25 KV Power Supply for 1/2MV Marx Construction Notes

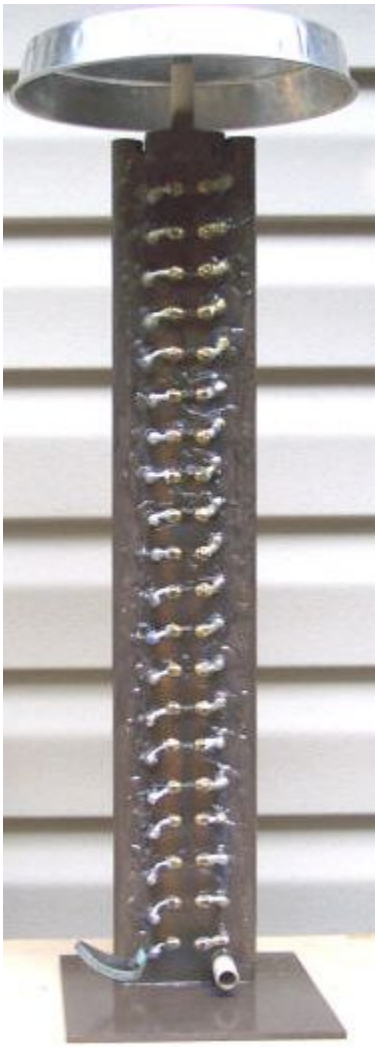
2 Mar 11

By Vaughn P. McDowell

Several years ago I was using my handy general purpose ten year old variable HV power supply to power up my 300KV mini-Marx generators. To free it up for other experiments a dedicated 20KV HVPS was constructed specific to these mini-Marx. Later on a 1/2 MV mini Marx was constructed requiring a 25KV HV power supply; based on the 20KV HVPS mentioned above I decided to build a similar unit specific to the new Marx.The original sketch construction operational notes got lost somewhere; the following is an attempt to reverse engineer and document its construction. The output power is about 15 - 20 watts, adequate for my purposes.

The 1/2 MV Marx is shown in the photos below at the left; the top right photo shows the Marx in action producing 18 inch blots. The 25 KV HVPS is shown in this photo and the one below it.

1/2 MV Marx



1/2 MV Marx \ 18 INCH BOLTS

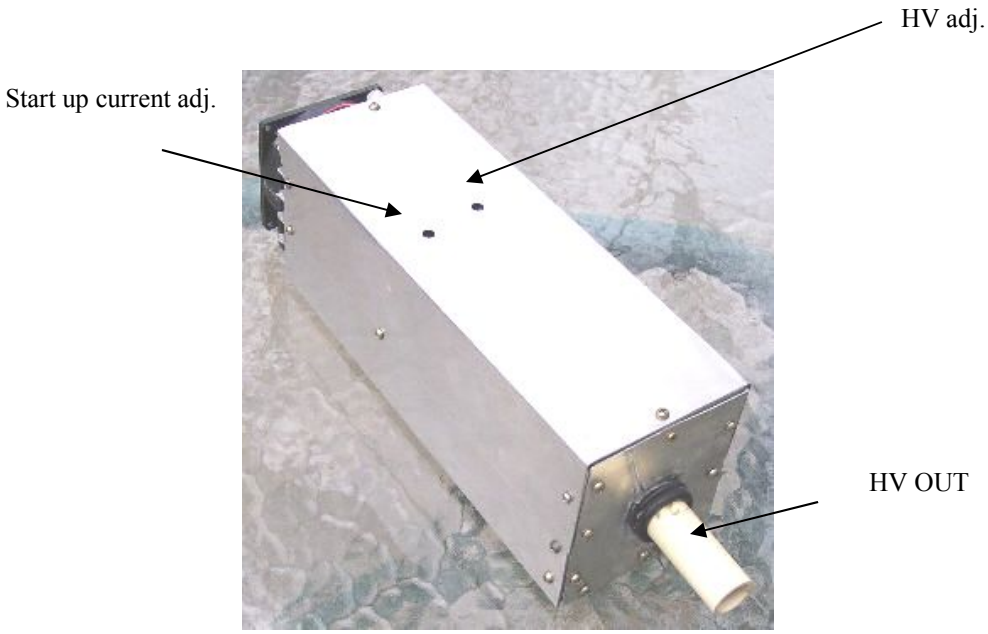
25KV HVPS

Expanded View

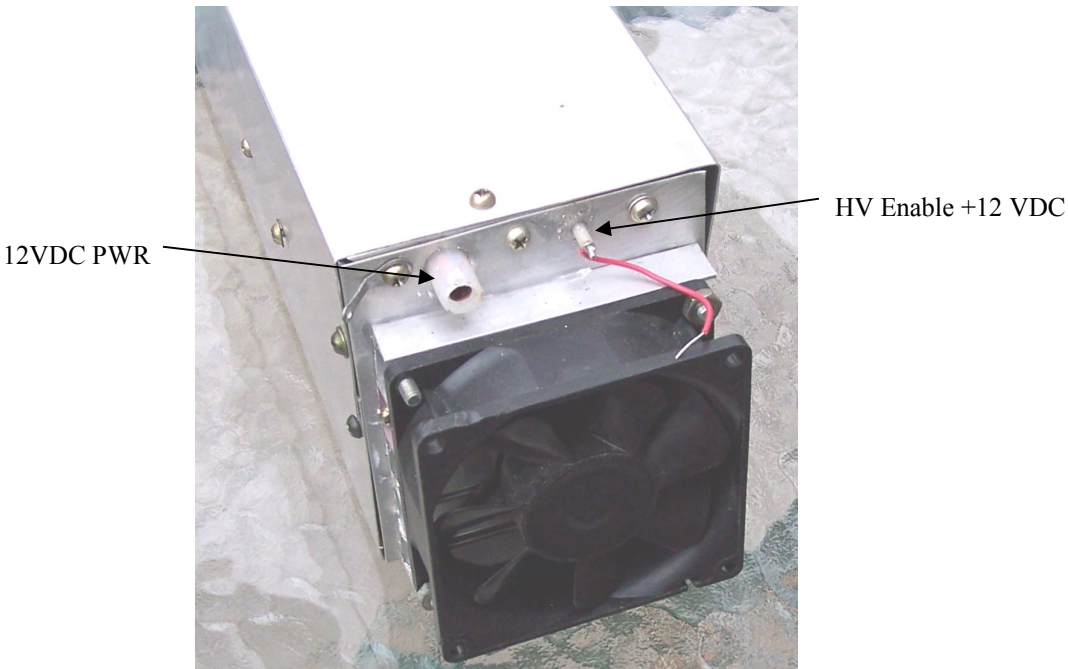
Some General Comments About This Unit

There are some power up issues that I hope to address in the near future; specifically when the unit is enabled during power up even while the HV output is not loaded. For example, sometimes when first powered up the unit often operates smoothly to its regulated voltage drawing little input rush current; other times the unit draws 4 or more amps overloading the 12VDC power supply rated for only a few amps until the power is interrupted; the applied voltage is pulled down 10 volts or less. This happens in spite of having one of the two sets of TL494 inputs used for current limit sensing. On the other hand if the 12 volt source supplies adequate current (ie car battery) the in rush current is momentary; after which it operates in it normal mode. If the unit is enabled after having been powered up, the unit operates smoothly drawing little input rush current. As long as proper precautions are taken the unit is quite functional; however it is obvious that there are some some design issues that need to be worked out.
When operating the 1/2 MV Marx the HVPS was powered up in the enable mode using a 12 volt car battery. In this manner the 25KV power supply operated very satisfactory.

