Lucent Technologies
Bell Labs Innovations

Lineage® 2000 200-Ampere, 60-Hertz Ferroresonant Rectifier J85503B-2

Product Manual
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Lucent Technologies Lineage® 2000 200-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 describes the J85503B-2, 3-phase, 200-ampere, 60-hertz, -48 and ±24 volt, floor-mounted ferroresonant rectifier. The manual covers rectifier technology, features and specifications, installation and testing, and operation and maintenance.

The J85503B-2 rectifier is a member of the Lucent Technologies family of Lineage® 2000 rectifiers. Like all Lineage® 2000 rectifiers, it represents a significant advancement in efficiency, space savings, and serviceability. The rectifier uses the electronically controlled, closed-loop, ferroresonant technology developed by Bell Laboratories. This technology provides excellent output regulation in spite of variations in the incoming commercial line voltage and frequency and the outgoing current or load.

The J85503B-2 rectifier converts commercial 208/240/480-volt ac input power at 60 hertz into highly regulated and filtered, low-noise, -48 and ±24 volt dc output power for telecommunications equipment loads. Central offices usually obtain electrical power from potentially noisy commercial ac lines and/or emergency generators during commercial power failures. The J85503B-2 rectifier provides the high quality dc power required for proper operation of telecommunications equipment.

Applications

Lucent developed the J85503B-2 rectifier to support large central office applications where high reliability, low maintenance, long life, and fault tolerance are critical.

Features

The J85503B-2 rectifier can be used with a Lineage® 2000 battery plant or any commercial battery plant. It can boost charge batteries and equalize batteries off-line to 65 volts (for -48-volt plants) or to ±32 volts (for ±24 volt plants), as well as operate without batteries. The rectifier works with Lucent Technologies controllers to provide control and alarm functions. An interface board is available to access these functions with commercial controllers.

Benefits

The J85503B-2 rectifier offers you the following:

- 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 far less noise into closely coupled telephone lines due to lower harmonic components in the input current waveshape.
- Provides highly efficient power conversion.

Ferroresonant technology and the rectifier's physical design features combine to provide reliable service, easy maintenance, and greater cost-effectiveness.

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, which results 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. Standardized modules simplify parts inventory, resulting in lower costs and better equipment availability.

Wide versatility: The rectifier can be used in a plant with or without batteries and with or without a controller. The load share

feature, equalize feature, noise filtering, and interface board adapt the rectifier to practically any application.

Customer Service

For customers in the United States, Puerto Rico, the U.S. Virgin Islands, and Canada, call 1-800-THE-1PWR (1-800-843-1797). Customer service specialists at this number can initiate the spare parts procurement process, order Lucent Technologies documents, and provide other product and service information.

Other customers world-wide may call 001-972-840-0382. This number is answered from 8:00 am until 4:30 pm, Central Time (Zone 6), Monday through Friday.

Technical Support

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

Technical support for Lucent Technology customers is available around the world during the normal product warranty period and also while specific contractual arrangements extend this service.

For customers in the United States, Puerto Rico, the U.S. Virgin Islands, and Canada, call our Technical Support telephone number 1-800-CAL RTAC (1-800-225-7822) to contact a Product Specialist 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.

For other customers world-wide, contact your local field support center or your sales representative to discuss your specific needs.

Product Repair and Return

Repair and return service for Lucent Technologies equipment is available to customers around the world. For customers in the United States, Puerto Rico, the U.S. Virgin Islands, and Canada, call 1-800-255-1402 for information on returning products for repair.

For other customers world-wide, contact your local field support center or your sales representative to discuss your specific needs.

2 Product Description

General

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 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.

Typical Battery Plant

Figure 2-1 shows a basic block diagram of a typical dc battery plant. The battery plant accepts alternating current from the commercial utility or a standby ac power source and rectifies it to produce dc power for the using equipment. The plant's control and alarm functions interact with the rectifiers and the office. In addition, the plant provides overcurrent protection, charge, discharge, and distribution facilities. Battery reserve automatically provides a source of dc power if the commercial or standby ac fails. This battery reserve is engineered to supply dc power for a specific period of time. In normal practice, battery capacity is sized to provide 3 to 8 hours of reserve time.

Battery Plant Subsystems

AC Input: connects the commercial and/or standby ac power sources to the rectifiers within the plant and provides overcurrent protection. This subsystem is usually supplied by the customer.

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.

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 used to interconnect the rectifiers, batteries, plant shunt, and dc distribution.

Converters: transform -48 volt source voltages into regulated, low-noise 24 volt dc power sources for use with telecommunications loads.

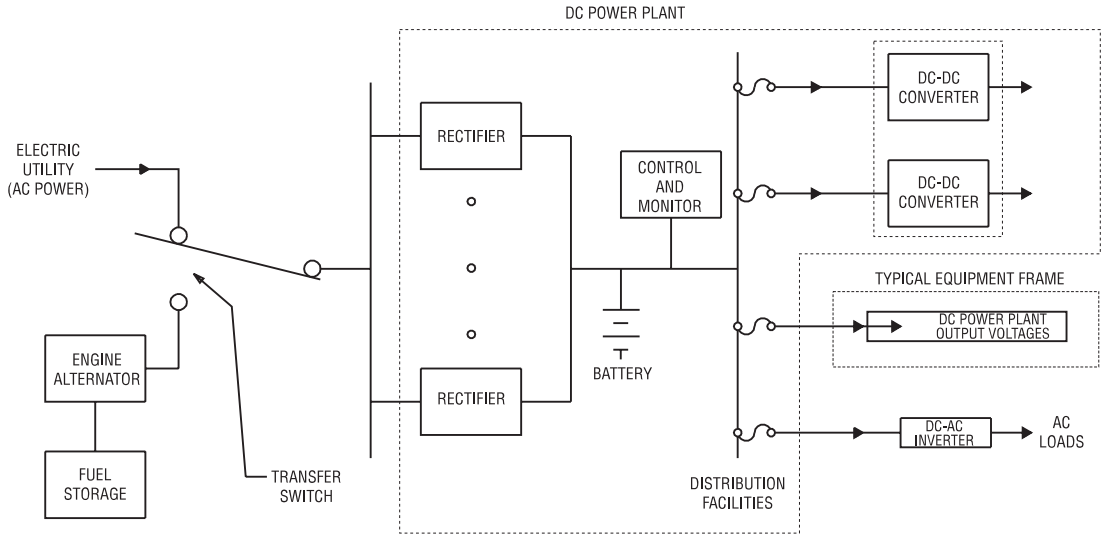


Figure 2-1: Block Diagram of a Typical Battery Plant

Features

The J85503B-2 rectifier offers 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 gradually increases to the required value in approximately 10 seconds. As the output voltage "walks in," so does output current. This feature minimizes the starting surge on the customer's power source and is especially important with a more limited power source, such as an engine driven alternator.

Electronic Current Limit

The rectifier provides a constant output voltage up to its rated output current, at which point it provides constant current. This current limit set point is typically adjustable from 30 to 110 percent of the rectifier rating, 60 to 220 amperes. When the output current tends to increase above the current limit setting, the current limit circuit overrides the voltage regulating signal and limits the output current of the rectifier.

Backup Current Limit

In addition to the electronic current limit, the ferroresonant transformers are naturally current limiting to 125 to175 percent of full load, or 250 to 350 amperes.

Selective High Voltage Shutdown

If the battery voltage goes too high, a Lineage® 2000 controller signals all of the connected rectifiers. This signal causes the rectifier(s) delivering more than 10 percent of full load to shut down. The remaining rectifiers continue to operate. The J85503B-2, 200 ampere also accepts a selective high voltage shutdown (HVSD) signal from any external source via the interface board.

Internal Selective High Voltage Shutdown (ISHVSD)

The rectifier will sense a high voltage condition at its output terminals. If delivering more than 10 percent of its rated output, 20 amperes, the rectifier shuts down. This high voltage threshold is user-selectable via programmable DIP switches. The ISHVSD is a backup to the selective HVSD.

Backup High Voltage Shutdown (BUHVSD)

This circuit operates if the selective HVSD or ISHVSD fails to operate. The circuit prevents damage to the rectifier or connected equipment in the event of high battery voltage. Each rectifier senses its own output voltage, and when the voltage exceeds a preset value, the rectifier shuts down. The backup high voltage threshold is user-selectable via programmable DIP switches. This circuit operates from an independent voltage source in order to provide improved reliability of the high voltage shutdowns.

Dynamic Response

For any step load change of 10 to 90 percent, or 90 to 10 percent, or a step change of 10 percent of the input voltage, the sense point voltage remains within 5 percent of its setting, and returns and remains in the 1/2 percent band within 300 milliseconds.

For operation without batteries, the sense point voltage remains within 10 percent of its setting and returns and remains in the 2 percent band within 500 milliseconds for any step load change of 50 to 90 percent, or 90 to 50 percent, or a step change of 10 percent of the input voltage.

Forced Electronic Load Sharing

The rectifier is equipped with a user selected option by which the rectifier is capable of load sharing with other J85503B-2 rectifiers to better than 10 percent of the full load rating of the rectifier.

Safety Interlocks

A series-loop circuit electrically interconnects all of the circuit modules and prevents rectifier operation if any circuit module is not properly installed.

Restart Circuit

The rectifier is compatible with the automatic restart features of Lineage® 2000 controllers. The rectifier will also accept an isolated restart signal from any external source via the interface board.

Output Circuit Breaker

An output circuit breaker protects the plant from rectifier malfunction and excessive current, and may be used to disconnect the rectifier from the battery. The standard breaker size is 215 amperes.

Output Current Indication

A precision resistor shunt measures the rectifier output current. When used with a Galaxy or Microprocessor Controlled System controller, the rectifier provides an isolated 2- to 10-volt signal, corresponding to a range of no-load to 125 percent of rated output load, to indicate the rectifier drain on the controller. In addition, shunt access points are available on the 329A board for measuring the shunt voltage directly.

Output Voltage Adjustment Range

The rectifier is capable of providing up to 65 volts dc (or ±32 volts dc in ±24 volt plants) output at 50 percent of its rated output power and nominal input voltage.

Float/Equalize/ Boost

The rectifier can be put into the Equalize mode in one of three ways:

1. Receiving a signal from a Lucent Galaxy Controller or an MCS Controller equipped with Version 4.0 firmware

2. Putting the front panel switch on the digital meter board in the Equalize position

3. Receiving a closure on the EQL and EQLR terminals of the interface board

Equalize Acknowledge

In addition to the front panel Equalize LED, an Equalize acknowledge signal (EQA, EQAR) is provided by the interface board. This signal indicates that the rectifier is in the Equalize mode.

Remote Sense Leads

These leads permit the rectifier to regulate the battery voltage by sensing the voltage at the battery. Up to a 2-volt lead drop between the rectifier and battery is permitted. The sense leads are also accessible from the interface board.

Local Sense

The rectifier has an option, via user-selected DIP switch settings, to regulate the voltage at the output terminals of the rectifier.

Remote Shutdown

The remote shutdown circuit permits the shutdown of a rectifier when the transfer (TR) signal is received from a Lucent controller. When the rectifier is used with a Galaxy or an MCS controller, spare rectifiers can be shut down via the TR signal, resulting in a significant energy saving. The controllers immediately turn the rectifiers back on if they are required to power the load or charge the battery. When not equipped with a Lucent controller, remote shutdown can be accomplished by applying a discharge ground signal to the TR lead on the interface board. When the rectifier is operated without battery, then -48Vdc must also be provided on the BAT lead on the interface board.

Remote Control Circuit

By connecting to the interface board, the rectifier can be turned on and off remotely. This feature can be enabled or disabled via a switch on the interface board.

Output Noise

The output noise is limited to 32 dBrnc. When measured with a Psophometric noise meter, the noise is less than two millivolts rms. (All of the above requirements are at full load, on battery, and the noise is measured at the battery).

Rectifier Failure Alarm (RFA) Test

A momentary closure either on the Control Board (208F1) or the Interface Board (330C) board simulates a rectifier fail, generates the RFA alarm, but does not shut the rectifier down.

Electromagnetic Compatibility (EMC)

In regard to radiated and conducted emissions, the J85503B-2 200-ampere rectifier complies with the United States of America Federal Communications Commission (FCC) as required for Class A applications. In addition, the rectifier meets all specified operating characteristics when subjected to electric fields up to 10 volts per meter over a frequency range of 20 to 1000 MHz.

Alarms

The J85503B-2, 200 ampere, 60-hertz rectifier can discern the following alarms as well as provide diagnostic information for certain alarms if you use a Galaxy or an MCS controller. When any other controller is used, most of these alarms are available from the interface board of the rectifier.

Load Share Fail (LSF)

In -48 volt plants, the load share circuitry is fused in each rectifier to prevent a failure in one rectifier from cascading into other rectifiers. If this fuse operates, the load share failure LED lights, and the LSF alarm issues. The rectifier continues to provide power with its load share feature automatically disabled. This alarm is not available in ±24 volt plants.

Fuse Alarms (FA)

The low-power control circuits, regulation leads, and dc capacitors are fused and alarmed. When any fuse alarm circuit operates, except for the LSF fuse, the rectifier shuts down and the fuse alarm (FA) and rectifier fail alarm (RFA) LEDs light. Tripping the output circuit breaker also generates an FA.

Rectifier Failure Alarm (RFA)

When a rectifier fails, an RFA issues to the controller and the interface board and lights the front panel RFA LED. The rectifier transmits a signal to a Lucent controller, if present, indicating which one of the following has occurred:

1. Fuse(s) inside the rectifier has operated.
2. Selective high voltage shutdown has operated.
3. Internal selective high voltage shutdown has operated.
4. Backup high voltage shutdown has operated.
5. Output circuit breaker has tripped.
6. Unbalance circuit has operated.

Auxiliary RFA Alarm An additional RFA alarm is provided on the rectifier fuse board to simplify the interface with adjunct monitoring devices.

Charger Fail Alarm (RFA/CFA) An RFA/CFA alarm is transmitted to the interface board when the ac input fails or the RFA relay operates.

Manual Alarm (MAN) A MAN alarm signals the interface board and a Lucent controller, if present, when either the rectifier has been turned off or lost power.

AC Fail (ACF) If the three-phase commercial ac into the rectifier fails and the rectifier is connected on battery, the ACF alarm is generated and a red LED on the front of the rectifier lights.

Circuit Breaker Alarm (CB) An output circuit breaker alarm signals the interface board and a Lucent controller, if present, when the circuit breaker trips.

Phase Monitor Circuit (PHA) The phase monitor circuit signals a Lucent controller, if present, when the input voltage decreases to less than 70 present of the nominal value, or when the voltage on any phase is completely missing. If the rectifier is supplying less than 20 percent of its rated output, the rectifier may remain operational; if it is supplying more than 20 percent of the load, the rectifier shuts down. When the rectifier shuts down, a limited output alarm, LOA, issues to an MCS Controller and to the interface board.

Unbalance Alarm Circuit

A severe unbalance developed in the rectifier triggers the rectifier fail circuit. The rectifier shuts down and an alarm is generated. This shutdown of the rectifier has a delay to prevent false operation from transient disturbances, such as may occur during initial turn-on.

Low Current Alarm (LCA)

If the forced electronic load share feature is enabled (**-48 volt plants only**) and any rectifier is providing less than 3 percent of its rating, a low current alarm issues. The alarm issues at 0.5 percent of the rectifier rating and discontinues at 3 percent.

Front Panel Controls And Indicators

Figure 2-2 shows the control panel on front of the J85503B-2, 200-ampere rectifier. The following list describes the controls and indicators on the control panel. Bold letters indicate labels that appear on the control panel or inside the rectifier.

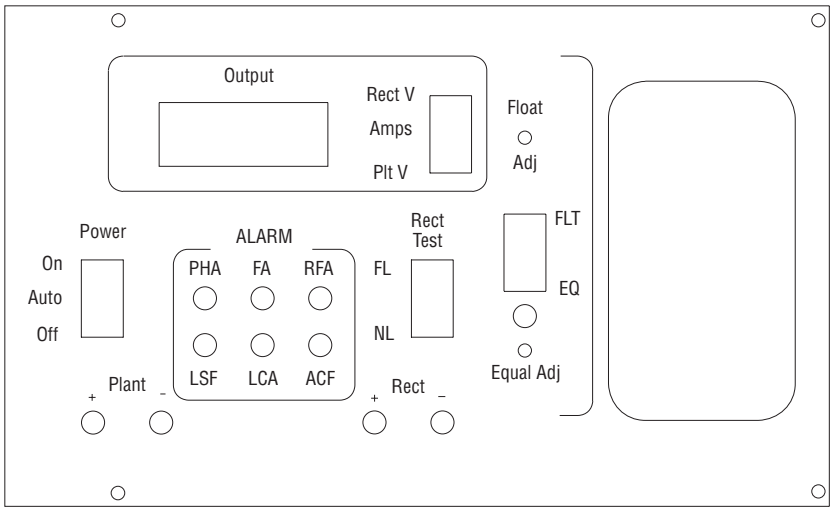


Figure 2-2: J85503B-2 Control Panel

Note

In Figure 2-2, “Equal Adj” and “EQ” LEDs may be labeled “Boost” and “BST,” respectively, for international customers.

Output Meter

The digital **Output** meter displays the following:

- The rectifier output current when the meter switch is in the **Amps** position

- The rectifier output voltage when the meter switch is in the **Rect V** position
- The battery voltage when the meter switch is in the **Plt V** position

Rect V The user may select whether the default position of the meter switch is rectifier current or battery voltage. Otherwise, moving the switch momentarily to the **Rect V** position displays the rectifier voltage. The user may also select the option of having the meter active when the rectifier is manually turned off.

Power Switch The **Power** switch turns the rectifier **On, Off,** or puts it in the **Auto** mode for remote control via a signal to the interface board. A green LED lights when the rectifier is on.

Alarms The control panel on the J85503B-2 has the following LEDs:

PHA: A red LED lights if the rectifier shuts down due to phase voltages falling below the normal operating range or total loss of a phase

FA: A red LED lights if any fuse, except the LSF fuse, operates or the output circuit breaker operates

RFA: A red LED lights if a failure occurs in the rectifier and the rectifier shuts down

LSF: A yellow LED lights if the fuse in the load share circuit of the rectifier operates

LCA: A yellow LED lights if the load share option is active and the rectifier is providing less than 1.5 amperes of output current. The LED remains on until output reaches 6 amperes.

ACF: A red LED lights if commercial ac fails.

Rect Test Switch The **Rect Test** switch provides a manual test of the rectifier regulation by simulating a full load (**FL**) or no load (**NL**) condition. Operating the switch raises or lowers the output voltage setting of the rectifier by 0.25 volt when on battery. When the switch is in the center position, the rectifier is in the normal operating state; when the switch is operated to FL, the

rectifier goes to maximum current (FL); when it is operated to NL, the rectifier goes to no current.

Rect + and - Test Jacks The **Rect +** and **-** test jacks allow for measuring the output voltage of the rectifier.

Plant + and -Test Jacks The **Plant +** and - test jacks measure the voltage between the points where the remote sense leads are connected. This measurement is accurate only when the remote sense leads are connected.

Float Adj The **Float Adj** potentiometer provides for manual adjustment of the output float voltage.

FLT/EQ The Float/Equalize, **FLT/EQ**, switch allows the user to select either the float or equalize operating mode. This switch is disabled when the rectifier is shipped from the factory and must be enabled via S2.1 of the 330C interface board in order to provide the local equalize feature. The yellow equalize LED lights when the rectifier is in the equalize mode.

Equal Adj The **Equal Adj** potentiometer provides for manual adjustment of the output equalize voltage.

Circuit Breaker The circuit breaker protects the plant from rectifier malfunction and excessive current, and may be used to disconnect the rectifier from the battery. When the circuit breaker trips (midway between On and Off) because of excessive current, an alarm is transmitted to the plant controller. When the circuit breaker is manually turned off, no alarm is transmitted.

Circuit Modules

The rectifier's signal processing and control circuitry are located on replaceable circuit modules or packs. Circuit modules are plug-in boards that are ordered separately. (See Section 3 for ordering information.) All modules are accessible by opening the rectifier door. Figure 2-3 shows the location of the modules and other features of the rectifier. Figures 6-2, 6-3, 7-1, and 5-6 show the **CM1** through **CM4** board layouts, respectively. A description of each module follows.

CM1 The **CM1** circuit module (329A Fuse Board) protects the control circuits from faults in the rectifier power train. It contains alarm fuses, bleeder resistors, access points for the plant shunt voltage, and an isolated RFA transfer contact.

CM2 The **CM2** circuit module (208F1 Control Board) contains the following circuits:

Table 2-A: CM2 Circuits

Local power supplies	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 relay	Load share circuit
Phase monitor	RFA test
Rectifier portion of external selective high voltage shutdown	

CM3 The **CM3** circuit module (323D Digital Meter Board) controls the digital **Output** meter and all indicators on the rectifier control panel. The meter displays the rectifier's output current, voltage, or the plant battery voltage, depending on the position of the selector switch. See Figure 2-2.

CM4 The **CM4** circuit module (330C Interface Board) provides alarm and control circuitry that permits the rectifier to interface with various controllers. It also provides additional monitoring points and new alarm interface points for AC fail, RFA test, load share, LCA, and LSF.

CM5/CM6 The **CM5** and **CM6** circuit modules are identical boards, ED83156-30 Group 3. These boards contain a triac/thyristor snubber network and EMI circuitry. Refer to schematic drawing SD83281-01 for further information**.**

CM7 The **CM7** circuit modules (425C and 425D Transformer Boards) contain the sense transformer, bleeder resistors, and walk-in reset relay. Use of these boards depends upon ac input voltage.

Warning

Circuit modules must not be connected or disconnected with voltages present. Personal injury or equipment damage may occur. See Section 8 for how to replace circuit modules.

Alarm and Control Flow

The J85503B-2 200-ampere rectifier is typically installed in a battery plant that is monitored and controlled by a Lucent Lineage® 2000 controller. The rectifier generates various monitoring and alarm signals and, in this type of installation, sends them to the controller for processing and subsequent action. The action may be local or remote alarm indications or control signals fed back to the rectifier. Refer to the various controller product manuals for a description of rectifier signal processing and resultant action.

Figure 2-4 shows the typical signal flow between a rectifier and a Galaxy controller. The control signals and alarms enter and leave the rectifier via the interface board, **CM4**. When used with a non-Lucent controller or if additional monitoring is desired, interface to **TB1**, **TB2**, and **TB3** of the 330C interface board. The plant controllers also use replaceable circuit modules.

