

# PCB 2.0B Assembly & Testing

Thank you for purchasing the Printed Circuit Board, (PCB) for the Pulse EDM. It is assumed that you have the book *Build a Pulse EDM*, have read it, and have a general understand of the machine. Before starting to assemble the board, read this **entire text** through to gain an understanding of the methods used. This circuit design is more advanced than what is described in the book. The complete schematic of the pulse machine (**different than what is in the book**) is found on page 4 of this instruction, **do not use the schematics in the book to assembly or trouble shoot this PCB.**

In the past several builders comment that once components were mounted the components ID's were covered. To avoid this problem component identifications are silkscreened to the side, or end, of most component locations. In a few locations this may be a little confusing. Below is a drawing of the board with most of the component ID's located directly on the components. **The board drawing below is shown as Pulse 2.0A, your PCB is labeled Pulse 2.0B. It is electrically identical, only minor cosmetic changes to the PCB.**

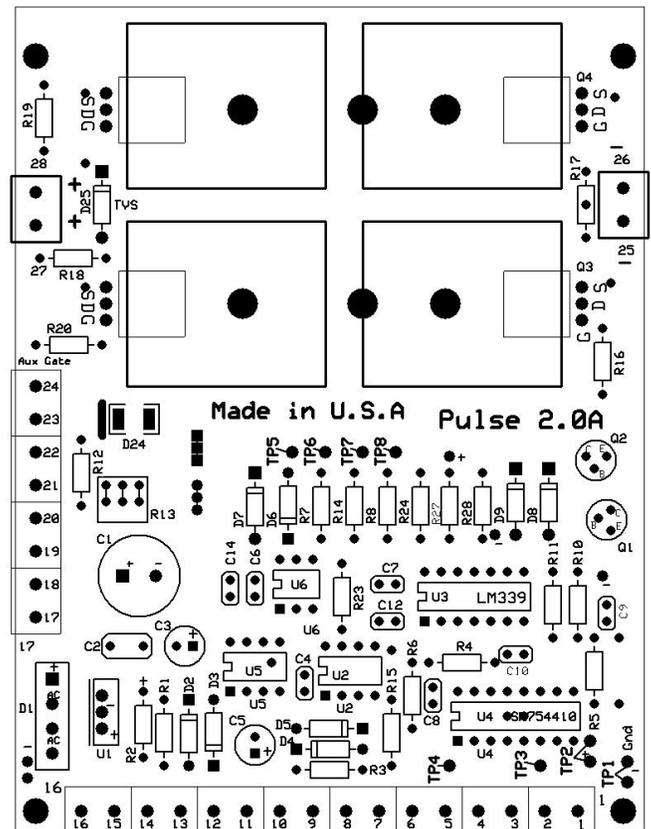
Before each assembly task find a [ ] box to check once the task is accomplished, this helps keep track of completed task. The stuffing of the PCB is fairly simple and straight forward; follow this sequence for each component,

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

**NOTE:** A good solder joint should be **bright and shiny**, if it is not, reheat the joint, and 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.

## Board stuffing, step by step

- [ ] Solder (5) 10 ohm (Brown Black, Black) R16,17,18,19, 20 resistors in place
- [ ] Solder (5) 1K (Brown, Black, Red) R1,2,3,14,15, resistors in place
- [ ] Solder (4) 10K (Brown, Black, Orange) R10,24,27,28 on the board
- [ ] Solder (2) 3.3K (Orange, Orange, Red) R4& 11 resistors in place
- [ ] Solder (2) 33K, (Orange, Orange, Orange) R5& R6 resistors in place
- [ ] solder (1) 510 ohm (Green, Brown, Brown) R23 resistor on the
- [ ] Solder (1) 5.1K (Green, Brown, Red) R8 resistor on the board
- [ ] Solder (1) 68K (Blue, Gray, Orange) R7 on the board
- [ ] Solder (1) 15K (Brown, Green, Orange) R12 resistor in place.  
**NOTE:** This resistor value may need to be changed depending on the meter used. Refer to your meter spec. for correct series resistor.
- [ ] Solder the small (1) 100K pot. R13 in place. The board is designed to accommodate inline or staggered lead pot.
- [ ] Place the multimeter probes on 21&22 (left hand side of board) with a screwdriver adjust R13 pot for **maximum** resistance.
- [ ] Solder the (7) .01 (103) caps. C4, 6,7,8,10 & 12,14 on the board
- [ ] Solder (1) .1 (104) caps. C2 on the board
- [ ] Solder (1) 47pf C9 capacitor on the board



The next sixteen (16) components are **polarity sensitive**, place the **long lead** into the square marked hole.

