** meter is not within the limits provided in the list below of the value indicated on the DMM, then go to Step 1 of the next paragraph “Calibrate CM3 Digital Meter” to calibrate the digital meter and repeat the procedures.

CM3 Board	Tolerance
Rectifier Current	± 2.5 percent of reading ± 2 amperes
Plant Voltage	± 0.1 volts
Rectifier Voltage	± 0.1 volts

Note

A partial sketch of the **CM3** board is provided in Figure 7-4.

13. If the rectifier meter cannot be calibrated, use the following procedure:
 - a. Replace the rectifier **CM2** control board as described in the paragraph “Replace CM2 Control Board”.
 - b. Repeat this procedure from Step 1.
14. Disconnect the DMM from the rectifier.

**Calibrate CM3
Digital Meter**

Use the following calibration procedure for field adjustment of the display meter on the 140V rectifier:

1. Set **S205.5** on **CM2** to **On**.
2. Use a Digital Multimeter (DMM) connected to the **Rectifier Voltage** test jacks to measure the rectifier voltage.
3. Place display select switch on front of unit to the **Rect V** position.
4. Using the **FL/NL Rect Test** switch, increment or decrement the display until the display reads the same as the DMM.
5. Use a DMM connected to the **Plant Voltage** test jacks to measure the plant voltage.
6. Place display select switch on front of unit to the **Plt V** position.
7. Using the **FL/NL Rect Test** switch, increment or decrement the display until the display reads the same as the DMM.
8. Use a DMM connected to the rectifier shunt test points on CM1 to measure the rectifier current as a millivolt level on the shunt.
9. Place display select switch on front of the unit to the **Current** position.
10. Using the **FL/NL Rect Test** switch, increment or decrement the display until the display reads 3.5 x DMM reading in millivolts.
11. Set **S205.5** on **CM2** to **Off**
12. If the rectifier meter does NOT meet the tolerances, replace the **CM2** control board as described in the paragraph "Replace CM2 Control Board." Repeat this procedure from Step 1.

13. Close the front door of the rectifier and secure it with the locking screws.

Meter Position	Tolerance
Rect V/Plt V	±0.1 volt
Amps	±2.5 percent* of reading ±2 amperes
*To compare, measure the shunt voltage. The shunt voltage should be 0.2857mV per amp. The rectifier shunt is 175A, 50mV.	

**Replace CM3
Digital Meter
Board**

1. At the rectifier, operate the rectifier **Power** switch to the **Off** position.
2. At the Control and Distribution Bay, remove the REG fuse associated with the rectifier.
3. Operate the rectifier **DC Output** circuit breaker to the **Off** position.
4. At the ac service cabinet supplying power to the rectifier, remove the input fuse assigned to the rectifier or operate the circuit breaker to the **Off** position.
5. At the rectifier, loosen the locking screws and open the front door.
6. Locate the **CM3** digital meter board.

Caution

Support the **CM3** digital meter board with your hands when connecting and disconnecting the cable leads or damage to the board may result.

Warning

Before performing operations inside rectifier, check that output filter capacitors have discharged below 50Vdc.

7. Disconnect the connecting cable from **CM3**.
8. Remove **CM3** from the two support standoffs by using a small pair of needle nose pliers to push in the latches on

Warning

Do NOT disconnect the cable connector from the **CM3** digital meter board by pulling the cable.

each standoff. Remove the one screw holding **CM3** in place.

9. Position the new digital meter board over the two support standoffs. Verify that the latches on each standoff snap to lock the meter board into place.
10. Plug in the cable connector that leads to **CM3**.
11. Check calibration of rectifier meter as described in the paragraph on “Check Calibration of CM3 Digital Meter” earlier in this section.
12. If the rectifier is to be tested, prepare the rectifier for testing as described in the paragraph on “Prepare Rectifier for Test” earlier in this section.
13. If the rectifier is to be restored to service, follow the procedure in the paragraph on “Restore Rectifier to Service” earlier in this section.

Isolated Current Measuring Circuit

These procedures provide information for checking and adjusting the isolated current measuring circuit (voltage proportional to current adjustment) on the rectifier's **CM2** control board. These procedures are required when the output current reading on the rectifier does not agree to within ± 2.5 percent of the controller reading. Also, these procedures must be performed while **J202** is connected to the controller and the rectifier is connected to a battery.

