

***Product Manual
J85501H-1***

***167-792-170
Comcode 108030354
Issue 3
November 1997***

Lucent Technologies Galaxy Rectifier Controller

Notice:

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

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1 Introduction

General Information

This product manual describes the Lucent Technologies Galaxy RC (Rectifier Controller). This controller, furnished as an integral part of various Lucent Technologies GPS (Galaxy Power System) series power plants, provides control and alarm functionality over a digital serial interface to the plant rectifiers and converters. This control includes the setting of converter output voltage, rectifier output voltage, current limit, high voltage shutdown, rectifier restart, sequencing and boost mode. This serial digital interface system automates the installation and setup process, eliminating the need to use potentiometers to separately set individual rectifier and converter output voltage levels.

Lucent Technologies rectifiers which currently can interface with the Galaxy RC via this state of the art digital serial interface bus include the Model 596A -48V, 50A; Model 596B +24V, 100A; Model 570A -48V, 100A; Model 595A -48V, 200A, and Model 595B -48V, 200A. Note that not all of these rectifiers support the complete feature set available through the Galaxy RC. For example, a Phase alarm would not be an intelligent piece of information on a single phase rectifier. Refer to the respective rectifier product manual for a complete listing of rectifier features available for a particular model.

The rectifiers and converters are connected to the Galaxy RC using a digital serial bus. The rectifier and converter voltage set points, rectifier load share, high voltage shutdown threshold, boost mode, and low voltage disconnect commands are sent via this bus.

Converter, rectifier and plant alarms are forwarded to the user through a front panel user display interface and to the user's alarm system through a set of Form C or transfer type contacts

for power major and power minor indications. An optional Enhanced Relay board provides additional detailed alarm functionality for those users requiring more than the basic major and minor alarm information.

The topics covered in this manual include general description of the basic features and options, operation, installation and configuration, acceptance testing, troubleshooting, and repair. Related product manuals for the GPS series power plants, rectifiers and batteries provide similar information for those products.

Technical Support

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

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

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

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

Central and South America

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

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

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

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

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East, and Africa***

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

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

2 *Product Description*

System Overview

A typical block diagram of the Galaxy Power System is shown in Figure 2-1. It illustrates the arrangement and interconnections of the system components from the ac input to the dc output. The power system accepts alternating current from a commercial utility or a standby ac power source and rectifies it to produce dc power for the using equipment. The system's control and alarm functions interact with the rectifiers and the office. In addition, the system provides overcurrent protection and charge, discharge, and distribution facilities. Battery reserve automatically provides a source of dc power if the commercial or standby ac fails. Battery reserve can be engineered to supply dc power for a specific period of time. In normal practice, battery capacity is sized to provide 3 to 8 hours of reserve time.

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

Rectifiers convert an ac source voltage into the 24-volt dc voltage required to charge and float the batteries and to power the plant converters and the using equipment.

Converters convert the 24-volt dc rectifier output into -48-volt dc voltage required to power the using equipment.

Controller provides the local and remote control, monitoring, and diagnostic functions required to administer the power system.

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

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

Battery Connection Module provides connection points for the battery strings through a contactor and current monitoring shunt.

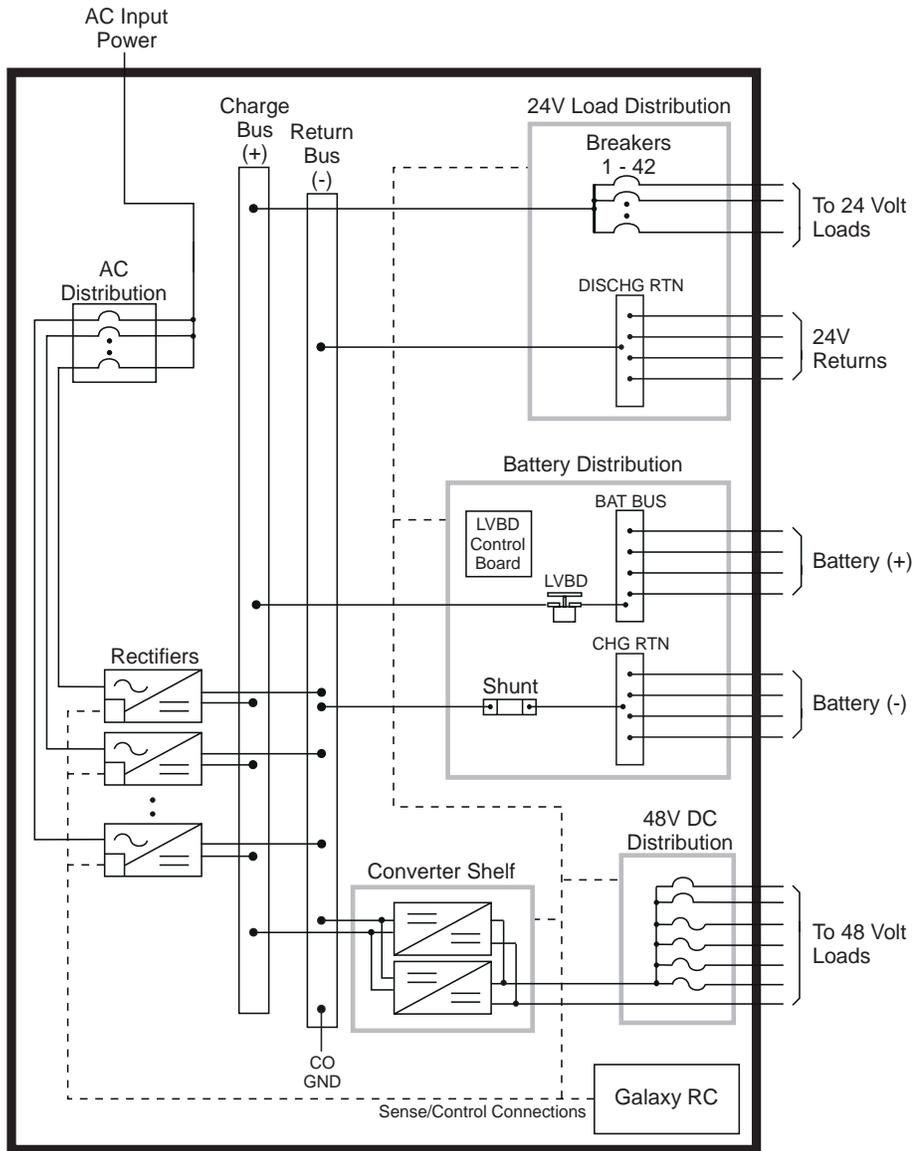


Figure 2-1: Block Diagram of a Typical Galaxy Power System

The **Galaxy Rectifier Controller** is mounted on the inside front door of a GPS plant with the control panel visible on the front of the door. See Figure 2-2.

The Galaxy Rectifier Controller (Galaxy RC) provides the GPS plants with a wide range of control and monitoring features. The basic controller consists of a BMY Control Board and a BMW Control Panel. These boards are mounted independently within the plant enclosure in a manner defined in the particular GPS series plant documentation. The controller issues only Power Major (PMJ) and Power Minor (PMN) office alarms off the BMY Control Board TB1. The controller can be supplemented with a BMU Enhanced Relay Board to provide two additional PMJ alarms, two additional PMN alarms, and twelve other discrete alarms.

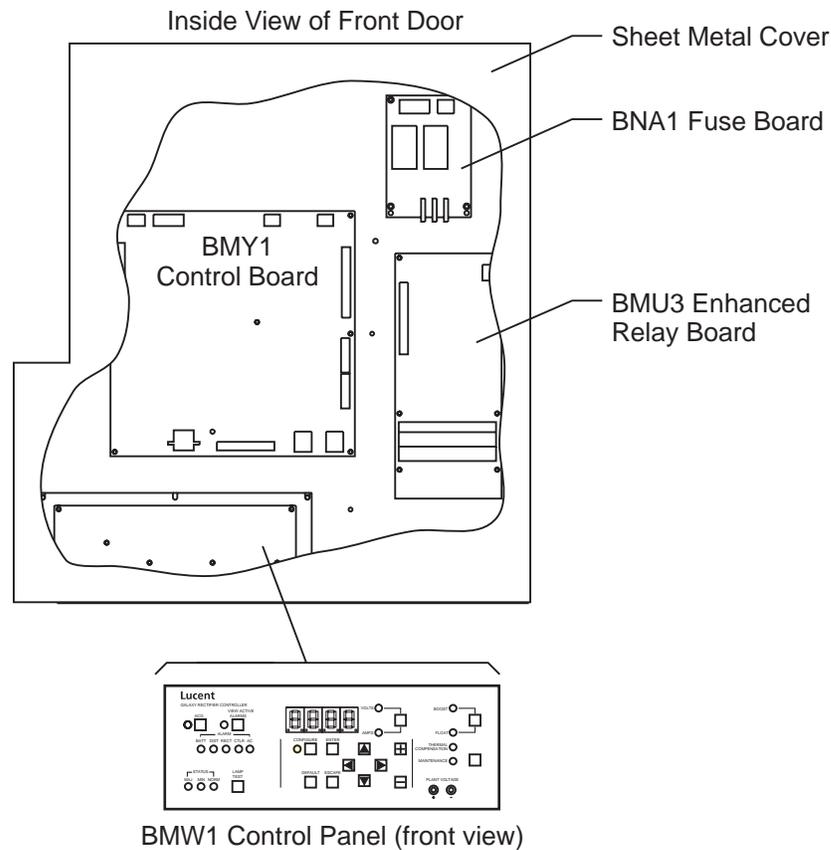


Figure 2-2: Galaxy Rectifier Controller in a typical GPS plant

Galaxy Rectifier Controller

Refer to Figure 2-3 for the Galaxy Rectifier Controller block diagram. The basic controller consists of a BMY Control Board and a BMW Control Panel. These boards are mounted independently within the plant enclosure in a manner defined in the particular GPS series plant documentation.

BMY Control Board Refer to Figure 2-4 for a view of the BMY Control Board. Each input/output port of the BMY is defined and explained below with the required user information.

P1: 34 pin ribbon cable for interface through port P1 of the optional BMU Enhanced Relay Board.

P2: 26 pin ribbon cable for interface through port P1 of the BMW Control Panel.

P3: 12 pin jack for plant interface power and alarm inputs. This port is typically factory wired for the particular GPS series plant application, but its leads may need to be accessed as plant features change.

Table 2-A: P3 Plant Interface Power and Alarm Input Wiring

P3 Pos	Designation	Description
1	PWR+	Input Power + (Fused externally at 1 1/3A if + plant)
2		
3	DG2	Disch Grd 2 - (Non-current carrying ground reference)
4	SH2+	+ Shunt Reference for Plant Shunt 2
5	Vsense+	+ Voltage Sense
6	SH1+	+ Shunt Reference for Plant Shunt 1
7	PWR -	Input Power - (Fused externally at 1 1/3A if - plant)
8	MJF IN	Major Fuse Alarm input signal. Resistive bat on alarm.
9	DG	Disch Grd - Return for signals referenced to battery.
10	SH2 -	- Shunt Reference for Plant Shunt 2
11	Vsense -	- Voltage Sense
12	SH1-	- Shunt Reference for Plant Shunt 1

P4: 6 pin jack to an optional LVD1 contactor driver circuit. P5 is the same for an optional second LVD2 contactor driver circuit. Refer to the respective GPS series plant product manual for additional information regarding these circuits.

