The Tellun Corporation

TLN-156 Neural Agonizer

User Guide, Rev. 1.1.1

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1. Introduction

The TLN-156 Neural Agonizer is a voltage controlled spring reverb processor. Although this module can be used to simulate room reverb with most audio signals, it includes numerous enhancements specifically designed for interfacing to a modular synthesizer. If you're looking for a smooth, natural sounding reverb system to make your synthesizer sound like its being played in the Concertgebouw, then go buy a Lexicon. This is not your grandmother's reverb tank, this is a noxious tool capable of inflicting some serious damage to your audio.

The TLN-156 features: an amplifier for controlling the input signal level, two reverb tanks that can be driven in series or parallel, separate recovery amplifiers and resonators for each reverb tank, a feedback amplifier with lowpass filter, and a deformation processor for combining the reverb tank outputs. Most parameters are voltage controllable and several patch points are available for adding additional signal processing. All inputs and outputs handle 10 Vpp audio signals and 5 volt control voltage signals (modular standard).

The TLN-156 started out as a replacement for a Hot Springs Reverb that I built in the early 1980s[1]. I modified that circuit to handle modular synthesizer signal levels and then added a host of new features until it mutated into the circuit described in this document. As designed, this circuit uses two Accutronics #1FB2B1D reverb tanks but will work with other reverb tanks provided that they have similar input and output impedances. Details are given later in this document.

2. Circuit Description

The block diagram (included at the end of this document) shows the signal flow through the TLN-156. The three dotted arrows indicate connections that should be normalized at the front panel jacks.

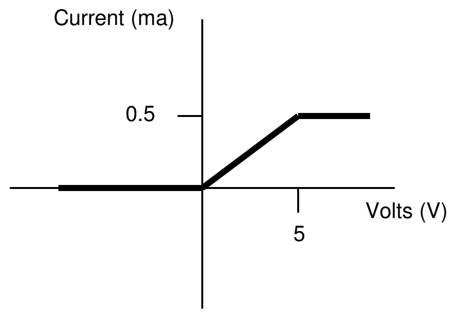
2.1. Input Amplifier

The input amplifier is shown in the upper left on page 1 of the schematic. The input signal enters at the IN jack (J1) and is buffered by U1a before feeding a VCA built from U3a, U2a, and U1b. The current into pin 3 of U3a controls the VCA gain. As designed, unity gain (measured from the IN jack to pin 7 of U1b) is achieved when the current into pin 3 of U3a is 0.5 mA.

The linear current source built around U2a and Q1 provides 0 to 0.5 mA of current as the voltage at the DRIVE input increases from 0 to +5 volts[2]. Negative voltages at the DRIVE input have no effect on the VCA; the current source will not go negative. R7 acts

[1] A Craig Anderton design available from Paia Electronics.
[2] This linear current source and portions of the VCA were borrowed from Tony Allgood.

as a current limiting resistor to prevent the current source from going above 0.5 mA. Thus we achieve the following voltage to current response:



VR1 (DRIVE pot) is a front panel pot for adding a constant gain to the VCA. The voltage appearing at the DRIVE jack (J2) is summed with the voltage dialed in by VR1 to set the overall VCA gain.

TP12 is used to balance any DC offset produced by the VCA.

Modifications

The input amplifier is designed to work with 10 Vpp audio signals and 0 to +5 volt control voltage signals. The VCA produces unity gain with VR1 fully clockwise or with +5 volts at the DRIVE jack.

To get more gain out of the VCA (if using audio signals less than 10Vpp), increase R8. To get more gain out of the VCA (if using control voltages less than +5 volts), decrease R10.

TL072 op amps can be used for U1 and U2.

2.2. Lowpass Filter

The lowpass filter (shown at the bottom left on page 1 of the schematic) is used to tame the feedback signal so that the system doesn't break into high frequency oscillation too easily. The feedback signal enters the filter through R18. U3b and U4b form a single pole voltage controlled lowpass filter[3]. The current into pin 6 of U3b controls the filter's cutoff frequency. C41 is used to block any DC from reaching the main driver amp.

An exponential current source for setting the cutoff frequency is created from U2b, Q2, and Q3[4]. This is not one of those fancy temperature compensated exponential current sources that are used in oscillators. This is a relatively simple current source intended

[3] This lowpass filter was borrowed from Jim Patchell.
[4] This exponential current source appears many times in Electronotes.

only to warp a linear control voltage into an exponential current. This response is necessary so that the LPF control will vary the filter's cutoff frequency with a fairly even response throughout the audible range.

The filter's cutoff frequency is set by front panel control VR2 (LPF pot) and by the voltage appearing at the LPF jack (J3). Cutoff frequency increases as the voltage is increased. As designed, the minimum cutoff frequency is around 10 Hz and the maximum is around 16 KHz.

TP1 is used to balance any DC offset produced by the filter.

No means of altering the resonance, or Q, of this filter is provided. Should there be a need to alter the resonance, or to use a filter of higher order, or of different type, then an external filter can be patched into the feedback loop using the FDBK IN and FDBK OUT jacks provided on the front panel.

Modifications

The filter is designed to work with 10 Vpp audio signals and 0 to +5 volt control voltage signals. Control voltages below 0 volts and above +5 volts will not harm the filter.

C40 can be changed to affect the overall frequency response of the filter. Lower values will raise the maximum cutoff frequency. R14 can be changed to 100K to produce (roughly) a 1 volt/octave frequency response. But this will require a 10 volt control signal to cover the entire audible range so it's best to leave R14 at 30K. The minimum cutoff frequency (i.e. when the LPF control is fully counter-clockwise) can be increased by changing R12 to 180K or higher. The curve of the exponential current source can be modified by changing R16 to 100K or 150K. The minimum and maximum cutoff frequencies will not change much if R16 is changed but the mid-point will (i.e. when the LPF control is at the middle position).

A TL072 op amp can be used for U2. A TL072, or similar BiFET high input impedance op-amp *must* be used for U4B otherwise the filter will not operate properly.

2.3. Tank Driver

The tank driver circuitry is shown in the right half on page 1 of the schematic. The outputs from the input amplifier and the lowpass filter are summed by U5a. The output from the lowpass filter is inverted so it must be inverted again by U5a to get it in phase with the input signal.

The two reverb tank input transformers are placed in the feedback loop of U5b (a non-inverting amplifier) so that they are driven by a current source rather than a voltage source. This is a well-known trick to getting a brighter frequency response from spring reverb tanks (which are essentially inductors and thus have a higher impedance at higher frequencies). Note that the reverb tank input transformers must not be connected to ground in order for this to work. Rewiring of the reverb tanks is discussed in another section of this document.

The ORDER switch reconfigures the two reverb tank input transformers from series to parallel. The #1FB2B1D reverb tanks have an input impedance of 1475 ohms. In series the effective impedance is double this value, while in parallel the effective impedance is half this value. Changing the configuration has a significant effect on the sound at different drive levels.

In parallel with the reverb tank input transformers are two frequency response modifiers.

The first modifier is the peak enhancement circuit. C42 and R27 react with the reverb tank's inductance to tune the driver's frequency response. The suggested values of 2.2 nF and 1 K provide a slight frequency peak in the 5 kHz range when the input transformers are connected in series, and at 10 kHz when the input transformers are connected in parallel.

The second modifier is the high frequency gain limit. The reverb tanks are essentially inductors and will have greater impedance at higher frequencies. Since they are connected in the feedback loop of U5b, they will provide higher gain at higher frequencies. TP2 and R28 set the maximum gain at high frequencies so that the driver won't clip when the input is, for example, a 10 kHz sine wave.

TP3 and R29 set the overall gain of the tank driver. Lower values produce more gain. R29 is used to limit the maximum gain to a reasonable value. C43 is an optional capacitor that forms a highpass filter with TP3 and R29. Use C43 only if you prefer to have a filter on the input, otherwise replace it with a scrap resistor lead. Do not leave C43 as an open circuit.

Modifications

C42 and R27 can be modified to set the driver's frequency response. The peak effect can be quite subtle and should be set to whatever sounds best to the user and the particular reverb tanks in use. C42 sets the frequency of the peak, and R27 sets the damping factor. Increasing C42 will lower the peak frequency. Increasing R27 will decrease the peak enhancement (by lowering the Q). The suggested range for C42 is 1 nF to 4.7 nF, and 0 K to 4.7 K for R27. Note that the Q of the peak enhancement circuit will be higher when the reverb tanks are connected in series (because the inductance is larger). Also note that if the peak frequency is F when the input transformers are connected in series, the peak frequency will be 2F when the input transformers are connected in parallel.

