

Instruction Manual

V6 SERIES

High Voltage Power Supply

MODEL :
SERIAL# :
DATE :

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IMPORTANT SAFETY PRECAUTIONS

SAFETY

THIS POWER SUPPLY GENERATES VOLTAGES THAT ARE DANGEROUS AND MAY BE FATAL.
OBSERVE EXTREME CAUTION WHEN WORKING WITH THIS EQUIPMENT.

High voltage power supplies must always be grounded.

Do not touch connections unless the equipment is off and the Capacitance of both the load and power supply is discharged.

Allow five minutes for discharge of internal capacitance of the power supply.

Do not ground yourself or work under wet or damp conditions.

SERVICING SAFETY

Maintenance may require removing the instrument cover with the power on.

Servicing should be done by qualified personnel aware of the electrical hazards.

WARNING note in the text call attention to hazards in operation of these units that could lead to possible injury or death.

CAUTION notes in the text indicate procedures to be followed to avoid possible damage to equipment.

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WICHTIGE SICHERHEITSHINWEISE

SICHERHEIT

DIESES HOCHSPANNUNGSNETZTEIL ERZEUGT LEBENSGEFÄHRLICHE HOCHSPANNUNG.
SEIN SIE SEHR VORSICHTIG BEI DER ARBEIT MIT DIESEM GERÄT.

Das Hochspannungsnetzteil muß immer geerdet sein.

Berühren Sie die Stecker des Netzteiles nur, wenn das Gerät ausgeschaltet ist und die elektrischen Kapazitäten des Netzteiles und der angeschlossenen Last entladen sind.

Die internen Kapazitäten des Hochspannungsnetzteiles benötigen ca. 5 Minuten, um sich zu entladen.

Erden Sie sich nicht, und arbeiten Sie nicht in feuchter oder nasser Umgebung.

SERVICESICHERHEIT

Notwendige Reparaturen können es erforderlich machen, den Gehäusedeckel während des Betriebes zu entfernen.

Reparaturen dürfen nur von qualifiziertem, eingewiesenem Personal ausgeführt werden.

“WARNING” im folgenden Text weist auf gefährliche Operationen hin, die zu Verletzungen oder zum Tod führen können.

“CAUTION” im folgenden Text weist auf Prozeduren hin, die genauestens befolgt werden müssen, um eventuelle Beschädigungen des Gerätes zu vermeiden.

PRECAUTIONS IMPORTANTES POUR VOTRE SECURITE

CONSIGNES DE SÉCURITÉ

CETTE ALIMENTATION GÉNÈRE DES TENSIONS QUI SONT DANGEUREUSES ET PEUVENT ÊTRE FATALES.
SOYEZ EXTRÊMEMENT VIGILANTS LORSQUE VOUS UTILISEZ CET ÉQUIPEMENT.

Les alimentations haute tension doivent toujours être mises à la masse.

Ne touchez pas les connectiques sans que l'équipement soit éteint et que la capacité à la fois de la charge et de l'alimentation soient déchargées.

Prévoyez 5 minutes pour la décharge de la capacité interne de l'alimentation.

Ne vous mettez pas à la masse, ou ne travaillez pas sous conditions mouillées ou humides.

CONSIGNES DE SÉCURITÉ EN CAS DE REPARATION

La maintenance peut nécessiter l'enlèvement du couvercle lorsque l'alimentation est encore allumée.

Les réparations doivent être effectuées par une personne qualifiée et connaissant les risques électriques.

Dans le manuel, les notes marquées « **WARNING** » attire l'attention sur les risques lors de la manipulation de ces équipements, qui peuvent entraîner de possibles blessures voire la mort.

Dans le manuel, les notes marquées « **CAUTION** » indiquent les procédures qui doivent être suivies afin d'éviter d'éventuels dommages sur l'équipement.

IMPORTANTI PRECAUZIONI DI SICUREZZA

SICUREZZA

QUESTO ALIMENTATORE GENERA TENSIONI CHE SONO PERICOLOSE E POTREBBERO ESSERE MORTALI.
PONI ESTREMA CAUTELA QUANDO OPERI CON QUESTO APPARECCHIO.

- Gli alimentatori ad alta tensione devono sempre essere collegati ad un impianto di terra.
- Non toccare le connessioni a meno che l'apparecchio sia stato spento e la capacità interna del carico e dell'alimentatore stesso siano scariche.
- Attendere cinque minuti per permettere la scarica della capacità interna dell'alimentatore ad alta tensione.
- Non mettere a terra il proprio corpo oppure operare in ambienti bagnati o saturi d'umidità.

SICUREZZA NELLA MANUTENZIONE.

- Manutenzione potrebbe essere richiesta, rimuovendo la copertura con apparecchio acceso.
- La manutenzione deve essere svolta da personale qualificato, coscio dei rischi elettrici.
- Attenzione alle **AVVERTENZE** contenute nel manuale, che richiamano all'attenzione ai rischi quando si opera con tali unità e che potrebbero causare possibili ferite o morte.
- Le note di **CAUTELA** contenute nel manuale, indicano le procedure da seguire per evitare possibili danni all'apparecchio.

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Chapter 1

INTRODUCTION

1.1 Description of the V6 Series

Spellman's V6 Series is a family of regulated, fixed output polarity module high voltage power supplies which provide exceptional performance and value in many applications. Utilizing proprietary power conversion technology these SMT based high voltage modules provide improved performance, reliability and easy system integration. The V6 series units are fully enclosed and designed for system or bench top operation.



The V6 is rated at 30 watts with output voltages spanning from 1kV to 30kV with fixed positive or negative polarities. Voltage & Current loops with automatic cross over control regulate the output into any load condition. The output voltage is controlled locally by an internal multi-turn potentiometer. Remote analog voltage and current programming capability are included in all models. Analog monitor outputs are also included for remote monitoring of output voltage and current. The V6 is a reliable and robust series that is arc and short circuit protected. The comprehensive standard interface provides interfacing flexibility and all V6 units are CE, UL and RoHS compliant.

