# Spellman
### High Voltage Electronics Corporation

# Instruction Manual

## ST/STA/STR SERIES

## High Voltage Power Supply

**MODEL :**
**SERIAL# :**
**DATE :**

**SPELLMAN**
**HIGH VOLTAGE ELECTRONICS**
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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.

# 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 EXTRÊMENT 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 entrainer 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 QUESO 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 ST/STR/STA Series



**ST/STR**



**STA**

T he ST series of high voltage power supplies provides very well regulated, low ripple high voltage in a highly efficient, compact design. Extremely stable voltage and current outputs result in significant performance improvements over previously available technology.

All of these advancements are possible only by Spellman's long history in high voltage power conversion technology. This series of power supplies utilizes extremely advanced quasi-resonant PWM conversion techniques, along with sophisticated digital technology. The output voltage, current and power are continuously adjustable over their full rated range. The standard ST operates from 180-264Vac, three phase power and is forced air cooled. An optional 360-528Vac input (400VAC) is available. Custom units to meet special requirements and specific applications can also be provided.

The STR Series high voltage power supplies are identical in form, fit and function to the ST Series the following exceptions:

1) The STR only provides 6kW's of output power.

2) The ripple specification for the STR is 0.1% p-p +1Vrms.

3) It is not possible to parallel STR chassis. If additional power is required use an ST Series unit.

4) The SRT is available with an optional 180-264Vac single phase input voltage.

Aside from these four points, the STR and ST are for all practical purposes identical. For the sake of clarification the following text only references ST, but all points apply to the STR Series as well.

The STA Series of high voltage power supplies are identical to the ST Series with the following exceptions:

1) The STA is a 5.25 inch tall (3U) chassis.

2) The STR only provides 4kW's of output power.

3) The ripple specification for the STA is 0.1% p-p +1Vrms.

4) It is not possible to parallel STA/STR chassis. If additional power is required use an ST Series unit.

5) The STA is available with an optional 180-264Vac single phase input voltage.

Customary warranty terms apply to standard units. Consult the Spellman Sales Department about the warranty for custom/X numbered units.

## 1.2 Standard Features

The ST series incorporates several standard features and software configurable items designed to optimize user utility, satisfaction and safety.

**FRONT PANEL CONTROL POWER/HIGH VOLTAGE ON/ HIGH VOLTAGE OFF SWITCHES**: These intuitive front panel controls allow the user to

easily turn the unit on and enable/disable the generation of high voltage.

**FRONT PANEL INDICATOR LAMPS:** CONTROL POWER ON, HIGH VOLTAGE OFF and HIGH VOLTAGE ON indicators are integral with the control switches and equipped with dual lamps for redundancy and safety.
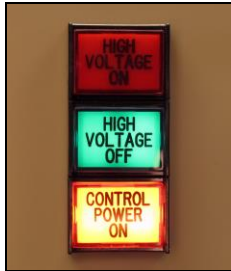


**FRONT PANEL POTENTIOMETERS:** Ten turn locking counting dials are provided for easy programming of the desired voltage and current regulation values.

**FRONT PANEL DIGITAL METERS:** 3.5 digit meters are provided to view the output voltage and current. A convenient Preset View Feature is provided: If the HIGH VOLTAGE OFF button is depressed and held in, the present voltage and current programming values will be displayed in actual kV and mA on the front panel meters.
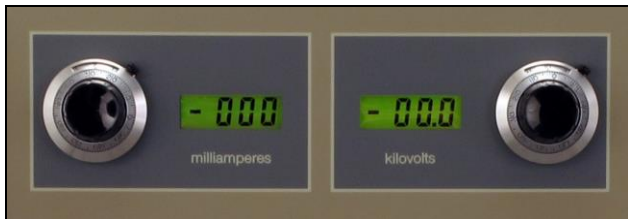


**ETHERNET AND RS-232 INTERFACE:** DSP based SMT circuitry provides both Ethernet and RS-232 digital interfacing capability simplifying the integration of the ST into your system design. A VB GUI is provided for the RS-232, the Ethernet has an imbedded applet for control.

**SLOW START RAMP TIME:** This feature provides a gradual increase of high voltage until the preset operating point is reached. The slow start time is factory set for ten seconds. Other slow start times can be software configured using the digital interface.

**ARC QUENCH/ARC RERAMP/ARC TRIP:** These features allow the user to tailor the power supply to meet specific needs in dynamic load applications. The standard configuration is if an arc occurs, the output is inhibited for approximately 200mS (Arc Quench), and then the output is ramped up to the preset level with the Slow Start circuitry time constant (Arc ReRamp). If four arcs occur in a ten second time period the unit will shut down displaying an "ARC" Fault (Arc Trip). See Chapter 3 for operating details and information for user customization for these parameters via the software and the digital interface.

**INTERNAL FAULT PROTECTION:** The ST series continually monitors internal circuits critical to the proper operation of the power supply. In the event that one of these circuits malfunctions, the fault detection circuit turns off the high voltage and reverts the unit to the POWER DOWN mode with the CONTROL POWER ON indicator lamp flashing ON/OFF slowly. The applicable fault indicator will be illuminated on the front panel requiring the user to clear (cycle the CONTROL POWER ON switch, cycle the AC line power or toggle the Reset/External Inhibit signal line).

**OUTPUT CABLE:** All standard models are provided with a ten foot shielded high voltage output cable. The cable is designed so that it can be easily removed from the mating receptacle located on the rear of the chassis.

## 1.2.1  Remote Operating Features

**REMOTE PROGRAMMING:** Allows remote adjustment of the output voltage, current, power and overvoltage regulation parameters via the use of external voltage sources.

**REMOTE MONITOR:** Allows remote monitoring of the output voltage, current and power test points.

**REMOTE HIGH VOLTAGE CONTROL:** Allows remote control of the HIGH VOLTAGE ON and HIGH VOLTAGE OFF functions. Signals are also provided for remote indication of HIGH VOLTAGE ON and HIGH VOLTAGE OFF status.

**REMOTE POWER ON:** Allows remote control of CONTROL POWER ON/OFF function. This feature also allows remote reset of the power supply in case of SYSTEM FAULT shutdown.

**RESET/EXTERNAL INHIBIT:** This circuit will reset any latched power supply faults and inhibit the high voltage output. A logic low/ground, will reset any fault(s) while inhibiting the high voltage output. A logic high/open will restore the high voltage output to the preset level. NOTE: The External Inhibit circuit should NOT be used for protection against injury or for safety interlocking. See External Interlock for this type of safety control.

**EXTERNAL INTERLOCK:** Interlock connections are provided on the rear panel interface connecter for connection to a safety switch. The unit will not operate unless the interlock circuit is closed. During high voltage operation, opening the interlock circuit will cause the

High Voltage to shut off. This circuit should be used for safety interlock circuits. Spellman strongly recommends the use of External Interlocking for safety purposes.

## 1.2.2 System Status and Fault Diagnostic Display

"Dead Front" backlight type indicators provide system operation and fault condition information. If a fault occurs the power supply will revert to the POWER DOWN mode. This is indicated by the flashing of the CONTROL POWER ON indicator. To reset the latched fault: cycle the CONTROL POWER ON switch, cycle the AC line power or toggle the Reset/External Inhibit signal line.



**VOLTAGE CONTROL:** Indicates the output voltage regulator circuit is maintaining voltage regulation.

**CURRENT CONTROL:** Indicates the output current regulator circuit is maintaining current regulation.

**POWER CONTROL:** Indicates the output power regulator circuit is maintaining power regulation.

**HV INHIBIT:** Indicates the high voltage supply is being inhibited by either the EXTERNAL INHIBIT signal line or by internal protection circuitry.

**INTLK CLOSED:** Indicates the EXTERNAL INTERLOCK connections are in the closed position.

**INTLK OPEN:** Indicates the EXTERNAL INTERLOCK connections are in the open position. This also indicates opening of internal power supply interlocks. It is not possible to enable HIGH VOLTAGE with an open EXTERNAL INTERLOCK.

**SYSTEM FAULT:** Indicates an internal fault or parallel chassis fault (in multiple chassis systems) has occurred.

**OVER VOLTAGE:** Indicates the overvoltage protection circuitry has caused the power supply to turn off. The default setting for the overvoltage protection circuitry is internally set to 105% of rated output voltage. This level can be set to anywhere from 0- 105% of rated output

voltage by the user via the remote overvoltage programming capability, see Chapter 3 for more details.

**OVER CURRENT:** Indicates the output current has exceeded the programmed current trip level when the AOL (Adjustable Overload Trip) feature has been software configured using the digital interface.

**OVER POWER:** Indicates the output power has exceeded the programmed regulating level. This signal could be either the internal potentiometer or the user provided remote power programming signal, dependent on configuration.

**OVER TEMP:** Indicates that excessive temperature has been sensed within the chassis and internal protection circuitry has shut down the power supply.

**ARC:** Indicates that an arc has occurred (one second flash) or that the ARC Intervention Circuitry has shutdown the power supply due to excessive arcing (latched "ARC" fault).

**AC FAULT:** Indicates a problem with the front end AC input circuitry and the corresponding generated inverter buss voltages.

**RGLT ERR:** 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 proper regulation. Possible causes could be due to low AC input voltage (below low line parameters, or a missing phase) or a malfunction of the power supply preventing it from generating the voltage/current being requested.

## 1.3 Options

**BFP**          **Blank Front Panel**



Local control functionality and metering is removed from the standard front panel, a popular cost saving measure for OEM applications where the unit will only be controlled remotely.

**HS**          **High Stability**

The standard voltage feedback divider is replaced with a high precision voltage feedback divider providing a 50ppm/°C temperature coefficient specification.

**LL(X)**          **High Voltage Cable Length**

Custom length high voltage output cables, indicated in foot measurement units. Various predetermined lengths are available along with entirely custom lengths; contact Spellman Sales Department for details.

**400VAC**          **360-528Vac Input**

This option factory configures the ST/STR to operate from 360-528Vac, three phase, 50/60Hz input power. This option cannot be implemented in the field.

**1PH**          **Single Phase Input**

Optional 180-264Vac single phase input voltage, available only on STR and STA.

See Section 5 for more information on these options. With few exceptions, these options can be retrofitted to your power supply at the factory in a short time. For price and retrofit arrangements, contact Spellman's Sales Department at:

sales@spellmanhv.com

## 1.4 Interpreting the Model Number:
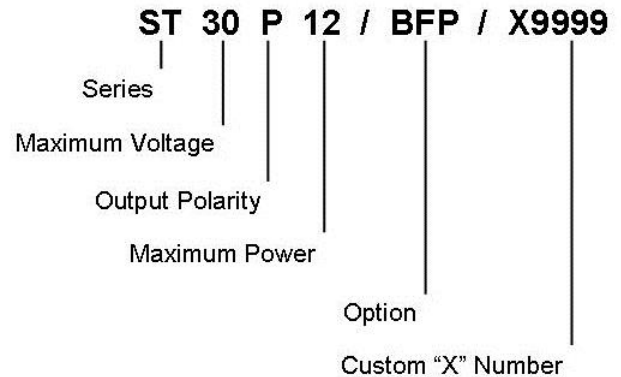


The model number of the power supply describes its capabilities. After the series name "**ST**" is:

● The maximum voltage in kV

● The polarity of the unit: positive (P) or negative (N). 1-10kV units are inherently reversible by design requiring and internal wiring change to swap polarity. All units required a polarity selection to be made at time of order.

● The maximum output power in kilowatts

● The option codes for all options that are included.

● Custom units have a unique 4 digit X number after the option code(s). This X number references a unique specification control drawing that takes precedent over the standard ST data sheet specifications.

# 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 discard any of the packing material used in a damaged shipment.

After unpacking, inspect the panel and chassis for visible damage.

Standard Spellman ST high voltage power supplies are covered by a warranty. Custom and special order models (with an X suffix in the model number) are also covered by a warranty. Check the specific warranty terms by referring to the Warranty document contained in this operator's manual.

## 2.2　Input Requirements

Units ordered with the 400VAC Option (360-528Vac) do NOT have a rear panel circuit breaker. For proper protection of the ST power supply a circuit breaker protected, dedicated three phase electrical service must be provided for each ST chassis. ST units are not phase dependent; the three AC input phase connections can be orientated in any manner with no adverse effect on power supply performance.　SEE TABLE 1

## 2.3　Mechanical Installation

Units in the ST series have front panel holes for standard EIA rack mounting. The rack must allow rear access for cable connections. Units are fully enclosed and are suitable for bench or tabletop operation. It is strongly recommended to support the chassis by guides or shelves.

## 2.4　Airflow Requirements

ST units are forced air cooled, air enters the chassis via openings on the right and left side panels and air is forcibly exhausted out the rear panel via three fans. Whatever mechanical installation is implemented airflow into and out of the unit must not be compromised. Additionally it is the responsibility of the user to assure that air entering the unit is not above the maximum ambient temperature of 40°C. Airflow volume is 300cfm for ST units, 200 cfm for STR units and 100 cfm for STA units.
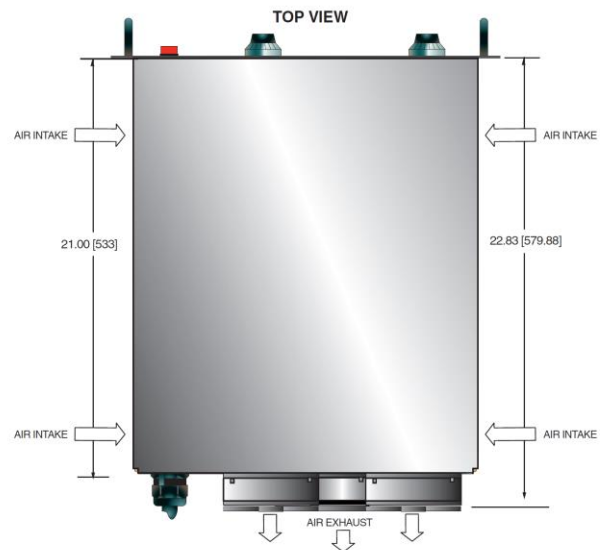


**Figure 2.1　ST/STR/STA Airflow**

| UNIT/INPUT VOLTAGE | FACTORY CONFIGURATION | MAXIMUM INPUT CURRENT PER PHASE |
| --- | --- | --- |
| ST     180-264Vac, 3 phase | Standard | 50 amps |
| ST     360-528Vac, 3 phase | Optional (400Vac) | 25 amps |
| STR  180-264Vac, 3 phase | Standard | 25 amps |
| STR  360-528Vac, 3 phase | Optional (400Vac) | 12.5 amps |
| STR  180-264Vac, 1 phase | Optional (1PH) | 57 amps |
| STA  180-264Vac, 3 phase | Standard | 17 amps |
| STA  180-264Vac, 1 phase | Optional (1PH) | 38 amps |

