LST High Voltage Power Supply
Users Handbook
(well, it might one day become a handbook)

**Do not attempt to service these power supply units yourself.
Do not open the box.**

1. **Hardware support**
   If you suspect your power supply has a hardware defect contact
   Shane Smith at the OSU electronics shop (614-292-9929, ssmith@mps.ohio-state.edu) or
   Klaus Honscheid (614-292-3287, kh@mps.ohio-state.edu)

2. **Software support**
   If you have problems with the power supply software contact
   Joe Regensburger (jregens@pacific.mps.ohio-state.edu),
   Klaus Honscheid or
   Gabriele Benelli at SLAC (gbenelli@slac.stanford.edu)

3. **Hardware installation (External HV Version)**
   To operate the power supply you will need
   a. Power cord, Ethernet cable (cat 5)
   b. External HV supply set to 6.6KV – 7KV with a current output of at least 4 mA. The current drawn from the external HV supply is largest when the OSU box is set to 0 (the outputs are off). In the situation the current from the external supply is around 3.6 – 4 mA. When all 4 HV channels of the OSU box are ramped to 5600 V the current from the external supply drops to ~1 mA.
   c. Rabbit Microprocessor download cable or AutoRun dongle (provided by OSU). Please note that the program is stored in flash memory on the Rabbit module itself. However, with the programming cable installed the Rabbit will enter monitor mode and will wait for the Dynamic C environment to download a new executable. With the AutoRun dongle installed the program starts automatically after power is turned on.
   d. Either the "hvserver" or "multiserver" programs (for the Rabbit) can be used in this configuration.
   e. External Interlocks
   The external HV enable signal has to be present before the HV outputs can be turned on. This is an opto-isolated signal so to set it you basically have to drive a LED in an opto-coupler chip. This can be accomplished by the BaBar slow control system (this comes later), 2 1.5V batteries in series with a 120 Ohm resistor, or with the OSU external interlock box. This box needs +5V to operate (in other words an external 5 V supply is required).

4. **Hardware installation (Internal HV Version)**
   To operate the power supply you will need
   a. Power cord, Ethernet cable (cat 5)
   b. Rabbit Microprocessor download cable or AutoRun dongle (provided by OSU). Please note that the program is stored in flash memory on the Rabbit module itself. However, with the programming cable installed the Rabbit will enter

monitor mode and will wait for the Dynamic C environment to download a new executable. With the AutoRun dongle installed the program starts automatically after power is turned on.

c. The "uvserver2" program (for the Rabbit) has to be used in this configuration.

d. External Interlocks

The external HV enable signal has to be present before the HV outputs can be turned on. This is an opto-isolated signal so to set it you basically have to drive a LED in an opto-coupler chip. This can be accomplished by the BaBar slow control system (this comes later), 2 1.5V batteries in series with a 120 Ohm resistor, or with the OSU external interlock box. This box needs +5V to operate (in other words an external 5 V supply is required).

5. **Operating Procedures**

It is important to follow a standard procedure when turning on the HV supplies:

a. Turn on the OSU HV supply first.

b. Use a program such as HVWin to connect to this supply and make sure the HV is disabled.

c. If an external HV supply is used turn it on now (set to ~7 KV).

d. Don't forget the frontpanel enable switch on the OSU supply

e. Ramp the OSU supply to whatever voltage you need.

f. When you are done and want to turn the system off ramp the OSU supply to 0 and disable the HV.

g. Then you can turn off the external HV power supply.

h. Turn off the OSU supply.

6. **Special Procedures, External HV Version**

a. **Avoid operating the system for extended periods with external HV supply on but the output HV of the OSU supply set to 0.**

    i. This configuration draws the largest current from the external supply.

    ii. If you don't need the system for a day you might as well turn in off.

    iii. We have tested this configuration for days without problems but before we remove this recommendation we would like to gain more experience.

b. **Before doing any work on the system (such as connecting cables) make sure that the external HV supply is turned off.**

c. **Even with the OSU system disabled or ramped to 0 the actual output voltage will not reach 0 V unless the external supply is turned off.**

    i. The actual value of the output voltage with the OSU system ramped to 0 ranges from 50 – 350 V depending on the setting of the external HV supply.

    ii. This also applies when only some of the HV channels are ramped.

