The Tellun Corporation

TLN-904 Veeblefetzer

User Guide, Rev. 1.3

1.   Introduction

The TLN-904 Veeblefetzer[1] is a signal level meter for modular synthesizers. This module produces no sound; it is used to indicate signal level (voltage level) for both audio and control signals.

Features:

- A 10 segment LED display driver for positive voltages (typically set for half volt increments from 0.5V to 5.0V).
- A 10 segment LED display driver for negative voltages (typically set for half volt increments from -0.5V to -5.0V).
- A zero LED driver for voltages that are too small to register on either the positive or negative displays.
- An adjustable positive peak detector LED driver.
- An adjustable negative peak detector LED driver.
- Two jacks on the front panel make it easy to connect the TLN-904 into a patch without having to use a multiple.

Description of panel controls:

- The MODE switch selects either BAR or DOT mode on the two 10 segment LED display drivers.
- The RANGE switch selects either a FIXED range for the two 10 segment LED display drivers (typically -5V to +5V) or an adjustable range that follows the PEAK knob setting. The adjustable range mode would be used to zoom the display out for viewing 20Vpp signals or to zoom the display in for viewing 1Vpp signals.
- The PEAK pot sets the level of the positive and negative peak detectors: 0V to +10V for the positive peak detector, 0V to -10V for the negative peak detector. This control also sets the range of the two 10 segment LED display drivers when the RANGE switch is set to PEAK mode.

2.   Circuit Description

The circuit consists of two LED display drivers, several comparators, and some buffers.

The input signal is applied to an input buffer and inverter built around U1. The signal can be applied to either J1 or J2. J2 is simply a "through" connection so make it easier to connect the TLN-904 into a patch without requiring a multiple. R1 provides some

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[1] The word *Veeblefetzer* is defined as "a purposely nonsensical sounding word applied to any sort of obscure or complicated object". One of the first circuits I ever built did nothing but flash a bunch of LEDs. It seemed complicated to me at the time, and so I called it a *Veeblefetzer*.

protection to the input op-amp in the event of an over voltage condition. R2 keeps the input grounded if no signal is applied. U1b creates an inverted version of the input signal.

The LED driver for positive voltages is shown in the upper left on page 2 of the schematic. An LM3914 chip does most of the work. This chip senses positive voltages and drives 10 LEDs to provide a linear analog display. The input signal is applied to pin 5. Pin 9 is connected to front panel MODE switch SW1 to select either BAR or DOT mode. The LM3914 has a built in voltage regulator for setting the voltage range. Resistors R25, R26 and trimmer TP2 are used to create a reference voltage of +5V (VREF1). R27 is used to increase the brightness of the 10 positive voltage LEDs. If R27 is left out, the brightness of the LEDs is determined by R25, R26 and TP2. R33 is used to shut off LED1 when no signal is present[2].

The LED driver for negative voltages is shown in the lower left on page 2 of the schematic. This is almost identical to the LED driver for negative voltages, except that the inverted version of the input signal is fed to pin 5, and the voltage regulator is used to create a +10V voltage reference (VREF2) via trimmer TP3.

The two voltage references (VREF1 and VREF2) are fed to front panel RANGE switch via two buffers built from U5 (see upper right on page 2 of the schematic). The +5.0V reference is the "fixed" voltage reference. The +10V reference is scaled by front panel PEAK pot (VR1) to provide a "variable" voltage reference. With the RANGE switch set to the FIXED position, the +5V reference is fed to pin 6 of both LM3914 chips. This scales the chips for +/-5V signals. With the RANGE switch set to the PEAK position, the variable reference is fed to pin 6 of both LM3914 chips. Thus they can be scaled to display signals from 0V up to +/-10V depending on the setting of the PEAK pot. This variable voltage reference (VPEAK) also feeds the peak detector circuits. R31 and R32 provide output protection for U5a and U5b in the event that switch SW2 is a "make before break" switch (which could short the two outputs together).

The positive peak detector circuit is shown in the middle left section on page 1 of the schematic. The variable voltage reference (VPEAK) and the buffered input signal both feed a comparator built around U4b. When the input signal exceeds the VPEAK level, the comparator output goes high and charges capacitor C17 through diode D1. The capacitor voltage is buffered by U4a and is then fed to the positive peak LED driver built around Q2, R17, and R18. R18 sets the brightness of the positive peak LED. R16 is used to discharge C17 after the comparator output goes low (when the input signal is less than VPEAK).

The negative peak detector circuit is shown in the lower left on page 1 of the schematic. It is identical to the positive peak detector circuit except that the inverted version of the input signal is compared to VPEAK. R24 sets the brightness of the negative peak LED.

Before discussing the zero detector circuit, it is necessary to first explain the voltage sources for the LEDs (see upper right on page 1 of the schematic). All LEDs are driven

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[2] Refer to the LM3914 data sheet for more information on why this is necessary.

from a +5V source to keep them from adding too much noise to the +15V line. The +5V source can come from either: an external +5V supply (i.e. from a MOTM-950 power supply), or from a +5V regulator on the TLN-904 (U3). In the latter case, the +5V source is tapped from the +15V power supply line. Jumper JP2 selects either the "external" +5V supply or the "internal" +5V supply for the LEDs. The 20 LEDs driven by the LM3914 are not connected directly to the +5V source, but are connected to it through R6 (a 100 ohm resistor). R6 performs two functions: it provides a current limit effect to the LM3914 LEDs, and it provides a reference voltage for the zero detector circuit. The former is used to lower the brightness of the LEDs as more of them are lit (makes it easier on the eyes). The latter function is discussed below.