TP3 and/or R29 can be changed to modify the overall gain of the tank driver. Higher values will decrease the gain.

C43 can be changed or left out entirely if no highpass filtering is required. Lowering C43 will increase the cutoff frequency of the highpass filter. Note that C43 reacts with TP3 and R29 to set the cutoff frequency. Lowering TP3 and/or R29 will increase the cutoff frequency of the highpass filter. **If C43 is left out, it must be replaced by a scrap resistor lead, do not leave it as an open circuit.**

TL072 op amps can be used for U5.

2.4. Tank B Amplifier and Resonator

The recovery amplifier for Tank B is shown in the bottom left on page 5 of the schematic. U15a is configured as a high gain non-inverting amplifier (the signal from the reverb tank's output transformer is very small). C51 and R86 form a lowpass filter with a cutoff frequency at approximately 16 kHz. R87 and TP8 set the gain of the amplifier. Lower values give more gain. TP8 is adjusted so that the output signal appearing at OUT B is approximately 10 Vpp.

C52 and R84 are optional components that are only used if it is desired to have a highpass filter on the recovery amplifier. C52 forms a highpass filter along with R87 and TP8. R85 sets the minimum gain for low frequencies. If a highpass filter is not necessary, then replace C52 with a scrap resistor lead (a short circuit), and leave R84 out (an open circuit).

TP9 is used to balance any DC offset produced by the recovery amplifier.

Connected in parallel with the recovery amplifier is the resonator circuit. The resonator is a voltage controlled processor that reacts with the inductance of the reverb tank's output transformer to produce a bizarre form of bandpass filter. Think of it as a voltage controlled capacitor and a voltage controlled resistor in parallel with the reverb tank's output transformer.

Two vactrols are used to modify the resonators frequency response. The LDR (light dependant resistor) half of VAC1 works with C49 and U15b to produce a voltage controlled capacitor. As the gain of the inverting amplifier increases, the effective capacitance increases. R83 sets the maximum resistance of the LDR half of VAC1 to 3.3 M (as seen by U15b). The LDR half of VAC2 acts as a voltage controlled resistor on the input leg of the inverting amplifier. R82 sets the maximum resistance of the LDR half of VAC2 to 330 K (as seen by U15b). The two vactrols interact to change the gain of the inverting amplifier and thus the frequency response of the resonator. C50 is used to limit the resonator's Q.

Two exponential current sources are used to drive the LED halves of the vactrols. These circuits, in the right half on page 5 of the schematics, are similar to the exponential current sources used in the lowpass filter (see Section 2.2).

A current source built from U16a, Q8, and Q9 controls the current through the LED half of VAC1 (and therefore the resistance of the LDR half of VAC1). As current increases through the LED half of a vactrol, the resistance decreases in the LDR half of the vactrol. The current through VAC1 can be set manually using VR6 (STRESS B pot) or via a control voltage at the STRESS B jack (J11). As designed, the current will range from 0 to 10 mA for a 0 to +5 volt signal at the STRESS B input. This translates to a resistance ranging from 3.3 M to 2 K (as seen by U15b). R94 limits the maximum current to 13.25 mA for VAC1.

A similar current source built from U16b, Q10, and Q11 controls the current through the LED half of VAC2. The current through VAC2 can be set manually using VR7 (TRAUMA B pot) or via a control voltage at the TRAUMA B jack (J12). As designed, the current will range from 0 to 12 mA for a 0 to +5 volt signal at the TRAUMA B input. This translates to a resistance ranging from 330 K to 2 K (as seen by U15b). R99 limits the maximum current to 13.25 mA for VAC2.

Modifications

The recovery amplifier is designed to output 10 Vpp audio signals. The resonator will accept 0 to +5 volt control voltage signals. Control voltages below 0 volts and above +5 volts will not harm the resonator.

C51 can be lowered to 33P to raise the cutoff frequency of the lowpass filter out of the audible range.

C50 can be changed to modify the resonator’s Q. Leaving C50 out entirely will raise the Q to maximum, resulting in a more nasal tone. A value of 33 pF will lower the Q so that the resonator has a more subtle effect.

TP8 and/or R87 can be changed to modify the overall gain of the recovery amplifier. Higher values will decrease the gain.

C52 can be changed or left out entirely if no highpass filtering is required. Lowering C52 will increase the cutoff frequency of the highpass filter. Note that C52 reacts with TP8 and R87 to set the cutoff frequency. Lowering TP8 and/or R87 will increase the cutoff frequency of the highpass filter. R84 can be changed to set the minimum gain for low frequencies. Lower values of R84 will provide more gain at low frequencies. Leave R84 out entirely to get no gain at DC. **If C52 is left out, it must be replaced by a scrap resistor lead, do not leave it as an open circuit. If C52 is left out, then R84 should also be left out (leave R84 as an open circuit).**

The resonator’s overall frequency response can be modified by changing C49. Recommended values range from1 nF to 2.2 nF. The maximum resistance of each vactrol can be modified by changing R82 and R83. Changing these values will likely require changing the gain of the STRESS B and TRAUMA B exponential current sources (R89, R90, R91 for VAC1 and R95, R96 for VAC2) so that the entire range can still be swept by a 0 to +5 volt control voltage. The curve of the exponential current sources can be modified by changing R93 (for VAC1) and R98 (for VAC2) to 100 K or 150 K.

TL072 op amps can be used for U15 and U16.

2.5. Tank A Amplifier and Resonator

This circuit is identical to the Tank B Amplifier and Resonator circuit (see Section 2.4).

2.6. Deformation Processor

The deformation processor is a voltage controlled mixer that takes two inputs (A and B) and produces various combinations of those inputs (A, B, A+B, A-B, B-A). These various combinations are referred to as "deformations". The two inputs are normalled to the Tank A and Tank B amplifier/resonator outputs. The output from the deformation processor is normalled to the feedback amplifier's input. These normalizations can be defeated by plugging external signals into the IN A, IN B, and FDBK IN jacks. In this way, the deformation processor can be completely isolated from the TLN-156 and used as a two input voltage controlled mixer. It can also be used to provide two additional signal inputs to the TLN-156.

The B channel input is shown in the upper left quadrant on page 2 of the schematic. The signal enters at the IN B jack (J4) and is buffered by U8a before feeding both a VCA (built around U10a, U7a, and Q4) and a summing amp (built around U9 in the bottom right on page 2 of the schematic). The VCA is identical to the one used in the input amplifier (see Section 2.1) including the linear current source. The only significant difference is that the gain ranges from 0 to –2.5 rather than 0 to 1.0[5]. The A channel input is shown in the upper right quadrant on page 2 of the schematic and is identical to the B channel input.

The deformation control voltage (bottom left quadrant on page 2 of the schematic) is set either by VR3 (DEFORM pot) or by a signal at the DEFORM jack (J5, range -2.5 volts to +2.5 volts). The deformation control voltage sets the gain of the A channel VCA. An inverted version of the deformation control voltage sets the gain of the B channel VCA. The outputs of the two VCAs along with the original A and B inputs are summed by U9 to create the FDBK OUT output signal. The transfer functions for the A and B signals (measured from the IN B/IN A inputs to the FDBK OUT output) are given below:

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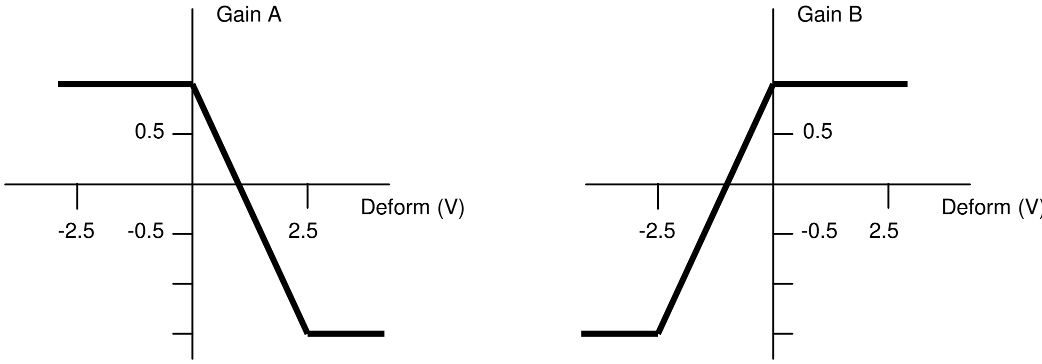
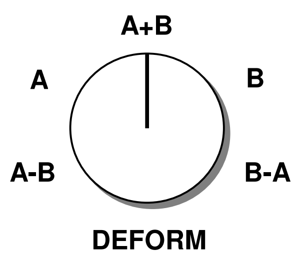
[5] This is not entirely true; the outputs are scaled to 70% by U9a to keep the signal levels reasonable. But ignoring this, for now, makes the math easier.



