

The Tellun Corporation

TLN-712 Doomsday Machine

User Guide, Rev. 1.0.1

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## 1. Introduction

The TLN-712 Doomsday Machine is a voltage controlled waveform animator for modular synthesizers. Originally conceived as two separate modules, the TLN-712 comprises two different animation circuits and four voltage-controlled LFOs (low frequency oscillators). The first animator (Thalaran Radiation Emitter) is based on the Multi-Phase Waveform Animator by Bernie Hutchins. The second animator (Cascading Biogenic Pulse) is based on the Pulse Width Multiplier by Craig Anderton. Both circuits require several modulation sources in order to generate their animation effect. The four built-in LFOs provide the necessary modulation without the need for external modules. Patch points are included for external modulation, if desired.

### Features:

- Four modulation sources. Each source has an OFFSET pot to set the initial modulation point, a MOD input jack with attenuator to allow for external control of modulation, and an internal LFO. All four modulation sources are internally connected to both animators.
- Each internal LFO has a RATE pot, an LED to provide visual indication of the rate, and a DEPTH pot to set the amount of LFO fed to the animators. Each LFO has a 10 Vpp triangle wave output that is available for external use. Internally, each LFO provides a sine wave to the two animators.
- The rate and depth of all LFOs can be changed en masse using the EXT RATE and EXT DEPTH jacks and attenuators. Use these with your keyboard control voltage, modulation wheel, or foot pedal to control the speed and depth of animation.
- The Thalaran Radiation Emitter has one input jack (IN A) and three output jacks (SAW, TRI, STEP). A sawtooth wave is normally applied to IN A, but sine or triangle waves can also be used (almost any waveform except pulse waves will produce some kind of useful output). With a sawtooth input, the SAW output comprises the input signal plus four phase shifted versions of the input signal (sounds like five sawtooth waves). The phase shift is controlled by the four modulation sources. The TRI output provides a similar effect but with five triangle waves. The STEP output is a bizarre staircase waveform where the depth of each step is controlled by the four modulation sources.
- The Cascading Biogenic Pulse has two input jacks (IN B and AUX) and four output jacks (PULSE 1-4). A triangle wave is normally applied to IN B, but sine or sawtooth waves can also be used (almost any waveform except pulse waves will work). The four PULSE outputs produce an intense pulse width modulation (PWM) effect with single, double, triple, and quadruple pulses appearing at outputs 1-4 respectively. Think of it as PWM on steroids. The PWM effect is controlled by the four modulation sources. The AUX input can be used to provide an additional level of animation, or to cascade two TLN-712s to get even more intense PWM, or to provide a cross-product effect.

- All inputs and outputs are DC-coupled. Either animator can be used to produce strangely wonderful waveforms for modulating other signals. The Cascading Biogenic Pulse can even be used to generate rhythmic gates and triggers.
- All inputs and outputs handle 10 Vpp audio signals and 5 volt control voltage signals (modular standard).

## **2. Circuit Description**

The block diagram (included at the end of this document) shows the signal flow through the TLN-712. There are three distinct sections to the TLN-712: the Thalaron Radiation Emitter (animator #1), the Cascading Biogenic Pulse (animator #2), and the modulation sources (that feed both animators).

### **2.1. Thalaron Radiation Emitter**

Refer to page 3 of the schematic. The input signal (IN A) is buffered and inverted by U13 before being fed to other parts of the circuit. The most significant feature here is the sawtooth phase shifter built around U14, R110- R114, TP1, and D5. When a 10 Vpp sawtooth wave is applied to IN A, a phase shifted version of that sawtooth wave is created at the SHIFT1 output. The amount of shift is controlled by the SUM1 voltage. By modulating the SUM1 voltage between  $-5V$  and  $+5V$ , a frequency modulated version of the sawtooth wave is created. This circuit originally appeared in Electronotes EN#87 by Bernie Hutchins in the Multi-Phase Waveform Animator. Refer to that article for a full description of how it works. This sawtooth phase shifter is used four times (U14 through U17) to create four phase shifted sawtooth waves. These four waves and the input sawtooth wave are then summed by U21b to create a composite animated sawtooth wave at the SAW output.

In Electronotes EN#108, Lester Ludwig presented some extensions to the Multi-Phase Waveform animator. One of those was the addition of a sawtooth to triangle wave converter for each of the sawtooth phase shifters in order to provide an additional animated waveform with much lower harmonic content. This has been incorporated into the TLN-712 using a simple full wave rectifier built around Q13, U18a, R130-R133, and TP5. R203 and C61 are used to add additional filtering to deglitch the sawtooth to triangle conversion. This same circuit is repeated five times: once for each of the four phase shifted sawtooth waves and once for the input sawtooth wave. The five triangle waves are then summed by U20b to create a composite animated triangle wave at the TRI output. The sawtooth to triangle converters have a DC offset. This offset is nulled by TP10.

The output from the first op-amp in each of the sawtooth phase shifters is a square wave whose duty cycle is controlled by the SUM1 voltage. U21b adds these signals from each of the phase shifters to create a bizarre animated step waveform at the STEP output.

It is not absolutely necessary to use a sawtooth wave for the IN A signal. What's most important is that the input level is 10 Vpp. Sine, triangle, almost any non-rectangular waveform will produce interesting results. However, the SAW and TRI outputs will only be "sawtooth shaped" and "triangle shaped" if a sawtooth wave is used for the IN A signal.

## **Modifications**

TL072 op amps can be used instead of the OP275.

