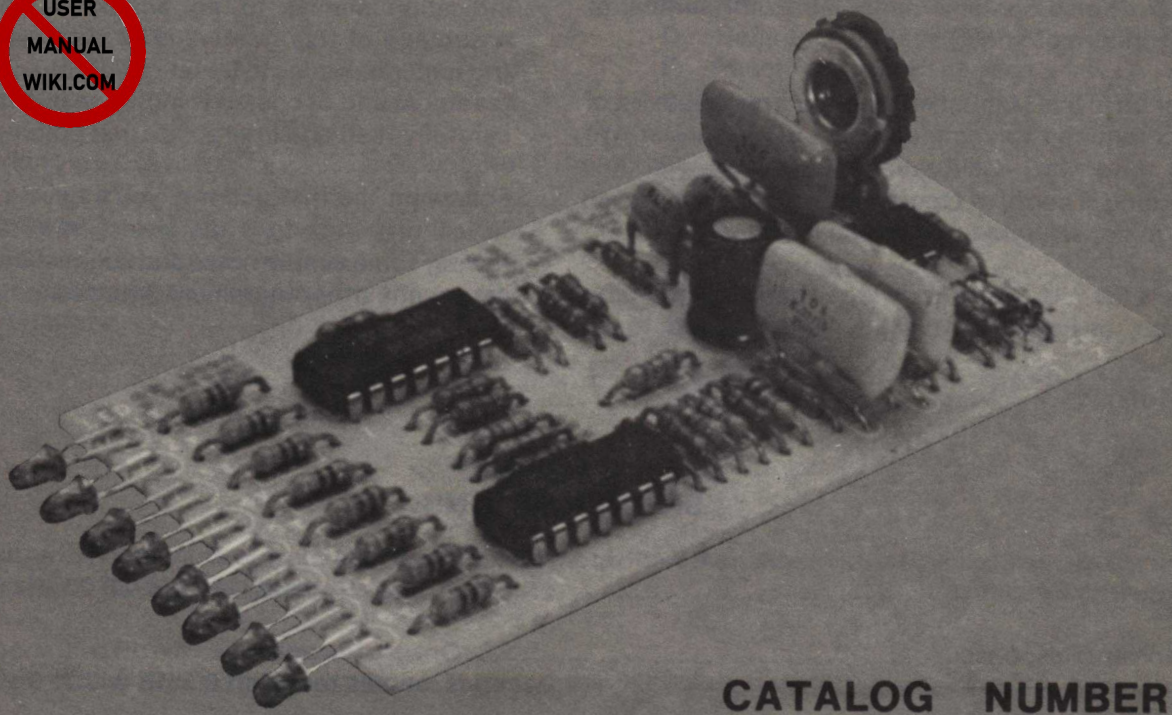
LED VU METER

project-board®

ARCHER®



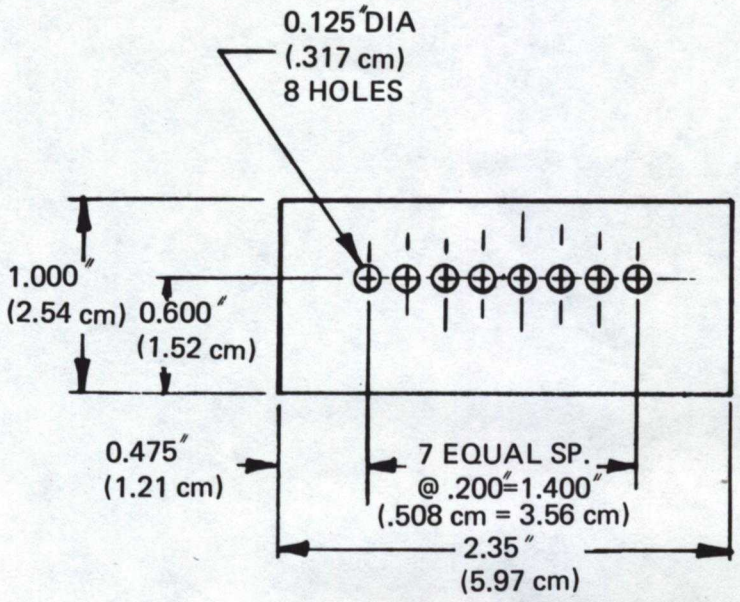
CATALOG NUMBER
277-116

The Project Board VU METER is an add-on component for an audio system. Utilizing a highly visible, rapidly responding string of LED's, the Project Board VU METER provides distinct advantages over standard type VU meters. It will respond to audio voltages and indicate differences of 3 dB (or less). It's linearity and accuracy are typically superior to a conventional VU meter.

The photograph is of a completed project, when built with the recommended Radio Shack parts. This package contains only the Printed Circuit Board and Panel Labels for vertical and/or horizontal mounting, plus instructions.

CUSTOM MANUFACTURED IN U.S.A. BY RADIO SHACK A DIVISION OF TANDY CORPORATION

DRILL TEMPLATE

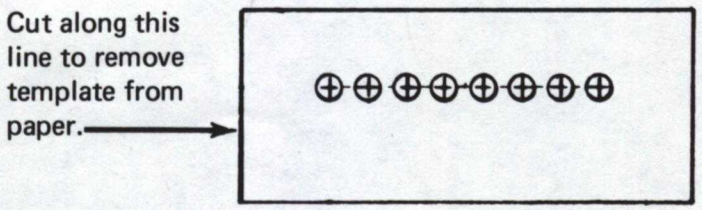


NOTE: We suggest that you measure the diameter of the LED before drilling. The LED you have may be slightly larger or smaller than the hole sizes called out in the drill template.

Use the drawing below as a template to drill the holes needed for mounting the VU METER.

Place the drawing over the area to be drilled and tape in place. Note that both a vertical and horizontal front panel label have been provided.

Center punch and drill the holes



IMPORTANT CONSTRUCTION NOTE

Before you start mounting parts on the Printed Circuit Board, we recommend that you thoroughly clean the foil side with fine or ultra-fine steel wool. When all copper is bright and clear, then start mounting parts and solder wires & leads. **Be sure you don't leave any stray pieces of steel wool on the Board.**

RADIO SHACK
Fort Worth, Tx.

INTRODUCTION

This package contains a complete circuit card for constructing a Light Emitting Diode (LED) VU Meter. It also contains panel labels for vertical or horizontal mounting.

Later on in this Manual we give you a complete list of parts required to complete this LED VU Meter. We also give you Calibration, Operation, Trouble Shooting, Theory of Operation, and diagrams to aid you in construction and application.

This LED VU Meter is a logarithmic responding device, designed specifically to be added to an existing electronic circuit system. Connect an audio voltage to the input and you'll obtain an output indication similar to an analog VU Meter. An advantage of this "meter" is its fast response time (no meter ballistics to upset rapidly changing signal readings) and of course is highly visible (no need to carefully read and interpolate that pointer reading).

Following the instructions, you'll have a VU Meter which responds to 3 dB levels; however, by following some simple notes and suggestions, you can set up any other increment you desire.

SPECIFICATIONS

Frequency Response ..... 20–20,000 Hz +0, -1 dB

Transient Response ..... Onset of steady tone: 1.6 dB overshoot at 0.05 seconds, settles to within 0.5 dB within 0.1 second.

Accuracy ..... ±0.4 dB per step maximum, ±0.15 dB per step typical.