1.2 Standard Features

The V6 Series incorporates several standard features designed to optimize user satisfaction and safety:

- **Current Regulating Loop:** Current programmability allows the user to set where the unit will current limit, anywhere from 0 to 100% of maximum rated current.

- **0 to +5Vdc Remote Programming Inputs:** Positive polarity, high impedance, ground referenced 0 to 5Vdc voltage programming inputs correspond to 0 to 100% rated voltage and current outputs.

- **Local Control:** Multi-turn potentiometer located on the top of the unit is provided to control the output voltage locally.

- **0 to +5Vdc Monitor Outputs:** Positive polarity, low impedance, ground referenced 0 to 5Vdc voltage monitor outputs correspond to 0 to 100% rated output voltage and current.

- **Precision +5Vdc Reference Output:** A precision micro power band gap reference of +5Vdc, $\pm 0.5\%$, 25ppm/ $^{\circ}\text{C}$ is provided to simplify remote programming of the power supply.

- **Arc and Short Circuit Protected:** Due to the fixed, high frequency conversion rate the V6 series output capacitance is small resulting in minimal stored energy. Through the use of generously rated surge limiting resistors and a fast acting current loop, all units are fully arc and short circuit protected.

1.3 Remote Operating Features

- **Enable Input:** The Enable Input allows the user to easily control the HV ON/OFF status of the power supply. HCMOS compatible signals A low (<1.5Vdc) enable input signal equals HV ON, while a high (open or >3Vdc) enable signal equals HV OFF.

Warning!

The Enable Input should not be used as protection against user injury or for a safety interlock function.



1.4 Option

RS232 interface is available

1.5 Interpreting the Model Number

The power supplies model number describes its capabilities. Model numbers are configured as follows:

U6A30P30RS where:

V6 is the product series name

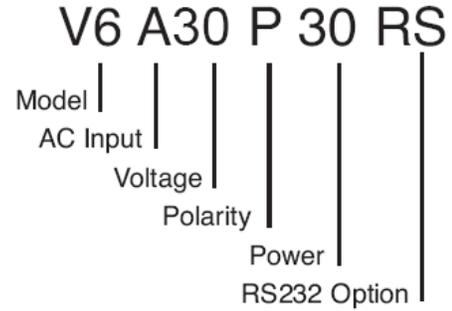
A is for AC input voltage and **D** for DC input voltage

30 is the maximum output voltage in kV

P is the output polarity

30 is the output power in watts

RS is for RS-232 interface (omit RS for analog interface)
Interface



X numbered units are unique units custom developed for specific application requirements above and beyond the scope of the available standard options. Each 4 digit X number corresponds to an applicable specification control drawing.

Chapter 2

INSPECTION & INSTALLATION

Initial inspection and preliminary checkout procedures are recommended. For safe operation, please follow the procedures described in Chapter 3, Operating Instructions.

2.1 Initial Inspection

Inspect the packaging exterior for evidence of damage due to improper handling in transit. Notify the carrier and Spellman High Voltage immediately if damage is evident. Do not destroy or remove any of the packing material used in a damaged shipment.

After unpacking inspect the power supply for any visible signs of damage.

2.2 Mechanical Installation

V6 units can be mounted in any position using the tapped holes in the base plate. 8-32 screws are required for mounting. Please see the V6 series data sheet for a more detailed dimensional drawing.

2.3 Temperature Consideration

It is the user's responsibility to maintain the case temperature below 50°C. Damage to the power supply due to inadequate cooling is considered misuse and repairs will not be covered under warranty

