07ESSS000
Galaxy Communication Protocol (GP)

for

Family Of Small Rectifiers

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(Document Owner)

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1 Scope

GE Critical Power has developed a proprietary protocol for managing and providing the means of interconnecting many types of devices in a variety of power systems. This protocol has been defined as the Galaxy Communication Protocol or GP. GP allows these devices to communicate with a power system master controller over a standard robust RS485 serial communication link. These power system controllers initiate all commands and information requests to the devices attached to the rectifier serial communication link. GP protocol allows dynamic detection of many types of devices, automatic configuration, and stable system operation without requiring operator intervention.

The protocol can be viewed as a simple four-layer hierarchical protocol with each layer providing services to the layer above it. The layers in this protocol are physical, data, link, and application. The physical layer provides the media that moves data bytes between devices. The data layer packages the data bytes into discrete packets with error detection. The link layer allows devices to be detected and included in the set of active devices presently communicating on the bus. The application layer allows the system controller to gather status data and take appropriate action on the different devices contained within the power system.

The variables defined in this document are utilized when communicating to the family of small rectifiers. Section 2 addresses the physical representation of the data. Section 3 describes how data is collected into individual packets. Section 4 describes how devices initiate communication and maintain a stable link. Section 5 describes the application level variables and control features that allow the controller to monitor and control the family of small rectifiers.

2 Physical Layer

2.1 Hardware Interconnect

GE Critical Powers' serial controlled power systems utilize RS-485 serial communication interconnectivity to support all data traffic within a power system. Bus communication is asynchronous, half-duplex, and operates at 19.2K Baud. In normal operation, there is at most one transmitter and one or more receivers connected to the serial bus. System operation is the classic single master to multiple slaves. Device receivers continually listen to the bus messages for specific traffic directed to them. A single master, the system controller, initiates all bus communications. Data is transmitted on the bus asynchronously using a start bit, eight data bits, a framing bit, and a stop bit. The data bits and framing bit are presented to the data layer for processing.

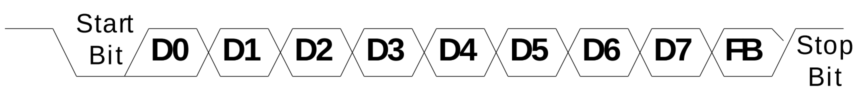

Figure 2.1- Serial Port Interface

2.2 Noise, Isolation, And Grounding

The drivers and receivers (transceivers) that comprise the RS485 bus conform to the standards dictated by the Telecommunications Industry Association in specification TIA/EIA-485-A. RS-485 is utilized because of its noise immunity advantages offered by the differential serial interface and its ability to have multiple devices attached to the interface.

The ***CP*** family of rectifiers is designed with non-isolated RS485 circuitry. RS485 circuitry in CP rectifiers is referenced to the non-grounded side of the DC output, typically coined Battery or "BAT". Thus, the RS485 circuitry in these rectifiers is referenced to the negative DC potential in a -48V rectifier. Thus, any controller design must take account for this potential either through referencing its respective RS485 circuitry to the same negative potential of the rectifier or by providing isolation that then can be referenced to the appropriate rectifier circuit potential. For the most part, a fully electrically isolated RS485 interface is recommended to minimize susceptibility to system and environment noise and problems that may occur between the different ground potentials in the devices attached to the bus. However, controllers with protected outputs referenced to the same potential of the rectifier's RS485 circuitry are acceptable.

The **NE** family of rectifiers is also designed with non-isolated RS485 circuitry. RS485 circuitry in NE rectifiers is referenced to the grounded side of the DC output, typically coined Discharge Ground or "DG". In NE systems this ground is also called "NECOMMON". Thus, the RS485 circuitry in these rectifiers is referenced to the positive DC potential in a -48V rectifier and the negative DC potential in a +24V rectifier. Thus, any controller design must take account for this potential either through referencing its respective RS485 circuitry to the same potential of the rectifier or by providing isolation that then can be referenced to the appropriate rectifier circuit potential. For the most part, a fully electrically isolated RS485 interface is recommended to minimize susceptibility to system and environment noise and problems that may occur between the different ground potentials in the devices attached to the bus. However, controllers with protected outputs referenced to the same potential of the rectifier's RS485 circuitry are acceptable. CP and NE rectifiers reference their RS485 circuitry to different potentials and should not be intermixed into a system.

2.3 Bus Termination

The problem of signal reflections on the RS485 serial communications link may become important as line speeds, edge rates, number of devices, and interconnecting lengths between devices increases. RS485 lines should be properly terminated for these cases. Termination circuitry should try and match the connecting cable or interconnect media's characteristic impedance. There are many different techniques for terminating a bus. The GP rectifier interface bus utilizes resistive termination. A 121-Ohm 2-Watt resistor located at each end of the serial link for standard twisted pair is recommended per the TIA/EIA 485-A specification for this particular link. Generally, a 121-ohm terminator is also located at the controller. The use of or non-use of terminating should be evaluated at the system level.

2.4 Maximum Loading

The TIA/EIA-485-A standard specifies a maximum of thirty-two unit loads on the bus. The CP family of rectifiers and associated controllers utilize transceivers that allow a minimum of 64 RS485 loads. It is suggested that the any interface to the CP family of rectifiers utilize 1/16 load transceiver devices or better.