The zero detector circuit is shown in the lower right on page 1 of the schematic. Built around U2, this comparator senses whenever none of the LEDs driven by the two LM3914 chips are on. It does this by comparing the difference between the +5V source and the LED driver voltage (VLED). When none of the 20 LM3914 LEDs are lit, there is no current drawn through R6, VLED is the same as the +5V source, and the comparator output goes high turning on the zero LED driver built around Q1, R11, and R12. R12 sets the brightness of the zero LED. If any of the LM3914 LEDs are lit, current is drawn through R6 producing a voltage drop at VLED. This voltage difference causes the comparator output to go low, shutting off the zero LED. Thus the zero detector circuit operates independently of the RANGE switch and PEAK pot setting. TP1 is used to fine tune the comparator operation (to account for a wide range of LED configurations and current draws).

3.   *Power Considerations*

There are two ways to power the TLN-904: using the more common 4-pin MTA-156 power connector (+/-15V and analog ground), or using the newer 6-pin MTA-156 power connector (+/-15V, analog ground, +5V, digital ground). Either will work fine. I recommend building the TLN-904 with a 6-pin MTA header. If you have a power supply with 6-pin connectors, then you can power the LEDs off the +5V line in the power supply (set jumper JP2 to the "external" position). If you have a power supply with only 4-pin connectors, plug the power connector into the right-most 4 pins on the TLN-904 and leave the 2 left-most pins unconnected (and set jumper JP2 to the "internal" position). This will power the LEDs from the regulator on the TLN-904 (see below).

        -15   gnd gnd   +15

Use these 4 pins on MTA-156 header for power supplies with 4-pin connectors.
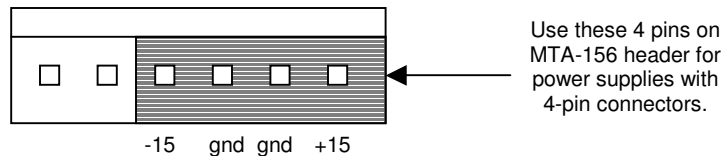
If you connect the TLN-904 to a power supply with 6-pin power connectors and have jumper JP2 set to the "internal" position, you will not damage anything. You will simply

be powering the LEDs from the regulator on the TLN-904 and ignoring the +5V line on the power supply.

4.   Modifications

The +5V regulator for the internal LED voltage source is sized for TO-220 (which can supply 1 Amp of current). You might be able to get away with a smaller TO-92 regulator (which can supply 100 mA). It all depends on how much current you try to draw from the regulator and whether or not you even use the internal regulator. I recommend going with the TO-220, it doesn't cost much more than a TO-92.

A similar argument applies to R6. The board layout is sized for a ½ watt resistor. But you may be able to use a ¼ watt resistor; it all depends on how much current you draw for the 20 LM3914 LEDs. If you don't have any 100 ohm ½ watt resistors, you can use two 51 ohm ¼ watt resistors in series, or two 220 ohm ¼ watt resistors in parallel. R6 can be increased to augment the current limit effect, which lowers the brightness of the LEDs as more of them are lit.

When testing this module I found that I was drawing only 33 mA through R6 and still getting a bright LED display. But I was using high brightness LEDs that didn't require a lot of current.

The decay time for the positive peak detector can be modified by changing either C17 or R16. It's probably easier to change R16. Lower values for either component will shorten the decay time. Higher values will lengthen the decay time.

The decay time for the negative peak detector can be modified by changing either C19 or R22. It's probably easier to change R22. Lower values for either component will shorten the decay time. Higher values will lengthen the decay time.

The reference voltages for the FIXED and PEAK settings can be modified by changing R26 and R29 respectively. Higher values will increase the reference voltages, lower values will lower the reference voltages.

The brightness of the LEDs (and therefore the amount of current drawn from the +5V source) can be modified by changing 5 resistors. R27 increases the brightness of the positive voltage LEDs. R30 increases the brightness of the negative voltage LEDs. R12 sets the brightness of the zero LED. R18 sets the brightness of the positive peak LED. R24 sets the brightness of the negative peak LED. See section 6 for some hints on selecting values for these 5 resistors.

VR1 acts as a load on pin 7 of U7. This load affects the minimum brightness of the negative value LEDs. VR1 can be increased to 1M to lower this effect.

5.   Hints for Selecting LEDs

LEDs are available in a wide selection of shapes, sizes, and colours. I can't say which ones are best for your particular application, but I can make the following suggestions. The widest selection of colours are available in T1¾ (5mm) format, but there isn't enough space on the LED daughterboard to fit lots of LEDs of that size. T1 (3mm) have the next best selection of colours available and they fit very well on the daughterboard. Rectangular (2x5 mm) LEDs also fit very well, but the colour selection isn't as good and they are only available with diffuse lenses. An LED with a diffuse lens tends to require more current than an LED with a transparent or water clear lens to get the same amount of perceived brightness. In general, the less current you draw, the happier your power supply will be.