Figure 1 Outline Dimensions

OUTLINE V6A SERIES AC INPUT MODELS

OUTLINE V6D SERIES DC INPUT MODELS

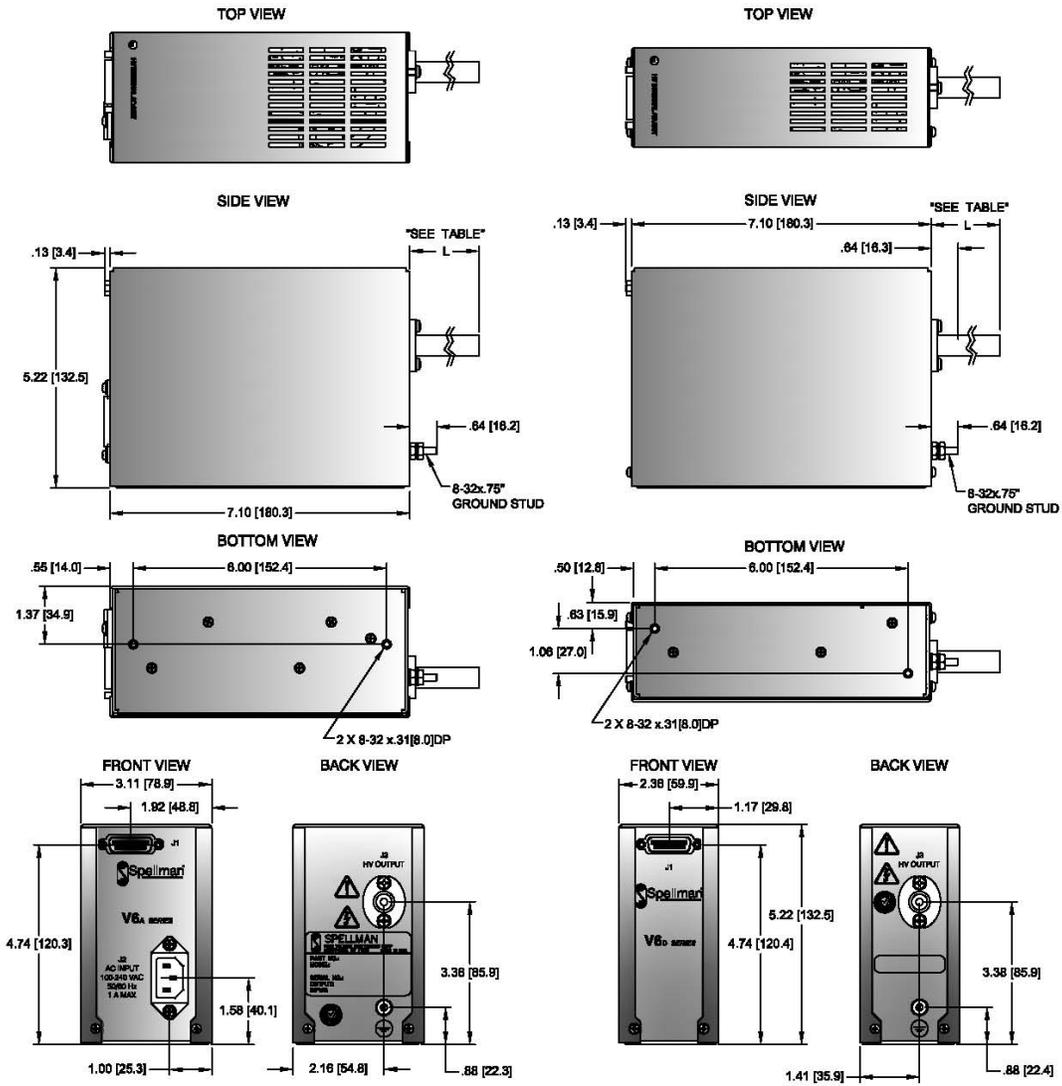


TABLE
HV CONNECTOR PROTRUSION

MODEL	L in [mm]
1kV, 1.5kV, 3kV, 5kV POSITIVE OR NEGATIVE	0.6 [20.3]
10kV, 15kV, 20kV, 30kV	1.88 [61.8]

DIMENSIONS IN BRACKETS ARE IN MILLIMETERS.

Chapter 3

Operating Instructions

3.1 Operation

WARNING!

This equipment generates dangerous voltages that may be fatal.

Proper grounding of all high voltage equipment is essential.

It is highly recommended that all testing comply with IEEE Standard 510-1983 IEEE

Recommended Practices for Safety in High Voltage and High Power Testing. A copy of this standard can be downloaded from the Spellman High Voltage website [here](#).



INPUT VOLTAGE

Check the identification label on the power supply and confirm it matches the input voltage of the source supply that will be used to power the V6 module. The DC units operate with +24Vdc \pm 10%, 2Amp. The AC units operate from 90Vac to 264Vac 50/60 Hertz, 1Amp

HIGH VOLTAGE CONNECTION

Insure that high voltage connection is properly terminated to the load. Confirm that adequate air isolations spacings exist for the maximum voltage of the power supply, using the guideline of 10kV per inch (25.4mm) to any points that will be elevated to high voltage. All accessible high voltage points should be enclosed in a protective Faraday enclosure. Any access panels on the safety enclosure should be interlocked.

GROUNDING

Proper grounding of the unit is essential for reliable operation. Power Ground, Signal Ground and HV Ground Return are connected internally.

The Power Ground connection (J1 Pin 13) carries the +24Vdc current that powers the unit. Make this connection adequate enough to handle 2 amps, minimum. Additionally it is recommended that this connection be used to tie the power supply to whatever potential is used as the local "system ground".

Signal grounds relating to programming and monitor functions should be referenced to the V6's Signal Ground (J1 Pin 6).

A physical load return connection must be made from the bottom of the load to the power supplies HV Ground stud (chassis).

See Figure 2 for DC modules details.

See Figure 3 for AC modules details.

OPTIONS

See Section 5 of this manual for RS-232 Communication Protocol. Custom X numbers units may also require special test requirements; consult the unit's specification control drawing for details.

SIGNAL CONNECTIONS

Connect the appropriate programming and monitoring signals to the unit as detailed in the figures in this chapter.

INITIAL TURN ON

- A) Set the voltage and current programming inputs for zero output (J1-4 and J1-9 respectively). Open the Enable Input (J1-8), to assure the unit is in HV OFF mode.
- B) The DC or AC input power can now be connected.
- C) Enable the power supply by grounding the Enable Input (J1-8).

- D) Set the current programming level (J1-9) to just above the current anticipated that will be drawn from the power supply.
- E) Slowly increase the voltage programming (J1-4) while monitoring the voltage and current monitors (J1-10 and J1-11 respectively). Carefully note proper equipment operation and that the load is behaving as predicted.
- F) To turn the HV OFF, open the Enable Input (J1-8). If the equipment is to be left off for an extended period of time or service of the unit or load is required, turn off the input power.

WARNING!

After turn off, do not touch anything that has been connected to the output of the power supply. Wait a minimum of 5 minutes, and then discharge any remaining stored energy by connecting the high voltage output to ground. Failure to follow these safety warnings can result in injury or death.



3.2 Standard Features

Programming and monitoring of the V6 Series is accomplished via the use of conventional positive polarity, ground referenced signals. All signal inputs and outputs are noise filtered, impedance protected and diode clamped providing an easy to use, robust analog customer interface. Excellent results have been obtained via the use of standard engineering design guidelines like twisted pair, shielded cables, the prudent dressing of interface wiring away from possible noise sources, short cable runs and adhering to a well thought out and executed grounding topology.

REMOTE PROGRAMMING

The V6's programming and monitor signals are based upon a universal, positive polarity, ground referenced signal such that 0 to 5Vdc corresponds to 0 to 100% rated output.

Programming can be accomplished via the use of an applicable customer provided ground referenced voltage source that meets the mentioned requirements. See Figure 4 for details.

