

**AGM 15  
-48 VDC, 15A  
POWER PLANT**

**PRODUCT MANUAL FOR  
P/N 110-4015-00**

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## RECEIVING INSTRUCTIONS & GENERAL EQUIPMENT INFORMATION

*Please Note: For your protection, the following information and the product manual should be read and thoroughly understood before unpacking, installing, or using the equipment.*

C & D Technologies presents all equipment to the delivering carrier securely packed and in perfect condition. Upon acceptance of the package from us, the delivering carrier assumed responsibility for its safe arrival to you. Once you receive the equipment, it is your responsibility to document any damage the carrier may have inflicted, and to file your claim promptly and accurately.

### **1. PACKAGE INSPECTION**

- 1.1 Examine the shipping crate or carton for any visible damage: punctures, dents, and any other signs of possible internal damage.
- 1.2 Describe any damage or shortage on the receiving documents, and have the carrier sign their full name.
- 1.3 If your receiving freight bill notes that a Tip-N-Tell is attached to your freight, locate it. If the Tip-N-Tell arrow has turned even partially blue, this means the freight has been tipped in transport. Make sure the carrier notes this on your receipt before you sign for the freight.

### **2. EQUIPMENT INSPECTION**

- 2.1 Within fifteen days, open the crate and inspect the contents for damages. While unpacking, be careful not to discard any equipment, parts, or manuals. If any damage is detected, call the delivering carrier to determine appropriate action. They may require an inspection.

**\*SAVE ALL SHIPPING MATERIAL FOR THE INSPECTOR TO SEE!**

- 2.2 After the inspection has been made, call C & D Technologies. We will determine if the equipment should be returned to our plant for repair, or if some other method would be more expeditious. If it is determined that the equipment should be returned to C & D Technologies, ask the delivering carrier to send the packages back to C & D Technologies at the delivering carrier's expense.
- 2.3 If repair is necessary, we will invoice you for the repair so that you may submit the bill to the delivering carrier with your claim form.

- 2.4 It is your responsibility to file a claim with the delivering carrier. Failure to properly file a claim for shipping damages may void warranty service for any physical damages later reported for repair.

### 3. **HANDLING**

Equipment can be universally heavy or top-heavy. Use adequate manpower or equipment for handling. Until the equipment is securely mounted, be careful to prevent the equipment from being accidentally tipped over.

### 4. **NAMEPLATE**

Each piece of C & D Technologies equipment is identified by a part number on the nameplate. Please refer to this number in all correspondence with C & D Technologies.

### 5. **INITIAL SETTINGS**

All equipment is shipped from our production area *fully checked and adjusted*. Do not make any adjustments until you have referred to the technical reference or product manual.

### 6. **SPARE PARTS**

To minimize downtime during installation or operation, we suggest you purchase spare fuses, circuit boards and other recommended components as listed on the Recommended Spare Parts List in the back of the product manual. If nothing else, we strongly recommend stocking spare fuses for all systems.

**ISSUE HISTORY**

<b>ISSUE</b>	<b>PAGE(S) ALTERED</b>	<b>DESCRIPTION</b>	<b>REVISOR/ DATE</b>
A		Preliminary issue	
1	ALL	Initial Release	jaj
2	ALL	Revised to show latest hardware changes (unreleased)	jaj / 04/30/98
3	ALL	Revised the order of content, combining some chapters	jaj / 08/07/98
4	ALL	Ensured correct company name throughout manual; incorporated cover with correct Dunlap plant address, phone #'s, fax #'s, & website address. Updated issue history sheet, added updated ENF005 sheet. See ECN 12731	MCM 12/20/99
5	ALL	SEE ECN 15561	MCM 5/30/06

**DOCUMENT SUMMARY**

This document is the User Product Manual for AGM 15 Power Plants.

SCOPE

This manual applies to all AGM 15 Power Plants, Part Number 110-4015-L.XA, and each of the four option configurations they can be ordered in:

<u>Shelf size</u>	<u>C&amp;D Ordering Part #</u>	<u>Plant Option/Features</u>
19 inch	J110-4015 List 1	Bulk Power (No Dist., No Controller)
19 inch	J110-4015 List 2	Basic Power Plant: Distribution only
19 inch	J110-4015 List 3	Full Featured, w Load Disconnect
19 inch	J110-4015 List 4	Full Featured, w Battery Disconnect

PURPOSE

This manual includes instructions for installing, operating, and maintaining the Plant.

**LEGAL DISCLAIMER**

C&D Technologies, Inc., believes that all information contained in this manual is accurate and reliable. However, this information does not constitute any guaranty or warranty by C&D, nor does it make C&D responsible for any damage that might occur during the installation, use or maintenance of the equipment described in this manual.

C&D Technologies, Inc., also does not guarantee that the suggested equipment uses given in this manual do not infringe upon any existing or pending patents.

Those who install, use, and maintain this equipment, should not assume that all possible safety measures that should be taken with this equipment are mentioned in this manual. Furthermore, no one should assume that no other precautionary measures may be required for safe installation, use and maintenance of this equipment, where unusual environmental conditions or circumstances dictate otherwise.

## TABLE OF ABBREVIATIONS

ABBREVIATION, ACRONYM OR SYMBOL	MEANING
AH	Ampere Hours
ANSI	American National Standards Institute
AWG	American wire gauge
CEV	controlled environment vault
CO	Central Office
CM	circular mils
DIP	dual in-line package
EMI	electromagnetic interference
ESD	electrostatic discharge
FA	-48 volt Fuse Alarm
HVA	normally energized high voltage Alarm
HVSD	High Voltage Shut Down
IEC	International Electrical Commission
IEEE	Institute of Electrical and Electronic Engineers
LED	Light Emitting Diode
LSD	Least Significant Digit
LVA	Low Voltage Alarm
LVD	Low Voltage Disconnect
NEC	National Electric Code
NEMA	National Electrical Manufacturers Association
PWB	Printed Wire Board
PDR	power distribution rack
RBOC	Regional Bell Operating Company
RFA	rectifier failure Alarm
SD	Schematic Diagram
Vdc	volts direct current
UL	Underwriters Laboratories
VRLA	Valve Regulated Lead Acid

**TABLE OF REFERENCES**

<b>DOCUMENT NUMBER</b>	<b>TITLE</b>
ANSI T1.311-1991	DC Power Systems - Telecommunications Environment Protection
ANSI/IEEE C 62.41-1980	IEEE Guide for Surge Voltages in Low-Voltage AC Power Circuits, ANSI 1980
IEC 801-2	IEC Electromagnetic Compatibility for Industrial-Process Measurement and Control Equipment, October 1987
NEC 1993	NEC Handbook, 1993 edition, National Fire Protection Association
No Number	OI-28 Standards
No Number	Central Office Telecommunications Equipment Engineering Standards, December 1984
PUB 77350	U S West Telecommunications Equipment Installation & Removal Guidelines, June 1990
PE-7-1985	Communications Type Battery Chargers, NEMA/ANSI
STD 487-1980	IEEE Guide For The Protection of Wire-Line Communications Facilities Serving Electrical Power Stations
TR-EOP-000151	Bellcore Generic Requirements for 24, 48, 130, & 140 Volt Central Office Power Plant Rectifiers, May 1985
TR-EOP-000154	Bellcore Generic Requirements for 24, 48, 130, & 140 Volt Central Office Power Plant Control and Distribution, May 1985
TR-NWT-000063	Bellcore Network Equipment-Building System Generic Equipment Requirements, ISSUE 5, July 1991
TR-TSY-000078	Bellcore Generic Physical Design Requirements for Telecommunication Products and Equipment
UL489	UL Molded Case Circuit Breaker Enclosures, May 1984

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## CHAPTER ONE: INTRODUCTION

### 1.0 GENERAL DESCRIPTION

The AGM 15 Power Plant is a compact –48 Vdc source, that fits in two rack spaces and supplies redundant load currents of 7.5 amps DC max. The Plant comes in a standard 19” rack mount-able cabinet. The AGM 15 was designed for applications such as customer premises and outdoor installations, where space is at a premium. The Plant can be easily configured for just about any application; from straight bulk power to an integrated distribution center, with either a battery or load disconnect. Based on modular switched-mode rectifier technology, the Plant can have up to three –48 Vdc, 7.5A plug-in rectifier modules installed. The rectifiers have all of the operation, alarm, and control features that are normally required of a Telecom compliant rectifier.

State of the art switched-mode technology has allowed us to produce a compact 450 watt –48 Vdc rectifier, which made a two-rack-space Power Plant possible. The Plant consists of a Motherboard PWB (A1), which all of the other boards plug into [the rectifiers, an optional Load Distribution PWB (A2), and an optional Control PWB (A3)]. This makes field upgrading and servicing, a quick and easy process.

The Distribution PWB, A2 has a 40A relay on it, which can be used as either a load or battery disconnect. Load distribution is provided through eight GMT fuses. The terminal blocks for all load and return wires are lug-less, compression clamp type connectors. Buss bars on the Distribution PWB provide a solid and convenient tie point to connect up to two battery strings to.

The Control PWB (A3) provides the disconnect functions, battery temperature compensation, rectifier control functions, and advanced alarm functions.

The functional separation between PWBs allow the Power Plant to be configured for :

1. Bulk Power Plant, with no distribution and no controller (List 1)
2. Basic Power Plant with load distribution (List 2)
3. Full featured Power Plant with load distribution, load or battery LVD, (List 3 & 4)  
battery temperature compensation, and advanced control and alarm features

### 2.0 SPECIFICATIONS

#### 2.1 Physical Specifications

	<b>Plant Cabinet</b>	<b>Rectifiers (ea.)</b>	<b>Combined</b>
<b>Width</b>	15.6" (40 cm)	4.0" (10 cm)	NA
<b>Depth</b>	12.0" (31 cm)	11.0" (28 cm)	NA
<b>Height</b>	3.5" (9 cm)	2.5" (6.4 cm)	NA
<b>Weight</b>	13.5 lbs. (6.1 kgms)	3 lb.s (1.4 kgms)	19.5 lbs. (8.8 kgms)

2.2 Environmental Specifications

<b>Operating temperature</b>	-40°F to +65°C (-40° to +149°F)
<b>Storage temperature</b>	-40°F to +85°C (-40° to +185°F)
<b>Shipping and handling</b>	<b>Plant:</b> shipped fully assembled, in packaging designed to withstand normal shipping & handling <b>rectifier modules:</b> each in its own protected box
<b>Humidity</b>	0 to 95 %, non-condensing
<b>Altitude</b>	13,858 ft (4,224 meters) Power Plants only. Rectifiers de-rate above 3,281 ft (1 kilometer) see rectifier manual for derating spec.'s
<b>Heat dissipation</b>	695 BTU/hour maximum, fully loaded to 15 Adc; approximately 347 BTU/hr/rectifier
<b>Cooling</b>	<b>distribution:</b> natural convection <b>rectifiers</b> forced air convection, w/ built-in over-temp. protection & automatic recovery
<b>Seismic</b>	Designed to comply with Bellcore seismic zone 4

2.3 Electrical I/O Specifications

<b>Input</b>	110 – 240 Vac, single phase, 45 – 65 Hz, 8.8 Aac, @ 110; 4.2 Aac, @ 240 Vac (w/ 2 rectifiers installed)	<b>Output</b>	Max: 22.5 Adc at -59 Vdc Temp. Coef. = ≤ 0.01 % / °C Voltage Stabilization < 1 min.  Max. charge buss Vdrop < 0.5 Vdc Max. discharge Vdrop < 0.25 Vdc
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2.4 Factory Settings

<b>Electrical Parameter</b>	<b>Set Point Value</b>
<b>Float voltage</b>	-54.26 Vdc, ± 0.1 Vdc
<b>Equalize voltage</b>	-55.9 Vdc, ± 0.1 Vdc
<b>HVSD</b>	-57.5 Vdc, ± 0.1 Vdc
<b>LVD</b> (disconnect, adjustable)	-42 Vdc, ± 0.1 Vdc
<b>LVD</b> (reconnect, not adjustable)	-49.5 Vdc, ± 0.1 Vdc

## 2.5 Noise Specifications

<b>“Voice Band” electrical noise</b>	Does not exceed <b>32 dBrnC</b> , when operating with or without batteries; @ 208/240 Vac in
<b>“Wide band” electrical noise</b>	Does not exceed <b>40 millivolts rms</b> in any 3 kHz freq. range, between 10 kHz & 20 MHz
<b>“Peak-to-peak” electrical noise</b>	Does not exceed <b>250 millivolts pk-pk</b> , at any frequencies of 20 MHz and under

## 2.6 Susceptibility Specifications

- Meets ESD requirements per IEC Specs on Electromagnetic Compatibility (IEC 801-2, Section 4.11).
- Meets Class A EMI requirements of CFR 47, parts 15C and 15J.
- Withstands lightning surges (without damage) between the battery charge buss or ground return buss and the equipment frame/Safety ground, per ANSI/IEEE C62.41.

## 2.7 Rectifier Specifications

<b>Efficiency</b>	<p>≥ 82 % when supplying full load current at 54 volts out, with 240 Vac in, at 25°C.</p> <p>≥50 %, when supplying 10% of full load, at 54 volts out, with 240 Vac in, at 25°C.</p>
<b>Power factor</b>	greater than 0.99 at rated full power out
<b>Protection</b>	Internally fused
<b>Service</b>	Rectifiers may be installed or removed without affecting Plant operation

## 2.8 Safety Specifications

Underwriters Laboratory Standards of Safety for Information Technology Equipment (UL 1950), and the Bellcore Network Equipment-Building System Generic Equipment Requirements (TR-EOP-000063) were used as guidelines in the specifications of all components and wiring. Particular attention was paid to Safety ratings and OI-28 flammability requirements.

