PVM2000 Instructions

THESE VIDEOS ARE A MUST-WATCH FOR SETUP & OPERATION:

https://youtu.be/dhkURRlvX0g

https://youtu.be/GfdBTIOXbpk

They contain essential operating information for the PVM2000.
Multiple viewings are highly recommended!

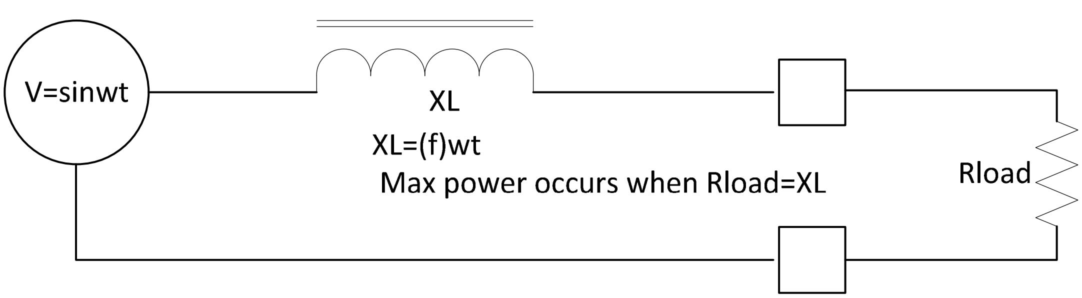
Then please read the following information on load type to determine whether your load is resistive or complex, as knowing this can greatly simplify operation:

TECH DATA ON NON-RESONANT AND RESONANT LOADS

This plasma driver system can drive both non-resonant resistive and resonant complex loads.

Non-Resonant Resistive Loads

The advantage of a ***straight resistive*** load is that the amount of voltage the load sees is dictated by the turns ratio of the transformer. The current drawn is a function of the real resistance of the load and the Inductive reactance of XL as the frequency that the unit is tuned to. Now the current will vary as the frequency is changed because the transformer secondary is basically a reactants and therefore the source impedance increases as you increase the frequency and vice versa as you decrease the frequency. The equivalent circuit for this approach is shown below.



XL increases with frequency and vice versa. This is not a resonant function but is dependent on turns ratio of transformer and freq of XL. This is a very useful feature controlling load power by only changing the frequency control!

The reactance also limits the short circuit current to a safe value and is all reactive energy.

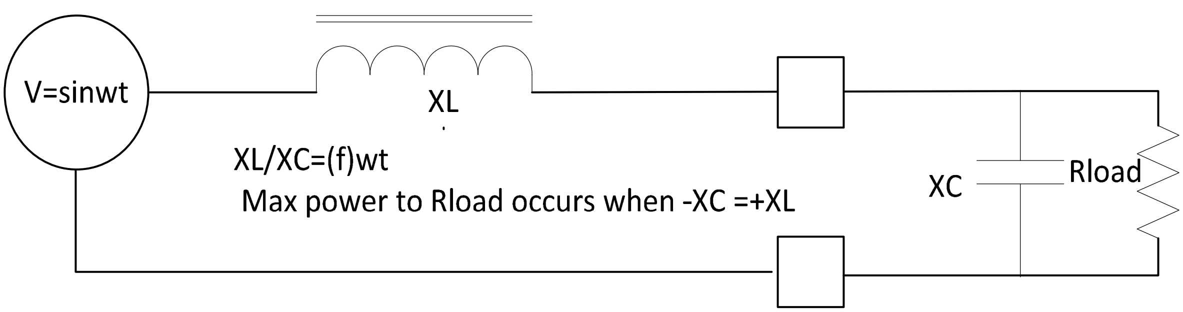
A good example of a resistive load is gas vessels with internal electrodes in direct contact with the plasma gases to be energized...

Resonant Complex Loads

A ***complex load*** is usually capacitive in nature due to the structure of the plasma cells and containment geometries. This presents a different problem as to get any current into the system requires the capacitive part of the load to be eliminated which is accomplished by varying the frequency of the generator to a point where the capacitive reactants of the load equals the inductive reactants of the secondary coil being the voltage source. The system is designed so that it works with a majority of the requirements that customers and experimenters have for cell structure, usually somewhere between 10 and 200pF. Note the system is not limited to those values and can have an optional transformer made to tune out higher values of capacitance.

