PCB 3.7A assembly & operating instructions

Thank you for purchasing this new and greatly upgraded **P**rinted **C**ircuit **B**oard, hereafter referred to as **PCB.** A couple of comments are in order. First DO NOT follow wiring instruction in the book, use this instruction for stuffing and wiring the PCB, there are lots of changes from what as published in the book. Read this **entire PDF** before starting construction. **IT IS IMPERATIVE** that the board receive a good flow of forced (fan) cooling air over it during the EDM operation otherwise the cutting capacitors **will quickly fail**!! The machine **SHOULD NOT** be operated for more than 2-3 minutes without forced cooling air!!

I found it virtually impossible to locate one source for all the required components. In the past I used Allied Electronics; they have almost everything, but their prices I think are high, especially on switches and pots in particular but (unlike other companies) Allied will sell you one, 1/8watt resistor. Jameco Electronics, comes the closest to having everything at the best price especially on switches and pots.. Example, Allied sells a SPST 6amp switch for $3.86 ea. Jameco sells a house brand for $1.50 each, in the complete power supply you could use as many as 8, that is nearly a $19 difference ! Maybe the Jameco switch is not quite as good quality (I am not convinced of that yet). If you were building a machine that is going to be operating 8-16hrs a day 5 days a week go for the best you can find. The intended audience buying this PCB will seldom use it more than a few hours at a time. When purchasing resistors; Jameco want to sell a minimum of 100 at a shot. I hate to have you buy 100 resistors when all you need is one or two!! For those in the U.S. just go to Radio Shack and buy the few resistors that is needed (and pay their high price) and save the cost of buying 100 resistor just to get one or two resistors.

The single biggest issue is a component not found on the PCB but is a single 10uf capacitor (C2) (crossover capacitor used in audio systems) used in the high voltage power circuit. Although this capacitor is not absolutely necessary I recommend its use. I haven't been able to locate an electronic supplier, other than those that specialize in audio electronics that handle this capacitor. To complicated the issue audio electronic suppliers don't normally sell items such as small resistors and IC chips that we need. Bottom line is you are going to have to purchase parts from at least two venders and pay the shipping and or minimum order fee, sorry. I have given thought to supplying kits but given the low volume of sales for these PCB, time and headache of the inventory, sorting and packaging, trips to the post office waiting in line, I find it difficult to justify at this time.

It is assumed that you have a copy of **THE EDM HOW-TO Book** and are familiar with the machine. This PCB **IS NOT** a direct drop in replacement for the board described in the book. To take full advantage of the boards new features a few modifications (as described in **this** text) to the original high voltage supply are needed. Though this PCB is nearly the same dimensions as the board detailed in the book the use of this board will most likely require using an enclosure larger than the 10x6x3.5" suggested in the book. This is because electrical connections are made on two sides **of this PCB** and the quarters get to be a bit tight if the smaller enclosure is used. I suggest an enclosure of at least 12x7x4" or larger. With this PCB the wiring to the external controls is much simpler, all connections to controls (pots, switches etc.) are made to the board so it is no longer necessary to run wires from one control device to another on the panel to supply current and function signals.

Most of the improvements made in this design offer more control over the burn hence more stable servo operation, which is beneficial when burning with various electrode and work piece combinations and/or when flushing conditions are less than optimal. Below is a brief description of features found with this board, a more lengthy description and operating procedure are found later.