### **2.2. Cascading Biogenic Pulse**

Refer to page 4 of the schematic. The core of this circuit is based on the Pulse Width Multiplier by Craig Anderton that appeared in the Jan-Feb 1981 issue of Polyphony. Four pulse width modulation circuits are connected with a quad exclusive-or gate (XOR) in a cascading arrangement where the output from the first stage is fed to the input of the second stage, and so on. The input signal (IN B) is buffered by U22b before being fed to four op-amps configured as comparators. Note that the output from U22b feeds the positive input on two of the comparators and the negative input on the other two comparators. Varying the SUM1-SUM4 signals between -5V and +5V creates pulse width modulated rectangular waves at the outputs of U23a-U23d. These PWM waves are then fed to the four XOR gates connected in cascade. Diodes D9-D12 block the negative half of the comparator output (the XOR gate works with positive voltages only). The outputs from each XOR gate are level shifted by U25a-U25d to create 10 Vpp pulse waves. The four PULSE outputs produce an intense pulse width modulation (PWM) effect with single, double, triple, and quadruple pulses appearing at outputs 1-4 respectively

U22a is another comparator that allows an external signal to "seed" the first XOR gate in the cascade. With nothing connected to the AUX input, the output from U22a is 0 volts (logic zero). As the AUX input signal goes above +0.65V the output from U22a goes high (logic one). This can be used to create a cross product effect by feeding in a second oscillator, or to cascade two TLN-712s together, or to add another level of animation.

A triangle or sine waveform works best for the IN B signal. However, almost any non-rectangular waveform will produce interesting results

### **2.3. Modulation Sources**

The four modulation sources (SUM1-SUM4) are shown on pages 1 and 2 of the schematic. The sources are all identical so we'll only look at SUM1 at the top of page 1. The LFO portion of the modulation source is based on the LFO in the MOTM-410 Triple Resonant Filter (Synthesis Technology 1999).

Ignoring U7a for a moment, U6a-U6b, R63-R66, and C25 are a triangle/square wave oscillator. If U7a were replaced by a potentiometer, this would be a simple manually controlled LFO. However, instead of a potentiometer, we have U7a (an OTA) whose output current determines the rate of the LFO. This current is determined by the voltage on pin 2 of Q7. Thus, by varying this voltage we can control the LFO rate. The RATE 1 pot sets the initial LFO rate. This is summed with the RATE external voltage (see right side of page 5 of the schematic) to allow an external voltage to modify the LFO rate. Note that the RATE external voltage is fed to all four modulation sources, so they are all affected equally. R52 is used to “warp” the response of the RATE control from linear to logarithmic to gain more resolution in the low frequency range, which is more useful in this application.

The 10 V<sub>pp</sub> triangle output from the LFO appears at the LFO 1 jack. U10b drives LED1. The driver is biased with a +5V reference so that the LED is completely off when the triangle output is at +5V and is completely on when the triangle output is at -5V. R75 sets the brightness of the LED.

The triangle output also feeds U7b, another OTA that is configured as a voltage controlled amplifier (VCA) to set the LFO depth on output SUM1. In addition to controlling LFO depth, this VCA also distorts the triangle wave into a sine wave (a sine wave sounds better than a triangle wave as a modulation source in this application). The VCA gain is controlled by the current into pin 16 of the OTA, which is a function of the output voltage from U6c. The DEPTH 1 control sets the initial LFO depth. This is summed with the DEPTH external voltage (see middle of page 5 of the schematic) to allow an external voltage to modify the LFO depth. Note that the DEPTH external voltage is fed to all four modulation sources, so they are all affected equally.

The LFO output, following the VCA, is then summed with the MOD 1 external voltage and the OFFSET 1 control by U6d to provide the total modulation source voltage SUM1.

## Modifications

TL072 op amps can be used instead of the MX1013.

Resistors R25, R50, R75, and R100 set the brightness of the four LEDs. You will likely need to change the value of these resistors if you use different LEDs than the ones specified in the parts list. The resistors should be chosen so that the LEDs are not too bright all the time; they should be visibly changing along with the LFO rate.

Resistors R2, R27, R52, and R77 are used to warp the response of the RATE 1-4 pots from linear to logarithmic. Lower values will result in more warping (i.e. more control at lower frequencies and less control at higher frequencies). Higher values (or removing these resistors entirely) will result in less warping (or no warping at all).

### 3. *Construction Tips*

Deal with the mechanical issues before doing any soldering. Prepare your panel and bracket first. Trim the bracket, drill the holes, and test fit everything, including the PCBs, and any pots and jacks that are close to the PCBs. Make sure you leave enough space between the PCBs and panel to fit the pots, jacks, and wires. If you use the same 3U wide panel layout with small knobs that I used, you'll need to modify a four pot long Stooze bracket by removing several pieces of metal (where the pot holes are located) and drill additional holes. See the website pictures to see how the bracket needs to be modified. You can use tin snips to remove the metal but make sure you **wear protective goggles** because sharp pieces of metal will fly off and hit you in the face (it happened to me). Use a drill press to drill two more 3/8" holes for the pots, and four 5/32" holes for mounting the circuit boards.

Board #2 attaches to the Stooze bracket with #6-32 screws and 1/4" spacers. Board #1 is mounted on top of Board #2 using #6-32 screws and 1" threaded standoffs. You may think it's daft to have board #2 with all the trimmers on the bottom, but it's not because the trimmers on board #2 will be set without board #1 connected at all. Board #1 has a lot more wires going to the panel, so that's why it's best for it to be on top.

The four 1/8" LEDs (T1 size) are attached to the front panel by using a small amount of epoxy. Most T1 LEDs have a small rim that comes into contact with the back of the panel when the LED is inserted from the back. Put a small amount of epoxy around this rim and stick the LED into the hole from the back. Give it a few hours to dry before handling the module. If you use thick wires for these LEDs, you may not even have to glue them in place; the wires alone may hold the LEDs in place. The prototype I built with a plastic panel did not need any glue to hold the LEDs in place. If you decide to glue the LEDs to the panel, make sure you do it at the very end of the project after everything is calibrated and working correctly.

IC sockets aren't necessary, but I like to use them because it lets me try out different op-amps.

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" pad spacing.

For VR1-VR18, 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. Be careful when soldering because the square pad is towards the bottom of the PCB for some of the pots and towards the top of the PCB for the others.

For J1-J20 the square pad on the PCB indicates the ground connection.