## 2.9 Monitoring Specifications

- Test jack for Plant voltage List 2, 3, and 4 models only
- Test jacks for Plant and battery shunts List 2, 3, and 4 models only  
(current shunts read 50 mV @ 20A)
- Test jacks on the rectifier for individual rectifier output currents  
(current shunt reads 50 mV @ 10A)

2.10 Alarm Specifications

<b>ALARM INDICATIONS (Visual/Local &amp; Electrical/Remote)</b>	
<b>FA (Open Fuse Alarm)</b>	Front panel red LED indicator Each open GMT fuse causes an FA Removing a fuse will not cause an FA
<b>Battery or Load LVD</b>	Front panel red LED indicator Indicates Plant voltage below the LVD trip point, & that the contactor is disconnected
<b>Major Alarm</b>	Front panel red LED indicator List 2: an FA causes a Major Alarm List 3 & 4: Controller failure, FA, LVD, >1 RFA, HVA, LVA, HVSD, & High Temp all cause Major Alarms
<b>Minor Alarm</b>	Front panel yellow LED indicator List 2: any 1 RFA causes a Minor Alarm List 3 & 4: 1 RFA, Test mode, and all coded warnings cause Minor Alarms
<b>List 1 Plants</b> <b>List 2, 3, &amp; 4 Plants</b>	<ul style="list-style-type: none"> <li>• Each rectifier's own RFA Alarm.</li> <li>• Form C relays for FA &amp; RFA alarms</li> <li>4 additional Form C Alarm relays for Major, Minor, LVD, &amp; High Temperature</li> </ul>

3.0 FEATURES

3.1 Overview of List 1 Bulk Power Plant Features

- 15 Adc redundant load current, 22.5 Adc Max.
- A Motherboard PWB, which interfaces to all three rectifier slots
- Front access to all (terminal block) connections
- Only one Single 110/208/240 Vac, 45-65 Hz power feed is required
- Terminal Blocks that access rectifier signals & controls: RFA, HVSD, RS, TR, & EQ
- Terminal blocks for Power, Battery, & Ground connections (on Motherboard PWB)

3.2 Overview of List 2 Basic Power Plant Features

- Same features as a List 1 Bulk Plant
  - 8 GMT distribution fuses (located on the Distribution PWB)
  - Lug-less terminal blocks for load connections and ground returns
  - Test jacks for Plant voltage, Plant current, and battery current
  - Buss bars with two hole lug connections for up to two battery strings
  - LED indicators for Major, Minor, FA, and LVD \* Alarms
  - Form C alarm output relays for FA and RFA Alarms
- \*optional manual battery service disconnect, only with List 2 Plants

### 3.3 Overview of List 3 & List 4 Plant Features

- ◆ Same features as List 1 and List 2 Plants
- ◆ Microcontroller based Control PWB adds:
  - Load (List 3) or Battery (List 4) Low Voltage Disconnect LVD
  - Single-point (Plant) Float voltage Remote Control Adjustment
  - Battery Temperature Compensation Capacity
  - High Temperature Alarm (2 Modes: Absolute or Delta)
  - Automatic & Manual Equalize Charge Modes
  - Battery Fail Alarm
  - Battery Sleep Mode
  - HVSD and Automatic ReStart Functions
  - Easy to use, User Control Interface, dip switches
  - Additional Major, Minor, LVD, and High Temp. alarm output relays
  - Green **CNTLR OK** LED flashes Status, Trouble & Warning Information

### 3.4 List 1 Bulk Power Plant Feature Details

#### 3.4.1 A Motherboard PWB, which interfaces to all three rectifier slots

The Bulk power model only has the Motherboard PWB installed. It makes all connections between the rectifier slots and all I/O terminal blocks (described below).

#### 3.4.2 Front access to all (terminal block) connections

All Motherboard mounted terminal blocks are accessible from the front of the cabinet.

#### 3.4.3 Only one Single 110/208/240 Vac, 45-65 Hz power feed is required

The connection point for AC input power is a 3 position, no-lug terminal block (TB1), located on the Motherboard PWB. All four Plant configurations have a single ac power cord (which is properly connected to TB1) that is terminated with a twist-lock 15 Amp 250 Vac plug. The mating twist-lock (15A/250 Vac) receptacle is also provided with each Plant. All Plants accept a “Universal range” (105–264 Vac) of AC input power.

#### 3.4.4 Terminal Blocks for accessing individual rectifier signals & controls:

##### **RFA, HVSD, RS, TR, & EQ**

Four plug-in, three-wire terminal blocks provide access to individual Rectifier Fail Alarms (RFA), and control inputs for HVSD, RS, TR, and Equalize mode. All control inputs are connected to the 3 rectifier slots in parallel. Each rectifier’s RFA signal line has a separate terminal block contact.

#### 3.4.5 A Terminal Block for Power, Battery, & Ground Connections

A large, two tiered, 3 position, no-lug terminal block (TB2), is the connection point for bulk output power, the MGB or CO ground, and any back-up battery connections.

### 3.5 List 2 Basic Power Plant Feature Details

#### 3.5.1 Same features as a List 1 Bulk Plant

#### 3.5.2 8 GMT distribution fuse slots (located on the Distribution PWB)

The GMT fuse block is situated so that all 8 fuses are visible from the front of the Plant, and the flag of a blown fuse can be readily spotted at a glance.

#### 3.5.3 Lug-less terminal blocks for load send & ground return connections

Load distribution and load return wires connect to lug-less terminal blocks TB1 & TB2. TB1 & TB2 are located just behind the GMT fuse block on the Distribution PWB (See J Drawing Sheet B 3, Figure 7). These blocks accept wires of up to 12 AWG.

#### 3.5.4 Test jacks for Plant Voltage, Plant Current and Battery Current

The test jacks for Plant Voltage measure directly across the battery buss bars. The test jacks for Plant Current and Battery Current, measure the voltage across series shunts, which read 50 mV @ 20A.

#### 3.5.5 Buss bars with two hole lug connections for up to two battery strings

Each of the two buss bars has four 10-24, 1/2" long studs on it, mounted on 5/8" centers. The studs are arranged in a staggered pattern, allowing side or rear access of the battery cables (See J Drawing, sheet B4, Figure 10, for a drawing of the battery buss bars).

#### 3.5.6 LED indicators for Major, Minor, FA, and LVD \* Alarms

The Distribution PWB has four LEDs on it, which light to indicate the four most significant Plant alarm conditions. The four LEDs are easily visible from the front of the Plant, even with the front cover closed. The red LVD LED lights when the SERVICE BY-PASS jumper, JP1 (located on the Distribution PWB), is placed in the DISABLED position (See J Drawing, sheet B3, Figure 7, for the location of JP1). The BY-PASS jumper, JP1, is a manual battery service disconnect, on List 2 Plants.

#### 3.5.7 Form C alarm output relays for FA and RFA Alarms

The Distribution PWB has two isolated, form C Alarm output relays; one Fuse Alarm (FA), and one Rectifier Failed Alarm (RFA). The FA activates when any GMT distribution fuse opens. The RFA activates when a rectifier sends out an RFA signal. These relay contacts can be connected directly to alarm annunciator panels or remote alarm monitoring equipment.

### 3.6 List 3 & 4 Plant Feature Details

#### 3.6.1 Same features as List 1 and List 2 Plants

#### 3.6.2 Microcontroller based Control PWB adds:

##### *3.6.2.1 Load (List 3) or Battery (List 4) Low Voltage Disconnect [LVD]*

The LVD function can be selected to be either a battery or a load disconnect, by a pair of jumpers on the Distribution PWB, A2. Four dip switches on the Control PWB, A3, set the disconnect voltage trip point for the LVD function. It is adjustable between  $-38.5$  and  $-46.0$  Vdc, in half volt steps. The reconnect voltage is fixed at  $-49.5$  Vdc. The standard factory setting of the disconnect voltage is  $-42.0$  volts. The red LVD LED on the front of the Distribution PWB illuminates, and a Major Alarm is issued, when the LVD function disconnects the batteries or the load. Four modes of LVD operation may be selected by two dip switches on the Control PWB. One of those modes is a TEST mode, which can be used to verify proper LVD operation. The other three LVD operation modes are described in more detail in Section 1.0, of Chapter Three, Operation.

##### *3.6.2.2 Single-point Plant Voltage Remote Control Adjustment*

Remote control of the Plant voltage, is enabled by a dip switch on the Control PWB, A3. When remote control is enabled, the output voltage adjustment potentiometers of the rectifiers are disabled. The Controller then sets the rectifier(s) output voltage through a dc analog control signal, which is also used for battery temperature compensation. A multi-turn potentiometer (R60), located on the front of the Control PWB, A3, sets the amplitude of the analog control signal. All Plants are shipped from the factory, with Plant voltage remote control enabled.

##### *3.6.2.3 Battery Temperature Compensation Capacity*

Three temperature sensors come with each Plant. The sensors are embedded in lead plated ring lugs, designed to be connected directly to battery terminals. Both battery sensors must be used, either both on the same battery string, or 1 each on 2 separate strings. One sensor is designated for measuring the ambient operating temperature. Temp. Sensor data are used to compensate the Float voltage for battery temperature.

##### *3.6.2.4 High Temperature Alarm (2 Modes: Absolute or Delta)*

Based on the data from the ambient and battery temperature sensors, two different high temperature alarms can be generated; Delta or Absolute. A single dip switch selects one of the two modes. In the Delta mode, the ambient temperature is subtracted from the highest battery temperature, and an alarm is generated when the difference is greater than  $36^{\circ}\text{F}$ . Delta mode takes ambient temperature changes into account. The Absolute mode simply compares the highest battery temperature reading against a fixed alarm trip point of  $145^{\circ}\text{F}$ . In either case, a Minor Alarm is generated, and a form C, High Temperature Alarm output relay is activated on the Distribution PWB, A2. The factory setting is Absolute mode.

### 3.6.2.5 Automatic & Manual Equalize Charge Modes

The Automatic Equalize Charge mode is dip switch select-able. During a battery discharge, the Control PWB, A3, records the discharge AHs of the batteries. Ten seconds after ac power returns, the Controller measures the Plant's output voltage. The Controller compares that measurement against a reference point (½ of the difference between the Plant's remote Float voltage set point and -42 volts). Usually, the "Ten seconds after the ac power returns" measurement will be higher than the reference point, unless the batteries have been deeply discharged. If the "Ten seconds after" measurement is lower than the reference point, the Controller waits until the battery recharge current drops to less than 75% of the initial recharge value, and then begins the Equalize Charge cycle. Once begun, the Plant voltage is raised 2 volts above the Plant's remote Float voltage set point, and a 10 hour timer is started.

The cycle ends by battery recharge current dropping below 1.5 amps, the batteries over heating, another incident of ac power loss, or after the 10 hour timer has timed out.

The Manual Equalize Charge mode places the rectifiers into Equalize mode (as opposed to the Automatic mode, which only raises the Remote Control Set-point voltage of the rectifiers). A ten hour timer is also started when the Plant is put into the Manual Equalize Charge mode (via a dip switch). The Manual Equalize Charge mode is either software terminated at the end of ten hours, or if battery temperature rises more than 30°C; or hardware terminated by moving the dip switch back DOWN, into the OFF state.

### 3.6.2.6 Battery Fail Alarm

The Control PWB, A3, records both the discharge AHs and the recharge AHs of the batteries, when a power outage occurs and then after power is restored, and the batteries have been recharged. It then compares the two, to determine the state of the batteries.

If the recharge AHs are more than 40% greater than the discharge AHs, a **"Battery Fail" Alarm** is activated and displayed through coded flashes of the PWB's [CNTLR OK] LED (see Chapter 3; Section 9.0, Control PWB [CNTLR OK] LED Status...).

### 3.6.2.7 Battery Sleep Mode

Sleep Mode provides another level of VRLA battery protection. Periodically taking batteries (virtually) out of service, by setting the Float voltage equal to the battery voltage, has shown evidence of increasing battery life expectancy by as much as 20%.

The List 3 and List 4 versions of the Plant have this feature. Sleep mode is dip switch select-able. When selected, the Control PWB will reduce the Float voltage to -52.0 volts ( $\pm$  ATC), for 2 days per week. Should a battery discharge occur, the periodic Sleep mode function is disabled until the batteries have fully recovered their charge.

### 3.6.2.8 HVSD & Automatic Restart Functions

The Plant's HVSD trip point is adjustable, in ½ volt steps, from -56.0 Vdc to -59.5 Vdc, (by 3 dip switches on the Control PWB, A3). A rectifier SHUTDOWN command is generated if the plant voltage reaches this HVSD trip point. A rectifier RESTART command is also generated when the plant voltage drops below -52 Vdc. The standard factory setting of the Control PWB's HVSD trip point voltage is -57.5 volts.

### *3.6.2.9 Easy to use, User Control Interface, dip switches*

Three banks of dip switches, which are located on the front of the Control PWB, A3 (see J Drawing, sheet B2, Figure 5), are used to program all of the variable parameter features of the List 3 & 4 Plants (See SD Drawing, sheet B3, FS4 for switch functions).

### *3.6.2.10 Additional Major, Minor, LVD, & High Temp. alarm output relays*

List 3 & 4 Plants have four, isolated, form C, Alarm output relays. Their contacts may be accessed through terminal blocks J5, J6, J7 & J8 on the Control PWB, A3. They report Major, Minor, LVD disconnected, and High Temperature Alarm conditions. These contacts can be connected directly to alarm annunciator panels or remote alarm monitoring equipment.

