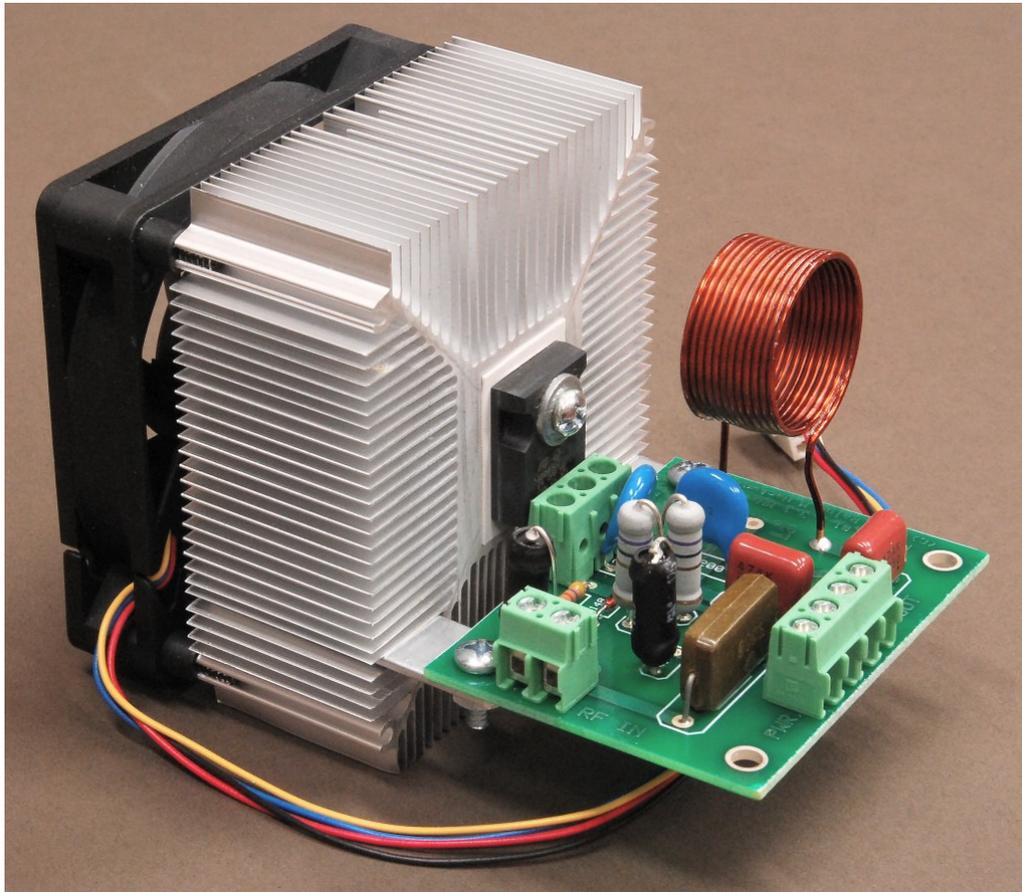


# Instruction Manual

For the

## PA1 3.1 MHz Switch Mode Plasma Tube Driver Amplifier v1.01 with HS2 Heat Sink Assembly



Manual v2.00 – 03 September 2012

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Spectrotek Services and Ralph M. Hartwell ARE NOT RESPONSIBLE for any damage or injuries of any sort or form that may be sustained by any person or persons, any animal, or to any equipment or any other thing or things while anyone is using, modifying, testing, or experimenting with the SSQ-2F or the PA1 in any manner whatsoever. This device has not been inspected or approved by any governmental or medical agency or inspection service. No medical claims are made for, nor implied by, the sale or use of this device. Using the PA1 is done solely at your own risk.

You are advised to always consult with your physician or other health care professional at any time should you have or think you might have a health problem of some sort. Please check with your physician or other health care professional before starting any diet, exercise, taking over-the-counter (OTC) medications or supplements and especially before taking any prescribed medication. Never stop taking any prescribed medications without first consulting your physician.

## **RADIO FREQUENCY WARNING NOTICE**

- The PA1 is a high-frequency switch mode power supply module designed to furnish a square wave modulated high voltage alternating current at a frequency of approximately 3.1 MHz across a 50 ohm load impedance.
- If the PA1 is installed incorrectly or used improperly, it is capable of causing severe radio frequency interference. To prevent this from occurring, observed the following warnings:
- The PA1 is to be used as a research device only, or as part of a complete system to drive a plasma tube.
- The PA1 is not intended to be used for any form of radio transmission in any manner whatsoever.
- The PA1 is not intended to be connected to an antenna or to any radiating element or to be used for any form of radio communications purposes in any manner whatsoever.
- The PA1 is designed solely to be a source of power to light a plasma tube.
- All electrical connections to the output terminals of the PA1 are to be made by the use of properly shielded 50-ohm coaxial cable capable of handling at least 500 watts at 3.1 MHz.
- All connections are to be made in such a manner as to minimize any RF radiation from the connecting wires to the PA1.
- The PA1 has been specifically designed to be driven by a high-level signal that is generated by the SSQ-2F v3.10 circuit board. The PA1 cannot be driven by a sine wave signal, such as from a low powered transmitter. It is not a linear amplifier, and it will not function as such.
- The operating frequency range of the PA1 has been restricted to a 1 MHz portion of the spectrum centered at 3.1 MHz.
- Any attempt to drive the PA1 with a radio frequency source such as a CB radio transmitter, will result in either no power output from the PA1 or immediate destruction of the STW20NK50Z MOSFET in the PA1.

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## **A note about the definition of the word POWER as used in this document.**

In this document, unless otherwise specified, when the word "**power**" is used it will mean **peak power**. For example, with a 50% duty cycle, 300 Watts peak power is the equivalent of 150 Watts **average power**. Likewise, with a 100% duty cycle, 300-Watts peak power is equivalent of 300-Watts **average power**.

## **What does the PA1 do?**

The PA1 is designed to increase the power output of the SSQ-2F v3.10 to a level as high as 300 to 500 Watts for driving larger plasma tubes.

## **What type of amplifier is the PA1?**

The PA1 is not a conventional RF power amplifier, and it cannot be used as such. It will not accept an RF drive signal from a conventional transmitter, such as a CB radio. The PA1 is actually a high-frequency switch-mode power supply designed to convert DC power into semi-square wave pulses of energy at 3.1 MHz and at a high voltage.

The PA1 has been designed so that its output matches a standard 50-ohm load impedance, making it possible to connect the output of the PA1 to a conventional antenna tuner or to the 3.1 MHz link coil coupler. Due to the unconventional design of the PA1, the output signal from the PA1 is just as good as the output signal from the SSQ-2F v3.10.

The PA1 is designed to be driven by the SSQ-2F v3.10. The PA1 increases the power output of the SSQ-2F v3.10 to between 300 to 500 Watts peak power. For modulation duty cycles between 0 to 100%, the PA1 will produce at least 300 Watts output. For modulation duty cycles between 1 to 50%, the PA1 can produce up to 500-Watts peak output. These power levels are sufficient to operate even the largest plasma tubes now available.

## **How much power can I get from the PA1?**

Depending upon the size and efficiency of the heat sink on which you have installed on the PA1, the power output of the PA1 may be between 300 to 500 Watts peak power or 150 to 250 Watts average power when using a 50% duty cycle modulation.

If the PA1 is installed on a sufficiently large heat sink, then higher duty cycle modulation may be used. This will provide a corresponding increase in output power from the PA1. With a large enough heat sink, the PA1 is capable of operating in excess of 500 Watts peak power output. When mounted on the HS2 heat sink assembly, the PA1 will operate at full rated power.

For most large plasma tubes, 300 Watts peak power is sufficient to properly drive the tube. Operation at higher power levels may cause overheating and possible damage to your plasma tube. Please consult with your plasma tube manufacturer to determine the correct power level for your plasma tube.

## **What changes do I have to make to my SSQ-2F v3.10 to use the PA1 ?**

The only change that is necessary is to lower the DC voltage applied to the amplifier section of the SSQ-2F v3.10 to reduce the output power of the SSQ-2F v3.10 so it will safely drive the PA1. When driving the PA1, the SSQ-2F v3.10 requires only a single power supply of 19 V DC for its operation.

