

## THE WD7S TRIODE CONTROL BOARD

Grounded grid triode amplifiers require several forms of protection to keep their tubes and operators safe. The control board described here contains features usually found only in the most expensive commercial amplifiers. These features are now available to those of us that wish to “homebrew” our own equipment and have it virtually indestructible. The following features are included in the control board and associated circuitry:

- Adjustable warm-up timer; holds off HV and key lines
- Adjustable grid over-current protection, un-keys amplifier; auto-reset 5-10 seconds
- Adjustable grid over-current warning led, set below above trip point
- Adjustable plate over-current protection, shuts down HV supply in less than 8.3 milliseconds avoiding damaging follow-on current during a HV arc
- Step-start HV turn-on, (soft-start) limits current inrush caused from discharged HV PS capacitor
- Tune/arc fault protection, un-keys amplifier when severely mistuned or during tank circuit arcing, preventing component damage; auto-reset 5-10 seconds
- HV presence fault, holds off key line if HV not present or low after warm-up
- Air fault, shuts down filament supply if air flow not present within 5 seconds after power on, stops all other functions
- Full break-in QSK, < 2 milliseconds, using vacuum relays
- T/R fault - hot switching protection, stops amplifier from keying if drive applied before key-line activated and prevents un-keying amplifier if drive is present at cathode
- Fully adjustable operating bias using a TL-431 adjustable precision reference
- Electronic bias switching, 2.5A max

- Dual key-line buffers, either +5-16vdc or ground will key the amplifier (TTL and CMOS compatible)
- Cool-down delay for blower, keeps blower running for a 4 minute cool-down period after shut-down
- Front panel status of ALL fault and operating conditions, no more guessing which fault triggered that single fault led
- Zero center tune meter, detects input and output power levels and displays variation from optimum gain figure
- Low voltage regulated power supply onboard, saves valuable space and simplifies interconnections
- Dependable solid state relays used for all AC switching, no more welded closed or dirty relay contacts to worry about
- Compact board size, 4 x 8 x 1.5 inches (WLH)
- Single source for all components used, (Mouser); no shopping around for hard to find parts

All of the above features are accomplished without the use of RF sensitive CMOS or TTL by using the very common LM339 comparator and only a handful of discrete devices. All IC's are in sockets to make replacement or trouble shooting easy if the need ever arises.

Although high SWR protection is not included, the soft fault line is brought out to the board connectors for interfacing to any number of out board protection devices (RF Applications Match Alert etc). The DS-1 bargraph display board includes a high SWR fault module and interfaces with the control board easily.

## **OVERVIEW OF OPERATION**

Figure one shows the block diagram of the board while figures two through seven show the actual board circuitry. Figures eight through ten show typical interconnections for a mono-band amplifier.

The board uses two fault lines; a hard fault line that can only be reset by turning off the power and a soft fault line that automatically resets the latching faults after approximately 5-10 seconds (IG and Tune). The hard

fault line controls the HV supply and monitors three fault modules; warm-up, IP over-current and air flow. The soft fault line is responsible for all other amplifier parameters including keying the TR relays. Both fault lines are “high” during transmit, reducing the possibility of false triggering from stray RF.

## **WARM-UP TIMER**

The warm-up timer of fig 2 controls both soft and hard fault lines. At power on, C3 momentarily fires Q2, discharging C4, the timing capacitor, which then begins charging through voltage divider R9/R10. When C4 charges to the reference voltage determined by R7, U1 switches off extinguishing the warm-up LED and releasing the fault lines. Q2 assures the time period is the same even with a quick on/off power switch cycle.

## **GRID TRIP/ GRID WARNING**

The grid trip module, (fig 2), monitors grid current as voltage drop across a 10-ohm resistor, (R7 of fig 9), connected from the B- rail to ground. R1 sets the trip threshold for U1a while R3 sets the level to light the IG warning LED with Q1, while C1 prevents false triggering on voice peaks and D1 protects U1a from transient damage. When grid current reaches the trip level, pin 2 goes low pulling pin 7 of U1b low which puts pin 1 low and latches with R5, lighting the grid trip LED and pulling the soft fault line low, un-keying the amplifier. Once the soft fault line goes low, voltage on the auto-reset buss begins climbing until pin 7 is above pin 6 and the latch is reset, releasing the fault line.

The variable resistor, R1a, is the adjustable meter multiplier and sized for a 0-1-ma movement.

## **STEP-START**

The step-start module, (fig 2), consists of U1d and Q3. Pin 11 of U1d is held low by the hard fault buss until the warm-up period has elapsed. Once pin 11 is released C5 begins charging through the voltage divider, R15/R14. When pin 11 reaches the reference voltage level of pin 10, (800 milliseconds), pin 13 goes high releasing the soft fault line. At the same time the base of Q3 goes high turning it on which turns on the step-start SSR of fig 8 and lights the SS LED. The SSR driver, Q3, can also drive an open-frame relay with a current requirement of 300ma or less if you prefer.

## **HV FAULT**

The HV fault module, U2a of fig 3, pulls the soft fault line low if the voltage at pin 5 is below the reference at pin 4. The voltage at pin 5 is taken from the HV metering multiplier of fig 8. The reference at pin 4 must be set low enough to account for the max plate voltage swing. The necessity of this fault module is questionable since the grid trip protection will also protect the tube in the event of a failed HV source.

## **TUNE/ARC FAULT**

The tune/arc fault module consists of U2b, U2c and U2d of fig 3. RF voltage detectors are placed at the input, (post T/R detector, fig 9), and output, (output detector, fig 9), of the amplifier; negative going at the output and positive going at the input. The ratio of voltage input to voltage output (gain) should be linear for all power levels. Once the amplifier is tuned up for the first time and checked for spectral purity, R22 is set for a zero center reading of the tune meter, (fig 10). The fault module monitors only positive deviation of the meter (more drive than output) since this is the condition of severe mistuning or a tank circuit arc. The low power switch, U2b, is set to keep pin 1 low during low power tuning, (20 watts drive or less). This grounds the bottom of the voltage divider, R26-R27, and effectively halves the sensitivity of U2c to eliminate excessive tripping during initial low power tuning. When voltage at pin 8 rises above the

reference set by R21, pin 14 goes low, pulling pin 11 low. This sends pin 13 low and latches U2d, pulling the soft fault line low and un-keying the amplifier while lighting the tune fault LED. Again the reset buss voltage begins to rise until U2d resets. The .33uf capacitor, C7, was added to my prototype to eliminate triggering from leading edge power spikes generated by some transceivers, (JRC, ICOM and others).

The zero center tune meter may be omitted as long as you have one to set up the amplifier initially, since negative deflection of the meter is rare (unless tube gain is increasing). The frequency linearity of the voltage detectors used here may not be suitable for multiband amplifiers and should be explored before using them in that type of application. Replacement with line section RF current detectors could be one possible alternative.

## **PLATE OVER-CURRENT FAULT**

The plate current fault module, (fig 4), consists of U3, U4c and U4d. Plate current is sampled as a voltage drop across R5, (fig 9), a 1 ohm 1% 10-watt resistor in the B- line. This voltage drop is monitored by U3, a 4n38 opto-isolater, which produces an output voltage at pin 4, proportional to plate current. Resistor R39 sets the trip point of U4d, which when triggered pulls pin 9 of U4c low, this sends pin 14 low and latches U4c. This pulls the hard fault buss low, turning off the HV SSR controlled by Q5 and lighting the IP over-current LED. The low hard fault line turns off the step-start module pulling the soft-fault line low at the same time. Capacitor C10 sets the latch at power up.

This fault system was tested by deliberately causing a HV short to ground through a six-inch piece of #40 wire and an appropriate B+ glitch resistor, (R19 fig8). When directly shorted to ground the circuit trips and the two-20A HV supply fuses blow, when the short to ground is through an arc, (the most common scenario in the real world) only the fault module trips and the fuses both survive. In both cases the #40 wire survives, only slightly discolored. This conforms to Eimac's suggestions for limiting fault current during an internal tube arc. The use of zero-crossing SSR's is key to this performance as the switching time is 8.3 milliseconds, (or less), 2-4 times faster than open-frame relays of the same current rating, (when they

don't weld themselves closed!!). Transistor Q5 will control an open frame relay drawing 300ma or less if so desired.

The component values used here should be adequate for plate currents up to 3.5 amps; capacitor C9 should prevent voice peak triggering. The value of R5, (fig 9), can be lowered to accommodate higher plate currents.

## **AIR FAULT AND FILAMENT SSR**

The air fault module consists of U4b and U4a of fig 4. At power up capacitor C12 sets the latch, (U4a), while C11 begins charging through R34. If the voltage at C11 reaches the 6v reference, (5 seconds), before the fan switch pulls it low, pin 1 of U4b goes low pulling pin5 of U4a low and latching pin2 low. This pulls the hard fault line low and turns off the filament SSR controlled by Q4 and lights the air fault LED. As with the plate over-current module reset can only take place by turning off the main power.

## **KEY LINE INTERFACE, QSK AND T/R FAULT**

Two types of key lines can be accommodated with the circuit of fig 5, positive 5-16vdc on transmit or ground to transmit. Mosfet Q6 controls the soft fault line and holds it low unless J1 is pulled low. Mosfet Q7 takes care of positive keying from J2 and is configured as an inverter, controlling Q6. Whenever the fault line is released by Q6, R50 turns on Q8 and grounds the transfer relays. The output of the post detector, (fig 9), is fed to the gate of Q7 which keeps the amplifier keyed if there is more than a few hundred milliwatts of drive present at the input of the matching network; this is one half of the hot switching protection. Both keying circuits are logic compatible and are reverse polarity protected.

Mosfets Q9 and Q10 are responsible for the other half of the hot switching protection. While the amplifier is un-keyed the drain of Q8 is high, this turns on Q9, with D26 setting the gate voltage. When drive is applied, voltage from the pre-detector turns on Q10. If Q9 is also on, (amp unkeyed), the soft fault line is pulled low and the T/R fault LED is turned on. Only if there is no drive present at the pre-detector can the amplifier be

keyed. During stand-by the fault module still functions with voltage from the auto reset circuit, keeping Q9 on. This blinks the T/R LED during modulation but presented no real problem so I left it as is.