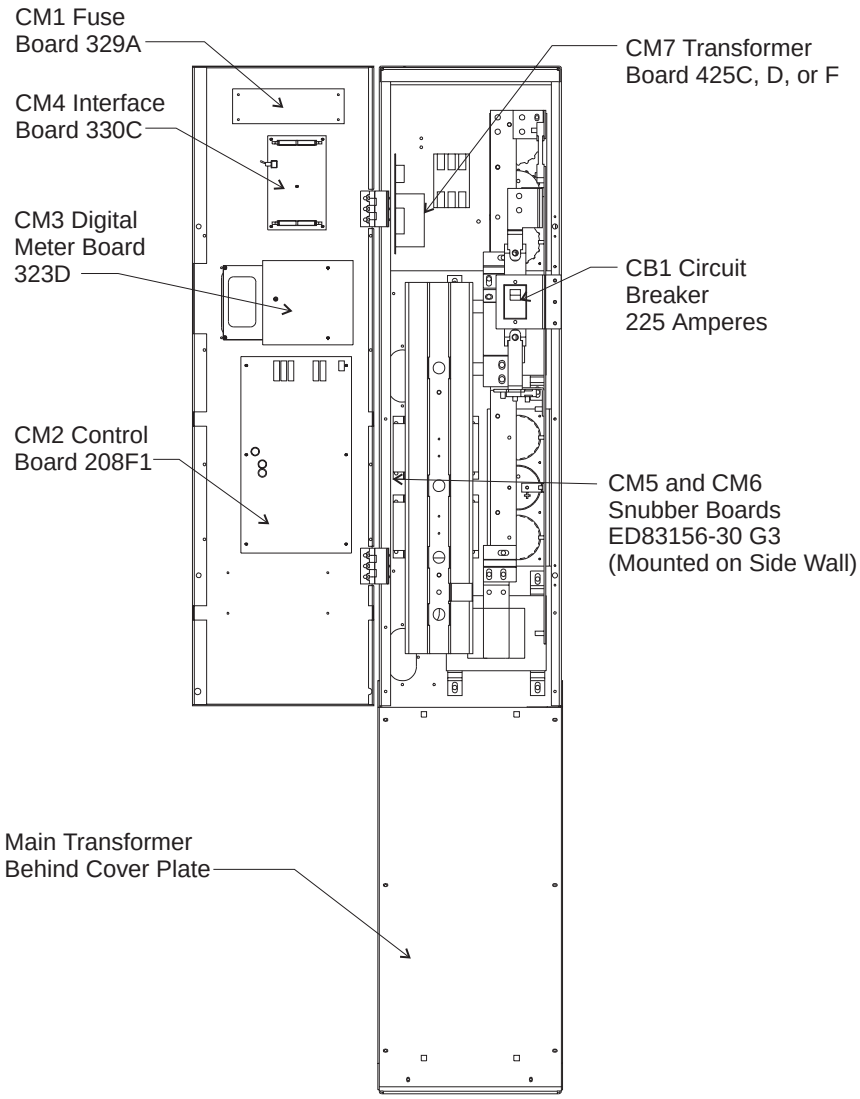


Figure 2-3: J85503B-2 Rectifier with Door Open

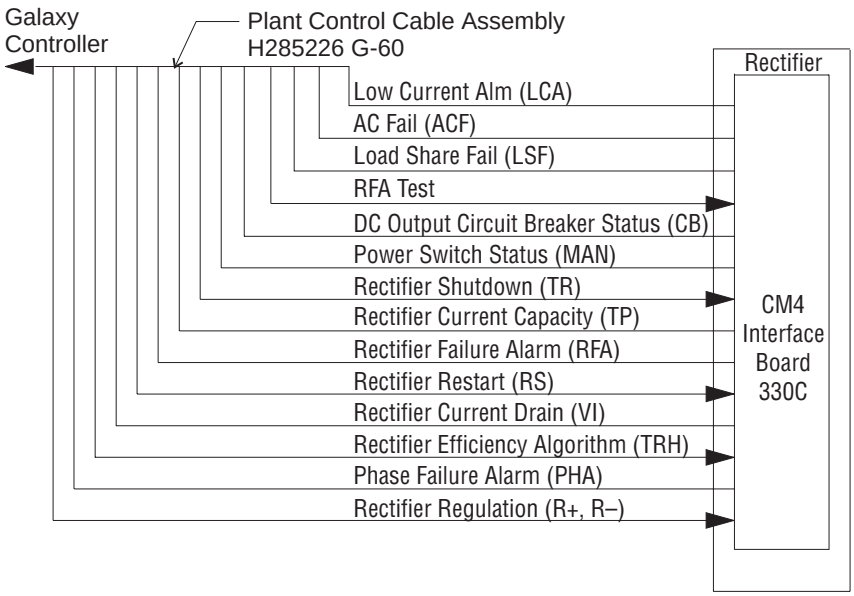


Figure 2-4: Signal Flow Rectifier/Galaxy Controller

Refer to the appropriate controller J drawing to order cable assemblies for other Galaxy configurations, the ECS-6U, ECS-12U, the MCS, and the CCS controllers.

Specifications

Table 2-B provides electrical and physical characteristics for the J85503B-2 rectifier.

Table 2-B: J85503B-2 Rectifier Specifications

Nominal Output Voltage		52 volts dc **or** 24 volts dc
Operating Output Voltage Ranges		48 - 65 volts dc **or** 24 - 32 volts dc
Operating Frequency Range		57 - 63 Hz
Output Current		0 - 200 amperes (Note 1)
Nominal Input Voltage		208/240/480/416 volts ac
Input Voltage Ranges		184 - 220 volts ac 212 - 254 volts ac 422 - 509 volts ac
Input Current	± 24V 18 17 9	-48V 38 amperes @ 208 volts ac (Note 2) 32 amperes @ 240 volts ac (Note 2) 17 amperes @ 480 volts ac (Note 2)
Efficiency		88% typical (Note 2)
Regulation on Battery		±0.5%

Table 2-B: J85503B-2 Rectifier Specifications

Regulation off Battery	± 2%
AC Ripple	50 millivolts peak to peak (Note 3)
Output Noise (On Battery)	< 46 dBrnc < 32 dBrnc (Note 3)
Psophometric Noise	< 2 mV rms (Note 4)
Load Share Accuracy	±20 amperes
Heat Dissipation	3700 BTU/hr (1100 watts) (Note 2)
Power Factor	>0.97 at full load
Humidity Rating	10 - 95% non-condensing
Operating Altitude	Sea level to 3048 meters (Note 5)
Operating Temperature	0 - 35° C (Lists 1, 2, 3, 4, 5, 6) 0 - 50° C (Lists 1, 2, 3, 4, 5, 6 at 150A output)
Audible Noise	<65 dBA
Earthquake rating	Zone 4 per Bellcore TR-EOP-000063
Width	330.2 mm (13 inches)
Height	1817.6 mm (71.56 inches)
Depth	393.7 mm (15.5 inches)

Notes for Table 2-B:

1. Can operate at 220 amperes output for periods shorter than 8 hours.

2. Measured at 54 volts or 27 volts under full load.

3. Measured on 800 ampere-hour battery with a 0.5-volt lead drop.

4. At full load measured at battery.

5. For altitudes above 1524 meters, derate the temperature by 2 degrees Celsius per 305 meters.

3 Engineering and Ordering

Rectifier Sizing

This section discusses how to determine the minimum number of rectifiers required in a battery plant. Rectifiers of different output current capacities can be paralleled in a plant; therefore, size mixing is also discussed.

Sizing Considerations

Any time the plant load exceeds the combined capacity of the rectifiers, the batteries, which are in parallel, must discharge in order to supply the additional current demand. Momentary discharges are handled easily by the batteries; in fact, this capability precludes the need for the rectifiers to handle infrequent, momentary peak current conditions. However, the total rectifier capacity of the plant must be designed to meet prolonged periods of current drain during "busy" demand times. In a telecommunications environment, this is known as the "average busy hour" (abh) current drain. It is defined as the average busy hour of busy season current drain drawn at normal plant operating voltage.

Other parameters which the customer must decide are the maximum length of time the batteries are allowed to discharge (reserve time), and the amount of time allowed for recharge of the batteries (recharge time). These two times are used in determining the "recharge factor" from battery data similar to that shown in Figure 3-1. The recharge factor determines the amount of current required, over and above the load demand, to recharge the batteries concurrently with supplying the abh load demand.

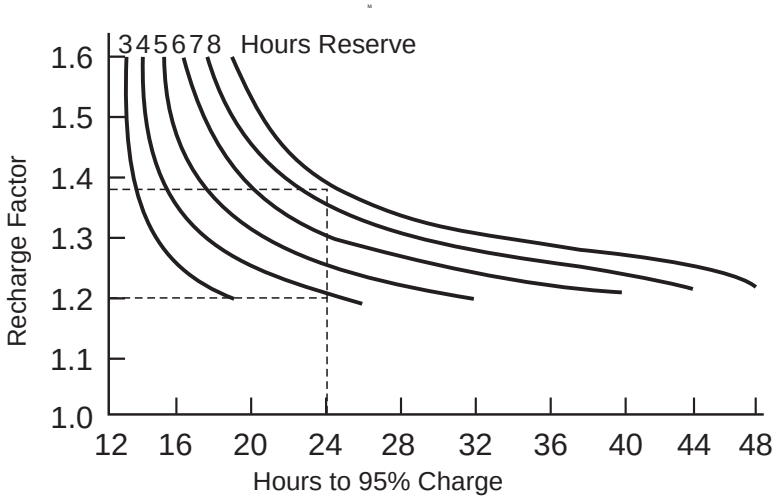


Figure 3-1: Recharge Time vs. Recharge Factor

Figure 3-1 illustrates some general bounds on sizing rectifiers for recharging batteries. With other conditions fixed, it illustrates three generalities.

As the reserve time of batteries increases, so does the recharge factor required for a given recharge time.

Some minimum recharge factor is required to effectively recharge the batteries.

Continuing to increase the recharge factor will not materially reduce the recharge time.

Redundant and non-redundant systems

The recharge factor (1.2 to 1.6) multiplied by the abh current drain gives the minimum installed rectifier capacity (mirc) for any plant.

mirc = abh x recharge factor

The mirc is also the sum of the abh and the recharge current. For example, a 1.2 recharge factor in a plant with an abh current drain of 100 amperes simultaneously allows 100 amperes for plant load, and 20 amperes for battery recharge in 24 hours, following a 3-hour discharge period.

The mirc value of current is a requirement of either a redundant or a non-redundant rectifier system. It is the only requirement

defining a non-redundant system. A redundant system additionally requires that the loss of any one rectifier does not cause the remaining rectifier capacity to fall below the abh value. This is another way of saying that the loss of any one rectifier in the system does not cause the batteries to discharge. In some cases, meeting the mirc current requirement also meets the additional requirement for a redundant system; in other cases it does not.

Sizing Example

The following examples illustrate the sizing principles given above.

1. The average busy hour current (abh) of a plant is 2850A. The plant is required to have a 4-hour reserve (discharge) time and a 24-hour recharge time. Calculate the minimum installed rectifier capacity (mirc) and the number of 200A rectifiers required in redundant and non-redundant systems.

   From Figure 3-1, a 24-hour recharge time intersects the 4-hour reserve curve at a recharge factor of approximately 1.2.

   mirc = abh x recharge factor

   mirc = 2850A x 1.2 = 3420A

   The number of 200A rectifiers required to supply at least 3420A is nine (9 x 200A = 3600A). Nine rectifiers are required in a non-redundant system. If one of the rectifiers fails, the remaining rectifier capacity is 3200A (8 x 200A), which is greater than the 2850A abh. Therefore, nine 200A rectifiers are also sufficient for a redundant system.

2. The average busy hour current drain (abh) of a plant is 210A. The plant is required to have an 8-hour reserve time and a 24-hour recharge time. Calculate the mirc and the number of 100A rectifiers required in redundant and non-redundant systems.

   From Figure 3-1, a 24-hour recharge time intersects the 8-hour reserve curve at a recharge factor of approximately 1.38.

mirc = abh x recharge factor

mirc = 210A x 1.38 = 290A

The number of 100A rectifiers required to supply at least 290A is three (3 x 100 = 300A). Three rectifiers are required in a non-redundant system. If one of the rectifiers fails, the remaining rectifier capacity is 200A (2 x 100A), which is less than the 210A abh. Therefore, at least one more 100A rectifier is required for a redundant system (four 100A rectifiers total). If one fails, 300A capacity remains, which is greater than the 210 abh.

Note that in this example, the redundant system could also be realized by either of the following combinations of rectifiers:

- One 200A and three 100A rectifiers
- Two 200A and one 100A rectifiers

As long as the loss of any one rectifier does not leave a remaining capacity of less than 210 amperes, the system is redundant.

Ordering Information

The J85503B-2 rectifier is ordered using the List (L) numbers and tables on the equipment drawing and has six main configurations based on different input/output voltage options.

- **List 1** provides a rectifier with a 208 volt ac input and a 24 volt dc output.
- **List 2** provides a rectifier with a 208 volt ac input and a 48 volt dc output.
- **List 3** provides a rectifier with a 240 volt ac input and a 24 volt dc output.
- **List 4** provides a rectifier with a 240 volt ac input and a 48 volt dc output.
- **List 5** provides a rectifier with a 480 volt ac input and a 24 volt dc output.
- **List 6** provides a rectifier with a 480 volt ac input and a 48 volt dc output.

Other lists on the J85503B-2 drawing are ordered as “Equipped With” items. This means that they are ordered in addition to a main list and will be assembled in the factory.

Rectifier Table 3-A provides a summary of the J85503B-2 list structure. Read all of the notes carefully before ordering.

Table 3-A: J85503B-2 Ordering Information

List	Description
1	Framework, assembly, wiring, and equipment for one rectifier, 24 volts dc 200 amperes output and 208 volts ac 60Hz input.
2	Framework, assembly, wiring, and equipment for one rectifier, 48 volt dc 200 amperes output and 208 volts ac 60Hz input.
3	Framework, assembly, wiring, and equipment for one rectifier, 24 volt dc 200 amperes output and 240 volts ac 60Hz input.
4	Framework, assembly, wiring, and equipment for one rectifier, 48 volt dc 200 amperes output and 240 volts ac 60Hz input.
5	Framework, assembly, wiring, and equipment for one rectifier, 24 volt dc 200 amperes output and 480 volts ac 60Hz input.
6	Framework, assembly, wiring, and equipment for one rectifier, 48 volt dc 200 amperes output and 480 volts ac 60Hz input.
7 - 14	Reserved
15	Optional equipment in addition to lists 1, 3, or 5 to provide additional filtering to limit the output noise to 32 dBrnc with a battery present.
16	Optional equipment in addition to lists 2, 4, or 6 to provide additional filtering to limit the output noise to 32 dBrnc with a battery present.
B	Required in addition to List 1, 3, or 5 to place circuit breaker in the positive output lead (negative ground system).

Notes

1. The 323D display meter board (CM3) features the following:

   – Power On/Off switch
   – Power On LED
   – PH LED
   – FA LED
   – RFA LED
   – LCA LED
   – LSF LED

- ACF LED
- Equalize LED
- Rectifier volts/Rectifier amperes/Plant voltage display selection switch
- NL/FL test switch
- Float/Equalize switch
- Output adjust potentiometer
- Equalize potentiometer
- Pin jacks for external meter

2. Adding the 330C Auxiliary Interface Board (CM4) to a 323D Digital Meter Board provides these additional features:

   - The digital meter can be set to display either the output current or the plant voltage.
   - The 330C monitors CFA/RFA, RFA, CB, LOA, EQA and MAN conditions. It also provides access to RM24, RM48, R+, R-, RS, RSR, TR, TRR, BAT, GND, HV, EQL, and EQLR.
   - Switches on the 330C enable or disable remote control capability, maintain the meter indication while the unit is off, and enables or disable the front panel equalize switch.
   - The power ON/AUTO/OFF switch enables or disables the remote control feature.

3. The standard output filter provided with Lists 1, 2, 3, 4, 5 and 6 meets Bell standard TR-EOP-000151 Issue 1 for output noise levels up to 44 dBrnc. The optional output filter (List 15 or 16) meets GTE standard GTS 8336 Issue 2 for output noise levels of 32 dBrnc for an on-battery condition only when measured at the battery position.

Hardware

4. The following items must be ordered from Table 3-B:

   - ac input connectors
   - frame ground connector
   - dc output connectors

5. The central office ground connector and the mounting anchor bolts (kit) are **not** provided with the rectifier. Order these items from Table 3-B.

Table 3-B: Hardware Ordering Information

Equipment	Requirement	Qty	Description	Comcode
Anchor Bolts (Kit)	Zone 3 or 4	1	H569-407 G-6	847320835
Anchor Bolts (Kit)	Zone 0, 1, or 2	1	H569-407 G-1	847135654
DC Output Connectors	4/0 AWG Class B	4	WP91412 L-59	405348251
DC Output Connectors	4/0 AWG Flex	4	WP91412 L-27	405347923
DC Output Connectors	350KCMIL Class B	4	WP91412 L-61	405348277
DC Output Connectors	350 KCMIL AWG Flex	4	WP91412 L-86	406021915
CO Ground Connectors	Class B	1	WP91412 L-54	405348202
CO Ground Connectors	Flex	1	WP91412 L-8	405347683
AC Input List 1, 3, 5, 6	10 AWG Strd	3	WP91412 L-93	406338145
AC Input List 2, 4	6 AWG Strd	3	WP91412 L-171	407334671
AC EG Connector	10 AWG Strd	1	WP91412 L-73	405356171

Use approved tooling for crimping connectors.

6. The standard output circuit breaker provided with Lists 1, 2, 3, 4, 5 and 6 is a 225 ampere breaker and meets Bellcore standard TR-EOP-000151 issue 1 for output protection.

7. When installing J85503B-2 rectifiers in a plant with other Lucent Lineage® 2000 rectifiers, cut lead 13 of the interface cable of all the rectifiers not equipped with an equalize feature to prevent the J85503B-2 rectifier from being placed permanently in an equalize mode of operation.

8. When lifting the rectifier from the top, use and install four 5/8-11 eyebolts (MacMaster Carr #3014T52) and four hex nuts (comcode 841063670).

Shims

9. Order shims for leveling the rectifier, as required. See Table 3-C.

Table 3-C: Shims Ordering Information

Thickness	Comcode
0.063 inch	842439861
0.125 inch	842439879
0.250 inch	842439887

Junction Plates

10. Order installation mounting plates (junction plates) for side-to-side or front-to-back support at the top of adjacent rectifiers from Table 3-D.

Table 3-D: Junction Plates Ordering Information

Type	Comcode
Side-to-side	848204640
Front-to-back (2 or 4 rectifiers)	848204657
Bolt to secure plates	804220838

11. If local codes permit, you may connect an overhead raceway to the rectifier with flex steel conduit. Flex steel conduit kit (846860682) comes complete with 17 inches of 1-1/4 inch diameter flex steel conduit, two KS20785 L-39 connectors, and two KS20785 L-114 insulating bushings.

12. Use the cable ties provided with the plant to secure the plant control cable to the top frame vertical post. The control cable should pass through the spiral wrap to the door where it is mounted with push-in tie wraps. You must secure a tie wrap to the control cable just above the top lid grommet so that the control cable cannot enter the rectifier cabinet. Do not, under any circumstance, roll the control cable up inside the rectifier. Roll up any extra length of control cable and tie it up at the controller.

13. The J85503B-2 -48 volt rectifier is capable of forced load share with other J85503B-2 rectifiers.

Spare Parts

The circuit modules described in Section 2 can be ordered as spare parts kits (K1, K2, or K3). Each kit has the same packs except for CM7, which is dependent on the J-List. Table 3-E shows the contents of the kits along with the part numbers to order modules individually.

Table 3-E: Circuit Modules in the J85503B-2 Rectifier

Kit - J85503C-3	J-List	Circuit Modules	Apparatus Code	Comcode	Description
List K1	1 or 2	CM7	425C	107134454	Transformer Board
List K2	3 or 4	CM7	425D	107134462	Transformer Board
List K3	5 or 6	CM7	425F	107134488	Transformer Board
List K1-K3	List 1 through 6	CM1	329A	106295280	Fuse Board
		CM2	208F1	107199184	Control Board
		CM3	323D	106938137	Digital Meter Board
		CM4	330C	107199192	Interface Board
		CM5 and CM6	ED83156-30 G-3	601326408	Snubber Board

Table 3-F: Spare Fuse Information

Reference Designation	Part Number	Rating	Vendor	Comcode
F1, F2, F3, F4, F5	FLM-30	30 amperes	Littlefuse™	406392290
F1, F2, F3 alarm fuses on CM1	WP90247 L-3	1/2 ampere	SAN-O™	405673161
F1 on CM2	WP90247 L-1	0.18 ampere	SAN-O™	405373002

Table 3-G: Spare Electrical Parts

Reference Designation	Comcode	Part Number
Diodes CR1 - CR4	405934449	WP91147 L-8 BSR
Triacs Q1 - Q2	406912816	BTA40-800B (SGS-Thomson Microelectronics)
AC capacitors C1 - C4	40618268	H62R6630E (Aerovox™)
DC capacitors C5 - C9	406962753	KS20133 L-14

Sample Order

This sample order is for a 200-ampere, 48 volt, 60 Hz rectifier with a 208 vac input. It includes a filter for limiting the output noise to 32 dBrnc, and a cable for connection to a Galaxy controller.

Sample Order

Item	Qty	Description
1	1	J85503B-2 L-2 200 Amp, 48V Rectifier E/W L-16
2	1	H285-225 G-60
		Cable Assembly
		"A" Dim = __ ft. lg.

Documentation References

The following documents provide the engineering, ordering, and installation information for the Lucent Lineage® 2000 200A ferroresonant rectifier.

Lineage® 2000 200A, 60 Hz Rectifier

Assembly and Ordering Drawing	J85503B-2
Wiring Diagram	T83281-30
Schematic Drawing	SD83281-01
Product Manual Select Code	169-790-128

Supplementary information on Lucent controllers may be found in the following documents.

Galaxy Controller

Assembly and Ordering Drawing	J85501F-1
Wiring Diagram	T83217-30
Schematic Drawing	SD83217-01
Product Manual Select Code	167-790-060

Galaxy Remote Peripheral Monitoring System

Assembly and Ordering Drawing	J85501G-1
Wiring Diagram	T83275-30
Schematic Drawing	SD83275-01
Product Manual Select Code	167-790-063

ECS-6U Controller

Assembly and Ordering Drawing	J85501E-1
Wiring Diagram	T83122-30
Schematic Drawing	SD83122-01
Product Manual Select Code	167-790-045

ECS-12U Controller

Assembly and Ordering Drawing	J85501E-2
Wiring Diagram	T83181-30
Schematic Drawing	SD83181-01
Product Manual Select Code	167-790-056

MCS Controller

Assembly and Ordering Drawing	J85501A-2
Wiring Diagram	T82588-31
Schematic Drawing	SD82588-02
Product Manual Select Code	115-010

CCS Controller

Assembly and Ordering Drawing	J85501A-3
Wiring Diagram	T82588-30
Schematic Drawing	SD82588-02
Product Manual Select Code	115-011

Rectifier/Controller Interconnect Cables

Assembly and Ordering Drawing	H285-226

4 Safety

Safety Precautions

Please read and follow all safety precautions and warnings before installing, maintaining, or troubleshooting the 200-ampere rectifier.