If such a source is not available a precision +5Vdc reference is provided on J1-7. A simple adjustable voltage divider can be created using this reference and an external potentiometer(s) which will provide full control of the voltage and current loops. See Figure 5 for details.

LOCAL PROGRAMMING

Local programming can be accomplished via the use the multi turn potentiometer on the top of the unit. Continuous multi-turn precision potentiometers directly dial the output voltage. The resolution of the pot is 0.05% of maximum. The potentiometers are screwdriver adjustable and easily accessed. For local voltage control the following pins must be shorted: J1-1 to J1-5, J1-7 to J1-9. See Figure 6 for details.

REMOTE MONITORING

The voltage and current monitor signals have adequate bandwidth capability to accurately represent the actual respective output within the dynamic limits of the power supply. See Figure 7 for details.

ENABLE INPUT

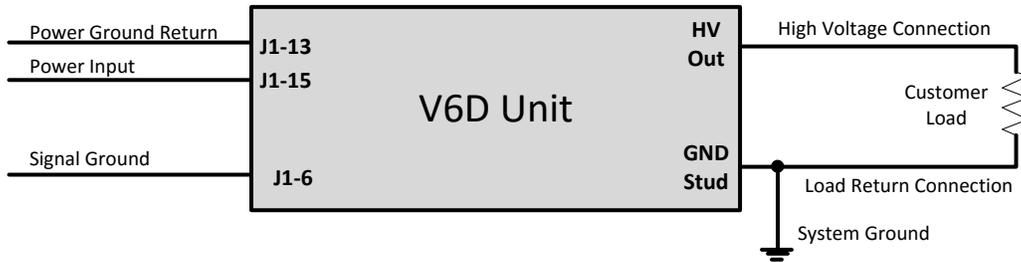
The enable input signal provides simple control of the ON/OFF functionality of the high voltage output. See Figure 8 for details.

WARNING!

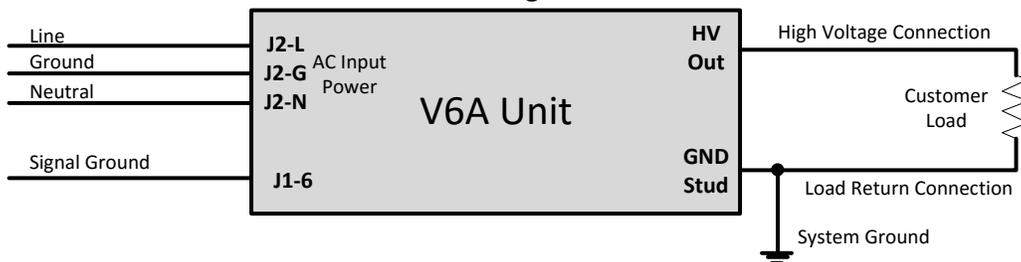
It is extremely dangerous to use this circuit to inhibit high voltage generation for the purpose of servicing or approaching any area considered unsafe during normal usage.



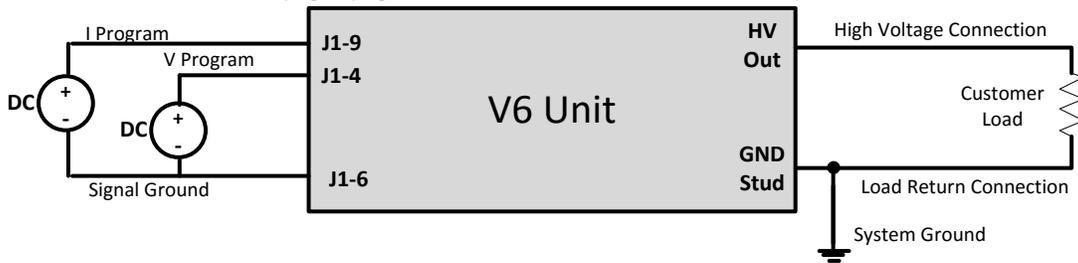
**Figure 2
Grounding DC Unit**



**Figure 3
Grounding AC Unit**



**Figure 4
Remote Programming with a Remote Voltage Source**
 $V_{prg} / I_{prg}: 0 \text{ to } 5\text{Vdc} = 0 \text{ to } 100\% \text{ Rated Output}$



**Figure 5
Programming using the +5V Reference**

If one pot is not used connect the other programming input directly to +5V Reference J1-7

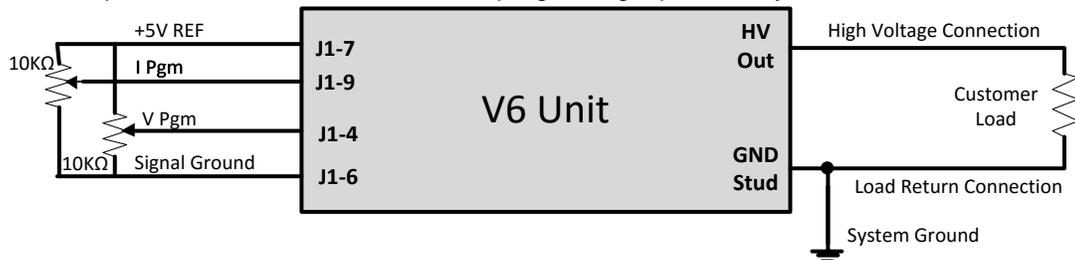


Figure 6
Local Programming using the internal multi turns potentiometer

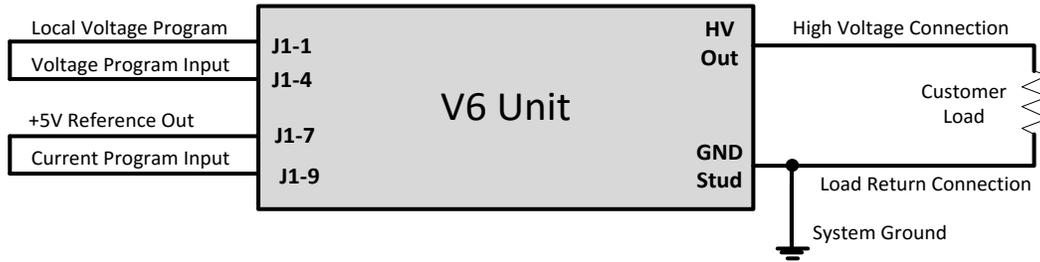


Figure 7
Remote Voltage and Current Monitoring
 $V_{mon} / I_{mon}: 0 \text{ to } 5\text{Vdc} = 0 \text{ to } 100\% \text{ Rated Output}$