The relay switching speed for the QSK is really a no-brainer as the RJ1A comes off the shelf closing at 2.3 milliseconds. I know this is contrary to some published QSK circuits but after timing 24 relays with a Tektronics TDS 210 digital oscilloscope and finding them all the same I examined Ten-Tec and Alpha Power's QSK circuitry using vacuum relays and found them to have no elaborate modifications, (other than slightly higher relay voltage). When the relay voltage is raised to 32vdc an RJ1A will close in 1.9 milliseconds but any further increase in voltage results in increased point bounce with little increase in closure time. By supplying 33vdc from the onboard power supply before the regulator I'm able to close these relays in 1.9ms. By replacing the normal clamping diode across the field terminals with a .1-.33uf 500v ceramic capacitor, the release time drops to 1.6ms and limits the reverse spike to ~70v, (it's 330v without any protection). Why is this a 250-dollar option on some amplifiers??

The auto-reset circuitry is shown in fig 5 and consists of a timing capacitor, C18, that's charged with R56 whenever the relays are un-keyed. A unusual feature of the fault circuitry made possible by the T/R fault module allows the amplifier to re-set without ever un-keying the exciter; it will re-key between speech syllables or CW characters, so just keep on CQing!

## **ADJUSTABLE BIAS AND BIAS SWITCHING**

Figure 6 shows details of the bias portion of the control board. Operating bias is set with R58 controlling D34, a programmable precision reference, (adjustable zener), which controls a darlington PNP pass-transistor. Transistor Q11, a darlington NPN, completes the by-pass of R4 of fig 10 during transmit. The MOV protects the pass transistors from spike damage and prevents the B- rail from soaring to the plate potential during stand-by if R4 fails open.

This bias system was tested on the bench and found to be rock solid with less than .2 volts drift over a one-hour period with 1 amp being pulled through it.

## **LOW VOLTAGE SUPPLY AND BLOWER COOL-DOWN**

The onboard low voltage power supply is shown in figure 7 and consists of a 20va pc mounted transformer with a full wave bridge and capacitor input filter. A 7824 regulator in a 220 case provides regulation for the entire board. Zener shunt regulators provide the 5.6-volt references. The MOV in the primary is provided for protection of the filament SSR. The snap-switch is glued with high-temp epoxy to a 4.2k 10-watt resistor. Another cool-down scheme is to mount the snap-switch to the tank compartment which only provides a cool-down delay if the amp is hotter than the off point of the switch. Always take the blower and control voltage ac supply from a separate fuse on the AC line, this allows the cool-down system and fault status to work after a major glitch.

### **Summary**

The control board should not be mounted in direct exposure to strong RF fields or in a spot where you can't access it while the amplifier is running since the tune meter zero center calibration and tune fault trip setting has to be done with the amplifier operating. Mounting in a cool place is also a good idea for this and any other heat sensitive circuitry. The SSR's need to be mounted to some form of heatsink to realize their full current rating, the enclosure floor or side panel seems to be sufficient as their load is not steady. Remember if you don't like one or more of the features on the board, pop the IC out and bend the output pin of that fault module up and re-insert the chip!!

73, Paul Hewitt WD7S  
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## WD7S TRIODE CONTROL BOARD ASSEMBLY NOTES

The first thing to do is mark the mounting holes or make a pattern to mark them later as they are nonsymmetrical and can be a pain to layout after the board is populated. The board-mounting holes were laid out for nylon stand-offs, as the trace clearance is too close for some metal stand-offs. There is room for metal hex (or round), spacers at the transformer end. The part numbers for the electrolytic capacitors are good as of now but electrolytic's are changing form factors so fast you may have trouble with lead spacing and or lead diameter. If you choose to use the solid-state relays for HV and step-start, be sure to include all the MOV's shown in figure 8.

Normal size prints of the top and bottom artwork, (view from above), as well as a one labeled with all the header connections and calibration points are also included. Be sure to use the new schematics I've included, as there are some small change from the older ones. The post-detector as well as the B- rail connection at the 10ohm resistor, (R7 fig 9), connects to two points on the board.

### ALIGNMENT PROCEDURE

All adjustments, except tune fault, can be done with no HV applied to the amp. Disconnect the HV transformer from the AC mains by removing the fuses. Remove the tube(s) or have the cooling system working, as the board will apply AC to the filament transformer while it's powered on.

**Remember that the solid-state relays have built in snubbers that pass a small amount of current, which results in a small voltage on the plate whenever the amp is plugged in and fuses are in place. In a 3600-volt supply this amounts to 70vdc.**

**PULL THE PLUG AND DISCHARGE THE HV CAPACITORS BEFORE WORKING ON THE HV SUPPLY OR THE AC MAINS!!**

This leakage is not present in the filament SSR. Apply 110vac to the control board and set the warm up timer to a very short period, adjust R7 counter-clockwise for a shorter time. You will need a 0-20VDC-bench power supply with current limiting and capable of supplying the same current that you intend to set the IP trip for.

### GRID-TRIP

Set R1A, R1 full clockwise and R3 full CCW. Connect the positive lead of the bench supply through an accurate milliamp meter to the B- rail at R7 of figure 9 and the negative lead to chassis ground. Apply enough voltage to get a current reading equal to the point you want the grid current warning led to light. Adjust R3 to light the warning led. Next set the meter calibration pot, R1A, for the same reading on the panel meter as the bench milliamp meter. Next increase the supply voltage until you reach the current level you want for the trip point and adjust R1 for a trip. Be very careful during these adjustments, as there is no protection for Q1 if you apply too much current

## **HV FAULT**

The HV meter voltage divider of figure 8 is designed for a full-scale reading of 5000 volts. If this is the circuit you are using the HV sense line supplies approximately 8vdc to the HV fault module with 5KV of plate voltage. This module is fast enough to trip on voltage swings caused by voice peaks so set it to trip at no more than ½ your expected plate voltage, for 3600 volts, with the above divider, this would be approximately 6 volts. Adjust R-24 of figure 3 for 3 volts on pin 4 of U2a. If R24 is set too high, during voice peaks you will just barely see the HV fault led blink before the amp un-keys and the TR fault led lights.

## **PLATE CURRENT TRIP**

If you are using a 1-ohm resistor for R5 of figure 9(B) the range of IP trip points will be from 2-3.5 amps of plate current. This is fine for most 1-1.5-amp plate operating currents since the trip circuit is fast enough to trip on voice peaks, which can be 2X the average current. If you want a lower trip point, (single 3cx800 or 3-500), change R5 to a 1.5 – 2 ohm resistor. This will also lower the upper limit current value. If you need a higher trip point, change R5 to a .5-ohm resistor, which will double the trip range of the 1 ohm circuit.

Connect the bench supply positive lead, through an accurate ammeter, to the B- line on the meter side of R5 on figure 9(B). Connect the negative lead to the B- line at the power supply side of R5. Set R-39 of figure 4 full CW. Apply enough voltage from the bench supply for a current matching the desired trip point and adjust R-39 for trip. Remember you have to turn off the power to reset, that's why the warm-up timer is temporarily set for a short period!!

## **BIAS ADJUSTMENT**

Apply enough voltage, (9v battery), to the HV fault module to extinguish the HV fault led. Defeat the fan switch if the fan isn't operating. The amp should now be able to be keyed via the key lines, after reset. Connect the bench supply positive lead to the B- line at the cathode side of R4, figure 9(B). Connect the negative lead to the B- line at the power supply side of R5. Set R58 full CCW. Connect a DMM to both sides of R4, positive lead to the cathode side. Set the power supply voltage to just above the desired bias voltage and then key the board via either key line then adjust R58 of figure 6 for the desired bias value as read on the DMM. If the voltage of the power supply is too far above the voltage set by R58 and the supply is not current limited, the IP over current circuit will trip or you may damage your plate current meter.

## **TUNE FAULT**

Set R23, R20 full CW and set R21 full CCW. Set the warm-up timer control, R7, to the desired time period. If this is in a multi-band amplifier make the following adjustments at 14 MHz. Warm up the amp and tune up with 20 watts of drive. Adjust R23 for a slight deflection of the tune meter and then adjust R22 for a zero-center reading. Still with 20 watts of drive, and a DMM attached to pin #8 of U2c, (cathode D10), adjust R20 until a jump in voltage is observed on the DMM. This is the point where the fault module switches to full sensitivity. If you're using a single 3cx800 or 3-500, set R20 with a lower power input level. Tune the amplifier up to the expected operating power

output level while making sure not to over drive the tune meter. Next, re-center the tune meter with R22 when all tuning parameters are where you want them. The severity of mistuning for the trip point is up to you. As a conservative rule of thumb, increase plate loading for a 25% decrease in power output. Adjust R23 for a 75% deflection, (positive), of the tune meter and then set R21 for trip. Keep key-down periods during this mistuned condition as short as possible. Under loading the amp should result in a grid trip fault long before the tune fault trips, (or an arc will fire the tune fault) .

### **MISCELLANEOUS PARTS**

The thermal snap switch used in figure 8 for the blower off delay was purchased from ALL Electronics, part #THSW-32. It's a close on rise at 133 degrees f. The blower switch also came from ALL Electronics, part #502. If you snap the cover off this switch there's an adjustment screw inside that will lower the "on" pressure to .25 inches water column. I mounted it with the inlet perpendicular to the airflow and attached a small tube to the inlet with a 60 degree cut on the end, which faces toward the airflow. The vacuum relays are available from MAX GAIN Systems and are removed from new – unused equipment. The owner Allen Bond, WB4GNT, has a web site at, [www.mgs4u.com](http://www.mgs4u.com). Phone number; 770-973-6251, before 9 PM eastern. He has both the Jennings RJ1A and the Kilovac HC1. I've just completed testing these relays with this control board and found these results: The RJ1A closes in 1.8ms and opens in 1ms; The HC1 closes in 2.3ms and opens in 600us. After 10 hours of continuous 20 hertz, (50wpm dit rate) operation the Jennings relay became magnetized and failed to release, (750,000 cycles). I quit after 24 hours with the Kilovac as it was still going strong. Both relays are \$32.50 from Allen so the choice is up to you.

