SERIAL INTERFACE OPTION SPECIFICATION

This document describes the hardware and firmware of the GlassmanHV RS-232C Serial and USB data interface option.

This interface is an add-on to Glassman high voltage power supplies. Its purpose is to provide remote monitoring and control capability of all analog and digital functions available for that product line, while providing 2500 V RMS voltage insulation between the power supply and the controlling computer. The interface is microcontroller-based and is built in a module that plugs into the rear of the power supply. Since the data link between the Customer computer and the Glassman HV Power Supply is fully dedicated and hardwired (there are no intermediate devices such as modems), none of the RS-232C handshaking signals are required.

Both a serial RS-232 interface and a USB interface are provided. When the USB interface is active, the serial interface is automatically disabled. USB communication is implemented by means of a virtual com port interface provided by the MS Windows control computer. MS windows drivers must be installed in order to use this the USB communication feature.

The interface uses ASCII encoded character strings for data transmission. Transmission error checking is implemented using modulo 256 checksums. The transmission format is 9600 baud, no parity and one stop bit.

The Power Supply Interface acts strictly as a slave device. It will not transmit any messages over the data link unless it is first commanded to by the Customer master computer.

The design is based on the MSP430F157 16 bit microcontroller. This unit has a built-in 9 channel analog multiplexer and 12-bit A/D Converter. To perform D/A conversion, we are using an external Quad 12-bit D/A Converter. To meet the resolution requirement of 0.1%, 10 bits is the minimum number of bits that can be used

SERIAL PORT OVERVIEW

RS-232C is used with single-ended transmission over relatively short distances. The standard defines the electrical characteristics for the interfacing of Data Terminal Equipment (DTE) and Data Communications Equipment (DCE). In our case the Customer Computer is the DTE and the Glassman HV Power Supply equipment is the DCE.

RS-232C recommends the use of DB-25 female connector jacks mounted on the DCE (the power supply) equipment. However, since none of the RS-232C handshaking lines will be used, a DB-9 female connector will be used to save space.

The DB-9 connector will be configured to work with a "standard" 9 pin IBM PC-AT compatible communications port as defined below. If the power supply is connected to a "standard" 25 pin communications port, the interconnect cable must reverse pins 2 and 3 as shown in Table 1.

The required signal connections at the power supply's DB-9 connector are:

Pin 2 – RxD – Receive Data (computer receive line/power supply transmit line)
Pin 3 – TxD – Transmit Data (computer transmit line/power supply receive line)
Pin 5 – GND – Signal Ground
Pins 1, 4 and 6 of the power supply's DB-9 connector are shorted together at the connector.
Pins 7 and 8 of the power supply's DB-9 connector are shorted together at the connector.
Pin 9 of the power supply's DB-9 connector is not used.

The signals and DB-9 pin numbers, with their DB-25 equivalents, are summarized below:

SIGNAL NAME	DB-9 PINOUT	DB-25 EQUIV	COMMENTS (PINS REFER TO DB-9)
Data Carrier Detect (DCD)	1	8	shorted to pins 4 and 6
Receive Data (RxD)	2	3	power supply transmit line
Transmit Data (TxD)	3	2	power supply receive line
Data Terminal Ready (DTR)	4	20	shorted to pins 1 and 6
Signal Ground (GND)	5	7	signal ground
Data Set Ready (DSR)	6	6	shorted to pins 1 and 4
Request To Send (RTS)	7	4	shorted to pin 8
Clear To Send (CTS)	8	5	shorted to pin 7
Ring Indicator (RI)	9	22	not used

Table 1A. DB-9 Pinouts

The ASCII codes that are used by the data interface are shown in Table 2.

USB PORT OVERVIEW

USB (Universal Serial Bus) is a cable bus that supports data exchange between a host computer and a wide range of simultaneously accessible peripherals. The attached peripherals share USB bandwidth through a host scheduled, token-based protocol. The bus allows peripherals to be attached, configured, used, and detached while the host and other peripherals are in operation. A USB system is described by three definitional areas: USB interconnects, USB devices, and a USB host. In our case the Customer Computer is the USB host and the Glassman HV Power Supply is the USB device.