[ ] Solder (2) 33uf capacitors C3&C5 in place, (**polarity sensitive**)

[ ] Solder the (6) 1N914 Diodes D2,3,4,5,6 & 7 the banded end of the diode goes in the square indicated hole, (**polarity sensitive**)

[ ] Solder the (2) 1N4742A Diodes D8 & 9 the banded end of the diode goes in the square indicated hole, (**polarity sensitive**)

[ ] Solder (1) D24 surface mounted diode (**polarity sensitive**). Note the banded (line) end of the diode (it maybe a little difficult to see on the component). The banded end of the diode should face the thick white silkscreened line on the board. Mount over the rectangular shaped solder pads and apply a small amount of solder to each end of the diode, it should sink neatly on to the pads with correct solder and heat.

[ ] Solder (1) D25 TVS diode the banded end of the diode goes in the square indicated hole (**polarity sensitive**)

[ ] Solder the P1 “edge finder” piezo buzzer in place. The P1 the piezo buzzer is a component that sometimes proves a little difficult to purchase with the correct diameter and pin spacing. The board has been laid out such that piezo buzzers of a larger diameter and different pin spacing (than the specified buzzer) may be accommodated. Ensure that the longer pin goes into **any** of the square holes (**polarity sensitive**) and the other component pin in one of the round indicated holes.

[ ] Solder the (1) U1 voltage regulator (**polarity sensitive**) on the board, the black plastic side faces the silkscreened D1 location.

[ ] Solder the (1) D1 bridge rectifier on the board, long leg in the square indicated hole, (**polarity sensitive**)

[ ] Solder the (1) C1 1000uf capacitor on the board, (**polarity sensitive**) long leg in the square indicated hole

[ ] Solder the (1) 6 pin DIP socket U6 on the board, (notch to left)

[ ] Solder the (2) 8 pin DIP sockets U2 & U5 on the board, (notch to left)

[ ] Solder the (1) 14 pin DIP socket U3 on the board, (notch to left)

[ ] Solder the (1) 16 pin DIP socket U4 on the board, (notch to left)

[ ] Solder the (1) PN2907 **PNP** Q1 transistor in place, Verify the **Emitter, Base, Collector** pins and ensure they are in the holes marked **E, B, C**. In most cases with (TO-92 package) the transistor flat side facing you the pins left to right are E,B,C.

[ ] Solder the (1) PN2222 **NPN** Q2 transistor in place, Verify the **Emitter, Base, Collector** pins and ensure they are in the holes marked **E, B, C**. In most cases with (TO-92 package) the transistor flat side facing you the pins left to right are E,B,C.

[ ] Attach a heat sink to the voltage regulator U1 using a 6-32 screw and nut



The (4) power mosfets (Hexfets) are **static sensitive** and easily destroyed; guidelines for their handling are found on page 5-12 of the ***Build a Pulse EDM Machine*** book. The number, type, and mounting of the Hexfets **are different** from what is shown in the book. Holding the Hexfet with the black plastic side facing you the leads are **Left to Right Gate Drain Source**. The PCB is silkscreened **GDS** for assembly purposes. Each Hexfet is mounted parallel with the board. The Hexfets and heat sinks are attached using a 6-32 screw. Thermal grease should be applied to the heat sinks and to the Hexfet’s to improve heat transfer.

To assemble, place the leads of the Hexfet in the board and bend it over and line it up with the mounting hole. Place a screw through the, Hexfet, heat sink, PCB, and a second heat sink on the **opposite side** of the board. Once this is accomplished solder the Hexfet in place. Before soldering make sure that the solder iron touches the board **FIRST**, to discharge any static charge. The Hexfet, the board and the soldering iron need to all be electrically the same potential. **After installing EACH Hexfet verify it is still good using a multimeter, read EDS Issues pages 5-12 &13 in the book.** The photo (above left) is of Q6, which is mounted on the **back side** of the board. Note: Since taking the photo I have changed the color of the PCB to blue otherwise the boards are virtually the same.