Table 2-B: P4/5 LVD Contactor Driver Circuit Wiring

P4/5 Pos	Designation	Description
1	LVD O	LVD Open. Closure to driver circuit Opens contactor.
2	LVD R	LVD Return
3	LVD C	LVD Closed. Closure to driver circuit Closes contactor.
4	LVD State	Signal from driver circuit indicating open/close state.
5		
6		

P6: 10 pin jack for connection to the optional CU216A battery thermal compensation modules. Up to five CU216A modules can be daisy-chained off this port to provide thermal compensation for up to 20 strings of sealed batteries. Refer to this product's documentation for information on its wiring and installation.

P7 to P9: Factory test jacks. Not used after factory test.

Caution: Do not plug the rectifier digital serial cable into P7 to P9.

J1/J2: 8 pin jacks for the digital serial interface bus. J1 and J2 are in parallel and can both be used if the plant rectifiers are physically disbursed.

J3: 9 pin female D-sub connector RS-232 DCE port for field upgrade access to the Flash PROM software. Access to this port is 9600 baud, N-8-1. DTR is used to indicate that a terminal or PC is connected to J3. When DTR is connected, the J1/J2 serial interface bus is disabled and the Galaxy Rectifier Controller is in maintenance mode. Communication to rectifiers and converters will be lost temporarily.

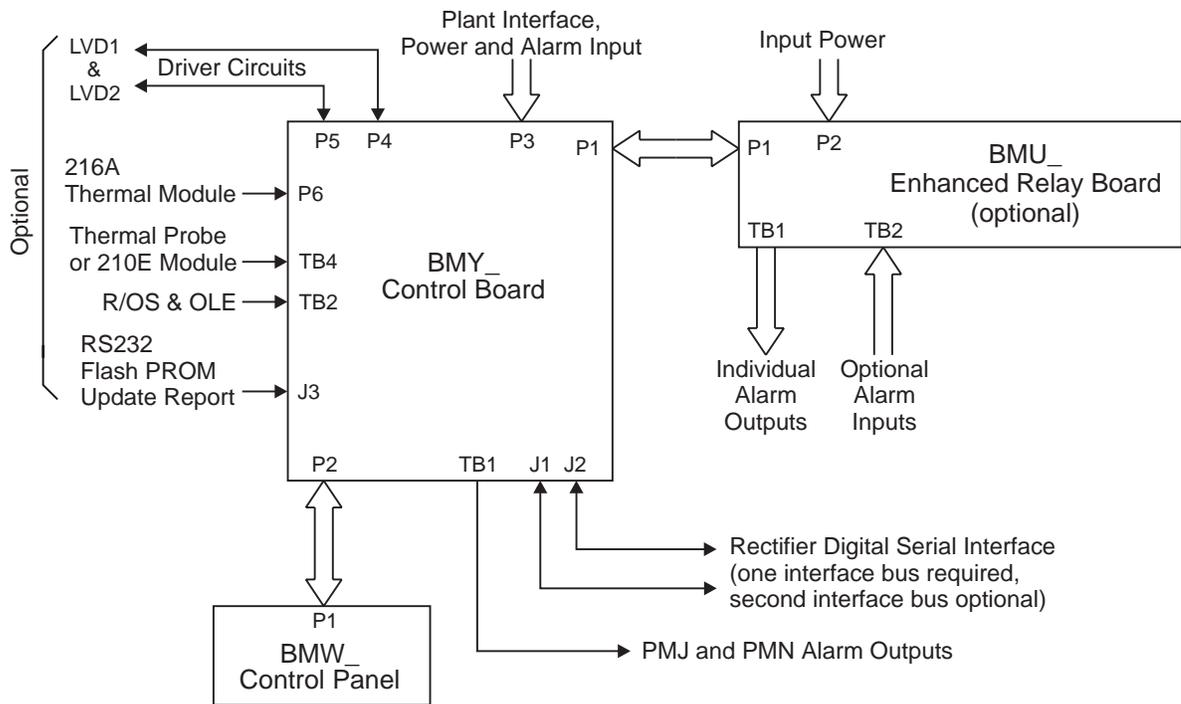


Figure 2-3: Galaxy Rectifier Controller block diagram

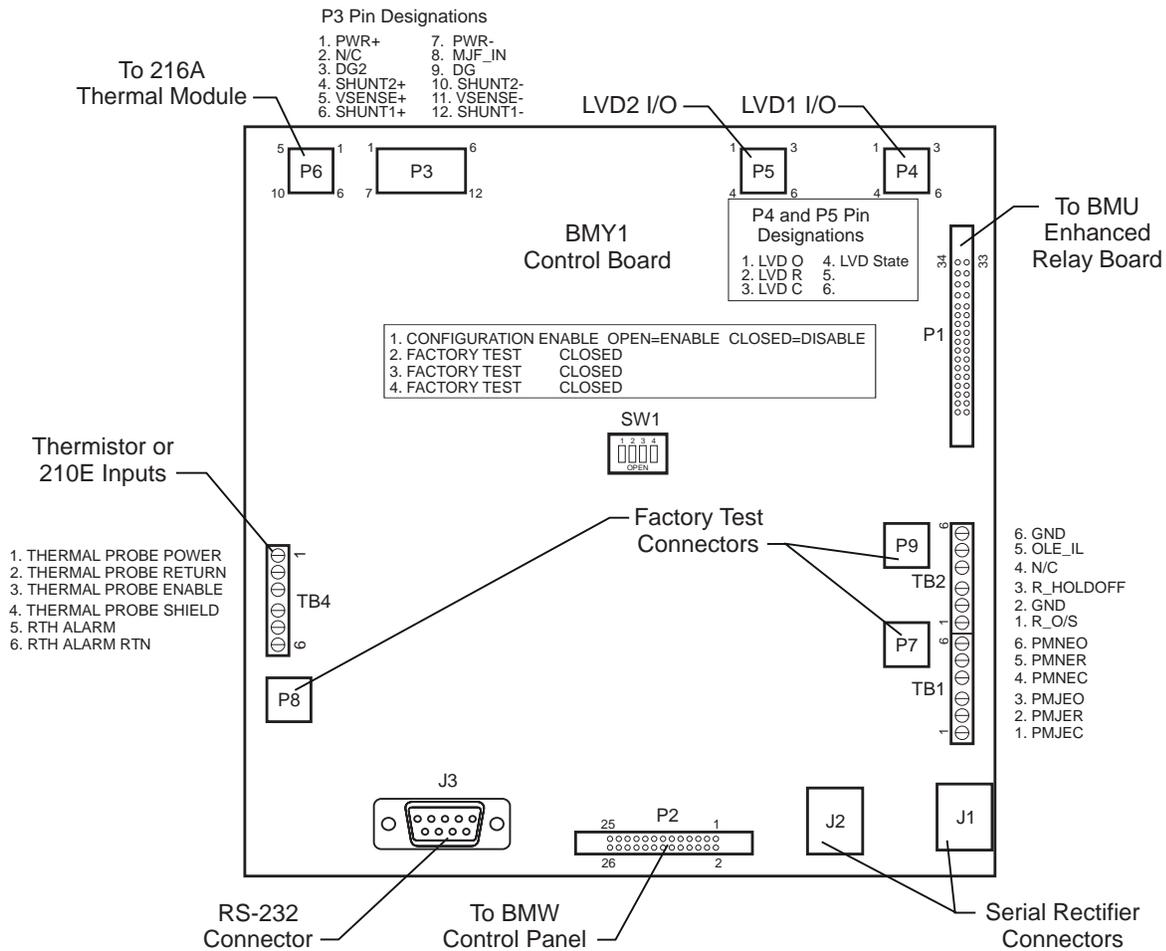


Figure 2-4: BMY Control Board

Table 2-C: RS232 DCE Port Wiring

J3 Pos	Designation	Description
2	TXD	Transmit
3	RXD	Receive
4	DTR	Data Terminal Ready
5	Grd	Ground

TB1: 6 position Terminal Block for user interface to the Power Major and Power Minor alarm relay contacts. All user output relays are isolated Form-C or transfer type, a combination of

normally open and normally closed contacts with the middle or return contact in common. The de-energized state of these relays is the alarm state, with an alarm condition resulting in a closure of the normally closed contact to the return contact and opening of the normally open contact to the return contact.

Table 2-D: TB1 Power Major/Power Minor Alarm Relay Wiring

TB1 Pos	Designation	Description
1	PMJEC	Power Major (Closed on Alarm)
2	PMJER	Power Major Return
3	PMJEO	Power Major (Open on Alarm)
4	PMNEC	Power Minor (Closed on Alarm)
5	PMNER	Power Minor Return
6	PMNEO	Power Minor (Open on Alarm)

TB2: 6 position Terminal Block for user interface for providing input signals for optional Rectifier On/Standby, Rectifier Holdoff, and Off-Line-Equalize Interlock features. Refer to the installation and configuration section of this manual for information on the use of these signals.

Table 2-E: TB2 Optional Rectifier Feature Wiring

TB2 Pos	Designation	Description
1	R O/S	Rectifier On/Standby (called ETR in earlier products)
2	GND	Ground (for R O/S, R Holdoff)
3	R Holdoff	Rectifier holdoff (called RO in earlier products)
4		
5	OLE IL	Off-line Equalize Interlock
6	GND	Ground (for Off-line Equalize Interlock)

TB4: 6 position Terminal Block for user interface to an optional thermistorthermistor or 210E thermal probe expansion module system for battery thermal slope/step compensation. Refer to the appropriate portion of the installation and configuration section of this manual for more details.

Table 2-F: TB4 Optional Thermistor or Thermal Probe Wiring

TB4 Pos	Designation	Description
1	TP Pwr	Thermal Probe Power
2	TP Return	Thermal Probe Return (Signal Lead)
3	TP Enable	Thermal Probe Enable
4	TP Shield	Thermal Probe Shield
5	RTH Alarm	Thermal Probe Alarm Signal to BMY

Table 2-F: TB4 Optional Thermistor or Thermal Probe Wiring

TB4 Pos	Designation	Description
6	RTH Alarm Rtn	Ground to RTH Alarm

SW1: 4 position dip switch for enabling or disabling software features.

Table 2-G: SW1 Software Enable/Disable Wiring

SW1 Pos	Description
1	Configuration Enable - Open to allow configuration changes
2	Factory Test - Leave in Closed position
3	Factory Test - Leave in Closed position
4	Factory Test - Leave in Closed position

BMW Control Panel

Refer to Figure 2-5 for a view of the BMW Control Panel. The BMW interfaces with the BMY Control Board via a 26 pin ribbon designated J1. It provides comprehensive user interface with the Galaxy RC. It is used to view plant voltage and load, configure thresholds and parameters, view active alarms and initiate certain plant operations. This interface consists of a 4 digit, 7-segment display, 16 keys and 18 LEDs. Refer to Table 3-A and 4-A for the alarm IDs and Configuration IDs respectively which can be displayed on the 4 digit, 7-segment display. Each of the keys and LEDs is defined and explained below.