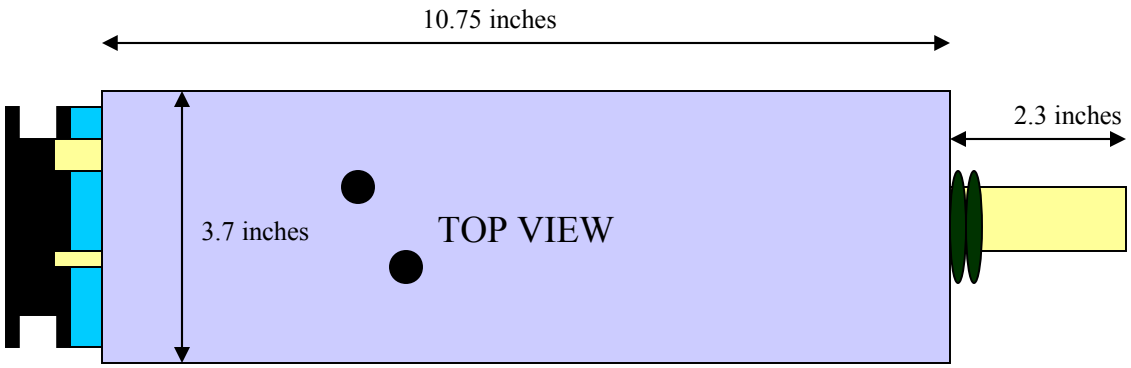
Construction Note Photos (25KV HVPS) \ angled and rear view

