

Lucent Technologies
Bell Labs Innovations



60V CPS
Small Broadband Power System
J85500Q-1

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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

60-volt Cabinet Power System

The low-maintenance, outside-plant 60-volt/60 Hz CPS integrates advanced technology in a modular system. The system delivers highly regulated, low-noise power over a wide range of load currents and input voltages. Using switchmode technology to process the power, along with forced-air cooling in the rectifiers, results in a power unit characterized by high power density, light weight, and an extended service life.

Applications

Lucent Technologies has developed the 60-volt, 60-Hertz Small Broadband Power System to support the growing needs of broadband video/telephony networks.

Configurations

The single-shelf Cabinet Power System (CPS) houses one rectifier and a Battery Polarity Switch (BPS). The rectifier uses commercial ac power to produce 82 volts dc. The BPS converts the 82-volt dc power to a nominal 60-volt ac @ 60 Hz output for powering the broadband network.

In a fully configured system, the CPS shelf contains one (1) ES664 rectifier and one (1) ES635 Battery Polarity Switch. In addition to converting the rectifier output, the BPS provides the alarm and control functions as well as the output distribution circuit breakers and connectors.

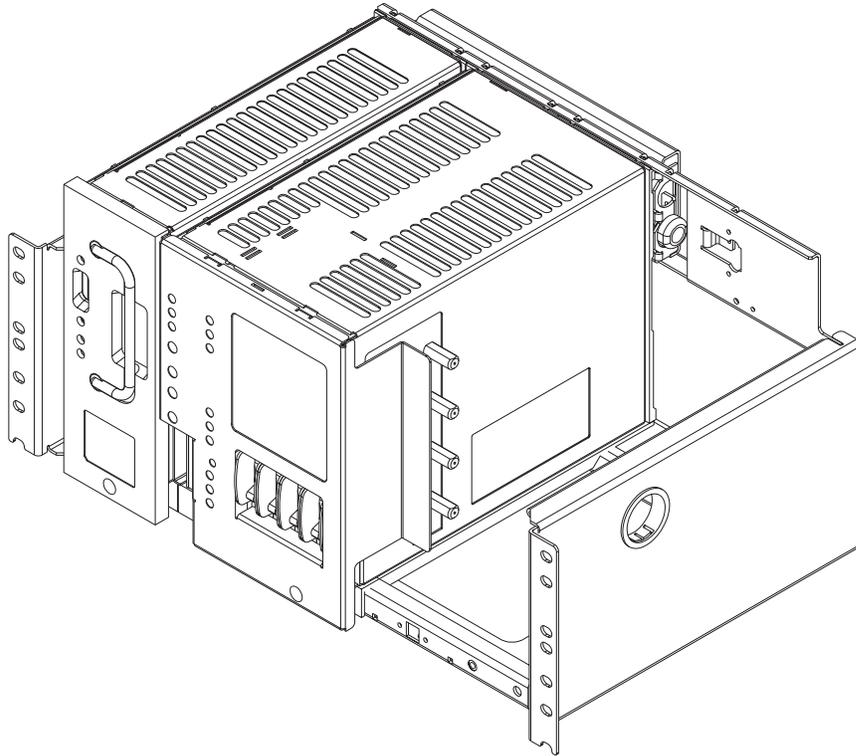


Figure 1-1: 60V/60Hz CPS Power Shelf with Power Modules

***Customer
Training***

Lucent Technologies offers customer training on many Power Systems products. For information call 1-972-284-2163. This number is answered from 8:00 a.m. until 4:30 p.m., Central Time Zone (Zone 6), Monday through Friday.

***Customer
Service***

For customers in the United States, Canada, Puerto Rico, and the US Virgin Islands, call 1-800-THE-1PWR (1-800-843-1797). Services provided through this contact include initiating the spare parts procurement process for out of service emergencies, ordering Lucent Technologies documents, and providing other product and service information.

For other customers worldwide, call 001-972-840-0382. This number is answered from 8:00 a.m. until 4:30 p.m., Central Time Zone (Zone 6), Monday through Friday.

***Technical
Support***

Technical support for Lucent Technologies customers is available around the world during the normal product warranty

period and also while specific contractual agreements extend this service.

For customers in the United States, Canada, Puerto Rico, and the US Virgin Islands, call 1-800-CAL-RTAC (1-800-225-7822) to contact a product specialist to answer your technical questions and assist in troubleshooting problems.

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

Product Repair and Return

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

For other customers worldwide, contact your sales representative to discuss your particular circumstances.

Warranty Service

For warranty service worldwide, contact your Warranty Service Manager (WSM). The WSM serves specific customer-groups, who have taken ownership of the product. For product conformance issues prior to customer ownership, contact your local customer service.

2 ***Product Description***

Overview

Figure 2-1 is a block diagram of a 60-volt/60 Hz CPS battery plant. The shelf assembly houses and interconnects the ES664 rectifier and the ES635 Battery Polarity Switch (BPS). The shelf design provides a platform which accepts plug-in modules, thereby simplifying plant assembly and repair. Furthermore, this plug-in design permits growth of plant capacity as well as easy maintenance without interruption of service. Keying prevents improper insertion of incompatible modules.

Power Modules

These units have been designed specifically for applications where size, weight, ease of installation and maintenance are important. Switchmode circuit design provides excellent output regulation over a wide range of load currents and input voltages. Power processing at higher frequencies allows for substantial reduction in the size and weight of energy storage elements. Higher frequencies and the use of forced-air cooling in the rectifier help achieve high power density and light weight. The ES635 (BPS) is convection cooled.

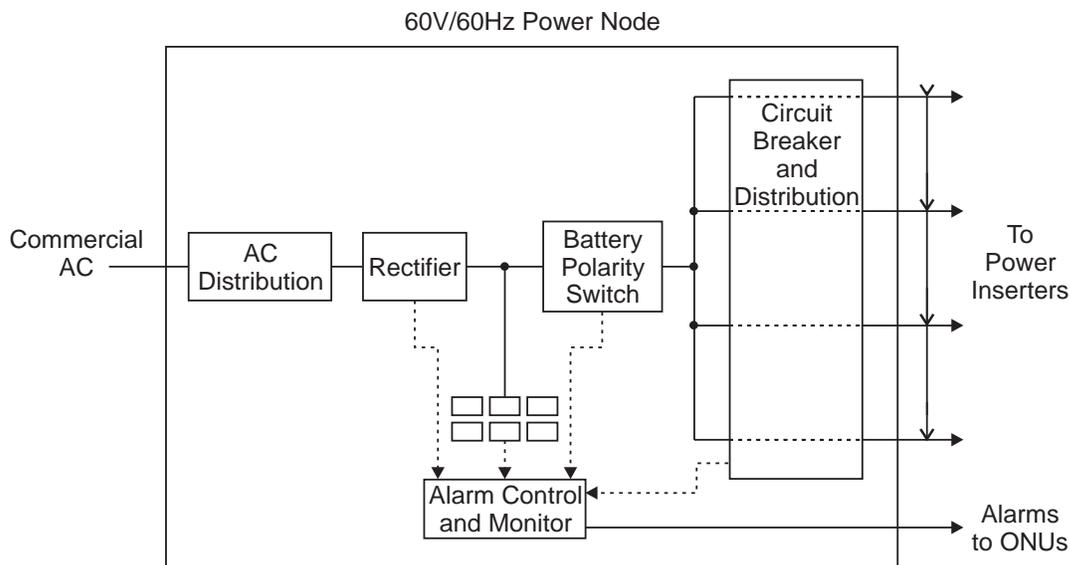


Figure 2-1: 60V/60 Hz CPS Block Diagram

The rectifier is equipped with field replaceable, self-contained cooling fans. Thermal alarm circuitry offers additional protection by shutting the power unit down and providing an alarm when the internal temperature exceeds 75° C. Forced air cooling improves the reliability of power units by maintaining their internal temperatures very close to the outside ambient temperature.