The amount of real power is the actual plasma or and Corona discharge formed in the real resistance of the load. The capacitive electrodes used in the geometry of the plasma structure as the capacitive part of the load and now produces a complex impedance when written in complex form is (R-Jx) see drawing schematic. When the cell of the containment structure capacitance is tuned out you will get a voltage peak from a resonant rise. The only limiting factor controlling the current now is the real resistance of the load. This can take on a range of values dependent on the Q factor of the load. This function has much to do with the amount of power that can be taken without exceeding the voltages or the ratings of the transformer. This is a series resonant system when tuned therefore unlike anti-resonance or a parallel circuit, the lower the resistance the higher the Q, as equal to X/R. So basically the power that you can deliver to your system depends a lot on the values you choose for your load. How-ever because the frequency of this unit can tune from 20 to almost 100 kHz it does give you a factor of controlling these parameters to a great extent.

One of the features of this unit is a current control by adjustment of the duty cycle. This feature allows your load to see the same voltage however it will be chopped so that when integrated over a period, the power will be controlled by the ratio of time on to time off and of course this allows tremendous flexibility when you have loads that want to draw high amounts of current over the ratings of the units.



As you adjust the frequency, a point will occur where you will get a sharp rise in current as noted on the ammeter. This is where the -XC=+Xl as a (f)wt and cancels out leaving only the Rload allowing more current/power to the load dependent on the circuit Q.

Impedance of resonant as a $f(1/t)$ $Z = (X^2 + R^2)^{1/2}$ Q=X/R

NOTE: Take care when first tuning for the resonance peak. Start with the input voltage at 20%, then adjust the duty cycle control and input voltage. You can damage your load or the unit if over powered!

A certain amount of knowledge helps to effectively operate the unit as in some cases it must be tuned to the output capacitance and resistance of the load. This is basic boilerplate technology to any electronics engineer and simply involves the handling of complex numbers, polar notation or simple impedance matching algebraic formulas.