### *3.6.2.11 Green CNTLR OK LED flashes Status, Trouble & Warning Information*

Steadily lit means normal Float mode Plant operation; various short and long flash combinations indicate a status other than normal; i.e., Equalize mode or some kind of trouble (see Chapter 3; Section 9.0, Control PWB Green [CNTLR OK] LED Status & Trouble Codes, for a table of flashing LED codes).

## CHAPTER TWO: POWER PLANT INSTALLATION

### 1.0 INTRODUCTION

#### 1.1 General Information

This chapter contains procedures with step by step instructions for a complete Plant installation. This includes making all of the necessary wiring connections to the Plant. A complete Drawing set (J Drawings and Schematic Diagram Drawings) of the Plant can be found in the back of this manual.

#### 1.2 Field Service Assistance

Installation questions are handled by our Field Service Representatives. They can be reached at.

**1-800-299-3907**

Between the hours of 8:00am to 4:00pm, Eastern Standard Time, this phone number reaches an answering service. That service then transfers you to the correct C&D Field Service Department.

#### 1.3 Equipment ID Numbers

Each Plant has an identification label on the side of it. Have the part number [110-4015 List X, or 110-4015 List X] from that label ready to give to the Field Service Representative that is helping you. This will enable them to serve you most quickly.

#### 1.4 Recommended Installation Tools & Test Equipment

The following tools and test equipment are recommended for a typical Plant installation:

**NOTE:** Adequately insulated tools help prevent accidental electrical short circuits.

- Screwdriver: Cabinet tipped, 3/16" (tip width) by 10" (shaft length) straight slot
- Screwdriver: Cabinet tipped, 1/8" (tip width) by 3" to 4" (shaft length) straight slot
- Screwdriver: Cabinet tipped, 3/32" (tip width) by 3" to 4" (shaft length) straight slot
- Screwdriver: Standard, # 2 Phillips tip
- Nut Driver: 3/8", hex
- Wire Strippers: Standard, 24 AWG to 10 AWG
- Long Nose Pliers (for inserting wires into the Load Distribution Terminal Blocks)
- Lug Crimpers: Up to 6 AWG (for Battery Lugs)
- Volt Meter: Hand held DMM, with MIN/MAX Peak Detect Function

#### 1.5 Connecting Wires to the Plant

##### Load Distribution Block & Battery Buss Bar Access (List 2, 3 & 4)

A cover on the front right side of the cabinet can be removed, allowing access to the Distribution PWB. The Distribution PWB can also be unplugged from the Motherboard PWB, and pulled partially from the cabinet, for better access to it's terminal blocks and it's battery buss bars.

Lug-less Terminal Block Wire Preparation

Each wire that is to be connected to a lug-less terminal block in the Plant, should have ¼ inch of exposed bare wire at it's end, to ensure good electrical contact to the wire clamp in the block.

**WARNING: Prevent loose wire strands from shorting to adjacent terminal block positions. Ensure that all strands of each wire go into the receptacle hole of that block position.**

Testing Lug-less Terminal Block Wire Connections

Verify the mechanical soundness of each wire that you clamp into a lug-less terminal block position, by gently pulling on it to make sure that it is securely clamped within the block. Use a pull test force of no greater than 8 inch pounds.

## 2.0 LOCATION SELECTION CRITERIA

**WARNING: Exposing an AGM 15 Power Plant to environmental conditions that it was not meant to withstand, will probably reduce it's usable life span!**

The PLANT installation location must meet the following criteria:

- Dry (protected from direct precipitation)
- Free of pests and vermin
- Well ventilated & unobstructed to forced air flow (air flows in the front & out the back)

## 3.0 PROCEDURE: DC POWER WIRE SIZE SELECTION

### 3.1 Safety, Performance & Reliability

Safety, overall system performance, and the reliability of circuit protection devices depend on the size of the DC load and return wires installed. It is the responsibility of the equipment installer to install adequately sized wire at each site. The following procedure gives a formula for calculating wire size, and a wire size table to help determine the proper wire size needed for a particular site.

### 3.2 Procedure: Select Wire Size

1. Calculate the circular mils [CM] of (copper) wire required for installation at this site:

$$CM = \frac{22.2 \times I \times L}{V}$$

where: CM = minimum area of circular mils in the cable  
I = maximum current (in amps)  
L = one-way cable length (in feet)  
V = tolerable loop voltage drop (in volts)

Example.: I out max. = 5 amps, tolerable loop voltage drop = 0.25 volts, and Plant is 10 feet from the load:  
CM = 4,500

2. Select the proper sized copper wire (based on your calculated CM) from the table below.  
If the calculated CM falls in between that of two standard wire sizes, choose the larger size wire.

**Table: Cross Sectional Area of Wire Sizes**

AWG wire size number	cross sect. area, CM	Current carrying capacity	dia (ins) bare conductor	RHW (ins) dia, with insulation	RHW bend radius, in inches	RHW net weight in lbs., per 1000 feet	RHW max length/reel in feet
14	4110	15	0.064	0.19	0.955	26	5000
12	6530	20	0.081	0.21	1.05	35	3000
10	10380	30	0.102	0.24	1.20	49	3000
8	16510	45	0.146	0.31	1.55	84	3000
6	26250	70	0.184	0.40	2.00	126	2000

**NOTE:** Data based on NEC Handbook 1993, Table 310-17; adjusted for 50°C ambient temperature.

3. Find the wire size required by the local wiring codes, for the number of Amps the wire is to conduct.
4. If the two wire sizes are not the same, use the larger wire size for your installation.

#### 4.0 PROCEDURES: INSTALLATION & WIRE HOOK-UP

##### 4.1 Cabinet Installation

###### PROCEDURE

1. Guide the Plant's factory installed AC power cord & connector to where you want it to go, as you slide the cabinet into place within the rack or enclosure that you are installing it in.
2. Start one 12-24 panel mounting screw into the top mounting hole on each side of the cabinet.
3. Put paint breaking washers under each of the bottom mounting screws, and tighten all four screws.
4. Perform a chassis ground TEST. Using an Ohmmeter, verify that there is less than one Ohm of resistance between the ground prong on the twist lock plug, and the screws that hold the Plant in place.

##### 4.2 Connecting & Verifying AC Input Power (All Models)

A single three wire AC power connection must be made to the (15 A/250 Vac) twist lock receptacle supplied with the Plant. The SO cord and the mating (15 A/250 Vac) twist lock plug come properly connected inside the Plant. Adhere to the requirements of the governing local Electrical Codes, when making the AC power connection to the Plant. There should be an adequately rated delayed-trip circuit breaker at the source of the AC feed to the Plant (See SD drawing sheet A1, Table C).

AC service run length & minimum gauge recommendations: < 25 Feet, 12 gauge; > 25 Feet, 10 gauge.  
Expected current draw over the AC input voltage range: 13.9 Aac @ 110 Vac; 6.3 Aac @ 240 Vac.  
Absolute maximum worst case current draw: 19.5 Aac @ 86 Vac, with 22.5 Adc out, @ -58 Vdc out.  
 (See SD drawings, sheet A1, Table C, for AC circuit breaker ratings).

###### PROCEDURE

1. Run the wiring to the Plant, as required by the governing local Electrical Codes for this installation site.
2. Terminate the wiring to the twist lock receptacle (J Drawing Sheet B4, Figure 11 has twist lock receptacle wiring details), and connect the receptacle to the mating plug on the Power Plant.

3. Connect the wiring to the circuit breaker protected AC source, and strain relieve it as necessary.
4. Perform an AC service TEST: stick the probes of an AC Voltmeter into the AC power prong slots on the 15 A/250 Vac twist lock receptacle, apply AC power to the line, and verify correct voltage.
5. Remove AC power from the Plant. Verify that AC power is no longer detectable at the twist lock receptacle. Do not reconnect AC power to the Plant until after the rectifiers are installed.

### 4.3 Connecting Battery Wires & the Main Ground Buss Wire

#### 4.3.1 Battery & MGB Wires, General Information

Telecom cabling regulations require that an adequately sized direct Main Ground Buss [MGB] connection be made from the Plant ground return to a valid MGB point. A properly made MGB connection bonds the DC output to earth ground, eliminating potential ground loops, and provides a safe path for potentially dangerous lightning induced voltages and currents. The two following documents define what an adequately sized direct MGB connection is:

- Central Office Telecommunications Equipment Engineering Standards, 1984
- TRP-EOP-000154 Bellcore Generic Req.'s for ...CO Power Plant Control & Distribution, 1985

#### **Recommended MGB connection point:**

The MGB should be connected to the +48V, or left side of TB2, located on the Motherboard PWB, A1 (see J Drawing, sheet B2, Figure 3; & SD Drawing, sheet B2, FS 2, for drawings of the location of TB2, and information on it's pin out, and wire size capacity).

#### **Two different battery connection points:**

List 1 bulk Power Plant: the only battery connection point is TB2 (See J Drawing, Sheet B2, Figure 3).

List 2, 3 or 4 Power Plants: the batteries are to be connected to the Distribution PWB buss bars. (See J Drawing, Sheet B2, Figure 10, & SD Drawing, sheet B1, FS1, and sheet B2, FS3 for more information.)

#### 4.3.2 Connect Battery & MGB Wires

#### PROCEDURE

1. List 3 & 4: Un-plug the Distribution PWB, A2, from the Motherboard, for access to TB2 (on PWB A1).
2. List 1, 2, 3 & 4: Clamp the MGB wire into TB2 & pull test it, ensuring that it is secure in the block, and then route the MGB wire to it's grounding point, connect it there, and restrain it in place.

#### **WARNING: Battery cables should have fuses installed in series with them.**

- 3.a List 1: Connect Battery cables to TB2 (ground to +48v (left side), and -48 volts to -48v (right side).
- 3.b List 2, 3 & 4: Feed the battery cables into the cabinet, and firmly hold the Distribution PWB in one hand, while bolting the battery cable lugs onto the buss bars (See J Drawing Sheet B4, Figure 10).
4. Route the battery cables to the batteries, connect them there, and restrain them in place.
5. Verify that the correct battery voltage and polarity can be measured on the Distribution PWB's buss bars before you plug it back into it's connector on the Motherboard PWB.
6. Remove the series battery fuses, so that battery power is not connected to the plant.

#### 4.4 Connecting Distribution Wires

##### 4.4.1 Distribution Wires, General Information

**Distribution Terminal Blocks, their location and maximum AWG capacity: (List 2, 3 & 4)**

All load distribution and return wires are to be connected to lug-less terminal blocks TB1 and TB2. TB1, the fused Load wire block, and TB2, the return wire block, are located just behind the GMT fuse block on the Distribution PWB (See J Drawing, Sheet B 3, Figure 7). These blocks accept wires of up to 12 AWG. If additional load wires are to be added later, the first load wire pair should be installed in location 8 (See J Drawing, Sheet B 3, Figure 7), towards the rear of the block. This leaves the unused locations accessible.

##### 4.4.2 Connect Distribution Wires

#### PROCEDURE

1. Decide which positions (1-8) on TB1 and TB2 that you are going to connect each pair of load and return wires to, and record that information in the worksheet table located at the bottom of this page.
2. Un-plug the Distribution PWB, A2, from the Motherboard, and pull it out (for better access to TB1 & TB2).
3. Decide which access hole you want the distribution wires to go out of (front side, back side, or rear), and remove the cover from that hole, if it has a cover (see J Drawing, sheet B1, Figure 2, Right side view).
4. Route the wires into the cabinet through that access hole, and strip the ends of each wire ¼ inch.
5. Clamp each wire into it's slot in TB1 [LOADS] or TB2 [RETURNS] (see J Drawing, sheet B3, Figure 7, & SD Drawing. sheet B2, FS 3), and pull test each wire (< 8 lb.s) to verify that it is well clamped.
6. Label the other end of each wire, so that each can be correctly routed to its destination. Create a service loop of 5 to 6 inches in the wires, and bundle and strain relieve them within the Plant.
7. Route the wires to their destinations, connect them, perform a continuity verification check, and tie down or restrain the wire bundle to secure it in it's place.
8. Transfer the LOAD number, RATING and DESCRIPTION information from the table below to the Distribution Log Sheet label, located on the hinged front door of the Plant.

<b>DISTRIBUTION LOG SHEET worksheet</b>		
<b>LOAD (FUSE) POSITION</b>	<b>RATING (AMPS)</b>	<b>(LOAD) DESCRIPTION</b>
<b>1</b>		
<b>2</b>		
<b>3</b>		
<b>4</b>		
<b>5</b>		
<b>6</b>		
<b>7</b>		
<b>8</b>		

## 4.5 Connecting Temp Sensors and Alarm & Control Wires

### 4.5.1 Temp Sensors and Alarm & Control Wires, General Information

Depending on the Plant configuration, there is additional wiring that must be completed, and some optional wiring that should be completed before power is connected to the Plant. Review these connections before you start wiring. It will simplify the process and prevent you from having to add connections to the Plant after it is in operation. Below are listed the required (**Req.**) and optional (**Opt**) connections:

(**Req.**) List 3 & 4 Plants need all temperature sensors attached (for battery temp comp operation).

(**Opt**) List 1 & 2 Plants have no direct rectifier control circuits for TR, HVSD, RS, or Equalize. Terminal blocks on the Motherboard provided an external controller access to these signal lines. (See J Drawing, sheet B2, Figure 3, for the location of these terminal blocks {TB 3, 4, 5 & 6})

(**Opt**) List 1, 2, 3, & 4 Plants have optional alarm outputs that can be wired to remote monitoring equip. or local alarm annunciators (See J Drawings: List 1, sheet B2, Fig. 3; List 2-4, sheet B3, Fig.'s 7 & 8).