Input Impedance
IN1 ..... 1 Meg Ohm
IN2 ..... 100K Ohm

Sensitivity ..... See table below.
Sensitivities specified in the table are for the threshold of the next to last LED to light (0 dB). Lowest level LED thresholds are 18 dB lower.

		INPUT 1 (IN1)		INPUT 2 (IN2)	
V_{cc}	POWER DRAIN	With R38 Set for Minimum Gain	With R38 Set for Maximum Gain	With R38 Set for Minimum Gain	With R38 Set for Maximum Gain
5V	3-55 mA	2.25 V RMS	25 mV RMS	225 mV RMS	2.5 mV RMS
9V	3-110 mA	4 V RMS	40 mV RMS	400 mV RMS	4 mV RMS
12V	3-135 mA	5.5 V RMS	55 mV RMS	540 mV RMS	5.5 mV RMS
15V	3-150 mA	6.8 V RMS	70 mV RMS	675 mV RMS	7 mV RMS

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PARTS LIST

Unless you substitute parts by your own decision, no parts other than those listed in these instructions are needed to build the LED VU Meter Project Board.

SYMBOL	DESCRIPTION	QUANTITY	RADIO SHACK CATALOG NUMBER
C1, C2	0.01 µF Disc Capacitor	2	272-131
C3, C5, C6	0.22 µF Printed Circuit Capacitor	3	272-1070
C4	10 µF Electrolytic Capacitor	1	272-952
CR1, CR2	1N914/1N4148 Diodes	2	276-1122
LED1-8	Light Emitting Diodes	8	276-042
R1 - R8, R28	470 Ohm (Yellow, Violet, Brown) 1/4-W, 5%	9	271-1300
R9	4.7K (Yellow, Violet, Red) 1/4-W, 5%	1	271-1300
R10, 11, 14, 17 18, 20, 21	270 Ohm (Red, Violet, Brown) 1/4-W, 5%	7	271-1300
R12, 13, 15, 16 19, 22, 23	2.2K (Red, Red, Red) 1/4-W, 5%	7	271-1300
R24, R29	10K (Brown, Black, Orange) 1/4-W, 5%	2	271-1300
R25	1K (Brown, Black, Red) 1/4-W, 5%	1	271-1300
R26, 27, 30, 31 34, 35, 36, 37	100K (Brown, Black, Yellow) 1/4-W, 5%	8	271-1300
R32	27K (Red, Violet, Orange) 1/4-W, 5%	1	271-1300
R33	33K (Orange, Orange, Orange) 1/4-W, 5%	1	271-1300
R38	100K Trim Potentiometer	1	271-220
R39	1 Meg (Brown, Black, Green) 1/4-W, 5%	1	271-1300
Z1, Z2	Integrated Circuit Comparators, RS339	2	276-1712
Z3	Integrated Circuit Quad Op-Amp, RS324/LM324	1	276-1711

IMPORTANT CONSTRUCTION NOTE: The foil areas on this board are extremely small and many are very close together. It is vital that you use:

A. Superior solder.
B. Fine gauge solder (thinner the better)
C. A low wattage iron (DO NOT USE A SOLDER GUN).
D. An iron with a small tip.

If you do not follow these suggestions, you will end up with solder "bridges", questionable connections and maybe even lifted foil paths.

MOUNTING OF PARTS ON PRINTED CIRCUIT BOARD

The following lists provide the recommended sequences for the mounting of parts to the Project Board.

To aid you with your construction, a "check box" has been provided at the left of each part listing. Check off each "box" ☑ as you mount that part.

Mount the following resistors:

☐ R1, 470 Ohm (Yellow, Violet, Brown)
☐ R2, 470 Ohm (Yellow, Violet, Brown)
☐ R3, 470 Ohm (Yellow, Violet, Brown)
☐ R4, 470 Ohm (Yellow, Violet, Brown)
☐ R5, 470 Ohm (Yellow, Violet, Brown)
☐ R6, 470 Ohm (Yellow, Violet, Brown)
☐ R7, 470 Ohm (Yellow, Violet, Brown)
☐ R8, 470 Ohm (Yellow, Violet, Brown)

☐ Turn the board over and solder. Trim off excess lead length.

☐ R9, 4.7K (Yellow, Violet, Red)
☐ R10, 270 Ohm (Red, Violet, Brown)
☐ R11, 270 Ohm (Red, Violet, Brown)
☐ R12, 2.2K (Red, Red, Red)
☐ R13, 2.2K (Red, Red, Red)
☐ R14, 270 Ohm (Red, Violet, Brown)
☐ R15, 2.2K (Red, Red, Red)
☐ R16, 2.2K (Red, Red, Red)
☐ R17, 270 Ohm (Red, Violet, Brown)
☐ R18, 270 Ohm (Red, Violet, Brown)

☐ Turn the board over and solder. Trim off excess lead length.

Continue with resistor mounting:

☐ R27, 100K (Brown, Black, Yellow)
☐ R28, 470 Ohm (Yellow, Violet, Brown)
☐ R29, 10K (Brown, Black, Orange)
☐ R30, 100K (Brown, Black, Yellow)
☐ R31, 100K (Brown, Black, Yellow)
☐ R39, 1 Meg (Brown, Black, Green)
☐ R19, 2.2K (Red, Red, Red)
☐ R20, 270 Ohm (Red, Violet, Brown)
☐ R21, 270 Ohm (Red, Violet, Brown)
☐ R22, 2.2K (Red, Red, Red)

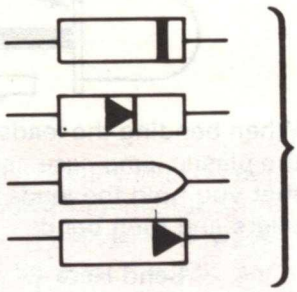
☐ Turn the board over and solder. Trim off excess lead length.

☐ R23, 2.2K (Red, Red, Red)
☐ R24, 10K (Brown, Black, Orange)
☐ R25, 1K (Brown, Black, Red)
☐ R26, 100K (Brown, Black, Yellow)
☐ R32, 27K (Red, Violet, Orange)
☐ R33, 33K (Orange, Orange, Orange)
☐ R34, 100K (Brown, Black, Yellow)
☐ R35, 100K (Brown, Black, Yellow)
☐ R36, 100K (Brown, Black, Yellow)
☐ R37, 100K (Brown, Black, Yellow)

☐ Turn the board over and solder. Trim off excess lead length.

The parts you will mount next are diodes, THESE PARTS MUST BE INSTALLED WITH THE BANDED END (CATHODE) POSITIONED AS INSTRUCTED.