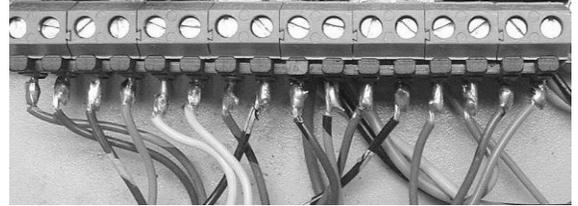
[ ] Mount the (4) IRF Hexfets Q3,4,5,6 and solder as per previous instructions. **NOTE !!!** Hexfets Q3&4 are mounted on the **TOP** (right hand side) of the PCB, Q5&6 are mounted on the **BOTTOM** side of the PCB.

## Connecting to panel

The method with which the PCB may be connected to components external to the PCB may vary, three options are outlined below. The simplest and least expensive is to solder wires from the panel and other power supply components directly to the PCB via the holes around the perimeter of the board labeled 1 thru 29. **I highly discourage this method** because should you need to remove the board for repair or inspection each of the 29 connections would require unsoldering and later re-soldering. The other two options involve purchasing terminal blocks and headers or purchasing commercially available male/female pluggable terminals.

### Terminal Block inline header option

The method used in previous versions of the board required purchasing screw type terminal blocks, soldering them on the board, and then cutting lengths of straight, single row 5mm male header and inserting the long end into the terminal block, and secure by tightening the screws, see photo to the right. Wires going to the non PCB components in the power supply enclosure are then soldered to the header pins. This work well, is low cost, and keep the wires organized. The disadvantage is each individual terminal block screw needs to be unscrewed and then retighten when the header is installed or uninstalled. Should you elect to use this method follow the instructions below.



[ ] INSERT the (8) **Terminal Blocks** (1-16) hereafter referred to as **TB's** 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 insertion with holes 1&2 **first** and continue to holes 15&16. If this sequence is not followed it is virtually impossible to get the interlocks to engage. Once they are in the board solder the TB's in place.

[ ] INSERT the (5) TB's (17-24) along the left side of the board with the screws facing outward. Began insertion with holes 17&18 continue to holes 23-24. Once inserted solder the TB's in place. TB 24 is access to the gate signal (optional) should you elect to mount a single large FET off board vice using the 4 PCB mounted FETS.

[ ] Finish by inserting TB 25&26 along the back right side of the board and 27&28 on the back left side of the board, be sure and face the screws outward.

### Male/ female pluggable terminals option



The final (more professional) method is to use male and female pluggable terminals as shown in the photos to the left. These are more expensive than the previous suggestion but once wired do not require the tightening and untightening of screws each time the external wiring needs to be detached. Assemble is similar to the previous.



[ ] INSERT two 8 position (male) terminals (1-16) along the front side of the board facing outward and solder in place.

[ ] INSERT an 8 position (male) terminal (17-24) along the left side of the board and solder in place.

[ ] Finish by inserting each of the two position (male) connectors 25&26 along the back right side of the board and 27&28 on the back left side of the board, solder both in place. The mating female connectors fit into the male connectors and wires are attached to the female connector and secured in place with the screws.

