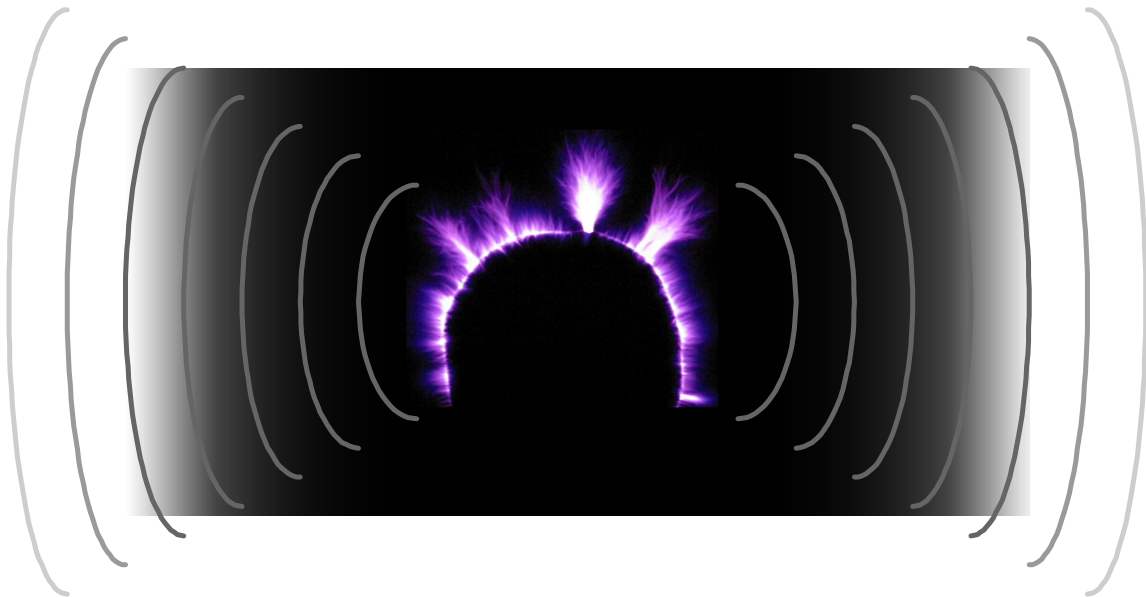# *PlasmaSonic™ CW Solid State Tesla Coil Board*

Instruction Manual

By Daniel McCauley

DISCLAIMER

The author of this document is an amateur, not a professional. The information, both technical and safety related, provided in this document should be interpreted with this distinction clearly in mind. The author hereby disclaims any liability for injury to persons or property that may result due to the construction and use of the PlasmaSonic SSTC board and other high voltage apparatus. This document is for informational purposes only, and makes no claims to its completeness or accuracy. While many of the dangers associated with the construction and use of the PlasmaSonic SSTC board have been pointed out in this document, other potential hazards may exist. Solid state tesla coils are inherently very dangerous devices and should only be constructed and operated by individuals familiar enough with these dangers.

REVISION A CHANGES

All changes made to this document in this revision are marked in bold, italic blue text.

DANGER

HIGH VOLTAGE

ELECTRICAL WARNING

This circuit utilizes dangerous line voltages up to 240VAC. Failure to handle this circuit in a safe manner may result in injury or death!

EXPLOSION WARNING

This is a solid state power device. Components may fail explosively at any time and eject high velocity projectiles.
EYE PROTECTION IS REQUIRED AT ALL TIMES!

RF HAZARD WARNING

This device when connected to a resonator will produce strong electric and magnetic fields. Exposure to this field should be limited.
NO BIOMEDICAL DEVICES WITHIN 50 FEET!
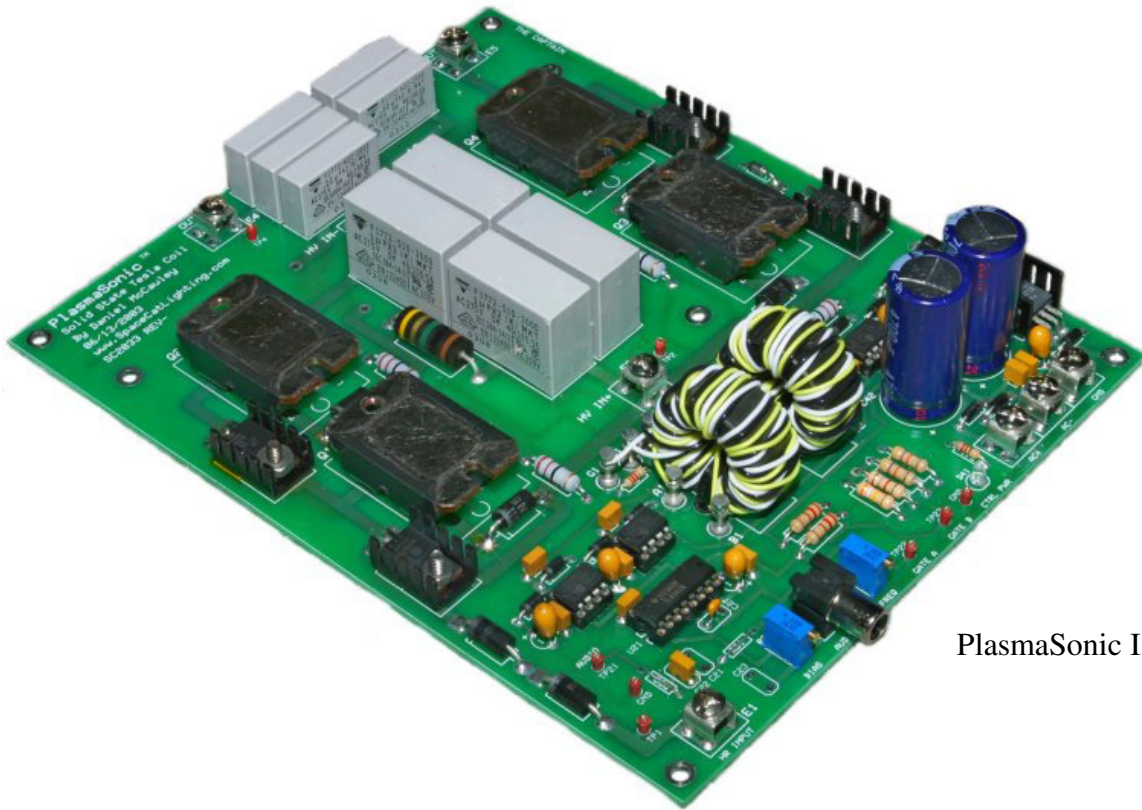
PlasmaSonic I Board

Introduction

The PlasmaSonic II Solid State Tesla Coil (SSTC) Board is the complete solution for those wanting to either create quality audio from a high voltage plasma or create impressive tesla coil type sparks. This document will outline the various configurations, how to implement them, and how to test and operate the PlasmaSonic II SSTC. This document assumes you have a basic understanding of electronics, test equipment, troubleshooting experience, **and above all, a clear understanding of the dangers involved in constructing and operating such a device.**

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Please read this manual in its entirety before building, testing, or operating your PlasmaSonic II SSTC board!