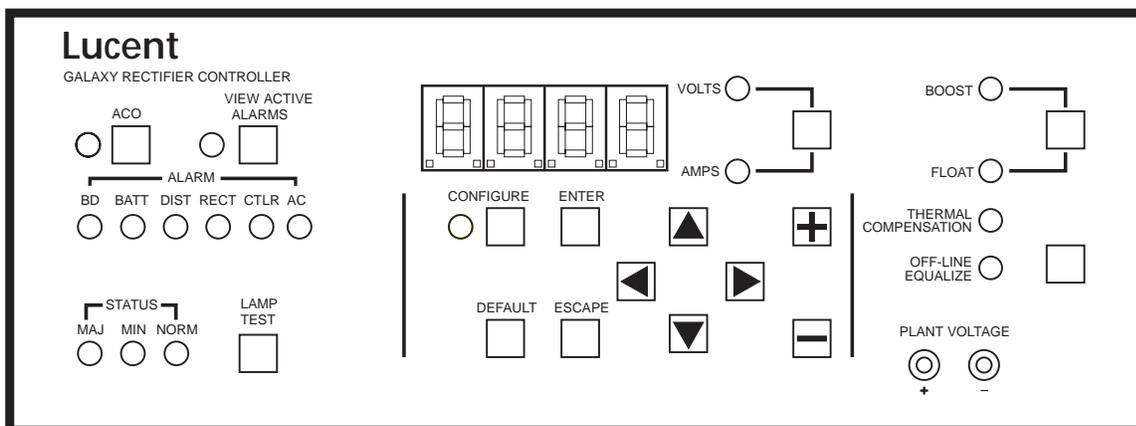


Figure 2-5: BMW Control Panel

Table 2-H: BMW Control Panel Keys and Functions

Key	Function
VOLTS/AMPS	Switch between voltage and current on the display
LAMP TEST	Causes all LEDs and display segments to activate for 10 seconds. LEDs of all equipment connected to the serial bus will also activate.
ACO	Switch among Normal, Alarm Cut Off and Maintenance modes. Affects only PMJ-A and PMN-A on the BMV Enhanced Relay Board when ACO function is selected.
FLOAT/BOOST	Switch between Float and Boost mode (when Boost is enabled).
OFF-LINE EQUALIZE	Future feature
VIEW ACTIVE ALARMS	Display active alarms. use +, -, ^, v to page through multiple alarms. Configure and View Active Alarms cannot be active simultaneously.
CONFIGURE	Enter Configuration mode. Configure and View Active Alarms cannot be active simultaneously.
ENTER	In Configure mode, accept a configuration parameter.
ESCAPE	In Configure mode, cancel configuration of a parameter.
+ or ^	In Configure mode, increment a parameter value.
- or v	In Configure mode, decrement a parameter value.
< or >	In Configure mode, select a digit to edit.
DEFAULT	In Configure mode, change a parameter to default value.

Table 2-I: BMW Control Panel LEDs and Functions

LED	Function
VOLTS	Indicates that plant voltage or converter voltage is displayed.
AMPS	Indicates that plant current or total converter current is displayed.
ACO	Indicates that Audible Alarm Cutoff is active.
THERMAL COMPENSATION	Indicates that the plant voltage has been adjusted by the Thermal Compensation feature.
FLOAT	Indicates that the plant is in Float mode.
BOOST	Indicates that the plant is in Boost mode and blinks while editing boost duration.
OFF-LINE EQUALIZE (OPTIONAL)	Future feature
VIEW ACTIVE ALARMS	Indicates Active Alarm display mode. Configure and View Active Alarms cannot be active simultaneously.
CONFIGURE	Indicates parameter configuration mode and blinks while a parameter is being viewed or edited. Configure and View Active Alarms cannot be active simultaneously.
MAJOR	Indicates that a Major alarm is active. If the MAJOR LED is lit, MINOR and NORM LEDs will not be.
MINOR	Indicates that a Minor alarm is active. If the MINOR LED is lit, there are no Major alarms active and the MAJOR and NORM LEDs will not be lit.
NORM	Indicates that no alarms are active. If the NORM LED is lit, MAJOR and MINOR LEDs will not be.
BD	Discrete alarm indicating that Battery on Discharge alarm is active.
BATT	Discrete alarm indicating that an alarm affecting the Battery is active.
DIST	Discrete alarm indicating that an alarm affecting the Distribution is active.
RECT	Discrete alarm indicating that an alarm affecting the Rectifier is active.
CTLR	Discrete alarm indicating that an alarm affecting the Controller is active.
AC	Discrete alarm indicating that an alarm affecting the AC service is active.

BMU Enhanced Relay Board

The BMU is the optional Enhanced Relay Board for the Galaxy RC. When this optional board is added to a basic system, it provides the user with a full set of office alarm contacts as well as several additional plant alarm input signals. Refer to Figure 2-6 for a view of this board and its input/output ports.

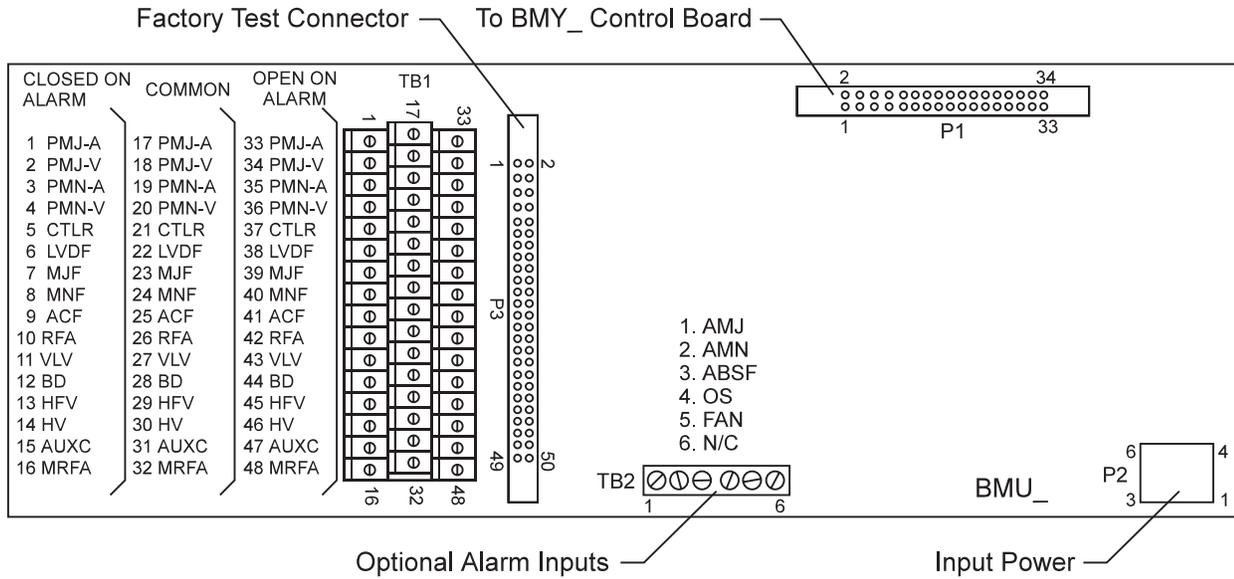


Figure 2-6: BMU Enhanced Relay Board

P1: 34 pin ribbon for interface through port P1 of the BMY Control Board.

P2: 6 pin jack for plant interface power and alarm inputs. This port is typically factory wired for the particular GPS series plant application, but its leads may need to be accessed as plant features change.

Table 2-J: P2 Plant Interface Power and Alarm Input Wiring

P2 Pos	Designation	Description
1	PWR+	Input power + (Fused externally a 1-1/3A if + plant)
2	DG	Discharge Ground
3		
4	PWR-	Input power - (Fused externally a 1-1/3A if - plant)
5		
6	FAN	Fuse Alarm Minor input signal. Resistive bat on alarm.

TB1: 48 position office alarm output Terminal Block. All 16 alarms provided here are dry contact isolated Form-C or transfer type alarms, a combination of normally open and normally closed contacts with the middle or return contact in common. The de-energized state of these relays is the alarm state, with an

alarm condition resulting in a closure of the normally closed contact to the return contact and opening of the normally open contact to the return contact. The alarms provided are:

Table 2-K: TB1 Office Alarm Output Wiring

TB1 Position (closed/ common/ open)	Designation	Description
1/17/33	PMJ-A	Power Major Audible (ACO on the BMW display retires). Also activates on a Controller Insanity signal.
2/18/34	PMJ-V	Power Major Visual. Also activates on a Controller Insanity signal.
3/19/35	PMN-A	Power Minor Audible (ACO on the BMW display retires).
4/20/36	PMN-V	Power Minor Visual.
5/21/37	CTLR	Controller Fail. This relay also activates on a Controller Insanity signal.
6/22/38	LVDF	Low Voltage Disconnect Fail
7/23/39	MJF	Major Fuse Alarm
8/24/40	MNF	Minor Fuse Alarm
9/25/41	ACF	AC Fail Alarm
10/26/42	RFA	Rectifier Fail Alarm
11/27/43	VLV	Very Low Voltage Alarm
12/28/44	BD	Battery on Discharge Alarm
13/29/45	HFV	High Float Voltage
14/30/46	HV	High Voltage
15/31/47	AUX	Converter Failure Alarm
16/32/48	MRFA	Multiple Rectifier Fail Alarm

TB2: 6 position Terminal Block for user interface for providing input signals for optional alarm inputs. Each of these inputs must provide a signal upon the desired alarm condition. Refer to Figure 2-7 and the installation and configuration section of this manual for information on the use of these signals.

Table 2-L: TB2 Input Signals for Optional Alarm Input Wiring

TB2 Pos	Designation	Description
1	AMJ	Auxiliary Major
2	AMN	Auxiliary Minor
3	ABSF	Alarm Battery Supply Fuse Fail
4	OS	Open String Alarm
5	FAN	Fuse Alarm Minor
6		

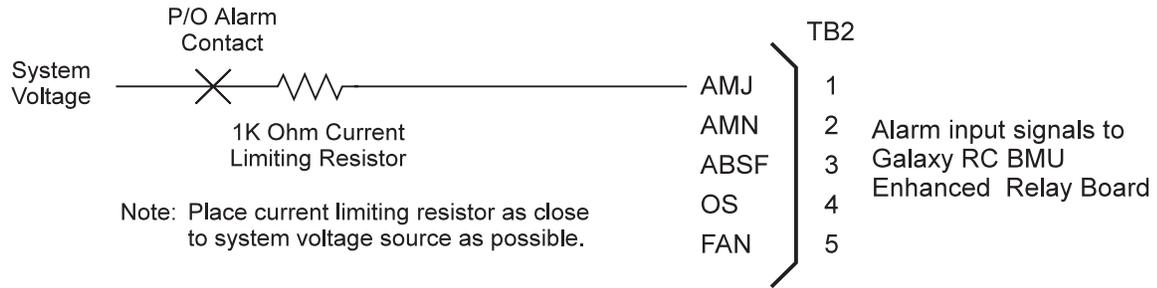


Figure 2-7: Optional alarm input wiring

3 *Operation*

Operating Voltage

The controller is powered by the plant dc voltage through the P3 plant interface jack of the BMY Control Board and the P2 plant jack of the optional BMU Enhanced Relay Board.