60-volt/60 Hz CPS series power units are self-protected such that short circuits and system overloads are handled automatically; i.e., if a short circuit is removed or a system overload reduced, the power units will automatically resume normal operation.

Signal interfaces between the 60-volt/60 Hz CPS rectifier and the plant control unit provide alarm monitoring, rectifier output voltage adjustment, lamp test, and rectifier On/Standby control. For inverters, the signal interface with the control unit provides alarm monitoring and lamp test, but does not allow voltage adjustment or current monitoring.

Features The following list describes standard features for 60-volt CPS series power modules.

- **Light weight, easy to install:** These connectorized, pluggable units may be installed in 60-volt CPS power plants in less than one minute.
- **Simplified plant administration:** Rectifiers may be installed in a working plant without adjustment and without interruption of service. System failures can be easily corrected by replacing defective power modules. Defective fans may be easily replaced in the field.
- **Front access only:** Power modules and the 60-volt CPS power plants may be installed and serviced without the need for rear access.
- **User friendly:** Front panel LED indicators on power modules as well as the control unit front panel indicate system status.
- **Lamp test:** A push-to-test switch on the plant Alarm Control Unit activates all plant alarm and status LED indicators.
- **Active inrush current limiting:** Upon application of the source voltage, an active circuit limits the peak inrush current, thus eliminating nuisance tripping of customer provided input breakers.
- **Output current limit:** Power modules provide a constant output voltage up to their rated output current, at which point they begin to provide constant current outputs. The maximum output current is inherently limited to less than 110% of the rated output without user adjustment.
- **Internal selective high-voltage shutdown:** If the plant voltage goes too high, only the defective power module will shut down.
- **Restart circuit:** If a rectifier or inverter has shut down due to high voltage, it will try to restart a maximum of two times automatically. After two unsuccessful tries, the power module shuts down and locks down.
- **Power module alarm:** The power module alarm provides both a local visual indication of low output voltage as well as a signal to the plant control unit. In addition, alarms are generated by either a high module temperature and/or an operated internal fuse.

- **Thermal alarm:** The rectifiers are fan cooled to increase their reliability. Excess internal temperature caused by fan failure or other conditions initiates a thermal alarm.
- **Power factor:** State-of-the-art circuits in the rectifiers increase the power factor to near unity.
- **Total harmonic distortion:** By controlling the power factor, the total harmonic distortion is reduced to less than five percent at full load.
- **Voltage range selection:** CPS power modules automatically accept a wide range of ac input voltages.
- **Dynamic response:** Step changes in load over the range of 10 to 90 percent, will not cause the voltage measured at the point of regulation to overshoot or undershoot more than 5 percent. After the step change, the voltage will return to and stay within the regulation band within 300 milliseconds.
- CPS power modules are capable of withstanding repeated surges of the following wave forms (per ANSI C62.41-1991 requirements) without damage:
 - Rise time of 8 microseconds to 3000 amperes peak amplitude and decay to 1500 amperes in 20 microseconds.
 - 0.5 microsecond-100 kHz ring wave with a peak voltage of 6000 volts.

Inverter (BPS)

Each BPS inverter, ES635, provides four outputs, with each delivering 110 Watts of power. The BPS output is 60 volts polarity-switched at 60 Hz.

The ES635 BPS is a double-wide unit that houses the Alarm Control Unit (EBM1) and distribution circuit breakers for the four outputs.

Alarm Control Unit

An Alarm Control Unit (ACU) is included in the 60-volt/60 Hz system. The ACU (EBM1) provides plant monitoring and control features as well as office alarm outputs.

Alarm reporting for the 60-volt/60 Hz CPS plants is typical of telecommunication battery plants. Alarms are categorized as

major alarms (PMJ) which indicate service affecting problems, and ac fail alarms (AC fail) which indicate that the rectifier has lost ac input voltage.

The ACU is a field-replaceable part of the BPS and is only accessible when the BPS faceplate is removed. It offers the following features:

- Green, yellow, and red LEDs that display the plant status
- Form-C office alarms corresponding to the alarm indicators
- Customer-accessible potentiometer to adjust the plant battery voltage
- Alarm monitor circuit that determines the status of the rectifier or inverter and incorporates this information into the plant power major alarms
- LED test switch that activates all plant LEDs.
- Option for a customer-provided remote On/Standby control that is “passed-on” to the rectifier
- Option for a customer-provided local plant battery test control

Batteries

Two strings of six IR30C batteries provide eight-hour battery back-up for the power system. The battery is connected in parallel with the dc output of the rectifier.

Low Voltage Shut-off/ Thermal Management Circuit Pack

The 60-volt/60 Hz ACU is equipped with a low voltage shut-off/thermal management circuit that provides the following features:

- Alarm conditioning for control unit presentation
- Thermal management (slope compensation) that adjusts the battery float voltage

Rectifier/ Inverter Plant

The rectifiers provide input power for inverters whose outputs are provided on the output bus. The BPS inverter has four circuit breaker protected outputs.

Certification Considerations

CPS plants must be installed over non-combustible surfaces in restricted access areas in accordance with Articles 110-16, 110-17, and 110-18 of the National Electric Code, ANSI/NFP Number 70 or per requirements of applicable local codes.

Specifications

Table 2-A: ES664 Rectifier Specifications

Nominal Output Voltage	81.72 volts dc
Operating Output Voltage Ranges	72 - 85 volts dc
Operating Frequency Range	47-63Hz
Output Current	0 - 9.2 amperes
Nominal Input Voltage	100/120/200/208/240 volts ac
Input Voltage Ranges	90 - 130 volts ac 180 - 264 volts ac
Input Current	3.6 amperes @ 240 volts ac 7.28 @ 120 volts ac
Efficiency	86% typical @ 208/240 volts ac
Regulation	±0.5%
Ripple	50 millivolts peak to peak maximum over the range 10 Hz to 20 MHz
Output Noise	32 dBrc
Load Share Accuracy	1.25 amperes maximum
Heat Dissipation	111 watts (380 BTU/hr) maximum (Note 1)
Power Factor	>0.98 for loads > 60% full load
Total Harmonic Distortion	<5% for loads > 60% full load
Selective High-Voltage Shutdown	83.2 volts dc
Backup High-Voltage Shutdown	90 volts dc

Table 2-B: ES635 Battery Polarity Switch Specifications

Nominal Output Voltage	60 volts polarity-switched at 60 Hz
Output Current	0 - 8.33 amperes @ 60V ac output
Nominal Input Voltage	81.72 volts dc
Input Voltage Range	60 - 84 volts dc
Input Current	0 - 6.59 amperes dc @ 81.72 Vdc input
Efficiency	>95% typical @ 81.72 volts dc
Regulation	60 ± 1% for input voltages above 67 Vdc
Ripple	250 millivolts peak to peak maximum, over the range 10 Hz to 20 MHz
Heat Dissipation	30 Watts
High-Voltage Shutdown	70 volts peak

Table 2-C: CPS 60-Volt/60 Hz Plant Specifications

60-volt/60 Hz dc Plant	One shelf with facilities to terminate up to two 82-volt battery strings
Plant Architecture	Single shelf
AC Input Distribution	One ac feed per shelf
BPS Output Distribution	Four PWB mounted F-type connector for each BPS output
Maximum Discharge Current	18 amperes per shelf
Maximum Recharge Current	Installed plant 82-volt rectifier capacity minus plant 82-volt load.
Low Voltage Shut-off	64 ± 1 volt or 61 ± 1 volt (strap selectable)
Operating Ambient Temperature	-40 to 149 degrees Fahrenheit -40 to 65 degrees Celsius (Note 1)
Altitude	-200 to 13,000 feet -61 to 3962 meters (Note 2)
Humidity	5 - 95% Non condensing
Audible Noise	<65 dBA measured 2 feet or 0.6 meters from the plant.
Electrostatic Discharge	IEC 801-2 Level 4 (10KV) at 40% relative humidity
Radiated and Conducted Emissions	FCC Part 15, Level A
Electromagnetic Immunity	10 V/m over the range of 20MHz to 2000 MHz
Earthquake Rating	Zone 4, upper floors
Safety Agency Approvals	The CPS 60-volt/60 Hz shelf equipped with the ES664 and ES635 is Underwriters Laboratories (UL) Listed per Subject Letter 1801: Power Distribution Center for Communications Equipment. (Note 3)
<p>Note 1: CPS can withstand temporary fluctuations in temperature up to 75°C (167°F).</p> <p>Note 2: For altitudes above 5000 feet, derate the temperature by 3.6 degrees Fahrenheit per 1000 feet. For altitudes above 1524 meters, derate the temperature by 0.656 degrees Celsius per 100 meters.</p> <p>Note 3: Rectifier and BPS are individually UL Recognized to UL1950.</p>	

3 *Ordering Information*

Modules

The 60-volt/60 Hz CPS plant is ordered using the List (L) numbers and tables on the J85500Q-1 equipment drawing. In this application the shelf is ordered as part of the 61A cabinet. Order the plug-in modules from the table below.