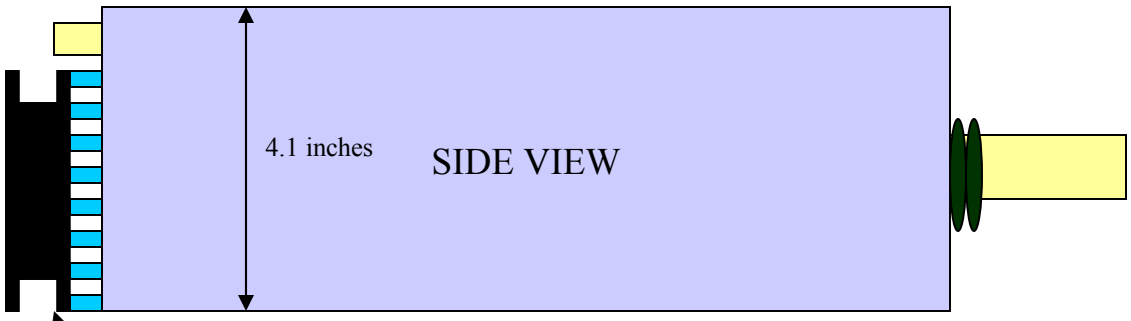


REAR VIEW



Construction Note 25KV HVPS UNIT \ Some Physical Outside Dimensions

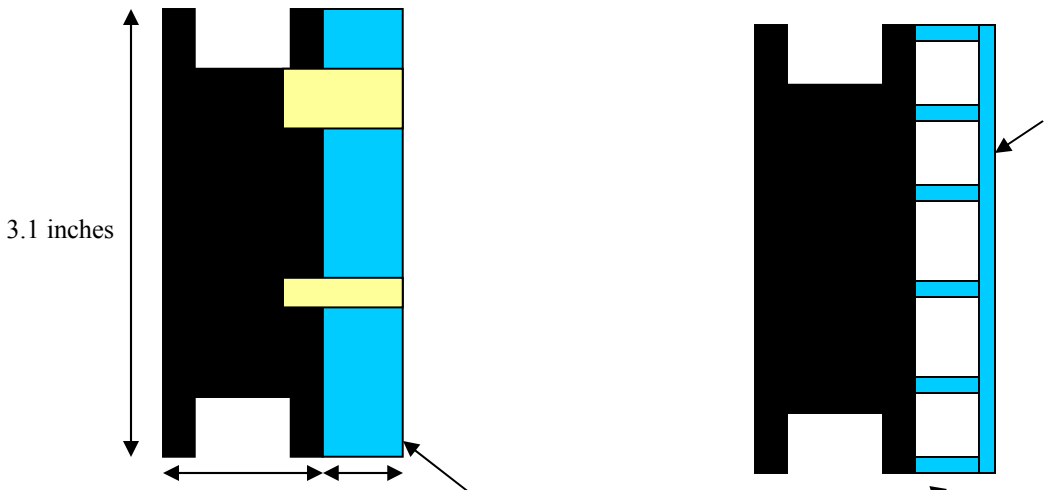


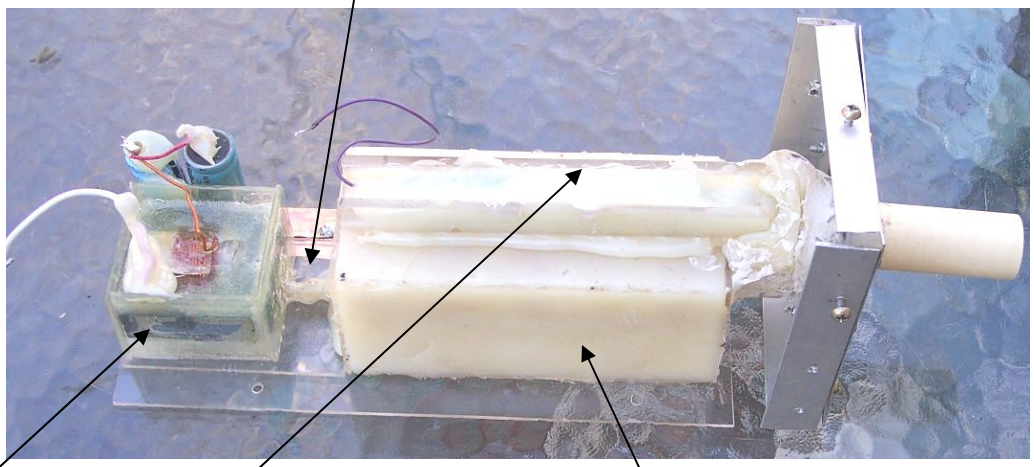


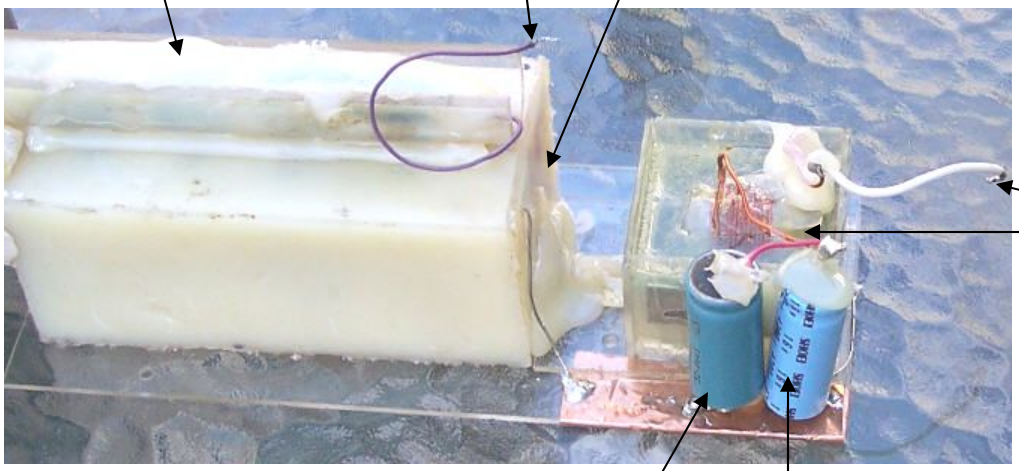
Cooling Fan 12VDC

TOP VIEW

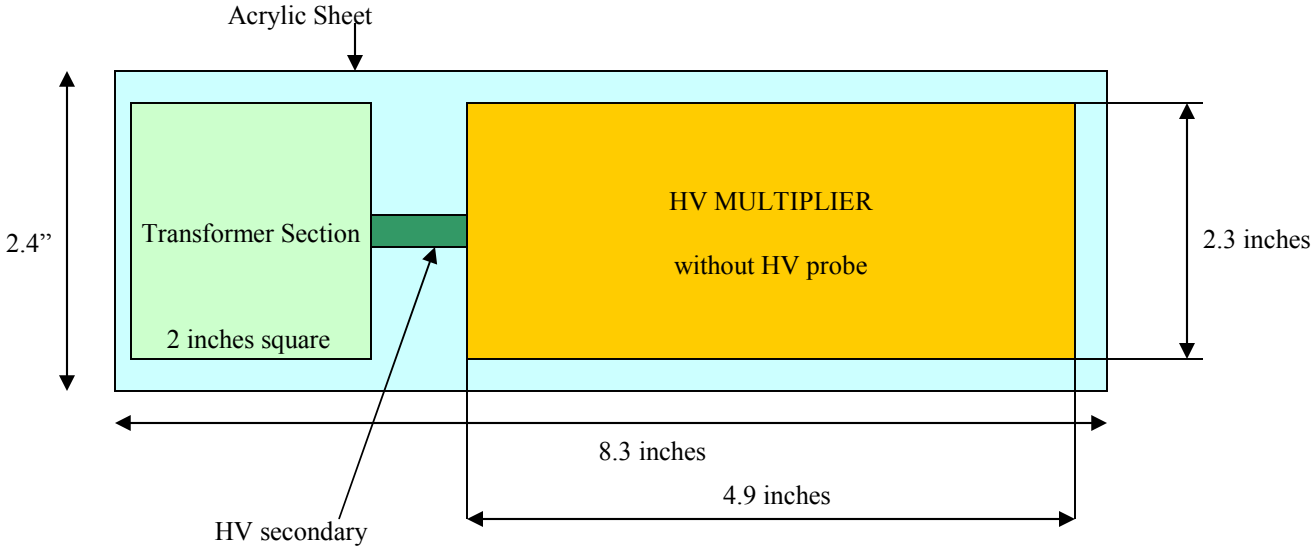
SIDE VIEW



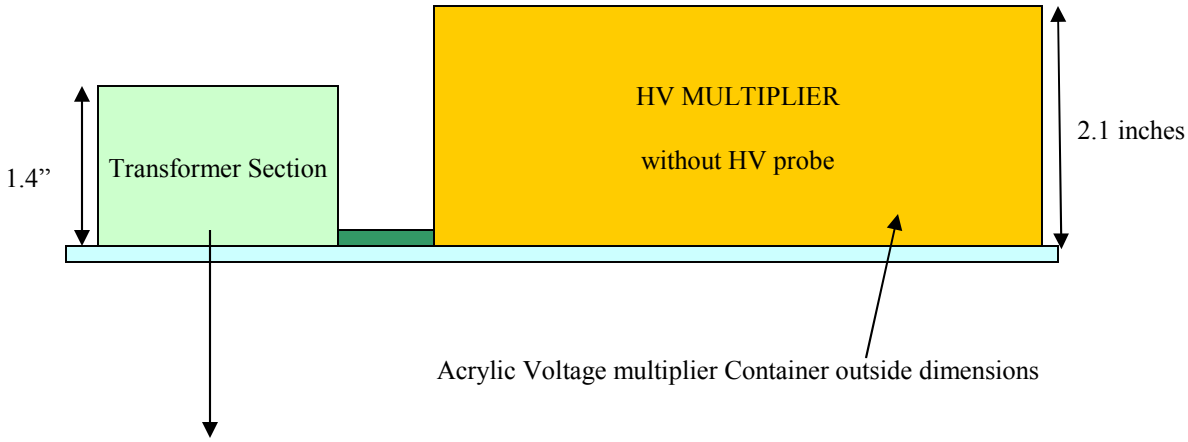

Transformer HV secondary
12-14 VDC
INPUT PWR
HV output
Flyback Transformer
HV probe
HV multiplier
HV probe feed back