To minimize end user termination problems, USB uses a "keyed connector" protocol. The physical difference in the Series "A" and "B" (or "mini-B") connectors insures proper end user connectivity. The "A" connector is the principle means of connecting USB devices directly to a host or to the downstream port of a hub. All USB hosts must have the standard Series "A" connector. The "B" (or "mini-B") connector allows device vendors to provide a standard detachable cable. In our case, the Glassman HV Power Supply uses a "mini-B" connector. The pin assignments for the "mini-B" connector at the power supply are as follows:

SIGNAL NAME	MINI-B PINOUT
VBUS	1
D-	2
D+	3
No Connect	4
Ground	5

Table 1B Mini-B Pinouts

The ASCII codes that are used by the data interface are shown in Table 2.

CHARACTER SENT	ASCII CODE (Hexadecimal)	COMMENTS
SOH	1	Start of header (Ctrl-A)
<CR>	0D	Carriage return (Enter)
0	30	
1	31	
2	32	
3	33	
4	34	
5	35	
6	36	
7	37	
8	38	
9	39	
A	41	CAPITAL letters only!
B	42	
C	43	
D	44	
E	45	
F	46	
Q	51	
R	52	
S	53	
V	56	

Table 2. Relevant ASCII Codes

SIGNAL SUMMARY

The data interface receives and transmits digital data packets between the Customer computer and the Glassman HV power supply that represent the analog and digital signals defined below:

Analog Control Signals sent from Customer Computer to GlassmanHV Power Supply:

1. Voltage Control (O – FFF hex represents 0 – Vmax output)

2. Current Control (O – FFF hex represents 0 – Imax output)

Internal to the power supply interface, the D/A converters have an analog output range of 0 to + 5 volts DC, where FFF hex represents full scale.

Digital Control Signals sent from Customer Computer to GlassmanHV Power Supply:

1. HV On (0 = off, 1 = on)
2. HV Off (0 = on, 1 = off)
3. Power Supply Reset (1 – reset)

Programming a digital control bit to a "1" will generate an internal 250 millisecond pulse that will assert the desired function.

Analog Monitor Signals sent from GlassmanHV Power Supply to Customer Computer:

1. Voltage Monitor (0 – 3FF hex represents 0 – Vmax output)
2. Current Monitor (0 – 3FF hex represents 0 – Imax output)

Internal to the power supply interface, the A/D converters have an analog input range of 0 to +5 volts DC, where 3FF hex represents full scale.

Digital Monitor Signals sent from GlassmanHV Power Supply to Customer Computer:

1. Power Supply Fault (1 = fault) when available.
2. HV On Status, (1 = on, 0= off) when available.
3. Control Mode Status (V mode = 1, I mode = 0) when available.

COMMAND STRUCTURE

The general operation of the data link is described in this section.

The Customer computer can send three possible commands to the Glassman HV power supply:

SET POWER SUPPLY (S) command

QUERY POWER SUPPLY (Q) command

SOFTWARE VERSION LEVEL REQUEST (V) command

A Set command contains a total of 18 bytes and instructs the power supply to change any or all of its control signals. The power supply will execute the Set command and respond with a simple 2 byte **ACKNOWLEDGE (A)** packet, or, if errors are detected, the power supply will not execute the Set command but will return a 5 byte **ERROR (E)** packet.

A Query command contains a total of 5 bytes, and is used to request that the power supply return an information packet containing the analog and digital information that it monitors. The power supply responds by sending back a 16 byte **RESPONSE (R)** packet.

In response to a 5 byte Version Request command, the power supply will return a 6 byte **SOFTWARE VERSION LEVEL RESPONSE (B)** packet to the computer.

For all these commands, if communication errors or illegal conditions are detected by the power supply, the command will not be executed and the appropriate 5 byte **ERROR (E)** packet will be sent back to the computer.

SET COMMAND ("S") AND ACKNOWLEDGE ("A") RESPONSE

Prior to sending a Set Command that performs any function other than a Power Supply Reset, the computer should ensure that no fault conditions are existing within the power supply. This is done by first sending a Query Command and examining the returned Response Packet.

Note that it is legal to send a Set Command that does not assert any of the three digital controls. For example, if the HV was on and it was desired to change one or more of the two analog controls, a command packet could be sent containing the new values for the analog controls but with the three digital control bits set to 0. In this case, the analog values will be changed and the HV will remain on.