Table 3-A: 60V/60 Hz CPS Plug-In Modules

Unit	Apparatus Code	Comcode
60V Rectifier	ES664	107551178
Battery Polarity Switch*	ES635	107635914
Alarm Control Unit	EBM1*	107635864

* The EBM1 circuit pack is factory-installed in the BPS.

Spares

With the exception of a fan or EBM1 failure, the ES664 rectifier and ES635 BPS are repaired by replacement; therefore, each service area needs one set of spares.

The table below contains recommended spare parts for the 60-volt/60 Hz CPS plant. One each is recommended for each service area.

Table 3-B: Recommended Spares

Unit	Apparatus Code	Comcode
60V Rectifier	ES664	107551178
Battery Polarity Switch	ES635	107635914
Alarm Control Unit	EBM1	107635864
DC Fan Cradle Assembly	N/A	847244100

***Documentation
References***

60V/60 Hz CPS Lineage[®] 2000 Battery Plant

Assembly and Ordering Drawing	J85500Q-1
Wiring Diagram	T83282-30
Schematic Drawing	SD83282-01
Product Manual Select Code	167-790-075

Batteries

Battery	Product Manual Select Code
IR Series Battery	157-622-020

4 *Safety*

Safety Statements

Please read and follow all safety warnings before installing, maintaining, or repairing the 60-volt/60 Hz CPS battery plant.

- All building wiring should comply with the NEC and other applicable local codes.
- The CPS plant must be installed over non-combustible surfaces.
- Install only in restricted access areas (dedicated equipment rooms, equipment closets, etc.) in accordance with articles 110-16, 110-17, and 110-18 of the U.S. National Electrical Code (NEC), ANSI/NFP No. 70, and pursuant to all applicable codes.
- For use in an environment where the humidity is maintained at levels that cannot cause condensation on the equipment, the contaminating dust is controlled, and the steady-state temperature is within the range specified. This equipment has been evaluated for operation up to 75° C.
- Battery input cables must be dressed and strain-relieved to avoid damage to the conductors and undue stress on the ac connectors. Conductors can be damaged when routed around sharp edges or where wires could be pinched.
- The battery cables provided are only suitable for internal wiring, i.e., inside telephone equipment cabinets.
- Hazardous energy and voltages are present in the unit (including all logic circuits in the BPS module) and on the interface cables and will shock or cause serious injury or

death if safety precautions are ignored. Follow all safety warnings and practices when servicing this equipment.

- Insulation on field-wired conductors should be rated no less than 90°C. Wire conductor size should be no less than allowed by electrical codes for 60°C wire (regardless of insulation temperature rating used) and based on the ampacity of the associated protection device. Wiring internal to enclosed equipment cabinets should be rated at 105°C (minimum).
- Alarm contacts are not fused within the BPS module. Therefore, current limiting protection for these contacts must be provided by external circuits. Maximum ratings for alarm connections are 60 Vdc and 0.5 amperes. Exceeding these maximum ratings could result in fire or damage to the unit.
- High leakage currents are possible. Earth ground connection is essential before connecting the ac source to the shelf.
- In enclosed equipment cabinets, the CPS mounting framework must be connected directly to the cabinet ac service ground bus. For applications in huts, vaults and central offices, the CPS mounting framework must be connected to the system integrated ground grid.
- In the event of emergency, an accessible ac circuit disconnect must be provided which removes power from **all** branch circuit inputs to the CPS.
- AC branch circuits must be protected using fuses or circuit breakers sized as required by the National Electric Code. Input ac circuit breakers should not exceed 15 amperes.
- All electrical connections should be made using the proper crimping tools and dies and shall be torqued to values specified on the product labels or tables in this manual, if applicable.
- Installing fuses or circuit breakers not specified for use may result in injury to service personnel or equipment damage. Use only replacement parts listed in this manual and on the equipment drawings.

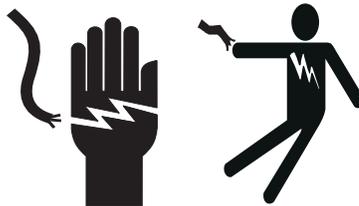
- While installing batteries, follow all safety precautions outlined in the appropriate battery product manuals.
- This unit must be installed, serviced, and operated only by skilled and qualified personnel who have the necessary knowledge and practical experience with electrical equipment and who understand the hazards that can arise when working on this type of equipment.
- Ensure that the appropriate circuit protection device for ac input being serviced is disconnected before and while servicing the equipment.
- All BPS internal circuits are at hazardous voltage with respect to ground (earth ground and equipment frame).
- The output of the DC/DC power module (e.g., 12V, 5V) that supplies power to these circuits are referenced to the floating battery input. Therefore, when the BPS switches, every other cycle will cause the logic circuits to be at high peak voltage levels, approximately 82 volts.
- Any strap settings required inside the BPS should be done with all power disconnected.

***Warning
Statements and
Safety Symbols***

The symbols may sometimes be accompanied by some type of statement; e.g., “Hazardous voltage/energy inside. Risk of injury. This unit must be accessed only by qualified personnel.”



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



These symbols (or equivalent) are used to identify the presence of hazardous ac mains voltage.



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



One of these two symbols (or equivalent) may be used to identify the presence of rectifier and battery voltages. The symbol may sometimes be accompanied by some type of statement, for example: "Battery voltage present. Risk of injury due to high current. Avoid contacting conductors with uninsulated metal objects. Follow safety precautions."



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



This symbol is used to identify the presence of a hot surface. The marked item should not be touched without taking care.



This symbol is used to identify the protective safety earth ground for the equipment.



This symbol is used to identify other bonding points within the equipment.



This symbol is used to identify the need for safety glasses and may sometimes be accompanied by some type of statement, for example: "Fuses can cause arcing and sparks. Risk of eye injury. Always wear safety glasses."

Precautions

When working on or using this type of equipment, the following precautions should be noted:

- This unit must be installed, serviced, and operated only by skilled and qualified personnel who have the necessary knowledge and practical experience with electrical equipment and who understand the hazards that can arise when working on this type of equipment.
- The equipment could be powered by multiple ac inputs. Ensure that the appropriate circuit protection device for each ac input being serviced is disconnected before servicing the equipment.
- For equipment connected to batteries, disconnecting the ac alone will not necessarily remove power to the equipment. Make sure the equipment is not also powered by the batteries or the batteries are not connected to the output of the equipment.
- Hazardous energy and voltages are present in the unit and on the interface cables that can shock or cause serious injury. Follow all safety warnings and practices when servicing this equipment. When equipped with certain DC/DC modules and ringer modules, hazardous voltages will be present on the secondary distribution board and connector J14. The ES613 plug-in distribution also contains hazardous ringer voltages.