Test Equipment

You will need the following test equipment to properly configure and test the board:

Digital Multimeter
Dual Channel Oscilloscope
Differential Oscilloscope Probe (optional)
Variac (typically a 0-140VAC, 7A or similar)
Fluorescent Tube, 2-3ft length

Selecting an Operating Mode

The first step in building the PlasmaSonic II SSTC board is to select an operational mode.

There are two operational modes. Push-Pull mode allows the SSTC to run at reduced power with up to 50% deadtime thereby allowing cooler operation for CW (DC Input) operation. For audio modulation, you must use Push-Pull mode since audio modulation of the SSTC requires CW operation. On the otherhand, if you looking to create large output sparks, you want to run in Single-Ended mode. Single-Ended mode allows you to run at up to 50% duty cycle with zero deadtime. Single-Ended mode is always used with AC half-rectified input.

(A)   **(B)**
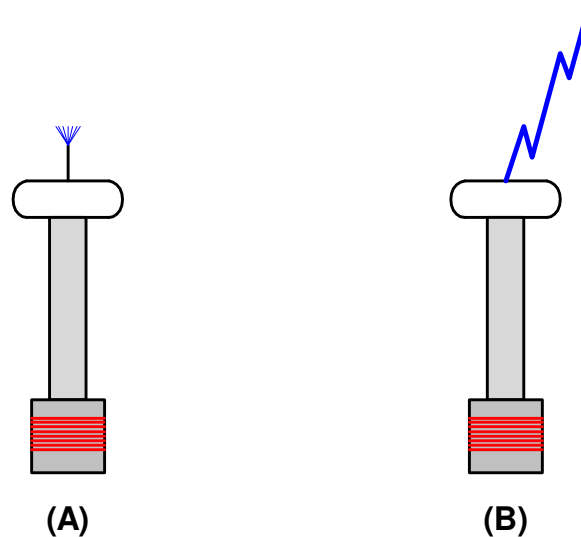
A. Push-Pull Mode – DC Input

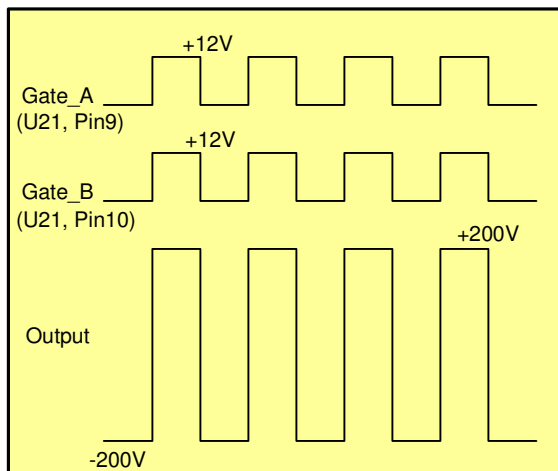B. Single-Ended Mode – Half-Rectified AC Input

Configuring Push-Pull Mode
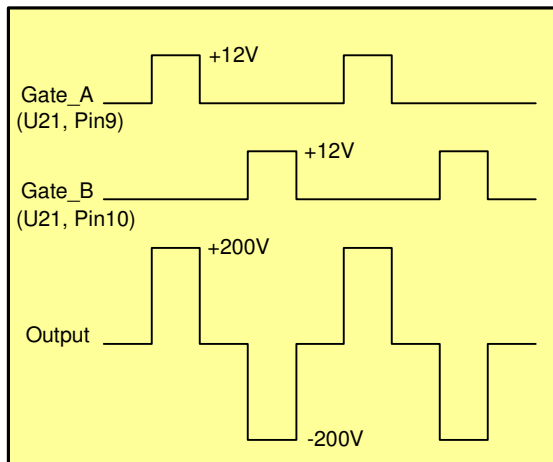
Push-Pull Gate Waveforms (DC Input)

1. U22-U25 should all be either TC4421s for all TC4422s.
2. JMP21 should be shorted from Pin1 to Pin2.
3. JMP23 should be left open.

Configuring Single-Ended Mode

Single-Ended Gate Waveforms (DC Input)

1. U22-U23 should be TC4422s
2. U24-U25 should be TC4421s
3. JMP21 should be shorted from Pin2 to Pin3.
4. JMP23 should be shorted
5. R28 needs to be removed

Thermal Considerations

It is extremely important to use a large heatsink attached to the FETs during operation. Although fan cooling may not be required for low power Single-Ended mode half-rectified input operation, it is absolutely required for CW operation (audio modulation.) See Figure 4 at the end of the document for an example cooling scheme.

Proper cooling is absolutely necessary for reliable operation of the PlasmaSonic II SSTC board. Failure to properly cool the FETs and associated switching devices during operation will result in component failure!

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Building and Testing the PlasmaSonic II SSTC Board

The following steps should be followed when building your board. You'll need to select an operating mode first as each mode requires different jumper configurations, and components.

1. Solder all components to the board except for the gate transformer. It is imperative to use IC sockets for U21-U25, and U52. DO NOT install the TL494, TC442x's, LM3916 or the MOSFETs (Q1-Q4) at this time. Install components and configure jumpers per the operational mode you will be running at.

2. Connect a 24V CT (Center-Tapped), 2A (48VA) Transformer as shown on the schematic to E51, E52, and E53 on the board. See Figure 1 and Figure 2 at the end of the document for wiring diagrams of this transformer. E53 should be tied to both GND (from your outlet) and the center tap winding of the transformer. Once this is hooked up, perform Test 1: Low Voltage Power Supply Check

3. Once Test 1 is complete, install the TL494 IC into the U21 socket and the LM3916 into the U52 socket. Perform Test 2: Initial SMPS Operation Check

4. When Test 2 is complete, install the TC442x ICs into their respective sockets and perform Test 3: High Power Gate Driver Test

5. Wind the gate transformers and attach them to the board. Perform Test 4: Verifying Gate Transformer Phasing

6. At this point, operation of the SMPS Controller circuit has been confirmed. The next step in the testing procedure is to test the full-bridge switching circuit.

Push-Pull Mode (Audio Modulation – DC Input)
If you configured your board for Push-Pull mode and are planning on using audio modulation, connect the external DC power supply (consisting of components BR101 and C101 as shown on sheet 3 of the schematic) to the board. DC_POSITIVE should connect to E2 and DC_NEGATIVE should connect to E3. See Figure 2 at the end of this document for wiring diagram.

Single-Ended Mode (AC Input)
If you configured your board for Single-Ended mode, connect the output of your variac to E1 and your AC NEUTRAL to E3. See Figure 1 at the end of this document for wiring diagram.

6. Perform Test 5: Output Low Voltage Test

7. Perform Test 6: Output Light Bulb Test

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8. Once all these tests check out, you can hook up your tesla coil resonator to the PlasmaSonic II SSTC board and begin tuning and operating your SSTC.

