STEREO/IMPACT/SIT HVPS REQUIREMENTS DOCUMENT

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Rev 1
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Revision History:

Rev 0	**30 Oct 2002**	**Initial release**
Rev 1	**21 Nov 2002**	**Corrected table in section 2.3** **Section 3.3 - changed value of sync frequency and added note.**

1. PURPOSE of DOCUMENT

The purpose of this document is to explain the reason for using a high voltage supply in SIT, characterizing the use and requirements for each of the voltages used and specifying the requirements on the inputs and outputs of the supply.

2. PURPOSE OF HVPS

The function of the HVPS is to provide six high voltages for the operation of the SIT time-of-flight (TOF) telescope.

2.1 Operation of TOF Telescope - The telescope measures the time required for incoming ions to travel from the front foil of the telescope to the solid-state detector (SSD) at its rear. It operates not by detecting the particles themselves, but by detecting the secondary electrons knocked off the front foil (forward scattered) and the SSD (backward scattered). Typically a few to a hundred electronics with energies of a few eV are emitted from the back surface of the foil and from the front surface of the SSD for each incoming particle, depending on the particle type and energy. In themselves, these electrons are too few and have too little energy to constitute a measurable signal, so the telescope does three things to correct this. First, it accelerates the electrons to approximately 1000v and second deflects them out of the ion path into the direction of the electron detector assembly. Finally, the electron detector - a pair of microchannel plates (MCP) - multiplies the number of electrons by a factor of about 10 million , collects the resulting signal on an anode and passes it on to the TOF electronics. A drawing of the telescope is shown in fig 1.

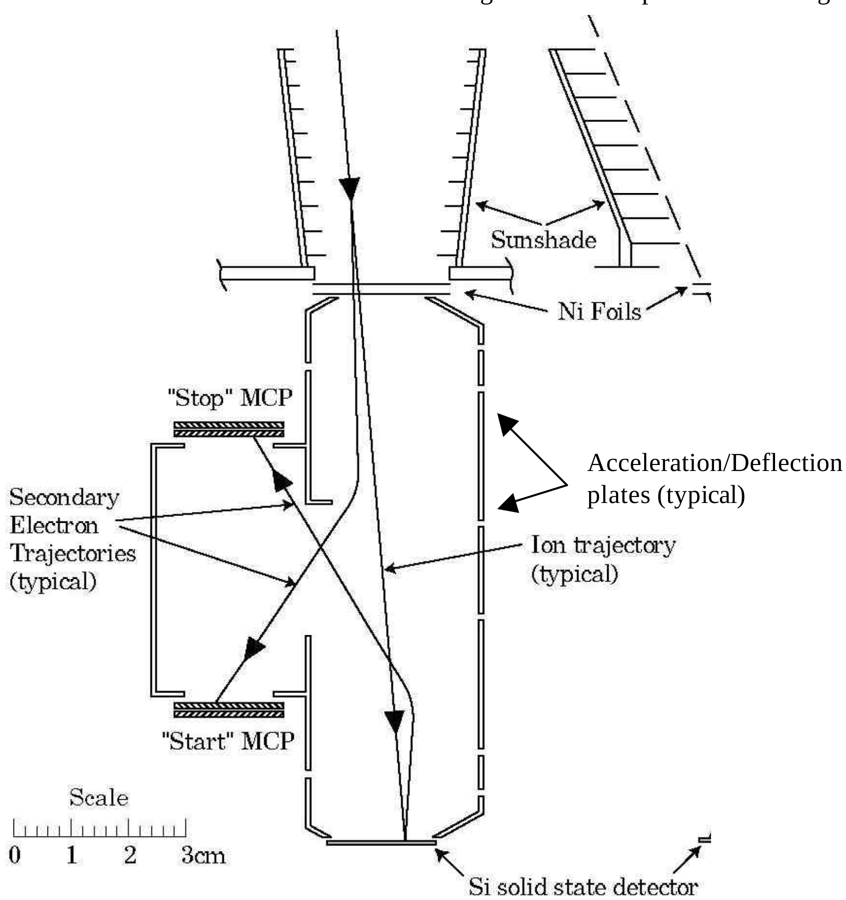

Fig. 1 Cross Section

There are obviously two sets of electron detectors, one for the electrons from the foil - the START signal- and the second for the electrons from the SSD - the STOP signal. The TOF electronics measures the time difference between the START and STOP signals, and through bench calibration, refers this to the time of flight of the primary ion.