- Batteries may be connected in parallel with the output of the rectifiers. Turning off the rectifiers will not necessarily remove power from the bus. Make sure the battery power is also disconnected and/or follow safety procedures while working on any equipment that contains hazardous energy/voltage.

- In addition to proper job training and safety procedures, the following are some basic precautions that should always be used:
 - Use **only** properly insulated tools.
 - Remove all metallic objects (key chains, glasses, rings, watches, or other jewelry).
 - Wear safety glasses.
 - Test circuits before touching.
 - Lock out and tag circuit breakers/fuses when possible to prevent accidental turn on.
 - Be aware of potential hazards before servicing equipment.
 - Identify exposed hazardous electrical potentials on connectors, wiring, etc. (note the condition of these circuits, especially wiring).
 - Use care when removing or replacing covers; avoid contacting circuits.

5 ***Installation***

Introduction

This section outlines the sequence for installing the CPS shelf and/or plug-in modules as well as a test procedure for verifying the integrity of the installation.

Installation Tools and Hardware

You will need the following tools and hardware to install and test the CPS plug-in modules:

- 3/16 inch Allen wrench
- 7/16 inch hex driver
- Test load of 60V @ 2 amperes (A space heater will work.)
- Test cable
- Digital meter with an accuracy of $\pm 0.02\%$
- Small screw driver
- ESD strap
- Appropriate mounting hardware, as required

General Information

The commercial ac power input wiring enters the shelf through a supply cord with a standard NEMA 5-15 P-Plug. The plant output wiring exits the plant on the right. Power connections between the rectifier and the Battery Polarity Switch (BPS) are on the backplane. The batteries are connected to the BPS at the front of the supply.

Safety

Read all of Section 4 of this manual before beginning installation.

Warning

This unit must be installed, serviced, and operated only by skilled and qualified personnel who have the necessary knowledge and practical experience with electrical equipment and who understand the hazards that can arise when working on this type of equipment.

Installation and Turn Up Sequence

The power equipment may be installed in any sequence. However, for turn-up, the CPS power modules should be turned up first. For safety reasons, connect the IR30C batteries last.

Figure 5-1 is a front equipment drawing of a 61A cabinet.

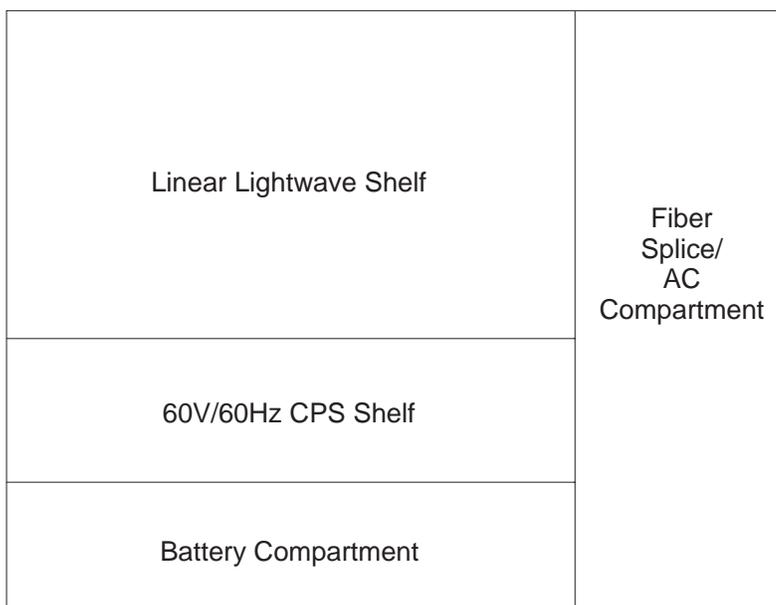


Figure 5-1: 61A Cabinet

Please review all safety warnings before beginning the installation process. Observe all warnings and labels on the equipment.

When handling the plug-in modules, wear an ESD strap. You must be properly grounded in order to prevent ESD damage to the unit(s).

Note

Before working on any BPS output beyond the cabinet distribution/breaker panel, turn off the associated 60V/60 Hz ac service circuit breakers.

Warning

AC input voltages are provided to the CPS via input cable. Ensure that the circuit breaker for the ac input is disconnected while installing this equipment. The BPS has dc inputs from the rectifier and the batteries. Disconnect all before working on the BPS.

Power Shelf

If a 60V/60 Hz CPS shelf is already mounted in a cabinet or frame, proceed to “AC Input Wiring.”

When installing a CPS shelf, ensure that adequate space is available for mounting the shelf. The shelf requires a minimum of 10.75 inches of vertical height, including a minimum of 1 inch above and 1 inch below the unit for cooling. Twelve inches of space in front of the shelf is required for insertion and removal of the shelf power units. The shelf may be mounted in either 19-inch framework or 23-inch framework in cabinets which requires bracket extensions.

When installing batteries, refer to the appropriate product manuals. Follow all safety precautions.

1. Mount the CPS shelves and battery modules in the frame. Screws are required in all mounting holes and should be torqued to a minimum of 30 inch-pounds.

Note

Supply appropriate mounting hardware for your application.

AC Input Wiring

The CPS 60-volt rectifier is powered from a branch circuit.

Note

Branch circuits to the rectifier should be protected using circuit breakers sized as required by the National Electric Code. The maximum rating of the circuit breakers used to protect the ac wiring is 15 amperes.

Warning

- High leakage currents are possible. Earth ground connection is essential before connecting the commercial ac power to the rectifier. Due to the hazardous voltage levels, it is essential that the shelf is also reliably earth grounded.
- Interconnecting control/logic circuits are at hazardous voltage levels with respect to ground.

Control Unit

1. Identify and unpack the Alarm Control Unit (ACU), EBM1 and the BPS.
2. Inspect for damage.
3. Remove the BPS faceplate.
4. Remove the ACU from the BPS.
5. Insert the ACU (EBM1) into the slot in the BPS. (See Figure 5-2.)
6. In order to complete the remaining steps, do not replace the faceplate on the BPS.

Plug-In Modules General

1. Ensure that the proper modules have been ordered and received.
2. Disconnect the power to the shelf by turning the ac service circuit breakers off.
3. The On/Standby switch on the rectifier **must** be in the Standby position.
4. Install the rectifier and the BPS by placing them on the rectifier shelf and carefully sliding them toward the back plane until its mounting screw prevents any further backward motion. Do not seat the rectifier or the BPS. (At this point, the BPS faceplate is not yet installed.)
5. The Low Voltage Shut-off function is pre-set in the factory at 61 volts, with strap STR1 across positions 1 and 2. See “Low Voltage Shut Off” in Section 6 for more information.

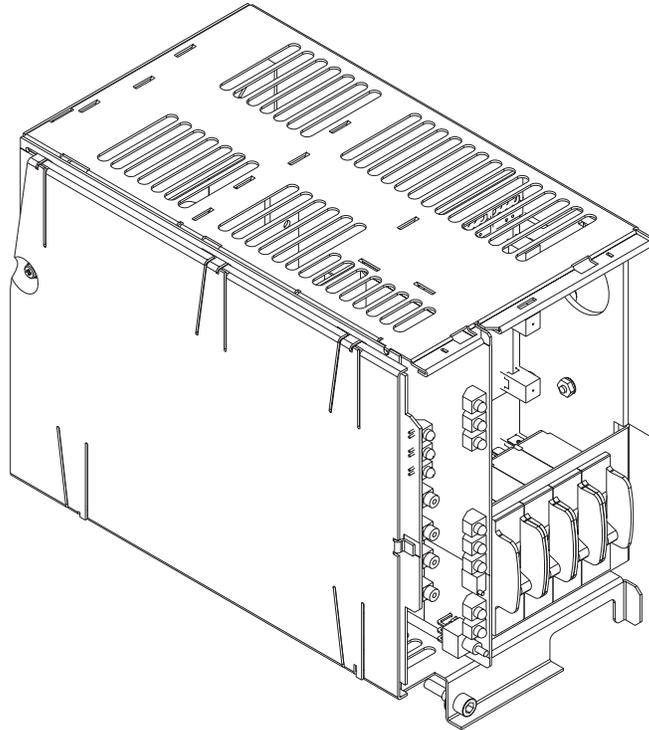


Figure 5-2: BPS with Faceplate Removed

Initial Start-up and Test

Refer to section 6 for a description of the parameters cited in this section.