Checking Adjustment of Circuit

Note

The test points and components on **CM2** are shown in Figure 7-2. The Plant Control Cable Connector **J202** MUST be connected to **P202** on **CM2** for standard application.

1. Connect a Digital Multimeter (DMM) across the rectifier shunt test points on CM1 (see Figure 7-3).
2. Connect a test load across the output of the rectifier and adjust it so the rectifier delivers approximately 50% of its rated current capacity. At full load (140 amps) the rectifier shunt voltage is 40 millivolts.
3. Observe DMM and record the rectifier's shunt voltage.
4. Convert the DMM indication to amperes ($0.2857 \times \text{DMM reading in mV}$).
5. Compare the amperes (calculated in Step 4) with the rectifier drain indication on the controller.
6. If the rectifier drain indication is between 0 and 2% higher than the amperes calculated in Step 4, this procedure is completed.
7. If the rectifier drain indication is between 0 and 2% lower than the amperes calculated in Step 4, adjust potentiometer **R435** on **CM2** to obtain a rectifier drain reading that is between 0 and 2% higher than the amperes calculated in Step 4.

Internal Selective High Voltage Setting

***For Rectifier
Without
Controller
Connected***

Note

To avoid over-voltage conditions on the actual battery plant loads, perform this procedure with the rectifier disconnected from the battery (this will be accomplished in the first step of the procedure). A portable test load that can supply a load of at least 10 percent above the rectifier's current rating is required.

1. Connect the test load as specified in the paragraph on “Test Load Connection and Removal” earlier in this section.
2. Operate the **Power** switch to **On**.
3. Operate the rectifier **DC Output** circuit breaker to **On**.
4. Adjust test load to 10 percent (or greater) of rectifier's rated capacity. Read load current on control panel meter.
5. Set Switches 205.1 and 205.2 on CM2 for 160V (ISHVSD).
6. Adjust rectifier **Output Volts Adjust** to obtain a rectifier voltage of 162.5 volts. Read voltage on control panel meter by holding meter switch in **Rect V** position. After 20 seconds the rectifier should shut down.
7. Decrease the load to less than 2 percent and restart the rectifier. The rectifier should start and operate normally. If the rectifier does not operate properly, go to the paragraph on “Diagnostics and Troubleshooting” earlier in this section.
8. Refer to the label inside the rectifier door and test the ISHVSD feature for the other settings of S205.1 and S205.2. Note that internal selective high voltage shutdown does not occur unless the rectifier is carrying at least a 10% load.
9. Disconnect the test load and reconnect the rectifier to the battery as specified in the paragraph on “Test Load Connection and Removal” earlier in this section.

Current Limit Circuit

Check and Adjustment Procedure (On Battery)

Notes

This procedure should be performed only if a current limit circuit problem is suspected.

There must be two or more rectifiers with a plant load of at least 25 percent higher than the capacity of the largest rectifier.

The method in the following notes applies to a working plant. If the conditions in the following notes cannot be met, the unit must be tested off battery as described in the next paragraph, "Current Limit Adjustment Procedure (Off Battery)."

In a working plant, the current limit set point can be found by adjusting the **Output Volts Adjust** on the rectifier under test to obtain approximately 3/4 load and a battery voltage of 151.9 volts.

1. Connect DMM to plant voltage jacks to verify the battery voltage.
2. In addition, depress the **Rect Test** switch to full load (**FL**) position to raise the rectifier output current to current limit. The rectifier output current shall indicate 100 to 101 percent of the rated output current.
3. If the rectifier current is not within 100 to 101 percent of the rated load, the current limit needs adjustment. Adjusting the current limit circuit requires that the rectifier test load switch be depressed to **FL** and that the current limit potentiometer **R488** be adjusted so that the rectifier delivers 100 to 101 percent load.

Note

At the rated output current of the rectifier, the shunt voltage is 40 millivolts. Read at CM1 shunt test points.

***Current Limit
Adjustment
Procedure
(Off Battery)***

Notes

This procedure is performed only if the current limit circuit has been verified to need adjustment.

This procedure assumes that the rectifier is off battery and that a test load is available. When connecting or disconnecting the test load, refer to the paragraph on “Test Load Connection and Removal” earlier in this section.

V_o is the voltage reading at the rectifier output bus.