The Telecommunications Industry Association released TSB89, an application guideline for TIA/EIA-485-A, in June of 1998. This bulletin was produced to embellish the original standard and will be updated in the future. Section 4.2.1 of TSB89 contains supporting information that illustrates under certain conditions the number of loads on a standard RS485 link can be increased. Some of the biggest factors that affect the number of possible loads on the bus are the common-mode voltage range, the data rates, and signal rise times utilized on the bus. Limiting the common-mode voltage range to a tighter range than the specified –7V to +12V range allows the number of loads that can be attached to the bus to be increased.

Note: Bus transceivers are allowed one millisecond to settle after they have been turned on.

2.5 Fault Management

Although many off-the-shelf transceivers offer some inherent protection against unwanted transients, ESD, and other problems that may occur on the RS485 bus, external protection circuitry may also be required for making the serial communication port more robust. Consult manufacturing data sheets and application notes to determine the best protection for the targeted system.

3 Data Layer

Individual data bytes are collected into packets of variable length in the data layer. A framing bit (FB) value of one (1) in the first byte indicates the start of a data packet.

X	X	X	X	X	X	X	X	**1**

←--------------------------------------- Byte 1 -----------------------------------→

Figure 3.1 - Framing Byte

All other bytes have the framing bit value of zero (0).

X	X	X	X	X	X	X	X	**0**

←------------------------- Byte 2, 3… PACKET_LEN------------------------→

Figure 3.2 - Data Byte

Since transmission errors may occur, it is important that both devices know when frames have been transferred successfully. Inherent to the hardware, are checks for framing error and collision detection (Reference H).

The Galaxy Communication Protocol uses a single packet to communicate information. A packet is broken down into three parts: the header, the body, and the checksum.

HEADER			**BODY**			**CHECKSUM**	
Byte 1	Byte 2	Byte 3	…				Byte $_{PACKET\_LEN}$
Address	Length	Type	Body [0]	. . .	Body [N]	CRC_MSB	CRC_LSB

←--- Packet 1 ---→

Figure 3.3 - Packet Composition

3.1 Header

The header is fixed in length (three bytes) and is used to determine the packet's destination, length, and type.

3.1.1 Address

The destination is selected through use of an address byte. Address bytes range in value from 00h to FFh. An address of 00h is reserved for the system controller. Addresses in the range of 01h to 7Fh are dynamically assigned to individual devices on the bus. Addresses in the range of 80h to FEh are statically assigned as a group address for devices that offer similar features. An address of FFh is reserved for broadcasting to all devices on the bus. Every device must respond to a broadcast at all times. The protocol does not support broadcast Read messages.

An address byte contains a set-framing bit that may be used for monitoring bus activity. In this fashion, every device on the bus simply reads the address byte and ignores any corresponding data if it itself isn't being addressed. This allows devices to sleep or work on other tasks.

3.1.2 Length

The second byte of the header, the packet length, is the total number of bytes that make up a packet. Presently, packets may be up to twenty bytes long. Longer packet lengths affect performance. Aside from standard processing of packets, the packet length is also used for supplemental data verification. The length is compared to the expected length for the variable types and the data is acted on only if they match.

3.1.3 Type

The third byte of the header indicates the type of the packet.

Packet Type	Name	Len	From	To	Used For	Notes
43h ('C')	Choose Slot	06h	Ctlr	Broadcast	Linkup	Refer to Section 4.6
50h ('P')	Poll Slot	06h	Ctlr	Broadcast		
70h ('p')	Poll Response	12h	Dev	Ctlr		
41h ('A')	Poll Acknowledge	12h	Ctlr	Dev		
52h ('R')	Read	Var.	Ctlr	Dev	Normal Operation	Request a value (See Section 5)
57h ('W')	Write	Var.	Ctlr	Dev		Set a value (See Section 5)
72h ('r')	Read Response	Var.	Dev	Ctlr		Response to read request (see Section 5)

Table 3.1 - Packet Types

3.2 Body

The body of the packet is variable in length and carries application specific data for higher layers in the protocol. Section 5 details the contents of the packet body.

3.3 Checksum

Data transmission integrity is verified through the use of a 16-bit Cyclic Redundancy Check composed of two bytes that are computed over the entire contents of the packet header and body. CRC is utilized since it is a common error-checking scheme to detect transmission errors. This scheme detects more errors than traditional additive checksum approaches. CRC is not calculated on the CRC bytes themselves. The CRC calculation is detailed in Appendix A.

4 Link Layer

Devices within the serial networked power system can be removed and replaced freely in the field. The controller recognizes when devices have been removed or inserted without user interaction. The link layer of the protocol provides for recognition of newly inserted or removed equipment. There are four packets involved: Choose Slot, Poll Slot, Poll Response, and Poll Acknowledge.

Once the controller recognizes devices, they are considered to be connected. Prior to being recognized, they are considered disconnected.

4.1 Choose Slot

The controller periodically issues a broadcast CHOOSE_SLOT packet which requests each disconnected device to choose a random integer number (time slot) within the range of 0 to (MAX_SLOTS – 1). MAX_SLOTS may be zero, in which case, all devices would select zero as the “random” number.

