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Spellman web site address [www.spellmanhv.com](http://www.spellmanhv.com)

## 2. Answers

Q1. Where can I get the +10V Precision Reference output from?

A1. The Reference is available from Pin 4, Precision 10V O/P is achieved by turning the internal control pot fully clockwise.

Q2. How much current can I take from the +10V Precision Reference?

A2. The maximum recommended current drain from the reference is 10mA.

Q3. What is the output current limit and what happens if it fails.

A3. The current limit on a standard unit is fixed at 110% nominal maximum output current i.e. 1.1mA for a 1kV unit. On the /VCC option the maximum output current is determined by the current program input. MPS units have two current limiting circuits. The secondary current limit which as above is fixed at 110% of rated output or controlled by the current control input and a primary current limit which if the secondary current limit fails will limit the output current to 200% - 300% of the rated output current

Q4. What will happen if the output current exceeds the limit?

A4. When the output current exceeds the 110% limit the unit maintains a constant output current by reducing the output voltage until the current drops to 110%. In this way the units can charge capacitors etc without problems. Please note this is a current limit, not a current trip.

Q5. What is the initial drift after switch on?

A5. If the unit is switched on from cold each time, the initial drift is approximate 100 – 300 ppm in the first few minutes of warm up.

Q6. What is the typical 8 hour drift?

A6. After a 2 hour warmup, The next 8 hours will have a drift of 75ppm.  
After a 3 hour warmup, The next 8 hours will have a drift of 50ppm.

Q7. What are the sources of the drift errors?

A7. The feedback resistor and the voltage reference can be considered the two main sources of error:-

### FEEDBACK RESISTOR ERRORS

The feedback resistor manufacturer specifies a drift of 10ppm per hour. (1% per 1000 hours).

This consists of two effects: -

1. A very small, slow, permanent change, which continues indefinitely.
2. An aging effect, which reduces logarithmically as the resistor becomes 'burnt-in'. This effect occurs mainly at elevated temperatures and/or with high voltage applied.

### VOLTAGE REFERENCE ERRORS

The manufacturer of the voltage reference specifies three sources of error: -

1. 40ppm per square root of 1000 hours. Therefore for longer times, the effect becomes less significant.
2. A small hysteresis, depending upon the temperature history of the IC. For example, if the IC has been cycled down to 0 degrees C or up to 70 degrees C, the hysteresis error between the two conditions will be less than 25ppm.
3. Errors from stress on the device legs via the PCB.

Q8. What are the recommendations for best repetitive accuracy?

A8. Recommendations for best repetitive accuracy.

1. Burn in the unit with 168 hours running at maximum output voltage.
2. Allow at least 3 hours warm-up.
3. Protect the unit from wide temperature swings when switched off.
4. Do not handle the unit, especially the input connector, between the operating periods.

