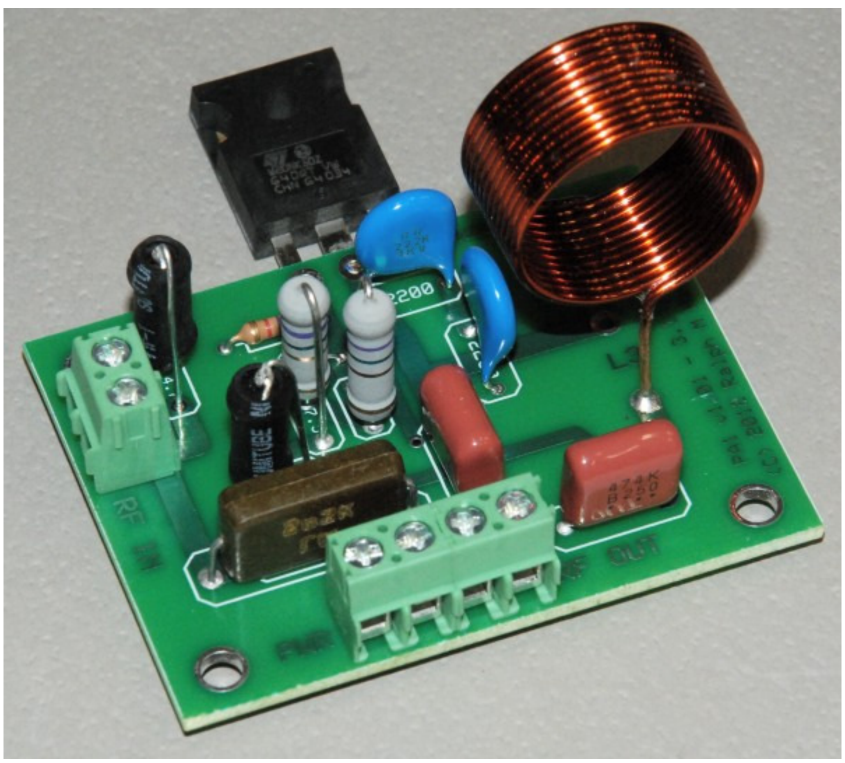
Instruction Manual

for the

PA1

3.1 MHz Switch Mode
Plasma Tube Driver Amplifier

v1.01



Manual v1.00

* LEGAL AND MEDICAL DISCLAIMER *

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.

Index and Table of Contents

List of Figures

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 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 at 500 Watts peak and average power output.

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.

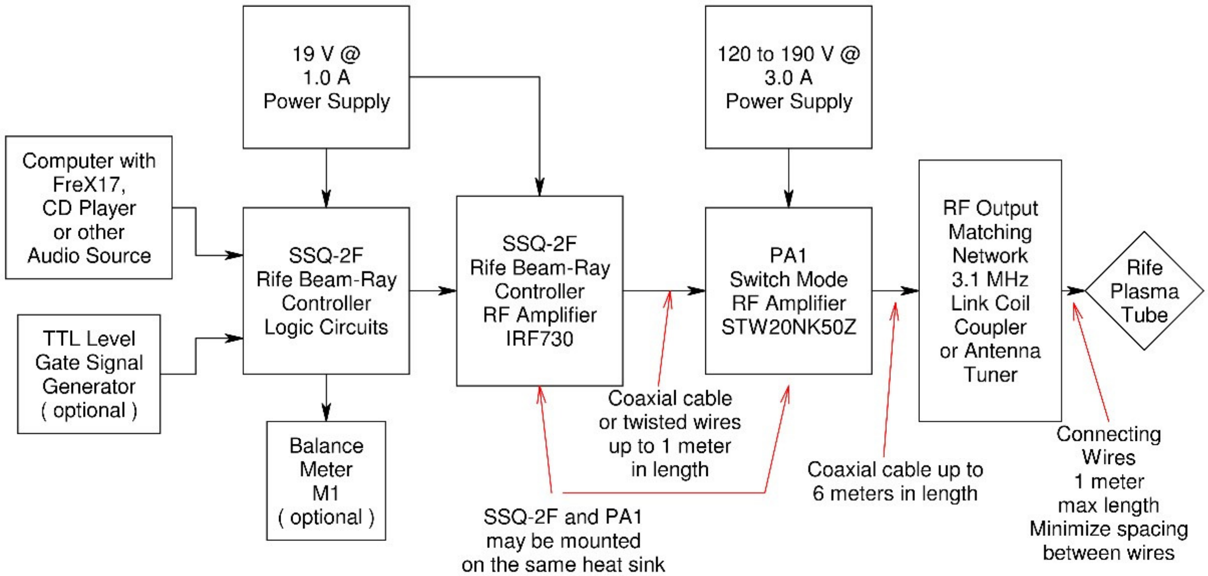


Figure 1

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.

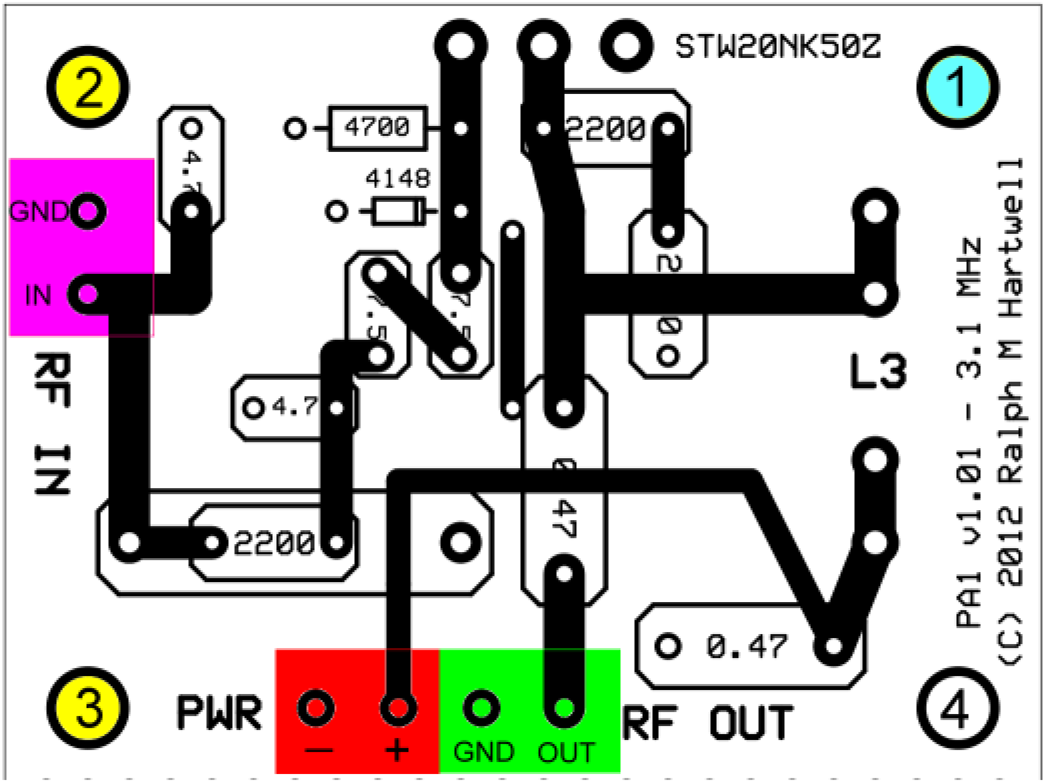


Figure 2

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)

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

The PA1 should be mounted on a suitable heat sink. If desired, a metal screen RF shield to prevent unwanted radio frequency radiation may cover the side of the heat sink upon which the PA1 is mounted. While this is not normally necessary when operating near sensitive electronic equipment, installing a shield may be desirable.

Please make sure the shield does not obstruct cooling air flow across the components of the PA1.

There are four mounting holes, one at each corner of the PA1. These are provided for mounting the PA1 circuit board to its heat sink or other support. When the PA1 is mounted next to a metal surface, then the use of metal standoffs at each mounting hole is recommended to prevent short circuits between the underside of the PA1 circuit board and the metal mounting surface. Metal spacers should be used as these will assist in grounding / earthing the PA1 properly to the heat sink.