PRI
3300uF
16VDC
4700uF
16VDC

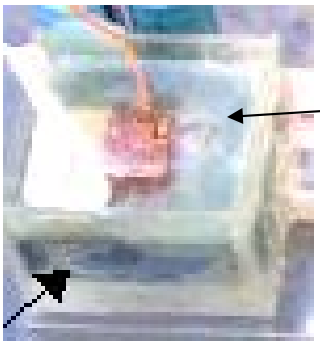
TOP VIEW



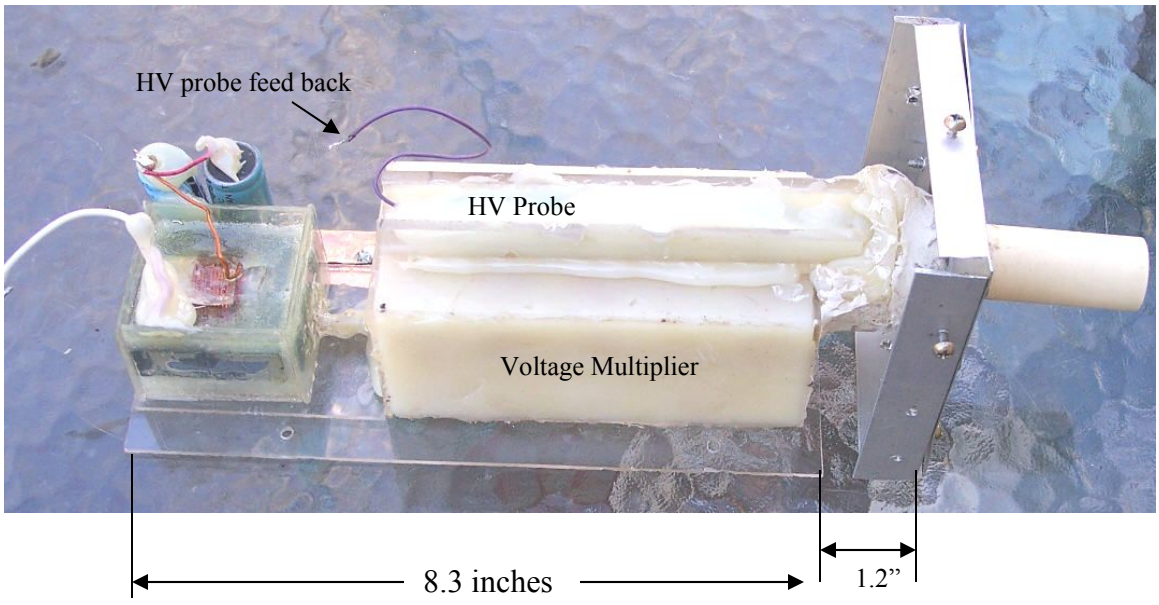
SIDE VIEW

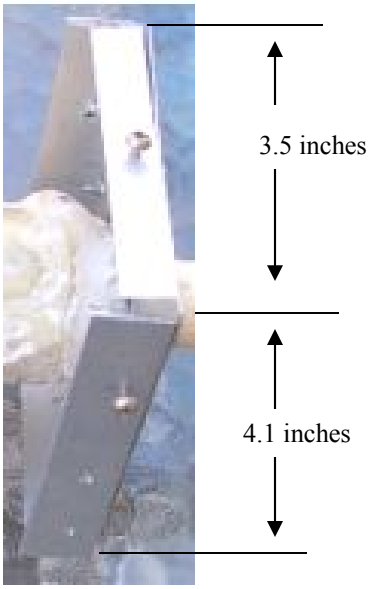


Acrylic Transformer Container outside dimensions



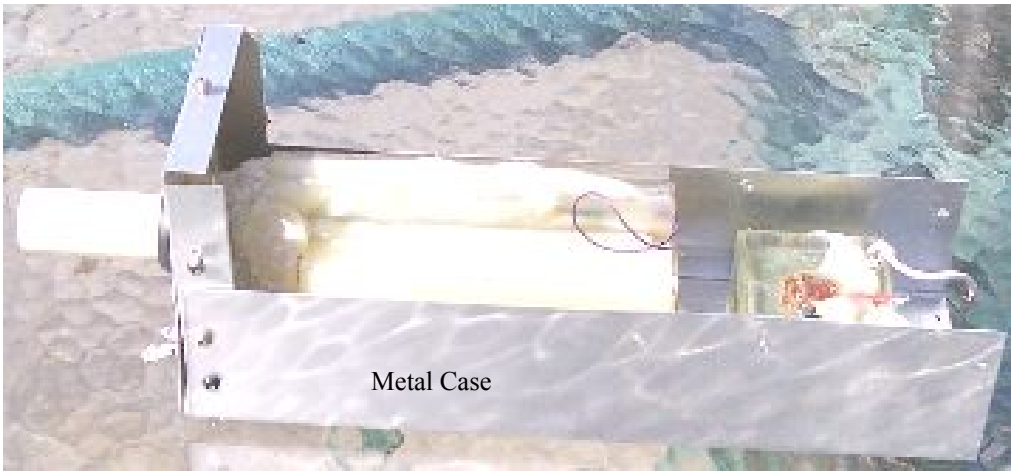
Transformer is inserted in the container which is then filled with epoxy


HV probe feed back
HV Probe
Voltage Multiplier
8.3 inches
1.2”