PVM2000 INSTRUCTIONS

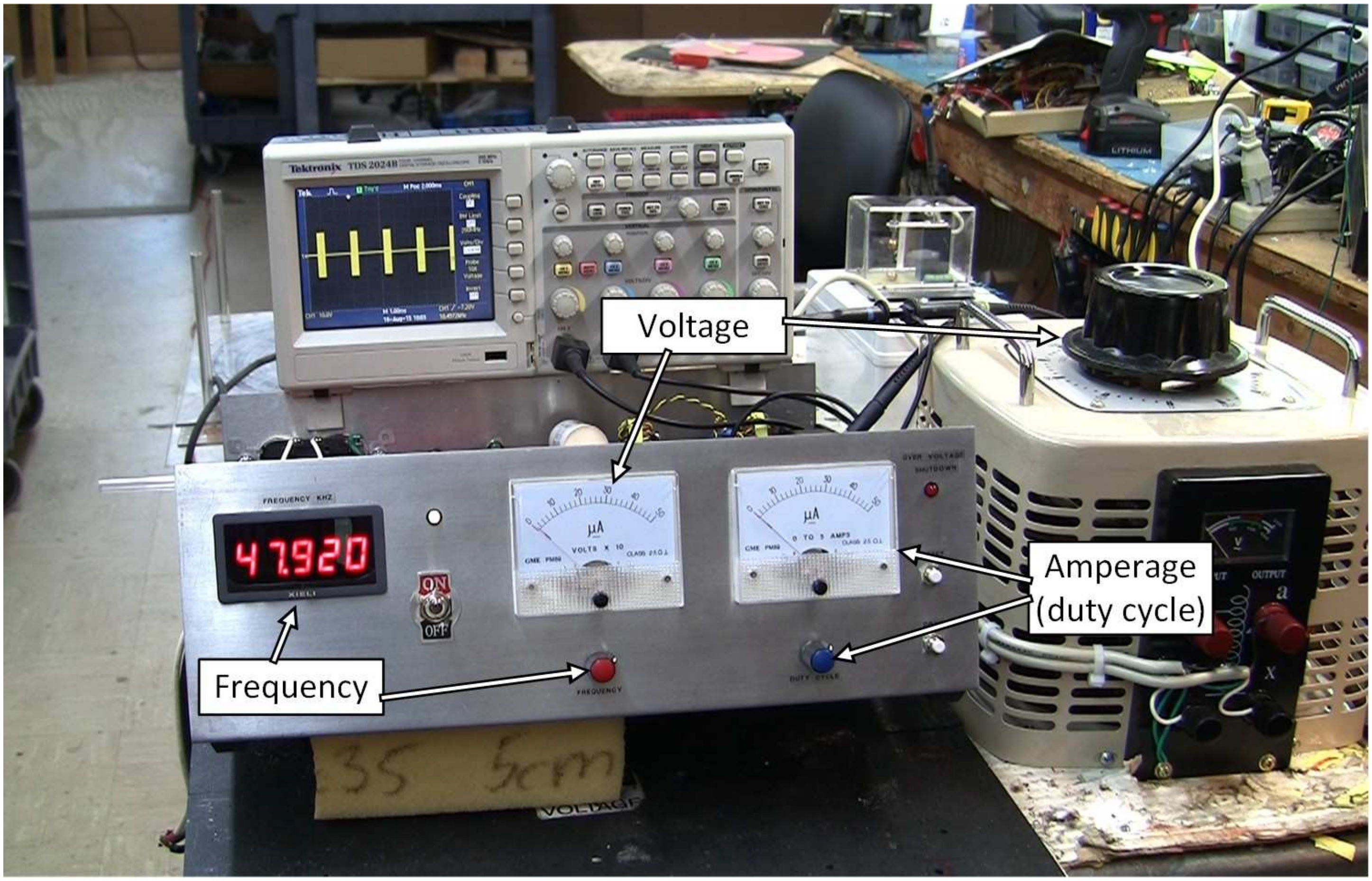


FIG 1: OVERVIEW & FRONT PANEL CONTROLS

Off on switch and associated pilot lamp controls the power to the internal control circuitry and to the external power to the VARIAC that is used for the main power of the switching rails that provide the main output. You will note figures 5 and 7 showing these external variac connections.

The frequency control knob allows adjustment from roughly 20 kHz to 70 kHz. It is not recommended to go below 10 kHz. This is the actual output switching frequency of the unit and it is this frequency as it varies that your target circuit must be resonant to, to get an effect of voltage rise. A digital meter displays the frequency as tuned by this control.
This is very important when used in plasma systems where you have capacitive coupling electrodes. Usually this capacitance must be tuned out to get the correct indication and the real power into the load. This usually takes a little basic knowledge from the user in knowing how to deal with complex algebra and real and unreal numbers and also of course the characteristics of anti- resonance of parallel circuits and resonance of series circuits.

The duty cycle control knob allows chopping the pulse so you can maintain the voltage values but control the current. When switched off the duty cycle is 100%, when switched on the duty cycle starts at minimum of 10% and then adjusts in a clockwise direction to 90%. We have enclosed in this data a more comprehensive description of the duty cycle control. This is very important because sometimes you can get a very high series resonant circuit if its is high Q can draw copious amounts of current and yes you can control this with the variac but you are also controlling the voltage. With the duty cycle control you control the current and the voltage remains at its required setting.

FIG 2: POWER METERS

Meters

The analog volt meter (left) reads the rail-to-rail voltage of the power amplifier from 0 to 500 Volts.

The analog current meter (right) reads the rail current from 0 to 5 Amps.

Between these two readings, it is a simple matter to determine the power component to the load (Power = Voltage x Current).

Shutdown Section (right side of panel)

Overvoltage Shutdown indicator: when an overvoltage breaks across the safety gap it will trigger the shutdown function, which turns off signal to the final drive. This lamp then illuminates.

Reset: this button turns the unit back on after an overvoltage has broken across the safety gap. Be sure to first reduce the voltage or the safety gap will be triggered again and the unit will shut right back down.

Drain: after the variac is turned all the way down, there may still be some charged voltage remaining. Depending on the type of load, the drain button will discharge that remaining voltage through the load.