Always take precautions to protect personal safety as well as the equipment when working on power systems. Precautions relating to personal safety are labeled **DANGER**. Those relating to equipment damage are labeled **Warning**.

Whenever working on or near electrically live equipment, observe the following **DANGER** warnings and those given within each procedure in this book.

1. Remove all jewelry and use insulated tools when working on or near electrically live parts.

2. Always wear appropriate eye protection.

3. Follow procedures in the proper order to minimize exposure to high voltages, up to 600 volts.

4. Use a voltmeter to insure no voltage, or the expected voltage, is present before contacting any uninsulated conductor surface.

5. Use gloves when handling thermally hot components inside the rectifier. Transformers are very hot after sustained operation.

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

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

8. Battery voltage may still be present on one side of the **CB1 c**ircuit breaker when both the ac power and dc circuit breaker are turned off.

9. Circuit modules must not be connected or disconnected with voltages present. Personal injury or equipment damage may occur.

10. Do not connect or disconnect circuit modules with voltages present or equipment damage may occur.

11. AC voltages may be present when the rectifier **Power** switch is off.

12. When servicing the rectifier, disconnect the ac service and dc battery buses. Work carefully because you are working with live cables at battery bus potentials and current capabilities. The disconnected charge battery and charge ground connectors must be taped adequately to prevent them from contacting each other or any other metal surface. Alternatively, the dc battery cables from the rectifier can be disconnected at the plant charge battery and charge ground buses.

13. 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 **CB1** before working on capacitors or associated buswork.

14. AC voltages up to 600 volts to ground, and dc voltages of -48 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. Exercise extreme caution when working near the battery bus bars.

15. The wire must be UL recognized with minimum ratings of 80° C and 150 volts ac.

ESD Precautions

1. Assume all circuit packs containing electronic (solid-state) components can be damaged by ESD.

2. 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.

3. 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.

4. 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.

5. Do not rub or wipe circuit packs to clean them unless you and the circuit pack are at the same ground potential.

6. Observe warning labels on bags and cartons. Whenever possible, do not remove circuit packs from antistatic bags or cartons until ready to insert into the rectifier. Otherwise, open all circuit packs at a static-safe work position with wrist straps and dissipative table mats.

7. Upon removal from the rectifier, immediately put circuit packs into antistatic packages. Always store and transport circuit packs in antistatic packaging. Shielding is not required unless specified.

8. Keep all static-generating materials away from all circuit packs. These materials include common plastics such as food wrappers, clear plastic bags, styrofoam containers, packing material, drinking cups, notebooks, and nonconductive plastic solder suckers. The insulation on small hand tools does not represent a static hazard.

9. Keep adhesive tape (Scotch, masking, etc.) away from static-sensitive devices.

10. When soldering static-sensitive semiconductor devices, the soldering iron must be grounded to the work table which must also be earth grounded.

11. Whenever possible, maintain relative humidity above the 20-percent level.

12. Minimize electrostatic discharge when handling circuit modules.

5 Installation

General

This section outlines a sequence for installing and testing the J85503B-2 rectifier in a battery plant. The section describes the input and output wiring required and the recommended procedure for installing the rectifier from uncrating through start-up.

Preparing for Installation

Location of the J85503B-2 rectifier and associated equipment must conform to the specific plans of each plant installation. Physical, thermal, and electrical characteristics are listed in Section 2. You need to consider these characteristics when planning any installation that includes this rectifier.

Floor Mounting

The J85503B-2 is a floor-mounted rectifier with four anchoring holes located in the base. The rectifier must be anchored to all types of flooring including masonry, wood, and raised floors. Figure 5-1 is a diagram of the template, showing the anchor holes, measurements, and instructions for drilling anchor holes for installation in earthquake zones 3 or 4. (Anchor bolts for Zones 0, 1, and 2 are self-drilling.) See Table 3-B for anchor bolt ordering information. The anchor bolts are self-drilling. Figure 5-2 shows these floor anchors.

Rectifier cabinets must be aligned and shimmed to satisfy plumbing requirements, and the floor anchors secured against the shims. Removing the rectifier bottom-front kickplate provides the installer with about six inches of vertical working space in the base of the cabinet for access to the anchors.

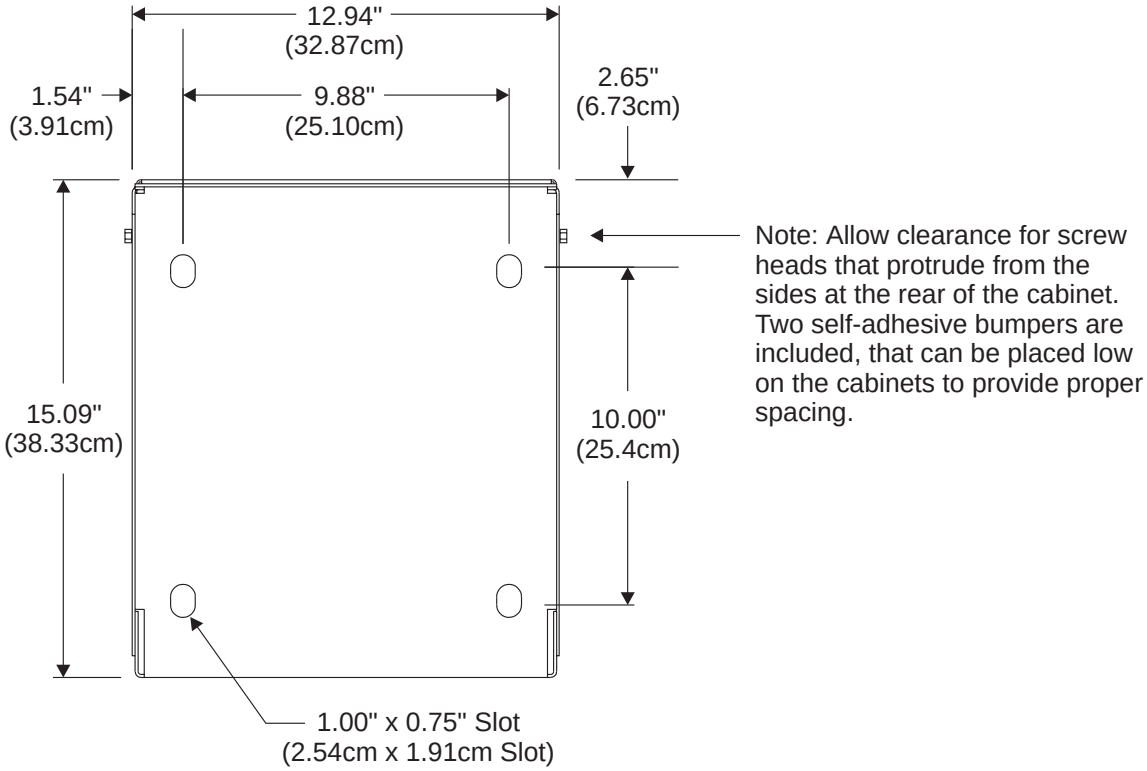


Figure 5-1: Floor Mounting Detail

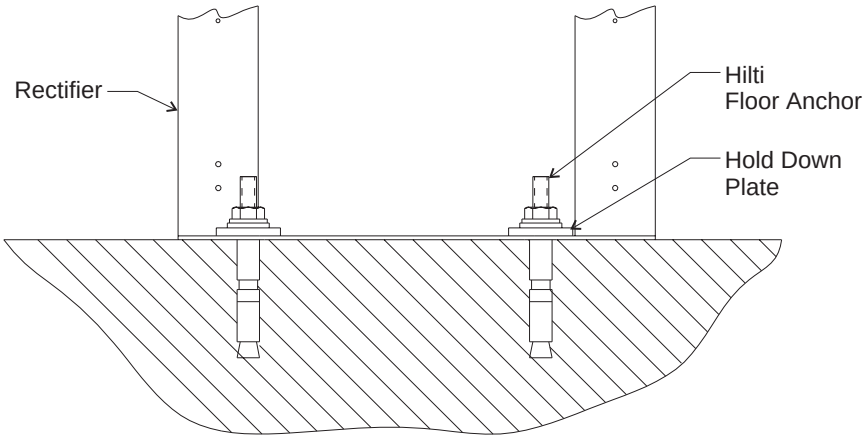


Figure 5-2: Floor Anchoring

Heat Dissipation Heat dissipated to the environment is another factor in selecting a location for the J85503B-2 rectifier. The maximum heat exhausted by each rectifier is approximately 1100 watts or 3700

BTU/hr. The rectifiers use free convective cooling, where cooler air enters the cabinet through perforations in the front bottom plate and is exhausted through perforations in the top cover. A minimum of 66.04cm (26 inches) in front and 30.48cm (12 inches) above the rectifier must be free of obstructions to allow the door to swing free and provide for adequate ventilation. In a side-by-side alignment of rectifiers, the cabinet door opens 90^{o} and projects approximately 33 cm into the front aisle causing no interference with adjacent rectifiers.

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

AC Input Power

The customer is responsible for providing ac power to the rectifier. Table 5-A gives requirements for the ac power installation. Separate branch circuits must be provided to each rectifier to ensure the reliability of the system. A branch circuit consists of all the phase leads to a rectifier plus the ac equipment ground (**AC EG**). The wiring method should meet national and local codes. A screw-type terminal is supplied on the rectifier.

Figure 5-4, top view of the rectifier, shows openings for the ac input conduit and two required grounds. Figure 5-3 shows the ac input wire termination points.

Table 5-A: AC Input Requirements

List	Volts/Amps	Line Fuse and Rating	Input Circuit Breaker	Number[1] of Input Wires/ Gauge	Armored Cable Trade Size	Input Wire Maximum Gauge	Conduit[2] Knockout/ Trade Size
1	208/18	FRN-R/30	30A	4/#10 AWG	1/2	6 AWG	1 3/4 1 1/4
3	240/17	FRN-R/25	25A				
5	480/9	FRS-R/15	15A				
2	208/38	FRN-R/50	50A	3/#6 AWG 1/#10 AWG	1		
4	240/35	FRN-R/40	40A				
6	480/18	FRS-R/25	25A	4/#10 AWG	1/2		

1. Input wire count includes one “green wire” ground. Consult Table 5-A and choose #14 AWG green, comcode 407405497 or #10 AWG green, comcode 407405570. For phase wiring, use KS24194 L3 (#14 AWG, comcode 407405489 gray; #10 AWG, comcode 407576636 gray; #6 AWG, comcode 407405646 gray) or 75° C commercial wire.

2. Where the trade size of the conduit used is smaller than the trade size for which the conduit knockout is sized, use appropriate knockout reducing washers.

Use the wire or cable in Table 5-A where available. Otherwise, use commercial UL listed wire or cable that meets the National Electric Code (NEC) and local requirements.

- KS20747 for conduit applications requiring a 28% oxygen index.
- KS22641 for conduit applications with a 23% oxygen index.
- KS23747 armored cable with an insulated ground conductor.

Table 5-A shows the recommended customer-supplied fuse size and type for the branch circuit protection located in the ac service panel supplying the rectifier input circuits. The fuse types shown are BUSSMANN™ fuses. Equivalent UL listed fuses or circuit breakers can be used in lieu of the fuses shown. If circuit breakers are used, they should have trip elements of an equivalent rating to the recommended fuse.

The "green wire," ac equipment ground (**AC EG**), is also known as frame ground (**FR GRD**). The connection for this ground is on the inside back wall of the rectifier.

The rectifier also requires a supplementary parallel ground, called central office (**CO**) ground. Two connections for this ground are labeled on top of the rectifier. Only one connection is required, whichever is more convenient. (See page 5-12 for installing the **CO** ground.)

DC Output Power

The J85503B-2 rectifier requires dc output cables connected to each of the positive and negative output terminals. Figure 5-3 shows the output terminals. Figure 5-4 shows the opening in the top of the rectifier for the dc output cables. Table 5-B specifies possible dc output cable sizes and their connectors.

The 4/0 cables allow for a maximum loop length of 100 feet while limiting the voltage drop to 2 volts between the rectifier output terminals and the batteries. The rectifier's regulation circuit, if connected, compensates for this drop. For a longer loop length, to reduce heat in cable racks, or to reduce the voltage drop from the rectifier to the battery, larger wire may be

used. The rectifier will accept one 350KCMIL cables at each of the positive and negative output terminals. The output cables must have a minimum rating of 90° C. KS24194 L2 (flex) or KS24194 L3 (Class B) are recommended for the distribution of dc power in the plant.

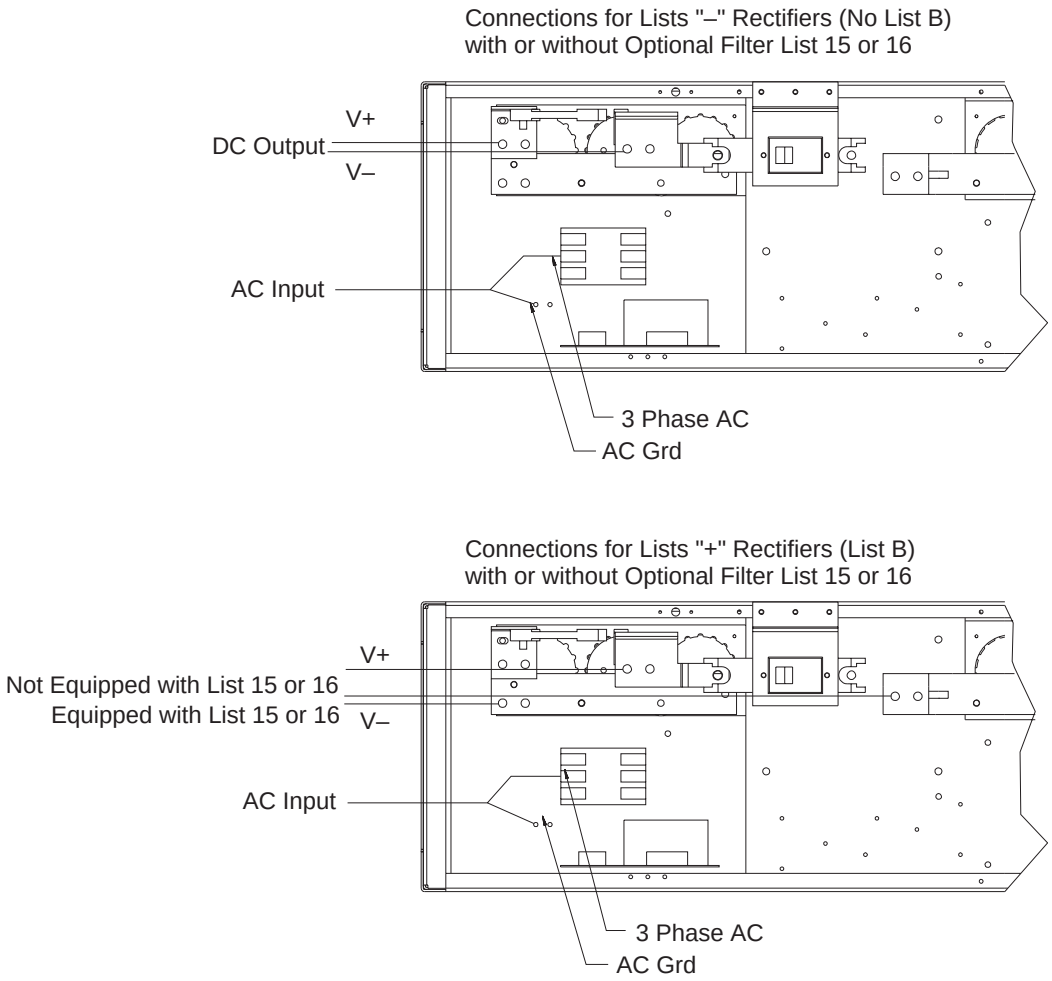


Figure 5-3: AC and DC Termination Points

Table 5-B: DC Output Options

Amps	Output Wire Gauge and Area (circular mils)	Connectors or Lugs	Nut Provided
200	4/0 AWG 211,600 circ mils	WP91412 L-59 (Class B) WP91412 L-27 (Flex)	3/8-16
	350KCMIL	WP91412 L-61 (Class B) WP91412 L-86 (Flex)	
Use KS24194 L2 (flex) or KS24194 L3 (Class B) for dc power distribution.			

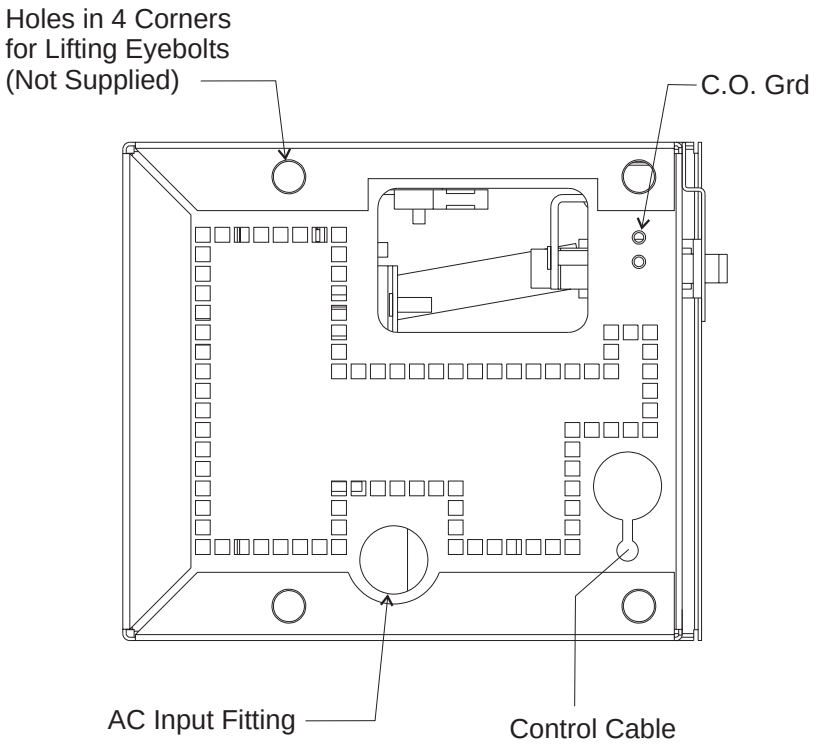


Figure 5-4: Top View of the J85503B-2 Rectifier

DC Power Cables

The term “rectifier charge cables” refers to the dc power cables which connect the dc power output of a rectifier to the power plant batteries. They are also called “rectifier output cables” or “battery charge cables.”

The rectifier charge cables are not fused and must be segregated from all other racks for their entire lengths. These cable racks must be dedicated to these conductors.

Rectifier control cables, framework ground cables, and ac input BX (where permitted) may be run on cable brackets off the cable rack stringers, but not on the rack itself.

NEC Article 318 restricts 1/0 to 4/0 cables to a **single layer** on a cable rack. However, NEC Article 318 allows two layers of cables 250KCMIL and larger up to a particular cable fill area. For these applications, 350CKMIL cable is usually more energy efficient.

Table 5-C provides widths for use with 350CKMIL cable.

Table 5-C: Rack Widths for 350KCMIL Cables

Rack Width	Number of 200 Ampere Rectifiers
12	8
15	10
20	14
25	18

Do not route other cable rack(s) above or through the area above the rectifiers or any other heat source.

Run the output conductors in pairs (positive and negative). Distribute the conductors evenly across the rectifier output racks. Pair the charge cables in the cable rack.

Figure 5-5 shows how to run the dc output cables from four 200 ampere rectifiers in a cable rack.

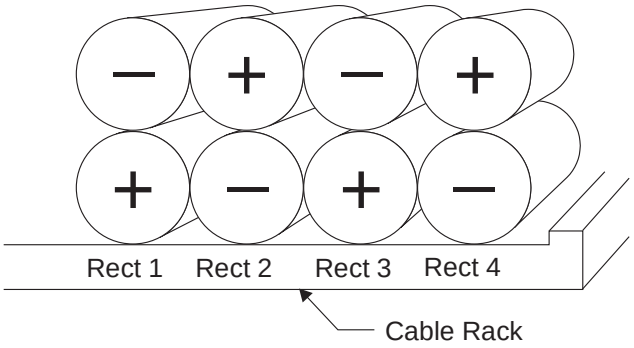


Figure 5-5: DC Output Cables in Cable Rack

Handling Equipment

Each J85503B-2 rectifier weighs at least 725 pounds. Therefore, make arrangements to have the appropriate material handling facilities and equipment to unload, uncrate, and set up the rectifier. Proper handling is necessary to ensure personal safety and protect the equipment. Each rectifier is shipped in a tri-walled corrugated cardboard container secured to a wooden shipping skid. Move the container with a forklift.

Lucent recommends that you use four lifting eyebolts to facilitate placing the rectifier upright in the central office. The four holes accommodate customer supplied lifting eyebolts. The holes are 5/8-11 threaded. For safety reasons, use all four

eyebolts. After the rectifiers are in place and the eyebolts removed, the 5/8-11 holes may be used for the threaded rods used to support cable racks.

Installation You will need the following for installing rectifiers.

- Material handling equipment to unload rectifiers at site, remove them from shipping containers, and place them in final positions
- Common electrician's hand tools, including jeweler's screwdriver, electrical tape, wire cutters and strippers, wire with area of 16,510 to 211,600 circ mils (8 AWG to 4/0 wire)
- Proper crimping tools and dies for connectors. Use only tooling (dies) recommended by the lug or connector manufacturer to assure proper connection and compliance with local and national codes.
- Common mechanic's hand tools, including flat blade screwdriver (.30 inch blade width), socket and torque wrench for 3/8 inch bolts, channel lock pliers for ac conduit tightening, hammer, and crowbar for uncrating
- Drill to bore holes for floor anchors, 3/4-inch bit
- Four 5/8-11 lifting eyebolts (Lifting with all four is required.)
- Digital multimeter (DMM) Fluke 8060A or equivalent with 0.02 percent accuracy on dc scale

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

1. Remove any shipping bands.
2. Check "tilt" or "shock" indicators. If tripped, contact shipping company and process claims form.
3. Pry off top, then sides of crate.
4. Inspect exposed exterior of rectifier for shipping damage.
5. With rectifier lying on its back, open the front door and visually inspect for shipping damage.
6. If material is damaged, contact shipping company and process claims form.

7. Remove parts package from inside rectifier.

8. Verify that the main ac voltage at your distribution panel agrees with the input specified on the label inside the rectifier door.

9. Using all four lifting eyebolts and appropriate material handling equipment, raise the rectifier from the pallet and set it on the floor in its upright vertical position.