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

Use a pass-thru MTA-156 connector to supply power to both PCBs using one power cable. This connector can be installed on an existing MOTM power cable to provide two outlets from one cable. See the website pictures for an example.

The four LFOs are not precise enough to track at 1V/Octave. However, you can improve tracking slightly by thermally coupling transistor pairs Q1-Q2, Q4-Q5, Q7-Q8, and Q10-Q11. If you look at the PCB, you'll see that those transistor pairs are all placed so that their faces are touching. Apply a small amount of heat sink grease to the face of one transistor in each pair, then stick the faces together and cover with a piece of 1/4" heat shrink tubing. Once the tubing is heated it will hold the transistors together. Then solder the pair of transistors to the PCB using no clean solder (do this after you're finished with the organic flux solder). Note that this is completely optional, the circuit will work fine if the transistor pairs are not touching. See the website pictures for an example of the transistor sandwich.

There are nine test pads on board #2 labeled T1-T9. These are intended to make it easier to clamp a probe onto the circuit when calibrating board #2. Solder a scrap resistor lead into each of these holes; about 1/4" is all you need. Longer is okay, you can trim it down later.

In addition to the panel wiring listed below, you'll also need to create a four-wire jumper cable to bridge the two PCBs. This jumper connects to each PCB using a 4 pin MTA-100 connector. The jumper only needs to be about 2 inches long (since the boards are only 1 inch apart).

**Panel Wiring Guide for Board #1**

<i>Panel Designation</i>	<i>PCB Designation</i>	<i>Wire Length (inches)</i>	<i>Wire Type</i>
MOD 3 jack	J1	7	twisted
MOD 4 jack	J2	4	twisted
MOD 1 jack	J3	7	twisted
MOD 2 jack	J4	9	twisted
LFO 3 jack	J5	6	twisted
LFO 4 jack	J6	4	twisted
LFO 1 jack	J7	6	twisted
LFO 2 jack	J8	8	twisted
RATE jack	J9	6	twisted
DEPTH jack	J10	5	twisted
OFFSET 3 pot	VR1	9	twisted
MOD 3 pot	VR2	8	twisted
RATE 3 pot	VR3	8	twisted
DEPTH 3 pot	VR4	7	twisted
OFFSET 4 pot	VR5	6	twisted
MOD 4 pot	VR6	5	twisted
RATE 4 pot	VR7	4	twisted
DEPTH 4 pot	VR8	4	twisted
OFFSET 1 pot	VR9	6	twisted
MOD 1 pot	VR10	4	twisted
RATE 1 pot	VR11	4	twisted
DEPTH 1 pot	VR12	4	twisted
OFFSET 2 pot	VR13	9	twisted
MOD 2 pot	VR14	8	twisted
RATE 2 pot	VR15	7	twisted
DEPTH 2 pot	VR16	7	twisted
RATE EXT pot	VR17	5	twisted
DEPTH EXT pot	VR18	5	twisted
LED 1	LED1	6	twisted
LED 2	LED2	6	twisted
LED 3	LED3	7	twisted
LED 4	LED4	6	twisted

**Panel Wiring Guide for Board #2**

<i>Panel Designation</i>	<i>PCB Designation</i>	<i>Wire Length (inches)</i>	<i>Wire Type</i>
IN A jack	J11	7	coax
TRI jack	J12	9	coax
SAW jack	J13	10	coax
STEP jack	J14	9	coax
IN B jack	J15	10	coax
AUX jack	J16	8	coax
PULSE 1 jack	J17	9	coax
PULSE 2 jack	J18	9	coax
PULSE 3 jack	J19	9	coax
PULSE 4 jack	J20	10	coax



## **4. Alternate Panel Layouts**

With 20 jacks, 18 pots, and four LEDs, the TLN-712 needs a lot of panel space. The only way to make this fit into a 3U wide panel is to use small knobs. I also chose to use small LEDs (1/8" T1 size), so that it looks more like the modules from Encore Electronics. But there is probably enough room to use standard MOTM sized Lumex LEDs. If you absolutely must use the standard MOTM sized knobs, here are some suggestions on what you can eliminate so that you don't wind up with a 5U wide module.

The OFFSET and MOD pots can be eliminated to save 8 pots. You can always use an external mixer, like an Oakley Multi-mix or MOTM-830 to get the same functionality. The external mixer should have a bias source and be capable of unity gain. I have posted modifications on my website for both the Oakley Multi-mix and the MOTM-830 to bring them up to this spec. If you eliminate the OFFSET pots, you should remove R20, R45, R70, and R95. If you remove the MOD pots, you'll need to attach a jumper between pins 2 and 3 on the PCB where each pot would have been connected.

If you are certain you'll never use the external MOD inputs, you can eliminate those four jacks as well (and remove R21, R46, R71, and R96). Alternately, if you are certain you'll never use the four LFO outputs, you could eliminate those jacks instead. Either choice will free up four jacks which brings the total panel count to: 10 pots, 14 jacks, and four LEDs, which will fit into a 3U panel using the standard MOTM sized knobs and LEDs.

## **5. Calibration & Testing**

### **Testing Board #1**

No calibration is required for board #1. This board contains four identical voltage controlled LFOs. The procedure for testing LFO 1 is described below. Use the same procedure to test the other three LFOs.

Connect power to board #1, you do not need to connect power to board #2 at all, set board #2 aside and don't connect the jumper between the two boards.

Set the OFFSET pot to the middle position. Set the MOD pot to the fully counter-clockwise position. Set the DEPTH pot to the fully counter-clockwise position. Set the RATE pot to the middle position, the LED should pulse with the LFO. Turn the RATE pot fully clockwise and connect a scope to the LFO output jack. You should see a 10 V<sub>pp</sub> triangle wave at roughly 100 Hz. Connect a scope to the S1 pin on the 4 pin MTA-100 connector to test LFO 1 (use S2 for LFO 2, S3 for LFO, and S4 for LFO 4). Turn the DEPTH pot clockwise and you should see a sine wave increase in amplitude with the DEPTH pot. The sine wave should reach 10 V<sub>pp</sub> when the DEPTH pot is fully clockwise. Now adjust the OFFSET pot from the middle position. You should see the sine wave shift up and down +/- 5 volts at the two extremes.