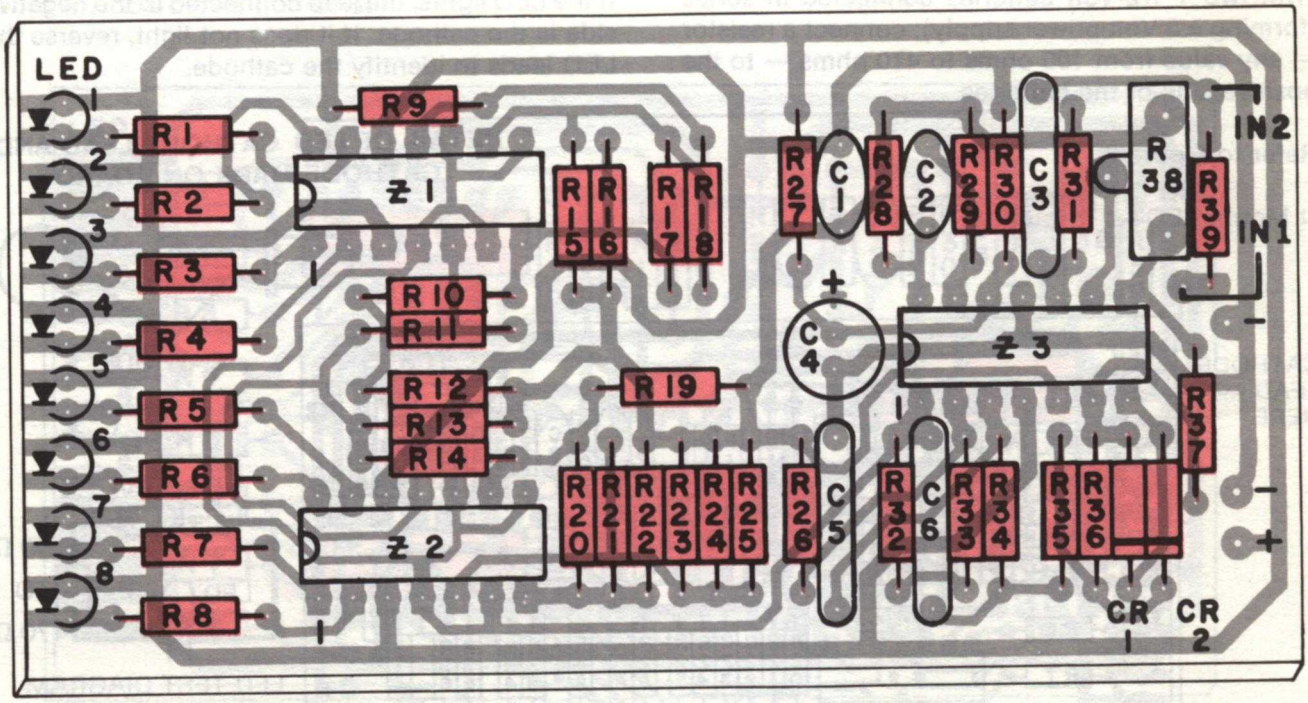
The banded end may be identified by any of the markings commonly used on diodes as shown in the detail:



Mount the following diodes:

☐ CR1 and CR2, 1N914 or 1N4148.

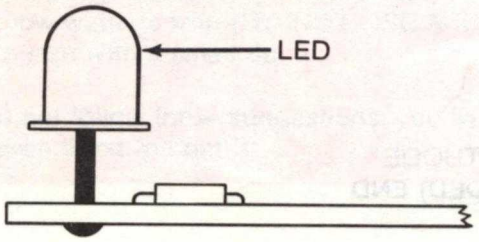
☐ Turn the board over and solder.
Trim off excess lead length.



RESISTOR AND DIODE MOUNTING
Figure 1.

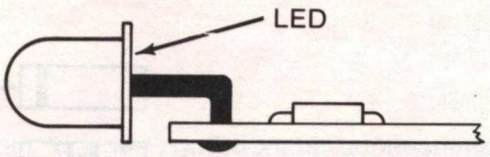
The LED's can be mounted vertical or horizontal to the Printed Circuit Board depending on how you intend to mount the unit in your equipment.

Vertical Mounting

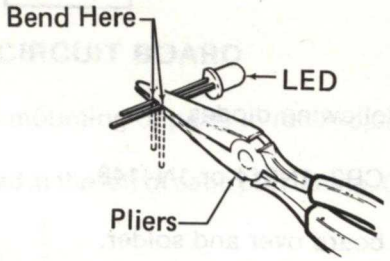


If you mount the LED's in this fashion, make sure that you allow enough lead length to permit the LED to stand up taller than the tallest part (component) on the Printed Circuit Board and then to penetrate the front panel of the unit in which it is to be installed.

Horizontal Mounting



When bending the leads of the LED, BE CAREFUL: the plastic lamp case can be damaged. We suggest that you hold the leads with a pair of needle-nose pliers and then bend.



LED Cathode Lead Identification:

Due to the reluctance of manufacturers to standardize the method of cathode and anode lead identification, it is advisable for you to test them. This can be done in the following manner:

With two 1 1/2-volt batteries connected in series (forming a 3 Volt power supply), connect a resistor — any value from 100 ohms to 470 ohms — to the positive side of the batteries.

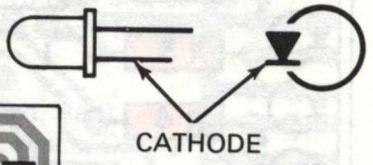
Test the LED's by connecting one lead of the LED to the negative side of the batteries and the other lead to the resistor which is connected to the positive side.

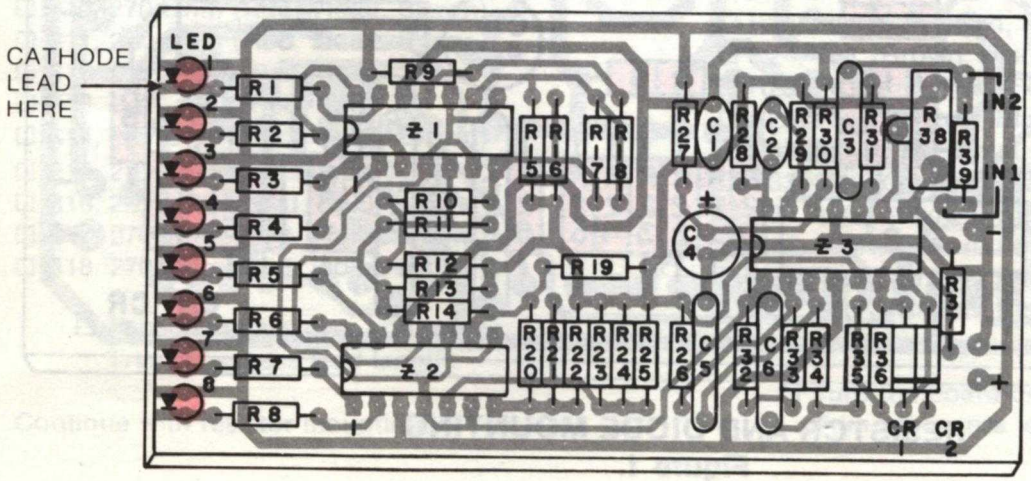
If the LED lights, the lead connected to the negative side is the cathode. If it does not light, reverse the LED leads to identify the cathode.

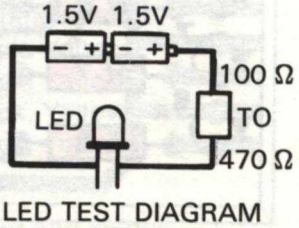
Refer to Figure 2.

□ Mount LED's 1 through 8.

DETAIL OF LED CATHODE LEAD AND CATHODE MARK ON BOARD





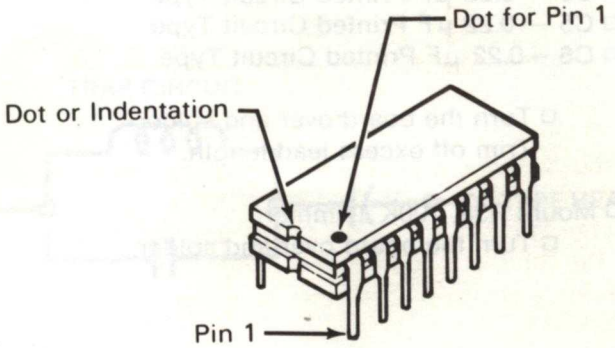


LED TEST DIAGRAM

LED MOUNTING
Figure 2.