- List 1 Plants allow access to the rectifier's isolated Form C RFA alarm relay outputs.
- List 2 Plants allow access to isolated Form C alarm relay outputs for FAs and rectifier RFAs.
- List 3 & 4 Plants provide access to isolated Form C alarm relay outputs for Minor, Major, LVD disconnected, and High Temperature alarms, in addition to the List 2 Plant alarms.

#### **Control & Alarm Terminal Blocks; their max AWG capacity & making connections to them:**

The control, alarm and temp. sensor terminal blocks are all two piece connectors. The receptacles are soldered into the PWBs. The removable plugs have the wire clamps in them, and accepts up to **16 AWG** wires. Removing a plug from its receptacle makes clamping wires into the plug easy. Looking at the connector plug from the back, with the clamping screws on top, pin 1 is on the left.

#### *4.5.1.1 Connecting wires to Plug-in Terminal Blocks*

##### PROCEDURE

1. Remove the plug-in from the receptacle of the terminal block that you wish to connect wires to.

**NOTE:** A 3/32" cabinet tipped, straight slot screw driver is required for clamping wires into these blocks.

2. Clamp the stripped ends of the wires into the plug. Pull test each wire (<8 lb.s) to ensure it's clamped.
3. Route the wired plug through an access hole, and plug it into it's socket on the correct PWB.
4. Create an adequate service loop ( $\approx 5''$ ) in the wires, and bundle the wires into place within the Plant.
5. Route the other end of the wires (other than temp sensors) to their destination and terminate them.

#### 4.5.2 Temperature Sensors (List 3 & 4)

Three temperature sensors come with each system. Each one has 30 feet of hook-up wire connected to it, and is packaged in its own separate bag. Each sensor has three wires that must be connected. They connect to terminal blocks J2, J3, or J4, which are located on the front, right side of the Control PWB [A3] (See J Drawing, sheet B3, Figure 8, for the location of J2, J3, & J4). A label, (on the bottom) inside the distribution portion of the cabinet, shows correct sensor wire connections (also, see SD Drawing sheet B3, FS 4, for a diagram of properly connected temp. sensors). The ambient temperature sensor connects to J2. The battery temperature sensors connect to J3 and J4. The sensors are embedded in lead plated ring lugs, designed to be connected directly to a battery terminal. Both battery temp sensors must be used (both on the same string, or one each on two separate strings).

##### *4.5.2.1 Connecting Temp Sensors to Terminal Blocks*

###### PROCEDURE

1. Mount the 2 battery temp. sensors directly to battery terminals (1/string, if more than 1 batt. string).
2. Identify each wire set and then route them all back into the Plant through one of the access holes.
3. Find a mounting location for the ambient sensor, that has enough thermal mass to prevent temperature reading fluctuations due to quick changes in the room or enclosure temperature. The sensor can be mounted to the rack or enclosure itself.
4. Mount the ambient sensor, identify its wire set, and route it into the Plant through an access hole.
5. Trim the excess wire from each temperature sensor wire set, and **follow Procedure:**
  - 4.5.1.1 Procedure: Connecting wires to Plug in Terminal Blocks; to connect them to the Plant.

**WARNING: Mis-connecting a temperature sensor may damage it! Hook them up right the first time!**

#### 4.5.3 Alarm & Control Wires (List 1)

Where the alarm and control wires connect to, in the Plant, and which control and alarm wires should be connected varies, depending on the List model Plant that you have, and the needs of your particular application.

##### *4.5.3.1 Connecting Alarm & Control Wires (List 1) to Terminal Blocks*

The List 1 Plant is a power source only, with no load distribution or control circuitry. However, rectifier alarm and control lines can be accessed on the Plant's Motherboard.

These control and signal lines are accessible at the four plug-in terminal blocks (TB 3, 4, 5 & 6), located on the right side of the Motherboard, directly below the main output power terminal block TB2. The pin-outs of the four terminal blocks are listed in the next table. (also, see J Drawing, sheet B2, Figure 3, & SD Drawing, sheet B2, FS 3, for TB 3-6 details)

**Table: List 1 Alarm and Control Signal Interface**

Term Blk # pin #	TB3 ≤250mA	TB4	TB5	TB6 2A max
1	RFA 1	HVSD	TR 1	+48V
2	RFA 2	RS	TR 2	
3	RFA 3	EQ	TR 3	-48V

**TB3** Connects to each rectifier’s internal RFA relay. A grounded RFA line indicates a failed rectifier. These signal lines should not be used to sink > 250mA.

**TB4** Connects to the paralleled HVSD, RS, and EQ lines of each rectifier slot. Momentarily grounding the HVSD or RS lines initiates the command. Equalize mode is only active while the EQ signal line is grounded. HVSD is latched, so shutdown rectifiers stay OFF until they receive an RS signal, or their AC power is cycled OFF, and then back ON again.

**TB5** Connects to the individual Temporary Release (TR) control input of each rectifier slot. While a TR input signal line is grounded, the rectifier does not deliver power. The rectifier will resume delivering power when the ground is removed from the TR input signal line.

**TB6** Provides a source of -48 Vdc power for an external controller. Any circuitry connected to this terminal block must be fused to protect the Plant, and to prevent service interruptions.

*4.5.3.2 Connect the Alarm and Control signal wires to the (List 1) Plant*  
(using 4.5.1.1 Procedure: Connecting wires to Plug in Terminal Blocks)

4.5.4 Alarm & Control Wires (List 2)

The List 2 Plant has load distribution capacity, but no rectifier control functions. The Distribution PWB has two isolated form C Alarm output relays; one Fuse Alarm (FA), accessible at J4, and one Rectifier Failed Alarm (RFA) accessible at J5. Both relays are normally de-energized. The FA activates when any GMT distribution fuse opens. The RFA activates when a rectifier sends out an RFA signal. These relay contacts can be connected directly to alarm annunciator panels or remote alarm monitoring equipment. The rectifier control functions described for List 1 Plants are also valid for List 2 Plants. Below are listed the pin-outs of the two blocks (also, see J Drawing, sheet B3, Figure 7, and SD Drawing, sheet B2, FS3, for drawings of Terminal Blocks J4 & J5).

**Table: List 2 Alarm and Control Signal Interface**

Term Blk # pin #	Term Blk J4 FA contacts	Term Blk J5 RFA contacts
1	Common	Common
2	Normally Closed	Normally Closed
3	Normally Open	Normally Open

*4.5.4.1 Connect the Alarm and Control signal wires to the (List 2) Plant*  
(using 4.5.1.1 Procedure: Connecting wires to Plug in Terminal Blocks)

4.5.5 Alarm Relay Output Wires (List 3 & 4)

List 3 & 4 Plants have four, isolated form C, Alarm output relays. Their contacts are accessible through terminal blocks J5, J6, J7 & J8 on the Control PWB. They report Major, Minor, LVD disconnected, and High Temperature Alarm conditions. Their contacts can be connected directly to alarm annunciator panels or remote alarm monitoring equipment. Below are listed the pin outs of the four Alarm relay contact terminal blocks (also, see J Drawing, sheet B3, Figure 8, and SD Drawing, sheet B3, FS 4).

**Table: List 3 & 4 Alarm Relay Contacts**

All contacts are shown in the “not alarmed state”				
Term Blk # pin #	Term Blk J5 Maj. contacts	Term Blk J6 Min. contacts	Term Blk J7 LVD contacts	Term Blk J8 Hi Temp contacts
1	Common	Common	Common	Common
2	Normally Closed*	Normally Closed	Normally Closed*	Normally Closed
3	Normally Open*	Normally Open	Normally Open*	Normally Open

**NOTE:** \*All Alarm relay contacts (on the J & SD Drawings or the PWB silk screens) are shown, as the relays are, with no power applied to them (de-energized). The Major Alarm relay and the LVD Alarm relay are both energized when they are not reporting an alarm. Therefore; in their “de-energized” or “alarm reporting” state (when wires are being hooked up), the Major and LVD Alarm relay contacts are reversed; the Normally Closed contact is open, and the Normally Open contact is closed.

4.5.5.1 *Connect the Alarm signal wires to the (List 3 & 4) Plant*  
(using 4.5.1.1 Procedure: Connecting wires to Plug in Terminal Blocks)

5.0 RECTIFIER INSTALLATION, POWER-UP & VERIFICATION

5.1 Rectifier Installation

Each rectifier monitors it’s performance, and reports rectifier status and problem information through the green NORM LED on the front of the rectifier. A series of short and long light pulses are used to convey any state other than normal operation. A label on the inside of the Plant’s front door describes what each pulse pattern means (See SD Drawing sheet A2, Note 64, for more details). The rectifier manual also provides more details about these light pulse codes. The most common status code likely to be seen, under normal operation, is the single long pulse for “Low Current”. (See the following Table for a legend of rectifier “NORM” LED coded “flash” messages)

**WARNING:** The rectifiers are open frame units that slide into the cabinet on card guides. Excess force or rough handling can mechanically damage the rectifiers or the card guides.

**NOTE:** Rectifiers are designed to be installed “Hot”, without interrupting normal Plant operation.

**Table: Rectifier [NORM] LED Coded Flash Message Legend**

Flashes		Coded Flash Messages & Their Problem or Status Indication Descriptions	
Long	Short	Coded Flash Message	Problem or Status Indication Description
	1	Low Output Current	Output Current below 0.375 Adc
	2	Internal HVSD	Occurs if V dc out > -61 Vdc, or 3 Vdc > set point
	3	AC Line Sag	When line should be 208–240 Vac, shows line is < 187 Vac
	4	Over Temperature	Occurs when internal heat sink temp > 110 °C
1	1	Rem. Control “out of range”	Voltage across REM. CNTRL. inputs > ± 2 Vdc (The rectifier’s FLOAT pot is setting it’s output voltage)
1	2	Load Share “out of range”	Voltage across LS inputs > ± 2 Vdc; Load Sharing inactive
1	3	Over Temp./ I out derated	Ambient Temperature > +65 °C; rectifier I out limit derated
1		Low Air Flow	Occurs when heat sink to ambient Δ > 30% over normal
2		External HVSD	The Plant has placed the rectifier into HVSD mode

### 5.1.1 Installing Rectifiers

**WARNING:** Keep rectifiers in their shipping containers, until you are ready to insert them into the cabinet. Being open framed units, they can sustain ESD damage if they are not kept protected.

**NOTE:** Although not critical, it is best to have each rectifier switched OFF during insertion and removal.

#### PROCEDURE

1. Align the front edges of the rectifier’s bottom PWB with the card guides in the cabinet.
2. Slide the rectifier into the cabinet, until it touches the edge connector on the Motherboard.
3. Press on the bottom corners of the rectifier’s front plate until the unit “seats” into place.
4. Install the remaining rectifiers the same way, leaving all switches OFF until initial power up.

### 5.2 Initial Rectifier Power-Up

#### 5.2.1 Required Equipment for Initial Rectifier Power Up

- A Variable Load, capable of handling at least 25 amps
- Five or more, 5 amp GMT fuses
- A DVM, with a millivolt scale that is accurate to at least 0.5%
- A Potentiometer adjustment tool
- A Ground jumper, of at least 12 AWG (for the complete testing of a List 1 or 2 Plant)

#### 5.2.2 Pre Power Up Steps

1. Connect the Variable Load to the Plant.

List 1 Plants: Motherboard Terminal block TB2, or some external connection point

List 2, 3, & 4 Plants: Motherboard Terminal block TB2, or Distribution PWB Battery buss bars.

2. Connect the DVM to the Plant (to monitor it's output voltage).

List 1 Plants: Motherboard Terminal block TB2, or some external connection point

List 2, 3, & 4 Plants: Across the "BAT VOLTS" and "COMMON" test jacks (Distribution PWB)  
(See J Drawing, sheet B3, Figure 7, for "BAT VOLTS" and "COMMON" test jack locations)

### 5.2.3 Initial Rectifier Power Up

**NOTE:** Batteries should not be connected to the Plant during this procedure. Ignore the "one short flash" [NORM] Rectifier LED code when the Plant is not loaded.

#### PROCEDURE

1. Apply AC service power to the Plant (Rectifier fans will start turning).
2. List 3 & 4 only: Put dip switch S2, positions 3 & 4, DOWN, into the OFF state.
3. Flip the toggle switch on a rectifier UP, into the ON state.
4. Verify that the Plant output [BAT VOLTS] to [COMMON] is  $-54.25 \text{ Vdc}$ ,  $\pm 0.1 \text{ Vdc}$ .
5. Flip the toggle switch on that rectifier DOWN, into the OFF state.
6. Repeat steps 3 – 5, on each rectifier, until you have verified that each one is working OK. (Green NORM LED shows one short flash, and REM, EQL & RFA LEDs are all not lit)
7. Flip the toggle switches on all rectifiers UP, into the ON state, and Verify that the Plant output voltage is  $-54.2 \text{ Vdc}$ ,  $\pm 0.25 \text{ Vdc}$ .
8. List 3 & 4 only: Put dip switch S2, position 4, back UP, into the ON state, and Verify that the Plant output voltage is  $-54.2 \text{ Vdc}$ ,  $\pm 0.25 \text{ Vdc}$ . (if it is not  $\cong -54.2 \text{ Vdc}$ , adjust it to that value, using the pot R60, on the Control PWB [A3] See J Drawing, sheet B3, Figure 8, for the location of pot R60).

#### Optional Tests

9. Set the variable load so that each rectifier is delivering approx. 3.75 Adc. (18.75 mVdc,  $\pm 2.5 \text{ mVdc}$  across the two rectifier "I+" and "I-" test jacks).