Please be sure to connect mounting hole 1 to the heat sink. Be careful that the mounting hardware does not cause short circuits on either side of the circuit board. It is not necessary to use all four mounting holes when attaching the PA1 to the heat sink.

RF Grounding / Earthing Connections for the PA1

It is essential that proper grounding / earthing procedures be used when installing the PA1.

Looking at figure 2 and the PA1 circuit board, you will see four mounting holes labeled 1, 2, 3, and 4.

Hole number 4 is provided for mounting purposes only, and is not concerned with grounding / earthing of the PA1. The holes numbered 2 and 3 may be grounded / earthed. Hole number 1, which is connected to the RF ground / earth circuit of the PA1 must be connected to the heat sink either directly by the mounting hardware passing through hole number 1, or by the use of these short length of wire jumper connected between heat sink and the mounting hardware at hole number 1.

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 or through a twisted pair of wires, 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 for 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.

The Heat Sink for the STW20NK50Z

Is important that an adequate heat sink be used with the PA1. The heat sink must be capable of dissipating approximately 120 Watts of heat during continuous full power operation of the PA1. In most cases, the normal power dissipation will be less than 120 Watts. You may be tempted to use a smaller heat sink, but using an undersized heat sink in an attempt to "get away with it" is sure to cause problems eventually. It is far better to have too large a heat sink then to have one that is too small.

Most heat sinks are rectangular in shape. They usually are flat on one side and have numerous heat dissipating fins on the other side. Additional cooling of the heat sink may be achieved by using one or more fans to blow cooling air over the fins of the heat sink. This greatly increases the heat dissipating ability of the heat sink.

A good heat sink will have several important characteristics. The surface upon which the transistor is mounted is called the base plate. The heat sink base plate should be at least 1/4 to 1/2 inch / 6 to 12 mm thick so that it has a large amount of thermal inertia. Thermal inertia gives the heat sink the ability to absorb sudden pulses of heat, as may happen when the amplifier is momentarily overloaded or intermittently operates at high duty cycles. Without a large thermal inertia, the area of the heat sink immediately under the transistor may increase in temperature to the point where the transistor may overheat and fail. A thick base plate gives the heat sink a large thermal inertia and the thick metal of the base plate allows the heat generated by the transistor to rapidly spread outward through the material of the base plate and into the fins where the heat can be dissipated into the air.

The addition of one or more cooling fans to the heat sink will greatly increase the heat dissipating ability of the sink. Consideration should be given to the proper placement and orientation of these fans to ensure uniform airflow across as many of the heat sink fins as possible. It may be necessary to take spot temperature measurements at various locations on the heat sink to ensure that it is being cooled properly.

Another good heat sink for use with the PA1 is the heat pipe heat sink. These are commonly used as CPU coolers in computers. A heat sink of this type may be adapted for use with the PA1 by utilizing a clamping device to hold the STW20NK50Z MOSFET of the PA1 against the heat sink base plate. This will usually involve mounting the PA1 upside down in order to mount the STW20NK50Z against the proper side of the heat sink base plate. The PA1 will perfectly well when mounted in any position, so inverted mounting is not a problem. Remember to connect a ground / earth strap between hole number 1 on the PA1 circuit board and the heat sink to help prevent any unwanted RF radiation.

Be sure to mount a heat pipe heat sink with a heat pipes pointed in a vertical position. Failure to mount the heat sink in a vertical position may prevent the cooling fluid from flowing back down the tubes and into the heat sink base plate area. This will result in an excessive temperature rise on the base plate and failure of the heat sink to properly cool the STW20NK50Z.

Electrically Insulating the STW20NK50Z from the heat sink

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.

Because the STW20NK50Z is operating at both a high DC voltage and a high RF voltage, 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.

Attaching the STW20NK50Z to the Heat Sink

Do not attempt to mount the STW20NK50Z to the heat sink by using a single screw through the manufacturer supplied mounting hole of the STW20NK50Z. Doing so will cause failure of the STW20NK50Z.

When operating a large power transistor, such as the STW20NK50Z at a high power output it is often impossible to obtain sufficient clamping pressure between the transistor and the heat sink when using a single mounting screw. For this reason, transistor manufacturers will recommend using some form of a horizontal clamping bar. This clamping bar presses the entire body of the transistor firmly against the heat sink. This allows the transistor to be clamped against the heat sink with a pressure of up to 300 pounds per square inch. It is necessary to use a high clamping pressure in order to obtain intimate physical contact between the transistor, the thermal pad, and the heat sink base plate. If this intimate contact is not achieved, the heat transfer between the transistor and the heat sink base plate will be greatly reduced.

It is necessary to clamp the STW20NK50Z firmly against the heat sink by using a horizontal clamping bar. This clamping bar may be fabricated from a piece of thick aluminum or steel and held in position with the use of two ¼ inch (6 to 8 mm) x 20 threads per inch bolts which are then screwed into threaded holes in the heat sink. The mounting holes drilled and tapped into the heat sink should be spaced at least 1 1/2 inches on either side of the STW20NK50Z. Spacing the holes closer together will prevent proper heat flow from the STW20NK50Z out through the base plate material.

The following photographs will show you the use of a suitable clamping bar to attach the STW20NK50Z to a flat heat sink.

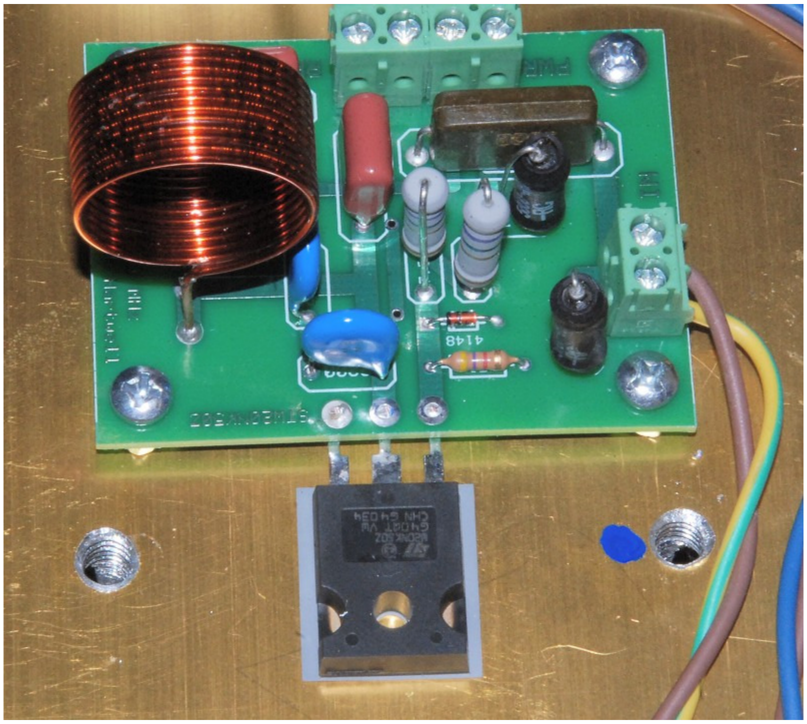


Figure 3

Threaded mounting holes for the pressure pad and clamping bar.

If you have purchased the "Quick Change" option for your PA1, then there will be a three terminal connector block installed at the location where the STW20NK50Z is connected to the PA1 circuit board. Please insert the pins of the STW20NK50Z into the three holes of the connector block then gently but firmly, tighten the clamp screws.

WARNING! **Connect the STW20NK50Z to the PA1 circuit board so that the black plastic side of the STW20NK50Z is facing the component side of the circuit board as shown in figure 3. The metal side of the STW20NK50Z must be facing the heat sink.**

When installing the clamping bar, it should not press directly against the plastic case of the STW20NK50Z. A firm but resilient rubber pad should be placed between the clamping bar and the top of the STW20NK50Z.

The rubber pad will correct for any variations in angular position of the clamping bar and the top of the STW20NK50Z while still allowing a constant pressure to be applied across the entire top surface of the STW20NK50Z. The rubber pad also takes care of any change in position or pressure caused by thermal expansion or contraction of the clamping bar.