## **What type of drive signal does the PA1 require?**

The PA1 is designed to be driven directly from the output of the SSQ-2F v3.10. The PA1 will not accept a drive signal from any other source.

## **What range of frequencies does the PA1 accept?**

The PA1 will operate across the range of 2.8 to 3.8 MHz. Operation outside this frequency range may cause serious damage to the PA1.

## **I am uncomfortable soldering wires to circuit boards. What do I do?**

All connections to the PA1 are made using screw terminals, so no soldering is required.

## **How can I power the PA1?**

The PA1 may be powered from any power supply that has an output voltage of 120 to 190 V DC. The maximum current required is approximately 3 amperes. For best results when operating the PA1, the power supply should be both voltage and current regulated. It is advisable to install a fast operating 3 ampere fuse in the positive voltage line.

## **Is the SSQ-2F v3.10 and the PA1 a complete Rife Plasma system?**

No, it is not a complete Rife plasma system.

The SSQ-2F v3.10 is designed to produce a correctly modulated RF signal for a Rife plasma system. It contains an on-board RF power amplifier that may be used to drive the PA1. By itself, the SSQ-2F v3.10 will produce up to 100 watts peak power output. This power level is suitable for driving a moderate sized Rife plasma tube

In some cases, the power output from the SSQ-2F v3.10 may not be high enough to drive the larger plasma tubes used by some researchers. The PA1 was developed to remedy this situation. The PA1 is capable of producing a higher power level, output when driven by the SSQ-2F v3.10. The PA1 cannot be driven by any other type of radio frequency source.

This block diagram shows how the SSQ-2F v3.10 and the PA1 are connected in typical Rife-type system.

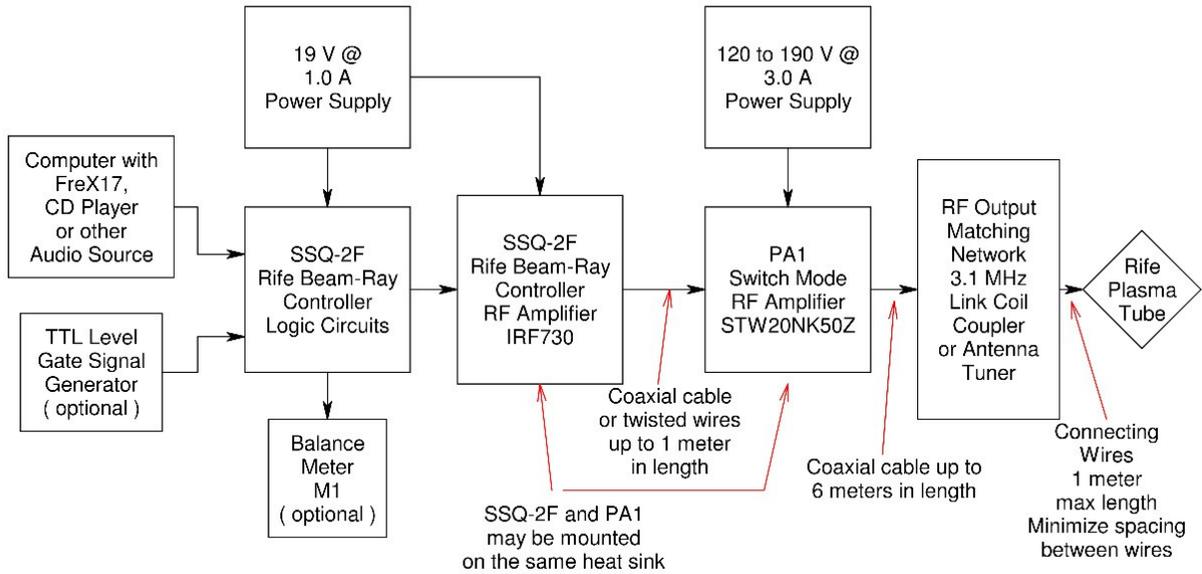


Figure 1

Block diagram of a typical Rife plasma system using the SSQ-2F v3.10 and the PA1.

## CONNECTIONS:

All connections to the PA1 are made by using the small screw terminals that are located in the plastic terminal blocks mounted on the edges of the circuit board. These will accept either solid or stranded conductor wire.

When tightening the screws, do not over tighten the screws to avoid damaging the connector. Just strip approximately ¼ inch / 6 mm of insulation off the end of each wire and insert it into the hole in the terminal block, then gently tighten the screw to clamp the wire in place.

The following diagram (Figure 2) shows the relative position of the various connectors on the PA1. They have been color coded in Figure 2 for ease of identification. Note that the terminal blocks on the PA1 will usually all be the same color.

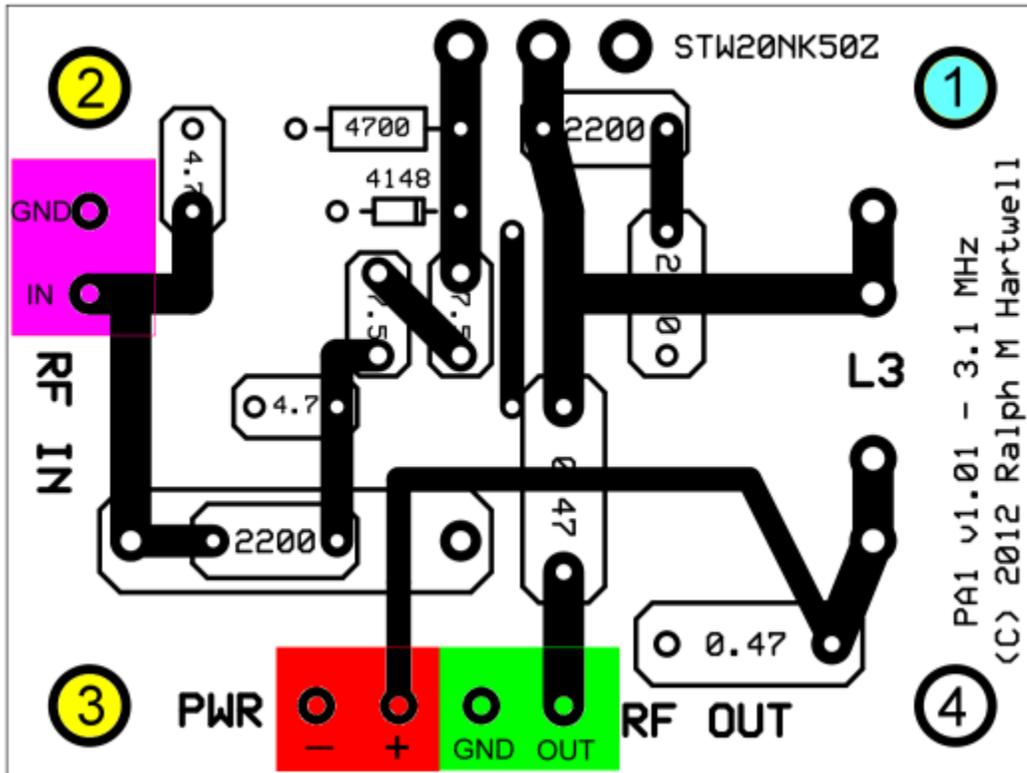


Figure 2

PA1 Terminal block identification as viewed on the component side of the board.

**Please refer to Figure 2 for the location of the following connections.**

**( PWR )**

This terminal block is used to connect DC power to the PA1. Any voltage between +120 to +190 volts may be used. The current required is approximately 3 amperes maximum. The left connection is power supply negative, and the right connection is power supply positive. ***The power supply output voltage MUST be isolated from the AC mains for safety.***

Note that the GND terminal of the RF OUT block, the ( - ) terminal of the PWR block, and the GND terminal of the RF IN block are all connected together and serve as the ground / earth connection for the PA1.

**(RF IN)**

This terminal block accepts the drive signal from the SSQ-2F v3.10. You may use either a twisted pair of wires or a length of coaxial cable to make this connection. Wire lengths of up to 6 feet / 2 meters in length may be used. The LEFT connection is RF or coaxial cable shield, and the RIGHT connection is RF drive or coaxial cable center connection.

Connect the cable shield or one of the wires in the twisted pair of wires to the LEFT terminal of the RF IN terminal block. This is the ground / earth connection.