### Wiring PCB to the panel controls

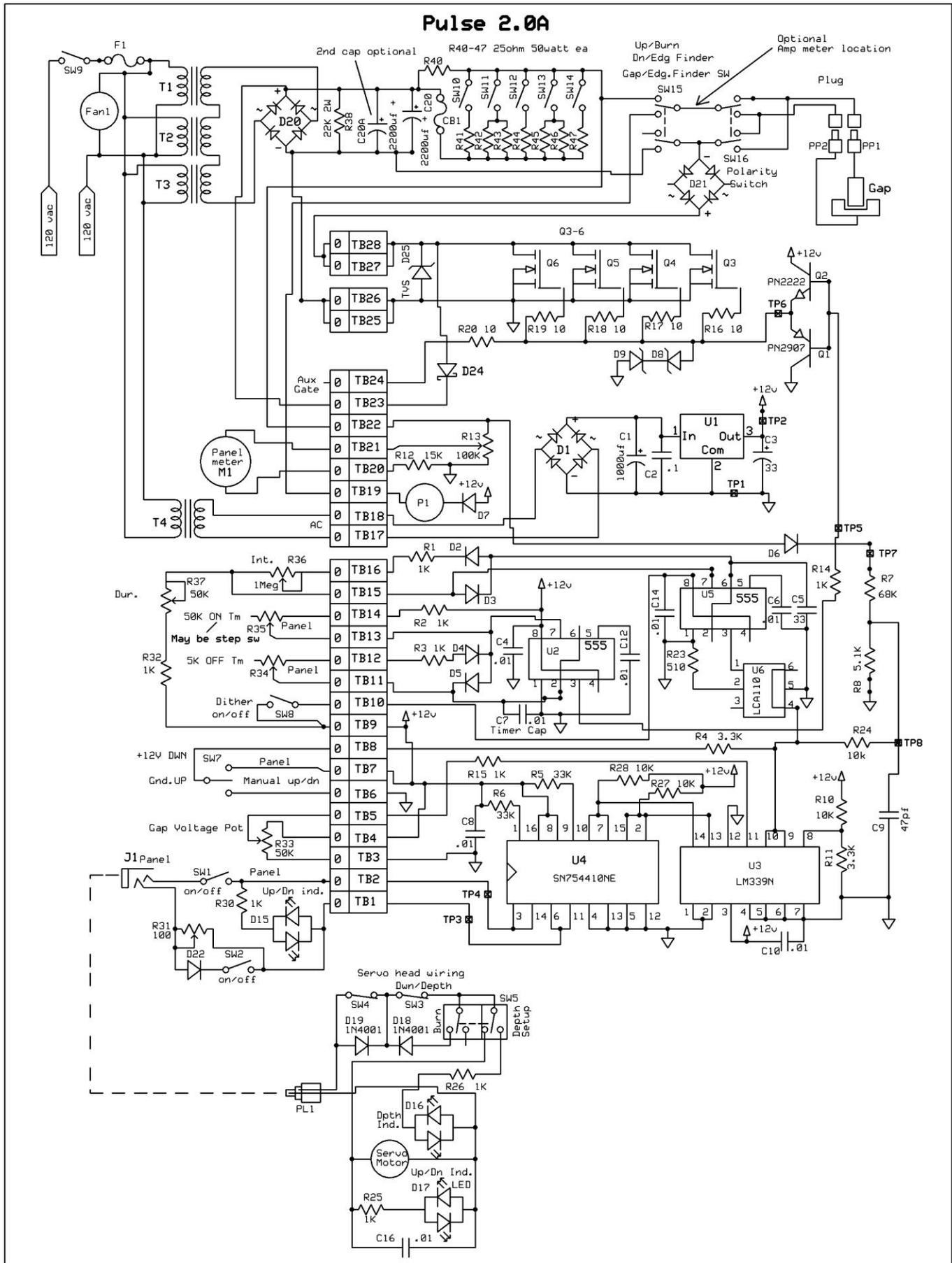
With the PCB stuffed and the necessary switches, LED's, pots etc. mounted in the power supply enclosure it is time (if you have not done so) to wire them to the board. In the schematic on page 4 the items to the right of the TB's are on the PCB.

Whether using the **Terminal Blocks** or the **Pluggable terminals** option, assemble is similar. Start wiring connections with terminal #1 located in the lower right hand corner of the board and connect the wires from the panel components to the correct terminal as shown on the schematic.

If you are using the **Terminal Blocks** and single row header it requires cutting the purchased headers to the correct length and then soldering the wires to the header pins. Insert the long headers into the **Terminal Blocks** and the wires are soldered to the short pins.

If you are using the pluggable terminals insert the wires in the female terminals and tighten screws against the wires.

The schematic below is Pulse 2.0A, your PCB is labeled Pulse 2.0B. It is electrically identical, only cosmetic changes to the PCB.



[ ] **Wire each terminal connection as per the schematic on the previous page of this text, (not the pulse book).** Note that TB9 is the only terminal that has two wires attached; also there is a 1K (R32) resistor in series with the leg going to the R37 pot.

Terminal 24 is a connection access to the gate signal (optional) should you elect to mount a single large FET off board instead of using the 4 PCB mounted FETS.

[ ] Exercise extra care when wiring to SW15 (DPDT) to ensure that the high voltage and low voltage connections are correct. Verify correct wiring with a multimeter (ohm meter) continuity reading prior to applying power to the circuit.