So what does this all mean? With 0 volts applied to the DEFORM input, the output signal is A+B. As the DEFORM voltage goes positive, the gain of B stays constant at 1.0, but the gain of A begins to drop in a linear manner until it reaches a minimum of –1.5. So the output goes from A+B, to B, to B-A, and then stops at B-1.5A. As the DEFORM voltage goes negative, the gain of A stays constant, but the gain of B begins to drop in a linear manner until it reaches a minimum of –1.5. So the output goes from A+B, to A, to A-B, and then stops at A-1.5B. Here's how it would look if marked on the DEFORM panel control (VR3):



When normalled to the Tank A and Tank B amplifier/resonator outputs, the A-B and B-A deformations have the ability to cancel significant portions of the input signal while leaving much of the reverb signal untouched[6].

TP4 and TP5 are used to balance any DC offsets produced by the VCAs.

Modifications

The deformation processor is designed to work with 10 Vpp audio signals and 0 to +5 volt control voltage signals. Control voltages below 0 volts and above +5 volts will not harm the circuit.

The DEFORM control voltage input is offset by 2.5 volts so that the effective input range is –2.5 volts to +2.5 volts when VR3 is set to the middle (A+B) position. This allows a 5

[6] This input canceling effect is used quite effectively in Craig Anderton's Hot Springs Reverb, which led to the implementation of the deformation processor.

volt signal (such as an envelope generator output) to sweep the entire range of deformations. R41 can be changed to 100K so that a 5 volt envelope generator signal will sweep only half the range.

R55 sets the overall gain of the deformation processor. As designed, the gain is 0.7 which keeps the signal levels reasonable when the deformation is at A+B. The gain can be lowered to 0.5 by changing R55 to 24 K, or raised to 1.0 by changing R55 to 47 K.

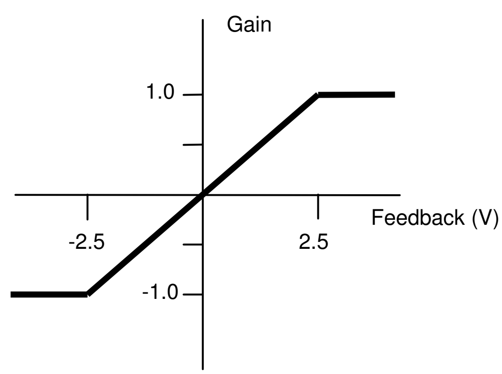
TL072 op amps can be used for U6, U7, U8, and U9.

2.7. Feedback Amplifier

The feedback amplifier is a voltage controlled amplifier that produces both inverted and non-inverted versions of an input signal. The input signal is normalled to the output of the deformation processor but can be defeated by plugging an external signal into the FDBK IN jack (J8).

The feedback amplifier is shown on page 4 of the schematic. The signal enters at the FDBK IN jack (J8) and is buffered by U13a before feeding both the negative and positive feedback VCAs. The negative feedback VCA (built around U14a, U12a, and Q6) is identical to the one used in the input amplifier (see Section 2.1) including the linear current source. The gain of this amplifier ranges from 0.0 to –1.0. The positive feedback VCA is shown in the upper right quadrant on page 4 of the schematic and is identical to the negative feedback VCA except that the gain is 0.0 to +1.0. The output from both VCAs are summed and converted to a voltage with U4b and R80.

The feedback control voltage (bottom left quadrant on page 4 of the schematic) is set either by VR5 (FEEDBACK pot) or by a signal at the FEEDBACK jack (J9, range -2.5 volts to +2.5 volts). The feedback control voltage sets the gain of the positive feedback VCA. An inverted version of the feedback control voltage sets the gain of the negative feedback VCA. The transfer function for the feedback amplifier (measured from the FDBK IN input to pin 1 of U4a) is given below:



TP6 and TP7 are used to balance any DC offsets produced by the VCAs.

Modifications

The feedback amplifier is designed to work with 10 Vpp audio signals and 0 to +5 volt control voltage signals. Control voltages below 0 volts and above +5 volts will not harm the circuit. The amplifier produces a gain of 1.0 with VR5 fully clockwise or with +2.5 volts at the FEEDBACK jack. The amplifier produces a gain of -1.0 with VR5 fully counter-clockwise or with -2.5 volts at the FEEDBACK jack

The FEEDBACK control voltage input is offset by 2.5 volts so that the effective input range is –2.5 volts to +2.5 volts when VR5 is set to the middle position. This allows a 5 volt signal (such as an envelope generator output) to sweep the entire range of feedback. R70 can be changed to 100K so that a 5 volt envelope generator signal will sweep only half the range.

R80 sets the overall gain of the feedback amplifier. As designed, the gain is 1.0, but can be modified by changing R80. Lower values will produce less gain.

TL072 op amps can be used for U11, U12, and U13.

2.8. Output Mixer

The output mixer is shown in the bottom right on page 3 of the schematic. VR4 (MIX pot) selects the input signal (post VCA), the deformation processor output, or a mixture of the two. U13b buffers the signal before sending it to the MIX OUT jack (J7).

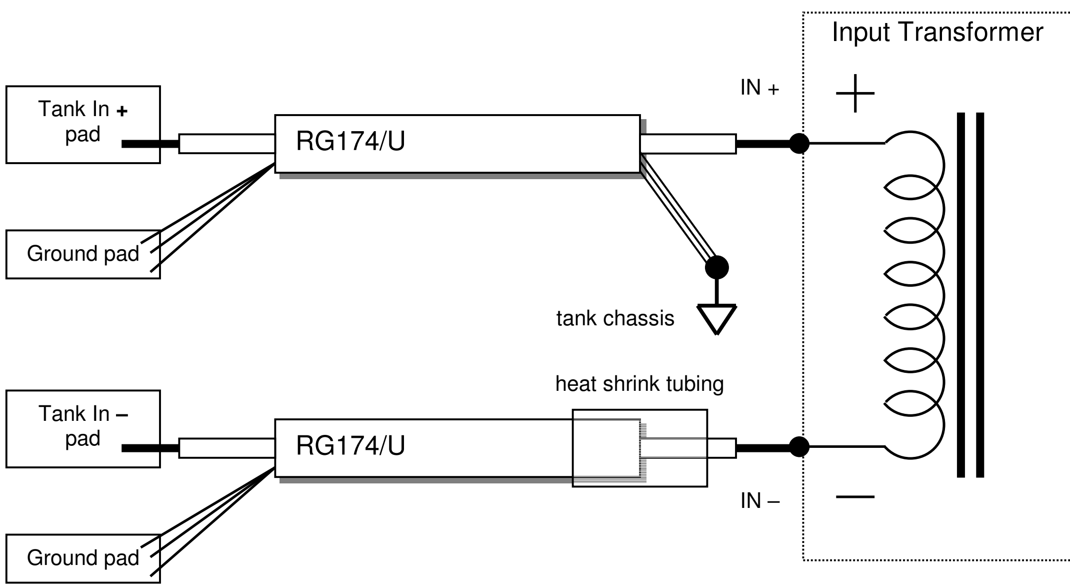
3. Connecting the Reverb Tanks

The reverb tanks need to be rewired before they can be used with the TLN-156. This rewiring is not the same as that done when building a Hot Springs Reverb. The chassis of each tank also needs to be grounded. The TLN-156 provides six PCB-mounted 1/8” (3.5 mm) phone jacks for connecting two reverb tanks, and two (optional) ground connections for the tank chassis using a two pin MTA-156 connector (JP5). You will need to prepare six coax cables that have <u>shielded</u> 1/8” (3.5 mm) phone plugs on one end and <u>shielded</u> phono plugs on the other end. The phone plugs will plug into the phone jacks on the TLN-156, the phono plugs will plug into the phono jacks on the reverb tanks. Keep these cables as short as possible, just long enough to comfortably reach the reverb tanks when the TLN-156 is mounted in the cabinet.