Connect the center wire of the coaxial cable or the other wire in the twisted pair of wires to the RIGHT terminal of the RF IN terminal block. This is the RF input connection.

### **( RF OUT )**

This terminal block is the RF output of the PA1. Connection to this terminal block requires the use of a shielded 50-ohm impedance coaxial cable between the terminal block of the PA1 and the matching system that will be connected to the plasma tube.

Connect the shield side of the coaxial cable to the LEFT connection of the RF OUT terminal block.

Connect the center wire of the coaxial cable to the RIGHT connection of the RF OUT terminal block.

### **( Mounting Holes 1, 2, 3, & 4 )**

*Please note that this section only applies if you are removing the PA1 from the HS2 heat sink and mounting the PA1 on a different heat sink assembly.*

The PA1 has four mounting holes. Mounting hole number 1 should be connected to electrical ground / earth and to the heat sink on which the PA1 is mounted. Make this connection by using either a very short wire, or by the use of a machine screw to mount the PA1 circuit board directly against the heat sink.

To avoid possible short circuits to the heat sink, the PA1 should be spaced slightly above the heat sink using a set of four metal spacers. Suitable spacers may be made by using several flat washers stacked together, or by the use of something such as a 6-32 mounting screw passing through the center of an 8-32 nut that is placed between the bottom of the PA1 and the surface of the heat sink.

Hole numbered 2 and 3 should be connected to electrical ground / earth, if possible.

Hole number four is electrically isolated and has no effect on ground / earthing the PA1.

## **Mounting the PA1 and the HS2 Heat Sink / Cooling Fan Assembly**

The PA1 is furnished already mounted on the HS2 heat sink / cooling fan assembly. The HS2 heat sink provides the proper cooling to allow the PA1 to operate at full rated power. Please be sure that nothing obstructs the flow of cooling air entering the fan or the warm discharge air leaving the heat sink.

When the PA1 is mounted on the HS2 heat sink, the result is a compact module that allows for easy incorporation of the PA1 into a complete plasma tube RF drive system. Both the SSQ-2F v3.10 and the PA1 may be mounted in the same enclosure or on the same metal mounting plate.

The HS2 heat sink with the PA1 attached to it may be mounted in place in your system by the use of a clamp, a bracket, or some type of strap that will hold the heat sink assembly firmly in place. It is important that the airflow through the heat sink not be obstructed in any manner. A plentiful supply of cool air must be allowed to enter the fan and the heat sink assembly. Likewise, the warm exhaust air must be allowed to freely exit the area of the heat sink.

### **VERY IMPORTANT !!**

**If the unit is placed in an enclosure, it is advisable to mount the air intake side of the fan immediately adjacent to an opening in the enclosure where fresh air from outside the enclosure can enter the fan. An unrestricted exhaust opening must be placed somewhere in the wall of the enclosure to let the warm air escape. The size of the exhaust opening must be equal to or larger than the opening for the cooling air inlet. Any restriction of the cooling air entering the heat sink assembly will result in overheating of the PA1 amplifier with possible failure.**

## **The Cooling Fan on the HS2**

The fan on the HS2 heat sink is powered by a 12 V @ 0.19 A. There are four wires attached to the fan. The wires are colored black, red, blue, and yellow. Only the black and red wires are used to provide power to the fan. The blue and yellow wires should not be connected to each other or to anything else. The supplied 4-pin connector may be cut off the end of the connecting wires and discarded.

To power the fan, connect +12 V DC to the red wire. The black wire connects to the negative side of the power supply. When the fan is supplied with power it will run at full speed.

The fan is very quiet and does not make much noise. It is easy to forget that it is running while you are working with your system. Please be careful not to allow your fingers or anything else to come in contact with the fan blades while the fan is in operation. Accidentally hitting the fan blades with your finger or a hard object such as a screwdriver may break one of the blades off of the fan hub. If this happens, it will be necessary to replace the fan.

## **RF Shielding Considerations to Prevent Interference to Other Devices**

If the RF output of the PA1 is taken through a properly installed and terminated coaxial cable, the incidental RF leakage from the PA1 will be minimal and no interference to radios or television receivers should occur due to radiation from the PA1 itself.

The most likely cause of electrical interference to other devices will occur from the radiation from the plasma tube and from the connecting wires between the plasma tube and the 3.1 MHz link coil coupler or the antenna tuner. It is important to minimize the length of these connecting wires. These wires should be equal in length, and spaced between 1 to 3 inches apart. Placing the wires close together helps to cancel unwanted RF radiation from the wires.

*In most jurisdictions, it is the responsibility of the operator of any radio frequency producing equipment to prevent the equipment from producing interference to other users of the radio frequency spectrum or other electronic equipment. Please be aware of local regulations before operating this equipment.*

## **Heat Sink and Cooling of the STW20NK50Z MOSFET**

The STW20NK50Z MOSFET, which is used as the RF power amplifier in the PA1, is a rugged device. However, as with all semiconductor devices, excessive heat will cause degradation or device failure. Evidence of STW20NK50Z failure will depend on the type of power supply you have connected to the PWR terminal block of the PA1.

If the supply is current limited, then the failure of the STW20NK50Z will very likely be silent - the RF output will simply drop to zero and the power supply will shut down due to over current. However, if you have a “stiff” power supply that can supply a large amount of current during a short-circuit condition, the STW20NK50Z may fail in a more spectacular manner, such as emitting smoke or bursting into flame or even exploding like popcorn.

Although it is unlikely, should the STW20NK50Z fail in an explosive manner, sharp pieces of the plastic case of the STW20NK50Z may be thrown violently in all directions, potentially causing injury to the operator. For this reason, it is recommended that the PA1 be mounted in such a manner as to contain any possible fragments.

## **Electrically Insulating the STW20NK50Z from the heat sink**

*This section only applies when it is necessary to replace the output transistor on the PA1.*

Because the STW20NK50Z generates a considerable amount of heat in a small package, a high quality thermal pad is required for safe operation of the STW20NK50Z.

The STW20NK50Z is operating at both a high DC voltage and a high RF voltage, therefore it is necessary to insert some form of electrical insulator (thermal pad) between the STW20NK50Z and the heat sink base plate. This insulator must be made of some material which both insulates the high voltage and at the same time it must be a good conductor for heat to allow the heat to flow from the STW20NK50Z to the heat sink base plate. Unfortunately, most materials which are good insulators for electricity are also good insulators for heat. Manufacturers have gone to a

great deal of trouble and expense to produce devices, commonly referred to as "thermal pads" which will function properly.

The Bergquist SPA2000-0.015-00-104 thermal pad is recommended for use with the PA1. If this pad is not available, a Wakefield 174-9-250P thermal pad may be substituted. However, the heat transfer capability of the Wakefield pad is approximately 50% of the Bergquist pad. Therefore when using the Wakefield thermal pad, the PA1 should not be operated above 300 Watts output with modulation duty cycles above 70%.

Before clamping the STW20NK50Z and the Bergquist thermal pad to the heat sink, use a liquid cleaning solution, such as 100% isopropyl alcohol and a lint free rag to carefully clean the underside of the STW20NK50Z and the area of the heat sink where the STW20NK50Z is to be mounted. Make sure that both sides of the thermal pad are very clean. Be sure that there are no stray particles of metal, lint, fiber, or other materials on the surface of the transistor, the thermal pad, or the heat sink before mounting the STW20NK50Z to the heat sink.

**When installing the thermal pad do NOT use any paste type thermal compound.** Using paste type thermal compound will cause decreased heat transfer and may cause damage to the thermal pad and/or destruction of the STW20NK50Z.

## **General Operation of the PA1**

### **RF Input from the SSQ-2F v3.10 to the PA1**

When connecting the RF output from the SSQ-2F v3.10 to the RF input of the PA1, a length of 50-ohm coaxial cable should be used. Type RG-58 cable is suggested. The length of the cable should be as short as possible, but in no case should the cable be longer than 3 feet / 1 meter in length. Longer cable lengths will degrade the drive waveform, which may damage the output transistor in the PA1.

### **Power Supply**

To use the PA1, you will need to use a power supply that provides a DC voltage between +120 to +190 volts, depending on the output power level you require. The higher the voltage, the more power output from the PA1. The current required is approximately 3 amperes maximum. The exact current drawn by the PA1 will depend upon the modulation duty cycle and the plasma tube load to which the PA1 is connected. The current is also affected by the tuning of the antenna tuner or the 3.1 MHz link coil coupler.