Installing or Adding a Rectifier

This procedure is appropriate for installing a rectifier in a new plant or adding a rectifier to an existing plant to increase capacity. The assumption here is that the rectifier is being added to an operating plant.

Observe the safety precautions in Section 4 and those within each procedure whenever working on or near electrically live equipment. Only persons trained and experienced in the installation of power equipment should install this rectifier.

Locate and Anchor the Rectifier

1. Using site drawing information, locate the exact position specified for the rectifier.

DANGER
Wear eye protection devices when drilling holes for floor anchors.

2. Using template found in service kit provided with each rectifier, drill holes for a minimum of two diagonally placed floor anchors. (In Earthquake Zone 3 or 4, drill all four holes.)

3. Set anchors and, if on raised floor, assemble tie down rods and couplings.

4. Using appropriate material handling equipment, move the rectifier into place, level, shim if necessary, and anchor with bolts and washers. Torque to 81 Newton-meters (Nm) or 60 foot-pounds (ft-lb). Torque bolts from kit H569-407 Group 1 to 30 Newton-meters (Nm) or 22 foot-pounds (ft-lb).

AC Power Cables

Use Figures 5-3 and 5-4 as references for this section. Observe all precautions in Section 4.

1. Disconnect ac power from ac distribution service panel that supplies power to the rectifier.

2. Install three fuse holders (one for each phase) or one circuit breaker for the rectifier in the ac service panel. Leave circuit breaker in **off** position or leave fuses out.

3. Install three phase leads and ac ground (**AC EG**) at service panel and route conductors to rectifier.

4. Install crimp connectors onto phase leads and **AC EG** lead as required by plant installation. Use the proper crimping tool and die for the connector to prevent damage to equipment. (See Table 5-A.)

5. Secure phase leads and **AC EG** lead in rectifier. Install ground lead first. Torque phase connections to 3 Nm or 30 inch-pounds (in-lb). Torque **AC EG** connection to 4 Nm (30 in-lb).

6. Verify that the branch circuit breaker to the rectifier in the ac service panel is **off** or fuses are removed. Reenergize ac service panel. Tag branch circuit breaker or fuse holders to inform others not to close (turn on) the breaker or insert fuses. If the branch circuit is protected by fuses, physically remove the fuses from the area of the ac distribution service panel.

DC Power Cables

Plant bus bars carry up to 52 volts dc. Observe **DANGER** warnings in Section 4. Use Figures 5-3 and 5-4 as references for this section.

1. Turn circuit breaker, **CB1** on the rectifier, off (down).

2. Measure the lengths of cable required to run the dc output cable from the rectifier to its termination point on the charge bus, and to run the dc return cable from the rectifier to its termination point on the charge ground bus.

3. Cut cables to length and install crimp connectors. Use the proper crimping tool and die for the connector to prevent damage to equipment. See Table 5-C.

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

5. Place the dc output return cable in cable rack.

6. Insert ends of return cables through top of rectifier and terminate connector on the positive ground bus bar in the rectifier. Torque connections to 30 Nm (240 in-lb). See Figure 5-3.

7. One at a time, remove tape or insulation from connector at other end of return cable and terminate on plant charge ground bus bar.

8. Place ungrounded negative output cables in cable rack.

9. Insert ends of charge cables through top of rectifier and terminate connectors on negative bus bar in rectifier. Torque to 30 Nm (240 in-lb). See Figure 5-3.

Warning:
Battery plants are an energy hazard. Avoid arc or sparks. Before making contact between connectors and bus bar in the next step, use a DMM to verify a true open circuit between each connector and known battery plant ground.

10. One at a time, remove tape or insulation from connector at other end of charge cable and terminate on negative charge bus bar.

Supplemental Central Office (CO) Ground

The central office (**CO**) ground is "daisy-chain" connected to all rectifiers in a plant and terminates on the central office ground bus. The ground conductor must be 2 AWG wire (66,370 cir mils), or equivalent, for which a lug should be ordered and two 1/4-20 bolts are provided. Connect the **CO** ground to the nearest connection point on top of the rectifier (see Figure 5-4). Torque to 8 Nm (65 in-lb).

Plant Control Cable Assembly (Lucent Controller)

All cables connecting Lucent controllers to this rectifier, have a 40-pin connector on the rectifier end, which terminates on connector **P5A** of the **CM4** interface board inside the rectifier door. (See Figures 2-3, 5-3, and 5-6.) Table 5-D provides the type of connector used to connect the cable to the controller.

Table 5-D: Controller Connectors

Controller	Equipment Code	Connector
Conventional Controlled System (CCS)	J85501A-3	24-pin
Microprocessor Controlled System (MCS)	J85501A-2	24-pin
Evolutionary Control System-6U (ECS-6U)	J85501E-1	40-pin
Evolutionary Control System-12U (ECS-12U)	J85501E-2	40-pin
Galaxy Controller	J85501F-1	40-pin

The connectors on the ends of the cable to the ECS controllers are identical (40-pin), except that the rectifier end has two flying leads in addition to the connector. The flying leads are labeled **E13** and **E14**, and connect to those points on the **CM2** control board.

Warning:
If installing a J85503B-2 rectifier with other Lucent Lineage® 2000 rectifiers, cut lead 13 of the interface cable of all rectifiers not equipped with an equalize feature, to prevent the J85503B-2 rectifier from being placed permanently in the equalize mode.

1. Route the control cable from the plant controller, via the cable racks, to the rectifier, through the split bushing provided for this cable, and through the top of the unit (see Figure 5-4). Attach a cable tie above the bushing as shown in Figure 5-3. Excessive cable length must be rolled-up and tied at the controller, not inside the rectifier.

2. Terminate the 40-pin connector on **P5A** of **CM4** and dress cable using push-in cable ties on the inside of the rectifier door. Allow for the door to open and close without putting stress on the cable. After securing the cable, disconnect the cable from **P5A**.

3. Determine the number to be assigned the rectifier in the rectifier lineup, that is, 1, 2, 3, etc.

4. If the controller is an MCS, cut lead TP0, TP1, TP2 (pins 19, 20, 21) in the controller end of the cable. (See the controller manual.) This signals to the controller that the rectifier is a J85503B-2. If the controller is a CCS, do not cut any lead.

5. Remove the plastic covers on the back of the bay housing CCS and MCS controllers. The backs of the controllers

have sixteen 24-pin connectors labeled **Rect 1** through **Rect 16**.

For ECS controllers, open the front panel and thread the control cable through the slot on the right side of the controller. On the backplane of the lower shelf inside the controller, the ECS-6U has six 40-pin connectors labeled **Rect 1** through **Rect 6.** The ECS-12U has twelve 40-pin connectors labeled **Rect 1** through **Rect 12**

Warning:
Remove the REG fuse associated with the rectifier from the controller.

6. Plug the cable into the connector assigned to the rectifier number determined in Step (3) above. This action will cause a minor alarm in an MCS controller. Therefore, notify alarm personnel that the unit is being installed.

7. If the rectifier is connected to a Lucent controller, verify that the rectifier **S2.1** switch on the **330C** interface board, **CM4**, is in the disable position. An MCS controller must have version 4 software to enable an equalize feature. If the MCS has version 4 software, cut strap ST1 on circuit module CP2 in the controller. This allows the equalize feature to operate correctly without causing the rectifier to shut down. The ECS-6U controller automatically enables equalize, and the CCS controller does not have a provision for equalize.

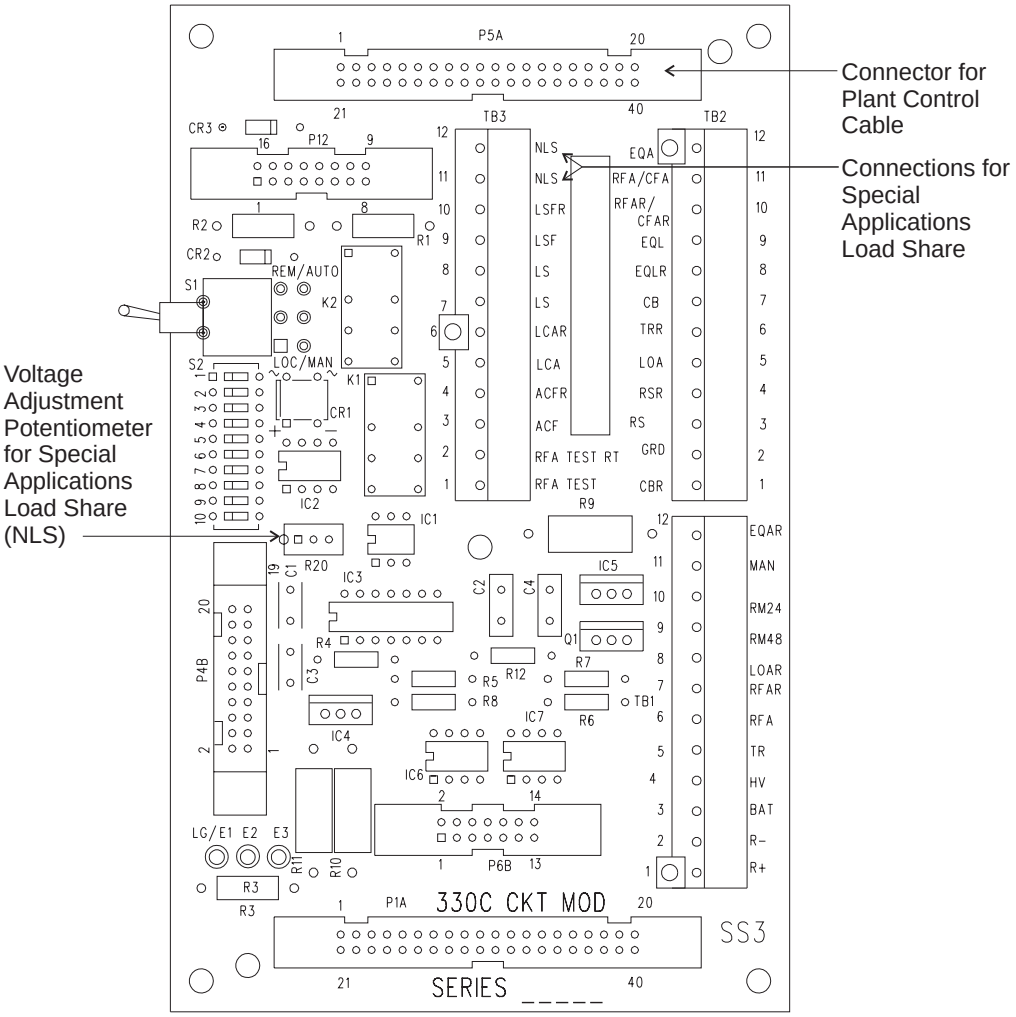


Figure 5-6: CM4 Interface Board (330C)

8. Dress and tie down the cable to provide stress relief at the connector.

9. This step is not necessary if a Galaxy controller is used with the H285-226 L60 enhanced signals control cable. If -48 volt rectifiers are to be operated in load share, connect a 20 gauge wire from **TB3-7** on **CM4** to **TB3-8** on **CM4** of the adjacent rectifier. See Figure 5-6. The wire must be UL recognized with minimum ratings of 80° C and 150 volts ac. All load-sharing rectifiers must be “daisy-chain” connected in this manner.

   In addition to the signals provided when a Lucent controller is used, 34 signals are readily accessible on the **CM4** interface board via terminal strips **TB1**, **TB2**, and

TB3. Note that when a Lucent controller is used, no connections are permitted from an external alarm/control bay to **R+, R-, BAT** and **GND** located on **TB1** and **TB2**. When a Lucent controller and an external monitoring system are used with the rectifier, the user provides the control cable assembly which links the rectifier to the external monitoring system. All 34 signals obtained from **TB1, TB2,** and **TB3** are also present in a Lucent controller, except the following:

RM48: This signal must be connected to turn the rectifier on or off remotely and should not be confused with the TR signal used to shut down the rectifier remotely.

RFA/CFA: This signal indicates that the rectifier's RFA relay has operated or that ac power is lost or turned off. This is not the same as an RFA signal.

EQL/EQLR: Shorting these signals together places the rectifier in equalize mode. These signals can be used with non-Lucent controllers or other monitoring systems provided the level of the selective high voltage shutdown (HVSD) on the controller is raised.

E25 and **E26** on **CM1,** the 329A fuse board, provide access to the 50mv, 250A shunt. **E22-E23-E24** is an isolated RFA transfer contact.

10. Secure the control cable on the cable rack and disconnect terminal strips **TB1, TB2,** and **TB3** from the **CM4** interface board.

Plant Control Cable Assembly (External Alarm/ Control Bay)

If a non-Lucent controller is used, the external alarm/control bay cable assembly is provided by the user. It connects to terminal strips **TB1, TB2**, and **TB3** of the **CM4** interface board located in the rectifier. Thirty-four signals are accessible from the **TB1, TB2**, and **TB3** terminal strips.

1. You may connect all the signals to the external alarm/ control bay. However, you must connect the following signals:

   R+ and **R-** to regulate externally at the batteries **BAT** and **GRD** to energize the TR, HV, and EQ relays

The **BAT** signal typically is the battery voltage.

2. Route the control cable from the external monitoring system to the rectifier via the cable rack. See Figures 5-4 and 5-3 for the connection point and Table B of note 311 on SD-83281-01, which describes the function of each signal.

3. Connect and enable load share, if required, as above.

The rectifier is now installed. The last three sections in this chapter provide additional information and optional procedures that may be needed at installation. If not, proceed to Section 6, Testing.

DIP Switch Settings

This section describes the DIP switch settings on circuit modules in theJ85503B-2 rectifier. Figures 5-7 and 5-8 show the DIP switch label inside the rectifier door .Figures 6-2, 6-3, 7-1, and 5-6 show **CM1, CM2, CM3**, and **CM4**, respectively. If the settings on the rectifier do not meet the requirements of your plant, change them according to this section and label.

208F Control Board (CM2)

S1.1 through **S1.5** and **S1.8** ensure stable rectifier output voltage for various Lucent rectifiers. For the J85503B-2, the switches are factory set for operation with a battery. If the rectifier is operated without a battery, change the settings indicated in the options column of Figure 5-7.

S1.6 controls the time of the walk-in circuit and is factory set for a walk-in time of about 10 seconds. Changing the factory setting will eliminate the rectifier walk-in.

S1.9 enables load share. The factory setting is off (load share disabled). This feature is available only on 48 volt rectifiers.

S2.1 through **S2.8** configure the rectifier as either a 24-volt or a 48-volt rectifier. For the J85503B-2, **S2.1** through **S2.8** are factory set and should not be changed.

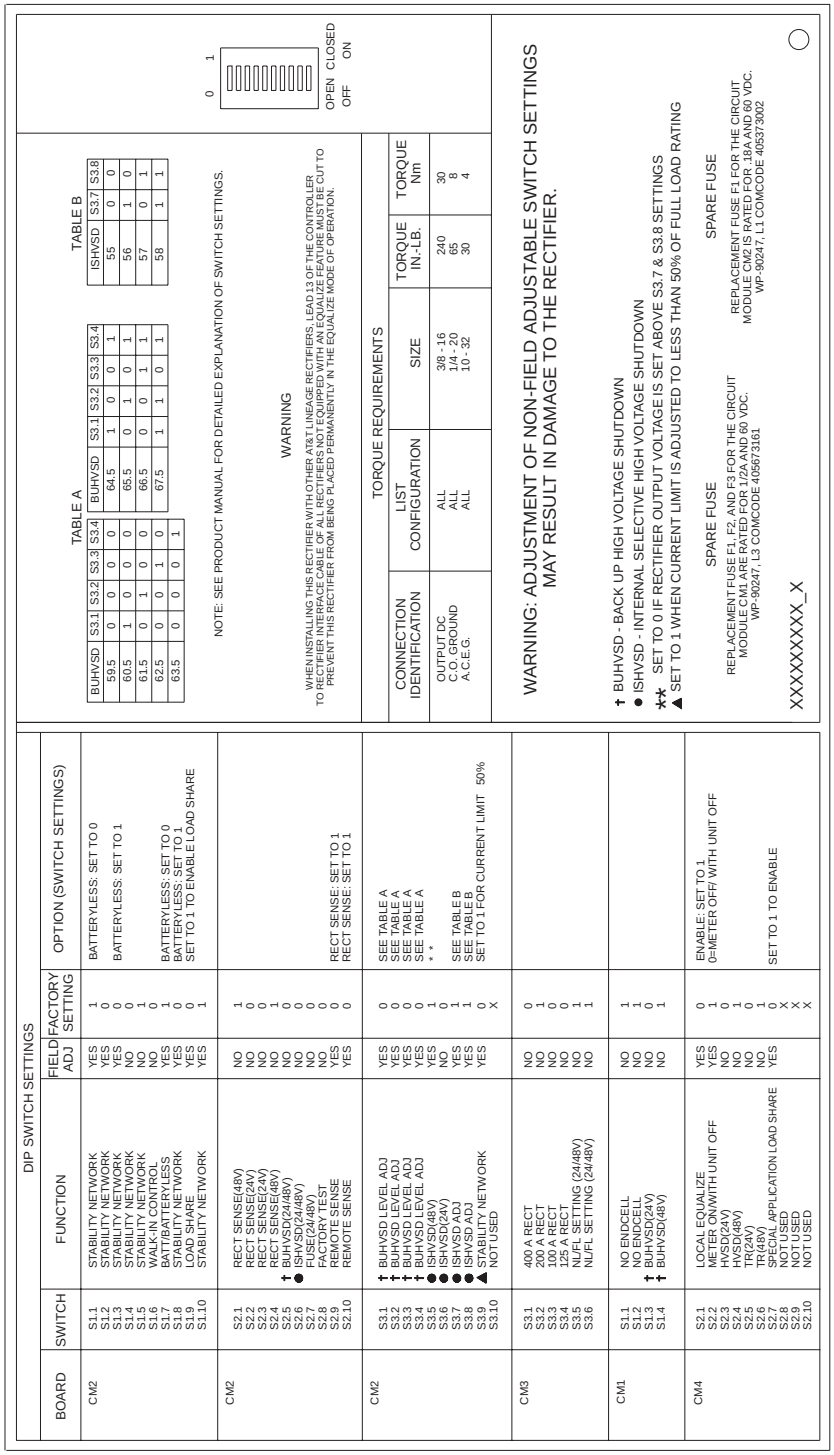


Figure 5-7: 48V DIP Switch Label

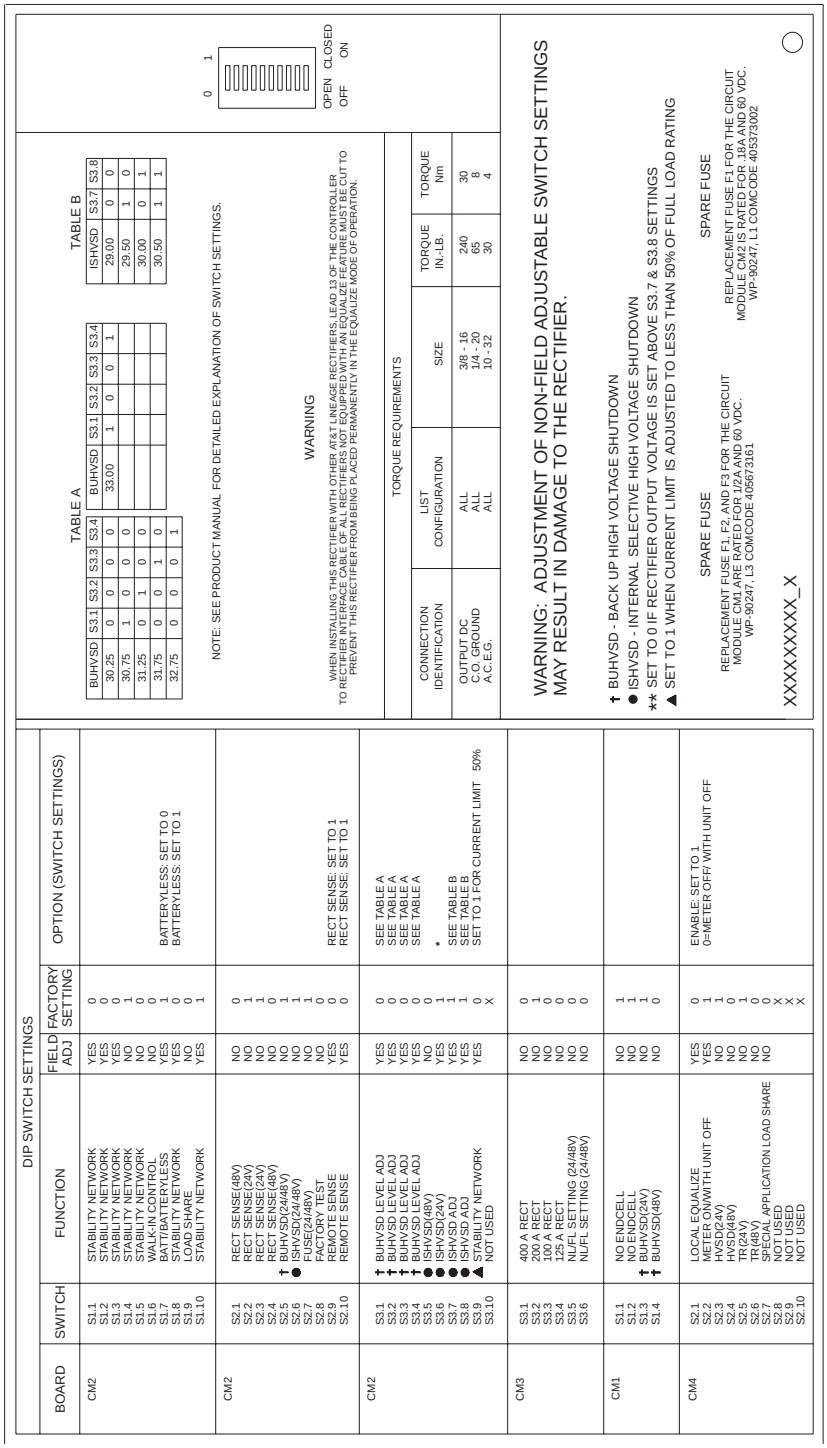


Figure 5-8: 24V DIP Switch Label

S2.9 and **S2.10** provide local or remote sense. In the factory setting position, the rectifier senses the output voltages remotely

via the regulation leads. If the settings are changed, the voltage is regulated at the output terminals of the rectifier.

S3.1 through **S3.4** adjust the level of the backup high voltage shutdown (BUHVSD). See Table A of Figure 5-8 for the range of BUHVSD settings. The factory setting is 59.5 Vdc for 48 volt rectifiers or 30.25 Vdc for 24 volt rectifiers.

S3.5 and **S3.6** are factory settings that notify the control circuit that the rectifier is configured as a 48 or 24 volt rectifier.

S3.7 and **S3.8** permit the internal selective high-voltage shutdown (ISHVSD) level to be adjusted to 55, 56, 57 or 58 volts. The factory setting is 58 volts.