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. Know that a clip on heat sink for U3 may make access to some of the Test Points (discussion below) difficult.

[ ] Mount PCB in cabinet using four 13/16" **nylon standoffs**

## Circuit Test Points

Once the board is completed, installed in the enclosure and connected to the panel (and other) components as per above, it's time to make sure everything is operating properly. Tests are made using the **Test Points (TP)** are located primarily in the lower right hand section of the board and in the center of the board, just below Q3&5; see the drawing on page 1 of this text. The **TP** locations are noted with large black dots on this drawing. All voltage readings are made using an analog or digital multimeter, though an oscilloscope maybe used. Most voltage readings should be within .5 to 1 volt of the suggested voltage. **TP1** (on most boards) has two holes labeled **A-B**. Insert a loop of wire between A-B and solder in place **this is TP1**. This loop will provide an easy connection for an alligator clip (or O-scope ground) to the common side of **all** the circuits in the power supply.

**TP1 (A-B) is common ground to ALL circuits (H.Volt and L.Volt);** TP2 is the board's **12VDC** test point.

[ ] There should be **NO** chips in the DIP sockets when starting the testing.

[ ] **To conduct each test turn the power supply AC switch (SW9) ON unless otherwise noted.**

[ ] **After each test, turn the power supply AC switch (SW9) OFF.**

[ ] For the first sequences of test the DC Servo motor leads, and the power leads to the electrode, are both disconnected.

[ ] Ensure all switches on the panel are turn **OFF**, and then turn the main AC switch (SW9) on.

[ ] Assuming no smoke appears when turned on, the first adjustment is not a **TP** voltage reading instead it is tweaking the meter pot. R13. If a 0-15VDC meter (the face will be graduated 0 to 15) is used it is possible to use the existing meter scale to effectively read 0-150VDC i.e. 5V represents 50V therefore 10V represents 100V etc. Adjust the R-13 pot. to reflect the open circuit voltage which should be about 108-110VDC.

[ ] **Make all tests with the black probe of your meter touching (or attached to) TP1 via a clip.** **TP1 (A-B)** is found in the extreme right-hand corner of the board. This is the common ground for the board as well as for the High Voltage supply.

[ ] **TP2** should read 11.8 to 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. If there is a short U1 will get **HOT** very quickly (depending on how much current is drawn), D1 could also get quite hot in this situation.

Assuming a correct voltage reading in the test above, the following test will start by inserting various chips in their sockets. When installing **all** chips ensure, the chip's notched end (or dot) faces the left side of the board. After installing each specified chip and applying power (SW9) feel it for overheating, if hot turn power off and investigate.

[ ] Insert U3 (LM339) in its socket.

[ ] Insert U4 (SN754410) in its socket

[ ] Rotate the Gap Voltage Pot. (R33) to mid position

[ ] Turn the AC power on (SW9)

[ ] The bicolor LED D15 may illuminate, if illuminated, rotate the Gap voltage Pot (R33) until D15 (bicolor LED) **goes out**. With the LED out the reading at TP3 should be 11.8VDC and the same on TP4 (i.e. both are “high”).

[ ] Continuing **TP3&4** test, by rotating the Gap voltage Pot (R33) until D15 glows. Hopefully it shows Green but depending on how it is wired it may glow Red. **The servo down signal is when TP4 reads (aprox.) .5VDC and TP3 reads (aprox.) 11.3VDC.**

As in the book, I suggest wiring the bicolor LED D15 so that when TP4 is low and TP3 is high D15 glows green. I think of it as Green Go (advance electrode) and Red Retract (retract electrode). **To change the color of the glow just reverse D15 connections.**

[ ] Remember turn the power supply OFF (SW9) insert chips U2 and U5, both are LM555 timer chips as well as U6 which is a solid state relay. When power is turn on (SW9) feel chips for over heating

[ ] Rotate the Gap Voltage Pot. (R33) to a position such that the D15 LED is OFF

[ ] Toggle the manual up/down switch (SW7) UP, D15 should glow Red, TP4 should read 11.2VDC TP3 should read .5VDC.

[ ] Toggle the manual up/down switch (SW7) Down, D15 should glow Green, TP4 should read .5VDC TP3 should read 11 .2VDC.