Return the OFFSET pot to the middle position. Turn the DEPTH pot fully counter-clockwise. Attach an external voltage source to the MOD jack (you can use the LFO output from the TLN-712 or an external LFO). Gradually turn the MOD pot clockwise, you should see the external signal on the S1 pin increase in amplitude with the MOD pot.

To test the external RATE and DEPTH controls, set the LFO's OFFSET, RATE, and DEPTH pots to the middle position, and the MOD pot fully counter-clockwise. Set the RATE EXT and DEPTH EXT pots fully counter-clockwise. Connect a scope to the S1 pin on the 4 pin MTA-100 connector to test LFO 1 (use S2 for LFO 2, S3 for LFO, and S4 for LFO 4). Attach a +5V constant voltage to the RATE and DEPTH jacks (you can use the + output from an MOTM-800 with SUSTAIN set to 10 if nothing is plugged into the GATE jack). Turn the RATE EXT pot clockwise, you should see the LFO rate increase. Turn the DEPTH EXT pot clockwise, you should see the LFO amplitude increase. Repeat the procedure using a -5V constant voltage on the RATE and DEPTH jacks (you can use the - output from an MOTM-800). As you turn the RATE EXT pot clockwise the LFO rate should decrease. As you turn the DEPTH EXT pot clockwise the LFO amplitude should decrease.

Note that the maximum LFO rate is about 150 Hz. You cannot make it go faster by applying larger voltages to the RATE jack. The only way to make it go faster is to use a smaller timing capacitor.

## **Calibrating Board #2**

There are 10 trimmers on board #2, all for calibrating the Thalaron Radiation Emitter (the Cascading Biogenic Pulse does not require calibration). The best way to calibrate board #2 is to use both a scope and your ears. The scope will get you in the ballpark, but you'll get the best results by using your ears to trim the circuit. If you don't have a scope, you can still calibrate the circuit, but it will take a bit longer.

You will also need a good sawtooth oscillator that has 10 V<sub>pp</sub> waveforms (e.g. MOTM-300 or MOTM-310). It is a good idea to select an oscillator for calibration that you will also use with the TLN-712 in practice. The reason being that different oscillators may have slightly different waveform magnitudes or DC offsets. You should calibrate the circuit with the same oscillator that you will eventually use to drive it.

Connect power to board #2, you do not need to connect power to board #1 at all, set board #1 aside and don't connect the jumper between the two boards. Connect a sawtooth wave from your oscillator to the IN A jack. Set the oscillator to about 440 Hz. If you have a two channel scope, use the oscillator signal for channel 1 and trigger off this channel, then use channel 2 for all other measurements.

Make sure you do the calibration in the order specified below because the effects are cumulative and changing a trimmer in the earlier stages will affect what happens in later stages.

### *Trimming the Sawtooth Phase Shifters*

Connect a scope to test point T1. What you should see is a sawtooth that is inverted and shifted 180 degrees with respect to the input signal. There should also be a discontinuity in the middle of the waveform (looks like a small step). Adjust TP1 to remove the discontinuity. The sweet spot should be very near the middle of the trimmer's rotation. Listening to this signal will not help much, you're best off to use a scope. If you don't have a scope, the best way to set this trimmer is to use the T1 signal as a frequency modulator for a second oscillator. You will have to change the driving oscillator from 440 Hz down to 0.5 Hz or slower, then apply the T1 signal to the FM input of a second oscillator. The pitch of the second oscillator should rise (or fall) with the T1 signal and there will be a glitch at the point of discontinuity. Adjust TP1 to minimize the glitch.

Repeat the above procedure for test points T2-T4 by adjusting trimmers TP2-TP4 respectively. Sadly, the labels for TP2-TP4 are obscured by vias on the PCB (Rev 1.0). However there is a component printout at the end of this user guide that you can use to find them.

You should have adjusted four trimmers (TP1-TP4) in this section before proceeding to the next section.

### *Trimming the Sawtooth to Triangle Converters*

Connect a 440 Hz 10 Vpp sawtooth wave to the IN A jack. Connect a scope (and amplifier) to test point T5. What you should see is a badly mangled triangle wave. Adjust TP5 to get the best looking, and best sounding, triangle wave you can. If you're not sure what a triangle wave should sound like, listen to the one on your MOTM-300 as a reference (it sounds like a filtered square wave). It doesn't have to be a perfect triangle wave; it just needs to not sound like a sawtooth wave. That's why it's best to use your ears for this part of the procedure.

Repeat the above procedure for test points T6-T9 by adjusting trimmers TP6-TP9.

You should have adjusted five trimmers (TP5-TP9) in this section before proceeding to the next section.

### *Trimming the Triangle DC Offset*

Connect a 440 Hz 10 Vpp sawtooth wave to the IN A jack. Connect a digital volt meter (DVM) to the TRI output jack. Set your DVM to measure DC volts and adjust TP10 until the voltage at the TRI output jack is zero.

Board #2 is now calibrated. Note that if you change TP1-TP4 you will have to recalibrate TP5-TP9. Similarly, if you change TP5-TP9 you will have to recalibrate TP10.

## Testing Board #2

Connect the two boards together with the 4 pin MTA-100 connector and apply power to both boards.

### *Testing the Thalaron Radiation Emitter*

Apply a 440 Hz 10 Vpp sawtooth wave to the IN A jack. Set the OFFSET and RATE pots on all four LFOs to the middle position. Set the MOD and DEPTH pots on all four LFOs fully counter-clockwise. Also set the RATE EXT and DEPTH EXT pots fully counter-clockwise.