**Table 1  Input Requirements**

# 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.
```

```
                  WARNING

   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 'G' IS
 REACHED. FAILURE TO FOLLOW THESE
PROCEDURES MAY VOID THE WARRANTY.
```

A)        Insure that the front panel CONTROL POWER ON switch is in the OFF position (switch bezel out).

B)        Check the input voltage rating on the 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 supply must be adequately grounded, preferably to the local "system ground" (cold water pipe ground, electrical conduit ground, copper ground rod, etc)   using a heavy gauge copper wire securely connecting to the ¼-20 ground stud on the rear panel of the of the unit.   See Figure 3.1 for a typical operating setup.

A heavy gauge user provided "load return" wire must be connected from the low end of the load back to the ¼-20 ground stud on the rear panel of the power supply.  Using a   separate   external   ground   at   the   load   is   not recommended.

A six foot long, captive, four-wire, unterminated line cord is  provided  for  connecting  to  the  AC  supply.    The BROWN, BLACK and BLUE wires are the three phase inputs. The GREEN/YELLOW wire is for chassis safety ground connection. This is a safety ground connection and is NOT adequate for system grounding purposes.

Attach the output cable to the load.

D)        Plug the high voltage output cable provided with the  unit  into  the  rear  of  the  supply  and  secure appropriately.

E)        **Options Note**:  See section 5 for hook up and operating  instructions  for  the  options  on  your  unit. Custom models may also require set up changes.

F)        For  initial  turn-on,  rotate  the  front  panel KILOVOLT    control    potentiometer    fully    counter-clockwise to the zero voltage position.

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

H)        Depress the CONTROL POWER ON switch. The green light inside the switch should light up.   The unit is now in the HIGH VOLTAGE OFF mode.   The HIGH VOLTAGE OFF light should be lit.

I)        Depress and hold the HIGH VOLTAGE OFF switch.  The front panel meters will now read the preset value  of  the  KILOVOLT  control  dial  and  the MILLAMPERES control dial.   To preset the desired level of  the  current  and  voltage  during  operation,  hold  the HIGH VOLTAGE OFF switch and rotate the appropriate control dial while noting its corresponding meter reading. Release the HIGH VOLTAGE OFF switch.

NOTE:  No actual high voltage is being produced at this time.

J)        Depress the HIGH VOLTAGE ON switch.  The red light inside the switch should illuminate and the output will slow start up to the preset level output voltage and/or output current.

**Note:**  The ST series is equipped with a slow start circuit that  ramps  the  output  up  to  its  maximum  setting  in approximately  10  seconds  after  the  HIGH  VOLTAGE ON switch is depressed.

K)        To  terminate  the  generation  of  output  power, depress the HIGH VOLTAGE OFF switch.  In the HIGH VOLTAGE  OFF  mode  the  power  supply's  fault  and interface circuits are still active.

L)        To  turn  off  the  power  supply,  depress  the CONTROL POWER ON switch to release the switch bezel to the out position. All front panel lights should extinguish.

NOTE: If a power supply fault, or system monitoring fault occurs, the power supply will revert to the POWER DOWN mode. In this mode the output power will be turned off. The CONTROL POWER ON lamp will flash indicating a SYSTEM FAULT. To reset the SYSTEM FAULT cycle the CONTROL POWER ON switch, cycle the AC line power or toggle the RESET/EXTERNAL INHIBIT signal line.

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### WARNING

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

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### WARNING

**THE VOLTMETER ON THE POWER SUPPLY FRONT PANEL DOES <u>NOT</u> READ THE OUTPUT VOLTAGE WHEN THE POWER IS TURNED OFF, EVEN IF A CHARGE STILL EXISTS ON THE LOAD.**

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### CAUTION

**TO ASSURE SAFETY AND PROPER COOLING ALWAYS OPERATE THE UNIT WITH THE COVER PANELS INSTALLED.**

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Fans maintain safe operating temperatures in the power supply by drawing air over the circuit components. The covers must be on in order to direct the air flow over the areas that need cooling. In operation, the units air intake and fan exhaust paths must be clear of any obstructions that might impede the flow of air.

## 3.2   Standard Features

A general note on remote interface circuitry and remote signal grounding:

When usage applications dictate, electrical isolation may be required when interfacing with high voltage power supply in question. For power control signals such as CONTROL POWER, EXTERNAL INTERLOCK, HIGH VOLTAGE OFF and HIGH VOLTAGE ON isolated relay contacts should be used. For status signals and control signals such as HIGH VOLTAGE ON, HIGH VOLTAGE OFF, EXTERNAL INHIBIT, etc. opto-isolation should be used. When usage applications dictate, analog programming and monitoring signals may require isolation via analog isolation amplifiers. All interface cables should be properly shielded. All power supply signals should be referenced to the power supplies signal ground on the rear panel interface connecter.

**LOCAL/REMOTE   PROGRAMMING:** Allows adjustment of the output voltage, current and power via the front panel/internal controls (local) or external voltage sources (remote).

LOCAL CONTROL - In local control (front panel control), jumpers are installed on rear panel interface connecter between pin 8 and pin 9 for current control; between pin 10 and pin 11 for voltage control and between pin 42 and pin 43 for power control. This will enable the front panel potentiometers for current/voltage control and the internal potentiometer for power control.

REMOTE CONTROL - For remote programming, the above mentioned jumpers are removed and a positive polarity, ground referenced voltage source is applied to the pin 8 for current, pin 10 for voltage and pin 42 for power. Programming signals should be referenced to pin 1, signal ground. Scaling is such that 0-10Vdc corresponds to 0-100% rated output respectively. See Figure 3.2A for wiring diagram.

An alternate method of controlling the output remotely is by using external resistance such as a potentiometer or a resistor network. For remote control the jumpers are removed and the desired resistor configuration is installed. See Figure 3.2B for wiring diagram.

**REMOTE MONITORS:** Test points are made available on the rear panel interface connecter for monitoring the current, voltage and power; pin 5, pin 6 and pin 25 respectively. The test points are always positive regardless of the output polarity, scaling is such that 0-10Vdc corresponds to 0-100% rated output respectively. Test points have an output impedance of 1k ohms, ±1%. See Figure 3.3 for test point designation.

**LOCAL/REMOTE   CONTROL POWER / HIGH VOLTAGE ON / HV OFF:** Allows for command of CONTROL POWER, HIGH VOLTAGE ON and HIGH VOLTAGE OFF by either the front panel controls or external signals via the rear panel external interface connecter.

LOCAL CONTROL - For local front panel switch command of the Control Power functionality a maintained connection between pin 12 and pin 13 is required. Once connected as outlined above, the front panel CONTROL POWER switch will alternate latch on/latch off with each successive pressing of the switch. For local front panel command of the HIGH VOLTAGE OFF functionality a maintained connection between pin 14 and pin 15 is required.

REMOTE CONTROL – Remote control of CONTROL POWER, HIGH VOLTAGE ON and HIGH VOLTAGE OFF can be accomplished via the rear panel interface. The CONTROL POWER is an on-off toggle contact between pins 12 and 13. With the front panel CONTROL POWER switch latched in the "ON" position, opening and closing the connection between pins 12 and pins 13 will allow remote command of the CONTROL POWER

functionality. HIGH VOLTAGE OFF and HIGH VOLTAGE ON are controlled by momentary normally closed, normally open contacts, respectively between pins 14 and 15, and pins 15 and 16. See Figure 3.4 for recommended interface.

**EXTERNAL INHIBIT:** The External inhibit allows the user to inhibit the power supply output without putting the power supply into the HIGH VOLTAGE OFF mode. This circuit can be used to generate fast slewing output waveforms or control high voltage generation as in Laser and Capacitor discharge applications. The maximum inhibit rate should not exceed 5Hz. Consult factory for higher repetition rates or high pulse load applications. See Figure 3.5 for the recommended interface circuit.

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### WARNING

**IT IS EXTREMELY DANGEROUS TO USE THE EXTERNAL INHIBIT TO STOP HIGH VOLTAGE GENERATION FOR THE PURPOSE OF SERVICING OR APPROACHING ANY AREA OF THE LOAD CONSIDERED UNSAFE DURING HIGH VOLTAGE OPERATION**

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**EXTERNAL INTERLOCK:** The External Interlock connections are provided on the rear panel interface connecter, pin 3 and pin 4, intended for use in the connection to a customer provided and implemented external safety switch. The unit will not operate unless the interlock circuit is closed. If the interlock is not being used (use is highly recommended), a jumper must be installed. During high voltage operation, opening the External Interlock will cause the unit to revert to the HIGH VOLTAGE OFF mode. Subsequent closing of the interlock circuit will NOT return the unit to HIGH VOLTAGE ON mode; this must be accomplished by depressing the HIGH VOLTAGE ON switch. See Figure 3.6 for the recommended interface circuit.

**ARC DETECT / ARC QUENCH /ARC COUNT:** The ARC Intervention Circuitry senses dynamic arcing or discharge conditions present at the output load with a wide bandwidth current transformer coupled to the return side of the high voltage multiplier.

The instant an arc is detected the generation of high voltage is electronically inhibited for 200mS; this is called the ARC Quench time period. After the 200mS period, the discharged HV output (level dependent upon arc impedance, arc duration, etc) is ramped back up to the previous set level. This ramp time is based on the standard 200mS Slow Start time constant. The ARC indicator on the front panel will illuminate for approximately 500mS after each arc has occurred. The HV INHIBIT indicator will also illuminate for 500mS indicating that the output is being inhibited (ARC Quench).

The factory default setting of the Arc Intervention circuitry is such that if four arcs occur in a ten second time period the unit will shut down into the POWER DOWN mode displaying an "ARC Fault". ARC parameters can be modified by using the digital interface and provided GUI but changing these settings can have serious consequences.

NOTE: Making changes to the ARC Intervention Circuitry along with excessive arcing of the power supply can thermally overheat and damage the internal short circuit limiting assembly. Damage to the power supplies internal short circuit limiting assembly is consider misuse of the unit and repairs will not be covered under the warranty. The ARC Intervention Circuitry is incorporated and configured to protect the power supply from excessive arcing, make changes to this circuitry at your own responsibility and risk.

**REMOTE HIGH VOLTAGE ON & REMOTE HIGH VOLTAGE OFF:** Signals are provided for remote monitoring of the HIGH VOLTAGE ON and HIGH VOLTAGE OFF status. See Figure 3.7 for recommended interface.

## 3.3 Digital Interface (RS-232/Ethernet)

The ST features standard RS-232 and Ethernet digital interface capability. Please see Appendix A for complete details on functionality and operation.

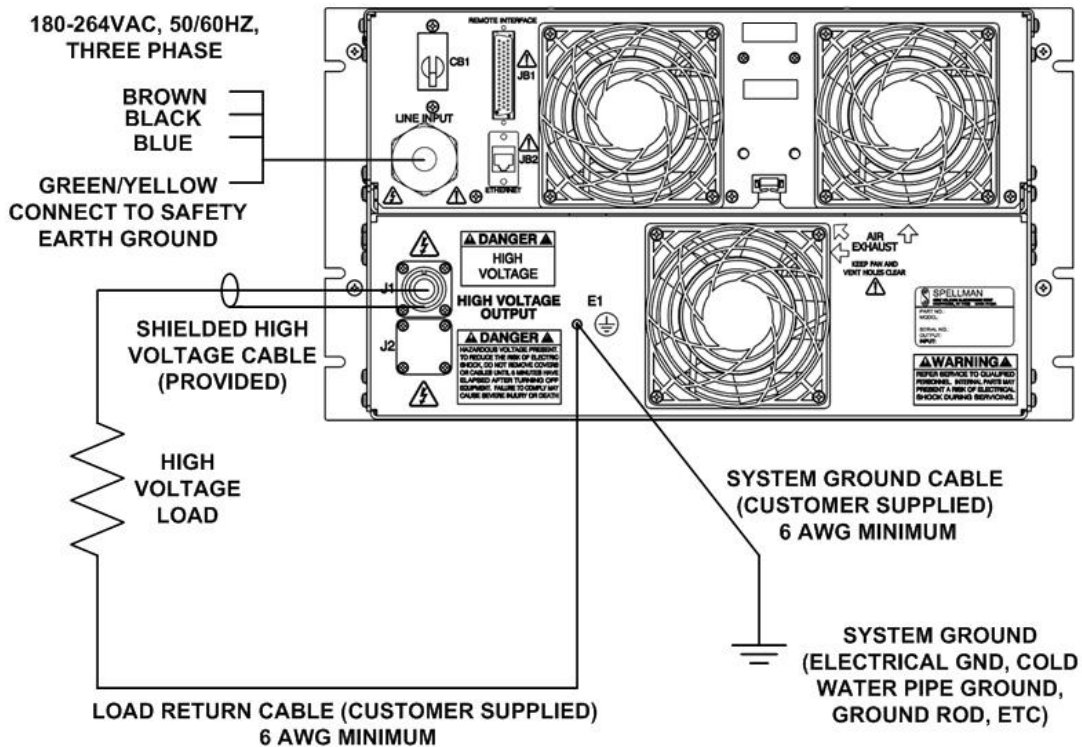## 3.4 Reversible Polarity (1-10kV Units Only) ST/STR Only

1 to 10kV units are inherently reversible by design but still require a polarity selection to be made at time of order. These units are air insulated and a simple wiring change made in the high voltage multiplier section can convert a positive polarity unit to a negative polarity unit, or vice versa.

## 3.5 Multiple Chassis Systems – ST Only

Additional ST chassis can be connected in parallel to achieve multiple 12kW increments of power to above and beyond 100kW's in a factory configured Master/Slave arrangement. The Master unit retains its full feature front panel while the Slave unit(s) have a Blank Front panel. From an interfacing and functionality standpoint the multiple chassis system behaves effectively like a single chassis higher power unit. This technique provides commonality of physically manageable hardware units and possibility redundancy further enhancing system uptime and reliability.

Typical Multiple Chassis Configuration



180-264VAC, 50/60HZ, THREE PHASE

BROWN
BLACK
BLUE

GREEN/YELLOW
CONNECT TO SAFETY
EARTH GROUND

SHIELDED HIGH
VOLTAGE CABLE
(PROVIDED)

HIGH
VOLTAGE
LOAD

HIGH VOLTAGE
OUTPUT

LOAD RETURN CABLE (CUSTOMER SUPPLIED)
6 AWG MINIMUM

SYSTEM GROUND CABLE
(CUSTOMER SUPPLIED)
6 AWG MINIMUM

SYSTEM GROUND
(ELECTRICAL GND, COLD
WATER PIPE GROUND,
GROUND ROD, ETC)

**Note: 400VAC units do not have an internal circuit breaker. The service connection to these units must be protected by an appropriately rated and circuit breaker protected power connection.**

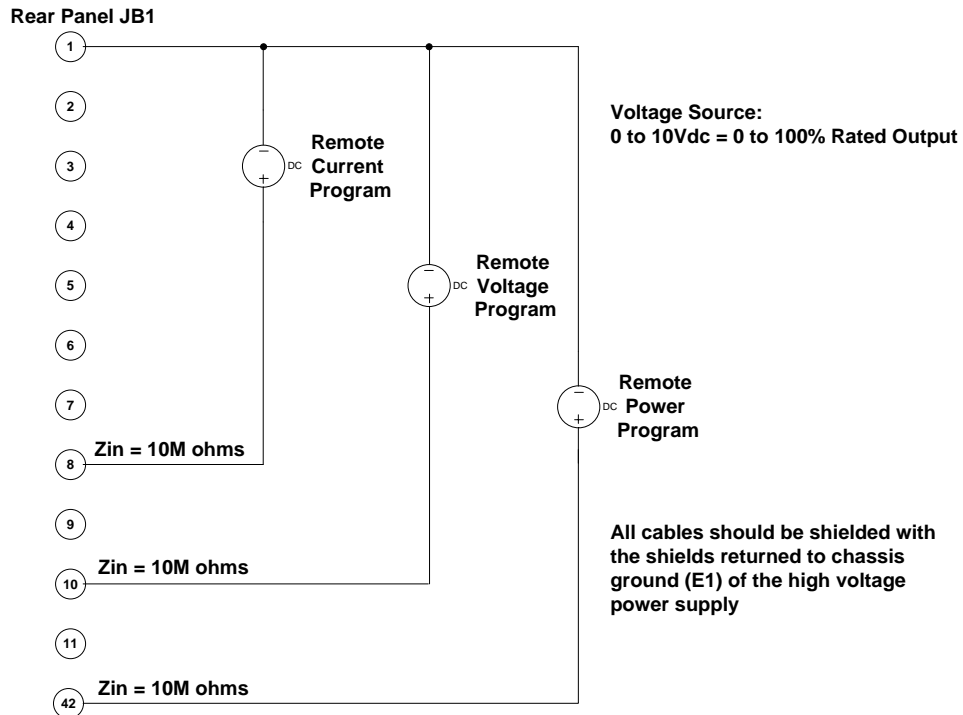**Figure 3.1  Typical Operating Setup ST**

Voltage Source:
0 to 10Vdc = 0 to 100% Rated Output

Remote
Current
Program

Remote
Voltage
Program

Remote
Power
Program

Zin = 10M ohms

Zin = 10M ohms

All cables should be shielded with
the shields returned to chassis
ground (E1) of the high voltage
power supply

Zin = 10M ohms

**Figure 3.2A Wiring Diagram for Remote Programming via Voltage Source**

Rear Panel JB1

Power Supply Ground

Potentiometer Settings:
Fully Counterclockwise = Zero Output
Fully Clockwise = 100% of Rated Output

Remote
Current
Control

Remote
Voltage
Control

Remote
Power
Control

50k Ohm

50k Ohm

50k Ohm

All cables should be shielded
with the shields returned to
chassis ground (E1) of the
high voltage power supply.

+10Vdc

Zin = 10M ohms

Zin = 10M ohms

Zin = 10M ohms

**Figure 3.2B  Wiring Diagram for Remote Programming via External Resistance**

**Rear Panel**
**JB1**

**Power Supply Ground**

(1)

(2)

(M) **Current**
**Monitor**  (3)

(4)

(5) **Zout = 1k ohm, ±1%**

(6) **Zout = 1k ohm, ±1%**

(7)

(25) **Zout = 1k ohm, ±1%**

(M) **Voltage**
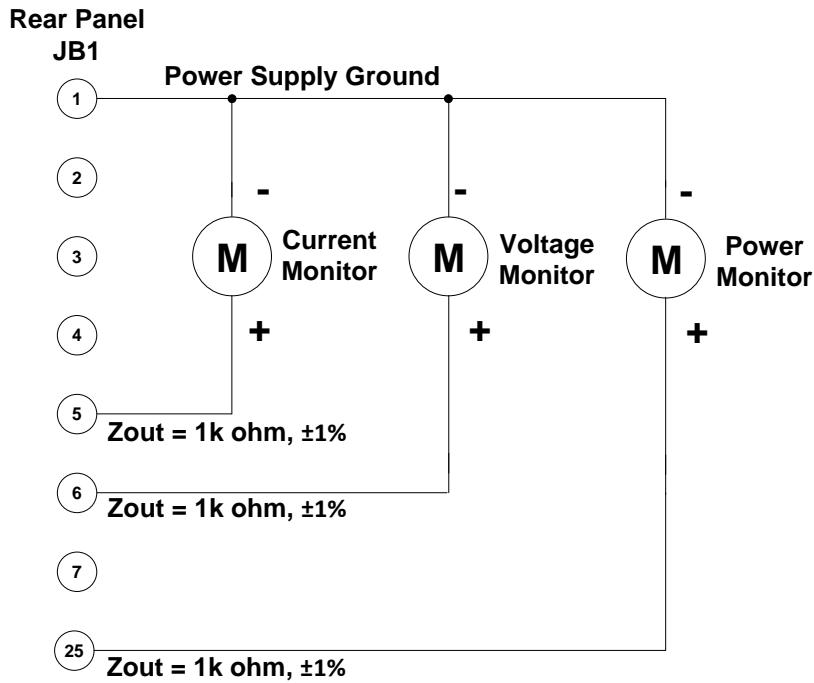**Monitor**

(M) **Power**
**Monitor**

**Figure 3.3  Remote Monitor Test Point Designations**

It is recommended to use relay contacts for S1, S2 and S3. Relays should be located as close as possible to the high voltage power supply.  Coils should be driven from isolated sources.  Signals are at ~24V, 100mA max, and are only to be used for contact closure.