A rubber pressure pad has been supplied with your assembled PA1 or your kit version of the PA1. As supplied, the rubber pad is moderately soft and flexible. After the pressure pad has been compressed for several hours, it will loosen up slightly, and you may need to retighten the mounting clamp slightly. Should you remove the rubber pressure pad, as when replacing the STW20NK50Z, you will find that the rubber pressure pad has taken on a permanent set. It will look squashed and slightly curved. Do not be alarmed, as this is normal. The rubber pressure pad may be reused.

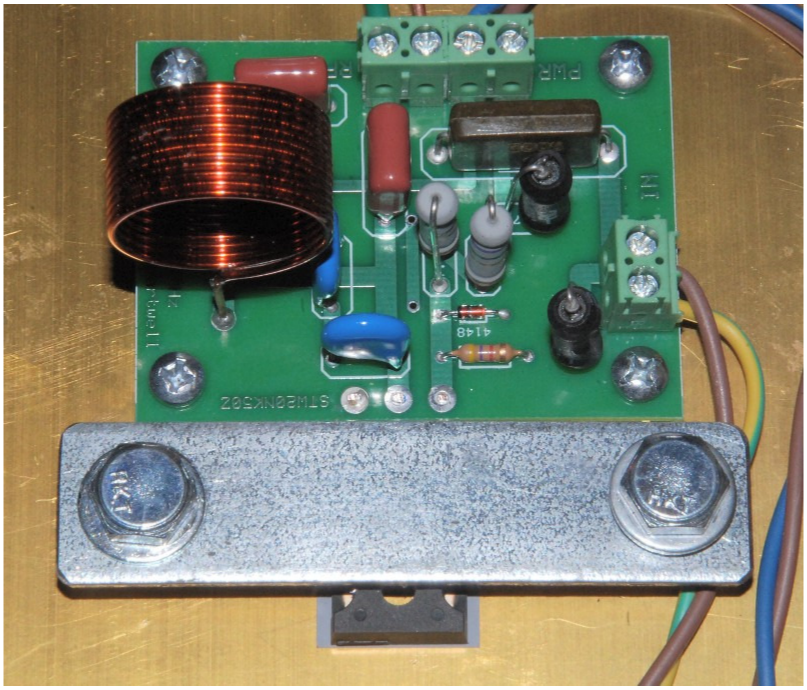


Figure 4

Pressure pad clamping bar in place.

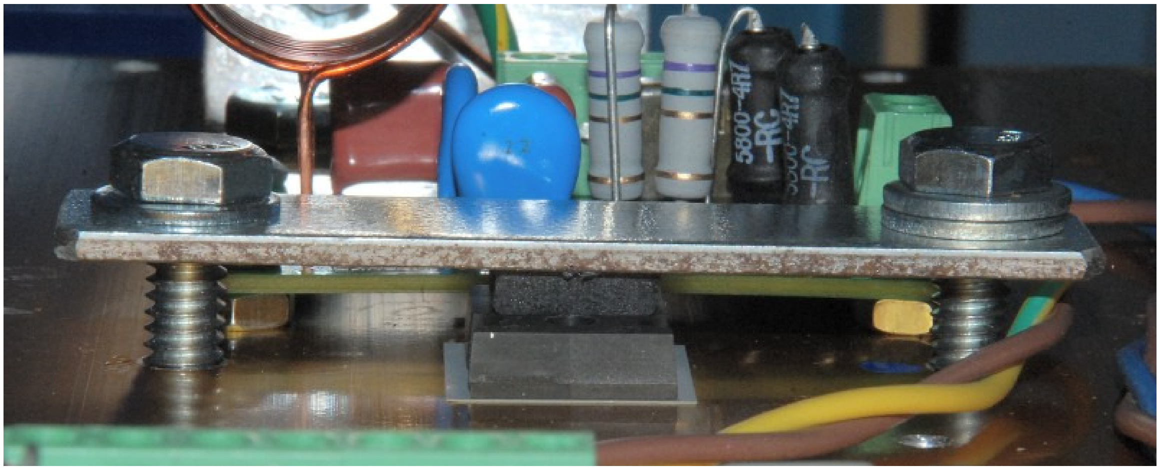


Figure 5

The rubber pressure pad is visible between the STW20NK50Z and the clamping bar.

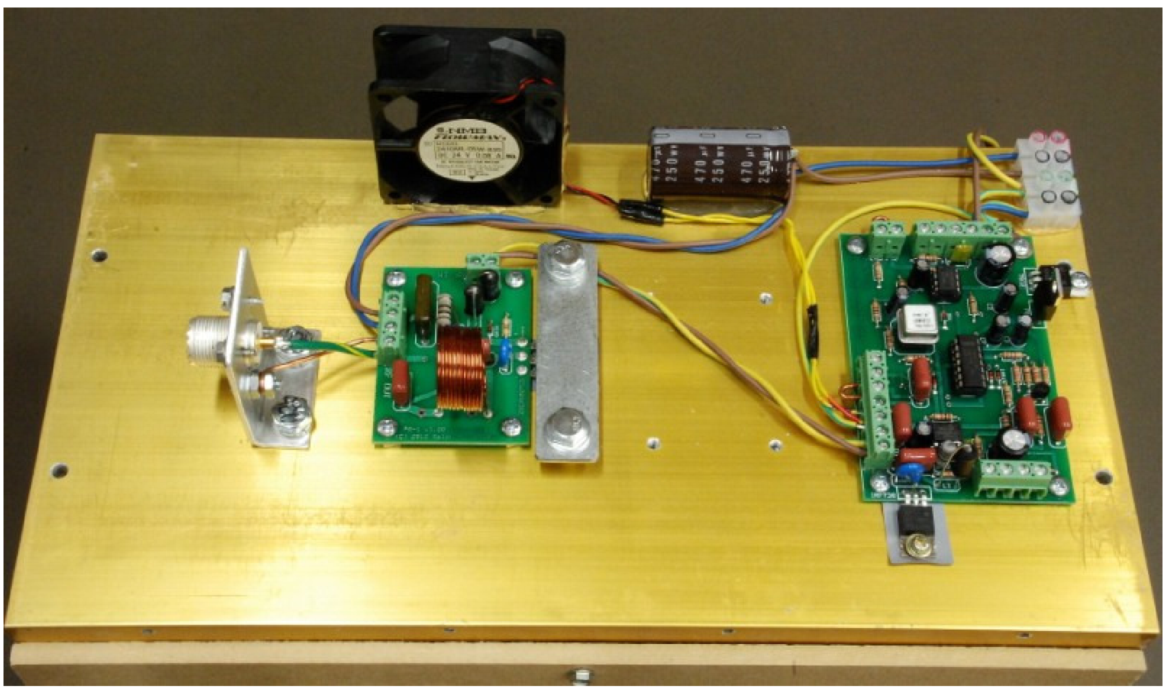


Figure 6

The PA1 and the SSQ-2F v3.10 mounted on a flat-plate finned aluminum heat sink.

This heat sink measures 7 x 13 x 1 inch (18 x 33 x 2.5 cm) and is cooled by two small fans that blow cooling air over the heat sink fins on the underside of the heat sink. Note the use of the metal clamping bar to hold the STW20NK50Z against the heat sink. The IRF730 and the MC7812 on the SSQ-2F v3.10 are also mounted against the heat sink. The IRF730 is insulated from the heat sink by using a Wakefield 175-6-280P thermal pad. The MC7812 needs no thermal pad and is mounted directly to the heat sink. By mounting the SSQ-2F in this manner, a metal shield is not required to prevent RF feedback into the circuits of the SSQ-2F. The brown electrolytic capacitor is connected across the power connections of the PA1. The cooling fan is used to cool the prototype version of the PA1 that is what is seen in this photo. Current production models of the PA1 do not need the fan. Note the simple connection from the RF OUT terminal block of the PA1 to a standard SO-239 coaxial connector.