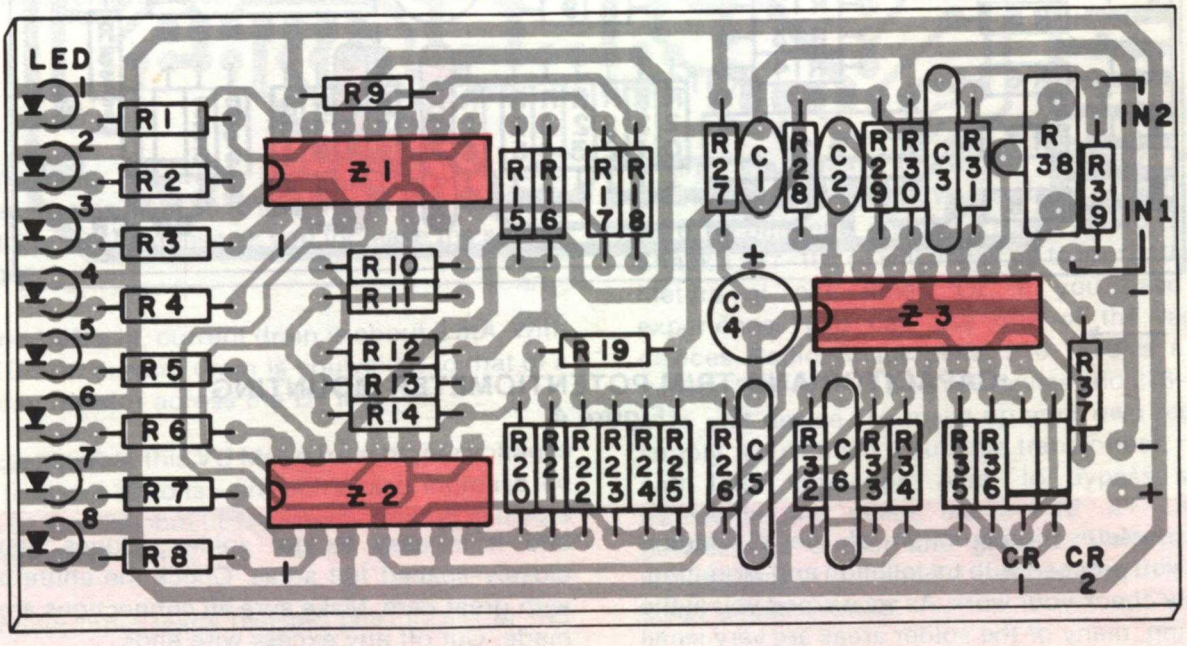
Next install the Integrated Circuits. With any IC, you must take care when handling them. When installing, make sure the leads are straight and that all leads protrude through the holes in the Printed Circuit Board.

NOTE: A dot or indentation at one end indicates pin 1. Line up the dot and/or indentation with the mark on the P. C. Board. Always DOUBLE-CHECK to be sure the IC's are positioned properly.



Refer to Figure 3.

- ☐ Z1-Comparator Integrated Circuit, RS339.
- ☐ Turn the board over and solder.
- ☐ Z2-Comparator Integrated Circuit, RS339.
- ☐ Turn the board over and solder.
- ☐ Z3-Quad Op-Amp Integrated Circuit, RS324.
- ☐ Turn the board over and solder.



INTEGRATED CIRCUIT MOUNTING
Figure 3.

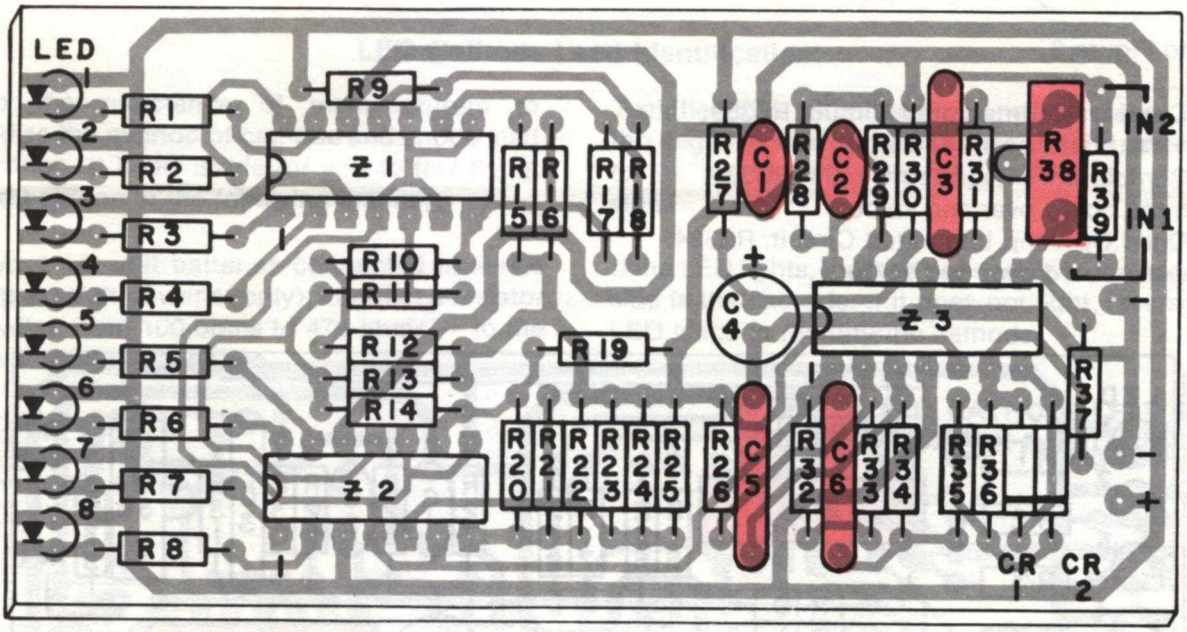
The next components you are going to mount are the Capacitors and the Trimmer Potentiometer R38.

Refer to Figure 4. Mount the following capacitors:

- ☐ C4 — 10 μF Electrolytic. Electrolytic Capacitors have + and/or - markings on them. You MUST be sure to get + and/or - leads into the correct holes.
- ☐ C1 — 0.01 μF Disc
- ☐ C2 — 0.01μF Disc
- ☐ C3 — 0.22 μF Printed Circuit Type
- ☐ C5 — 0.22 μF Printed Circuit Type
- ☐ C6 —0.22 μF Printed Circuit Type

  - ☐ Turn the board over and solder. Trim off excess lead length.

- ☐ Mount R38, 100K Trimmer.
  - ☐ Turn the board over and solder.



CAPACITOR AND TRIM POTENTIOMETER MOUNTING
Figure 4.

This completes construction of the VU Meter. Before you proceed with Installation and Mounting, carefully check your work. As we warned you at the beginning, many of the solder areas are very small and it is easy to get solder bridges between closely-spaced foil areas. Check the entire board with great care. Make sure all connections are well made. Cut off any excess wire ends.

