miniBrute DRSSTC Addendum

The following document outlines the known errors and omissions in the miniBrute DRSSTC design. These include both the book, *DRSSTC: Building the Modern Day Tesla Coil miniBrute Reference Design* as well as the PC Board design for the miniBrute DRSSTC.

That said, if you know of any additional errors or omissions, please let us as know at the email address below so that we may add them to this list. Thank you

support@easternvoltageresearch.com

DRSSTC: Building the Modern Day Tesla Coil miniBrute Reference Design Book

❒ **1. Figure 2-8 miniBrute DRSSTC System Schematic**
The schematic shows current transformers T1 and T21 sensing the secondary RF ground current. This is incorrect. T1 and T21 should be sensing the primary current and should be placed between the OUTPUT of the Half-Bridge Power Board, A1 and the MMC capacitor which is comprised of C102-C105.

❒ **2. Display Board Instruction 4 – Page 89**
Please update the instruction as follows:

FROM:
Apply +15V to the "HV SAMPLE" terminal on the self-resonant board. Verify that the red LED, D6 (HV Charge) is illuminated on the display board.

TO:
First remove the connection between R124 and the DC_SUPPLY+ node (see page 28). Apply +15V to the top side of R125 as shown in Figure 2-7 on page 28. The return of the +15V should be placed at the HV_SAMPLE-.

Basically you want to apply the +15V through the 50k resistor stack, and not directly to the HV SAMPLE terminals as previously stated as this will damage the optocoupler.

❒ **3. Display Board Instruction 6 – Page 89**
Please update the instruction as follows:

FROM:
Apply a variable voltage source to the "ISENSE" terminal on self-resonant control board. The positive connection should connect to the square pad end of the terminal block.

TO:
Lift up one end of R21, 1.6 ohm, 2W resistor, then apply a variable voltage source to the "ISENSE" terminal on self-resonant control board. The positive connection should connect to the square pad end of the terminal block.

If R21 was installed during this test, it would burn up as it was sized for the low duty cycle operation of the DRSSTC, and not for a DC voltage as is indicated in this test.

❒ **4. Table 4-2 Advanced Modulator Parts List**
Item 20, SW2 and SW3 should be a DPDT rocker switch. The correct part number for these switches are DIGIKEY Part Number, CKC2009-ND.

❒ **5. Alternative IGBTs**
To date, Fairchild Semiconductor is no longer manufacturing the HGT1N40N60 IGBT. An alternate IGBT is the IXYS IXGN60N60C2D1 IGBT. It is a drop-in replacement component.

❒ **6. Alternative Capacitors for C61, C65**
Capacitors, C61 and C65, which are 4700uF, 35V electrolytics may be replaced with 2200uF, 35V electrolytics.

❒ **7. Transient Voltage Suppressor, VR61**
Transient Voltage Suppressor, VR61, may be replaced with either a 1.5KE18CA, 1.5KE15CA, or 1.5KE12CA or left out altogether.

❒ **8. Operational Amplifier, U23, LT1630**
Due to the high cost of the LT1630, the part will now be replaced with an TLC2272CP. LT1630 was chosen due to its rail-to-rail output capability, so any operational amplifer with the same pin-out and that has rail-to-rail output capability may be substituted.

❒ **9. Reliability Improvements**
A properly tuned and set-up (proper current limit, etc…) will yield a reliable DRSSTC. However, to improve reliability even further, please follow the steps below:

a. The MOST important thing to remember for reliability is to PREVENT arcs from striking downward towards the primary coil. Although there is a grounded strike rail above the primary coil, strikes to the grounded strike rail may jump back into the primary coil. Strikes to the primary coil are a sure way to blow the half-bridge IGBTs. Position the break-out point on the toroid upwards, and use a closely positioned strike target. Also, a pointed object placed about 6 inches from the side of the enclosure (on the same side as the break-out point) and sticking up to about strike rail height will capture any arcs that are propogating downward. This CANNOT be stressed enough. **Preventing Primary Coil and Strike Rail strikes = Higher Reliability!**

b. Ensure the inductance between the DC Bus capacitors (C121, C122) is extremely low. This can be achieved by making the connect between the Half-Bridge PC Board and C121,C122 as short as possible. Also, the leads between these should be twisted TIGHTLY together. A flat busbar arrangement also works and will provide even additional coupling and lower inductance.

c. To improve the reliability in high current (bright white arcs) ground strikes, running a long extension cord between the variac and wall outlet will provide some resistive and inductive ballasting. Although this won't affect the nominal arc length during air arc strikes, it will reduce the peak currents during ground strikes.

d. Operate the DRSSTC using the shortest pulsewidth possible for a given arc length. When adjusting pulsewidth, there will be a point where additional pulsewidth will not increase arc length, but only increase apparent "thickness" of the arc. Increase pulsewidth only up to this point for maximum reliability.