When using the PA1 and the LC31 link coupler to drive the Cheb 8 inch Phanotron plasma tube, a power supply voltage of between 120 – 130 V is required.

**IMPORTANT!** Be sure to connect a large electrolytic capacitor of at least 200 uF with a voltage rating of 250 volts DC or higher as close to the PWR terminal block as possible. This will help avoid power supply "bounce" and ripple in the RF output waveform that is caused when the RF amplifier section of the PA1 draws pulses of current through the inductance of the wires from the power supply.

If you have wires connecting the power supply to the PA1 that are at least 16 gauge / 1.62 mm in diameter and that are not longer than 6 feet / 2 m, then the capacitor may be placed across the output terminals of the power supply.

If the capacitor is not mounted close to the PA1, you should observe the RF envelope from the PA1 with a 50% duty cycle and a 1 kHz audio frequency input. If there is excessive bounce or ripple on the leading edge of the envelope, then the capacitor is either too small or needs to be moved closer to the PA1.

The power output from the PA1 is adjusted by varying the DC supply voltage connected to the PWR terminal block.

### **WARNING!**

*Do not attempt to adjust the output for the PA1 by changing the drive level from the SSQ-2F v3.10. Doing so will cause overheating and damage to the STW20NK50Z. Only change the power level of the PA1 by varying the DC power supply voltage of the PA1.*

## **RF Coupling Systems**

### **The LC31P or the LC31S 3.1 MHz Link Coupler System**

Using the LC31 coupler eliminates most of the RF losses of the antenna tuner and gives the RF signal at the plasma tube a sharper rise and fall time, resulting in a better, brighter plasma discharge and a more effective frequency output.

Using the LC31 coupler is simple. Simply connect a 20-foot length of solid dielectric 50-ohm coaxial cable between the output of the PA1 amplifier, and the input to the LC31 coupler. Connect the appropriate length of wire between the output of the LC31 coupler and the plasma tube. Then turn on the power. There are no tuning adjustments required.

Please see the LC31 instruction manual for more information on using the LC31 3.1 MHz link coil coupler.

## **Commercial Antenna Tuners**

*The use of commercial antenna tuners with the PA1 is strongly discouraged. The PA1 was designed to work best with the LC31 link coil coupler. While it is possible to use a commercial antenna tuner with the PA1, because of the large number of tuners available, it is impossible to give specific instructions for using each tuner. Therefore, the information presented below is only for general information, and should not to be considered as specific instructions for using a commercial antenna tuner with the PA1.*

*If you are attempting to use a commercial antenna tuner, you should begin your initial tune up with a DC supply voltage to the PA1 of no more than 75 to 90 V to prevent damage to the PA1 during the tuning process. After you have achieved a reasonable impedance match with the tuner, you may increase the DC voltage while simultaneously adjusting the settings on the*

*tuner to compensate for the difference in impedance of the tube. As the power level is increased.*

**It is strongly suggested that you use the type LC31 link coil coupler.**

To couple the RF energy from the PA1 to the plasma tube, a commercial antenna tuner of some sort may be used. This has been the standard practice for many plasma tube system operators and generally works satisfactorily. However, because the PA1 operates at 3.1 MHz instead of the more commonly used frequency of 27.120 MHz, an antenna tuner designed for Amateur Radio service is necessary. Most Amateur Radio antenna tuners will go down to 1.8 MHz. Due to the continuous duty operation of plasma tube systems, and the high power output from the PA1, you will need to use a tuner that is rated for at least 1200 peak. Tuners with less power handling ability may overheat, and they will deliver less useful power from the PA1 to your plasma tube.

If you are using a commercial antenna tuner, you will need to connect one end of a length of 50-ohm coaxial cable to the RF OUT terminal block of the PA1. Connect the other end of the coaxial cable to the input of the antenna tuner, usually labeled “Transmitter” or “Xmtr.”

If the tuner has a balanced wire output, then it has an internal balun transformer. In this case, connect a pair of wires from the balanced wire terminals on the tuner to the electrodes of the plasma tube.

If the tuner has only coaxial cable antenna output connectors, then you will need to add an external balun. Connect the input of the balun transformer to the antenna output jacks of the tuner. Connect the output leads of the balun through a pair of wires to the electrodes of the plasma tube.

To prevent unwanted RF radiation, the wires leading to the plasma tube should be as short as possible and placed as close together as possible without shorting them together.

**Caution:**

**When operating a large diameter external electrode plasma tube, such as the Cheb Super Tube at power levels above 200 Watts, the RF voltage developed across the tube during normal operation may rise to high enough levels to cause insulation failure in the balun.**

Is important to choose an antenna tuner or an external balun that is capable of handling high power and has excellent insulation.

## Tuning Your Home Built 3.1 MHz Link Coil Coupler System

If you have built your own 3.1 MHz link coil coupler system, the following procedure will assist you in getting it working properly.

Regardless of whether you use a commercial antenna tuner or a link coupling system, the basic tuning procedure is the same. You want to tune for the lowest VSWR reading and the brightest glow in the tube. Usually these will be close to the same tuning position.

Leave the PA PWR supply turned off. Set the audio frequency going to the SSQ-2F v3.10 to about 6000 Hz. Apply power to the SSQ-2F v3.10. A single power supply for both the logic circuit and the RF amplifier circuit of the SSQ-2F v3.10 is all that is required. The voltage should be between 19 to 24 V. This may be supplied by using a laptop computer power supply adapter. Next, adjust the audio level to the SSQ-2F v3.10 to obtain a modulation duty cycle reading of about 50%.

Start the initial tune up procedure with about 75 to 100 volts applied to the PA PWR terminal block of the PA1. Be sure to monitor the current drawn by the PA1. During the tuning process, please try to keep the current below 2 amperes to prevent possible damage to the PA1. This is low enough to protect the STW20NK50Z during the early stages of tuning. After tuning is complete, the DC voltage may be increased to the desired power level and the tuning adjusted as needed.

**CAUTION: When operating a plasma tube, if the RF power going to the plasma tube is changed, the tuning of the system will change.**

The system tuning will be erratic until the tube is fully lit, that is, until there is a discharge established across the complete length of the entire gap between the electrodes of the tube.

As soon as the tube is fully lit, a stable tuning situation will exist. As the RF power applied to the tube is increased, it will be necessary to tune the system to a slightly higher frequency in order to maintain optimum performance and lowest VSWR. When using the 3.1 MHz link coil coupler, if you have a variable capacitor installed for tuning instead of a fixed coaxial tuning capacitor, it will be necessary to slightly reduce the tuning capacitance slightly as the power to the plasma tube is increased. This is normal, and this effect will occur regardless of the type of plasma tube or the amplifier.

Now adjust the antenna tuner or link coupler tuning for the lowest VSWR / brightest glow in the tube. These should pretty much coincide. If you have an oscilloscope, you can “tweak” the tuning by observing the RF waveform at the RF OUT terminal block.

If you are using a 3.1 MHz link coil coupler, which has a fixed capacitor instead of a variable tuning capacitor, then it is only necessary to adjust the DC voltage supplied to the PA1 to a value which will provide the proper output level to drive your plasma tube. There are no other tuning adjustments required.

## Tuning Waveforms

If you have an oscilloscope available, then the best way to tune the matching circuit between the PA1 and the plasma tube is to observe the waveform at the drain of the STW20NK50Z MOSFET.

*Please be careful what taking these measurements!*

*When operating at high power levels, the voltage existing at the drain terminal of the STW20NK50Z may exceed 500 Volts RF along with a steady DC voltage of up to 190 V.*

The following pictures show the RF waveforms at the RF output of the PA1. They are taken at the RF OUT terminal block. For these pictures, the PA1 was connected to either a 50 ohm dummy load or to a plasma tube through the 3.1 MHz link coupler.