I tried about 30 different LEDs in various combinations and decided to use these for my first TLN-904:

Colour	Description	Manufacturer Part No.	Supplier Part No.
super orange	T1 (3mm) water clear	Lumex #SSL-LX3044SOC	Digikey #67-1074-ND Mouser #696-SSL-LX3044SOC
super red	T1 (3mm) water clear	Lumex #SSL-LX3044SRC/D	Digikey #67-1647-ND Mouser #696-SSL-LX3044SRC/D
green	T1 (3mm) water clear	Lumex #SSL-LX3044GC	Digikey #67-1059-ND Mouser #696-SSL-LX3044GC
blue	T1 (3mm) diffuse	Lumex #SSL-LX3044USBD	Digikey #67-1748-ND Mouser #696-SSL-LX3044USBD
blue-green	T1 (3mm) water clear	Stanley #DC3804X	Digikey #404-1116-ND

I chose water clear lenses because they throw a lot of light forward without requiring a lot of current and they look like little diamonds on the black felt when the TLN-904 is powered down. The only exception was the blue LED (which I used for the zero indicator). Although Lumex calls it "diffuse" it's almost clear and has a wider viewing angle than the "water clear" equivalent part.

Here are a number of other LEDs that I can recommend for use with the TLN-904:

Colour	Description	Manufacturer Part No.	Supplier Part No.
yellow	T1 (3mm) water clear	Lumex #SSL-LX3044YC	Digikey #67-1077-ND Mouser #696-SSL-LX3044YC
super yellow	T1 (3mm) water clear	Lumex #SSL-LX3044SYC	Digikey #67-1076-ND Mouser #696-SSL-LX3044SYC
red	T1 (3mm) water clear	Lumex #SSL-LX3044IC	Digikey #67-1065-ND Mouser #696-SSL-LX3044IC
blue	T1 (3mm) water clear	Lumex #SSL-LX3044USBC	Digikey #67-1747-ND Mouser #696-SSL-LX3044USBC
yellow	T1 (3mm) transparent	Lumex #SSL-LX3044YT	Digikey #67-1081-ND Mouser #696-SSL-LX3044YT
green	T1 (3mm) transparent	Lumex #SSL-LX3044GT	Digikey #67-1063-ND Mouser #696-SSL-LX3044GT
red	T1 (3mm) transparent	Lumex #SSL-LX3044IT	Digikey #67-1069-ND Mouser #696-SSL-LX3044IT

red	2x5 mm rectangular diffuse	Lumex #SSL-LX2573ID	Digikey #67-1047-ND Mouser #696-SSL-LX2573ID
super red	2x5 mm rectangular diffuse	Lumex #SSL-LX2573SRD	Digikey #67-1049-ND Mouser #696-SSL-LX2573SRD
amber	2x5 mm rectangular diffuse	Lumex #SSL-LX2573AD	Digikey #67-1045-ND Mouser #696-SSL-LX2573AD
green	2x5 mm rectangular diffuse	Lumex #SSL-LX2573GD	Digikey #67-1046-ND Mouser #696-SSL-LX2573GD
pure green	2x5 mm rectangular diffuse	Lumex #SSL-LX2573PGD	Digikey #67-1048-ND Mouser #696-SSL-LX2573PGD
yellow	2x5 mm rectangular diffuse	Lumex #SSL-LX2573YD	Digikey #67-1050-ND Mouser #696-SSL-LX2573YD

If you decide to use more than one type of LED with the LM3914 display drivers, be sure to test them before you solder them into the daughterboard. The LM3914 will draw the same amount of current through each LED. But LEDs have different forward voltage drops and brightness/current ratings. You may be able to mix red, green, and yellow LEDs from the same manufacturer with the same model number, but mixing blue LEDs with anything else probably won't work. Test before you solder.

Water clear LEDs all look the same when powered off, so be careful that you don't get them mixed up when soldering them to the LED daughterboard.

6.   Hints for Selecting R12, R18, R24, R27, R30

There are five resistors that are used to adjust the brightness of the LEDs:

- R12 sets the brightness of the zero indicator LED.
- R18 sets the brightness of the positive peak detector LED.
- R24 sets the brightness of the negative peak detector LED.
- R27 increases the brightness of the 10 positive value LEDs.
- R30 increases the brightness of the 10 negative value LEDs.

You will have to determine the values for these resistors after you've selected your LEDs and have the TLN-904 built and (partially) calibrated. Before you start this procedure, do a rough calibration of the two voltage references and get the zero detector circuit to illuminate the zero LED.

Solder some scrap resistor leads in place of R12, R18, R24, R27, and R30. Clip some jump leads to these scraps so that you can easily swap in different resistors (or a pot).

Set the PEAK control fully clockwise. Set the RANGE switch to the FIXED position. With no signal applied, the zero LED should be lit (and nothing else). Adjust R12 to set the brightness to something comfortable (remember, it's a level meter, not a lighthouse).

Apply a 10 Vpp triangle or sine wave from an LFO to the input. Adjust R27 and R30 to increase the brightness of the positive and negative voltage LEDs. Use the MODE switch

to select between BAR and DOT mode and try a variety of LFO frequencies. Adjust R12, R27, and R30 until you are happy with the brightness of the positive, negative, and zero LEDs.