Batteryless Operation

The Galaxy RC is suitable for use in power plants with or without batteries. In batteryless plants, the loss of ac power causes an immediate loss of dc power to the controller and the activation of all office alarm relays. When ac power is restored, plant rectifiers will return to their last specified voltage point. The Galaxy RC will automatically return to its last configuration.

Office Alarm Contacts

All user output relays are isolated Form-C or transfer type, a combination of normally open and normally closed contacts with the middle or return contact in common. The de-energized state of these relays is the alarm state, with an alarm condition resulting in a closure of the normally closed contact to the return contact and opening of the normally open contact to the return contact. If the controller goes into an alarm state, the PMJ is active, along with the CTRLR alarm if the BMU Enhanced Relay Board is equipped.

The basic Galaxy RC issues only PMJ and PMN office alarms off the BMY Control Board TB1, as described in Section 2. When supplemented with the BMU Enhanced Relay Board, 2 additional PMJ and 2 additional PMN alarms and 12 other discreet alarms as described in Section 2 are made available. Refer to Table 3-A for a listing of the various alarms and their mnemonics which are available and the office alarm relays on the BMU Board which change state on their activation.

Table 3-A: Alarm Identification

NUM	ID	MNEM	Description	Alarm Status	BMW LED	BMU Relay
0	nonE	nonE	No Active Alarms Present	Norm	NORM	None
1	EL0	LLO	Very Low Voltage	Major	BATT	VLV
2	bod	bod	Battery on Discharge	Major	BD	BD
3	HFO	HFO	High Float Voltage	Minor	RECT	HFV
4	HO	HO	High Voltage	Major	RECT	HV
5	SEnS	SEnS	Voltage Sense Fuse Alarm	Major	CTLR	CTLR
6	ACF	ACF	AC Fail	Minor	AC	ACF
7	nACF	nACF	Multiple AC Fail	Major	AC	ACF
8	rFA	rFA	Rectifier Fail	Minor	RECT	RFA
9	nRFA	nRFA	Multiple Rectifier Fail	Major	RECT	MRFA / RFA
10	rid	rid	Invalid Rectifier ID	Major	RECT	None
11	rOFF	rOFF	Rectifier Manual Off Alarm	Minor	RECT	None
12	rHPA	rHPA	Rectifier Half Power Alarm	Minor	RECT	None
13	rPHA	rPHA	Rectifier Phase Alarm	Minor	AC	None
14	rOS	rOS	Rectifier On Standby Due To Engine Transfer	Minor	RECT	None
15	EtO	EtO	Engine Time Out	Minor	AC	None
16	CFA	CFA	Converter Fail	Minor	RECT	AUX
17	nCFA	nCFA	Multiple Converter Fail	Major	RECT	AUX
18	Cid	Cid	Invalid Converter ID	Major	RECT	None
19	CdSt	CdSt	Converter Distribution Alarm	Major	DIST	MJF
20	FAJ	FAJ	Major Fuse	Major	DIST	MJF
21	FAn	FAn	Minor Fuse	Minor	DIST	MNF
22	AUJ	AUJ	Auxiliary Major	Major	None	None
23	AUn	AUn	Auxiliary Minor	Minor	None	None
24	Abs	Abs	Alarm Battery Source Fuse Alarm	Major	CTLR	CTLR
25	OS	OS	Open String	Minor	BATT	None
26	C1O	C1O	Contact 1 Open	Minor	None	None
27	C1F	C1F	Contact 1 Failed	Minor	None	LVDF
28	C2O	C2O	Contact 2 Open	Minor	None	None
29	C2F	C2F	Contact 2 Failed	Minor	None	LVDF
30	btA	btA	Battery Thermal Alarm	Major	BATT	None
31	tPA	tPA	Temperature Probe Failure	Minor	CTLR	CTLR
32	Erc	Erc	Enhanced RC Failure	Major	CTLR	CTLR

Alarm Descriptions

A mnemonic abbreviation (MNEM) for each alarm is displayed on the BMW Control Panel. See Table 3-A. These mnemonics are given in parentheses () in the descriptions below.

Battery on Discharge and Very Low Voltage Alarms (bod and LLO)

If rectifier output is insufficient to supply the load current for any reason (typically because of an ac power failure), the battery reserve will provide the necessary current. This discharge results in a drop of the plant bus voltage. Any time that the plant voltage is below the threshold selected for BD, the Battery on Discharge alarm (bod) activates. If the plant voltage continues to drop, a second, lower threshold can be reached, activating a Very Low Voltage alarm (LLO). These thresholds are set in the Galaxy RC in the configuration mode as described in the Installation, Configuration and Operation section of this manual (Section 4).

Note that a BD alarm does not necessarily mean that the batteries are discharging, only that the present voltage is lower than the set point for this alarm. This alarm may be activated by an incorrectly set BD threshold or plant voltage set point. Following the restoration of ac power after a battery discharge of significant depth, this alarm will remain active for some time during the recharge period, until the batteries have recharged to a level which allows the plant voltage to rise above the BD threshold.

BD thresholds are typically set approximately 0.5V below float in 24V systems and 1.0V below float in 48V systems with slope thermal compensation disabled. In systems with slope thermal compensation, the BD threshold should be 0.5V below the slope upper temperature voltage for 24V systems and 1.0V below the slope upper temperature voltage for 48V systems. These levels generally avoid nuisance alarms from transient conditions yet provide alarm indications early in a true BD event, so that sufficient time is provided for maintenance personnel to respond before battery reserve is exhausted. VLV should be activated towards the end of the battery reserve period to indicate a critical service condition.

High Float Voltage Alarm and High Voltage Alarm and Shutdown (HFO and HO)

The Galaxy RC is equipped to detect a high voltage condition on the plant bus. Such a high voltage condition may typically be

caused by lightning-induced transients on the commercial ac or a rectifier failure may cause an individual rectifier to go high. To prevent a high voltage condition from damaging the connected load, the RC also sends a signal for the rectifiers to shut down if the plant voltage goes above a second threshold.

When the plant voltage increases above the threshold for “High Float Voltage,” it issues the HFV alarm (HFO) as a minor. If the voltage continues to rise and reaches the threshold for “High Voltage,” that alarm (HO) is issued as a major and a shutdown signal is issued simultaneously to the plant rectifiers. Any rectifier which is producing at least 10% of its rated capacity and is 10% over the average of all rectifier outputs in the plant, will respond to this shutdown signal by shutting down with a RFA or ALM condition active and reported back to the RC. A series of restart attempts will occur over the next 5 minutes until this rectifier finally shuts down and locks out if it continues to go high.

For plants with the battery thermal lower temperature compensation disabled, the HFV threshold is usually set approximately 0.5V above float for a 48V plant and 0.25V above float for a 24V plant. HV shutdown threshold is then usually set approximately 1V above float for a 48V plant and 0.5V above float for a 24V plant. In plants with battery thermal lower temperature compensation enabled, the HFV threshold is usually set approximately 0.5V above the maximum voltage due to low temperature in a 48V plant and 0.25V in a 24V plant.

HV shutdown is usually 0.5V above the HFV threshold for 48V plants and 0.25V above the HFV threshold in 24V plants. Like the BD and VLV thresholds, these are set in the Galaxy RC in the configuration mode as described in the Installation, Configuration and Operation section of this manual (Section 4).

Rectifier Failure and Multiple Rectifier Failure Alarms (rFA and nrFA)

Various rectifier failure modes cause in a rectifier failure signal to be issued to the controller, such as high voltage, temperature over threshold, fan failure, and rectifier circuit breaker open. Additionally, when rectifiers are removed or fail to communicate with the RC, a RFA alarm is generated. This RFA alarm is cleared by setting the USL parameter to 1 (see Configuration, Section 4). The RFA signal results in a RFA alarm (rFA) and Power Minor alarm being issued by the RC.

More than one RFA at any time results in a MRFA alarm (nrFA) and Power Major. The RC does not attempt restarts for RFAs caused by TA (Thermal Alarm), CB trip, or Fan Failure.

Rectifier ID (rid) alarm

This alarm occurs when rectifier ID numbers are duplicated or are zero. Refer to the rectifier manuals for setting and viewing the rectifier ID numbers.

Rectifier Manual Off alarm (rOFF)

Whenever the rectifier is manually turned off, this alarm will occur. There is a switch on the front panel for each rectifier. One can manually turn the rectifier on or standby. When the switch is in standby position, the rOFF alarm is on.

Rectifier Half Power alarm (rHPA)

This alarm has not been implemented.

Rectifier Phase alarm (rPHA)

This alarm is for multiphase rectifier. When AC is lost in one or more phase but not all phases, this alarm (rHPA) occurs.

Rectifier On Standby Due To Engine Transfer (rOS)

Rectifier will be on standby mode when input power is transferring from AC line to engine generator or reverse. This alarm will be active during this transition.

Converter Distribution alarm (CdSt)

Any fuse or breaker open at the converter output side (-48v distribution) will cause this alarm.

Converter Failure and Multiple Converter Failure alarm (CFA and nCFA)

Converter failure alarms are generated for various reasons. These include failure in the converter, the converter is removed, the converter interface board is removed, or communication is lost with the converter interface board. The removed CFA is cleared by setting the USL parameter to 1 (see Configuration, Section 4).

Converter ID (cid) alarm

This alarm occurs when converter ID numbers are other than 1 through 8, or are duplicated. Refer to the converter section of the plant manual for setting and viewing ID numbers.

Contactor 1 Open, Contactor 2 Open, Contactor 1 Failure, Contactor 2 Failure alarm (C1O, C2O, C1F, C2F)

See Low Voltage Converter Disconnect section below.

AC Fail and Multiple AC Fail Alarms (ACF and nACF and EtO)

If the proper ac input voltage is not available to any plant rectifier which is connected to the RC bus, an AC Fail alarm (ACF) activates as a PMN. More than one ACF results in a Multiple AC Fail alarm (nACF), changing this alarm status to a PMJ.

Rectifier Phase alarm (rPHA) and Engine Time Out (EtO) are additional detected ac conditions. EtO occurs if the rectifier On/Standby (rOS) signal applied to BMY TB2-1 remains active for longer than 30 minutes. If this occurs, it is likely that there is something wrong with this signal, so the rectifiers are released from their rOS condition and EtO is activated.

Major and Minor Fuse Alarms (FAJ, FAn, AUJ, AUn, AbS, and OS)

The operation of an output distribution fuse or circuit breaker places resistive battery onto pin 8 of the BMY P3 plant interface port (See Figure 2-4), activating the Major Fuse alarm (FAJ).

If the optional BMU Relay Board is equipped, five similar alarms, also activated by battery voltage through a series resistor, are also available as follows:

BMU P2-6 or TB2-5/Minor Fuse alarm (FAn)

BMU TB2-1/Auxiliary Major alarm (AUJ)

BMU TB2-2/Auxiliary Minor alarm (AUn)

BMU TB2-3/Alarm Battery Supply Fuse alarm (AbS)

BMU TB2-4/Open String alarm (OS)

AUJ and AUn can be user-assigned for any supplemental alarm monitoring for which a resistive battery signal (1K ohms) can be obtained. AbS is usually reserved for the monitoring of distribution fuses or breakers which power an alarm system. OS is used to indicate that one or more battery string disconnect switches or breakers is open.