- Verify that all ac service circuit breakers are off.
- Verify that the four (4) quadrant circuit breakers on the BPS are off.
- Verify that the On/Standby switch is in the Standby position on the rectifier.
- Ensure that the batteries are not connected to the CPS shelf.

Resistive Load

Use the battery connector on the BPS to connect a test load. (See Figure 5-3.) Set the test load to approximately 2 amperes. This test verifies that the rectifier(s) will support a load.

Rectifier

1. Turn the ac service circuit breakers on.
2. Seat the rectifier and BPS using the 3/16-inch Allen wrench, turning the mounting screw clockwise. (The BPS has two mounting screw positions; use the left one to

- secure the unit.) Verify that the fan operates on the rectifier.
3. After the rectifier is seated, verify that the yellow Standby LED lights on the rectifier.
 4. Turn the rectifier on using the On/Standby switch. Verify that the yellow Standby LED extinguishes and the green On LED lights on the rectifier.
 5. Verify that the LEDs on the ACU portion of the BPS, with the exception of the PMJ, MJF and the Battery Connect LEDs, extinguish after the rectifier switch is in the On position.
 6. Disconnect the thermal probe cables at the connector plug (P15 and P16) on the BPS before adjusting the plant voltage.
 7. Plug a digital multimeter (DMM) into the V_{batt} test jacks on the ACU.
 8. Verify that the plant voltage is 81.72 ± 0.7 using the V_{adj} potentiometer located on the ACU.
 9. Reconnect the thermal probe cables at the connector plug on the BPS.
 10. Test the thermal management feature using the procedure in steps 11 and 12. Perform this procedure for all probes.
 11. Locate the exposed pins on the rear of a thermal probe. Short these pins. Verify that the "Probe Fail" LED lights and the PMJ LED lights on the ACU. Remove the short.
 12. Unplug the cable from the thermal probe. Verify that the "Probe Fail" LED and the PMN LED light on the ACU.
 13. Replace the thermal probes.
 14. Replace the BPS faceplate.

Output Wiring

1. Verify that the output circuit breakers are in the off position.

2. Turn the rectifier off.
3. Connect the output cables to each F-type coax connection.

Note

A difference in potential may exist between the rectifier output ground and the coax cable grounds. Some arcing may occur when connecting the first output cable to a shelf when the rectifier is on or battery voltage is present. When replacing cables on an active shelf, as long as one output cable is connected, no arcing will occur when connecting or disconnecting others.

4. Turn the rectifier on.
5. Close all four circuit breakers.
6. Verify that the MJF LED extinguishes.

***Installing
Batteries***

Warning

Connecting battery to ground will damage the ES635 (BPS) circuits. The batteries must be floating when connected to the system.

1. To install the IR-type batteries refer to the appropriate product manual listed in Section 2.
2. Connect the batteries to the battery interconnect cable.
3. Connect the battery interconnect cable to the front of the BPS.
4. Repeat steps 2 and 3 for the second battery string.
5. Verify that the Battery Connect LED and the PMJ LED extinguish and the green Normal LED lights.
6. Route thermal probe cables and battery interconnect cables through cable ties on the front of the shelf. See Figure 5-3.

7. Position one thermal probe between the batteries in each string.

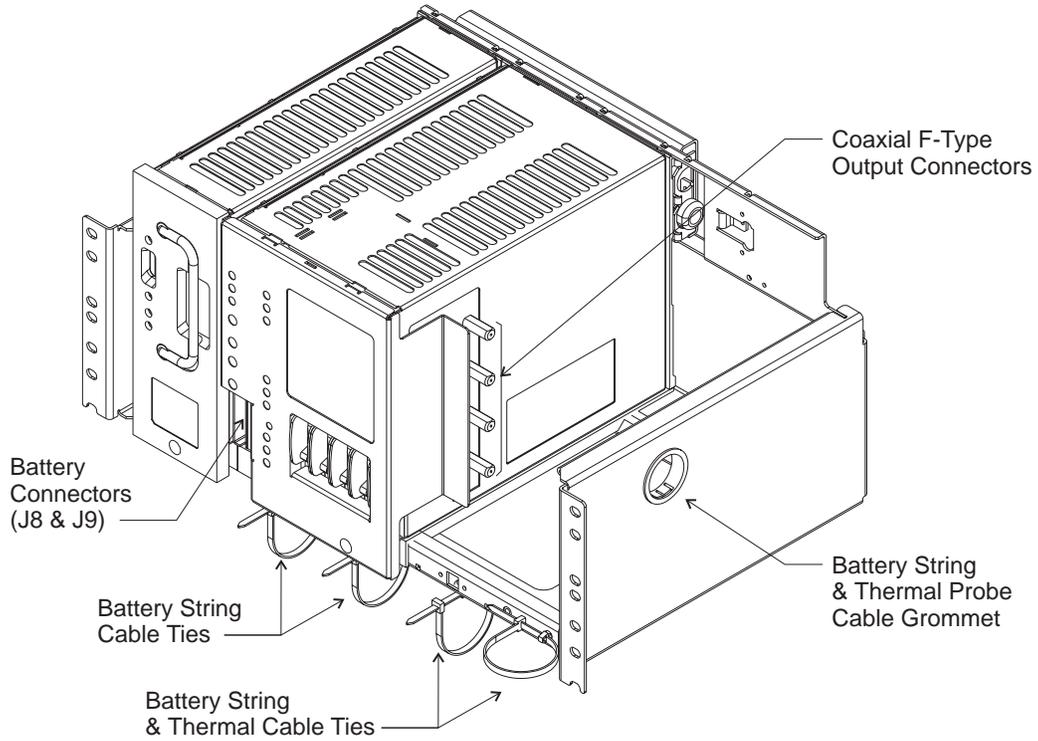


Figure 5-3: Cable Ties and Connecting Points

6 *Alarms, Controls, and Displays*

Displays

The faceplate of the ES635 BPS unit features the following LEDs:

- Battery connection
- Alarm
- Overcurrent
- Normal
- PMJ
- MJF
- Probe Fail
- Temperature Compensation
- High Battery Temperature
- AC Fail
- BD
- A low voltage shut-off control circuit

The ES635 faceplate also has two monitoring points, V_{out} and V_{batt} as well as one control point, V_{adj} .

