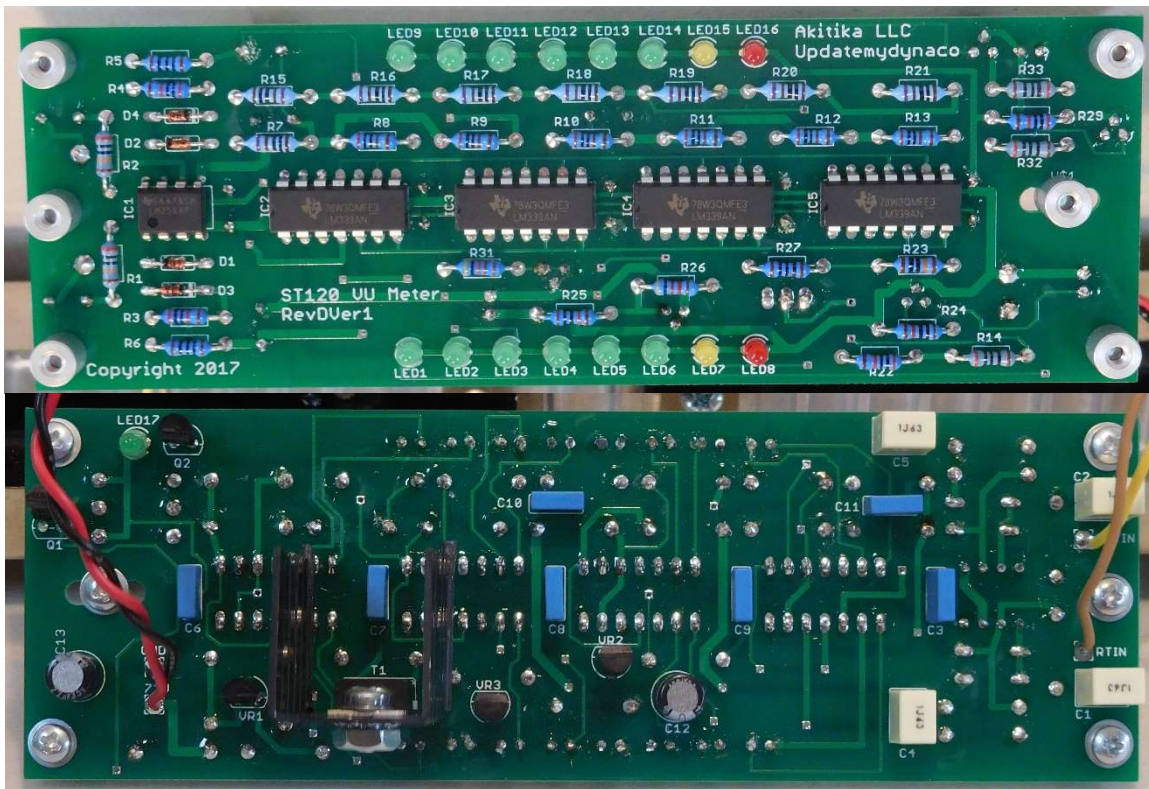


Stereo 120 VU Meter ASSEMBLY MANUAL



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Section 1: About This Manual

This manual gives the information you need to build and install the Stereo 120 VU Meter, part number ST120VU, into your Dynaco Stereo 120 Power Amplifier. This kit has 8 LED level indicators, spaced 6 dB apart for each channel. Therefore, it displays the signal level over a wide range, 42 dB. The lowest levels are indicated with green LEDs, the next to highest level by a yellow LED, and the highest level, near clipping, with a red LED.

In order to have room to install the kit in the usual place, you will have had to install the amplifier module upgrade kits (TCK). As of this writing, the following other Stereo 120 upgrades are available from Updatemydynaco, a division of Akitika LLC:

- Blue Light Kit (BLUE)
- Regulated Power Supply (PSUG)
- Amplifier Upgrade Modules (TCK)
- New RCA Jacks (RCAJ)
- Complete Rebuild kit (combines some of the above, ST120CRK)

Who Should Attempt these Projects?

You can build this kit if you can:

1. solder (using normal rosin core solder and a soldering iron),
2. use simple hand tools like screwdrivers, wire cutters, and pliers, and
3. Read and follow directions.

It helps if you:

1. know a bit about electronics, or
2. have a friend who knows a bit about electronics
3. can get to YouTube to watch a few helpful videos about the assembly process (not available as of this version of the manual)

Tools and Supplies You'll Need

You'll need the following tools:

1. flat blade screwdrivers for #4 and #6 screws, #2 Philips head screwdriver
2. needle nose pliers (helpful, but not strictly necessary)
3. pencil type soldering iron of 25 to 50 Watts (no huge honking soldering guns or blowtorches)
4. wire cutters and strippers
5. de-soldering tools (see Appendix 1 and Appendix 2)
6. Magnifying glass, if you're over 42!
7. A multi-meter for measuring Ohms and DC volts is strongly recommended.
8. Possibly a drill with a 1/8" bit.

Recommended Solder

The kit must be assembled with 60/40 Rosin Core solder. The recommended diameter is 0.032 inches. Among many such sources of solder, I have used Radio Shack part number

64-009. It contains 8 oz. of solder, which is *much* more than you'll need to assemble this kit.

Project Overview

Broadly, the project consists of the following steps:

1. Building the ST120VU circuit board.
2. Installing the assembled circuit board and connecting it to the amplifier.
3. Reassembling the power amplifier.

Important Safety Notes

By purchasing, using, or assembling this kit, you have agreed to hold AkitikA, LLC harmless for any injuries you may receive in its assembly and/or use. To prevent injuries:

- Wear safety glasses when soldering to prevent eye injuries.
- Always unplug the power before working on the equipment.
- Large capacitors hold lots of energy for a long time. Before you put your hands into the equipment:
 - Pull the AC plug!
 - Wait 1 full minute for the capacitors to discharge!
- Remove jewelry and rings from your hands and wrists, or anything that might dangle into the amplifier.
- If working in the amplifier, keep one hand in your pocket, especially if you're near the power supply or power supply wires. This can prevent serious shocks.
- Build with a buddy nearby. If you've ignored all the previous advice, they can dial 911 or get you to the hospital.

Section 2: Building the ST120VU PCB

When completed

When completed, the ST120VU will be mounted inside the amplifier, attached to the underside of the cover. The level indicating LED's will be visible through the cover.

Before you begin – determine your hole pattern

The hole pattern in the cover of the Stereo 120 is not consistent across all production. Therefore, we've devised a flexible mounting arrangement to accommodate these variations. In this section, you'll determine which mounting arrangement best fits your Stereo 120.