Turn the PEAK control down until both the positive and negative peak detector LEDs start to light up. Set the brightness of these LEDs with R18 and R24.

When you're satisfied with the brightness of all the LEDs, power down the TLN-904, and replace the scrap resistor leads with the resistors.

7.   Sample Configurations

I came up with two different configurations for resistors and LEDs. The first one is the "high brightness" version. Here are the LEDs and values I used for R12, R18, R24, R27, and R30:

Resistor	Value	LED Used	Notes
R12	4.7K	Lumex #SSL-LX3044USBD	one blue LED for the zero indicator
R18	3.3K	Lumex #SSL-LX3044SOC	two super orange LEDs in parallel for positive peak indicator
R24	470	Stanley #DC3804X	two blue-green LEDs in parallel for negative peak indicator
R27	4.7K	Lumex #SSL-LX3044GC	one green LED for each of the 10 positive value indicators
R30	not used	Lumex #SSL-LX3044SRC/D	one super red LED for each of the 10 negative value indicators

The super-red LEDs are so bright that R30 is not needed at all. Note that I used two LEDs connected in parallel for both the positive peak and negative peak indicators. If you use the same LEDs in the same configuration, you may choose to use these same values. But you don't have to use these values, use whatever values you want to set the display brightness.

For the second configuration, the "low brightness" version, I had to make a number of changes to lower the brightness of the positive and negative LEDs. The super-red LEDs were moved to the positive value display, and the green LEDs were moved to the negative display. R25 and R26 were increased to 100K and 47K respectively to lower the brightness of the super-red LEDs. R6 was increased to 470 ohms so that the zero detector circuit would still function with the reduced current draw to the LEDs. Note that VR1 acts as a 100K load on pin 7 of U7, which adds to the brightness of the negative value LEDs. To lower the brightness of the negative value LEDs, VR1 must be changed to a 1 M pot. I didn't change VR1 for this configuration; I just swapped the red and green LEDs. Here are the LEDs and values I used for R12, R18, R24, R27, and R30:

Resistor	Value	LED Used	Notes
R12	10K	Lumex #SSL-LX3044USBD	one blue LED for the zero indicator
R18	4.7K	Stanley #DC3804X	two blue-green LEDs in parallel for positive peak indicator
R24	22K	Lumex #SSL-LX3044SOC	two super orange LEDs in parallel for negative peak indicator
R27	not used	Lumex #SSL-LX3044GC	one super-red LED for each of the 10 positive value indicators
R30	not used	Lumex #SSL-LX3044SRC/D	one green LED for each of the 10 negative value indicators

R27 and R30 are not needed at all. Note that I used two LEDs connected in parallel for both the positive peak and negative peak indicators. If you use the same LEDs in the same configuration, you may choose to use these same values. But you don't have to use these values, use whatever values you want to set the display brightness.

8.   Construction Tips

Deal with the mechanical issues before doing any soldering. It is important to spend some time making sure the LED daughterboard lines up with the centre of the display bezel and that the LEDs do not protrude through the lens.

Prepare your panel first, drill all the holes and put the bezel in place (including the clear lens if you are using it). Trim 2.75" off the front edge of the Stooge bracket. The bracket attaches to the panel using VR1 only; the remainder of the front edge of the bracket must be removed to avoid interfering with the display bezel. Attach the bracket to the panel using VR1 (remember to add an extra nut to VR1 on the inside of the bracket).
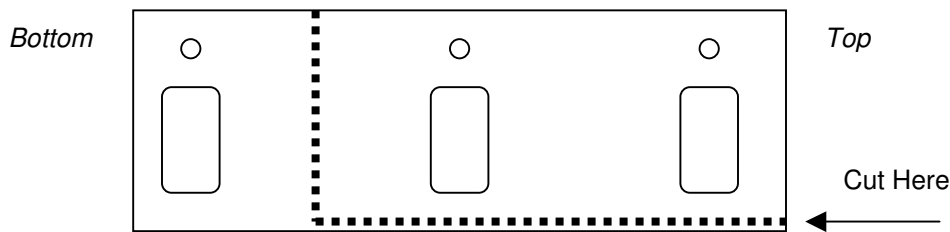
Attach the LED daughterboard to the motherboard using the 48 pin right-angle connector. <u>Do not solder the connector to either board yet</u>. The connector will fit quite snugly into the motherboard and LED daughterboard so that you can figure out exactly which holes you need to use to get everything lined up with the display bezel. The right-angle pins attach to the underside of the motherboard. The straight pins go into the LED daughterboard. There are three rows of pins on both the motherboard and the daughterboard, use whichever rows work best for you.