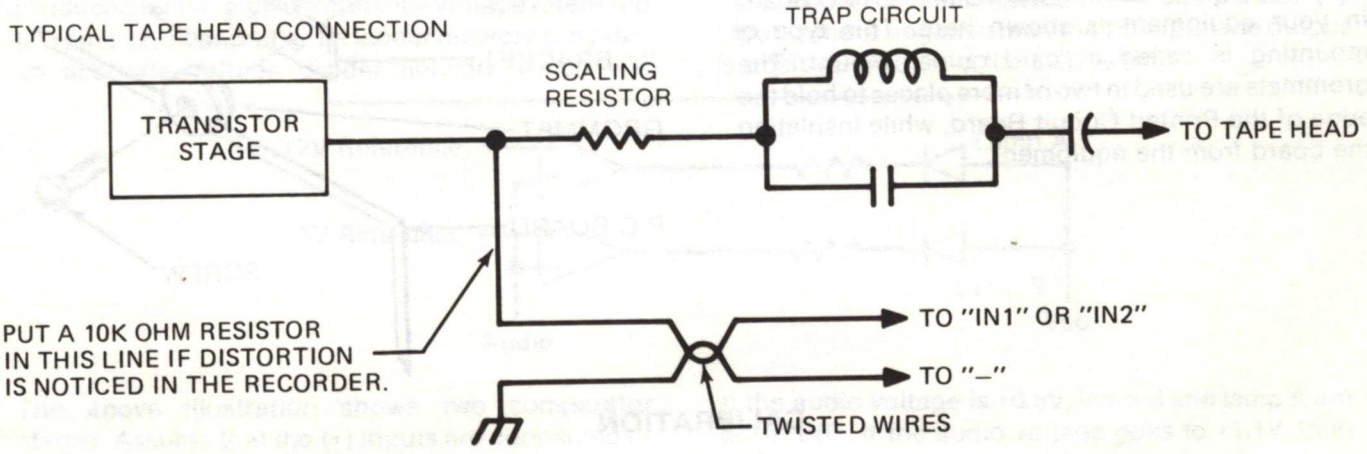
Are you sure everything is OK? Proceed to the next page.

INSTALLATION

INPUT CONNECTIONS

Two inputs are provided: IN1 is for high level signals and has an input impedance of about 1-Megohm. IN2 is for lower level signals and has an input impedance of about 100K ohms. Look at the Specifications for input sensitivity specifications.

For stable readings, the input leads should be twisted wires or a shielded cable. Be sure to connect the signal wire to IN1 or IN2 and the ground wire to (-). DO NOT connect the cable between IN1 and IN2. Keep the leads as short as possible to minimize noise and other interference.



Other Applications: Make connections as short as possible.

1. Pre-Amp: Connect the Output terminals (or jacks) to the VU Meter IN1 or IN2.
2. Receiver/Amplifier: Connect the speaker terminal to the VU Meter IN1 or IN2.

POWER CONNECTION

The VU Meter requires a DC source of 5-15 volts (current drains from 50 to about 150 mA). Note that sensitivity will decrease as you increase the supply voltage.

With no LED's lit, current drain is about 3 mA. With all LED's lit, current drain is equivalent to that of a 100 ohm resistor across the B+ line.

You can operate this VU Meter from higher voltages — 16 to about 30 volts — in such a case, increase the value of the 470 ohm LED current-limiting resistors to about 1000 ohms.

- ☐ Connect Input leads (twisted pair) to IN1 or IN2 and adjacent "-" (ground) point.
- ☐ Connect DC power to "+" and "-".

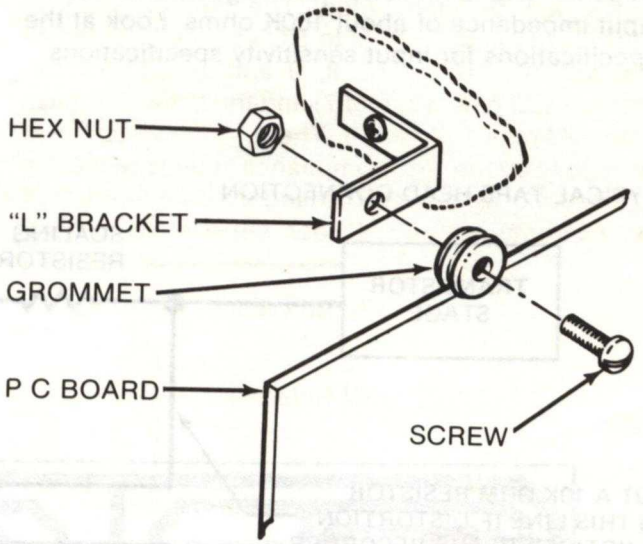
If the equipment to which you are making connection does not have a suitable power supply, we'd recommend another Project Board — Radio Shack's 277-102 (it will power up to four of these VU Meters at one time). Or, if you have some experience, you can use one of the regulator devices Radio Shack sells: 276-1770 is a 5 volt device, 276-1771 is a 12 volt device and 276-1772 is a 15 volt device. To make up your own regulated supply, you'll need a suitable transformer, rectifier and filter capacitor. Also, to bypass start-up transients and noise, use a 0.22 μF capacitor between its output and ground. Make sure the power supply common (-) is connected to the audio stage signal ground.

MOUNTING

Use the drill template supplied on the separate sheet to mark and drill your panel at a location where you want to mount your LED VU METER. Follow the directions on the drill template.

Once you have drilled the hole(s), apply a thin coat of glue (R.S. Cat. No. 64-2309) approximately 1/4 inch in from the edges of the back side of the decal label. Align the decal label over the holes, press in place and allow the glue to dry.

One method of mounting the VU METER PC Board in your equipment is shown here. This type of mounting is called a "card guide" mount. The grommets are used in two or more places to hold the edge of the Printed Circuit Board, while insulating the board from the equipment.



CALIBRATION

The sensitivity of the meter is adjustable over a range noted in the specs. This is accomplished with the trimmer resistor R38 (after the installation is complete).

R38 should be adjusted with a screwdriver to avoid your body affecting the signals. DO NOT set R38 completely clockwise or counter clockwise.

Tape Head Installation: Record a constant signal at various volume settings. Play back and note the volume setting that created audible distortion. Now adjust R38 so that the +3 dB light is on at that level. A signal that causes the 0 dB light to come on should not result in audible distortion. As a suggestion, an AM radio station recorded with a microphone can provide a fairly constant signal source. If you are replacing an existing VU Meter movement, you can compare readings between the LED VU Meter and the original meter movement (and thus achieve suitable calibration).

Pre-Amp or Power Amp Installation: With the VU Meter connected to the Pre-Amp or Power Amp outputs, apply a constant signal through the system at various volume settings. Note the point at which audible distortion is created and adjust R38 so that the +3 dB light comes on at that level. 0 dB should not result in distortion.

With this calibration, the Meter responds from 18 dB below to 3 dB above system saturation.

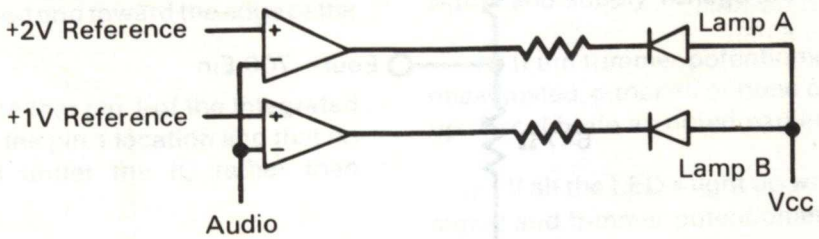
NOTE: If the meter sensitivity is too low and you are not able to calibrate the unit to +3 dB, move the signal input wire from IN1 to IN2, which lowers the input impedance to 100K and raises the sensitivity by 20 dB.