Depending on the hole pattern spacing and size for your particular amp, you will attach the ST120VU to the cover with either 2 screws, 3 screws or 4 screws. To determine the mounting style, lay the bare PCB on top of your Stereo 120 with the silk-screen for LED1 through LED16 visible. Place the side of the PCB with R1 and R2 closest to the RCA connector and binding post side of the amp. Center the PCB left-to-right, with the edge of the PCB about 1.5" from the edge of the amp.

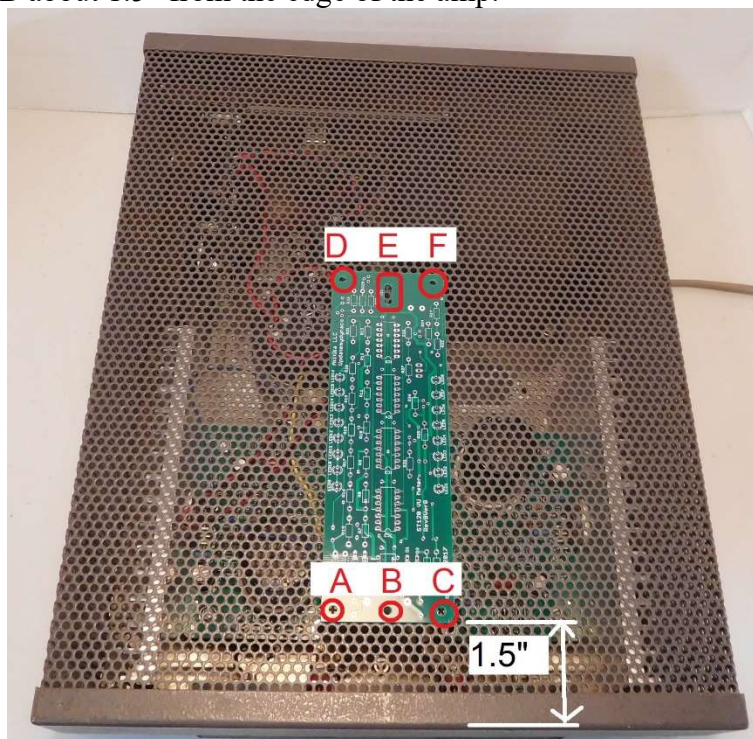


Figure 1-Determining the mounting arrangement

Four Hole Mounting

Look through the 4 outside mounting holes (A, C, D, F) in Figure 1. Keep the board parallel to the rows and columns of holes as you search for a position where all four holes in the PCB line up with holes in the cover. If this happens, you will use the 4-hole mounting arrangement at final assembly.

Three Hole Mounting

If 4-holes don't line up with 4-holes in the cover, then check for a three-hole mounting arrangement using holes A and C and slot E.

Two Hole Mounting

If 3 holes don't line up, then check for a two-hole mounting arrangement using hole B and slot E.

Other Arrangements

So long as you can line up one screw from the A,B,C group and one screw from the D, E, F group, you will be able to securely mount your Stereo 120 VU meter kit.

Components on Both Sides!

This kit is a bit unusual, in that components are installed from both sides of the PCB. Remain calm and follow the directions, and everything will turn out fine!

Installing components on the resistor side of the board

We have named the PC board sides:

1. Resistor side – since all the resistors install from this side of the board
2. Capacitor side – since all of the capacitors install from this side of the board

The resistor side of the PCB is shown in Figure 2.

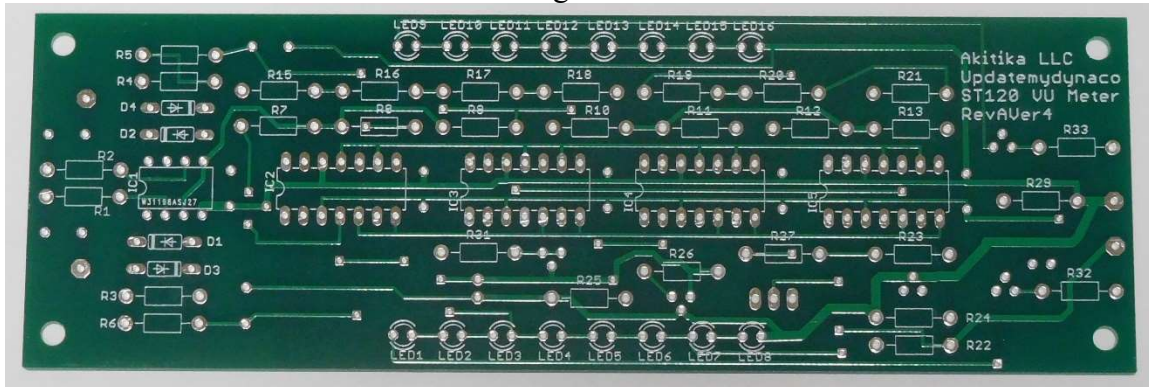
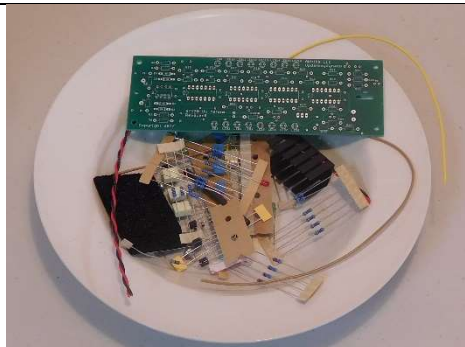


Figure 2-Resistor side of the PCB before loading

Begin by carefully emptying the contents of the parts envelope into a broad soup bowl, as shown below. In general, you'll start with the components that lay closest to the board, working your way towards the taller components. You will:

1. Install the diodes
2. Install the resistors
3. Install the IC's
4. Install the LEDs



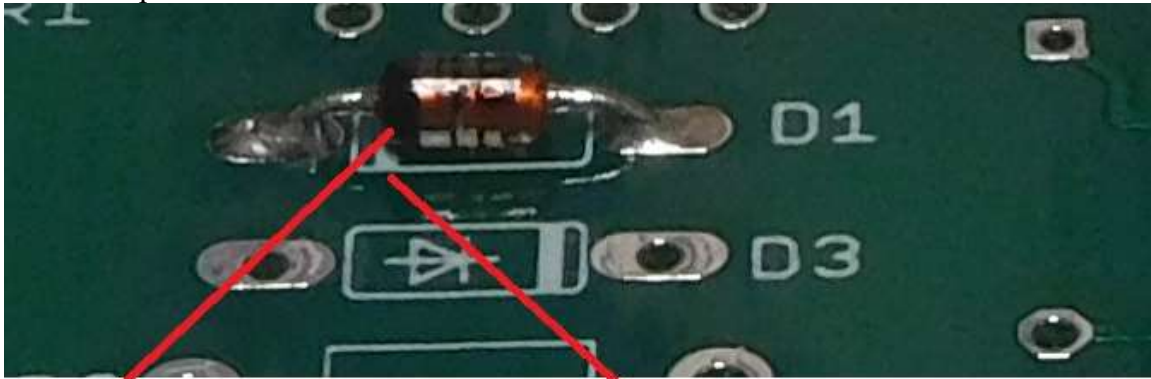
Component Order

You'll notice that the component designations in the directions don't go exactly in order. We have grouped them so that all components with the same value appear together. This makes assembly easier. You'll find in the parts kit that similar parts, e.g. 1N4148 diodes, are typically (though not always) taped together.