New features of this board

Electronic edge finder makes it a simple matter to locate the edge or top of the work piece.
Variable window control, this circuit makes it easy with the turn of a single knob to fine tune the cut to conditions.
Gap stabilizer circuit this control adds addition control over the servo motor, under certain machining conditions.
Electrode dither control is used to assist in flushing of the gap when gap conditions are poor**.**
Variable servo speed control provides more control of the servo in difficult burn situations
Compact cutting capacitors making it possible to have a larger range of cutting speeds and surface finishes in a compact package.
Test Points there are 10 Test Point (TP) on the board where voltage reading maybe be taken to simplify troubleshooting.
Ease of wiring to external circuitry

Before each assembly task I provide a **[ ]** box to check off once the task is accomplished, this help keep track of task to complete. Stuffing of the PCB is fairly simple and straight forward; follow this sequence for each component,

(1.) Insert each component into the board at the specified location screened on the board.
(2.) Bend the leads slightly so that the component does not fall out when the board is turn over.
(3.) Solder the item in place ensuring that enough heat is applied so that the solder flow readily.
(4.) Trim the leads and proceed to the next listed component and then repeat steps 1-4.

NOTE: A good solder joint should be bright and shiny, if it is not, reheat the joint, if necessary apply a little more solder. Cold solder joints are far and away the largest reason for board failure. A good solder joint **will NEVER** have a dull grayish appearance.

PCB stuffing step by step

[ ] Solder the (3) 33K, (Orange, Orange, Orange) R1, R2 & R9 resistors on the board

[ ] Solder the (2) 100K (Brown, Black, Yellow) R3 & R7 resistors in place

[ ] Solder (2) 4.7K (Yellow, Violet, Red) R4 & R8, resistors on the board

[ ] Solder the (2) 1K (Brown, Black, Red) R5 & R6 resistors on the board

[ ] Solder the (3) D2, D3, & D4 diodes, these components are polarity sensitive, insert the lead, on the "banded end" of the diode into the square indicated hole on the board.

[ ] Solder the small R10 100K pot. in place. You will note that there are four holes in the board but the pot. only has three legs. The board is design such that if you have an in line three legged pot. instead of the specified pot it will still work.

[ ] Using a small screwdriver, rotate the R10 pot. to mid position

[ ] Solder in place the (4) C2, C5, C6 & C7 .1 (104) caps

[ ] Solder the (2) C3&C8 33uf capacitors in place, These two components are polarity sensitive, place the long lead (+) into the square marked hole.

[ ] Solder the C9 .01uf (103) capacitors on the board

[ ] Solder the C10 .1uf (104) capacitors on the board

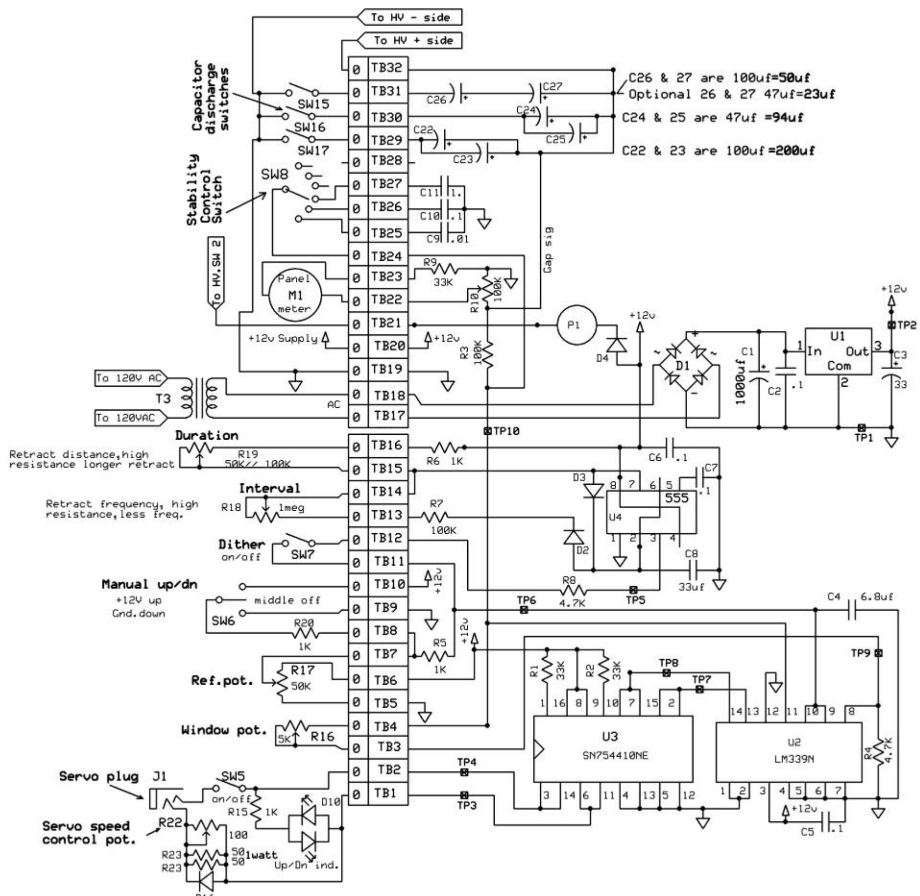
[ ] Solder the C11 1.uf (105) capacitors on the board