S3.9 is used to maintain voltage stability when the current limit is set below 50% of full load.

S3.10 is not used.

323D Digital Meter Board (CM3)

S3.1 through **S3.4** tell the rectifier's ammeters the rectifier's current capacity.

S3.5 through **S3.6** configure the NL/FL switch on the front of the rectifier for either 24 or 48 volts.

329A Fuse Board (CM1)

S1.1 through **S1.4** are not field adjustable.

330C Interface Board (CM4)

S2.1 enables the front panel equalize switch on the rectifier.

S2.2 keeps the front panel display on or off when the control switch is in the off position. When **S2.2** is on, the front panel display is always on. When **S2.2** is off, the front panel display is off when the rectifier is turned off either via the front panel or via the controller.

S2.3-S2.6 configure the rectifier for operation with a 24- or 48-volt plant.

Converting AC Voltage

The main list number of the J85503B-2 rectifier (Lists 1, 2, 3, 4, 5, or 6) determines the ac input voltage of the unit. (See Table 3-A.) Lists 1 and 2 have 208-volt ac input and use the 425C transformer board. Lists 3 and 4 have 240-volt ac input and use the 425D transformer board. Lists 5 and 6 have 480-volt ac input and use the 425F transformer board. Each list number requires different connections to windings of main transformers **T1** and **T2**.

Underwriters Laboratory, Inc. (UL) requires the proper circuit module, wiring configuration, input, and product identifying labels for any unit. Therefore, only Lucent installation personnel are permitted to implement ac input conversions.

Initial Battery Charging

Initial battery charging should be planned as part of the plant installation.

Note
If initial battery charging is desired, the rectifier should be tested before following this procedure. (See Section 6.)

The J85503B-2 rectifier 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 is sufficient to supply the charge.

1. Set the ac supply and rectifier controls as shown in Table 5-E

Table 5-E: Control Settings for Initial Battery Charge

Controls	Position/Status
Rectifier Power Switch	Off (down)
Rectifier Circuit Breaker (CB1)	Off (down)
Float Adj potentiometer	Fully counterclockwise (20 turns to click)
Plant control connectors P5A, TB1, and TB2 on CM4 interface board	Disconnected from CM4
Associated REG fuse in plant controller	Removed

2. To disable internal selective high voltage shutdown (ISHVSD), open **S3.5** on the **CM2** board for 48V rectifiers. For 24V applications, open **S3.6** to disable ISHVSD. See Figure 6-3.

3. To raise the backup HVSD level, adjust **S3.1-S3.4** on **CM2** to one of the levels given in Table A on the rectifier door. Choose a level 1 to 2 volts above the initial charge voltage.

4. Close the rectifier door and turn the **Power** switch **On**. The green **Power** LED must be on. (If not, do not attempt to turn on the circuit breaker, **CB1**. Troubleshoot the problem per Section 7). Keep the rectifier on for 10 seconds.

5. Hold the meter selector switch in the **Rect V** position, and use a small screwdriver to turn the **Float Adj** potentiometer clockwise until the digital meter reads approximately battery voltage, typically 52 volts.

6. Turn circuit breaker **CB1** on (up).

7. Adjust the **Float Adj** potentiometer to obtain the desired initial charge voltage within the limits specified by the battery manufacturer.

After completing the initial charge,

1. Turn the rectifier **Power** switch **Off** and the circuit breaker off (down).

2. Restore the original switch settings by closing **S3.5** (48V) or **S3.6** (24V) and restoring the backup HVSD on the **CM2** board. Refer to switch setting label located on the inside of the rectifier door.

3. To restore the rectifier to service, follow the procedure in Section 7.

6 Testing

General

This section gives test procedures for newly installed and/or operating rectifiers. If the plant in which a rectifier is being installed has never been operational, the plant and controller tests must be performed before the rectifier tests. Consult the plant and controller product manuals for their installation test procedures.

Rectifiers can be tested on- or off-line. “On-line” means a battery string and/or office load is connected to the rectifier. A dummy test load is required for testing off-line, and a Battery Plant Simulator Test Set is desirable.Without a simulator, a minimum set of tests can be performed. See page 6-2 for a description of the simulator and test load. For troubleshooting and diagnostic procedures, refer to Section 7. Those unfamiliar with the function of rectifier controls and indicators should read Section 2.

Precautions

When working on power systems, observe safety precautions in Section 4 and those within each procedure.

- The ac input voltage powers certain control circuits and relays, the front panel LEDs except ac fail, and the ac contactor. Voltage is available to these circuits whenever the ac service is available to the rectifier.
- Remote sensing of rectifier output occurs via the plant control cable connected to **P5A** or **TB1** and **TB2** on **CM4.** This cable must be disconnected when internal sensing is desired, as when testing off line using a test load.

Warning

Do not turn the **CB1** circuit breaker ON, close an external charge circuit breaker, or install an external charge fuse until told to do so.

Tools and Test Equipment

The following items for testing the rectifier.

- DMM (Digital Multimeter) Fluke 8060A or equivalent meter having 0.02 percent accuracy on dc scale
- Battery Plant Simulator Test Set (customer constructed, or equivalent)
- Test load, 52-volt or 24-volt with adjustment to provide a load of 480 amperes, 120 percent of the rectifier's rating
- Small screwdriver for adjusting potentiometers
- Paper clip with insulation on one end or equivalent that can be used to make an electrical connection between the power and alarm contact of a fuse.

Battery Plant Simulator Test Set

The Battery Plant Simulator Test Set is a convenient tool used to isolate communication trouble between the plant controller and the rectifier. It simulates the plant controller relative to receiving signals from, and sending signals to, the rectifier. If there is a problem and the rectifier works properly with the test set, the problem is either at the controller or in the interface wiring (plant cable).

Figure 6-1 shows how to construct a test set. (Note: The Battery Plant Simulator Test Set shown in Figure 6-1 is equivalent to a Lucent Technologies ITE6369 test set, which is not available to customers.)

Table 6-A shows how to connect the test set to the rectifier.

Table 6-A: Test Set Connections

Test Clip	Connection	Figure	Voltage
Red	E13 on CM2 (Positive side of capacitor C4)	6-3	+27V
Black	E14 on CM2 (Negative side of capacitor C4)	6-3	GRD
Blue	Cathode of diode CR56 on CM2	6-3	-V
White	E25 on CM1	6-2	+V

Test Load Connection

Use the following procedures to connect a test load when called for in a test or other procedure. Test load connections are made on the internal bus of the rectifier. Therefore, to isolate the rectifier from the batteries and plant bus, the rectifier **DC Output** circuit breaker must be left open (off) while the test load is connected.

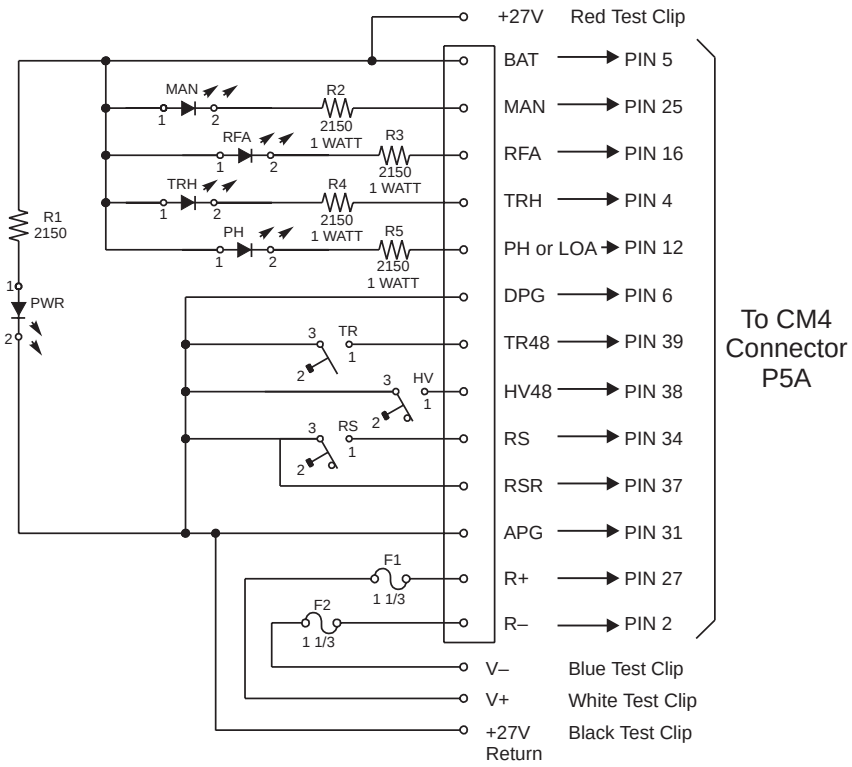
1. At the ac service panel, remove ac power to the rectifier.

2. Turn off (down) the rectifier **CB1** circuit breaker.

Warning
Support the **CM4** interface board with your hands when disconnecting the cable leads or damage to the interface board may result.Do NOT disconnect plant control cable connector **J5A** from interface board **CM4** by pulling the cable.

3. Disconnect **J5A** from **CM4** by unlatching first, then pulling the cable connector.

4. Refer to Figure 5-3 and connect the test load between the input bus to circuit breaker **CB1**, (labeled **Test Load**), and any convenient point on the ground bus anywhere in the plant.



Use 24 AWG multiconductor wire and 40-pin female connector from AMP, Inc., Harrisburg PA. Cable will then plug into the P5A connector on the CM4 board. The suggested AMP hardware part numbers are as follows:

Description	Quantity	Part Number
Housing	1	102398-8
Cover	1	102537-8
Cover	1	102536-8

Terminate the remaining 4 extension wires outside the brace with miniature alligator clips, color-coded as shown.

Figure 6-1: Battery Plant Simulator Test Set

Initial Conditions for Testing Off Line

The following steps verify that the rectifier responds properly to plant controller commands and outputs proper signals in return. Referring to Schematic Drawing SD83281-01 may be helpful while performing these procedures.

1. Verify that the ac supply and rectifier controls are as shown in Table 6-B.

Table 6-B: Rectifier Control Settings for Testing Off Line

Controls	Position/Status
Associated ac circuit breaker or fuses at the ac service distribution panel	Off or fuses removed and holders tagged "Out of service"
Rectifier Power switch	Off (down)
Rectifier CB1 circuit breaker	Off (down)
Float Add potentiometer	Fully counterclockwise (20 turns to click)
Plant control connector J5A (and J12, if applicable) on control cable	Disconnected from P5A (and P12) on CM4
Dip switch S1 settings on CM2 (See Figure 6-3.)	Off Battery switch settings as shown on door label (See Figure 5-7 or 5-8.)

2. Use the documentation for the particular battery plant to perform all the preliminary checks on the plant prior to the rectifier tests. If the rectifier is in a microprocessor-controlled plant with an efficiency algorithm feature, disable this feature. (See the appropriate controller manual for instructions.)

3. Using the digital multimeter (DMM) on the dc volts scale, make the following checks:

   - Verify that dc voltage is not present between the rectifier output bus bars. See Figure 5-3.
   - Install the regulation (REG) fuse associated with the rectifier in the plant controller.
   - Check for battery voltage between pins 27 and 2 of control cable connector **J5A**. The **J5A** connector is at the rectifier end of the plant control cable. Pin 27 should be positive with respect to pin 2.
   - As an extra precaution, check for battery voltage between ground and pin 2 (-48V or -24V rectifier) or pin 27 (+24V rectifier). If no voltage exists, there is a wiring problem associated with the control cable or controller. The problem must be found and repaired before proceeding with testing.

- With the BAT fuse installed in the plant controller, check for battery voltage between pin 5 of **J5A** and ground.
- If the plant is equipped with an MCS Controller or with a Galaxy Controller with Intelligent features, again on **J5A**, check for 15-20 volts dc between pins 35 and 31. Pin 35 should be positive with respect to pin 31.

4. Place the Battery Plant Simulator Test Set (Figure 6-1), at a convenient location near the rectifier. Connect **J5A**, on the other end of the cable from the test set, to connector **P5A** on the **CM4** interface board mounted on the inside of the rectifier door. Connect the red, black, blue, and white test clips from the test set as detailed in Table 6-A. Refer to Figures 6-2 and 6-3.

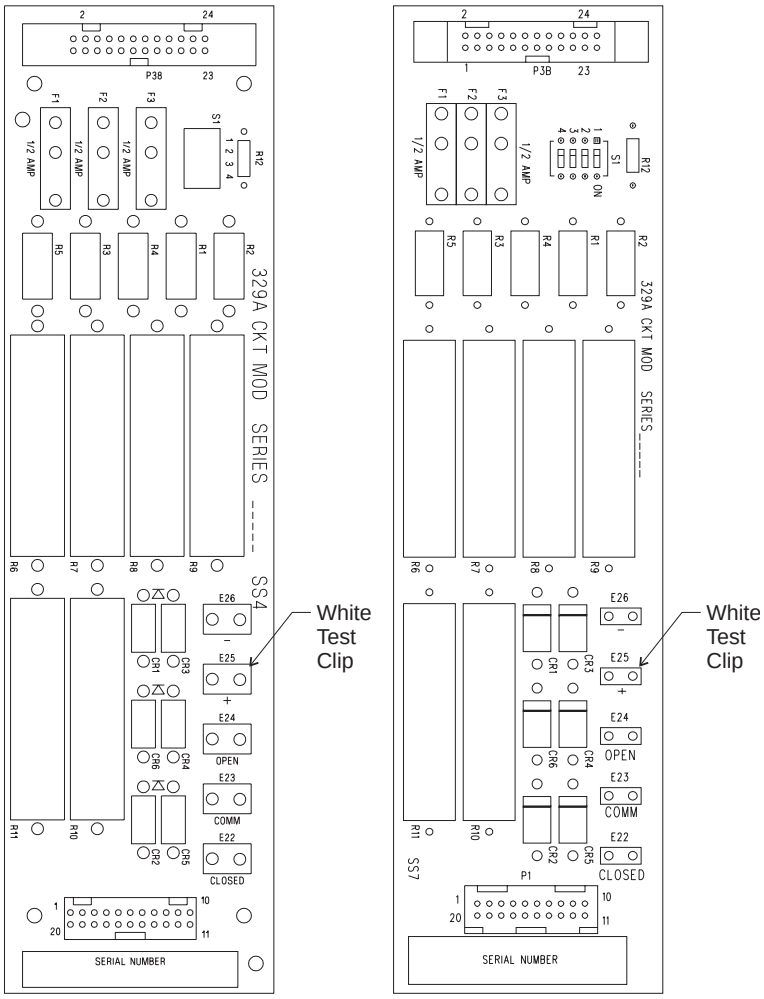


Figure 6-2: CM1 Fuse Board with Clip Connections (Older version of CM1 on the left)

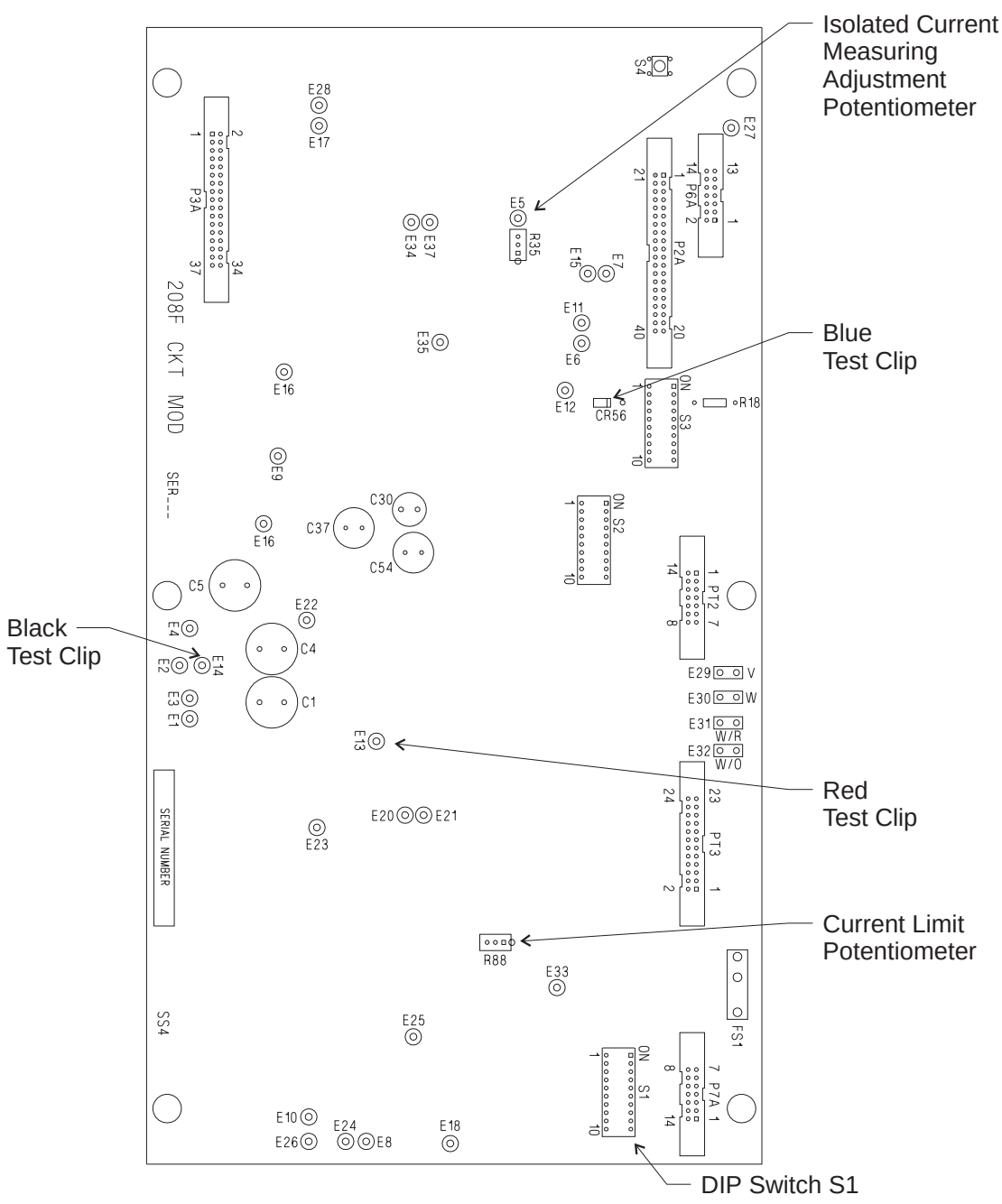


Figure 6-3: CM2 Board with Clip Connections

Testing Off Line

The following tests involve use of the test load and a Battery Plant Simulator Test Set. Refer to page 6-2 for the procedure to connect a test load and pages 6-2 and 6-3 for a Battery Plant Simulator Test Set.

If the rectifier fails any of the tests in this section, replace the **CM2** board and begin testing again.

Startup

1. Turn on the ac supply to the rectifier. The PWR lamp on the test set should light brightly. If it does not light properly, check the connection of the two small red and black clip leads. They may be reversed or otherwise incorrectly connected. These leads provide the operating voltages in the test set, and the red lead should be approximately +27 volts dc with respect to the black lead.

2. The PWR lamp should remain lit during the remaining tests as long as the ac supply is turned on.

3. Set the test meter to the 100 volts range, and connect it to the **Rect** jacks on the rectifier control panel. (See Figure 2-2.)

4. Adjust the test load so that when the rectifier is turned on, it will deliver 10-40A, 5 to 20 percent of full load.

5. Place the **S1** switch on **CM4** in the **LOC** position (see Figure 5-5), and turn the **Power** switch **On.** The rectifier should start and the green **Power** LED on the front panel should light. The test meter should indicate 40-50 or 22-26 volts. The MAN lamp on the test set should light and remain lit as long as the rectifier is turned on.

Regulation (NL/FL) Test

1. Watch the test meter and move the **Rect Test** switch to **NL**. In the **NL** position, the voltage should drop between 0.3 and 0.6 volt.

2. Repeat Step 1 with the Rect Test switch in the FL position. The voltage should increase between 0.1 and 0.4 volt.

Rectifier Failure Alarm Test

1. Holding the insulation on a piece of bare wire or the end of a paper clip, insert the wire into the fuse holder of the **F1** alarm fuse on **CM1**. Note that the rectifier shuts down, and

the **RFA** and **FA** LEDs on the control panel and RFA lamp on the test set light.

2. Turn the **Power** switch **Off**, then back **On**. The rectifier should start, and the LEDs lights should go off.

3. Repeat Steps (1) and (2) at the **F2** and **F3** fuses on **CM1**.

Current Limit Test

Notes
Adjust the current limit only after verifying that a current limit problem exists. It is recommended that this test be performed on battery.

V_{out} is the voltage reading between the rectifier output bus bars. See Figure 5-3.

1. Connect the test meter to the **Test Load** bus bar at the bottom of **CB1** and the **+V** output bus bar.

2. Strap a short across **E18** to **E33** on **CM2**, see Figure 6-3.

3. At I_{load} = 200-202A, 100 to 101 percent of rated output current, use the **Float Adj** potentiometer to adjust V_{out} to 52.08 (26.04) volts.

4. Remove strap from **E18** to **E33.** Observe that V_{out} is 51.98 (25.99) to 52.03 (26.0) volts. If not, see Section 7.

5. Increase the load, as indicated on the load box to 218-222 amperes, 110± 1 percent. V_{out} should be below 51.58 (25.9) volts. If not, see Section 7.

6. Decrease the load to 192-196A, 96 to 98 percent of the rectifier rating. Observe that V_{out} is greater than 52.03 (26.01) volts.

Phase Failure Alarm (PHA) Test

1. Set the load to 100-120A, 50 to 60 percent of the rectifier's rated amperage.

2. With the **Power** switch still **On**, turn off the ac service and note that the rectifier shuts down and that both the PWR and MAN lamps on the test set go off.

3. Verify that no ac voltage is present on the input leads of the ac contactor **K1.** (See Figure 5-3.)

4. Disconnect one input lead, **L1, L2**, or **L3** on **K1**, or at the ac service panel, whichever is more convenient. Insulate the lead.

5. Turn on the ac at the service panel. The rectifier should not restart, and the PWR, MAN, and PH lamps on the test set should light. The **PHA** lamp on the rectifier should light.

6. Turn off the ac at the service panel and reconnect the input lead.

7. Turn on the ac at the service panel. The rectifier should restart. On the test set, only the PWR and MAN lamps should light.

8. Repeat for the other two phases.

Backup High Voltage Shutdown (HVSD) Test

1. Disable the internal selective HVSD by opening **S3.5** or **S3.6** on **CM2**. Move switch to the left. See Figure 6-3.

