

Instruction Manual

SLM SERIES

High Voltage Power Supply

MODEL :
SERIAL# :
DATE :

**SPELLMAN
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CORPORATION**

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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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This information contained in this publication is derived in part from proprietary and patent data. This information has been prepared for the express purpose of assisting operating and maintenance personnel in the efficient use of the model described herein, and publication of this information does not convey any right to reproduce it or to use it for any purpose other than in connection with installation, operation, and maintenance of the equipment described.

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 SLM Series

The SLM Series of high voltage generator modules are designed for OEM applications up to 70kV and up to 1200watts. Its universal input, small package size and choice of three standard digital interfaces simplifies integrating the SLM into your system. DSP based control circuitry provides excellent regulation, along with outstanding stability performance. User programmable firmware option makes the operation of the SLM flexible.

The dramatically reduced size of the SLM module, compared to traditional high voltage modules, is obtained by a state of the art off-line resonant converter. The resonant converter utilizes a unique control scheme, which allows constant frequency operation while maintaining high efficiency. The high efficiency is obtained by zero current switching (ZCS) resonant control. High operating frequency, typically 50 kHz, allows for low ripple and excellent dynamic response capabilities.

The DC output voltage and current are controllable over the full range of operation. Monitoring and control signals are provided for simple, yet flexible control of the power supply. The SLM series operates from 90 - 265Vac, at 50/60 Hz single phase for the 300Watt models and 180-264Vac, at 50/60 Hz single phase for the 600Watt and 1200Watt models. The input is power factor corrected and the SLM series operates at full power continuous. The ambient temperature must be kept below the maximum rating as specified in 1.2. The standard warranty applies to the modules. Consult factory about the warranty for custom SLM modules.

1.2 SLM Specifications

- **Input Voltage:**
 - 90-264Vac 47-63Hz, for 300watt models
 - 180-264Vac 47-63Hz, for 600watt models
 - 180-264Vac 47-63Hz, for 1200watt models
- **Power Factor:**
 - FL:** ≥ 0.99
- **Output Voltage:**
 - 22 models: 1kv to 70kv
- **Voltage Regulation:**
 - $\leq 0.01\%$ of rated output voltage over specified input voltage range
 - $\leq 0.01\%$ of rated output voltage for a full load change
- **Current Regulation:**
 - $\leq 0.01\%$ of rated output current over specified input voltage range
 - $\leq 0.01\%$ of rated output current for a $\pm 100\mu\text{A}$ for a full voltage change
- **Ripple:** $\leq 0.2\%$ rms of maximum rated voltage, measured with a 10 foot long HV cable
- **Polarity:** Positive or Negative polarity with respect to ground. (Specify at time of ordering).
- **Stability:** $\leq 50\text{ppm/hr}$ after a 2 hour warm up
- **Temperature Coefficient:** $\leq 100\text{ppm}/^\circ\text{C}$.
- **Temperature:**
 - Operating: 0°C to 40°C
 - Storage: -40°C to $+85^\circ$
 - Humidity: 20% to 85% RH, non-condensing.

Control Interface

- **Local Interface:** Voltage and current are externally programmable over the entire range from zero to maximum rating via 0-10VDC input.
- **+10Vdc Reference:** A +10Vdc reference is provided for local programming via two potentiometers to be used to adjust voltage and current.
- **Remote Interface:** USB, Ethernet and RS232 are standard, implemented with 12 bits of resolution. All digital monitors have an accuracy specification of 2%.
- **Control Software:** A VB GUI will be provided for RS-232/USB, the Ethernet interface will have an embedded applet for control.
- **Monitor Signals:**
 - Voltage and current monitor signals are scaled 0-10Vdc equals 0-100% of full scale. Accuracy is 1%.
- **HV Control Enable/Interlock:**
 - A dry contact, hardware based interlock is provided for remote mode. In local mode this I/O is the enable.

- **Cooling:**
Forced air
- **Dimensions:**
4.75" H X 6" W X 12" D (120.65mm x 152.4mm x 304.8mm)
- **Weight:**
14 pounds (5.44kg)
- **Input Line Connector:**
IEC320 cord set with integrated EMI filter
- **Output Cable:**
A detachable 10' (3.3m) long shielded HV cable is provided

1.3 Standard Features

The SLM series incorporates several standard features designed to optimize user operation.

Standard Firmware Configurable Features:

Slow Start:

Provides a gradual increase in high voltage output until the maximum set point is reached. This ramp time can be configured in the firmware from 0.1 seconds to 60 seconds, and is stored internally in the SLM memory. The factory default setting is 5 seconds.

Adjustable Overload Trip: AOL

The overload trip protection feature shuts down the high voltage output when the current exceeds the limit set by the current control. The DSP inhibits the generation of high voltage and reverts the unit to HV OFF mode, illuminating the OVER CURRENT indicator. This can be enabled in the firmware and is stored internally in the SLM memory. When AOL is disabled the default overcurrent trip point is 110% of full-scaled output. The factory default setting for AOL is disabled.

Remote Overvoltage Adjust: ROV

The overvoltage trip protection feature shuts down the high voltage output when the voltage exceeds the limit configured in the firmware. The DSP inhibits the generation of high voltage and reverts the unit to HV OFF mode, illuminating the OVER VOLTAGE indicator. This can be enabled in the firmware and is adjustable from 0% to 110% of full-scaled output voltage. The select values are stored internally in the SLM memory. When ROV is disabled the default overvoltage trip point is 110% of full-

scaled output. The factory default setting for ROV is disabled.

ARC Trip: AT

The SLM provides firmware configurable arc detection. The user can set the arc detection parameters to custom fit their requirements. The follow parameters are programmable in the firmware and are stored internally in the SLM memory:

Arc Count:

This sets how many arc's are require within the selected time period to cause an arc shutdown. It is programmable from 1 arc to 20 arc. The factory default setting is 8 arc.

Time Period:

This sets the time period that the selected arc count must occur within to cause an arc shutdown .It is programmable from 1 second to 60 seconds. The factory default setting is 20 seconds.

Quench Time:

This sets the length of time that the high voltage is shutdown to quench the arc after an arc occurs. It is programmable from 100ms to 500ms. The factory default setting is 500ms.

Re-Ramp:

After an arc occurs, the kV output will slow start at the programmed ramp time. If Re-ramp is disabled then there will be no ramping after an arc. The factory default setting is enabled.

The SLM will not accept Arc Count and Time Period setting that exceed 1 arc per second.

No Arc Detect: NAD

When No Arc Detect mode (NAD) is enabled, the HVPS has no arc shutdown protection. When an arc occurs the arc LED and the digital interface will indicate an arc for 2 seconds. The PS Fault is not effected. The quench is active, but the arc count and period are disregarded preventing shutdown. Re-ramp is active if enabled. The HVPS is designed to handle an arc rate of 1 arc per second. **Exceeding 1 arc per second could cause damage to the HVPS. HVPS failure caused by excessive arc will not be covered under the warranty.** The factory default setting for NAD is disabled.

Watchdog Timer

If there is no communication between the HVPS and the host computer for more than 10 seconds the HV output will shutdown and the Watchdog Timer fault will be sent

via the digital communication when and if communication is resumed. This can be enabled via the digital communication and is defaulted to disable upon power up.

Standard Input Features:

Power Factor and Universal Input: The input voltage of the SLM can operate within the range from 90Vac to 265Vac for the 300Watt model and at 180–264Vac, for the 600Watt model. The power factor is actively corrected across this entire range and is better than 0.99 at full load.

Internal EMI Filter and Fuse Protection: An internal EMI filter and fuse provide protection against line voltage surges and power supply faults.

Remote Operating Features

Remote Control: USB, Ethernet and RS232 are standard. A provided G.U.I allow user to control the unit via RS232 and USB interfaces. An imbedded Applet web browser allow user to control the unit via Ethernet. Refer to SLM digital protocol spec for details.

Remote Monitor: Allows remote monitoring of the Output voltage, current, HV On clock counter, and user configurable firmware features via the USB, Ethernet or RS232.

Remote Programming: Allows remote programming of the output voltage, current and user configurable firmware features via the USB, Ethernet or RS232.

HV Enable/Interlock: In local mode, allows remote ON/OFF control of the high voltage. In remote mode, the hardware based dry contact closure must be closed in order to enable the high voltage via the USB, Ethernet or RS232.

IMPORTANT

This control signal is not a safety interlock and should not be used for protection from high voltage generation for safety purposes.

1.4 System Status and Fault Diagnostic Display

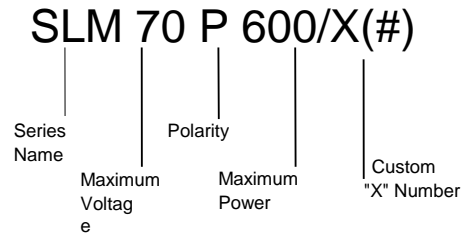
If a fault occurs, the power supply will revert to the Shutdown mode indicated by extinguishing of HV ON LED and via RS-232 as HV OFF. To reset a fault in local mode the enable must be reset. To reset a fault in remote

mode a HV ON or a RESET FAULTS command must be sent via the RS-232, USB or Ethernet.

- **OVER CURRENT FAULT:** Indicates the over current protection circuitry has caused the high voltage to turn off. This fault will occur if the output current exceeds 110% of full scale. If AOL is enable this fault will occur when the current exceeds the current program set point. This fault is indicated by illumination of over current LED status on the front panel and via RS-232, USB or Ethernet as Over Current.
- **OVERVOLTAGE:** Indicates the over voltage protection circuitry has caused the high voltage to turn off. This fault will occur if the output voltage exceeds 110% of full scale. If ROV is enable this fault will occur when the voltage exceeds the programmed ROV setpoint. This fault is indicated by over voltage LED status on the front panel and via the RS-232, USB or Ethernet as Over Voltage.
- **ARC FAULT:** Indicates that the programmed arc count was exceeded within programmed time period. This fault is indicated by steady state illumination of Arc Fault LED status on front panel and via RS-232, USB or Ethernet as Arc Fault. The LED will pulse for each arc, but will be a steady state ON if a shutdown occurs.
- **REGULATION ERROR:** Indicates a failure in the voltage, current or power regulation circuitry. This fault usually occurs when there is a lack of output power to maintain regulation. This fault is indicated by illumination of the Regulation Error LED status on front panel and via RS-232, USB or Ethernet as Under Current.
- **OVER TEMPERATURE:** Indicates either a failure in the cooling system that would cause the internal heat sink temperature to exceed the operating range or the ambient temperature to exceed 40 degrees C, resulting in shutdown of HV. This fault is indicated by Over Temperature LED status on the front panel and via RS-232, USB or Ethernet as Over Temperature.
- **PS Fault Indication:** PS Faults an open collector output with a 1k ohm impedance on J2-1, indicates that a faults has occurred. High = no faults
- **HV On Indication:** HV On Signal is an open collector output with a 1k ohm impedance on J2-14, indicates that HV is enabled. High = HV OFF

- **HV On LED:** When the high voltage status is “On” state it is indicated by HV ON LED status on the front panel.
- **Power On LED:** When the input power is applied to the unit it is indicated by PWR ON LED status on the front panel.
- **I MODE:** Indicates the output current regulator circuit is maintaining current regulation. This is indicated by I Mode LED status on the front panel and via RS-232, USB or Ethernet as I Mode.

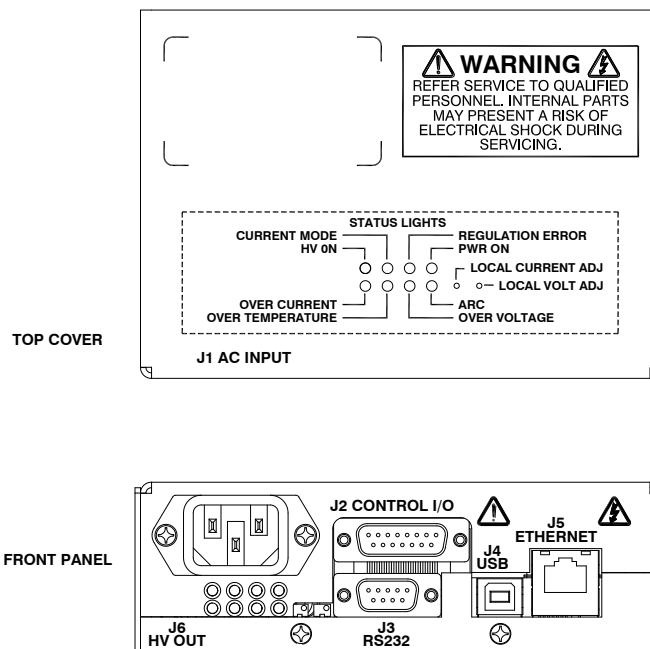
(4) Custom “X” number representing details listed in a separate specification control drawing.



1.5 Interpreting the Model Number:

The model number of the power supply describes its capabilities. After the series name is:

- (1) The maximum voltage in kilovolts.
- (2) The polarity of the output – positive (P), or negative (N).
- (3) The maximum output in watts.



**Figure 1.1 LED Legend and Connector Assignment
 (shown 300W and 600W)**

Chapter 2

INSPECTION AND INSTALLATION

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

2.1 Initial Inspection

Inspect the package exterior for evidence of damage due to handling in transit. Notify the carrier and Spellman immediately if damage is evident. Do not destroy or remove any of the packing material used in a damaged shipment. After unpacking, inspect the panel and chassis for visible damage.

Fill out and mail the Warranty Registration card accompanying the unit. Standard SLM high voltage power supplies and components are covered by warranty. Custom and special order models (with an X suffix in the model number) are also covered by warranty.

2.2 Mechanical Installation

The SLM series module power supplies are designed for installation into existing or newly developed OEM equipment. The power supply can also easily fit into bench top applications or test set requirements. Standard unit dimensions are shown in Figure 2.1

For custom mounting requirements or specific package size requirements consult Spellman's Sales Department. Spellman has many package designs available, or can design a specific enclosure for your requirements.

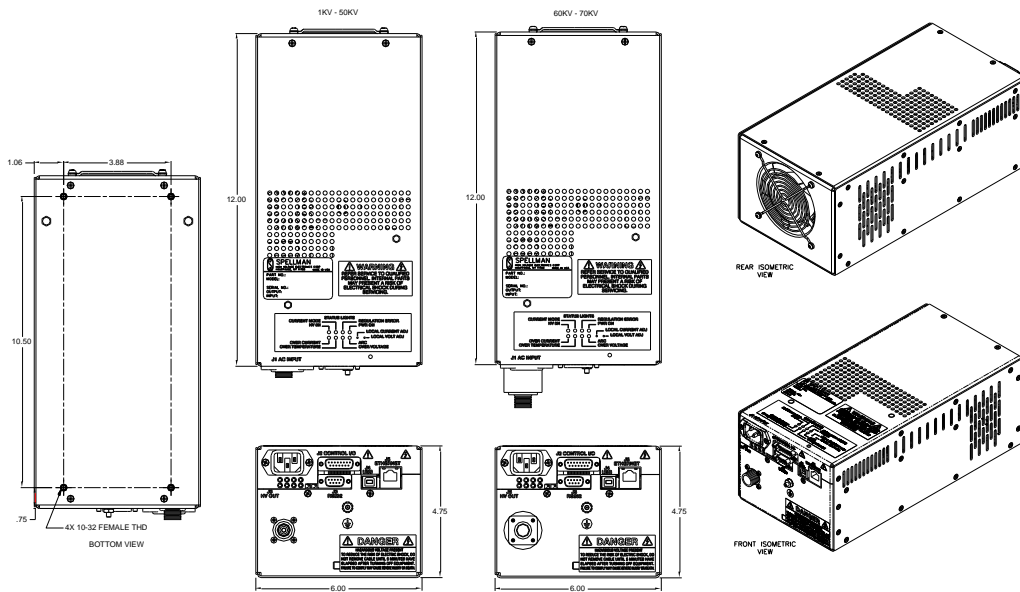


Figure 2.1 Unit Dimensions (300W and 600W)

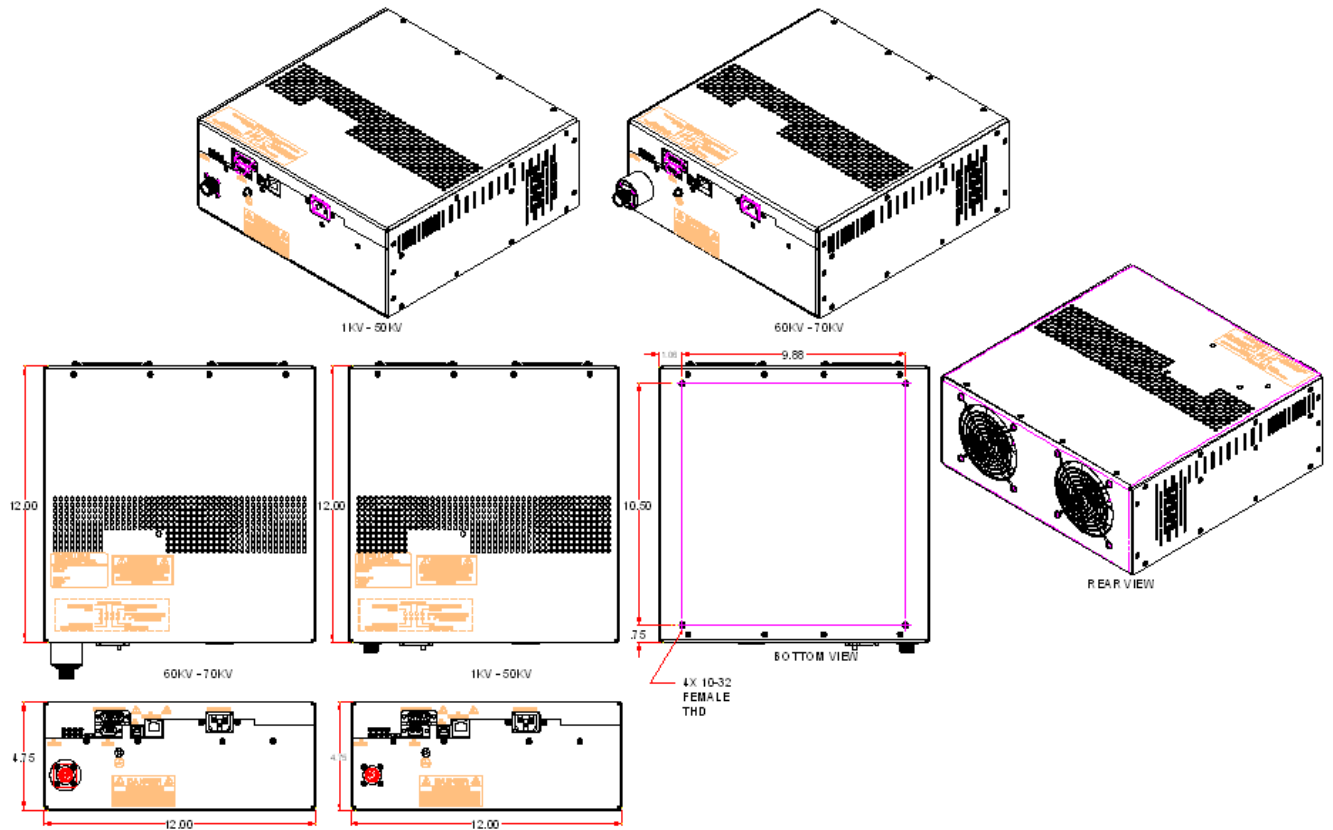


Figure 2.2 Unit Dimensions (1200W)

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.