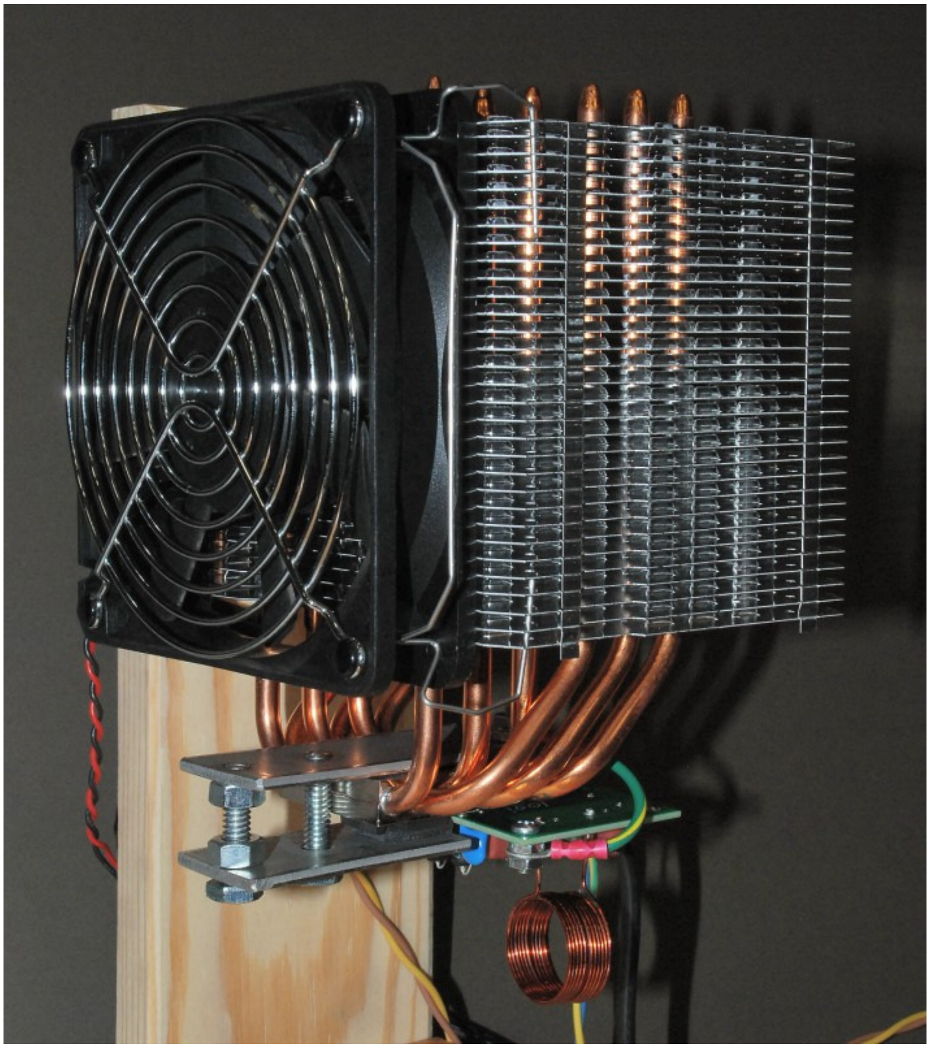


Figure 7

The PA1 and the SSQ-2F v3.10 mounted on a Thermalright HR-02 Macho heat sink.

The manufacturer-supplied cooling fan for the HR-02 heat sink in this photo has been replaced with a more powerful fan for engineering tests. The STW20NK50Z and the PA1 are mounted upside down against the underside of the heat sink base plate. A homemade mounting clamp squeezes the rubber pressure pad against the STW20NK50Z. This holds the STW20NK50Z and the Bergquist thermal pad firmly against the heat sink.

General Operation of 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. The exact voltage required will depend upon the power output you wish to achieve from the PA1. 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.

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 then 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

Commercial Antenna Tuners

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, all you need to do is to connect one end of a length of 50-ohm coaxial cable 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.

The 3.1 MHz Link Coupler System

A lower loss and less expensive coupling system is a tuned tank coil link coupled matching system as seen at:

http://rife-beam-ray.com/3.1mhz_match/index.htm

Using this system eliminates most of the RF losses of the antenna tuner and gives the RF signal a sharper rise and fall time, resulting in a better, brighter plasma discharge.

Tuning the 3.1 MHz Link Coil Coupler System

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 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 tube bridging the gap between the electrodes of the tube.

As soon as the tube is fully lit a stable tuning situation exists. As the RF power applied to the tube increases, 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, it will be necessary to slightly reduce the tuning capacitance 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.

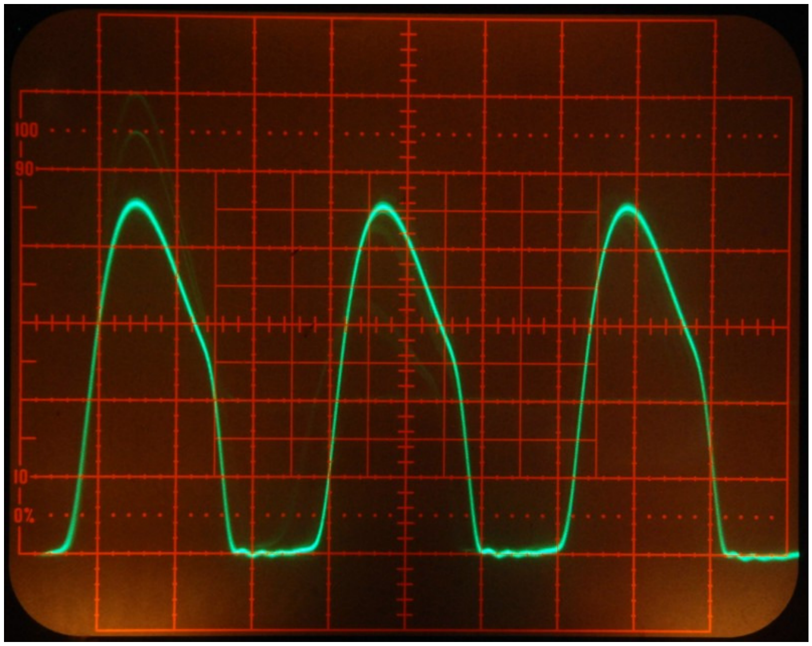


Figure 8

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 a 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.