Expected accuracy

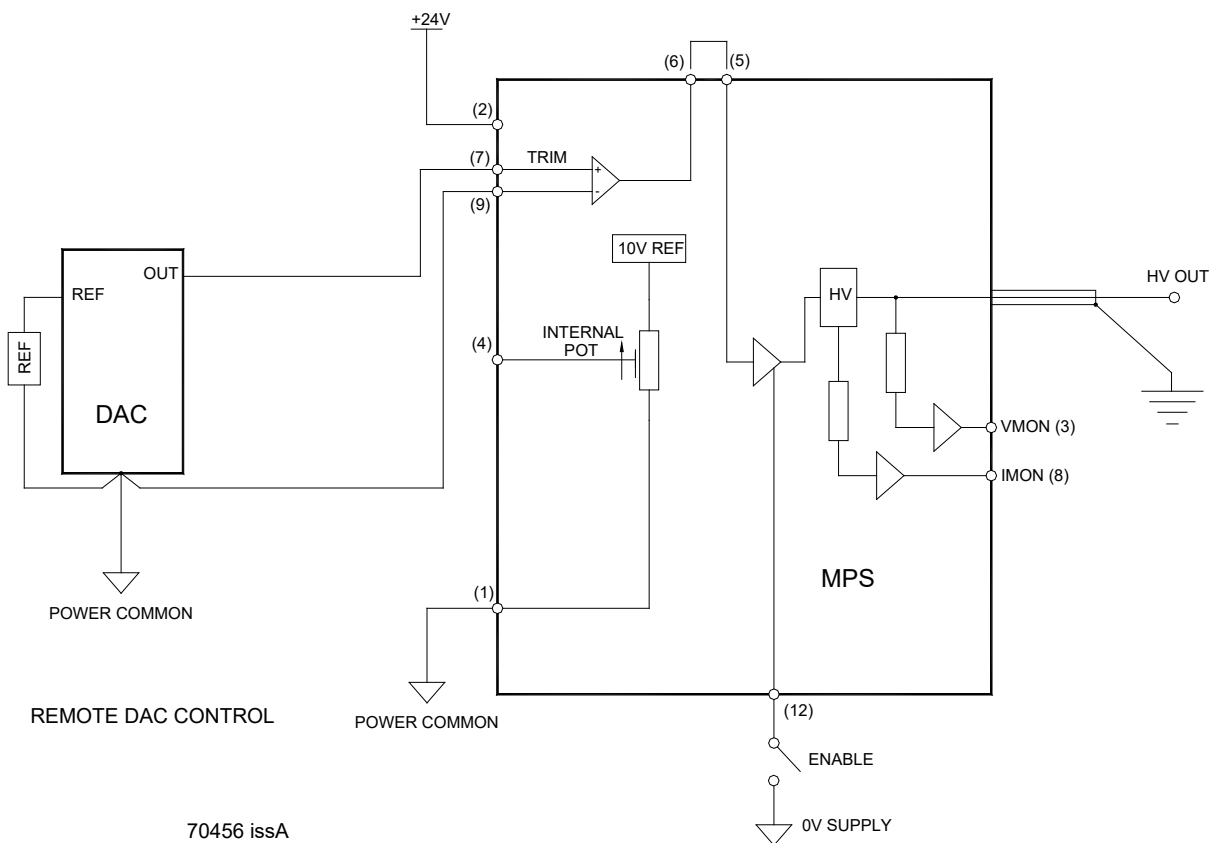
We would expect the repetitive accuracy of the unit to be within 50ppm in normal usage. This will improve with continued operating cycles.

Q9. How do I connect the unit for Remote DAC control?

A9. Remote DAC control

The differential input allows the voltage programming circuit to be remote from the power supply. It prevents voltage drops in the ground connection from affecting the programming signal. However, if there are voltage drops in the ground connection, the DAC should be provided with its own reference.

Pin No:	Connections
1	Power Ground
2	24V Power input
3	Voltage Monitor output
5 & 6	Link together
7	0 to 10V programming signal
8	Current Monitor output
9	Programming signal ground
12	Connect to ground to enable HV



Q10. How do I connect the unit for Local DAC control?