Winding the Gate Transformers
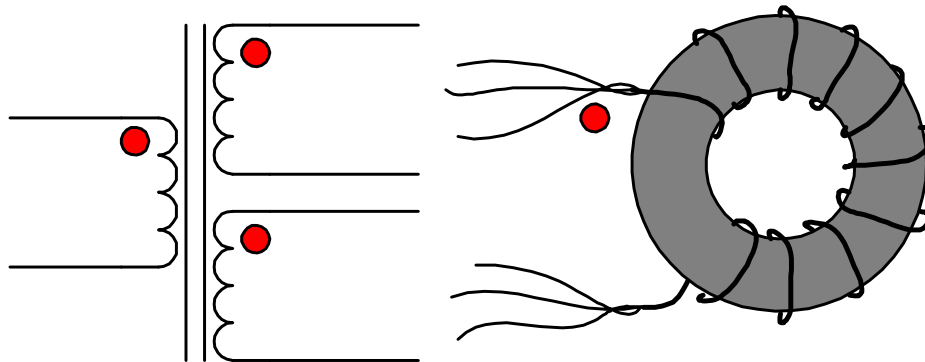
Winding the gate transformers is a simple and easy process. The following steps will take you through the process.

1. Cut three pieces of 24-28 AWG magnet or standard wire (solid or stranded) to lengths of about 3 feet. Knot one end, secure it to something, and then twist the wire together creating the trifillar winding. This type of winding will maximize the coupling between the three windings and minimize the amount of leakage inductance. Maximizing coupling between the windings and reducing leakage inductance is EXTREMELY important when switching at high frequencies (>300kHz).

2. Wind these cores with 15 turns of the trifillar windings created above. It is strongly recommended to use the cores listed on the parts list. If you do use other ferrite cores, you will need to verify their operation separately before using them on the board to reduce the chance of damaging the full-bridge switching circuit.

3. Once the core is wound, you can secure the entire transformer to the board by using wire ties. Once secured, you can trim the wires to the desired length and solder to either the rectangular surface mount pads on the board or via turret terminals in the holes provided.

4. When connecting the windings to the board, it is extremely important to maintain proper phasing. In the diagram shown above, the red phasing dot shows relatively phasing of the transformer. All windings entering the transformer will have the same

relative phase. The windings should be connected to the board EXACTLY how they are shown on the schematic.

Be sure to maintain proper phasing when attaching the gate transformers to the PlasmaSonic II SSTC board. Failure to maintain proper phasing will SEVERELY damage the board and components.

Configuring Audio Filter

For normal operation, the input audio filter should be configured as follows:

1. Use a zero-ohm jumper (or wire) for R22 and R23.
2. C21 and C23 should be left open

Connecting Audio

Audio should be connected to the PlasmaSonic II through the RCA connector at J21. The audio should be a high-impedance source such as that from the line-level outputs of a CD player. Care should be taken so that the audio level doesn't exceed 2V p-p, otherwise, permanent damage may be result to the TL494 PWM Controller IC. Low impedance inputs such as speaker level outputs should not be used. If they absolutely must be used, series 10k resistors should be wired inline between each speaker wire to J21 and the level limited to 2V p-p. Also, the use of speaker level will greatly degrade the quality of your audio modulated output of the SSTC.

Improving Audio Quality

There are a few ways to vastly improve the audio quality of your PlasmaSonic II SSTC.

1. The number one way to increase both audio quality and volume is to use a stereo pair of PlasmaSonic II SSTCs. The stereo imaging from this arrangement is absolutely incredible and guaranteed to be like nothing you've heard before. Each SSTC acts as a omni-directional point source (unlike traditional uni-directional axial tweeters), and with your eyes closed, it is impossible to determine the location of where the audio is coming from.

2. Use an equalizer. With an equalizer, you can vary the gains of various frequencies and reduce the distortion that may be produced. You will also increase the bass response of your system by tuning it with an equalizer.

3. Use the "Corona Ring Speaker" electrode. Although this increases ozone production, and the associated background hiss, it will greatly improve lower frequency response, visual effects, and overall sound volume.

4. Experiment with many CDs. Each CD has its own mixing characteristics and will work differently with your PlasmaSonic II SSTC. Find a CD which performs best and use that one for your demonstrations. Some of the best tracks I've found to work are:

"Deliverance" by Yanni (No, this has nothing to do with the movie)

"Closer" by Nine Inch Nails (Perfect for the SSTC, although harsh language)

"She Blinded Me with Science" by Thomas Dolby

Configuring VU Meter

The onboard 10 LED VU Meter can be operated in two operational modes.

Peak Measurement
In this mode, the VU Meter will capture audio peaks and hold them briefly.

Real Time Measurement *(Recommended)*
In this mode, the VU Meter will display exactly what audio levels are being inputted without any type of peak and hold circuitry.

The onboard 10 LED VU Meter has two display modes.

Bar Mode *(Recommended)*
In this mode, the VU Meter displays an entire row of LEDs for each power level. For example, if the audio signal was +2dB, then LEDs 1 through 9 would be illuminated.

Dot Mode
In this mode, the VU Meter displays only a single LED for the power level it reads in. For example, if the audio signal was –3dB, only the LED 5 would be illuminated.

The following table shows the various configurations for the VU Meter.

Operational Mode	JMP 51	JMP 52
Real-Time, Dot Mode	OPEN	Short Pin2 to Pin3
Real-Time, Bar Mode	SHORT	Short Pin2 to Pin3

Peak and Hold, Dot Mode	OPEN	Short Pin1 to Pin2
Peak and Hold, Bar Mode	SHORT	Short Pin1 to Pin2

Adjusting the VU Meter

Peak/Hold Delay
When operating in Peak Measurement mode, R55 can be used to vary the delay time for peak measurements. If additional or less delay time is required than what R55 can be set for, then C57 can be changed accordingly.

Input Sensitivity
To calibrate the VU Meter, use the gain adjust, R57.
With your audio source connected, vary R57 until almost all LEDs light at the musical peaks. This will give a ballpark setting.

Test 1 : Low Voltage Power Supply Check

At this point, all components, except the gate transformers, should be soldered to the board including all the IC sockets for U21-U25, and U52. At this time, the TL494, TC442x, or LM3916 ICs should not be installed.

Recheck all components and ensure they match the schematic, parts list, and component layout. If components are not installed correctly, they may cause component failure throughout the board.

Turn on power to the 24VCT transformer.

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No power should be applied to the full bridge circuit during this test!

Using a multimeter, measure the voltage at the following locations and verify that the correct voltage is present. All measurements should be referenced to E53 (GND).

Component	Measuring Point	Voltage
U51	Pin 3	12V ± 0.5V
U51	Pin 3	12V ± 0.5V
U52	*Pin 1*	*18V ±1.0V*
U21	Pin 8	12V ± 0.5V
U21	Pin 11	12V ± 0.5V
U21	Pin 12	12V ± 0.5V
U22	Pin 1	12V ± 0.5V
U22	Pin 8	12V ± 0.5V
U23	Pin 1	12V ± 0.5V
U23	Pin 8	12V ± 0.5V
U24	Pin 1	12V ± 0.5V
U24	Pin 8	12V ± 0.5V
U25	Pin 1	12V ± 0.5V
U25	Pin 8	12V ± 0.5V

If any of the above measured voltages are in error, you will need to troubleshoot the board before proceeding.