Install the Diodes

Install the diodes by placing the body on "resistor" side of the board, and the leads through the indicated holes. Bend the leads over on the back of the board to keep the components from falling out until you solder them in place. Try to bend the leads in a direction that won't lead to solder bridges between traces that should remain disconnected. We recommend the following procedure:

1. Insert all the components of the same value or type.
2. Bend the leads as described above.
3. Solder the leads on the back of the board.
4. Clip the leads.



Black band on diode matches

white band on silk-screen

Figure 3-match black band on diode to white band on silk-screen

Track your progress by placing a check-mark in the done column as you install each diode. The diode leads are spaced at 0.3". If you have a lead bender, this will speed up and neaten your assembly. A lead bender is not required.

Note: Diodes are polarized. Make sure that the banded end of the diode is matched with the band on the silk-screen.			
Desig	Type	Marking	Done <input checked="" type="checkbox"/>
D1	1N4148, switching diode	4148	<input type="checkbox"/>
D2	1N4148, switching diode	4148	<input type="checkbox"/>
D3	1N4148, switching diode	4148	<input type="checkbox"/>
D4	1N4148, switching diode	4148	<input type="checkbox"/>

Install the resistors

Before you install the resistors, we recommend checking them both by color code and with a meter. As Norm Abram of “This Old House” would say, “measure twice cut once”.

Desig	Value	Marking	Done <input checked="" type="checkbox"/>
R5	100	Brown, black, black, black, brown	<input type="checkbox"/>
R6	100	Brown, black, black, black, brown	<input type="checkbox"/>
R27	100	Brown, black, black, black, brown	<input type="checkbox"/>
R14	200	Red, black, black, black, brown	<input type="checkbox"/>
R32	200	Red, black, black, black, brown	<input type="checkbox"/>
R33	200	Red, black, black, black, brown	<input type="checkbox"/>
R7	1K	Brown, black, black, brown, brown	<input type="checkbox"/>
R15	1K	Brown, black, black, brown, brown	<input type="checkbox"/>
R16	1K	Brown, black, black, brown, brown	<input type="checkbox"/>
R17	1K	Brown, black, black, brown, brown	<input type="checkbox"/>
R18	1K	Brown, black, black, brown, brown	<input type="checkbox"/>
R19	1K	Brown, black, black, brown, brown	<input type="checkbox"/>
R20	1K	Brown, black, black, brown, brown	<input type="checkbox"/>
R21	1K	Brown, black, black, brown, brown	<input type="checkbox"/>
R8	2K	Red, black, black, brown, brown	<input type="checkbox"/>
R9	2K	Red, black, black, brown, brown	<input type="checkbox"/>
R10	2K	Red, black, black, brown, brown	<input type="checkbox"/>
R11	2K	Red, black, black, brown, brown	<input type="checkbox"/>
R12	2K	Red, black, black, brown, brown	<input type="checkbox"/>
R13	2K	Red, black, black, brown, brown	<input type="checkbox"/>
R31	4020	Yellow, black, red, brown, brown	<input type="checkbox"/>
R24	10K	Brown, black, black, red, brown	<input type="checkbox"/>
R25	10K	Brown, black, black, red, brown	<input type="checkbox"/>
R3	20K	Red, black, black, red, brown	<input type="checkbox"/>
R4	20K	Red, black, black, red, brown	<input type="checkbox"/>
R22	20K	Red, black, black, red, brown	<input type="checkbox"/>
R29	20K	Red, black, black, red, brown	<input type="checkbox"/>
R26	40K2	Yellow, black, red, red, brown	<input type="checkbox"/>
R23	100K	Brown, black, black, orange, brown	<input type="checkbox"/>
R1	200K	Red, black, black, orange, brown	<input type="checkbox"/>
R2	200K	Red, black, black, orange, brown	<input type="checkbox"/>
R28	--	Neither present nor used	<input type="checkbox"/>
R30	--	Neither present nor used	<input type="checkbox"/>

Install the Integrated Circuits

Install the integrated circuits (ICs), making sure that:

1. they sit flat on the PCB.
2. That the orientation is correct!

For the IC orientation, please refer to Figure 4.