LED board bottomside
(facing display bezel)

motherboard topside
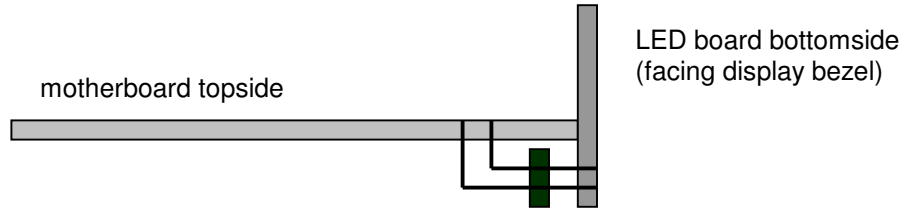
You must determine where to drill four holes in the Stooge bracket for attaching the motherboard. Since the holes aren't drilled yet, you can't attach the motherboard to the bracket to check the alignment. But you can simulate the finished article: place four #6 nuts on your workbench beneath the existing four holes in the Stooge bracket, place the bracket on top of the nuts, place four spacers on top of the bracket, place the motherboard on top of the spacers. Spend some time lining up the motherboard with the display bezel while keeping it within the bounds of the Stooge bracket. You may have to readjust the LED daughterboard alignment with the 48-pin connector. Once everything is perfectly lined up, mark the spots to drill the four holes in the bracket for mounting the motherboard. Drill the four holes then reassemble the whole thing with all screws in place to make sure everything still lines up properly.

Now it's safe to solder all the parts on the motherboard and the wires that will go to the jacks, switches, and pot. Leave R12, R18, R24, R27, and R30 off for now (unless you are sure you know what their values should be). If cost is no option, you may be able to permanently fit some 10K trimmers in for those resistors. Before you attach the LEDs to the daughterboard, glue a piece of black felt onto the side of the daughterboard that faces the display bezel so that you won't see the green PCB when the module is mounted in your cabinet. Don't trim the felt too close to the edge of the daughterboard, leave an inch of overlap on all sides; you can trim it down later. Eventually you'll have to solder the 48-pin connector to the LED daughterboard, so keep that in mind when you glue the felt on; don't put glue on the holes that you'll be soldering on. You don't need to use superglue; a glue stick for paper products will work fine. Use a pin to poke holes through the felt so you can pass the LED leads through the felt. The LEDs mount on the side of the daughterboard that faces the display bezel, on top of the felt. Solder the LEDs onto the daughterboard from the underside (the side that faces the motherboard). Attach wires to the LED leads and cover them with heat shrink cable.

When soldering the LEDs to the daughterboard, put all the LEDs in place and then solder just one lead on each LED. This will keep the LEDs from falling out but still allow you to tweak their position a little to ensure they are pointing straight up and are all in a straight line (if a straight line is what you want). Pressing the edge of a ruler, or other straight edge, against the LEDs also helps to get them all lined up. Solder the other lead on each LED once you've got them all aligned.

You can eliminate a lot of wires between the motherboard and LED daughterboard by noting that the 20 positive and negative LEDs all share a common anode connection with VLED. Similarly, the zero LED, positive peak LED, and negative peak LED all share a

common anode connection with the +5V bus. By making VLED and +5V busses on the daughterboard you can eliminate 21 wires to the motherboard.

Eventually you'll have to solder the 48-pin connector to both the motherboard and the LED daughterboard. You'll probably have to solder this connector to the motherboard before you attach the LED wires to the motherboard. Leave the connector unsoldered from the daughterboard as long as you can because you'll never get it off once you've soldered it in. After the LEDs are all attached, hook up the wires to the jacks, switches, and pot. Plug the ICs into their sockets, test, and calibrate the voltage references. Then spend some time figuring out the best values for R12, R18, R24, R27, and R30 as discussed in section 6. Once these resistors have been soldered into place, assemble the whole module then run through the entire calibration sequence.

There is no need to use scrap resistor leads to tie the input jacks to ground when nothing is plugged into them. IC sockets aren't necessary, but I like to use them. Coax cable is not necessary for this circuit. There are four ground connections on the circuit board. These can be used to tie a ground connection to the LED daughterboard if you decide to put extra circuitry on the daughterboard.

The PCB uses 0.4" spacing for the resistor pads (except for R6), 0.4" spacing for the ferrite bead pads, 0.3" for the diode pads, and 0.2" spacing for most of the capacitor pads. The electrolytic caps have a 0.1" pad spacing. The LED connection points on the motherboard have a 0.1" spacing.

For VR1, the square pad on the PCB indicates pin 1, the middle pad is pin 2, and the remaining pad is pin 3. The pin out for most pots is (left to right): 3, 2, 1 when viewing the back of the pot with the leads facing down.

For J1, the square pad on the PCB indicates the ground connection. For J2, jumper two wires over from J1 (signal lug and ground lug).

For the LED connection points on the motherboard, the square pad indicates the cathode. The cathode is normally the shorter lead on an LED.

For SW1, the two wires connect to the middle and bottom lug. For SW2, the square pad on the PCB (labeled "P") connects to the bottom lug, the middle pad connects to the middle lug, and the pad labeled "F" connects to the top lug.

8.1.   Panel Wiring Guide

Panel Designation	PCB Designation	Wire Length (inches)	Wire Type
IN jack	J1	5	twisted (2 wire)
THRU jack	J2	1.5	2 small wires
PEAK pot	VR1	5	twisted (3 wire)
MODE switch	SW1	3.5	twisted (2 wire)
RANGE switch	SW2	5.5	twisted (3 wire)

9.   *Calibration*

This circuit is fairly easy to calibrate. Don't plug anything into the IN or THRU jacks for the first part of calibration. Set the MODE switch to DOT and set the RANGE switch to FIXED. Turn the PEAK pot control fully clockwise. Apply power to the module and set JP2 to either internal +5V or external +5V as necessary.