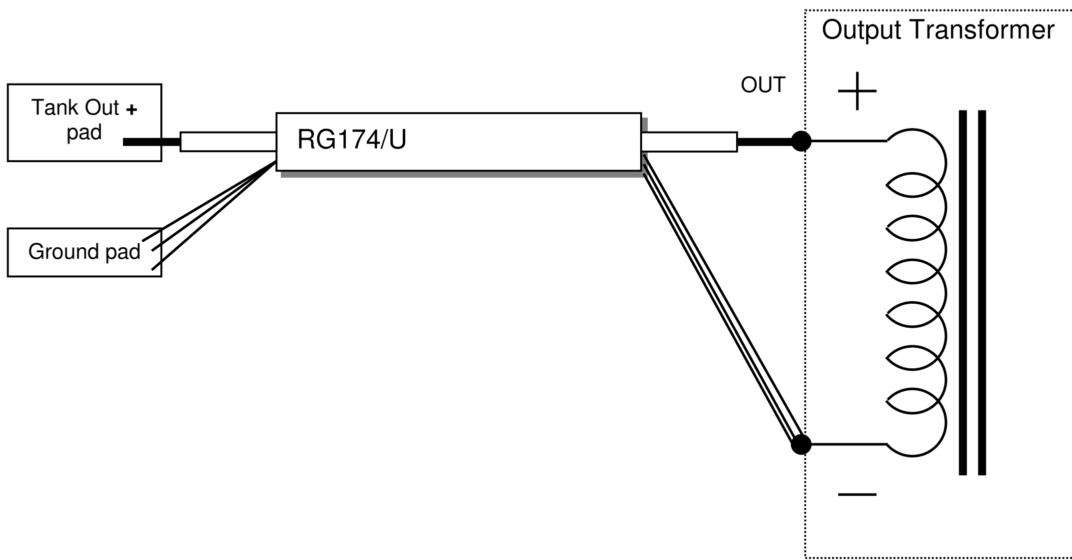
The input transformer has two leads that need to be brought back to the TLN-156 PCB using two separate pieces of coax cable. The core (inside) of the two coax cables connect to the Tank Input + and Tank Input – pads on the PCB via the phone jacks on the TLN-156 PCB. Neither lead of the input transformer is connected to ground. The easiest way to make these connections is to add a third phono jack to the reverb tank. The tank already has an IN and OUT jack. Drill a hole in the reverb tank chassis and mount a third phono jack near the IN jack. Call this third jack IN–. Call the original IN jack IN+. Connect the positive lead of the input transformer to the center conductor of the IN+ phono jack. Connect the negative lead of the input transformer to the center conductor of the IN–.

The shield (outside) of the two coax cables must be connected to ground at the PCB end. Whether or not the shield is also connected to ground at the IN+ and IN– jacks depends on how you decide to ground the chassis of your tank. Some models of reverb tanks have the IN and/or OUT jack's ground connection also connected to the chassis. You can use this connection to ground the chassis with the coax shield simply by hooking up the shield to the ground connection at either the IN+ or OUT jack. Alternatively, you can also ground the chassis using the coax shield on the newly added IN– jack if this jack's ground connection is connected to the chassis. If none of the reverb tank jacks have ground connected to the chassis, you will have to run a wire from the (optional) two pin MTA-156 connector (JP5) on the TLN-156 PCB to the chassis of each reverb tank.

You should only have one ground connection going to the chassis of each reverb tank to avoid group loops. If the coax shield is not to be connected to anything at the input transformer end, snip it off and cover with a piece of heat shrink tubing to prevent any stray strands from coming into contact with anything. The diagram below illustrates how the input transformer is to be hooked up to the TLN-PCB (the phone plugs/jacks and the phono plugs/jacks are not shown for clarity). In this example, the chassis is also grounded via the coax shield at the IN+ jack. To avoid ground loops, the coax shield leading to the IN– jack is snipped off and covered with heat shrink tubing.



The output transformer is a bit simpler to hook up. It has two leads that need to be brought back to the TLN-156 PCB using one piece of coax. At the PCB end, the core (inside) of the coax connects to the Tank Out + pad while the shield (outside) connects to a ground pad. At the output transformer end, the coax core is connected to the positive wire (+) while the coax shield is connected to the negative (–) wire. The diagram below illustrates how the output transformer is to be hooked up to the TLN-PCB (the phone plugs/jacks and the phono plugs/jacks are not shown for clarity).



4. *Construction Tips*

Consider using sockets for the op-amps so you can try out different types. In particular, the recovery amps (U15 and U17) can be quite noisy when using a high resonator gain. A TL072 may result in lower noise than an OP275. Use whatever sounds best to you.

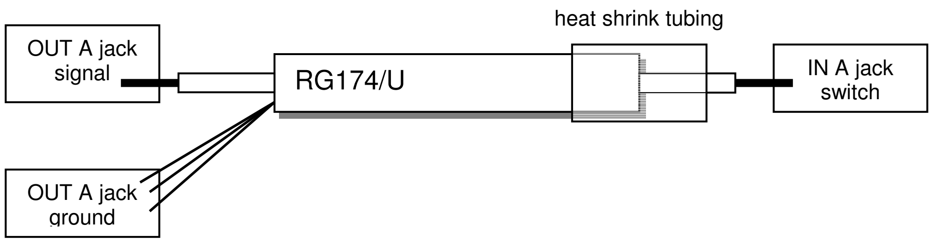
The vactrols should be installed so that the resistor ends (the two thinner wires) are flush with the PCB. The LED wires (the two thicker wires) must be bent 180 degrees around to fit into the holes on the PCB. Match the + on the PCB with the + on the vactrol.

VR1, VR3, VR4, and VR5 can be mounted directly on the PCB if using Spectrol 149 series pots (and a four pot long Stooge bracket to mount the PCB to the panel).

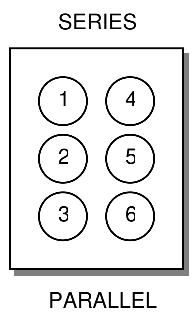
Save some scrap resistor leads and use them to connect the switching lug of the phone jacks to ground for the control voltage inputs: DRIVE (J2), LPF (J3), DEFORM (J5), FEEDBACK (J9), STRESS B (J11), TRAUMA B (J12), STRESS A (J14), TRAUMA A (J15).

Use coax cable when normalizing the OUT A jack (J13) to the IN A jack (J6), the OUT B jack (J10) to the IN B jack (J4), and the FDBK OUT jack (J16) to the FDBK IN jack

(J8). Connect the coax shield to ground at one end only (at the OUT A, OUT B, and FDBK OUT jacks) to avoid introducing ground loops. Clip the coax shield from the other end and cover with a piece of heat shrink tubing to prevent any stray strands from coming into contact with anything. At this clipped end, connect the core (inside) conductor to the switching lug of the IN A, IN B, and FDBK IN jacks.

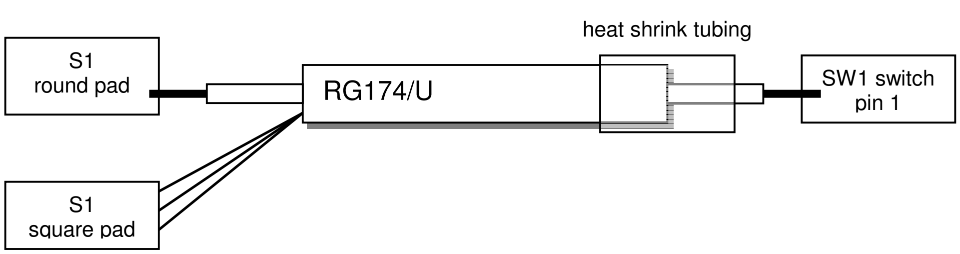


SW1 is connected to the PCB with four pieces of coax cable. Pads on the PCB (S1, S2, S4, S5) indicate which of the four switch pins to connect using the following numbering convention:



Switch viewed from behind (pins facing toward you). With switch in the up position (SERIES) pins 2 and 3 are connected, and pins 5 and 6 are also connected.

A jumper <u>must</u> also be connected between pins 1 and 6 on SW1. Pin 3 on SW1 is not connected to anything. Each of the four pieces of coax should have the shield connected to ground at the PCB end only. The square pad on the PCB indicates the ground connection. Clip the coax shield from the other end and cover with a piece of heat shrink tubing to prevent any stray strands from coming into contact with anything. At this clipped end, connect the core (inside) conductor to the switch.



JP3 and JP4 are optional jumpers intended to allow the resonators on the recovery amps to be temporarily disconnected to make calibration a little easier. These jumpers can be left out and replaced with a scrap resistor lead, or replaced with a small PCB mountable switch that uses 0.1" pin spacing.

The PCB uses 0.4" spacing for the resistor pads, 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" or 0.138" (for 100 uF) pad spacing. The polystyrene caps have a 0.6" pad spacing.