IMPORTANT:

Before connecting the power supply to the AC line, follow this step-by-step procedure. Do not connect the power supply to the AC line until Step F is reached. Failure to follow these procedures may void the warranty.

A) Insure that the high voltage cable is properly installed and terminated to the load. Insure that all circuits connected to the high voltage output are safely interlocked against accidental contact. Insure external load is discharged.

B) Check the input voltage rating on the serial nameplate of the supply and make certain that this is the rating of the available power source

C) **PROPER GROUNDING TECHNIQUE:** The chassis of high voltage power supplies must be grounded, preferably to a water system ground using copper pipe or other earth ground. A ground stud is provided on the front panel. See Figure 3.1 for a typical operating setup. The return line from the load should be connected to the power supply chassis. Using a separate external ground at the load is not recommended. An IEC 320 connector is provided for connection to the line voltage source. A standard line cord is also provided.

D) **Hook-up:** Connect control and monitoring connections as described in this manual.

E) For initial turn-on, program the voltage and current for zero output. Connect the enable/disable signal to disable.

F) The input power cable may now be connected to the AC power line.

G) Enable the power supply via the enable/disable hardware based, dry contact closure.

H) Slowly program the output voltage and current to desired level. Monitor the output voltage and current via the monitoring test points. Note equipment operation is normal, i.e. load is behaving as predicted.

I) To turn high voltage off, use the enable/disable signal. If equipment is to be kept off for extended periods, disconnect power supply from line voltage source.

WARNING

AFTER TURNOFF, DO NOT HANDLE THE LOAD UNTIL THE CAPACITANCE HAS BEEN DISCHARGED! LOAD CAPACITANCE MAY BE DISCHARGED BY SHORTING TO GROUND.

WARNING

THE VOLTAGE MONITOR ON THE POWER SUPPLY FRONT PANEL DOES NOT READ THE OUTPUT VOLTAGE WHEN THE POWER IS TURNED OFF, EVEN IF A CHARGE STILL EXISTS ON THE LOAD.

CAUTION

ALWAYS OPERATE THE UNIT WITH THE COVER ON. DO NOT ATTEMPT TO ACCESS OR REPAIR ANY INTERNAL CIRCUITS. DANGEROUS AND LETHAL VOLTAGES ARE GENERATED INSIDE THE MODULE.

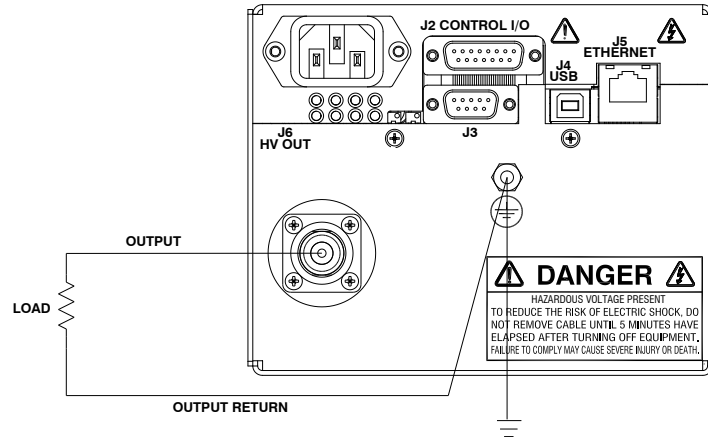


Figure 3.1 Proper Grounding Technique

3.2 Standard Features

A note on remote interface circuitry and remote signal grounding: whenever possible, electrical isolation should be provided when interfacing with any high voltage power supply. For enable/disable signal connections, an isolated relay or optocoupler should be used. For PS Fault indication an optocoupler should be used. If possible, analog programming and monitoring signals should be isolated via analog isolation amplifiers. Spellman application engineers are available to assist in interface circuitry design. All interface cables should be properly shielded. All power supply signals should be referenced to the power supplies signal ground or power supply chassis ground

Local Programming potentiometers: The voltage and current controls on the front panel can be used as follows: For local current control, jump J2-2 to J2-7. For local voltage control, jump J2-3 to J2-5. See Figure 3.2.

LOCAL PROGRAMMING: Allows local adjustment of the output voltage and current level via an external voltage source. 0-10Vdc signal is supplied to pin 3 of the J2 for voltage programming and 0-10 Vdc signal is supplied to Pin 2 J2 for current programming. Programming signals should be referenced to Pin 9 of J2, signal ground. By adjusting the voltage source from 0 volts (zero output) to 10 Vdc (full rated output) the desired output can be selected. See Figure 3.3 for wiring diagram and specifications.

Local Monitoring: Monitor outputs are made available for monitoring the voltage and current output. The monitor outputs are always positive regardless of the output polarity, where zero 0 to 10 Vdc equals 0-100% of

output. See Figure 3.4 for monitoring wiring and see data sheet for pin outs.

HV Enable/Interlock: In Local Mode allows ON/OFF control of the high voltage. The hardware based dry contact closure must be closed in to enable the high voltage. In Remote Mode this I/O acts as an Interlock. The hardware based dry contact closure must be closed in order to enable the high voltage via the USB, Ethernet or RS232. This can be done by connecting pins 11 and 12 on J2. See Figure 3.5.

REMOTE PROGRAMMING:

After establishing communication with the UUT as per the SLM Digital Protocol spec. Switch the UUT to Remote Mode by sending a Program Local/Remote Mode command (this is done automatically upon opening of the Spellman GUI/APPLET). If the unit is in Local Mode and enabled prior to switching it to Remote Mode, the UUT will shutdown and a P.S Fault indicator will occur when it is switch to Remote Mode. A clear command can be sent to clear this fault.

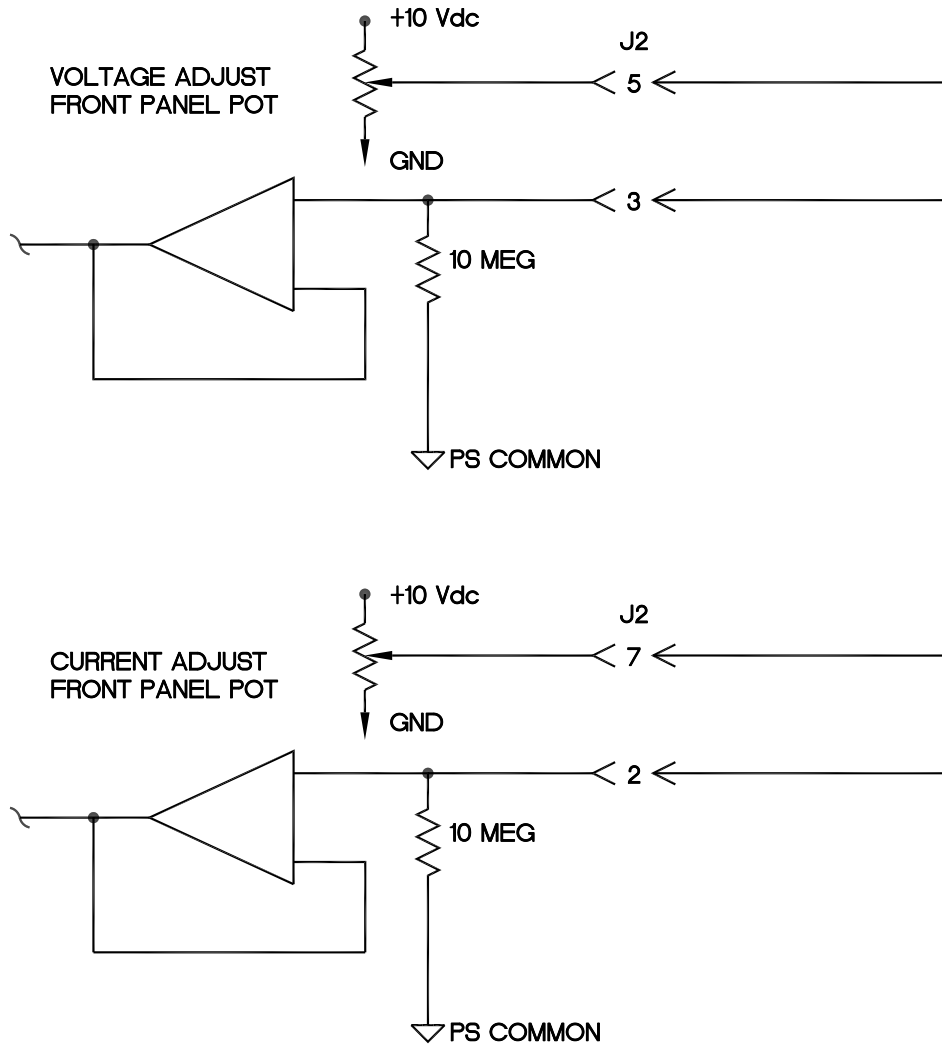
Remote Control: USB, Ethernet and RS232 are standard Refer to SLM Digital Protocol spec for Details.

Remote Monitor: Allows remote monitoring of the Output voltage and current via the USB, Ethernet or RS232.

Remote Programming: Allows remote programming of the Output voltage and current via the USB, Ethernet or RS232.

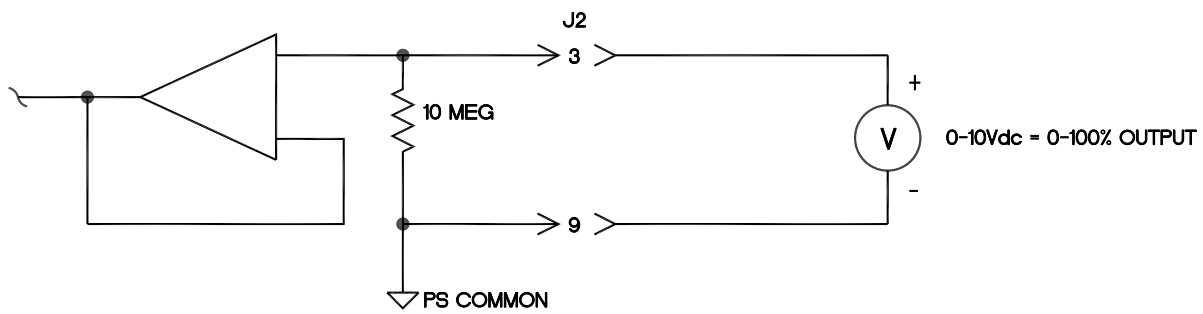
WARNING

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

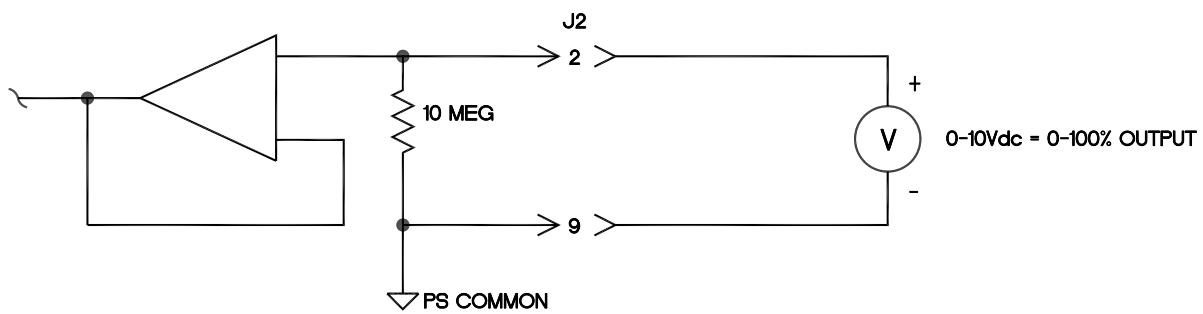


VOLTAGE + CURRENT LOCAL POT CONTROL

Figure 3.2 Local Programming Via Internal Front Panel Pot Voltage Source.



VOLTAGE CONTROL



CURRENT CONTROL

Figure 3.3 Local Programming via External Voltage Source

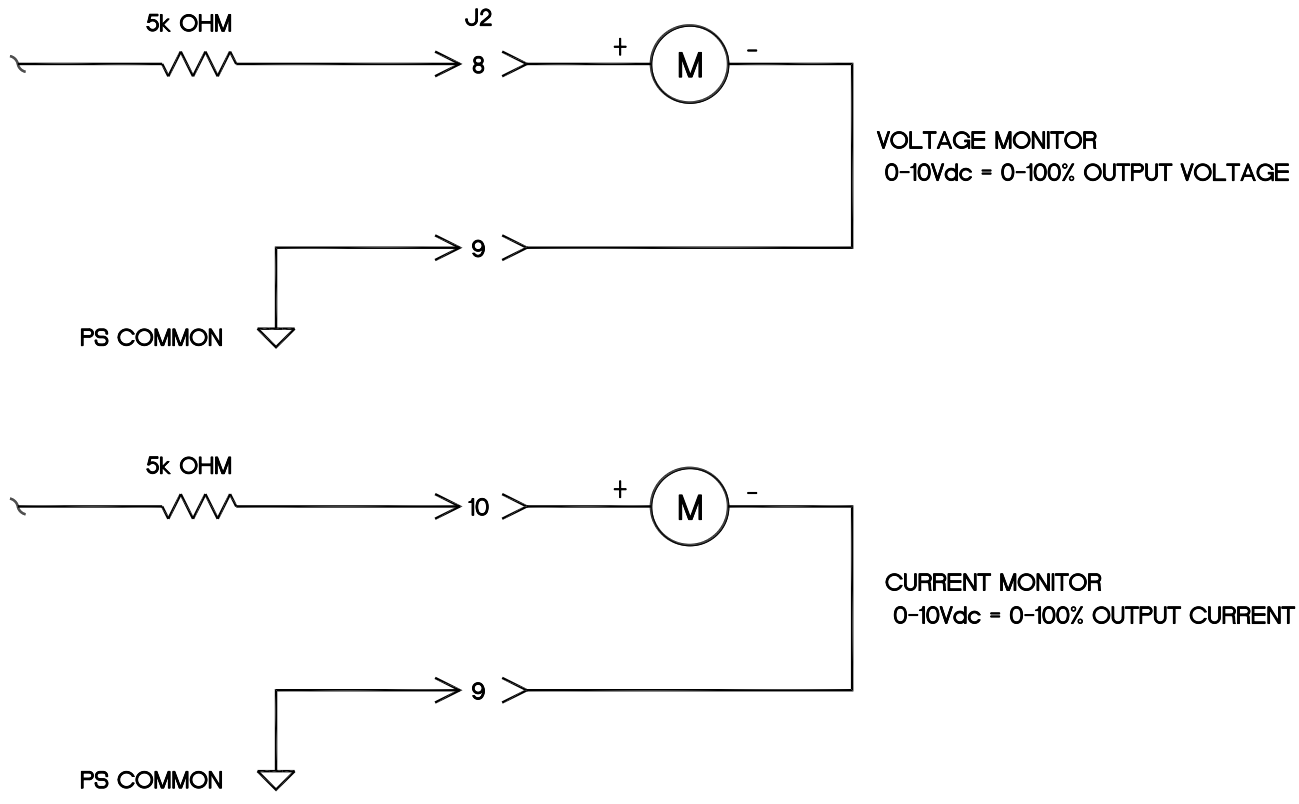


Figure 3.4 Remote Monitoring

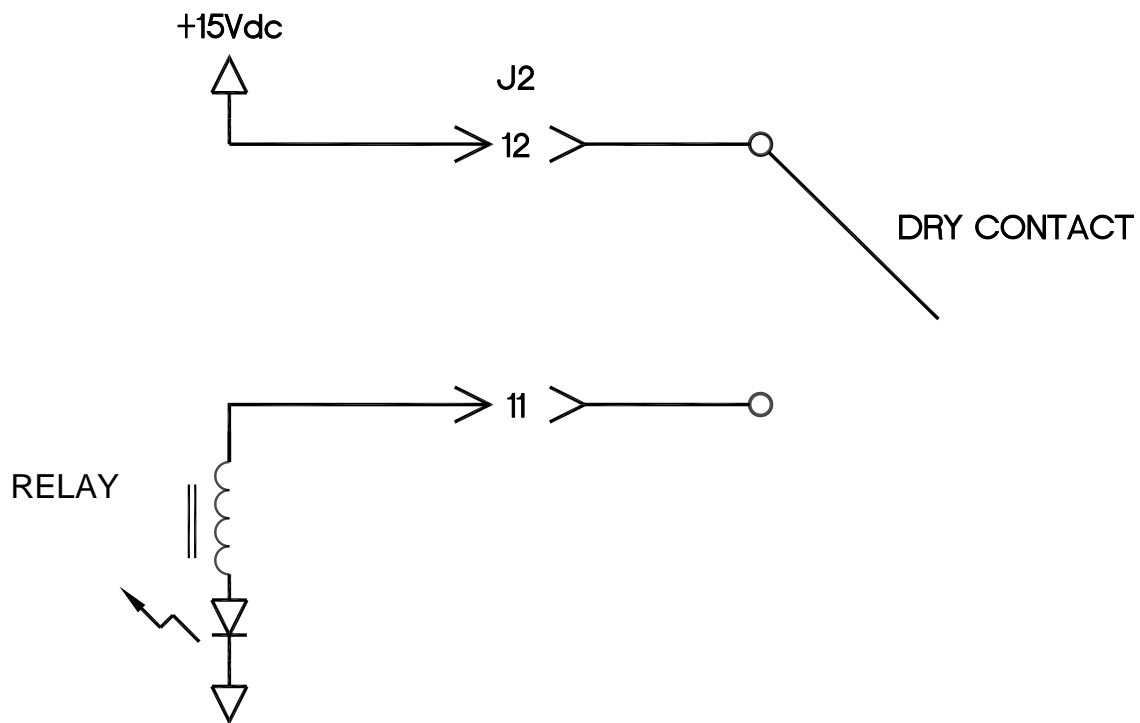


Figure 3.5 Enable/Interlock Logic Control

WARNING

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

Chapter 4

PRINCIPLES OF OPERATION

The SLM Series of high voltage power supplies utilizes sophisticated power conversion technology.