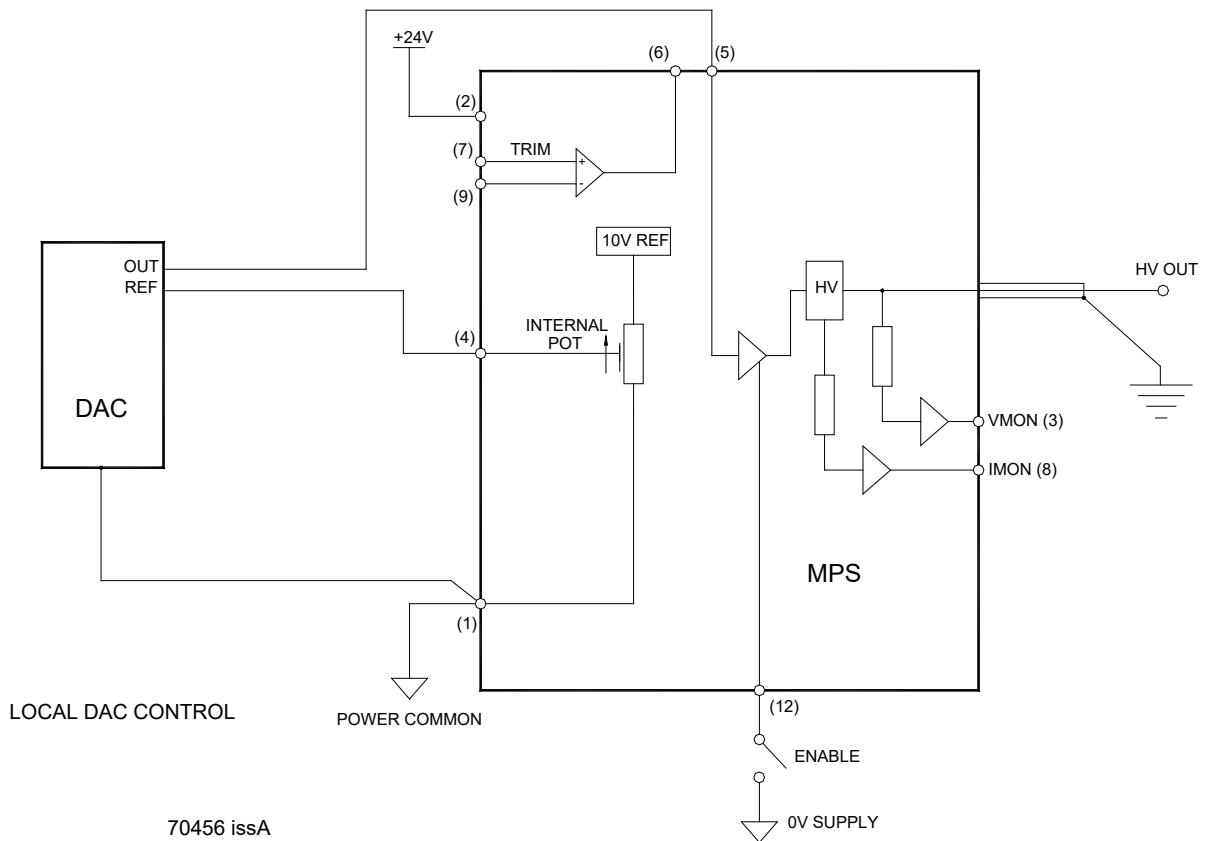
A10. Local DAC control

The unit has an internal potentiometer near the D type input connector, which is internally connected to the +10V precision reference. The output from the wiper of the internal pot may be used as a reference for the DAC. Set the internal pot to fully clockwise to make the +10V precision reference available to external circuits.

It is not necessary to use the differential input when the voltage control circuit is close to the power supply, however it is important to connect all grounds to Pin 1 of the PSU to prevent voltage drops in the ground circuit from affecting the programming signal. Take care to avoid ground loops.

Pin No:	Connections
1	Power Ground
2	24V Power input
3	Voltage Monitor output
4	Connect to DAC reference
5	Connect DAC output
8	Current Monitor output
12	Connect to ground to enable HV

Set the internal pot fully clockwise.