For VR1-VR9, 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-J16 and S1, S2, S4, S5, the square pad on the PCB indicates the ground connection.

For the tank input and output jacks (TA IN +, TA IN –, TB IN +, TB IN –, TA OUT, TB OUT), the square pad on the PCB indicates the ground connection, pin 2 is the signal, and pin 3 is unconnected.

Holes are provided on the PCBs for using cable ties (ala MOTM) with some of the coax connections: J1, J4, J6, J7, J8, J10, J13, J16. Cable ties are not required, these holes are merely provided for those who wish to use them.

The circuit is divided into two PCBs so that it will fit within the bounds of a Stooge bracket. Board #1 is the larger board and has 8 holes for mounting onto a 4 pot long Stooge bracket. 6 of the holes match up with holes on the bracket, you'll have to drill 2 holes in the bracket for the holes along the back edge of the board. Use #6-32 screws and 1/4" aluminum spacers for mounting board #1 to the bracket. Board #2 is the smaller board and has 4 holes so that it can be mounted above board #1 using 3/4" standoffs. Board #2 contains all the circuitry for the recovery amps and resonators (pages 5-6 of the schematic). These circuits use fairly high gain and are thus susceptible to picking up signals from nearby circuits. Consider installing a piece of shielding (e.g. a piece of metal 3-5/8" by 5") underneath board #2 to keep it from picking up signals from board #1. Use #6-32 screws and 1/4" aluminum spacers for mounting board #2 and the metal shield to the standoffs.

4.1. Panel Wiring Guide

Panel Designation	*PCB Designation*	*Wire Length (inches)*	*Wire Type*
IN jack	J1	7	coax
DRIVE jack	J2	10	twisted
LPF jack	J3	8.5	twisted
IN B jack	J4	3	coax
DEFORM jack	J5	9	twisted
IN A jack	J6	3	coax
MIX OUT jack	J7	4.5	coax
FDBK IN jack	J8	6	coax
FEEDBACK jack	J9	8	twisted
OUT B jack	J10	6	coax
STRESS B jack	J11	6	twisted
TRAUMA B jack	J12	6	twisted
OUT A jack	J13	4.5	coax
STRESS A jack	J14	6	twisted
TRAUMA A jack	J15	6	twisted
FDBK OUT jack	J16	5.5	coax
DRIVE pot	VR1	2*	twisted
LPF pot	VR2	8	twisted
DEFORM pot	VR3	2*	twisted
MIX pot	VR4	2*	coax
FEEDBACK pot	VR5	2*	twisted
STRESS B pot	VR6	5	twisted
TRAUMA B pot	VR7	6	twisted
STRESS A pot	VR8	5	twisted
TRAUMA A pot	VR9	5	twisted
SW1 pin 1	S1	8	coax
SW1 pin 2	S2	8	coax
SW1 pin 4	S4	8	coax
SW1 pin 5	S5	8	coax
SW1 pin 1 to SW1 pin 6		1.5	twisted
OUT A jack to IN A jack		2	coax
OUT B jack to IN B jack		2	coax
FDBK OUT jack to FDBK IN jack		2	coax

*Only necessary if pot is not mounted directly on PCB.

5. Calibration

This circuit has a lot of trimmers. Most of them are for balancing DC offsets from the OTAs and recovery amps. The rest are for setting the driver and recovery amp gain characteristics. Board #2 obscures some of the DC offset trimmers on board #1, so it will need to be disconnected during the first part of the calibration. Board #2 does not need to have power applied while it is disconnected. The reverb tanks can also be disconnected during the first part of calibration.

Make sure you do the calibration in the order specified below.

TP12 adjusts the DC offset from the input VCA. Plug a ground connection into the IN jack. Turn the MIX pot to the 0 position (fully counter-clockwise). Apply a 10 Vpp audio signal from an oscillator to the DRIVE jack (a 30 Hz square wave works well). Turn the DRIVE pot to the 10 position (fully clockwise). Attach a scope probe to the MIX OUT jack. Adjust TP12 to minimize the signal at the MIX OUT jack.

TP4 and TP5 both adjust the DC offset from the deformation processor. Plug a ground connection into the IN B and IN A jacks. With nothing plugged into the DEFORM jack, attach a DVM to pin 1 of U6 and adjust the DEFORM pot until the DVM reads as close to 0.0 volts as you can get (the DEFORM pot will be near the 5 position). Now apply a 10 Vpp audio signal from an oscillator to the DEFORM jack (a 30 Hz square wave works well). Attach a scope probe to the FDBK OUT jack. Adjust TP4 and TP5 to minimize the signal at the FDBK OUT jack. TP4 affects the negative half of the signal at the DEFORM jack, TP5 affects the positive half.

TP6 and TP7 both adjust the DC offset from the feedback amplifier. Plug a ground connection into the FDBK IN jack. With nothing plugged into the FEEDBACK jack, attach a DVM to pin 1 of U11 and adjust the FEEDBACK pot until the DVM reads as close to 0.0 volts as you can get (the FEEDBACK pot will be near the 5 position). Now apply a 10 Vpp audio signal from an oscillator to the FEEDBACK jack (a 30 Hz square wave works well). Attach a scope probe to pin 7 of U4. Adjust TP6 and TP7 to minimize the signal at pin 7 of U4. TP6 affects the negative half of the signal at the FEEDBACK jack, TP7 affects the positive half. You may have to re-adjust TP6 after adjusting TP7 because there is some interaction between the two.

TP1 adjusts the DC offset from the lowpass filter. Plug a ground connection into the FDBK IN jack. Set the FEEDBACK pot to the 5 position. Set the LPF pot to the 10 position (fully clockwise). Attach a DVM to pin 1 of U4. Adjust TP1 to get 0.000 volts at pin 1 of U4.

Shut off the power. Attach board #2 and the reverb tanks. Turn the power back on.

TP2 and TP3 set the gain characteristics of the input driver. TP3 sets the overall driver gain. TP2 sets the high frequency gain. There is no right or wrong way to set these trimmers. You must set them to achieve whatever driver response you want. I will explain how I set these trimmers for my reverb tanks; use this as a guide to set the response for your tanks. You will likely want to come back to tweak TP2 and TP3 after you've tried using the TLN-156 with a variety of signals. I recommend tweaking while listening to the signal at the MIX OUT jack rather than relying on a scope. But for now, follow the procedure outlined below to get in the ballpark.

Plug a ground connection into the FDBK IN jack. Set TP2 and TP3 to their middle positions. Set the ORDER switch to SERIAL. Apply a 30 Hz 10 Vpp sine wave from an oscillator to the IN jack. Set the DRIVE pot to the 5 position. Attach a scope probe to pin

7 of U5 (I call this the “driver signal”). Adjust TP3 until the driver signal is 10 Vpp. This provides a clean driver signal when the DRIVE pot is at the 5 position and an overdriven driver signal when the DRIVE pot is at the 10 position.

Now change the sine wave oscillator’s frequency to 10 kHz. The driver signal should be going from rail to rail with severe clipping. Adjust TP2 until the driver signal is just below clipping (this will happen when TP2 is very close to it’s minimum resistance). Now add one full turn to TP2 so that the signal is clipping again. If TP2 is turned too much to its minimum the reverb will sound dull (lacking in the high end). If TP2 is turned too much to its maximum the driver will clip too easily with high frequency signals. Be prepared to experiment a bit with TP2.

TP8 and TP10 set the gain for the recovery amps. Like TP2 and TP3, there is no right or wrong way to set these trimmers. You must set them to achieve whatever gain you want, and this depends on how you’ve set the driver gain for TP2 and TP3. TP8 and TP10 are to be set so that you get (approximately) 10 Vpp signals from the OUT A and OUT B jacks from a variety of input signals. I will explain how I set these trimmers for my reverb tanks; use this as a guide to set the gain for your tanks. You will likely want to come back to tweak TP8 and TP10 after you’ve tried using the TLN-156 with a variety of signals. I recommend tweaking while listening to the signal at the OUT A and OUT B jacks rather than relying on a scope. But for now, follow the procedure outlined below to get in the ballpark.

Make sure jumpers JP3 and JP4 are in the OFF position. Plug a ground connection into the FDBK IN jack. Set TP8 and TP10 to their middle positions. Set the ORDER switch to SERIAL. Set the DRIVE pot to the 5 position. Apply a 10 Vpp sawtooth wave from an oscillator to the IN jack. This sawtooth wave should be frequency modulated so that it sweeps the entire audible range over a 1-2 second period. I recommend using a second sawtooth oscillator plugged into the 1V/OCT input of the first. Attach scope probes to the OUT A and OUT B jacks. Adjust TP8 and TP10 so that the output signals are generally within a 10 Vpp range and that they are both relatively the same amplitude.