e. Operate the DRSSTC at 100Hz PRF. Increasing PRF above 100Hz increases duty cycle and thereby increases power and heating of the switching components. For best reliability, maintain a lower PRF. It has been determined that 100Hz yields the best performance for this particular design.

f. Ensure the break-point on the toroid directs arcs upward and away from the primary coil. Although there is a strike rail in the miniBrute system, any arcs from secondary / toroid to primary may cause damage to the power electronics and thus should be prevented if possible. A grounded strike target can also be positioned to ensure that output arcs are attracted to the target and not downwards toward the primary coil.

g. Reduce the current setpoint and operating voltage. Although increasing the peak current output setpoint and operating voltage will yield much longer arcs, for demonstration purposes where reliability needs to be maximized, the system should not be operated at maximum. With a variac with 0-140 dial marks, I typically set that variac at about 100 for most reliable results.

h. Always ensure the toroid break-out point is in place. Failure to have a break-out point in place can lead to enormous peak currents in the power circuit and can lead to IGBT failure.

❒ **10. Parts List, R125**
Line 20 on the Parts List (Table 2-1) has incorrect REFDES information. The correct REFDES for Line 20 are R124, R126.

miniBrute DRSSTC PCB Boards – REV-

❒ **1. Capacitor, C32, 10pF Ceramic Capacitor**
10pF Capacitor, C32 is shown on the schematic (page 20), but not on the Self-Resonant Control Board PCB. C32 should be manually placed (on bottom of board) as close to U3, Pin 4 as possible.

❒ **2. Capacitor, C86, 0.1uF Ceramic Capacitor**
0.1uF Capacitor, C86 is shown on the schematic (page 25), but not on the Self-Resonant Control Board PCB. It is not needed for the design and should be omitted.

❒ **3. Resistor, R28**
As indicated on the schematic (page 25), R28 should be left OPEN.

❒ **4. Capacitor, C81, C82, 0.1uF, 1uF Ceramic Capacitors**
0.1uF and 1uF Capacitors, C81 and C82, are shown on the schematic (page 25), but not on the Self-Resonant Control Board PCB. These capacitors should be installed directly on the temperature sensor, U81, leads.

❒ **5. LEDs, Display Board**
Just a note that the square pads on the Display Board PCB indicate the anode side of the LED. The silkscreen is backwards, and it is important to follow this note. The note is also printed on the Display Board PCB as a reminder.

❒ **6. Self-Resonant Control Board – ARTWORK mistake**
The top of potentiometer, R23 (page 20), should be connected to +15V. The REV- artwork has this node connected to +5V. To correct this, use the following instructions”

a. First, cut the trace on the top of the board between the top pin of potentiometer, R23, and R25.

b. On the bottom of the board, connect a jumper wire between the top pin of potentiometer, R23, and U23, Pin 8.

Without this modification, the current limit will be limited to about 475A peak current.

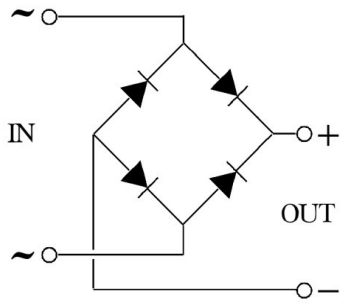
❒ **7. Rectifier Board**

We no longer recommend the use of the Rectifier PCB board and the discrete diodes CR121, and CR122. Instead, use a quick terminal type bridge rectifier, such as Digikey Part No. GBPC3508DI-ND. You can use the bridge rectifier and connect it so that it only utilizes (2) of the internal diodes of the bridge rectifier.

a. 120VAC_BRIDGE_FUSED connects to one of the AC terminals of the bridge rectifier.

b. DC_SUPPLY+ connects to the "+" terminal.

c. DC_SUPPLY- connects to the "-" terminal.



❒ 8. **Thermal Sensor (LM35)**

The LM35 thermal sensor is no longer recommended for use with the miniBrute DRSSTC and is no longer included in any of the miniBrute DRSSTC kits. Supporting components are still included if you wish to still use this.

miniBrute DRSSTC PCB Boards – REVA

❒ **1. Capacitor, C32, 10pF Ceramic Capacitor**

10pF Capacitor, C32 is shown on the schematic (page 20), but not on the Self-Resonant Control Board PCB. C32 should be manually placed (on bottom of board) as close to U3, Pin 4 as possible.

❒ 2. **Capacitor, C86, 0.1uF Ceramic Capacitor**
0.1uF Capacitor, C86 is shown on the schematic (page 25), but not on the Self-Resonant Control Board PCB. It is not needed for the design and should be omitted.

❒ 3. **Resistor, R28**
As indicated on the schematic (page 25), R28 should be left OPEN.