S1 must be closed to enable HIGH VOLTAGE ON. Momentary closure of S2 will enable HIGH VOLTAGE ON.

Opening S1 will disable HIGH VOLTAGE ON and switch the unit to the HIGH VOLTAGE OFF mode.
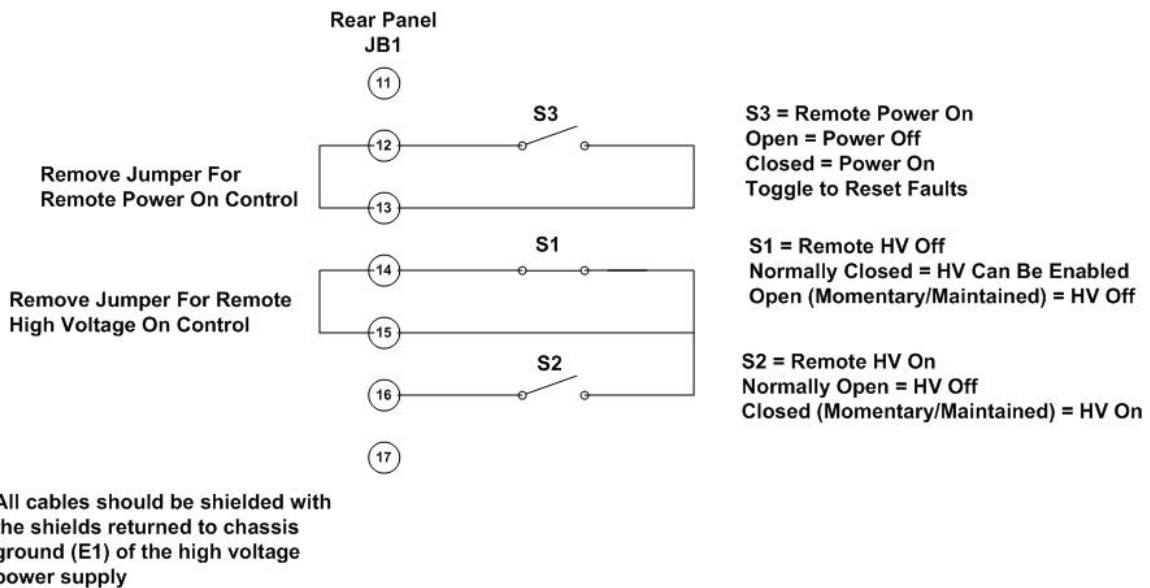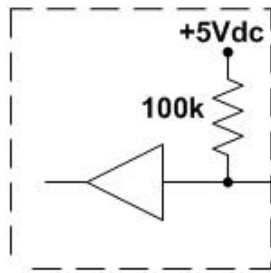
**Rear Panel**
**JB1**

(11)

(12)  **S3**

Remove Jumper For
Remote Power On Control

(13)

S3 = Remote Power On
Open = Power Off
Closed = Power On
Toggle to Reset Faults

(14)  **S1**

Remove Jumper For Remote
High Voltage On Control

(15)

S1 = Remote HV Off
Normally Closed = HV Can Be Enabled
Open (Momentary/Maintained) = HV Off

(16)  **S2**

(17)

S2 = Remote HV On
Normally Open = HV Off
Closed (Momentary/Maintained) = HV On

All cables should be shielded with
the shields returned to chassis
ground (E1) of the high voltage
power supply

**Figure 3.4 Remote Control of Power ON, High Voltage ON and High Voltage OFF**

**High Voltage Power Supply Inhibit Circuitry**

**Rear Panel JB1**

+5Vdc

100k
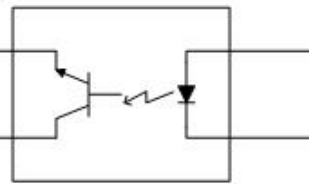
Power Supply Ground

1

2

3
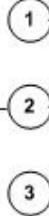
Optocoupler should be located as close as possible to the power supply
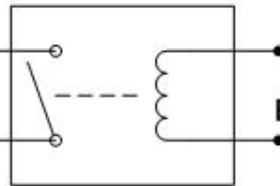
Active LED Current Inhibits High Voltage

All cables should be shielded with the shields returned to chassis ground (E1) of the high voltage power supply

**Figure 3.5  External Inhibit Interface Circuit**

---

**Rear Panel JB1**

1

2

3

4

5

Customer provided relay for control of External Inhibit Circuit

It is recommended to use relay contacts for the control of the External Interlock. The relay should be located as close as possible to the power supply. Signals are ≈+24Vdc @ 100mA, maximum, and are only to be used for contact closure.

Relay Coil for Safety External Interlock Control

All cables should be shielded with the shields returned to chassis ground (E1) of the high voltage power supply

JB1-3 and JB1-4 @ Open = External Interlock Open, HV Disable, No HV Enable Possible
JB1-3 and JB1-4 @ Closed = External Interlock Closed, HV Can Be Enabled

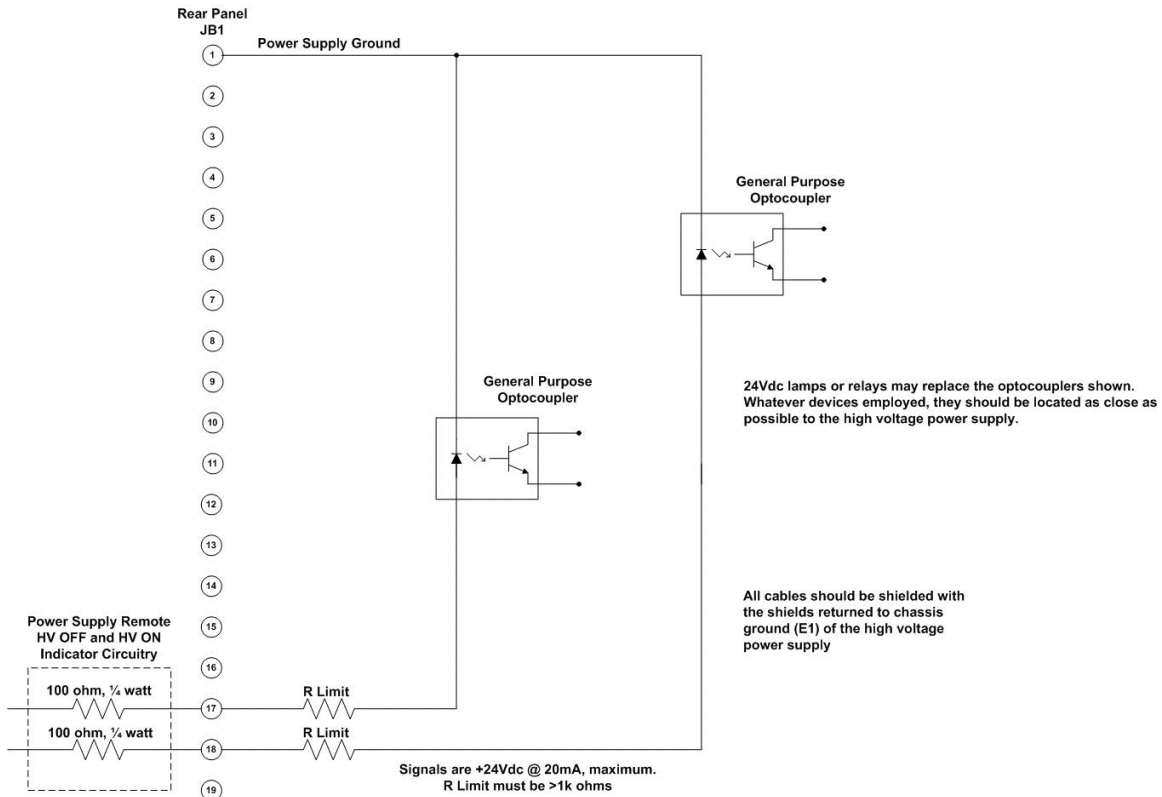**Figure 3.6  External Interlock Interface Circuit**

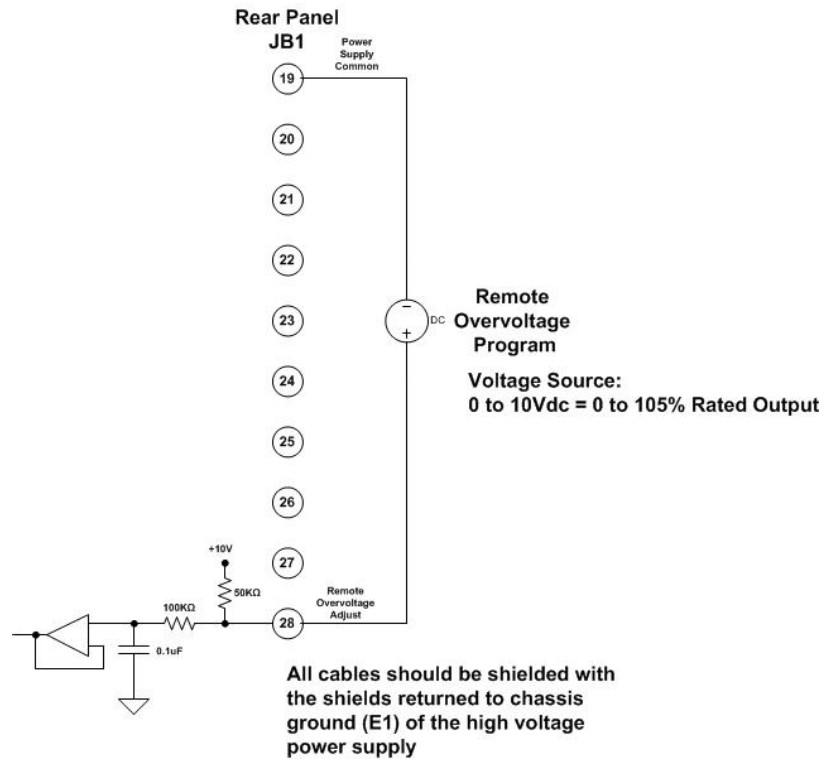**Figure 3.7  Remote High Voltage ON and Remote High Voltage OFF Indicator**
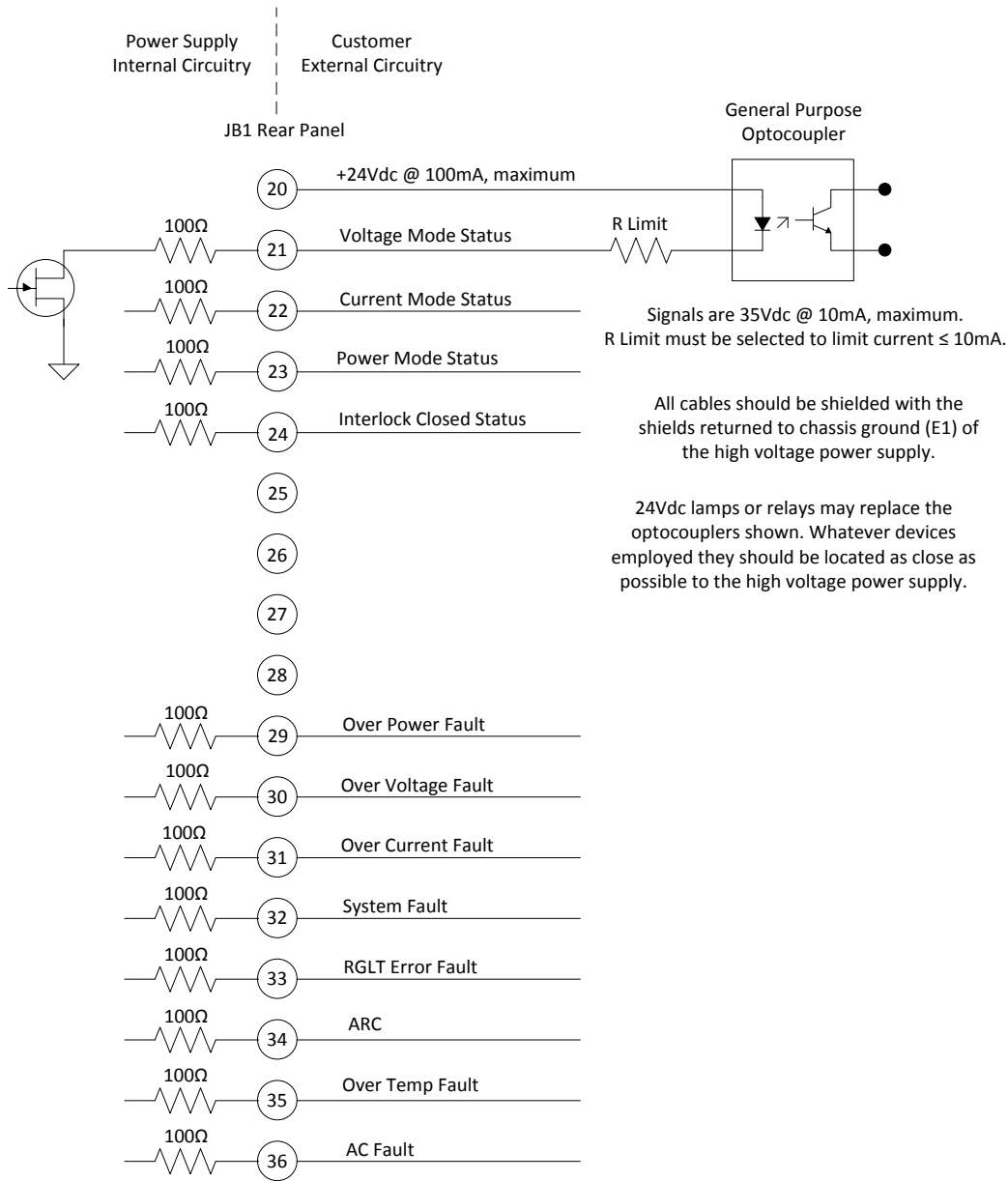


**Figure 3.8  Remote Overvoltage Adjust Interface**

Power Supply
Internal Circuitry

Customer
External Circuitry

JB1 Rear Panel

General Purpose
Optocoupler

(20) +24Vdc @ 100mA, maximum

100Ω (21) Voltage Mode Status    R Limit

100Ω (22) Current Mode Status

100Ω (23) Power Mode Status

100Ω (24) Interlock Closed Status

(25)

(26)

(27)

(28)

100Ω (29) Over Power Fault

100Ω (30) Over Voltage Fault

100Ω (31) Over Current Fault

100Ω (32) System Fault

100Ω (33) RGLT Error Fault

100Ω (34) ARC

100Ω (35) Over Temp Fault

100Ω (36) AC Fault

Signals are 35Vdc @ 10mA, maximum.
R Limit must be selected to limit current ≤ 10mA.

All cables should be shielded with the
shields returned to chassis ground (E1) of
the high voltage power supply.

24Vdc lamps or relays may replace the
optocouplers shown. Whatever devices
employed they should be located as close as
possible to the high voltage power supply.

**Figure 3.9  Remote Status and Fault Indicator Interface**

| Pin | Signal | Parameters |
|-----|--------|------------|
| 1 | Power Supply Common | Power Supply Ground |
| 2 | Reset/HV Inhibit | Toggle to reset latched faults, Ground = Inhibit, Open = HIGH VOLTAGE ON |
| 3 | External Interlock | +24Vdc @ open, <25mA @ closed |
| 4 | External Interlock Return | Return for External Interlock. Pins 3 and 4 must be connected to HV enable |
| 5 | mA Test Point | 0-10Vdc = 0-100% rated output, Zout = 1kΩ, 1% |
| 6 | kV Test Point | 0-10Vdc = 0-100% rated output, Zout = 1kΩ, 1% |
| 7 | +10Vdc Reference | +10Vdc @ 1mA |
| 8 | mA Program Input | 0-10Vdc = 0-100% rated output, Zin =>10MΩ, jump to pin 8 for local control |
| 9 | Local mA Program Output | 0-10Vdc = 0-100% rated output, front panel potentiometer |
| 10 | kV Program Input | 0-10Vdc = 0-100% rated output, Zin =>10MΩ, jump to pin 11 for local control |
| 11 | Local kV Program Output | 0-10Vdc = 0-100% rated output, front panel potentiometer |
| 12 | Remote Power On Output | 24Vdc @ open, 2A peak, 1A DC @ closed |
| 13 | Remote Power On Return | Return for Remote Power On |
| 14 | Remote HV OFF | +24Vdc @ open, 2A peak, 1A DC @ closed, connect to pin 15 for front panel operation |
| 15 | Remote HV OFF/ON Common | Remote HV OFF/ON Common |
| 16 | Remote HIGH VOLTAGE ON | +24Vdc @ open, 2A peak, 1A DC @ closed, momentarily connect to pin 15 for HV enable |
| 17 | HIGH VOLTAGE OFFIndicator | +24Vdc @ 25mA = HV OFF |
| 18 | HIGH VOLTAGE ON Indicator | +24Vdc @ 25mA = HIGH VOLTAGE ON |
| 19 | Power Supply Common | Power Supply Ground |
| 20 | +24Vdc Output | +24Vdc @ 100mA, maximum |
| 21 | Voltage Mode Status | Open collector, Low = Active, 35V maximum @ 10mA |
| 22 | Current Mode Status | Open collector, Low = Active, 35V maximum @ 10mA |
| 23 | Power Mode Status | Open collector, Low = Active, 35V maximum @ 10mA |
| 24 | Interlock Closed Status | Open collector, Low = Active, 35V maximum @ 10mA |
| 25 | Power Test Point | 0-10Vdc = 0-100% rated output, Zout = 5kΩ, 1% |
| 26 | Spare | |
| 27 | Spare | |
| 28 | Remote Overvoltage Adjust | 0-10Vdc = 0-105% rated output |
| 29 | Over Power Fault | Open collector, Low = Active, 35V maximum @ 10mA |
| 30 | Over Voltage Fault | Open collector, Low = Active, 35V maximum @ 10mA |
| 31 | Over Current Fault | Open collector, Low = Active, 35V maximum @ 10mA |
| 32 | System Fault | Open collector, Low = Active, 35V maximum @ 10mA |
| 33 | RGLT Error Fault | Open collector, Low = Active, 35V maximum @ 10mA |
| 34 | ARC | Open collector, Low = Active, 35V maximum @ 10mA |
| 35 | Over Temp Fault | Open collector, Low = Active, 35V maximum @ 10mA |
| 36 | AC Fault | Open collector, Low = Active, 35V maximum @ 10mA |
| 37 | Spare | |
| 38 | Spare | |
| 39 | Spare | |
| 40 | Spare | |
| 41 | Spare | |
| 42 | Remote Power Program Input | 0-10Vdc = 0-100% rated output, Zout = 1kΩ, 1%, jump to pin 43 for local control |
| 43 | Local Power Program Output | 0-10Vdc = 0-100% rated output, internal potentiometer |
| 44 | +5Vdc Output | +5Vdc @ 100mA, maximum |
| 45 | +15Vdc Output | +15Vdc @ 100mA, maximum |
| 46 | -15Vdc Output | -15Vdc @ 10mA, maximum |
| 47 | RS-232 Tx | RS-232 Tx |
| 48 | RS-232 Rx | RS-232 Rx |
| 49 | RS-232 GND | RS-232 GND |
| 50 | Power Supply Common | Power Supply Ground |

⌐ = Denotes jumper connection for simplified local front panel control

**Figure 3.10    JB1 Rear Panel Interface Connecter**

# Chapter 4

# Principles of Operation

The ST series of high voltage power supplies utilizes sophisticated power conversion technology. A variety of analog, digital and power conversion techniques are employed. This Principles of Operation will introduce the basic function blocks that comprise the ST power supply. For details on a specific circuit, consult Spellman's Engineering Department.

The ST power supply is an AC to DC converter. Within the power supply, conversions of AC to DC, high frequency AC, then to high voltage DC take place. By reviewing functionality of the subassemblies, a basic understanding of the process can be gained.

<div style="text-align:center">

**WARNING**

</div>

**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.**

## 4.1 Line Rectification and Filtering

<div style="text-align:center">

**WARNING**

</div>

**LINE VOLTAGE IS PRESENT WHENEVER THE POWER SUPPLY IS CONNECTED TO THE INPUT LINE VOLTAGE. BE SURE TO DISCONNECT THE LINE CORD BEFORE OPENING THE UNIT. ALLOW 5 MINUTES FOR INTERNAL CAPACITANCE TO DISCHARGE BEFORE TOUCHING ANYTHING CONNECTED TO LINE REFERENCED CIRCUITRY**

Simple three phase rectification provides the DC buss voltage for the high frequency inverter.

An input line cord, three phase circuit breaker (customer provided on 400Vac Option units), EMI Filter Assembly, contactor, inrush bridge rectifier, electrolytic capacitors, rail inductor and rail capacitor comprise the basic components required for input line rectification.

The standard line input voltage for the ST Series is 180-264Vac, 50/60Hz. An optional 360-528Vac, 50/60Hz input voltage is available (400Vac Option). Optional Single Phase input is available on the STR and STA. If the user is unsure which input voltage is required, check the serial tag on the rear of the power supply or consult Spellman's Sales Department

The customer provided AC power input is provided to the unit via the four conductor AC line cord. Circuit protection is provided by CB1, a fast acting magnetic trip type circuit breaker. The load side of CB1 is connected to EMI filter A2. The output of the EMI filter connects to K1, a three phase contactor. K1 provides fail-safe type disconnection of the line voltage to the power supply rectification circuits. K1's coil is controlled by a variety of circuit conditions, which will be described later on. The load side of CB1 is also connected to low voltage power supply assembly A9, which provides various voltages for housekeeping and control circuit power.

When contactor K1 is energized, voltage is applied to isolated bridge rectifier power module CR1, used for line voltage rectification. The output of CR1 is connected to aluminum electrolytic capacitors C1 and C2 for line filtering purposes. Capacitors C1 and C2 are initially charged through inrush limiting charging resistors which is located on POWER PWB – A6.

After an appropriate period of time to charge C1 and C2, relays on POWER PWB – A6 are energized to short out the inrush limiting resistors. The generated DC buss voltage is supplied to the inverter circuitry through L2, L3, L6 and L7. The inductors provide isolation for the electrolytic capacitors C1 and C2, so the inverter's high frequency pulse currents are drawn from the metalized film high frequency "rail capacitors" C3 and C12.

The POWER PWB – A6 provides the inrush limiting function via R1, R2, R3 and R4. Relays K1 and K2 short out the limiting resistors once the initial charging of C1 and C2 is complete. Resistors R7, R8, and R10, R11 form two feedback divider circuits with terminating resistors located on the SYSTEM CONTROL PWB – A1. These impedance limited, low voltage + and – rail feedback signals are monitored and if any abnormal conditions appear, circuitry will shutdown the power supply.

Typically a SYSTEM FAULT and AC FAULT indication will appear on the front panel if an error in the charging circuits has occurred.

R5 on the POWER PWB – A6 functions as a bleeder resistor, which is used to discharge the front end filter capacitors C1 and C2. DS1 provides visual indication when DC voltage is present. This indicator should not be relied on for confirming the presence or absence of the DC voltage in any situation where user safety is of concern.

## 4.2    Inverter

The inverter employs a proprietary, quasi-resonant, pulse width modulated topology. L1 and L5 are the resonating inductors. Q1, Q2 Q3 and Q4 are high speed IGBT isolated power modules. These devices provide high frequency switching capability to control the flow of current through the primary of the high voltage step up transformers. The gate control for the switching devices is provided by GATE DRIVE PWB A3 and A4. The control signals are generated by the SYSTEM CONTROL PWB – A1.

## 4.3    High Voltage Transformer

The output of the Inverter is connected to the primary of the High Voltage Transformer. The High Voltage Transformer is a step-up type. Typical secondary voltages are in the range of 1kV to 4.5kV depending upon the units specific maximum output voltage rating.

## 4.4    High Voltage Assembly

The High Voltage Assembly will vary depending upon the model ordered. The circuitry typically consists of a full wave, full bridge, or full wave doubler for voltage outputs in the range of 1kV to 10kV. The higher voltage ranges utilize various parallel, series arrangements of a full wave voltage doubler. For example, the 8kV output is obtained by connecting a number of full wave voltage doublers in parallel. The 120kV output is obtained by connecting a number of full wave voltage doublers in series.

Output filtering is typically provided by an L-C type filter. Voltage feedback for regulation and monitoring is provided by a high bandwidth resistive/capacitive compensated feedback divider. Current feedback for regulation and monitoring is provided by a sense resistor connected at the low voltage end of the High Voltage output section.

## 4.5    System Control PWB

The majority of control circuits for power supply controls are located on the SYSTEM CONTROL PWB – A1. For trouble shooting and testing purposes, this board can be easily accessed by removing the screws located on the side panels near the front panel. The front panel will hinge down allowing for easy access to the SYSTEM CONTROL PWB

## 4.6    Front Panel Assembly

Front Panel CONTROL POWER, HV OFF, HIGH VOLTAGE ON, switches, voltage and current programming potentiometers, voltage and current digital meters, and status indications are connected to the FRONT PANEL PWB. – A7. The FRONT PANEL PWB interfaces directly to the SYSTEM CONTROL PWB - A1.

## 4.7    Master/Slave Rear Panel PWB – ST Only

This assembly is only required and installed when more than one ST chassis is configured in the system. By configuring chassis in parallel using a Master/Slave arrangements additional power increments of 12kW's can be obtained for each chassis added. This Master/Slave Rear Panel PWB provided the necessary control signal connectivity and functionality to operate multiple chassis in parallel as a single high powered system.

# Chapter 5

## OPTIONS

THe options available for this power supply are described in this section. Options are specified by including the option code in the model number as described in Section 1.5.

### 5.1    Blank Front Panel          BFP



The Blank Front Panel Option removes local control functionality and metering from the standard front panel. This is a popular cost saving measure for OEM applications where the unit will only be controlled remotely. The local front panel fault diagnostic panel is retained providing comprehensive power supply operational information.

### 5.2    High Stability          HS

The standard internal voltage feedback divider is replaced with a high precision voltage feedback divider providing a 50ppm/°C temperature coefficient.

### 5.3    High Voltage Cable Length          LL(X)

Custom length high voltage output cables, indicated in foot measurement units. Various predetermined lengths are available along with entirely custom lengths; contact Spellman Sales Department for details.

### 5.4    360-528Vac Input 400VAC

This option factory configures the ST/STR to operate from 360-528Vac, three phase, 50/60Hz input power.