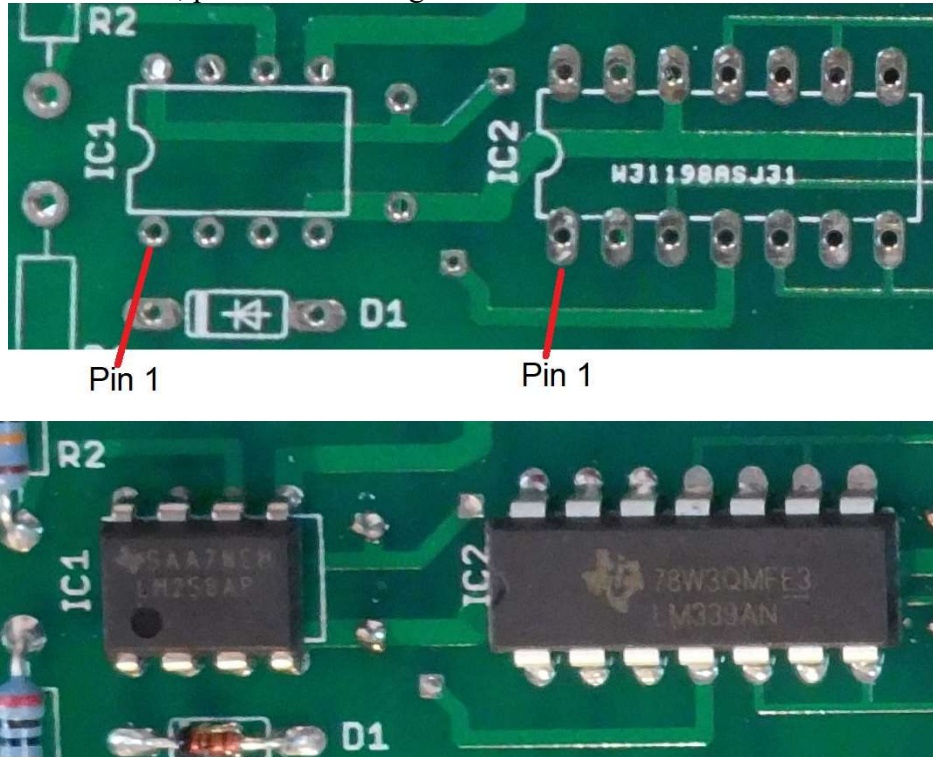


Figure 4-Locating Pin 1 of the ICs

1. Solder just two corner pins at first. Inspect the result to make sure that:
 - a. the IC is sitting flat on the board, and
 - b. All the IC pins are protruding through their holes in the PCB
 - c. Double check that the orientation of the IC has pin 1 in the correct position.
2. Given that just two joints have been done at this point, it's easy to reheat one or both and adjust the IC as needed.
3. When everything looks good, solder the rest of the IC pins.
4. Inspect your work to make sure that every pin has been soldered.

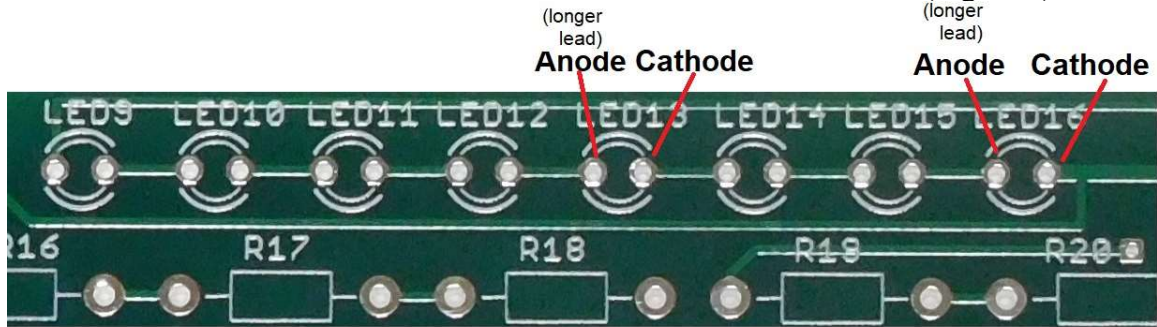
Designation	Value	Description	Done ✓
IC1	LM258AN	Dual Opamp (check part number)	<input type="checkbox"/>
IC2	LM339AN ¹	Quad comparator, open collector output	<input type="checkbox"/>
IC3	LM339AN	Quad comparator, open collector output	<input type="checkbox"/>
IC4	LM339AN	Quad comparator, open collector output	<input type="checkbox"/>
IC5	LM339AN	Quad comparator, open collector output	<input type="checkbox"/>

¹ LM339AN version chosen rather than LM339N as it has lower offset voltage, which makes the most sensitive indicator LED more accurate.

Install the LEDs

Now you'll install the LEDs. LEDs are polarized. Please be careful to insert them with the correct polarity. Here's how you can tell the polarity:

1. Given uncut leads, the slightly longer lead is the anode.
2. Viewed from above, the LED package outline is basically circular, with a flat on one side. That flat side marks the cathode.
3. All the LEDs have the same orientation for Anode and Cathode (Figure 5).



All the diodes have the same orientation of anode/cathode

Figure 5-Anode and Cathode² for the LEDs

4. Note that LED17 will install from the “capacitor” side of the PCB. Its installation is thus covered later in the manual.

For the sake of consistency, try to center the LEDs in their mounting. That will center the LEDs on the holes in the cover. The best way to do this is to just solder one lead of the LED. In that way, it's easy to heat one lead to adjust the LED position. When it's in the right place, solder the second lead of the LED.

Desig	Value	Marking	Done <input checked="" type="checkbox"/>
LED1	T1, green	None, but watch the polarity	<input type="checkbox"/>
LED2	T1, green	None, but watch the polarity	<input type="checkbox"/>
LED3	T1, green	None, but watch the polarity	<input type="checkbox"/>
LED4	T1, green	None, but watch the polarity	<input type="checkbox"/>
LED5	T1, green	None, but watch the polarity	<input type="checkbox"/>
LED6	T1, green	None, but watch the polarity	<input type="checkbox"/>
LED9	T1, green	None, but watch the polarity	<input type="checkbox"/>
LED10	T1, green	None, but watch the polarity	<input type="checkbox"/>
LED11	T1, green	None, but watch the polarity	<input type="checkbox"/>
LED12	T1, green	None, but watch the polarity	<input type="checkbox"/>
LED13	T1, green	None, but watch the polarity	<input type="checkbox"/>
LED14	T1, green	None, but watch the polarity	<input type="checkbox"/>

For the yellow and red LEDs, there is no flat side on the package. The anode is still indicated by the longer of the two leads on the uncut part.



² To further dispel any diode confusion we present the following picture:

Desig	Value	Marking	Done <input checked="" type="checkbox"/>
LED7	T1, yellow	None, but watch the polarity	<input type="checkbox"/>
LED15	T1, yellow	None, but watch the polarity	<input type="checkbox"/>
LED8	T1, red	None, but watch the polarity	<input type="checkbox"/>
LED16	T1, red	None, but watch the polarity	<input type="checkbox"/>

Installing components on the capacitor side of the board

All of the following components get installed on the capacitor side of the board. Look for the corresponding silk-screen markings. You'll install the components listed in this section on from the capacitor side, and solder them on the resistor side.

Install the non-polar capacitors

Install the following box-shaped non-polar capacitors. Because they aren't polarized, you can install them with either orientation.

Desig	Value	Marking	Done <input checked="" type="checkbox"/>
C3	0.1 μ F, 100V film	μ 1J100	<input type="checkbox"/>
C6	0.1 μ F, 100V film	μ 1J100	<input type="checkbox"/>
C7	0.1 μ F, 100V film	μ 1J100	<input type="checkbox"/>
C8	0.1 μ F, 100V film	μ 1J100	<input type="checkbox"/>
C9	0.1 μ F, 100V film	μ 1J100	<input type="checkbox"/>
C10	0.1 μ F, 100V film	μ 1J100	<input type="checkbox"/>
C11	0.1 μ F, 100V film	μ 1J100	<input type="checkbox"/>
C1	1 μ F, 63V film	1J63	<input type="checkbox"/>
C2	1 μ F, 63V film	1J63	<input type="checkbox"/>
C4	1 μ F, 63V film	1J63	<input type="checkbox"/>
C5	1 μ F, 63V film	1J63	<input type="checkbox"/>

Install the polarized aluminum electrolytic capacitors

Make sure that the end marked with the minus signs is away from the plus marking on the silk screen.