Advanced analog and power conversion techniques are used in the SLM series. The intention of the Principles of Operation is to introduce the basic function blocks that comprise the SLM power supply. For details on a specific circuit, consult Spellman's Engineering Department.

The SLM power supply is basically an AC to DC power converter. Within the power supply, conversions of AC to DC then to high frequency AC, then to high voltage DC take place.

Typical SLM power supplies comprise a few basic building blocks. These are: 1) AC to DC rectifier, 2) Power Factor correction boost circuitry 3) High frequency quasi-resonant inverter, 4) High voltage transformer and rectifier circuits, and 5) Control and monitoring circuits. The following is a brief description of each building block.

4.1 Power Factor and Associated Circuits

The SLM series can operate from 90 - 265Vac, for the 300Watt model and 180 - 264Vac for the 600 and 1200Watt models. The input voltage is connected via a typical IEC 320 type input connector. An internal EMI filter and fuse housing is an integral part of the SLM module. The input circuits actively correct the power factor.

The input line voltage is applied to a current limit device to reduce the initial inrush current. The input line voltage is converted to a 400Vdc voltage via an active PFC Converter.

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 a sufficient knowledge of the dangers and hazards of working with high voltage. Do not attempt to approach or touch any internal or external circuits or components that are connected 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 #510-1983.

4.2 High Frequency Inverter

The SLM is a resonant converter operating in a zero current switching, series resonant, parallel loaded topology. MOSFET transistors switch the 400 Vdc voltage to the resonant tank circuit. Typical operating frequency is in the range of 35-65 KHz depending on model. Control of the resonant circuit output is done by the low voltage control circuits, and are isolated by an isolated pulse transformer. The output of the resonant circuit is applied to the primary of the high voltage transformer.

4.3 High Voltage Circuits

The high voltage transformer is a step-up type. The secondary of the high voltage transformer is connected to the high voltage output circuit. The output circuit will vary depending upon the rated output voltage and a full wave Cockcroft-Walton multiplier is used. A feedback signal is generated by the high voltage resistor divider. This feedback signal is sent to control circuits to provide voltage regulation and monitoring. A current sense resistor is connected at the low voltage end of the output circuit. The circuit sense signal is sent to the control circuits to provide current regulation and monitoring.

The high voltage output is connected to the output limiting resistors. These resistors limit the peak surge current in the event an arc or discharge occurs. The limiting resistor output is connected to the output connector provided.

WARNING

THE HVPS IS DESIGNED TO HANDLE AN ARC RATE OF 1 ARC PER SECOND, EXCEEDING 1 ARC PER SECOND COULD CAUSE DAMAGE TO THE HVPS. HVPS FAILURE CAUSED BY EXCESSIVE ARC WILL NOT BE COVERED UNDER THE WARRANTY.

4.4 Control Circuits

Control circuits are used for regulation, monitoring, pulse-width, control, slow-start and inhibit control. Feedback signals are calibrated and buffered via general purpose OP-AMPS. Pulse width control is accomplished by a typical PWM type control I.C. Logic enable/disable is provided by a logic gate I.C. Regulators generate $\pm 15\text{Vdc}$ and 10Vdc . DSP based control circuitry provides excellent regulation, along with outstanding stability performance

WARNING

**LINE VOLTAGE IS PRESENT
WHENEVER THE POWER SUPPLY IS
CONNECTED TO EXTERNAL LINE
VOLTAGES. BE SURE TO DISCONNECT
THE LINE CORD BEFORE OPENING THE
UNIT. ALLOW 5 MINUTES FOR
INTERNAL CAPACITANCE TO
DISCHARGE BEFORE REMOVING ANY
COVER.**

4.5 Options

Due to the variations of models and options provided in the SLM series, details of actual circuits used may differ slightly from above descriptions. Consult Spellman's Engineering Department for questions regarding the principles of operations for the SLM series.

Chapter 5

5.1 Custom Designed Models X (#)

Units built to customer specifications are assigned an X number by the factory. If this unit is an X model, specification control sheet is added at the end of this instruction manual.

Chapter 6

MAINTENANCE

This section describes periodic servicing and performance testing procedures.

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

Approximately once a year (more often in high dust environments), disconnect the power to the unit. Use compressed air to blow dust out of the inside of the unit. Avoid touching or handling the high voltage assembly.

6.2 Performance Test

WARNING

HIGH VOLTAGE IS DANGEROUS. ONLY QUALIFIED PERSONNEL SHOULD PERFORM THESE TESTS.

High voltage test procedures are described in Bulletin STP-783, Standard Test Procedures for High Voltage Power Supplies. Copies can be obtained from the Spellman Customer Service Department. Test equipment, including an oscilloscope, a high impedance voltmeter, and a high voltage divider such as the Spellman HVD-100 is needed for performance tests. All test components must be rated for operating voltage.

6.3 High Voltage Dividers

High voltage dividers for precise measurements of output voltage with an accuracy up to 0.1% are available from Spellman. The HVD-100 is used for voltages up to 100KV. The Spellman divider is designed for use with differential voltmeters or high impedance digital voltmeters. The high input impedance is ideal for measuring high voltage low current sources, which would be overloaded by traditional lower impedance dividers.

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 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.

THE SLM HVPS IS DESIGNED TO HANDLE AN ARC RATE OF 1 ARC PER SECOND. EXCEEDING 1 ARC PER SECOND COULD CAUSE DAMAGE TO THE HVPS. HVPS FAILURE CAUSED BY EXCESSIVE ARC WILL NOT BE COVERED UNDER THE WARRANTY.

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 Ordering Options and Modifications

Many of the options listed in Chapter 5 can be retrofitted into Spellman power supplies by our factory. For prices and arrangements, contact our Sales Department.

7.4 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.
475 Wireless Boulevard
Hauppauge, New York 11788
TEL: (631) 630-3000 FAX: (631) 435-1620
E-Mail: sales@Spellmanhv.com
<http://www.spellmanhv.com>

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

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



SLM Digital Interface Manual

Ethernet Serial – RS-232 Universal Serial Bus - USB



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WARNING

THIS EQUIPMENT GENERATES DANGEROUS VOLTAGES THAT MAY BE FATAL. PROPER GROUNDING OF ALL HIGH VOLTAGE EQUIPMENT IS ESSENTIAL. SEE SLM OWNERS MANUAL FOR PROPER GROUNDING TECHNIQUE AND SAFETY PRECAUTIONS BEFORE APPLYING AC INPUT POWER TO THE SLM UNIT.

TO PREVENT DAMAGE TO THE HOST COMPUTER ,THE COMPUTER SHOULD BE GROUNDED TO THE UNIT.

1.0 SCOPE

This document applies to the communications interfaces on the SLM, assembly 460067.

2.0 FUNCTIONAL DESCRIPTION

The SLM provides 3 different types of digital communications interfaces:

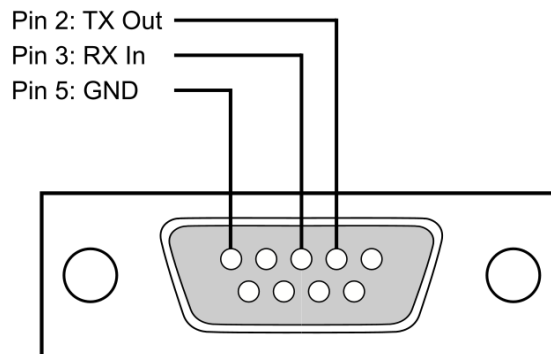
- RS-232 on J3
- Ethernet (10/100-Base-T) on J5
- Universal Serial Bus on J4.

3.0 GETTING STARTED - INTERFACE WIRING AND PIN-OUTS

3.1 RS232 INTERFACE

The RS232C interface has the following attributes:

- 115K bits per second
- No Parity
- 8 Data Bits
- 1 Stop Bit
- No handshaking
- DB-9 connector as shown in Figure 1



SIC Serial Port: DB-9 Female

Figure 1 – J3, RS-232 DB-9M pinout (front view)

PIN	DESCRIPTION
1	-
2	Tx Out
3	Rx In
4	-
5	Ground
6	-
7	-
8	-
9	-

3.2 ETHERNET INTERFACE

The Ethernet interface has the following attributes:

- 10/100-Base-T
- IP address can be set by the system integrator
- Network Mask can be set by the system integrator
- TCP Port Number can be set by the system integrator
- RJ-45 connector
- Network attachment via Crossover and Standard Ethernet cables.
- Supported Operating Systems: Windows 98 2ED, Windows 2000 (SP2), Windows NT (SP6), Windows XP Professional

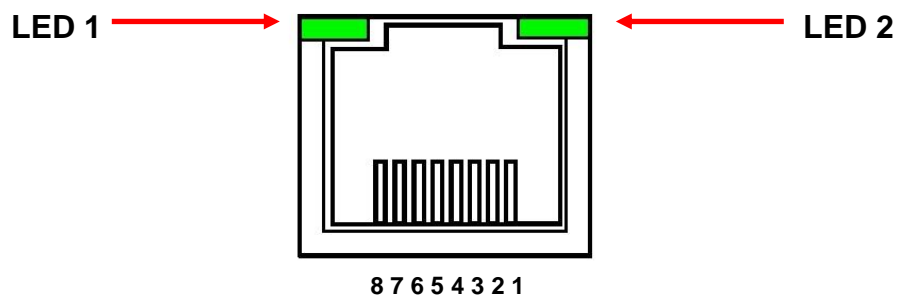


Figure 2 – J5, Ethernet RJ45 Jack (front view)

PIN	DESCRIPTION
1	TX+
2	TX-
3	RX+
4	-
5	-
6	RX-
7	-
8	-

The Ethernet RJ-45 has two LED indicators, as shown in Figure 2. The left LED, LED1 indicates that the network processor has a valid network link. The right LED, LED2 indicates network activity.

3.3 USB – UNIVERSAL SERIAL BUS INTERFACE

The USB interface has the following attributes:

- Compliant with USB 1.1 and USB 2.0 specifications
- Type B male connector
- Included driver can be communicated with via standard Windows serial communications methods



Figure 3 – J4, USB Type B (front view)

PIN	DESCRIPTION
1	Vbus +5V
2	D-
3	D+
4	Ground

3.4 RS-232 CABLING

A standard shielded RS-232 cable is used to connect the SLM serial port to the serial port on a standard personal computer. Please refer to the following chart.

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

3.5 ETHERNET CABLING

Unshielded Category 5e (CAT5e) Ethernet patch cables are used to connect the SLM to the host computer. There are two ways to connect to the SLM board via Ethernet: the first is to directly cable between the host and the SLM board, and the second is through the use of a switch, hub, or network. Although it is not recommended to use shielded cables, if a shielded Ethernet cable is used, it is advised to only connect the shield to Earth ground at one end of the Ethernet cable. This will prevent ground

loops and other issues from occurring that can cause data corruption. Please note the SLM's Ethernet connector's (J5) shell is connected Earth ground. The end user should conduct tests to determine the best method of grounding the cable shield for their application.

A direct connection requires a non-standard cable where the wires are not run straight through. Please refer to the two cable ends shown below in figure 4.

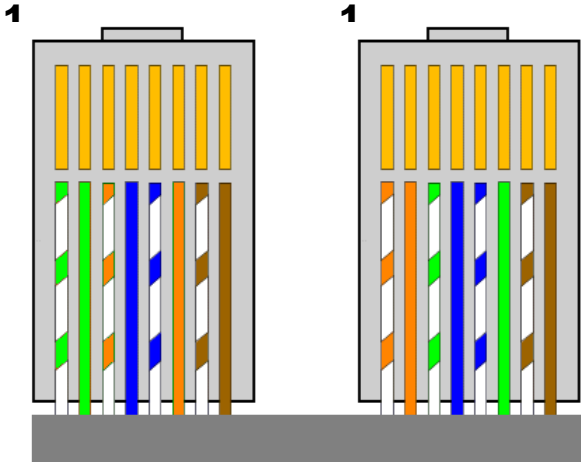


Figure 4 – Crossover Cable for Direct Connection

A standard connection through a hub, switch, or network uses a standard CAT5 patch cable. Please refer to the two cable ends shown below in figure 5.

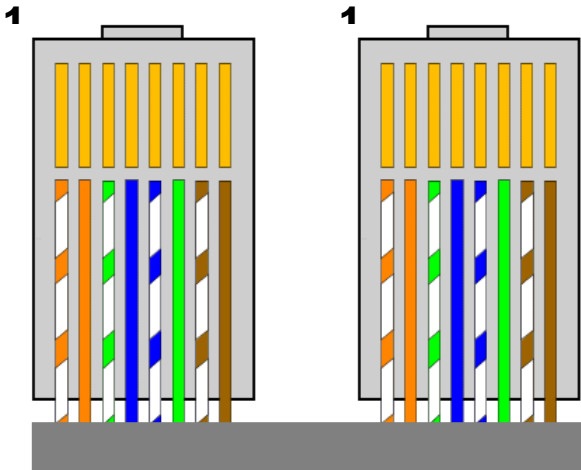


Figure 5 – Standard Straight Through Cable – Standard CAT5 Patch

3.6 USB CABLING

A high-quality double-shielded USB 2.0 Type A to B (host to slave) cable should be used in all applications. This type of cable is a standard PC to peripheral cable that utilizes full-size connectors.



Figure 6 – USB A-to-B cable

3.6.1 HIGH EMI ENVIRONMENTS

If the SLM USB interface is being used in a high-EMI environment, ferrites should be added to the USB cable. Figure 7 illustrates the possible combinations of ferrites that can be used to achieve acceptable operation under these conditions.

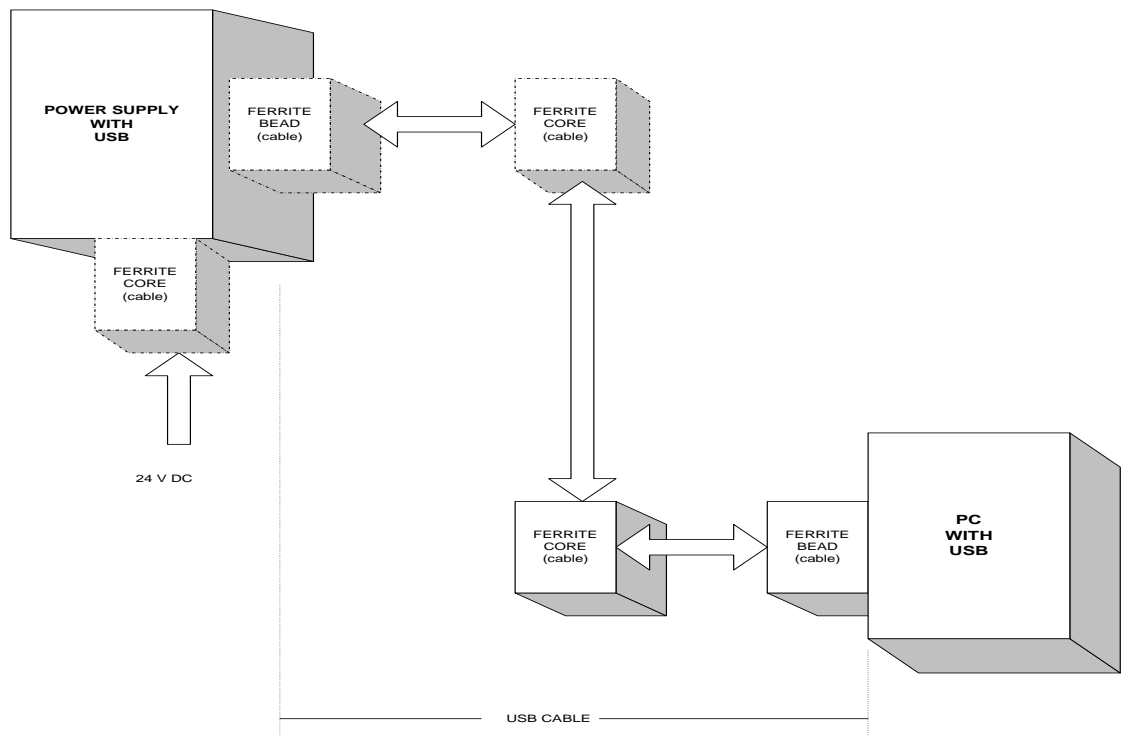


Figure 7 – Block Diagram of USB Cable Utilizing Ferrites

Ferrite beads should be attached to the USB cable next to the connectors – both sides should be installed. In extreme cases ferrite cores may be added where the cable is looped 3 or 4 times around the core as shown in figure 8. Cores of 1.5 to 2 inches should be used at both ends of the cable.



Figure 8 - Example of a USB Cable Using Ferrites

Please refer to the USB Interface Setup section, for an explanation of how USB works and why EMI may present a problem for this communications interface.

4.0 GETTING STARTED – SOFTWARE

The following sections detail how to create software to interface to the SLM 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. The programmer should also review section 4.3 for programming considerations for the USB interface as the code is nearly identical for the RS-232 interface.

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

- A default Baud rate of 115.2K bps
- No Parity
- 8 Data Bits
- 1 Stop Bit
- No handshaking

The Baud rate can be changed to 115.2K ,57.6k,38.4k,19.2k or 9600 bps and stored in the unit.

4.1.1 Enabling Communications Objects in Visual Basic for RS-232

Communications in Microsoft Visual Basic 6.0 are directed to a control that abstracts the port. In the case of serial and USB we need Microsoft Comm Control 6.0. To enable this in your VB 6 project, go to:

Project -> Components

Then in the list make sure that Microsoft Comm Control 6.0 has a check next to it. The Comm Control Object should then appear in your toolbox. It will have an icon of a telephone and will be named: MSComm. This can be dragged and dropped into your application. You will then need to set the object’s properties.

4.1.2 Configuring Communications in Visual Basic for RS-232

In order to configure the MSComm Object, first you must initialize it in the Object properties:

Settings	115200,n,8,1
Handshaking	0 – comNone

The application can be set to either default to a specific COM Port or the End User can be allowed to choose one for the particular

PC. For the “Default” scenario, include the following commands in the Form_Load() routine:

```
MSComm1.CommPort = portNumber  
MSComm1.PortOpen = True
```

For the “Choice” scenario, place the above two commands in a selectable menu item.