Connect a scope and amplifier to the SAW output. What you should see (and hear) is a sawtooth wave with a kink in it. Turn the DEPTH 1 pot clockwise, you will see the kink start to move and you should hear the sound of two sawtooth waves beating together. Adjust the RATE 1 pot to note the effect it has on the beat frequency. Adjust the OFFSET 1 pot and note how it affects the center point of the animation; at the extreme settings the animation effect will cut in and out. Return the OFFSET 1 pot to the middle position. Repeat this test two more times but connect the scope and amplifier to the TRI and STEP outputs. Note the difference in the harmonic content of the three outputs and how they react to the animation.

Repeat the above procedure for the remaining three LFOs to make sure they are all having the same effect on the SAW, TRI, and STEP outputs. Test each LFO individually by setting the DEPTH pots for all other LFOs fully counter-clockwise.

### *Testing the Cascading Biogenic Pulse*

Apply a 440 Hz 10 Vpp triangle wave (not a sawtooth wave) to the IN B jack. Set the OFFSET and RATE pots on all four LFOs to the middle position. Set the MOD and DEPTH pots on all four LFOs fully counter-clockwise. Also set the RATE EXT and DEPTH EXT pots fully counter-clockwise.

Connect a scope and amplifier to the PULSE 1 output. What you should see (and hear) is a square wave. Turn the DEPTH 1 pot clockwise, you should hear a pulse width modulation (PWM) effect. Adjust the RATE 1 pot to note the effect it has on the PWM. Adjust the OFFSET 1 pot and note how it affects the center point of the animation; at the extreme settings the PWM effect will cut in and out. Return the OFFSET 1 pot to the middle position.

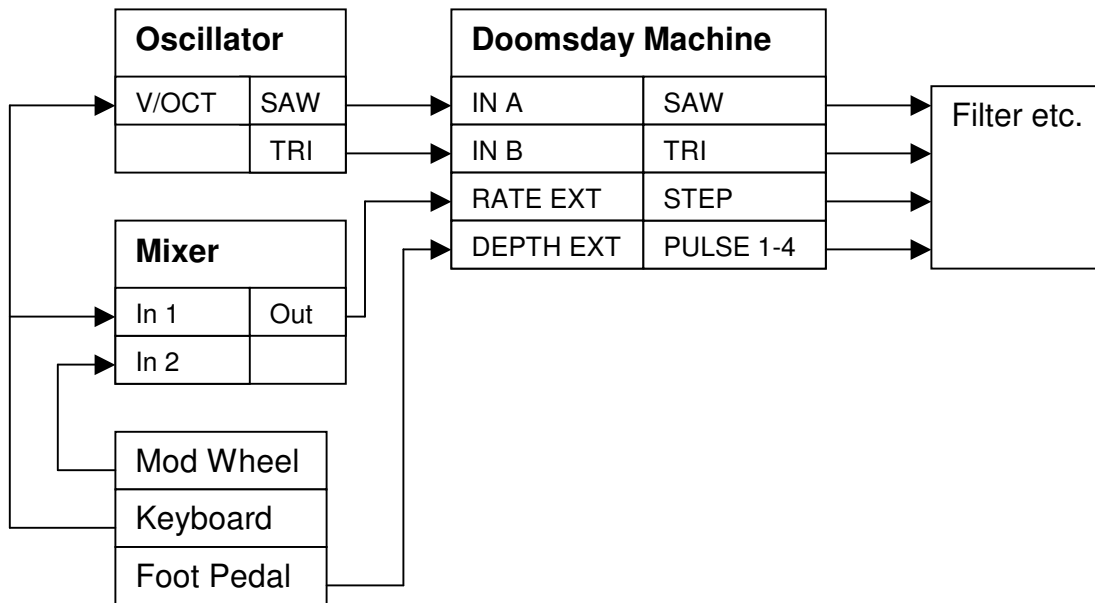
Repeat the above procedure for the remaining three LFOs to make sure they are creating a PWM effect on the PULSE 1-4 outputs. Test each LFO individually by setting the DEPTH pots for all other LFOs fully counter-clockwise. However, remember that the modulations sources are cascaded: LFO 1 affects all PULSE outputs, but LFO 2 only affects PULSE 2-4, LFO 3 only affects PULSE 3-4, and LFO 4 only affects PULSE 4.

Once you've verified that the PULSE outputs are working correctly, try applying a second triangle oscillator to the AUX jack. Note the effect it has on the PULSE outputs when the second oscillator is set to the same frequency as the first oscillator, or at some harmonic, or inharmonic interval.

## 6. In Use

The OFFSET pots are bipolar and should be left in the middle (12 o'clock) position when no offset is needed. The four LFO RATE pots should give the slowest LFO rate when turned fully counter-clockwise and the fastest rate when turned fully clockwise. All other pots are simply attenuators and should be turned fully counter-clockwise to turn them off.

There are many ways to use the TLN-712 and several examples have been posted on the website to get you started. The block diagram below shows a typical patch for oscillator waveform animation.



Note the use of the RATE EXT and RATE DEPTH jacks and the external mixer. In general, you'll find that the RATE settings that work well for low frequencies will not work well for high frequencies. Thus it is critical that the keyboard control voltage that sets the oscillator pitch also be patched to the RATE EXT jack. It is also recommended that you use your keyboard mod wheel and/or foot pedal (e.g. MOTM-850) to allow manually changing the RATE and DEPTH of the four internal LFOs. You'll need to use an external mixer (e.g. Oakley Multi-mix or MOTM-830) in order to use both the keyboard control voltage and the mod wheel voltage. The external mixer should have a bias source and be capable of unity gain. I have posted modifications on my website for

both the Oakley Multi-mix and the MOTM-830 to bring them up to this spec. If you don't have a suitable mixer, patch the keyboard control voltage directly to the RATE EXT jack and your oscillator's V/OCT input.