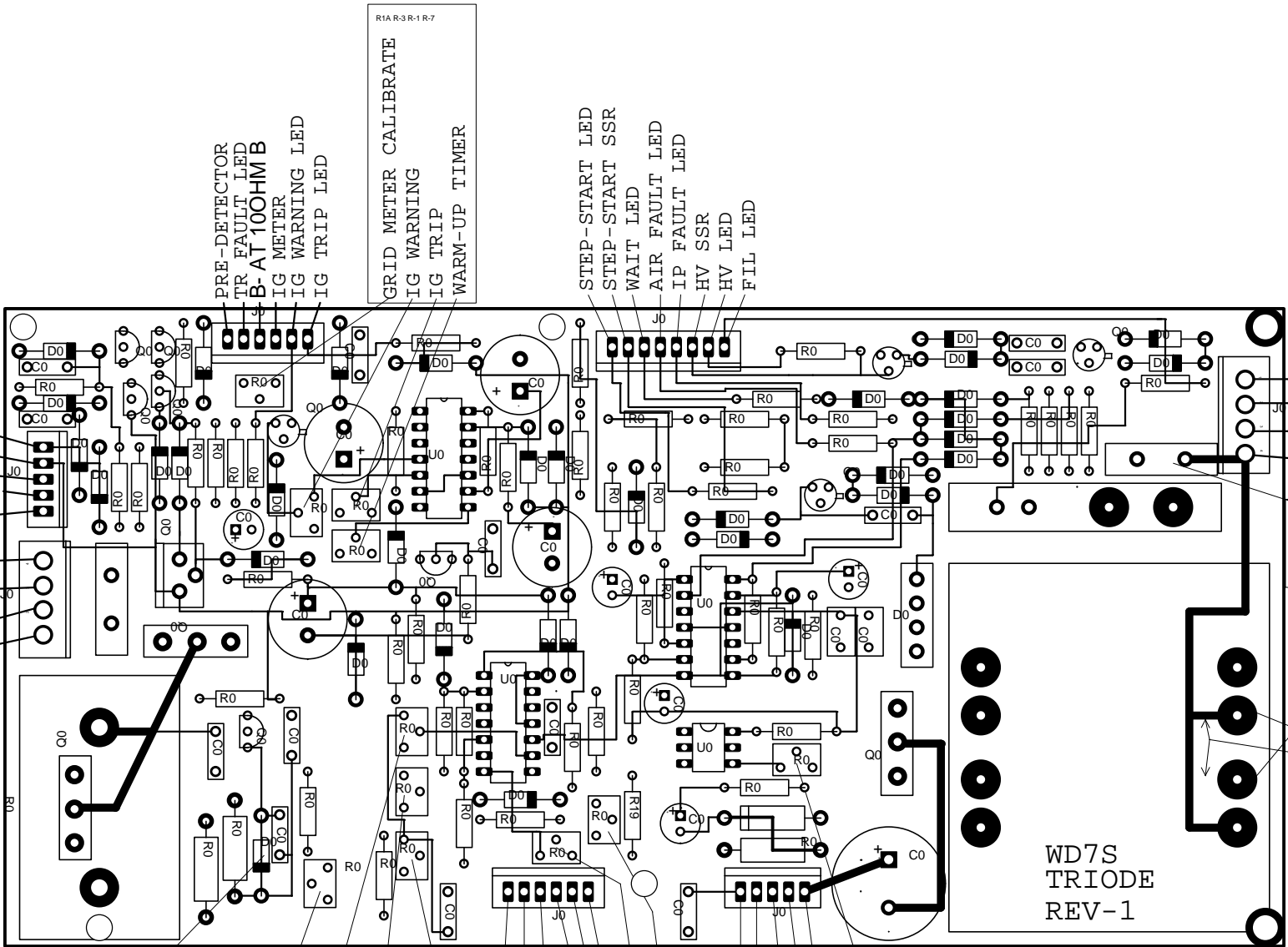
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## WD7S TRIODE PARTS LIST

C1, 10UF 50V ELECTROLYTIC, Mouser, 140-XRL50V10  
(12), C2, 6,8,13,14,15,16,17,19,20,21,C25, .01UF DISK, Mouser, 140-50U5-103M  
(3), C9, 10,12, 2.2UF NON-POLARIZED, Mouser, 140-NPRL50V2.2  
(4), C4, 5,18,24, 100UF 63V, Mouser, 140-HTRL63v100  
C7, .22UF DISK, Mouser, 140-50V5-224Z  
C11, 22UF 50V, Mouser, 140-XLR50V22  
C22, 1000UF 50V, Mouser, 75-517D50V1000  
(2), C23, C3 .1UF DISK, Mouser, 140-CD50V10-104Z  
(4), D1, D23, D36, D37, 5.6V 500MW ZENER, Mouser, 78-1N5232B  
(24), D2, 3,4,5,6,7,8,9,10,11,12,15,16,17,18,19,20,21,22,28,29,30,32,33, 1N914B,  
Mouser, 583-1N914B  
D14, 3.3V 5W ZENER, Included with board  
(4), D24, 26, 27, D38, 16v 500MW ZENER, Mouser, 625-1N5246B  
D25, 12V 500MW ZENER, Mouser, 625-1N5242B  
D34, TL431, TO-92 plastic package, Mouser, 513-NJM431L  
D35, BRIDGE RECTIFIER 2AMP, Mouser, 583-RS203L  
(2), D39, D31, 1N4007  
MOV, 2ea, Mouser, 570-V130LA10A  
(4), Q1, 3,4,5, 2N2222A TO-18 package, Mouser, 511-2N2222A  
(5), Q2, 6,7,9,10, 2N7000, Mouser, 625-2N7000  
Q8, IRF620, Mouser, 511-IRF620  
Q11, TIP142, Mouser, 511-TIP142  
Q12, TIP147, Mouser, 511-TIP147  
(9), R1, 1A, 3,7,20,21,22,24,39, 10K MULTI-TURN POT, Mouser, 72-T93YB-10k, top  
screw adjust  
(3), R2, 31,60, 1K .25W  
(11), R4, 6,12,19,29,32,40,43,44,47,57, 2.7K .25W  
(4), R5, 11,28,52 47K .25W  
(4), R8, 13,30,48, 8.2M .25W  
(2), R9, 41, 3.3M .25W  
(2), R10, 34, 1M .25W  
(5), R14, 15,35,51,54, 100K .25W  
(3), R17, 33,45, 2K .25W  
(9), R18, 42,46,25, 26,27,36,37,63, 10K .25W  
R23, 100K MULTI TURN POT, Mouser, 72-T93YB-100K, top screw adjust  
(1), R38, 20 .25W  
(5), R49, 50,53,65,66, 20K .25W  
R55, 200 .25W  
R56, 75K .25W  
R58, 20K MULTI TURN POT, Mouser, 72-T93YB-20K, top screw adjust  
R59, 47 .5W, Mouser, 293-47  
(2), R61, R64, 100 .5W, Mouser, 293-100

T1, 20VAC CT @1AMP PC MOUNT TRANSFORMER, Mouser, 553-FS20-1000,  
Magnetek  
U1, 2, 4, LM339, Mouser, 511-LM339AN  
U3, 4N38, Mouser, 512-4N38  
V1, L78S24V VOLTAGE REGULATOR, Mouser, 511-L78S24CV  
FIL SSR, CRYDOM CXE240D5, Mouser, 558-CXE240D5  
HEAT SINK, Mouser, 532-507302B00, 2 each  
HEAT SINK, Mouser, 532-529801B25, 1 each  
HEADER 4-PIN, 2EA, .156, Mouser, 571-6404454  
HEADER 5-PIN, 2EA, .100, Mouser, 538-22-23-2051  
HEADER 6-PIN, 2EA, .100, Mouser, 538-22-23-2061  
HEADER 8-PIN, 1EA, .100, Mouser, 538-22-23-2081  
14 PIN DIP SOCKET, 3EA, Mouser, 571-26403574  
6 PIN DIP SOCKET, 1EA, Mouser, 571-26412964  
All .25-watt resistors are carbon film types, Mouser, 291-(Resistance)  
All .5-watt resistors are carbon film types, Mouser, 293-(resistance)