Desig	Value	Marking	Done <input checked="" type="checkbox"/>
C12	22 μ F, 35 V	22 μ F, 35 V	<input type="checkbox"/>
C13	22 μ F, 35 V	22 μ F, 35 V	<input type="checkbox"/>

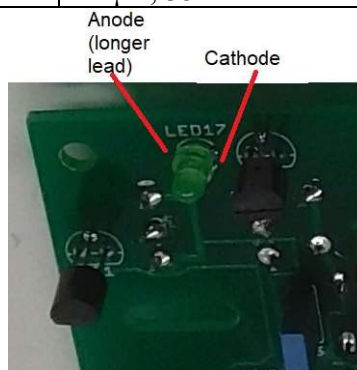


Figure 6-LED17 orientation

Install the LED

There is one LED on the “capacitor” side of the board. Install it now. Be careful to observe the polarity! See Figure 6 for orientation. Remember that before cutting, the anode has the longer lead.

Desig	Value	Marking	Done <input checked="" type="checkbox"/>
LED17	T1, green	None, but watch the polarity	<input type="checkbox"/>

Install the transistors

Install the transistors so that the top of the transistor body is about even with the tops of the 1 μ F box caps. Make sure that the shape of the transistor package matches the shape of the silk-screen outline.

Desig	Value	Done <input checked="" type="checkbox"/>
Q1	2N3906, 40-volt PNP	<input type="checkbox"/>
Q2	2N3906, 40-volt PNP	<input type="checkbox"/>

Install the voltage regulators

Install the TL431 voltage regulators. They come in a package that looks very much like a transistor, so be sure to double check the markings. Install the regulators so that the top of the transistor body is about even with or a bit below the tops of the 1 μ F box caps. Make sure that the shape of the regulator package matches the shape of the silk-screen outline.

Desig	Value	Done <input checked="" type="checkbox"/>
VR1	TL431	<input type="checkbox"/>
VR2	TL431	<input type="checkbox"/>
VR3	TL431	<input type="checkbox"/>

Install the Power Transistor

For the following ICs, cut the ends of these (already soldered) pins short:

IC5 – pins 1, 2, 3, 12, 13, 14

IC4 – pins 4, 5, 6, 9, 10, 11

T1 will be fitted with a heatsink before installation. The first step is to prepare the heatsink. Cut two 1” lengths of the black 1/8” heat-shrink tubing. Slide one piece over the left and right bottom legs of the heat-sink. Shrink the heat-shrink tubing to retain it in place by sliding your soldering iron along the sides of the heat-shrink tubing. The heat sink is symmetric, so the “bottom” designation is arbitrary.

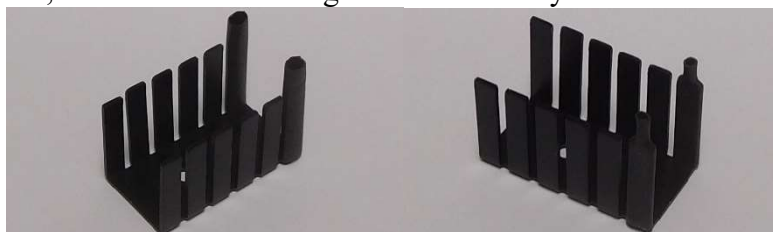


Figure 7-Insulate the bottom legs of the heatsink (before and after shrinking)

Desig	Value	Done <input checked="" type="checkbox"/>
T1	TIP31C, NPN 60V, TO-220	<input type="checkbox"/>

Be sure to follow the silk screen to get the orientation correct. Install T1 perpendicular to the board. Insert the device to where further penetration is stopped by the shoulders of the T0-220 leads.

Use the 6-32x1/4" sems screw and keps nut to fasten the heatsink in place. These fasteners have built-in lock-washers.

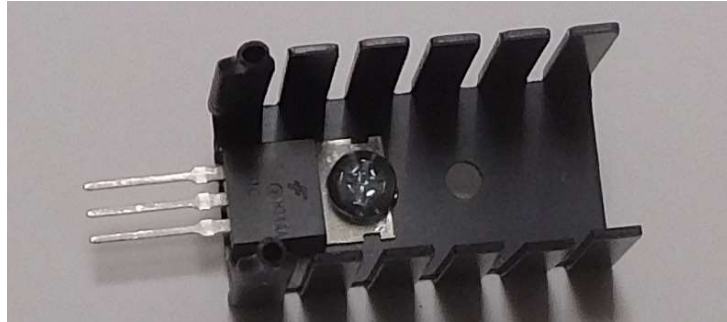


Figure 8-Mounting T1 and its heatsink

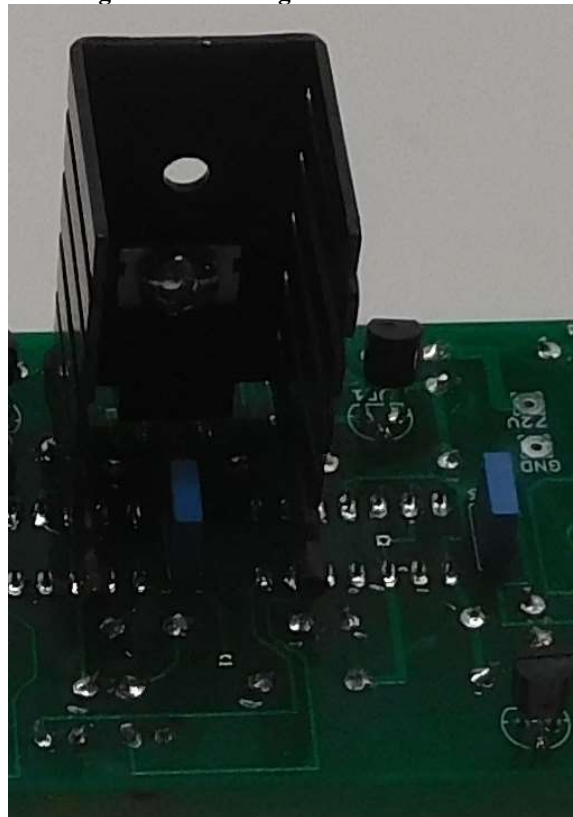


Figure 9-Heatsink Installation. Heat shrink keeps heat sink from shorting to PCB

The heat-sink is connected to the collector of T1. That means it will have 72 volts on it in normal operation. Make sure that the heat-sink cannot come into contact with any other conductive surfaces.