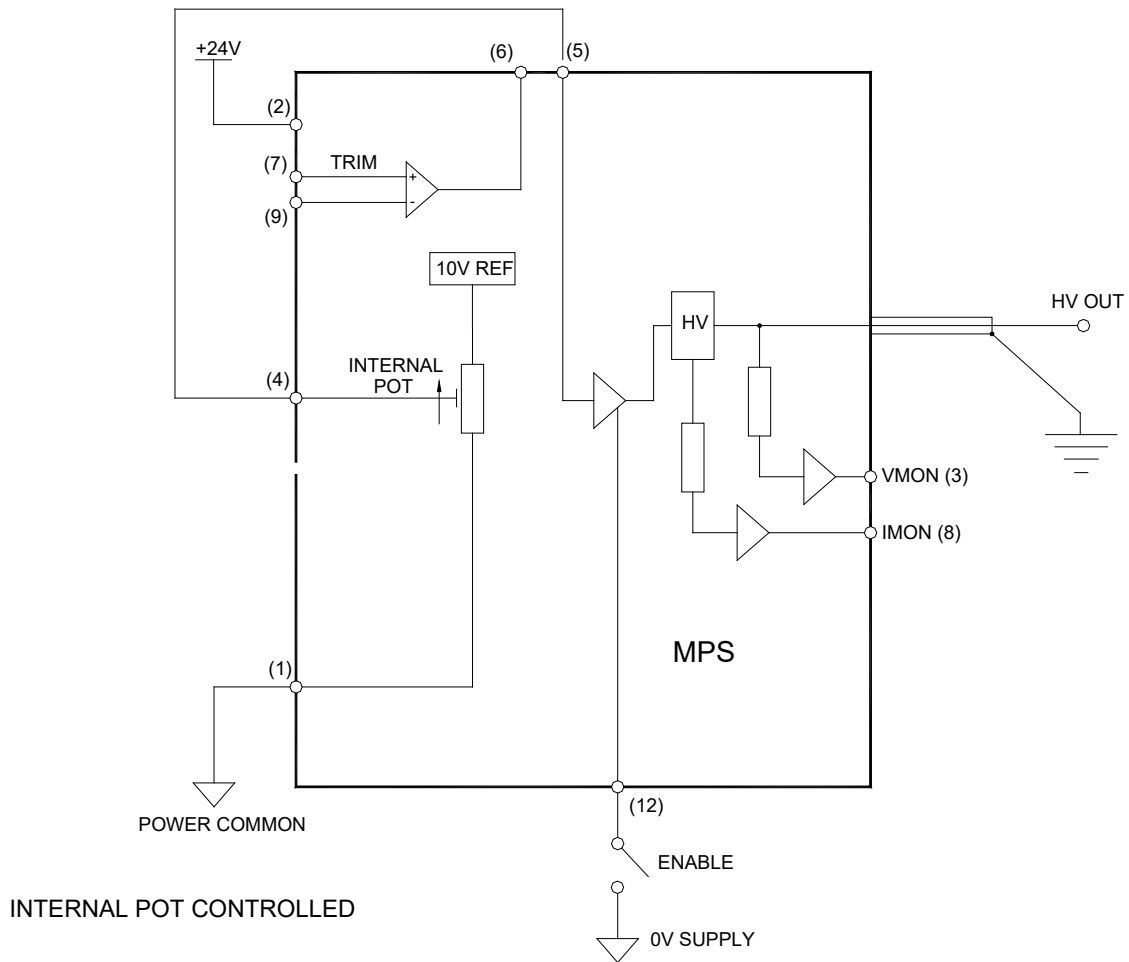
Q11. How do I connect the unit for Internal potentiometer control?

A11. Internal potentiometer control

The unit has an internal potentiometer near the D type input connector, which is internally connected to the +10V precision reference.

The unit may be controlled by the internal potentiometer as follows: -

Pin No:	Connections
1	Power Ground
2	24V Power input
3	Voltage Monitor output
4 & 5	Link together
8	Current Monitor output
12	Connect to ground to enable HV