JULY 18, 2007



POST DETECTOR  
PERATE SW FAULT  
+ KEY-LINE  
GROUND KEY LINE  
TO RELAYS

GROUND  
GROUND  
25K AT B-, B  
25K AT B-, C

OPTIONAL  
BIAS DIODE  
CUT TRACE  
BELOW

BIAS ADJUST  
TUNE TRIP  
THRESHOLD  
HV FAULT  
THRESHOLD  
LOW POWER  
THRESHOLD

HV SENSE  
HV LED  
POST DETECTOR  
OUTPUT DETECTOR  
TUNE METER  
TUNE LED

ZERO CENTER  
TUNE METER  
CALIBRATE

FAN SWITCH  
B  
A  
VCC  
33VDC

TRIP TRIP

PRE-DETECTOR  
TR FAULT LED  
B- AT 100HM B  
IG METER  
IG WARNING LED  
IG TRIP LED

RIA R-3 R-1 R-7  
GRID METER CALIBRATE  
IG WARNING  
IG TRIP  
WARM-UP TIMER

STEP-START LED  
STEP-START SSR  
WAIT LED  
AIR FAULT LED  
IP FAULT LED  
HV SSR  
HV LED  
FIL LED

GROUND  
FIL TRANSFORMER  
LINE IN  
NEUTRAL  
(LINE-240VAC)  
REPLACE MOV  
WITH 260 VOLT  
FOR 240VAC  
OPERATION

FOR 240VAC  
BRIDGE PADS  
CUT TRACES

WD7S  
TRIODE  
REV-1

R-58 R-23 R-24 R-20

R-22 R23

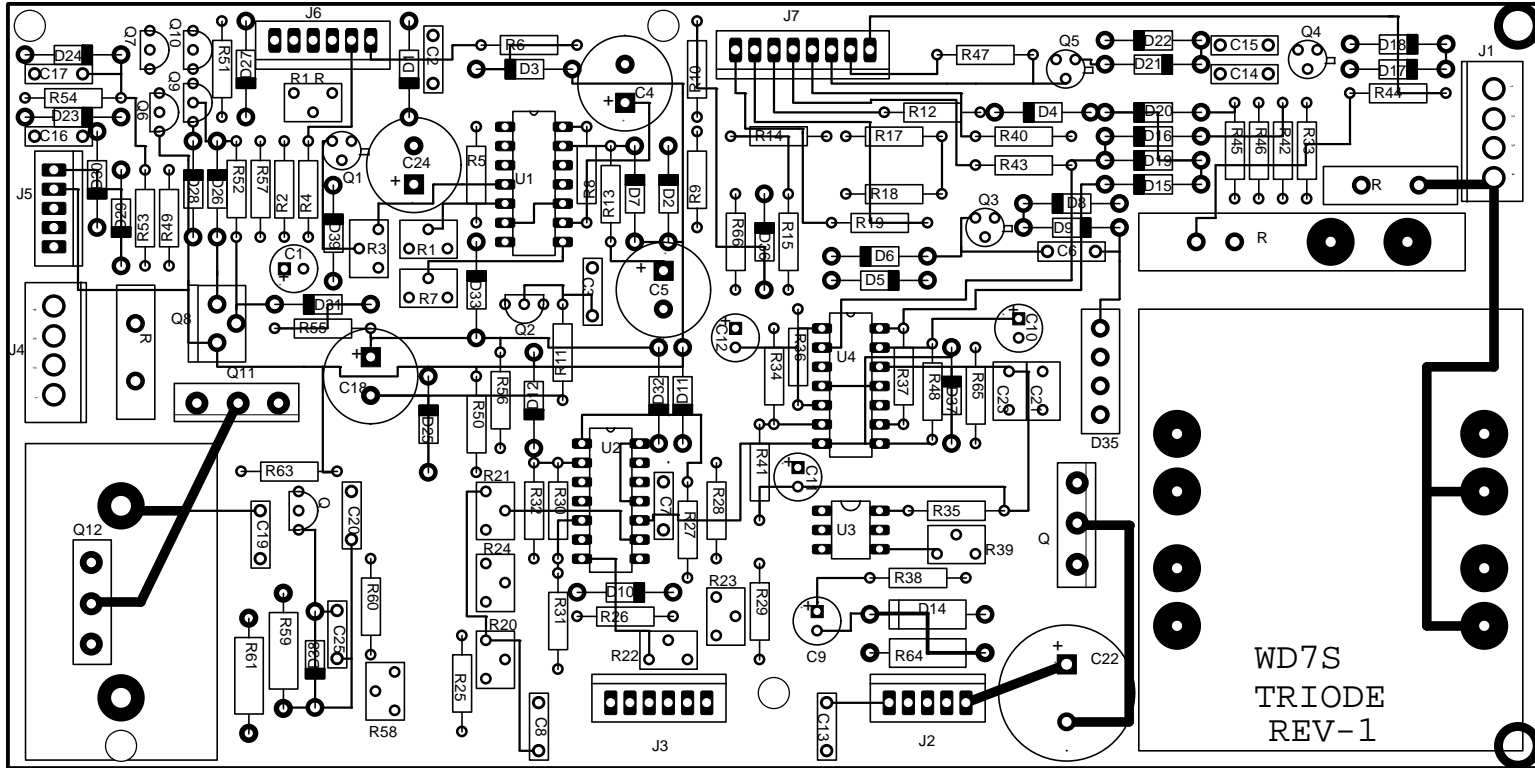
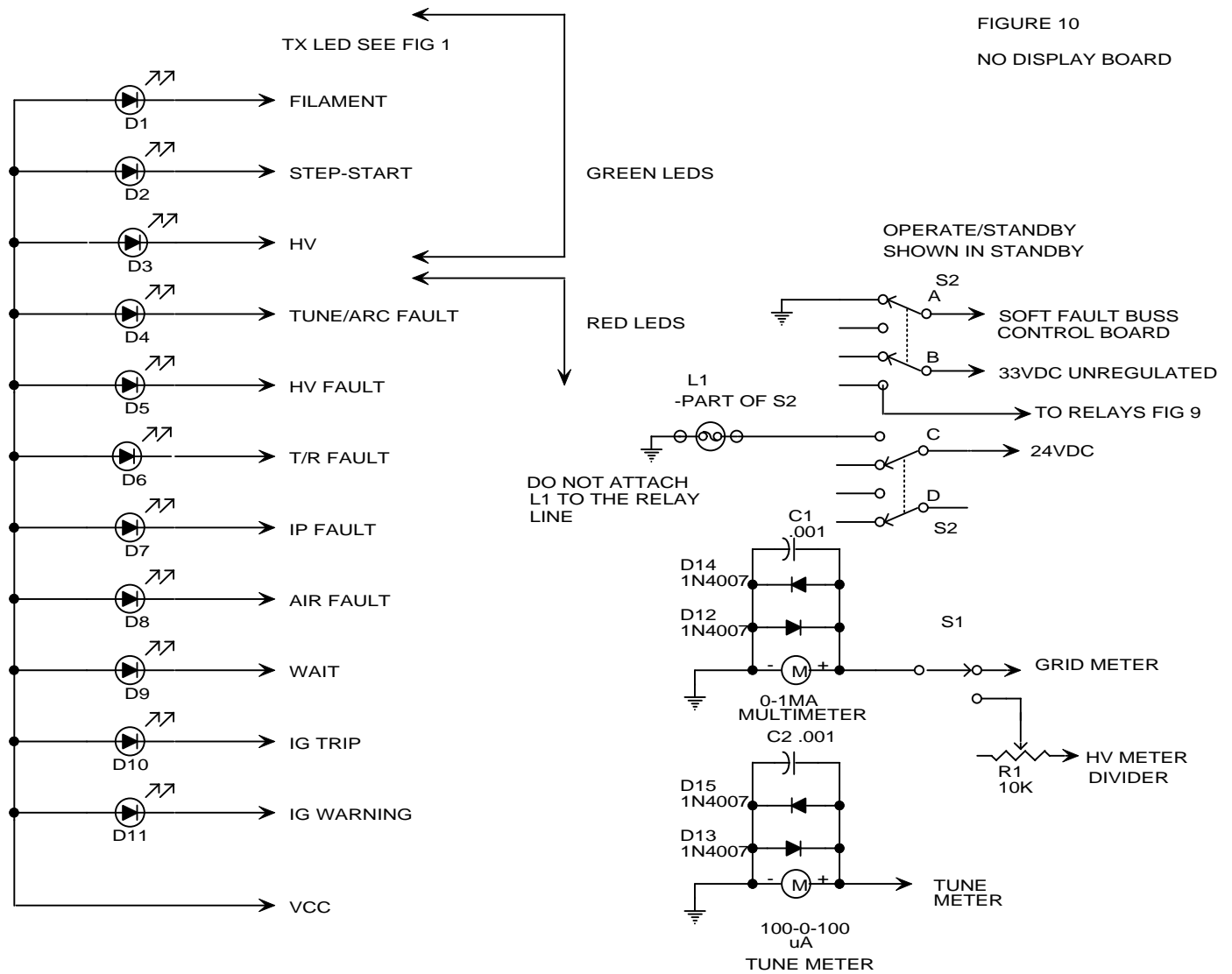




FIGURE 10  
NO DISPLAY BOARD



# WD7S PRODUCTIONS

Title: WD7S TRIODE-FIG10.PIC

Size A | FRONT PANEL CONNECTIONS NO DISPLAY | Rev

Date: 1/01/09 Thu

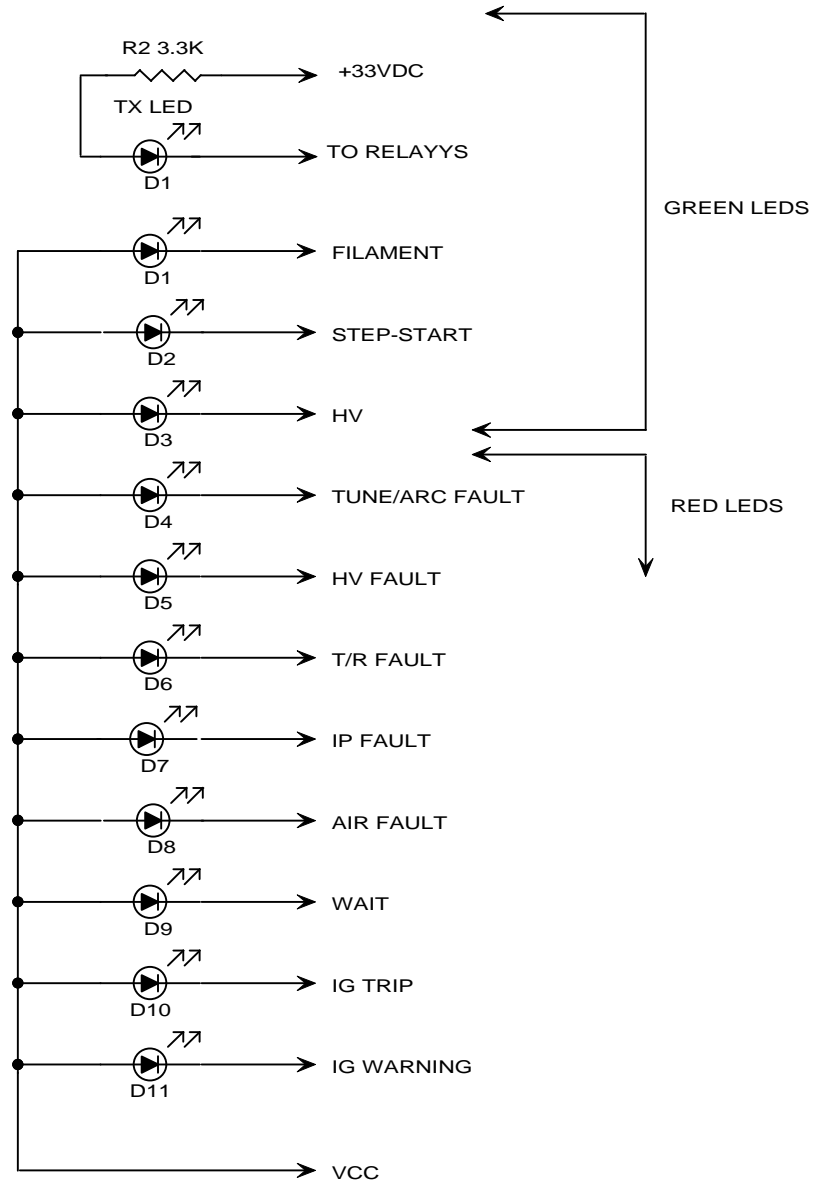
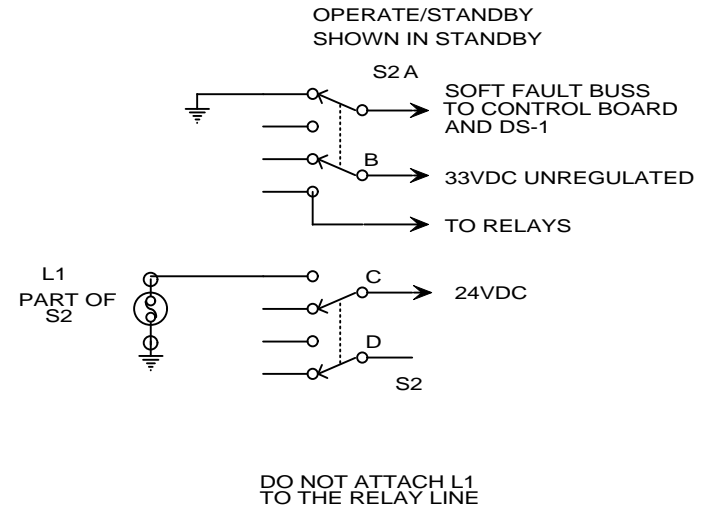