### 5.5    180-264Vac Single Phase Input  (1PH)

This option factory configures STR and STA units to operate from 180-264Vac, single phase, 50/60Hz input power.

### 5.6    Custom Designed Models          X(#)

Units built to customer specifications are assigned an X number by the factory.  If this unit is an X model, a specification control sheet is added at the end of this instructional manual. Spellman welcomes the opportunity to tailor units to fit your requirements or to develop new products for your applications.  Contact the Spellman Sales Department with your need.

## 5.7  Parallel Option Units (Multiple Chassis Systems – ST only)

Physically install the units in a cabinet or stack them one on top the other, typically the Master units is located at the top to ease access to the local controls on the full featured front panel.  Cabling up the system is similar regardless of the numbers of Slave chassis. The following items will be required to connect up each parallel option unit:

Control Jumper Cable (gray cable, 15 pin D connecters on each end)
Ground Jumper Cable (green/yellow cable, ring lugs on each end)
High Voltage Jumper Cable (black cable, HV connecter on each end)
Terminator Plug (black plastic clam shell, 15 pin D connecter)

One cable of each type is required for each Slave chassis; only one terminator plug is required for each system. The connections are as follows; repeat as needed for additional Slave Chassis:

**Control Jumper Cable** – Connect one side to JB3 of the Master chassis, connect the other side to JB4 of the Slave Chassis.

**Ground Jumper Cable** – Connect one side to E1 ground stud on the Master chassis, connect the other side to E1 ground stud of the Slave chassis. ***Connect the customer provided "System Ground Cable" and the customer provided "Load Return Cable" to the E1 ground stud on the back of the Master Chassis. Please see Typical Operating Setup ST figure for required ground connections***

**High Voltage Jumper Cable** – Connect one side to J1 of the Master chassis; connect the other side to J1 of the Slave Chassis. Connect the terminated side of the High voltage output cable to J2 of the Slave chassis; connect the unterminated side to the load as applicable.

**Terminator Plug**– Plug the Terminator Plug into JB3 of the Slave Chassis.

The instructions above are for a two chassis Master/Slave unit, but these instructions can be used for systems with any number of Slave units keeping these two points in mind:

●The High Voltage Output Cable always exists from the "last" Slave unit
●The Terminator Plug is always connected to the JB3 connecter of the "last" Slave unit.

See the annotated photograph of the wiring connections for a 3 chassis system (Master/Slave1/Slave2) that follows these instructions.

Cooling Note:
For proper cooling, and to maximize product life span, a minimum of 1U (1.75") rack space should be provided above and below each chassis, and between chassis of multi-chassis systems. This will allow air circulation, and also reduce heating effects on other equipment in the cabinet.

105708-685
Local Control Plug

303480-003
Ground Jumper
Cable

MASTER
CHASSIS

303010-002
Control Jumper
Cable

407508-001
HV Jumper Cable

SLAVE ONE
CHASSIS

304948-001
Terminator Plug

SLAVE TWO
CHASSIS

407508-002
HV Output Cable
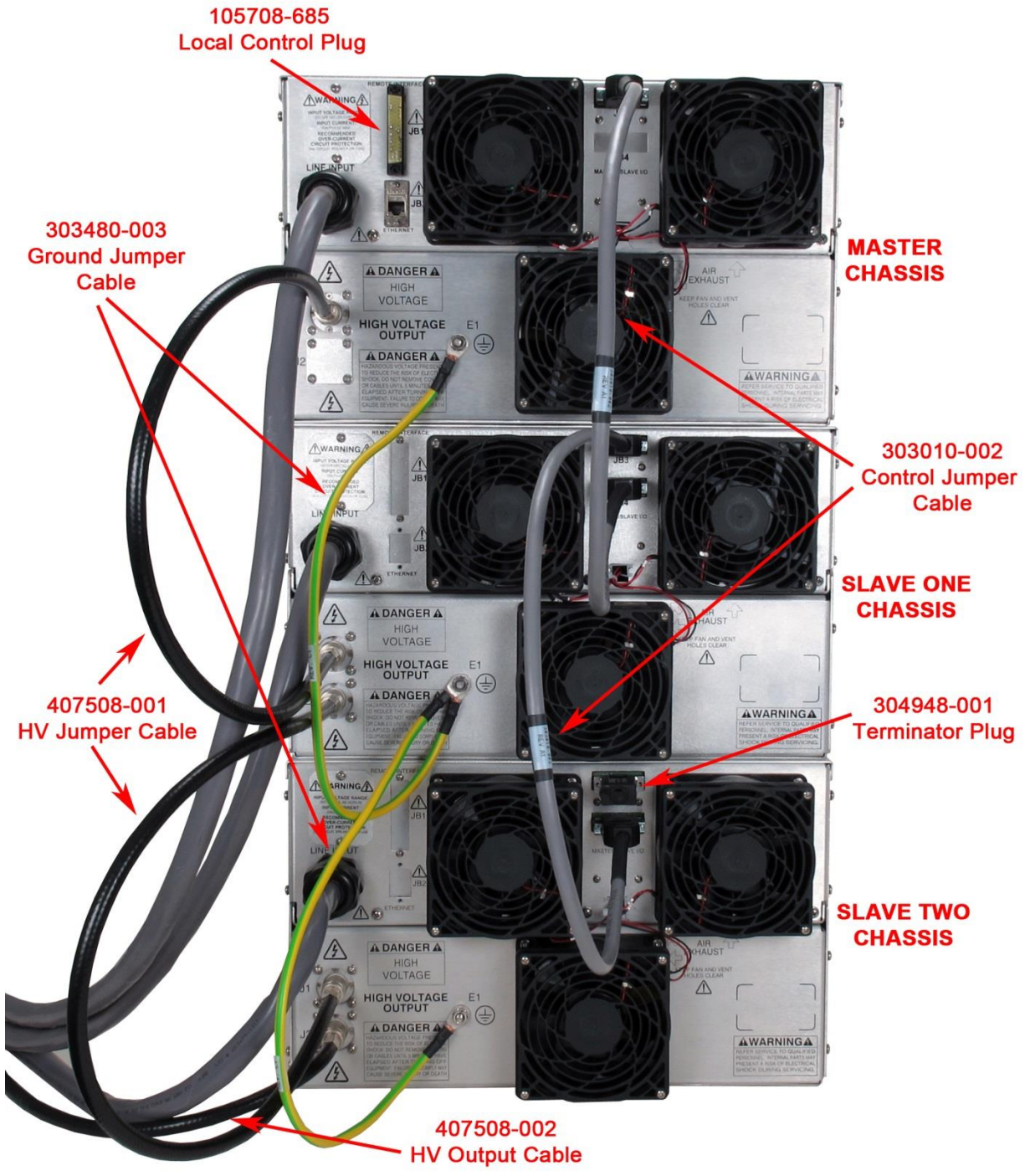
# Chapter 6

## MAINTENANCE

This section describes periodic servicing and performance testing procedures.

<div style="text-align:center">

**WARNING**

</div>

**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 and remove the top cover. Use compressed air to blow dust out of the inside of the unit. Avoid touching or handling the high voltage assembly. Be sure that the fan is not obstructed and spins freely. The fan has sealed bearings and does not need lubrication. Be sure to replace the cover before operating for proper cooling.

Turn the chassis over and remove the bottom cover. Use compressed air to blow dust out. NOTE: On 10kV and below, an air insulated high voltage section is used. Avoid touching or handling the high voltage assembly. Be sure to replace the bottom cover before operating the unit.

## 6.2   Performance Test

<div style="text-align:center">

**WARNING**

</div>

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

High voltage test procedures are described in Bulletin STP-783, available by clicking the following link Standard Test Procedures for High Voltage Power Supplies. 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 applicable operating voltage.

## 6.3   High Voltage Dividers



- **HIGH INPUT IMPEDANCE**
- **25PPM TEMPERATURE COEFFICIENT**
- **100KV, 200KV AND 400KV MODELS**
- **CORONA FREE OPERATION**
- **0.5% ACCURACY**
  **(HIGHER ACCURACIES AVAILABLE)**
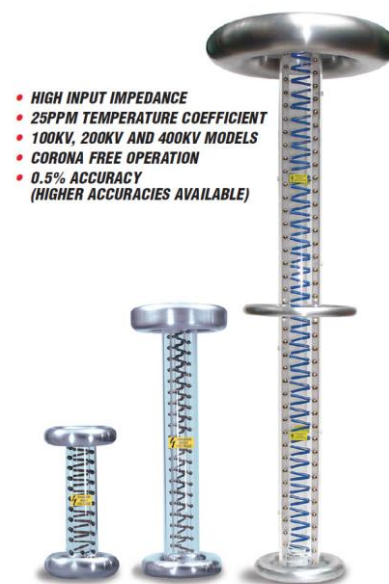
High voltage dividers for precise measurements of output voltage with accuracy up to 0.1% are available from Spellman. The HVD-100 is used for voltages up to 100kV, the HVD-200 measures up to 200kV and the HVD-400 measures up to 400kV. The Spellman HVD divider is designed for use with differential voltmeters or high impedance digital voltmeters. The data sheet for Spellman's series of HVD dividers can be viewed by clicking here.

# Chapter 7

# REPLACEMENT PARTS

## 7.1 Replacement Parts

Contact the Spellman Customer Service Department for parts lists for specific models.

Spellman provides parts and subassemblies for its high voltage power supplies but recommends that only qualified personnel perform repairs. High voltage is dangerous; even minor mistakes in repairs can have serious consequences.

When requesting parts, please provide the complete model number and serial number of the power supply in question.

## 7.2 Correspondence and Ordering Spare Parts

Each Spellman power supply has an identification label on the rear of the chassis that bears its model and serial number.

When requesting engineering or applications information, please state the model and serial number of the power supply. If specific components or circuit sections are involved in the inquiry, it is helpful to indicate the component symbol number(s) shown on the applicable schematic diagram.

When ordering spare parts, please specify the part's description, the part's reference designation or part number, and the model and serial number of the unit.

# Chapter 8

# FACTORY SERVICE

## 8.1    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 8.2.  The customer shall pay for shipping to and from Spellman.

## 8.2    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.

## 8.3    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.

## 8.4 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
www.spellmanhv.com

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

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

# Table Of Contents

| WARNING |
| --- |

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

**TO PREVENT DAMAGE TO THE HOST COMPUTER THE COMPUTER SHOULD BE
GROUNDED TO THE SAME GROUND AS THE UUT.**

## 1.0  SCOPE

This document applies to the communications interfaces on the ST, assembly
460231.

## 2.0  FUNCTIONAL DESCRIPTION

The ST provides 3 different types of digital communications interfaces:
- DB-50F Digital Breakout on JB1
- Ethernet (10/100-Base-T) on JB9

## 3.0  GETTING STARTED - INTERFACE WIRING AND PIN-OUTS

### 3.1  RS-232 INTERFACE

The RS-232 interface has the following attributes:
- 115.2K bits per second
- No Parity
- 8 Data Bits
- 1 Stop Bit
- No handshaking
- Included in DB-50F Digital Breakout

The pinout of the DB-50F connector is:

| Pin | Signal | Parameters |
|---|---|---|
| 1 | Power Supply Common | Power Supply Ground |
| 2 | Reset/HV Inhibit | Toggle to reset latched faults, Ground = Inhibit, Open = HV ON |
| 3 | External Interlock | +24Vdc @ open, <25mA @ closed |
| 4 | External Interlock Return | Return for External Interlock. Pins 3 and 4 must be connected to HV enable |
| 5 | mA Test Point | 0-10Vdc = 0-100% rated output, Zout = 1kΩ, 1% |
| 6 | kV Test Point | 0-10Vdc = 0-100% rated output, Zout = 1kΩ, 1% |
| 7 | +10Vdc Reference | +10Vdc @ 1mA |
| 8 | mA Program Input | 0-10Vdc = 0-100% rated output, Zin =>10MΩ, jump to pin 8 for local control |
| 9 | Local mA Program Output | 0-10Vdc = 0-100% rated output, front panel potentiometer |
| 10 | kV Program Input | 0-10Vdc = 0-100% rated output, Zin =>10MΩ, jump to pin 11 for local control |
| 11 | Local kV Program Output | 0-10Vdc = 0-100% rated output, front panel potentiometer |
| 12 | Remote Power On Output | 24Vdc @ open, <25mA @ closed |
| 13 | Remote Power On Return | Return for Remote Power On |
| 14 | Remote HV OFF | +24Vdc @ open, <25mA @ closed, connect to pin 15 for front panel operation |
| 15 | Remote HV OFF/ON Common | Remote HV OFF/ON Common |
| 16 | Remote HV ON | +24Vdc @ open, <25mA @ closed, momentarily connect to pin 15 for HV enable |
| 17 | HV OFF Indicator | +24Vdc @ 25mA = HV OFF |
| 18 | HV ON Indicator | +24Vdc @ 25mA = HV ON |
| 19 | Power Supply Common | Power Supply Ground |
| 20 | +24Vdc Output | +24Vdc @ 100mA, maximum |
| 21 | Voltage Mode Status | Open collector, Low = Active, 35V maximum @ 10mA |
| 22 | Current Mode Status | Open collector, Low = Active, 35V maximum @ 10mA |
| 23 | Power Mode Status | Open collector, Low = Active, 35V maximum @ 10mA |
| 24 | Interlock Closed Status | Open collector, Low = Active, 35V maximum @ 10mA |
| 25 | Power Test Point | 0-10Vdc = 0-100% rated output, Zout = 5kΩ, 1% |
| 26 | Spare | |
| 27 | Spare | |
| 28 | Remote Overvoltage Adjust | 0-10Vdc = 0-105% rated output |
| 29 | Over Power Fault | Open collector, Low = Active, 35V maximum @ 10mA |
| 30 | Over Voltage Fault | Open collector, Low = Active, 35V maximum @ 10mA |
| 31 | Over Current Fault | Open collector, Low = Active, 35V maximum @ 10mA |
| 32 | System Fault | Open collector, Low = Active, 35V maximum @ 10mA |
| 33 | RGLT Error Fault | Open collector, Low = Active, 35V maximum @ 10mA |
| 34 | ARC | Open collector, Low = Active, 35V maximum @ 10mA |
| 35 | Over Temp Fault | Open collector, Low = Active, 35V maximum @ 10mA |
| 36 | AC Fault | Open collector, Low = Active, 35V maximum @ 10mA |
| 37 | Spare | |
| 38 | Spare | |
| 39 | Spare | |
| 40 | Spare | |
| 41 | Spare | |
| 42 | Remote Power Program Input | 0-10Vdc = 0-100% rated output, Zout = 1kΩ, 1%, jump to pin 43 for local control |
| 43 | Local Power Program Output | 0-10Vdc = 0-100% rated output, internal potentiometer |
| 44 | +5Vdc Output | +5Vdc @ 100mA, maximum |
| 45 | +15Vdc Output | +15Vdc @ 100mA, maximum |
| 46 | -15Vdc Output | -15Vdc @ 10mA, maximum |
| 47 | RS-232 Tx | RS-232 Tx |
| 48 | RS-232 Rx | RS-232 Rx |
| 49 | RS-232 GND | RS-232 GND |
| 50 | Power Supply Common | Power Supply Ground |

The necessary connections for the RS-232 interface are on pins 47, 48 and 49.

### 3.2   ETHERNET INTERFACE

The Ethernet interface has the following attributes:
- 10/100-Base-T
- IP address can be set by the system integrator (Default Address: 192.168.1.4)
- Network Mask can be set by the system integrator (Default Mask: 255.255.255.0)
- TCP Port Number can be set by the system integrator (Default Port: 50000)

- 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
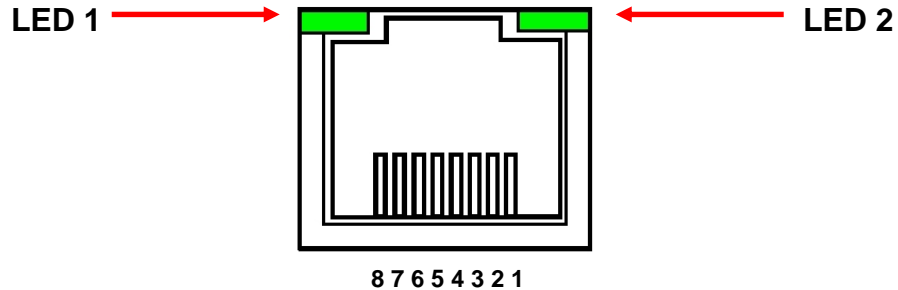
LED 1 →                              ← LED 2

8 7 6 5 4 3 2 1

**Figure 2 – JB9, 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   RS-232 CABLING

A shielded cable is used to connect the ST serial port through the 50 pin breakout to the serial port on a standard personal computer. Please refer to the following chart.

| PC to ST Board Cable Details | |
|---|---|
| PC Connector  (DB-9 Female) | ST Connector  (DB-50 male) |
| Pin 2:  TX from ST to PC | Pin 47:  TX from ST to PC |
| Pin 3:  RX to ST from PC | Pin 48:  RX to ST from PC |
| Pin 5:  Ground | Pin 49:  Ground |

## 3.4   ETHERNET CABLING

Shielded Category 5 (CAT5) Ethernet patch cables are used to connect the ST to the host computer. There are two ways to connect to the ST

board via Ethernet: the first is to directly cable between the host and the ST board, and the second is through the use of a switch, hub, or network.

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.
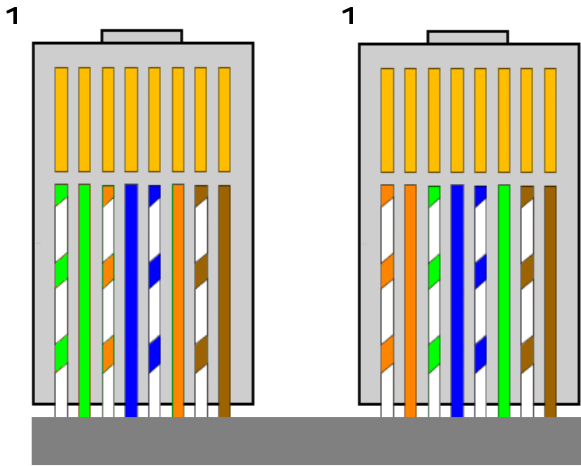
**Figure 4 – Crossover Cable for Direct Connection**

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
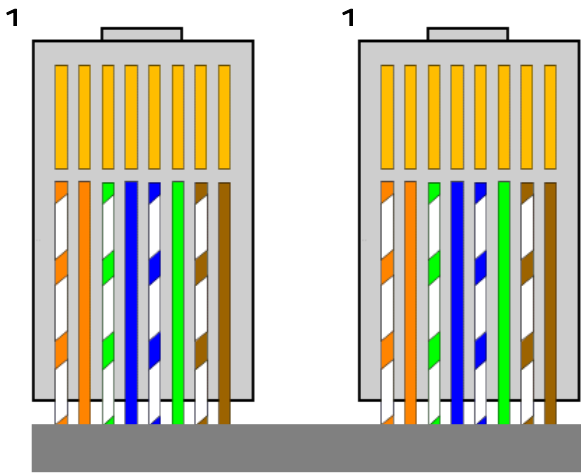
**Figure 5 – Standard Straight Through Cable – Standard CAT5 Patch**

## 4.0    GETTING STARTED – SOFTWARE
The following sections detail how to create software to interface to the ST communications interfaces.

## 4.1 RS-232

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

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

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

### 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 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 ST contains an embedded diagnostic web server that can be accessed through any standard web browser by browsing to the ST'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 Direct Connection between the ST and a Computer

A direct Ethernet connection between the ST 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. Please see figure 4 on rage 7 for reference.

When direct connecting the ST 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 |

### 4.2.2.1    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.
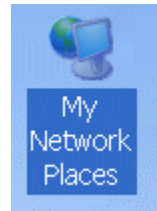


**Figure 16 – Right Click on Desktop**
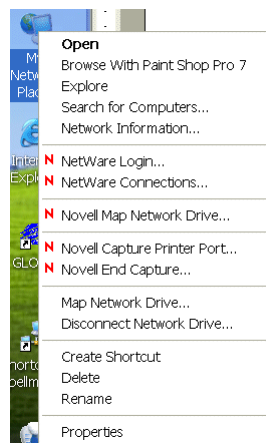


**Figure 17 – Select Properties**

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.
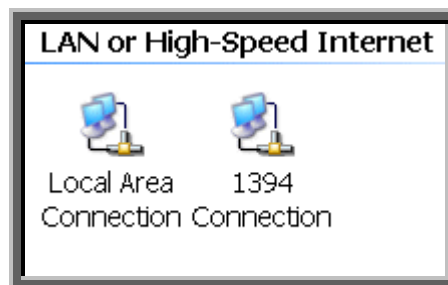


**Figure 18 – Here you must Right Click and Select Properties**
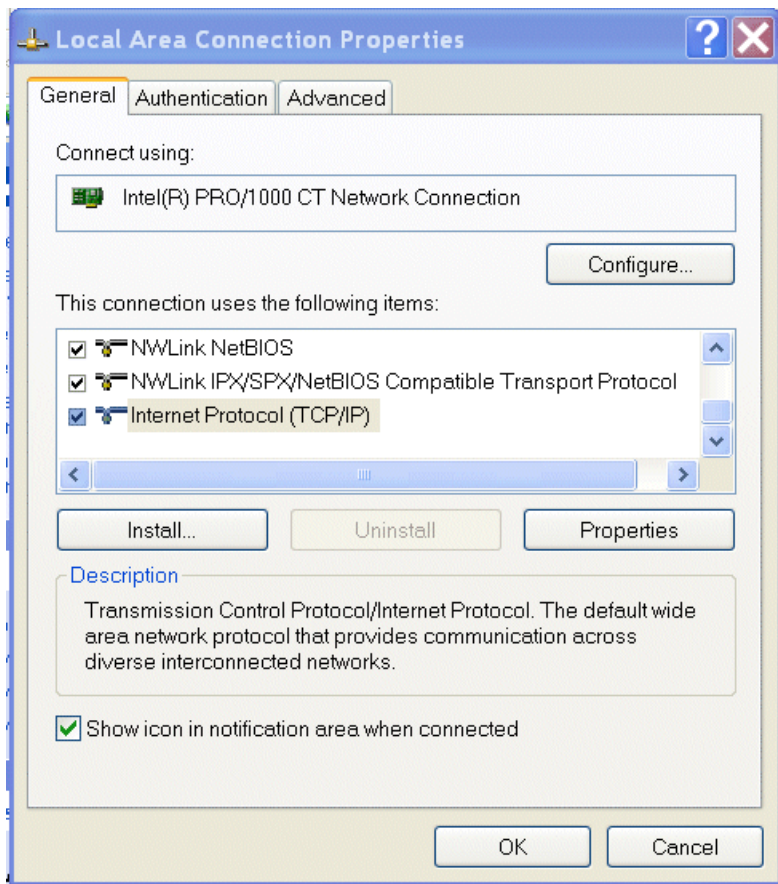
**Figure 19 – Local Area Connection Properties**

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.
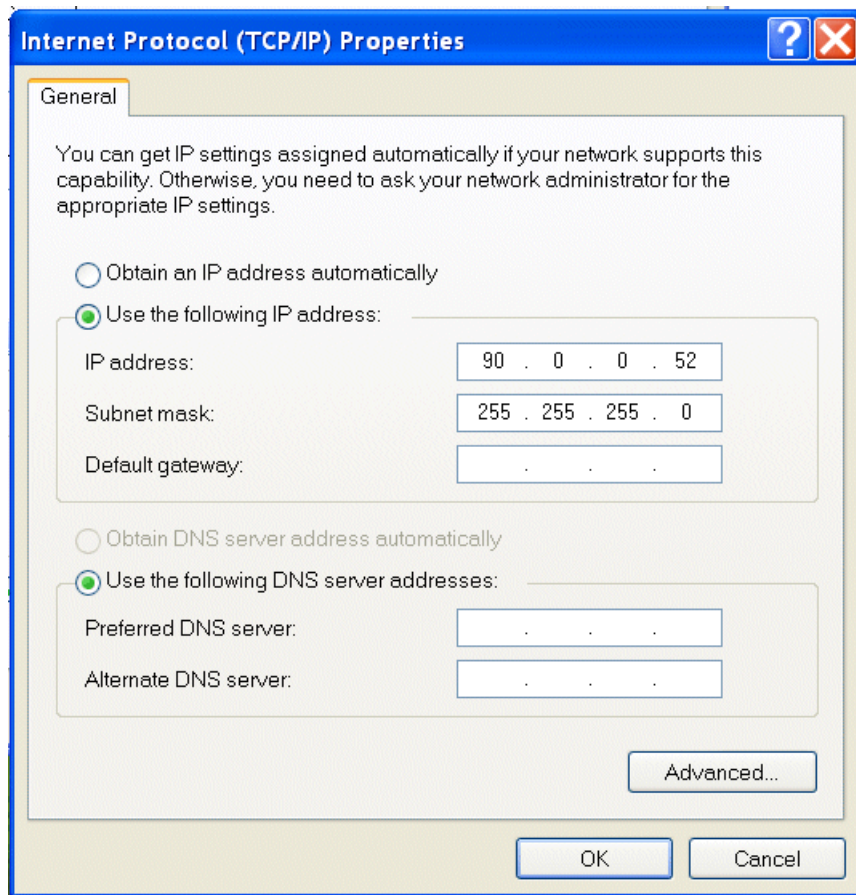
**Figure 20 – TCP/IP Properties**

### 4.2.2.2 Testing a Direct Connection

You can use the program "Ping" to test a network connection between the computer and the ST. "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 ST 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

### 4.2.3  Configuring the ST For a Local Area Network (LAN)

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

- A CAT5 network patch cable to physically connect the ST to the LAN

- A static IP address to assign to the ST.

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  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 it will be named: Winsock.This can be dragged and dropped into your application.  Then set the object's properties.

### 4.2.5  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.

### 4.2.5.1    Data Output Example

MSComm1 is the serial port and 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
```