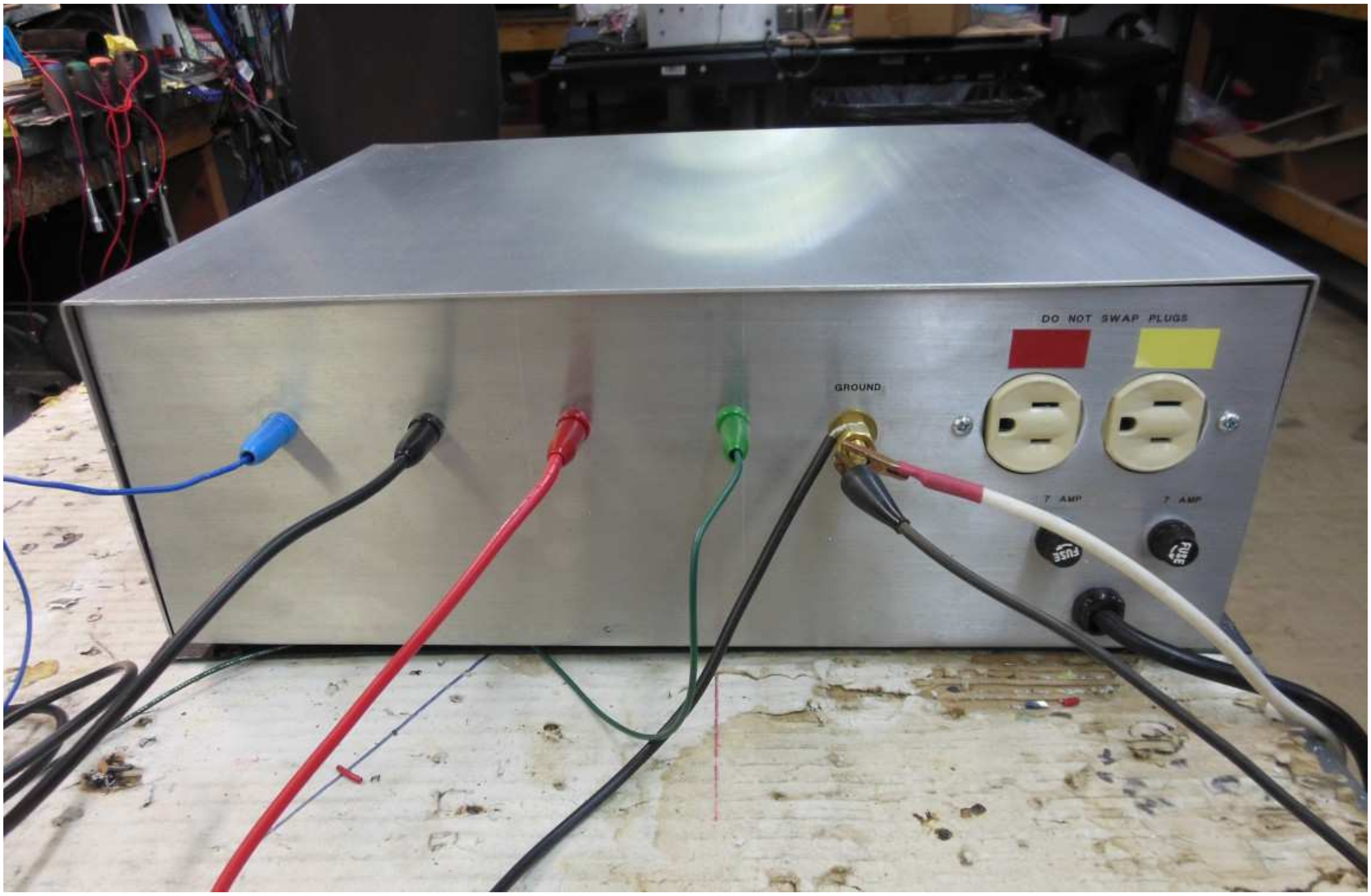


FIG 3: OUTPUT LEADS FROM FULL BRIDGE AMPLIFIER TO OUTPUT TRANSFORMER (FIG 4A)

Green ground Jack is chassis ground.

Red lead is output of full bridge that is connected to the output transformer figure 4

Black lead is remaining output lead of full bridge that is also connected to output transformer figure 4

These leads carry a maximum voltage of 400. Signal is a square wave at the frequency set by the freq pot