1. Strap a short across E18 to E33.
2. Adjust V_o to 151.9 volts at $I_{load} = 100\%$ to 101% of full load rating.
3. Remove strap from E18 to E33. Observe that V_o is between 151.5 and 151.75. If it is not, adjust **R488** of **CM2** to obtain a reading in this range.
4. Increase the load to $110 \pm 1\%$. V_o should be below 150.4 volts. If it is not, repeat Step 3.
5. Decrease the load to 96% to 98% of the rectifier rating. Observe that V_o is greater than 151.75.

***Initial Battery
Charge
Procedure***

For this procedure, refer to the paragraph on “Test Procedures” in Section 5, *Installation and Testing*.

Preventive Maintenance

At 12-month intervals, perform the following:

- Check calibration of rectifier's digital meter. The procedure is given in the paragraph "Calibrate CM3 Digital Meter" earlier in this section.
- Check torque on various connections, such as ac input and dc output connectors. **OBSERVE SAFETY PRECAUTIONS IF WORKING IN LIVE PLANT.** See Tables 7-A and 7-B, and refer to the torque values listed in Table 7-C.

Table 7-C: Torque Values

Lists 1 and 2	Torque input connections to 50 in-lbs.
List 3	Torque input connections to 30 in-lbs.
Output connections	Torque to 240 in-lbs
Central Office ground	Torque to 65 in-lbs
Frame ground (AC equipment ground)	Torque to 30 in-lbs

8 *Spare Parts and Replacement Procedures*

Please read Section 4, *Safety*, carefully before replacing parts on the J87132B-2 rectifier.

Spare Parts

Information provided includes orderable spare parts (circuit boards, fuses, and electrical components) and handling precautions.

Circuit Modules

The **CM1, CM2, CM3, CM7, and CM8** circuit boards are orderable spare parts from Lucent Technologies. Table 8-A gives the information required for ordering.

Table 8-A: J87132B-2 Rectifier Circuit Module Spare Kits

Comcode	Description	Circuit Designation
107855694	329B Fuse Board	CM1
107855678	208G Control Board	CM2
107855686	323E Display Board	CM3
107134454	425C Transformer Sense Board	CM7
107134462	425D Transformer Sense Board	CM7
107134488	425F Transformer Sense Board	CM7
107932840	868A Resistor Bleeder Board	CM8

Fuses Table 8-B provides spare fuse information

Table 8-B: J87132B-2 Rectifier Spare Fuses

Reference Designation	Part Number	Vendor	Rating	Comcode
F1, F2, F3, F4, F5, F6	KLKD-25	Littlefuse	25 A	406097105
F101, F102, F103, F104, F105 alarm fuses located on CM1	WP-90247 L101	SAN-O	.18 A	407715713

Note: The rectifier comes equipped with three spare WP-90247 L103 fuses.

Electrical Parts Table 8-C provides spare electrical parts information.

Table 8-C: J87132B-2 Rectifier Spare Electrical Parts

Reference Designation	Part Number	Comcode
CR1-CR4	WP91147L8BSR	405934449
Q1, Q2	BTA40-800B (565 Thomson)	406912816
C1-C6	H62R6630E92AC Aerovox	406918268
C7-C12	U32D200L G183 M76 X117LP	407681659
CM5-CM6	ED83156-30 Group 4	601832025

Electrostatic Discharge Prevention

The following guidelines describe an ESD (Electrostatic Discharge) prevention method that is consistent with the intent of proper handling and protection of circuit packs in a central office or outside plant type of environment. These guidelines satisfy the minimum requirements for all three ESD-sensitive classifications (I, II, and III) and, therefore, all circuit packs in these classes are handled in the same manner, regardless of sensitivity. Factory packaging will provide shielding in the rare instances where it is necessary.

ESD Warning

Grounded antistatic wrist straps must be worn for all circuit pack handling. The alligator clip connector of the wrist strap must be connected to a bare metal frame ground. The wrist strap must contact the skin and is not to be worn over clothing. At least once every week of use, verify that the resistance between the wrist strap and its connector plug is 1 megohm ± 10 percent. If a static-sensitive pack has already been found faulty, do not ignore requirements for handling static-sensitive packs. Continued mishandling may create other, more serious, problems with the pack.