<u>CAUTION!</u>

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

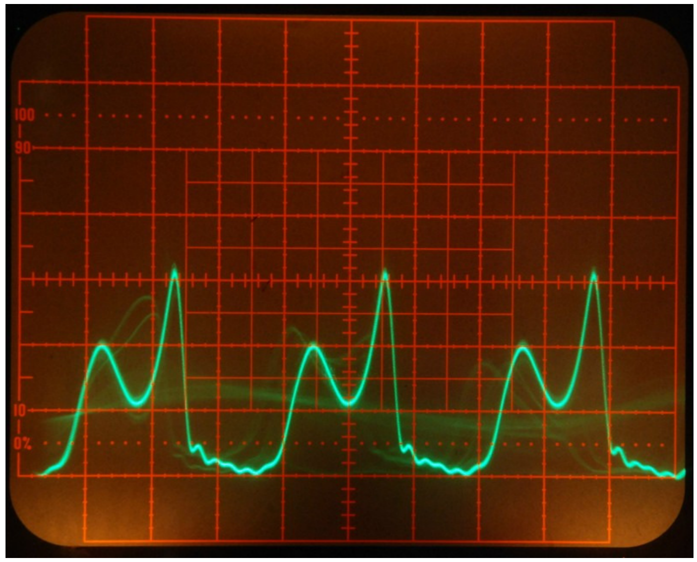


Figure 9

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.**

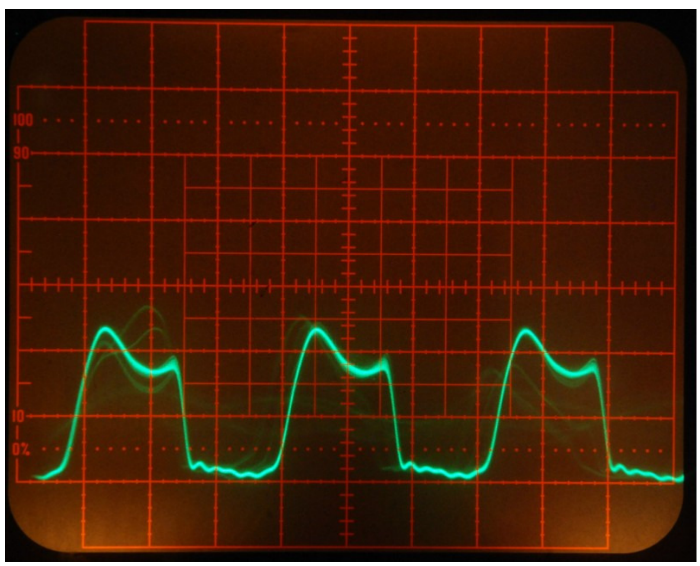


Figure 10

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.**

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

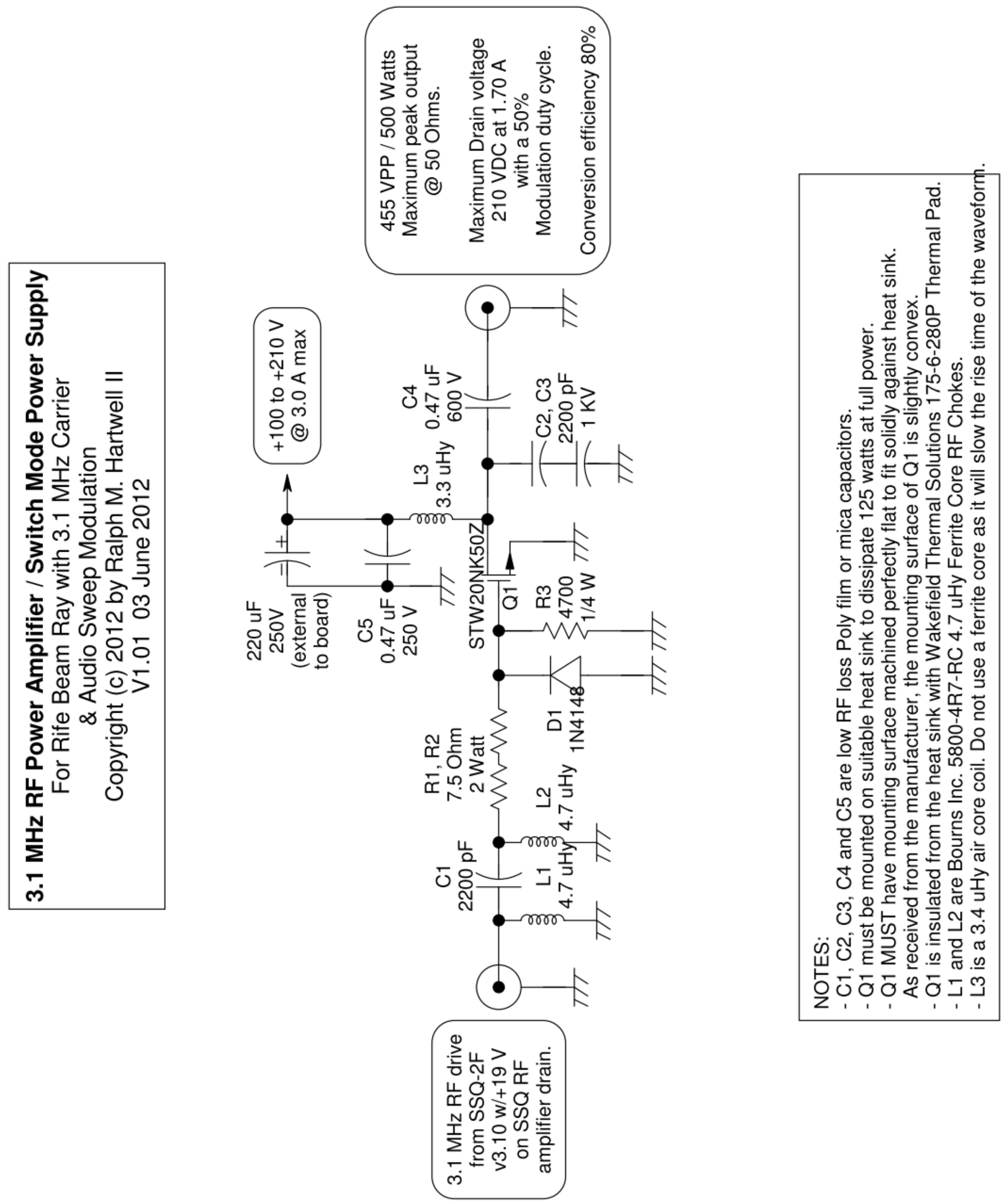


Figure 11

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.