**NOTE:** All rectifiers should load share, and be operating normally within 30 seconds (all rectifier "NORM" LEDs should be lit continuously, with no flashing codes displayed, and the REM, EQL and RFA LEDs are all not lit).

10. Set the variable load so that each rectifier is delivering approx. 7.0 Adc (from 32.5 mVdc to 37.5 mVdc {35 mVdc,  $\pm 2.5 \text{ mVdc}$ } across the two rectifier "I+" and "I-" test jacks).

**NOTE:** Plant voltage should not change, and there should be no alarms or flashing rectifier LEDs.

11. Set the variable load so that each rectifier is delivering approx. 3.75 Adc. (18.75 mVdc,  $\pm 2.5 \text{ mVdc}$  across the two rectifier "I+" and "I-" test jacks).
12. Perform the next two steps on each rectifier, one rectifier at a time.

13. Flip a rectifier's toggle switch DOWN, into the OFF state (it's green NORM LED will flash 1 short flash for low current, and it's red RFA LED will be lit continuously).
14. Verify that the other rectifiers pick up the load and continue load sharing equally, that no Alarms occur, and that the Plant output voltage does not change  $> \pm 250$  mVdc.
15. **Initial test completed!** Flip all rectifier toggle switches DOWN, into the OFF state.  
 For List 1 & 2 Plants, go directly to Section 9.0 Final Rectifier Set Up & Verification.  
 For List 3 & 4 Plants, perform the procedures in Sections 6, 7, & 8 of this chapter, before going to Section 9.0, Final Rectifier Set Up & Verification.

## 6.0 LVD SET-UP & OPERATION VERIFICATION

### 6.1 LVD Op Verification, Gen. Info.

Correct LVD operation should be verified, if that function will be used. The LVD function must be put in the TEST mode to verify it's correct operation. With LVD in the TEST mode, the selected trip point is ignored, and a trip point of  $-48$  Vdc is used. Also, the adjustment range of the Plant's remote control Float voltage adjust pot (R60) is increased (and it's adjustment sensitivity is decreased). The adjustment range (and sensitivity) returns to normal when the LVD function is taken out of the TEST mode. To verify the correct operation of the LVD function, perform the following Procedure.

**WARNING: If an on-line Plant is placed in the TEST mode, either Load service (List 3) or battery back-up capacity (List 4) will be interrupted if the LVD function is actuated.**

### 6.2 Verify LVD Operation

#### PROCEDURE

1. Select the LVD function TEST mode: Move dip switch S2, positions 7 & 8, UP.

**NOTE:** In TEST mode, the Minor Alarm LED will be lit, and the Green [CNTLR OK] LED will flash 2 long and 2 short flashes, indicating that the Plant is in the LVD TEST mode.

2. Flip the toggle switch on all rectifiers except one, DOWN, into the OFF position; then stick the leads of a DVM into the "BAT VOLTS" & "COMMON" test jacks.
3. Verify that the DVM reads  $\cong -54$  Vdc, and that the red LVD LED is not lit.
4. Use a pot adjustment tool to turn the Plant's remote control Float voltage adjust pot (R60) CCW, as you observe the red LVD LED, and watch for it to become lit.
5. When the red LVD LED lights, stop turning R60 CCW, observe the reading on the DVM, and verify that the DVM reading is approximately  $-48$  Vdc,  $\pm 250$  mVdc.
6. Use a pot adjustment tool to turn the Plant's remote control Float voltage adjust pot (R60) CW, as you observe the red LVD LED, and watch for it to go out (the TEST mode reconnect point is  $-52$  Vdc).

7. When the red LVD LED goes out, stop turning R60 CW, observe the reading on the DVM, and verify that the DVM reading is approximately  $-52 \text{ Vdc}$ ,  $\pm 250 \text{ mVdc}$ .
8. Set dip switch S2, positions 7 & 8 back DOWN, putting the LVD function into automatic mode.
9. Adjust the Plant's remote control Float voltage adjust pot (R60) to the correct setting.  
**This completes the LVD test.**

### 6.3 Select an LVD Trip Point

Dip switch S1, positions 1, 2, 3 & 4 set the LVD trip point, in  $\frac{1}{2}$  volt steps, from  $-38.5$  to  $-46.0 \text{ Vdc}$ . To change the LVD trip point voltage, set the switches according to the following table, the label on the inside of the front door of the Plant, or the table in the SD Drawing set, sheet B3, FS4.

#### PROCEDURE

1. Select the desired LVD trip voltage, and set the dip switches accordingly.

**Table: Dip Switch S1, Positions 1, 2, 3, & 4 and LVD Trip Point Voltages**

LVD Voltage	38. 5	39	39. 5	40	40. 5	41	41. 5	42	42. 5	43	43. 5	44	44. 5	45	45. 5	46
<b>S1, Pos. 1</b>	DN	UP	DN	UP	DN	UP	DN	UP	DN	UP	DN	UP	DN	UP	DN	UP
<b>S1, Pos. 2</b>	DN	D N	UP	UP	DN	D N	UP	UP	DN	D N	UP	UP	DN	D N	UP	UP
<b>S1, Pos. 3</b>	DN	D N	DN	D N	UP	UP	UP	UP	DN	D N	DN	D N	UP	UP	UP	UP
<b>S1, Pos. 4</b>	DN	D N	DN	D N	DN	D N	DN	D N	UP	UP	UP	UP	UP	UP	UP	UP

Legend: UP = switch toggle in the UP position; DN = switch toggle in the DOWN position

## 7.0 BATTERY TEMPERATURE COMPENSATION (BTC) SET-UP & OPERATION VERIFICATION

### 7.1 BTC Operation Verification Overview

Battery temperature compensation can be easily verified. Simply heat one of the battery temp. sensors while monitoring the Plant's Float voltage, and see that the Float voltage changes correctly.

### 7.2 Verify BTC Operation

**NOTE:** The Plant must be powered and operating, but without any load on it.

#### PROCEDURE

1. Plug DVM leads into the "BAT VOLTS" & "COMMON" test jacks on the front of the Plant.
2. Move dip switch S2, position 3, DOWN, and wait for the reading on the DVM to stop changing.
3. Record the reading on the DVM (the Plant's uncompensated Float voltage).
4. Use a DVM (set on millivolt range) to measure across pins 2 and 3 (the blue and black leads) of that temp. sensor's input terminal block, while keeping the heat source on the sensor.

5. Record that measurement in millivolts, and translate it into degrees Fahrenheit by dividing it by 10.  
Example: 850 mV = 85°F. (the heat source must be kept on the temp. sensor while doing this)
6. Pick a Battery Temp. Sensor, and unbolt it from the battery connection that it is mounted to.
7. Heat the sensor by holding it tightly in your hand, or by using a convenient heat source.
8. Use a DVM (set on millivolt range) to measure across pins 2 and 3 (the blue and black leads) of that temp. sensor's input terminal block, while keeping the heat source on the sensor.
9. Record that measurement in millivolts, and translate it into degrees Fahrenheit by dividing it by 10.  
Example: 850 mV = 85°F. (the heat source must be kept on the temp. sensor while doing this)
10. Subtract the first temperature reading from the second reading (to get the increase in temperature).
11. Put the DVM leads back into the Plant's "BAT VOLTS" & "COMMON" test jacks.
12. Move dip switch S2, position 3, UP, and wait for the reading on the DVM to stop changing  
(the heat source must be kept on the temp. sensor while doing this).
13. Record the reading on the DVM (the heat source can now be removed from the temp. sensor).
14. Subtract the first, uncompensated, voltage measurement from the second, compensated measurement to obtain the voltage change caused by the BTC function.
15. Divide the result from the previous step by 48, to obtain the increase in temperature.
16. The last result should be within  $\pm 2^{\circ}\text{F}$  of the earlier result, if BTC is working properly.  
This completes the test. Reconnect the Battery temp. sensor to it's installed location.

### 7.3 BTC Offset Span Selection Criteria

In order to select the best BTC offset voltage span, consider the following:

- The temperature extremes of the location where the Plant is installed
- Temperature effects on battery reserve capacity and battery life expectancy
- The input voltage variance range that the load equipment can tolerate
- The costs of responding to nuisance alarms (caused by too wide of a BTC span)

### 7.4 Select BTC Offset Span

The span of the BTC offset voltage is selected by changing the settings of dip switch S2, positions 1 & 2. The following table lists the four offset voltage span ranges, the temperature ranges that each covers, and the dip switch settings for each offset span range (also, see SD Drawing, sheet B3, FS4, switch-S2 table, for the dip switch settings for each offset span range).

#### PROCEDURE

1. Select the BTC offset voltage span that you wish to have the Plant's BTC function operate in.

**Table: Dip Switch S2, Positions 1 & 2, and BTC Offset Voltage Span Ranges**

BTC Span	Temperature Range Spanned		Dip Switch S2	
	Min Temp	Max Temp	Pos 1	Pos 2
±1 Vdc	58°F (14.4°C)	98°F (36.6°C)	DN	DN
±2 Vdc	38°F (3.3°C)	118°F (47.7°C)	UP	DN
±3 Vdc	18°F (-7.7°C)	138°F (58.8°C)	DN	UP
±4 Vdc	-4°F (-20°C)	158°F (70°C)	UP	UP

Legend: UP = switch toggle UP; DN = switch toggle DOWN

## 8.0 LVA, HVA & HVSD OPERATION VERIFICATION

### 8.1 Verifying LVA, HVA & HVSD Trip Points

In order to verify the correct operation of the LVA, HVA & HVSD Trip Points, a temporary HVSD trip point must be selected, that is within the Float voltage adjustment range of the Plant's remotely controlled Float voltage potentiometer. The LVA trip point is fixed at -51.5 Vdc, ±0.25 Vdc. The HVA trip point, is set by the Control PWB, at 1 Vdc less than the HVSD trip point, ± the BTC offset voltage. The LVA trip point is not user alterable. The HVA trip point is user alterable, to the extent that the user can select the HVSD trip point. The 1 Vdc margin of the HVA trip point, below the HVSD trip point, is not user alterable. Both LVA and HVA are indicated by different coded flashes of the Green [CNTLR OK] LED. A Major Alarm also accompanies both an LVA or an HVA.

#### 8.1.1 HVSD Trip Point Selection

The Plant HVSD trip point is selected using dip switch S1, positions 5, 6, and 7. The following table lists the Plant's HVSD trip points, and the dip switch settings for each.

**Table: Dip Switch S1, Positions 5, 6, & 7 and HVSD Trip Point Voltages**

HVSD Voltage	56	56.5	57	57.5	58	58.5	59	59.5
<b>S1, Position 5</b>	D N	UP	D N	UP	D N	UP	D N	UP
<b>S1, Position 6</b>	D N	DN	UP	UP	D N	DN	UP	UP
<b>S1, Position 7</b>	D N	DN	D N	DN	UP	UP	UP	UP

Legend: UP = switch toggle in the UP position; DN = switch toggle in the DOWN position

### 8.2 Verify LVA, HVA & HVSD Trip Points

#### PROCEDURE

1. Operate the Plant normally, with at least two rectifiers installed and working, and enough load so that there are no rectifier or Plant alarms.
2. Place the Plant into the LVD TEST mode: move dip switch S2, positions 7 & 8 UP (the Minor Alarm LED will light, & the Green [CNTLR OK] LED will flash the TEST mode code).
3. Turn Battery Temperature Compensation OFF and Plant voltage remote control ON: Move dip switch S2, position 3 DOWN, and dip switch S2, position 4 UP.

4. Select the  $-56.0$  Vdc HVSD trip point: Move dip switch S1 positions 5,6, and 7 DOWN.
  5. Insert the probes of a DVM into the “BAT VOLTS” & “COMMON” test jacks on the Plant.
  6. Watch the Major Alarm LED, as you slowly turn the remote control FLOAT voltage adjust pot (R60 on the Control PWB) CCW, and stop turning the pot as soon as the Major Alarm LED lights.
  7. Verify the following: the DVM reads  $-51.5$  Vdc,  $\pm 0.3$  Vdc, and the Green [CNTLR OK] LED flashes the code for an LVA (1 short flash).
  8. Watch the Major Alarm LED, as you slowly turn the remote control FLOAT voltage adjust pot (R60 on the Control PWB) CW, and stop turning the pot as soon as the Major Alarm LED goes out.
  9. Verify that the DVM reads from  **$-51.5$  to  $-52.5$  Vdc**, and the Green [CNTLR OK] LED is steadily lit.
  10. Connect the batteries to the Plant (install the series battery fuses).
  11. Watch the Major Alarm LED, as you continue turning the remote control FLOAT voltage adjust pot (R60 on the Control PWB) CW, and stop turning the pot as soon as the Major Alarm LED lights.
  12. Verify that the DVM reads from  **$-54.5$  to  $-55.5$  Vdc**, and the Green [CNTLR OK] LED flashes the code for an HVA (2 short flashes).
  13. Place the DVM into the Peak Detect mode of operation, and set it to catch Maximum value.
  14. Watch a rectifier NORM LED, as you continue to slowly turn the remote control FLOAT voltage adjust pot (R60 on the Control PWB) CW, and stop turning the pot as soon as the rectifier NORM LED goes out and the rectifier RFA LED lights.
  15. Verify that the following criteria are all true: The DVM reads from  **$-55.5$  to  $-56.5$  Vdc**, the Green [CNTLR OK] LED flashes the code for the HVSD trip point set too low (4 short flashes), and that all rectifier NORM LEDs are flashing an external HVSD code (2 long flashes).
- NOTE:** With all working rectifiers shut down, the Plant is on battery back-up.
16. Turn the remote control FLOAT voltage adjust pot (R60 on the Control PWB) CCW 3 full turns.
  17. If you need to verify the Plant’s HVSD/ReStart function, do not change any Plant settings and go to 8.3: Procedure Verify HVSD/ ReStart Function. If not, perform the next step.
  18. Remove the Plant from the LVD TEST mode: move dip switch S2, positions 7 & 8 DOWN, put the Plant’s HVSD trip point back where it should be set at, ReStart all rectifiers by cycling the AC power to the Plant OFF, and then back ON again (the Minor Alarm LED will go out, & the Green [CNTLR OK] LED will become steadily lit.) and readjust the remote control FLOAT voltage adjust pot to the desired Plant voltage value.