- Assume all circuit packs containing electronic (solid-state) components can be damaged by ESD.
- When handling circuit packs (storing, inserting, removing, etc.) or when working on the backplane, always use the appropriate grounding procedure: either a wrist strap connected to ground or, when standing, a heel strap with a grounded dissipative floor mat.
- A grounded person must never hand an unprotected circuit pack to an ungrounded person. A static discharge from the ungrounded person through the circuit pack to the grounded person could cause an electrostatic discharge failure. All persons and equipment at a work location must be at the same common ground potential to be static safe.
- In addition, handle all circuit packs by the faceplate or latch and by the top and bottom outermost edges. Never touch the components, conductors, or connector pins.
- Do not rub or wipe circuit packs to clean them unless you and the circuit pack are at the same ground potential.
- Observe warning labels on bags and cartons. Whenever possible, do not remove circuit packs from antistatic bags or cartons until ready to insert into a bay. Otherwise, open all circuit packs at a static-safe work position with wrist straps and dissipative table mats.
- Upon removal from the bay, immediately put circuit packs into antistatic packages. Always store and transport circuit packs in antistatic packaging. Shielding is not required unless specified.
- Keep all static-generating materials away from all circuit packs. These materials include common plastics such as food wrappers, clear plastic bags, styrofoam containers and packing material, plastic drinking cups, notebooks, and nonconductive plastic solder suckers. The plastic insulation on small hand tools does not represent a static hazard.

- Keep adhesive tape (Scotch, masking etc.) away from static-sensitive devices.
- When soldering static-sensitive semiconductor devices, the soldering iron must be grounded to the work table which must also be earth grounded.
- Do not wax the equipment aisles in central offices.
- Whenever possible, maintain relative humidity above the 20 percent level.

Component Removal

This section provides component removal procedures for the J87132B-2 Rectifier described in this manual. The purpose of this section is to facilitate removal and replacement of rectifier components. Troubleshooting procedures, or fault isolation techniques, are not provided in this section, except in the case of rectifier diodes (see Section 7, *Maintenance*, for these procedures).

Only disassembly or component removal procedures are given. It is implied that reinstallation procedures are the exact reverse of removal procedures (i.e., the removal procedures are followed in reverse to accomplish reinstallation). Where this does not apply exactly, or where special considerations or precautions must be taken during reinstallation, specific instructions are given. Also, cautions are given as part of the removal procedures in cases where they are necessary to facilitate subsequent reinstallation work.

Common Considerations

The following is a discussion of some points common to all disassembly work. Please read this, and the following part, before reading or using the actual rectifier disassembly procedures.

It is most important to take precautions against accidental personal injury (or damage to equipment). Please observe the following admonishment before undertaking any disassembly or reinstallation procedure on a rectifier. Note that the ac service and dc battery buses can be safely disconnected from the rectifier by following the first six steps of the "Test Load Connection and Removal" procedure given in Section 7, *Maintenance*. All work must be carefully done because you are working with live cables at battery bus potentials and current capabilities. Also, the disconnected charge (battery) and charge ground connectors must be adequately taped in order to prevent them from contacting each other or any other metal surface.

Alternatively, the dc battery cables from the rectifier to be worked on can be disconnected at the plant's battery buses (i.e., at the charge battery and charge ground buses that usually mount over the plant's battery stand.

DANGER

Any of the following disassembly or reinstallation procedures **MUST** be performed only on a rectifier completely disconnected from the plant's battery buses, **AND** with no ac input from the ac service connected to the rectifier. The plant control cable and remote sense cable, connected to the rectifier CM2 board should also be disconnected.

When a rectifier must be removed from a bay, applicable portions of Section 5, *Installation and Testing*, covering adding or removing a rectifier from an operating plant, may provide useful information. Applicable portions of "Initial Startup and Checkout" in Section 5 can be employed after reinstallation of a rectifier to verify proper operation.

Always use common sense. For example, always read through the relevant procedure at least once before starting work. Always make note of the lead connection points (terminating positions) before unsoldering or disconnecting them to insure trouble-free reinstallation. This would include potentiometer leads, or the solderless "quick-disconnect" type connections used on circuit boards, relays, inductors and transformers, and wire bundles. Quick-disconnect connections should always be disconnected by pulling straight apart to avoid bending or breaking the tabs. Do not pull on wire. Always remember to save hardware, thermal pads, and other items necessary for reassembly in a convenient place.

DANGER

DC capacitors may be charged even with power disconnected from the rectifier. This would be true even if the main bus bar fuses are open. Always check all dc capacitor terminals (observe polarity) with a voltmeter before performing this procedure, and discharge capacitors safely, if necessary.