The next test will indicated if the timer chip U2 is working.

[ ] With the power supply on, take readings at TP5. This voltage will vary between a volt or two above 0 to approximately 11.2VDC as the ON and OFF timer pots. and/or switches R34 and R35 are adjusted.

If you have access to an oscilloscope view the square wave output of the timers and verify the ON and OFF time periods

[ ] Read the voltage at TP6, this is the voltage being applied to the gates of the Hexfets (Q3-8). Expect to see similar reading as observed at TP5 (above) though with slightly higher voltage. Again with an oscilloscope the actual wave form may be seen.

[ ] The voltage reading on TP7 is the open circuit gap voltage should be about 108-110VDC. With an oscilloscope you may want to look at the actual gap signal during a burn, if so this is the TP to use.

[ ] The voltage reading at TP8 is approximately 7.4VDC this is the input control signal to U3. By looking at this signal and the signal at TP7 with an oscilloscope you can actually see the gap and control signals and how they interrelate.

With a two channel oscilloscope it is also educational to look at various TP's during a stable burn and compare them. An oscilloscope is a tremendously beneficial tool in understanding the operations of a pulse supply.

There isn't really a TP for testing the dither circuit. But the following test indicates if the Dither timer is working properly.

[ ] Rotate the Gap Voltage Pot. (R33) to a position such that the D15 LED is on and glowing green. Toggle the Dither on/off switch (SW8) **ON**, all the while observing D15. Depending on the setting of pots. R36 (Interval) and R37 (Duration) LED D15 should flash

The manual UP Down switch SW7 Is tested as follows:

[ ] Rotate the Gap Voltage Pot. (R33) to a position such that the D15 LED is not illuminated.

[ ] Toggle the manual UP Down switch SW7 in one direction and D15 should glow Green when toggled in the opposite direction it should glow Red. This is an indication that the manual UP Down circuit is working correctly.

**For testing the actual servo head movements do the following.**

[ ] Rotate the Gap Voltage Pot. (R33) to a position such that the D15 LED is not illuminated i.e. TP 3&4 should be high (11.2VDC).

[ ] Connect the servo head to the power supply by inserting PL1 into the J1 panel jack.

[ ] Rotate the Gap Voltage Pot. (R33) to a position such that the D15 LED glows Green i.e. TP4 reads (aprox.) .5VDC and TP3 reads (aprox.) 11.3VDC. The servo should be advancing the ram, if it is not, reverse the wires on the servo motor terminals.

[ ] To test the manual control of the motor rotate the Gap Voltage Pot. (R33) to a position such that the D15 LED is NOT illuminated. The servo motor should be stationary. Toggle SW7 in both directions and the servo motor should respond in like matter.

[ ] To test for gap short circuit control

[ ] Rotate the Gap Voltage Pot. (R33) to a position such that the D15 LED is NOT illuminated.

[ ] Toggle **all** the Gap Power switches off.

[ ] Connect gap power leads to the the power supply

[ ] 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.

This completes the test, of the PCB assuming all test are as per the instructions your EDM Pulse machine is ready for it's first test burn. NOTE: IT IS IMPERATIVE that the PCB receives a good flow of cooling air over it during the EDM operation in particular when operating at the short (25-50us) ON times, otherwise the power mosfets may fail!! The machine **SHOULD NOT** be operated for more than 3-4 minutes without forced cooling air!! See chapter 17 in the book for correct operation for the first burn

### For the experimenters among us

The resistance values of power resistors R41-R47 (high voltage circuit page 5-11) may be lowered to increase the current flow through the gap. Should the resistances values be decreased the wattage rating needs to increase. Changes to these resistors values could cause the power transformers to burn out. The final current limiting factor is the ability of the transformers to deliver.

The value of capacitor C9 can have an effect on the stability of the servo system. You may wish to experiment with different values for C9 especially if you are operating with short ON and OFF times. For example if you have a production job where only one ON/OFF time combination is used and you wish to fine tune just for that setting.

**AMP Meter** installation. I show photos of and amp meter on the power supply in the book, thought I do not reference it. Any analog ammeter with at least a 10 amp rating will perform well. I suggest inserting it in the circuit between SW 15 & SW16 in the high voltage circuit.