Other ways to use the TLN-712:

- Use an LFO for the IN A signal (e.g. MOTM-320) or an oscillator set to a very low frequency to create strange modulation waveforms at the SAW, STEP, and TRI outputs. Use a lag processor (e.g. TLN-862 or MOTM-820) to smooth out any sharp edges or glitches in the animated LFO waveforms.
- Use different waveforms for the IN A signal (e.g. sine, saw, triangle, Blacet Miniwave waveform). Normally, you would use a sawtooth wave for the IN A signal, but almost any waveform (except pulse waves) will create some kind of useful output. You just won't get sawtooth or triangle waves from the SAW and TRI outputs. Same thing for the IN B signal; a triangle wave works best, but almost any waveform (except pulse waves) will create a useful output.
- Use the PULSE 1-4 outputs to generate gate signals for envelope generators (e.g. MOTM-800). Use an LFO for the IN B signal, or an oscillator set to a very low frequency.
- Use external modulation sources (e.g. MOTM-800 or Encore Electronics UEG) patched to the MOD 1-4 inputs to control the waveform animation. You can do this with or without the four internal LFOs.
- Use the LFO 1-4 outputs to drive other modules in your synthesizer, or to correlate the waveform animation with external processes such as VCA panning or frequency shifting.
- Use feedback by patching the PULSE 1-4 outputs back into the AUX input. You'll need to put another module in the feedback path. A Blacet Time Machine or Encore Electronics Frequency Shifter works well in the feedback path.
- Use both IN A and IN B inputs at the same time, driven from one or two oscillators. The oscillators don't have to be set to the same frequency. Try using harmonic or inharmonic ratios. Use the SAW, TRI, or STEP outputs as IN B or AUX inputs.
- Use the STEP or PULSE 1-4 outputs to animate sync signals (hard sync or soft sync).
- Use two TLN-712s to get more complex animation. Patch the PULSE 4 output from the first TLN-712 to the AUX input of the second TLN-712 to get PULSE 5-8 outputs from the second TLN-712.

## TLN-712 Parts List

### Resistors (206)

Quantity	Description	Part No.	Notes
15	1K	R18, R24, R43, R49, R68, R74, R93, R99, R157, R164, R170, R186, R191, R196, R201	5% or better, Mouser #291-1K-RC
4	3K9	R4, R29, R54, R79	5% or better, Mouser #291-3.9K-RC
5	4K7	R15, R40, R65, R90, R176	5% or better, Mouser #291-4.7K-RC
4	6K8 (see text)	R25, R50, R75, R100	5% or better, Mouser #291-2.2K-RC
4	6K8	R5, R30, R55, R80	5% or better, Mouser #291-6.8K-RC
4	8K2	R6, R31, R56, R81	5% or better, Mouser #291-8.2K-RC
3	10K	R102, R169, R174	5% or better, Mouser #291-10K-RC
4	18K	R8, R33, R58, R83	5% or better, Mouser #291-18K-RC
1	33K	R163	5% or better, Mouser #291-33K-RC
8	39K	R14, R16, R39, R41, R64, R66, R89, R91	5% or better, Mouser #291-39K-RC
12	47K	R2, R9, R12, R27, R34, R37, R52, R59, R62, R77, R84, R87	5% or better, Mouser #291-47K-RC
4	51K	R10, R35, R60, R85	5% or better, Mouser #291-51K-RC
4	56K	R17, R42, R67, R92	5% or better, Mouser #291-56K-RC
29	100K	R11, R13, R36, R38, R61, R63, R86, R88, R150, R151, R152, R153, R154, R155, R158, R159, R160, R161, R162, R165, R166, R167, R168, R175, R177, R178, R179, R180, R181	5% or better, Mouser #291-100K-RC
8	220K	R1, R3, R26, R28, R51, R53, R76, R78	5% or better, Mouser #291-220K-RC
1	330K	R173	5% or better, Mouser #291-330K-RC
1	100	R202	1%, Mouser #271-100-RC
5	22K 1%	R131, R135, R139, R143, R147	1%, Mouser #271-22K-RC
4	24K9 1%	R19, R44, R69, R94	1%, Mouser #271-24.9K-RC
5	27K 1%	R130, R134, R138, R142, R146	1%, Mouser #271-27K-RC
4	36K 1%	R203, R204, R205, R206	1%, Mouser #271-36K-RC
5	49K9 1%	R7, R32, R57, R82, R103	1%, Mouser #271-49.9K-RC
1	62K 1%	R156	1%, Mouser #271-62K-RC
55	100K 1%	R21, R22, R23, R46, R47, R48, R71, R72, R73, R96, R97, R98, R101, R104, R105, R106, R107, R108, R109, R110, R113, R114, R115, R118, R119, R120, R123, R124, R125, R128, R129, R132, R133, R136, R137, R140, R141, R144, R145, R148, R149, R171, R172, R183, R184, R185, R188, R189, R190, R193, R194, R195, R198, R199, R200	1%, Mouser #271-100K-RC
4	130K 1%	R112, R117, R122, R127	1%, Mouser #271-130K-RC
12	300K 1%	R20, R45, R70, R95, R111, R116, R121, R126, R182, R187, R192, R197	1%, Mouser #271-300K-RC

**Capacitors (64)**

<i>Quantity</i>	<i>Description</i>	<i>Part No.</i>	<i>Notes</i>
43	0.1 uF ceramic	C1 – C19 C27 – C50	Mouser #147-72-104-RC Mouser #581-SA105E104MAR (for power supply decoupling)
4	470 nF polyester	C23 – C26	Mouser #581-BQ074D0474J
4	47 uF 35V elec.	C21, C22, C51, C52	Mouser #140-XRL35V47-RC (for power supply decoupling)
1	10 uF 35V elec.	C20	Mouser #140-XRL35V10-RC (for power supply decoupling)
5	33 pF ceramic	C55 – C59	Mouser #140-50N5-330J-RC Mouser #147-75-330-RC
5	39 pF ceramic	C60 – C64	Mouser #147-75-390-RC
2	150 pF ceramic	C53, C54	Mouser #140-50N5-151J-RC Mouser #147-75-151-RC