DC capacitors can be examined to see if they have "blown" (i.e., vented) due to voltage breakdown failure. A small hole in the capacitor top, called a "blow-hole", is plugged in a new or good

capacitor, but is empty (blown out) in a failed unit. A dental-type mirror will aid in viewing these capacitors' blow-holes before disassembly. Also, it is recommended that all dc capacitors in a rectifier be replaced whenever any one of them has blown. Remember that dc capacitors can still hold a charge even with the ac and battery disconnected. Always verify the charge condition of these capacitors and discharge them, if necessary, before working near them or removing them.

Most component removals are straightforward and, for the most part, obvious. Therefore, these procedures can be used as a guide by qualified service personnel, rather than as step-by-step procedures. For example, it may be a matter of personal preference to remove a part not called for in order to make more room for access to a component being replaced.

Tables 8-D and 8-E provide the reassembly torquing requirements for both the electrical and mechanical connections in the rectifier. Use these values unless otherwise directed in the procedures.

Removal Procedures

See Figures 5-3, 5-5, and 8-1.

DANGER

Any of the following disassembly or reinstallation procedures **MUST** be performed only on a rectifier completely disconnected from the plant's battery buses, **AND** with no ac input from the ac service connected to the rectifier. The control cable, connected to the rectifier CM2 board, should also be disconnected.

Warning

Thermally hot surfaces are located inside the rectifier. Use gloves when handling hot components.

Note

The front door must be opened prior to any of these replacement procedures. To open the front door, loosen the two screws located on the right front of the door.

Table 8-D: Minimum Torque For All Electrical Connections

Screw Size	Torques - lb-in or (lb-ft)					
	Wire Connectors		Head Tightened		Nut Tightened	
	Slotted Machine	Hex or Socket Cap	Slotted Machine	Hex or Socket Cap	Slotted Machine or Hex Cap	Socket Cap
8-32	15	15	19	19	19	23
10-24	21	21	27	27	27	33
1/4-20	50	50	65	65	65	80
5/16-20	--	100	--	135	135	165
3/8-16	--	180	--	240	240	290
7/16-14	--	280	--	385	385	465
1/2-13	--	500	--	585	585	710
5/8-11	--	(71)	--	(97)	(97)	(118)
3/4-10	--	(125)	--	(172)	(172)	(209)

Notes:

1. Slotted machine screws should be the pan-head type.
2. Slotted machine and hex cap screws should be SAE Grade 2 steel.
3. Socket cap screws should have 100,000 PSI minimum tensile strength.
4. Steel flat washers should be furnished under heads of socket cap screws.
5. Ferrous screws and washers should have a corrosion protective finish.
6. Locking means is only required for connections subject to vibration. Belleville-type washers or jam nuts are the preferred means.
7. For less than 1/4" thick tapped copper bars, use slotted no.8, no.10, or 1/4" machine screws to minimize applicable torque. When larger size machine screws are required, provide captive-type steel nuts or reduce torques.
8. Torque recommendations are also suitable for all non-ferrous fasteners except aluminum.
9. Where application permits, hex cap screws should be used.

Table 8-E: Torque and Minimum Yield Strength for Mechanical Connections (Using Hex Head Cap Screws)

Cap Screw Diameter	Grade 2	
	Minimum Yield Strength (PSI)	Torque (Ft-Lb) UNRC
1/4	57,000	5
3/16	57,000	12
3/8	57,000	22
7/16	57,000	35
1/2	57,000	54
9/16	57,000	77
5/8	57,000	107
3/4	57,000	190
7/8	36,000	193
1	36,000	290
1-1/8	36,000	410
1-1/4	36,000	580
1-3/8	36,000	760
1-1/2	36,000	1010

**CM2 Control Module (208G),
CM3 Digital Meter Board (323E)**

1. Remove all headers and quick-disconnect connectors from board.
2. Support board with one hand and push in on plastic locking tabs to free board. (The digital meter board CM3 requires the removal of one screw.)
3. Verify DIP switch setting before turning unit on (see the paragraph on “DIP Switch Settings” in Section 5, *Installation and Testing*).

Note

To get at various sets of components in the 140-ampere rectifier, it may be necessary to remove protective plastic shields.