FIGURE 10B  
WITH DISPLAY



# WD7S PRODUCTIONS

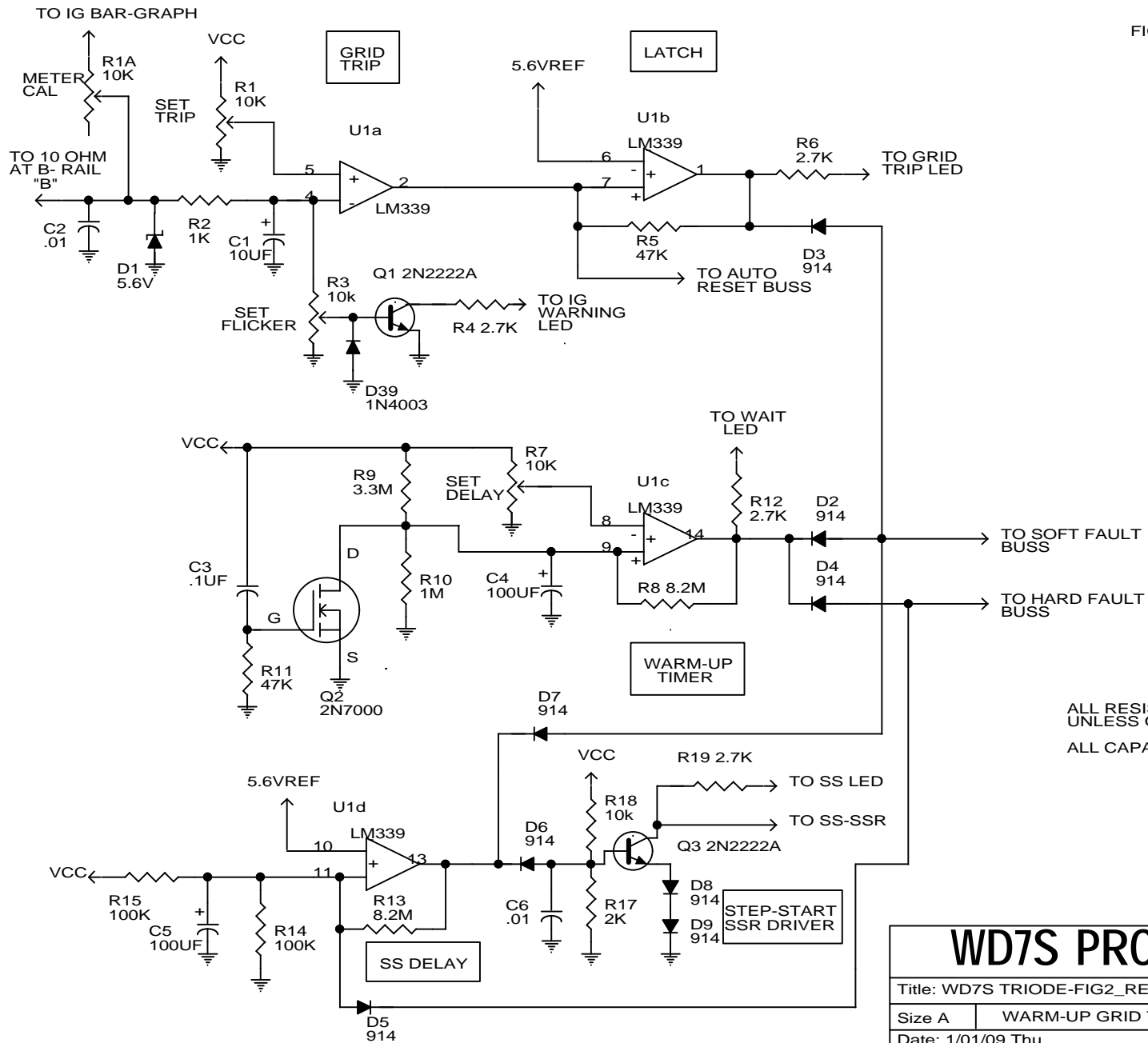
Title: WD7S TRIODE-FIG10B.PIC

Size A | OPR SW & STATUS LEDS W/DISPLAY | Rev

Date: 1/01/09 Thu

REV 7/09/06

FIGURE 2

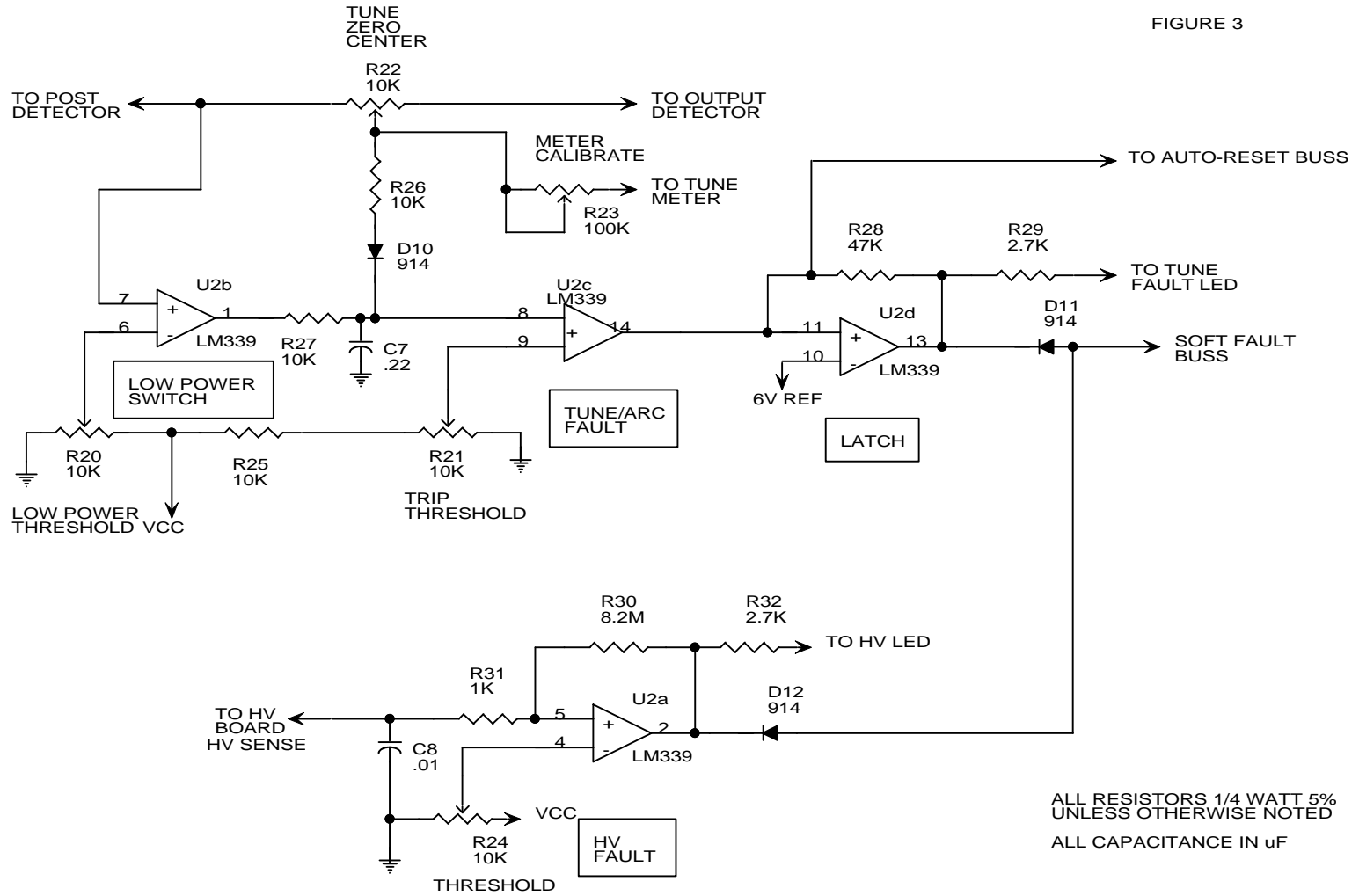


ALL RESISTORS 1/4 WATT 5%  
UNLESS OTHERWISE NOTED  
ALL CAPACITANCE IN uf

# WD7S PRODUCTIONS

|  |                      |     |
|--|----------------------|-----|
| Title: WD7S TRIODE-FIG2_REV1.PIC REV-1 |                      |     |
| Size A                                 | WARM-UP GRID TRIP SS | Rev |
| Date: 1/01/09 Thu                      |                      |     |