TP2 sets the FIXED reference voltage to +5V. Attach a DVM to pin 7 of U6. Adjust TP2 until the voltage reads exactly +5.00V.

TP3 sets the PEAK reference voltage maximum to +10V. Attach a DVM to pin 7 of U7. Adjust TP3 until the voltage reads exactly +10.00V.

TP1 sets the comparator trigger point for the zero detector circuit. If TP1 is not set correctly, the zero LED will either stay on all the time (or flicker all the time), or it will stay off all the time. Apply a 10 Vpp triangle or sine wave from an LFO to the IN jack. Set the MODE switch to DOT, set the RANGE switch to FIXED, and turn the PEAK control fully clockwise. Attach a scope probe to the comparator output (pin 7 of U2). As the LFO goes between +0.5V and –0.5V the comparator output should go high. Adjust TP1 until the comparator output is the same for both rising and falling voltages.

You can also calibrate TP1 by simply applying a variable DC voltage to J1 that goes between +1V and –1V and adjusting TP1 so that the zero LED goes on when none of the other LEDs are on and that it goes off when any other LED is on.

TLN-904 Parts List

Resistors (34)

Quantity	Description	Part No.	Notes
2	100	R31, R32	5% or better, Mouser #291-100
1	1K	R9	5% or better, Mouser #291-1K
3	4.7 K	R11, R17, R23	5% or better, Mouser #291-4.7K
8	10 K	R1, R7, R13, R14, R19, R20, R33, R34	5% or better, Mouser #291-10K
1	56 K	R10	1%, Mouser #271-56K
1	470 K	R2	5% or better, Mouser #291-470K
5	1 M	R8, R15, R16, R21, R22	5% or better, Mouser #291-1M
1	4.99 K	R5	1%, Mouser #271-4.99K
2	10 K	R3, R4	1%, Mouser #271-10K
2	22 K	R25, R28	1%, Mouser #271-22K
1	27 K	R26	1%, Mouser #271-27K
1	68 K	R29	1%, Mouser #271-68K
1		R12	Zero LED current/brightness (see text)
1		R18	Peak+ LED current/brightness (see text)
1		R24	Peak– LED current/brightness (see text)
1		R27	Positive LED current/brightness (see text)
1		R30	Negative LED current/brightness (see text)
1	100	R6	½ watt 5% or better (see text) Mouser #293-100

Capacitors (21)

Quantity	Description	Part No.	Notes
3	100 pF ceramic	C16, C18, C20	Mouser #140-50N5-101J Mouser #147-75-101
3	0.01 uF ceramic	C15, C17, C19	Mouser #147-71-103 Digikey #1103PHCT-ND
12	0.1 uF ceramic	C1 – C11, C21	Mouser #147-72-104 Mouser #581-SA105E104M (for p/s decoupling)
3	22 uF 35V elec.	C12 – C14	Mouser #140-XRL35V22 (for p/s decoupling)

Semiconductors (12, 23+)

Quantity	Description	Part No.	Notes
1	TL072 dual op amp	U1	Allied #735-2727 Mouser #595-TL072CP
1	LM311N	U2	Mouser #511-LM311N Digikey #LM311NNS-ND
1	LM7805	U3	Mouser #511-L7805CV Digikey #LM7805CT-ND (TO-220, see text)
1	TL074 quad op amp	U4	Mouser #595-TL074CN
1	MX1013	U5	Allied #735-3671 Mouser #595-LT1013CP
2	LM3914 LED driver	U6, U7	Digikey #LM3914N-1-ND

2	1N4148 diode	D1 – D2	Allied #950-1550 Mouser #512-1N4148 (can substitute 1N914)
3	BC549B transistor (NPN)	Q1 – Q3	Mouser #625-BC549B, (can substitute BC550)
23+	LEDs	LED1 – LED23	see text

Potentiometers & Trimmers (4)