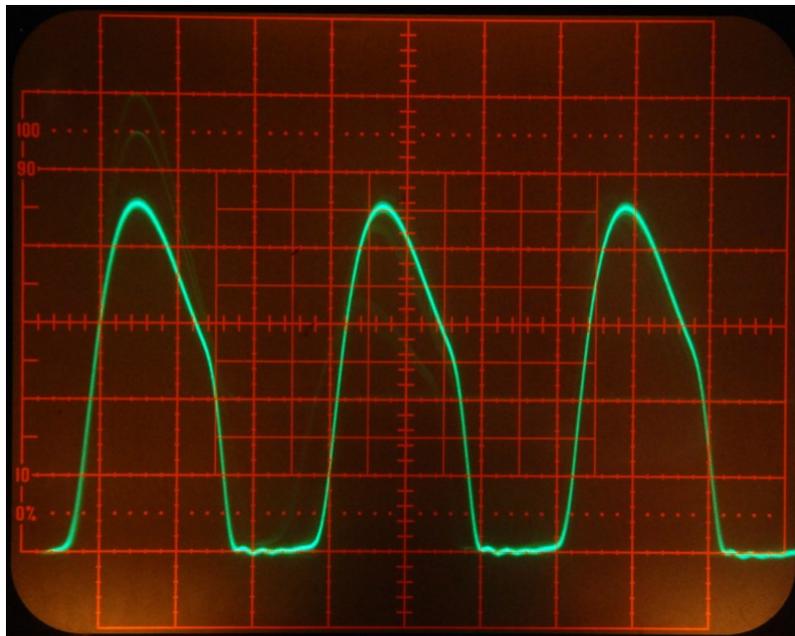


Figure 3

PA1 output waveform across a 50-ohm load.

This is also what the waveform looks like when the PA1 is properly tuned and connected to a plasma tube. Note that the upper part of the right-hand side of the waveform slopes slightly to the left. This is correct, and indicates the proper amount of tuning capacitance in the coupling system. If the waveform slopes to the right, then the tuning capacitance is too low. It is better to operate with too much capacitance, then too little.

### **CAUTION!**

**Operating the PA1 at high power levels when the system is tuned with too low a value of tuning capacitance will result in the STW20NK50Z drawing excessive drain current. This may cause the STW20NK50Z to fail due to overheating.**

**Operating the PA1 at high power levels with the system is tuned with too large a value of tuning capacitance will result in the drain voltage of the STW20NK50Z rising to excessively high levels. This may cause the STW20NK50Z to fail due to over voltage.**

The next two pictures show what the waveform looks like when the coupling system has too low a value of tuning capacitance.

**CAUTION!**

**Operating the PA1 at high power in this tuning condition may destroy the STW20NK50Z.**



Figure 4

This photograph shows the waveform from the PA1 when the tuning capacitor of the matching system is too low. In other words, the system is tuned too high in frequency. **Operating the PA1 at high power in this tuning condition may destroy the STW20NK50Z.**



Figure 5

This photograph shows waveform from the PA1 when the tuning capacitor of the matching system is too low. In this case, the system is much closer to resonance, but it is still tuned too high in frequency. Additional tuning capacity must be added or the STW20NK50Z may fail during high power operation. **Operating the PA1 at high power in this tuning condition may destroy the STW20NK50Z.**

## Replacing the STW20NK50Z on the PA1

Although the STW20NK50Z MOSFET that is used in the PA1 is a very rugged device, it is still possible for it to fail if the PA1 is operated under an excessive load or under improper operating conditions. Should this happen, it will be necessary to replace the STW20NK50Z MOSFET. This is not particularly difficult to do. Please read the following sequence of operations before attempting to replace the transistor.

1 – Using a small flat-blade screwdriver, carefully loosen the three clamping screws in the terminal strip that fastens the leads of the STW20NK50Z MOSFET in place.

2 – Remove the two 6-32 x 3/8” Phillips head screws and nuts that hold the PA1 to aluminum mounting bars that are attached to the heat sink. Place the screws and nuts where they will not become lost.

3 – Carefully remove the PA1 from the heat sink assembly.

4 – Using a Phillips head or a flat-blade screwdriver, unscrew the 6-32 x 3/4” screw and flat washer that clamps the STW20NK50Z MOSFET against the heat sink. Place the screw and flat washer where they will not become lost.

5 – Carefully remove the defective STW20NK50Z MOSFET from the heat sink.

Because the MOSFET will be probably stick to the Bergquist thermal pad that is between the MOSFET and the heat sink, you may have to use a pair of pliers to carefully pull the defective MOSFET away from the thermal pad. Be sure not to damage the thermal pad. It is very soft, and scratches or punctures easily. If it is damaged in any way, it will be necessary to replace it with a new thermal pad of the same type before installing the new MOSFET against the heat sink.

6 – Take the new STW20NK50Z MOSFET and carefully bend its leads into the same shape as the leads of the defective MOSFET.

Do not bend them too sharply or they may weaken and break off at the bend.

7 – Carefully trim approximately 1.5 mm from the end of the pins of the MOSFET. Be careful not to remove too much of the pin length.

8 – Using a small piece of lint free cloth and 100% isopropyl alcohol, gently clean the surface of the Bergquist thermal pad and the metal surface of the STW20NK50Z MOSFET that will mount against the thermal pad.

9 – Carefully position the replacement MOSFET against the surface of the thermal pad, and press it firmly against the thermal pad.

10 – Using the 6-32 screw and the flat washer, clamp the new MOSFET firmly against the Bergquist thermal pad and heat sink. Do not allow the MOSFET and the thermal pad to twist sideways while tightening the screw.

Although it may seem that the length of the 6-32 screw is a longer than it needs to be, it is necessary to use a long screw in order to spread the clamping force across a number of screw threads that are tapped in the heat sink. The screw must be tightened very firmly against the transistor. The flat washer must be used to spread the clamping force over the transistor body and prevent cracking of the transistor case.

11 – Carefully position the PA1 circuit board so that the leads of the new STW20NK50Z enter the holes of the mounting block on the PA1. Be sure that you do not bend the leads of the STW20NK50Z in the process.

12 - When you observe that the leads have entered the mounting block correctly, then you may replace the two Phillips head screws and nuts that clamp the PA1 circuit board to the aluminum mounting bars that are attached to the heat sink.

13 – Gently, but firmly, tighten the three clamp screws that hold the leads of the STW20NK50Z to the PA1 circuit board. ***Do not omit this step or the MOSFET may be destroyed during operation!***

14 – Inspect your work to make sure that there are no short circuits, metal particles, or anything else that might interfere with the proper operation of the PA1. If all is correct, you may replace the heat sink assembly and the PA1 in your system and resume normal operation.

## **SPECIFICATIONS:**

### **DC Power Supply Input:**

- +15 to +190 volts DC at a maximum current of 3.0 amperes; nominal operating current less than 2.1 amperes, depending on output power level and modulation duty cycle.

### **Input Drive Signal:**

- 3 to 4 watt power level, semi-square wave pulse waveform obtained from the SSQ-2F v3.10.

### **Operating Frequency:**

- 2.8 to 3.8 MHz. Operation outside of this frequency range may cause damage to the PA1.

### **RF Power Output:**

- When set for driving a plasma tube or as an exciter for an external vacuum tube RF amplifier, the PA1 will produce up to 500 watts peak power, 250 watts average power as measured across a 50-ohm load when the carrier is modulated by a 50% duty cycle square wave.
- When operated at a peak power level of 300 watts, the PA1 may be operated with any duty cycle between 0 to 100%.
- The power output of the PA1 may be adjusted by varying the DC voltage supplied to the PA1.

## **Warranty**

All our products carry a one (1) year warranty against manufacturing defects. Mechanical damage is not covered; i.e., you dropped it on the floor and then accidentally stepped on it. For warranty claims, you pay shipping to us; we pay shipping back to you.

Kits assembled by the purchaser are also have a one (1) year against component failure. Breakage or overheating damage from soldering of components during assembly is not covered under warranty.

Damage to the STW20NK50Z MOSFET transistor due to over voltage operation or inadequate cooling is not covered under warranty.

For all warranty claims or equipment service, please contact us by email or telephone before returning equipment for service.

Out-of-Warranty repair service is at the rate of \$20/hour, with a maximum charge of \$50 per item, unless otherwise specified. Please contact us for additional pricing on custom repair services.