***CM1 Fuse
Board, CM5 or
CM6 Snubber
Board, CM8
Resistor Bleeder
Board***

1. Remove the quick-disconnect connectors from the board.
2. Push in on the four plastic locking tabs to free the board.

***Thyristors (Q1,
Q2)***

1. Remove the wires attached to the thyristor. (Note their position for reinstallation.)
2. Remove the two nuts that secure the thyristor to the heat sink. (Save the nuts and the thermal pad located under the thyristor.)
3. When reinstalling a new thyristor, use the hardware and thermal pad (DP102, comcode 403208242) saved from above. (Note that the gate terminal, the small one, always faces down.) Torque the mounting nuts to 10 in-lb. Reconnect the wires to the new thyristor.

***Diode Heat Sink
Assemblies***

1. Remove the nuts securing the pigtail of the diode to be replaced from the power transformer.
2. Use a meter with a diode test function (or measure the forward and backward resistances of the diode) to determine if the diode is good. A good diode should measure at least 50 ohms in both directions, and one direction should measure at least 50 times the other. The larger resistance is the back resistance, and the smaller is the forward resistance. Most diodes that fail do so by shorting (i.e., they will measure shorted or almost shorted in both directions).
3. If the diode checked bad, replace it. If the diode checked good, reinstall it.
4. Remove the nut on the back side of the diode. Save the thermal pad and nut. Cut cable tie securing the pigtail lead.
5. Reinstall diode with thermal pad. Dress pigtail lead away from any sharp corners. Torque diode nut to 275 to 325 in-lbs. Torque pigtail connection to transformers to 100 in-lb.

**DC Capacitors
(C7 through C12)**

DANGER

DC capacitors may be charged even with power disconnected from the rectifier. This would be true if the main bus bar fuses are open. Always check all of the dc capacitor terminals (observe polarity) with a voltmeter before performing this procedure, and discharge capacitors safely, if necessary.

1. DC capacitors C7, C9, C11, and C12 are mounted in a column on the left, and C8 and C10 are mounted in a column on the right as shown in Figure 8-1. The capacitors are located behind the capacitor bus bars. The bus bars are mounted directly to the capacitors by the capacitors' terminal screws. In order to remove a capacitor from either column, remove fuse board CM1 as described earlier in this section under "CM1 Fuse Board, CM5 or CM6 Snubber Board", all of the capacitors' terminal screws, mounting screws, and the screw supporting the fuse assembly. Note that this will completely free the capacitor bus bar in question.
2. Remove capacitor from its capacitor clamp by pulling it toward you on the capacitor.
3. Replace the capacitor by pushing it into the clamp with the negative terminal toward the inside.

Note

All output capacitors should be replaced if any are being replaced.

4. Replace the positive bus bar. Tighten the mounting screws first and then the capacitor terminal screws.
5. Replace the fuse assembly. (Replace the fuse if required.)