### 4.2.5.2    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
```

## 5.0    ETHERNET COMMANDS

### 5.1    TCP/IP FORMAT

Each Ethernet command will consist of a TCP/IP header followed by the required data bytes. Figure 27 summarizes the TCP/IP header configuration. Please note that this functionality is provided by the software implementation of the Open Systems Interconnection (OSI) TCP/IP protocol stack, specifically the upper 4 layers.

| Byte | | | | | | | | | | |
|------|---|---|---|---|---|---|---|---|---|---|
| 0 | Protocol Version | Header Length | Type Of Service | | Total Length | | | | | |
| 4 | Packet ID | | | Flags | Fragmentation Offset | | | | | |
| 8 | Time To Live | | Protocol | | Header checksum | | | | | |
| 12 | Source Address | | | | | | | | | |
| 16 | Destination Address | | | | | | | | | |
| 20 | Source Port | | | Destination Port | | | | | | |
| 24 | Sequence Number | | | | | | | | | |
| 28 | Acknowledgement Number | | | | | | | | | |
| 32 | Data Offset | Reserved | Code Bits | Window | | | | | | |
| 36 | Checksum | | | Urgent Pointer | | | | | | |
| 40 | Data Byte 1 | | Data Byte 2 | | Data Byte 3 | | Data Byte N | | | |

**Figure 24: Network TCP/IP datagram header**

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

| TCP/IP Command Overview | | | |
|---|---|---|---|
| Command Name | <CMD> | <ARG> | RANGE |
| Program User Configurations | 9 | See Desc. | See Desc. |
| Program kV Setpoint | 10 | 1-4 ASCII | 0-4095 |
| Program mA Setpoint | 11 | 1-4 ASCII | 0-4095 |
| Request kV Setpoint | 14 | None | - |
| Request mA Setpoint | 15 | None | - |
| Request Misc. Analog Monitor Readbacks | 20 | None | - |
| Request Status | 22 | None | - |
| Request Software Version | 23 | None | - |
| Request Model Number | 26 | None | - |
| Request User Configs | 27 | None | - |
| Request Unit Scaling | 28 | None | - |
| Request FPGA Version | 43 | None | - |
| Request kV monitor | 60 | None | - |
| Request mA monitor | 61 | None | - |
| Request Slave Faults | 68 | None | - |
| Request System Voltages | 69 | None | - |
| Reset Faults | 74 | None | - |
| 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 | 10 ASCII |
| Request mA Setpoint | 15 | 10 ASCII |
| Request Misc. Analog Readbacks | 20 | 21 – 45 ASCII |
| Request Status | 22 | 37 ASCII |
| Request Software Version | 23 | 22 ASCII |
| Request Model Number | 26 | 7 – 21 ASCII |
| Request User Configs | 27 | 9 – 17 ASCII |
| Request Unit Scaling | 28 | 9 – 14 ASCII |
| Request FPGA Version | 43 | 22 ASCII |
| Request kV monitor | 60 | 7 – 10 ASCII |
| Request mA monitor | 61 | 7 – 10 ASCII |
| Request Slave Faults | 68 | 31 ASCII |
| Request System Voltages | 69 | 45 ASCII |

## 5.5 COMMAND STRUCTURE

### 5.5.1 Program User Configurations

Description:
The host requests that the firmware set the kV and mA ramp rates.

Direction:
Host to supply

Syntax:
<STX><09><,><ARG1><,><ARG2><,><ETX>

Where:
<ARG1> = kV Rate Ramp
<ARG2> = mA Rate Ramp
<ARG3> = AOL Enable
<ARG4> = APT Enable

Range:
Valid values for ARG1 and ARG2 are from 0 through 10000 milliseconds.
In 10 milliseconds increments. For ARG3 and ARG4 they are 0 (disabled) and 1 (enabled).

Response:
If an error is detected, the Power Supply responds with:
<STX>09,!,<ERROR>,<ETX>
Please reference the Error Code section for a list of valid error codes.

If the message is accepted, the Power Supply responds with:
<STX>09,$,<ETX>

Example:
Set kV and mA to a 10 ms ramp, with AOL and APT disabled.
<STX>09,10,10,0,0,<ETX>

### 5.5.2  Program kV

<u>Description:</u>
The host requests that the firmware change the kV setpoint.

<u>Direction:</u>
Host to supply

<u>Syntax:</u>
<STX><10><,><ARG><,><ETX>

<u>Where:</u>
<ARG> = 0 - 4095 in ASCII format

<u>Response:</u>
If an error is detected, the Power Supply responds with:
<STX>10,!,<ERROR>,<ETX>
Please reference the Error Code section for a list of valid error codes.

If the message is accepted, the Power Supply responds with:
<STX>10,$, <ETX>

<u>Example:</u>
Set kV to the full scale voltage.
<STX>10,4095,<ETX>

### 5.5.3  Program mA

Description:
The host requests that the firmware change the mA setpoint.

Direction:
Host to supply

Syntax:
<STX><11><,><ARG><,><ETX>

Where:
<ARG> = 0 - 4095 in ASCII format

Response:
If an error is detected, the Power Supply responds with:
<STX>11,!,<ERROR>,<ETX>
Please reference the Error Code section for a list of valid error codes.

If the message is accepted, the Power Supply responds with:
<STX>11,$,<ETX>

Example:
Set mA to the full scale current.
<STX>11,4095,<ETX>

### 5.5.4  Request kV Setpoint

Description:
The host requests that the firmware report the kV setpoint.

Direction:
Host to supply

Syntax:
<STX><14><,><ETX>

Response:
If an error is detected, the Power Supply responds with:
<STX>14,!,<ERROR>,<ETX>
Please reference the Error Code section for a list of valid error codes..

If the message is accepted, the Power Supply responds with:
<STX>14,<ARG>,<ETX>

Where:
<ARG> = 0 - 4095 in ASCII format

Example Response:
KV setpoint is set to full scale.
<STX>14,4095,<ETX>

### 5.5.5  Request mA Setpoint

Description:
The host requests that the firmware report the current mA setpoint.

Direction:
Host to supply

Syntax:
<STX><15><,><ETX>

Response:
If an error is detected, the Power Supply responds with:
<STX>15,!,<ERROR>,<ETX>
Please reference the Error Code section for a list of valid error codes.

If the message is accepted, the Power Supply responds with:
<STX>15,<ARG>,<ETX>

Where:
<ARG> = 0 - 4095 in ASCII format

Example Response:
MA setpoint is set to full scale.
<STX>15,4095,<ETX>

### 5.5.6  Request Miscellaneous Analog Monitor Readbacks

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

Direction:
Host to supply

Syntax:
<STX><20><,><ETX>

Response:
If an error is detected, the Power Supply responds with:
<STX>20,!,<ERROR>,<ETX>
Please reference the Error Code section for a list of valid error codes.

If the message is accepted, the Power Supply responds with:
<STX>20,<ARG1>,<ARG2>,<ARG3>,<ARG4>,<ARG5>,<ARG6>,<ARG7
>,<ARG8>,<ETX>

Where:
<ARG1> = Remote Over Voltage Protection
<ARG2> = Spare
<ARG3> = Power Reference
<ARG4> = Power Monitor
<ARG5> = Control Board Temperature
<ARG6> = Spare
<ARG7> = Spare
<ARG8> = Spare

Range:
Valid values are 0 - 4095 in ASCII format.

Example Response:.
<STX>20,2048,0,4095,4095,1023,0,0,0,<ETX>

### 5.5.7 Request Status/Faults

Description:
The host requests that the firmware sends the power supply statuses and faults.

Direction:
Host to supply

Syntax:
<STX><22><,><ETX>

Response:
If an error is detected, the Power Supply responds with:
<STX>22,!,<ERROR>,<ETX>
Please reference the Error Code section for a list of valid error codes.

If the message is accepted, the Power Supply responds with:
<STX>22,<ARG1>,<ARG2>,<ARG3>,<ARG4>,<ARG5>,<ARG6>,
<ARG7>,<ARG8>,<ARG9>,<ARG10>,<ARG11>,<ARG12>,
<ARG13>,<ARG14>,<ARG15>,<ARG16>,<ARG17>,<CSUM>
<ETX>

Where:
<ARG1> = Power On                  <ARG10> = Regulation Error
<ARG2> = HV Ray On                 <ARG11> = Current Control Mode
<ARG3> = Arc                       <ARG12> = Over Temperature
<ARG4> = Interlock Closed          <ARG13> = Power Control Mode
<ARG5> = Over Current              <ARG14> = AC Fault
<ARG6> = Over Power                <ARG15> = Local/Remote Mode
<ARG7> = Over Voltage              <ARG16> = LVPS Fault
<ARG8> = Voltage Control Mode      <ARG17> = HV Inhibit
<ARG9> = System Fault

Range:
Valid values are 0 or 1 in ASCII format.
0 = Off/No Fault
1= On/Fault

Example Response:.
Power's On with an Over Current Fault.
<STX>22,1,0,0,0,1,0,0,0,1,0,0,0,0,0,0,0,<ETX>

### 5.5.8 Request DSP Software Part Number/Version

Description:
The host requests that the firmware sends the firmware send the DSP Software part and build number.

Direction:
Host to supply

Syntax:
<STX><23><,><ETX>

Response:
If an error is detected, the Power Supply responds with:
<STX>23,!,<ERROR>,<ETX>
Please reference the Error Code section for a list of valid error codes.

If the message is accepted, the Power Supply responds with:
<STX>23,<ARG1>,<ARG2>,<ETX>

Where:
<ARG1> = Consists of eleven ASCII characters representing the current firmware part number/version. The format is SWM9999-999.
<ARG2> = Consists of four ASCII characters representing the current build number.  The format is 3261.

Example Response:
<STX>23, SWM9999-999,3261,<ETX>

### 5.5.9  Request Model Number

Description:
The host requests that the firmware sends the unit model number.

Direction:
Host to supply

Syntax:
<STX><26><,><ETX>

Response:
If an error is detected, the Power Supply responds with:
<STX>26,!,<ERROR>,<ETX>
Please reference the Error Code section for a list of valid error codes.

If the message is accepted, the Power Supply responds with:
<STX>26,<ARG>,<ETX>

Where:
<ARG> = Consists up to fifteen ASCII characters representing the current model number.

Example Response:
<STX>26,ST100P100X4249,<ETX>

### 5.5.10  Request User Configurations

Description:
The host requests that the firmware send the user configurable items.

Direction:
Host to supply

Syntax:
<STX><27><,><ETX>

Response:
If an error is detected, the Power Supply responds with:
<STX>27,!,<ERROR>,<ETX>
Please reference the Error Code section for a list of valid error codes.

If the message is accepted, the Power Supply responds with:
<STX>27,<ARG1>,<ARG2>,<ETX>

Where:
<ARG1> = kV Rate Ramp
<ARG2> = mA Rate Ramp
<ARG3> = AOL Enabled
<ARG4> = APT Enabled

Range:
Valid values for ARG1 and ARG2 are from 0 through 10000 milliseconds.
For ARG3 and ARG4 the valid values are 0 (disabled) and 1 (enabled).

Example Response:
 kV and mA set to a 10 millisecond ramp, with AOL enabled and APT disabled.
<STX>27,10,10,1,0,<ETX>

### 5.5.11  Request Unit Scaling

Description:
The host requests that the firmware send the full scale range values.

Direction:
Host to supply

Syntax:
<STX><28><,><ETX>

Response:
If an error is detected, the Power Supply responds with:
<STX>28,!,<ERROR>,<ETX>
Please reference the Error Code section for a list of valid error codes.

If the message is accepted, the Power Supply responds with:
<STX>28,<ARG1>,<ARG2>,<ETX>

Where:
<ARG1> = Full Scale kV Value
<ARG2> = Full Scale mA Value

Example Response:
For a 100kV/1000mA power supply
<STX>28,100,1000,<ETX>

### 5.5.12  Request FPGA Software Part Number/Version

Description:
The host requests that the firmware sends the firmware send the FPGA Software part and build number.

Direction:
Host to supply

Syntax:
<STX><43><,><ETX>

Response:
If an error is detected, the Power Supply responds with:
<STX>43,!,<ERROR>,<ETX>
Please reference the Error Code section for a list of valid error codes.

If the message is accepted, the Power Supply responds with:
<STX>43,<ARG1>,<ARG2>,<ETX>

Where:
<ARG1> = Consists of eleven ASCII characters representing the current firmware part number/version. The format is SWM9999-999.
<ARG2> = Consists of four ASCII characters representing the current build number.  The format is 3261.

Example Response:
<STX>43,SWM9999-999,3261,<ETX>

### 5.5.13  Request kV Monitor

Description:
The host requests that the firmware report kV monitor.

Direction:
Host to supply

Syntax:
<STX><60><,><ETX>

Response:
If an error is detected, the Power Supply responds with:
<STX>60,!,<ERROR>,<ETX>
Please reference the Error Code section for a list of valid error codes.

If the message is accepted, the Power Supply responds with:
<STX>60,<ARG>,<ETX>

Where:
<ARG> = 0 - 4095 in ASCII format

Example Response:
KV monitor is set to full scale.
<STX>60,4095,<ETX>

### 5.5.14  Request mA Monitor

Description:
The host requests that the firmware report mA monitor.

Direction:
Host to supply

Syntax:
<STX><61><,><ETX>

Response:
If an error is detected, the Power Supply responds with:
<STX>61,!,<ERROR>,<ETX>
Please reference the Error Code section for a list of valid error codes.

If the message is accepted, the Power Supply responds with:
<STX>61,<ARG>,<ETX>

Where:
<ARG> = 0 - 4095 in ASCII format

Example Response:
mA monitor is set to full scale.
<STX>61,4095,<ETX>

### 5.5.15  Request Slave Faults

Description:
The host requests that the firmware report Slave Faults.

Direction:
Host to supply

Syntax:
<STX><68><,><ETX>

Response:
If an error is detected, the Power Supply responds with:
<STX>68,!,<ERROR>,<ETX>
Please reference the Error Code section for a list of valid error codes.

If the message is accepted, the Power Supply responds with:
<STX>68,<ARG1>,<ARG2>,<ARG3>,<ARG4>,<ARG5>,<ARG6>,
<ARG7>,<ARG8>,<ARG9>,<ETX>

Where:
<ARG1> = Slave 1 Faults
<ARG2> = Slave 2 Faults
<ARG3> = Slave 3 Faults
<ARG4> = Slave 4 Faults
<ARG5> = Slave 5 Faults
<ARG6> = Slave 6 Faults
<ARG7> = Slave 7 Faults
<ARG8> = Slave 8 Faults
<ARG9> = Slave 9 Faults

Range:
Valid values are 0 to 65535 in ASCII format.
0 = Off/No Fault
1= On/Fault

Other Error Codes to TBD.

Example Response:.
Slave number 4 has a Fault.
<STX>68,0,0,0,1,0,0,0,0,0,0,0,0,0,<ETX>

### 5.5.16  Request System Voltages

<u>Description:</u>
The host requests that the firmware report System Voltages.

<u>Direction:</u>
Host to supply

<u>Syntax:</u>
<STX><69><,><ETX>

<u>Response:</u>
If an error is detected, the Power Supply responds with:
<STX>69,!,<ERROR>,<ETX>
Please reference the Error Code section for a list of valid error codes.

If the message is accepted, the Power Supply responds with:
<STX>69,<ARG1>,<ARG2>,<ARG3>,<ARG4>,<ARG5>,<ARG6>,
<ARG7>,<ETX>

Where:
<ARG1> = AC Line Voltage in ASCII 0-4095 format, 0 to 375V
<ARG2> = 24V rail in ASCII 0-4095 format, 0 to 33V
<ARG3> = 15V rail in ASCII 0-4095 format, 0 to 21V
<ARG4> = 5V rail in ASCII 0-4095 format, 0 to 6V
<ARG5> = 3.3V rail in ASCII 0-4095 format, 0 to 5 V
<ARG6> = -15V in ASCII 0-4095 format, 0 to -33V
<ARG7> = Spare rail in ASCII 0-4095 format, 0 to 45V

<u>Example Response:</u>.
<STX>69,1302,3047,3008,3426,2711,1857,2243,<ETX>

### 5.5.17 Reset Faults

Description:
The host requests the firmware to clear latched faults.

Direction:
Host to supply

Syntax:
<STX><74><,><ETX>

Response:
If an error is detected, the Power Supply responds with:
<STX>74,!,<ERROR>,<ETX>
Please reference the Error Code section for a list of valid error codes.

If the message is accepted, the Power Supply responds with:
<STX>74,$,<ETX>

### 5.5.18    Program Local/Remote Mode

Description:
The host requests 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

Response:
If an error is detected, the Power Supply responds with:
<STX>99,!,<ERROR>,<ETX>
Please reference the Error Code section for a list of valid error codes.

If the message is accepted, the Power Supply responds with:
<STX>99,$,<ETX>

## 6.0 SERIAL COMMANDS – RS-232
### 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 acknowledge or data is sent back to the host. A timeout will act as an implied NACK.

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

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

*Dim i As Integer*
*Dim CSb1 As Integer*
*Dim CSb2 As Integer*