BROADCAST_ADDR	CHOOSE_SLOT_LEN	CHOOSE_SLOT	MAX_SLOTS	CRC_MSB	CRC_LSB

4.2 Poll Slot

The controller proceeds to poll each slot, successively, with a broadcasted POLL_SLOT packet.

BROADCAST_ADDR	POLL_SLOT_LEN	POLL_SLOT	SLOT[1]	CRC_MSB	CRC_LSB

Note 1: Where: $0 \leq \text{SLOT} < \text{MAX\_SLOTS}$

4.3 Poll Response

If a disconnected device recognizes that the polled slot number matches its randomly chosen slot number, it will attempt to respond with a POLL_RESPONSE packet by sending its unique serial number and group address (refer to Appendix B for additional information on serial numbers). If more than one device has the same slot number, multiple responses will cause a collision to occur at which time the controller receives garbage.

The device must respond within 142 milliseconds or the controller will think the device is not present.

MASTER_ADDR	POLL_ RESPONSE_LEN	POLL_ RESPONSE	SERIAL NUMBER (*12 Least Significant bytes)	GROUP_ ADDR	CRC_MSB	CRC_LSB

* Note: As of October 1, 2006 Telcordia GR-383 defines new Serial Number to be 18 characters rather than the previous 12 characters. "LBTYCO" is pre-pended (MSBs) to the previous 12 digit serial number format. Controller/monitoring software must account for the possibility of seeing product with both sizes.

4.4 Poll Acknowledge

Upon receiving a response, the controller acknowledges the device through a broadcasted POLL_ACKNOWLEDGE packet by sending back the serial number and assigning the device an available address.

BROADCAST_ ADDR	POLL_ ACKNOWLEDGE_LEN	POLL_ ACKNOWLEDGE	SERIAL NUMBER (*12 Least Significant bytes)	DEVICE _ ADDR	CRC_ MSB	CRC_ LSB

* Note: As of October 1, 2006 Telcordia GR-383 defines new Serial Number to be 18 characters rather than the previous 12 characters. "LBTYCO" is pre-pended (MSBs) to the previous 12 digit serial number format. Controller/monitoring software must account for the possibility of seeing product with both sizes.

Upon receiving an acknowledgement, the device will consider itself connected. Individual device information is now accessible through the use of the device address. Broadcast and group commands must still be respected. During this process, once devices are recognized and connected on the link only unrecognized and unconnected devices will respond to broadcast choose slot messages.

4.5 Link Failure (Timeouts)

A slave device must be accessed periodically in order to determine if the communication link is still established. It is the responsibility of the controller to access each device in an appropriate amount of time. If the controller fails to access a device within the device's timeout interval, the device will become disconnected and appropriate system and device alarms will be asserted.

Conversely, it is the responsibility of each device to respond to the controller within 142 milliseconds. If the device fails to respond soon enough to the original or repeated attempts (142 millisecond timeout each, GP_MAX_TRIES), the controller shall consider the device disconnected.

The standard device timeout is set at 10 seconds. The CP families of rectifiers, as well as other newer GE Critical Power serial rectifiers, support the modification of the timeout setting through a Galaxy protocol variable. This variable is the “TIMEOUT_SCALE_RW” variable given in Table 5.3. Once the link between the device and acting controller is established, the device timeout can be set. The device's communication link timeout can be set to any value between 10 and 60 seconds. This value is stored in volatile memory. A modified timeout value will remain as long as power is supplied to the rectifier. Upon loss of power, the value will be reset to 10 seconds on power-up. The timeout must be reset on power-up to maintain the desired value.

4.6 Sample Link Initialization

Given a system that can house a controller and six devices. It is populated with a controller, a rectifier (S/N: “99DJ07501234”), and two converters (Conv A - S/N: “99DJ07301234” and Conv B- S/N: “99DJ07301235”). At power up, the controller broadcasts a CHOOSE_SLOT packet with MAX_SLOTS equal to six (6). Each device generates a random number less than six. The rectifier chooses slot three. Conv A chooses slot one, and Conv B chooses slot five.

The numbers shown in Figure 4.1 are all in hexadecimal notation. The CRC-16 values have not been computed for each transfer, but are distinguished by a suffix representing a different value.