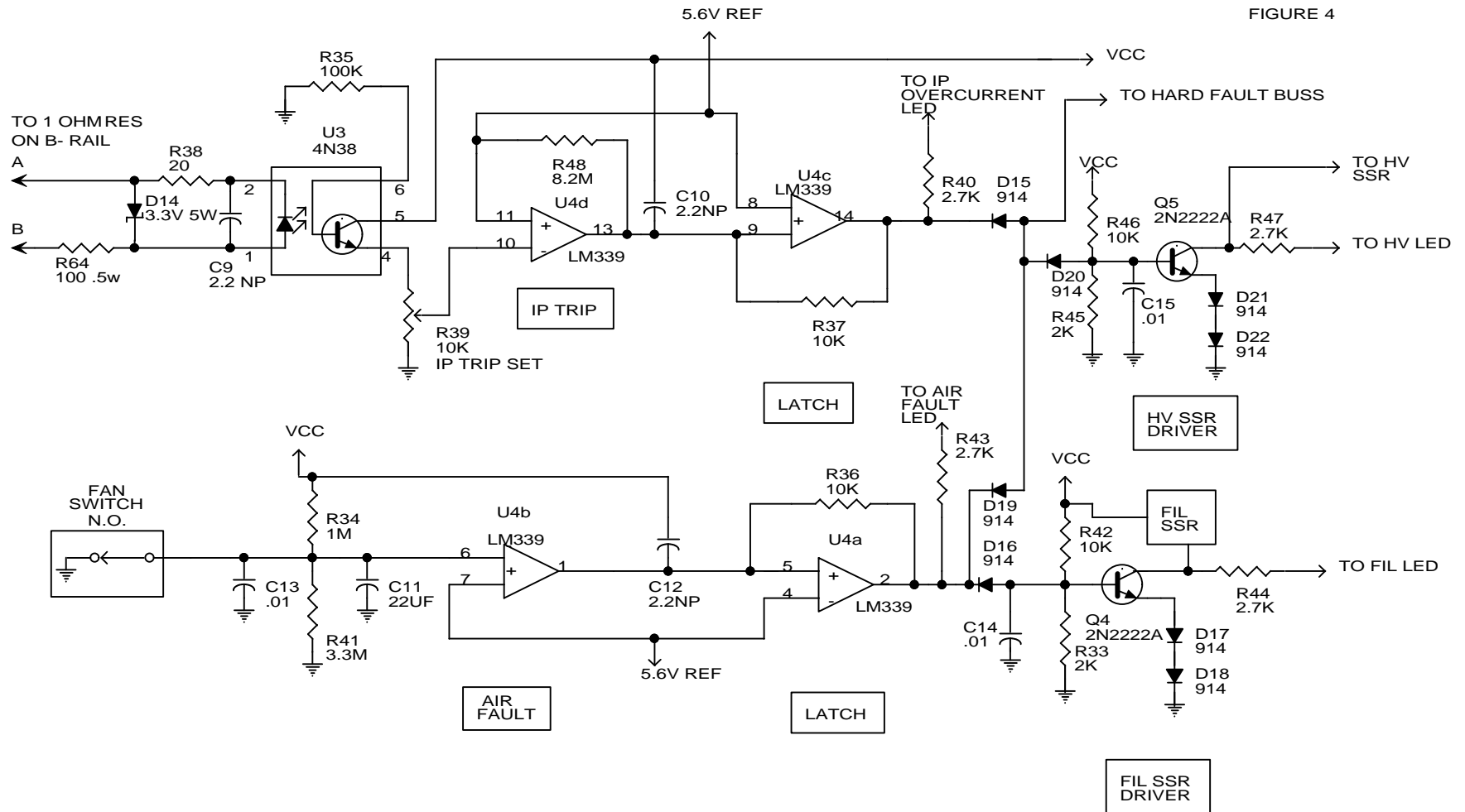
FIGURE 3



# WD7S PRODUCTIONS

|                             |                          |     |
|-----------------------------|--------------------------|-----|
| Title: WD7S TRIODE-FIG3.PIC |                          |     |
| Size A                      | TUNE/ARC FAULT, HV FAULT | Rev |
| Date: 1/01/09 Thu           |                          |     |

FIGURE 4

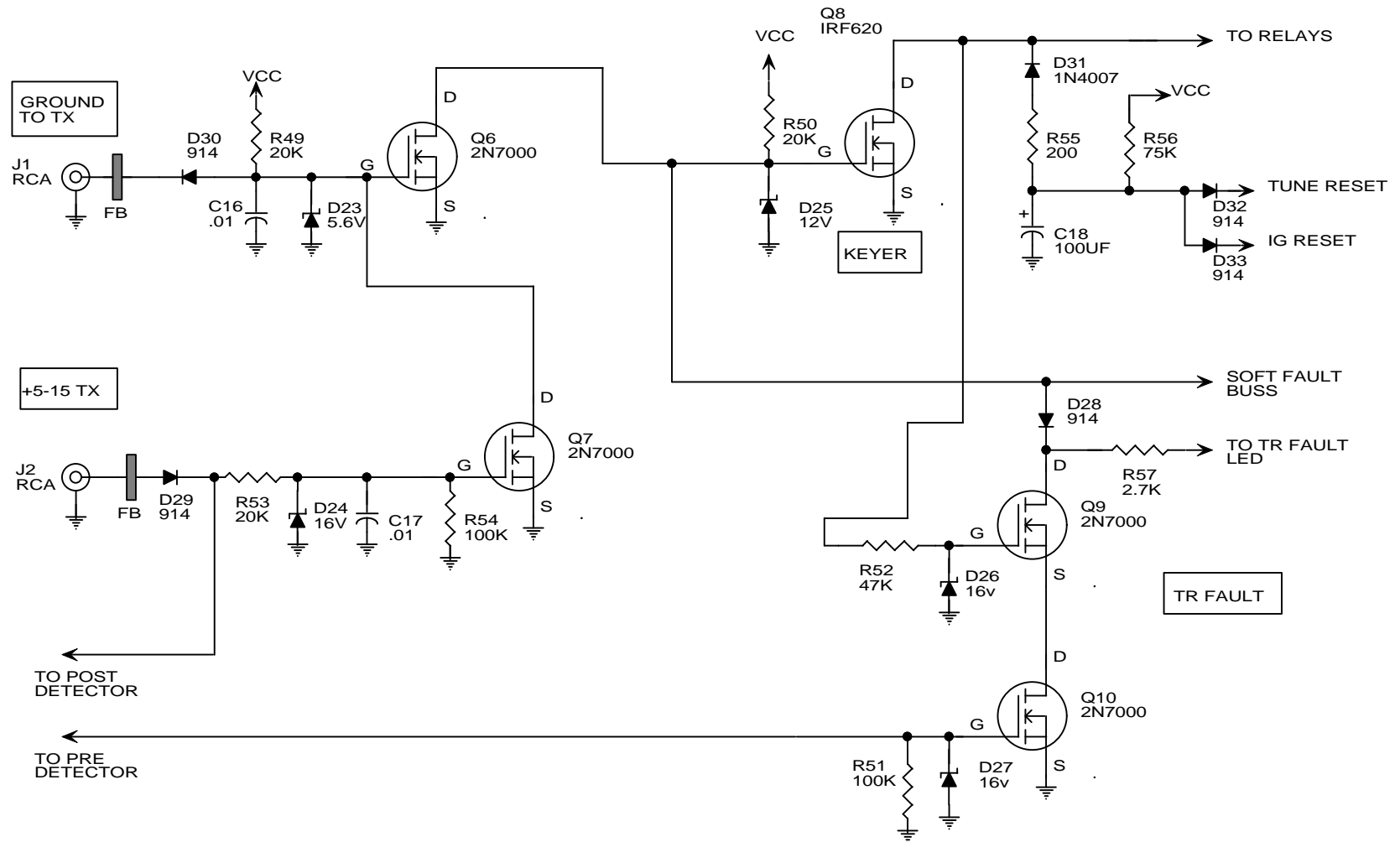


ALL RESISTORS 1/4 WATT 5%  
UNLESS OTHERWISE NOTED  
ALL CAPACITANCE IN uF

# WD7S PRODUCTIONS

|                             |                  |             |
|-----------------------------|------------------|-------------|
| Title: WD7S TRIODE-FIG4.PIC |                  | Rev 4-20-01 |
| Size A                      | IP AND AIR FAULT | Rev         |
| Date: 1/01/09 Thu           |                  |             |

FIGURE 5

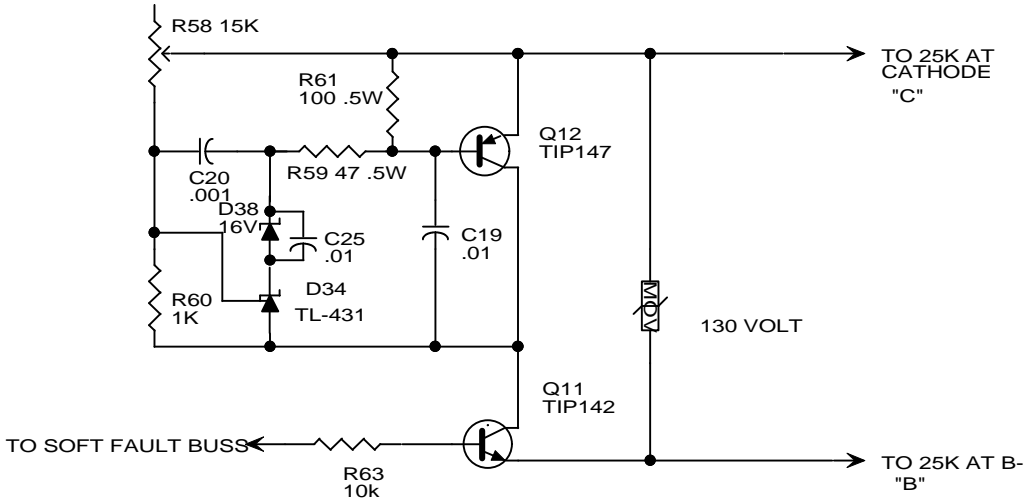


ALL RESISTORS 1/4 WATT 5%  
UNLESS OTHERWISE NOTED  
ALL CAPACITANCE IN  $\mu$ F

# WD7S PRODUCTIONS

|                             |                         |     |
|-----------------------------|-------------------------|-----|
| Title: WD7S TRIODE-FIG5.PIC |                         |     |
| Size A                      | TR FAULT- KEY INTERFACE | Rev |
| Date: 1/01/09 Thu           |                         |     |