4.2 ETHERNET

The SLM contains an embedded diagnostic web server that can be accessed through any standard web browser by browsing to the SLM's IP address. For example:

`http://192.168.1.4`

The Ethernet interface communicates using the following protocols:

- TCP/IP
- HTTP
- TFTP
- FTP

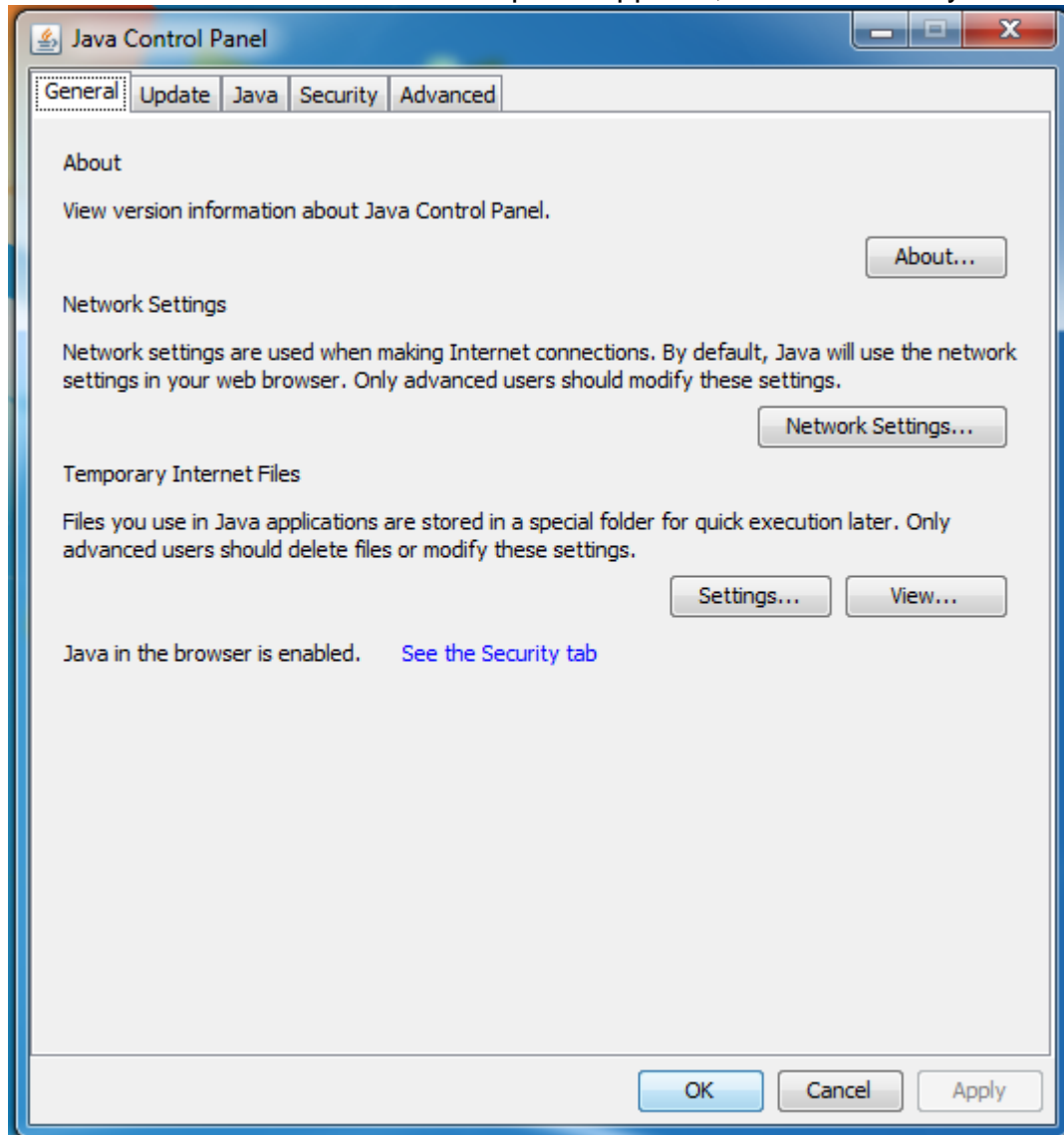
4.2.1 Diagnostic Web Server

The diagnostic web server can control and monitor an SLM equipped power supply from a web browser. It displays operating status of the Power Supply and allows the unit to be configured in real time. The application consists of three web pages; a page displaying contact information, a license agreement, and a monitoring and control applet that is at the heart of this application. In order for the Web Server to work with the latest Java release, an exception has to be made in java. The following steps explain how to enter an Applet's designated IP address to Java's exception list. We used Java 7 Update 60 and Internet Explorer 10.

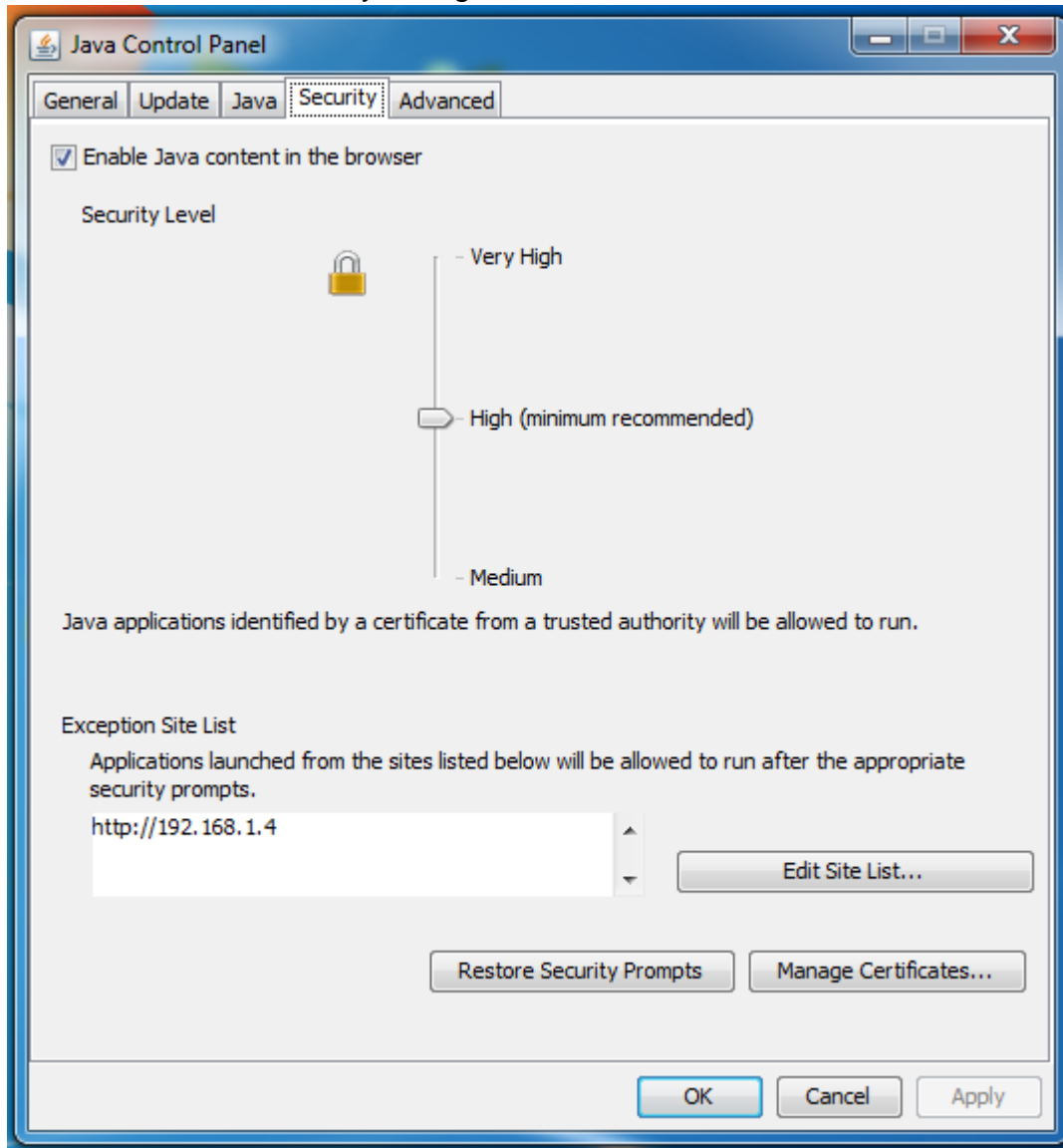
1. The exception feature of Java allows to run an Applet which doesn't meet all of Java's security checks. To use it, you need to open the Java Configure menu and enter the IP address assigned to the device which hosts the Applet. To open the Java Configure menu, you click on the Windows icon and look for the Configure Java program; if it doesn't show on the Task Bar, select All Programs and look for the Java folder and click it. You should see the Configure Java option, click on it.



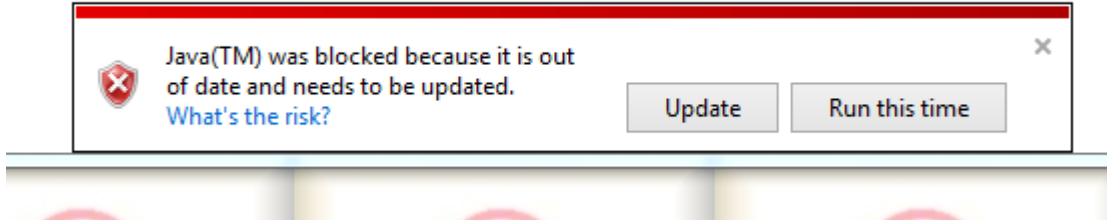
2. When the Java Control panel appears, click on Security tab.



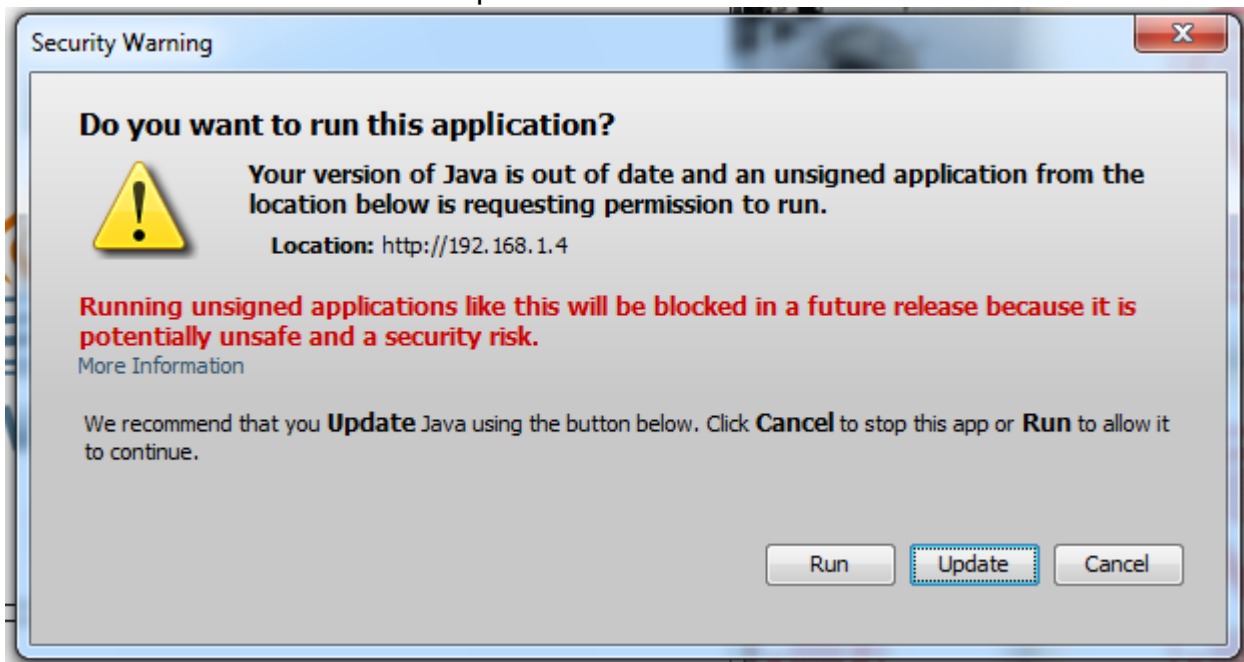
3. On the blank text box enter the IP address assigned to your unit as shown below. The IP address shown in the picture below is the default factory configuration IP address.



4. You have finished entering your device address on Java's exception list. Next, you will open your browser and try to talk to the Applet the way you normally do. If you are using Internet Explorer and get the following window, select the Run this time button.



5. If you are using Internet Explorer and get the following window, select the RUN option.



6. After entering Username and Password, the applet should connect with your unit.

4.2.2 Web Pages

4.2.2.1 Web Page 1: Contact Information Page

Figure 9 displays a picture of the SLM and information on how to contact Spellman High Voltage Electronics Corporation. By clicking on the picture of the SLM or on the button labeled “Click Here to Monitor and Control” one can move on to the next screen, the license agreement.



Figure 9 - Web Page 1- Contact Information

4.2.2.2 Web Page 2: License Agreement Page

Figure 10 displays the license agreement. Here the user can either agree or disagree with the Spellman license agreement. Click on “I Accept” to continue on to the applet.

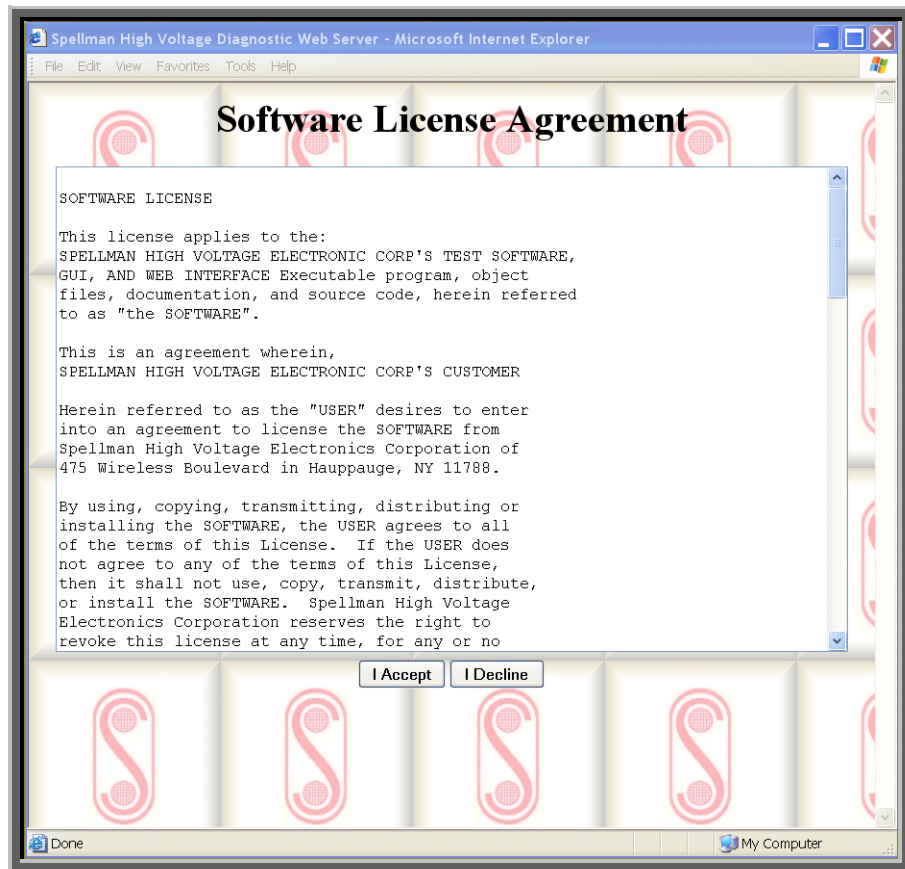


Figure 10 - Web Page 2 – License Agreement

4.2.2.3 Web Page 3 - Monitor and Control Applet

4.2.2.3.1 Requirements

The Monitor and Control Applet is a java “applet” (“small java application” specifically written to be embedded in a web page and invoked from a browser) that requires an Internet browser with an installed JVM (Java Virtual Machine). The password for the applet is: **shvapplet**. We have tested under Internet Explorer 5 and 6, Microsoft JVM 5 and Sun JVM versions 1.6 and higher.

4.2.2.3.2 Description of Monitor and Control Applet

Figure 11 displays an example of an embedded monitor and control application.

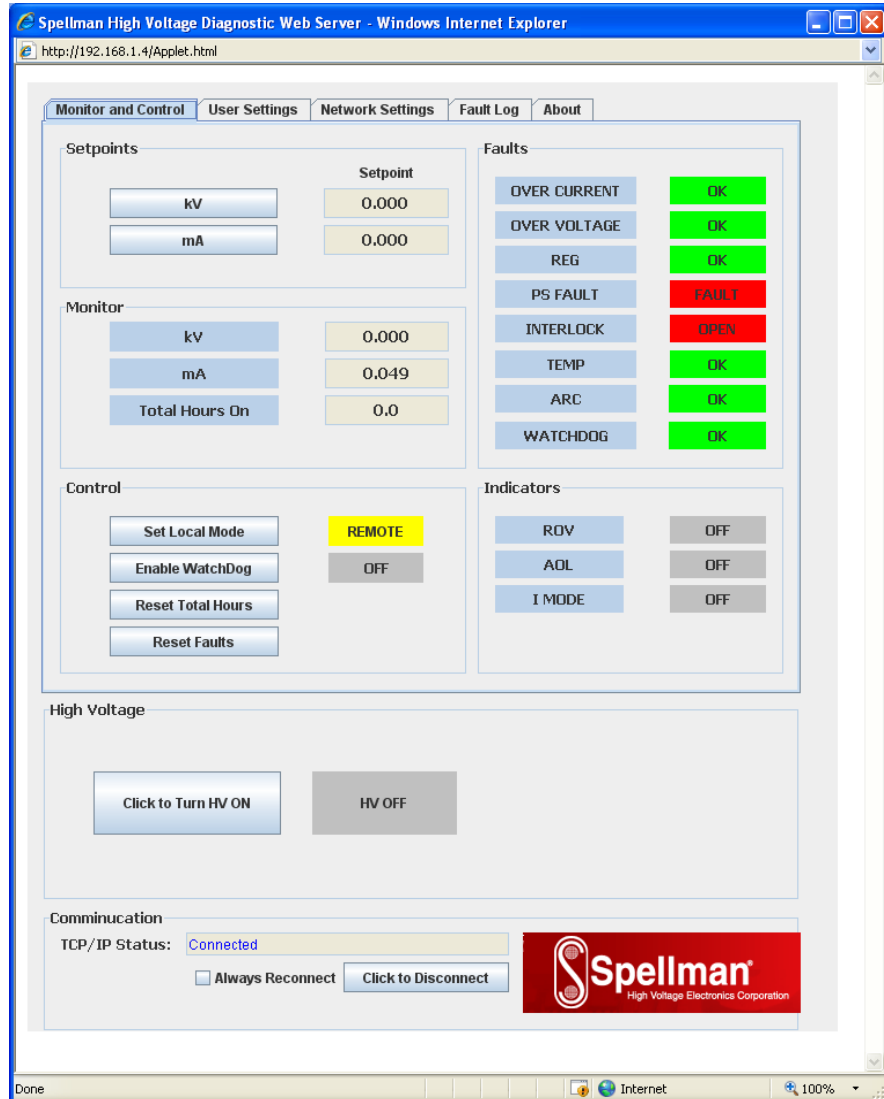


Figure 11 - Control and Monitor Applet

View the screen as a “left” and a “right” with the right half containing status read from the SLM and the left half containing the values that are programmable by the user. For any programmable setting you click on the button to the left of the setting, which brings up the program set point screen. For example, click on the button labeled, ‘V’ to set the output voltage set point. Refer to figure 12.