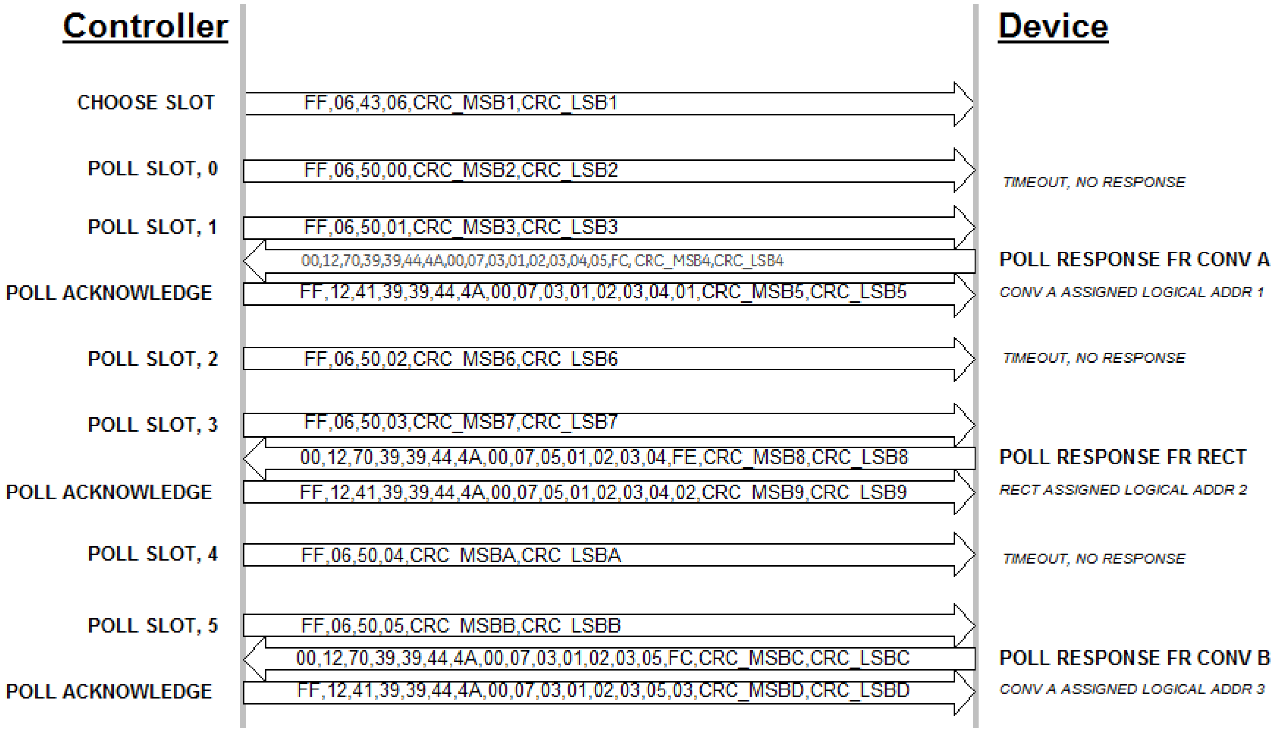

Figure 4.1 - Sample Link Sequence

5 Application Layer

The controller interacts with the system devices using the READ, WRITE, and READ RESPONSE packets. Each packet carries a unique body that details the variables and values of interest in the system device. A READ packet transmits the variable name to the system device, which then returns a value to the controller with the READ RESPONSE packet. The WRITE packet transmits a variable name and new value to a system device, which records it. The WRITE packet is also used to cause specific actions to occur within the device. The variable names and commands that are found in the packet bodies define the Galaxy Power System application. The remainder of this section will detail the specific packet body contents. First described are the basic data types used widely in the application. Generic variables that all devices must support are then described followed by the unique variables associated with specific devices.

Table 5.1 - Basic Data Types

Data Types	Data Type Definition
Null	No value
Uchar	8-bit unsigned integer
Ushort	16-bit unsigned integer
Short	16-bit signed integer
Ulong	32-bit unsigned integer
Long	32-bit signed integer

Note: All multi-byte integer data types are BIG ENDIAN format (MSB,LSB)

5.1 Write

The family of small rectifiers utilizes a standard Galaxy Protocol (GP) Write command. The standard GP Write command allows a GE Critical Power system controller or other polling equipment to transmit data to a specific device. This protocol command is standard among the family of GE Critical Power switch-mode powered rectifiers and will be discussed in this document.

5.1.1 Standard Galaxy Protocol Write

The standard ***WRITE*** packet writes to specific protocol variables in a device. A Write packet may be sent to a specific device, to all devices of the same group, or to all devices on the bus.

Writing to a specific device:

DEVICE_ADDR	6+data length	WRITE	VARIABLE_NUM (see tables)	data (see tables)	CRC_MSB	CRC_LSB

Writing to all devices with the same group address:

GROUP_ADDR	6+data length	WRITE	VARIABLE_NUM (see tables)	data (see tables)	CRC_MSB	CRC_LSB

Writing or Broadcasting to all devices:

BROADCAST_ ADDR	6+data length	WRITE	VARIABLE_NUM (see tables)	data (see tables)	CRC_MSB	CRC_LSB

5.2 Read

The family of small rectifiers supports a standard Galaxy Protocol ***Read*** command. This standard GP Read command allows a GE Critical Power system controller or other polling equipment to obtain data from a specific device. This command and the information obtained with its use are standard among the family of switch-mode powered rectifiers.

5.2.1 Standard Galaxy Protocol Read

The Read packet reads specific protocol variables from a device. Generally, a Read command is only sent to a specific device, in this case it would be a switch-mode rectifier.

Reading from a specific device:

DEVICE_ADDR	6	READ	VARIABLE_NUM (see tables)	CRC_MSB	CRC_LSB

5.3 Read Response

Similarly, the family of small rectifiers utilizing the Galaxy Protocol has standard responses to the Read commands. The device (rectifier) sends a standard GP Read Response packet in response to a standard Read packet from the power system controller.