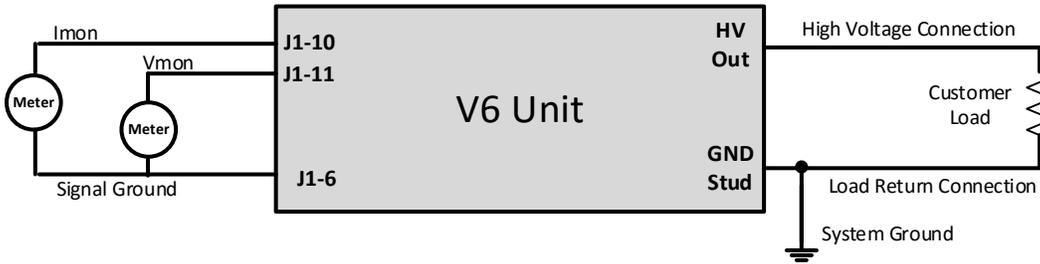
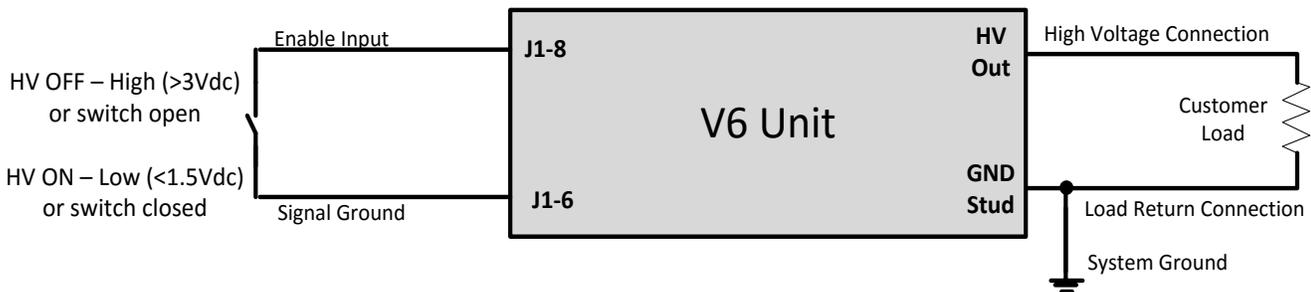


Figure 8
Enable Input



Chapter 4

Principles of Operation

Warning!

The energy levels used and generated by the power supply can be lethal! Do not attempt to operate the power supply unless the user has sufficient knowledge of the dangers and hazards of working with high voltage. Do not attempt to approach or touch any circuits that are connected to or have been connected to the power supply. Be certain to discharge any stored energy that may be present before and after the power supply is used. Consult IEEE recommended practices for safety in high voltage testing document number 510-1983.



4.1 DC/AC Input

The V6 Series is a DC to DC converter. Within the power supply conversions from low voltage DC, to low voltage AC, to high voltage AC and finally to high voltage DC takes place. The DC input +24Vdc powers the power conversion circuitry that creates the high voltage output along with the low voltage DC housekeeping voltages that provide power to the affiliated support control circuitry. The AC units use an off the shelf universal input 24V switching power supply.

4.2 Inverter

The DC input voltage is fed to the Inverter circuitry. Here the low voltage DC is converted to a low voltage, high frequency AC signal. This power conversion step allows for all subsequent power processing to take advantage of component miniaturization due to the high operational frequency. The Inverter functionality is controlled via the power supply's regulating loops which allows for complete command of the desired output voltage and current.

4.3 High Voltage Transformer

The high voltage transformer is a ferrite core step up type in which the primary is driven from the output of the Inverter circuit. The secondary of the high voltage transformer feeds the High Voltage Output Section.

4.4 High Voltage Output Section

The High Voltage Output Section utilizes an arrangement of half wave Cockcroft-Walton voltage multiplier stages to obtain the necessary output voltage.

The actual output voltage is sampled via a high impedance divider to create a voltage feedback signal. A current feedback signal is created via a current sense resistor in the low end return of the High Voltage Output Circuitry. These two accurate ground referenced feedback signals are used to precisely regulate and control the unit, in addition to providing external monitoring.

4.5 Control Circuitry

Various SMT based control circuitry is used for all interfacing, monitoring and regulation functionality of the V6 modular power supply.

The voltage and current feedback signals generated in the High Voltage Output Section are compared to the requested voltage and current commands from the remote interface. The voltage or current loop error amplifier creates the appropriate error signal which is then provided to the Pulse Width Modulation (PWM) circuitry.

The output of the PWM circuitry drives the Inverter circuit to provide the required output in a continuous closed loop control process, regulating in either voltage mode or current mode as required.

The internally generated voltage and current feedback signals are processed and provided to the remote interface for monitoring purposes.

A precision +5Vdc, $\pm 0.5\%$, 25ppm/ $^{\circ}\text{C}$ micro power band gap reference output is provided for user programming convenience.

The Enable Input from the remote interface controls the HV ON and HV OFF status of the power supply by interfacing with the PWM circuitry.