**Semiconductors (59)**

<i>Quantity</i>	<i>Description</i>	<i>Part No.</i>	<i>Notes</i>
13	1N4148 diode	D1 – D13	Mouser #512-1N4148TA Allied #431-0614 Digikey #1N4148FS-ND
4	LED (see text)	LED1 – LED4	Mouser #696-SSL-LX3044ID
12	BC559B or BC560 transistor (PNP)	Q1 – Q12	Mouser #625-BC559B
5	BC549B or BC550 transistor (NPN)	Q13 – Q17	Mouser #625-BC549B
1	LM78L05 +5V regulator TO-220	U12	Mouser #511-L78L05ACZ Digikey #LM7805CT-ND
6	TL074 quad op amp	U1, U3, U6, U8, U23, U25	Mouser #595-TL074CN Mouser #511-TL074CN
3	TL072 dual op amp	U5, U10, U22	Allied #735-1866 Mouser #595-TL072CP Mouser #511-TL072CN Digikey #296-1775-5-ND
1	MXL1013 (or LT1013) dual op amp can substitute TL072	U11	Mouser #595-LT1013CP Allied #735-1175 Digikey #296-1399-5-ND
9	OP275GP dual op amp can substitute TL072	U13 – U21	Allied #630-0737 Digikey #OP275GP-ND
4	LM13700 dual OTA	U2, U4, U7, U9	Mouser #513-NJM#13700D Digikey #LM13700N-ND
1	CD4070 quad ex-or gate	U24	Mouser #511-4070 Allied #735-10 Digikey #296-14128-5-ND



## Potentiometers & Trimmers (28)

Quantity	Description	Part No.	Notes
18	100 K linear pot	VR1 – VR18	<i>Spectrol 149-71104:</i> Mouser # 594-149-7104 Allied #970-1791 <i>Bourns 91A1A-B24-B20L:</i> Mouser #652-91A1A-B24-B20 Allied #754-2132
4	20 K trimmer (multi-turn)	TP1 – TP4	Mouser #72-T93YA-20K
5	10 K trimmer (multi-turn)	TP5 – TP9	Mouser #72-T93YA-10K
1	100 K trimmer (multi-turn)	TP10	Mouser #72-T93YA-100K