5.3.1 Standard Galaxy Protocol Read Response

The standard GP Read packet reads specific protocol variables from a device. Generally, a Read command is only sent to a specific device, in this case it would be a switch-mode rectifier. The rectifier or addressed device will send a Read Response packet within 142ms of receiving the Read packet. Read messages shall be sent one at a time. A second read message should only be sent after receiving the response of the first Read message. This activity is the responsibility of the system-controlling device.

Read Response from a specific device:

MASTER_ADDR	5+data length	Read Response	data (see tables)	CRC_MSB	CRC_LSB

5.4 GP Group Number And Variable For Family Of Small Rectifiers

Table 5.2 provides the variable name, description, and Hex address for the small rectifier family.

Table 5.2 – Family Of Small Rectifier Group Number Definition

Variable Name	Group Number	Description
SMALL_RECTIFIER_ADDR	F6h	The Family Of Small Rectifiers

Table 5.3 - GROUP F6h: Small Rectifier Family Specific Variables

Variable Name	Num	Len	Data Type	Description
DUMMY_RW	00h	00h	null	Used to exercise the protocol for test purposes.
SERIAL_NUMBER_RW	01h	12h	uchar[18]	Serial number as an array of 12 or 18 ASCII characters.
GROUP_ADDRESS_R	02h	01h	uchar	Small rectifier group address F6h.
PROTOCOL_CONTROL_W	04h	01h	uchar	01h – forces devices to disconnect or drop their link
STATION_TYPE_R	05h	09-0Eh	uchar[9-14]	Device type as an array of 9 to 14 ASCII characters.
APPLICATION_VERSION_R	07h	07h	uchar[7]	Software version: v.d M/D/Y h:m v – version ones d – version tenths M – Month D – Day Y – Year H – Hour M – Minute

Variable Name	Num	Len	Data Type	Description
TIMEOUT_SCALE_RW	09h	01h	uchar	Timeout value for protocol in 1 sec. Increments, default is 10 seconds. If the device does not receive communication from controller within the timeout period, it will change its state to disconnected. Value will be reset to 10 second after communication failure with system controller.
LAMP_TEST_W	0Ah	00h	null	Lamp Test command.
I_R	0Ah	02h	ushort	Output current in A x 10
T_INTERNAL_R	0Bh	01h	uchar	Most important Internal rectifier temperature in degrees C
STATUS_R	0Ch	02h	ushort	Device status
PRES_STAT				0001h: 1 = rectifier present
ACF_STAT				0002h: 1 = AC input failure
------				0004h: Not Used
TA_STAT				0008h: 1 = Rectifier shutdown due to thermal alarm
RFA_STAT				0010h: 1 = Rectifier failure
AC_LOW_LINE_STAT				0020h: 1 = Low line input, 0 = high line input
LS_IMBALANCE_STAT				0040h: 1 = Load share imbalance
LS_STAT				0080h: 1 = Participating in digital load share (Enabled)
------				0100h: Not Used
TRH_STAT				0200h: Transfer, 1 = Standby from controller requested
HVSD_STAT				0400h: 1 = Rectifier shutdown due to high voltage
ON_STAT				0800h: Rectifier Power Status, 1 = On and producing power
LSABLE_STAT				1000h: 1 = Ready to participate in digital load share
ID_STAT				2000h: 1 = ID # has changed (cleared when read)
FAN_STAT				4000h: 1 = Fan failed
CL_STAT				8000h: 1 = Rectifier is in current limit/Power Limit
VSET_RW	0Eh	06h	ushort[3]	Voltage set-points. ushort[0] Float voltage set-point (volts x 400) ushort[1] Not Used ushort[2] Not Used
CMD_W	0Fh	02h	ushort	Device control
STANDBY_CMD				0001h: Place rectifier in Standby mode
ON_CMD				0002h: Place rectifier in On mode
SHVSD_CMD				0004h: Controller high voltage shutdown request from controller, shutdown if current is higher than load share percentage +10% of rated capacity
LS_ON_CMD				0008h: Participate in digital load share, default enabled
LS_OFF_CMD				0010h: Don't participate in digital load share, default disabled
RESTART_CMD				0020h: Restart a rectifier that is in lockdown
LAMPTEST_CMD				0040h: Lamp test, Lamp test shall assert LEDs in the following nature. • Single-color LEDs: 8sec On, 2sec Off, Return to Previous state • Bi-color LEDs: 1st color 4sec On, 2nd color 4sec On, all Off 2sec, Return to Previous state • Tri-color LEDs: 1st color ~2.6sec On, 2nd color ~2.6sec On, 3rd color ~2.6 sec On, all Off 2sec, Return to Previous state
TEMP_RESTART_CMD				0080h: Enable auto restart from high temp shutdown, default enabled
FAULT_LED_ON				0100h: Request fault LED ON
FAULT_LED_OFF				0200h: Request fault LED OFF
------				0400h: Not Used
------				0800h: Not Used
------				1000h: Not Used
------				2000h: Not Used
------				4000h: Not Used
------				8000h: Not Used
CAPACITY_R	11h	02h	ushort	Current capacity (A x 10) of rectifier. This is the rectifier's nominal ratings at 54.5 and 27.25.
VCMD_RW	13h	02h	ushort	Output voltage set point (V x 400)