2. Slowly turn the **Float Adj** potentiometer clockwise until the rectifier shuts down.

3. When the rectifier shuts down its voltage should correspond to the settings of **S3.1** through **S3.4** of the **CM2** control board. The factory setting is 59.5± 0.5 volts for 48V rectifiers. The factory setting for 24V applications is 30.25 ± 0.25 volts. The **RFA** LEDs on the rectifier and the test set should light.

4. Turn the **Float Adj** potentiometer counterclockwise four full turns.

5. Restart the rectifier using the RS switch on the test set.

6. Adjust the voltage to approximately 52.0 (26.0) volts. The **RFA** lamps on the rectifier and the test set should go out.

7. To enable ISHVSD, close **S3.5** on **CM2.**

Control (TR) Test

1. Press and hold the transfer rectifier (TR) switch on the test set for 5 seconds. The rectifier should turn off simulating a remote shutdown from the controller. The TRH lamp on the test set should light.
2. Release the switch. The rectifier should restart and the TRH lamp should go out.
3. Reduce the test load to 0 amperes.
4. Press the HV switch on the test set. The rectifier should continue to operate.

Selective High Voltage Shutdown (SHVSD) and Restart

1. Adjust the test load so that the rectifier delivers 20 to 30A, 10 to 15 percent of its rated amperage.
2. Momentarily press the HV switch on the test set. The rectifier should shut down, and the **RFA** LEDs on the control panel and on the test set should light.
3. Momentarily press the RS switch on the test set. The rectifier should restart and both **RFA** lamps should go off.

Float/Equalize Test

1. Adjust the load so that the rectifier delivers between 20 and 30 amperes.
2. Turn the **Power** switch **Off**.
3. Short **TB2** terminals **EQL** and **EQLR** on **CM4**.
4. Turn the **Power** switch **On.** The equalize LED should light.
5. Use the **Equal Adj** potentiometer on the control panel to set the voltage per the plant requirement, normally 2.0 (1.0) volts above float voltage.
6. Turn the **Power** switch **Off**.
7. Remove strap from **TB2** on **CM4** or return it to original setting.
8. Turn the **Power** switch **On.**

Local Equalize Control Test

1. Set switch **S2.1** on **CM4** to on (right).
2. Move the **FLT/EQ** switch on the control panel (**S2** on **CM3**) to the equalize position. The equalize LED should light.
3. Disable the local equalize feature, if necessary, by setting the **S2.1** switch on **CM4** to off (left).
4. Return the **FLT/EQ** switch to the float position.

Low Current Alarm (LCA) Test (48V only)

1. If using the load share option, verify that the **S1.9** switch on **CM2** is in the 1 position (on).
2. Reduce the load to 0 amperes.
3. The **LCA** LED on the front panel should light and the **LCA** alarm should issue to **TB3**, terminals 5 and 6.

Load Share Fail (LSF) Test (48V only)

1. Holding the insulation on a piece of wire, insert the wire in **FS1** on **CM2**.
2. The **LSF** LED on the control panel should light and the LSF alarm should be generated on **TB3-9** and **TB3-10** of **CM4**.

Meter Test

1. Adjust the load so that the rectifier delivers approximately 100 amperes, 50% of its rated current capacity.
2. Connect a DMM, set on the dc millivolt scale, across the 329 test points E25/E26. See Figure 6-2.
3. Observe the DMM and record the rectifier's shunt voltage. The shunt is rated 250A/50mV = 5A/mV, which means that each millivolt of voltage drop across the shunt indicates 5A of output current.
4. Convert the DMM shunt voltage reading to amperes. For example, if the DMM reads 20mV, then 20mV x 5A/mV = 100A of output current.

5. Compare the amperes calculated in Step 4 with the digital display of the meter while the switch is in the AMPS position.

6. If the digital display is between ±2% ±2A than the amperes calculated in Step 4, this procedure is completed.

7. If the rectifier drain indication is not as indicated in Step 6, calibrate the CM3 card via its R15 potentiometer as specified in Section 7.

Off Line Test Completion

1. Reduce the load to zero.

2. Turn the **Power** switch **Off**.

3. Turn off the ac power at the ac service panel.

4. Disconnect and remove the Battery Plant Simulator Test Set, the DMM (Digital Multimeter), and the test load.

5. If the reason for performing the rectifier tests was to affirm the operation of the rectifier, and was not part of total plant testing, restore the rectifier to service by following the procedures in Section 7. If this is part of total plant testing, leave the plant control cable disconnected at this time, until directed to reconnect it as part of another plant procedure.

Bringing a Rectifier On Line

The following steps bring the rectifier into service in preparation for testing on line. The term “on-line” means a battery string and/or office load is connected to the rectifier.

Perform all the preliminary checks on the plant before testing the rectifiers. The same precautions for personal safety and equipment protection should be taken as when testing off-line.

1. Verify the ac supply and rectifier controls are as shown in Table 6-C.

Table 6-C: Rectifier Control Settings for Testing On Line

Controls	Position/Status
Associated ac circuit breaker or fuses at the ac service distribution panel	Off or fuses removed and holders tagged “Out of service”
Rectifier Power switch	Off (down)
Rectifier CB1 circuit breaker	Off (down)
Float Adj potentiometer	Fully counterclockwise (20 turns to click)
Plant control connector J5A (and J12, if applicable) on control cable	Disconnected from P5A (and P12) on CM4
Dip switch S1 settings on CM2 (See Figure 6-3)	On Battery switch settings as shown on door label (See Figure 5-7 or 5-8)

2. If the rectifier is in a microprocessor-controlled plant with an efficiency algorithm feature, disable this feature. (See the controller manual for instructions.)

3. At the ac service panel supplying power to the rectifier, insert the input fuses assigned to the rectifier or turn the circuit breaker On.

Warning
DO NOT turn on the **CB1** circuit breaker until indicated in the procedure.

4. To bring the rectifier into service, do the following:

   a. Remove REG fuse at controller.

   b. Turn the rectifier **Power** switch **On**. The green **Power** LED must light. Wait 10 seconds.

   c. Hold the meter selector switch in the **Rect V** position, and use a small screwdriver to turn the **Float Adj** potentiometer clockwise until the digital meter reads approximately battery voltage, typically 52 (26) volts.

   d. Turn the rectifier **Power** switch **Off** and immediately (within 5 seconds) turn circuit breaker **CB1** on (up).

5. For testing with a controller, connect plant control cable **J5A** to **P5A** on **CM4**, and then replace the REG fuse in the controller. For a controllerless application, leave **J5A** disconnected, and replace the REG fuse in the remote bay.

6. Turn rectifier **Power** switch **On**. It may be necessary to readjust the **Float Adj** potentiometer further clockwise in order for the rectifier output to return to plant float voltage and assume any load now that it has changed to external regulation mode.

Testing On Line

On- and off-line testing require different procedures, although most tests can be performed in either situation. If you have just tested the rectifier off line, it is not necessary to repeat the tests on line.

When testing on-line, connect the rectifier control cable to the rectifier and to the associated plant controller. Also, install the rectifier's associated regulation battery (sense) fuse in the controller.

If no load is present, connect a test load to the rectifier (page 6-2). Disable load share by setting **S1.9** on **CM2** to 0.

If the rectifier fails any of the tests in this section, replace the **CM2** board and begin testing again.

Regulation (NL/FL) Test

Notes

At least two rectifiers must be supplying some current when this test is done, and the load requirement must be greater than 20A, 10% of the rated output for the rectifier under test.

Do not perform this test with load share enabled.

1. Observe the amperes reading on the **Output** meter. Hold the **Rect Test** switch in the **NL** position. The output amperes should decrease.

2. Observe the amperes reading on the **Output** meter. Hold the **Rect Test** switch in the **FL** position. The output current should increase.

Rectifier Failure Alarm/Fuse Alarm Test

Note

This procedure causes the rectifier to fail and issue alarms to the plant controller. When the procedure is performed on line, sufficient rectifiers must be operating to assume the load of the rectifier being tested.

1. Holding the insulation on a piece of bare wire or the end of a paper clip, insert the wire into the fuse holder F1 on the CM1 fuse board. Note that the rectifier shuts down and the RFA and FA lamps on the control panel light.

2. Turn the **Power** switch **Off**, then back **On**. The **RFA** and **FA** lamps should go off.

3. Repeat Steps (1) and (2) at the **F2** and **F3** fuses on **CM1**.

Current Limit Test

Note

Please read and comply with the following before testing:

- Adjust the current limit only after verifying that a current limit circuit problem exists.
- There must be two or more rectifiers with a plant load of at least 25 percent higher than the capacity of the largest rectifier.
- This method applies to a working plant. If the conditions below cannot be met, the unit must be tested off line.
- In a working plant, the current limit set point can be found by adjusting the **Float Adj** potentiometer on the rectifier under test to obtain approximately 3/4 load and a battery voltage of 52.08 (26.04) volts.

Verify that the load share feature is disabled, **S1.9** on **CM2** set to 0 (off).

1. Connect a DDM to the **Plant** test jacks to verify the battery voltage.

2. Hold the **Rect Test** switch in the full load (**FL**) position to raise the rectifier output current to current limit. The output current should indicate 200-202A, 100 to 101 percent of the rated output current.

3. If the output current is not within 200 to202 amperes, the current limit needs adjustment. See Section 7.

4. Restore load share.

Isolated Current Measuring (VI) Test

This procedure checks the isolated current measuring circuit (voltage proportional to current adjustment) on the **CM2** control board. The procedure is required for plants using Galaxy

controllers or Lineage® 2000 MCS controllers and when the output current reading on the rectifier does not agree to within ±2.5 percent of the rectifier output current reading on the controller. This procedure must be performed while connected to the controller and a battery.

Refer to Figure 6-3 for components on the **208F1** control board. Plant control cable connector **J5A** MUST be connected to **P5A** on **CM4** for this procedure.

1. Connect a DMM, set on the dc millivolt scale, across the 329 test points E25/E26. See Figure 6-2.

2. Adjust the rectifier to deliver approximately 100A, 50% of its rated current capacity.

3. Observe the DMM and record the rectifier's shunt voltage. The shunt is rated

   250A/50*m*V = 5A/*m*V

   which means that each millivolt of voltage drop across the shunt indicates 5A of output current.

4. Convert the DMM shunt voltage reading to amperes. For example, if the DMM reads 40mV, then

   40mV X 5A/*m*V = 200A

   of output current. As this calculation indicates, the rectifier is operating at full load, and the rectifier shunt voltage is 40mV at full load.

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, and indicated on the controller, this procedure is completed.

7. If the rectifier drain indication is not as indicated in Step 6, adjust potentiometer **R35** on **CM2** control board to obtain a rectifier drain reading on the controller that is between 0 and 2% higher than the amperes calculated in Step 4.

Phase Failure Test

1. With the **Power** switch still **On**, turn off the ac service and note that the rectifier shuts down.
2. Verify that no ac voltage is present on the input leads of the ac contactor **K1** (Figure 5-3).
3. Disconnect one input lead, **L1, L2**, or **L3** on **K1**, or at the ac service panel, whichever is more convenient. Insulate the lead.
4. Turn on the ac at the service panel. The rectifier should not restart.
5. Turn off the ac at the service panel and reconnect the input lead.
6. Turn on the ac at the service panel. The rectifier should restart.

Backup High Voltage Shutdown (BUHVSD) Test

1. Turn both the rectifer **Power** switch and dc output circuit breaker OFF (down). At the plant controller (if present), remove the regulation fuse assigned to the rectifier being tested.
2. Set a DMM to measure 54 volts, and connect it between the rectifier input conductor at the bottom of **CB1** and dc output return.
3. Slowly turn the **Float Adj** potentiometer clockwise until the rectifier shuts down. This should occur at the voltage corresponding to the switch settings for BUHVSD. The **RFA** lamp on the rectifier should light.
4. Turn the **Float Adj** potentiometer counterclockwise four turns.
5. Restart the rectifier by turning the **Power** switch **Off** then back **On**.
6. Adjust the voltage to approximately 52.0 (26.0) volts. The **RFA** lamp on the rectifier should go out.
7. Turn OFF the rectifier **Power** switch once again, and CLOSE (turn on) the dc output circuit breaker (up) within 5 seconds. Then, at the plant controller (if present), replace

the regulation fuse assigned to the rectifier being tested. (This is the fuse removed in Step 1.) Now, turn ON the rectifer **Power** switch once again, and turn the **Float Adj** potentiometer on the front display clockwise to return the rectifier output voltage to the plant float voltage level where it accepts load from any other rectifiers also on the distribution bus.

Control (TR) Test

1. a. MCS or CCS: Place a ground on lug 29 of TB1 in the MCS or CCS controller to turn off rectifiers 1 and 2 (MCS 9 and 10, CCS 3 and 4) via the TR signal. The rectifiers should turn off.

   b. ECS-6U or ECS-12U: Place a ground on TB101-9 in the ECS controller to turn off rectifiers 1 and 5 (and 9 in ECS-12U) via the TR signal. The rectifier(s) should turn off.

   c. Galaxy: Place a ground on TB3-8 in the Galaxy controller to turn off rectifiers 1, 2, 9, 10, 17, and 18 via the TR signal. The rectifier(s) should turn off.

2. Remove the ground. The rectifier(s) should turn on.

3. Repeat Steps 1 and 2 on:

   a. MCS or CCS: TB1-30 to test rectifiers 3, 4, 11, and 12 (MCS) or 5, 6, 7, and 8 (CCS).

   b. ECS-6U and ECS-12U: TB101-10 to test rectifiers 2 and 6 (and 10, ECS-12U).

   c. Galaxy: TB3-9 to test rectifiers 3, 4, 11, 12, 19, and 20.

4. Repeat Steps 1 and 2 on:

   a. MCS or CCS: TB1-31 to test rectifiers 5, 6, 13, and 14 (MCS) or 9, 10, 11, and 12 (CCS).

   b. ECS-6U and ECS-12U: TB101-11 to test rectifiers 3 (7 and 11, ECS-12U).

   c. Galaxy: TB3-10 to test rectifiers 5, 6, 13, 14, 21, and 22.

5. Repeat Steps 1 and 2 on:

   a. MCS or CCS: TB1-32 to test rectifiers 7, 8, 15, and 16 (MCS) or 13, 14, 15, and 16 (CCS).

   b. ECS-6U and ECS-12U: TB101-12 to test rectifiers 4 (8 and 12, ECS-12U).

   c. Galaxy: TB3-11 to test rectifiers 7, 8, 15, 16, 23, and 24.

Selective High Voltage Shutdown (SHVSD) and Restart

Warning
This procedure is safe only if the using equipment can tolerate the higher voltage.

1. Using the **Float Adj** potentiometer, raise the rectifier voltage to the SHVSD level of the controller.

2. Adjust the load so the rectifier delivers 20-30A, 10 to 15 percent of its rated amperage.

3. The rectifier should shut down, and the **RFA** LED on the control panel should light.

4. Observe that the rectifier restarts after 4 seconds and shuts down again. With an **MCS** controller, a second restart may occur.

5. Adjust rectifier back to its proper setting. Turn the unit off, then back on. The rectifier should restart and **RFA** lamp should go off.

AC Fail Test

This test must be done on battery, with **CB1** on.

1. Turn off the ac service to the rectifier. The **ACF** LED on the control panel should light and an ac fail alarm should be generated on **TB3-3** and **TB3-4** of **CM4**.

2. Restore ac to the rectifier.

RFA Circuit Verification RFA Test

This procedure tests the alarm system.

1. Provide a contact closure on **TB3-1** and **TB3-2** of **CM4**.

2. The rectifier and controller should indicate an RFA, but the rectifier should **not** shut down.

Meter Test (on line)

Table 6-D: Rectifier Controls for Meter Test On Line

Controls	Position/Status
Rectifier Power switch	On (up)
Rectifier must be connected to the battery. Rectifier CB1 circuit breaker	On (up)
Plant control connector J5A (and J12, if applicable) on control cable	Connected to P5A (and P12) on CM4

1. Adjust the load so that the rectifier delivers approximately 100 amperes, 50% of its rated current capacity.

2. Connect a DMM, set on the dc millivolt scale, across the 329 test points E25/E26. See Figure 6-2.

3. Observe the DMM and record the rectifier's shunt voltage. The shunt is rated 250A/50mV = 5A/mV, which means that each millivolt of voltage drop across the shunt indicates 5A of output current.

4. Convert the DMM shunt voltage reading to amperes. For example, if the DMM reads 20mV, then 20mV x 5A/mV = 100A of output current.

5. Compare the amperes calculated in Step 4 with the digital display of the meter while the switch is in the AMPS position.

6. If the digital display is between ±2% ±2A than the amperes calculated in Step 4, this procedure is completed.

7. If the rectifier drain indication is not as indicated in Step 6, calibrate the CM3 card via its R15 potentiometer, as specified in Section 7.

Adjust Rectifiers to Float Voltage

Float voltage is the optimum voltage level at which a battery string gives maximum life and full capacity. This voltage depends on the type and number of batteries in a plant.

Float voltage per cell x number of cells = battery string float voltage

The float voltage for flooded lead-acid batteries such as the Round Cell is 2.17 volts per cell. For a 24-cell configuration of Round Cells, string voltage is

2.17 x 24 = 52.08 volts

To adjust rectifiers to the predetermined float voltage, the rectifiers must be on line with plant cables connected and REG fuses installed in the plant controller or a remote bay.

Adjust Rectifiers Individually

The fastest way to adjust a group of rectifiers to float voltage is to adjust them individually, turning each one off after adjustment, and turning them all on after the last adjustment. In order to use this method, however, the load requirement at the time of the adjustments must be **less than** the capacity of the smallest rectifier.

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

2. If the battery voltage is not the predetermined float voltage or the desired battery float voltage, perform the following:

   a. If the voltage is too high, turn the **Float Adj** potentiometer counterclockwise.

   b. If the voltage is too low, turn the **Float Adj** potentiometer clockwise.

   c. Check the battery voltage and repeat Steps (a) and (b) above until the battery voltage is within the required tolerance of the desired float voltage.

3. Turn the rectifier off and repeat this procedure for each rectifier in the group.

4. Turn all rectifiers on after the last rectifier is adjusted.

Adjust Rectifiers as a Group

If the load requirement is always **greater than** the capacity of the smallest rectifier, adjust the rectifiers to float voltage using the following procedure. Rectifiers must be on line with plant cables connected and REG fuses installed in the plant controller or a remote bay.

1. Measure the battery voltage with a test meter connected to the **Plant** test jacks.

2. If the battery voltage is not at the predetermined float voltage or the desired battery float voltage, perform the following:

   a. If the voltage is too high, turn the **Float Adj** potentiometer counterclockwise on the rectifier with the highest output current.

   b. If the voltage is too low, turn the **Float Adj** potentiometer clockwise on the rectifier with the lowest output current.

3. Check the battery voltage and repeat Steps (a) and (b) above until the battery voltage is within the required tolerance of the desired float voltage.

4. If all rectifiers are not carrying some load current (between 5 percent and 95 percent of rated load), perform the following:

Note
Rectifiers are not required to share load current equally unless load share is enabled.

   a. Turn off all spare rectifiers, but leave enough rectifiers on to handle the load current.

   b. Turn up (clockwise) the **Float Adj** potentiometer on rectifiers carrying less than 5 percent rated load till they carry more than 5 percent rated load, and

   c. Turn down (counterclockwise) the **Float Adj** potentiometer on rectifiers carrying more than 95 percent rated load until they carry less than 95 percent rated load.

5. 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.

6. Turn on one of the spare rectifiers, and turn off one of the previously loaded rectifiers (same number of rectifiers on).

7. Repeat Steps (2) through (4).

8. Repeat for each rectifier that has not been adjusted.

9. Upon completion, turn all rectifiers on.

Enable and Test Load Share

Note
This test applies only to -48V rectifiers.

After adjusting the rectifiers to float voltage as described above, enable the load share feature.

1. Make sure that each rectifier is carrying some load current, between 5% and 95% of full load.

2. Move **S1.9** on **CM2** right to the 1 (on) position on each load-sharing rectifier. Each rectifier should load share to within 20 amperes.

Note

A minimum of two load-sharing rectifiers are required for testing. Each rectifier must be supplying 10 to 90 percent of the plant load. **S1.9** on **CM2** must be in the **on** position and the rectifiers must be connected for load sharing. Test at any convenient current between 10 and 90 percent of the rectifier capacity.

3. Verify that load-sharing rectifiers are producing the same current ± 20 amperes.

4. Simulate a blown **F1** fuse (**FS1** socket) on the **CM2** control board. The **LSF** LED on the control panel should light and a load share alarm should be generated on **TB3-9** and **TB3-10** of **CM4**.

5. Remove the simulated failure. If the rectifier is providing a load greater than 12 amperes, the **LCA** LED should go off.

6. With the rectifier load sharing, turn the **Float Adj** potentiometer fully counterclockwise. The **LCA** LED should light and generate an alarm on **TB3-5** and **TB3-6** of **CM4**.

7. Restore the rectifier voltage.

Special Application Load Share (NLS)

Note
This test applies only to -48V rectifiers.

1. Remove the controller cables or remote sense leads. Connect test the load. Although adjustment is made off-line, special application load share can only be used in a remote sense mode.

2. Disconnect and insulate the NLS bus leads from **TB3-11** and **12** of **CM4**, shown in Figure 5-6.

3. Turn the rectifier on and adjust the test load until the rectifier output equals full load.

4. Enable load share by closing **S2.7**. If not already adjusted in a previous procedure, adjust the output voltage to the desired level. You may need to readjust the test load so that output current equals full load again.

5. Using a DDM, measure the NLS voltage across **TB1-2** (R-) and **TB3-12** (NLS) of **CM4**. The measured voltage should be 8Vdc± 1%. If the voltage is other than specified, adjust **R20** on **CM4** until the measured voltage is 8 volts.

6. Remove the test load. Bring the rectifier on line and restore the controller cables or remote sense leads. Readjust output voltage to desired float voltage if necessary.

7. Reconnect NLS bus connections.

8. Repeat Steps (1) through (7) on each rectifier in the plant. Adjust non-Lucent according to their respective manuals.

9. After all adjustments have been made, turn on all rectifiers. Total load current should be shared in proportion to the full

load rating of the largest rectifier. You may fine tune the output of each rectifier to reduce the overall variation in load current. (Raise or lower the voltage in order to raise or lower the output current with respect to other rectifiers in the plant.) If plant voltage is not at the desired level, use the same method to fine tune output voltage and currents at the same time.

Note
At least two load-sharing rectifiers are required for testing. Each rectifier must be adjusted according to Steps 1 through 9 above. **S2.7** on **CM4** must be closed.

10. Verify that load-sharing rectifiers are producing the same current ± 5% of the full load rating of the largest rectifier. If not, fine tune according to Step 9.

11. With the rectifier load sharing, turn the **Float Adj** potentiometer clockwise a few turns. The **LCA** LED should light and generate an alarm on **TB3-5** and **TB3-6** of **CM4**.