## **Contact us**

Ralph Hartwell

Spectrotek Services

641 Sisson Road  
Natchitoches, LA  
71457-6743  
USA

318-527-6766

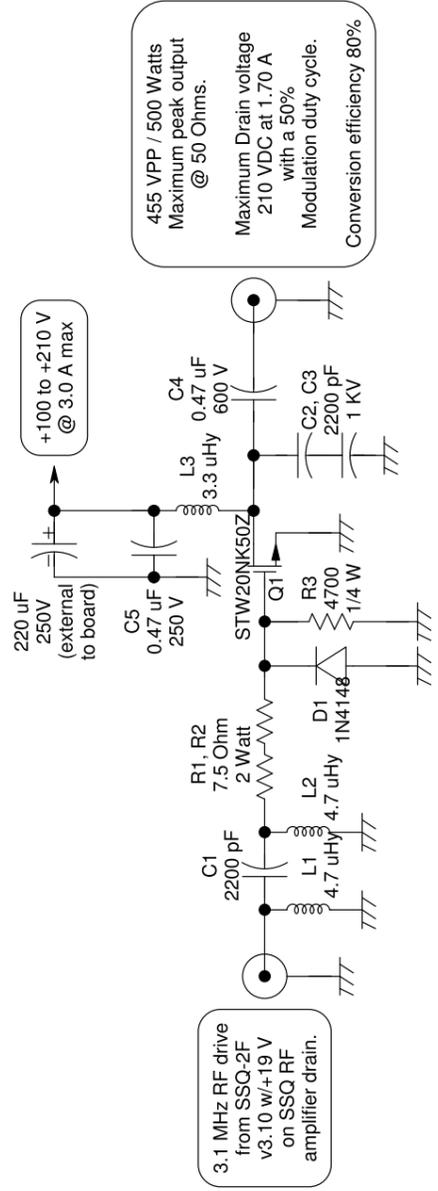
ralph@spectrotek.com

<http://rife-beam-ray.com>

<http://rifebeamray.com>

<http://w5jgv.com/rife>

**3.1 MHz RF Power Amplifier / Switch Mode Power Supply**  
 For Rifle Beam Ray with 3.1 MHz Carrier  
 & Audio Sweep Modulation  
 Copyright (c) 2012 by Ralph M. Hartwell II  
 V1.01 03 June 2012



- NOTES:**
- C1, C2, C3, C4 and C5 are low RF loss Poly film or mica capacitors.
  - Q1 must be mounted on suitable heat sink to dissipate 125 watts at full power.
  - Q1 MUST have mounting surface machined perfectly flat to fit solidly against heat sink. As received from the manufacturer, the mounting surface of Q1 is slightly convex.
  - Q1 is insulated from the heat sink with Wakefield Thermal Solutions 175-6-280P Thermal Pad.
  - L1 and L2 are Bourns Inc. 5800-4R7-RC 4.7 uHy Ferrite Core RF Chokes.
  - L3 is a 3.4 uHy air core coil. Do not use a ferrite core as it will slow the rise time of the waveform.

Figure 6

**Schematic Diagram of the PA1 v1.01.**

# WAVEFORMS

The following waveform photographs were obtained using a Tektronix type 466 oscilloscope that was adjusted to a 20 MHz bandwidth.

The connecting coaxial cable between the PA1 and the 50 ohm dummy load or between the PA1 and the 3.1 MHz link coil coupler, (which was connected to the plasma tube,) was a 20 foot / 6 meter length of RG-58/U coaxial cable.

The PA1 was driven by an SSQ-2F v3.10.

The output power level of the PA1 was 300 watts peak, 150 watts average.

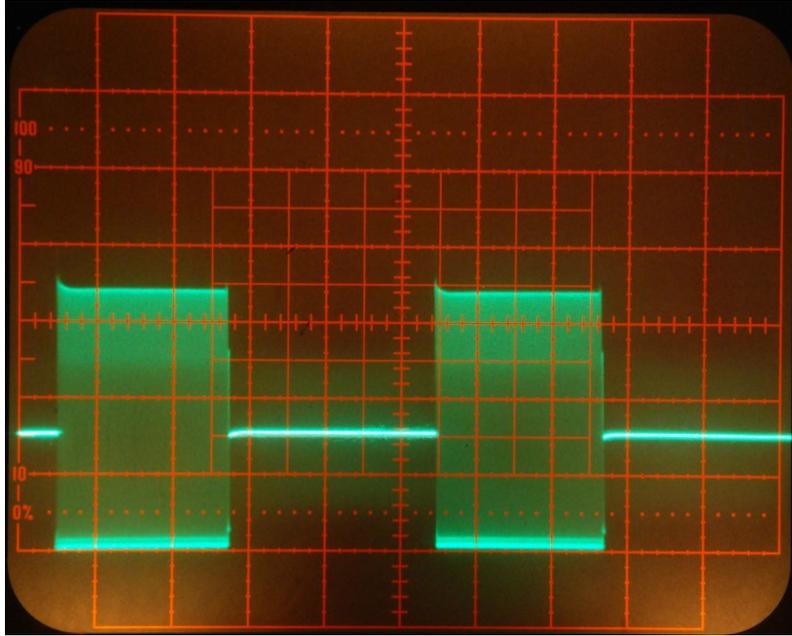


Figure 7

Output of the PA1 connected to 50 Ohm Dummy Load with a Modulating Frequency of 20 Hz at a 50% Duty Cycle.

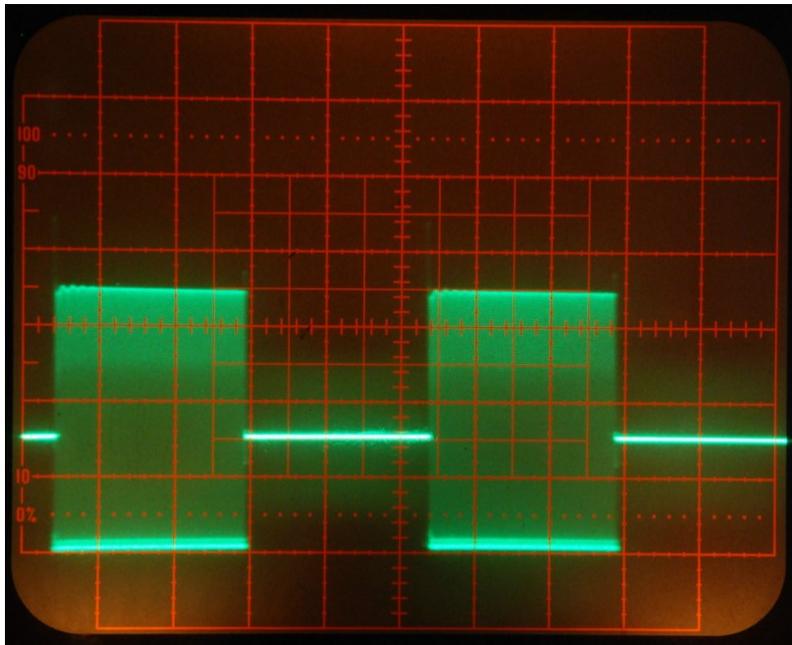


Figure 8

Output of the PA1 connected to 50 Ohm Dummy Load with a Modulating Frequency of 2000 Hz at a 50% Duty Cycle.

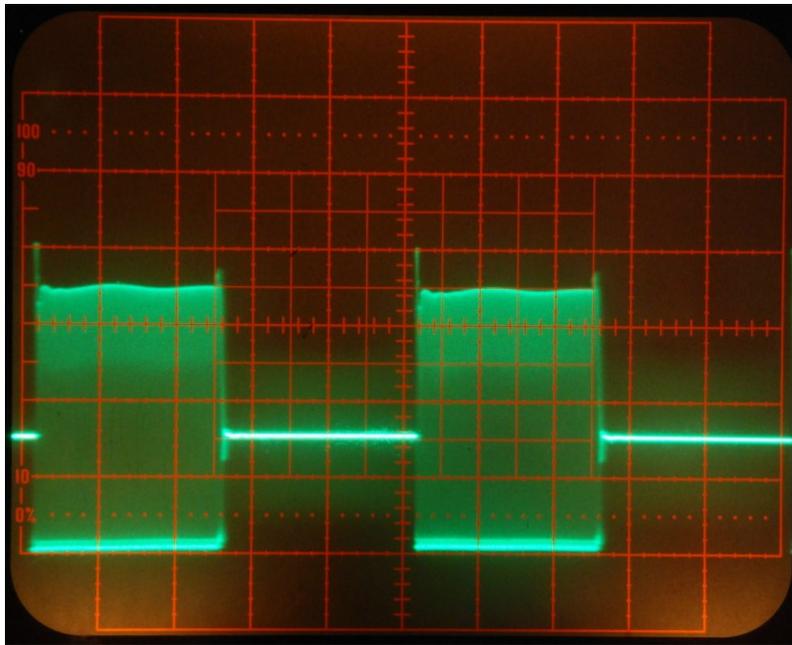


Figure 9

Output of The PA1 connected to 50 Ohm Dummy Load with a Modulating Frequency of 20 KHz at a 50% Duty Cycle.