### 8.3 Verify HVSD/ ReStart Function

**WARNING: Do not draw more than twice the AH rating out of the batteries, in discharging them!**

#### PROCEDURE

1. Connect a load to the Plant's batteries, and monitor the battery voltage on the DVM (leave the probes of the DVM in the "BAT VOLTS" & "COMMON" test jacks on the Plant, and put the DVM in the Peak Detect mode of operation, and set it to catch a Minimum value).
2. When the rectifiers ReStart and the Plant resumes normal operation (with no alarm indications), verify that the DVM Peak Detect function captured  $-52.0$  Vdc,  $\pm 0.3$  Vdc.
3. This completes the testing of the Plant's HVSD/ ReStart Function. Disconnect the batteries from the Plant (remove the series fuses). Remove the Plant from the LVD TEST mode: move dip switch S2, positions 7 & 8 DOWN, and put the Plant's HVSD trip point back where it should be set at, and then readjust the remote control FLOAT voltage adjust pot to the desired Plant voltage value.

### 9.0 FINAL RECTIFIER SET-UP & VERIFICATION

Final adjustment and verification, before the Plant is brought on-line, involves the following: Setting the Float and Equalize voltages of each Rectifier, verify proper load sharing at these settings; and for List 3 & 4 Plants, adjusting the remote control voltage set point.

**NOTE:** Batteries should be disconnected from the Plant for this last procedure.

#### PROCEDURE

1. Reconnect the variable load and the DVM to the Plant (as in the last procedure).
2. Flip all rectifier toggle switches DOWN, into the OFF state; and then apply AC.
3. List 3 & 4 Plants: Put dip switch S2, positions 3 & 4, DOWN, into the OFF state.
4. Perform the next five steps (5 – 9) on each rectifier, one rectifier at a time.
5. Flip a rectifier's toggle switch UP, into the ON state.
6. Adjust the rectifier's Float [FLT] voltage Pot until the DVM reads the desired value.

**NOTE:** Allow 15 seconds, after each adjustment, for the unit to adjust it's output voltage.

- 7.a List 1 & 2: Manually place the Rectifiers into their Equalize mode: Put a jumper wire between TB4 pin 3 and TB6 pin 1 on the Motherboard PWB (See J Drawing, sheet B2, Figure 3, and SD Drawing, sheet B2, FS 3, for the location of TB's 4 and 6).
- 7.b List 3 & 4: Manually place the Rectifiers into their Equalize mode: Move dip switch 2, position 6, UP into the ON state (See J Drawing, sheet B3, Figure 8, and SD Drawing, sheet B3, FS 4, for the location of dip switch 2, position 6).

8. Adjust the rectifier's Equalize [EQL] voltage Pot until the DVM reads the desired value.
- NOTE:** Allow 15 seconds, after each adjustment, for the unit to adjust it's output voltage.
9. Flip the rectifier's toggle switches DOWN, into the OFF state, and adjust the remaining rectifiers.
10. List 3 & 4 Plants: Move dip switch S2, position 4, UP, and Flip all rectifier toggle switches UP (See J Drawing, sheet B3, Figure 8, and SD Drawing, sheet B3, FS 4, for dip switch locations).
11. Adjust the "Remote Control Float Voltage Adjust Pot" [called "ADJ FLOAT VOTLAGE" on the door label ] (R60, located on the front edge of the Control PWB [A3] ) until the DVM reads the desired "Remotely Controlled" Float Voltage value.
12. Set the variable load so that the rectifiers are each delivering approximately 3.5 Adc.
13. Using the DVM, on the millivolt range, check the current sense jacks ("I+" and "I-") of each rectifier. Verify that each rectifier is load sharing within 1 Adc ( $\pm 5$  mVdc) of each other.
14. **Procedure complete!** Flip all rectifier toggle switches OFF & disconnect the variable load.

**End of Installation:** Install the GMT fuses, and the series Battery fuses and put the Plant into service.

## 10.0 ADDING LOADS TO AN ON-LINE PLANT

Adding loads to an on-line Plant should be done at a time when the Plant can be temporarily removed from service. Down time can be limited to a few minutes if properly planned. If removing the Plant from service is not an option, use the following guidelines to minimize difficulty and potential problems.

**CAUTION:** Using insulated tools should minimize the likelihood of accidentally causing short circuits.

### PROCEDURE

1. Remove the front side cover, and pick the available fuse location(s) you wish to add a load to.

**WARNING:** Do not install GMT fuses until all load wires are connected. Installed fuses put the terminal block screws at battery potential. Do not let loose wire strands short to adjacent positions.

2. Run the wires from the load to the Plant (leaving the load unterminated until the Plant is connected).

**WARNING:** If the wires enter the Plant from the rear, do not strip the ends until you are ready to terminate.

3. Route the wires up to TB1 & TB2, with enough slack to create a reasonable service loop.
4. Turn the terminal block clamping screws counter clockwise, to ensure that the wire entrance is open.
5. Remove ¼" of insulation and ensure that the wire strands are tightly bundled (to prevent shorts).
6. Bend the end of the wire approximately 90°, just behind where it is stripped back to.

7. Grab the wire close to the bend, from the front of the Plant with a pair of insulated long nose pliers. Insert the wire into the terminal block opening, and hold it there while tightening the clamp screw.
8. Pull test each wire (with  $\leq 8$  inch pounds) after tightening it's terminal block clamp screw.
9. Repeat steps 5 – 8 for each wire you install.
10. Create a service loop in the wires, bundle them together, and terminate them to the load.
11. Identify the load on the Distribution Log sheet label, which is located on the inside of the front door.
12. Insert a GMT fuse into the correct fuse holder slot.
13. Turn ON the new load and ensure that it is operating correctly.
14. Verify that the Plant is operating normally, and close it up.

## CHAPTER THREE: PLANT OPERATION

- 1.0 Low Voltage Disconnect Operation
- 2.0 Battery Temperature Compensation Operation
- 3.0 Battery Temperature Alarm Operation
- 4.0 Equalization Charge Mode Operation
- 5.0 Plant Voltage Remote Control Operation
- 6.0 Battery Sleep Mode Operation
- 7.0 Miscellaneous Functions Operation
- 8.0 Circuit Board (PWB) Locations within the Plant
- 9.0 Plant Performance Monitoring, Status Indication, and Default Settings

### 1.0 LOW VOLTAGE DISCONNECT (LVD) OPERATION

#### 1.1 LVD Normal Operation Overview

During a power outage, when service to the loads is being supplied by the batteries, The Plant Control PWB causes the LVD relay to disconnect the load (List 3), or the batteries (List 4) from the Plant, when the battery voltage drops below a user select-able trip point. The battery voltage must remain below the trip point for more than 2 seconds, before the relay will disconnect. This delay prevents transients from causing unnecessary disconnects. The Plant Control PWB automatically reconnects the LVD relay when the Plant voltage rises above a fixed reconnect trip point of  $-49.5$  Vdc (usually right after power returns). The LVD function can protect batteries from deep discharge damage, or protect load equipment from unacceptable low input voltage. The LVD operation mode and the disconnect voltage trip point are selected by dip switches, located on the front of the Control PWB. Dip switch settings are monitored by the Control PWB, and changes are implemented immediately. The Factory setting is  $-42.0$  volts.

#### 1.2 LVD Hardware and By-pass Operation

The LVD relay is located on the Distribution PWB, near the rear “edge connector” end of the board. A manual by-pass jumper, JP1, is located near the lower front edge of the Distribution PWB. With the jumper in the forward “Enabled” position, the LVD relay control is by-passed, and the relay contacts stay closed. In this mode, the Control PWB can be removed for service, without taking the Plant off-line. When the Control PWB is plugged back in, JP1 must be moved back to the “Disabled” position, to have normal LVD operation. There is no warning indication or alarm to alert a user that the by-pass Jumper is in the “Enabled” position; the user must remember to move the jumper back to the “Disabled” position.

#### 1.3 LVD Function & Plant Alarm Status

The Control PWB has a form C, alarm output relay on it, which reports when the LVD relay contacts are open. The Distribution PWB has a red LVD LED on it, which lights when the LVD relay contacts are open. Whenever the LVD relay contacts are open, the Plant is in a Major Alarm state; the red Major Alarm LED is lit, and the Major Alarm, form C, alarm output relay is reporting the Major Alarm state [it's N.O. contacts are closed and it's N.C. contacts are open. see 4.4.5 Alarm Relay Output Wires (List 3 & 4)].

## 1.4 LVD Trip Point Setting

Dip switch S1, positions 1, 2, 3 & 4 set the LVD trip point, in ½ volt steps, from –38.5 to –46.0 volts. To change the LVD trip point voltage, set the switches according to the following table, the label on the inside of the front door of the Plant, or the dip switch settings table in the SD Drawing set, sheet B3, FS4.

**Table: Dip Switch S1, Positions 1, 2, 3, & 4 and LVD Trip Point Voltages**

LVD Voltage	38.5	39	39.5	40	40.5	41	41.5	42	42.5	43	43.5	44	44.5	45	45.5	46
<b>S1, Pos. 1</b>	DN	UP	DN	UP	DN	UP	DN	UP	DN	UP	DN	UP	DN	UP	DN	UP
<b>S1, Pos. 2</b>	DN	D N	UP	UP	DN	D N	UP	UP	DN	D N	UP	UP	DN	D N	UP	UP
<b>S1, Pos. 3</b>	DN	D N	DN	D N	UP	UP	UP	UP	DN	D N	DN	D N	UP	UP	UP	UP
<b>S1, Pos. 4</b>	DN	D N	DN	D N	DN	D N	DN	D N	UP	UP	UP	UP	UP	UP	UP	UP

Legend: UP = switch toggle in the UP position; DN = switch toggle in the DOWN position

## 1.5 LVD Operation mode Selection

Dip switch S2 positions 7 and 8 select the LVD operation mode. If the LVD function is being used, the Automatic mode will usually be active. Two manual modes (fixed ON & fixed OFF) are available for emergency and service use. The LVD function also has a TEST mode.

### 1.5.1 Automatic mode

In this mode, the LVD relay contacts are closed, while the Plant or battery voltage is above the selected LVD trip point. If the battery or Plant voltage drops below the LVD trip point for more than two seconds, the LVD relay contacts open, disconnecting the Load (List 3) or Batteries (List 4) from the Plant. The LVD relay contacts remain open until the battery or Plant voltage rises above –49.5 Vdc for more than two seconds. Then the LVD relay contacts close again, reconnecting the Load or Batteries to the Plant. S2 positions 7 and 8 must both be DOWN to select the Automatic mode.

### 1.5.2 The Fixed ON mode

The Fixed ON mode makes the LVD relay contacts stay closed, regardless of Plant or battery voltage. This mode could be used to maintain service during an extended power outage. The Fixed ON mode is selected by moving S2, position 7, UP, , and leaving S2, position 8, DOWN.

### 1.5.3 The Fixed OFF mode

The Fixed OFF mode makes the LVD relay contacts remain open, regardless of Plant or battery voltage. This mode could be used to take the batteries off-line for servicing. The Fixed OFF mode is selected by leaving S2, position 7, DOWN, and moving S2, position 8, UP. The red LVD Disconnected LED will be lit when the Plant is in the Fixed OFF mode, indicating that the LVD relay is open.

### 1.5.4 The TEST mode

In the TEST mode, the LVD relay disconnects at –48 Vdc, and reconnects at –51 Vdc, so that it's operation can be easily verified. The TEST mode is for operation verification and troubleshooting only. Testing the LVD on a live Plant will disconnect the load or battery, resulting in a loss of load service or battery reserves. The TEST mode is selected by moving S2, positions 7 & 8 both UP. See Chapter TWO Installation, Section 6.0, for Instructions on using the TEST mode to verify LVD operation, or to troubleshoot an LVD problem.

## 2.0 BATTERY TEMPERATURE COMPENSATION (BTC) OPERATION

### 2.1 BTC Normal Operation Overview

BTC adjusts Plant voltage according to changes in battery temperature. The Plant monitors two battery temp. sensors and one ambient temp. sensor. The higher reading of the two battery temp. sensors is used to calculate the BTC offset voltage.

### 2.2 Turning BTC ON or OFF

Dip switch S2, position 3, on the front of the Control PWB, turns BTC on or off. When S2, position 3 is UP, BTC is ON, when S2, position 3 is DOWN, BTC is OFF.

BTC must be turned OFF to perform the following tasks:

- To verify or set the Plant Float voltage (OFF removes the BTC offset from the Plant voltage)
- Calculating battery temperature using the difference between comp'd & un-comp'd Plant voltage (See Chapter 2, Section 7.0, for how to calculate battery temp. using Plant voltage differences).