Verify that the +12V_PWR LED (D51) is illuminated. If it is not, check the polarity of the LED to ensure its installed properly.

If all the measurements above pass and the LED is working correctly, this test is complete.

Test 2 : Initial SMPS Operation Check

Before beginning this test, turn off power to the board. Install the TL494 IC into the U21 socket and the LM3916 into the U52 socket. Once this is complete, turn power back on the board.

⚠️

No power should be applied to the full bridge circuit during this test!

It is important that both R24 and R26 be initially set about halfway through their adjustment range. If they are not, the TL494 may not operate properly for this initial test.

Using a dual channel oscilloscope, monitor the voltages at both TP22 and TP23.
Verify that the following pulses are present and have the proper amplitudes according to the mode you are running your PlasmaSonic II SSTC. Each oscilloscope channel should be DC coupled and set at about 5V per division. The GND of the oscilloscope should be connected to E53 or another GND point on the board.
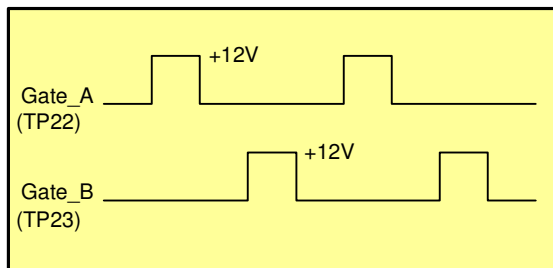
Push-Pull Mode
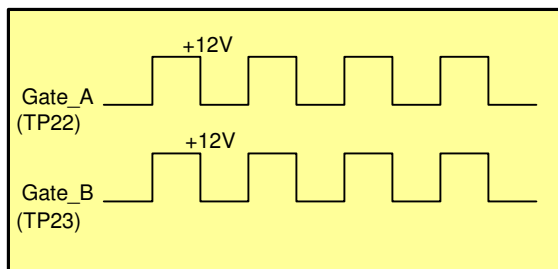
Single-Ended Mode

Once the above pulses are verified, you can start verifying the BIAS Adj and FREQ Adj controls.

Adjust R26 (FREQ Adj) and verify that the frequency of your pulses adjusts over the range of 1kHz to 500kHz.

Adjust R24 (BIAS Adj) and verify that the duty cycle of the output pulses is adjustable according to the following specifications:

Operational Mode	Duty Cycle Lower Limit	Duty Cycle Upper Limit
Push-Pull	0%	25%
Single-Ended	0%	50%

Using an oscilloscope, verify that the pulses at TP22 are also seen at U22, Pin2 and U23, Pin2. (Note: The TC442x ICs should still not be installed at this time)

Using an oscilloscope, verify that the pulses at TP23 are also seen at U24, Pin2 and U25, Pin2. (Note: The TC442x ICs should still not be installed at this time)

If all these measurements are completed and verified, then this test is complete.

Test 3 : High Power Gate Driver Test

Before beginning this test, turn off power to the board. Dependent on the operational mode of your board, install the TC442x ICs into their respective sockets.

Please note that the type of TC442x ICs you install on the board is dependent on the operational mode you are operating in. Failure to install the correct ICs will damage your board and components.

Once the correct components are installed, apply power to the board.

No power should be applied to the full bridge circuit during this test!

Using a dual channel oscilloscope, set Channel 1 to look at the signal at TP22. The GND of the oscilloscope should be connected to E53 or another GND point on the board.

On Channel 2, monitor the following points and verify that the signals present match those required for the operational mode you are operating in. Each pulse should have an amplitude of +12V with respect to GND and should either be inverted or non-inverted with respect to the pulse seen at TP22.

Operational Mode	Measurement Test Point	Signal
Push-Pull	U22, Pin 6 or Pin 7	Non-Inverted
Push-Pull	U23, Pin 6 or Pin 7	Non-Inverted
Push-Pull	U24, Pin 6 or Pin 7	Non-Inverted (Delayed 50%)
Push-Pull	U25, Pin 6 or Pin 7	Non-Inverted (Delayed 50%)
Single-Ended	U22, Pin 6 or Pin 7	Non-Inverted
Single-Ended	U23, Pin 6 or Pin 7	Non-Inverted
Single-Ended	U24, Pin 6 or Pin 7	Inverted
Single-Ended	U25, Pin 6 or Pin 7	Inverted

Once the above signals have been verified, this test is complete. If the signals are incorrect, please correct the problem before proceeding otherwise you risk serious damage to board.

## Test 4 : Verifying Gate Transformer Phasing

During this test, you will be verifying the phasing of the gate transformers. The MOSFETs (Q1-Q4) should NOT be installed at this time. To verify the phasing of the gate transformers, we are simply going to look at the general polarity of the signals as viewed at the gates of the MOSFETs (Q1-Q4). This is mainly because to accurately look and compare gate signals with one another you need either two differential probes or a four channel oscilloscope.

Apply power to the board.

No power should be applied to the full bridge circuit during this test!

To compare relative polarities of the gate drive signals and to confirm their phasing, simply take the Channel 1 oscilloscope probe and touch it on the GATE pad of the one MOSFET, and then take the Channel 2 oscilloscope probe and touch it on the GATE pad of the second MOSFET. **The GNDs of the oscilloscope probes should NOT be connected to anything.** When performing this test, there will be two scenarios visible of the oscilloscope:

Gate Signals - Identical Phasing

Gate Signals - Opposite Phasing
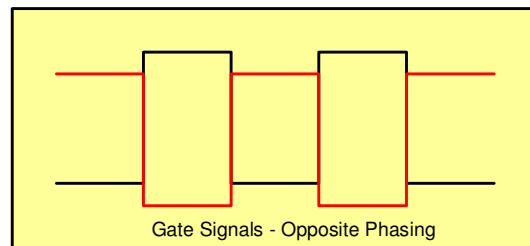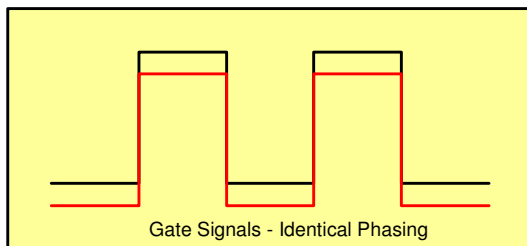
In the image on the left, the phasing of the gate signals is identical. In the image on the right, the phasing of the gate signals is opposite or inverted of one another. The actual signals you see on your oscilloscope will look quite a bit different than this, but all we are interested in is the relatively polarity of the signals.

Perform this test according to the table below to verify phasing:

Oscilloscope Channel 1	Oscilloscope Channel 2	Phasing
Q1, Gate	Q4, Gate	Identical
Q2, Gate	Q3, Gate	Identical
Q1, Gate	Q3, Gate	Opposite
Q2, Gate	Q4, Gate	Opposite

Test 5 : Output Test – No Load

During this test, you will verify the operation of the full-bridge circuit by switching under no load conditions.

The first step of this test is to hook and set-up your oscilloscope to monitor the output waveform of the full-bridge circuit. There are two ways to accomplish this:

Method One: Differential Probe
If you are lucky enough to have access to a differential probe, attach this probe across E4 (OUTPUT+) and E5 (OUTPUT-) on the board.