TP9 and TP11 adjust the DC offset for the recovery amps. Set jumpers JP3 and JP4 to the ON position. Plug a ground connection into the FDBK IN jack. Set the DRIVE pot to the 0 position (fully counter-clockwise). There should be no signal driving the reverb tanks and no signal appearing at the OUT B or OUT A jacks. Attach a DVM to the OUT B jack. Adjust TP9 to get 0.000 volts at the OUT B jack. Attach a DVM to the OUT A jack. Adjust TP11 to get 0.000 volts at the OUT A jack.

The TLN-156 is now calibrated.

6. In Use

The FEEDBACK amplifier will try its best to blow your speakers. Keep the LPF and FEEDBACK pots set to their 0 positions until you get a handle on how they work. In general, a constant amount of FEEDBACK is rarely useful since the LPF will have to be set very low to avoid runaway feedback. Much more interesting is to use an envelope generator, or an LFO, plugged into the FEEDBACK or LPF jacks to provide short bursts of controlled feedback as a timbre modifier.

An analogue delay plugged into the feedback path (via the FDBK IN and FDBK OUT jacks) is a fabulous addition to the TLN-156. Particularly if the analogue delay is also undergoing some form of modulation.

Patch filters or analogue delays into the IN A/B and OUT A/B jacks to process the raw reverb tank output before it is fed back to the deformation processor and feedback amplifier.

The STRESS and TRAUMA pots/jacks modify a capacitor and resistor that are in parallel with the reverb tank's output transformer (which is essentially an inductor). The capacitor, inductor, and resistor form a resonant circuit whose frequency and Q can be changed with the STRESS and TRAUMA controls. Increasing the amount of stress, by rotating the STRESS pot clockwise or applying an increasing voltage to the STRESS jack, causes the capacitor value to decrease. As the capacitor value decreases, the resonant frequency of the circuit increases. Increasing the amount of trauma, by rotating the TRAUMA pot clockwise or applying an increasing voltage to the TRAUMA jack, causes the resistor value to decrease. As the resistor value decreases, the amount of loading it places on the reverb tank's output transformer increases and the Q drops.

Use different settings for the STRESS A/B and TRAUMA A/B controls to get different frequency responses from the two reverb tanks. Then use the DEFORM pot and jack as a voltage controlled mixer to sweep between the two responses.

The OUT A and OUT B jacks can be used as separate "left" and "right" outputs to provide a pseudo-stereo reverb effect. You'll need to set the STRESS and TRAUMA controls to similar values for the A and B channels so that the "left" and "right" outputs have a similar sound (if a similar sound is what you want).

The IN A and IN B jacks can be used as two additional signal input jacks. Use the DEFORM controls to mix the two signals at the IN A/B jacks. Use the FEEDBACK controls to control the level and phase of the mix (set the LPF control fully clockwise). The reverb output must be taken from the OUT A/B jacks. The signal at the MIX OUT jack will be a mix of the IN, IN A, and IN B signals. The signal at the FDBK OUT jack will be a mix of the IN A and IN B signals.

7. Choosing Reverb Tanks

The Accutronics Reverb website has all the info you need about their reverb tanks: www.accutronicsreverb.com. Reverb tank part numbers consist of a seven digit code (my tanks are #1FB2B1D). Each digit in the part number represents a specification. The recommended parameters for the TLN-156 are as follows:

1st digit	Reverb Type	Your choice: 1, 4, 8, or 9.
2nd digit	Input Impedance	F - 1475 ohm for types 1 and 4, 1925 ohm for types 8 and 9.
3rd digit	Output Impedance	B - 2250 ohm for types 1 and 4, 2575 ohm for types 8 and 9.
4th digit	Decay	Your choice: 1, 2, or 3.
5th digit	Connectors	D - Input Insulated / Output Insulated (best) B - Input Grounded / Output Insulated (ok)
6th digit	Locking Devices	Only once choice: 1.
7th digit	Mounting Plane	Your choice: A, B, C, D, E, or F.

TLN-156 Parts List

Resistors (118)

Quantity	*Description*	*Part No.*	*Notes*
4	1 K	R58, R59, R88, R107	5% or better, Mouser #291-1K
4	10 K	R1, R30, R44, R60	5% or better, Mouser #291-10K
12	330 K	R2, R5, R22, R31, R33, R45, R47, R61, R65, R74, R82, R101	5% or better, Mouser #291-330K
2	470 K	R89, R108	5% or better, Mouser #291-470K
4	3.3 M	R83, R85, R102, R104	5% or better, Mouser #291-3.3M
6	100	R28, R29, R81, R87, R100, R106	1%, Mouser #271-100
7	1 K	R27, R84*, R94, R99, R103*, R113, R118	1%, Mouser #271-1K
5	1.8 K	R15, R92, R97, R111, R116	1%, Mouser #271-1.8K
5	2.2 K	R11, R38, R52, R68, R79	1%, Mouser #271-2.2K
1	4.99 K	R19	1%, Mouser #271-4.99K
14	10 K	R3, R4, R10, R18, R20, R32, R35, R37, R46, R49, R51, R62, R67, R78	1%, Mouser #271-10K
1	18 K	R8	1%, Mouser #271-18K
2	20 K	R64, R76	1%, Mouser #271-20K
6	27 K	R7, R21, R36, R50, R66, R77	1%, Mouser #271-27K
2	30 K	R9, R14	1%, Mouser #271-30K
1	33 K	R55	1%, Mouser #271-33K
1	36 K	R80	1%, Mouser #271-36K
2	47 K	R53, R54	1%, Mouser #271-47K
3	49.9 K	R16, R41, R70	1%, Mouser #271-49.9K
2	56 K	R91, R110	1%, Mouser #271-56K
8	68 K	R6, R17, R34, R48, R63, R75, R96, R115	1%, Mouser #271-68K
1	82 K	R13	1%, Mouser #271-82K
18	100 K	R23, R24, R25, R26, R40, R42, R43, R56, R57, R71, R72, R73, R86, R93, R98, R105, R112, R117	1%, Mouser #271-100K
3	150 K	R12, R90, R109	1%, Mouser #271-150K
2	180 K	R95, R114	1%, Mouser #271-180K
2	300 K	R39, R69	1%, Mouser #271-300K

Capacitors (58)

Quantity	*Description*	*Part No.*	*Notes*
2	10 pF ceramic	C50, C54	Mouser #140-50N5-100J Mouser #147-75-100
1	33 pF ceramic	C46	Mouser #140-50N5-330J Mouser #147-75-330
2	100 pF ceramic	C51, C55	Mouser #140-50N5-101J Mouser #147-75-101
1	1.0 uF	C41	Mouser #140-NPRL50V1.0 (non-polar elec.) Mouser #581-1000NJ63 (polyester) (for audio coupling)

1	2.2 nF polystyrene	C42	Mouser #23PS222 (for tank driver)
1	1.0 nF polystyrene	C40	Mouser #23PS210 (for low pass filter)
2	1.0 nF polystyrene	C49, C53	Mouser #23PS210 (for resonator)
5	1.0 nF	C39, C44, C45, C47, C48	Mouser #581-1N0J63 (polyester) Mouser #147-75-102 (ceramic) (for linear current source)
36	0.1 uF ceramic	C3 – C38	Mouser #147-72-104 Mouser #581-SA105E104M (for p/s decoupling)
2	47 uF 35V elec.	C57, C58	Mouser #140-XRL35V47 (for p/s decoupling)
3	100 uF 35V elec.	C1, C2, C43*	Mouser #140-XRL35V100 (for p/s decoupling & driver highpass filter)
2	10 uF 35V elec.	C52*, C56*	Mouser #140-XRL35V10 (for recovery amp highpass filter)

Semiconductors (42)

Quantity	*Description*	*Part No.*	*Notes*
7	MXL1013 (or LT1013) dual op amp	U2, U6, U7, U11, U12, U16, U18	Allied #735-3671, can substitute TL072
1	TL072CP dual op amp	U4	Allied #735-2727
7	OP275GP dual op amp	U1, U5, U8, U9, U13, U15, U17	Allied #630-9295, can substitute TL072
3	CA3280E dual OTA	U3, U10, U14	Future-Active #CA3280E INTERSIL
5	1N4148 diode	D1 – D5	Allied #950-1550, can substitute 1N914
10	BC559B transistor (PNP)	Q1, Q3, Q4, Q5, Q6, Q7, Q9, Q11, Q13, Q15	Mouser #625-BC559B, can substitute BC560
5	BC549B transistor (NPN)	Q2, Q8, Q10, Q12, Q14	Mouser #625-BC549B, can substitute BC550
4	VTL5C3 vactrol	VAC1 – VAC4	Allied #980-0710