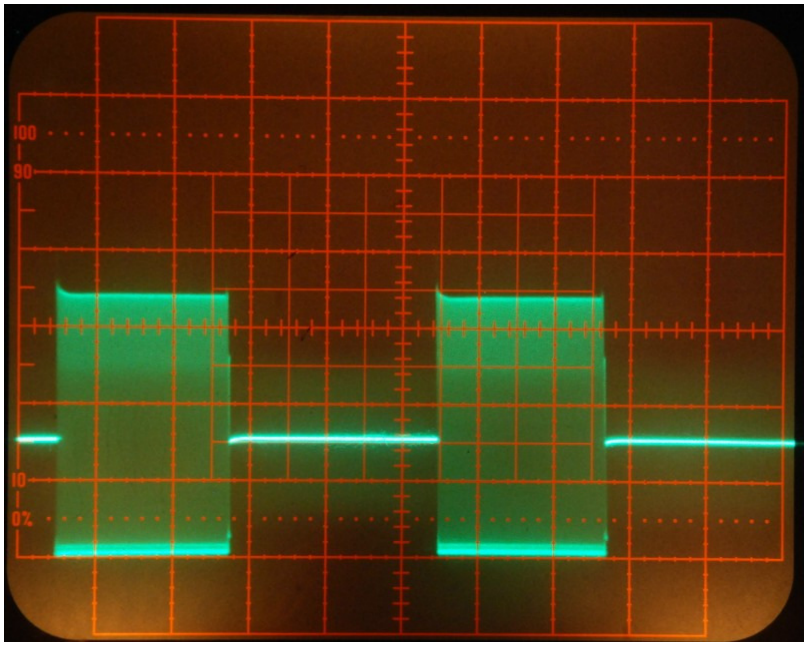


Figure 12

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

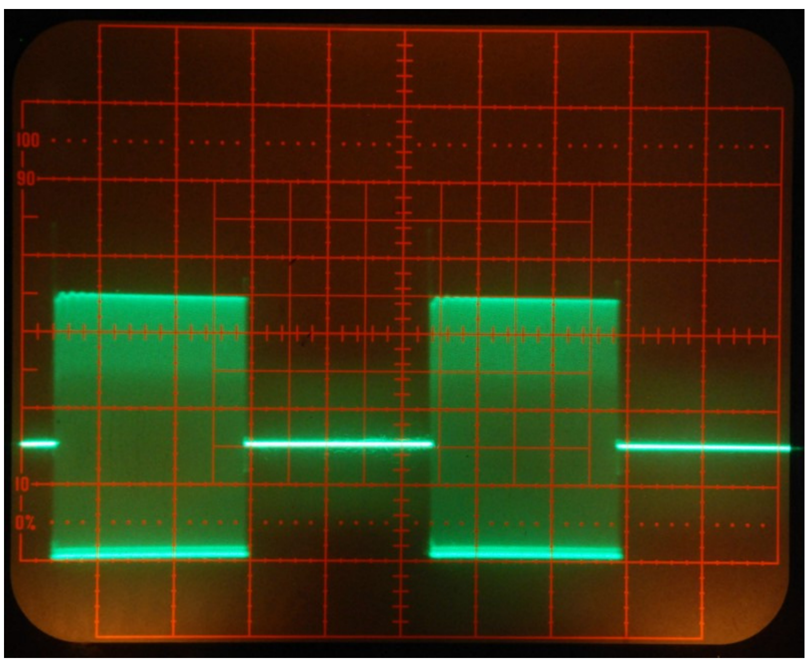


Figure 13

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

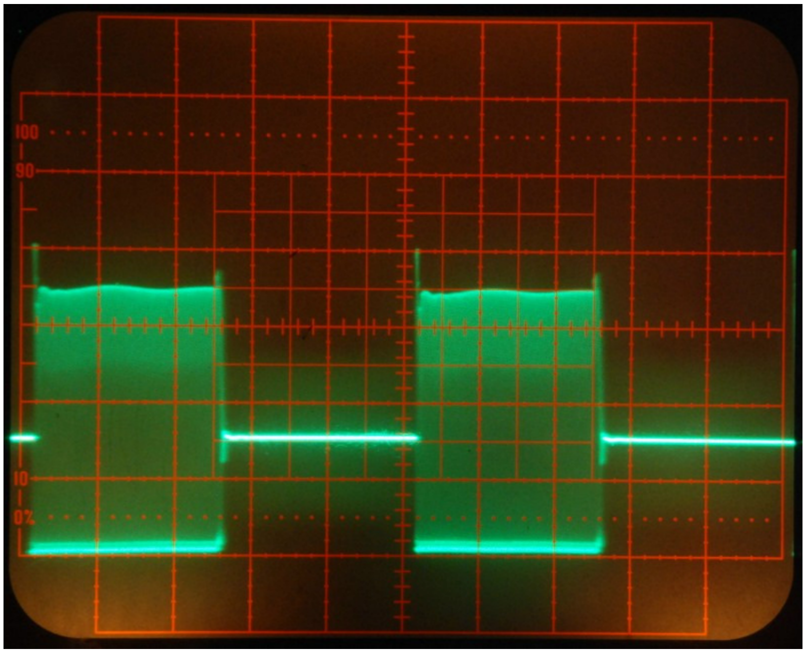


Figure 14

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

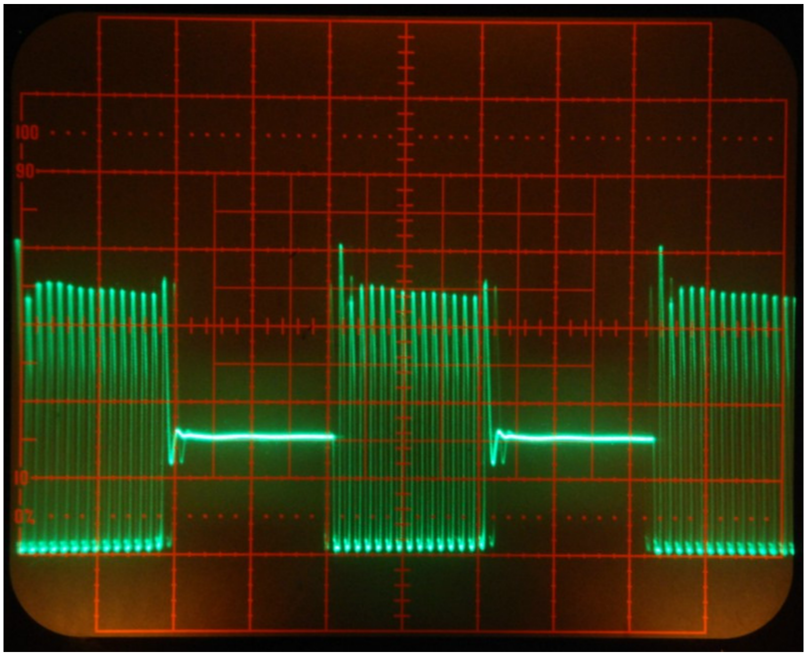


Figure 15

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

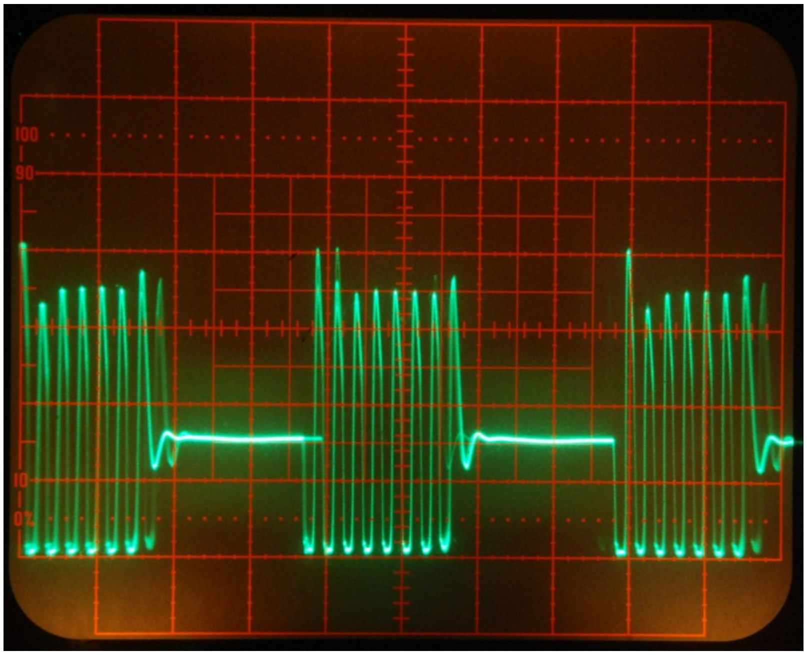


Figure 16

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

Figure 17

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