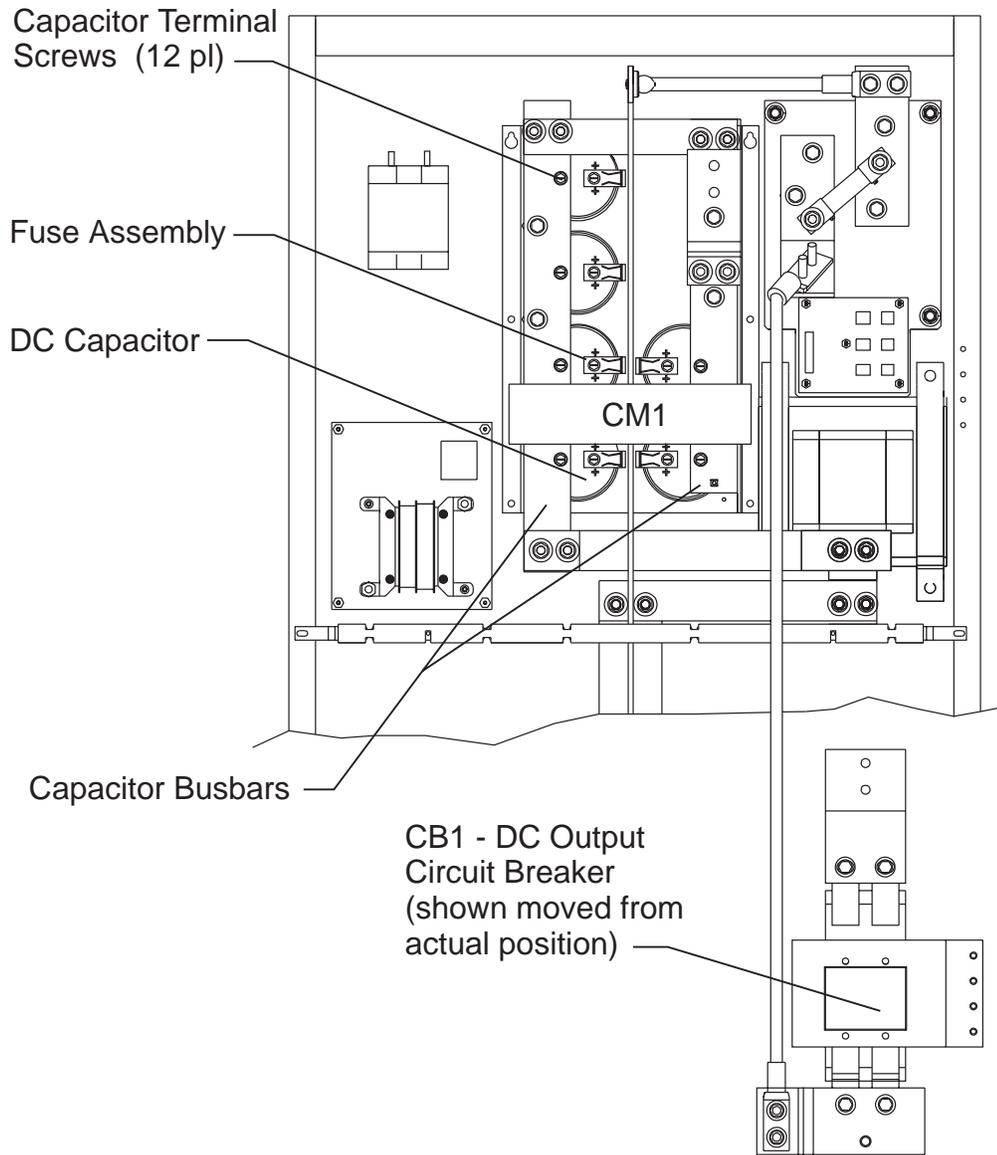


Figure 8-1: DC Distribution Showing Capacitor Bus Bars

**CB1 Circuit
Breaker**

1. Remove the output cables connected to the rectifier.
2. Remove the bolts securing the input bus bar to the circuit breaker.
3. Support the breaker and remove the four screws securing the breaker to the side upright. (Note that there are two alarm connections attached to the rear of the breaker. Remove these once the breaker is free.)

DC Inductor L3

Note

To replace L3, the circuit breaker must first be removed. See “CB1 Circuit Breaker”.

1. Remove the electrical connection of the inductor to be replaced.
2. While supporting the weight of the inductor, remove all four of the mounting nuts that secure it to the mounting surface.

**Contactor Relay
(K1)**

1. Remove all six of the heavy gauge (input and output) wires from K1.
2. Remove the five smaller gauge wires from K1.
3. Remove the three mounting screws to remove K1 from the rear wall.

Note

Save the six input and output screws to use in new contactor. These screws have lock washers and keep wires from coming loose. These screws can also be ordered from the J-drawing. Torque values: 10x32 torque to 30 in/lbs; 1/4x20 torque to 50 in/lbs.

**AC Inductors
(L1 or L2)**

1. Remove the cables and wires from both terminals of inductor (the terminals are mounted on insulator standoff associated with the inductors).

2. While supporting the weight of the inductor, remove the inductor from the rectifier.

***AC Capacitors
(C1-C6)***

1. Remove the quick-disconnect connectors from the capacitor.
2. Remove the screws securing the capacitor clamp and capacitor to the mounting plate.
3. Loosen the clamp on the capacitor and remove.

***Main
Transformers
(T1 or T2)***

1. Remove all of the cables from the transformer.
2. To access the transformer mounting screws, remove the kickplate (five screws) from the bottom of the rectifier frame.
3. Remove the four transformer mounting screws (from underneath the T1/T2 mounting bracket) that secure the transformer.
4. While supporting the transformer with adequate lifting equipment (at least 1000 lbs.), slide the transformer outward.