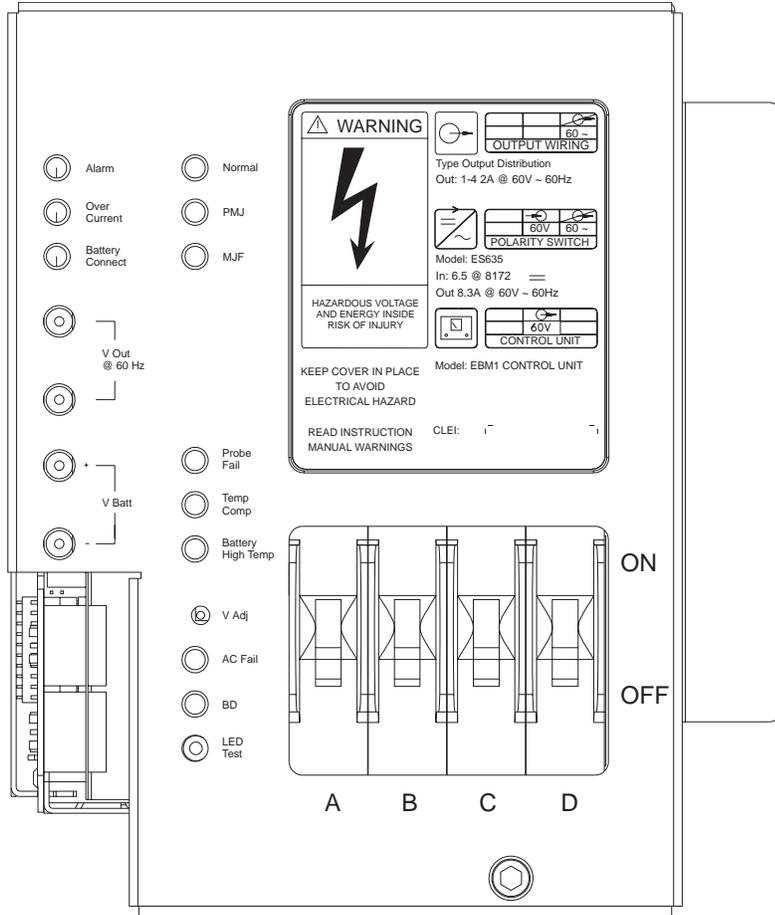


Figure 6-1: ES635 (BPS) Faceplate

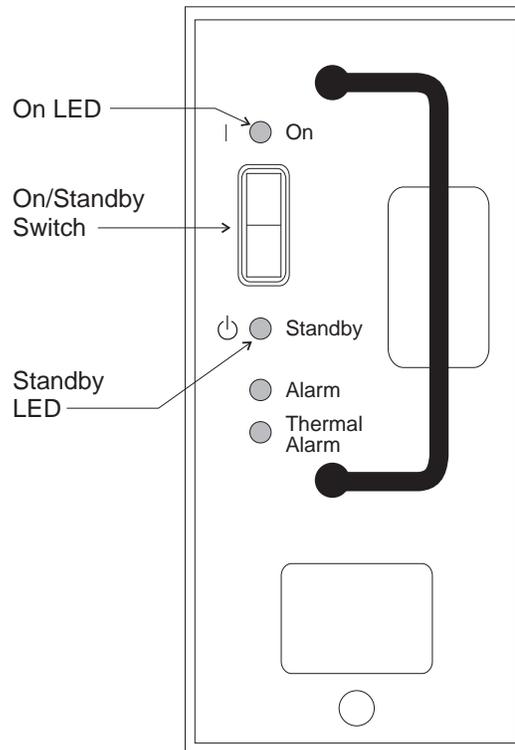


Figure 6-2: ES664 Rectifier Faceplate

Alarm Processing

The Alarm Control Unit (ACU) in the 60-volt/60 Hz plant is part of the BPS and administers alarm processing, plant on-standby control and plant voltage adjustments in CPS. It presents alarms and conditions to the user as front panel LED indicators and Form-C relay contact closures and sends them for remote reporting.

Power Major Alarms

Conditions that impact service and require immediate attention are classified as major alarms and designated as Power Major (PMJ) alarms. This red LED lights to signify one or more of the following conditions:

- Rectifier failure
- Excessive battery temperature
- Battery on Discharge alarm
- BPS failure
- Output distribution circuit breaker operation
- Battery string not connected
- AC failure
- Thermal probe failure

- BPS current limit

Power Alarms

One or more of the alarm conditions listed below results in a power major alarm transmitted via the office alarm connector and causes a red LED labeled **PMJ** on the ACU to light. The following table lists the reason for the power major alarm transmitted as well as the device where the red LED is displayed.

Table 6-A: Plant Alarm Conditions and Indications

Alarm Condition	Office Alarm (Contact Closure)	Rectifier ES664 (LED)	ACU/EBM1 (LED)	BPS ES635
BPS Alarm	PMJ		PMJ	Alarm
Rectifier Standby	PMJ	Stby	PMJ	
Rectifier Alarm	PMJ	Alarm	PMJ	
AC Fail	PMJ/ACF		PMJ/ACF	
Excess Battery Temp.			Temp Comp	
High Battery Temp.	PMJ		PMJ/High Battery Temp	
Battery String Connection	PMJ		PMJ	Battery Connect
Battery on Discharge	PMJ		PMJ/BD	
Probe Fail/Open	PMJ		PMJ/Probe Fail	
Major Fuse Alarm (MJF)	PMJ		PMJ/MJF	
Current Limit	PMJ		PMJ	Current Limit

Office Alarm Contacts A set of Form-C contacts is brought out on TB1 for each of the following plant alarms:

- Power Major (PMJ)
- AC Fail (ACF)

Each set of isolated contacts consists of a combination of normally open (NO) and normally closed (NC) contacts with one side of each common (C). When an alarm condition exists, a closure exists between the NC and C poles and an open exists between the NO and C poles. Table 6-B gives the office alarm pin assignments on TB1.

Table 6-B: Office Alarm Assignments (TB1)

Pin Number	Office Alarm
1	PMJ - NO
2	PMJ - C
3	PMJ - NC
4	ACF - NO
5	ACF - C
6	ACF - NC
7	R OS IN
8	PBT IN
9	OS - PBT - RTN
10 - 12	Unassigned

Battery on Discharge (BD)

In the event that AC power is lost, the batteries provide power for the load. While the batteries are providing the plant's power, the plant voltage will decrease below the float voltage. The EBM1 (ACU) monitors the plant voltage and features a BD alarm. A strap (P1) on the ACU controls the set point for the BD threshold. Whenever the plant voltage drops below this preset threshold, the ACU issues BD and PMJ alarms; and the corresponding red PMJ LED light.

Voltage Threshold for the BD Alarm

The voltage threshold for the BD alarm is factory set to 76 ± 1 Vdc.

Low Voltage Shut Off

Strap STR1 on the BPS allows the user to set the plant voltage at which the plant load is disconnected from the battery. STR1 is a three-position strap located above the LEDs. When STR1 is placed across positions 1 and 2, the shut off voltage is 61 volts. For a shut off voltage of 64 volts, place STR1 across positions 2 and 3. The factory default setting is 64 volts.

AC Fail

The AC Fail Alarm indicates that ac input power to the rectifier is missing or has dropped below the minimum ac voltage for the operating range being used. This alarm results in an isolated transfer contact for the office alarm system. An ACF alarm also results in a PMJ alarm; thus both the PMJ and ACF LEDs will light on the ACU.

- Alarm** This red LED lights to indicate that a rectifier or a BPS has shut down due to an output overvoltage condition, a thermal alarm, an operated internal fuse, or an internal failure that results in a low voltage condition.
- Battery Connect** This alarm and LED indicate that one or both battery strings are not connected.
- Battery High Temp** This alarm and LED indicate that the battery temperature has exceeded 65°C.
- Lamp Test** Depressing the Lamp Test button on the ACU will cause all of the LEDs to light.
- Major Fuse Alarm (MJF)** The ACU monitors the distribution for tripped circuit breakers. A tripped circuit breaker indicates that some part of the customer's equipment has lost power; therefore, the ACU issues a PMJ and an MJF alarm and causes the appropriate LED(s) to light.
- Normal** This green LED lights while the plant is operating normally and is able to furnish power to the load. While in this operational mode, the rectifiers can be switched to the Standby mode by a control signal originated by the customer and routed to the power units through the office alarm connector. The BPS cannot be put in the standby mode.
- Office Alarms** The office alarm and control signals listed below are available to facilitate the monitoring and control of the CPS plant. The Signal Interface is a signal path interface between the Alarm Control Unit and the Office Alarm Interface which provides customer access to the office alarm and control tie-points on TB1.
- On** This green LED lights while the rectifier is operating normally and is able to furnish power to the load. While in this operational mode, the rectifier can be switched to the Standby mode under local control.

Output Voltage Adjust A battery plant voltage control originating in the ACU which sets the rectifier output voltage to the desired value within the rectifier operating voltage range.

Overcurrent Alarm This red LED lights when a BPS has shutdown due to an overcurrent condition.