### 2.3 Why a Variable BTC Offset Span

The BTC generated offset voltage can put the Plant into an alarm condition, or even take it out of service. The added or subtracted offset voltage can cause the Plant Float voltage to trip a High Voltage Alarm [HVA], a Low Voltage Alarm [LVA], or even cause a High Voltage Shut-Down [HVSD] to occur. Load equipment may also require a tighter regulation of the Plant Float voltage, than can be maintained at the widest BTC span. To prevent meaningless HVAs & LVAs from occurring, as well as unwanted HVSDs, the span of the BTC offset can be reduced from the Factory setting of  $\pm 4$  Vdc, to  $\pm 3$ ,  $\pm 2$ , or  $\pm 1$  Vdc.

#### 2.3.1 BTC Offset Span & HVSD Conflicts

If remote control of the Plant's Float voltage is ON, and the Plant's Float voltage is being driven towards the Plant's HVSD trip point, the Control PWB will stop the BTC's offsetting of the Float voltage, at 1 Vdc below the Plant's HVSD trip point, and thus preventing the BTC offset from causing an HVSD. When the Plant's Float voltage is so clamped, the Green [CNTLR OK] LED will flash a code indicating that the Plant's Float voltage is clamped. Also, if the Plant's remotely set Float voltage is within 2.5 Vdc of the Plant's HVSD trip point, the Green [CNTLR OK] LED will flash a code indicating that there is an inadequate safety margin between the two set points. Both of the above described conditions cause the Control PWB to generate a Minor Alarm.

### 2.4 BTC Offset Span Selection Criteria

In order to select the best BTC offset voltage span, consider the following:

- The temperature extremes of the location where the Plant is installed
- Temperature effects on battery reserve capacity and battery life expectancy
- The input voltage variance range that the load equipment can tolerate
- The costs of responding to nuisance alarms (caused by too wide of a BTC span)

## 2.5 BTC Offset Span Selection

The span of the BTC offset voltage is selected by changing the settings of dip switch S2, positions 1 & 2. The following table lists the four offset voltage span ranges, the temperature ranges that each covers, and the dip switch settings for each offset span range (also, see SD Drawing, sheet B3, FS4, switch-S2 table, for the dip switch settings for each offset span range).

**Table: Dip Switch S2, Positions 1 & 2, and BTC Offset Voltage Span Ranges**

BTC Span	Temperature Range Spanned		Dip Switch S2	
	Min Temp	Max Temp	Pos 1	Pos 2
±1 Vdc	58°F (14.4°C)	98°F (36.6°C)	DN	DN
±2 Vdc	38°F (3.3°C)	118°F (47.7°C)	UP	DN
±3 Vdc	18°F (-7.7°C)	138°F (58.8°C)	DN	UP
±4 Vdc	-4°F (-20°C)	158°F (70°C)	UP	UP

Legend: UP = switch toggle UP; DN = switch toggle DOWN

## 3.0 BATTERY TEMPERATURE ALARM (BTA) OPERATION

The BTA function is only active when BTC is turned ON. When BTC is ON, the higher reading of the two battery temp. sensors, and the reading from the ambient temp. sensor are used to trigger a BTA.

Whenever battery temp. or the difference between battery temp. and ambient temp. exceed the trip point of the currently active Battery Temp. Alarm mode, the following three actions occur: A Battery Temp. Alarm, and a Minor Alarm are generated, and the green [CNTLR OK] LED flashes a temperature alarm code (See Chapter 3, Section 9.0, or SD Drawing, sheet A2, Note 70, for a Table of [CNTLR OK] LED flash codes). Plants normally leave the factory with the BTA function in the Absolute mode.

### 3.1 BTA Operation Requirements

All three temp. sensors must be correctly connected to their terminal blocks on the Control PWB, and operating normally for the High Temp. Alarm to function properly. The Control PWB detects open or out of range temperature sensors. Should a temp. sensor become open circuited, or it's reading be out of range, a Minor Alarm will be generated and the Green [CNTLR OK] LED will flash a code indicating a temperature sensor problem (See Chapter 3, Section 9.0, or SD Drawing, sheet A2, Note 70, for a Table of [CNTLR OK] LED flash codes).

### 3.2 BTA Mode Selection

The BTA mode is changed by dip switch S1, position 8. With dip switch S1, position 8, UP, the BTA is in the Absolute mode (a BTA will occur only if a Battery Temp. Sensor's reading is greater than 145°F). With dip switch S1, position 8, DOWN, the BTA is in the Delta mode (a BTA will occur only if a Battery Temp. Sensor's reading is greater than 36°F above that of the Ambient Temp. Sensor).

## 4.0 EQUALIZE CHARGE MODE OPERATION

The Plant has two Equalize Charge modes; Automatic and Manual. Both modes raise the Plant output voltage above the (Plant or individual rectifier) normal "Float" voltage. Both modes also run for a duration of no longer than 10 hours at a time, thanks to a timer function on the Control PWB.

#### 4.1 Manual Equalize Charge Mode Operation

Moving dip switch S2, position 6, UP, manually places the Plant's rectifiers into their Equalize voltage mode. Manual Equalize puts the rectifiers into Equalize mode (as opposed to Automatic Equalize, which merely increases the set point of the Plant's remote voltage control signal, raising rectifier output voltage 2 volts). When Manual Equalize is enabled, a 10 hour count-down timer starts. After 10 hours, the Control PWB puts the rectifiers back into Float mode. Manual Equalize mode is also terminated if the reading of a battery temperature sensor rises more than 30°F during the charge cycle. Moving dip switch S2, position 6, DOWN, also terminates the Manual Equalize Charge mode.

#### 4.2 Automatic Equalize Charge Mode Operation

Moving dip switch S2, position 5, UP, places the Plant in Automatic Equalize mode. The Control PWB only initiates an Equalize charge cycle if the batteries become deeply discharged during a power outage. The following sequence of events occurs when the Control PWB is in the process of determining if an Equalize charge cycle is necessary or not.

**State 0:**

The Plant confirms an ac power outage by detecting an RFA from each installed rectifier. During the resulting battery discharge cycle, the Control PWB monitors the discharge AHs of the batteries.

**State 1:**

Ten seconds after AC power returns, the Control PWB measures the Plant Float voltage, and compares it against a trip point calculated as:  $(\text{Original Plant Float voltage} + 46.0 \text{ v})/2$ . Usually the "Ten seconds after AC power returns" measurement will be higher than the calculated trip point, unless very deep discharge has occurred.

**State 2:**

If the "Ten seconds after" measurement is lower than the calculated reference point, the Control PWB waits until the battery recharge current drops below 75% of the initial recharge value, and then begins the Equalize Charge cycle. The Control PWB then puts the Equalize Charge mode into state 4. If the "Ten seconds after" measurement is higher than the calculated reference point, the Control PWB puts the Equalize Charge mode into state 3.

**State 3:**

Normal Float mode. The Plant remains in this mode until another ac power outage starts the sequence all over again.

**State 4:**

A Ten hour Equalize charge cycle is started, and the Plant's output voltage is raised 2 Vdc above the normal, remotely set Plant Float voltage. The cycle ends by battery recharge current dropping below 1.5 Adc, the batteries over heating, another incident of ac power loss, or after ten hours has elapsed.

### 5.0 PLANT VOLTAGE REMOTE CONTROL OPERATION

Moving dip switch S2, position 4, UP, into the ON state, puts the output voltage, of all rectifiers installed in the Plant, under the control of the Remote Control pot (R60), located on the Control PWB. Moving dip switch S2, position 4, DOWN, into the OFF state, puts the output voltage, of all rectifiers installed in the Plant, under the control of their own FLT control pots.

## 6.0 BATTERY SLEEP MODE OPERATION

Moving dip switch S3, position 1, UP, into the ON state, puts the Plant into “Sleep Mode”. When active, the Control PWB reduces the remotely set Plant Float voltage to  $-52.0$  volts ( $\pm$  BTC), for 2 days per week. Should a battery discharge occur, the periodic Sleep mode function is disabled until the batteries have fully recovered their charge. An additional safeguard puts the batteries into Sleep Mode whenever the battery temperature rises above 95°F.

## 7.0 MISCELLANEOUS FUNCTIONS OPERATION

### 7.1 LVA & HVA Trip Points

The Low Voltage Alarm (LVA) trip point is fixed at  $-51.5$  Vdc,  $\pm 0.25$  Vdc. The high Voltage Alarm (HVA) trip point, is set by the Control PWB, at 1 Vdc less than the HVSD trip point, plus the BTC offset voltage. These trip points are not user alterable. Both alarm conditions are indicated by coded flashes of the Green [CNTLR OK] LED. A Major Alarm also accompanies an LVA or an HVA.

### 7.2 HVSD Trip Point

If the Plant voltage exceeds the HVSD trip point, an HVSD command is sent to the rectifiers.

#### 7.2.1 HVSD Trip Point Selection

The Plant HVSD trip point is selected using dip switch S1, positions 5, 6, and 7. It can be set, in  $\frac{1}{2}$  volt steps, from a low of  $-56$  Vdc to a high of  $-59.5$  Vdc. The Factory set HVSD trip point is  $-57.5$  Vdc. The following table lists the Plant’s HVSD trip points, and the dip switch settings for each (also, see SD Drawing, sheet B3, FS4, switch-S1 table, for the dip switch settings for the HVSD trip point).

**Table: Dip Switch S1, Positions 5, 6, & 7 and HVSD Trip Point Voltages**

<b>HVSD Voltage</b>	<b>56</b>	<b>56. 5</b>	<b>57</b>	<b>57. 5</b>	<b>58</b>	<b>58. 5</b>	<b>59</b>	<b>59. 5</b>
<b>S1, Position 5</b>	D N	UP	D N	UP	D N	UP	D N	UP
<b>S1, Position 6</b>	D N	DN	UP	UP	D N	DN	UP	UP
<b>S1, Position 7</b>	D N	DN	D N	DN	UP	UP	UP	UP

Legend: UP = switch toggle in the UP position; DN = switch toggle in the DOWN position

#### 7.2.2 HVSD & Float Voltage Proximity Conflicts

If a Plant HVSD trip point is selected, that is within 2.5 Vdc of the remotely set Plant Float voltage, the Green [CNTLR OK] LED will flash a code indicating an inadequate safety margin between the two points. The currently selected BTC span is used to determine if the safety margin is adequate.

### 7.2.3 Effects of an HVSD Occurrence

If an HVSD event occurs, only rectifiers delivering more than 0.75 Adc will be shut down. The Control PWB will also generate a Restart (RS) when the Plant voltage drops below -52.0 volts. The Restart is give for one reason: To put all functional rectifiers back into service. Good, working rectifiers will be shut down by a Plant generated HVSD, if they are sourcing more than 0.75 Adc. This can occur, if the source of the high voltage was external to the Plant. A rectifier in HVSD will have it's red RFA LED lit, and will have a code flashing on it's green "NORM" LED, indicating the type (internal or external) of HVSD. The Plant also generates a Major Alarm when an HVSD occurs.

### 7.2.4 Reviving Shut-Down Rectifiers

Rectifiers, of revision 4 and lower, can only be revived from an HVSD, by cycling the AC power to them OFF, and then ON again, or by disconnecting each rectifier from the Plant's Motherboard momentarily, and then plugging it back in. A rectifier, of revision 5 and higher, can also be revived from an HVSD, by flipping it's toggle switch DOWN, into the OFF position, and leaving it OFF for at least ten seconds, and then flipping it back UP, into the ON position.

## 7.3 Battery FAIL Alarm Operation

The control PWB uses the actual discharge and recharge AHs to determine the state of the batteries. The recharge AHs are compared to the discharge AHs + 40% (of the discharge AHs). If the recharge AHs are more than 40% above the discharge AHs, a BATTERY FAIL Alarm is generated, and displayed as a series of coded flashes on the Green [CNTLR OK] LED.

## 7.4 Alarm Operation Overview

Alarms only serve to communicate trouble information. No alarm affects Plant operation. Following are lists of what criteria cause the various alarms to be generated.

### 7.4.1 Major Alarm Criteria

- > one rectifier fails [RFA] (If only one rectifier is installed, a single RFA causes a Major Alarm)
- Plant voltage drops below the LVA trip point, -51.5 Vdc
- Plant voltage rises above the HVA trip point, (1 Vdc < the Plant HVSD trip point)
- A GMT (Distribution) fuse opens [FA]
- A low voltage disconnect [LVD] occurs
- The Plant Control PWB fails

### 7.4.2 Minor Alarm Criteria

- A single rectifier fails [RFA]
- A high battery temperature [HIGH TEMP] Alarm occurs
- The Plant's LVD function is in the TEST mode
- Plant voltage is clamped to prevent an HVSD
- HVSD is set too low, & is within the BTC offset's voltage span
- A temperature sensor is open or out of range

### 7.4.3 Other Alarm Criteria

- |              |                 |  |
|--------------|-----------------|--|
| • LVD        | (List 3 & 4)    | Plant Voltage is < LVD trip point, or LVD is in FIXED OFF mode |
| • High Temp. | (List 3 & 4)    | Battery Temp. has exceeded 145°F, or is > 36°F over ambient    |
| • Fuse [FA]  | (List 2, 3 & 4) | A GMT (distribution) fuse has opened                           |
| • RFA        | (List 2, 3 & 4) | A rectifier is not working properly, and has generated an RFA  |

## 7.5 Alarm Remote Reporting Hardware

There are two form-C contacts for List 2 Plants and four additional form C contacts for List 3 & 4 Plants. All form C Alarm output relay contacts are rated for 0.5 Adc @ 60 Vdc. All remote alarm contact outputs connect to three position terminal blocks that have polarized plug-in wire clamp sections which can be unplugged for wiring ease.

All alarm relay pin-outs for Common (C ), Normally Closed (NC), and Normally Open (NO) reflect the normal non-energized state. As a fail safe precaution the normally energized Major and Battery Disconnect Alarm relays will still generate an alarm in the event of a total power loss.