4.2.2.4 Program Set Point Screen

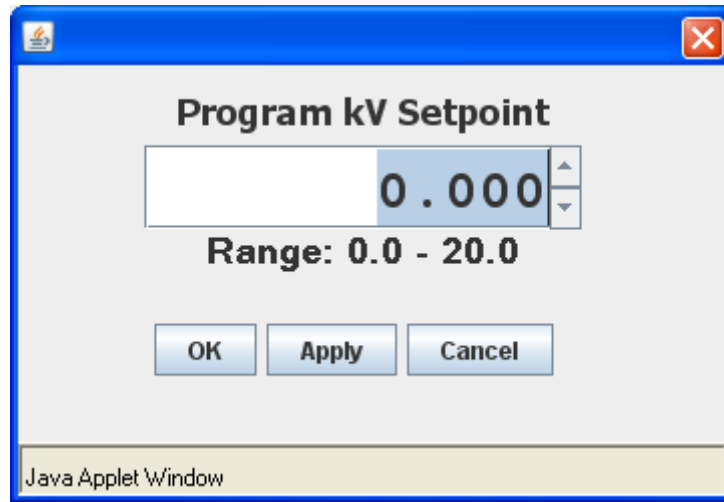


Figure 12 - Program Configurable Values Screen

The field is the scaled value or real world value. Enter the desired set point level within the shown range.

The user can then click Apply to send the set point to the SLM and remain in the set point screen, or click OK to send the set point and close the set point entry window. The user may also click on Cancel to close the window without sending any changes.

To reset the Total hour On meter to zero via the Applet a password is required. The password is “**SHV_Reset**”

4.2.2.5 Java Warning Messages

You may notice a message at the bottom of all dialog windows that are displayed from the SLM Control and Monitor Applet. The wording may vary slightly depending on the JVM version but on some the message is “Java Applet Window”. This message informs the user that the dialog window was generated by an applet. The design philosophy for the JVM was for secure computing, so the origins of new windows are supposed to be as obvious as possible.

4.2.2.6 “Tabs” on Applet

The user can view and set operating parameters of the applet or network configurations of the SLM or view firmware version information by changing tabs.

4.2.2.7 User Settings

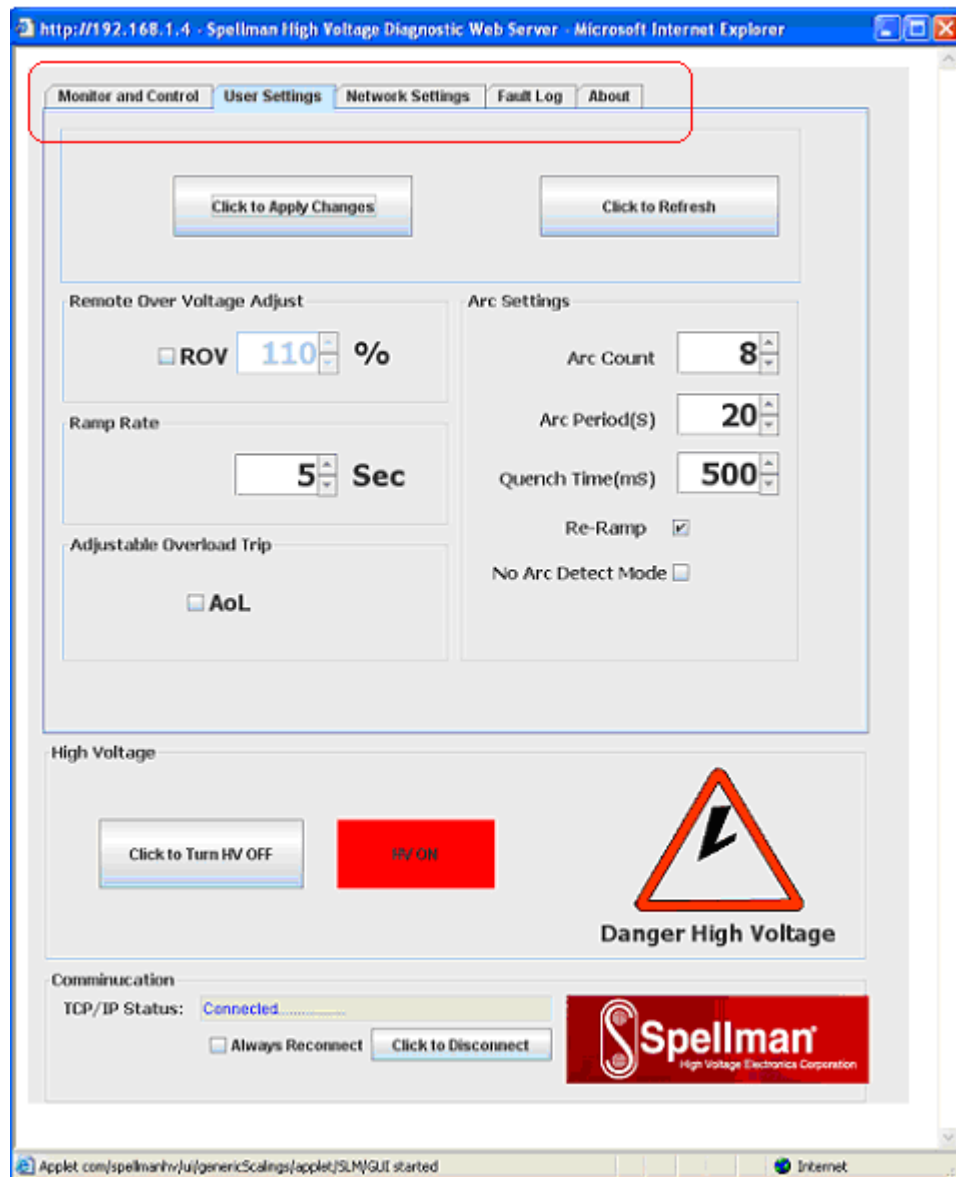


Figure 13 – User Setting

The User Settings tab allows the user to set firmware configurable options, as shown above. After making changes to the options, click on the “Click to Apply Changes” button.

4.2.2.8 Fault log



Figure 14 – Fault log
Fault log displays faults with their date and time.

4.2.2.9 About

Displays version information and model number.

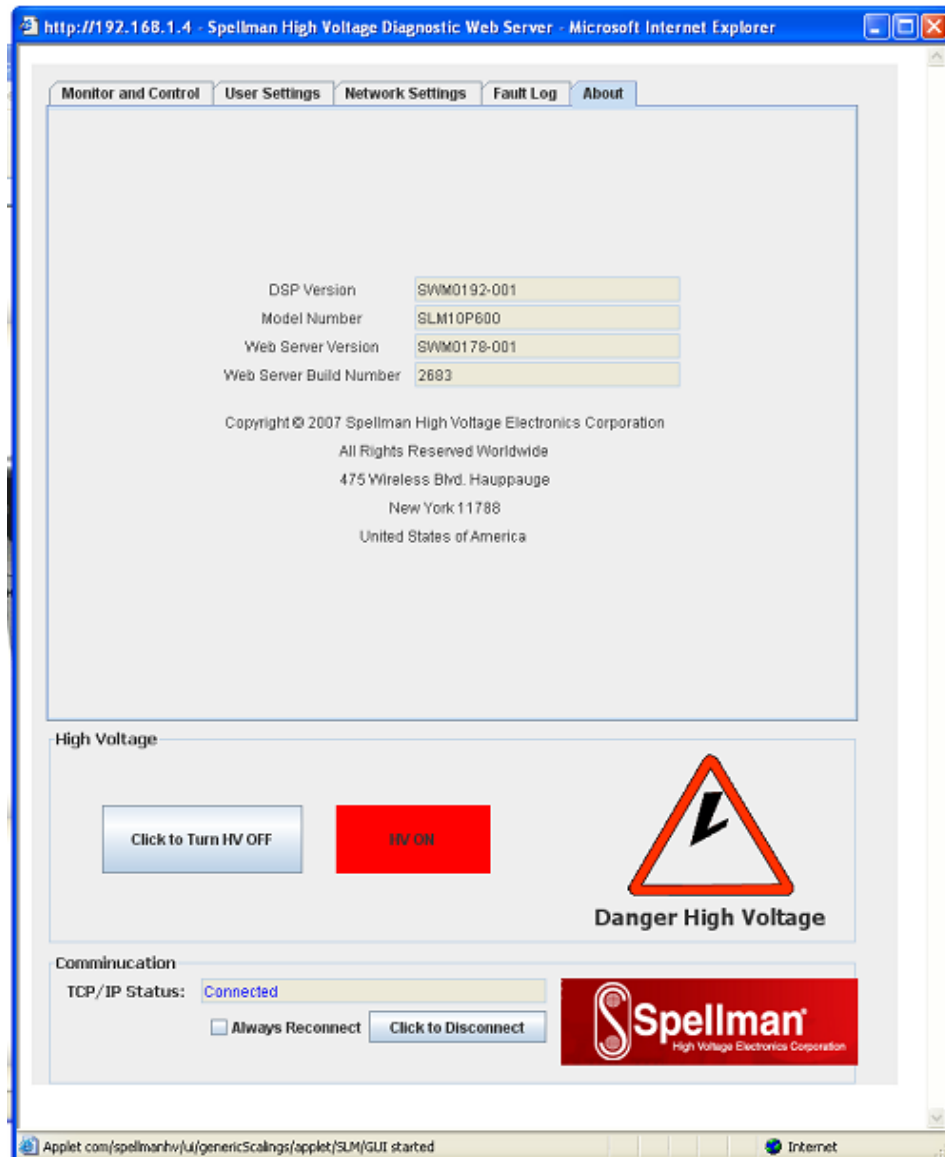


Figure 15 – About

4.2.2.10 Turning the SLM HV On/Off and Connection Status

Please refer to Figure 11, the Monitor and Control Applet.

<u>Setting Name</u>	<u>Range Values</u>
Local/Remote	Local mode/Remote mode
HV	On/Off
Interlock	Open/Closed
Fault Status	OK/Fault
Connection Status	Connected/No Data Received/Disconnected

Unlike the controls we previously discussed at the top of the screen which required a separate dialog screen to enter values, these are controlled by a button. For example, an On/Off button controls the HV. When HV is on, the Control is labeled “Click to Turn HV Off”. When HV is off, the control is labeled “Click to Turn HV On”. Thereby handling the two distinct states.

Notice that at the very bottom of the screen is a text field that displays the current connection status, which as mentioned above is one of three values. “Connected” is displayed when there exists a valid TCP/IP session connecting the SLM and the Applet and data is being received by the applet from the SLM. The next state is “No Data Received” which is when there is still a valid connection but no responses have been received from the SLM for 2 seconds. Lastly, the text field displays “Disconnected” when the TCP/IP session has been disconnected. To operate the UUT using the Computer interface the UUT must be set to Remote Mode by Clicking “Click to Set Remote, the SLM Applet automatically sets the unit to Remote mode upon connecting.

When the Applet is first started and anytime the “Click To Connect” button is clicked there is a 5 second delay as the Applet starts up the threads necessary for communication between it and the SLM.

4.2.3 Direct Connection between the SLM and a Computer

A direct Ethernet connection between the SLM and the computer requires an RJ45 crossover cable. The end connectors will look identical to a “normal” RJ45 connector but the colors of some of the wires in the connectors will be “reversed”. Hold up the two ends of the RJ45 cable and look at the color of the wires from left to right. They should differ on the two connectors.

When direct connecting the SLM to a computer using a crossover cable over Ethernet they are essentially participating in a private network. As such you need to pick two valid IP addresses, one for each device.

The table below illustrates that not all IP addresses are actually valid IP addresses. For example, IP addresses beginning with 127 are not valid.

Class	Address Range
A	1.0.0.0-126.255.255.255
B	128.0.0.0-191.255.255.255
C	192.0.0.0-223.255.255.255

4.2.3.1 Configuring the Computer for Direct Ethernet Connection

As mentioned above both the IP Address and Subnet Mask need to be configured. In our environment computers normally are assigned IP addresses dynamically, using DHCP. We need to change this and assign the IP Address statically to the one we have selected.

Here are the steps on Windows XP. On the desktop right click on “My Network Places” and select properties at the bottom of the menu.

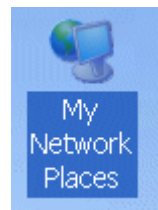


Figure 16 – Right Click on Desktop

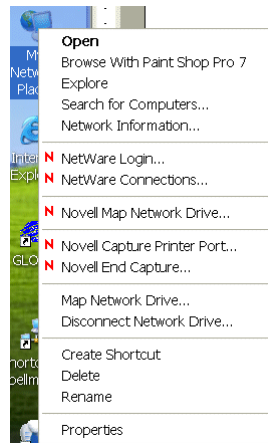


Figure 17 – Select Properties

After selecting properties you are brought up to the screen below (Figure 18). You must **RIGHT CLICK** and select Properties on Local Area Connection, and not double click which will display a window similar to figure 19.

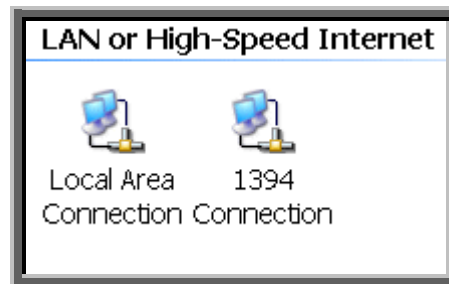


Figure 18 – Here you must Right Click and Select Properties

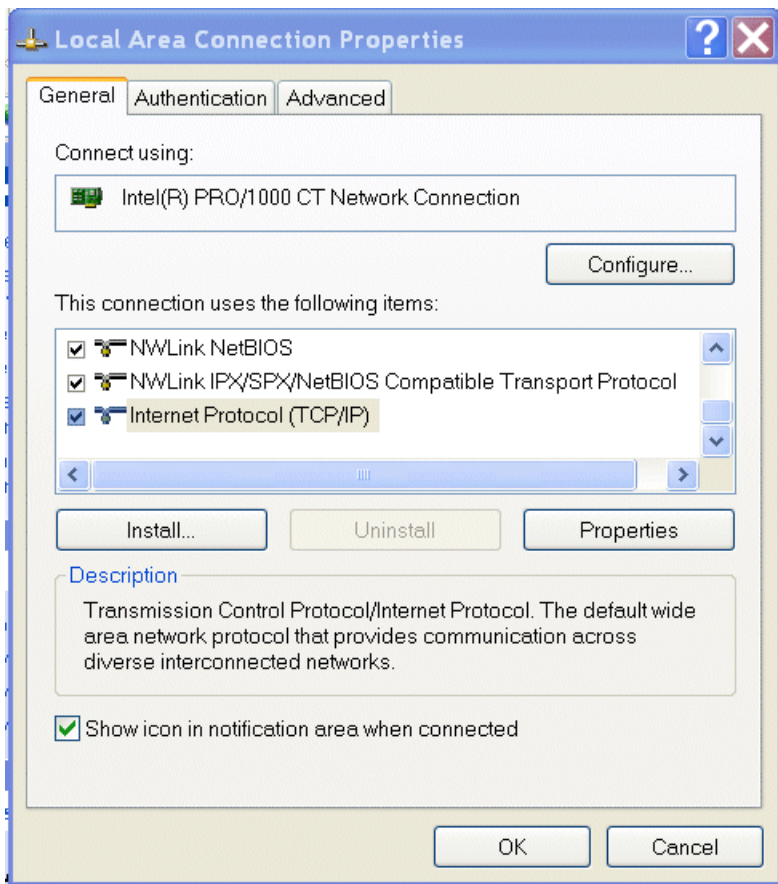


Figure 19 – Local Area Connection Properties

Now you must select “Internet Protocol (TCP/IP)” and click on the Properties button to be brought to figure 20. Lastly you must disable any firewall software you have running. If you are running a proxy server for Internet access, you must also disable the proxy client. Disabling this also requires a reboot.