Plant Battery Test A plant battery test feature is available which allows the user to test battery health and capacity safely without jeopardizing the load; i.e., a user-supplied contact closure across TB1-8 and TB1-9 will reduce the rectifier output voltage set point to approximately 72 volts which creates a battery on discharge condition.

If the batteries are present and healthy, the plant voltage will remain above 72 volts. If the batteries are not present or are not able to support the load, the plant voltage will immediately drop to the rectifier set point without any consequence to the load.

If the batteries are present and working, the user may then safely place the rectifiers in standby by placing a short across TB1-7 and TB1-9 in order to continue the discharge and further determine the reserve capacity of the batteries.

Power On/Standby Switch This two-position switch determines the operational status of the rectifier.

Probe Fail This alarm and LED indicate that one of the thermal probes has shorted or is open.

Rectifier/BPS Alarms Whenever the ACU receives a rectifier or BPS alarm, it issues a Power Major (PMJ) alarm. A red LED lights on the BPS face plate.

Rectifier Alarm A signal to the ACU indicating low rectifier output voltage resulting from a rectifier failure or excess load.

Standby This yellow LED lights while rectifier is in the Standby mode. In this mode, the power unit control and alarm circuits are powered;

however, the power circuits are inhibited to prevent these units from producing output power. To switch the power units from Standby to On, both the local and remote control signals must be switched to the power On state.

Temp Comp This LED indicates that the battery thermal protection feature is working. Whenever the battery temperature exceeds 25° C, the plant voltage is automatically reduced to help protect the batteries against thermal instability.

If the temperature of the batteries exceeds 25° Celsius (77° Fahrenheit), the thermal management control transmits a signal to the alarm and control unit, which then lowers the float voltage on the batteries proportionally to the rise in temperature above 25° Celsius and lights a yellow LED on the LVD/Thermal Management circuit pack. The thermal compensation algorithm, demonstrated in Figure 6-1, operates as follows:

- As temperature rises between 25° C and 53° C (127° F), plant voltage is lowered 108mV per degree. At 53° C the plant voltage is 3 volts less than the uncompensated battery float voltage.
- For temperatures between 53° C and 75° C (167° F), the plant voltage remains at 3 volts less than the uncompensated battery float voltage.

For temperatures higher than 75° C, the plant voltage is reduced to approximately 72 volts.

Test Jacks Test points are provided on the BPS faceplate so that the plant battery voltage and the plant output voltage may be checked with the user's meter. The test points are current-limited to protect against accidental short-circuits.

Thermal Alarm This red LED lights whenever the rectifier shuts down due to inadequate air flow indicating possible intake air blockage, fan failure, or inlet air temperature above 75° C.

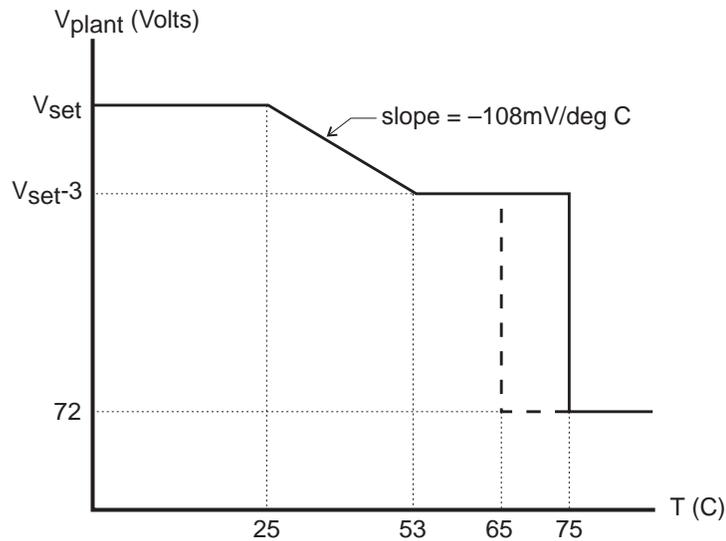
Voltage Adjust A potentiometer is provided on the BPS faceplate to allow the customer to adjust the rectifier output voltage. If the BPS panel loses power, the Voltage Adjust signal from the BPS is

disconnected from the voltage adjust bus allowing the rectifier to operate at its preset output voltage (approximately 79 volts dc).

Warning

Remove thermal probes before adjusting the voltage.

Voltage Test Jacks Test jacks are provided to measure the battery voltage and the plant output voltage in CPS Plants.



$T < 25; V_{plant} = V_{set}$
 $25 < T < 53; V_{plant} = V_{set} - 0.108(T - 25)$

$53 < T < 75; V_{plant} = V_{set} - 3$
 $T > 75; V_{plant} = 72$] Rising Temperature

$53 < T < 65; V_{plant} = V_{set} - 3$
 $T > 65; V_{plant} = 72$] Falling Temperature

T = maximum temperature sensed by any of up to four thermal probes

V_{plant} = Battery Plant Voltage
 V_{set} = Initial Plant Voltage Set Point
 Determined by Control Unit
 Potentiometer Setting @ $T < 25$

Figure 6-1: 60-Volt Temperature Compensation Algorithm

7 *Maintenance*

General

This section provides field maintenance information and procedures for the power modules. Before performing the maintenance procedures, review the safety information in Section 4.

Warning

The modules intended for use in the CPS shelf are not suitable as disconnect means and the spacings of the shelf backplane do not provide adequate spacing to act as a disconnect means.

AC input voltages are provided to the CPS via input cables. Ensure that the circuit breaker for the ac input is disconnected while installing this equipment.

Note

Before working on any output circuit, turn off ac service circuit breakers to the CPS shelf and turn off circuit breakers on the BPS output. Disconnect batteries.

Power Modules

With the exception of a fan or ACU failure, the power units are repaired by replacement. Refer to figure 7-1.

ACU (EBM1) Replacement

1. Make sure you are properly grounded.
2. Remove the faceplate on the BPS.
3. Remove the ACU (EBM1) by pulling it carefully toward you. **Do not wiggle it back and forth while removing it.**

4. Verify the BD setting on the replacement ACU.
5. Insert the replacement unit.
6. Disconnect thermal probes and adjust the rectifier output voltage to 81.72 volts dc.
7. Replace the thermal probes.
8. Replace the BPS faceplate.

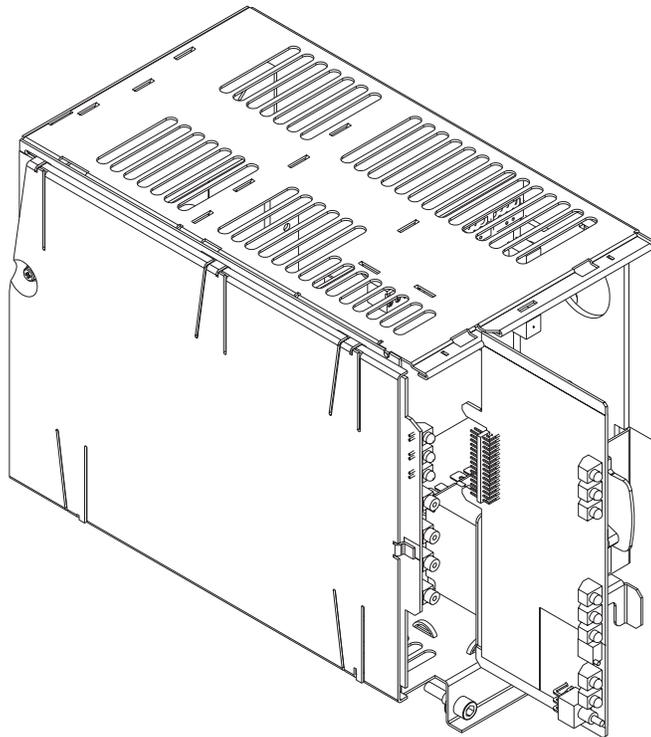


Figure 7-1: BPS with ACU (EBM1) Partially Removed

Fan Maintenance The expected life of the power unit fans at 25°C (77°F) is seven years. The fans in CPS power modules may be replaced in the field without opening the power unit. When one or both fans fail, the power unit shuts down and issues a power unit alarm and a thermal alarm.