## 8.0 CIRCUIT BOARD (PWB) LOCATIONS WITHIN THE PLANT

### 8.1 The Control PWB, A3

The Control PWB, A3, slides into a pair of card guides, located on the top side of the Plant's Distribution Bay. It seats into a 50 pin edge connector on the Motherboard PWB, A1. The three temperature sensors connect to terminal blocks on this board, which are located along it's right side edge, when it is properly installed in it's normal horizontal position (it goes into the Plant upside down, with it's component side of the board facing down into the Distribution Bay). The terminal blocks for connecting to the Major, Minor, LVD, and High Temperature Alarm output relays are also located on the right side of this board.

**WARNING: Do NOT attempt to install the Control PWB component side up!**

The user interface dip switches S1, S2 & S3, the remote Float voltage adjust pot (R60), and the Green [CNTLR OK] LED are located on the front edge of this PWB.

### 8.2 The Distribution PWB, A2

The Distribution PWB, A2, slides into a pair of card guides, located on the left side wall of the Plant's Distribution Bay. It also seats into a 50 pin edge connector on the Motherboard PWB, A1. It is installed in a vertical orientation, near the Control PWB, A3.

### 8.3 The Motherboard PWB, A1

The Motherboard, A1, is mounted across the back of the cabinet. It connects the rectifiers, the Distribution PWB, and the Control PWB. The AC input power connection comes factory terminated to the Motherboard. A dual three position terminal block, located near the right end of the motherboard provides Ground and Battery connections for List 1 Plants, and an MGB connection spot.

## 9.0 PLANT PERFORMANCE MONITORING, STATUS INDICATION, AND DEFAULT SETTINGS

### 9.1 Plant Voltage and Current Monitoring

List 2, 3, and 4 Plants have front accessible test jacks, which are mounted on the Distribution PWB. Plant voltage is measured across the battery input buss bars on the Distribution PWB; accuracy =  $\pm 0.5\%$ . The Plant and battery shunts read 50 mV @ 20A. Plant and battery current measurements are direct readings across PWB mounted shunts, which are located on the Distribution PWB; accuracy =  $\pm 1\%$ . Each rectifier has a pair of test jacks that monitor it's output current [10A @ 50 mV]; accuracy =  $\pm 1\%$ .

9.2 Control PWB Green [CNTLR OK] LED Status & Trouble Codes

The Green [CNTLR OK] LED displays a number of alarm and status codes using short and long flash combinations. The coded flashes are arranged in priority of display. The highest priority code will always be displayed continuously until the event that triggered that code is no longer true. Once the highest priority code is cleared, the next highest priority code will be displayed, and so on. Using a single LED for so many codes made groupings necessary, so the codes have been arranged into related groups: the Equalize charge mode, operating temperature conditions, and Plant issues. Although some of the priorities may seem out of order, many of the codes will rarely, if ever occur.

**Table: Green [CNTLR OK] LED Status & Trouble Codes**

Grouping	Priority	Flashes		Status or Trouble CODE Description
		Long	Short	
Equalize Mode	1	2		Plant is in a Manual or Automatic Equalize charge cycle
Temp. condition	2	1		Temperature sensor missing or out of range
Temp. condition	3	1	1	Temperature compensation requires a range > selected span
Temp. condition	4	1	2	Temperature Delta > 36°F
Temp. condition	4	1	3	Battery temperature > 145°F
Temp. condition	5	1	4	Battery over-heated during Equalize (>20°F over ambient)
Plant Issue	6		3	The Plant's sleep mode is active
Plant Issue	7		1	Low Voltage Alarm: (LVA) Plant voltage < -51.5 volts
Plant Issue	8		2	High Voltage Alarm: (HVA) Plant voltage > HVSD trip pt, -1 Vdc
Plant Issue	9		4	HVSD set too low: Plant voltage within 2.5 volts of HVSD trip pt.
Plant Issue	10		5	Plant Voltage Clamped to avoid Temp. Comp. caused HVSD
Plant Issue	11	2	1	Battery fail: Recharge AH > 140% of Discharge AH
Plant Issue	12	2	2	Test mode: Test mode selected with dip switch S2-7 & 8 ON

9.3 Dip Switch Default Settings

The following table shows the dip switches on the Control PWB, A3, as they are set when shipped from the factory. This is how the switches are seen, when viewed looking in from the front of the Plant, with the Control PWB properly installed in its designated slot. The default switch settings are also depicted on a label, located on the inside of the Plant's front door.

**Table: Dip Switch S1, S2 & S3 Default Settings**

O	O	O	O		O	O	O	O	O	O	O	O		O	O	O	O	O	O	O	
F	F	F	F		F	F	F	F	N	N	N	N		N	F	N	N	F	N	N	
F	F	F	F		F	F	F	F						F	F			F			
4	3	2	1		8	7	6	5	4	3	2	1		8	7	6	5	4	3	2	1
<b>DIP SW S3</b>					<b>DIP SWITCH (BANK) S2</b>								<b>DIP SWITCH (BANK) S1</b>								

The majority of dip switch changes will not immediately affect Plant operation. Changing from local to remote Float voltage adjustment (S2-4) could cause a large immediate change in the Float voltage, depending on the setting of the remote voltage adjustment potentiometer.

**WARNING: Moving dip switch S2, position 8, UP, to the ON state, will immediately disconnect the LVD relay, resulting in a load or battery disconnect.**

Always verify you are flipping the correct switch position before changing a dip switch setting.

## 9.4 Verifying Temperature Sensors and Alarms

To verify a High temperature Alarm trip point and the correct operation of the temperature sensors, one sensor will be removed from the battery bank and heated until an over temperature alarm is generated. Then, one sensor will be unplugged to verify that an open sensor can be detected.

### 9.4.1 Temperature Sensor Operation Verification

#### PROCEDURE

1. Ensure that all three sensors are properly connected to the Plant (see Chapter 2, section 4.5.2, Temperature Sensors), and that the Plant is operating normally (no load is necessary for this test).

**WARNING: Shorting a sensor's blue and red leads may damage it, so don't do it!**

2. Measure (with a DVM on mV range) across the blue and black wires of each sensor, and record it's reading.

**NOTE:** The reading for each sensor should be within a reasonable range (10 mV/°F), considering the temperature of the site (the sensors have an accuracy of  $\pm 2$  °F, and a slow thermal response).

3. Put the Plant into the Delta temperature Alarm mode; move dip switch S1, position 8, DOWN.

**WARNING: Do NOT heat the temperature sensor with a flame (you are near a VRLA battery bank) !**

4. Remove a battery temperature sensor from the battery bank, start heating it, and watch for the Plant's Major Alarm LED to light up.

5. When the Major Alarm LED lights up, stop heating the sensor, and measure across it's blue and black wires.

**NOTE:** The reading should be within 250 to 550 mV higher than that of the ambient temperature sensor, and the Green [CNTLR OK] LED should flash a Delta High Temp. Alarm (1 Long & 2 short flashes).

6. Set the sensor down on a cool surface. When the Major Alarm LED goes out and the Green [CNTLR OK] LED stops flashing the Delta code, take another measurement across the sensor's blue and black wires.

**NOTE:** The reading should be less than 250 mV higher than that of the ambient temperature sensor.

7. Reconnect the sensor to the battery bank, and then unplug it's terminal block plug-in connector.

8. Verify that the Green [CNTLR OK] LED flashes a temp. sensor missing code (1 long flash).

9. Plug the sensor's plug-in connector back into it's receptacle.

End of Procedure

## CHAPTER FOUR: TROUBLESHOOTING

Most of the Plant problems that may occur, will be detected by the microcontroller on the Control PWB, A3, and reported by the board's green [CNTLR OK] LED. It displays a number of alarm and status codes using short and long flash combinations. The coded flashes are arranged in priority of display. The highest priority code will always be displayed continuously until the event that triggered that code is no longer true.

Once the highest priority code is cleared, the next highest priority code will display, and so on, until all codes are cleared. Although some of the priorities may seem out of order, many of the codes are unlikely to occur.

**Table: Green [CNTLR OK] LED Status & Trouble Codes**

Grouping	Priority	Flashes		Status or Trouble CODE Description
		Long	Short	
<b>Equalize Mode</b>	1	2		Plant is in a Manual or Automatic Equalize charge cycle
<b>Temp. condition</b>	2	1		Temperature sensor missing or out of range
<b>Temp. condition</b>	3	1	1	Temperature compensation requires a range > selected span
<b>Temp. condition</b>	4	1	2	Temperature Delta > 36°F
<b>Temp. condition</b>	4	1	3	Battery temperature > 145°F
<b>Temp. condition</b>	5	1	4	Battery over-heated during Equalize (>20°F over ambient)
<b>Plant Issue</b>	6		3	The Plant's sleep mode is active
<b>Plant Issue</b>	7		1	Low Voltage Alarm: (LVA) Plant voltage < -51.5 volts
<b>Plant Issue</b>	8		2	High Voltage Alarm: (HVA) Plant voltage > HVSD trip pt, -1 Vdc
<b>Plant Issue</b>	9		4	HVSD set too low: Plant voltage within 2.5 volts of HVSD trip pt.
<b>Plant Issue</b>	10		5	Plant Voltage Clamped to avoid Temp. Comp. caused HVSD
<b>Plant Issue</b>	11	2	1	Battery fail: Recharge AH > 140% of Discharge AH
<b>Plant Issue</b>	12	2	2	Test mode: Test mode selected with dip switch S2-7 & 8 ON

Most of the rectifier problems that may occur, will be detected by the microcontroller in the rectifier, and reported through the unit's green [NORM] LED. The green [NORM] LED conveys the nature of the problem, using short and long flash combinations. The coded flashes are arranged in priority of display. The highest priority code is displayed continuously until the event that triggered that code is no longer true. Once the highest priority code is cleared, the next highest priority code will be displayed, and so on.

**Table: Rectifier [NORM] LED Coded Flash Message Legend**

Flashes		Coded Flash Messages & Their Problem or Status Indication Descriptions	
Long	Short	Coded Flash Message	Problem or Status Indication Description
	<b>1</b>	Low Output Current	Output Current below 0.375 Adc
	<b>2</b>	Internal HVSD	Occurs if V dc out > -61 Vdc, or 3 Vdc > set point
	<b>3</b>	AC Line Sag	When line should be 208-240 Vac, shows line is < 187 Vac
	<b>4</b>	Over Temperature	Occurs when internal heat sink temp > 110 °C
<b>1</b>	<b>1</b>	Rem. Control "out of range"	Voltage across REM. CNTRL. inputs > ± 2 Vdc (The rectifier's FLOAT pot is setting it's output voltage)
<b>1</b>	<b>2</b>	Load Share "out of range"	Voltage across LS inputs > ± 2 Vdc; Load Sharing inactive
<b>1</b>	<b>3</b>	Over Temp./ I out derated	Ambient Temperature > +65 °C; rectifier I out limit derated
<b>1</b>		Low Air Flow	Occurs when heat sink to ambient Δ > 30% over normal
<b>2</b>		External HVSD	The Plant has placed the rectifier into HVSD mode

The following table shows the dip switches on the Control PWB, A3, as they are set when shipped from the factory. This is how the switches are seen, when viewed looking in from the front of the Plant, with the Control PWB properly installed in it's designated slot. The default switch settings are also depicted on a label, located on the inside of the Plant's front door.

**Table: Dip Switch S1, S2 & S3 Default Settings**

O	O	O	O		O	O	O	O	O	O	O	O		O	O	O	O	O	O	O	
F	F	F	F		F	F	F	F	N	N	N	N		N	F	N	N	F	N	N	N
F	F	F	F		F	F	F	F						F	F			F			
4	3	2	1		8	7	6	5	4	3	2	1		8	7	6	5	4	3	2	1
<b>DIP SW S3</b>					<b>DIP SWITCH (BANK) S2</b>									<b>DIP SWITCH (BANK) S1</b>							

## CHAPTER FIVE: MAINTENANCE

Perform the following maintenance procedure twice a year:

### PROCEDURE

1. Open the front door of the Plant and visually inspect for signs of overheating or arcing.
2. Check all mechanical connections, and tighten any that are noticeably loose.
3. Verify that all rectifiers are on-line and operating normally with no alarms indicated.
4. Verify that the Plant voltage is set correctly.
5. Measure the current shunts (at the test jacks on each rectifier) and divide each one by 5.

**NOTE:** Each rectifier's current reading should be within  $\pm 5\text{mv}$  (or  $\pm 1\text{A dc}$ ) of each other.

6. If the load on the Plant allows, remove each rectifier one at a time, and use low pressure air to remove all accumulated dust and debris from the rectifiers.
7. Check all Control PWB dip switch settings, and verify that they are correctly set.
8. Swap all spare rectifiers into service, taking out those that have been in service the longest.

## CHAPTER SIX: SPARE PARTS

- (1) We recommend that a Control PWB be stocked as a spare: P/N 306-2923-04
- (2) We recommend that at least one modular rectifier be stocked as a spare:  
-48v/7.5A P/N 100-7507-48
- (3) We recommend that various GMT fuses be stocked as spares:
- |       |                 |
|-------|-----------------|
| 0.50A | P/N 280-0700-00 |
| 1.0A  | P/N 280-0710-00 |
| 2.0A  | P/N 280-0735-00 |
| 3.0A  | P/N 280-0760-00 |
| 5.0A  | P/N 280-0740-00 |
| 7.5A  | P/N 280-0750-00 |
| 10A   | P/N 280-0770-00 |
| Dummy | P/N 276-0001-00 |
- (4) We recommend that an LVD relay be stocked as a spare: P/N 245-0114-00