Method Two: Two Channel Oscilloscope Measurement
In this method, you will use Channel 1 and Channel 2 of the oscilloscope to measure the differential voltage across E4 (OUTPUT+) and E5 (OUTPUT-).

1. Attach the Channel 1 Oscilloscope probe to E4 (OUTPUT+)

2. Attach the Channel 2 Oscilloscope probe to E5 (OUTPUT-)

3. Attach the GND clips of each oscilloscope probe together, but to nothing else.

Do NOT attach the GND leads of the oscilloscope probes to E4 or E5. This will severely damage the full-bridge circuit and likely destroy all MOSFETs and most components!

Do NOT increase the input voltage to the full-bridge circuit beyond the ratings that the oscilloscope can measure. If the voltage output of the full-bridge exceeds oscilloscope or oscilloscope probe ratings, then you may damage the oscilloscope and/or oscilloscope probe!

4. Set oscilloscope mode to ADD for Channel 1 and Channel 2.

5. Set Channel 2 to INVERT. This will show a single waveform on the oscilloscope which is the differential voltage across E4 and E5.
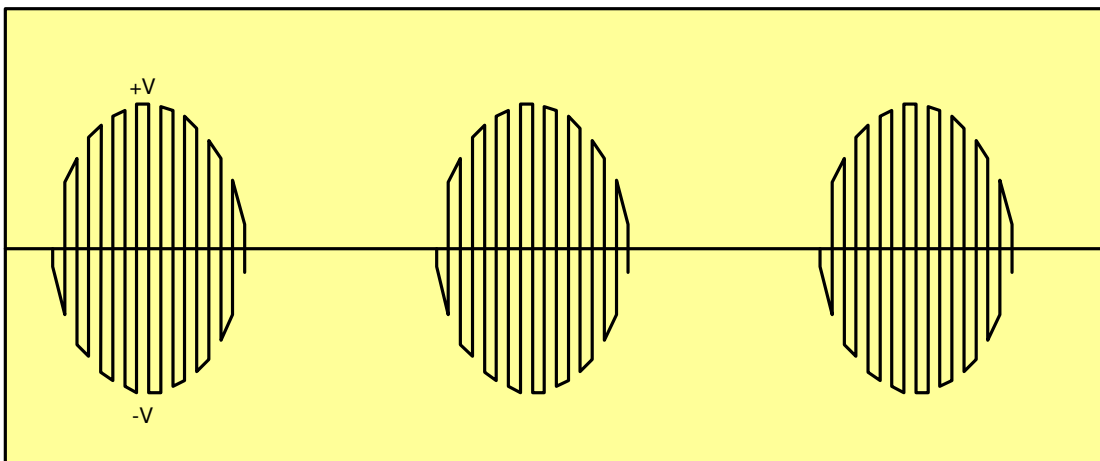
Channel 1 + INVERT (Channel 2)

Turn on power to the SMPS Controller circuit.

Start increasing voltage to the full-bridge switching circuit to about 5V. You should start seeing the following waveforms if everything is working correctly:
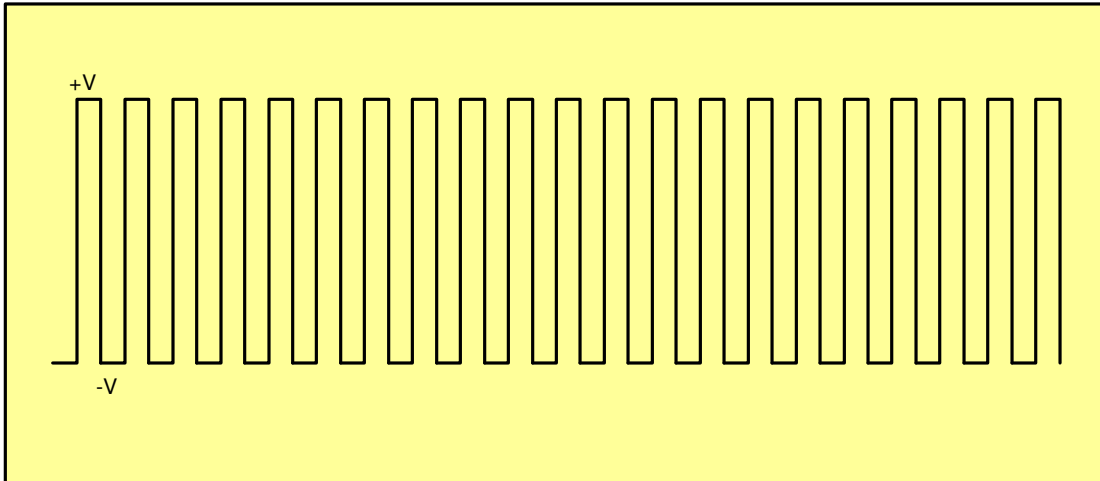
Push-Pull Mode – DC Input

Single-Ended Mode – AC Half-Rectified Input

Continue increasing the voltage in 5V steps using your variac and letting the full-bridge switching circuit operate for a few minutes at a time. After each voltage level, turn off all power, check all components for any unusually hot spots, and continue. If any component seems hot to the touch, or the waveforms start looking unusual, turn off all power, and troubleshoot the circuit. Do not proceed to the next test unless the waveforms for this test are verified all the way up to your maximum operating voltage.

MAXIMUM VOLTAGE LIMTS
Single-Ended Mode – Half Rectified AC = 240VAC
Push-Pull Mode – DC Input = 170VDC
These are the maximum tested limits of the PlasmaSonic II SSTC Board. Although operation past these maximum limits is possible, it is not recommended.

When waveforms are verified for the full range of output voltages for your particular operational mode, this test is completed. Turn off power to both the full-bridge circuit and the SMPS Controller circuit and proceed to Test 6.

Test 6 : Output Test – Resistive Load

This test is a repeat of Test 5 except this time, the full-bridge circuit will be under load.

Attach a 100W light bulb across E4 (OUTPUT+) and E5 (OUTPUT-).

Measure the voltage differential across E4 (OUTPUT+) and E5 (OUTPUT-) as described in Test 5.

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Do NOT attach the GND leads of the oscilloscope probes to E4 or E5. This will severely damage the full-bridge circuit and likely destroy all MOSFETs and most components!

Repeat Test 5. If your full-bridge circuit is working correctly, you should be getting the same waveforms as in Test 5 and the light bulb should be illuminated. Please note that in Single-Ended mode with half-rectified AC input, that the light bulb won't appear as bright as it would be if run from direct 60Hz AC.

Again, increase the voltage to the full-bridge circuit in 5V increments. After each voltage increase, let the full-bridge switch at that voltage for a few minutes, turn off all power, and check temperatures of all components. No components should be more than slightly warm. If any component feels significantly warm or hot to the touch, there is a problem which was must be fixed before proceeding.

Once at maximum voltage, let the full-bridge run for about 5 minutes and recheck for hot components.