[ ] Solder the 14 pin DIP socket U2 on the board, (notch to left)

[ ] Solder the 16 pin DIP socket U3 on the board, (notch to left)

[ ] Solder the 8 pin DIP socket U4 on the board, (notch to left)

[ ] Solder the U1 Voltage regulator in place. The black plastic side faces the silkscreened D1 location.



[ ] The following **four** components are polarity sensitive, the long lead (+) goes in the square hole.

[ ] Solder the P1 "Edge finder" buzzer in place. There is an extra round for P, this additional hole may be used if a buzzer with different lead spacing is used. Both of the round holes are electrically the same point.

[ ] Solder the C4 6.8uf capacitors on the board.

[ ] Solder the D1 Bridge rectifier on the board.

[ ] Solder the C1 1000uf Capacitor on the board.

[ ] INSERT the 8 **T**erminal **B**locks (1-16) hereafter referred to as **TB** along the front side of the board with the screws facing outward. These blocks have a mechanical interlock, make sure this interlock is correct **before** soldering. Began the insertion with holes 1&2 **first** and continue to holes 15&16.

[ ] INSERT the 8 TB (32-17) along the back side of the board with the screws facing outward. Began the insertion with holes 32&31 **first** and continue to holes 18-17. If this sequence is not followed it is virtually impossible to get the interlocks to engage.

The six large cutting capacitors (C22-27) are located on the left hand side of the board. The silkscreen at first may appear confusing. The board is designed to accommodate the two most common diameter size (13mm and 16mm) 100uf capacitors. If you use **13mm** diameter 100uf capacitors for C22 the ordination of the leads is vertical along the silkscreened line. The shorter (negative) lead of the capacitor is inserted in the hole labeled **-** in the 12 o'clock position and the longer, positive lead goes through the hole below it in the 6 o'clock position. If you use the larger **16mm** caps use the holes in the 9 o'clock and 3 o'clock - position. Make sure the negative leg of the capacitor is in the correct hole, otherwise there will be great unhappiness upon firing the EDM up.
The 47uf capacitors are most commonly found in a 13mm diameter package so no provisions are made for the larger size.

Option Note: By changing C26 & 27 to 47uf caps (vice 100uf as screened on PCB) you can change the total capacitance to 23.5uf thus giving you a finer finish. If you elect not to use **C2** (see schematic on page 3) in the HV circuit I recommend this option.

[ ] Solder the (2) C 24 & C25 47uf capacitors on the board, note polarity.

[ ] Solder the (2) C 22 & C23 100uf capacitors on the board, note polarity.

[ ] Solder the (2) C 26 & C27 100uf capacitors on the board note polarity, see **Option Note** above.

Power Enclosure Panel mounted items

The front panel layout of the power supply is up to you, but know that there are several additional pots and switches than what is described in the book. To take full advantage of this board mount the following items.