Variable Name	Num	Len	Data Type	Description
VNOMINAL_RW	1Bh	02h	ushort	Ideal voltage set-point (V x 400)
CLCAP_RW	1Ch	02h	ushort	Current limit set point in % of rectifier capacity. Configurable from 30 to 100.
ID_R	1Fh	02h	uchar	Rectifier ID #, Defines location of rectifier in the shelf as well as the shelf number.
VOP_R	20h	02h	ushort	Actual output voltage (V x 400) of rectifier
LS_PERCENT_RW [1]	24h	01h	uchar	Utilize for digital load share, the load share current is a % of rectifier full scale output. LS_PERCENT_RW = (ΣI_R_R / ΣCAPACITY_R)•100. This is the average current as a % of capacity. Note: for digital load share, closure of this loop should be less often than closing the voltage loop.
COMCODE_RW	03h	0Bh	uchar[11]	Read/Write of GE Critical Power's Internal Part Number as an array of 11 ASCII characters
STATUS_CURRENT_R	32h	04h	ushort[2]	Status and Current Data ushort[0] Rectifier status word ushort[1] Output current (A x 10)

[1] The CP family of rectifiers utilize analog load share between the rectifiers. The NE family of rectifiers do not have analog load share. They may be allowed to "Droop" share or dynamically managed by performing adjustments through digital means.

6 Version Control

Rev 0.1 1/22/2007 Roy Jaescentt Davis

- Initial release for internal review (Brooke, Smith, Johnson, Hirsch)

Rev 1.0 1/23/2007 Roy Jaescentt Davis

- Initial Document release to Matrix

Rev 1.1 1/23/2007 Roy Jaescentt Davis

- Incorporated feedback from Mark Johnson

Rev 1.2 4/09/2007 Roy Jaescentt Davis

- Changed references from CP to CP/NE
- Added paragraph on NE RS485 grounding in section 2.2
- Added parameters to table 5.3 required for digital current share in rectifiers that utilize digital load share: LS_PERCENT_RW, LS_STAT, LSABLE_STAT, LS_ON_CMD, and LS_OFF_CMD
- Added note about CP and NE load share

Rev 1.3 3/13/2009 Roy Jaescentt Davis

- Changed Tyco references to Lineage
- Changed references from CP/NE to family of small rectifiers

Rev 1.4 6/21/2013 Roy Jaescentt Davis

- Changed Lineage references to GE Critical Power
- Changed COMCODE_RW from 2Ch 09h to 03h 0Bh
- Added length of 02h to CMD_W
- Changed length of ID_R from 01h to 02h
- Corrected Poll Response from CONV A in Fig 4.1
- The documented Read response length was changed to 5+data length from 6+data length
- Added VARIABLE_NUM column to Reading from a specific device table

Rev 1.5 6/21/2013 Roy Jaescentt Davis

- Corrected COMCODE_RW from 03h 09h to 03h 0Bh.
- Changed width of Station_Type_R to 0Eh from 09-0Eh
-

Rev 1.6 8/05/2013 Roy Jaescentt Davis

- Added CLCAP_RW

Appendix A CRC Calculation

The 16-bit Cyclic Redundancy Check (CRC) may be implemented in a purely mathematical fashion or a tabular *and* mathematical fashion. The latter method is currently used. The formula is derived from an article by Stephen Satchell (Copyright © 1986). Programmers may incorporate any or all code into their programs, giving proper credit within the source. Publication of the source routines is permitted so long as proper credit is given to Stephen Satchell, Satchell Evaluations and Chuck Forsberg, Omen Technology. Note that this CRC does not use a standard generator polynomial, so it is not compatable with CRC-16 or CRC-ITT. Generation of the CRC should not be performed on the CRC, only the data.

```
crc = 0xffff;        /* Initial Value */
for (i = 0; i < len_body; i ++)
        crc = ((crc >> 8) & 0xFF) ^  table_crc [(crc ^  *ptr_msg_body++) & 0xFF];
```

Mark G. Mendel, Network Systems Corporation calculated the CRC table.