Refer to Figure 2-7 for input alarm wiring examples for these signals.

Controller Alarms (SEnS and Erc)

A lack of voltage on the Vsense +/- pair of the BMY P3-5/11 jack results in a controller alarm identified as a Voltage Sense Fuse alarm (SEnS).

A failure of or loss of power to the BMU Enhanced Relay Board similarly results in an Enhanced RC Failure alarm (Erc).

Sanity Fail in the Galaxy RC BMY microprocessor results in operation of the PMJ alarm, along with the CTRLR alarm if the BMU Enhanced Relay Board is equipped.

Contactor Open and Fail Alarms (C1O, C2O, C1F and C2F)

A Contactor Open alarm (C1O or C2O) is reported whenever the Galaxy RC senses that a contactor is open. This alarm is processed by the RC as a PMJ.

A Contactor Fail alarm (C1F or C2F) is reported whenever the Galaxy RC senses that a contactor should be open or closed is in the opposite state (closed or open). This alarm is also processed as a PMJ.

Battery Thermal Alarms (btA, tPA)

See Figure 3-1. Galaxy RC reports a Battery Thermal Alarm (btA) when the temperature rises above the configured set point. See Section 4, "Installation, Configuration and Operation," for information on battery thermal compensation settings. Galaxy RC reports a Thermal Probe Alarm (tPA) when thermal compensation is enabled and a temperature probe is disconnected or returns a grossly inaccurate reading to the Thermal Compensation circuit.

Plant Features

Load and Battery Contactor Features and Alarms

The Galaxy RC has two distinct circuits for controlling the state of external Load and Battery Disconnect Contactors. Ports P4 and P5 of the BMY Control Board provide the interface from the RC to separate contactor driver circuits which must be furnished as part of the plant circuitry.

Each contactor can be configured as none, load, or battery.

When configured as a battery contactor:

- The contactor is open when the plant voltage is less than the respective low voltage battery disconnect threshold.
- The contactor is closed when the plant voltage is greater than the respective low voltage battery reconnect threshold.

Optionally, the battery contactor can be configured for high voltage battery disconnect. When the high voltage disconnect setting is enabled:

- The contactor is open when the plant voltage is greater than the respective high voltage battery disconnect threshold and there are no rectifier phase alarms and ac failure alarms. This is to protect the service.
- The contactor is closed when the plant voltage is less than the reconnect threshold, or any rectifier phase alarms or ac failure alarms are active.

When configured as a load contactor:

- The contactor is open when the plant voltage is less than the respective low voltage load disconnect threshold.
- The contactor is closed when the plant voltage is greater than the respective low voltage load disconnect threshold. Additionally, there must be no active ac failure and rectifier phase alarms, since the load would immediately disconnect after reconnecting. There is also a 10-second delay before the load is reconnected to allow the rectifiers to walk in.

Refer to the Alarm Descriptions section for alarms associated with these two contactors (Contactor Open and Contactor Fail).

Refer to the associated plant documentation for information on connecting these Load and Battery Disconnect driver circuits to the BMY Control Board ports P4/5.

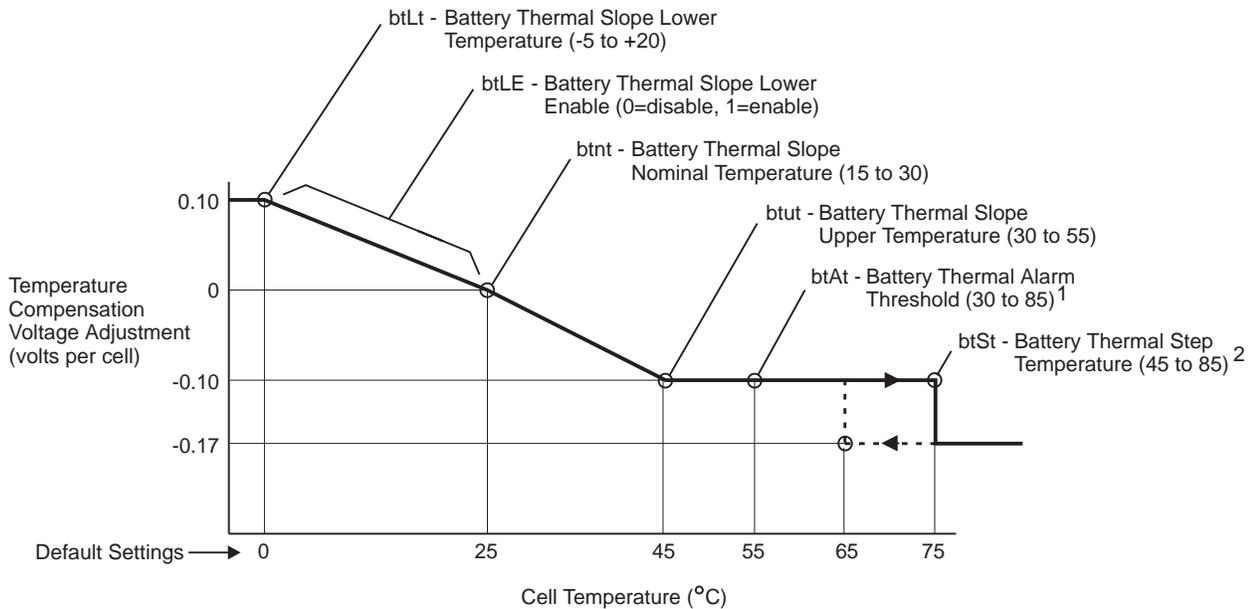
Thermal Compensation Features and Alarms

The Galaxy RC has a flexible Thermal Compensation feature which provides voltage compensation from that level established by the Plant Float Set-Point (FSP), dependent on the highest temperature monitored by thermistors located at the plant batteries. Thermal Compensation should only be enabled when the RC is used in a plant containing “sealed” or valve regulated “maintenance free” batteries. This feature requires the use of external thermistors at the plant batteries to monitor cell temperatures. Refer to the Installation section for more details on wiring and configuring this feature.

Thermal Compensation lowers plant voltage from the FSP for monitored battery temperatures which are above the ideal temperature established during configuration as the Battery Thermal Slope Nominal Temperature (btnt). Lowering the plant voltage helps to keep the batteries at their optimum state of charge while protecting them from thermal runaway. Thermal runaway is a complex sealed battery phenomena where, for one or more of a number of reasons, one or more cells in a string are unable to dissipate the internal heat generated by their charging current and experience an increase in internal temperature. By lowering the float voltage as cell temperature increases, the float current is lowered to a point where this destructive behavior can be avoided. If a cell failure is imminent and the cell temperature continues to rise above the threshold configured for Battery Thermal Step Temperature (btSt), plant voltage drops in a single step to a level which keeps from overcharging the remaining cells in the string and damaging them also. Refer to Figure 3-1 for a graphical view of Battery Thermal Compensation and the relationship of its various set points.

Refer to the Alarm Descriptions section for the Battery Thermal Alarm and Temperature Probe Failure Alarm.

The Galaxy RC can also increase plant voltage above that set by the FSP for colder environments, again seeking to keeping batteries in such an environment at their optimum charge state. Since this feature results in an increase in plant voltage, it is activated through a second enable switch during configuration. Again, refer to Figure 3-1.



1. The Battery Thermal Alarm occurs when the temperature rises above the btAt set point. It retires when the temperature decreases to 10°C below the btAt set point (45°C default).
2. Plant voltage decreases 0.17 volts per cell when the temperature increases above the btSt set point. It is increased 0.17 volts per cell when the temperature decreases to 10°C below the btSt set point, as indicated by the dashed line (65 °C default).

Figure 3-1: Battery Thermal Compensation set points

Note: Anytime that Battery Thermal Compensation is actively changing the plant voltage above or below that set by the FSP parameter during configuration, the green Thermal Compensation LED of the BMW Display will be active. This is not an alarm condition, only an indication to the user that plant voltage is different than that set by the FSP parameter. **It is imperative that thermal compensation be disabled (btEn = 0) under the Configuration mode prior to adjusting plant voltage through the FSP parameter. Never adjust plant voltage with the Thermal Compensation LED active. Adjusting plant voltage while thermal compensation is enabled may result in too high or too low a charging voltage, which may cause battery thermal runaway or undercharging. Rectifiers will be overcurrent if charging voltage is too high.**

Slope compensation is automatically disabled while the plant is in Boost mode.

Rectifier Sequencing

Rectifier Sequencing is a feature which allows the RC to bring the plant rectifiers back on line one at a time following an ac power interruption. This serves to minimize their impact on the ac service, especially useful in avoiding loading down an emergency generator with an inrush surge.

The Rect On/Standby pair must be connected to BMY TB2 1-2. This should be a clean contact closure whenever ac service is not available and an open at all other times. This signal, known as ETR/ETR Return in previous controllers, can be obtained in a variety of ways. The most common means are through auxiliary contacts on the office ac transfer switch which provide a closure only during the period when the switch is changing buses, or through ac relays which are simply monitoring the status of the ac service.

When the RC senses a release of the Rect On/Standby signal (meaning ac is now available to the rectifiers), it pauses 10 seconds and starts the plant rectifier with the lowest Rectifier ID assignment. Every 10 seconds after that, another rectifier starts and the cycle repeats until all rectifiers have come back on line.

Rect Holdoff has no present function in this release of the Galaxy RC.

Shunt Types and Sizes

The RC provides three separate methods and up to two separate shunt signals for use in determining the plant current to display when AMPS is selected on the BMW Front Display. The 2 shunt signals used connect to the BMY plant interface port P3 at pins 6-12 and 4-10 as shown in Figure 2-2, and are 50 mV signals in the range of 0-9999 amps. Refer to the configuration section of this manual for additional details.

Float Mode Controls and Thresholds

Float mode is the default mode of operation and is active if the Boost mode LED is not active on the BMW Display. Plant voltage, while in Float mode, is determined by the configuration parameter Plant Float Set Point (FSP), and may be adjusted by the Battery Thermal Compensation circuit, if enabled. There is no individual adjustment of plant rectifiers in this digital serial bus interface arrangement. Load share among plant rectifiers is

automatic in all plant modes and will take effect within several seconds of a new rectifier being added to the bus and turned on.

The FSP chosen should correspond to the battery type used and the battery manufacturer's recommendations. For example, Lucent Technologies KS20472 Round Cell (flooded) battery floats at 2.17 volts per cell (VPC). A 12 cell, 24V plant would therefore have a FSP of $2.17 \times 12 = 26.04V$. The Lucent Technologies KS23619 Enhanced VR (Valve regulated) battery floats at 2.27 VPC, if Battery Thermal Compensation is enabled or 2.25 VPC if used without Battery Thermal Compensation. A 12 cell, 24V plant using this battery would have a desired FSP of $2.27 \times 12 = 27.24V$ with or $2.25 \times 12 = 27.00V$ without Battery Thermal compensation.