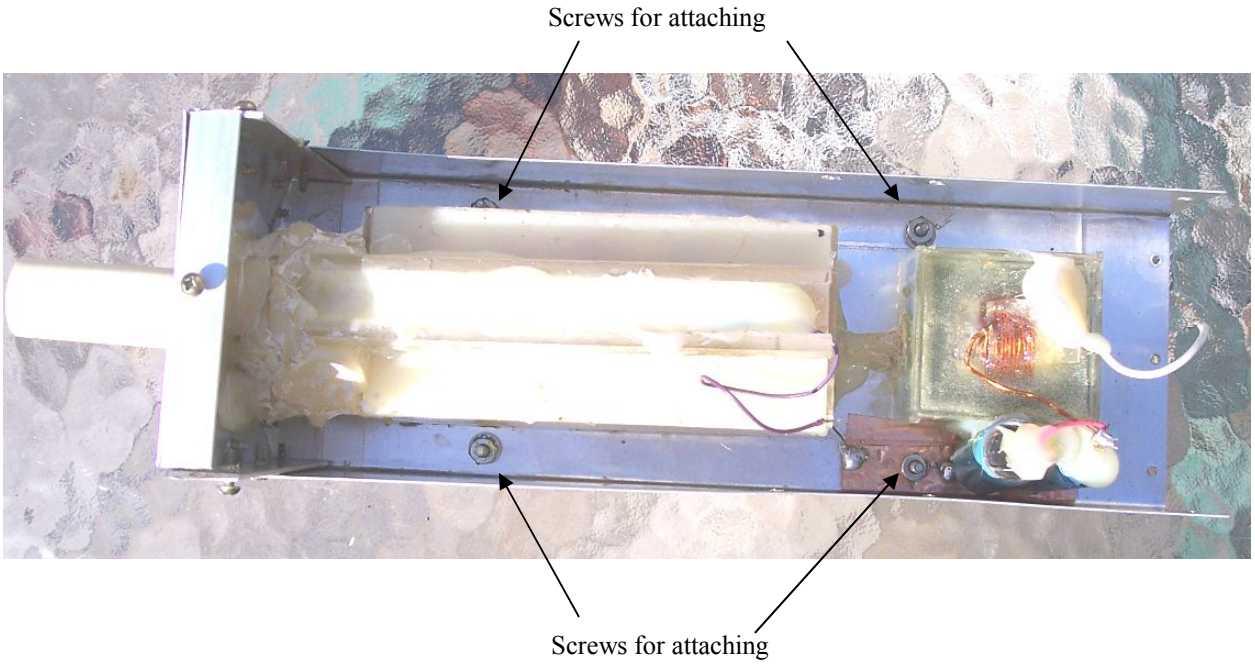

3.5 inches
4.1 inches

Construction Note Photos (Quick Overview) \ HV section \ Mounted to Metal Case

Side View

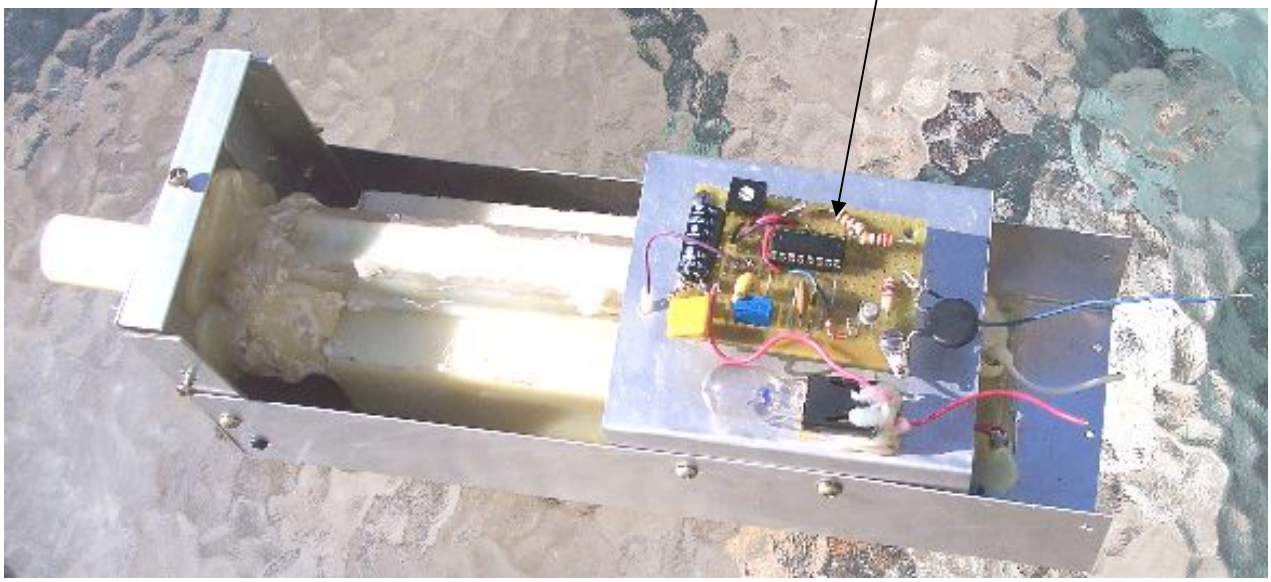


Top View



Construction Note Photos (Quick Overview) \ Controller Circuit \ Mounted to Metal Case