Figure 10

Output of the PA1 connected to 50 Ohm Dummy Load with a Modulating Frequency of 100 KHz at a 50% Duty Cycle.



Figure 11

Output of the PA1 connected to 50 Ohm Dummy Load – with a Modulating Frequency of 200 KHz at a 50% Duty Cycle.



Figure 12

Output of the PA1 connected to 50 Ohm Dummy Load with a Modulating Frequency of 400 KHz at a 50% Duty Cycle.

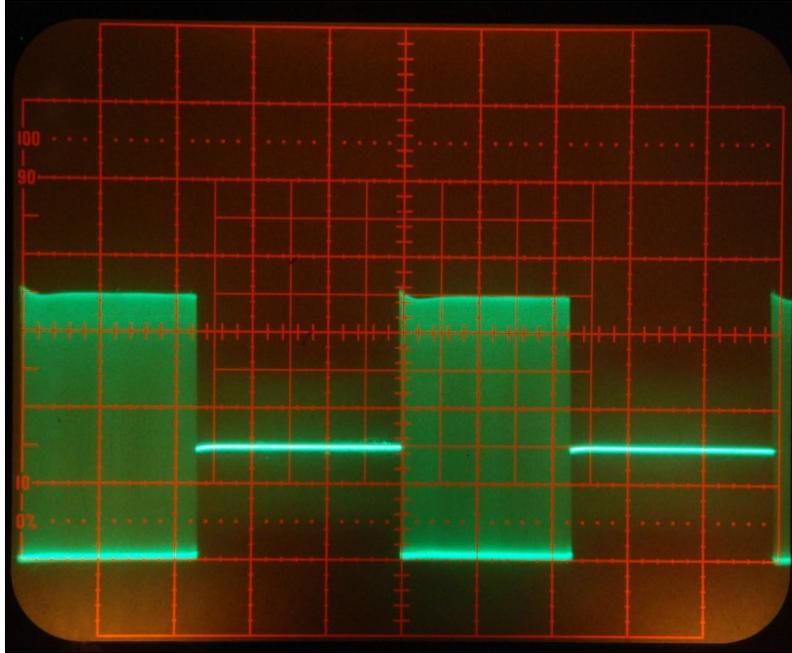


Figure 13

Output of the PA1 connected to Chev 8" Phanotron Tube with a Modulating Frequency of 20 Hz at a 50% Duty Cycle.

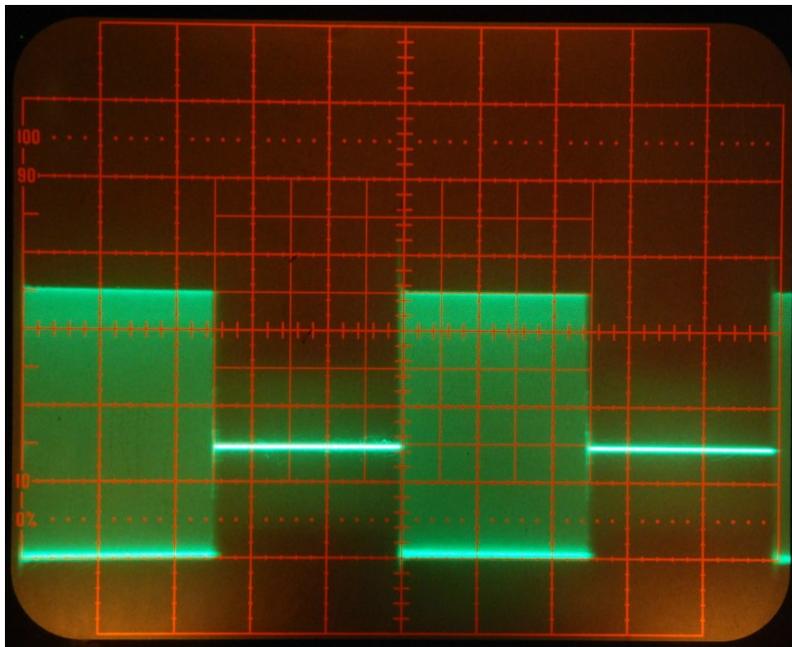


Figure 14

Output of the PA1 connected to Chev 8" Phanotron Tube with a Modulating Frequency of 2000 Hz at a 50% Duty Cycle.

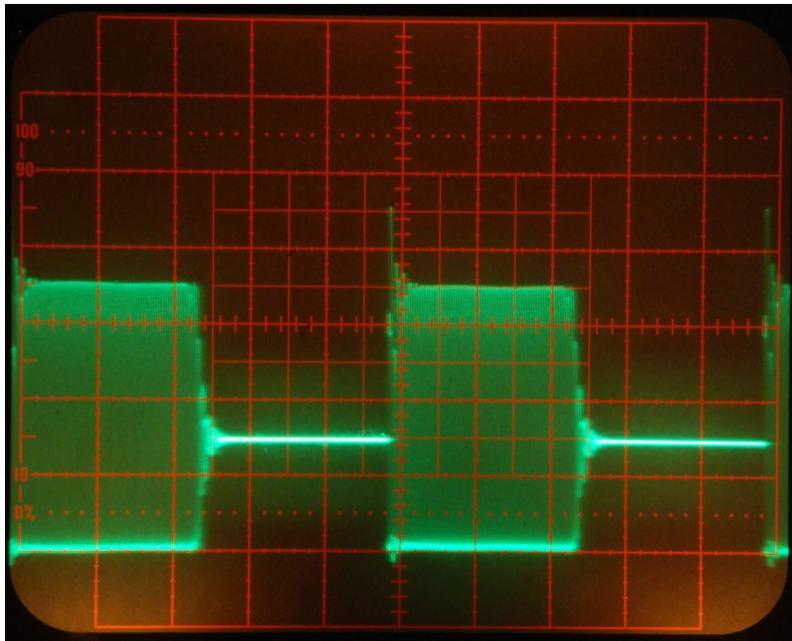


Figure 15

Output of the PA1 connected to Chev 8" Phanotron Tube with a Modulating Frequency of 20 KHz at a 50% Duty Cycle.

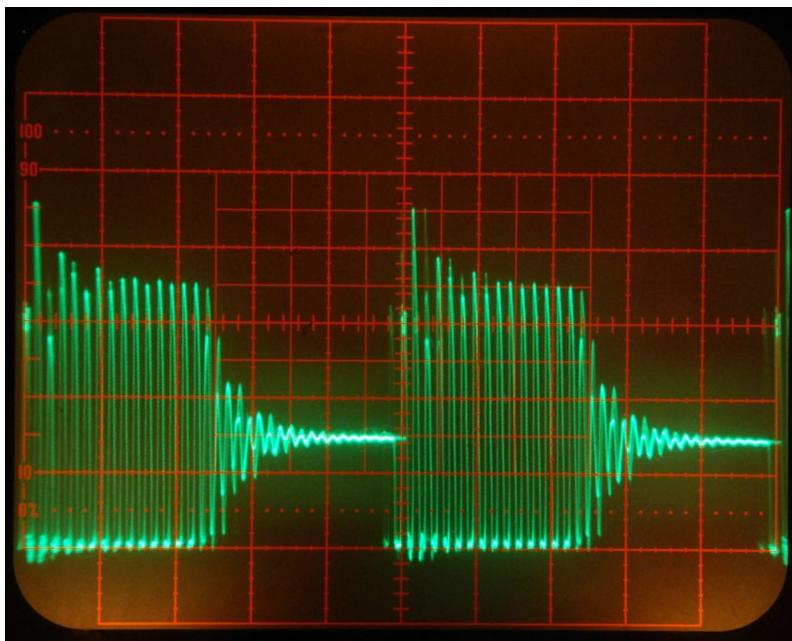


Figure 16

Output of the PA1 connected to Chev 8" Phanotron Tube with a Modulating Frequency of 100 KHz at a 50% Duty Cycle.