```
Dim CSb3 As Integer
Dim CSb$
Dim X

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

CSb1 = 256 - X
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
```

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

The original message with a placeholder for the checksum is

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

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

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

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

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

(0x100 – 0x18B) & 0x7F = 0x75

- Finally, bitwise OR the result with 0x40:

0x75 | 0x40 = 0x75

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

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

The original message with a placeholder for checksum is:

<STX>22,<CSUM><ETX>

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

0x32 + 0x32 + 0x2C = 0x90

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

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

(0x100 – 0x90) & 0x7F = 0x70

- Finally, bitwise OR the result with 0x40:

0x70 | 0x40 = 0x70
The checksum byte is 0x70 (Decimal 112, ASCII: p)

## 6.4    COMMAND OVERVIEW

| Serial Command Overview | | | |
|---|---|---|---|
| Command Name | <CMD> | <ARG> | RANGE |
| Program User Configurations | 9 | See Desc. | See Desc. |
| Program kV Setpoint | 10 | 1-4 ASCII | 0-4095 |
| Program mA Setpoint | 11 | 1-4 ASCII | 0-4095 |
| Request kV Setpoint | 14 | None | - |
| Request mA Setpoint | 15 | None | - |
| Request Misc. Analog Monitor Readbacks | 20 | None | - |
| Request Status | 22 | None | - |
| Request Software Version | 23 | None | - |
| Request Model Number | 26 | None | - |
| Request User Configs | 27 | None | - |
| Request Unit Scaling | 28 | None | - |
| Request FPGA Version | 43 | None | - |
| Request kV monitor | 60 | None | - |
| Request mA monitor | 61 | None | - |
| Request Slave Faults | 68 | None | - |
| Reset Faults | 74 | None | - |
| 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 | 11 ASCII |
| Request mA Setpoint | 15 | 11 ASCII |
| Request Misc. Analog Readbacks | 20 | 22 – 46 ASCII |
| Request Status | 22 | 38 ASCII |
| Request Software Version | 23 | 23 ASCII |
| Request Model Number | 26 | 8 – 22 ASCII |
| Request User Configs | 27 | 10 – 18 ASCII |
| Request Unit Scaling | 28 | 10 – 15 ASCII |
| Request FPGA Version | 43 | 23 ASCII |
| Request kV monitor | 60 | 8 – 11 ASCII |
| Request mA monitor | 61 | 8 – 11 ASCII |
| Request Slave Faults | 68 | 32 ASCII |
| Request System Voltages | 69 | 46 ASCII |

## 6.6 COMMAND STRUCTURE

### 6.6.1 Program User Configurations

Description:
The host requests that the firmware set the user configurable items.

Direction:
Host to supply

Syntax:
<STX><09><,><ARG1><,><ARG2><,><CSUM><ETX>

Where:
<ARG1> = kV Rate Ramp
<ARG2> = mA Rate Ramp
<ARG3> = AOL Enable
<ARG4> = APT Enable

Range:
Valid values for ARG1 and ARG2 are from 0 through 10000 milliseconds.
In 10 milliseconds increments. For ARG3 and ARG4 they are 0 (disabled)
and 1 (enabled).

Response:
If an error is detected, the Power Supply responds with:
<STX>09,!,<ERROR>,<CSUM><ETX>
Please reference the Error Code section for a list of valid error codes.

If the message is accepted, the Power Supply responds with:
<STX>09,$,<CSUM><ETX>

Example:
Set kV and mA to a 10 ms ramp, with AOL and APT disabled.
<STX>09,10,10,0,0,<CSUM><ETX>

### 6.6.2 Program kV

Description:
The host requests that the firmware change the kV setpoint.

Direction:
Host to supply

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

Where:
<ARG> = 0 - 4095 in ASCII format

Response:
If an error is detected, the Power Supply responds with:
<STX>10,!,<ERROR>,<CSUM><ETX>
Please reference the Error Code section for a list of valid error codes.

If the message is accepted, the Power Supply responds with:
<STX>10,$,<CSUM><ETX>

Example:
Set kV to the full scale voltage.
<STX>10,4095,<CSUM><ETX>

### 6.6.3  Program mA

Description:
The host requests that the firmware change the mA setpoint.

Direction:
Host to supply

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

Where:
<ARG> = 0 - 4095 in ASCII format

Response:
If an error is detected, the Power Supply responds with:
<STX>11,!,<ERROR>,<ETX>
Please reference the Error Code section for a list of valid error codes.

If the message is accepted, the Power Supply responds with:
<STX>11,$,<CSUM><ETX>

Example:
Set mA to the full scale current.
<STX>11,4095,<CSUM><ETX>

### 6.6.4  Request kV Setpoint

Description:
The host requests that the firmware report the kV setpoint.

Direction:
Host to supply

Syntax:
<STX><14><,><CSUM><ETX>

Response:
If an error is detected, the Power Supply responds with:
<STX>14,!,<ERROR>,<CSUM><ETX>
Please reference the Error Code section for a list of valid error codes..

If the message is accepted, the Power Supply responds with:
<STX>14,<ARG>,<CSUM><ETX>

Where:
<ARG> = 0 - 4095 in ASCII format

Example Response:
KV setpoint is set to full scale.
<STX>14,4095,<CSUM><ETX>

### 6.6.5  Request mA Setpoint

Description:
The host requests that the firmware report the current mA setpoint.

Direction:
Host to supply

Syntax:
<STX><15><,><CSUM><ETX>

Response:
If an error is detected, the Power Supply responds with:
<STX>15,!,<ERROR>,<CSUM><ETX>
Please reference the Error Code section for a list of valid error codes.

If the message is accepted, the Power Supply responds with:
<STX>15,<ARG>,<CSUM><ETX>

Where:
<ARG> = 0 - 4095 in ASCII format

Example Response:
MA setpoint is set to full scale.
<STX>15,4095,<CSUM><ETX>

### 6.6.6  Request Miscellaneous Analog Monitor Readbacks

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

Direction:
Host to supply

Syntax:
<STX><20><,><CSUM><ETX>

Response:
If an error is detected, the Power Supply responds with:
<STX>20,!,<ERROR>,<CSUM><ETX>
Please reference the Error Code section for a list of valid error codes.

If the message is accepted, the Power Supply responds with:
<STX>20,<ARG1>,<ARG2>,<ARG3>,<ARG4>,<ARG5>,<ARG6>,<ARG7>,<ARG8>,<CSUM><ETX>

Where:
<ARG1> = Remote Over Voltage Protection
<ARG2> = Spare
<ARG3> = Power Reference
<ARG4> = Power Monitor
<ARG5> = Control Board Temperature
<ARG6> = Spare
<ARG7> = Spare
<ARG8> = Spare

Range:
Valid values are 0 - 4095 in ASCII format.

Example Response:.
<STX>20,2048,0,4095,4095,1023,0,0,0,<CSUM><ETX>

### 6.6.7  Request Status/Faults

Description:
The host requests that the firmware sends the power supply statuses and faults.

Direction:
Host to supply

Syntax:
<STX><22><,><CSUM><ETX>

Response:
If an error is detected, the Power Supply responds with:
<STX>22,!,<ERROR>,<CSUM><ETX>
Please reference the Error Code section for a list of valid error codes.

If the message is accepted, the Power Supply responds with:
<STX>22,<ARG1>,<ARG2>,<ARG3>,<ARG4>,<ARG5>,<ARG6>,
<ARG7>,<ARG8>,<ARG9>,<ARG10>,<ARG11>,<ARG12>,
<ARG13>,<ARG14>,<ARG15>,<ARG16>,<ARG17>,<CSUM>
<ETX>

Where:
| | |
|---|---|
| <ARG1> = Power On | <ARG10> = Regulation Error |
| <ARG2> = HV Ray On | <ARG11> = Current Control Mode |
| <ARG3> = Arc | <ARG12> = Over Temperature |
| <ARG4> = Interlock Closed | <ARG13> = Power Control Mode |
| <ARG5> = Over Current | <ARG14> = AC Fault |
| <ARG6> = Over Power | <ARG15> = Local/Remote Mode |
| <ARG7> = Over Voltage | <ARG16> = LVPS Fault |
| <ARG8> = Voltage Control Mode | <ARG17> = HV Inhibit |
| <ARG9> = System Fault | |

Range:
Valid values are 0 or 1 in ASCII format.
0 = Off/No Fault
1= On/Fault

Example Response:.
Power's On with an Over Current Fault.
<STX>22,1,0,0,0,1,0,0,0,1,0,0,0,0,0,0,0,<CSUM><ETX>

### 6.6.8  Request DSP Software Part Number/Version

Description:
The host requests that the firmware sends the firmware send the DSP Software part and build number.

Direction:
Host to supply

Syntax:
<STX><23><,><CSUM><ETX>

Response:
If an error is detected, the Power Supply responds with:
<STX>23,!,<ERROR>,<CSUM><ETX>
Please reference the Error Code section for a list of valid error codes.

If the message is accepted, the Power Supply responds with:
<STX>23,<ARG1>,<ARG2>,<CSUM><ETX>

Where:
<ARG1> = Consists of eleven ASCII characters representing the current firmware part number/version. The format is SWM9999-999.
<ARG2> = Consists of four ASCII characters representing the current build number.  The format is 3261.

Example Response:
<STX>23, SWM9999-999,3261,<CSUM><ETX>

### 6.6.9 Request Model Number

Description:
The host requests that the firmware sends the unit model number.

Direction:
Host to supply

Syntax:
<STX><26><,><CSUM><ETX>

Response:
If an error is detected, the Power Supply responds with:
<STX>26,!,<ERROR>,<CSUM><ETX>
Please reference the Error Code section for a list of valid error codes.

If the message is accepted, the Power Supply responds with:
<STX>26,<ARG>,<CSUM><ETX>

Where:
<ARG> = Consists up to fifteen ASCII characters representing the current model number.

Example Response:
<STX>26,ST100P100X4249,<CSUM><ETX>

### 6.6.10  Request User Configurations

<u>Description:</u>
The host requests that the firmware send the user configurable items.

<u>Direction:</u>
Host to supply

<u>Syntax:</u>
<STX><27><,><CSUM><ETX>

<u>Response:</u>
If an error is detected, the Power Supply responds with:
<STX>27,!,<ERROR>,<ETX>
Please reference the Error Code section for a list of valid error codes.

If the message is accepted, the Power Supply responds with:
<STX>27,<ARG1>,<ARG2>,<CSUM><ETX>

<u>Where:</u>
<ARG1> = kV Rate Ramp
<ARG2> = mA Rate Ramp
<ARG3> = AOL Enabled
<ARG4> = APT Enabled

<u>Range:</u>
Valid values for ARG1 and ARG2 are from 0 through 10000 milliseconds.
For ARG3 and ARG4 the valid values are 0 (disabled) and 1 (enabled).

<u>Example Response:</u>
 kV and mA to a 10 millisecond ramp, with AOL enabled and APT
disabled.
<STX>27,10,10,1,0,<CSUM><ETX>

### 6.6.11  Request Unit Scaling

Description:
The host requests that the firmware send the full scale range values.

Direction:
Host to supply

Syntax:
<STX><28><,><CSUM><ETX>

Response:
If an error is detected, the Power Supply responds with:
<STX>28,!,<ERROR>,<ETX>
Please reference the Error Code section for a list of valid error codes.

If the message is accepted, the Power Supply responds with:
<STX>28,<ARG1>,<ARG2>,<CSUM><ETX>

Where:
<ARG1> = Full Scale kV Value
<ARG2> = Full Scale mA Value

Example Response:
For a 100kV/1000mA power supply
<STX>28,100,1000,<CSUM><ETX>

### 6.6.12 Request FPGA Software Part Number/Version

Description:
The host requests that the firmware sends the firmware send the FPGA Software part and build number.

Direction:
Host to supply

Syntax:
<STX><43><,><CSUM><ETX>

Response:
If an error is detected, the Power Supply responds with:
<STX>43,!,<ERROR>,<CSUM><ETX>
Please reference the Error Code section for a list of valid error codes.

If the message is accepted, the Power Supply responds with:
<STX>43,<ARG1>,<ARG2>,<CSUM><ETX>

Where:
<ARG1> = Consists of eleven ASCII characters representing the current firmware part number/version. The format is SWM9999-999.
<ARG2> = Consists of four ASCII characters representing the current build number.  The format is 3261.

Example Response:
<STX>43,SWM9999-999,3261,<CSUM><ETX>

### 6.6.13  Request kV Monitor

Description:
The host requests that the firmware report kV monitor.

Direction:
Host to supply

Syntax:
<STX><60><,><CSUM><ETX>

Response:
If an error is detected, the Power Supply responds with:
<STX>60,!,<ERROR>,<CSUM><ETX>
Please reference the Error Code section for a list of valid error codes.

If the message is accepted, the Power Supply responds with:
<STX>60,<ARG>,<CSUM><ETX>

Where:
<ARG> = 0 - 4095 in ASCII format

Example Response:
KV monitor is set to full scale.
<STX>60,4095,<CSUM><ETX>

### 6.6.14  Request mA Monitor

Description:
The host requests that the firmware report mA monitor.

Direction:
Host to supply

Syntax:
<STX><61><,><CSUM><ETX>

Response:
If an error is detected, the Power Supply responds with:
<STX>61,!,<ERROR>,<CSUM><ETX>
Please reference the Error Code section for a list of valid error codes.

If the message is accepted, the Power Supply responds with:
<STX>61,<ARG>,<CSUM><ETX>

Where:
<ARG> = 0 - 4095 in ASCII format

Example Response:
mA monitor is set to full scale.
<STX>61,4095,<CSUM><ETX>

### 6.6.15 Request Slave Faults

Description:
The host requests that the firmware report Slave Faults.

Direction:
Host to supply

Syntax:
<STX><68><,><CSUM><ETX>

Response:
If an error is detected, the Power Supply responds with:
<STX>68,!,<ERROR>,<CSUM><ETX>
Please reference the Error Code section for a list of valid error codes.

If the message is accepted, the Power Supply responds with:
<STX>68,<ARG1>,<ARG2>,<ARG3>,<ARG4>,<ARG5>,<ARG6>,<ARG7>,<ARG8>,<ARG9>,<CSUM><ETX>

Where:
<ARG1> = Slave 1 Faults
<ARG2> = Slave 2 Faults
<ARG3> = Slave 3 Faults
<ARG4> = Slave 4 Faults
<ARG5> = Slave 5 Faults
<ARG6> = Slave 6 Faults
<ARG7> = Slave 7 Faults
<ARG8> = Slave 8 Faults
<ARG9> = Slave 9 Faults

Range:
Valid values are 0 to 65535 in ASCII format.
0 = Off/No Fault
1= On/Fault

Other Error Codes to TBD.

Example Response:.
Slave number 4 has a Fault.
<STX>68,0,0,0,1,0,0,0,0,0,0,0,0,0,<CSUM><ETX>

### 6.6.16  Request System Voltages

Description:
The host requests that the firmware report System Voltages.

Direction:
Host to supply

Syntax:
<STX><69><,><CSUM><ETX>

Response:
If an error is detected, the Power Supply responds with:
<STX>69,!,<ERROR>,<CSUM><ETX>
Please reference the Error Code section for a list of valid error codes.

If the message is accepted, the Power Supply responds with:
<STX>68,<ARG1>,<ARG2>,<ARG3>,<ARG4>,<ARG5>,<ARG6>,
<ARG7>,<CSUM><ETX>

Where:
<ARG1> = FPGA Voltage in ASCII
<ARG2> = 24V rail in ASCII
<ARG3> = 15V rail in ASCII
<ARG4> = 5V rail in ASCII
<ARG5> = 3.3V rail in ASCII
<ARG6> = -15V in ASCII
<ARG7> = Spare rail in ASCII


Example Response:.
Slave number 4 has a Fault.
<STX>69,1302,3047,3008,3426,2711,1857,2243,<ETX>

### 6.6.17 Reset Faults

Description:
The host requests the firmware to clear latched faults.

Direction:
Host to supply

Syntax:
<STX><74><,><CSUM><ETX>

Response:
If an error is detected, the Power Supply responds with:
<STX>74,!,<ERROR>,<CSUM><ETX>
Please reference the Error Code section for a list of valid error codes.

If the message is accepted, the Power Supply responds with:
<STX>74,$,<CSUM><ETX>

### 6.6.18 Program Local/Remote Mode

Description:
The host requests 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

Response:
If an error is detected, the Power Supply responds with:
<STX>99,!,<ERROR>,<CSUM><ETX>
Please reference the Error Code section for a list of valid error codes.

If the message is accepted, the Power Supply responds with:
<STX>99,$,<CSUM><ETX>

## 6.7   SPELLMAN TEST COMMANDS

- Program Hardware Version (Hardware setup)
- Program Model number(Hardware setup)
- 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.

### 7.0 ERROR CODES

Possible error codes are:
- 1 – Incorrectly formatted packet/message
- 2 – Invalid Command ID
- 3 – Parameter out of range
- 4 – Packet overrun FPGA Register read and write
- 5 – Flash programming error
- 7 – Bootloader failed

# SPELLMAN
## HIGH VOLTAGE ELECTRONICS CORPORATION

| PROCEDURE NO. 100960-551 | | REV: **B** | SHEET 1 of 7 |
|---|---|---|---|
| TITLE: **TI Upload Procedure** | | | |
| PREPARED BY: | APPROVED : S.CONGDON | | DATE: 5/9/06 |
| Bill Brasch | APPROVED : J.GALLEA | | DATE: 5/11/06 |

**1.0** PURPOSE:

This document defines the procedure required to program in-system-programmable TI DSP or Altera FPGA.

**2.0** SCOPE:

This document is limited to the programming of in-system programmable TI DSP or Altera FPGA device using a RS-232 port and TI Upload GUI on the PC.

**3.0** FILES TO BE USED:

3.1  DSP/FPGA Programming files:

3.1.1  The appropriate S2 file as listed in the bill of materials.

**4.0** EQUIPMENT REQUIRED

4.1  A PC with at least one available RS-232 port.

4.1.1  **NOTE\*-** Do not use a USB-Serial Converter for the firmware upload process. Doing so may corrupt the firmware updating process.

4.2  Target Control board.

**5.0** RS-232 Port Setting

5.1  115,200 - Baud

8 - Data bits

N - No parity

1 - Stop bit

**6.0** PROGRAMMING PROCEDURE:

- When first entering the Firmware Upload GUI, the **Program** buttons will not be accessible but the **Load File** button will.

- When the **Load File** Button is clicked the following window will appear. In this window you can navigate to the directory where the programming files are stored. The GUI recognizes S record files (SWPxxxx-xxx.S2/altera_rev###.S2 for the FPGA and SWMxxxx-xxx.S2/tidsp_rev### .S2 for the DSP). Select the file and click on the **Open** Button.
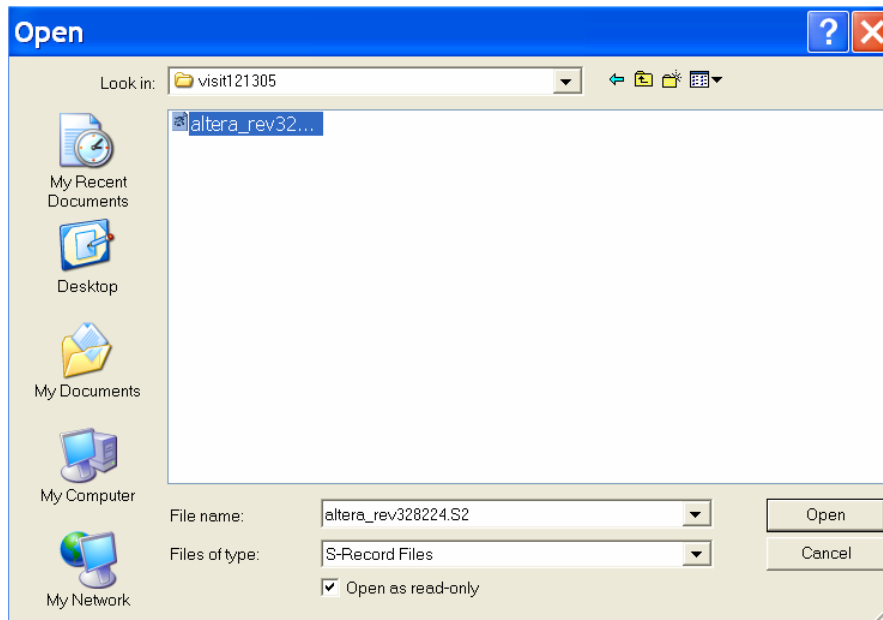


- A **firmUpload** window will open, click the **OK** button.
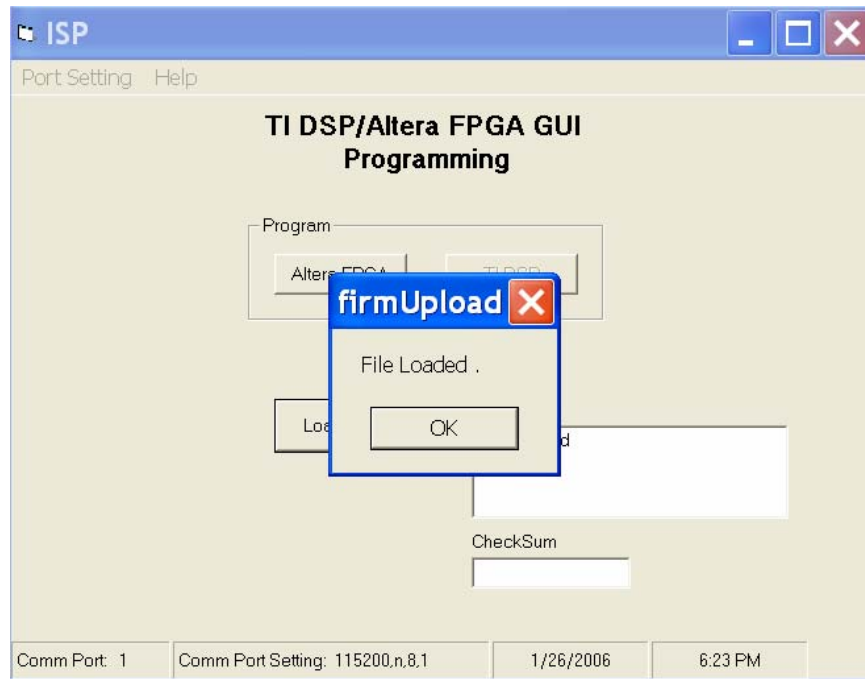
- Depending upon the programming file selected the appropriate Program button will be enabled. Since the file selected started with SWPxxxx-xxx/altera_rev the Altera FPGA button is shown as enabled. If the file selected started with SWMxxxx-xxx/tidsp_rev then the TI DSP button would be enabled. Click the enabled **Program** button.
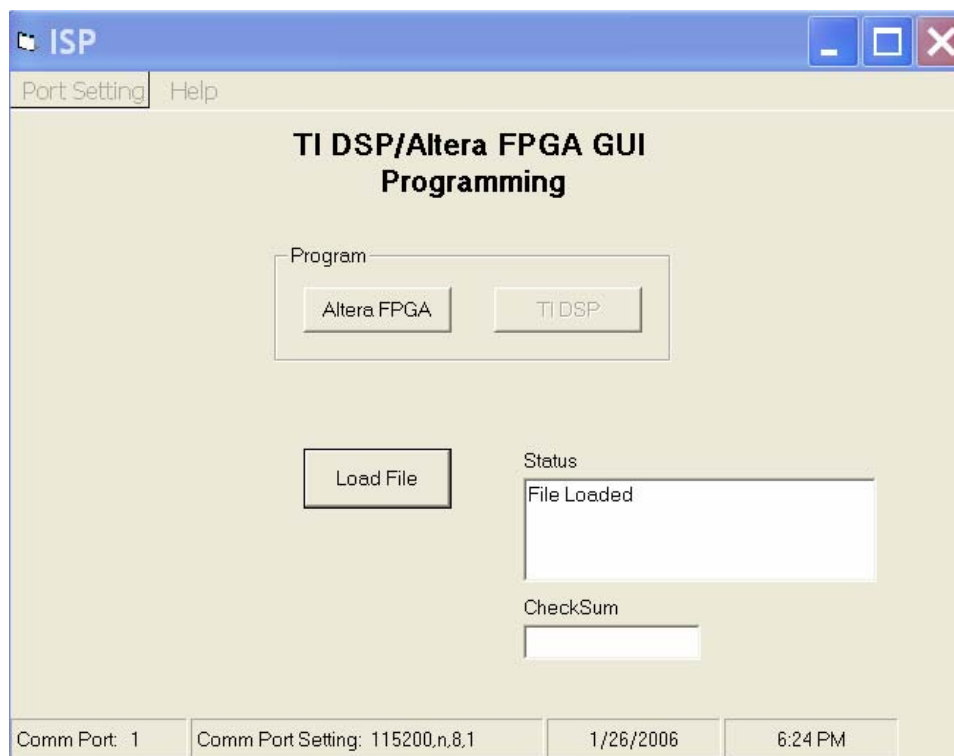
- This window will appear asking if you are sure you want to program the FPGA (DSP if that was the programming file selected). Click the **Yes** button.
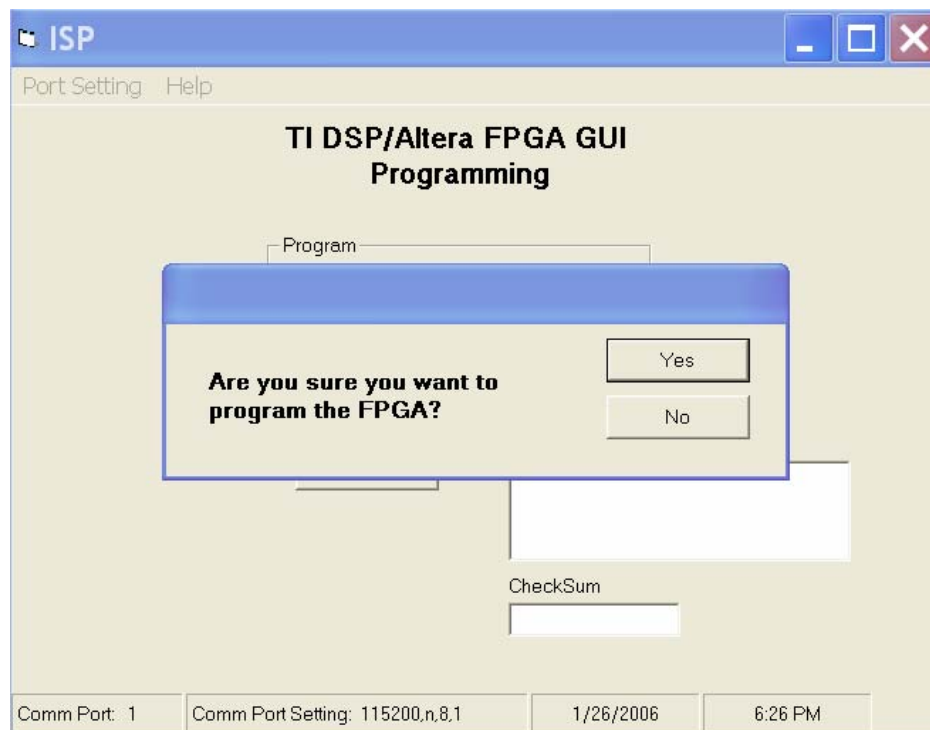
o   If the No button was clicked then a **frmUpload** window will appear, click **OK**. You will then return to the Main GUI window with the program buttons disabled (as in the first step).
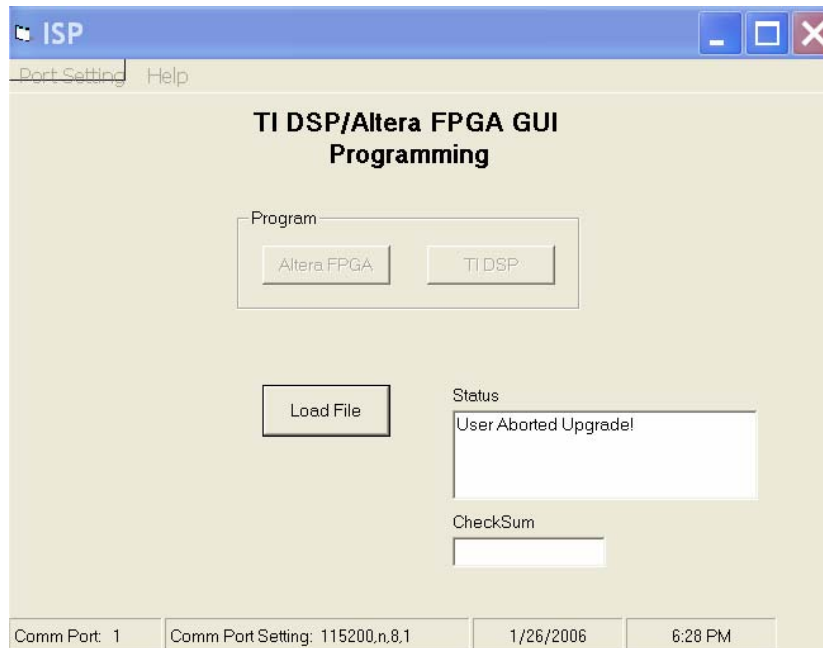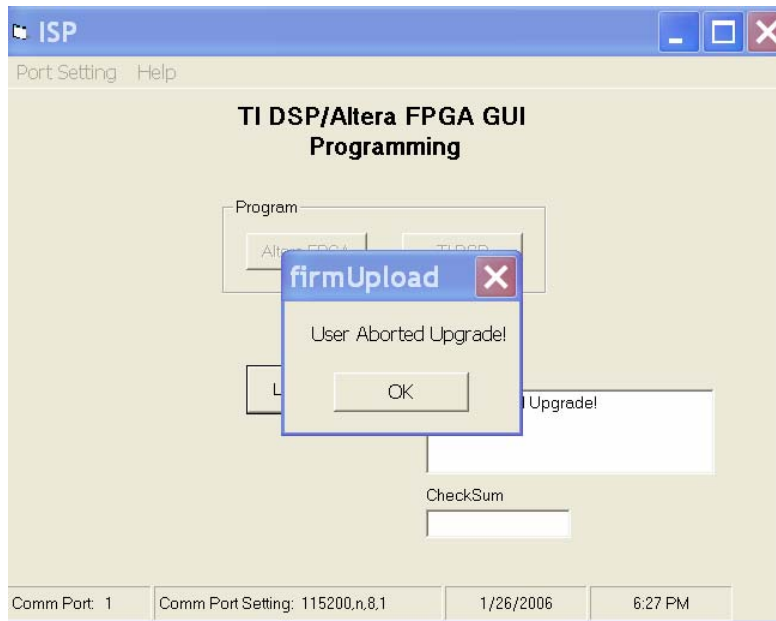




*   After clicking Yes to program the FPGA the following progress bar window will open.

**TI DSP 2812**

Uploading C:\projects\SrecordGenerator\M0345-001
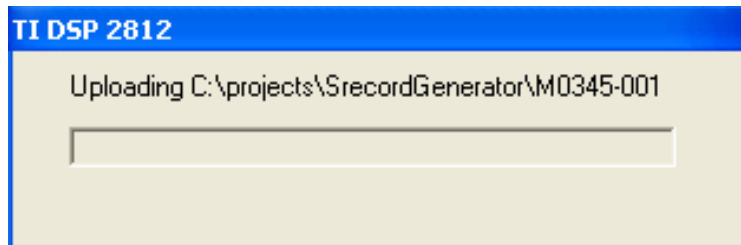
- When programming has completed a **firmUpload** window will appear indicating "**Firmware Update Completed"**.  Click the **OK** button.

**firmUpload** ✕

Firmware Update Completed.

OK
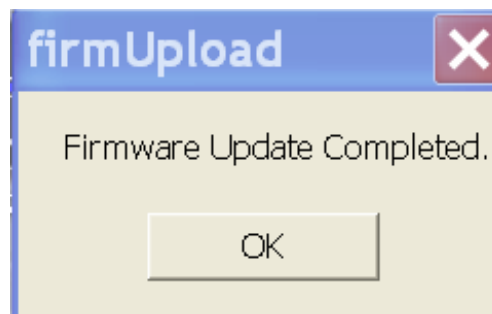
- The Main GUI window will appear with the **Program** buttons disabled.
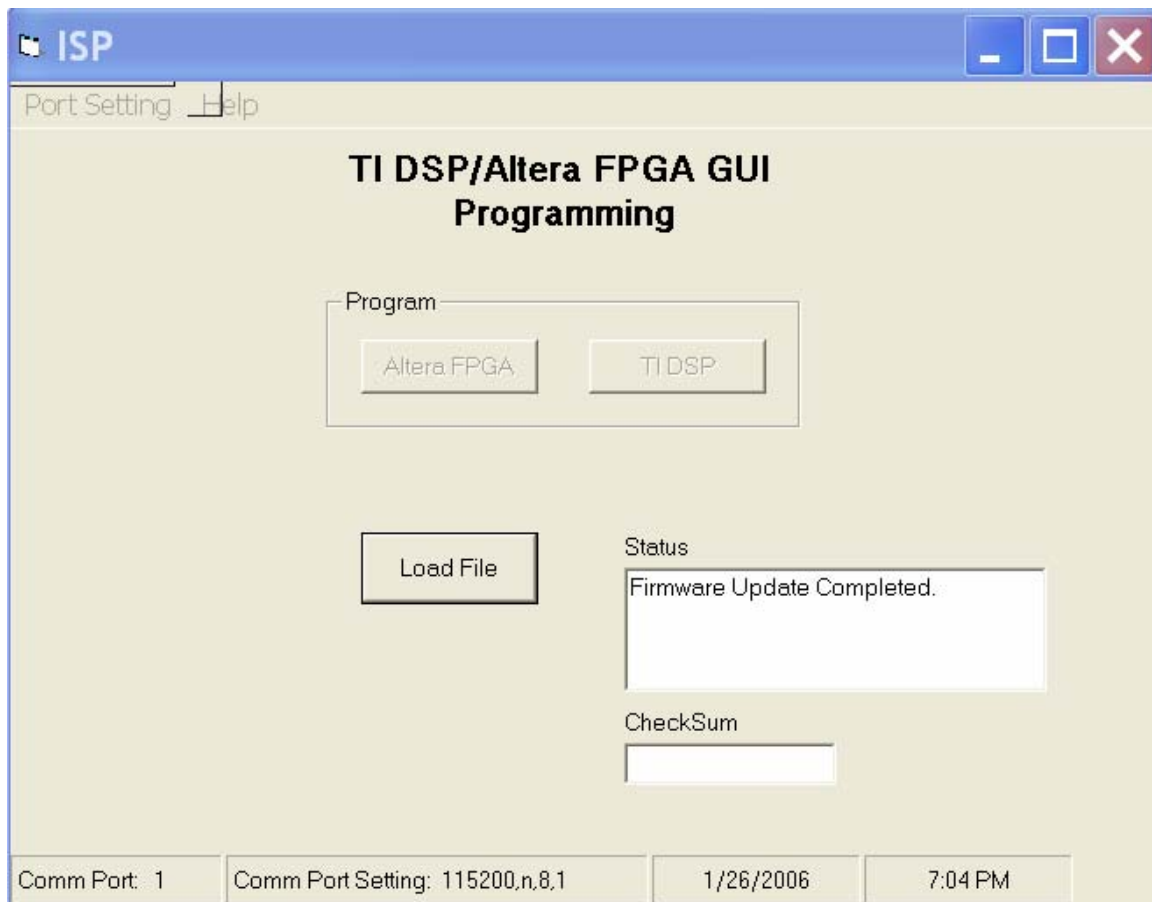
End of document.

# SPELLMAN
## HIGH VOLTAGE ELECTRONICS CORPORATION

| PROCEDURE NO. 101501-580 | | REV: A | SHEET 1 of 12 |
|---|---|---|---|
| TITLE; PROC. STANDARD ST GUI INSTALLATION INSTRUCTIONS | | | |
| PREPARED BY: | APPROVED :M.PARIS | | DATE: 10/13/11 |