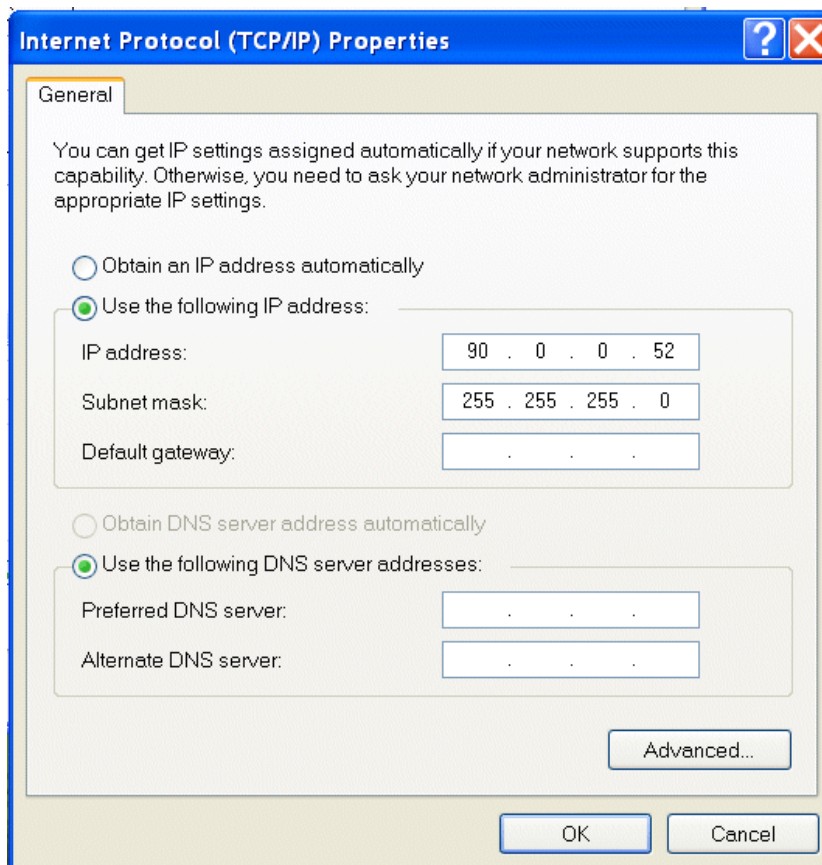


Figure 20 – TCP/IP Properties

4.2.3.2 Testing a Direct Connection

You can use the program “Ping” to test a network connection between the computer and the SLM. “Ping” is a command line tool so we will need to bring up a command prompt. Under Windows NT, 2000 and XP the name of this command is “CMD”. Under Windows 98 the name of this command is “Command”.

To do this, click on Start->Run->Cmd

Then on the command line type

Ping <IP Address>

For example

Ping 192.168.1.4

If the SLM is found at the specified IP address, the Ping command will respond with a report that is similar to:

Pinging 192.168.1.4 with 32 bytes of data:

Reply from 192.168.1.4: bytes=32 time<1ms TTL=64

Reply from 192.168.1.4: bytes=32 time<1ms TTL=64

Reply from 192.168.1.4: bytes=32 time<1ms TTL=64

Reply from 192.168.1.4: bytes=32 time<1ms TTL=64

Ping statistics for 192.168.1.4:

Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),

Approximate round trip times in milli-seconds:

Minimum = 0ms, Maximum = 0ms, Average = 0ms

4.2.4 Configuring the SLM For a Local Area Network (LAN)

If you have chosen to place the SLM onto your local area network you will need:

- A CAT5 network patch cable to physically connect the SLM to the LAN
- A static IP address to assign to the SLM.

Remember that even if the IP address you have selected is in general a valid IP address it needs to be valid for your LAN (local area network). Otherwise the device will not be accessible from an Internet browser or Ping.

4.2.4.1 Configuring the Network Settings from the Monitor and Configure Applet

The network settings are configurable from the Network Settings tab, refer to figure 21.

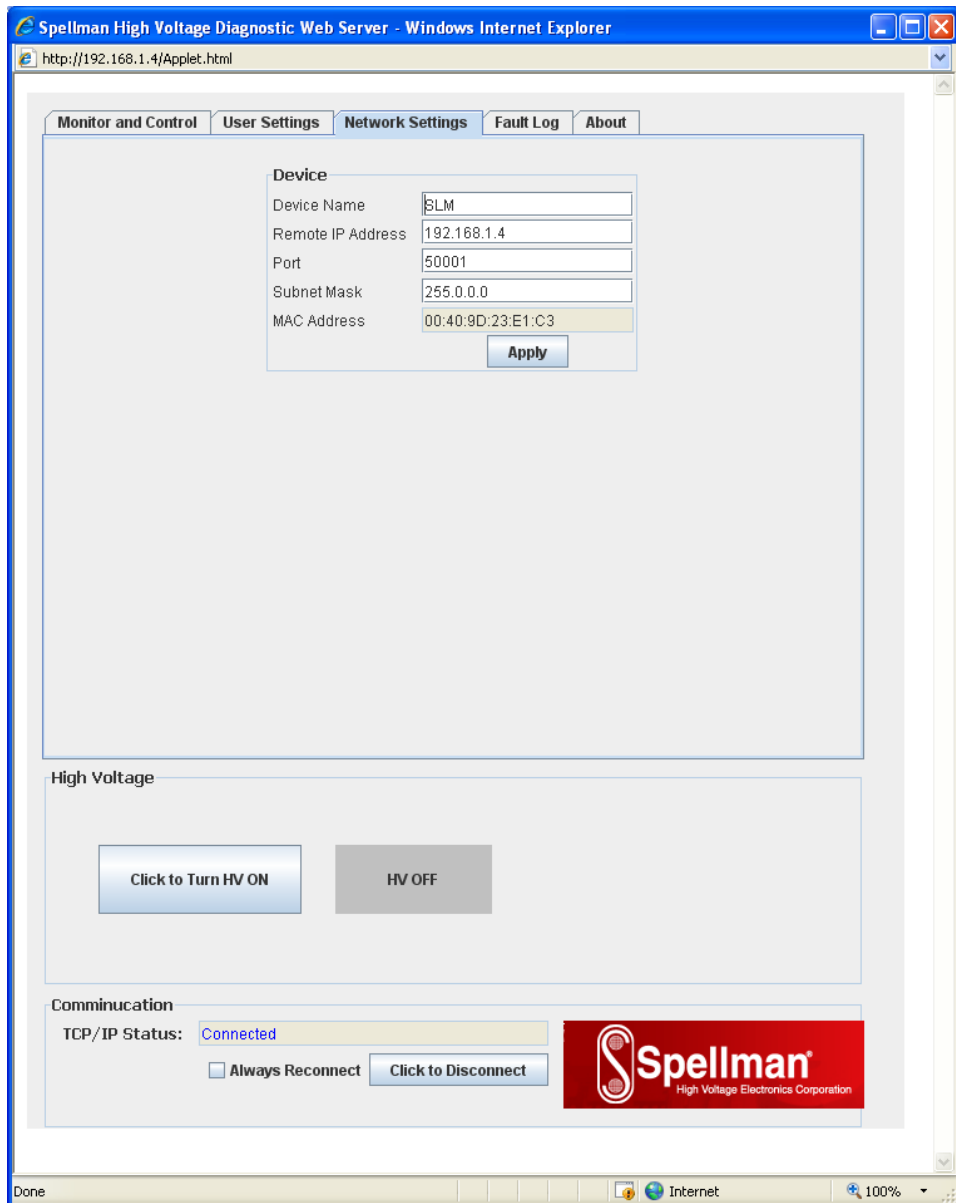


Figure 21 - Configure Network Settings

The settings that can be changed are the:

- Device Name
- IP Address
- TCP Port
- Subnet Mask

Once the Apply button is clicked on the network settings screen, the network component of the SLM is configured, rebooted and the applet is disconnected from the SLM. You must type the NEW IP address into a web browser to bring up a new instance of the applet to monitor and control the SLM after reconfiguring it. This

may also require reconfiguring the host computer with the correct host IP address, subnet mask, and TCP port.

The device name does not affect the operation of the SLM; it is simply a way for the user to differentiate multiple units on the same network.

Depending on the type of network you are attaching the SLM to, you may need to configure the host PC's IP address and subnet mask as shown in section 4.2.3.1. You can also test a network connection to the SLM by following the instructions listed in section 4.2.3.2 .

4.2.5 Enabling Communications Objects in Visual Basic for Ethernet Communications

For Ethernet communications, we need Microsoft Winsock Control 6.0 and SP5. To enable this in your VB 6 project, go to:

Project -> Components

Once selected in your toolbox, you will have an icon of two computers linked together and will be named: Winsock. This can be dragged and dropped into your application. Then set the object's properties.

4.2.6 Configuring Communications in Visual Basic for Ethernet

In order to configure the Winsock Object, you must make the following initialization in the object's properties:

Protocol 0 – sckTCPProtocol

Then, in the application code, include the following commands:

```
tcpClient.RemoteHost = host  
tcpClient.RemotePort = portNumber  
tcpClient.Connect
```

For further information regarding the use of the above commands, please refer to your Visual Studio Help File.

4.2.6.1 Data Output Example

MSComm1 is both the serial and USB port. TcpClient is the Ethernet port.

```

If (portType = "ethernet") Then
    tcpClient.SendData (str)
Else
    MSComm1.InBufferCount = 0
    On Error GoTo done
    MSComm1.Output = str
done:
    tmrOpenClose.Enabled = True
End If

```

4.2.6.2 Data Input Example

```

If (portType = "ethernet") Then
    Do
        DoEvents
        .....
        .....tcpClient.GetData temp$
        str = str + temp$
        Loop Until InStr(str, Chr(3)) Or Timer - t1 > 1
        On Error Resume Next
    Else
        Do
            DoEvents
            If MSComm1.InBufferCount > 0 Then
                str = str & MSComm1.Input
            End If
            Loop Until InStr(str, Chr(3)) Or Timer - t1 > 1
            If InStr(str, Chr(3)) > 0 Then
                tmrOpenClose.Enabled = False
            End If
        End If
    End If

```


4.3 USB

The USB interface makes use of a standard 'command/response' communications protocol. See section 6.0 for the syntax of the serial interface protocol.

The USB interface is accessed through a Windows USB Human Interface driver (HID).

4.3.1 USB Driver Installation

The HID driver is a Windows driver installed with the operating system. To determine if the driver had been acquired open the System properties window selecting the Control Panel System Properties.



Figure 22 – System Properties

Then select Device Manager and expand the Human Interface Devices. View the properties of the USB Human Interface Device icon and verify that Spellman USB HID appears in the Location section.

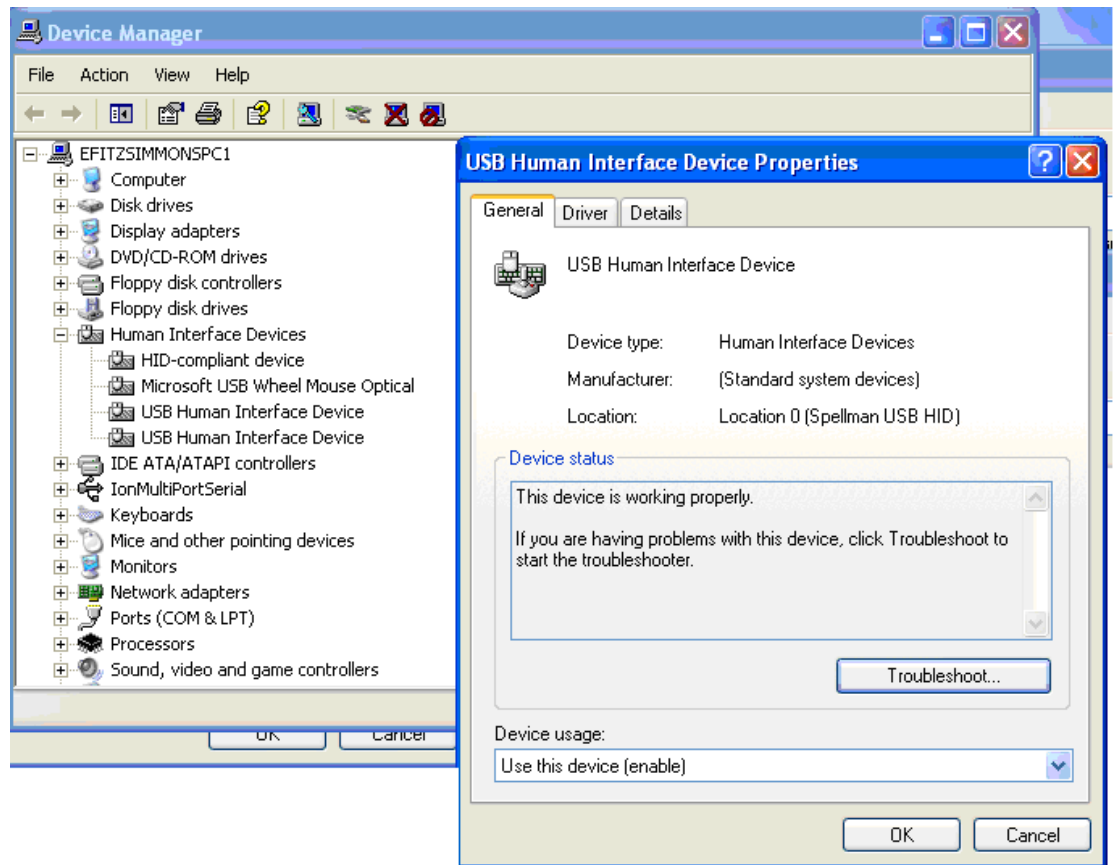


Figure 23 – Device Manager showing USB HID

4.3.2 USB and EMI

The USB protocol utilizes a heartbeat signal from each client device back to the host (PC). If the heartbeat is interrupted due to radiated or conducted transient noise, it is possible that the host may lose connection with the client. This can cause problems with data transfers over the USB cable.

The DXM when used in combination with the HID Windows driver makes it possible for the host to renumerate the client connection and reestablish communications. This is providing the control application implements a method of timeout and retry.

NOTE: If an EMI disruption occurs the DXM will continue to renumerate until a connection with the GUI is re-established.

4.3.3 Enabling Communications Objects in Visual Basic for USB

The dynamic link library USB_dll.dll will be provided which needs to be added to the project. The library has three functions that can be called from the VB code.

The three functions are:

- FindTheHid – finds the connection with the correct VID, PID and Serial Number
- WriteReport(str) – Writes a string to the connected HID interface
- ReadReport() – Returns a string from the connected HID interface

4.3.4 Configuring Communications in Visual Basic for USB

To use the USB_dll.dll in VB the following statements are needed.

```
Dim usb As usbDll
Dim MyDeviceDetected As Boolean
```

```
Set usb = New usbDll
```

Using this statement determines whether a connection is present.

```
MyDeviceDetected = usb.FindTheHid
```

If MyDeviceDetected is true then the connection is present.

4.3.5 Software Considerations for USB Reconnection

The following Visual Basic code snippets are presented as a guideline for implementation with revision C and higher assemblies.

4.3.5.1 Recognize partial, corrupt, or absent data

```
1: temp2$ = inputInputString
2: If temp2$ <> "" Then
3:   btn_UPDATEDATA.Value = False
4:   CommStatusFlag = True
5:   CommaPos = InStr(Start, temp2$, Comma, vbTextCompare)
6:   ' Channel 0
7:   On Error GoTo endhere
8:   AmbTemp = Mid(temp2$, Start, (CommaPos - Start))
```

Please note that even though we have guarded against no data, in line 2, we still need to guard against bad data, in this case no comma, on line 8. If there is no comma, we wind up passing a negative value to Mid, which is an error, that we should trap for.

4.3.5.2 Retrieve data only if it exists

```
1: Do
2:   DoEvents
3:   If MSComm1.InBufferCount > 0 Then
4:     str = str & MSComm1.Input
5:   End If
6:   Loop Until InStr(str, Chr(3)) Or Timer - t1 > 1
7:   'str = str & MSComm1.Input
8:   If InStr(str, Chr(3)) > 0 Then
9:     tmrOpenClose.Enabled = False
10:  End If
```

Notice that in line 3 we check for the existence of data before we extract data from the USB port. Normally, if there is no data, line 4 would append an empty string. However, during a noise event, retrieving data without first checking the existence of data could hang.

4.3.5.3 Example Output Routine

Notice that on line 13 we register an error handler in case the port is invalid because we have closed it in another routine. Notice that on line 16 we start a timer. When we output data on the port we start a timer to keep track of incoming data. If we get no incoming data it means that communications have been interrupted.

```
1: Private Sub outputOutputString(outputString As String)
2:   Dim str As String
3:   str = ProcessOutputString(outputString)
4:   StatusBar1.Panels(4).Text = "TX: " & str
5:   'StatusBar1.Panels(3).Text = "RX: Waiting"
6:   If (portType = "ethernet") Then
7:     tcpClient.SendData (str)
8:   ElseIf (portType = "USB") Then
9:     usb.WriteReport (str)
10:  Else
11:    MSComm1.InBufferCount = 0
12:
13:  On Error GoTo done
14:    MSComm1.Output = str
15: done:
16:    tmrOpenClose.Enabled = True
17:  End If
18: End Sub
```

4.3.5.4 Example Input Routine

Notice on line 26 we check for data first before extracting data from the input. Then if we have actual data we turn off the timer. Otherwise the timer routine toggles the port open/close.

```
1: Private Function inputInputString() As String
2:   Dim str As String
3:   Dim t1 As Single
4:   Dim temp$

5:   Dim stra As String
6:   Dim stri(300) As String

7:   t1 = Timer
8:
9:   If (portType = "ethernet") Then
10:    Do
11:      DoEvents
12:      tcpClient.GetData temp$
13:      str = str + temp$
14:      Loop Until InStr(str, Chr(3)) Or Timer - t1 > 1
15:      On Error Resume Next

16:   ElseIf (portType = "USB") Then
17:    Do
18:      DoEvents
19:      stra = usb.ReadReport
20:      str = str & stra
21:      'str = str & ReadReport
22:      Loop Until InStr(str, Asc(3)) Or Timer - t1 > 0.09

23:   Else
24:    Do
25:      DoEvents
26:      If MSComm1.InBufferCount > 0 Then
27:        str = str & MSComm1.Input
28:      End If
29:      Loop Until InStr(str, Chr(3)) Or Timer - t1 > 1
30:
31:      If InStr(str, Chr(3)) > 0 Then
32:        tmrOpenClose.Enabled = False
33:      End If
34:
35:      frm_EXTRAS.txt_MSCOMMBUFF.Text = str
36:      tmr_COMMWDT.Enabled = True
37:      On Error Resume Next
```

```
38: End If
39: StatusBar1.Panels(3).Text = "RX: " & str
40: inputInputString = str
41: tmr_RCVTIMER.Enabled = True
42: End Function
```

4.3.5.5 Example Timer Routine: Toggle Port State

This is the timer routine in which the open/closed state of the port is toggled. If communications are interrupted, the USB device will re-register itself with the OS (vendor term: reenumeration). Once this happens, re-opening the port will enable communications. Until the re-registration happens, open operations will fail. Notice line 5 where we register an error handler.

```
1:Private Sub tmrOpenClose_Timer()
2: If MSComm1.PortOpen = True Then
3:
4:     MSComm1.PortOpen = False
5:     On Error GoTo done
6:     MSComm1.PortOpen = True
7: done:
8:     tmrOpenClose.Enabled = False
9: End If
10:
11: End Sub
```

4.3.5.6 Example Timer Routine: Port Reconnection

This is another timer routine whose purpose is to turn the port on if it is off. Notice that in line 8 an error handler is called because if the device has not re-registered itself with the OS, an error will be raised.

```
1: Private Sub tmr_COMMWDT_Timer()
2:
3: tmr_COMMWDT.Enabled = False
4:
5: If CommStatusFlag = True Then
6:
7:     If MSComm1.PortOpen = False Then
8:         On Error GoTo done
9:         MSComm1.PortOpen = True
10: done:
11: End If
12:
13: Elseif CommStatusFlag = False Then
14:
```

```

15: If MSCComm1.PortOpen = False Then
16:
17:     MSCComm1.PortOpen = True
18: Else
19:     MSCComm1.PortOpen = False
20: End If
21:
22: End If

```

4.3.5.7 Data Parsing Example

Here we have an example of a code that parses incoming data. Notice that it makes use of our generic input and output routines. The important consideration is to gracefully handle corrupted input data after a noise event. In this case we may get data, so a test against empty string returns false, but we may not get commas in the correct place. Notice that we register an error handler on line 26 so that the mid function, which would raise an error when given a negative number, is handled.

```

1: Private Sub btn_EMI_Click()
2: Dim temp2$
3: Dim Response1$
4: Dim Response2$
5: Dim number$
6: Dim Comma
7: Dim CommaPos
8: Dim Start
9: Dim ODATA$
10:
11: Comma = ","
12: Start = 5
13:
14: If tmr_RCVTIMER.Enabled = True Then
tmr_RCVTIMER.Enabled = False
15: If tmr_NETRCVTMR.Enabled = True Then
tmr_NETRCVTMR.Enabled = False
16:
17: If AutoUpdate = True Then
18: tmr_UPDATE.Enabled = False
19: End If
20:
21: number$ = "15,"
22: outputOutputString (number$)
23:
24: temp2$ = inputInputString
25: CommaPos = InStr(Start, temp2$, Comma, vbTextCompare)

```

```
26: On Error GoTo endhere
27: Response1$ = Mid(temp2$, Start, (CommaPos - Start))
28:
29: 'With a 5v reference:
30: ODATA$ = Format(str(Response1$ * 0.0004884), "0.##0")
31:
32: txt_DACB.Text = ODATA$ + " mA"
33: frm_RAWDATA.txt_RAWDACB.Text = str(Response1$)
34: txt_DACB.BackColor = vbWhite
35: CommStatusFlag = True
36: endhere:
37:
38: If portType = "ethernet" Then
39: tmr_NETRCVTMR.Enabled = True
40: Else
41: tmr_RCVTIMER.Enabled = True
42: End If
43:
44: If AutoUpdate = True Then tmr_UPDATE.Enabled = True
46: End Sub
```


The format of Data Bytes 1 through N are as follows:

<STX><CMD><,>ARG><,><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
 <ETX> = 1 ASCII 0x03 End of Text character

5.2 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.