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MAXIMUM VOLTAGE LIMTS
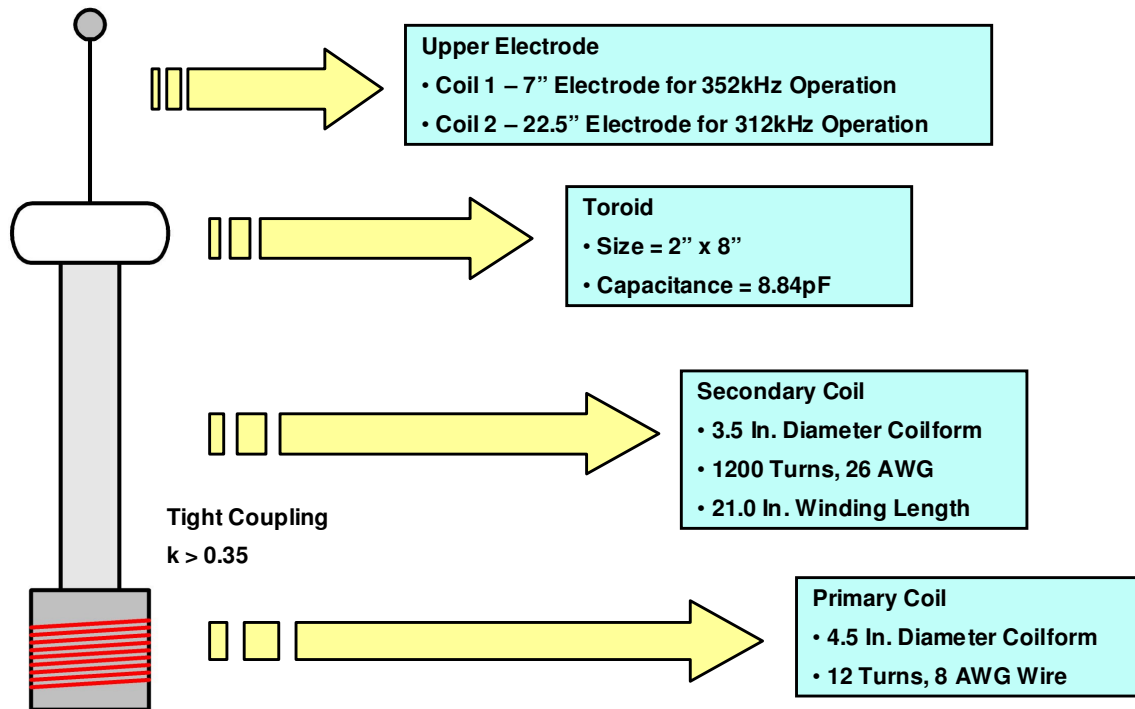**Single-Ended Mode – Half Rectified AC = 240VAC**
Push-Pull Mode – DC Input = 170VDC
These are the maximum tested limits of the PlasmaSonic II SSTC Board. Although operation past these maximum limits is possible, it is not recommended.

When waveforms are verified for the full range of output voltages for your particular operational mode, this test is completed. Turn off power to both the full-bridge circuit and the SMPS Controller circuit. The PlasmaSonic II SSTC Board's operation is verified and ready to be connected to your tesla coil.

Building a Tesla Coil Resonator

This manual will not go into any detail on how to design or build a tesla coil resonator, but does include an example tesla coil which will work well for this system which is shown below:

Upper Electrode

• Coil 1 – 7" Electrode for 352kHz Operation

• Coil 2 – 22.5" Electrode for 312kHz Operation

Toroid

• Size = 2" x 8"

• Capacitance = 8.84pF

Secondary Coil

• 3.5 In. Diameter Coilform

• 1200 Turns, 26 AWG

• 21.0 In. Winding Length

Primary Coil

• 4.5 In. Diameter Coilform

• 12 Turns, 8 AWG Wire

**Tight Coupling
k > 0.35**

Solid state tesla coils require tight coupling between primary and secondary coils for proper operation. To accommodate this, the primary is of a solenoid type coil. Loosely coupled primary coils such as those used in spark gap tesla coils, will not work with solid state drivers such as the PlasmaSonic II board.

Building the PlasmaSonic II Audio Discharge Electrode
(Audio Modulation Only)

The discharge electrode of the PlasmaSonic II is very important for the following reasons:

1. Creates a break-out point for corona to form.

2. Maximizes surface area to increase volume and low frequency response.

Figure 4 at the end of this document illustrates what the electrode should look like. In this example, a loop of wire is used. However, in practice a wide variety of shapes can be used and experimented with as each shape has its own unique visual and audio characteristics.

It is very important that a corona ball be used, otherwise corona will break-out at the point there instead of around the wire loop.

Operating the PlasmaSonic II with a Tesla Coil

The procedure below outlines the proper steps for interfacing and operating your tesla coil with the PlasmaSonic II SSTC board.

1. Measure (or calculate) the resonant frequency of the secondary coil with the toroid attached.

2. Connect the two ends of the primary coil with E4 (OUTPUT+) and E5 (OUTPUT-).

3. The RF ground of the secondary coil should be connected to standard electrical GND. The GND in your three-prong outlet should suffice for solid state tesla coils up to 1kW. A dedicated GND may be used for higher power coils.

⚠️

No power should be applied to the full bridge circuit during these adjustments. (No. 4 & 5)

4. Turn on power to the SMPS Controller circuit. Using an oscilloscope or frequency counter connected to TP22, adjust R26 so that the frequency at TP22 matches the measured resonant frequency of the secondary / toroid assembly.

5. Next, adjust R24 so that the duty cycle is 50% for Single-Ended mode and 50% of its maximum obtainable duty cycle for Push-Pull mode.

6. The next step is to turn on power to the full-bridge switching circuit and to fine tune the operating frequency. This is best done with using a variac and a small fluorescent light tube. Holding the fluorescent light tube lengthwise at the level of the primary coil, slowly bring up the input voltage using a variac. Increase the voltage just until the fluorescent tube begins to glow. If you are above 30% on the variac and the fluorescent tube is not glowing, there is likely a problem somewhere, so turn off all power and check

your connections and frequency adjustments again before proceeding. The fluorescent tube will start glowing well before any corona appears at the top of the secondary.

Once the tube is glowing, adjust R26 until the fluorescent tube is its brightest.

7. Now, slowly increase the variac towards full voltage. Corona (CW mode) or long arcs (half-rectified AC mode) should start appearing at the top of the secondary. Re-adjust R26 to maximize high voltage output. Let the coil operate for a few minutes, turn off power, and re-check for hot components. If the heatsinks and FETs are more than slightly warm, you will need additional fan cooling.