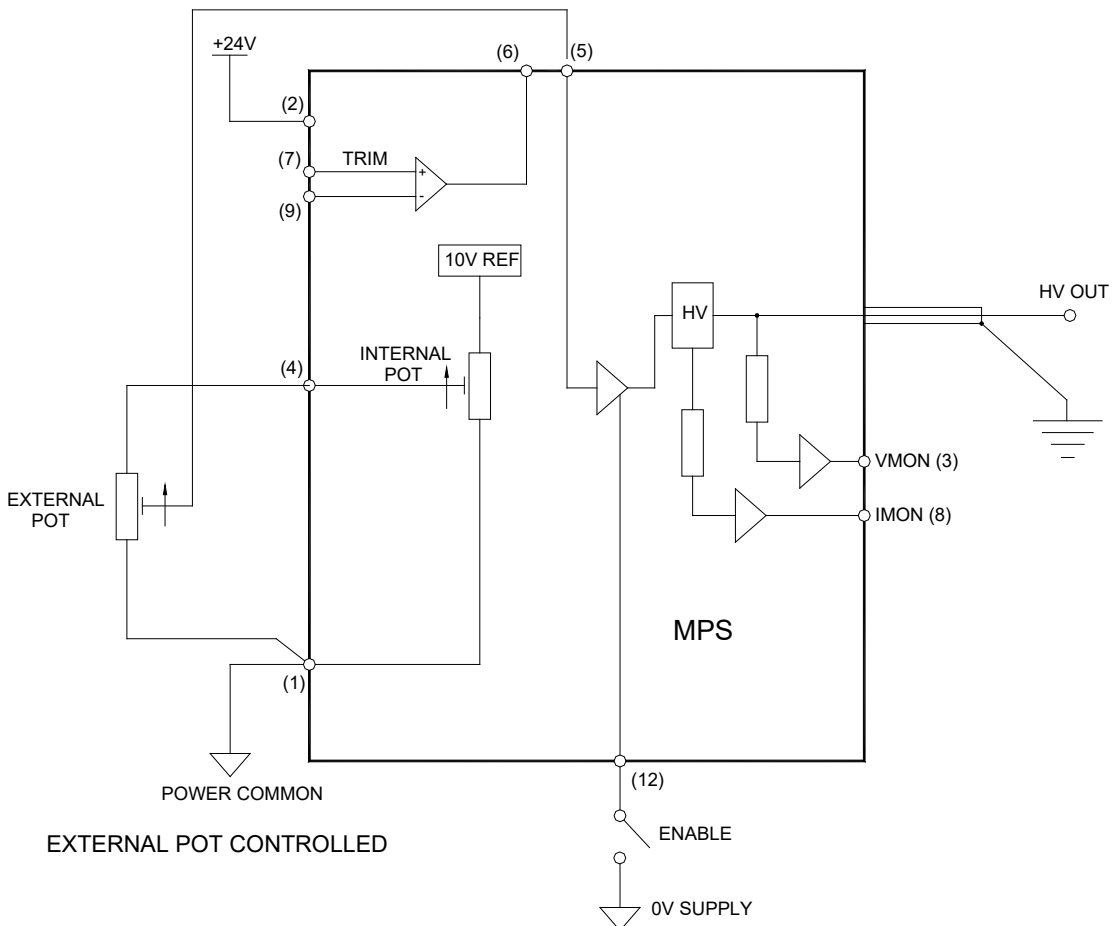
Q12. How do I connect the unit for External potentiometer control?

A12. External potentiometer control

The unit has an internal potentiometer near the D type input connector, which is connected to the +10V precision reference. An external potentiometer may be connected to the wiper of the internal pot. Set the internal pot to give the desired maximum output voltage and control the unit using the external potentiometer.

The unit may be controlled by an external potentiometer as follows: -

Pin No:	Connections
1	Power Ground and Connect to external pot CCW
2	24V Power input
3	Voltage Monitor output
4	Connect to external pot CW
5	Connect external pot wiper
8	Current Monitor output
12	Connect to ground to enable HV



Q13. Can I control and monitor the unit via a digital interface ?

A13. Digital Control

Yes, there is an option of a daughter PCB which is fitted internally that allows the use of RS232 or RS485. USB or Ethernet can be supported however this is not standard. The RS232/RS485 connections are provided via the existing connector however for Ethernet or USB an additional connector is provided. A simple ASCII protocol is implemented as standard however custom protocols can be supported.