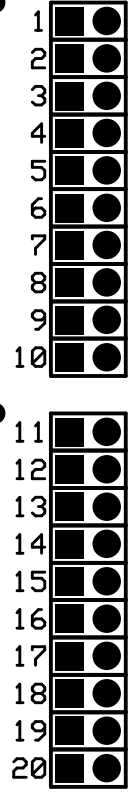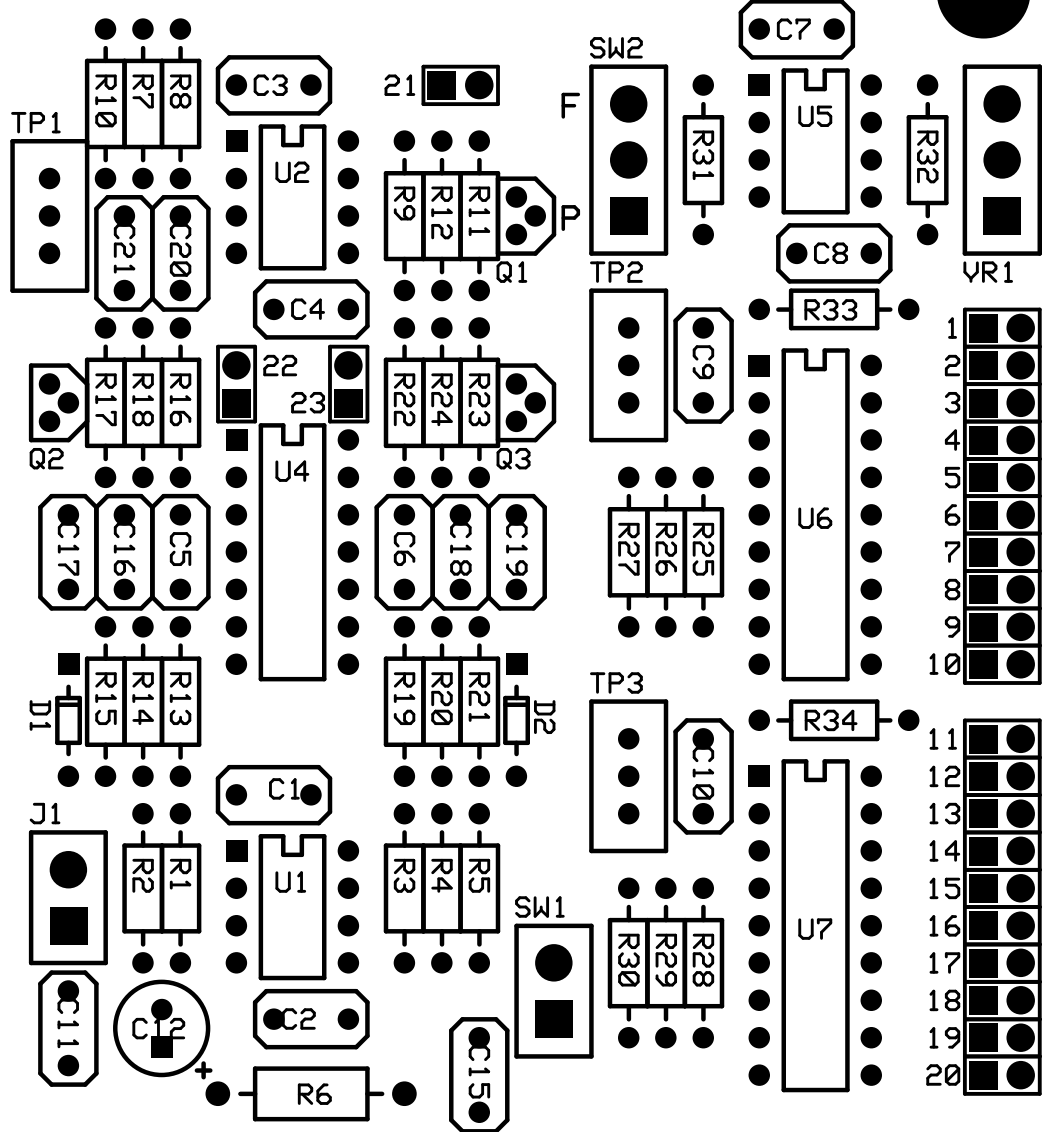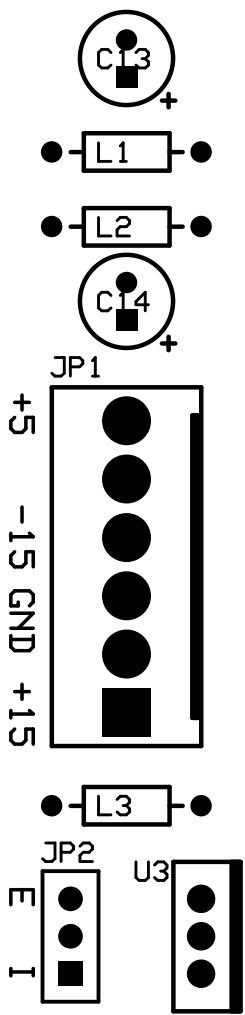| Quantity	Description	Part No.	Notes
1	100 K linear pot	VR1	Spectrol 149 series, Allied #970-1791, or Bournes 91 series, Allied #754-9420
3	10 K trimmer (multi-turn)	TP1– TP3	Mouser #72-T93YA-10K