| Mat Krass | APPROVED :M.SHAH | | DATE: 10/13/11 |

1.0     PURPOSE:
        This document defines the procedure required for Standard ST GUI installation.

2.0     PROCEDURE:
        Installation procedure is as follows:


1. Installation Instruction for Standard ST GUI:


    1.      If you received the software on a CD, insert the CD in to your computer and navigate to the CD using 'My Computer', if you received the software via internet download, navigate to the directory where the software installer was downloaded. Double click on the 'setup.exe' icon, a window will appear offering to install the ST_GUI software on your computer:
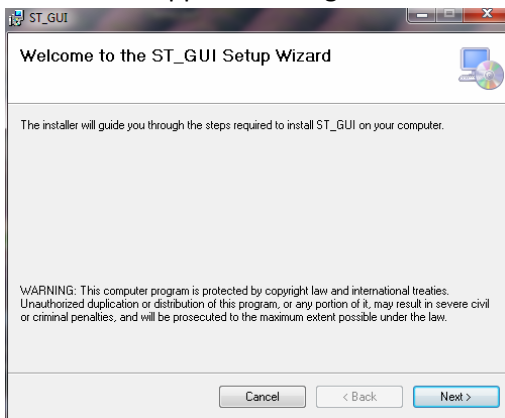


    2       Proceed by selecting 'Next' in the bottom right corner
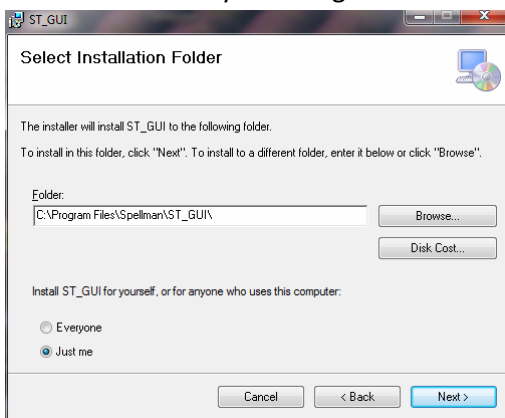


| REV:A | ECN:26000 | APPVD:MP,MS,MS | DATE:10/14/11 | REV: | ECN: | APPVD: | DATE: |
|---|---|---|---|---|---|---|---|
| REV: | ECN: | APPVD: | DATE | REV: | ECN: | APPVD: | DATE: |
| REV: | ECN: | APPVD: | DATE: | REV: | ECN: | APPVD: | DATE: |

3 If you wish to change the path the software will install to, select the 'Browse' button and navigate to a new path, otherwise select 'Next'
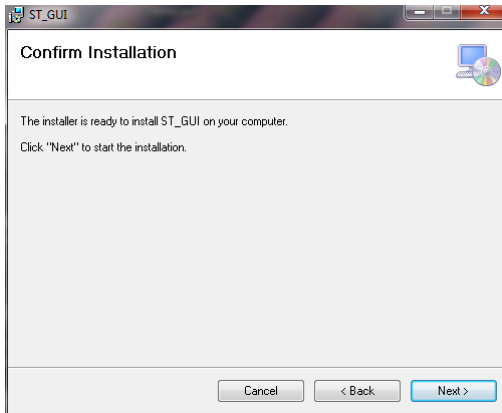


4 At this point, the installer is ready to proceed, if you want to change the path, you can select 'Back' and then 'Browse' from the previous screen, or select 'Cancel' to abort the installation before any changes are made to your computer. If you are ready to install, click 'Next'.
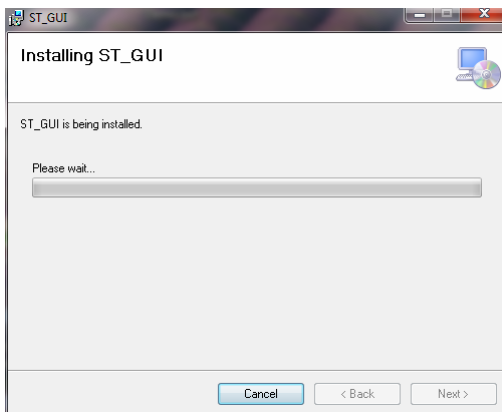


5 Installation will begin and a progress bar will indicate the status of the install, this may take up to 3 minutes.
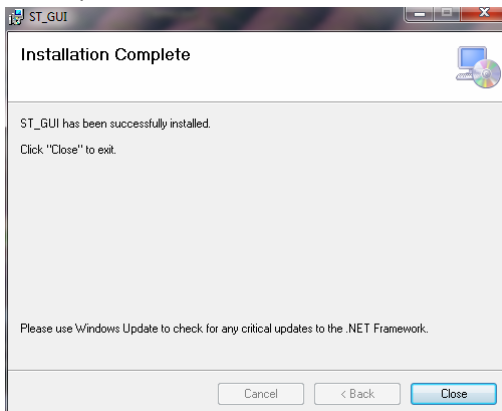


6 Once completed, the installer will display a message indicating successful installation, simply click 'Close' to finish.

2      Initial startup and configuration – Serial port

     1.   Using the Start Menu, navigate to the Spellman High Voltage Demo GUI program group and select the ST_GUI application there. Upon first startup, the GUI will display the main screen, and indicate it is not connected in the title bar.



     2.   To begin configuration of the software for your power supply, select the 'Coms' tab.



Select 'Coms' tab here to configure your software
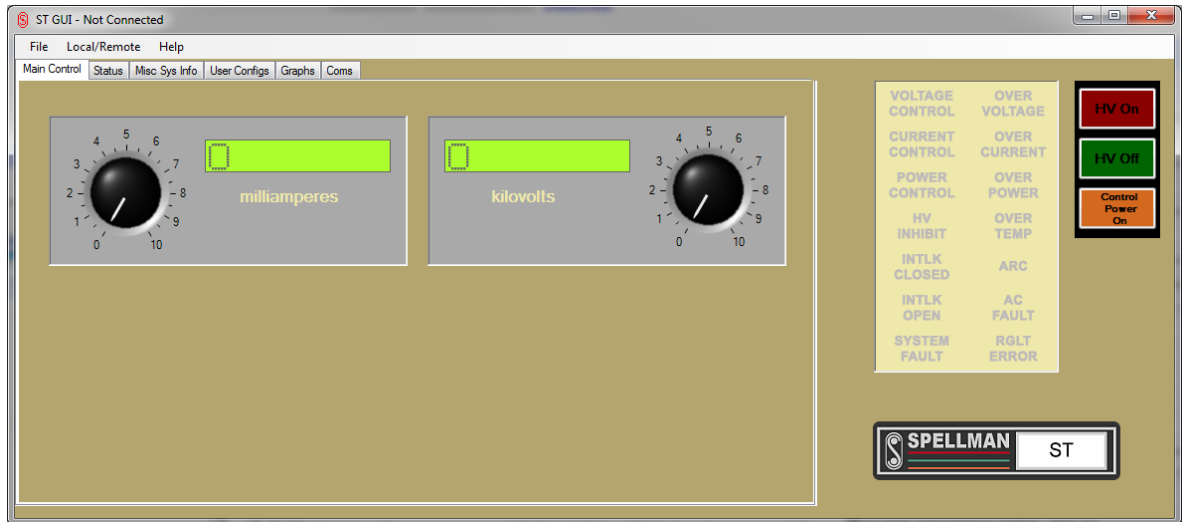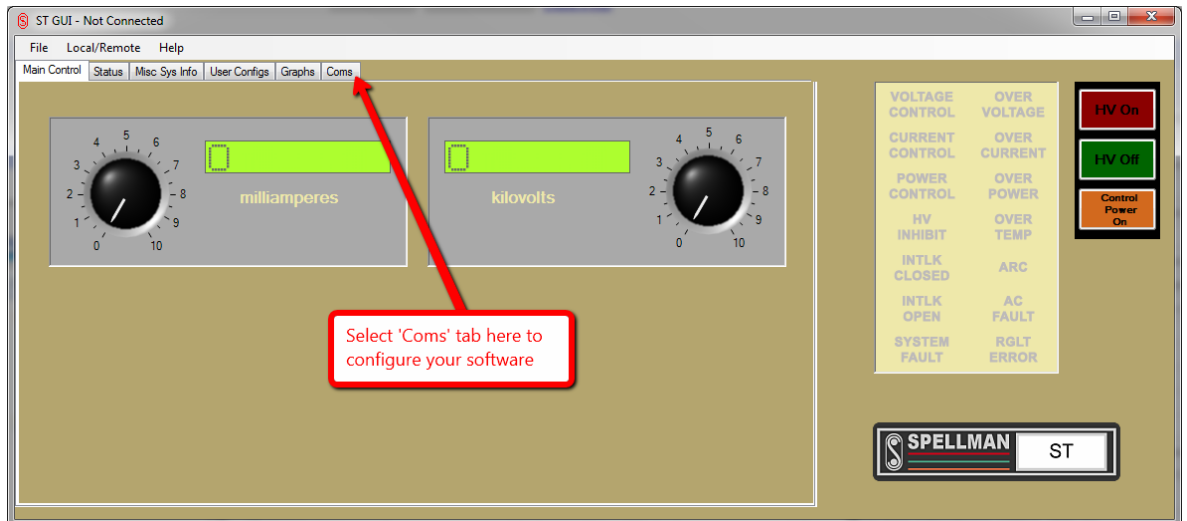
3. Select RS-232 Communications by clicking the radio button to the left of it, and you will be presented with a list of available COM ports on your computer.
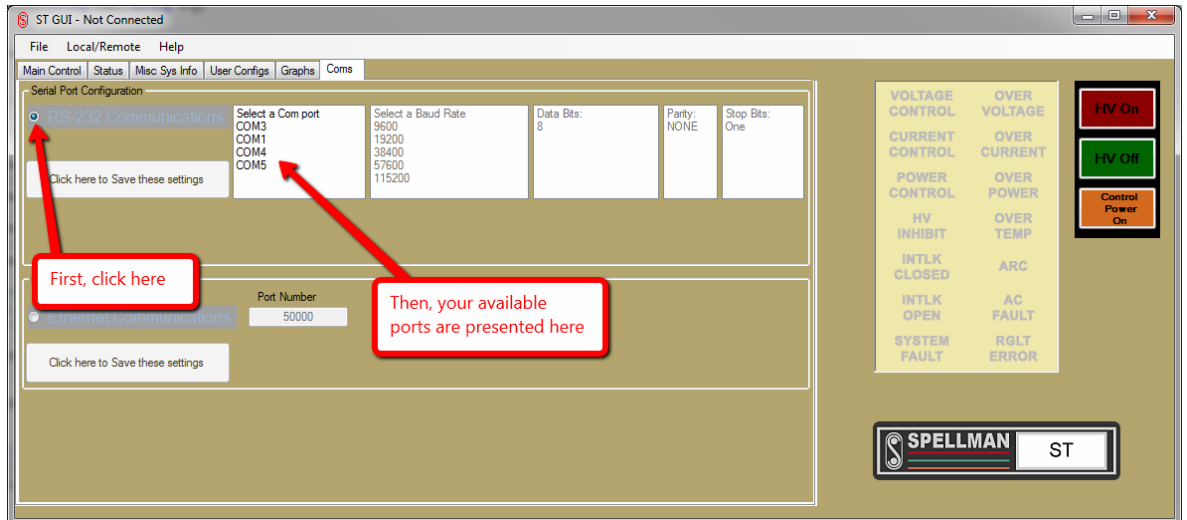


4. Select the port you are using by clicking it with the mouse, it will be highlighted and you will then be presented with options for available baud rates.
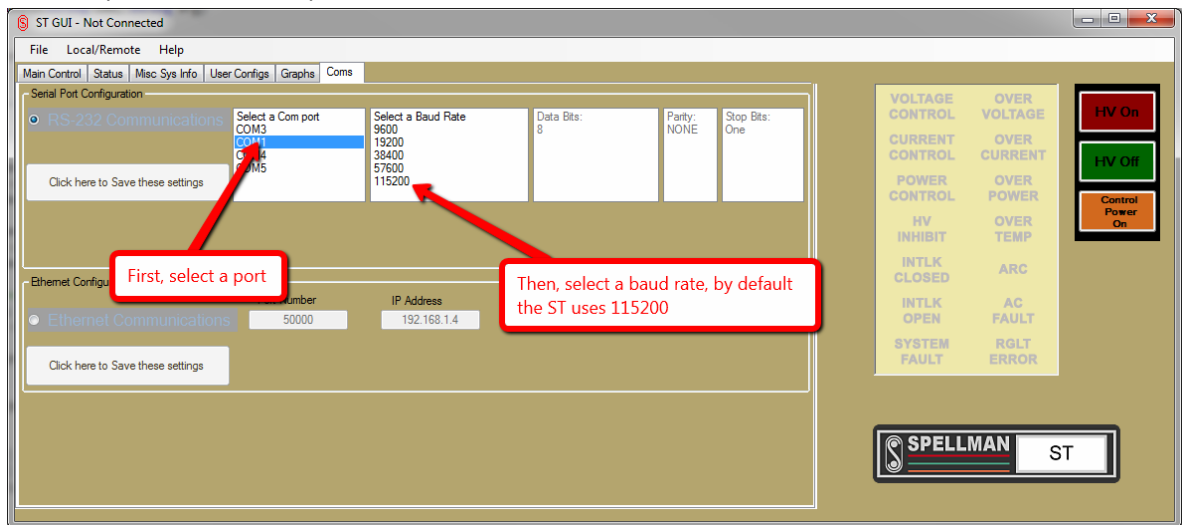


5. Select the baud rate in the same manner by clicking on it with the mouse, note that the default baud rate for ST units is 115200, and this is the option you should select unless you have specifically requested a different baud rate. Once selected, you will be presented with an option for selecting the Data Bit number.
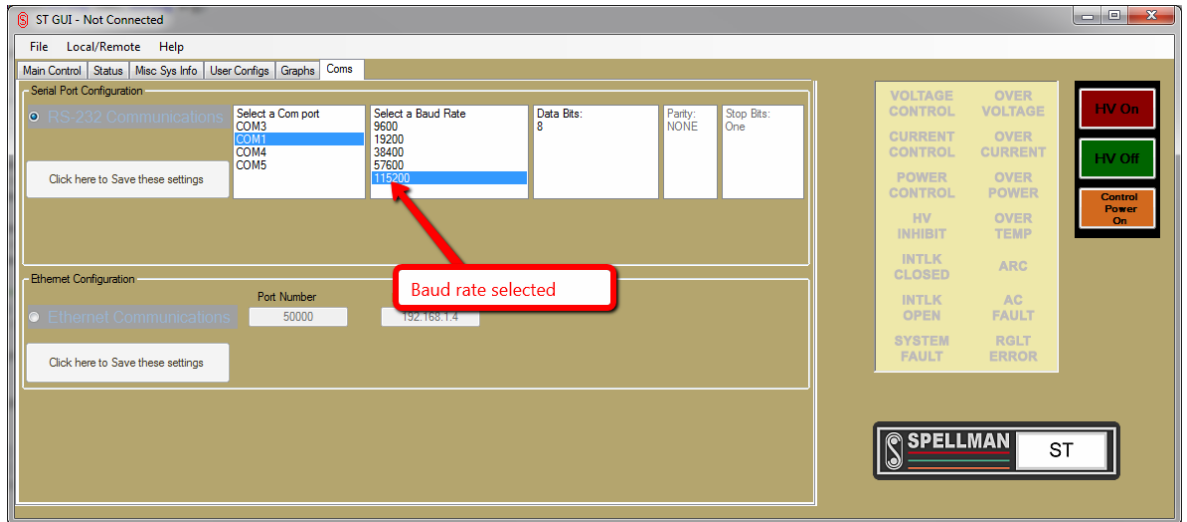
6. For the remaining three settings, you are presented with one option apiece, and should select that option as your default, if you have requested specifically different settings, please contact Spellman High Voltage for instruction on how to configure your system for these options.
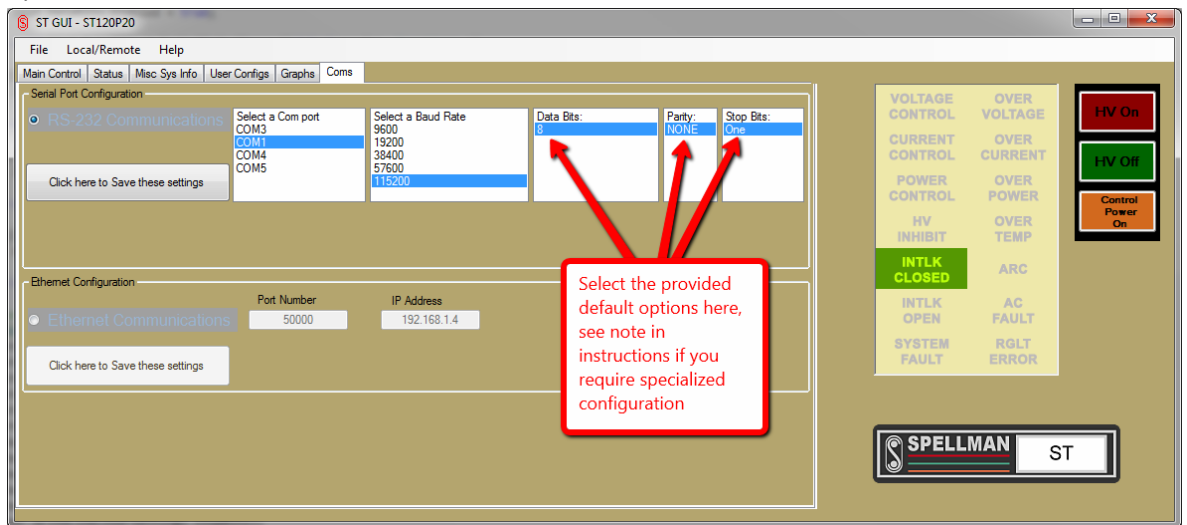


7. Make sure the power supply has control power and is properly connected to the serial port on your computer, then click 'Click here to Save these settings' to save the settings and connect to the power supply. After a moment, the indicator panel to the right should become active and show the same as the panel on the front of the supply, and the model number should appear in the title bar.
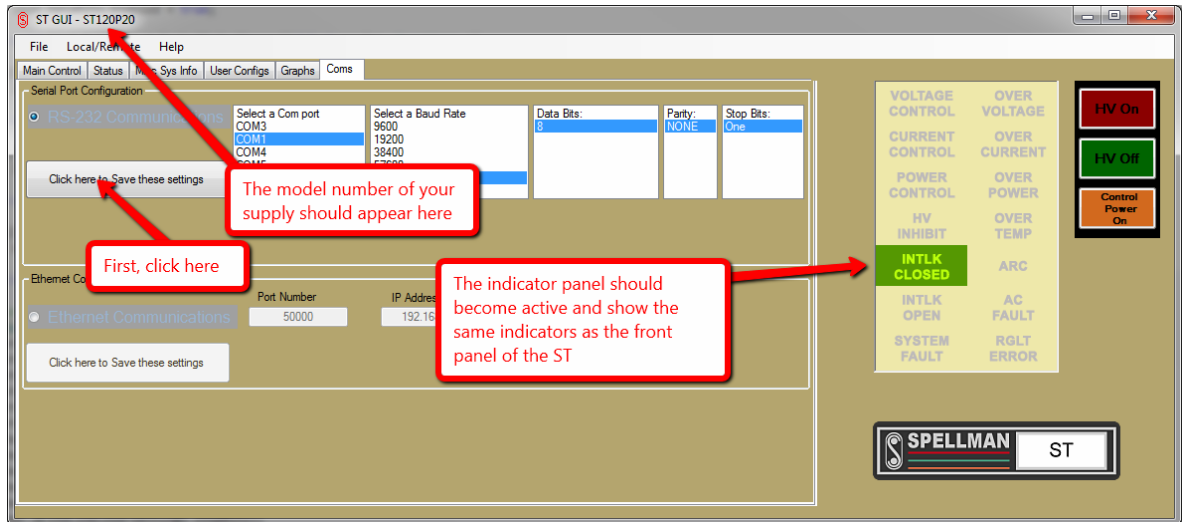
8.  The unit is now configured, these settings will automatically save upon connection so you will not need to configure the software again unless you need different settings. Please see Section 4 – Main Operation for an overview of the main control screens.

3    Initial startup and configuration – Ethernet

1.   Using the Start Menu, navigate to the Spellman High Voltage Demo GUI program group and select the ST_GUI application there. Upon first startup, the GUI will display the main screen, and indicate it is not connected in the title bar.
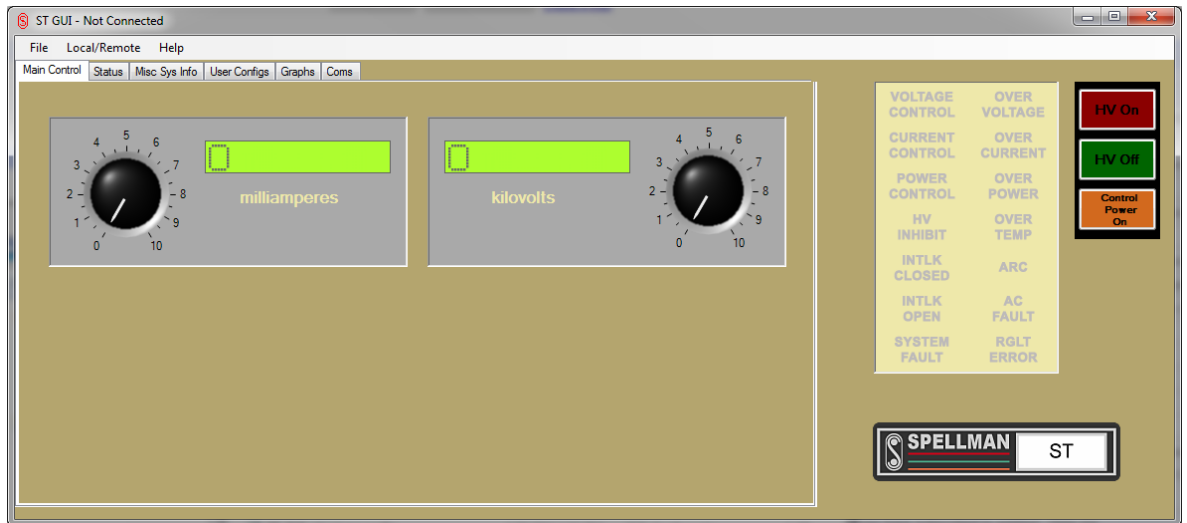


2.   To begin configuration of the software for your power supply, select the 'Coms' tab.
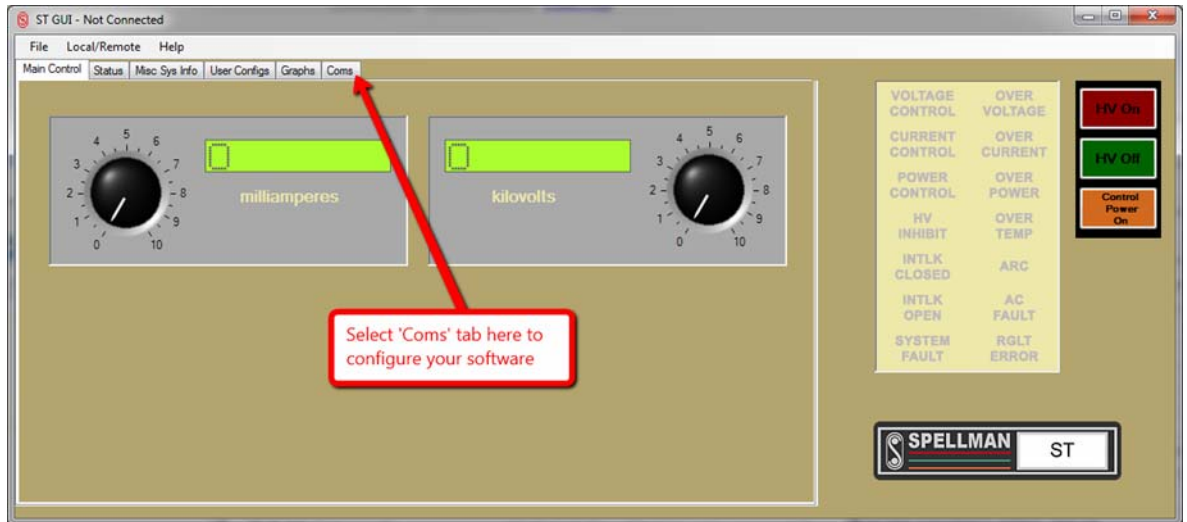
3.  Select RS-232 Communications by clicking the radio button to the left of it, the fields for IP address and port number will become active.
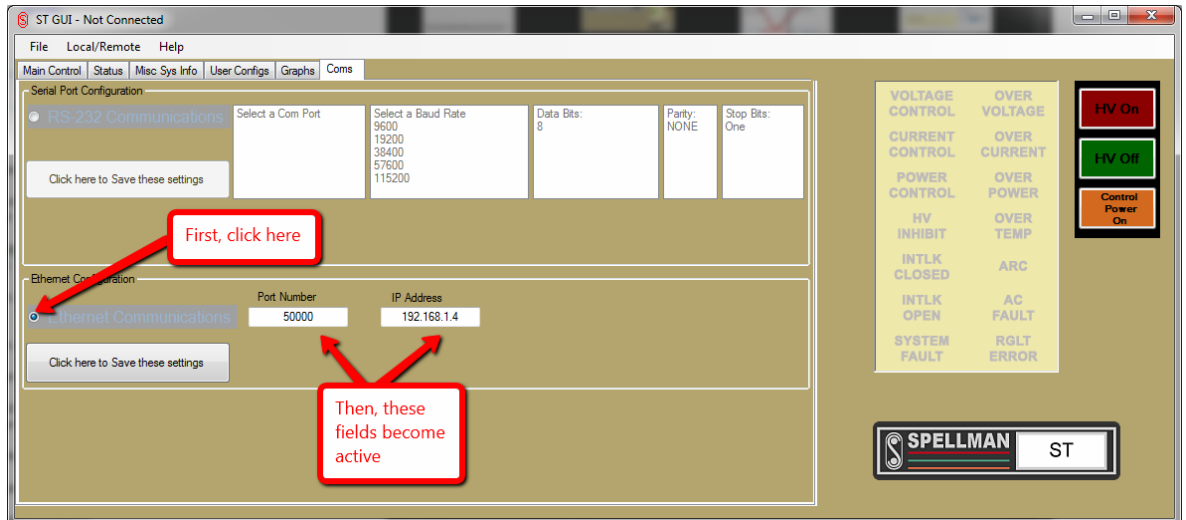


4.  The default address and port number are automatically entered for you in the field, if you requested a different configuration with the unit, or have changed the units settings in the past, enter the correct information here. If you did not request a different configuration and you are unable to use the default settings, please contact Spellman High Voltage to address the situation.

5.  Make sure the power supply has control power and is properly connected to the same computer network your computer, or that it is connected directly via cross-over cable, then click 'Click here to Save these settings' to save the settings and connect to the power supply. After a moment, the indicator panel to the right should become active and show the same as the panel on the front of the supply, and the model number should appear in the title bar.
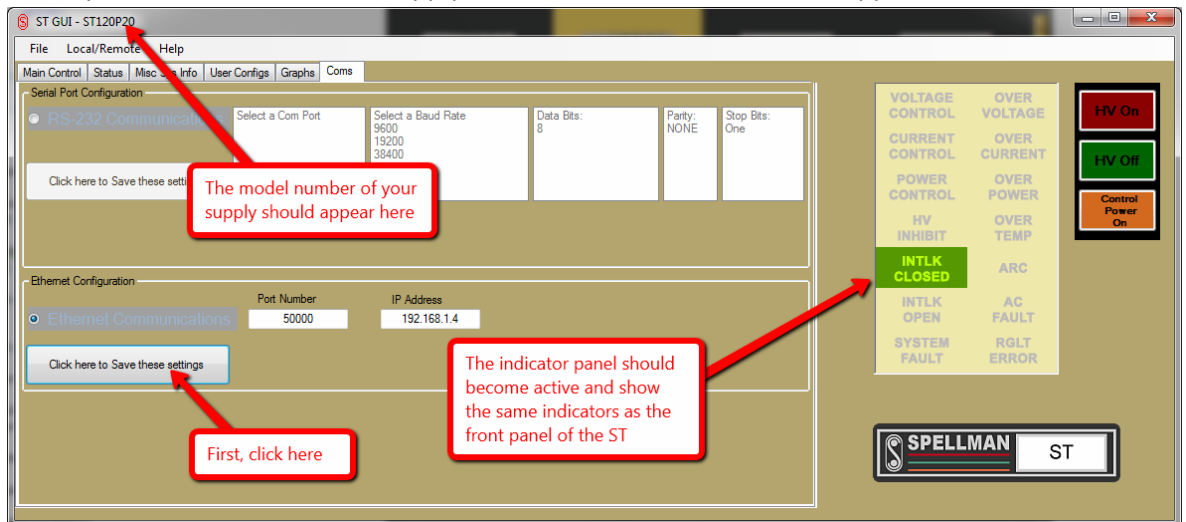


6.  The unit is now configured, these settings will automatically save upon connection so you will not need to configure the software again unless you need different settings. Please see Section 4 – Main Operation for an overview of the main control screens.

4     Main Operation

1. Once the software has established a connection to the supply, you can access the 'Main Control' tab by selecting it with the mouse. This tab is selected by default on startup once the software has been configured..
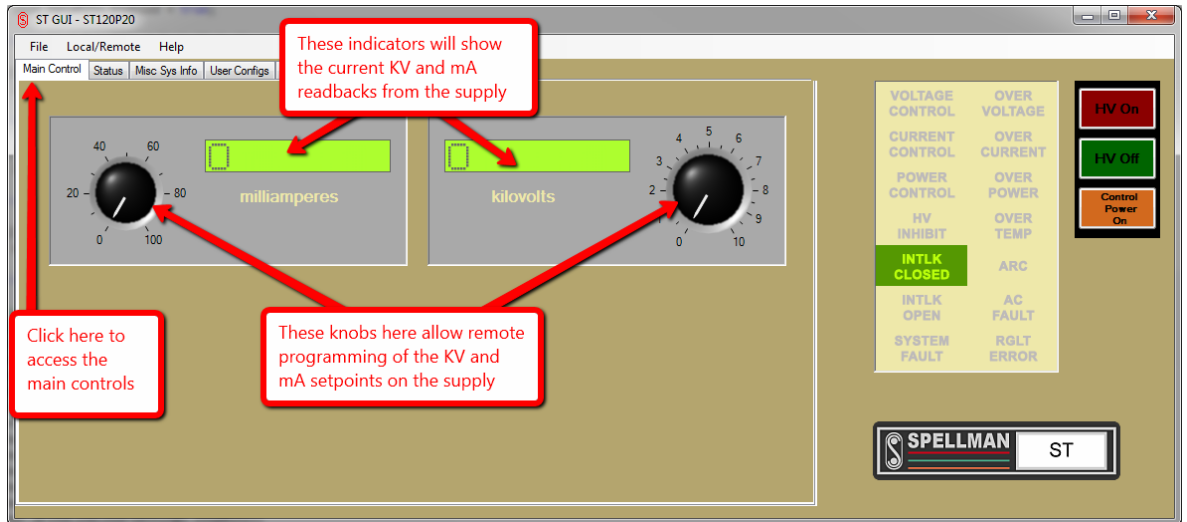


2. From the main control screen, you can see the current readbacks for KV and mA, and you can also use the knobs to set the remote programming levels for both KV and mA. This screen cannot enable high voltage output; that can be only controlled using the hardware interface.

> NOTE: In order to use the remote programming knobs, the power supply must be put in remote mode by selecting the 'Local/Remote' menu, and then selecting 'Remote':
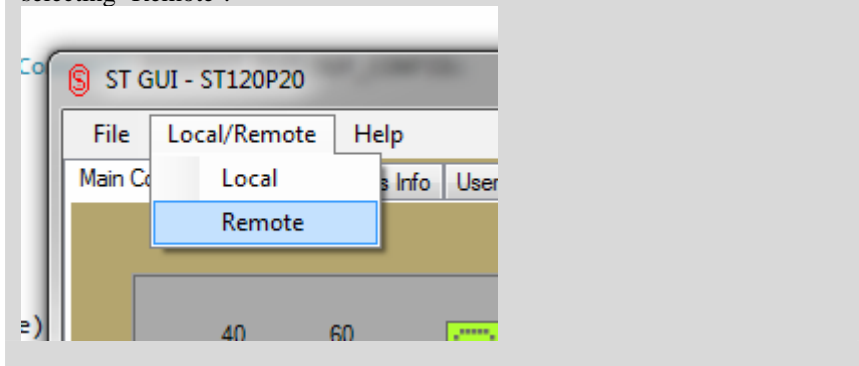


3. To control the power supply, use the front panel or remote hardware interface to power on the supply, and if you wish to program the output using the software, follow the above instructions to put the supply in remote mode. Once the power supply is creating high

voltage, the proper indicators should appear on the screen.
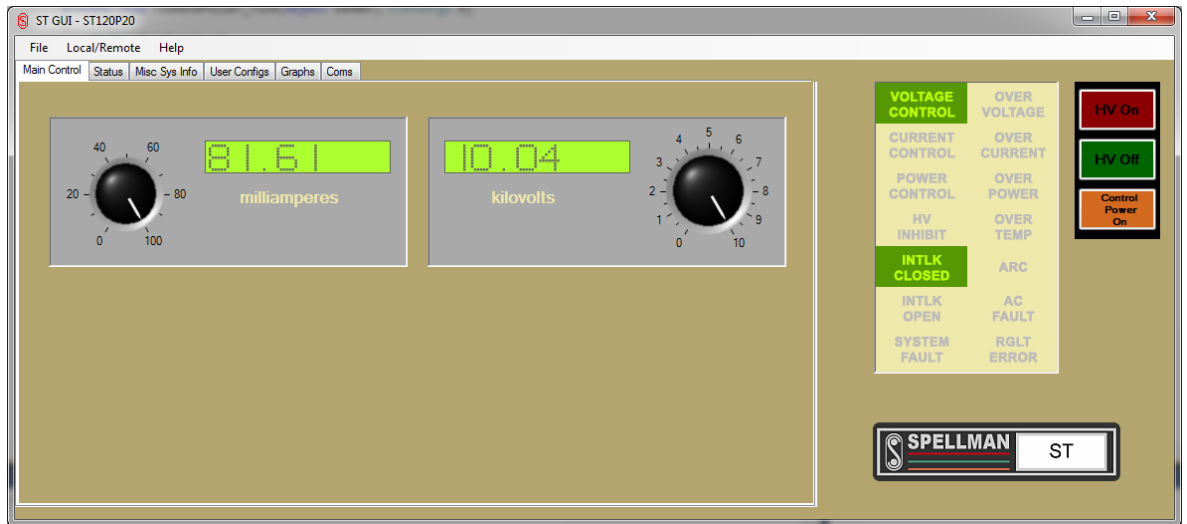


4.  The other tabs provide additional operating information about the power supply and its current status, for more information on these screens, see Section 5 – Status, Configuration and Graphing.

# 5 Status, Configuration and Graphing

Besides the 'Coms' and 'Main Control' tabs are four other auxiliary tabs that display additional information and configuration options for the system. In order, these are the 'Status', 'Misc Sys Info', 'User Configs' and 'Graphs' tabs. Each one is explain in depth below

## 5.1 Status Tab
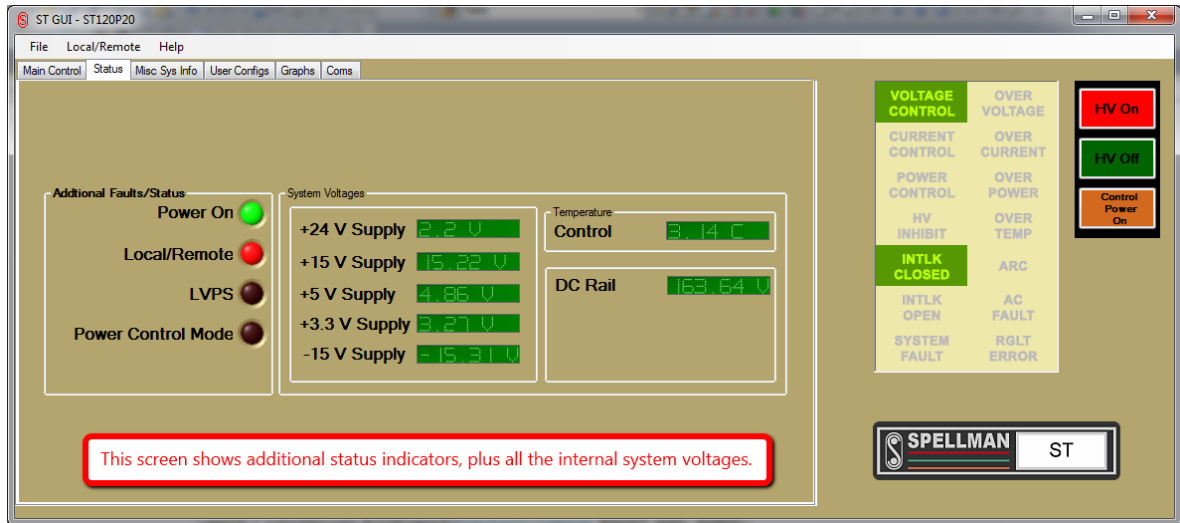


This tab shows a variety of status indicators including the state of the control power, local/remote mode indicators, the Low Voltage Power Supply problem indicator and a variety of housekeeping voltages in the Low Voltage Power Supply.

## 5.2 Misc Sys Info Tab
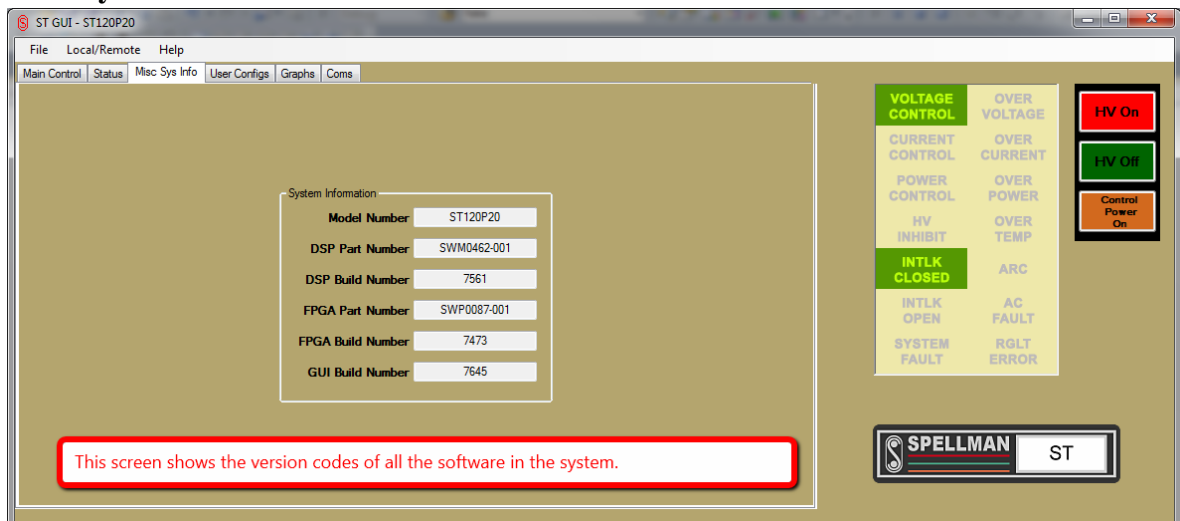


This tab indicates the model number and software version information for the power supply, as well as the desktop GUI version currently running.

### 5.3 User Configs Tab
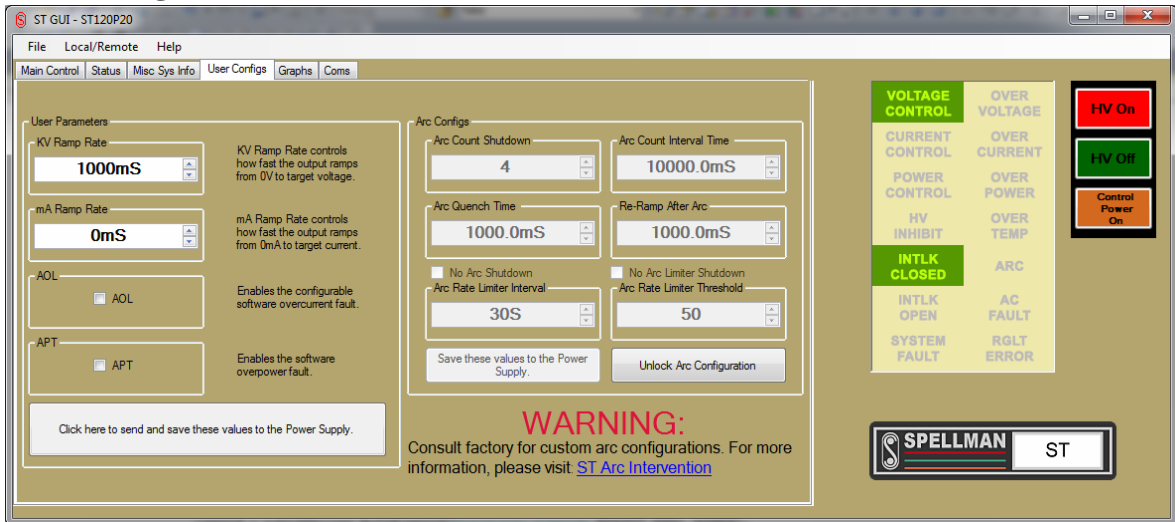


This tab allows configuration of the advanced parameters of the ST power supply unit. This tab should not be used unless you have read the manual and understand the implications of your changes. The normal user parameters include the initial ramp rates for the KV and mA as well as options for controlling AOL (Automatic OverLoad Protection) and APT (Automatic Power Trip) protection features. In addition, controls for configuring arc detection and protection schemes are present, but cannot be accessed without a password from Spellman High Voltage due to the high risk posed by changing these settings. If you require specialized arc configurations, please contact Spellman High Voltage for assistance.

### 5.4 Graphs Tab
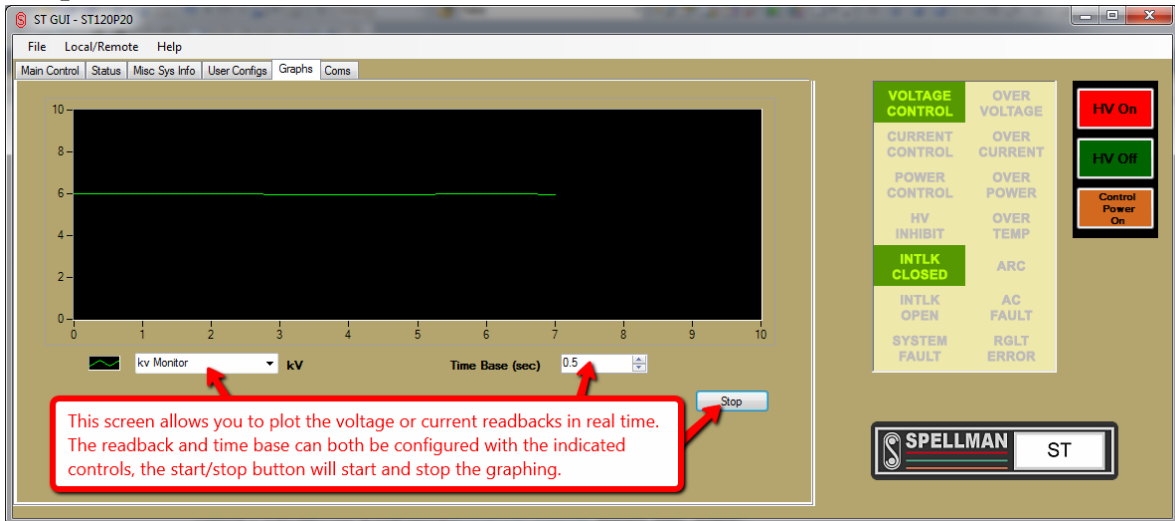


This tab allows real time graphing of the KV, mA or temperature read back. A selector is available to choose which of the three to display, and another selector allows the update rate to be specified in seconds. A start/stop button will start and stop the graphing.

End of Document.