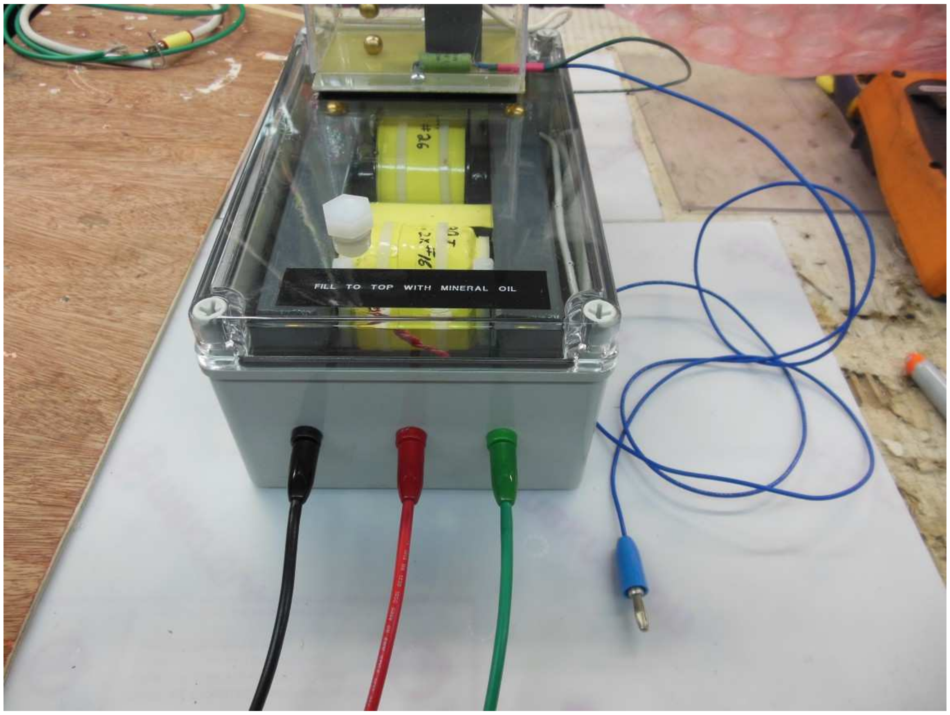


FIG 4A: FRONT OF POWER TRANSFORMER SHOWING INPUTS

Remove top oil plug and fill with mineral oil to top of container.

Connect inputs and ground leads to appropriate color-coded connections, as shown.

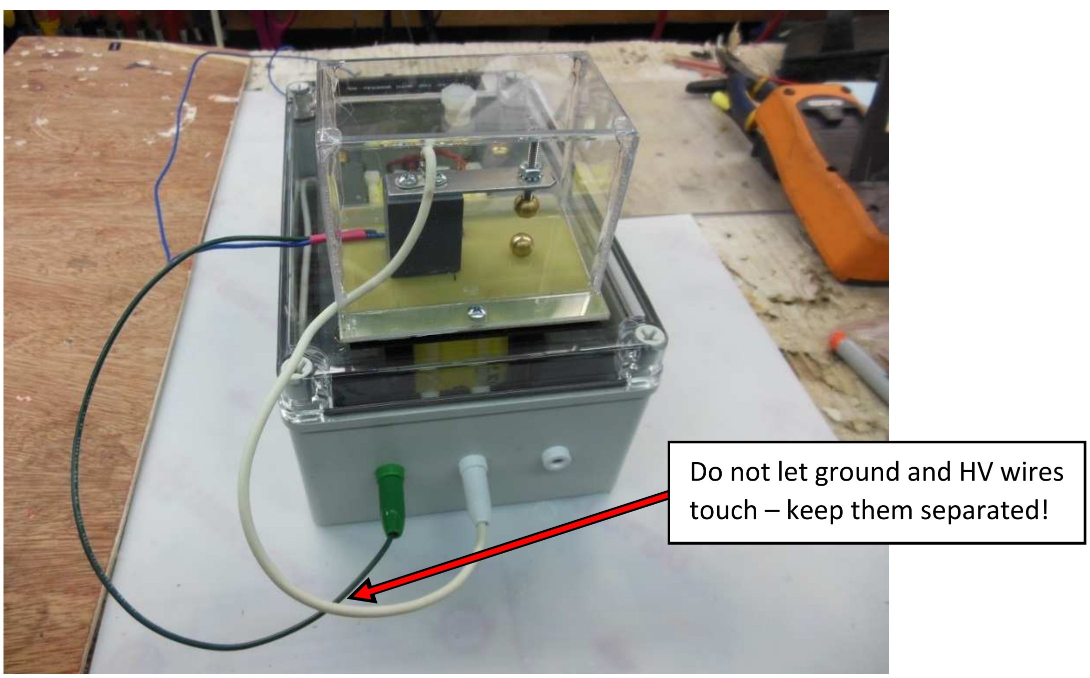


FIG 4B: BACK OF POWER TRANSFORMER SHOWING OUTPUT

Connect capacitive load to high VOLTAGE OUTPUT and HV GROUND with suitable insulated leads. Note that these leads can have a voltage of many thousands dependent on circuit Q and drive volts.