Install the Signal Wires

Connect the input signal wires to the PCB:

1. Cut the supplied yellow 22 AWG wire to a length of about 10 inches. Strip 1/4" of insulation from both ends.

2. Insert one end of the yellow wire into LFTIN eyelet on the capacitor side of the board, and solder it on the resistor side. Cut off the extra length of wire that protrudes through the board.
3. Cut the supplied Brown 22 AWG wire to a length of about 12 inches. Strip $\frac{1}{4}$ " of insulation from both ends.
4. Insert one end of the brown wire into RTIN eyelet on the capacitor side of the board, and solder it on the resistor side. Cut off the extra length of wire that protrudes through the board.

Install the Power Wires

Connect the power wires to the PCB:

1. Strip $\frac{1}{4}$ " from all four ends (2 red, 2 black) of the supplied 12" length of red/black 22 AWG twisted wire.
2. Insert one end of the **red** wire into the **72V** eyelet on the capacitor side of the board, and solder it on the resistor side. Cut off the extra length of wire that protrudes through the board.
3. Insert one end of the **black** wire into **GND** eyelet on the capacitor side of the board, and solder it on the resistor side. Cut off the extra length of wire that protrudes through the board.

Install the standoffs

Standoffs are installed using 4-40x $\frac{1}{4}$ " sems screws. These are silver colored screws with built-in lockwashers. Insert the screw into the capacitor side of the PCB. Insert the standoff onto the resistor side of the PCB. Attach all 6 standoffs. For now, center the stand-off in the slotted hole. You'll move it later if it is needed.

Depending on the hole pattern you found at the beginning of this manual, you will use between 2 and 4 of the 4-40x $\frac{3}{16}$ " black-oxide screws to fasten the standoffs to the cover of your Stereo 120. This will be done in a later section of the manual.

Installing the VU Meter into your Stereo 120

Disconnect your Stereo 120 from your music system. In particular, make sure the AC plug is not plugged in.

<i>IMPORTANT – Make sure that the AC plug is not plugged in!</i>
--

1. Turn your Stereo 120 bottom side up.
2. Remove the four screws in the bottom of the chassis that hold the perforated metal cover in place.
3. Hold the cover and chassis together and invert the combination.
4. Lift the perforated metal cover straight up.

Connecting the power wires

You will connect the red/black twisted pair power wires to C12, the 72-volt output that supplies power to the amplifier modules.

1. Solder the red wire to the positive terminal of C12 (there may be multiple positive terminals of C12 if you've installed the C12 upgrade kit).

2. Solder the black wire to the negative terminal of C12 (there may be multiple negative terminals of C12 if you've installed the C12 upgrade kit).

Connecting the signal wires

You will connect the brown and yellow signal wires to the red speaker binding posts.

1. Solder the brown wire to the red binding post for the right channel.
2. Solder the yellow wire to the red binding post for the left channel.

Fasten the PCB to the perforated metal cover

Locate the PCB inside the perforated metal cover as shown in Figure 10.

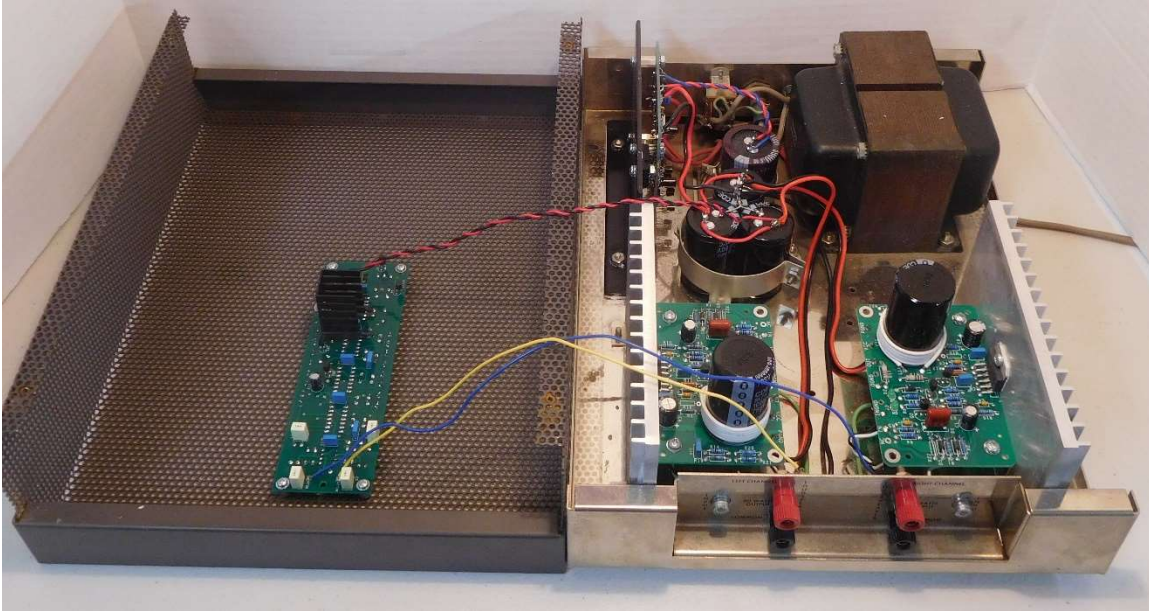


Figure 10-Mounting the PCB inside the cover

Four-hole mounting method

Use 4 of the 3/16" black oxide 4-40 screws, inserted from the outside of the cover into each of the 4 standoffs at the outside of the PCB. You may have to drill out (expand) the holes in the cover if they are too small for the black oxide 4-40 screws. Use a 1/8" drill bit.

Three-hole mounting method

Use 3 of the 3/16" black oxide 4-40 screws, inserted from the outside of the cover into the 2 standoffs on one end of the board and into the slotted hole standoff on the other end of the board. You may have to adjust the position of the standoff in its slot. You may also have to drill out (expand) the holes in the cover if they are too small for the black oxide 4-40 screws. Use a 1/8" drill bit.

Two-hole mounting method

Use 2 of the 3/16" black oxide 4-40 screws, inserted from the outside of the cover into each of the 2 standoffs located into the center of the short sides of the PCB. One of these is the slotted hole. Adjust the standoff that mounts in the slot to line up with a hole in the cover. You may have to try it a couple of times. When everything lines up well, then tighten up the PCB-side screw in the slot. Use two screws inserted through the cover into

these standoffs. The other 4 standoffs will keep the board from tipping, but they will not have black oxide mounting screws.

Re-assemble your power amp and pre-test your work

Return the cover and PCB combination to its normal position on the amplifier. You'll now execute the pre-test:

1. Ensure that the amp is off.
2. Plug the amp in.
3. Turn the amp on.

Be careful – stay away from the 120 or 240 volts AC now present inside the amplifier when power is on. Also stay away from the 72V DC on capacitor C12 and the amplifier boards.