The microchannel plates in each electron detector are arranged as a chevron pair. The plates act as a large set of parallel electron multiplier tubes - an electron, as it enters a channel is accelerated downward by the voltage across the plate and strikes the inner wall of the channel liberating more electrons. These continue to cascade down the tube in an ever-increasing swarm. A plate with a bias of about 800-1000 volts will generate several thousand electrons for each one entering a channel. As the swarm of electrons reaches the end of the first plate, it enters a gap where it is accelerated by two hundred volts or so onto the front surface of the second plate where they enter numerous channels and again are multiplied by a factor of several thousand. At the end of the second plate the enlarged swarm of several million electrons is accelerated onto the collection anode with a voltage of a couple hundred volts. The pair of plates is called a chevron because the channels in each plate are at an angle of about 19 degrees to the surface, and the plates are arranged so that the angles on each plate face in opposite directions. This is done to prevent positive ions knocked off from the inner surface of the channels by all the electrons from working their way back up the tube to the front of the stack and initiating a second cascade of electrons - an effect called ion feedback. By using a pair of plates with channels facing in opposite directions, ions can only get as far as the front of the plate they were generated in, not producing a large enough signal to be detected.

The front foil is at 0 volts, to prevent collection of low energy ions from outside, and the voltages required become progressively more positive as we move through the collection path. The acceleration/deflection plates are at a voltage of ~+1000v. Normally, the front of the front MCP would also be at this voltage, but there is one additional effect to worry about. Some of the START and STOP electrons do not enter a channel on the MCP but instead hit an inactive portion of the plate between channels (only about half of the surface of the plate is open channels, the rest is made up of the channel walls). These unfortunate electrons knock off yet more secondary electrons which wander around until they eventually get sucked into an open channel. At this point, however, they are hopelessly late to aid in the measurement of the TOF and merely generate confusing background signals sometimes causing an incorrect TOF measurement. To prevent this, we bias the front of the front MCP slightly (~50-100v) less positive than the acceleration/deflection plates, nominally +950v. The back of the front MCP is nominally about 1000v positive with respect to the front, or +2000V. The front of the next plate is 200v more positive or +2200, the bias across the plate is 1000v so the back of the plate is +3200v and finally the collection anode is another 200v positive or +3400volts. Obviously we need to capacitively couple this signal into the TOF electronics, which we do by taking the signal off the back of the collection anode.

2.2 Nominal Voltages - All of this leads to the following tables, first of nominal biases:

Acceleration voltage	1000v
Reverse bias on front of front MCP	50v
Front MCP Operating voltage	1000v
Inter-plate voltage	200v
Rear MCP Operating voltage	1000v
Collection anode bias	200v

and derived from that, the table of nominal voltages:

Foil	0v
Acceleration/deflection plates	+1000v
Front of Front MCP	+950v
Rear of Front MCP	+2000v
Front of Rear MCP	+2200v
Rear of Rear MCP	+3200v
Collection Anode	+3400v

2.3 Currents - Manufacturer's specifications for the microchannel plates we are using state that the operating current for a pair of plates operating at 1000v per plate will be 5-10 uA. There are two sets of MCPs (START and STOP) so the total current through the MCPs will be 10-20uA. We will not know before delivery exactly what the total current will be but it will be reasonably stable (within a couple of uA) over the expected mission. Other currents - acceleration to ground, between MCPs, MCP to anode - are expected to be vanishingly small (<<1uA) and can be neglected. This leads to the following table of nominal currents:

	Nom. Voltage	Current (uA)	To/From
Foil	0	0	anywhere
Acceleration/deflection plates	1000	0	anywhere
Front of Front MCP	950	10-20	to Rear of Front MCP
Rear of Front MCP	2000	10-20	from Front of Front MCP
Front of Rear MCP	2200	10-20	to Rear of Rear MCP
Rear of Rear MCP	3200	10-20	from Front of Rear MCP
Collection Anode	3400	0	anywhere

2.4 Operation - Nominal operation of the supply will be 3400volts, providing 1000volts across each plate. However, the voltage will be varied as the mission progresses to accommodate changing MCP gain. Early in the mission when he plates are fresh we may operate as low as 80% of nominal (2700v) and late in the mission we may need to go up to 120% (4050v). Turn on will be stepped. Power will be applied with the control voltage at 0v and the control voltage will be raised is several (probably 5-6) steps over a period of a minute or so until operating voltage is reached. In space, first turn-on will be performed over several days to allow the plates time to adjust and the instrument to outgas fully. Subsequent turn-ons will probably be performed by stored commands on the S/C and will be timed to take place over several minutes (SIT logic is designed to send commands only on minute boundaries). Turn off will be abrupt. Control voltage will not necessarily be removed before power is turned off. It is important that HV output not rise in an uncontrolled fashion when this occurs.

2.5 Tolerances - The following tolerances apply over the output voltage range of 80-120% of nominal and for the range of currents listed above.

	Nominal V.	Minimum V.	Maximum V.
Acceleration/Deflection	1000	700	1300
Reverse bias on front of front MCP	50	30	100
Difference in voltage across MCPs	0	-100	+100
Voltage Between MCPs	200	100	280
Collection Anode Bias	200	100	280

Of the above, the most important is the matching of the voltages across the plates. They should be within 100v of each other over the full expected range of operation. For example if one plate has 1000v across it the other should have between 900-1100volts.

2.6 Synchronization - Synchronization will nominally be external from a 3volt source. Nominal synch frequency is 150kHz but this will be derived from a 32MHz crystal by integer division so the actual frequency will be close to 150.23kHz. The supply should continue to operate in the case of loss of synch (open synch wire is the most likely mode of failure. A shorted synch line is also possible but less likely.)

3 INTERFACE REQUIREMENTS

3.1 Input Connector

Type: MDM9 -S-H-B-A174

Pinout:

Pin	Name	Function
1	+13.5V	+13.5V power in
2	IMON	current monitor output
3	HV_CONT	HV control voltage input
4	VMON	HV monitor output
5	-13.5V	-13.5 v power in
6	Limit Return	return for the 300volt limit input
7	GND	power return
8	SYNC	synchronization signal input
9	300V_LIMIT	input limiting supply to 300v

3.2 HV Output Wires

Number: 7 (6 HV and one HV return)

Type: Reynolds 167289

Length: 12inch minimum

Termination: bare

3.3 Input Signals

Power +/-13.5v, +/-10%

Sync

Frequency 150kHz square wave, crystal controlled at 149.53kHz
Signal levels: nominal 3.3v CMOS logic
Duty cycle: 50% (+/-5)
Input impedance: 5k ohm, nominal

(Note: the sync is derived by dividing the 32.00MHz crystal clock. Dividing by 214 gives the above frequency of 149.53kHz. Dividing by 213 gives 150.23, which is closer to the desired value of 150.0kHz, but division by an even number allows to duty cycle of 50% to be met. Thus we diide by 214.)

HV Control 0-4.2v nominal. No damage limits: 0-5.0v. Input impedance 50k nominal.

300v Limit open to ground (pin 6) or short to ground (pin 6).

3.4 Output Signals

HV see discussion in section 2 above

VMON	voltage monitor, mirrors HV control voltage. Output impedance 50k nominal.
IMON	Output current monitor. Optional. 1volt/10uA. Output impedance 50k nom.