5.3 COMMAND OVERVIEW

Data Byte section of the TCP/IP Datagram			
Command Name	<CMD>	<ARG>	RANGE
Program RS-232 unit baud rate	07	1 ASCII	1 - 5
Program User Configs	09	9 ASCII	See Description
Program kV	10	1-4 ASCII	0-4095
Program mA	11	1-4 ASCII	0-4095
Request kV Setpoint	14	None	-
Request mA Setpoint	15	None	-
Request Analog Monitor Readbacks	19	None	-
Request HV On Hours Counter	21	None	-
Request Status	22	None	-
Request Software Version	23	None	-
Request Hardware Version	24	None	-
Request Web Server Version	25	None	-
Request Model Number	26	None	-

Request User Configs	27	None	
Request unit Scaling	28	None	
Reset HV On Hours Counter	30	None	-
Reset Faults	31	None	-
Request Network Settings	50	None	-
Program Network Settings	51	6 ASCII	See Description
Read Interlock Status	55	1 ASCII	0 or 1
Request kV monitor	60	None	-
Request mA monitor	61	None	-
Request -15V LVPS	65	None	-
Watchdog Tickle	88	None	-
Watchdog enable	89	1 ASCII	0 or 1
Turn HV on/off	98	1 ASCII	0 or 1
Program Local/Remote Mode	99	1 ASCII	0 or 1

5.4 RESPONSE OVERVIEW

The command responses will follow the same network TCP/IP header format as outlined above in section 5.1. 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 will be seven ASCII characters in length.

Response Name	<CMD>	Response
Request kV Setpoint	14	7-10 ASCII
Request mA Setpoint	15	7-10 ASCII
Request Analog Monitor Readbacks	19	11-22 ASCII
Request Total Hours High Voltage On	21	13 ASCII
Request Status	22	12 ASCII
Request DSP Software Version	23	17 ASCII
Request Hardware Version	24	9 ASCII
Request Web Server Version	25	17 ASCII
Request Model number	26	11 ASCII
Request User Configs	27	8-16 ASCII
Request unit Scaling	28	23-31 ASCII
Request Network Settings	50	48-104 ASCII
Read Interlock Status	55	7 ASCII
Request kV monitor	60	7-10 ASCII
Request mA monitor	61	7-10 ASCII
Request -15V LVPS	65	7-10 ASCII
Request Faults	68	19 ASCII

5.5 COMMAND STRUCTURE

5.5.1 Program kV

Description:

The host requests that the firmware change the setpoint of kV.

Direction:

Host to supply

Syntax:

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

Where:

<ARG> = 0 - 4095 in ASCII format

Example:

<STX>10,4095,<ETX>

Response:

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

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

where <ARG> = error code

Error Codes TBD, 1 = out of range

0-4095 = 0 to full scale rated kV

5.5.2 Program mA

Description:

The host requests that the firmware change the setpoint of mA.

Direction:

Host to supply

Syntax:

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

Where:

<ARG> = 0 - 4095 in ASCII format

Example:

<STX>11,4095,<ETX>

Response:

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

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

where <ARG> = error code

Error Codes TBD, 1 = out of range

0-4095 = 0 to full scale rated mA

5.5.3 Request Total Hours High Voltage On

Description:

The host requests that the firmware sends the present value of the Total Hours High Voltage On.

Direction:

Host to supply

Syntax:

<STX><21><.,><ETX>

Example:

<STX>21,<ETX>

Response:

<STX><21><.,><ARG1>< ARG2>< ARG3><ARG4><ARG5>
<.><ARG6><.,><ETX>

Where:

<.> = ASCII 0x2E

ARGx =0-9 in ASCII format

Example:

<STX>21,99999.9,<ETX>

5.5.4 Request Status

Description:

The host requests that the firmware sends the power supply status.

Direction:

Host to supply

Syntax:

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

Example:

<STX>22,<ETX>

Response:

<STX><22><,><ARG1><,><ARG2><,><ARG3><,><ARG4><,><ARG5><,><ARG6><,><ARG7><,><ARG8><,><ETX>

Where:

<ARG1> 1 = HvOn, 0 = HvOff

<ARG2> 1 = Interlock 1 Open, 0 = Interlock 1 Closed

<ARG3> 1 = Fault Condition, 0 = No Fault

<ARG4> 1 = Remote Mode, 0 = Local Mode

<ARG5> 1 = I Mode on, 0 = I Mode off

<ARG6> 1 = ROV Enabled, 0 = ROV Disabled

<ARG7> 1 = AOL Enabled, 0 = AOL Disabled

<ARG8> 1 = Watchdog Enabled, 0 = Watchdog Disabled

Example:

<STX>22,1,1,0,0,0,0,0,<ETX>

5.5.5 Request DSP Software Part Number/Version

Description:

The host requests that the firmware sends the DSP firmware version.

Direction:

Host to supply

Syntax:

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

Example:

<STX>23,<STX>

Response:

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

Example:

<STX>24,<ETX>

Response:

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

5.5.7 Request Webserver Software Part Number/Version

Description:

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

Direction:

Host to supply

Syntax:

<STX><25><,><ETX>

Example:

<STX>25,<ETX>

Response:

<STX><25><,><ARG><,><ETX>

Where:

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

Example:

<STX>25,SWM9999-999,<ETX>

5.5.8 Request Model Number

Description:

The host requests that the firmware sends the unit model number

Direction:

Host to supply

Syntax:

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

Example:

<STX>26,<ETX>

Response:

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

Where:

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

Example:

<STX>25,SLM70P600,<ETX> or <STX>25,X9999,<ETX>

5.5.9 Reset Run Hours

Description:

The host requests that the firmware resets the run hour counter.

Direction:

Host to supply

Syntax:

<STX><30><,><ETX>

Example:

<STX>30,<ETX>

Response:

<STX><30><,><\$><,><ETX>

5.5.10 Reset Faults

Description:

The host requests that the firmware resets all Fault messages and indicators.

Direction:

Host to supply

Syntax:

<STX><31><,><ETX>

Example:

<STX>31,<ETX>

Response:

<STX><31><,><\$><,><ETX>

5.5.11 Request Network Settings

Description:

The host requests that the firmware transmits the network settings

Application:

	ARG 1	ARG2	ARG3	ARG4	ARG5
Function	Device Name	Remote Address	Remote Port	Subnet Mask	MAC Address

Direction:

Host to supply

Syntax:

<STX><50><,><ETX>

Example:

<STX>50,<ETX>

Response:

<STX><50><,><ARG1><,><ARG2><,><ARG3><,><ARG4><,><ARG5><,><,><ETX>

Arguments:

Device Name is limited to 20 characters or less. Remote address is a ip address in dotted notation. Remote port is a decimal number. Subnet Mask and Default Gateway are also dotted notation and MAC address is in MAC Address notation.

ARG1: Device Name	1 character minimum, up to 20 maximum
ARG2: IP Address	<nnn><.><nnn><.><nnn><.><nnn>, where <nnn> represents a number from 0 to 255.
ARG3: Remote Port	5001 or from 49152 to 65535.
ARG4: Subnet Mask	<xxx><.><xxx><.><xxx><.><xxx>, where <xxx> represents a number from 0 to 255.
ARG5: MACAddress	<ZZZ><:><ZZZ><:><ZZZ><:><ZZZ><:><ZZZ>, where <ZZZ> represents a number from 0 to 255.

Example:

<STX>50,Spellman2.0,32.78.110.37,1026,255.0.0.0,0:100:33:1:32:84,<ETX>

5.5.12 Program Network Settings

Description:

The host requests that the firmware programs the network settings and then reboots.

Application:

	ARG 1	ARG2	ARG3	ARG4	ARG5
Function	Device Name	Remote Address	Remote Port	Subnet Mask	MAC Address

Direction:

Host to supply

Syntax:

```
<STX><51><,><ARG1><,><ARG2><,><ARG3><,><ARG4><,>  
<ARG5><,><ARG6><,><ETX>
```

Arguments:

Device Name is limited to 20 characters or less. Remote address is a ip address in dotted notation. Remote port is a decimal number. Subnet Mask and Default Gateway are also dotted notation and MAC address is in MAC Address notation.

ARG1: Device Name 1 character minimum, up to 20 maximum
ARG2: IP Address <nnn><.><nnn><.><nnn><.><nnn>, where
 <nnn> represents a number from 0 to 255.
ARG3: Remote Port 5001 or from 49152 to 65535.
ARG4: Subnet Mask <xxx><.><xxx><.><xxx><.><xxx>, where
 <xxx> represents a number from 0 to 255.
ARG5: MACAddress <zzz><:><zzz><:><zzz><:><zzz><:><zzz>
 <:><zzz> , where <zzz> represents a number
 from 0 to 255.

Example:

```
<STX>51,Spellman2.0,32.78.110.37,1026,255.0.0.0,0:100:33:1:32:84,<E  
TX>
```

Response:

None, as Embedded server reboots with new settings.

5.5.13 Read Interlock Status

Description:

The host requests that the firmware read the status of the interlock channel.

Direction:

Host to supply

Syntax:

<STX><55><,><ETX>

Response:

<STX><55><,><ARG1><,><ETX>

Where ARG1 is Interlocks 1. A 1 indicates that the Interlock is energized

Example:

<STX>55,1,<ETX>

5.5.14 Request kV Monitor

Description:

The host requests that the firmware report kV monitor.

Direction:

Host to supply

Syntax:

<STX><60><,><ETX>

Response:

<STX><60><,><ARG><,><ETX>

Where:

<ARG>=0-4095 in ASCII format representing unscaled value.

Example:

<STX>60,4095,<ETX>

0-4095 = 0 to full scale rated kV

5.5.15 Request mA Monitor

Description:

The host requests that the firmware report mA monitor.

Direction:

Host to supply

Syntax:

<STX><61><,><ETX>

Response:

<STX><61><,><ARG><,><ETX>

Where:

<ARG>=0-4095 in ASCII format representing unscaled value.

Example:

<STX>61,4095,<ETX>

0-4095 = 0 to full scale rated mA

5.5.16 Request –15V LVPS

Description:

The host requests that the firmware report –15V LVPS.

Direction:

Host to supply

Syntax:

<STX><65><,><ETX>

Response:

<STX><65><,><ARG><,><ETX>

Where:

<ARG>=0-4095 in ASCII format representing unscaled value.

Example:

<STX>65,4095,<ETX>

5.5.17 Request Faults

Description:

The host requests that the firmware report Faults.

Direction:

Host to supply

Syntax:

<STX><68><,><ETX>

Response:

<STX><68><,><ARG1><,><ARG2><,><ARG3><,><ARG4><,><ARG5><,><ARG6><,><ARG7><,><ETX>

Where:

<ARGx> 1 = Fault, 0 = No Fault in ASCII format

ARG1 = ARC

ARG2 = Over Temperature

ARG3 = Over Voltage

ARG4 = RegulationError

ARG5 = Over Current

ARG6 = Not used – always reports 0

ARG7 = Watchdog

Example:

<STX>68,0,0,0,0,1,0,0,<ETX>

5.5.18 Turn HV on/off

Description:

The host requests that the firmware turn high voltage on or high voltage off.

Direction:

Host to supply

Syntax:

<STX><98><,><ARG><,><ETX>

Where:

<ARG> 1 = HV on, 0 = HV off in ASCII format

Example:

<STX>98,1,<ETX>

Response:

<STX><98><,><\$><,><ETX>

<STX><98><,><ARG><,><ETX>

where <ARG> = error code

Error Codes TBD,

1 = out of range

5.5.19 Program Local/Remote Mode

Description:

The host requests that the firmware to switch between Local and Remote Mode.

Direction:

Host to supply

Syntax:

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

Where:

<ARG> 1 = Remote, 0 = Local in ASCII format

Example:

<STX>99,1,<ETX>

Response:

<STX><99><,><\$><,><ETX>

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

where <ARG> = error code

Error Codes TBD,

1 = out of range

5.5.20 Program RS-232 Baud rate

Description:

The host requests that the firmware change the Baud rate for RS-232.

Direction:

Host to supply

Syntax:

<STX><07><,><ARG><,><ETX>

Where:

<ARG> 1 = 9.6k in ASCII format

<ARG> 2 = 19.2k in ASCII format

<ARG> 3 = 38.4k in ASCII format

<ARG> 4 = 57.6k in ASCII format

<ARG> 5 = 15.2k in ASCII format

Example:

<STX>07,1,<ETX>

Response:

<STX><07><,><\$><,><ETX>

<STX><07><,><ARG><,><ETX>

where <ARG> = error code

Error Codes TBD,

1 = out of range

5.5.22 Program User Configs

Description:

The host requests that the firmware program the user configs.

Direction:

Host to supply

Syntax:

```
<STX><09><,><ARG1><,><ARG2><,><ARG3><,><ARG4><,><ARG5><,>  
><ARG6><,><ARG7><,><ARG8><,><ARG9><,><ETX>
```

Where:

<ARG1> = 1 = ROV enabled, 0 = ROV disabled in ASCII format.

<ARG2> = 0-110 in ASCII format representing the overvoltage percentage.

<ARG3> = 1-600 in ASCII format representing the ramp rate in seconds from .1 to 60sec.

<ARG4> = 1 = AOL enabled, 0 = AOL disabled in ASCII format.value.

<ARG5> = 0-20 in ASCII format representing the arc count.

<ARG6> = 0-60 in ASCII format representing the arc period in seconds.

<ARG7> = 0-500 in ASCII format representing the arc quench time in milli-seconds.

<ARG8> = 1 = ARC re-ramp enabled, 0 = ARC re-ramp disabled in ASCII format.

<ARG9> = 1 = No Arc detect, 0 = Arc detect in ASCII format.

Example:

```
<STX>09,1,50,100,0,10,30,250,1,0,<ETX>
```

Response:

```
<STX><09><,><$><,><ETX>
```

```
<STX><09><,><ARG><,><ETX>
```

where <ARG> = error code

Error Codes

1 in ASCII format = Invalid Arc Rate warning message:

An invalid arc rate(Time period/Arc Count) of more than 1 arc per second has been entered,these values along with the other variables in the command string have been disregarded by the HVPS.

2 in ASCII format = NAD Enabled warning message:

The **Not Arc Detect** mode has been enabled. In this mode the HVPS has no Arc shutdown protection. The HVPS is designed to handle 1 arc per second.

Exceeding 1 arc per second could cause damage to the HVPS.**HVPS failure caused by excessive arcing will not be covered under the warranty.**

5.5.23 Request unit Scaling

Description:

The host requests that the firmware report the unit scaling.

Direction:

Host to supply

Syntax:

<STX><28><,><ETX>

Example:

<STX>28,<ETX>

Response:

<STX><28><,>< ARG1><,>< ARG2><,><ETX>

Where:

<ARG1> =0-65535 in ASCII format representing the voltage full-scale value.

<ARG2> =0-65535 in ASCII format representing the current full-scale value.

Example:

<STX>28, 7000, 856<ETX>

Voltage full scale = 70.00kV

Current full scale = 8.56mA

5.5.24 Request User Configs

Description:

The host requests that the firmware report the User Configs.

Direction:

Host to supply

Syntax:

<STX><27><,><ETX>

Example:

<STX>27,<ETX>

Response:

<STX><27><,><ARG1><,><ARG2><,><ARG3><,><ARG4><,><ARG5><,><ARG6><,><ARG7><,><ARG8><,><ARG9><,><ETX>

Where:

<ARG1> = 1 = ROV enabled, 0 = ROV disabled in ASCII format.

<ARG2> = 0-110 in ASCII format representing the overvoltage percentage.

<ARG3> = 1-600 in ASCII format representing the ramp rate in seconds from .1 to 60sec.

<ARG4> = 1 = AOL enabled, 0 = AOL disabled in ASCII format.value.

<ARG5> = 0-20 in ASCII format representing the arc count.

<ARG6> = 0-60 in ASCII format representing the arc period in seconds.

<ARG7> = 0-500 in ASCII format representing the arc quench time in milli-seconds.