If any of the analog monitor fault bits are active, the Set Command packet must include a Power Supply reset assertion.

The protocol for the Set Command is as follows:

The power supply receives the "S" command and performs a checksum comparison and other error checking. If a communication or other error is detected, the power supply will not execute the command but will send an error message back to the computer. If the

checksum compares properly and no other errors exist, the power supply will execute the Set Command and return a simple 2 byte Acknowledge message. The computer should then Query the power supply to be sure that the power supply parameters are set as desired.

The data will be ASCII encoded, where scaling is done in the Customer computer. The resolution for the four analog controls is 12 bits, so full scale will be represented by FFF hex. The first byte "SOH", can be entered at the keyboard by the "CONTROL-A" key combination ("CTRL-A").

All alphabetical entries should use CAPITAL letters only. Use of lower case letters will result in errors.

The byte definitions of the command message are shown in Table 3. Note that high order bytes are sent first.

BYTE	DESCRIPTION
1	Start of message character ("SOH" character: hex 01)
2	Command Identifier Character (S character, hex 53)
3 - 5	Voltage command (0 – Vmax corresponds to 0 – FFF hex)
6 - 8	Current command (0 – Imax corresponds to 0 – FFF hex)
9 -14	Not implemented
15	Digital control data (HV On, HV Off, Power Supply Reset)
16 -17	Modulo 256 Checksum of all previous bytes except start character
18	End of message character (carriage return, hex OD)

Table 3. SET Command Byte Contents

An example will illustrate the ASCII data protocol is used. Assume that the Customer computer sends a command to the power supply that sets the analog power supply parameters to 55% Vmax, 25% Imax, and asserts the digital HV Off control.

The following 18 byte packet will be sent:

The first byte will contain the ASCII character SOH, which will be sent as 01 hex = 0000 0001 binary (enter CTRL-A at the computer keyboard).

Byte 2 is the Set Power Supply command identifier character S. In ASCII, this is 53 hex = 0101 0011 binary (enter capital S at the computer keyboard).

Bytes 3 through 5 represent the voltage, 55% of full scale. Full scale with 12 bit resolution is FFF hex. 55% is therefore represented as 8CC hex (within an error of 1 lsb). Bytes 3-5 will be sent containing the ASCII representation of 8CC hex (enter 8CC at the computer keyboard):

Byte 3:	38 hex = 0011 1000 binary
Byte 4:	43 hex = 0100 0011 binary
Byte 5:	43 hex = 0100 0011 binary

Bytes 6 through 8 represent the current, 25% of full scale. Full scale with 12 bit resolution if FFF hex. 25% is therefore represented as 3FF hex (within an error of 1 lsb). Bytes 6 – 8 will be sent containing the ASCII representation of 3FF hex (enter 3FF at the computer keyboard):

Byte 6:	33 hex = 0011 0011 binary
Byte 7:	46 hex = 0100 0110 binary
Byte 8:	46 hex = 0100 0110 binary

Bytes 9 through 14 are not implemented, and are set to 30 hex = 0 decimal all of them.

Byte 15 represents the digital control data. The digital control byte is assigned as follows (only the least significant four bits are encoded into the ASCII byte):

Bit 0	HV Off (Off = 1)
Bit 1	HV On (On = 1)
Bit 2	Perform Reset (reset = 1). Sets V = 0, I = 0 & HV Enable = off,
Bit 3	Unused

The digital control nibble will therefore contain 0001 binary = 01 hex. The ASCII representation is (enter the number 1 at the computer keyboard):

Byte 15:	31 hex = 0011 0001 binary

The checksum is calculated on all bytes before it except the SOH character. Bytes 16 and 17 will therefore contain the remainder of a modulo 256 addition of bytes 2 through 15. In hex, these bytes are:

53 + 38 + 43 + 43+ 33 + 46 + 46 + 30 + 30 + 30 + 30 + 30 + 30 + 31 hex = 321 hex

Since modulo 256 decimal is modulo 100 hex, we can divide 321 hex by 100 hex. The remainder is 21 hex. Therefore 21 hex will be sent in bytes 16 and 17 in ASCII representation as 32 hex and 31 hex. Note that the actual implementation of the checksum by the

data interface is very simple and requires no actual division. The data bytes are simply added up on an eight bit counter whose carry overflow is ignored. The result stored in the counter will be the checksum remainder (If entering the checksum directly from the computer keyboard, enter the numbers 2 and 1):