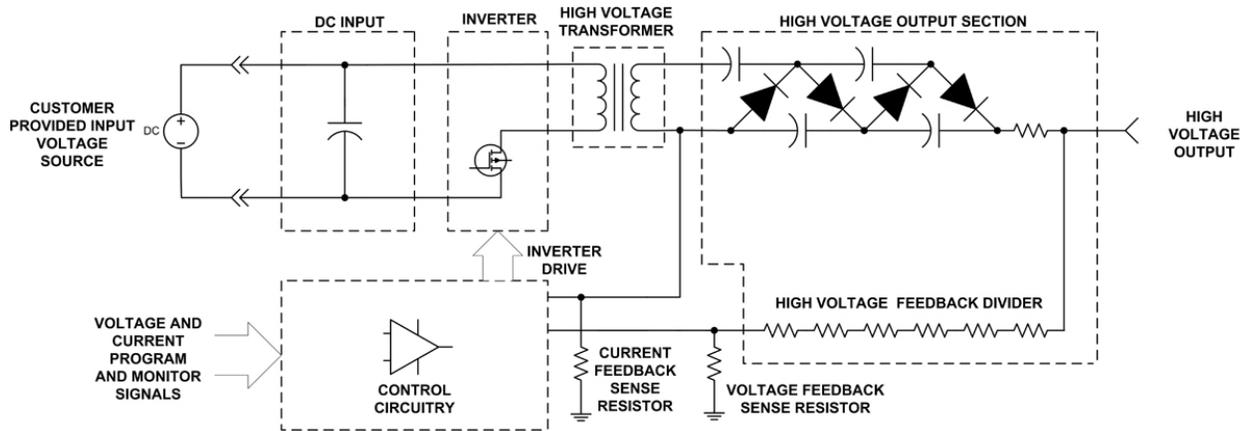


Figure 9 - Block Diagram

Chapter 5

OPTION

5.1 RS-232 Interface

See attached document 118109-001
for Communication Protocol

RS-232 interface options, see table below

V6 AC/DC Analog/Digital Interface J1 15 pin D-connector Table

PIN	SIGNAL PARAMETERS
1	Not Used
2	RS232 Receive Data
3	RS232 Transmit Data
4	Not Used
5	RS232 Ground
6	Ground
7	Not Used
8	Not Used
9	Not Used
10	0 to 5V=0 to 100% Rated Output, Zout=10k Ω (Analog)
11	0 to 5V=0 to 100% Rated Output, Zout=10k Ω (Analog)
12	Not Used
13	Input Voltage Return used for DC
14	Input Voltage 24V \pm 10%, 2A used for DC
15	Input Voltage 24V \pm 10%, 2A used for DC

Chapter 6

MAINTENANCE

WARNING!

This power supply generates voltages that are dangerous and may be fatal.

Observe extreme caution when working with high voltage.



6.1 Periodic Servicing

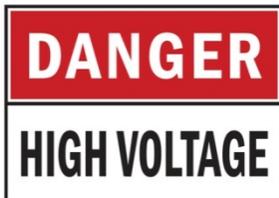
The V6 product family does not require any periodic maintenance or servicing.

6.2 Performance Testing

WARNING!

***High Voltage is dangerous.
Only qualified personnel should perform these tests.***

It is highly recommended that all testing comply with IEEE Standard 510-1983 IEEE Recommended Practices for Safety in High Voltage and High Power Testing. A copy of this standard can be downloaded from the Spellman High Voltage website [here](#).



Generalized high voltage test procedures are described in Bulletin STP-783, Standard Test Procedures for High Voltage Power Supplies.

A copy of this bulletin can be downloaded from the Spellman High Voltage website [here](#).

Test equipment includes, but is not limited to: an oscilloscope, a high impedance digital volt meter, a current meter, a ripple checker, a high voltage load, a high voltage divider (such as the Spellman HVD-100 or HVD-200) an insulated load stick and insulated short circuit stick and a safety interlocked Faraday test cage to safety conduct the tests inside of. All equipment must be properly rated for the power supply to be tested. If you do not possess the required equipment and skills necessary to safety conduct these tests do not attempt to perform these performance tests.

6.3 High Voltage Dividers

High voltage dividers for precise measurements of output voltage with accuracy up to 0.1% are available from Spellman. The HVD-100 is used for voltages up to 100KV, the HVD-200 measures up to 200KV.

The HVD Series of high voltage dividers are designed for use with differential voltmeters or high impedance digital voltmeters. The high input impedance of the HVD Series is ideal for measuring high voltage low current sources, which would be overloaded by traditional lower impedance dividers.



HVD Dividers

The HVD Series data sheet can be downloaded from the Spellman High Voltage website [here](#). Contact the Spellman Sales Department for information on price and availability.

Chapter 7

FACTORY SERVICE

7.1 Warranty Repairs

During the Warranty period, Spellman will repair all units free of charge. The Warranty is void if the unit is worked on by anyone other than Spellman personnel. See the Warranty in the rear of this manual for more information. Follow the return procedures described in Section 7.2. The customer shall pay for shipping to and from Spellman.

7.2 Factory Service Procedures

Spellman has a well-equipped factory repair department. If a unit is returned to the factory for calibration or repair, a detailed description of the specific problem should be attached.

For all units returned for repair, please obtain an authorization to ship from the Customer Service Department, either by phone or mail prior to shipping. When you call, please state the model and serial numbers, which are on the plate on the rear of the power supply, and the purchase order number for the repair. A Return Material Authorization Code Number (RMA Number) is needed for all returns. This RMA Number should be marked clearly on the outside of the shipping container. Packages received without an RMA Number will be returned to the customer. The Customer shall pay for shipping to and from Spellman.

A preliminary estimate for repairs will be given by phone by Customer Service. A purchase order for this amount is requested upon issuance of the RMA Number. A more detailed estimate will be made when the power supply is received at the Spellman Repair Center. In the event that repair work is extensive, Spellman will call to seek additional authorization from your company before completing the repairs.