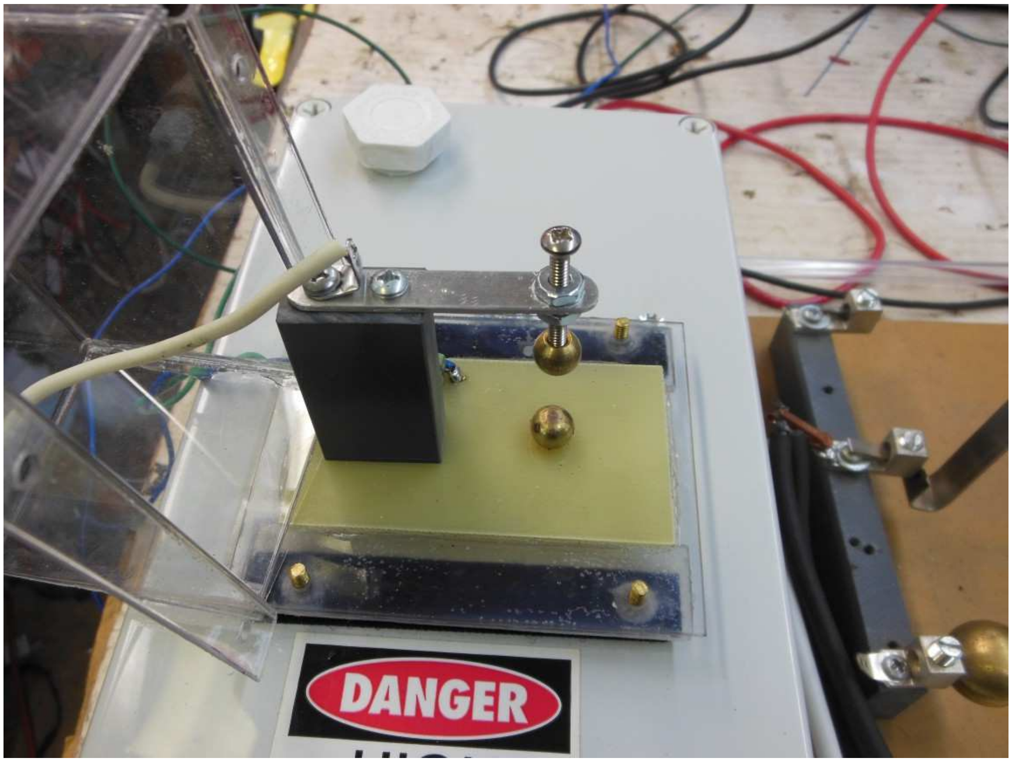


FIG 4C: SAFETY GAP

We keep this at about 1/2 inch (12mm), but you can adjust this to your desired safety shutdown voltage.

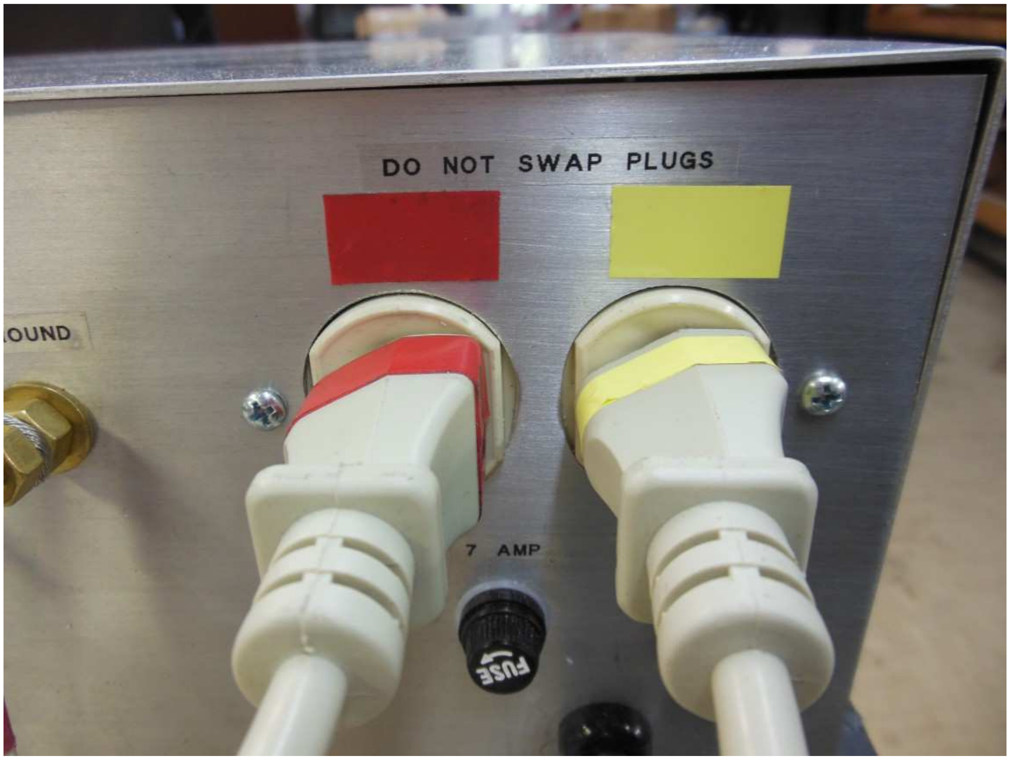


FIGURE 5: REAR OF AMPLIFIER SHOWING OUTPUT CONNECTIONS

It is very important that the variac input and output are plugged to the correct sockets. The sockets are coded with colored tape, which are matched to color-coded plugs. Left is “from variac” and right is “to variac”

FIGURE 6 BASIC OPERATING INSTRUCTIONS

1. Connect load to the high voltage output and ground of the power output transformer see figure 4.

2. Preset all controls CCW. Preset variac control knob from 25 to 30. This is approximately 25 to 30 V AC.

3. It is assumed that your load has a capacitance within a value that is going to be resonant with the output inductance of the transformer. The value of capacitance that will resonate with the current transformer coil is in the low picofarads.
We have enclosed a special coil that you can substitute with the current secondary for up to 700 pF load capacitance. You should have some grasp on complex loads to operate this machine with any degree of success.