9 *Product Warranty*

A. Seller warrants to Customer only, that:

1. As of the date title to Products passes, Seller will have the right to sell, transfer, and assign such Products and the title conveyed by Seller shall be good;
2. Upon shipment, Seller's Manufactured Products will be free from defects in material and workmanship, and will conform to Seller's specifications or any other agreed-upon specification referenced in the order for such Product;
3. With respect to Vendor items, Seller, to the extent permitted, does hereby assign to Customer the warranties given to Seller by its vendor of such Vendor Items, such assignment to be effective upon Customer's acceptance of such Vendor Items. With respect to Vendor items recommended by Seller in its specifications for which the vendor's warranty cannot be assigned to Customer, or if assigned, less than Sixty (60) days remain of the vendor's warranty or warranty period when the Vendor's items are shipped to Customer or when Seller submits its notice of completion of installation if installed by Seller, Seller warrants that such Vendor's Items will be free from defects in material and workmanship on the date of shipment to Customer. In such an event, the applicable Warranty Period will be sixty (60) days.

B. The Warranty Period listed below is applicable to Seller's Manufactured Products furnished pursuant to this Agreement, unless otherwise stated:

WARRANTY PERIOD

Product Type	New Product	Repaired Product or Part
Central Office Power Equipment	24 Months	6 Months

*The Warranty Period for a repaired Product or part thereof is as listed or, in the case of Products under Warranty, is the period listed or the unexpired term of the new Product Warranty Period, whichever is longer.

**The Warranty Period for Products ordered for Use in Systems or equipment Manufactured by and furnished by Seller is that of the initial Systems or equipment.

C. If, under normal and proper use during the applicable Warranty Period, a defect or nonconformity is identified in a Product and Customer notifies Seller in writing of such defect or nonconformity promptly after Customer discovers such defect or nonconformity, and follows Seller's instructions regarding return of defective or nonconforming Products, Seller shall, at its option attempt first to repair or replace such Product without charge at its facility or, if not feasible, provide a refund or credit based on the original purchase price and installation charges if installed by Seller. Where Seller has elected to repair a Seller's Manufactured Product (other than Cable and Wire Products) which has been installed by Seller and Seller ascertains that the Product is not readily returnable for repair, Seller will repair the Product at Customer's site.

With respect to Cable and Wire Products manufactured by Seller which Seller elects to repair but which are not readily returnable for repair, whether or not installed by Seller, Seller at its option, may repair the cable and Wire Products at Customer's site.

D. If Seller has elected to repair or replace a defective Product, Customer shall have the option of removing and reinstalling or having Seller remove and reinstall the defective or nonconforming Product. The cost of the removal and the reinstallation shall be borne by Customer. With respect to Cable and Wire Products, Customer has the further responsibility, at its expense, to make the Cable and Wire Products accessible for repair or replacement and to restore

the site. Products returned for repair or replacement will be accepted by Seller only in accordance with its instructions and procedures for such returns. The transportation expense associated with returning such Product to Seller shall be borne by Customer. Seller shall pay the cost of transportation of the repair or replacing Product to the destination designated by Customer within the Territory.

- E. The defective or nonconforming Products or parts which are replaced shall become Seller's property.

- F. If Seller determines that a Product for which warranty service is claimed is not defective or nonconforming, Customer shall pay Seller all costs of handling, inspecting, testing, and transportation and, if applicable, traveling and related expenses.

- G. Seller makes no warranty with respect to defective conditions or nonconformities resulting from actions of anyone other than Seller or its subcontractors, caused by any of the following: modifications, misuse, neglect, accident, or abuse; improper wiring, repairing, splicing, alteration, installation, storage, or maintenance; use in a manner not in accordance with Seller's or vendor's specifications or operating instructions, or failure of Customer to apply previously applicable Seller modifications and corrections. In addition, Seller makes no warranty with respect to Products which have had their serial numbers or month and year of manufacture removed, altered, or with respect to expendable items, including, without limitation, fuses, light bulbs, motor brushes, and the like.

THE FOREGOING WARRANTIES ARE EXCLUSIVE AND ARE IN LIEU OF ALL OTHER EXPRESS AND IMPLIED WARRANTIES, INCLUDING BUT NOT LIMITED TO WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE. CUSTOMER'S SOLE AND EXCLUSIVE REMEDY SHALL BE SELLER'S OBLIGATION TO REPAIR, REPLACE, CREDIT, OR REFUND AS SET FORTH ABOVE IN THIS WARRANTY.

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