More details on the protocol can be found in the document 80419-1 Small Module Serial Protocol.

The general message format is shown below :-

Transmit from host

<STX><ADDR><DEVTYPE>< DATA><CSUM><<LF>

Response from host

<STX><ADDR><DEVTYPE><DATA><CSUM><LF>

Where:

<STX> = 1 ASCII 0x02 Start of Text character.

<ADDR> = 1 ASCII character representing the address of the unit to which the message is being sent.

<DEVTYPE> = 1 ASCII characters representing the type of power module.

< DATA> = Command Argument, up to 4 ASCII characters.

<CSUM> = Checksum

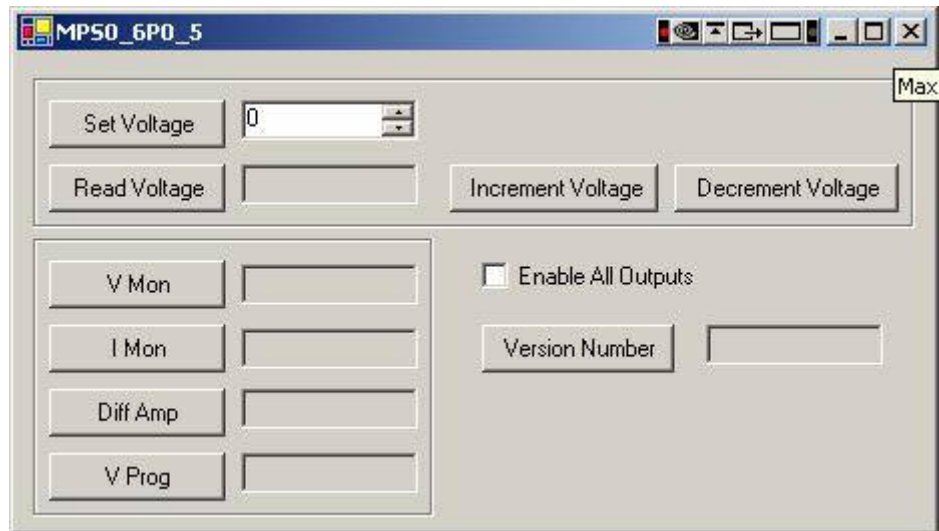
<LF> = 1 ASCII 0x0A Line Feed character

The basic command set is :-

V1= xxxxx	Set output voltage where xxxxx is a voltage from 0 to 10000
V1?	Request present value of the output voltage
V1+	Increment output voltage by one volt
V1-	Decrement output voltage by one volt
M0?	Read Voltage Monitor
M1?	Read Current Monitor
EN0	Disable all outputs
EN1	Enable all outputs
SW?	Request software version number

A simple GUI (see below) can be provided with the units to allow testing if the eventual target software to control the units is not available.





Q14. Can the MPS unit sink current ?

A14. Current sinking

No, the only means of sinking current is via the feedback resistor within the unit.

Q15. What is the minimum useable output voltage from the unit ?

A15. Minimum useable output voltage

The minimum useable output voltage depends on the full output voltage of the unit. As a guide the table below shows typical minimum output voltages :-

Model number	Minimum output voltage
MPS1	2V
MPS3	3V
MPS5	5V
MPS10	10V

Q16. What is the linearity performance of the unit ?

A16. Linearity performance

There are a number of factors which affect the apparent linearity of the unit :-

a) Zero Offset Error

This zero offset error is defined as the deviation from the expected output voltage at a nominal 50 V output. On a typical 10kV unit this is about 10V (slightly more in single ended control operation and slightly less when using the differential input.)

b) Full-Scale Error

The full scale error is defined as the deviation from the expected output voltage at the nominal maximum output once the zero offset error has been accounted for. On a typical 10kV unit this is about 55V (slightly more – 60V – in differential mode and slightly less – 55V- in single ended control)

c) DNL (Differential Non-Linearity)

The differential non-linearity is defined as the difference between the expected and actual slope of the program voltage vs. output voltage relationship, expressed as a percentage of the expected output voltage. A typical 10kV unit has a DNL of < 0.1% above 50V and < 0.01% above 1000V.

d) INL (Integral Non-Linearity)

The integral non-linearity is defined as the difference between the expected and actual output voltage once the offset error has been accounted for, expressed as a percentage of the expected output voltage.