<ARG8> = 1 = ARC re-ramp enabled, 0 = ARC re-ramp disabled in ASCII format.

<ARG9> = 1 = No Arc detect, 0 = Arc detect in ASCII format.

Example:

<STX>27,1,50,100,0,10,30,250,1,0,<ETX>

5.5.25 Watchdog Enable

Description:

The host requests that the firmware enable the Communication Watchdog.

Direction:

Host to supply

Syntax:

<STX><89><,><ARG><,><ETX>

Where:

<ARG> 1 = enable, 0 = disable in ASCII format

Example:

<STX>89,1,<ETX>

Response:

<STX><89><,><\$><,><ETX>

<STX><89><,><ARG><,><ETX>

where <ARG> = error code

5.5.26 Watchdog Tickle

Description:

The host requests that the firmware resets the Watchdog timer.

Direction:

Host to supply

Syntax:

<STX><88><,><ETX>

Response:

<STX><88><,><\$><,><ETX>

<STX><88><,><ARG><,><ETX>

where <ARG> = error code

5.5.27 Request Analog Monitor Readbacks

Description:

The host requests that the firmware transmit the present values of Analog Monitor Readbacks.

Direction:

Host to supply

Syntax:

<STX><19><,><ETX>

Example:

<STX><19>,<ETX>

Response:

<STX><19><,><ARG1><,><ARG2><,><ARG3><,><ETX>

Where:

ARG1 = kV monitor = 0 – 4095

ARG2 = mA monitor = 0 – 4095

ARG3 = unused = 0– 4095

Example:

<STX><19>,4095,4095,4095,<ETX>

6.0 SERIAL COMMANDS – RS-232 / USB

6.1 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 6.3 for details)
<ETX>	= 1 ASCII 0x03 End of Text character

6.2 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.

6.3 CHECKSUMS

The checksum is computed as follows:

- Add the <CMD>, <,>, and <ARG> 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 acknowledgement 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
CSb2 = 127 And (CSb1) 'Twos Complement
CSb3 = 64 Or (CSb2) 'OR 0x40
CSb$ = Chr(Val("&H" & (Hex(CSb3))))
ProcessOutputString = Chr(2) & outputString & CSb$ & Chr(3)

End Function
```


6.4 COMMAND OVERVIEW

Data Byte section of the TCP/IP Datagram			
Command Name	<CMD>	<ARG>	RANGE
Program RS-232 unit baud rate	07	1 ASCII	1 - 5
Program User Configs	09	9 ASCII	See Description
Program kV	10	1-4 ASCII	0-4095
Program mA	11	1-4 ASCII	0-4095
Request kV Setpoint	14	None	-
Request mA Setpoint	15	None	-
Request Analog Monitor Readbacks	19	None	-
Request HV On Hours Counter	21	None	-
Request Status	22	None	-
Request Software Version	23	None	-
Request Hardware Version	24	None	-
Request Web Server Version	25	None	-
Request Model Number	26	None	-
Reset HV On Hours Counter	30	None	-
Reset Faults	31	None	-
Read Interlock Status	55	None	-
Request kV monitor	60	None	-
Request mA monitor	61	None	-
Request -15V LVPS	65	None	-
Wathdog Tickle	88	None	-
Wathdog enable	89	1 ASCII	0 or 1
Turn HV on/off	98	1 ASCII	0 or 1

Program Local/Remote Mode	99	1 ASCII	0 or 1
---------------------------------	----	---------	--------

6.5 RESPONSE OVERVIEW

The command responses will follow the same format as outlined above in section 6.1. 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 kV Setpoint	14	8-11 ASCII
Request mA Setpoint	15	8-11 ASCII
Request Analog Monitor Readbacks	19	12-23 ASCII
Request Total Hours High Voltage On	21	14 ASCII
Request Status	22	13 ASCII
Request DSP Software Version	23	18 ASCII
Request Hardware Version	24	10 ASCII
Request Web Server Version	25	18 ASCII
Request Model number	26	12 ASCII
Request User Configs	27	9-17 ASCII
Request unit Scaling	28	24-32 ASCII
Read Interlock Status	55	8 ASCII
Request kV monitor	60	8-11 ASCII
Request mA monitor	61	8-11 ASCII
Request -15V LVPS	65	8-11 ASCII

Request Faults	68	20 ASCII
----------------	----	----------

6.6 COMMAND STRUCTURE

6.6.1 Program kV

Description:

The host requests that the firmware change the setpoint of kV.

Direction:

Host to supply

Syntax:

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

Where:

<ARG> = 0 - 4095 in ASCII format

Example:

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

Response:

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

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

where <ARG> = error code

Error Codes TBD, 1=out of range

0-4095 = 0 to full scale rated kV

6.6.2 Program mA

Description:

The host requests that the firmware change the setpoint of mA.

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>

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

where <ARG> = error code

Error Codes TBD, 1=out of range

0-4095 = 0 to full scale rated mA

6.6.3 Request Total Hours High Voltage On

Description:

The host requests that the firmware sends the present value of the Total Hours High Voltage On.

Direction:

Host to supply

Syntax:

<STX><21><,><CSUM><ETX>

Example:

<STX>21,<CSUM><ETX>

Response:

<STX><21><,><ARG1>< ARG2>< ARG3><ARG4><ARG5>
<.><ARG6><,><CSUM><ETX>

Where:

<.> = ASCII 0x2E

ARGx = 0 - 9 in ASCII format

Example:

<STX>21,99999.9,<CSUM><ETX>

6.6.4 Request Status

Description:

The host requests that the firmware sends the power supply status.

Direction:

Host to supply

Syntax:

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

Example:

<STX>22,<CSUM><ETX>

Response:

<STX><22><,><ARG1><,><ARG2><,><ARG3><,><ARG4><,><ARG5><,><ARG6><,><ARG7><,><ARG8><,><CSUM><ETX>

Where:

<ARG1> 1 = HvOn, 0 = HvOff

<ARG2> 1 = Interlock 1 Open, 0 = Interlock 1 Closed

<ARG3> 1 = Fault Condition, 0 = No Fault

<ARG4> 1 = Remote Mode, 0 = Local Mode

<ARG5> 1 = I Mode on, 0 = I Mode off

<ARG6> 1 = ROV Enabled, 0 = ROV Disabled

<ARG7> 1 = AOL Enabled, 0 = AOL Disabled

<ARG8> 1 = Watchdog Enabled, 0 = Watchdog Disabled

Example:

<STX>22,1,1,0,0,0,0,0,0,<CSUM><ETX>

6.6.5 Request DSP Software Part Number/Version

Description:

The host requests that the firmware sends the DSP firmware version.

Direction:

Host to supply

Syntax:

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

Example:

<STX>23,<CSUM><STX>

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>

6.6.6 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>

6.6.7 Request Webserver Software Part Number/Version

Description:

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

Direction:

Host to supply

Syntax:

<STX><25><,><CSUM><ETX>

Example:

<STX>25,<CSUM><ETX>

Response:

<STX><25><,><ARG><,><CSUM><ETX>

Where:

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

Example:

<STX>25,SWM9999-999,<CSUM><ETX>

6.6.8 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 SLMNNANNN or XNNNN, where N is a numeric character and where A is a letter character.

Example:

<STX>25,X9999,<CSUM><ETX>

or

<STX>25,SLM70P600,<CSUM><ETX>

6.6.9 Reset Run Hours

Description:

The host requests that the firmware resets the run hour counter.

Direction:

Host to supply

Syntax:

<STX><30><,><CSUM><ETX>

Example:

<STX>30,<CSUM><ETX>

Response:

<STX><30><,><\$><,><CSUM><ETX>

6.6.10 Reset Faults

Description:

The host requests that the firmware resets all Fault messages and indicators.

Direction:

Host to supply

Syntax:

<STX><31><,><CSUM><ETX>

Example:

<STX>31,<CSUM><ETX>

Response:

<STX><31><,><\$><,><CSUM><ETX>

6.6.11 Read Interlock Status

Description:

The host requests that the firmware read the status of the interlock channel.

Direction:

Host to supply

Syntax:

<STX><55><,><CSUM><ETX>

Response:

<STX><55><,><ARG1><,><CSUM><ETX>

Where ARG1 is Interlocks 1. A 1 indicates that the Interlock is energized

Example:

<STX>55,1,<CSUM><ETX>

6.6.12 Request kV Monitor

Description:

The host requests that the firmware report kV monitor.

Direction:

Host to supply

Syntax:

<STX><60><,><CSUM><ETX>

Response:

<STX><60><,><ARG><,><CSUM><ETX>

Where:

<ARG>=0-4095 in ASCII format representing unscaled value.

Example:

<STX>60,4095,<CSUM><ETX>

0-4095 = 0 to full scale rated kV

6.6.13 Request mA Monitor

Description:

The host requests that the firmware report mA monitor.

Direction:

Host to supply

Syntax:

<STX><61><,><CSUM><ETX>

Response:

<STX><61><,><ARG><,><CSUM><ETX>

Where:

<ARG>=0-4095 in ASCII format representing unscaled value.

Example:

<STX>61,4095,<CSUM><ETX>

0-4095 = 0 to full scale rated mA

6.6.14 Request –15V LVPS

Description:

The host requests that the firmware report –15V LVPS.

Direction:

Host to supply

Syntax:

<STX><65><,><CSUM><ETX>

Response:

<STX><65><,><ARG><,><CSUM><ETX>

Where:

<ARG>=0-4095 in ASCII format representing unscaled value.

Example:

<STX>65,4095,<CSUM><ETX>

6.6.15 Request Faults

Description:

The host requests that the firmware report Faults.

Direction:

Host to supply

Syntax:

<STX><68><,><CSUM><ETX>

Response:

<STX><68><,><ARG1><,><ARG2><,><ARG3><,><ARG4><,><ARG5><,><ARG6><,><ARG7><,><CSUM><ETX>

Where:

<ARGx> 1 = Fault, 0 = No Fault in ASCII format

ARG1 = ARC

ARG2 = Over Temperature

ARG3 = Over Voltage

ARG4 = RegulationError

ARG5 = Over Current

ARG6 = Not used – always reports 0

ARG7 = Watchdog

Example:

<STX>67,0,0,0,0,1,0,0,<CSUM><ETX>

6.6.16 Program Local/Remote Mode

Description:

The host requests that the firmware to switch between Local and Remote Mode.

Direction:

Host to supply

Syntax:

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

Where:

<ARG> 1 = Remote, 0 = Local in ASCII format

Example:

<STX>99,1,<CSUM><ETX>

Response:

<STX><99><,><\$><,><CSUM><ETX>

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

where <ARG> = error code

Error Codes TBD,

1 = out of range

6.6.17 Program RS-232 Baud rate

Description:

The host requests that the firmware change the Baud rate for RS-232.

Direction:

Host to supply

Syntax:

<STX><07><,><ARG><,><CSUM><ETX>

Where:

<ARG> 1 = 9.6k in ASCII format
<ARG> 2 = 19.2k in ASCII format
<ARG> 3 = 38.4k in ASCII format
<ARG> 4 = 57.6k in ASCII format
<ARG> 5 = 115.2k in ASCII format

Example:

<STX>07,1,<CSUM><ETX>

Response:

<STX><07><,><\$><,><CSUM><ETX>
<STX><07><,><ARG><,><CSUM><ETX>

where <ARG> = error code

Error Codes TBD,

1 = out of range

6.6.19 Program User Configs

Description:

The host requests that the firmware program the user configs.

Direction:

Host to supply

Syntax:

```
<STX><09><,><ARG1><,><ARG2><,><ARG3><,><ARG4><,><ARG5><,>  
><ARG6><,><ARG7><,><ARG8><,><ARG9><,><CSUM><ETX>
```

Where:

<ARG1> = 1 = ROV enabled, 0 = ROV disabled in ASCII format.

<ARG2> = 0-110 in ASCII format representing the overvoltage percentage.

<ARG3> = 1-600 in ASCII format representing the ramp rate in seconds from .1 to 60sec.

<ARG4> = 1 = AOL enabled, 0 = AOL disabled in ASCII format.value.

<ARG5> = 0-20 in ASCII format representing the arc count.

<ARG6> = 0-60 in ASCII format representing the arc period in seconds.

<ARG7> = 0-500 in ASCII format representing the arc quench time in milli-seconds.

<ARG8> = 1 = ARC re-ramp enabled, 0 = ARC re-ramp disabled in ASCII format.

<ARG9> = 1 = No Arc detect, 0 = Arc detect in ASCII format.

Example:

```
<STX>09,1,50,100,0,10,30,250,1,0, <CSUM><ETX>
```

Response:

```
<STX><09><,><$><,><CSUM><ETX>
```

```
<STX><09><,><ARG><,><CSUM><ETX>
```

where <ARG> = error code

Error Codes

1 in ASCII format = Invalid Arc Rate warning message:

An invalid arc rate(Time period/Arc Count) of more than 1 arc per second has been entered, these values along with the other variables in the command string have been disregarded by the HVPS.

2 in ASCII format = NAD Enabled warning message:

The **Not Arc Detect** mode has been enabled. In this mode the HVPS has no Arc shutdown protection. The HVPS is designed to handle 1 arc per second. Exceeding 1 arc per second could cause damage to the HVPS.**HVPS failure caused by excessive arcing will not be covered under the warranty.**

6.6.20 Request unit Scaling

Description:

The host requests that the firmware report the unit scaling.

Direction:

Host to supply

Syntax:

<STX><28><,><CSUM><ETX>

Example:

<STX>28, <CSUM><ETX>

Response:

<STX><28><,>< ARG1><,>< ARG2><,><CSUM><ETX>

Where:

<ARG1> =0-65535 in ASCII format representing the voltage full-scale value.

<ARG2> =0-65535 in ASCII format representing the current full-scale value.

Example:

<STX>28,7000,856<CSUM><ETX>

Voltage full scale = 70.00kV

Current full scale = 8.56mA

6.6.21 Request User Configs

Description:

The host requests that the firmware report the User Configs.

Direction:

Host to supply

Syntax:

<STX><27><,><CSUM><ETX>

Example:

<STX>27, <CSUM><ETX>

Response:

<STX><27><,><ARG1><,><ARG2><,><ARG3><,><ARG4><,><ARG5><,><ARG6><,><ARG7><,><ARG8><,><ARG9><,><CSUM><ETX>

Where:

<ARG1> = 1 = ROV enabled, 0 = ROV disabled in ASCII format.

<ARG2> = 0-110 in ASCII format representing the overvoltage percentage.

<ARG3> = 1-600 in ASCII format representing the ramp rate in seconds from .1 to 60sec.

<ARG4> = 1 = AOL enabled, 0 = AOL disabled in ASCII format.value.

<ARG5> = 0-20 in ASCII format representing the arc count.

<ARG6> = 0-60 in ASCII format representing the arc period in seconds.

<ARG7> = 0-500 in ASCII format representing the arc quench time in milli-seconds.

<ARG8> = 1 = ARC re-ramp enabled, 0 = ARC re-ramp disabled in ASCII format.

<ARG9> = 1 = No Arc detect, 0 = Arc detect in ASCII format.

Example:

<STX>27,1,50,100,0,10,30,250,1,0, <CSUM><ETX>

6.6.22 Watchdog Enable

Description:

The host requests that the firmware enable the Communication Watchdog.

Direction:

Host to supply

Syntax:

<STX><89><,><ARG><,><CSUM><ETX>

Where:

<ARG> 1 = Enable, 0 = Disable in ASCII format

Example:

<STX>89,1,<CSUM><ETX>

Response:

<STX><89><,><\$><,><CSUM><ETX>

<STX><89><,><ARG><,><CSUM><ETX>

where <ARG> = error code

Error Codes TBD,

1 = out of range

6.6.23 Watchdog Tickle

Description:

The host requests that the firmware resets the Watchdog timer.

Direction:

Host to supply

Syntax:

<STX><88><,><CSUM><ETX>

Response:

<STX><88><,><\$><,><CSUM><ETX>

<STX><88><,><ARG><,><CSUM><ETX>

where <ARG> = error code

Error Codes TBD,

1 = out of range

6.6.24 Request Analog Monitor Readbacks

Description:

The host requests that the firmware transmit the present values of Analog Monitor Readbacks.

Direction:

Host to supply

Syntax:

<STX><19><,>< CSUM><ETX>

Example:

<STX><19>,< CSUM><ETX>

Response:

<STX><19><,><ARG1><,><ARG2><,><ARG3><,>< CSUM><ETX>

Where:

ARG1 = kV monitor = 0 – 4095

ARG2 = mA monitor = 0 – 4095

ARG3 = unused = 0– 4095

Example:

<STX><19>,4095,4095,4095,< CSUM><ETX>

6.6.25 Turn HV on/off

Description:

The host requests that the firmware turn high voltage on or high voltage off.

Direction:

Host to supply

Syntax:

<STX><98><,><ARG><,><ETX>

Where:

<ARG> 1 = HV on, 0 = HV off in ASCII format

Example:

<STX>98,1,<ETX>

Response:

<STX><98><,><\$><,><ETX>

<STX><98><,><ARG><,><ETX>

where <ARG> = error code

Error Codes TBD,

1 = out of range

6.7 SPELLMAN TEST COMMANDS

- Program Hardware Version (Hardware setup)
- Program Model number(Hardware setup)
- Set USB Mode (Program USB)
- Set USB Page Address (Program USB)
- Send USB Page Data (Program USB)
- Toggle Passthrough Mode (Diagnostics)
- Store A/D Calibration Value (Hardware setup)
- Request Miscellaneous Analog Readbacks

Contact Spellman High Voltage for details and the syntax of these commands.

6.8 SERIAL COMMAND HANDLING

6.8.1 Command Time Out The host computer should set a serial time out at approximately 100mS. This allows the DSP to process the incoming message, and transmit a response. The DSP will initiate a reply to incoming messages in approximately 1-2mS, with a worst case of 5mS.

6.8.2 Buffer Flushing

The DSP will flush the incoming serial data buffer every time an STX is received. This provides a mechanism to clear the receive buffer of partial or corrupt messages.

6.8.3 Handshaking

The only handshaking implemented on the host interface, is built in to the implementation of this protocol. That is, the host must initiate all communications. If the supply receives a program command, an acknowledge message is sent back to the host via the "\$" message. If the host does not receive an acknowledge within the time out window, the host should consider the message lost or the device off-line.

Similarly, if the supply receives a request command, the requested data is sent back to the host. If the host does not receive the requested data within the time out window, the host should consider the message lost or the device off-line.

This essentially uses the full-duplex channel in a half-duplex communication mode.