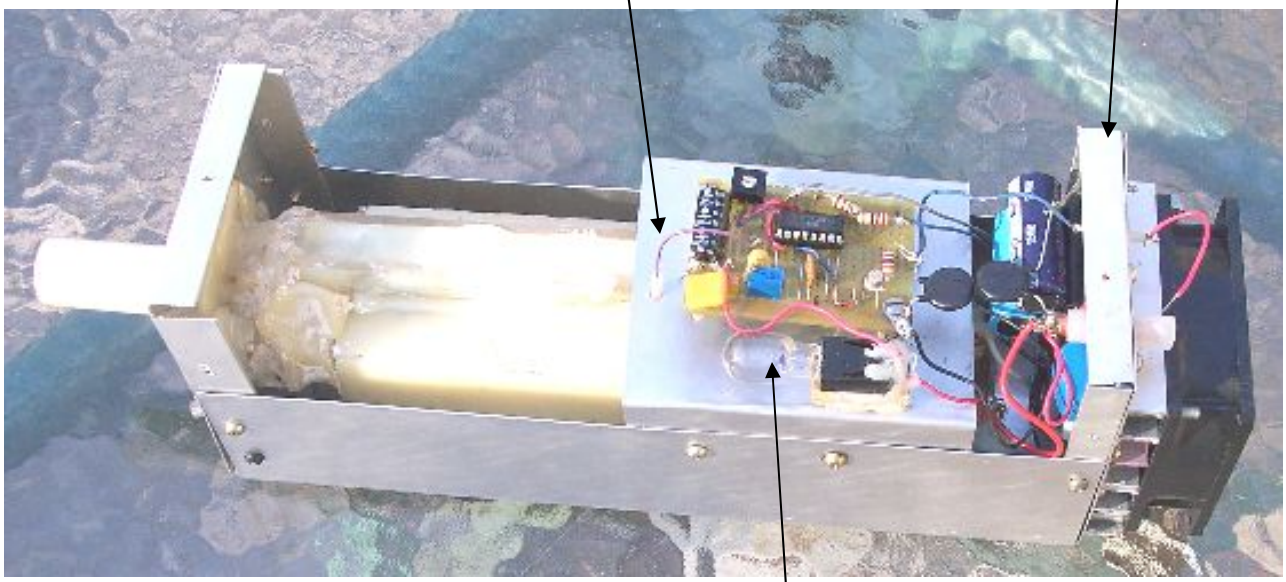
Controller circuit



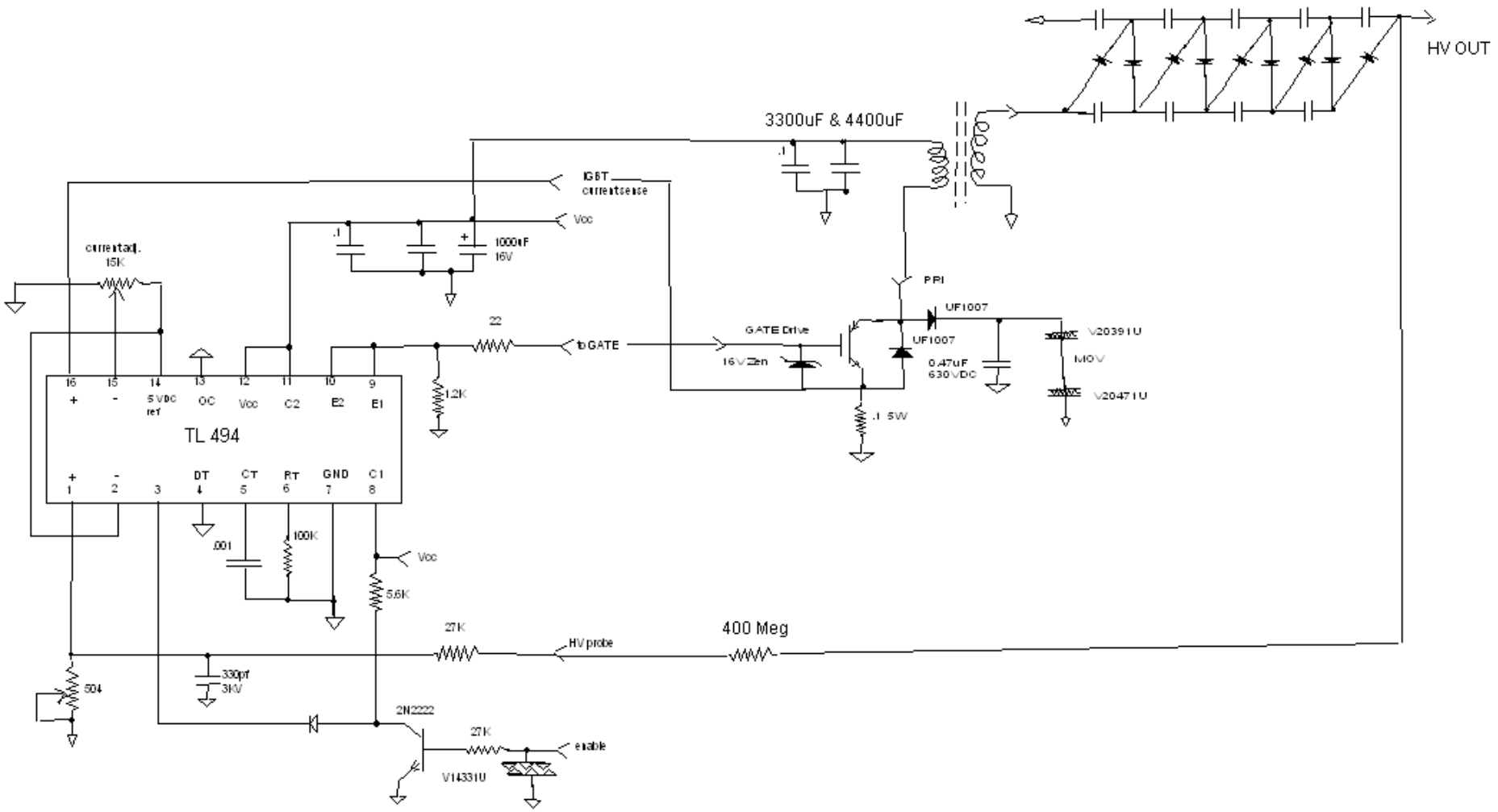
COMPLETED UNIT / Lid Removed

IGBT Section

HV probe feed back



Light bulb current ballast


HV OUT
3300uF & 4400uF
IGBT currentsense
Vcc
1000uF 16V
currentadj. 15K
PPI
UF1007
GATE Drive
16V Zen
UF1007
0.47uF 630VDC
V20391U
MOV
V20471U
22
toGATE
1.2K
.1 5W
TL 494
5 VDC ref
OC
Vcc
C2
E2
E1
DT
CT
RT
GND
C1
.001
100K
Vcc
5.6K
27K
HV probe
400 Meg
330pf 3KV
504
2N2222
27K
enable
V14331U

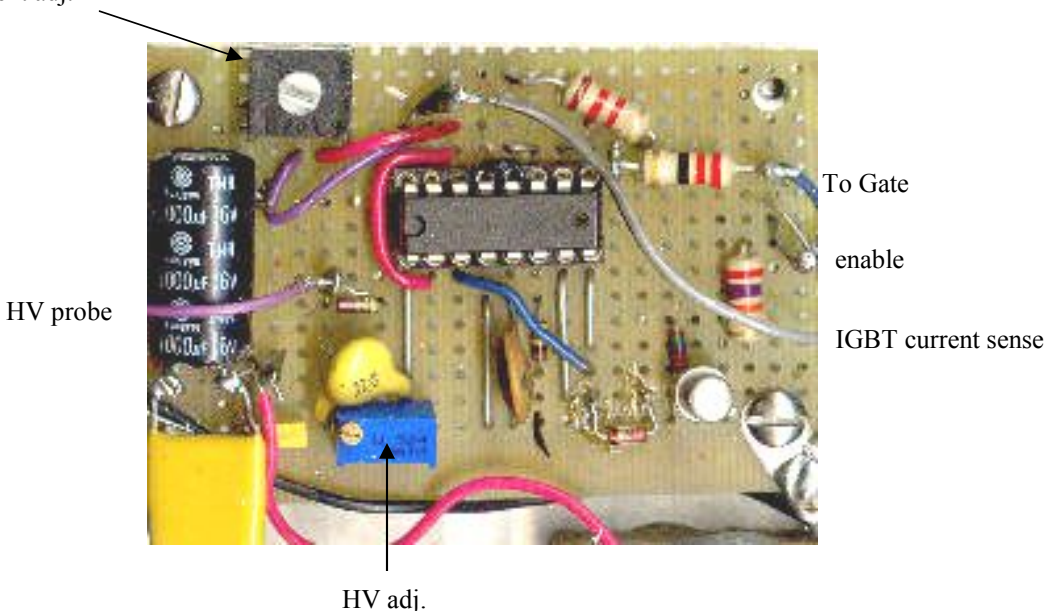
Construction Note Details \ Controller Circuit

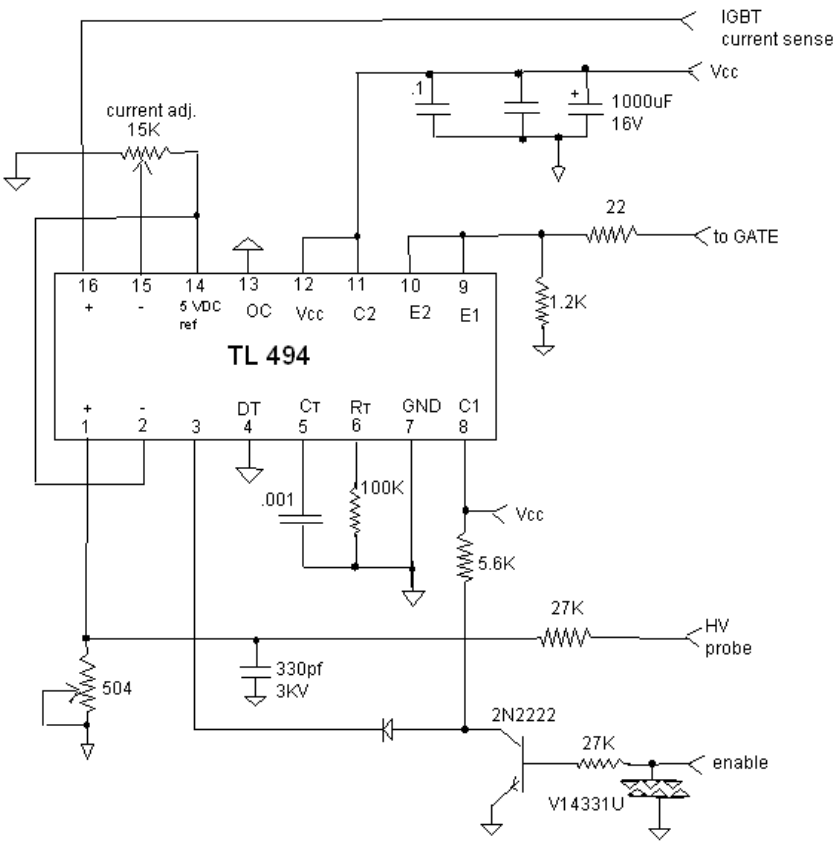
Comments:

The gate drive source and sink is enhanced by paralleling E1 &2 and C1 & 2 (emitter and collector). The gate capacitance has the tendency to increase the rise time; the temptation is to connect the gate directly to the drive source. I have learned the hard way that when the IGBT fails the gate seems to short out which in turn shorts the494 drive. For this reason a gate current limited resistor (22 ohms) is used. A 1.2K resistor keeps the gate voltage close to zero when the IC is removed for diagnostic purposes.

A third input control was added to pin 3 for the enable circuitry (1N4148, 2N2222, ..). The first input is for voltage adjustment, the second for limiting the current.

This circuit needs design improvements; mostly to address the start up power draw instabilities. Automatic enable after power up etc..