Also note that sensitivity can be decreased by lowering the value of R9 (4700 Ohm) or increased by raising the value of R9.

THEORY OF OPERATION

The VU METER consists of circuits which convert the audio signal to a DC voltage. This voltage is compared to a reference voltage. As the audio voltage becomes equal to the reference voltage, the LED's will be illuminated. The circuits used to convert the audio signal to DC voltages consist of the amplifier (Z3, pins 8, 9 and 10), the active rectifier (Z3 pins 5, 6 and 7) and the active low pass filter (Z3 pins 1, 2 and 3). The reference voltage is produced by the high compliance voltage reference (Z3 pins 12, 13 and 14). The ladder network provides an accurate voltage divider network which will provide different reference voltages in 3 dB steps to each of the eight comparator stages. The comparator stages are provided in Z2 and Z1 (quad comparators).

The comparator IC operates as follows: When the minus input (-) is equal to or has a more positive signal than the plus input (+), the output is caused to switch towards ground. This ground signal causes the LED to be illuminated. If the comparator (-) input is more negative than the (+) input, the output is positive (Vcc) and the LED is off.



The above illustration shows two comparator stages. Assume that the (+) inputs are connected to a reference voltage source with two taps, one at +1V and one at +2V. The audio voltage may vary from zero volts to +2.5V.

If the audio voltage is +0.5V, lamp B and lamp A are both "off". If the audio voltage goes to +1.1V, then lamp B is "on" and lamp A is still "off". If the audio voltage then goes to +2.1V, both lamp B and lamp A are "on". With this in mind, let's look at the individual circuit breakdown.

AUDIO CONVERSION CIRCUITS

Amplifier: The input amplifier stage allows the sensitivity of the VU METER to be set and prevents excessive loading of the signal source by offering a 1 Meg impedance at IN1 (IN2 provides a 100K Ohm impedance). It also assures that the remainder of the circuit has enough drive voltage to operate properly. The VU METER is DC-isolated from the signal source with a 0.22 μF, 250V capacitor (C3).

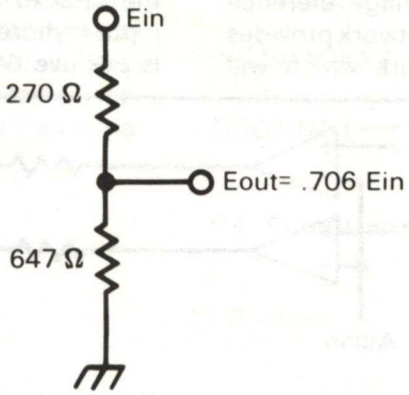
Active Rectifier: An active rectifier stage follows the input amplifier. The difference between an active rectifier and an ordinary diode is that the active rectifier utilizes an op-amp to amplify the signal across the diode about 100,000 times. A feedback circuit keeps the output voltage equal to the input. The active rectifier thus effectively reduces the normal 0.6 volt diode drop to 6 microvolts which is necessary if the VU METER is to maintain linearity and accuracy for small signals (i.e., the center and bottom of the scale). This is achieved by separating the feedback of the rectifier stage which is an inverting-follower circuit (refer to the Schematic). This separation is accomplished as follows: If the op-amp output is positive, the signal and feedback go through CR2 and R36 and the final output appearing at R35 is equal to the input. If the op-amp output is negative, the feedback is through CR1 and the final output at R35 is zero. Therefore, the final output can only be zero or positive.

Active Low Pass Filter: An active filter, made up of the op-amp stage, R32-35, R26, C5 and C6 takes the rectified signal and smooths it into a DC voltage proportional to the input. This is an active two-pole Butterworth low pass filter with a cutoff of 7.25 Hz. This filter was chosen because: a) audible frequencies are attenuated to the extent that they do not affect the LED's (no flicker is visible due to steady bass tones), b) the response time is about 1/10th second, and c) overshoot, equivalent to meter swing, is negligible, amounting to about 1.5 dB.

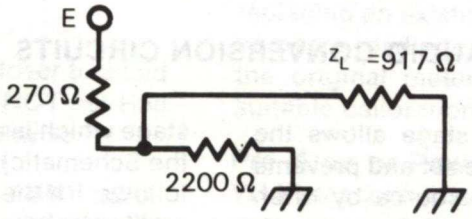
REFERENCE VOLTAGE CIRCUITS

High Compliance Voltage Reference: The remaining op-amp of Z3 (pins 12, 13 and 14) is used to control the reference voltage for the op-amps and ladder network; its sole purpose is to provide a stable DC voltage that will not be affected by the load created by the other circuits.

Ladder Network: The ladder network is simply a series of voltage dividers. Each one operates in the fashion shown below:



Note that the output voltage (Eout) is almost exactly 3 dB, or a factor of 0.7071 (0.706 to be precise), lower than the input voltage (Ein). The 647 Ohm equivalent-resistor is made up of a 2200 Ohm resistor and a 917 Ohm load.



The 917 Ohm load is made up of more 270/2200 Ohm resistor combinations (note that 220 Ohm + 647 Ohm = 917 Ohm, and $\frac{2200 \cdot 917}{2200 + 917}$ = 647 Ohm), and the last load is made up of a 2200 Ohm, a 1000 Ohm and a 10,000 Ohm resistor all in parallel for a resistance of 643 Ohms, an error much smaller than the resistor tolerance of 5%. The final result is a sequence of eight DC voltages varying by a factor of 0.706, or almost exactly 3 dB from each other.

When the rectified and filtered audio from Z3 pin 1 is more positive than the reference voltage supplied from the ladder network, the comparator output will switch towards ground and cause the LED to light. Since the comparator IC's tap the ladder network at different voltage points, their reference voltage differs from one comparator stage to the next. As explained, the reference voltages are 3 dB apart. This results in a string of LED's being lit whose length is proportional to the audio level.

You can set up the LED string to light at increments other than 3 dB; see **Experimenter Options** for information and details.

TROUBLESHOOTING

If difficulty is encountered, the first thing is to recheck your construction:

a) Use assembly diagrams to check that all resistors are installed with the proper value. In particular, 10K resistors (Brown, Black, Orange) and 100K resistors (Brown, Black, Yellow) are easily mistaken, as are other resistors which differ only in the third color band.

b) Make sure that the electrolytic capacitor C4 is installed with the negative and positive terminals connected as shown on the instructions and on the Board itself.

c) Check that both diodes CR1 and CR2 are installed with the banded end toward the edge of the board.

d) Check to be sure that pin 1 of the integrated circuits is mounted in the pin 1 location and that no pin has been folded under the IC rather than through the board.

e) The LED's should be installed with the negative (cathode) terminal to one of the 470 ohm resistors R1-R8. (This can be checked by applying 3V or more to the "+" terminal and grounding the terminals of R1-R8 opposite the LED's; this should light the corresponding LED. If the LED does not light, it should be reversed or replaced. Do not apply a voltage directly across the LED.)