If all is well:

1. There will be no smoke, bangs, pops, or other drama.
2. A few of the lower level lights will light up while the amplifier's operating point stabilizes.
3. All of the lights will go dark.

If everything looks good:

1. Turn the amp off.
2. Unplug the amp.
3. Wait for one minute for the capacitors to discharge.
4. Hold the amp and cover together as you invert the amp.
5. Install the 4 screws that hold the cover in place.
6. Return the amp to service in your system.

Theory of Operation

Changing the level indicator sensitivity

You can change the input voltage that turns on the red light by changing the value of R1 and R2. When R1=R2=200K, the red light comes on with about 19-20 Volts RMS

coming into either LFTIN or RTIN. This is equivalent to $\frac{V_{rms}^2}{R_{load}} = \frac{20^2}{8} = 50$ Watts.

You can solve for the new value of R1 and R2 for other sensitivities using this equation:

$$R1orR2New = \frac{V_{rms}(new)}{20} \cdot 200000$$

Using other than 72 Volts

You can use the level indicator with DC input voltages different than 72 volts.

- For voltages greater than 60 Volts, no changes are needed.
- For voltages between 37 and 60 volts, change R22 from 20K to 6.49K.
- Other voltages may be possible. Consult with Updatemydynaco for more details.

Circuit Description

Figure 11 shows the input amplifiers and precision rectifiers that produce a voltage proportional to the peaks of the input signal. The following discussion refers to the top

half of the figure and the left channel. However, the bottom of the figure and right channel works similarly.

C1 blocks any DC voltage in the input signal. R1 and R3 set the gain to the input signal. D1, D3, and IC1A form a precision rectifier that charges C4 to a voltage proportional to the peaks of the input signal, LFTPk.

LFTPk drives a string of comparators that drive the LEDs. Each comparator has a 2.5 Volt reference voltage created by VR2 and the R-2R ladder created by R7-R13 and R15-R21. The reference for the bottom comparators is 2.5 volts (with respect to Vmid). Each capacitor up the string has a voltage that is diminished by a factor of $\frac{1}{2}$. The smallest voltage is 2^{-7} times 2.5, or 19.53 mV. Due to the unavoidable offset voltage in the circuit, the lowest level may be a bit off of the ideal threshold, but each successively higher threshold is more accurate.

Notice that all the LED's for a given side are in series. The comparators have open collector outputs. They bring the nodes between the series LEDs to ground as the level varies. For example, with no input signal, all of the comparator outputs are low, including IC2A pin 2, and no current flows through the LED string.

When the input voltage causes LFTPk to exceed 19.53 mV, then IC2A pin 2 becomes open, and current flows through LED1. As the input signal increases, more and more of the comparator outputs become open circuits, and more of the LEDs illuminate. Finally, when input is large enough that LFTPk exceeds 2.5 volts, all the comparator outputs become open circuits, and the current from Q1, LFTILED, flows through, and illuminates all of the LEDs in the left channel string.

R22-R24, R27, VR1 and T1 make a 27-volt rail that runs the circuit. LED17, R29, Q1 and Q2 make the current sources that run the LEDs and set their brightness. VR3, C12, R25 and R26 generate a midpoint voltage VMID for the opamps of about 12.5 volts DC. REF2P5, generated by VR2, is 2.5 volts above VMID.

It's interesting to note that this is an inherently low noise circuit in that the power supply current drain is independent of the number of illuminated LEDs.

A Troubleshooting Note

For a given channel, all of the LEDs are in series. If you find that the low signal indicating LEDs light, e.g. just LED9 and LED10, but not LED11-LED16, then the problem is somewhere in the LED11-LED16 string. Most likely LED11, or one of its associated connections, if LED11 is the first one not to work. Perhaps a backwards LED, perhaps an unsoldered lead on an LED. Of course, there may be other faults that would cause a similar symptom, but this possibility is worth eliminating.