[ ] J1 power plug (for the servo motor power)

[ ] D10 up/down LED

[ ] SW5 servo on/off switch

[ ] R22 (and R23) is the servo speed control pot

I was unable to locate a the required 2watt low resistance rheostat, so one is formed with the combination of R22&R23. R22 is a 100ohm wire wound pot., R 23 is approximately 51ohm one watt resistor (or equivalent resistance/ wattage) connected in parallel. Pot. R22 has the center terminal and one of the adjacent terminals soldered together in a **rheostat configuration**

[ ] R16 window pot. (wired in rheostat configuration) . **Note**: R18 &R19 are wired in similar fashion.

[ ] R17 reference pot

[ ] SW6 manual up/down switch. This switch is different from the other switches, it has a spring loaded center off position

[ ] SW7 dither on/off switch

[ ] R18 dither interval pot. (wired in rheostat configuration)

[ ] R19 dither duration pot. (wired in rheostat configuration)

[ ] SW8 stability control rotary switch

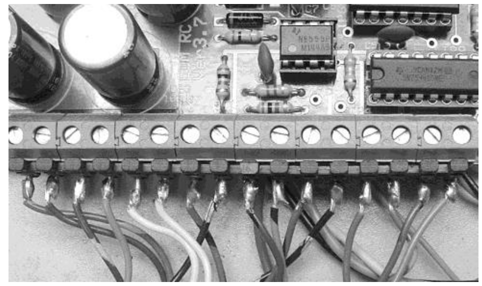
[ ] M1 Panel meter (optional) though very useful.

[ ] S15, S16, & S17 three (3) power capacitor switches

[ ] Mount the PCB in the power supply enclosure the hole spacing for the board is 3 9/16" (90.49mm) x 2 5/16" (58.73mm)

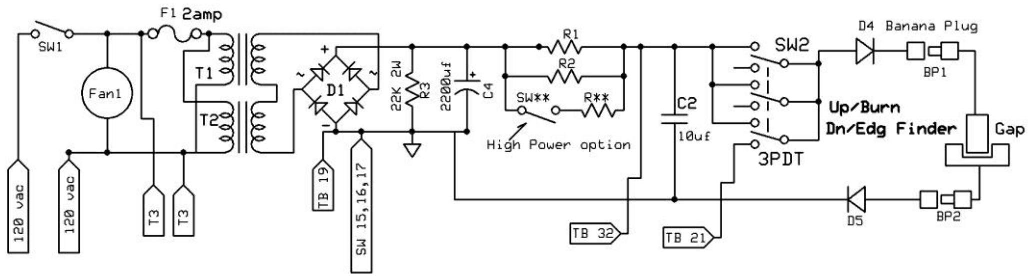
Wiring the PCB to the panel controls

With the PCB stuffed and the necessary switches, LED's, pots etc. mounted in the enclosure it is time to wire them to the board as per the schematic on page 2 **of this PDF.** The 32 connection point via the **T**erminal **B**locks may be wired with individual wires from the control devices (switches and pots.) on the front panel to the **TB**. I prefer to use a length of straight, single row male header, pin spacing of .200 (5.08mm).



[ ] Cut two, 16 pin lengths of header. The long header pins inserted into the **T**erminal **B**locks and the wire connections are soldered to the short pins, (see photo to the right). Should you need to remove the PCB, loosen the Terminal Blocks screws and remove the header with soldered wires. Reassembly is simple, insert the header back into the Terminal Blocks and snug the screws, it sure beats reconnecting about 32 individual wires each time!

I am not going into detail of how to wire the high voltage/current circuit (see schematic right) since it is covered in detail in the book but you will note a few changes on this schematic (mainly R3 and HV SW2). I suggest changing the capacitor bleeder resistor R3 to a 6.8K 1watt resistor for faster cap. discharge.



NOTE: Some readers have indicated they would like to increase the burn rated of the EDM described in the book. This can be accomplished by increasing the current flowing in the gap during a burn. Increased current requires virtually **everything** in the power circuit to be beefed up, i.e. transformers, switches, rectifier, wiring, etc to carry the increased current. Example; if you increase T1&2 to 10 amps all the switches in the circuit must be rated for at least 10 amps.