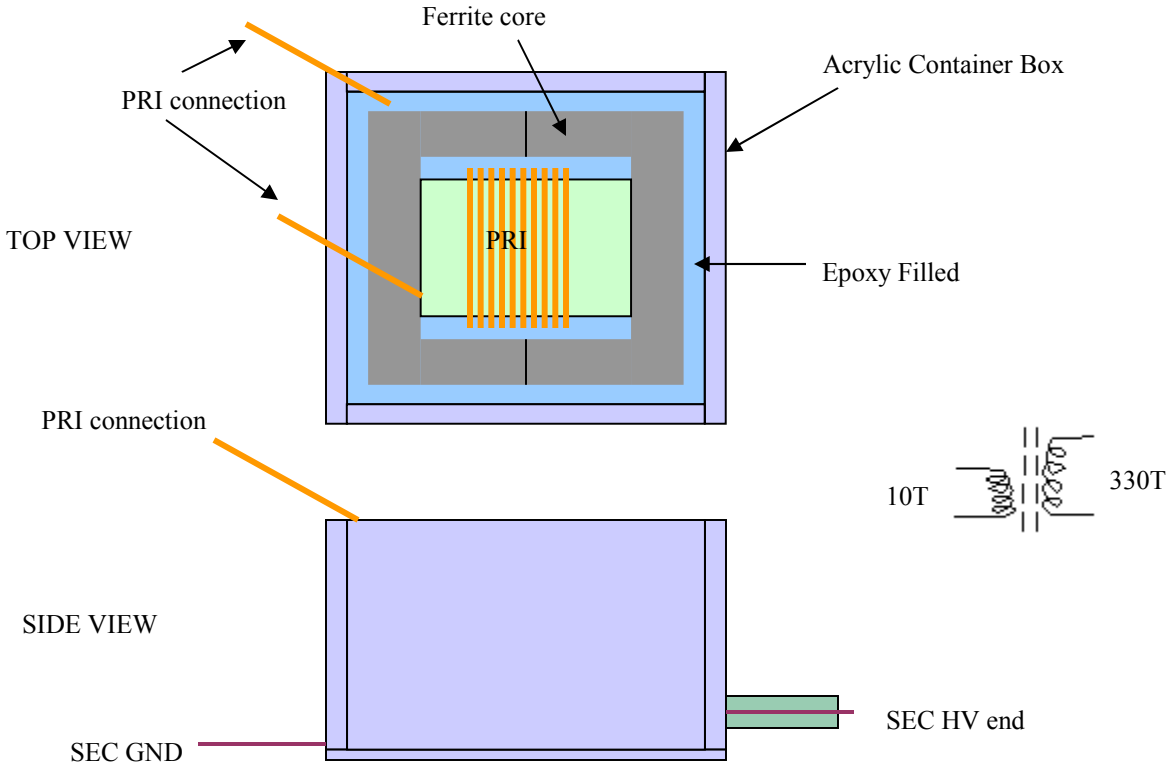




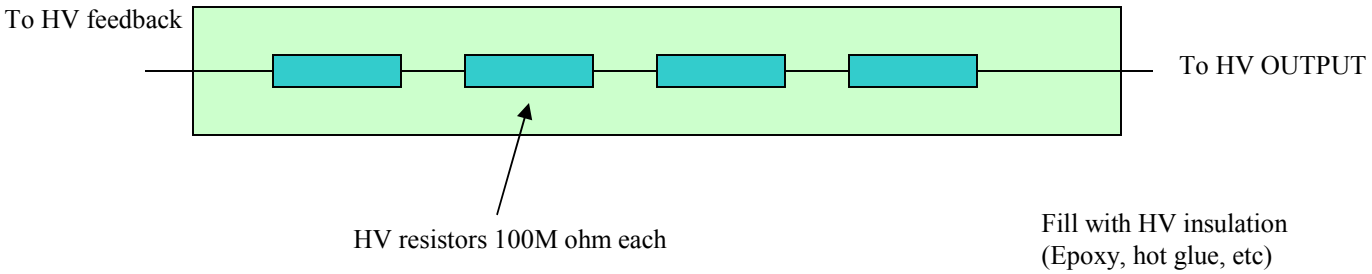
Construction Note Details \ Transformer

The technique for the flyback transformer construction is described at:
(http://vaughns_page.50webs.com/HV/transformer/flybk_A/flybk_a.html)

This project used, when convenient, pre-constructed components; this particular transformer assembly was constructed about two years before this project was conceived. The Fair-Rite core type is believed to be 77; the core itself is ETD part # 9577440002. The primary is 10 T of # 20 magnet wire; the secondary about 330 T # 30 magnet wire.

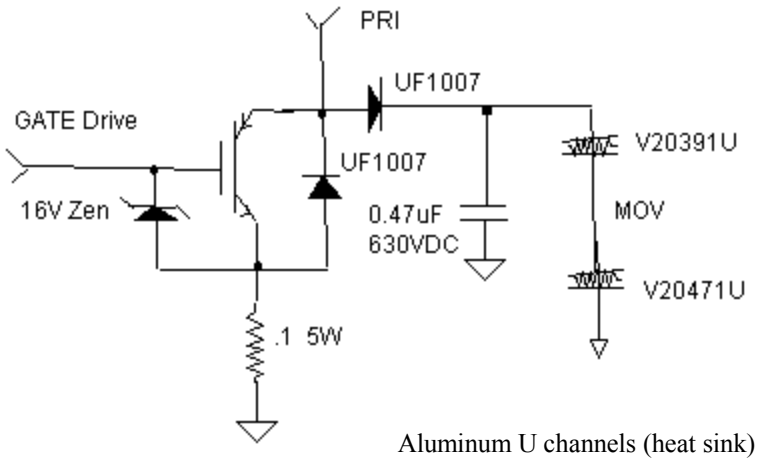


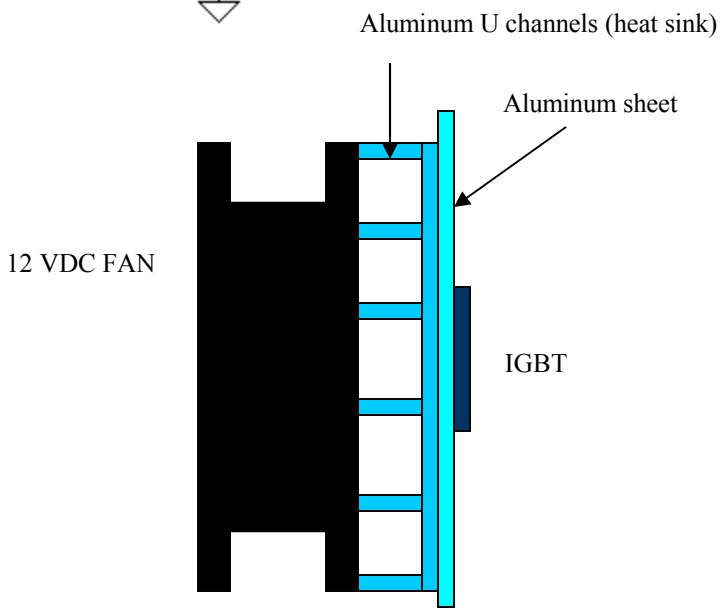
Construction Note Details \ HV Probe



Construction Note Details \ IGBT Section

The IGBT section is a circuit I used ten years ago on a flyback transformer project; the IGBT is of the 1200 Volt type IRG4PH50U or similar; the diodes are of the ultra fast recovery UF1007. The remaining components protect the GATE (16 volt Zenor) and anode (MOVs etc.)