FIGURE 6

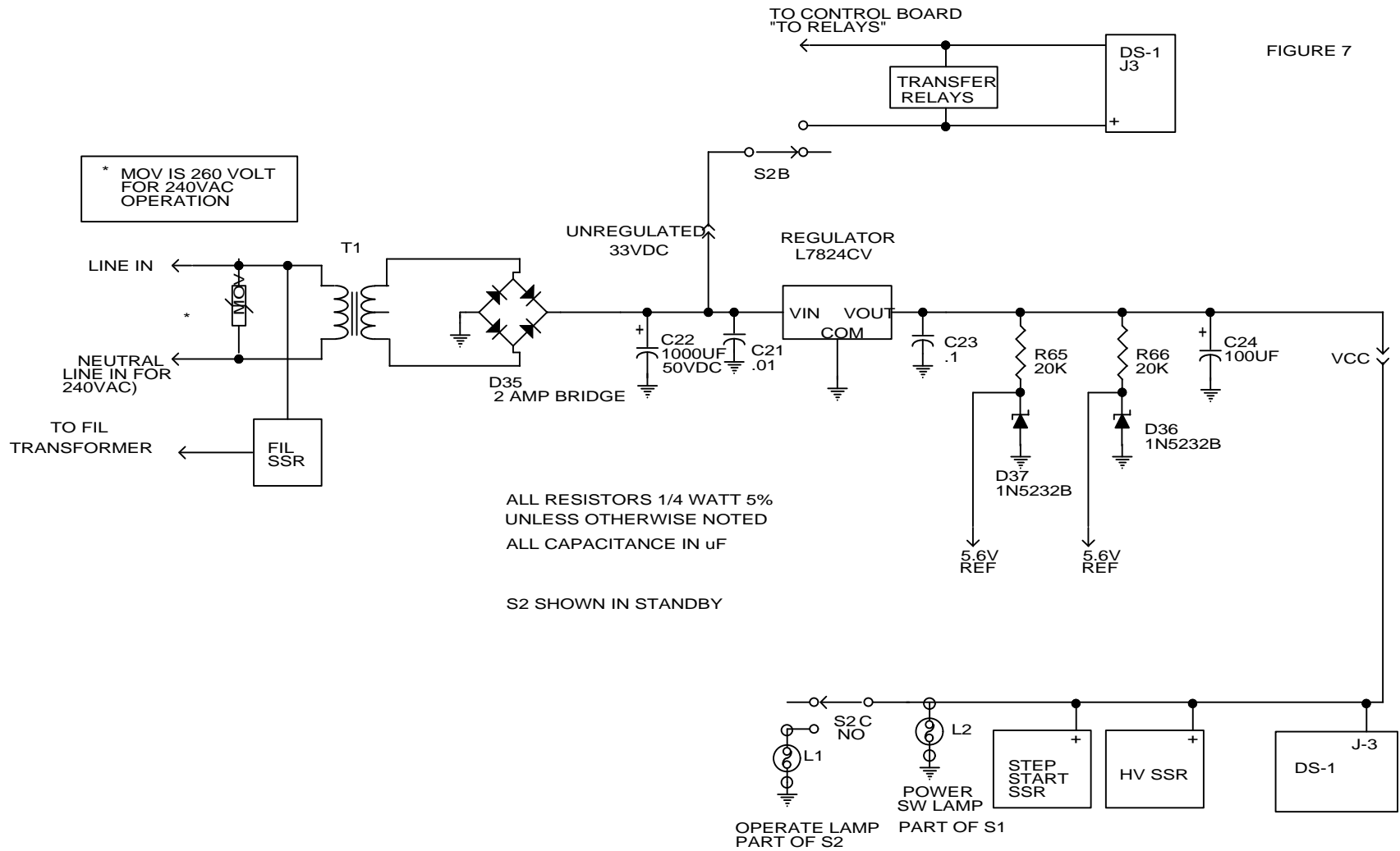


CUT TRACE UNDER  
D-38 FOR HIGHER  
BIAS VOLTAGE

ALL RESISTORS 1/4 WATT 5%  
UNLESS OTHERWISE NOTED  
ALL CAPACITANCE IN uF

|                                  |                      |       |
|----------------------------------|----------------------|-------|
| <b>WD7S PRODUCTIONS</b>          |                      |       |
| Title: WD7S TRIODE-FIG6_REV1.PIC |                      | REV-1 |
| Size A                           | BIAS AND BIAS SWITCH | Rev   |
| Date: 1/01/09 Thu                |                      |       |