Miscellaneous

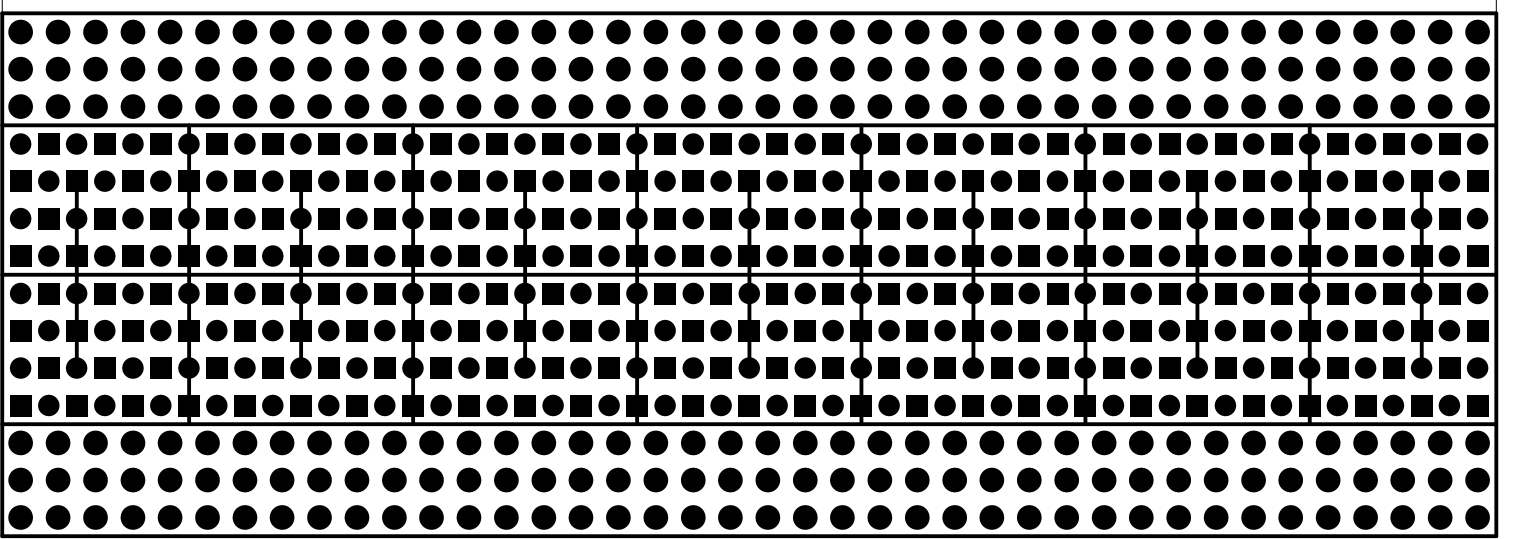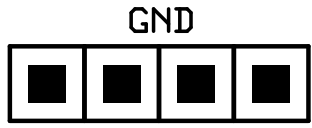| Quantity	Description	Part No.	Notes
2	phone jack	J1 – J2	Switchcraft 112A, Allied #932-9391 Mouser #512-112A
2	18 pin DIP socket		for LM3914
1	14 pin DIP socket		for TL074
3	8 pin DIP socket		for MXL1013, LM311N, and TL072
3	axial ferrite bead	L1, L2, L3	Active #MURJP2141, Mouser #623-2743002112
2	SPDT switch, NKK M2012ES1W01	SW1, SW2	Allied #870-8646 Mouser #633-M201202
1	3 position 0.1" header	JP2	Digikey #A26512-ND (40 pin, break away as many pins as you need) Mouser #571-6404523 (3 pin)
1	2 pin shunt for JP2		Mouser #517-952-10
1	MTA-156 6 pin header	JP1	Mouser #571-6404456 Digikey #A1973-ND (for power supply, see text)

Hardware

Quantity	Description	Notes
1	knob	ALCO PKES90B1/4
1	TLN-904 panel	front panel
1	TLN-904 PCB set	printed circuit boards (2)
1	3 pot short Stooge bracket	Stooge bracket
4	#6-32 screw, 1/4" spacer, and nut	(for mounting main circuit board to Stooge bracket)
1	pot nut	Mouser #534-1456 (for mounting Stooge bracket to front panel)
1	MTA-156 power cable	Digikey #A1953-ND (6 pin receptacle) Digikey #A19764-ND (6 pin dust cover) Mouser #571-6404266 (6 pin receptacle) Mouser #571-6405516 (6 pin dust cover)
1	48 pin right-angle 0.1" connector (2 rows, 24 pins per row)	Digikey #S2111-24-ND (for mounting LED daughterboard to main circuit board, see text)
1	display bezel and clear lens	Digikey #PRD360B-ND (bezel) Digikey #PRD360C-ND (clear lens)

4	#8-32 black screw	(for mounting module to cabinet)
	3" x 5.5" piece of black felt (or cloth)	to cover up LED daughterboard so it won't be seen through display bezel
	heat shrink cable	
	cable ties	
	hookup wire	
	solder	both organic and no clean

TOP

C13 +

L1

L2

C14 +

JP1
+5 -15 GND +15

L3

JP2
E I

U3

TP1

R10 R7 R8

C21 C20

C3

U2

C4

R17 R18 R16

Q2

C17 C16 C5

R15 R14 R13

D1

J1

R2 R1

C1

U1

C11

C12 +

C2

R6

21

R9 R12 R11

Q1 P

22

23

U4

R22 R24 R23

Q3

C6 C18 C19

R19 R20 R21

D2

R3 R4 R5

SW1

C15

SW2
F

TP2

TP3

R31

C7

U5

C8

R33

R27 R26 R25

R34

C10

R30 R29 R28

C9

R32

VR1

1
2
3
4
5
6
7
8
9
10

U6

11
12
13
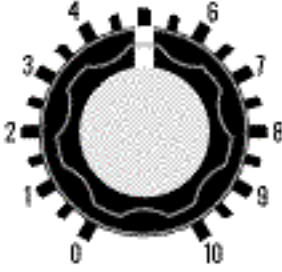14
15
16
17
18
19
20

U7

GND

The Tellun Corporation
TLN-904 Rev. 1.0
January 2004

PEAK

MODE
BAR
DOT

RANGE
PEAK
FIXED

IN **THRU**

TELLUN CORP
VEEBLEFETZER