SW** and R** show how resistors maybe paralleled (and switched in and out) to increase current flow. Make sure that R1&2 and any other resistors you might use (R**) have wattage ratings large enough to dissipate the energy when a short circuit occurs in the gap. The formula is P=I x E. Power P (in watts) that the resistors must dissipate is equal to the current (I) times (E) Voltage. I usually size them for about 75% of the load though to be completely on the safe side, sizes them for 100% of the load. The reason for being able to derate is the resistors only see a short circuit condition for a very short time. In normal operation they experience lower current flow because of the of saw tooth wave form that is generated as the cutting capacitors charge.

The symbol on the schematic show which **T**erminal **B**locks (**TB**) on the PCB (and the HV power supply) the particular wire connects to.

[ ] To take advantage of the Edge Finder circuit capability it's necessary to place a 3PDT (3 Pole Double Throw) switch (HV) SW2 in series with the gap (a 4PDT may also be used). This is the major deviation from the book High Voltage circuit.

[ ] Wire HV SW2 as per the Modified HV schematic shown above.

[ ] **Make sure the wire going to TB32 connects between R1 & R2 and HV SW2.**

[ ] The **TB** SW15,16,17 and the **TB**19 connection is the common ground connections between the two circuits. This maybe two wires, one going to TB19 and the other to the switches, or you can run a single wire but make sure TB19 and the switches are all connected.

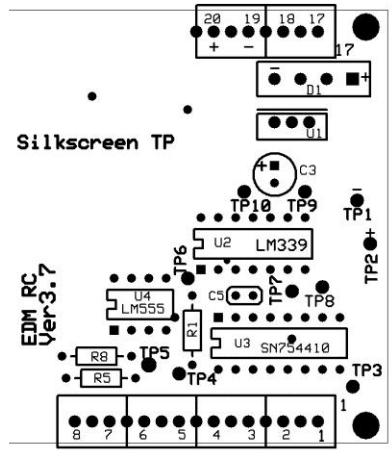
[ ] Make connections to the low voltage T3 transformer.

[ ] The remaining connections are to the PCB control components. Wire as required to complete the circuits as per the schematic.

[ ] J1 is the connection to the servo motor.

[ ] U1 **should** have a heat sink, U3 (motor driver) normally does not require a heat sink but the use of a clip on heat sink with some of the larger DC motors is a good idea. A clip on heat sink for U3 may make access to some of the Test Points (discussion below) difficult.

Circuit Test Points



Once the board is completed, installed in the enclosure and connected to the panel components, it's time make sure everything is operating properly. There should be **NO** chips in the DIP sockets when starting the testing. Tests are made using the Test **P**oints (**TP**) located primarily in the lower right quadrant of the board; see drawing to the right. Some of the board components in this drawing have been removed so that it is easier to identify the **TP** location noted with large black dots.

[ ] After **each test,** turn the power supply AC switch (SW1) off.

[ ] Ensure all switches on the panel are turn **OFF**, and then turn the main AC switch (SW1) on.

[ ] Assuming no smoke appears when turned on, the first adjustment is not a **TP** instead it is tweaking the meter pot. (R10) to read the desired voltage on the meter.

[ ] **TP1** is found about midway down on the right hand side of the board. This is the common ground for the board as well as for the High Voltage supply when they are wired together (via TB19).

[ ] **Make all tests** with the black probe of your meter touching **TP1**.

[ ] **TP2** should read 12VDC + this indicates the onboard low voltage power supply is operating properly. If this reading is not very close to 12vdc it indicates there is a failure of D1 and or U1, or there is short somewhere on the board.

[ ] Insert U2 (LM339) in its socket. When installing **all** chips ensure, pin#1 on the chip face the left side of the board.