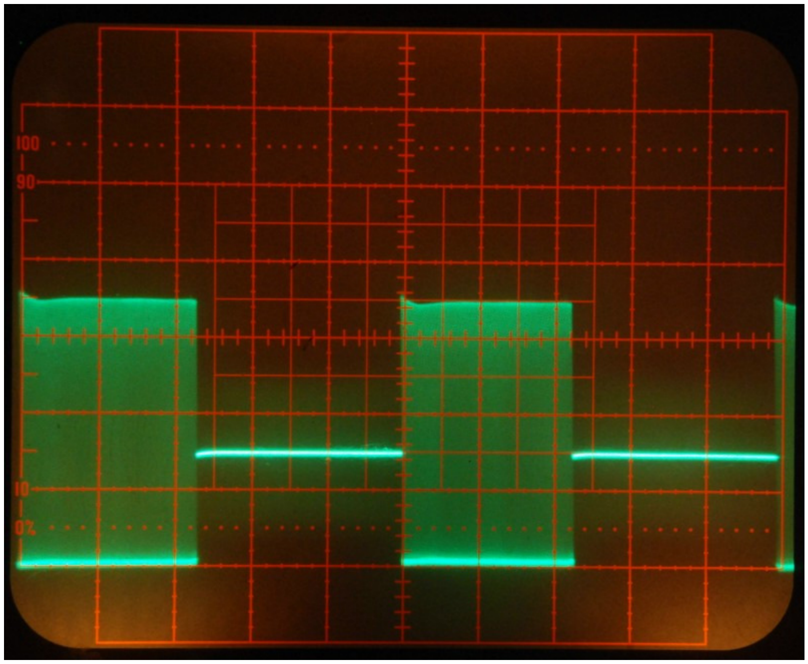


Figure 18

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

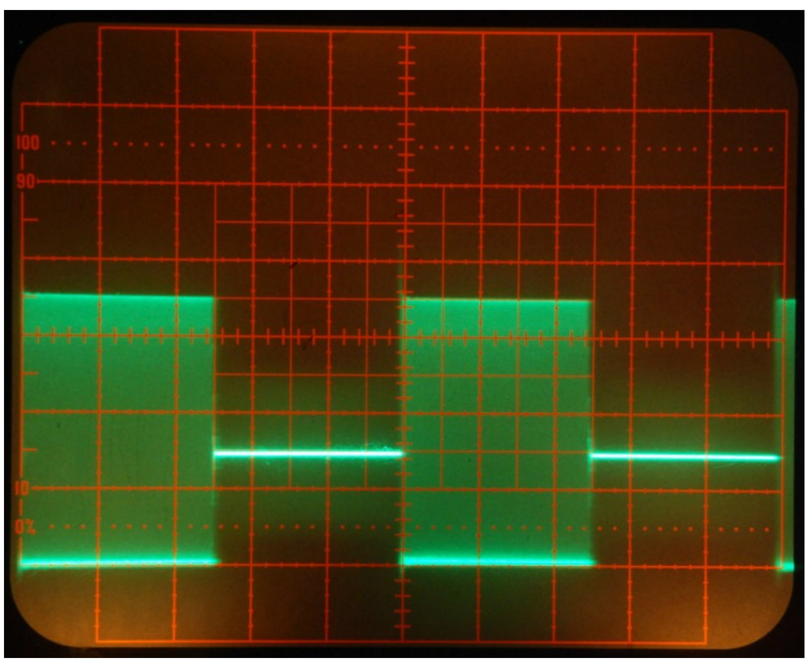


Figure 19

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

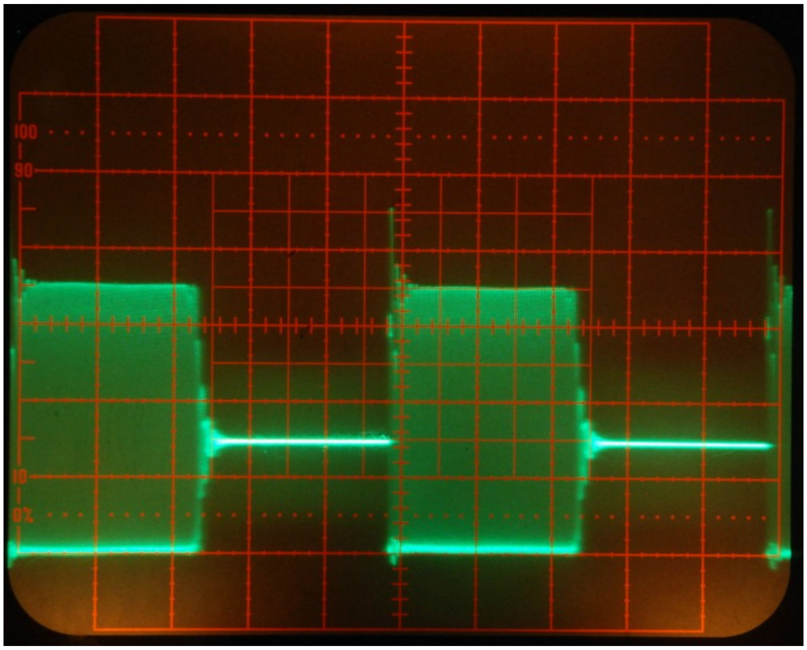


Figure 20

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

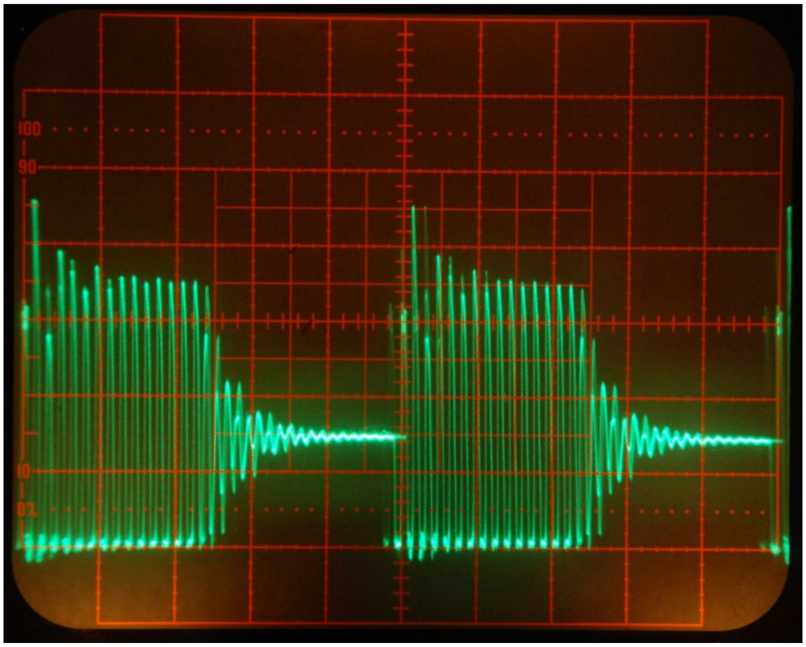


Figure 21

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

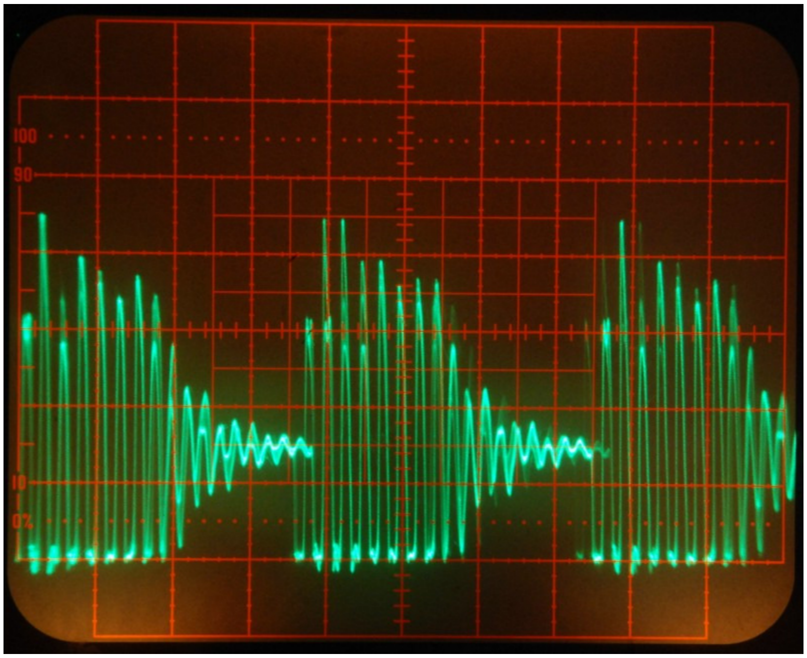


Figure 22

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

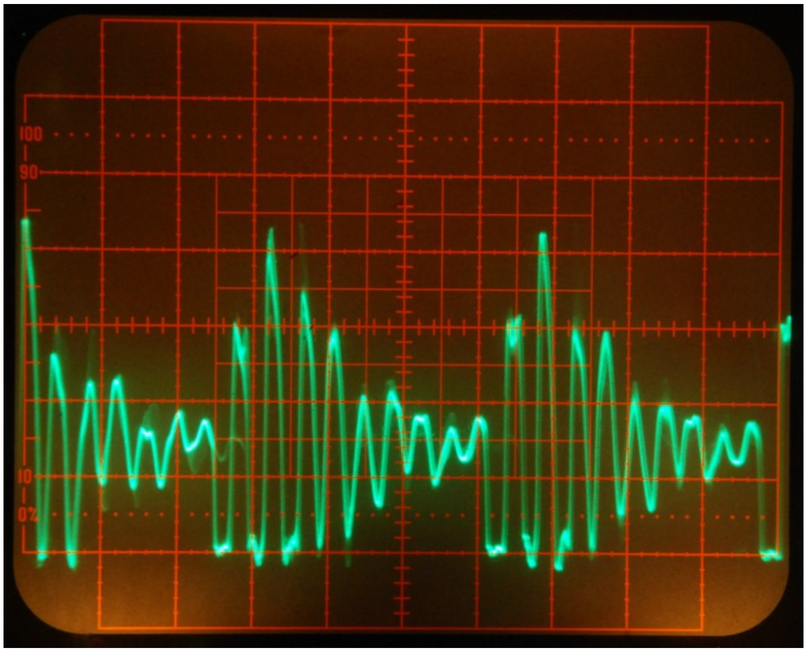


Figure 23