Rectifier Current Limit in Float mode (FCL) is an adjustable configuration parameter from 30% to 110% of rectifier capacity. This parameter can be important in limiting the recharge current available following a deep discharge in a plant using a "sealed" or valve-regulated battery type to a level which is safe for that battery and not cause unnecessary internal pressure buildup and venting. Typically, this maximum safe recharge rate for "sealed" or valve-regulated battery types in the industry is in the range of 1/10 of the 8 or 10 hour rating. Refer to your specific battery manufacturer for recommendations regarding the battery type used. The following typical example shows the use of the FCL feature to maintain the maximum recharge rate decided upon.

Consider a plant with three strings of 2VR375E Lucent Technologies KS23619 Enhanced VR Series batteries, four 100A rectifiers and a 200 amp typical load. When ac power returns following a significant discharge, 200 amps will be available for recharging these batteries, a rate of 67A per string (200A / 3 strings). Recharge should be limited to approximately 40A per string (1/10 of 375) however, resulting in the possibility of venting and life depreciation of the batteries. Calculate current limit for limiting recharge to 40A per string as follows:

$$CL = [\text{Plant Load} + (\text{Max Recharge per String} \times \# \text{ Strings}) / (\text{Rect Cap} \times \# \text{ Rect})] \times 100$$

$$CL = [200 + (40 \times 3) / (100 \times 4)] \times 100$$

$$CL = [(200 + 120) / 400] \times 100$$

$$CL = (320 / 400) \times 100 = 80\%$$

Check for N + 1 redundancy with this CL value with the following statement:

$$\text{Plant Load} < [\text{Rect Cap} \times (\# \text{ Rect} - 1) \times \text{CL}] / 100$$

$$200 < [100 \times (4 - 1) \times 80] / 100$$

$$200 < [(100 \times 3) \times 80] / 100$$

$$200 < (300 \times 80) / 100$$

$$200 < 240$$

Float mode adjustments are also available for High Float Voltage Float Threshold (FHFO) which activates the HFV (alarm only) minor when exceeded and the High Voltage Float threshold (FHO) which activates the HV major alarm and rectifier shutdown. Battery on Discharge Float Threshold (Fbd) and Very Low Voltage Threshold (LLO) are additional Float mode configuration parameters. Refer to the Alarm Descriptions section for additional information regarding these alarms.

Boost Mode Controls and Thresholds

Boost mode is a feature of the Galaxy RC which allows the user to temporarily raise the plant voltage to a higher, predetermined level for a specified period of time. This feature may be useful in plants using a flooded battery type where the batteries are displaying symptoms of an undercharged state such as differing cell voltages or in the case of the Lucent Technologies KS20472 Round Cell, lead-sulfate crystals visible on the vertical positive plate columns. Boost mode may also be used to accelerate the recharge of discharged strings to their full charge condition.

Plant voltage, while in Boost mode, is determined by the configuration parameter Plant Boost Set- Point (bSP). Refer to “Plant Boost Mode Settings” in Section 4. Like Float mode, there is no individual adjustment of plant rectifiers and load share among plant rectifiers is automatic.

Boost voltage (bSP) is again determined from the battery manufacturer’s recommendations, but must also be less than the maximum voltage rating of all connected loads since Boost Mode raises the entire plant bus voltage. Typical boost levels and durations used might include 2.25 VPC for 96 hours, 2.27

VPC for 72 hours, or 2.30 VPC for 48 hours. **Do not exceed the maximum voltage rating of any connected load.**

Boost is typically not used with “sealed” or valve regulated battery types or is completed at significantly lower levels than that of flooded battery design to avoid the build up of pressure and venting noted under the Float mode section on Float Current Limit. When Boost mode is disabled under configuration, the Float/Boost switch and Boost LEDs on the BMW Display are disabled.

Once enabled, Boost mode is entered by pressing the Float/Boost switch on the BMW Display while in Float mode. The Boost LED will blink and the present Boost duration will be displayed in hours. This Boost duration can be edited with 0 and 24 hour minimum and maximum values (0 = forever) and Boost mode initiated by pressing ENTER at this point. Pressing ESCAPE prior to initiating Boost returns the display to the default Voltage Display mode without placing the plant into Boost mode. Once Boost is initiated, the RC can be returned to Float mode by pressing the Float/Boost switch again. If a HV, HFV or RFA alarm occurs in Boost mode, the plant will return immediately to Float mode. AC Fail and Phase Fail alarms will not affect Boost mode.

Boost mode has its own configuration parameters for Rectifier Boost Current Limit (bCL), High Float Voltage Boost Threshold (bHFO), High Voltage Boost Threshold (bHO), and Battery on Discharge Boost Threshold (bbd), all of which control these respective features and alarms whenever Boost mode is active.

Auto Timed Boost

The plant will go into Boost mode automatically if the following conditions occur:

- Boost is enabled (bEn is 1)
- Autoboot factor (bAF is not 0). The autoboot is disabled when set at 0, but when enabled the autoboot factor can range from 1 to 9.
- A battery on discharge alarm occurs with AC Failure alarms, or rectifier phase alarms occur for at least four minutes.

When all rectifier phase and AC Failure alarms retire, the plant automatically goes into boost mode.

The duration of the boost period will be BD and AC Failure or Phase alarm duration multiplied by the autobost factor. The maximum boost duration is limited to 24 hours.

If AC Failure alarms and Phase alarms are asserted while the plant is in autobost mode, the plant re-enters float mode, retaining the remaining boost duration. If the Battery on Discharge (BD) alarm asserts while the AC Failure or phase alarm is active, the new multiplied time will be added to the boost duration. When the AC Failure and Phase alarms retire, the plant re-enters the boost mode for the remaining boost duration.

During autobost, if the plant has a HV, HFV, or RFA alarm, the plant returns to float mode and the remaining autobost time is cancelled.

4 *Installation, Configuration and Operation*

This section covers the installation and configuration procedures specific to the Galaxy RC controller. This controller should be typically factory wired and assembled in a GPS series battery plant equipped with serialized bus communication rectifiers. Follow the installation instructions of the appropriate plant, rectifier, converter and battery products to complete all external wiring related to those components of the system.

Wiring

Refer to the block diagram in Figure 2-3 for a summary of all input/output connections associated with the Galaxy RC. Insure that the factory connections between the BMY Control Board and BMW Control Panel and the optional BMU Relay Board are present and secure. Plant interface power and alarm inputs should also be connected to the BMY P3 and optional BMU P2 ports. The digital serial bus must be established from either or both of BMY ports J1/J2 to the rectifiers and other controlled devices in the system.

Power Major (PMJ) and Power Minor (PMN) office alarm wiring is extended from the BMY TB1 and optionally from the BMU TB1 to the office alarm system as described in Section 2 of this manual. Refer to Figure 2-4 and Figure 2-6 for details. If the BMU is provided, any of the optional battery voltage alarm input signals through series resistors may also be wired to TB2 of the BMU, if desired. Refer to Section 2 and Figure 2-6 and 2-7.

If either or both of the available Low Voltage Disconnect (LVD) circuits, LVD1 or LVD2 is equipped, the wiring from BMY port P4 / P5 to the associated driver circuit and associated wiring from this driver circuit to the Low Voltage Battery Disconnect or Low Voltage Load Disconnect must be completed. The installation of this circuitry is covered in the appropriate plant product manual.

If the plant batteries are the “sealed” or maintenance free valve regulated type, Battery Thermal Compensation may be used. This feature requires the use of either CU216A or 210E style external thermistor devices which wire back into BMY ports P6 or TB4 as shown in Figure 2-4. The installation of this equipment is covered in its respective product manual.

The Galaxy RC performs rectifier sequencing based on the state of the Rectifier On/Standby signal terminated at BMY TB2 1-2. If this feature is to be used, complete this wiring as described in Section 3 and assign the Rectifier ID numbers to all plant rectifiers as described in their respective rectifier product manuals.

Configuration

All rectifiers and converters must be numbered uniquely. Valid numbers for rectifiers are 1 through 24. Valid numbers for converters are 1 through 8. Refer to the appropriate sections of the rectifier and converter manuals for setting ID numbers.

SW1 and Navigation of the BMW Display in Configuration Mode

SW1-1 of the BMY Control Board is a hardware enable switch for Configuration mode of the BMW Control Panel. If SW1-1 is not enabled (open), the CONFIGURE switch of the display only permits the user to access and view the configuration parameters, but not to change any of them. Once configuration has been completed, it is a good practice to disable (close) SW1-1 to prohibit someone from mistakenly changing these parameters.

Configuration mode is entered by pressing the CONFIGURE key while in the default Voltage Display mode. After entering this mode, the CONFIGURE LED will light and the first parameter of the configuration menu will be displayed. Refer to Table 4-A for a description of the parameters of the configuration menu.

Table 4-A: Configuration Parameters

NUM	ID	MNEM	Description	Range	Default
1	StYP	StYP	Shunt Type	0 to 2 (0=none, 1=plant, 2=battery)	2
2	SH1A	SH1A	Shunt 1 Size	0 to 9999A (0=disable, other=shunt rated amps)	800
3	SH2A	SH2A	Shunt 2 Size	0 to 9999A (0=disable, other=shunt rated amps)	0
4	FSP	FSP	Plant Float Set Point	22 to 28V, 44 to 56V	27.24, 54
5	FCL	FCL	Rectifier Float Current Limit	30 to 110%	100
6	FHO	FHO	High Voltage Float Threshold	25 to 30V, 50 to 60V	28.24, 57
7	FHFO	FHFO	High Float Voltage Float Threshold	25 to 30V, 50 to 60V	27.74, 56
8	Fbd	Fbd	Battery on Discharge Threshold	23 to 27.5V, 46 to 55V	25.54, 51.1
9	LLO	LLO	Very Low Voltage Threshold	20 to 25.5V, 40 to 51V	23, 46
10	btAt	btAt	Battery Thermal Alarm Threshold	30 to 85 Deg C	55
11	btSt	btSt	Battery Thermal Step Temperature	45 to 85 Deg C	75
12	btut	btut	Battery Thermal Slope Upper Temperature	30 to 55 Deg C	45
13	btnt	btnt	Battery Thermal Slope Nominal Temperature	15 to 30 Deg C	25
14	btLt	btLt	Battery Thermal Slope Lower Temperature	-5 to 20 Deg C	0
15	btLE	btLE	Battery Thermal Slope Lower Enable	0 to 1 (0=disable, 1=enable)	0
16	btEn	btEn	Battery Thermal Compensation Enable	0 to 1 (0=disable, 1=enable)	0
17	C1Ld	C1Ld	Contact 1 Low Voltage Disconnect Threshold	20 to 26V, 40 to 52V	21, 43.2
18	C1Lr	C1Lr	Contact 1 Low Voltage Reconnect Threshold	20 to 26V, 40 to 52V	22.2, 44.4
19	C1Hd	C1Hd	Contact 1 High Voltage Disconnect Threshold	25-30V, 52 to 60V	29, 56.4
20	C1Hr	C1Hr	Contact 1 High Voltage Reconnect Threshold	25-30V, 52 to 60V	28.5, 55.6
21	C1HE	C1HE	Contact 1 High Voltage Disconnect Enable	0 to 1 (0=disable, 1=enable)	0
22	C1tY	C1tY	Contact 1 Type	0 to 2 (0=none, 1=load, 2=battery)	0
23	C2Ld	C2Ld	Contact 2 Low Voltage Disconnect Threshold	20 to 26V, 40 to 52V	21, 43.2
24	C2Lr	C2Lr	Contact 2 Low Voltage Reconnect Threshold	20 to 26V, 40 to 52V	22.2, 44.4
25	C2Hd	C2Hd	Contact 2 High Voltage Disconnect Threshold	25-30V, 52 to 60V	29, 56.4
26	C2Hr	C2Hr	Contact 2 High Voltage Reconnect Threshold	25-30V, 52 to 60V	28.5, 55.6
27	C2HE	C2HE	Contact 2 High Voltage Disconnect Enable	0 to 1 (0=disable, 1=enable)	0
28	C2tY	C2tY	Contact 2 Type	0 to 2 (0=none, 1=load, 2=battery)	0
29	bSP	bSP	Plant Boost Set-Point	24 to 30V, 48 to 60V	27.24, 55.2
30	bCL	bCL	Rectifier Boost Current Limit	30 to 110%	100
31	bHO	bHO	High Voltage Boost Threshold	26 to 30V, 52 to 60V	28.24, 57
32	bHFO	bHFO	High Float Voltage Boost Threshold	25 to 30V, 50 to 60V	27.74, 56.2
33	bbd	bbd	Battery on Discharge Boost Threshold	23 to 27.5V, 46 to 55V	25.54, 52