12. Restore the rectifier to load sharing according to Step 9.

7 Troubleshooting and Adjustments

General

This section provides troubleshooting information and adjustment procedures for the J85503B-2 rectifier. Whenever working on or near electrically live equipment, observe all safety precautions given in Section 4, *Safety*, and within each procedure. For tools and test equipment required for certain adjustments, refer to Section 5, *Installation*.

Disconnecting a Rectifier

DANGER
AC voltages up to 600 volts to ground, and dc voltages of -48 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. Exercise extreme caution when working near the battery bus bars.

1. At the rectifier control panel, turn the **Power** switch **Off**. Turn the **CB1** circuit breaker **Off** (down).

2. At the ac service panel, remove the fuses or open the circuit breakers which supply the rectifier with ac power. Tag fuse holders or circuit breaker to instruct all to leave circuit de-energized.

3. Remove regulation fuses associated with the rectifier remote sense leads (usually located in the plant controller).

4. When a Lucent controller is used, disconnect the plant cable assembly from the rectifier **CM4** interface board at connector **P5A**. The cable assembly must be removed from

the cable tie anchors to permit its 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 assembly from undesirable abrasion and bending.

When a Lucent controller is not used, disconnect the remote bay cable assembly from the rectifier at terminal strips **TB1** and **TB2** of interface board **CM4**.

5. The rectifier's output filter capacitor must be completely discharged. Verify by connecting a DMM directly to the capacitor bus bars inside the rectifier. It will take a few minutes to completely discharge the capacitors, after the **CB1** circuit breaker is turned off in Step (1).

6. One at a time, disconnect the battery plant end of the dc output and output return conductors from the battery plant charge and charge ground bus bars. Insulate the connector ends and label the conductors for easy identification when reconnecting.

7. One at a time, disconnect the dc output conductors from the rectifier “hot” and return bus bars. Insulate the connector ends and label the conductors for easy identification when reconnecting.

8. One at a time, disconnect the ac input conductors from their terminations, the ac equipment ground (green) conductor from the **AC EG/FR GRD** in the cabinet, and the central office (**CO**) ground interconnecting the top of the rectifiers. Insulate the connector ends and label the conductors for easy identification when reconnecting.

9. Unfasten the ac conduit that is structurally attached to the rectifier. Place the disconnected conduit to the side, and, if necessary, tie the conduit to an adjacent structure to prevent interference with the rectifier removal.

10. Withdraw all disconnected conductors from the rectifier cabinet and place them aside so as not to interfere with the rectifier removal or cause a personnel hazard.

11. If provided, remove the straps fastening adjacent cabinets together on the top surface.

12. Remove the anchoring fasteners from inside the cabinet base and save for reuse.

13. Four lifting eyebolts, supplied by the customer, must be securely fastened into the threaded holes in the top corners of the cabinet.

14. The rectifier is now both electrically and physically disconnected and, with proper lifting equipment, may be safely removed from the plant equipment lineup.

Diagnostics

Table 7-A lists possible problems, causes, and solutions that may occur with the rectifier subsystems. Refer to schematic drawing SD-83281-01 shipped with the J85503B-2 rectifier.

Table 7-A: Troubleshooting

Problem	Probable Cause	Probable Corrective Action
1. Rectifier will not start and no indication on front panel. (**J5A** should be disconnected. If not, the controller could be shutting the rectifier down.)	1. No ac input to rectifier.	1. Check for ac input voltage to rectifier.
	2. Board improperly installed.	2. Check board interlocks and connections to boards.
2. Rectifier will not start and gives **RFA** alarm.	1. **CM2** control board is defective.	1. Check for +27 Vdc between **E13**(+) and **E14**(-) on **CM2**. Check for +12 Vdc between **E1** and **E14** and -12 Vdc between **E3** and **E14**. If present, replace the **CM2**
	2. **CM7** transformer board is defective	2. Check wiring associated with coil of **K1** and contacts **4-8** of **K3** on **CM7**. If bad, replace **CM7**.
	3. Board improperly installed or defective ribbon cable.	3. Check board interlocks, connections to boards, and ribbon cables.
	4. **CM3** meter board is defective.	4. Replace **CM3**.
	5. **CM4** interface board is defective	5. Replace **CM4**.
3. Rectifier starts but give **FA** and **RFA** alarms.	1. Fuses blown.	1. Check alarm fuses on **CM1**. Check filter capacitor fuses.

Table 7-A: Troubleshooting

Problem	Probable Cause	Probable Corrective Action
4. Rectifier starts but gives **RFA** alarm.	1. **CM2** is defective.	1. Measure output voltage while rectifier is "walking in." If the output voltage exceeds 58 (28) volts, the rectifier is shutting down due to high output voltage. See Probable Causes for Problem 9. 2. Replace **CM2**.
	2. **CM3** is defective.	3. Replace **CM3**.
5. Rectifier gives Phase Alarm.	1. One of the phase voltages is too low under a load condition.	1. Check connections and voltage at contactor.
	2. One of the phase voltages coming into **CM2** is too low.	2. Verify that the voltages across **C9, C10,** and **C11** are equal to ± 2 volts.
	3. **CM2** is defective.	3. Replace **CM2**.
6. Rectifier goes into high voltage at turn-on.	1. **Float Adj** potentiometer is set too high.	1. Turn **Float Adj** potentiometer all the way counterclockwise. Hold meter selector switch in **Rect V** position and turn potentiometer clockwise until the rectifier shuts down. Note at what voltage this occurs.
	2. Internal selective high voltage shutdown (ISHVSD) may be set too low.	2. Verify ISHVSD is set to 58 volts.
	3. **CM2** is defective.	3. If the rectifier did not shut sown at the BUHVSD setting, replace **CM2**. 4. If the rectifier did shut down within the limits specified, rotate the potentiometer one full turn counterclockwise. Turn the rectifier **Power** switch **Off** then back **On**. (Rectifier restarts.)
7. Rectifier gives **RFA** alarm at certain loads.	1. **CM2** is defective.	1. Replace **CM2**. Verify that the rectifier is on and delivering at least 2 1/2% of its rated output current (if not connected to batteries). See Problem 5.
	2. Defect in control and alarm leads from fuses to **CM2**.	2. Check alarm leads. 3. Check for +27Vdc (±5V) across **C4** on **CM2**.

Table 7-A: Troubleshooting

Problem	Probable Cause	Probable Corrective Action
8. Rectifier does not shut down at no load but may shut down at 10% load or more.	1. Shorted or open triac.	1. Replace triacs.
	2. Winding 13 or 14 of **T1** or **T2** is open.	2. Check wiring asso-ciated with windings 13 or 14 of **T1** or **T2**.
9. Rectifier will not start; ac is present, digital meter is on, and **Power** switch is on.	1. Input contactor coil may be open.	1. Check coil of input contactor **K1**. If it is open replace the contactor.
10. Rectifier tries to start but immediately gives **RFA/CFA** alarm.	1. **CM1** is defective.	1. Check fuses.
	2. **JT2** cable between **CM2** and triacs is defective.	2. Check **JT2** cable.
	3. **CM5** or **CM6** is defective.	3. Replace **CM5** and/or **CM6**.
11. Control panel digital meter does not light when rectifier is on.	1. Defective wiring on **CM3**.	1. Check wiring on **CM3**.
	2. **CM3** is defective.	2. Check if contacts 2 and 5 of **K2** on **cm7** are closed. 3. Check connectors **J1B** and **J3A.** 4. Replace **CM3**.
12. Battery voltage, measured by **Plt V** position on digital meter, does not agree with battery voltage measured across **Plant** test jacks.		1. Connect a DMM to the **Plant** jacks. Hold the meter switch in the **Plt V** position while adjusting **R15** on **CM3** until the two meters agree within ± 0.02 volt.
13. Rectifier emits excessive noise.	1. Defective magnetics	1. Call your RTAC representative on 1-800-CAL-RTAC (1-800-225-7822).
Rectifier tests OK off line, but does not deliver current when connected to plant.	Rectifier was on internal sensing for off-line tests when its control cable was disconnected and/or REG/BAT fuse was removed. When cable and fuse are restored, rectifier operates in remote sensing mode and output voltage is lowered.	Advance the OUTPUT VOLT ADJ control clockwise to compensate.

Front Panel Conditions

Table 7-B lists possible front panel conditions and describes their significance. Tables 7-C, 7-D, and 7-E list conditions of the **CM4** interface board and the associated alarm status or control function. Table 7-F gives additional information concerning conditions and their causes on the J85503B-2 rectifier. Copy these pages for maintenance personnel or leave a copy of them near the rectifier(s).

Table 7-B: Front Panel Conditions and Indications

Condition	Indication
Power switch On or Auto Power LED and Output meter on	Rectifier operating normally
Power switch on Power LED and meter off	Rectifier turned off by plant controller or ac power loss
Power switch Auto Power LED and meter off	Rectifier turned off by removing ground on RM48 or CM4 or ac power bus
Power switch On or Auto Power LED off, meter off or On PHA LED on	Unacceptable ac input source, either too low or loss of phase
Power switch On or Auto Power LED off, meter off or On FA and RFA LEDs on	Blown fuse inside the rectifier or tripped circuit breaker
Power switch On or Auto Power LED off, meter off or On RFA LED on	Rectifier shut down due to high voltage, internal unbalance or internal power supply failure on **CM2**
Power switch On or Auto Power and Equalize LEDs on	Rectifier placed in equalize mode by MCS controller or by placing short between EQL and EQLR on **CM4**
Power switch On or Auto Power and Equalize LEDs on **FLT/EQ** switch on **EQ**	Rectifier placed in equalize manually
Power switch On or Auto **Power** and Equalize LEDs on **CB1** tripped (midway between on and off) **RFA** and **FA** LEDs on	Rectifier's output breaker tripped
Power switch On or Auto Power and Equalize LEDs on **CB1** off	Rectifier's output breaker turned off manually

Table 7-B: Front Panel Conditions and Indications

Condition	Indication
Power switch off	Rectifier turned off manually
Power switch off or On **Power** LED off **Output** meter on	Rectifier operating normally; **S2.2** of **CM4** has been enabled.
Power switch off or On (Enabled) Power **LED off** **LCA** LED On	Load share feature is not operating properly
ACF LED On All other conditions "don't care"	AC input to rectifier fails on all three phases
Power switch on On or Auto (Standard) **Power** LED On (Standard) Rectifier operating normally except not load sharing **LSF** LED On	Load share interconnect bus has a short circuit. Load share bus has opened, but rectifier is otherwise normal.
Notes **S2.2** on **CM4** permits the meter to be On or Off with the rectifier turned Off. **S1** of **CM4** must be in "Remote/Auto Control" position if the **Power** switch is in the **Auto** position.	

Table 7-C: Alarms on TB1/TB2 of CM4

Alarm Status	TB1, TB2 Interface Condition	
No alarm	CB, CBR	Open
Output circuit breaker tripped	CB, CBR	Closed
No alarm	CB, CBR	Open
Output circuit breaker tripped	CB, CBR	Closed
No alarm	RFA, RFAR	Open
Rectifier Fail Alarm	RFA,RFAR	Closed
No alarm	RFA/CFA, RFAR,CFAR	Open
Charger Fail Alarm (RFA or CFA)	RFA/CFA/RFAR/ CFAR	Closed
No alarm	LOA, LOAR	Open
AC Fail or Phase Alarm	LOA, LOAR	Closed
No alarm	MAN, LOAR	Open
Rectifier turned off manually	MAN, LOAR	Closed
Equalize acknowledge signal not present	EQA/ EQAR	Open
Equalize acknowledge signal present	EQA/ EQAR	Closed

Table 7-D: Controls on TB1/TB2 of CM4

Control Status	TB1/TB2 Interface Condition
No control	Open circuit between RS, RSR
Rectifier restart initiated	Momentary short applied to RS, RSR
No control	Open circuit between TR, TRR
Rectifier shuts down	Short applied between TR, TRR
Rectifier turns On after being off	Short removed from TR, TRR
No control	Open short between HV, TRR
Rectifier shuts down	Short applied between HV, TRR
Rectifier off	Short removed from HV, TRR
No control	Open circuit between EQL, EQLR
Rectifier in equalize mode	Short applied between EQL. EQLR
Rectifier in float after being in equalize	Short removed from EQL, EQLR
No control	Open circuit between RM48, TRR
48V rectifier turns on	Short applied between RM48, TRR
48V rectifier shuts down after being On	Short removed from RM48, TRR
No control	Open circuit between RM24, TRR
24V rectifier turns on	Short applied between RM24, TRR
24V rectifier shuts down after being On	Short removed from RM24, TRR

Table 7-E: Signals on TB3 of CM4

Alarm Status	TB3 Interface Condition	
No test	RFAT	Open
RFA alarm generated without turning the rectifier off	RFAT	Closed
No alarm	ACF, ACFR	Open
AC has failed	ACF, ACFR	Closed
No alarm	LCA, LCAR	Open
*Load share enable; output current less than 3 amperes	LCA, LCAR	Closed
No alarm	LSF, LSFR	Open
*Load share enabled; rectifier not load sharing	LSF, LSFR	Closed
No connection	LS Standard Load Share not connected	
Connection	LS Standard Load Share connected (Must also be enabled via S1.9 on CM2)	
No connection	NLS Special Application Load Share not connected	
Connection	NLS Special Application Load Share not connected (Must also be enabled via S2.7 on CM4)	

* Load sharing applies only to the -48V rectifier.

Table 7-F: Additional Conditions/Indications on the J85503B-2

Signal/Condition	Indication
BAT, GRD	Nominal 52 or 24 volt control battery fused at 1-1/3 amperes and ground should be applied when a Lucent controller is not connected to the rectifier. When a Lucent controller is not present, BAT is a supply to energize the HV, TR, and EQ relays. The GRD is connected to TRR and can serve as the discharge GRD for HV, TR, or RM.
R+, R-	Battery plant regulation voltage, fused at 1-1/3 amperes and regulation ground can be applied when a Lucent controller is not connected to the rectifier. In this situation, R+ and R- are used for external regulation sensing.
Front panel digital meter always active	Switch S2.2 on CM set to Closed (1)
Front panel digital meter active only when rectifier is ON	Switch S2.2 on CM set to Open (0)
Local equalize switch enabled	Switch S2.1 on CM set to Closed (1)
Local equalize switch disabled	Switch S2.1 on CM set to Open (0)
Remote control (RM48, RM24) enabled	Switch S1 on CM4 set to Auto/Remote
Local control (RM48, RM24)	Switch S1 on CM4 set to Local/Manual

Adjustments

This section includes procedures to check fuses (Clear RFA and FA), calibrate the meter, adjust the current limit, and set the internal selective high voltage shutdown (ISHVSD) for rectifiers without controllers. It may be necessary to remove the rectifier from service before completing these procedures.

Clear Rectifier Failure Alarm (RFA)

A fuse alarm (FA) may be present with the RFA alarm.

1. Observe and record the status of the fuses in the plant controller. If the controller has an efficiency algorithm, disable this feature.

2. Turn the rectifier **Power** switch **Off**.

3. If any of the following fuses are blown, remove the rectifier from service and replace fuse(s) with one of the same type and capacity.

   – Alarm fuses **F1, F2, and F3** on **CM1**
   – Output filter capacitor fuses **F1, F2, F3, F4, F5**.

4. Restore the rectifier to service.

5. If the rectifier started, minor alarm retired on controller, and the rectifier **RFA** light extinguished, then the RFA problem has been cleared. Otherwise, continue with the following procedures.

The rectifier voltage may be too high.

1. Observe and record the rectifier output voltage, **Rect V**, and plant float voltage, **Plt V**. The rectifier voltage is normally greater than the plant voltage by an amount equal to the lead drop between rectifier and batteries, less than 2 volts. Adjusting the plant voltage makes a corresponding adjustment in the rectifier voltage.

2. If the rectifier output voltage is **greater than** the plant float voltage by more than the expected lead drop, then use the following procedures:

   a. Holding the meter selector switch in the Plt V position, turn the **Float Adj** potentiometer counterclockwise to lower the output voltage to the correct value.

b. If the rectifier **Float Adj** potentiometer can be used to adjust the voltage to the correct level, the RFA problem has been cleared. Otherwise, continue with the following procedures.

3. If the rectifier output voltage is **less than** the plant voltage and/or all rectifiers shut down, then use the following procedures.

   a. If the **CM2** board has not been replaced, then replace it at this time.

   b. If the rectifier started, minor alarm retired on controller, and the rectifier **RFA** light extinguished, then the RFA problem has been cleared. Otherwise, continue with the following procedures.

4. If replacing the **CM2** board does not clear the problem, then the outputs from **T1** and **T2** are probably unbalanced. Try the following:

   a. Check the wiring to the thyristors (see Figure 8-1).

   b. Check for defective thyristors. If defective, replace.

5. Verify that the controller's high voltage shutdown circuit is operating properly (see the controller manual).

Clear Fuse Alarm (FA)

1. If the circuit breaker (**CB1**) is tripped, restore the rectifier to service.

2. If **CB1** did not trip, check alarm fuses **F1**, **F2**, and **F3** on **CM1**. These fuses are accessible by opening the door of the rectifier. **CM1** is near the output filter capacitors.

3. If the **F2** or **F3** alarm fuse is blown, check for possible trouble and replace the fuse.

4. If the **F1, F2, F3, F4,** or **F5** capacitor fuse or **F1** alarm fuse on **CM1** is blown, check for a shorted output capacitor. Remove the rectifier from service to replace any shorted capacitor and/or blown fuse.

Calibrate CM3 Digital Meter

Calibration is not feasible unless the test meter has an accuracy of ± 0.02 percent or better.

1. Loosen the locking screws and open the front door of the rectifier.

2. Locate the **CM3** digital meter board on the inside of the front door.

Warning
Exercise extreme care when removing the **CM3** board from the support standoffs.

The **CM3** board can be calibrated **without removing** the board from the support standoffs.

3. Locate the **R15** potentiometer on the meter board (see Figure 7-1). **R15** is easily accessible on the component side of the board.

4. Adjust the load so that the rectifier delivers approximately 100 amperes, 50% of its rated current capacity.

5. Connect a DMM, set on the dc millivolt scale, across the 329 test points E25/E26. See Figure 6-2.

6. Observe the DMM and record the rectifier's shunt voltage. The shunt is rated 250A/50mV=5A/mV, which means that each millivolt of voltage drop across the shunt indicates 5A of output current.

7. Convert the DMM shunt voltage reading to amperes. For example, if the DMM reads 20mV, then 20mV x 5A/mV = 100A of output current.

8. Compare the amperes calculated in Step 7 with the digital display of the meter while the switch is in the AMPS position. If the digital display is not between ±2% ±2A of the amperes calculated in Step 7, calibrate the CM3 card via its R15 potentiometer.

Table 7-G provides digital meter tolerances.

Table 7-G: Digital Meter Tolerance

Switch Position	Tolerance
Rect V	± 0.1 volt

Table 7-G: Digital Meter Tolerance

Switch Position	Tolerance
Amps	± 2.5% of reading ± 2 amperes*

* To compare, measure the shunt voltage. 1mV of shunt voltage indicates 5 amperes of output current. For example, the shunt voltage should be 40 mV at full load (200 amperes). At 125% of full load (250 amperes), the shunt voltage should be 50 mV.

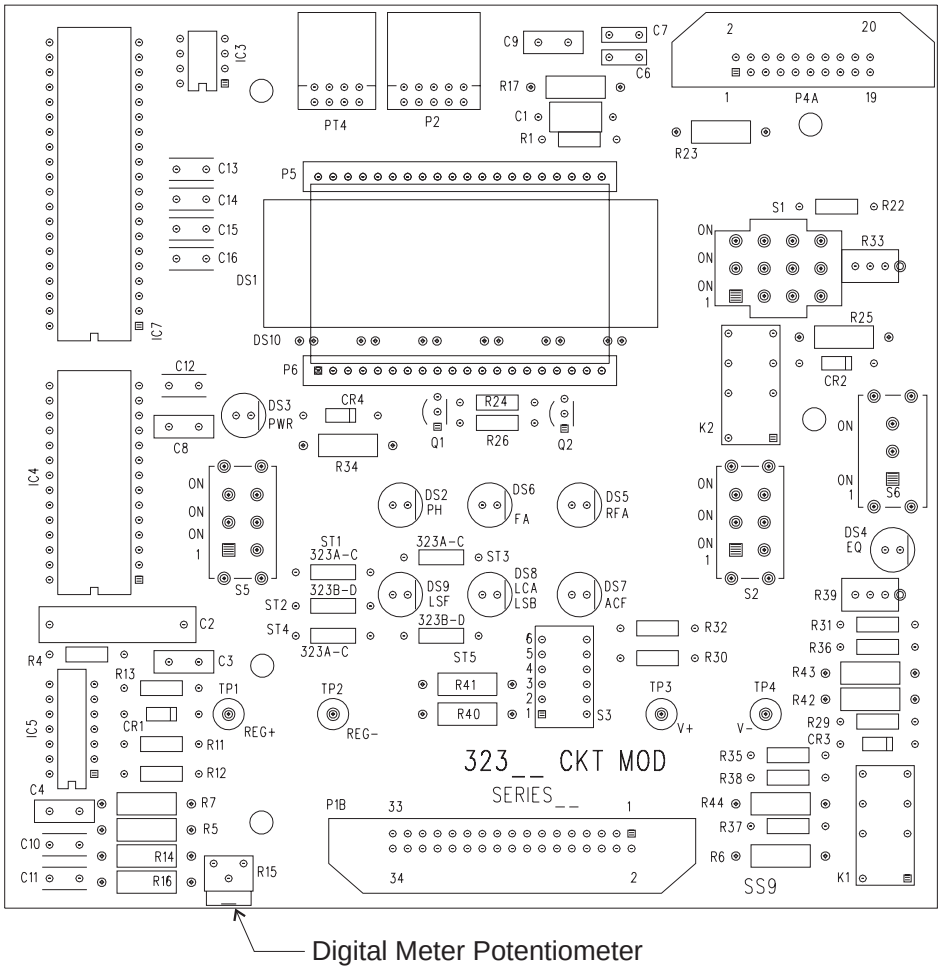


Figure 7-1: Adjustment Potentiometer on CM3

Adjust Current Limit **Off Line Adjustment**: Use the Current Limit Test (Off Line) to verify that the current limit circuit needs adjustment, before continuing with this procedure.

In steps (4) and (5) of the Current Limit Test in Section 6, if V_{out} is not within the required range, adjust **R88** on **CM2** (see Figure 6-3) until a correct voltage reading is obtained.

On Line Adjustment: Use the Current Limit Test (On Line), Section 6, to verify that the current limit circuit needs adjustment, before continuing with this procedure.

1. Hold the **Rect Test** switch in the full load (**FL**) position and observe the output current.

2. If the output current is not within 200-202A, hold the **Rect Test** switch in the full load (**FL**) position and adjust the current limit potentiometer **R88** on **CM2**, (see Figure 6-3), until the rectifier delivers 200-202A.