[ ] After installing **each** chip and applying power feel for overheating, if hot turn power off and investigate.

[ ] Insert U3 (SN754410) in its socket

[ ] Rotate the window pot (R16) to mid position

[ ] Turn the servo on/off switch (SW5) **on**.

[ ] If illuminated, rotate the Ref. Pot (R17) until D10 (bicolor LED) **goes out**. The reading at **TP3&4** should be approximately 12vdc.

[ ] Continuing **TP3&4** test, by rotating the Ref Pot (R17) one direction and the other direction, **TB3&4** will alternate toggling from 0 to 12vdc. When **TP3** on goes high **TP4** goes low, and vice versa. I suggest wiring the bicolor LED D10 so that when **TP4** is 12V it glows green. Assuming the correct reading the motor driver chip is functioning correctly, if not, there are issues with the U3 chip.

[ ] Move to **TP6**, toggle the manual up/down switch (SW6) one direction, reads 12v. When switch is in mid position the voltage will vary as per setting of the Ref Pot. (R17), in the remaining position the reading should be 0v. The LED D10 switches green/red.

[ ] Make sure that the dither switch, SW7 is off.

[ ] Insert U4 (LM555)

[ ] **TP5** indicates if the Dither timer is working properly. Toggle the Dither on/off switch (SW7) **ON,** you should read 12vdc and then 0 alternating back and forth. The D10 LED should switch color from red/green. Rotate the Interval (R18) and Duration (R19) pots and verify that the Interval and Duration times change, If not, there is a problem with U4 or associated circuitry.

[ ] Turn the Dither on/off switch (SW7) **OFF**, rotate the Reference pot. (R17) the voltage at **TP6** should vary from 0-12vdc.

[ ] **TP10** is the Window Pot (R16), rotate the pot, the voltage varies approximately 4-5V depending on the resistance value of the pot.

[ ] **TP9** is the bottom of the comparator window by rotating the Window pot it will cause this voltage to shift a volt or two.

This completes the test, in the future the PCB is easy to trouble shoot by referring to these Test Points and comparing them to the above correct voltages.

Use of Power supply controls

An effective EDM machine **is not** determined solely by how great a power supply and control circuit you have, but how good a **system** you build. The flushing and filtering system is just as important as the power supply. A good work tank and flush system can make a crappy power supply appear to perform quite well and a poorly designed flushing filter system can make a great power supply appear very poor.

The most effective and efficient EDM burn is one where the electrode and work piece **never** come in contact with each other during the burn (clean and correct pressure flush contribute mainly to this condition). Shorting is sensed by the control circuit and it withdraws the electrode until the short is cleared and then reestablishes the burn. The perfect burn is difficult to achieve (in particular as the hole gets deeper) but with good flushing and correct setting of the power supply controls it is possible to come close to this objective. When adjusting the controls of this power supply you will find that there is some interaction between the various controls, i.e. if you adjust the window pot it may require a small tweaking of the reference pot. to ensure the most stable burn condition. Don't be afraid to play with the controls especially early on as you are learning how the machine works, practice make good operators.

[ ] The ram servo motor connects to the J1 plug and the SW5 is the ram on and off switch.

[ ] The **Speed control pot** (R22) may be used during normal burns, or rapid up down movement of the ram, adjustment of this control will slow the motor speed in the **down** direction only. The D16 diode may be omitted if you desire the motor speed to be slowed in the down as well as the up direction. This control is designed to assist in damping out ram oscillations that sometime occurs under poor EDMing conditions.

[ ] The **Window Pot** (R16) control most likely will make the biggest difference (other than flushing) in controlling stability of a burn. Experiment with this control to establish the most stable burn conditions. Watch the D10, bicolor LED, as you adjust this control, it will change from a yellowish color to more green. The object is to have the **least yellowish color and still have a stable burn**. Another indicator is a very stable meter reading, so adjust the **Window Pot**. to obtain the most steady meter readings.