Byte 16:	32 hex = 0011 0010 binary
Byte 17:	31 hex = 0011 0001 binary

The last byte is the carriage return (press the "Enter" key on the computer keyboard), represented in ASCII as:

Byte 18:	OD hex = 0000 1101 binary

To summarize, the entire 18 ASCII character packet will be sent as follows, where the start character, SOH = Ctrl-A = 01 hex is the first byte sent and the carriage return = OD hex is the last byte sent:

Byte Number:

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18

Entered at the keyboard:

Ctrl-A	S	8	C	C	3	F	F	0	0	0	0	0	0	1	9	8	Enter

Sent in ASCII coded hexadecimal:

01	53	38	43	43	33	46	46	30	30	30	30	30	30	31	32	31	OD

(Note that the spaces between bytes are shown for clarity only and are not actually sent.)

The actual data is sent in serial binary format. Each 8-bit byte is framed with 1 start and 1 stop bit. No parity bits are being sent or received. Therefore this data packet is 180 bits long.

The data interface will receive this command and place it in a temporary memory area. Before executing the command, several checks are made. If an illegal condition is detected, the command will not be executed and an error message will be sent back to the computer. The conditions that are checked are described in Section 1.5 (Errors) of this document.

If no errors are detected, the data interface will execute the command, and then send a 2 byte Acknowledge Packet back to the computer.

The format of the Acknowledge Packet is:

A <CR> where <CR> indicates the carriage return.

In ASCII coded hexadecimal:

41 OD

QUERY COMMAND ("Q")

The 5 byte command to request power supply status information is the Query ("Q") command.

The protocol for the Query command will be as follows:

The power supply will receive a Q command requesting information. If the command is properly received with no errors detected, the power supply will return the Response packet back to the computer. If errors are detected in the command, the power supply will return an appropriate error message.

The format of the command is:

SOH	Q	Check1	Check2	<CR>

Entered at the keyboard:

Ctrl-A	Q	5	1	Enter

Sent in ASCII coded hexadecimal:

01	51	35	31	0D

where the checksum, which does not include the SOH character, will always be hex 51, transmitted in two ASCII bytes representing 5 and 1.

RESPONSE PACKET ("R")

The 16 byte Response Packet will be returned to the computer in response to a valid Query command. It will contain status information in the following order:

BYTE #	DESCRIPTION
1	Response identifier character "R"
2-4	Voltage monitored (0 – Vmax) corresponds to (0 – 3FF) hex.
5-7	Cathode Current monitored (0 – Imax) corresponds to (0 – 3FF) Hex.
8-10	Reserved, Set to 0 decimal = 30 hex.
11-13	Digital monitors (12 bits encoded in three ASCII bytes)
14-15	Modulo 256 checksum of bytes 2 –13
16	End of message character (carriage return, hex 0D)

Table 4. Response Packet Byte Contents

Note that the analog monitors have 10 bit resolution, therefore, full scale is represented in hexadecimal as 3FF. The checksum is calculated on bytes 2 through 13.

The 12 digital monitor status bits are sent as three ASCII characters. The bit assignments are as follows:

Byte 11:
- Bit 0 Control Mode: Voltage Mode = 0, Current Mode = 1
- Bit 1 Power Supply Fault (1 = Fault) when available.
- Bit 2 HV On Indicator (1 = on) when available
- Bit 3 Unused = 30 hex

Byte 12:
- Bit 0 Unused = 30 hex
- Bit 1 Unused = 30 hex
- Bit 2 Unused = 30 hex
- Bit 3 Unused = 30 hex

Byte 13:
- Bit 0 Unused = 30 hex
- Bit 1 Unused = 30 hex
- Bit 2 Unused = 30 hex
- Bit 3 Unused = 30 hex

For example, a monitored voltage of Vmax will correspond to 3FF hex, sent with ACII encoding as follows:

Byte 2: 33 hex (00110011 binary)
Byte 3: 46 hex (01000110 binary)