Two approaches can be taken to fan maintenance. The first approach is to replace the fan cradle assembly on a routine basis every five years; this ensures that the fans do not fail in the field under normal operating conditions. This approach is appropriate when there are no remote alarm facilities at the site. The second

approach, assuming one has remote alarm capability, is to wait until the fans fail. The power unit will safely shutdown and issue both a fail alarm and a thermal alarm. The fan cradle assembly can then be replaced. Since it is likely that all the power units in that installation are of roughly the same age, all power unit fans at that site should be replaced at that time. The approach used depends on the convenience of the site as well as the monitoring of alarms used at the site.

Fan Replacement

1. Using the Allen wrench provided, remove the power unit from the system.
2. Remove the screw holding fan cradle assembly onto the bottom of chassis.
3. Separate fan cradle assembly from the chassis.
4. Unplug the connectors on the old fans from the power unit.
5. Plug in fan connectors on the new fan cradle.
6. Reattach fan cradle assembly to chassis bottom panel using one screw.
7. Replace the power unit according to the procedures outlined in Section 5.

8 *Troubleshooting*

Safety Warnings

Review all safety instructions and warnings before troubleshooting the CPS.

Warning

The modules intended for use in the CPS shelf are not suitable as disconnect means and the spacings of the shelf backplane do not provide adequate spacing to act as a disconnect means.

AC input voltages are provided to the CPS via input cable. Ensure that the circuit breaker for the ac input is disconnected while installing or servicing this equipment.

Note

Before working on any output circuit, turn off circuit breakers on the BPS output.

Rectifier

Before beginning to troubleshoot the ES664 rectifier, check the following:

- Is there an ac failure?
- Is the ac source connected?
- Is the input circuit breaker on?
- Are any LEDs lit?
- Is the rectifier properly installed in the shelf?

Table 8-A lists indications, possible cause, and the corrective action(s) to take when a rectifier does not deliver power. Match specific site conditions to those in the “indication” column and complete the corresponding corrective action.

Table 8-A: Rectifier Trouble Conditions

Indication(s)	Possible Cause	Corrective Action
No LED is lit.	AC source not connected.	Check ac source.
No LED is lit.	Circuit breaker is not on line.	Turn the input circuit breaker on.
No LED is lit.	Rectifier may not be fully seated in shelf.	Insert rectifier in shelf.
No LED is lit.	Rectifier defective.	Replace rectifier.
Alarm and Thermal Alarm LEDs are lit.	Fan obstruction.	Check for fan obstruction. Remove it. Restart rectifier.
Thermal Alarm LED is lit. There is no fan obstruction.	Fans defective.	Remove rectifier from shelf. Replace fans. Reinstall rectifier.
Alarm LED is lit and Thermal Alarm LED is not.	Load may be greater than capacity.	Decrease load.
Thermal Alarm LED is not lit. Load is not greater than capacity.	Rectifier may need to be reset.	Turn the On/Standby switch to the Standby position and then on again. a. Rectifier restarts. Check plant voltage and adjust as required. b. If rectifier does not restart, replace it.
Standby LED is not lit. Green (normal) LED is lit.	Circuit breakers not operated.	Operate circuit breaker.
Standby LED is not lit. Green (normal) LED is lit. Circuit breaker is on.	Defective rectifier	Replace rectifier.
Standby LED is lit.	Power switch may be in the Standby position.	Turn power switch on.

Table 8-A: Rectifier Trouble Conditions

Indication(s)	Possible Cause	Corrective Action
Standby LED is lit. Power switch is in the On position.	Control unit may have shut down rectifier using remote/on standby control.	Remove control unit. Rectifier restarts. a. Verify that it continues to operate after one minute. Check rectifier for proper on/standby control. b. If rectifier does not continue to operate after one minute, check for excessive load.
Standby LED is lit. Power switch is on. Control unit has been removed.	Defective rectifier.	If rectifier does not restart after the control unit is removed, replace the rectifier.

If none of these corrective actions remedies the problem, call your local RTAC representative at 1-800-CAL-RTAC (1-800-225-7822).

Battery Polarity Switch (BPS)

Before beginning to troubleshoot the ES635 BPS, check the following:

- Is the dc source connected?
- Are any LEDs lit?
- Is the BPS properly installed in the shelf?

Table 8-B lists indications, possible cause, and the corrective action(s) to take when a BPS does not deliver power and/or alarms are present. Match specific site conditions to those in the “indication” column and complete the corresponding corrective action.

Table 8-B: BPS Trouble Conditions

Indication(s)	Possible Cause	Corrective Action
No LED is lit.	DC source not connected.	Check dc source.
No LED is lit.	BPS may not be fully seated in shelf.	Insert BPS in shelf.
Overcurrent LED is lit.	Load may be greater than capacity.	Decrease load. Push unit reset button.
Alarm LED is lit.	BPS defective.	Replace BPS.
Normal LED is lit with no output power.	Output circuit breakers not in the ON position.	Place circuit breakers in the ON position.
Normal LED is lit. Circuit breaker is on. No output power.	Defective BPS.	Replace BPS.
Normal LED is not lit and no other LEDs on the ACU are lit.	ACU board not fully seated in BPS.	Insert ACU in BPS.
Normal LED is not lit and no other LEDs on the ACU are lit.	ACU board defective.	Replace ACU.
Battery Connect and PMJ LEDs are lit.	One or both of the battery cables is not connected to the BPS.	Connect battery interconnect cables to BPS.
PMJ and MJF LEDs are lit.	One or more output circuit breakers have tripped or are in the OFF position.	Place circuit breakers in the ON position.
PMJ and Probe Fail LEDs are lit.	One or more battery temperature probes have failed open or short.	Replace failed temperature probe.
PMJ and Battery High Temp LEDs are lit.	Battery temperature in excess of 65° C.	a. Check battery string for shorted cells. b. Check cabinet for proper ventilation.
PMJ and AC Fail LEDs are lit.	Input ac source to rectifier is off or below input voltage range.	Check ac source to rectifier.

Table 8-B: BPS Trouble Conditions

Indication(s)	Possible Cause	Corrective Action
PMJ and BD LEDs are lit.	BPS input voltage is below 76 Vdc due to rectifier failure.	Replace rectifier.
	BPS input voltage is below 76 Vdc because the rectifier ac source voltage is off	Turn on ac source.
	BPS input voltage is below 76 Vdc because the rectifier voltage adjustment is below 76 Vdc.	Adjust rectifier output voltage to appropriate level.

If none of these corrective actions remedies the problem, call your local RTAC representative at 1-800-CAL-RTAC (1-800-225-7822).

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
<p>*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.</p> <p>**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.</p>		

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) that has been installed by Seller and Seller ascertains that the Product is not readily returnable for repair, Seller will repair the Product at Customer's site.

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

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

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

- E. The defective or nonconforming Products or parts which are replaced shall become Seller's property.
- F. If Seller determines that a Product for which warranty service is claimed is not defective or nonconforming, Customer shall pay Seller all costs of handling, inspecting, testing, and transportation and, if applicable, traveling and related expenses.
- G. Seller makes no warranty with respect to defective conditions or nonconformities resulting from actions of anyone other than Seller or its subcontractors, caused by any of the following: modifications, misuse, neglect, accident, or abuse; improper wiring, repairing, splicing, alteration, installation, storage, or maintenance; use in a manner not in accordance with Seller's or Vendor's specifications or operating instructions, or failure of Customer to apply previously applicable Seller modifications and corrections. In addition, Seller makes no warranty with respect to Products which have had their serial numbers or month and year of manufacture removed, altered, or with respect to expendable items, including, without limitation, fuses, light bulbs, motor brushes, and the like.

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

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