4. You can also put in air gaps into the core on the secondary side only, to also vary the inductance and extend the tunable range. You are limited in the air gap spacing as the core will not properly fit together on the primary side. If your tuning appears to be on the high-frequency side this usually will not be a problem as the core is wound to accommodate a wide range of frequencies, if they are all above 10 kHz.

5. To find resonant peak you can turn the variac to 25 or 30 V.

6. Slowly adjust frequency and very carefully note the current meter for any tendency to peak even if the peak is just barely noticeable and there are no other peaks. This is probably the frequency of resonance.

7. You may now turn up the variac another 10 to 20 V and check the peak again it should be higher.

8. You may now connect a circuit for your resistive load if you need one and make the adjustments according to what is needed for your application.

9. The digital frequency meter on the panel Fig 1 will display the frequency that you are at and as you tune.

NOTE: Resonant Rise

Please read, as this is important for proper operation of this product!

Please note that the voltage that this unit will generate is not a function of the turns ratio on the transformer. We set the transformer to usually produce a voltage of **50,000 V pk-pk**. The transformer secondary circuit mathematically is equated as a voltage source driving a reactance. This reactance is controlled by the airgap in the secondary only of the transformer, the number of turns, and the frequency that you happen to be tuning to. This is the inductance part of the resonant system that tunes out the capacitive reactance of your load. Now when you connect this to your load which is capacitive you're going to tune the frequency and obtain a resonant rise in voltage that is going to be dependent on the Q of the circuit you are driving. So now the voltage output is a function of these parameters. You now control the voltage with the voltage control that is on the unit to prevent a potential transformer failure. **Our higher powered units have** built-in protection circuitry that will shut the system down should the voltage on the transformer exceed the rating that the transformer is insulated for. Usually this is at least **60,000 V pk-pk, 30kV pk, 20kV rms as at resonance waveshape is sinusoidal.**

NOTE: Duty Cycle

Our duty cycle controlled power is used in several of our projects: our large Tesla coil (Chapter 15), solid state Tesla coil (16), HHO power conditioner (22), large Jacob's ladder (19), induction heater (18), 100W CO2 laser (17), 1000A power supply (14), coil gun (13), black hole generator (10), and trigger/ignitor/shocker (9). It has many advantages over other methods of power distribution. When power is controlled by a variac or other voltage reducing mechanisms, output to the load decreases by Ohms Law where power = E x I, and the load sees a reduced voltage to control power. Both voltage and amps are simultaneously decreased as they are dependent functions on one another. An example is in attempting to dim a gas discharge tube such as a piece of neon or fluorescent tubing. As the voltage is decreased the tube dims to a point where now the gas discharge pulls from the ends, or extinguishes. Loads such as HHO reaction cells, corona or ozone production, paint spraying, flocking, or other chemical reactions suffer simultaneous voltage and current changing as dictated by the load resistance.

Duty cycled controlled power utilizes the time domain of the voltage. The waveform sketches show various ratios of the voltage wave form over a 1 second period. The sketch at A shows 10 volts at 100% "time on." The power produced in a 5 ohm resistor is simply volt squared divided by load resistance, in this case 10^2/5=20 watts. Sketch B shows a 50% "time on." One might think that the power is now 10 watts…but this is WRONG! For the 1-second period the voltage is discontinuous. It is 10 volts for half the 1 sec period and zero for the other half. The load sees full voltage and full current therefore full power of 20 watt for 1/2 sec. The energy for the one sec period is 5 joules. As the time "on" decreases the load still sees full voltage for the "on" interval, but now proportionately less energy in joules.

A plasma such as ionized neon gas in a long glass tube clearly shows this neat effect. The display can be reduced to a snake like thin line of energized plasma. The plasma would not pull from the ends of the discharge tube but would be obviously very dim. This is the result of very short full voltage pulses at corresponding current but much less joulean energy as energy = ∫ vi(t)

The load (if a gas discharge tube, solid state Tesla coil, HHO gas generator or those mentioned above) will now maintain the operational benefit of full voltage intervals but greatly reduced energy due to the shorter time "on".