Table 4-A: Configuration Parameters (Continued)

NUM	ID	MNEM	Description	Range	Default
34	bAF	bAF	Boost Auto Mode Factor	0 to 9 (0=disable or 1-9 times BD duration)	0
35	bEn	bEn	Boost Enable	0 to 1 (0=disable, 1=enable)	0
36	CSP	CSP	Converter Voltage Set-Point	48 to 54V	50
37	CLd	CLd	Converter Low Voltage Disconnect Threshold	20 to 25V	21
38	CLr	CLr	Converter Low Voltage Reconnect Threshold	20 to 25V	23
39	CLdE	CLdE	Converter Low Voltage Disconnect Enable	0 to 1 (0=disable, 1=enable)	0
40	CFPC	CFPC	Converter Control Panel Voltage Calibration	48 to 54V	Converter V
41	FPC	FPC	Control Panel Voltage Calibration	22-28V, 44 to 56V	Plant V
42	SH1C	SH1C	Control Panel Shunt 1 Calibration	0 to 9999A	Shunt 1 A
43	SH2C	SH2C	Control Panel Shunt 2 Calibration	0 to 9999A	Shunt 2 A
44	USL	USL	Update Serial Link and Clear Alarms	0 to 1 (0=do nothing, 1=update)	0
45	id	id	Identifiers Enable	0 to 1 (0=numeric, 1=alphanumeric)	1
46	rEL	rEL	Display Software Release		

Once in configuration mode, use either the + and - keys or the ^ and v keys to select a parameter to edit and the ENTER key to choose a parameter to edit. While in configuration mode, the CONFIGURE LED will blink. Use the < or > keys to select a digit in the displayed parameter to change and the + and - or ^ and v keys to increase or decrease the value of the selected digit. The DEFAULT key may also be used while editing a parameter to set it to its factory default, as defined in Table 4-A. If an attempt is made to set a parameter higher than allowable, the maximum value will be displayed. Likewise, an attempt to set a parameter lower than allowed results in display of the minimum value.

To save changes made to a parameter value and return to the configure menu, press the ENTER key. To return to the configure menu without saving any changes to a parameter, press the ESCAPE key. To exit configuration mode and return to the default Voltage Display mode, press ESCAPE while viewing the configuration menu. If no key is pressed for 30 seconds, the display will return to the Voltage Display mode automatically.

Refer to Table 4-A as each of the Configuration Parameters is explained in the following sections.

***Shunt Type/
Size(s)***

Three separate methods and up to two separate shunt signals can be used for determining the plant current to display when AMPS is selected on the BMW Front Display. The two shunt signals, if used, connect to the BMY plant interface port P3 at pins 6-12 and 4-10 as shown in Figure 2-4, and are 50 mV signals in the range of 0-9999 amps.

The method used by the RC is determined by configuration parameter NUM-1, Shunt Type (StYP). The three choices for this parameter are 0 = “none”, 1 = “plant”, and 2 = “battery”.

None: If no shunt is used or connected to BMY port P3 6-12 and 4-10, this parameter results in the current displayed to be the sum of the individual rectifier loads. This will not be a true “load” current, but will also include the portion of the rectifier loads which is float or recharge current for the batteries. For a batteryless application however, this would be an accurate depiction of plant load.

Plant: If one or both of the shunt signals received on BMY port P3 6-12 and 4-10 is monitoring load current, this parameter displays that load or the sum of both loads if two are used. Battery float or charge current can be determined by subtracting this load current from the sum of the individual rectifier loads. The use of 2 separate shunt signals allows loads to separate distribution bays or loads to be monitored separately. If the current is displayed as “Err,” the system may contain a battery shunt or may be improperly wired.

Battery: Placing one or both shunts in the charge/discharge path of the plant batteries and choosing this configuration parameter results in a current display that is the difference of the sum of the individual rectifier currents and the sum of the battery charge currents from the two shunts if both shunts are used in the charge/discharge path.

Configuration parameters NUM-2 and 3, Shunt 1 Size (SH1A) and Shunt 2 Size (SH2A) are used to configure the full scale load rating of the 2 available shunts. Each shunt range is from 1 to 9999 amps and 0 disables that shunt.

***Plant Float Mode
Settings***

Configuration parameters NUM-4 to 8 are settings which are active anytime the plant is in Float mode.

NUM-4/Plant Float Set-Point (FSP): This is the voltage that all plant rectifiers will be set to while in Float mode. If Battery Thermal Compensation is enabled and active, actual plant voltage will be adjusted from FSP based on the highest battery temperature monitored.

NUM-5/Rectifier Float Current Limit (FCL): Rectifier current limit is adjustable from 30 to 110% of rectifier capacity while in Float mode.

NUM-6/High Voltage Float Threshold (FHO): Plant voltage monitored above this threshold results in a High Voltage alarm and shutdown while in Float mode.

NUM-7/High Float Voltage Float Threshold (FHFO): Plant voltage monitored above this threshold results in a High Float Voltage alarm (no shutdown) while in Float mode.

NUM-8/Battery on Discharge Float Threshold (Fbd): Plant voltage monitored below this threshold results in a Battery Discharge alarm while in Float mode.

NUM-9/Very Low Voltage Threshold (LLO): In any plant mode, plant voltage monitored below this threshold results in a Very Low Voltage alarm.

***Battery Thermal
Compensation
Settings***

Refer to Figure 3-1 for a graphical representation of the various Battery Thermal Compensation settings.

NUM-10/Battery Thermal Alarm Threshold (btAt): A monitored battery temperature above this threshold results in a Battery Thermal alarm.

NUM-11/Battery Thermal Step Temperature (btSt): A monitored battery temperature above this threshold results in a “step” decrease in plant voltage to a level corresponding to 0.17 volts per cell (VPC) below the Plant Float Set-Point (FSP).

NUM-12/Battery Thermal Slope Upper Temperature (btut): The upper temperature where Battery Thermal Compensation will have reduced plant voltage to a level corresponding to 0.10 VPC below the FSP. Plant voltage will be reduced proportionally at any temperature between this point and the Battery Thermal Slope Nominal Temperature (btnt).

NUM-13/Battery Thermal Slope Nominal Temperature

(btnt): The zero compensation temperature point. Temperatures monitored between this point and the Battery Thermal Slope Upper Temperature (btut) will result in a proportional decrease of plant voltage to a level corresponding to 0.10 VPC below the FSP at the btut. If Battery Thermal Slope Lower Compensation is enabled, temperatures monitored between this point and the Battery Thermal Slope Lower Temperature (btLt) will result in a proportional increase of plant voltage to a level corresponding to 0.10 VPC above the FSP at the btLt.

NUM-14/Battery Thermal Slope Lower Temperature

(btLt): The lower temperature where, if Battery Thermal Slope Lower Compensation is enabled, Battery Thermal Compensation will have increased plant voltage to a level corresponding to 0.10 VPC above the FSP. Plant voltage will be increased proportionally at any temperature between this point and the Battery Thermal Slope Nominal Temperature (btnt).

NUM-15/Battery Thermal Slope Lower Enable (btLE):

0 disables and 1 enables Battery Thermal Slope Lower Compensation. Since btLE increases plant voltage rather than decreasing it based on temperature, the option is provided to disable it separately from the entire feature so that equipment loads sensitive to high voltages can be protected.

NUM-16/Battery Thermal Compensation Enable (btEn):

0 disables and 1 enables the Battery Thermal Compensation

*Low Voltage
Disconnect
Contactor 1/2
Settings*

NUM-17/Contactor 1 Low Voltage Disconnect Threshold (C1Ld)

NUM-23/Contactor 2 Low Voltage Disconnect Threshold

(C2Ld): The low voltage at which a signal will be sent to the respective contactor driver circuit, causing it to open, disconnecting either the load or the batteries, depending on the contactor's location in the circuit.

NUM-18/Contactor 1 Low Voltage Reconnect Threshold (C1Lr)

NUM-24/Contactor 2 Low Voltage Reconnect Threshold

(C2Lr): The low voltage at which a signal will be sent to the respective contactor driver circuit, causing it to close, reconnecting either the load or the batteries, depending on the contactor's location in the circuit.

NUM-19/Contactor 1 High Voltage Battery Disconnect Threshold (C1Hd)

NUM-25 / Contactor 2 High Voltage Battery Disconnect Threshold (C2Hd): The high voltage at which a signal will be sent to the respective contactor driver circuit, causing it to open, disconnecting batteries. This threshold is used by the controller only when the respective contactor type is set to 2 (battery).

NUM-20/Contactor 1 High Voltage Battery Reconnect Threshold (C1Hd)

NUM-26/Contactor 2 High Voltage Battery Reconnect Threshold (C2Hd): The high voltage at which a signal will be sent to the respective contactor driver circuit, causing it to close, reconnecting batteries. This threshold is used by the controller only when the respective contactor type is set to 2 (battery).

NUM-21/Contactor 1 High Voltage Battery Disconnect Enable (C1HE)

NUM-27/Contactor 2 High Voltage Battery Disconnect Enable (C2HE): 0 disables and 1 enables the respective high voltage battery disconnect feature.

NUM-22/Contactor 1 Type (C1tY)

NUM-28/Contactor 2 Type (C2tY): The contactor type can be set to one of these three choices:

- 0 no contactor available
- 1 load contactor (low voltage disconnect only)
- 2 battery contactor (low and high voltage disconnect available)

Plant Boost Mode Settings

Configuration parameters NUM-29 to 35 are settings which are active anytime the plant is in Boost mode.

NUM-29/Plant Boost Set-Point (bSP): This is the voltage that all plant rectifiers will be set to while in Boost mode.

NUM-30/Rectifier Boost Current Limit (bCL): Rectifier current limit is adjustable from 30 to 110% of rectifier capacity while in Boost mode.

NUM-31/High Voltage Boost Threshold (bHO): Plant voltage monitored above this threshold results in a High Voltage alarm and shutdown while in Boost mode.

NUM-32/High Float Voltage Boost Threshold (bHFO): Plant voltage monitored above this threshold results in a High Float Voltage alarm (no shutdown) while in Boost mode.