Table A.1 - CRC-16 Table

0x0000	0xC0C1	0xC181	0x0140	0xC301	0x03C0	0x0280	0xC241
0xC601	0x06C0	0x0780	0xC741	0x0500	0xC5C1	0xC481	0x0440
0xCC01	0x0CC0	0x0D80	0xCD41	0x0F00	0xCFC1	0xCE81	0x0E40
0x0A00	0xCAC1	0xCB81	0x0B40	0xC901	0x09C0	0x0880	0xC841
0xD801	0x18C0	0x1980	0xD941	0x1B00	0xDBC1	0xDA81	0x1A40
0x1E00	0xDEC1	0xDF81	0x1F40	0xDD01	0x1DC0	0x1C80	0xDC41
0x1400	0xD4C1	0xD581	0x1540	0xD701	0x17C0	0x1680	0xD641
0xD201	0x12C0	0x1380	0xD341	0x1100	0xD1C1	0xD081	0x1040
0xF001	0x30C0	0x3180	0xF141	0x3300	0xF3C1	0xF281	0x3240
0x3600	0xF6C1	0xF781	0x3740	0xF501	0x35C0	0x3480	0xF441
0x3C00	0xFCC1	0xFD81	0x3D40	0xFF01	0x3FC0	0x3E80	0xFE41
0xFA01	0x3AC0	0x3B80	0xFB41	0x3900	0xF9C1	0xF881	0x3840
0x2800	0xE8C1	0xE981	0x2940	0xEB01	0x2BC0	0x2A80	0xEA41
0xEE01	0x2EC0	0x2F80	0xEF41	0x2D00	0xEDC1	0xEC81	0x2C40
0xE401	0x24C0	0x2580	0xE541	0x2700	0xE7C1	0xE681	0x2640
0x2200	0xE2C1	0xE381	0x2340	0xE101	0x21C0	0x2080	0xE041
0xA001	0x60C0	0x6180	0xA141	0x6300	0xA3C1	0xA281	0x6240
0x6600	0xA6C1	0xA781	0x6740	0xA501	0x65C0	0x6480	0xA441
0x6C00	0xACC1	0xAD81	0x6D40	0xAF01	0x6FC0	0x6E80	0xAE41
0xAA01	0x6AC0	0x6B80	0xAB41	0x6900	0xA9C1	0xA881	0x6840
0x7800	0xB8C1	0xB981	0x7940	0xBB01	0x7BC0	0x7A80	0xBA41
0xBE01	0x7EC0	0x7F80	0xBF41	0x7D00	0xBDC1	0xBC81	0x7C40
0xB401	0x74C0	0x7580	0xB541	0x7700	0xB7C1	0xB681	0x7640
0x7200	0xB2C1	0xB381	0x7340	0xB101	0x71C0	0x7080	0xB041
0x5000	0x90C1	0x9181	0x5140	0x9301	0x53C0	0x5280	0x9241
0x9601	0x56C0	0x5780	0x9741	0x5500	0x95C1	0x9481	0x5440
0x9C01	0x5CC0	0x5D80	0x9D41	0x5F00	0x9FC1	0x9E81	0x5E40
0x5A00	0x9AC1	0x9B81	0x5B40	0x9901	0x59C0	0x5880	0x9841
0x8801	0x48C0	0x4980	0x8941	0x4B00	0x8BC1	0x8A81	0x4A40
0x4E00	0x8EC1	0x8F81	0x4F40	0x8D01	0x4DC0	0x4C80	0x8C41
0x4400	0x84C1	0x8581	0x4540	0x8701	0x47C0	0x4680	0x8641
0x8201	0x42C0	0x4380	0x8341	0x4100	0x81C1	0x8081	0x4040

Galaxy Controller Simulator (GCS)

A.1 Scope

The Galaxy Controller Simulator is a small device that may be configured to behave as a system controller or slave device. The GCS communicates via the Galaxy Communication Protocol over an RS485 serial link through a standard 8-pin phone jack.

The GCS is intended to aide manufacturing and facilitate development. Rather than requiring an actual system controller to be used, the GCS's dedicated functions allow calibration time, test time, and inventory to be reduced. For specific information concerning the GCS refer to the GCS3 Users Guide For Small Rectifier Systems.

A.2 Connector Interface

Figure B.1 and Table B.1 detail the pinout for the device.

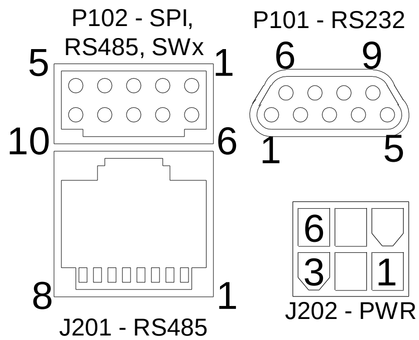

Figure B.1 - GCS Connector Interface

Table B.1- GCS Connector Pinout

Pin Num	Name	Dir	Description
P101	**RS232 (IBM 9-pin)**	**DCE**	
1	DCD	O	Data Carrier Detect - tied to DTR and DSR
2	RXD	I	Receive
3	TXD	O	Transmit
4	DTR	I	Data Terminal Ready - tied to DCD and DSR
5	SG	Ref	Signal Ground – tied to Vss
6	DSR	O	Data Set Ready - tied to DCD and DTR
7	RTS	I	Request To Send
8	CTS	O	Clear To Send
9	RI		Ringing Indicator

P102	**SPI, RS485, SWx**		
1	Vcc		+5V wrt Vss
2	MOSI	O	SPI – Master Out, Slave In
3	SCK	O	SPI – Serial Clock
4	/CS	O	Chip Select
5	RS485+	I/O	Auxiliary Galaxy Protocol Interface wrt VSS
6	SW1	I/O	General Purpose Pin – DEBUG_GPS48100 ACTIVITY
7	SW2	I/O	General Purpose Pin - DEBUG_GPS48100 MY_ACTIVITY
8	/LB	I	Loopback
9	RS485-	I/O	Auxiliary Galaxy Protocol Interface wrt VSS
10	Vss	Ref	Digital Ground