[ ] The **Reference Pot** (R17) operates as per the description in the book. It controls the voltage drop across the gap. i.e. you can increase and decrease the distance between the electrode and the work piece with this control. Adjust this control to achieve the lowest voltage on the panel meter and still maintain a stable reading.

[ ] The **manual up/down** switch gives manual control over the servo motor in either the up, or down, direction. In the book I use two push button switches, this is replace with a single (spring loaded center off position) switch in this application.

[ ] The **Dither switch** turns on/off the dither circuit. The purpose of the dither circuit is to momentarily retract the electrode to permit better flushing of the burn area. This circuit should be used ONLY when poor flush conditions exist after your best efforts are exhausted (in obtaining proper flushing). There are three rules in EDM for getting good result FLUSH, FLUSH, FLUSH

[ ] The **Interval control** is part of the dither circuit; it determines how frequently the electrode is retracted.

[ ] The **Duration control** is part of the dither circuit, determines how long the electrode is retracted.

[ ] The rotary **Stability control switch**. With certain electrode materials (graphite, copper, brass) and various type of work piece materials, as well as flushing and discharge capacitor combinations it can have a big effect. Given a different combination, it may have little to no effect. In some condition it may actually make things worse, so experiment with this control to find the sweet spot. There is no "off switch" but by rotating the rotary switch to an unused portion of the switch it is effectively turned off.

[ ] **Edge finder** mode, see description below

[ ] Switch 15, 16 & 17 switch in and out the burn capacitors. Any combination of these switches may be used to achieve the desired surface finish. If all the capacitors are switch in the surface finish of the work piece will be very course. If only SW15 is switch in the surface will be much smoother.

[ ] If Cap C2 10uf (found in the HV circuit schematic) is not used I suggest deleting switch SW15 (which connects to TB 31) and straight wiring TB31 to the high voltage circuit. This will place 50uf of capacitance across the gap at all times.

Operating the EDM

[ ] **Failure may result** if the enclosure is not forced fan cooled. **Do NOT** operated for more than 2-3 mins. continuous without fan.

[ ] Turn **all** switches on the power supply off and ensure HV SW2 is in the burn position.

[ ] Turn the power supply on via SW1; rotate the **Reference pot** (R17) knob until the D-10 LED goes out.

[ ] Plug the servo ram motor into the power supply via J1

[ ] Turn the servo on/off switch (SW5) on.

[ ] Rotate the Reference Pot (R17) until the motor starts to move the ram observe D10 LED color and direction of ram movement.

[ ] Rotate the Reference Pot (R17) in the opposite direction till ram moves; observe D10 LED color and direction of ram movement.

[ ] Rotate the **Reference pot** (R17) knob until and the ram stop moving (the D-10 LED goes out).

[ ] Insert the electrode leads into the banana plugs, DO NOT touch the bare clips!! and ensure the clips are not touching each other.

[ ] Turn SW15 (50uf) switch on (if it is not straight wired to the HV circuit).

[ ] Grasp the power leads by the **insulated wire** and momentarily short the power leads together. The servo motor should retract (move the slide toward the motor). If the motor **does not** retract but advances, swap the wires going to the motor. Run the test again to verify that it retracts when the power leads are shorted. This test indicates the motor is correctly wired to the power supply.

Using the Edge finder should you need to accurately position the electrode the **Edge finder** will be invaluable. When the circuit is wired as per the above **High Voltage schematic** with the HVSW2 toggled down a low voltage is present from the PCB but the circuit is not completed because the electrode and work piece are not in contact. When the electrode comes in contact with the work piece the circuit is complete and the P1 buzzer on the PCB sounds indicating the edge (or top) of the part is found.