Byte 4: 46 hex (01000110 binary)

If HV was On, and the Voltage Mode was set, the digital status bytes will be:

Byte 11: 35 hex (00110101 binary)
Byte 12: 30 hex (00110000 binary)
Byte 13: 30 hex (00110000 binary)

SOFTWARE VERSION REQUEST ("V") COMMAND AND RESPONSE ("B")

The 5 byte command to request the software revision level of the power supply's data interface is the "V" command.
The protocol for the V command will be as follows:

The power supply will receive a V command requesting information. If the command is properly received with no errors detected, the power supply will return the 6 byte Version Response (B) packet back to the computer. If errors are detected in the V command, the power supply will return an appropriate error message.

The format of the V command is:

SOH	V	Check1	Check2	<CR>

Entered at the keyboard:

Ctrl-A	V	5	6	Enter

Sent in ASCII coded hexadecimal:

01	56	35	36	0D

where the checksum, which does not include the SOH character, will always be hex 56, transmitted in two ASCII bytes representing 5 and 6.

The format of the 6 byte Response Packet (B) will be:

B	2 byte revision level	2 byte checksum	<CR>

For example, if a V command was properly received by a data interface with software revision level 25, the following packet will be returned to the computer:

B	25	2 byte Checksum	<CR>

Sent in ASCII coded hexadecimal:

42	32	35	36	37	0D

since the checksum of 32 hex + 35 hex is 67 hex which is transmitted in ASCII as two bytes containing 36 and 37 hex.

ERROR RESPONSES (E) AND ILLEGAL CONDITIONS

Error responses are messages sent back to the computer in response to a communication error detected on receipt of an S, Q, or V command or an illegal setting in an S command. The 5 byte error response packet takes the following form:

E	1 byte error code	2 byte checksum	>CR>

The checksum is only calculated on the 1 byte error code. For example, for error 5, the error byte will be transmitted as 35 hex. The checksum of 35 hex is 35 hex which is transmitted in ASCII as two bytes containing 33 and 35 to represent the 3 digit and 5 digit, respectively.

Error Codes Are:

1. Undefined Command Code – the command character received was not an S, Q, or V. The power supply will send back this error message if the second character of the received command packet is not an S, Q, or V. The error packet that will be returned to the computer will be:

Characters sent:	E	1	3	1	<CR>
In ASCII coded hexadecimal:	45	31	33	31	0D

2. Checksum Error – the transmitted checksum received in the command packet did not match the checksum calculated on the received bytes. The error packet that will be returned to the computer will be:

Characters sent:	E	2	3	2	<CR>
In ASCII coded hexadecimal:	45	32	33	32	0D

3. Extra Byte(s) Received – a byte other than the carriage return character was received in the last expected byte position of the command. The error packet that will be returned to the computer will be:

Characters sent:	E	3	3	3	<CR>
In ASCII coded hexadecimal:	45	33	33	33	0D

4. Illegal Digital Control Byte In Set Command – only one of the following three conditions can be set in the digital control byte of the Set command at any one time:

   HV On
   HV Off
   Power supply Reset

   If the computer requests that the power supply set more than one of the above three conditions simultaneously, error 4 will be generated. The error packet that will be returned to the computer will be:

Characters sent:	E	4	3	4	<CR>
In ASCII coded hexadecimal:	45	34	33	34	0D

5. Illegal Set Command Received While a Fault is Active – if a fault is active at the time a Set command is received. The command must assert the Power Supply Reset line. If the computer attempts to turn HV On or HV Off, or to change only the analog control signals while a fault is active, the command will be rejected and error 5 will be generated. The error packet that will be returned to the computer will be:

Characters sent:	E	5	3	5	<CR>
In ASCII coded hexadecimal:	45	35	33	35	0D

6. Processing Error: Data received was valid, however an error was detected when executing the Command. The error packet that will be returned to the computer will be:

Characters sent:	E	6	3	6	<CR>
In ASCII coded hexadecimal:	45	36	33	36	0D

The fault signals that are checked are:

Power Supply Fault (when available)

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REVISION HISTORY:

Rev	Date	Drawn	Check	ECN	Description
NR	011107	JJC3	KJD	----	Created.