J201	**RS485**		
1	RS485-	I/O	Galaxy Protocol Interface wrt RS485GND
2	RS485+	I/O	Galaxy Protocol Interface wrt RS485GND
3	RS485GND	Ref	
4	Open	N/A	
5	Open	N/A	
6	Open	N/A	
7	Open	N/A	
8	Open	N/A	

J202	**POWER**		
1	N.C.	N/A	
2	N.C.	N/A	
3	VIN+	I	18V – 72Vdc Input wrt VIN-
4	N.C.	N/A	
5	N.C.	N/A	
6	VIN-	Ref	Reference for VIN+

A.3 Configuration And Physical User Interface

When the GCS is configured as a controller, a DB9 connector allows for RS-232 communications to a host computer or terminal. The pinout is compatible with most PC's and laptops. The data format is 9600 baud, 8 data bits, 1 stop bit, no parity, and RTS/CTS (hardware) flow control.

Three LEDs are provided by the GCS. At power-up, the LEDs are cycled to indicate proper operation. When the GCS is configured as a controller, the green and yellow LEDs flash until a device is detected on the RS-485 link and communication is established. At this time, the green LED will flash, indicating normal operation. If devices are not present or are removed after establishing communication, both the green and yellow LEDs will begin to flash after the device's respective timeout interval has expired. Should the GCS lose sanity, the red LED will begin to flash rapidly.

When the GCS is configured as a (slave) device, the green LED will flash until communication has been established, at which time, the green LED will remain on continuously. The yellow LED will flash momentarily when the slave device's EEPROM is being updated.

A.4 Command Line Interface

The GCS has a very simple command set. A menu of available commands and their description can be displayed on a terminal by typing **help** at the terminal prompt.

Table B.2- GCS Command Set

Command	Description
help	Display menu with this information
version	GCS Software version
stations	List active stations on RS485 link
read	Read Parameter: read sta par len (“” for string)
write	Write Parameter: write sta par len (hh hh..., “string”)

A.4.1 Command Set Tutorial

The following examples will demonstrate each command. Data entered from the terminal keyboard are shown in **BOLD PRINT**.

a)
```
GCS3> <ENTER>
?
GCS3>
```

b)
```
GCS3> help<ENTER>
help     Display this menu
version  GCS Software version
stations List active stations on RS485 link
read     Read Parameter: read sta par len (“” for string)
write    Write Parameter: write sta par len (hh hh..., “string”)

GCS3>
```

c)
```
GCS3> version<ENTER>
Version: 1.2
         12/08/97  15:26:10

GCS3>
```

d)
```
GCS3> stations<ENTER>
00000009

GCS3>
```

Note: The response is a 32-bit binary encoded long word in which each set bit represents a device communicating on the link. In the above example, stations 1 and 4 are present and communicating.

e) `GCS3>` **`read 01 01 0C "<ENTER>`**
`97DJ00001234`

`GCS3>`

*Note: The read command in this example requests from station **1** the serial number (variable number **0x01** with length **0x0C**) as a text string (**"**). Without ' **"** ', the following would be returned:*

`39 37 44 4A 30 30 30 30 31 32 33 34`

f) `GCS3>` **`read 01 02 01<ENTER>`**
`FE`

`GCS3>`

*Note: The read command in this example requests from station **1** its group address (variable number **0x02** with length **0x01**).*

g) `GCS3>` **`read 0C 02 01<ENTER>`**
`error`

`GCS3>`

Note: If a read is performed to a non-existing or non-responding station, an error message will be displayed on the terminal and the station will be dropped from the station list. The station will also be dropped if it is given a request for a non-implemented parameter.

h) `GCS3>` **`write 01 01 0C "99DJ12345678<ENTER>`**

`GCS3>`

Note: Although numeric data is always entered as a hex number, one quotation mark is necessary to write data as a text string. The write command does not verify itself for a successful write. A read succeeding the write is recommended for data verification.

Appendix B Serial Numbers

B.1 Device Serial Number vs. Circuit Pack

The device serial number is used by the protocol. The serial number is used to confirm a device ID number that is used for individual device accesses. However, this number should be the assembled device's (e.g. rectifier) serial number, and not the circuit pack's (e.g. rectifier interface circuit (RIC) pack) serial number. This implies that the device's serial number must be accessible to the microcontroller.

Appendix C Physical To Logical Mapping

When power is applied to a system, the controller assigns a logical address to each device on the serial link. These logical addresses may be physically mapped to a location in the system. Physically mapping (e.g. RECT1 in bottom left hand corner of rack, RECT2 next to RECT1 on the right, etc) a rectifier to a location in the system may be done in a variety. Depending on the device, mapping is performed by front panel rocker switches, on board DIP switches, or through shelf configurable address jumpers and cables. In small rectifier power systems, this logical to physical mapping is performed through shelf ID configuration. A shelf ID is configured and each rectifier in that shelf has a known position. Thus, the rectifier ID variable is now comprised of a shelf ID number and a rectifier number. As an example, an ID of 21 is broken down to shelf 2 rectifier 1. Once a system is configured and mapped, in the event of a power loss or removal / replacement of devices, the physical mapping is recorded by the power system controller. The system controllers report all system device status via the physical mapping. Logical addresses are transparent to the user.