Potentiometers & Trimmers (21)

Quantity	*Description*	*Part No.*	*Notes*
9	100 K linear pot	VR1 – VR9	Spectrol 149 series, Allied #970-1791, or Bournes 91 series, Allied #754-9420, VR1, VR3, VR4, and VR5 must be Spectrol 149 series if mounting on the PCB
3	1 K trimmer (multi-turn)	TP3, TP8, TP10	Mouser #72-T93YA-1K
9	100 K trimmer (multi-turn)	TP1, TP2, TP4, TP5, TP6, TP7, TP9, TP11, TP12	Mouser #72-T93YA-100K

Miscellaneous

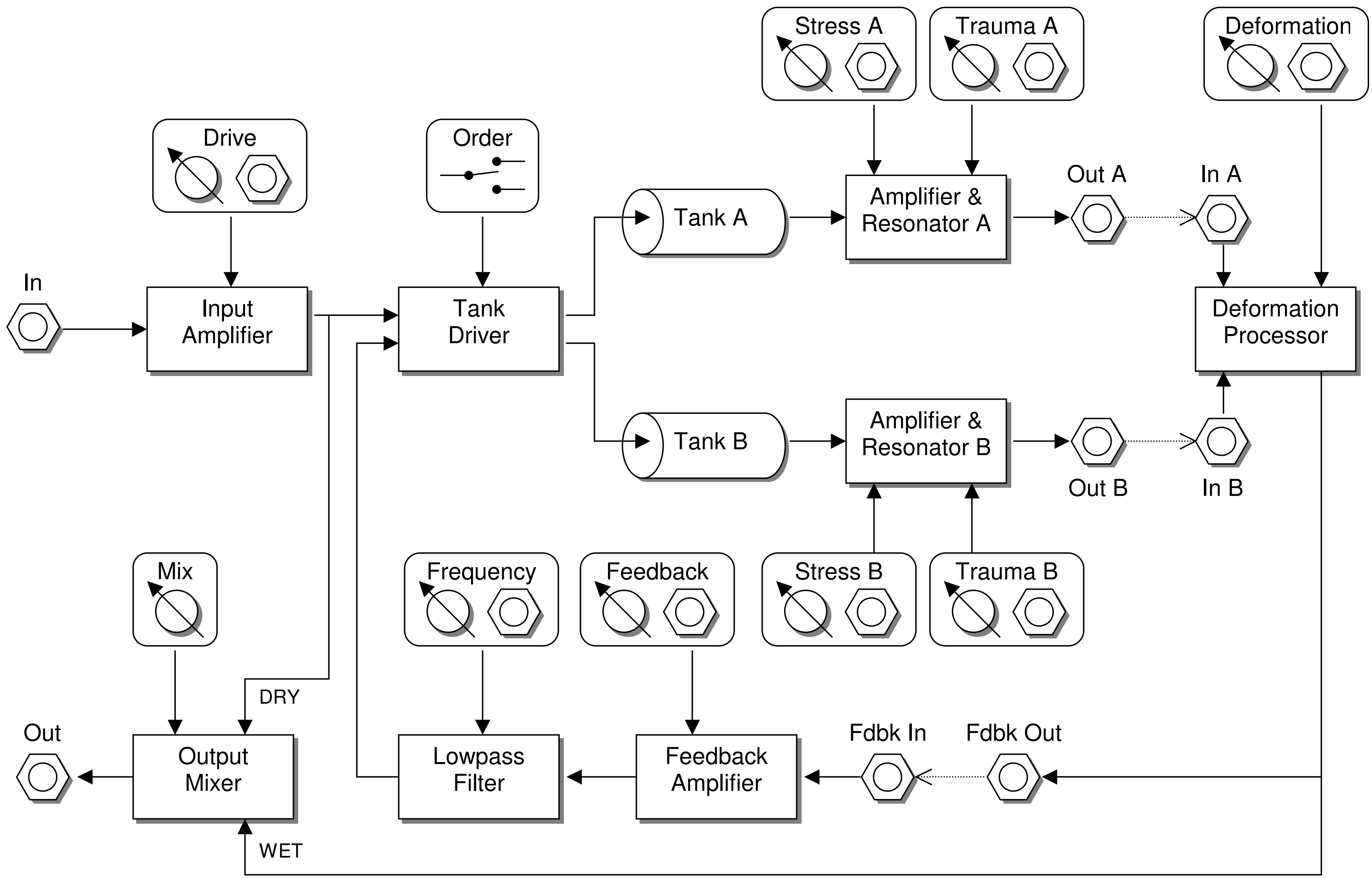
Quantity	*Description*	*Part No.*	*Notes*
16	phone jack	J1 – J16	Switchcraft 112A, Allied #932-9391
3	16 pin DIP socket		for CA3280E
15	8 pin DIP socket		for MXL1013, TL072, and OP275GP

4	axial ferrite bead	L1, L2, L3, L4	Active #MURJP2141, Mouser #623-2743002112
1	DPDT switch, NKK M2022ES1W01	SW1	Allied #870-8652
2	MTA-156 4 pin header	JP1, JP2	Mouser #571-6404454 (header) (for power supply)
1	MTA-156 2 pin	JP5*	Mouser #571-6404452 (header) Mouser #571-6404262 (connector) Mouser #571-640551-2 (dust cover) (for tank chassis ground)
2	MTA-100 3 pin header with 2 pin shunt	JP3*, JP4*	Mouser #571-6404523 (header) Mouser #517-952-10 (shunt) (for disconnecting resonator)
2	spring reverb tank	T1, T2	Accutronics #1FB2B1D, can substitute other spring reverb tanks provided they have an input impedance “F” and an output impedance “B”, both tanks should be the same model # for best results
6	PCB mount 1/8” (3.5 mm) phone jack		Mouser #161-3525

Hardware

Quantity	*Description*	*Notes*
9	knobs	ALCO PKES90B1/4
1	TLN-156 panel	front panel
1	TLN-156 PCB set	printed circuit boards (2)
1	4 pot long Stooge bracket	Stooge bracket
8-12	#6-32 screw, 1/4” spacer, and nut	for mounting boards to each other and to Stooge bracket
4-9	pot nut	Mouser #534-1456 4 for mounting Stooge bracket to front panel, may need to use a nut for all pots so that they can all be set to the same depth behind the panel otherwise some knobs will stick out too far
4	#8-32 black screw	for mounting module to cabinet
2	MTA-156 power cable	Mouser #571-6404264 (connector) Mouser #571-6405514 (dust cover)
	heat shrink cable	
	cable ties	
	coax cable (RG174/U)	Mouser #566-8216-100 (100 foot spool)
	hookup wire	
	solder	both organic and no clean
2	phono jack (RCA)	Mouser #161-2052 (for IN– jack on reverb tanks)
6	shielded 1/8” (3.5 mm) phone plug	Mouser #171-1041 for connecting printed circuit boards to reverb tanks
6	shielded phono plug (RCA)	Mouser #17PP058 for connecting printed circuit boards to reverb tanks
4	3/4” standoff (6-32 thread)	Mouser #534-2211 (for mounting board #2 above board #1)
1	3-5/8” by 5” piece of metal*	to provide shielding between printed circuit boards (optional)