7. **Special Procedures, Internal HV Version**

a. **Internal Current Limit**

    i. The firmware inside the HV power supply monitors the current drawn from the Ultravolt HV modules and limits it to 2.8 mA (3 mA is the maximum). In case this current limit is reached the output voltage is automatically reduced. During normal operation with all 4 HV channels on this limit never comes into play (the current is typically less than 1 mA). Due to the design of the OSU HV system the largest current is drawn when the outputs are set to 0 and the HV source is set to its nominal value (~7KV). In this version of the power supplies we control the Ultravolt module and reduce its output value when the OSU supply is

set to 0 V. This not only reduces the current drawn from the HV module but also avoids the problem of non-zero output voltages (see section 6.c above). When the output voltage is ramped up we synchronously ramp the output voltage of the Ultravolt module.

ii. The most likely way to run into the current limit is if you decide to ramp only one HV channel to 6000 Volts while keeping the other three channels off, ie at 0 V. This forces the Ultravolt output voltage to go to 7000 V which in turns means that the three off-channels draw a fairly large amount of current. The internal protection logic will stop HV ramping or even reduces the HV should the current drawn from the Ultravolt module exceeds a predefined limit (currently set to 2.8 mA). In this situation, if you need only one HV output channel it is necessary to ramp at least two HV channels. Should this become a problem we have prepared the hardware to operate with two Ultravolt modules, each powering two HV channels.

b. Temperature Monitor
A temperature sensor monitors the temperature inside the power supply box. Should the temperature rise above 60 degrees C a warning is issued. Should the temperature rise above 70 degrees C, the HV is ramped down and the Ultravolt module is turned off to reduce internal power dissipation and to avoid damage to ower supply itself. The limits can be adjusted in the firmware. A fan is provided to cool the HV power supply box.

8. **Box Number and IP address**
At OSU we configured the hvserver program (that is executed by the embedded Rabbit microcontroller) to use the box number (front panel switch) to specify the IP address. This is a convenient way to operate several boxes at a time without having to worry about the network connection. Please note that the HV supply acts as a TCPIP server so DHCP without static assignments can't be used.
OSU and SLAC and Princeton use different network configurations. The IP address is coupled to the box number which can be set with a thumb-dial switch on the front panel. Box numbers 40-49 are currently reserved for SLAC/Princeton. In the current version the software does not support automatic switching of the gateway IP address and the netmask. We will attempt to correct this in future versions. For now, the rabbit program has to be adopted to either the SLAC/Princeton or Ohio State environment (comment/un-comment the relevant definitions at the beginning of the program)

9. **Front Panel Indicators**
   a. TRIP
   an overcurrent situation has been detected by the power supply hardware. The HV is turned off. With the current implementation all 4 HV channel are turned off regardless of where the trip occurred. This can by modified if necessary.
   b. External HV Enabled
   The external HV enable signal is present
   c. HV Enabled
   The HV enable condition has been met (external signal and front panel switch and software enable)
   d. Ramping
   The output voltage is changing.
   e. At V0
   All 4 HV channels are at V0 voltage.
   f. HV On (channel 1, 2, 3, 4)
   The voltage for this channel is 500 V or larger. The threshold can be set by

software.

10. Noise

The hardware design includes 80 current monitor circuits that are powered by floating power supplies. These are operated with a 1 MHz oscillator. This causes some noise on the output lines. We have added filter stages and shielding and found the noise levels to be less than 10 mV. With a 30m long Kerpen cable as we will use in BaBar the noise level as measured on the wire signal cable was further reduced to 1-2 mV. These noise levels will not affect the performance of the LST detector.

11. Protection

a. ZEUS diode circuit
This is described in a separate document.

b. Overcurrent (HV trip)
Each of the 80 current monitor channel is periodically monitored by the control logic implemented in a Xilinx FPGA. With the default settings each channel is monitored every 80 ms. If the current is above a threshold (configurable) the system turns off the HV without requiring any user/software intervention. An acknowldgement by the user/operator is required before HV can be re-enabled.

c. Overcurrent (Ultravolt HV module)
The output current of the Ultravolt HV modules is monitored periodically by the Xilinx FPGA (every 80 ms in the default settings). If an overcurrent situation is detected the output voltages of both the Ultravolt module as well as the OSU power supply are reduced automatically.