7.3 Shipping Instructions

All power supplies returned to Spellman must be sent shipping prepaid. Pack the units carefully and securely in a suitable container, preferably in the original container, if available. The power supply should be surrounded by at least four inches of shock absorbing material. Please return all associated materials, i.e. high voltage output cables, interconnection cables, etc., so that we can examine and test the entire system.

All correspondence and phone calls should be directed to:

Spellman High Voltage Electronics Corp.

One Commerce Park

Valhalla, New York 10595

TEL: (914) 686-3600

FAX: (914) 686-5424

E-Mail: sales@Spellmanhv.com

To obtain information on Spellman's product warranty please visit our website at:

<http://www.spellmanhv.com/en/About/Warranty.aspx>





V6 Series Power Supply Communication Protocol

Serial – RS-232

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DOC. 118109-001 REV B

USA

EUROPE

JAPAN

MEXICO

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1.0 SCOPE

This document applies to the communication interface on the V6 Series Power Supply.

2.0 FUNCTIONAL DESCRIPTION

The V6 Series power supply provides a serial communications interface:

- RS-232 on J1 I/O Connector

Data acquisition and control capabilities are provided by:

- 14 channels of 12-bit analog-to-digital converters
- 2 additional analog channels that monitor the house-keeping power supply and ambient temperature
- 5 digital output bits
- 8 digital inputs bits
- 3 relays/interlocks

3.0 GETTING STARTED – HARDWARE SETUP

The digital hardware includes a 40MIPS digital signal processor processor/controller

3.1 RS232 INTERFACE

The RS232C interface has the following attributes:

- 115.2K bits per second
- No Parity
- 8 Data Bits
- 1 Stop Bit
- No handshaking

3.2 RS-232 CABLING

An RS-232 cable where one end is a DB9 connector and the other end is a DB15 male connector. Line 2 is connected straight through to pin 2 and 3 line is connected straight through to line 3. Please refer to the following chart.

PC to SIC Board Cable Details	
PC Connector (DB-9 Female)	J1 Connector (DB-15 Female)
Pin 2: RX In	Pin 2: RX Out
Pin 3: TX Out	Pin 3: TX In
Pin 5: Ground	Pin 5: Ground

4.0 GETTING STARTED – SOFTWARE

The following sections detail how to create software to interface to the V6 Series communications interfaces.

4.1 RS-232

The RS-232 interface makes use of a standard ‘command/response’ communications protocol. See section 6.0 for the syntax of the serial interface protocol.

All software that addresses the RS-232 interface must adhere to the following parameters:

- 115K.2 bits per second
- No Parity
- 8 Data Bits
- 1 Stop Bit
- No handshaking

5.0- SERIAL INTERFACE PROTOCOL

Serial communications will use the following protocol:

<STX><CMD><,>ARG><,><CSUM><ETX>

Where:

<STX> = 1 ASCII 0x02 Start of Text character
 <CMD> = 2 ASCII characters representing the command ID
 <,> = 1 ASCII 0x2C character

<ARG> = Command Argument
<,> = 1 ASCII 0x2C character
<CSUM> = Checksum (see section 5.2 for details)
<ETX> = 1 ASCII 0x03 End of Text character

5.1 COMMAND ARGUMENTS

The format of the numbers is a variable length string. To represent the number 42, the string '42', '042', or '0042' can be used. This being the case, commands and responses that carry data are variable in length.

5.2 CHECKSUMS

The checksum is computed as follows:

- Add the <CMD>, <,>, and <ARG>, and <,> bytes into a 16 bit (or larger) word. The bytes are added as unsigned integers.
- Take the 2's compliment (negate it).
- Truncate the result down to the eight least significant bits.
- Clear the most significant bit (bit 7) of the resultant byte, (bitwise AND with 0x7F).
- Set the next most significant bit (bit 6) of the resultant byte (bitwise OR with 0x40).

Using this method, the checksum is always a number between 0x40 and 0x7F. The checksum can never be confused with the <STX> or <ETX> control characters, since these have non-overlapping ASCII values.

If the DSP detects a checksum error, the received message is ignored – no acknowledge or data is sent back to the host. A timeout will act as an implied NACK.

The following is sample code, written in Visual Basic, for the generation of checksums:

```
Public Function ProcessOutputString(outputString As String) As String

Dim i As Integer
Dim CSb1 As Integer
Dim CSb2 As Integer
Dim CSb3 As Integer
Dim CSb$
Dim X

X = 0
For i = 1 To (Len(outputString)) 'Starting with the CMD character
    X = X + Asc(Mid(outputString, i, 1)) 'adds ascii values together
Next i

CSb1 = 256 - X 'Twos Complement
CSb2 = 63 And (CSb1)
CSb3 = 64 Or (CSb2) 'OR 0x40
CSb$ = Chr(Val("&H" & (Hex(CSb3))))
ProcessOutputString = Chr(2) & outputString & CSb$ & Chr(3)

End Function
```

Here is an example of an actual Checksum calculation for command 10 (Program kV setpoint)

The original message with a placeholder for the checksum is

<STX>10,4095,<CSUM><ETX>

- First, you add up all the characters starting with the '1' in the command number, to the comma before the checksum with their ASCII values (in hexadecimal):

$$0x31 + 0x30 + 0x2C + 0x34 + 0x30 + 0x39 + 0x35 + 0x2C = 0x18B$$

- Next, you then take the two's complement of that number by negating it, by subtracting it from 0x100 (decimal 256), and only retain the lowest 7 bits by bitwise ANDing the results with 0x7F. :

NOTE: This combines the steps of getting the twos complement, truncating the result to 8 bits and clearing the 8th bit.