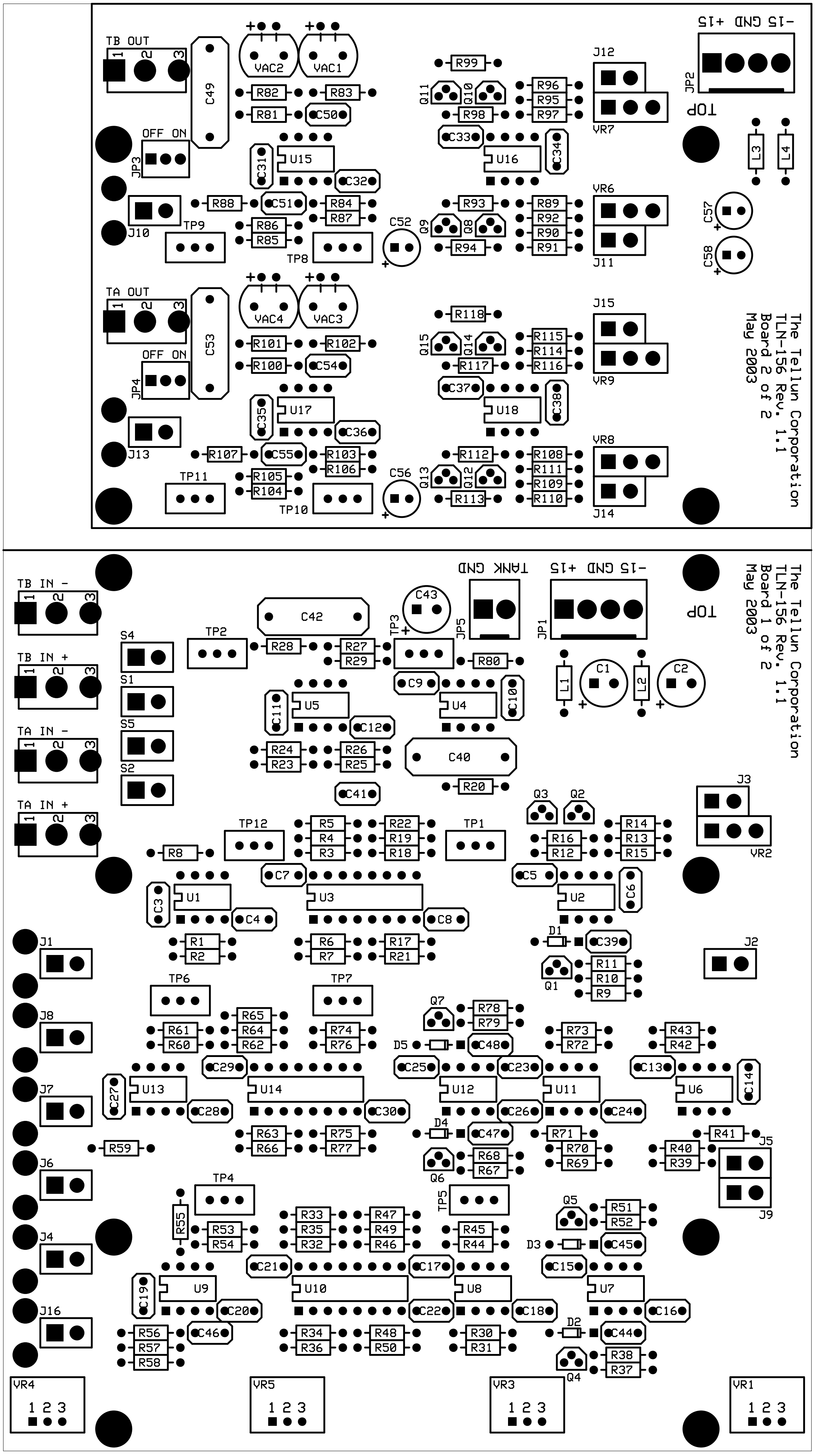
Items marked with an asterisk (*) are optional. See the Circuit Description section. Several choices are given for the capacitors. Pick whichever you prefer.



TLN-156 Neural Agonizer Block Diagram

Revision 1.1, 2003/04/26

Scott Juskiw, scott@tellun.com


The Tellun Corporation
TLN-156 Rev. 1.1
Board 2 of 2
May 2003
TOP
-15 GND +15
JP2
TB OUT
TA OUT
OFF ON
JP3
JP4
VAC1
VAC2
VAC3
VAC4
C49
C53
J10
J11
J12
J13
J14
J15
VR6
VR7
VR8
VR9
TP8
TP9
TP10
TP11
U15
U16
U17
U18
L3
L4
C57
C58
The Tellun Corporation
TLN-156 Rev. 1.1
Board 1 of 2
May 2003
TOP
-15 GND +15
TANK GND
JP1
JP5
TB IN -
TB IN +
TA IN -
TA IN +
S1
S2
S4
S5
J1
J2
J3
J4
J5
J6
J7
J8
J9
J16
VR1
VR2
VR3
VR4
VR5
1 2 3
TP1
TP2
TP3
TP4
TP5
TP6
TP7
TP12
C40
C42
C43
L1
L2
C1
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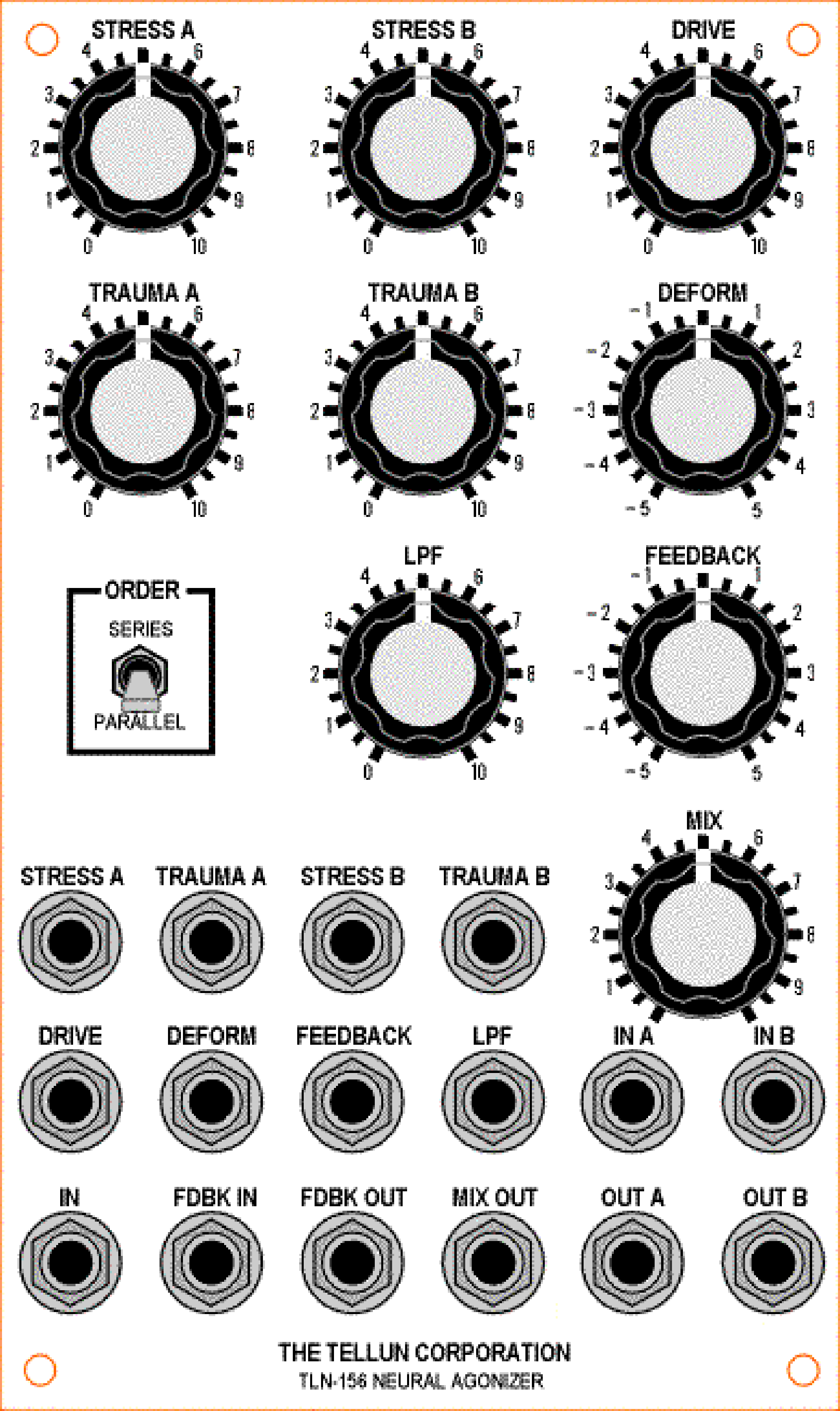
U11
U12
U13
U14


STRESS A
STRESS B
DRIVE
TRAUMA A
TRAUMA B
DEFORM
ORDER
SERIES
PARALLEL
LPF
FEEDBACK
MIX
STRESS A
TRAUMA A
STRESS B
TRAUMA B
DRIVE
DEFORM
FEEDBACK
LPF
IN A
IN B
IN
FDBK IN
FDBK OUT
MIX OUT
OUT A
OUT B
THE TELLUN CORPORATION
TLN-156 NEURAL AGONIZER