### Electronics Parts list

All parts listed below are available from Mouser electronics <http://www.mouser.com/>  
or from Marlin P. Jones Assoc. <http://www.mpja.com/>

**All part number are Mouser Electronics unless otherwise noted.**

**Items in Black are PCB items, Items listed in Red are NON PCB related.**

Qty.	Item	Description	Mouser number	
(1)	C1	1000uf	667-EEU-FR1V102B	Electrolytic 35v
(3)	C2	.1	810-FK28X7R1E104K	Ceramic 25v
(2)	C3,5	33	667-EEU-FR1V330	Electrolytic 25v
(8)	C4,6,7,8,10 12,14, 16	.01	80-C320C103K5R	Ceramic 50v
(1)	C9	47pf	75-561R10TCCQ47	Ceramic 25v
(1)	C20	2200uf+	75-36DX202F200BC2A	Electrolytic 200v
Optional, use 1 (or 2) of the following capacitors see page 5-6				
(1)(2)	C20&20A	2200uf+	661-ESMH201VNN222MA	Electrolytic 200v
<b>Note: Select and purchase a capacitor mounting ring specific to size capacitor/s purchased</b>				
(1)	CB1	35-2110	655-W57-XB7A4A10-10	Circuit breaker
(1)	D1,	KBP04G	621-KBP04G	2 amp.
(6)	D2-7	1N914	610-1N914	Signal diode
(2)	D8, 9	1N4742A	512-1N4742A	
(3)	D15,16,17	Bi color LED	604WP937EGW	
(3)	D18,19,22	1N4001	625-1N4001GP-E3/54	1 amp diode
(2)	D20, 21	KBPC2502	512-GBPC2502	25 amp bridge 200v rev.

Qty.	Item	Description	Mouser number	
(1)	D24	Schottky Diode	512-S320	3A 200V
(1)	D25	TVS diode	512-P6KE200A	600Watt TVS
(1)	F1	Fuse holder	504-BK-HKP-BBHH-R	
(1)	Fuse	10 amp	576-0314010.HXP	Fuse
(1)	Fan1	Fan	OA4715-12TB	100 CFM minimum
(1)	J1	3.5MM jack	161-MJ355W-EX	
(1)	PL1	3.5mm plug	568-NYS231B	

Mouser's analog voltmeters are very high quality and expensive, average price about \$70. I suggest using another supplier. For those in the U.S. **Radio Shack** sells a 0-15VDC meter that works well, it is catalog # 22-036 Listed below is a meter from Marlin P. Jones <http://www.mpja.com/> that is fine.

(1)	Meter DC	15 VDC	<u>28718 ME</u>	
(1)	P1	Buzzer	539-PK-12N40PQ	Piezoelectric
(1)	AC Power Plug		693-6100.3300	AC power inlet
(1)	AC power Cord		562-212004-01	AC cord
(1)	Gap power plug	PP1&2	161-0708-1-E	Power plug module to electrode
(1)	Gap Power Cord		562-318007-01	power cord to electrode
(1)	Q1	PN2907	512-PN2907ABU	PNP
(1)	Q2	PN2222	512-PN2222ABU	NPN
(4)	Q3-6	Pwr. FET	942-IRFB4127PBF	Hexfet 200V

**Note:** you may want to order a couple extra Hexfet's should one be destroyed by Static Discharge (ESD)

(9)	R1,2,3,14,15, .25,26,30,32	1K	279-CBT25J1K0	1/4W Carbon
(2)	R4, 11	3.3K	291-3.3K-RC	1/4W "
(2)	R5-6	33K	660-CFS1/4CT52R333J	1/4W "
(1)	R7	68K	660-CF1/4C683J	1/4W "
(1)	R8	5.1K	291-5.1K-RC	1/4W "
(4)	R10,24,27,28	10K	660-CFS1/4C103J	1/4W "
(1)	R12	15K	299-15K-RC	1/4W " <b>See text page 1</b>
(1)	R13	100K	72-T70YB-100K	Pot. miniature
(5)	R16 thru 20	10 ohm	291-10-RC	1/4W Carbon
(1)	R23	510	71-CCF07510RJKE36	1/4W "
(1)	R31	100	785-53C3100	Pot.
(1)	R33	50K	785-53C350K	Pot.

You may find a 10 turn pot. for R33 (gap voltage pot.) advantageous especially with short ON times and low power.