Schematics

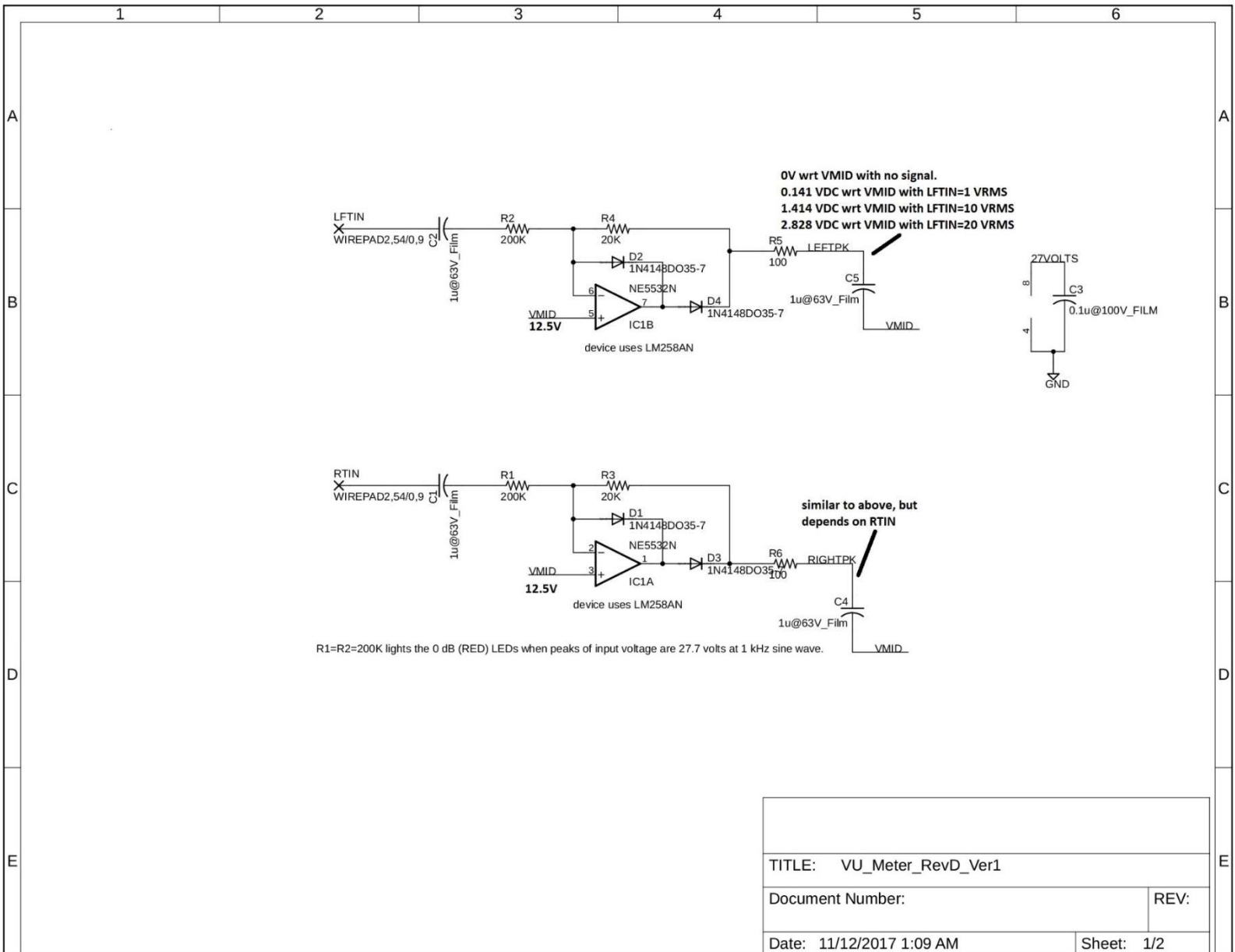


Figure 11-VU meter schematics, page 1

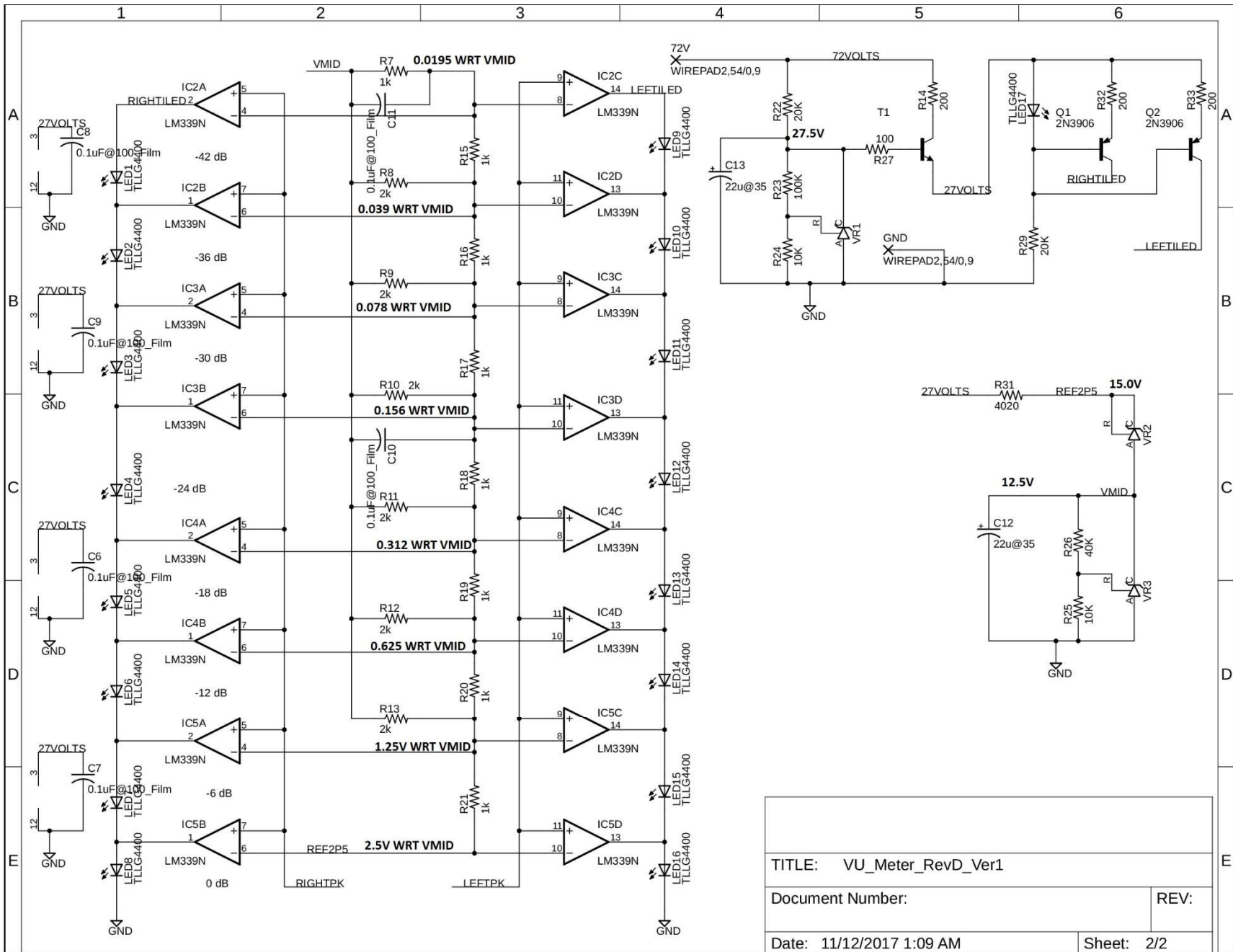


Figure 12-VU meter schematics, page 2

Appendix 1: The Toothpick Trick

This appendix describes an easy way to clear the solder from a hole in the PCB. It can also be used to clear the solder from terminals on pots or jacks. Doing so makes it easier to install a new component, or reinstall wires that were temporarily removed to allow access to some other component.

All you'll need is a soldering iron and some toothpicks with sharp points. The diameter of the pointed part of the toothpick must be smaller than the diameter of the hole that you're trying to clear.

Heat the solder land on the component side of the board until the solder flows. Insert the toothpick from the component side of the board while pushing and twisting the toothpick. If the solder has melted, the toothpick should push through the board, displacing the solder. Remove the soldering iron, but let the toothpick remain in the hole until the solder has solidified. Now remove the toothpick. There should be a hole through the solder sufficiently large to allow you to insert the component lead or wire.

Sometimes, a bit of the toothpick will break off in the hole. If this happens, use a stiff piece of wire to push the toothpick fragment out of the hole.

Appendix 2 - Resistor Color Code



Figure 13-demonstrating the resistor color code

Here's an extreme close-up of a $\frac{1}{4}$ W metal film 20K (20,000) Ohm resistor, designated by the standard resistor color code.

The colors map to numbers:

Color	Number
Black	0
Brown	1
Red	2
Orange	3
Yellow	4
Green	5
Blue	6
Violet	7
Gray	8
White	9

The color band positions have the following meaning:

Position	Meaning
1	Left-most Digit (e.g. most significant)
2	Next digit to the right
3	Next digit to the right.
4	Number of zeros that follow the three digits, unless: <ul style="list-style-type: none"> • Band 4 is gold => multiply by 0.1 • Band 4 is silver=> multiply by 0.01
5	Tolerance: <ul style="list-style-type: none"> • Violet => 0.1% • Brown =>1% • Red => 2% • Gold=> 5% • Silver=>10%