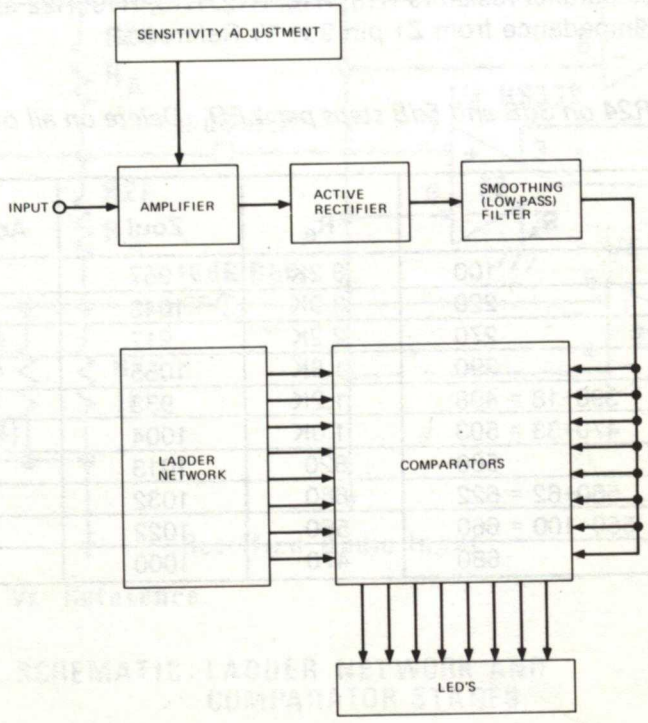
f) Make sure that all components are soldered properly, and that the board has not been shorted with solder bridges between I.C. pins or other closely spaced connections.

g) The signal input and ground must not be reversed. Also, check to make sure that the supply voltage and ground are not reversed, and that the signal and supply voltage are not reversed.

h) If the trimmer potentiometer (R38) is grossly misadjusted, either all or none of the LED's will light up. Recalibrate as noted earlier.

j) If all the LED's light up when there is **any** input signal and trimmer potentiometer (R38) is adjusted full counterclockwise (as viewed from the input end of the printed circuit board), the sensitivity of the unit is too high for the voltage used. Connect the input signal to IN1 and re-calibrate. (Make sure R39 is 1 Meg — Brown, Black, Green.)

FUNCTIONAL BLOCK DIAGRAM



EXPERIMENTER OPTIONS

The Project Board as presented in its basic form is a VU Meter with adjustable sensitivity. However, the basic device can be used wherever audio levels are measured on a log or dB scale. The steps between the LED's (set in the basic device at 3 dB) can be changed 1 dB to 10 dB as outlined below.

Possible applications are:

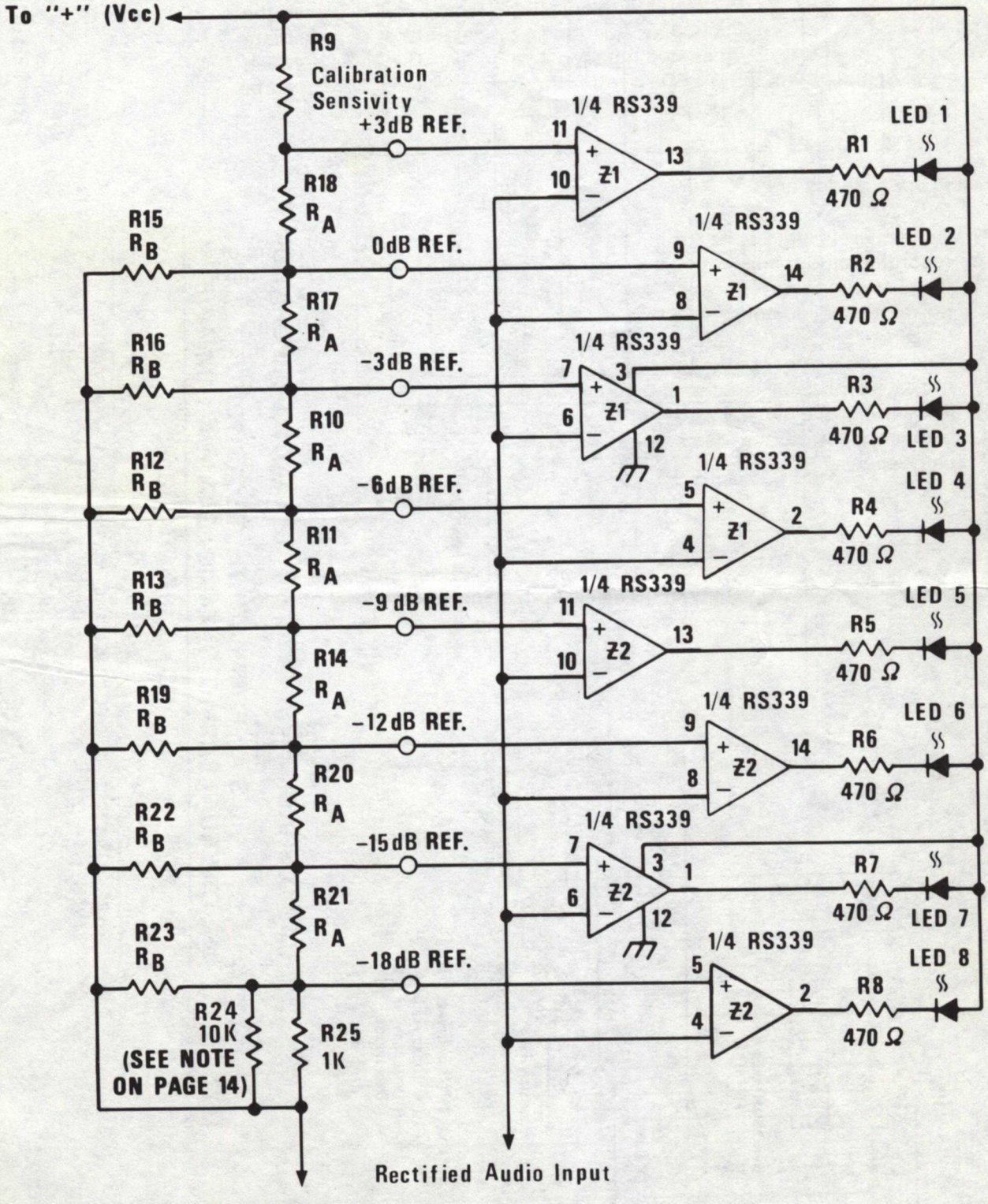
1) Audio level indicators for multi-channel recording studio mixers
2) Quick-responding speaker or amplifier power level indicators
3) Channel balance/VU Meters for cassette record and playback equipment
4) Indicators of audio input and audio level on lines not available for aural monitoring of background music systems, such as mike lines, speaker lines, auxiliary P.A. inputs, etc.
5) Visual monitors of audio input lines used for switching or mixing, such as instrument mixers used in live musical performances
6) Visual monitors of output line levels of instrument mixers and other similar equipment

A table of suggested R_A, R_B values, in Ohms, for a variety of dB levels and an impedance level of 1000 is given below.