As an example, assume a .500 square electrode is used and you want to position it 1" in on the X&Y axis. To find the edge or top of a work piece with the most accuracy ensure the electrode and work piece are dry. Toggle HV SW2 (down) to Edge Finder mode. Position the Z axis so the electrode is below the surface of the work piece. Move the work piece on the X axis until tone is heard. Lift the Z axis, then moved the X axis half the width of the electrode or .250 in this case. This places the centerline of the electrode on the exact edge of the work piece. Next move the X axis 1" to the desired location. Repeat the same process on the Y axis.
Once positioned Toggle SW2 (up) to the burn position, fill the tank with dielectric and follow instruction in chapters 14 & 15 of the book. Keep in mind you have more control over the servo with this PCB than with the design in the book, have fun EDMing

The following is a Bill of materials is **only for the High Voltage circuit** shown on page 4 of this PDF. All part available from Jameco electronics (unless indicated) **http://www.jameco.com**

Qty	Sch I.D	Component	Jameco #
1	D1	Bridge Rectifier	2132242
2	D4&5	Diode	177818
1	SW1	Pwr Switch	76232
1	SW2	SW DPDT	21979
2	T1&2	PWR transformer	112513 (only two required)

Jameco does not carry the following items but they are available Allied Electronics http://www.alliedelec.com

2	BP1&2	Female Bananas Plug	70090144
2	R1&2	20 ohm50W resistors	70201851
1	R3	6.8K Resistor	70023682
1	C4	2200Uf Cap	70189809

Neither Jameco or Allied sells the following part but it is available from Amazon. **http://www.amazon.com**

1	C2 (HV cirt)	10uf 250Vdc	B0002KRDF8

The **B**ill **o**f **M**aterials listed below is for the PCB and associated circuit shown on page 2 of this PDF
Source for parts listed below **http://www.jameco.com**
All Capacitors are in Micro Farads (uf) all resistors are ¼ watt unless noted

Qty	Sch I.D	Component	Jameco #	
1	C1	1000uf	93835	
5	C2,5,6,7,10	.1uf	151116	Lot of 10
2	C3,8	33uf	93747	Lot of 10
1	C4	6.8uf	33873	
1	C9	.01uf	15231	Lot of 10
1	C11	1uf	544956	

Capacitors C22 thr 27 MUST be rated for 105C

4	C22,23,26,27	100uf	609967	16mm
2	C24,25	47uf	610010	13mm

For C26 & 27 listed below see **optional note on page 2 right hand side of schematic toward top**

2	C26 & 27	47uf	610010	13mm
1	D1	2 amp	119562	
3	D2,3,4	1N914	36311	Lot of 10
1	D10	Up/Dn ind.	334182	Lot of 10
1	D16	1N4001	35991	Lot of 10
1	J1	3.5mm stereo	568392	
1	M1	meter	316671	
1	P1	Buzzer	1956696	
3	R1,2,9	33K	691227	
2	R3,7	100K	691340	
1	R10	100K pot.	254036	
2	R4,8	4.7K	691024	
4	R5,6,15,20	1K	690865	
1	R16	5K	286265	
2	R17,19	50K	286214	
1	R18	1meg	286337	
1	R22	100 Pwr pot.	140514	

The following (R23) resistor should be able to dissipate at least 1watt. The resistance should be approximately 50 ohms. It may be composed using several resistors in parallel as shown in the schematic or a single resistor, so long as the total resistance and wattage is of the required value.

1	R23	50 (1Watt)	661191
2	SW5,7	on/off	76523
1	HV SW2	3PDT	547436
1	SW6	on/off/on	75889
1	SW8	Rotary SW	101574
3	SW15,16,17	SPST	317287
1	T3	12v trans	221400
16	TB1-32	Term Blok	152347
1	U1	LM7812CT	51334
1	U2	LM339N	826742
1	U3	SN754410NE	1054684
1	U4	LM555	904085
1	Header	5mm spacing	164815
1	8 Pin	Dip socket	51626
1	14 Pin	Dip socket	37197
1	16 Pin	Dip socket	37402
1	Heat Sink	U1	1115900
1	Fan1	115VAC fan	2126070