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

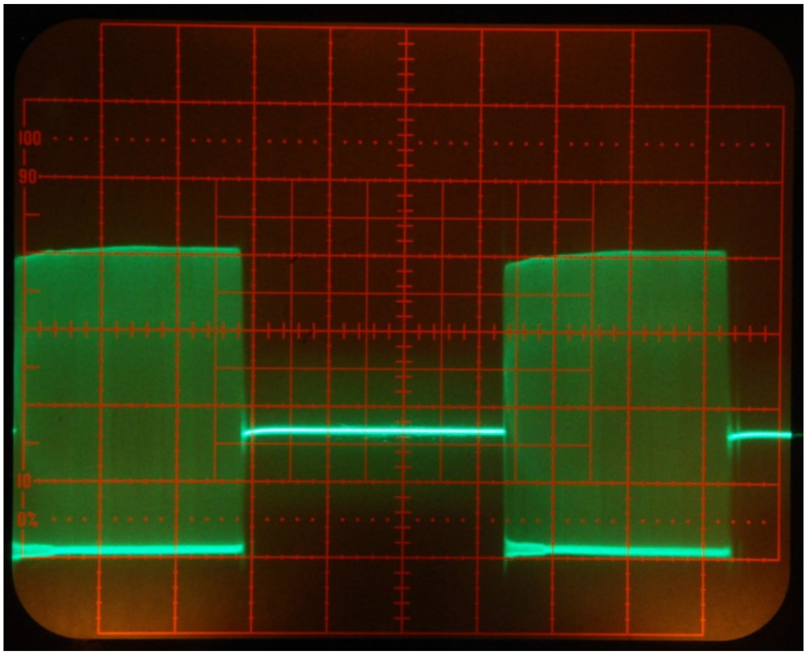


Figure 24

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

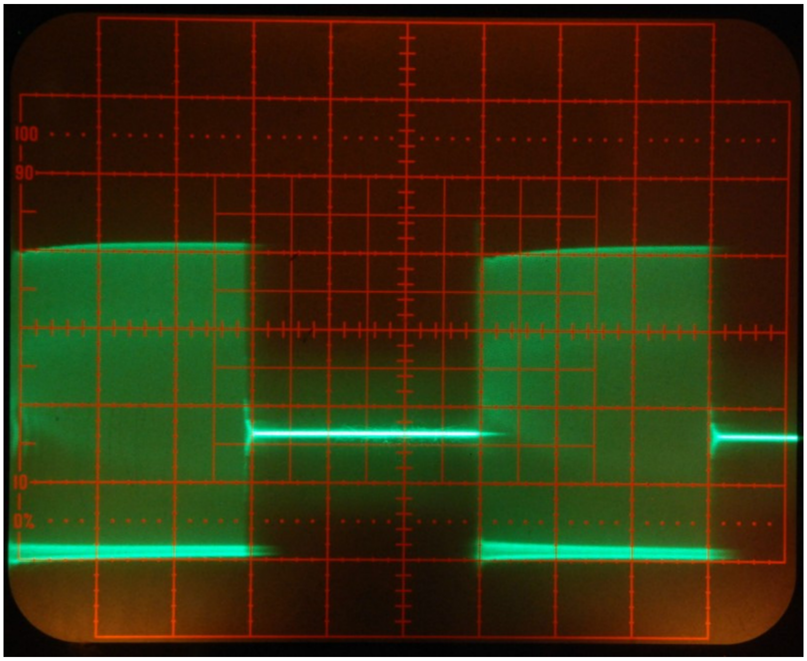


Figure 25

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

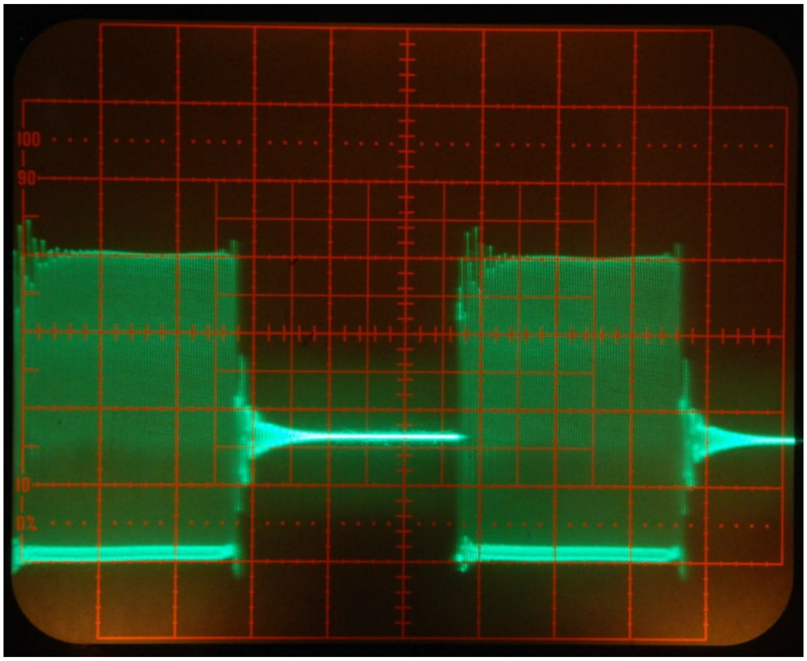


Figure 26

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

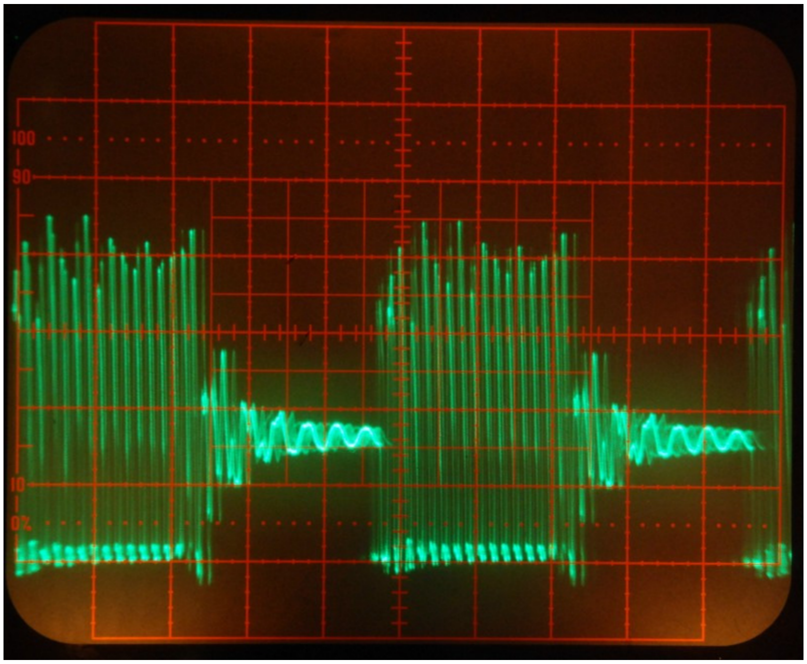


Figure 27

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

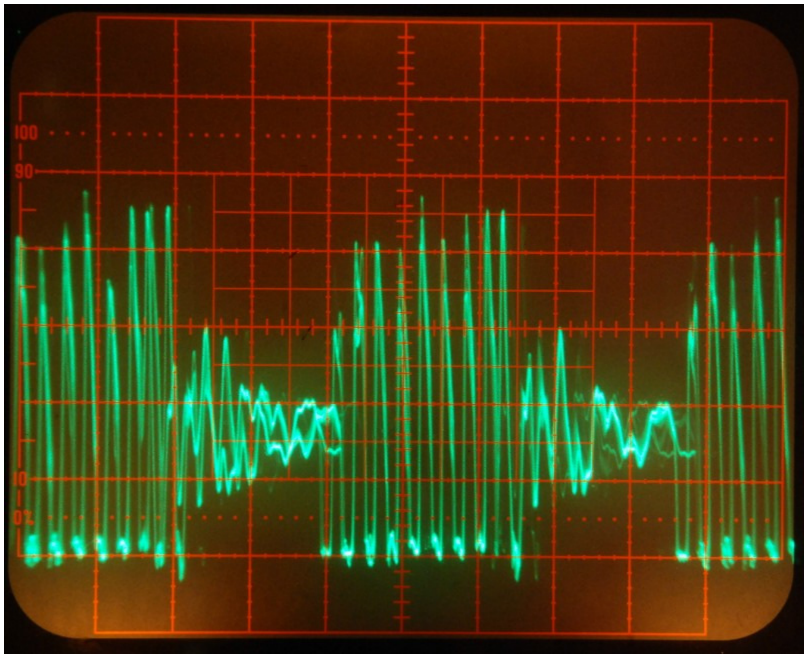


Figure 28

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

Edited by  CAT