A typical 10kV unit has an INL value of < 0.4%.

If improved linearity is require over a smaller range of output the INL can be reduced by compensating for the offset at higher output. This improves the performance of the unit above the offset point, but worsens it dramatically below that point. As an example compensating the unit for its offset at 500 V the INL is 2.5%-2.9% much below 500 V but in single ended control mode is reduced to <0.32% over the rest of the range.

Q17. How fast does the unit react to the enable/disable control ?

A17. The unit starts to react within a few ms however the time for the output voltage to reach it's set point (or decay to it's minimum voltage) is primarily determined by the response of the unit's control loop, refer to the answer to question 14 for more details.

Q18. How fast can the unit ramp up and down in output voltage ?

A18. Under no load conditions the unit will ramp up to maximum output in 150ms – 200ms, under full load it is 250ms to 300ms. The decay time is much more dependent on load conditions but with at full load (resistive load only) the voltage will fall from it's maximum to the minimum voltage in 250ms – 300ms. Any significant load capacitance will obviously extend this time.

Q19. Why does the MPS seem to have four points connected to ground or equivalent with ground potential ?

A19. The various ground points are :-

- A: 15 pin D connector, #1 pin, POWER / SIGNAL GROUND
- B: 15 pin D connector, #15 pin, ANALOG SIGNAL GROUND
- C: Shield of output cable
- D: Chassis
- E: Shell of input connector

All of these points are connected together inside the power supply.  
For best performance, each must be used correctly.

Note that the MPS15 to MPS30 and the 20W versions have an additional ground on pin 15 compared to the MPS1 – 10kV units.

A - 15 pin D connector, #1 pin, POWER GROUND:

On the higher voltage and higher power units, this connection is exclusively for the high current ground connection of the 24V power supply.

B - 15 pin D connector, #15 pin, ANALOG SIGNAL GROUND:

On the higher voltage and higher power units, this connection is exclusively for the low current analogue signal ground connection. If the user has separate analogue ground, it allows accurate use of the on-board reference.

If it is not possible for the user to separate the analogue and power grounds, the differential program inputs on pins 7 and 9 still give good rejection of ground voltages.

C - Shield of output cable

This must be connected near where the HV load is situated. Make sure that in the event of an arc, this shield is connected to the metalwork that the arc goes to. Arc currents are very high and will destroy analogue circuitry and power supplies if allowed to flow through analogue or power grounds.

D - Chassis

The chassis should be bolted down to the system chassis. This will often provide additional protection during arcing.

Conduction through the chassis is a useful way to conduct heat away from the power supply in addition to convection and radiation from the top of the case. This is a linear power supply, so adequate cooling is especially important when operating at low output voltage and high current.

E - Shell of input connector

The shell of the input connector is grounded and dimpled to provide a ground contact for the input connector shell and metal backshell. This can provide noise protection for the input program signal.

Q20. What is the accuracy (and offset) of the monitor signals

A20. The absolute accuracy is +/-2% of full scale however at low values the offset error starts to become significant. This is typically 10mV. The voltage monitor offset comes from the input offset voltage and the input offset current into 100k impedance of the input op amp plus the effects of a little noise. This op amp contributes 2 or 3mV at room temperature, less than 12.5mV over the full temperature range.

The current monitor offset is as above, but with an additional error from the cancellation circuit that subtracts the internal feedback resistor current. This is proportional to output voltage. As an example the worst case value is an additional 25mV at 5kV (2.5mV at 500V).

Q21. What is the efficiency of the unit ?

A21. The efficiency varies slightly depending on which specific model but generally it is 60%.