❒ 4. **Capacitor, C81, C82, 0.1uF, 1uF Ceramic Capacitors**
0.1uF and 1uF, Capacitors, C81 and C82, are shown on the schematic (page 25), but not on the Self-Resonant Control Board PCB. These capacitors should be installed directly on the temperature sensor, U81, leads. (Note: The thermal sensor circuit is no longer required for proper operation and should be omitted)

❒ 5. **LEDs, Display Board**
Just a note that the square pads on the Display Board PCB indicate the anode side of the LED. The silkscreen is backwards, and it is important to follow this note. The note is also printed on the Display Board PCB as a reminder.

❒ 6. **Self-Resonant Control Board – ARTWORK mistake**
The top of potentiometer, R23 (page 20), should be connected to +15V. The REVA artwork has this node connected to +5V. To correct this, use the following instructions"

a. First, cut the trace on the top of the board between the top pin of potentiometer, R23, and R25.

b. On the bottom of the board, connect a jumper wire between the top pin of potentiometer, R23, and U23, Pin 8.

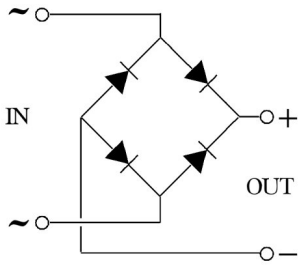
Without this modification, the current limit will be limited to about 475A peak current.

❒ 7. **Rectifier Board**
We no longer recommend the use of the Rectifier PCB board and the discrete diodes CR121, and CR122. Instead, use a quick terminal type bridge rectifier, such as Digikey Part No. GBPC3508DI-ND. You can use the bridge rectifier and connect it so that it only utilizes (2) of the internal diodes of the bridge rectifier.

a. 120VAC_BRIDGE_FUSED connects to one of the AC terminals of the bridge rectifier.

b. DC_SUPPLY+ connects to the "+" terminal.

c. DC_SUPPLY- connects to the "-" terminal.



❒ 8. **Thermal Sensor (LM35)**
The LM35 thermal sensor is no longer recommended for use with the miniBrute DRSSTC and is no longer included in any of the miniBrute DRSSTC kits. Supporting components are still included if you wish to still use this.

General Kit Notes – Apply to all board revisions

❒ 1. **1.5KE220CA (220V Transient Suppressors)**
Some kits may be supplied with 1.5KE220A unipolar transient suppressors. These have a stripe on them which indicate cathode. These should be installed (VR107, VR108, VR109, VR110) with the strip (cathode) facing towards the DC_SUPPLY+. These will continue to clamp in the positive (forward) direction across the C-E terminals of the IGBT. For the reverse direction, the internal diode of the IGBT will clamp reverse excursions, thus eliminating the need for a bipolar transient suppressor at this location.

❒ 2. **Display Board Ribbon Cable**
Note, that in some kits, you may receive an extra long ribbon cable for the Display Board interface. These are provided so that one can adjust the length to the desired length necessary. To adjust the length, very CAREFULLY lift up on the ribbon cable connector clamp, and lift the ribbon cable up and trim as required. Simply press back on the connector pins and re-close the clamp.

❒ 3. **Thermal Sensor (LM35)**
The LM35 thermal sensor is no longer recommended for use with the miniBrute DRSSTC and is no longer included in any of the miniBrute DRSSTC kits. Supporting components are still included if you wish to still use this.

The following thermal sensor components may be omitted:

C81, 0.1uF Capacitor
C82, 1uF Capacitor

C83, 0.1uF Capacitor
C84, 0.1uF Capacitor
C85, 1uF Capacitor
C86, 0.1uF Capacitor
R81, 1k Resistor
R82, 13k Resistor
R83, 5k (10k) Potentiometer
R84, 100k Resistor
U81, LM35DM Thermal Sensor
U82 , LM311 Comparator

❒ 4. **Potentiometers, R42, R83**

10k potentiometers are supplied for R42 and R83 instead of the documented 5k value. This was done to reduce the number of different components used in the miniBrute DRSSTC design and has no negative effect on performance.

❒ 5. **Capacitors, C4, C5, C6**

Capacitors, C4, C5, and C6 should use 10uF, 35V (or 25V) tantalum capacitors as is documented in the parts list and schematic.

❒ 6. **Capacitors, C24, C26, C28, C31, C42, C63, C67**

These capacitors are shown in the parts list as being 10uF, 35V tantalums. However, we are now using alternative 10uF, 50V electrolytics for these locations. These 10uF, 50V electrolytic are blue in color.

❒ 7. **MMC Capacitors, C103, C104, C105**

Due to cost and performance, we are no longer using the three (3) GE 42L 0.33uF, 2kV capacitors for the MMC capacitor. We now use six (6) CDE 942C 0.15uF, 2kV capacitors in a series / parallel configuration as shown in the provided schematic. There should be two (2) 0.15uF, 2kV capacitors installed one on top of each other in parallel for each capacitor location, C103, C104, and C105.