FIGURE 7



# WD7S PRODUCTIONS

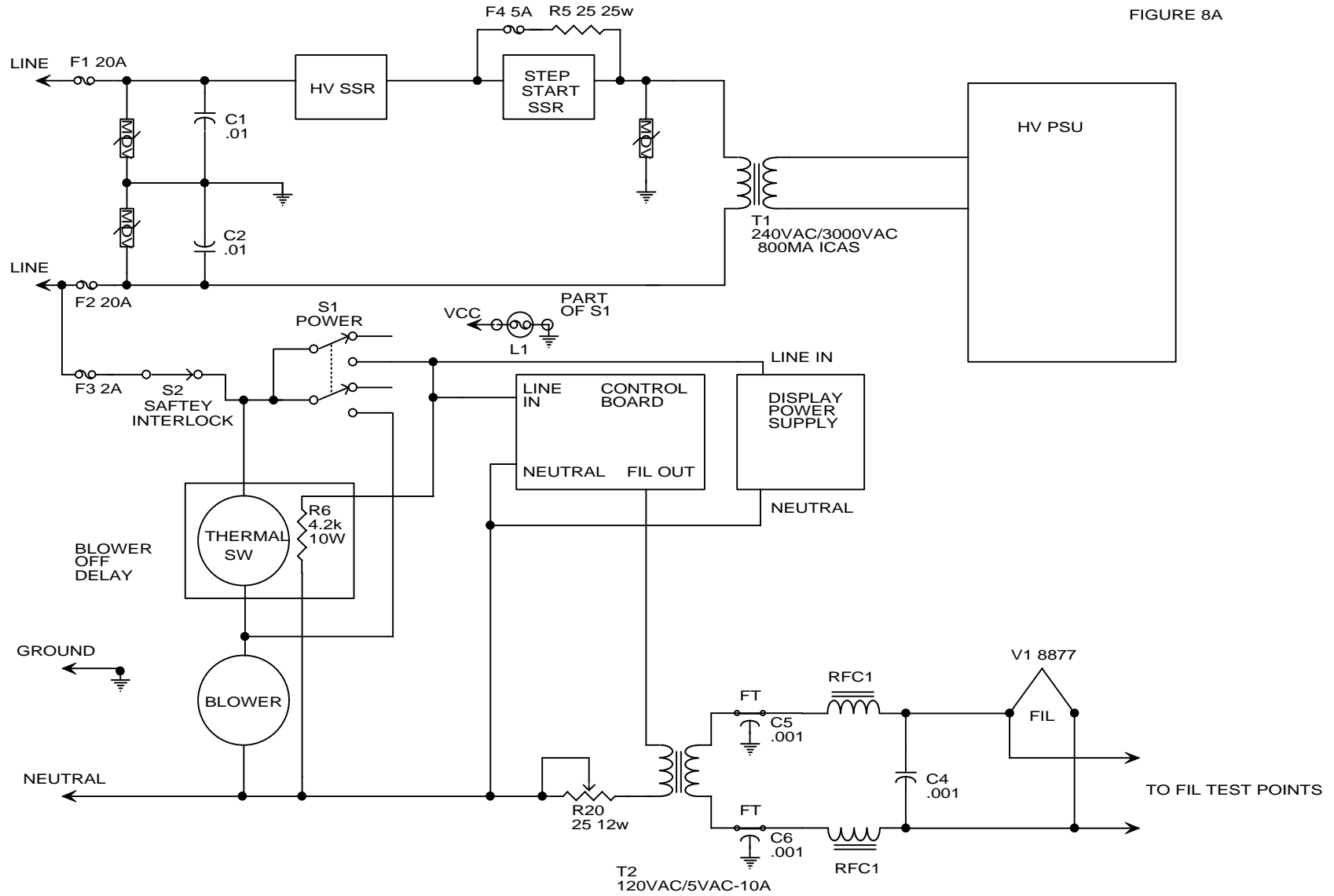
Title: WD7S TRIODE-FIG7-REV.PIC

Size A | LOW VOLTAGE POWER SUPPLY | Rev

Date: 1/01/09 Thu

REV 7-9-06

FIGURE 8A



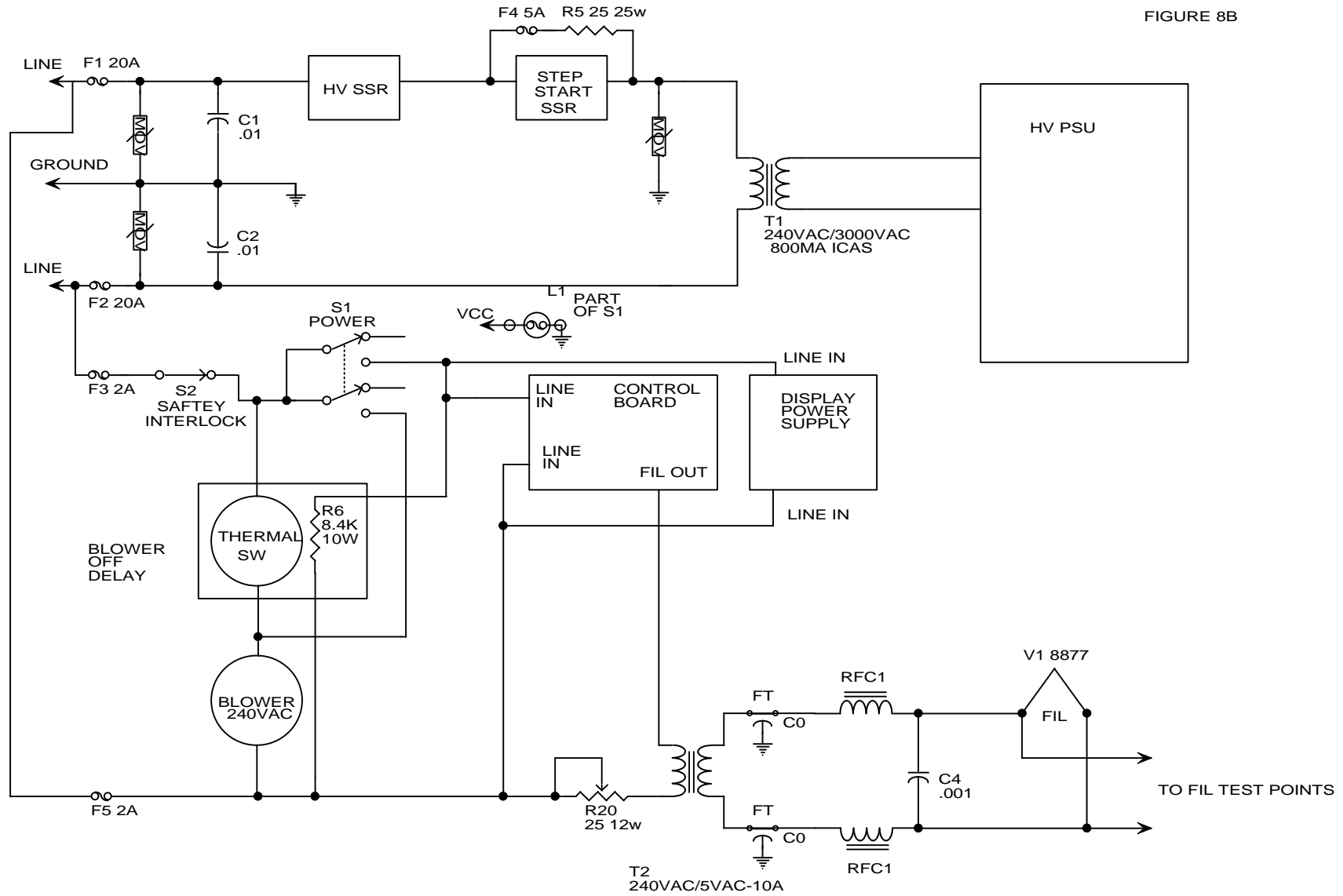
# WD7S PRODUCTIONS

Title: WD7S TRIODE-FIG8A.PIC

|        |              |                |     |
|--------|--------------|----------------|-----|
| Size A | TYP AC MAINS | 120VAC CONTROL | Rev |
|--------|--------------|----------------|-----|

Date: 1/01/09 Thu

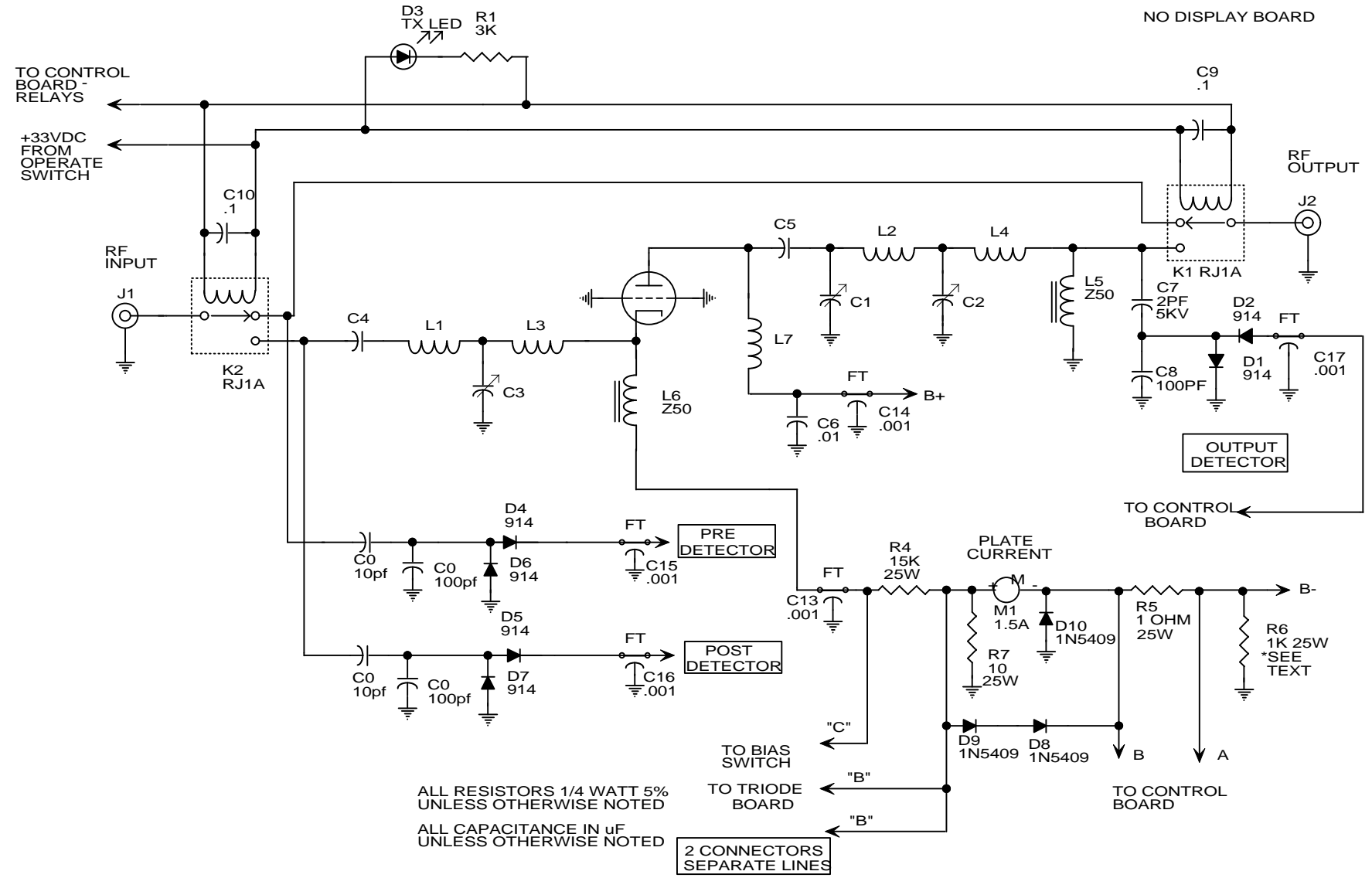
FIGURE 8B



# WD7S PRODUCTIONS

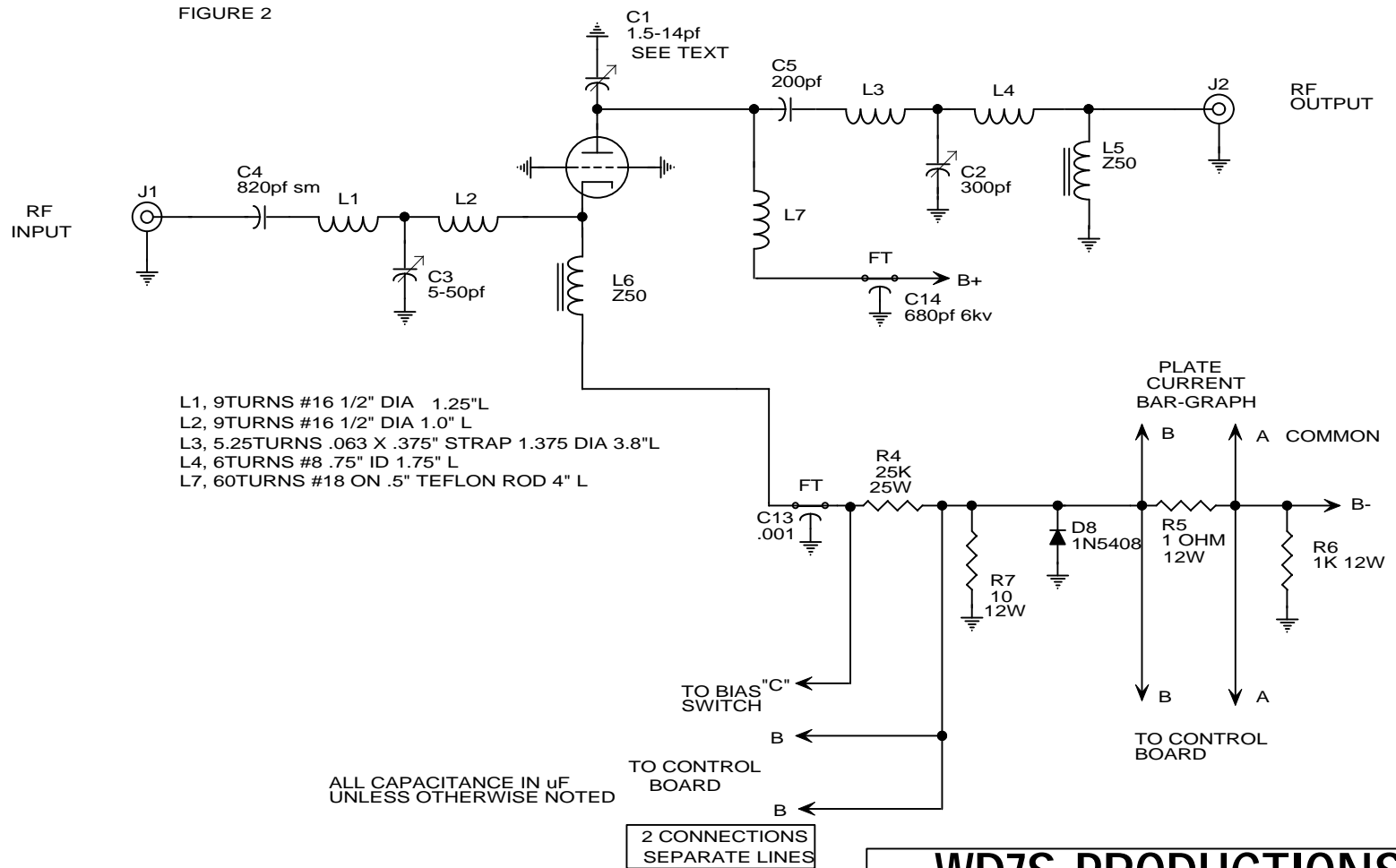
|                              |                             |     |
|------------------------------|-----------------------------|-----|
| Title: WD7S TRIODE-FIG8B.PIC |                             |     |
| Size A                       | TYP AC MAINS 240VAC CONTROL | Rev |
| Date: 1/01/09 Thu            |                             |     |

FIGURE 9  
NO DISPLAY BOARD



|                             |                      |             |
|-----------------------------|----------------------|-------------|
| <b>WD7S PRODUCTIONS</b>     |                      |             |
| Title: WD7S TRIODE-FIG9.PIC |                      | REV 4-20-01 |
| Size A                      | MONOBAND CONNECTIONS | Rev         |
| Date: 1/01/09 Thu           |                      |             |

FIGURE 9B  
WITH DISPLAY BOARD



# WD7S PRODUCTIONS

Title: WD7S TRIODE-FIG9B\_DISPLAY.PIC

Size A MONOBAND CONNECTIONS WITH DISPLAY Rev

Date: 1/01/09 Thu