NUM-33/Battery on Discharge Boost Threshold (bbd): Plant voltage monitored below this threshold results in a Battery Discharge alarm while in Boost mode.

NUM-34/Boost Auto Mode Factor (bAF): 0 disables the auto boost features. A value from 1 to 9 enables auto boost and sets the factor that determines how long the plant is in boost mode after a discharge. The Boost Enable parameter must be set to 1 (enabled) for this feature to be available.

NUM-35/Boost Enable (bEn): 0 disables and 1 enables the manual timed Boost feature.

***Converter
Settings***

Configuration parameters NUM-36 to 40 are settings which affect the operation of any converters which are connected to the serial bus.

NUM-36/Converter Voltage Set-Point (CSP): This is the output voltage that all converters will be set to by RC.

NUM-37/Converter Low Voltage Disconnect Thrshold (CLd): The low plant voltage at which the converters are placed into standby.

NUM-38/Converter Low Voltage Reconnect Thrshold (CLr): The low plant voltage at which the converters are retired from standby.

NUM-39/Converter Low Voltage Disconnect Enable (CLdE): 0 disables and 1 enables the converter low voltage disconnect feature.

NUM-40/Converter Front Panel Voltage Calibration (CFPC): The voltage displayed here initially is the uncalibrated plant voltage as seen by the controller. Adjust the displayed voltage until it matches the voltage displayed on a calibrated voltmeter measuring the voltage across the first and last cells of the batteries.

***Voltage and
Current
Calibration***

Controller voltage and current sensing may be calibrated to a known, calibrated meter.

Caution:

This calibration affects all controller functions using plant voltage and/or current values. These functions include the float and boost set points.

NUM-41/Front Panel Voltage Calibration (FPC): Adjust the displayed voltage until it matches the voltage displayed on a calibrated voltmeter measuring the plant or converter output voltage.

**NUM-42/Front Panel Shunt 1 Calibration (SH1C) and
NUM-43/Front Panel Shunt 2 Calibration (SH2C):**

1. Record the configured values of shunt sizes (SH1A, SH2A) and shunt type (STYP)
2. Disable shunt 2 (configure SH2A = 2)
3. Configure STYP = 1 (plant)
4. Measure shunt 1 voltage with a calibrated milli-voltmeter
5. Calculate the current:

$$I = \frac{V \times \text{Shunt Size}}{0.050}$$

6. Configure SH1C to the calculated value by adjusting the displayed value
7. Enable shunt 2 and disable shunt 1 (configure: SH1A = 2, SH2A = value recorded in step 1)
8. Repeat steps 4, 5 and 6 for shunt 2
9. Enable shunt 1 (configure SH1A = value recorded in step 1)
10. Restore shunt type (configure STYP = value recorded in step 1)

***Serial Bus
Updating and
Clearing***

Once a rectifier is connected to the digital serial bus and recognized by the Galaxy RC, it is remembered and a Rectifier Fail Alarm (RFA) will be active if it is removed. If the controller is indicating Rectifier Fail Alarm (RFA) and no alarm is indicated by the LEDs of the rectifier, it may be necessary to clear the Galaxy RC rectifier memory. Update Serial Link and clear Alarms (USL) to reset the Galaxy RC rectifier memory and sent a clear alarms message to the rectifiers by configuring USL **NUM-44** = 1 (0 = nothing, 1 = Update the Link).

Note: A few moments after executing Update Link and Clear Alarms the controller alarm RFA should clear and each rectifier should display no alarms. If alarms continue to be displayed, see Section 5, Troubleshooting. USL will not restart the rectifier at any time.

***Choice of
Identifiers or
Numeric Codes***

Throughout this section, both the Numeric codes of all configuration parameters and their Mnemonic Identifier codes have been used in the parameter descriptions. Both are also displayed in Table 4-A for reference. Configuration parameter **NUM-45**/Identifiers Enable (Id) allows a choice between the Mnemonic Identifier codes (default) and the Numeric codes for all configuration parameters and all active alarm codes shown in Table3-A. 0 = Numeric codes, 1 = Mnemonic Identifier codes.

***Software Release
Information***

The final parameter in configuration mode is **NUM-46** / Display Software Release (rEL) and is actually just a report of the present software release active in the BMY microprocessor.

***Front Panel
Operation***

Voltage Display Mode

Voltage Display is the default operating mode. Plant voltage is displayed while in this mode. Regardless of the active display mode, if no key is pressed for 30 seconds, the RC returns to Voltage Display mode and the VOLTS LED is active. The VOLTS/AMPS switch toggles between Voltage Display mode and Current Display mode. The +, -, ^, v keys toggle between plant and converter voltages while in this mode. The symbol for Plant or Converter is displayed briefly, followed by the value. If no key is pressed within 30 seconds, the display goes back to its default mode, the Plant Voltage display.

Current Display Mode

This mode is entered from the Voltage Display mode by pressing the VOLTS/AMPS switch one time and is indicated by the AMPS LED. While in this mode, the +, -, ^, v keys toggle between plant current and converter current. While viewing the plant current the display value depends on the Shunt Type (StYP) configuration parameter (none, plant, or battery).

None (0): If no shunt is used or connected to BMY port P3 6-12 and 4-10, this parameter displays a current reading that is the sum of the individual rectifier loads.

Plant (1): If one or both of the shunt signals received on BMY port P3 6-12 and 4-10 is monitoring load current, this parameter displays that load or the sum of both loads if two are used.

Battery (2): Placing one or both shunts in the charge/discharge path of the plant batteries and choosing this configuration parameter displays a current reading that is the difference of the sum of the individual rectifier currents and the sum of the battery charge currents.

View Active Alarms Mode

This mode is entered by pressing the VIEW ACTIVE ALARMS switch while in Voltage Display or Current Display mode and is indicated by an active VIEW ACTIVE ALARMS LED. While in this mode, a code for an active alarm is displayed. Refer to Table 3-A for a listing of all available alarm conditions and their Mnemonic Identifier and Numeric Identifier codes. The + and - or ^ and v keys may be used to scroll through the list of active alarms. When no alarm is present, this mode displays nonE or 0. To exit View Active Alarms mode, press ENTER, ESCAPE, VOLTS/AMPS, or VIEW ACTIVE ALARMS again. If no key is pressed for 30 seconds, the RC returns to the Voltage Display mode automatically.

Software Release Upgrade

The operating system of the microprocessor on the BMY Control Board is held in a Flash PROM which can be field upgradable. If a new release of the operating software becomes available, obtain the upgrade kit from Lucent Technologies.

5 Troubleshooting

Replacing Circuit Packs Table 5-A lists the circuit packs available as replacements in the Galaxy RC Controller.

Table 5-A: Replacement Circuit Packs and Temperature Modules

Designation	Description	Ordering Number
210E	Thermal Probe Multiplexer	107789513
CU216A	Thermal Probe Multiplexer	
847757382	Terminal Module for 210E	847757382
BMU1	24V RC Relay Board	107924434
BMU2	48V RC Relay Board	107964132
BMW1	RC Control Panel	107792442
BMY1	24V RC Control Board	107792459
BMY2	48V RC Control Board	107964157
BNA1	RC Fuse Board	107832677

Checking the highest battery temperature

If temperature probes are connected to the controller and thermal compensation is enabled, the highest battery temperature can be calculated based on the plant voltage. Temperatures between the battery thermal lower temperature and the battery thermal nominal temperature can be calculated if the raising of plant voltage is also enabled.

Calculate the temperature as follows:

$$\text{voltage difference} = \frac{(\text{plant set point} - \text{plant voltage reading})}{\text{cells per string}}$$

where cells per string is the number of 2-volt cells per string.

If voltage difference ≥ 0.17 , the highest battery temperature is at least as high as the battery thermal step temperature hysteresis value, which is the battery thermal step temperature – 10 degrees C.

If voltage difference = 0.1, the highest battery temperature is between the battery thermal upper temperature and the battery thermal step hysteresis value.

If voltage difference > 0 and voltage difference < 0.10 ,
temperature = thermal nominal temp + voltage difference \times
(thermal upper temp – thermal nominal temp)

Note: This will be a temperature in the range of the battery thermal nominal temperature setting and the battery thermal upper temperature setting.

If voltage difference ≤ -0.10 , the highest battery temperature is at or lower than the battery thermal lower temperature setting.

If voltage difference < 0 and voltage difference > -0.10 ,
temperature = thermal lower temp – voltage difference \times
(thermal nominal temp – thermal lower temp)

Note: this will be a temperature in the range of the battery thermal lower temperature setting and the battery thermal nominal temperature setting.

***Inaccurate Plant
Voltage Readings***

If the Thermal Compensation LED is on, this indicates that the plant voltage is altered to higher or lower battery temperature. Temporarily disabling the Battery Thermal Compensation Enable setting (set btEn to 0) will return the plant voltage to the set point.

The plant voltage may also differ from an external meter due to user calibration of the external voltmeter. See to the plant voltage configuration section.

***Inaccurate Plant
Current Readings***

The plant current may need to be calibrated, or re-calibrated. See Configuration, Section 4. If the current is displayed as “Err,” the system may contain a battery shunt or may be improperly wired.

The plant current may also differ from an external meter due to user calibration of the external voltmeter. See to the plant current configuration section.

Temperature Probe Alarm (tPA) is present

The tPA alarm indicates that either there is something wrong with the temperature connections, or that there is a problem with one the external temperature processing units. Additionally, the tPA alarm indicates that the thermal compensation feature is enabled, and no temperature probes are present. If there are no temperature probes connected to the RC, then disable the Battery Thermal Compensation Enable setting (set btEn to 0).

Unexplained Rectifier Failure Alarm (rFA) and Multiple Rectifier Failure Alarm (nrFA)

Rectifiers that are removed from the plant will generate rFA alarms and perhaps nrFA alarms. To clear these alarm conditions, set the Update Serial Link (USL) parameter to 1.

Note: A few minutes after executing Update Link and Clear Alarms, the controller alarm RFA should clear and each rectifier should display no alarms. If alarms continue to be displayed, see the Troubleshooting section in the Plant Product Manual.

Unexplained Converter Failure Alarm (CFA) and Multiple Converter Failure Alarm (nCFA)

Converters that are removed from the plant will generate CFA alarms and perhaps nCFA alarms. To clear these alarm conditions, set the Update Serial Link (USL) parameter to 1.

Note: A few minutes after executing Update Link and Clear Alarms, the controller alarm CFA should clear and each inverter should display no alarms. If alarms continue to be displayed, see the Troubleshooting section in the Plant Product Manual.

Rectifier Id (rid) alarm is set

Verify all rectifiers are numbered between 1 and 24. Refer to numbering procedure in rectifier manual.

Converter Id (cid)

Verify all converters are numbered between 1 and 8. Refer to numbering procedure in bay manual.

Display is in unusual mode

Move/verify that DIP switch SW1 positions 2-4 are in the closed position. Press the volt/amps button.

6 *Product Warranty*

A. Seller warrants to Customer only, that:

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

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

C. If, under normal and proper use during the applicable Warranty Period, a defect or nonconformity is identified

WARRANTY PERIOD

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

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

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

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

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

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

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

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

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