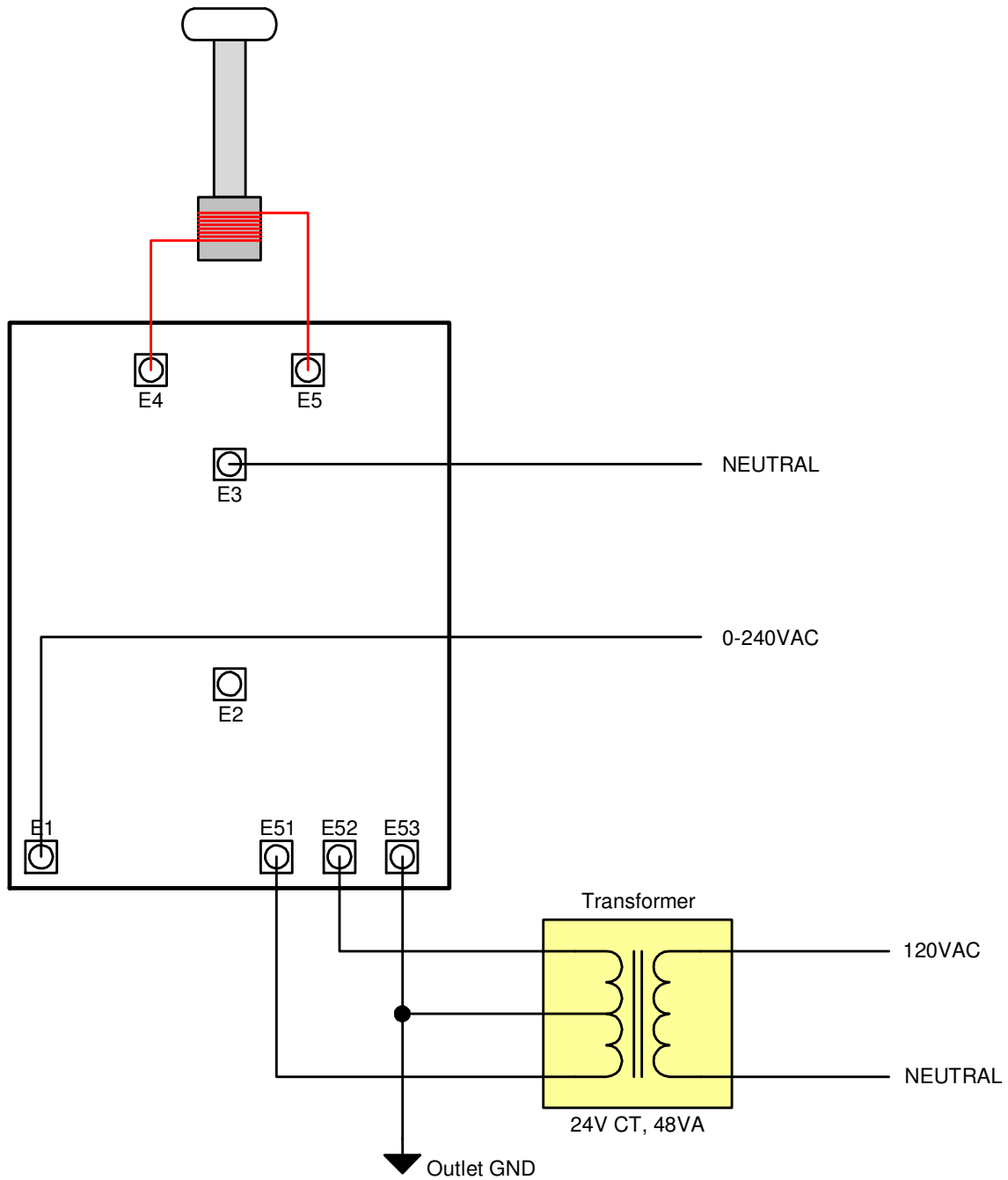Congratulations. Your PlasmaSonic II SSTC is now successfully running.

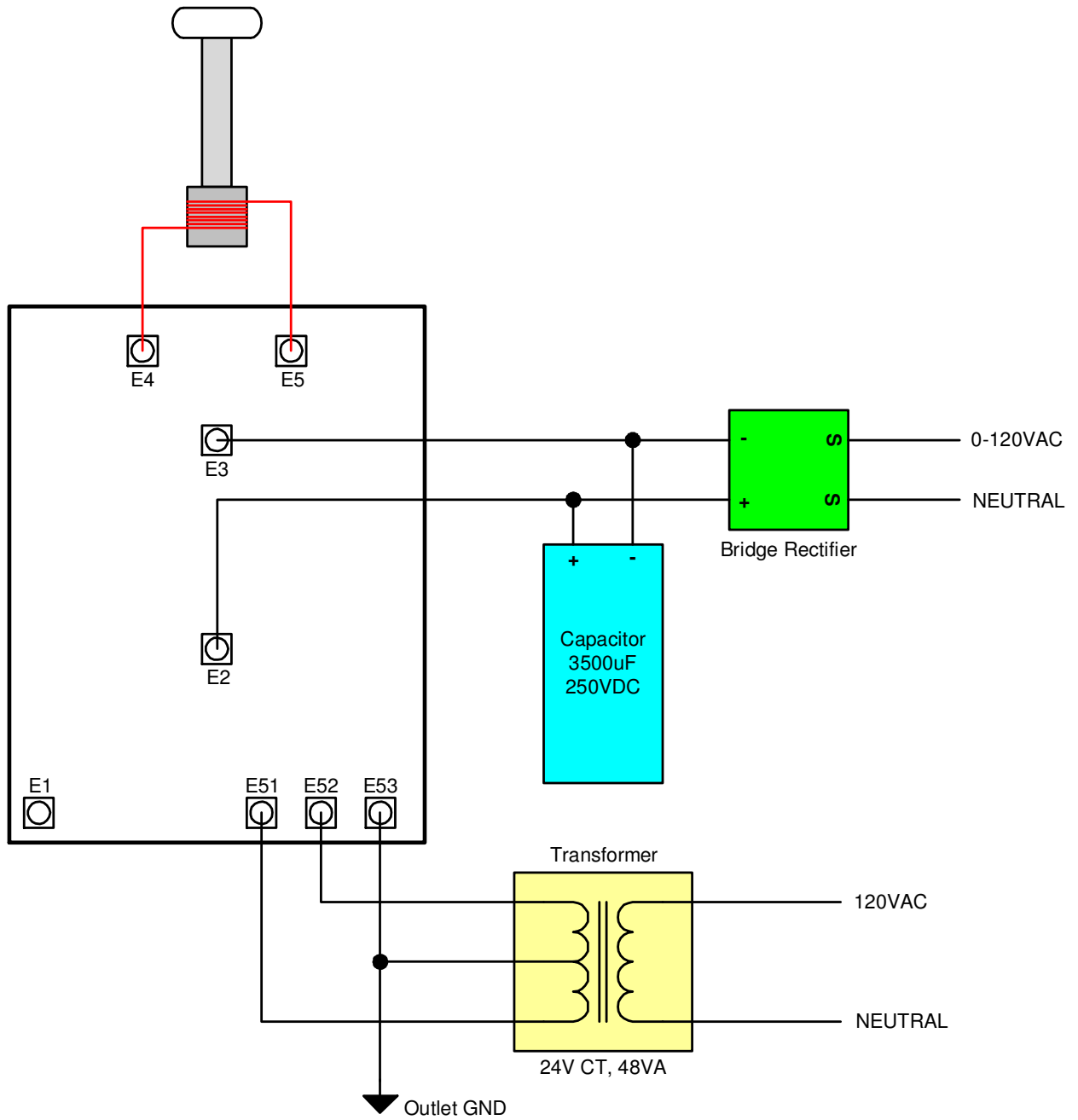**Figure 1 – PlasmaSonic II SSTC Half-Rectified AC Mode (Big Arcs)**