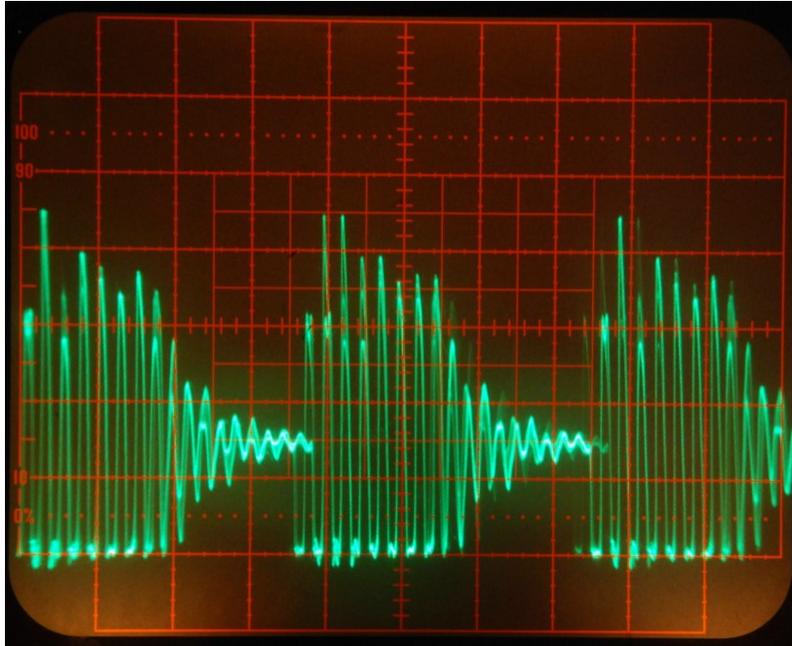


Figure 17

Output of the PA1 connected to Chev 8" Phanotron Tube with a Modulating Frequency of 200 KHz at a 50% Duty Cycle.



Figure 18

Output of the PA1 connected to Chev 8" Phanotron Tube with a Modulating Frequency of 400 KHz at a 50% Duty Cycle.

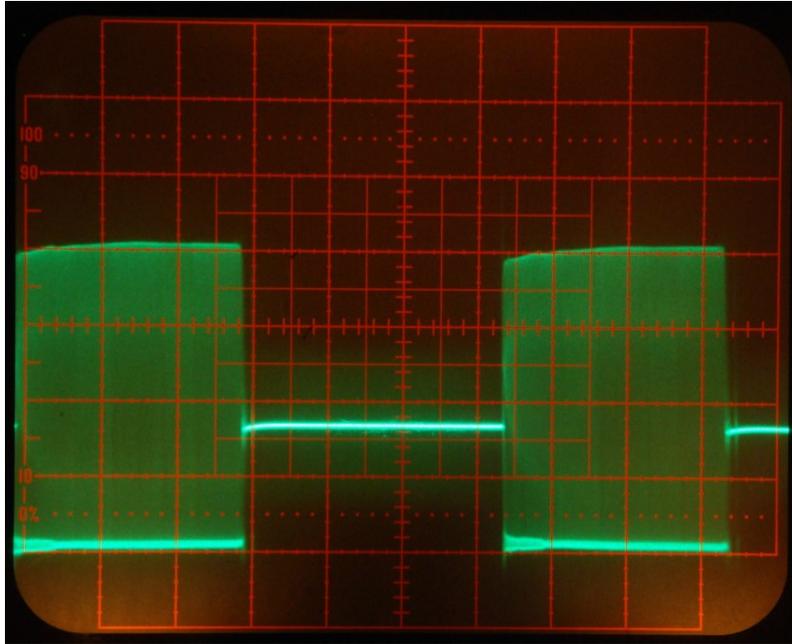


Figure 19

Output of the PA1 connected to Chev 2" x 24" Super Tube with a Modulating Frequency of 20 Hz at a 50% Duty Cycle.

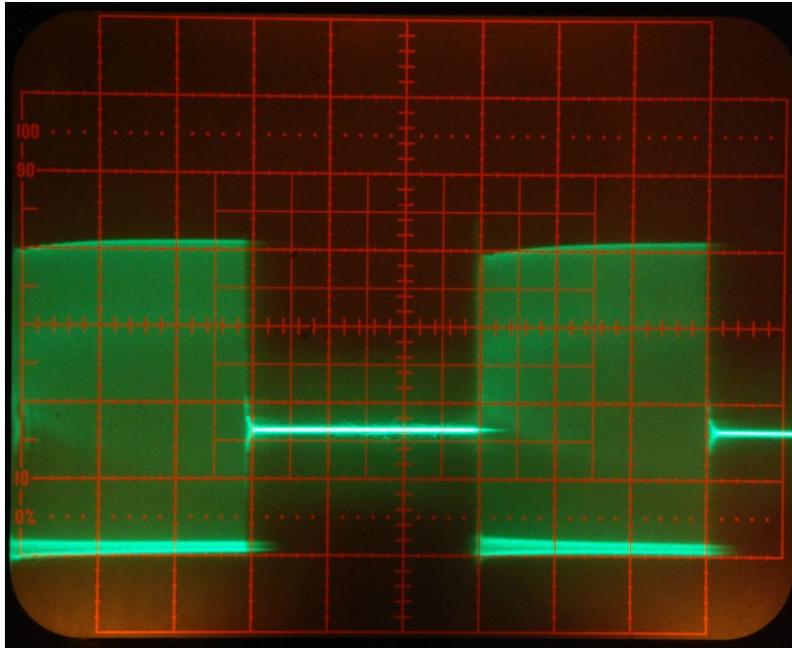


Figure 20

Output of the PA1 connected to Chev 2" x 24" Super Tube with a Modulating Frequency of 2000 Hz at a 50% Duty Cycle.

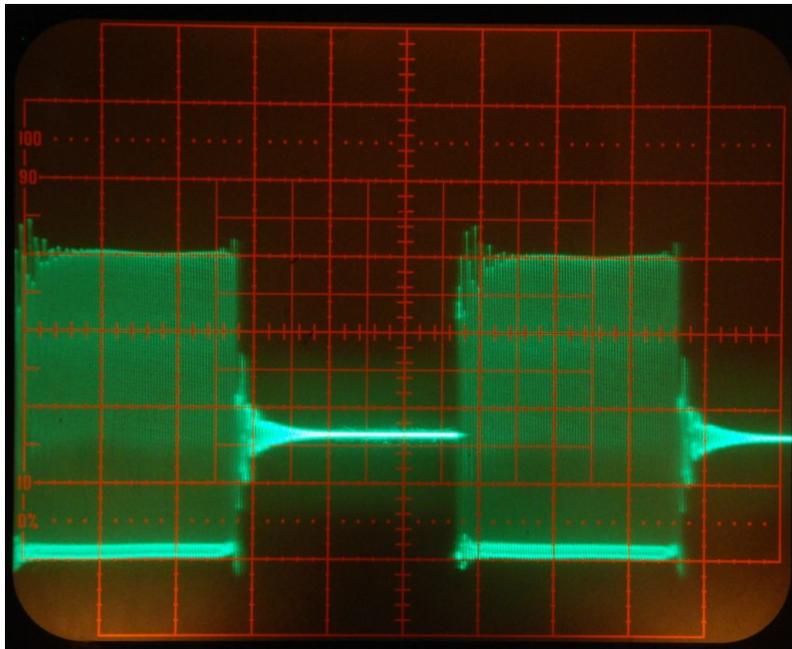


Figure 21

Output of the PA1 connected to Chev 2'' x 24'' Super Tube with a Modulating Frequency of 20 KHz at a 50% Duty Cycle.



Figure 22

Output of the PA1 connected to Chev 2'' x 24'' Super Tube with a Modulating Frequency of 100 KHz at a 50% Duty Cycle.



Figure 23

Output of the PA1 connected to Chev 2" x 24" Super Tube with a Modulating Frequency of 200 KHz at a 50% Duty Cycle.



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