Warning
The rectifier is designed to provide 200 amperes. If the current limit is set beyond this rating, the unit may overheat, and its useful life may be severely shortened.

ISHVSD in Plants Without a Controller

To avoid overvoltage conditions on the actual battery plant loads, perform this procedure with the rectifier disconnected from the battery. A portable test load that can supply at least 220A, 10 percent above the rectifier's current rating, is required.

1. Connect the test load as specified in Section 6. Then restore ac power to the rectifier.

2. Turn the **Power** switch **On**.

3. Turn the **CB1** circuit breaker **On**.

4. Adjust test load to 220A or greater. Read load current on control panel meter.

5. Open switch contacts **S3.7** and **S3.8** on **CM2**.

6. Adjust the **Float Adj** potentiometer to obtain a rectifier voltage of 55.0 (29.0) ± 0.6 volts. Read voltage on control panel meter by holding meter switch in **Rect V** position. 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, refer to "Diagnostics" section.

8. Turn on dip switch **S3.7** on **CM2**, restart the rectifier, and adjust the load to at least 10 percent, 20A.

   Optional: To verify proper operation of the ISHVSD circuit, do the following:

   a. Adjust the **Float Adj** potentiometer to obtain 56 (29.5) ± 0.5 volts. Read voltage on control panel meter by holding meter switch in the **Rect V** position. The rectifier should shut down.

   b. Open switch contact **S3.7**, close switch contact **S3.8**, and restart rectifier.

   c. Adjust the **Float Adj** potentiometer to obtain 57 (30.0) ±0.5 volts. Read voltage on control panel meter by holding meter switch in the **Rect V** position. The rectifier should shut down.

   d. Close switch contact **S3.7**, and restart rectifier.

   e. Adjust the **Float Adj** potentiometer to obtain 58 (30.5) ±0.5 volts. Read voltage on control panel meter by holding meter switch in the **Rect V** position. The rectifier should shut down.

9. Set ISHVSD to desired level.

10. Remove ac power to the rectifier at the ac service panel, and disconnect the test load.

11. Reconnect the rectifier to the battery.

Restore Rectifier to Service

1. Set the ac supply and rectifier controls as shown in Table 7-H.

Table 7-H: Control Settings Prior to Restoring a Rectifier to Service

Controls	Position/Status
Associated ac circuit breaker or fuses at the ac service distribution panel	**Off** or fuses removed and holders tagged "Out of Service"
Rectifier **Power** switch	**Off** (down)
Rectifier **CB1** circuit breaker	**Off** (down)
Rectifier REG fuse in the plant controller	Removed

2. If the rectifier voltage was NOT at the desired float voltage before it was turned off, rotate the **Float Adj** potentiometer fully counterclockwise.

3. At the ac service panel, install the ac fuses or turn the ac input circuit breaker On.

4. To bring the rectifier into service:

   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, and use a small screwdriver to turn the **Float Adj** potentiometer clockwise until the digital meter reads approximately battery voltage.

   c. Turn the rectifier **Power** switch **Off** and immediately (within 5 seconds) turn circuit breaker **CB1** on (up).

5. At the rectifier, connect the control cable connector **J5A**.

6. At the plant controller, install the REG fuse associated with the rectifier that is being restored to service.

7. Turn the rectifier **Power** switch **On**.

8. Close the rectifier front door and secure the locking screws.

9. Adjust the rectifier to float voltage per Section 6.

10. If the rectifier is installed in a microprocessor-controlled plant that has an efficiency algorithm feature, enable this feature. (See the controller manual for instructions).

Preventive Maintenance

We recommend that all maintenance be done OFF LINE, with all ac input and dc bus voltages disconnected from the rectifier being serviced. Follow the instructions in "Disconnecting a Rectifier" at the beginning of this section. At 12-month intervals, check torque on various connections, such as ac input and dc output connectors. See Tables 8-A and 8-B for torque requirements. OBSERVE SAFETY PRECAUTIONS IF WORKING IN A LIVE PLANT.

Check calibration of the rectifier's digital meter.

8 Replacing Components and Circuit Modules

General Considerations for Replacing Components

Only disassembly procedures are given in this section. Some points are common to all rectifier disassembly work.

Reinstallation procedures are usually the exact reverse of removal procedures (i.e., follow the removal procedures in reverse order to reinstall the component). Specific instructions are given when this does not apply exactly, or where special considerations or precautions must be taken during reinstallation. Applicable portions of Section 5, *Installation*, may be helpful. Portions of Section 6, *Testing*, can be used after reinstallation to verify proper operation of the rectifier.

Note
Read **all** of the considerations below before using the rectifier disassembly procedures.

- Take proper precautions against accidental personal injury or damage to equipment. Observe warnings given in Section 4, *Safety*, in addition to the following admonishment before undertaking any disassembly or reinstallation procedure on a rectifier.

DANGER
The following procedures MUST be performed only on a rectifier completely disconnected from the plant battery buses, AND with no input from the ac service panel connected to the rectifier. The plant control cable, J5A must also be disconnected from the CM4 board.

- The ac service and dc battery buses can be safely disconnected from the rectifier by following the steps in Section 7, “Disconnecting a Rectifier.” All work must be done carefully because you are working with live cables at battery bus potentials and current capabilities. The disconnected charge battery and charge ground connectors must be taped adequately to prevent them from contacting each other or any other metal surface. Alternatively, the dc battery cables from the rectifier can be disconnected at the plant charge battery and charge ground buses.
- Always make note of the lead connection points (termination points) before unsoldering or disconnecting them to insure trouble-free reinstallation. This includes potentiometer leads, or the solderless, quick-disconnect type connections used on circuit boards, relays, inductors, transformers, and wire bundles.
- Always disconnect quick-disconnect connections by pulling straight apart with pliers to avoid bending or breaking the tabs. Do not pull on wire. Always remember to save hardware, thermal pads, and other items in a convenient place for reassembly.
- 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 “blowhole,” is plugged in a new or good capacitor, but is empty (blown out) in a failed unit. Some capacitor blowholes cannot be viewed directly until removed or almost removed from the rectifier. A dental-type mirror aids in viewing these capacitors' blowholes before disassembly. Lucent recommends that all dc capacitors in a rectifier be replaced whenever any one of them blows.
- Most component removals are straightforward and obvious. Therefore, these procedures can be used as a guide by qualified service personnel, rather than as step-by-step procedures. For example, you may prefer to remove a part not called for in order to make more room for access to a component being replaced.

Tables 8-A and 8-B provide the reassembly torquing requirements for the electrical and mechanical connections in the rectifier. Torque values are given in inch-pounds or foot-pounds and Newton-meters. Use these values unless otherwise directed in the procedures.

Table 8-A: Minimum Torque for Electrical Connections

Screw Size	Torque Values in In-Lb (or Ft-Lb)/Nm											
	Wire Connections				Head Tightened				Nut Tightened			
	Slotted Machine		Hex /Socket Cap		Slotted Machine		Hex /Socket Cap		Slotted Machine/ Hex Cap		Socket Cap	
	In-Lb	Nm	In-Lb	Nm	In-Lb	Nm	In-Lb	Nm	In-Lb	Nm	In-Lb	Nm
8-32	15	/2	15	2	19	2	19	2	19	2	23	2.3
10-24	21	2.5	21	2.5	27	3	27	3	27	3	33	4
1/4-20	50	5.5	50	5.5	65	8	65	8	65	8	80	9
5/16-18	-	-	100	11	-	-	135	15	135	15	165	19
3/8-16	-	-	108	20	-	-	240	27	240	27	290	33
7/16-14	-	-	280	32	-	-	385	44	385	44	465	55
1/2-13	-	-	500	56	-	-	585	66	585	66	710	80
5/8-11	-	-	(71)	96	-	-	(97)	131	(97)	131	(118)	160
3/4-10	-	-	(125)	170	-	-	(172)	233	(172)	233	(209)	283

General notes for Table 8-A:

- Slotted machine screws should be the pan-head type.
- Slotted machine and hex cap screws should be SAE Grade 2 steel or equivalent.
- Socket cap screws should have 100,000 psi minimum tensile strength.
- Locking means is only required for connections subject to vibration. Belville-type washers or jam nuts are preferred.
- Ferrous screws and washers should have a corrosion protective finish.
- For tapped copper bars less than 1/4-inch thick, use slotted No. 8, No. 10, or 1/4-inch machine screws to minimize applicable torque. When larger size screws are required, provide captive-type steel nuts or reduce torque.
- Torque recommendations are also suitable for all non-ferrous fasteners, except aluminum.
- Where the application permits, use hex cap screws.

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

Cap Screw Diameter (Inch)	Min. Yield Strength	Torque	
		Ft-Lb UNRC	Nm
1/4	57,000	6	8
3/16	57,000	12	16
3/8	57,000	22	30
7/16	57,000	35	47
1/2	57,000	54	73
9/16	57,000	77	104
5/8	57,000	107	145
3/4	57,000	190	257
7/8	36,000	193	261
1	36,000	290	393
1-1/8	36,000	410	556
1-1/4	36,000	580	786
1-3/8	36,000	760	1030
1-1/2	36,000	1010	1370

Replacing Components

DANGER
The following procedures MUST be performed only on a rectifier completely disconnected from the plant battery buses, AND with no input from the ac service panel connected to the rectifier. The plant control cable, J5A should also be disconnected from the CM4 board.

1. Remove the rectifier from service following the procedure in Section 7, “Disconnecting a Rectifier.”

2. After replacing components, restore the rectifier to service following the procedure in Section 7, “Restore Rectifier to Service.”

3. Remove plastic shields where necessary to access components in the J85503B-2 rectifier.

4. Refer to Figures 2-3 and 8-1 for component locations.

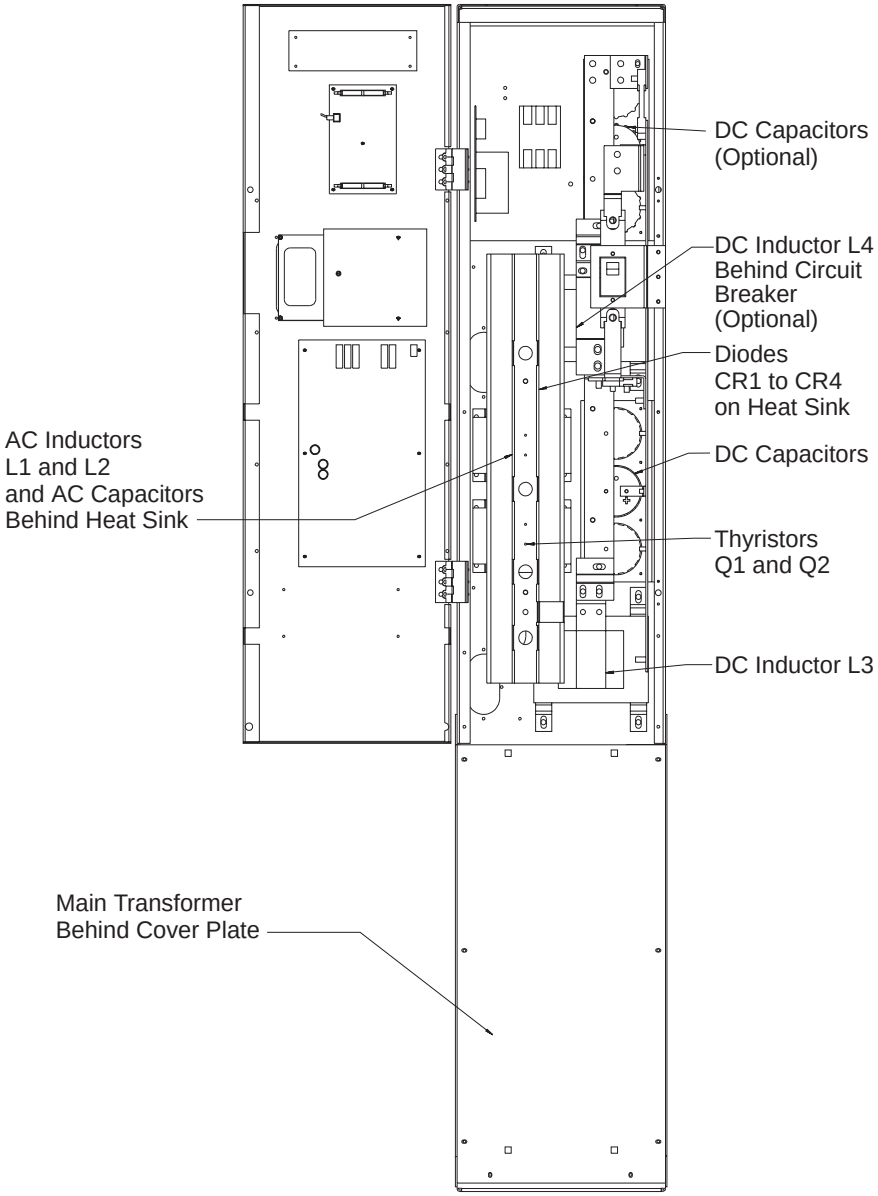


Figure 8-1: Component Locations

Thyristors (Q1, Q2)

1. Remove the wires attached to the thyristor. Note their position for reinstallation. The T4013NK thyristors, originally in the rectifier, use a beryllium ceramic. If the case is cracked, the manufacturer (Semiconductors Ltd., A Raytheon Company) recommends the component be handled with gloves, placed in a plastic bag, and sealed before discarding. The replacement part does not use a beryllium ceramic.

2. Remove the two nuts that secure the thyristor to the heat sink. Save the nuts and the thermal pad from under the thyristor.

3. When reinstalling a new thyristor, use the hardware and thermal pad (DP102 comcode 403208242) saved in Step (2). Note that the small gate terminal 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 300 in-lbs. Torque pigtail connection to transformers to 65 in-lb. Reinstall cable ties.

DC Capacitors (C7 through C12)

DANGER

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 CB1 before working on capacitors or associated buswork.

1. DC Capacitors **C5** through **C9** are located behind the capacitor bus bars. The bus bars are mounted directly to the capacitors by the capacitor terminal screws. In order to remove a capacitor, remove fuse board **CM1**, the capacitor terminal screws, mounting screws, and the screw supporting the fuse assembly. Note that this completely frees the capacitor bus bar in question.

2. Remove the capacitor from its clamp by pulling toward you on the capacitor.

3. Replace the capacitor by pushing it into the clamp with the positive terminal toward the inside.

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

4. Replace the negative bus bar. Tighten the mounting screws first and then the capacitor terminal screws.

5. Replace the fuse assembly. Replace fuse if required.

CB1 Circuit Breaker

1. Remove the output cables 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.

4. Reinstall in reverse order.

DC Inductor (L3, L4)

Note
Before replacing a dc inductor (L3 or L4), remove the 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 frame. Reinstall in reverse order.

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** and identify their position for reinstallation.
3. Remove the three mounting screws to free **K1** from the rear wall.
4. Install the new relay in the reverse order. Torque to 25 in-lbs.

AC Inductors (L1, L2)

1. Remove the cables and wires from both terminals of the inductor.
2. While supporting the weight of the inductor, remove the inductor from the rectifier.
3. Install the new inductor in the reverse order.

AC Capacitors (C1 - C6, C13 and C14)

1. Remove the quick-disconnect receptacles from the capacitor and note their positions.
2. Remove the screws securing the capacitor clamp and capacitor to the mounting plate.
3. Loosen the clamp on the capacitor and remove.
4. Reinstall the capacitor in the reverse order.

Main Transformers (T1, T2)

1. Remove the rectifier from the line up and lay it on its back.
2. Remove all of the cables from the transformers.
3. To access the transformer mounting screws, remove the kickplate (five screws) from the bottom of the rectifier frame and side plates.

4. Remove the four transformer mounting nuts, from under the **T1**/**T2** mounting bracket, that secure the transformer.

5. While supporting the transformer with adequate lifting equipment (at least 1000 lb), lift the transformer outward.

6. Reinstall the new transformer in the reverse order.

Handling Circuit Modules

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

Electrostatic Discharge 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 milliohm ±10%. 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.

- 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 the rectifier. Otherwise, open all circuit packs at a static-safe work position with wrist straps and dissipative table mats.
- Upon removal from the rectifier, 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, packing material, drinking cups, notebooks, and nonconductive plastic solder suckers. The 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.

Replacing Circuit Modules

This procedure gives instructions for replacing the circuit modules.

Warning
Minimize electrostatic discharge when handling circuit modules. Do not connect or disconnect circuit modules with voltages present or equipment damage may occur. AC voltages may be present when the rectifier **Power** switch is **Off**.

CM1 Fuse Board

1. Turn the rectifier **Power** switch **Off**.

2. Turn the rectifier **CB1** circuit breaker Off (down).

3. At the ac service panel supplying power to the rectifier, remove the input fuses assigned to the rectifier, or turn the circuit breaker Off.

4. At the plant controller, remove the REG fuse associated with the rectifier.

5. At the rectifier, loosen the locking screws and open the door.

6. Measure the voltage on each of the **C5** through **C9** capacitors. Discharge to below 20 volts before proceeding.

Caution
Support the **CM1** fuse board with your hands when connecting and disconnecting the cables, or damage to the board may result. Do NOT disconnect cables by pulling the cable.

7. Disconnect control cable connector **J5A** from the **CM4** board by unlatching first, then pulling the connector.

8. Remove all cables from **CM1** by unlatching first, then pulling the cable connector.

9. Remove **CM1** from its four support standoffs by using a small flat-bladed screwdriver to push in the latches on each standoff.

10. Position the new **CM1** over the four support standoffs. Verify that each latch snaps and locks in place.

11. Reconnect all cables that were disconnected in step (7).

12. If the rectifier is to be restored to service, refer to Section 7, “Restore Rectifier to Service.”

CM2 Control Board

Minimize electrostatic discharge when handling circuit modules. Observe all warnings in Section 4, *Safety*.

1. Turn the rectifier **Power** switch **Off**.

2. Turn the rectifier **CB1** circuit breaker off (down).

3. At the ac service panel supplying power to the rectifier, remove the input fuses assigned to the rectifier, or turn the circuit breaker off.

4. At the plant controller, remove the fuse REG fuse associated with the rectifier.

5. At the rectifier, loosen the locking screws and open the door.

Caution
Support the **CM2** control board with your hands when connecting and disconnecting the cables, or damage to the board may result. DO NOT disconnect cables by pulling the cable.

6. Disconnect control cable connector **J5A** from the **CM4** board by unlatching first, then pulling the connector.

7. Disconnect **JT2, JT3, J3A, J4, J5, J6**, and **J7** connecting cables from **CM2**.

8. Remove **CM2** from the six support standoffs by using a small flat-bladed screwdriver to push in the latches on each standoff.

9. Position the new **CM2** board over the six standoffs. Verify that each latch snaps and locks in place.

10. Reconnect **JT2, JT3, J3A, J4, J5, J6**, and **J7** connecting cables to **CM2**.

11. If the rectifier is to be restored to service, refer to Section 7, "Restore Rectifier to Service."

CM3 Digital Meter Board

Minimize electrostatic discharge when handling circuit modules. Observe all warnings in Section 4, *Safety*.

1. Turn the rectifier **Power** switch **Off**.

2. Turn the rectifier **CB1** circuit breaker off (down).

3. At the ac service panel supplying power to the rectifier, remove the input fuses assigned to the rectifier, or turn the circuit breaker Off.

4. At the plant controller, remove the fuse REG fuse associated with the rectifier.

5. At the rectifier, loosen the locking screws and open the door.

Caution
Support the **CM3** control board with your hands when connecting and disconnecting the cables, or damage to the board may result. DO NOT disconnect cables by pulling the cable.

6. Disconnect control cable connector **J5A** from the **CM4** board by unlatching first, then pulling the connector.

7. Disconnect the connecting cables from **CM3**.

8. Remove **CM3** from the two support standoffs by using a small flat-bladed screwdriver to push in the latches on each standoff. Remove the one screw holding **CM3** in place.

9. Position the new **CM3** board over the two standoffs. Replace the screw. Verify that each latch snaps and locks in place.

10. Reconnect connecting cables to **CM3**.

11. Check calibration of rectifier meter per Section 7, "Calibrate CM3 Digital Meter."

12. If the rectifier is to be restored to service, refer to Section 7, "Restore Rectifier to Service."

CM4 Interface Board

Minimize electrostatic discharge when handling circuit modules. Observe all warnings in Section 4, *Safety*.

1. Turn the rectifier **Power** switch **Off**.

2. Turn the rectifier **CB1** circuit breaker **Off** (down).

3. At the ac service panel supplying power to the rectifier, remove the input fuses assigned to the rectifier, or turn the circuit breaker **Off**.

4. At the plant controller, remove the fuse REG fuse associated with the rectifier.

5. At the rectifier, loosen the locking screws and open the door.

Caution
Support the **CM4** control board with your hands when connecting and disconnecting the cables, or damage to the board may result. DO NOT disconnect cables by pulling the cable.

6. Disconnect control cable connector **J5A** from the **CM4** board by unlatching first, then pulling the connector.

7. Disconnect the connecting cables from **CM4**.

8. Remove **CM4** from the support standoffs by using a small flat-bladed screwdriver to push in the latches on each standoff.

9. Position the new **CM4** board over the standoffs. Verify that each latch snaps and locks in place.

10. Reconnect connecting cables to **CM4**.

11. If the rectifier is to be restored to service, refer to Section 7, "Restore Rectifier to Service."

CM5 or CM6 Snubber Board

1. Remove the quick-disconnect connectors from the board.

2. Push in on the plastic locking tabs to free the board.

3. Remove any screws holding the board in place.

4. Reinstall in reverse order.

CM7 Transformer Board

Minimize electrostatic discharge when handling circuit modules. Observe all warnings in Section 4, *Safety*.

1. Turn the rectifier **Power** switch **Off**.

2. Turn the rectifier **CB1** circuit breaker **Off** (down).

3. At the ac service panel supplying power to the rectifier, remove the input fuses assigned to the rectifier, or turn the circuit breaker **Off**.

4. At the plant controller, remove the fuse REG fuse associated with the rectifier.

5. At the rectifier, loosen the locking screws and open the door.

Caution
Support the **CM7** control board with your hands when connecting and disconnecting the cables, or damage to the board may result. DO NOT disconnect cables by pulling the cable.

6. Disconnect control cable connector **J5A** from the **CM4** board by unlatching first, then pulling the connector.

7. Disconnect the connecting cables from **CM7**.

8. Remove **CM7** from any support standoffs by using a small flat-bladed screwdriver to push in the latches on each standoff. Remove the two screws holding **CM7** in place.

9. Position the new **CM7** board over the two screw standoffs. Verify that each latch snaps and locks in place. Restore the two screws.

10. Reconnect connecting cables to **CM7**.

11. If the rectifier is to be restored to service, refer to Section 7, “Restore Rectifier to Service.”

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.