$(0x100 - 0x18B) \& 0x7F = 0x75$

- Finally, bitwise OR the result with 0x40:

$0x75 | 0x40 = 0x75$

The checksum byte is 0x75 (Decimal 117, ASCII: u)

Here is another example, this time for command 22 (Request Status) which has no arguments.

The original message with a placeholder for checksum is:

<STX>22,<CSUM><ETX>

- First, you add up all the characters starting with the '2' in the command number to the comma before the checksum with their ASCII values (in hexadecimal):

$0x32 + 0x32 + 0x2C = 0x90$

- Next, you then take the two's complement of that number by negating it, by subtracting it from 0x100 (decimal 256), and only retain the lowest 7 bits by bitwise ANDing the results with 0x7F:

NOTE: This combines the steps of getting the twos complement, truncating the result to 8 bits and clearing the 8th bit.

$(0x100 - 0x90) \& 0x7F = 0x70$

- Finally, bitwise OR the result with 0x40:

$0x70 | 0x40 = 0x70$

The checksum byte is 0x70 (Decimal 112, ASCII: p)

5.3 COMMAND OVERVIEW

Command Name	<CMD>	<ARG>	RANGE
Program KV (DAC A)	10	1-4 ASCII	0-4095
Program Output Current (DAC B)	11	1-4 ASCII	0-4095
Request ADC Data	20	None	-
Request Status	22	None	-
Request Software Version	23	None	-
Request Hardware Version	24	None	-
Request Model Number	26	None	-
Set H.V. OnOff	99	1 or 0	-

5.4 RESPONSE OVERVIEW

The command responses will follow the same format as outlined above in section 5.3. This list is comprised of Commands with complex responses only. Commands using a simple response will use the <\$> character (ASCII 0x24) as a “Success” response or a single character error code. These responses will be eight ASCII characters in length.

Response Name	<CMD>	Response
Request Analog Readbacks – KV & MA	20	20-41 ASCII
Request Status	22	12 ASCII
Request DSP Software Version	23	18 ASCII
Request Hardware Version	24	10 ASCII
Request Model number	26	12 ASCII

5.5 COMMAND STRUCTURE

5.5.1 Program KV

Description:

The host requests that the firmware change the setpoint of DAC Channel A.

Direction:

Host to supply

Syntax:

<STX><10><,><ARG><,><CSUM><ETX>

Where:

<ARG> = 0 - 4095 in ASCII format

Example:

<STX>10,4095,<CSUM><ETX>

Detailed Example:

02 31 30 2C 34 30 39 35 2C 75 03

Response:

<STX><10><,><\$><,><CSUM><ETX>

5.5.2 Program Output Current

Description:

The host requests that the firmware change the setpoint of DAC Channel B.

Direction:

Host to supply

Syntax:

<STX><11><,><ARG><,><CSUM><ETX>

Where:

<ARG> = 0 - 4095 in ASCII format

Example:

<STX>11,4095,<CSUM><ETX>

Response:

<STX><11><,><\$><,><CSUM><ETX>

5.5.3 Request ADC Data

Description:

The host requests that the firmware report the current ADC Channel KV monitor, and Channel MA monitor.

Direction:

Host to supply

Syntax:

<STX><20><,><CSUM><ETX>

Response:

<STX><20><,><ARG1><,><ARG2><,><CSUM><ETX>

Where:

<ARG1> KV: 0 - 4095 in ASCII format

<ARG2> MA: 0 - 4095 in ASCII format

Example:

<STX>20,4095,4095,<CSUM><ETX>

5.5.4 Request Status

Description:

The host requests that the firmware report the current DAC Channel D setpoint.

Direction:

Host to supply

Syntax:

<STX><22><,><CSUM><ETX>

Response:

<STX><22><,><ARG1><,><ARG2><,><ARG3><,><CSUM><ETX>

Where:

<ARG1> 1 = Over Voltage, 0 = Normal

<ARG2> 1 = Over Current, 0 = Normal

<ARG3> 1 = Enable, 0 = Disable

Example:

<STX>22,0,0,0,<CSUM><ETX>

5.5.5 Request Software Version

Description:

The host requests that the firmware sends the DSP firmware part number/version.

Direction:

Host to supply

Syntax:

<STX><23><,><CSUM><ETX>

Example:

<STX>23,<CSUM><ETX>

Response:

<STX><23><,><ARG><,><CSUM><ETX>

Where:

<ARG> consists of eleven ASCII characters representing the current firmware part number/version. The format is SWM9999-999

Example:

<STX>23,SWM9999-999,<CSUM><ETX>

5.5.6 Request Hardware Version

Description:

The host requests that the firmware sends the hardware version.

Direction:

Host to supply

Syntax:

<STX><24><,><CSUM><ETX>

Example:

<STX>24,<CSUM><ETX>

Response:

<STX><24><,>< ARG><,><CSUM><ETX>

Where:

<ARG> consists of 3 ASCII characters representing the hardware version. The format is ANN, where A is an alpha character and N is a numeric character

Example:

<STX>24,A01,<CSUM><ETX>

5.5.7 Request Model Number

Description:

The host requests that the firmware sends the unit model number

Direction:

Host to supply

Syntax:

<STX><26><,><CSUM><ETX>

Example:

<STX>26,<CSUM><ETX>

Response:

<STX><26><,><ARG><,><CSUM><ETX>

Where:

<ARG> consists of five ASCII characters representing the model number. The format is XNNNN, where N is a numeric character.

Example:

<STX>26,X9999,<CSUM><ETX>

5.5.8 Set H.V. OffOn

Description:

The host requests that the firmware set H.V. Off or On

Direction:

Host to supply

Syntax:

<STX><99><,><ARG><,><CSUM><ETX>

Where:

<ARG> = 0 = HV Off, 1 = HV On.

Example:

<STX>10,1,<CSUM><ETX>

Response:

<STX><10><,><\$><,><CSUM><ETX>