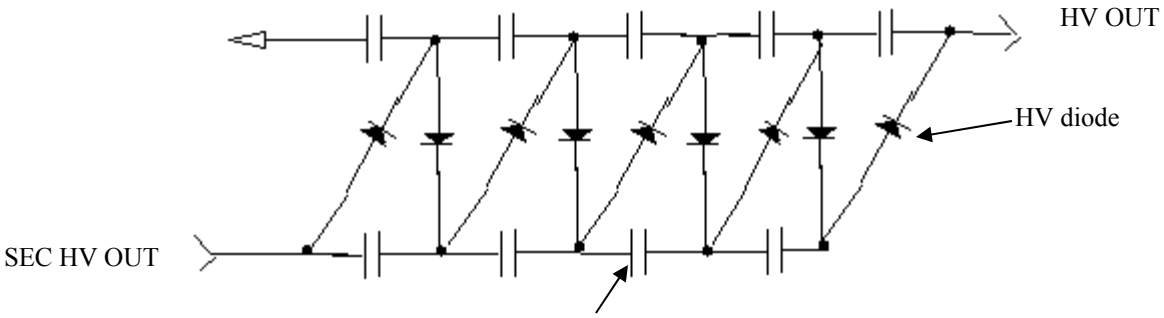




Construction Note Details \ HV Multiplier Section

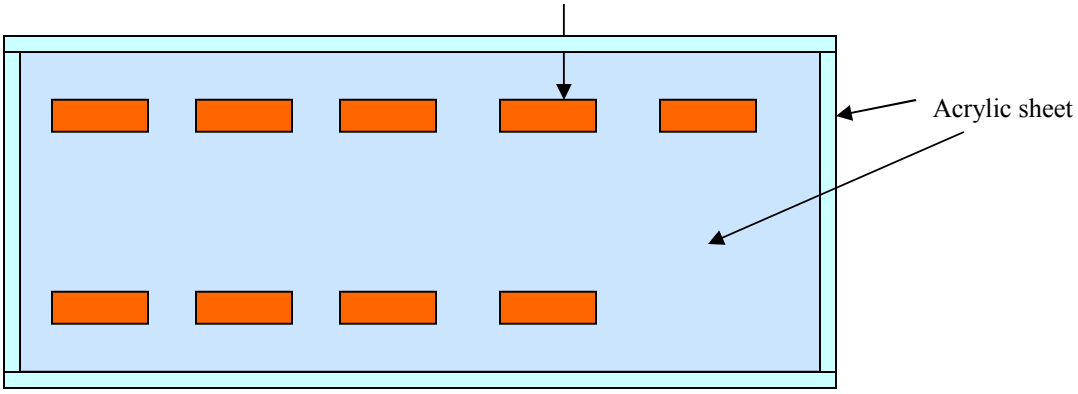
Comments:

The voltage multiplier was constructed some time ago and shelved; most of the components are not visible being immersed in HV insulation (epoxy and hot glue). The circuit diagram shown below (for documentation purposes) is my best guess even though it doesn't represent the type I normally use;



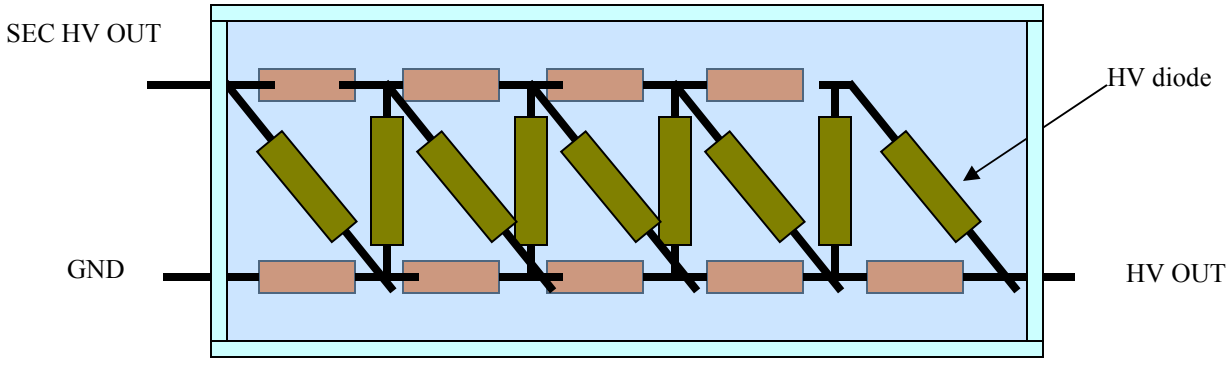
Each capacitor :CERAMITE 2.5nF 15 KV

SIDE A VIEW



Fill Acrylic enclosure with HV insulation

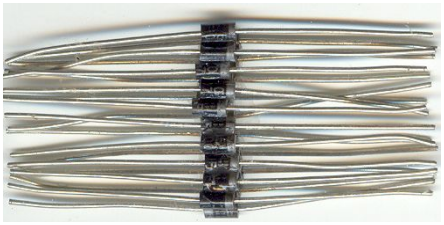
SIDE B VIEW



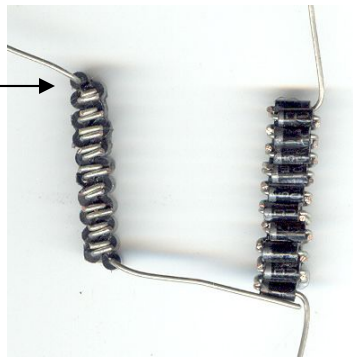
Construction Note Details \ HV Multiplier Section\ HV Diodes

HV Diode Construction

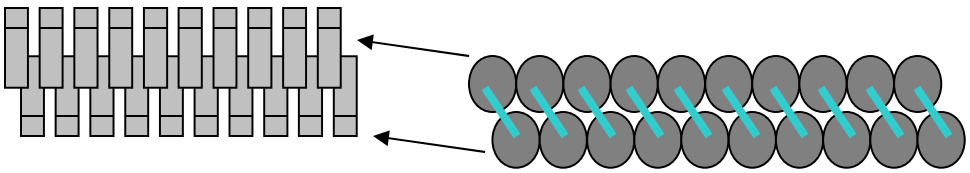
Ultra fast diode type UF1007 1KV PIV @ 1A (Digi-Key) are laid out parallel in groups of tens super glued together. After drying two of the ten glued diode sections are stacked and glued. Take careful note below of the orientation of the anode and cathode. These twenty diodes are to be connected and soldered in series. When carefully assembled I have had very good success with these.



After the two layers are glued the leads are trimmed to length except for the end sections



The folded and trimmed leads are carefully soldered together; keep solder smooth as possible to reduce HV stress



The soldered diode assembly is cleaned(alcohol) and dried; then carefully given an epoxy coating being careful to work out any air bubbles between the soldered leads

Construction Note Details \ HV Multiplier Section\ HV Probe