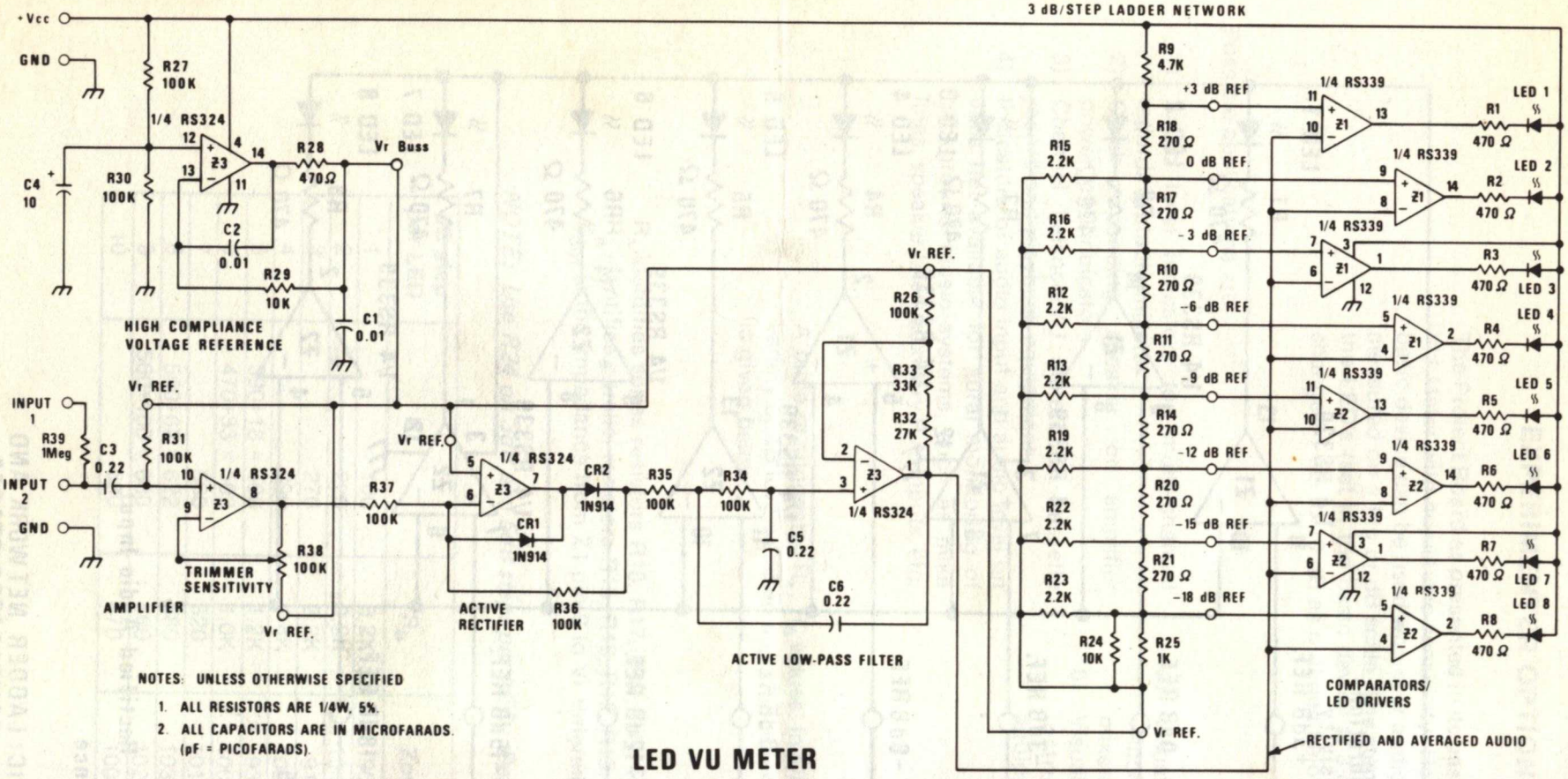
R_A identifies series resistors R18, R17, R10, R11, R14, R20 and R21.
R_B identifies parallel resistors R15, R16, R12, R13, R19, R22 and R23.
Z_{OUT} is the impedance from Z1 pin 9 to Vr Reference.

NOTE: Use R24 on 3dB and 5dB steps per LED. Delete on all other steps.

dB step per LED	R_A	R_B	Zout	Actual dB
1	100	8.2K	957	0.96
2	220	3.9K	1043	2.06
3	270	2.2K	917	3.03
4	390	1.8K	1055	4.01
5	390+18 = 408	1.2K	933	5.00
6	470+33 = 503	1.0K	1004	6.04
7	560	820	1013	6.99
8	560+62 = 622	680	1032	8.02
9	560+100 = 660	560	1022	9.02
10	680	470	1000	9.90



SCHEMATIC: LADDER NETWORK AND COMPARATOR STAGES



NOTES: UNLESS OTHERWISE SPECIFIED

1. ALL RESISTORS ARE 1/4W, 5%.
2. ALL CAPACITORS ARE IN MICROFARADS. (pF = PICOFARADS).

LED VU METER

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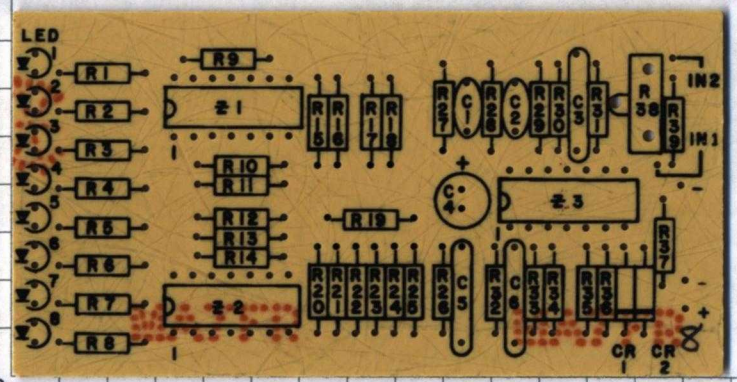

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STEAM POWERED RADIO ENGINEERING
PINOLE CALIFORNIA

CIRCUIT BOARD SCALE 5_5 X 8_5 INCHES

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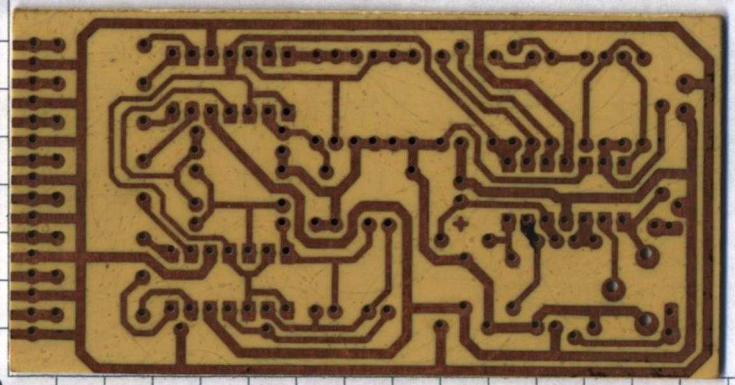
APPROVED BY: TUCKER WIGFIELD	08/20/16	SCALE: FULL	SHEET 1 OF 1



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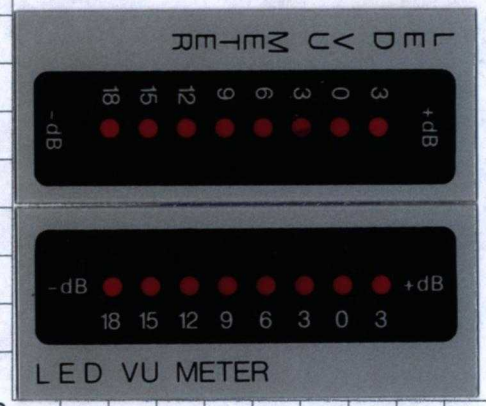

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