If you dimmed the same tube by reducing the entire voltage time domain you would get dimming with display pulling away from the end electrodes and becoming very inhomogeneous. Other devices would function very erratically due the lack of voltage during the "on" time of the period.

To summarize: you can control the power to a device by control of the current without reduction of the applied voltage. The device operates at normal voltage and current for a variable domain in time.

100% DUTY CYCLE

50% DUTY CYCLE

25% DUTY CYCLE

ADDENDUM: Example letter to customer

The specifications that you have required on your order can be met. However at a higher frequency than 70 kHz you may not be able to get the full 2000 Watts. This power supply is primarily designed to drive resonant loads where the real resistance in the complex impedance expressed in complex form (R + JX). The amount of power that can be drawn will be a function of the circuit (Q) of your resonant circuit. So there are certain variables that the user must be familiar with to operate this unit to its full extent. We have tried in the instructions, explain to the user these basic functions. There are several hundred of these out in the tech field without problems once the user is shown or becomes knowledgeable of complex impedances.

The power supply can also be operated in the nonresonant mode when driving virtually a pure resistance load and will operate throughout a wide band of frequencies only dropping off at the higher frequencies due to the inductive reactants of the driver transformer.

In the resonant mode of operation, these devices have the capability to tune out the capacitance of the cell or plasma container. This feature produces a resonant rise in current now allowing efficient power transfer to the real resistance of the load being the energy transferred to the actual plasma. When operated in this resonant mode the voltage generated is not a function of the turns ratio of the transformer. These transformers have been set to produce a maximum voltage of 10 to 20,000 V rms by the turns ratio. In resonant operation the transformer secondary circuit mathematically is equated as a voltage source driving an inductive reactance. This reactance is controlled by the air-gap in the secondary, the number of turns, and the selected operating frequency. Now the inductance part of the resonant system tunes out the capacitive reactance of the load by adjusting the frequency control. When connected to a capacitive load the frequency should be tuned to obtain a resonant rise in voltage that is going to be dependent on the Q of the circuit being driven. So now the voltage output can be a function of these parameters and be considerably more than what is available when operated in the conventional un-tuned mode! The duty cycle control adjusts the current. See Duty Cycle download for more information.

A certain amount of knowledge helps to effectively operate the unit as in some cases it must be tuned to the output capacitance and resistance of the load. This is basic boilerplate technology to any electronics engineer and simply involves the handling of complex numbers, polar notation or simple impedance matching algebraic formulas.

ADDENDUM

The plasma driver system can drive a complex load as well as a straight resistive load.

The advantage of a straight resistive load is that the amount of voltage the load sees is dictated by the turns ratio of the transformer. The current drawn is a function of the real resistance of the load and the frequency that the unit is tuned to. Now the current will change as the frequency is varied because the transformer secondary is basically an inductive reactance and therefore the source impedance increases as you increase the frequency and vice versa as you decrease the frequency. The equivalent circuit for this approach is shown.

A complex load is usually capacitive in nature due to structure of the plasma cells and containment geometries. This now presents a different problem as to get any current into the system requires that the capacitive part of the load be eliminated and this is accomplished by varying the frequency of the generator to a point where the capacitive reactance of the load equals the inductive reactance of the secondary coil being the source. The system is designed as a majority of the requirements that customers and experimenters have being for cell structure usually is somewhere between 10 and 200 pF. The system is not limited to those values and can have an optional transformer made to tune to higher values of capacitance.

The amount of real power which is the actual plasma or Corona discharge formed is the real resistance of the load and is usually negative.

The capacitive electrodes used in the geometry of the plasma structure is the capacitive part of the load and now produces a complex impedance when written in complex form (R – jXC) see drawing schematic. When the cell of the containment structure capacitance is tuned out you will get a voltage resonant rise in current as now the only limiting factor is the real resistance of the load. This can take on many forms and values. Consequently, the Q of the load has much to do with the amount of power that can be taken without exceeding the voltages ratings of the transformer. The equivalence circuit will show this is a series resonant system. When tuned, unlike anti-resonance power at resonance is higher the lower the resistance and the higher the queue as Q as equal to Xc/R. So basically, the power that you can deliver to your system depends a lot on the values you choose for your load. The frequency of this unit can tune from 20 to almost 100 kHz giving you a decent range of controlling these parameters.

One of the features of this unit is current control by adjustment of the duty cycle. This allows your load to see the same voltage, however it will be chopped so when integrated over a period, the power will be controlled by the ratio of time on to two time off. This allows tremendous flexibility when you have loads that want to draw high amounts of current over the ratings of the units capacity.