A suitable 10 turn pot. would be Mouser 6523590S15031 Pot.

(1) R34, 5K pot. 785-53C35K Pot.

If you do NOT to use the recommended bank of stepped resistor for R35 then purchase a single 50K pot., regardless you will need at one 50K pot for R37

(2) R35, 37 50K pot 785-53C350K Pot.

If stepped fix resistors are chosen (in place of R35pot.) it is your responsibility to choose resistor's values.

For aprox. resistor values see page 4-3 in the book, 1/8 watt resistor will work fine.

A suitable rotary switch for selecting the stepped resistor bank (R35) is listed below

(1)	Rotary switch for ON time selections	Mouser part number	105-SR2511F-26RN	
(1)	R36	1meg pot.	78553C31MEG	Pot.
(1)	R38	22K 2W	594-5083NW22K00J	2W carbon
(8)	R40-47	25ohm 50W	588-L50J25RE	50W Wire wound

**NOTE:** all switches except for SW3,4&5 may be purchased from Marlin P. Jones at considerably less than the Mouser price.

The Marlin P. Jones switches are 15A imported from China, see page 5-2

(3)	SW1,2,8	SPST 3A	103-0132-EVX	Marlin#	16082 SW
(2)	SW3,4	SPST	103-1016-EVX	(momentary contact for servo head)	
(1)	SW5	DPDT	611-7201-001	(miniature toggle switch for servo head)	

(1)	SW7	15A SPDT	(ON-OFF-ON)	Marlin#	16085 SW
<b>Qty.</b>	<b>Item</b>	<b>Description</b>	<b>Mouser number</b>		
(6)	SW9-14	15A SPST	691-2FA53-73/TABS	Marlin#	16082 SW
(2)	SW15,16	15A DPDT		Marlin#	16087 SW

Transformers T 1,2,3, are the single most expensive items in the power supply Marlin P. Jones Co. has the least expensive transformers by far, see page 5-7 . The Marlin part number is below after the Mouser number.

(3)	T1,2,3	10 amp	553-F401U	Marlin#	7846-TR
T4 is a control transformer; I suggest ordering transformer T4 from the supplier of the larger transformers.					
(1)	T4	2amp	553-F218X	Marlin#	7839 TR

(1)	U1	LM7812CT	595-UA7812CKCT	12V+ reg.
(2)	U2,5	555	512-LM555CN	Timer
(1)	U3	LM339N	863-LM339NG	Voltage comp.
(1)	U4	SN754410NE	595-SN754410NEE4	Motor driver
(1)	U6	LCA110	849-LCA110	SSRelay
(1)		Therm grease	532-249 (less costly thermal grease may be purchased from Radio Shack)	
(6)		<b>Knobs</b>	<b>5164-150 or builder may choose knobs of their choice</b>	
(1)		6 Pin Dip	575-191306	
(2)		8 Pin DIP	571-26412601	
(1)		14 Pin Dip	855-D2814-42	
(1)		16 Pin Dip	855-D2816-42	
(1)		Heat sink U4	532-580200B00	Clip on
(1)		Heat sink U1	532-577202B00	Screw on
(8)		Heat sink Q3-6	532-530613B00	Screw on
(4)		13/16" standoff	761-1133-4-N	Nylon standoff

Misc. 6-32 & 4-40 screws, as required for you particular build, available via local hardware store/home centers

The follow ordering information is for **either** the (15) individual **Terminal Blocks** or the **Male/Female Pluggable Terminal blocks**. You will be ordering one or the other, **but not** both types.

Qty.	Item	Description	Mouser number	
(14)	TB1-28	Term. Block	845-MBE152	used if Pluggable Terminal blocks <b>are not</b> used, See text

The following straight headers are used in conjunction with the above (15) Terminal Blocks.

(2)	<b>Optional header</b>	5mm (.200)	534-8727	Unfortunately Mouser's selection is very limited in the 5mm pitch header.
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If you choose to use Pluggable (male/female) Terminal blocks instead the information below applies.

(3)	8 position	<b>male</b>	651 1754559	Pluggable terminal block
(3)	8 position	<b>female</b>	651 1754562	Pluggable terminal block
(2)	2 position	<b>male</b>	651 1754436	Pluggable terminal block
(2)	2 position	<b>female</b>	651 1754449	Pluggable terminal block