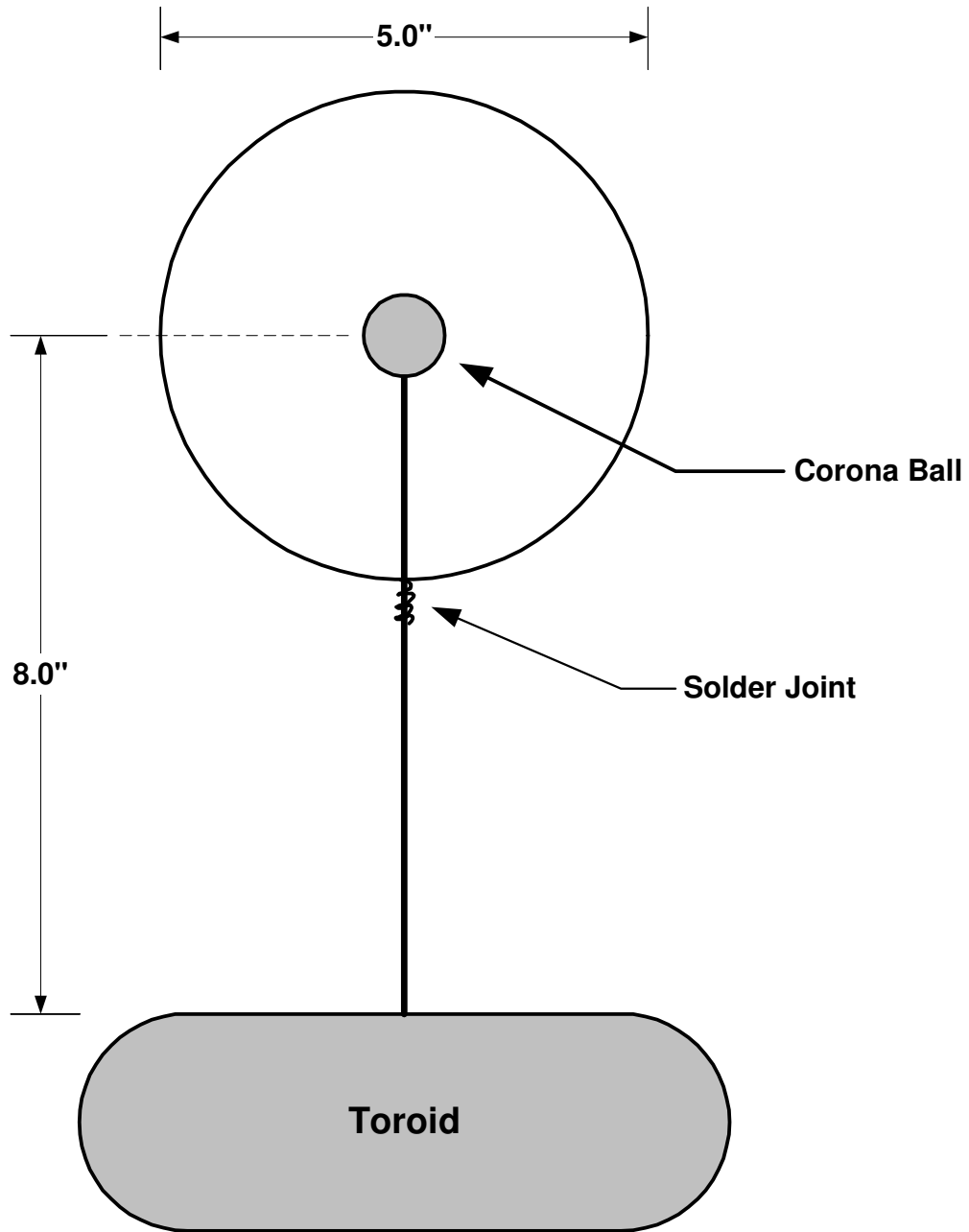**Figure 2 – PlasmaSonic II SSTC CW Operation (Audio Modulation)**

5.0"

Corona Ball

Solder Joint

8.0"

Toroid

Figure 3 – Discharge Electrode (Audio Modulation only)

AIRFLOW

MUFFIN FAN

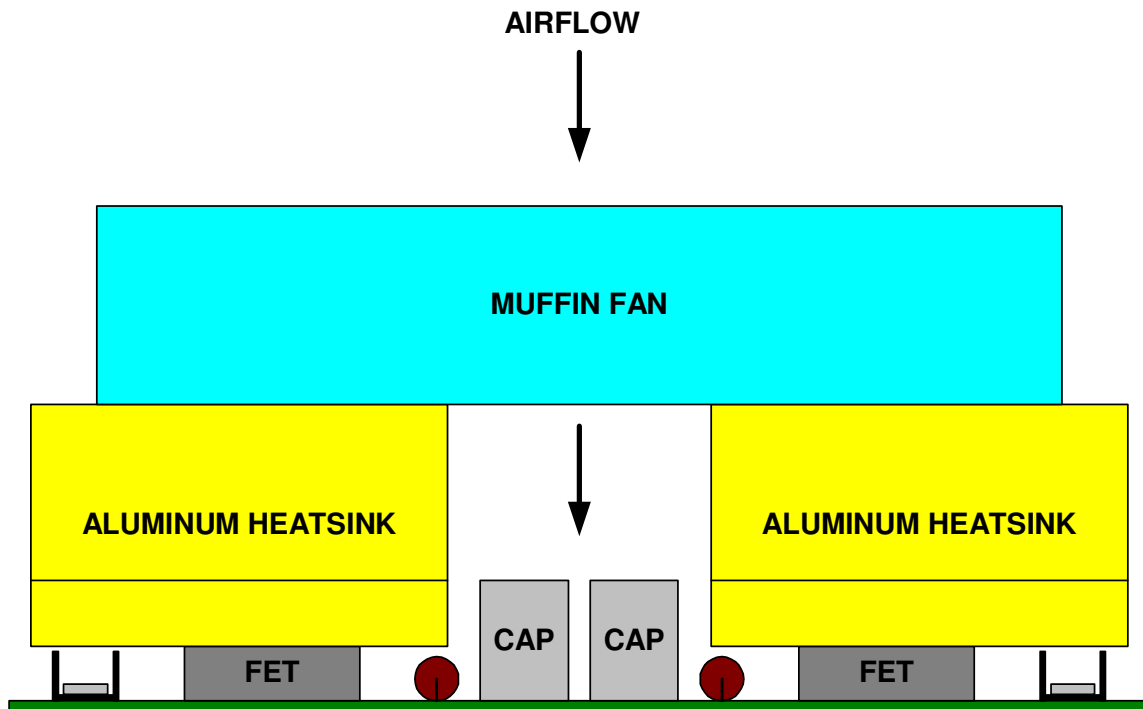**ALUMINUM HEATSINK**   **ALUMINUM HEATSINK**

CAP   CAP

FET   FET

Figure 4 – Example Cooling Configuration