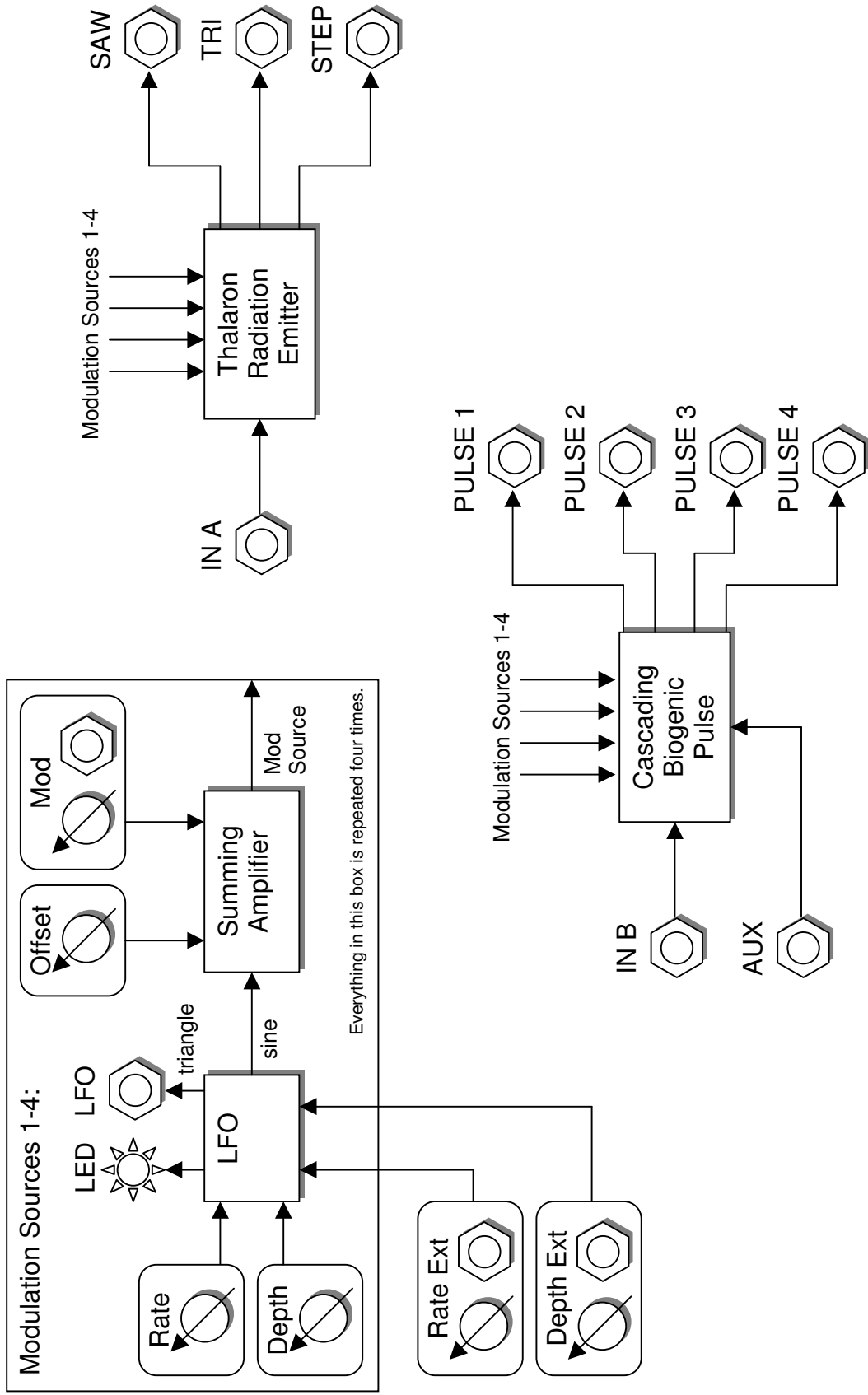
## Miscellaneous

Quantity	Description	Part No.	Notes
20	phone jack Switchcraft 112A	J1 – J20	Mouser # 502-N112AX Allied #932-9391 Digikey # SC1104-ND
2	MTA-156 4 pin header	JP1, JP3	Mouser #571-6404454 (for power supply)
2	MTA-100 4 pin header	JP2, JP4	Mouser #571-6404564
4	axial ferrite bead	L1, L2, L3, L4	Active #MURJP2141, Mouser #623-2743002112LF
4	16 pin DIP socket	optional	Mouser #575-199316
7	14 pin DIP socket	optional	Mouser #575-199314
13	8 pin DIP socket	optional	Mouser #575-199308

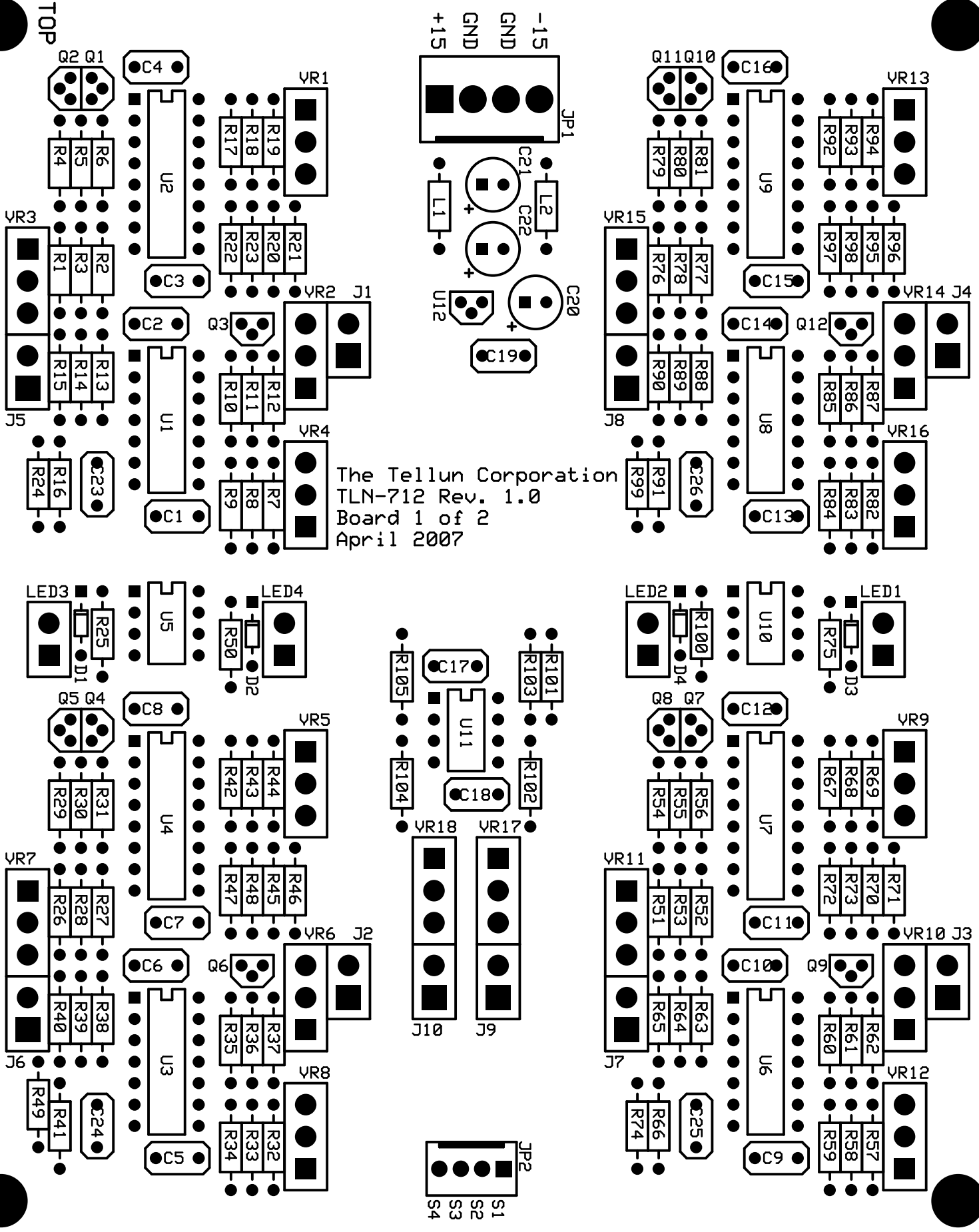
## Hardware

Quantity	Description	Notes
18	knob ALCO PKES60B1/4	Mouser #506-PKES60B1/4 Allied #759-2100 (not the same size as MOTM knobs, this is the smaller knob found on Encore's UEG and Frequency Shifter, Radio Shack has a knob that looks almost identical to this)
1 or 2	MTA-156 power cable	Mouser #571-6404264 (connector) Mouser #571-6405514 (dust cover)
1 or 0	MTA-156 4 pin pass-thru	Mouser #571-6405994 (connector) Mouser #571-6406434 (dust cover) (optional, for supplying power to both PCBs using one power cable, see text)
2	MTA-100 connection cable	Mouser #571-6404404 (connector) Mouser #571-6405504 (dust cover)
1	TLN-712 panel	front panel
1	TLN-712 PCB set	printed circuit boards (2)
1	4 pot long Stoooge bracket	Stoooge bracket
18	pot nut	Mouser #534-1456 for mounting Stoooge 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 may stick out too far
8-12	#6-32 screw, 1/4" spacer, and nut	for mounting boards to each other and to Stooage bracket
4	1" threaded standoff (6-32 thread)	Mouser #534-2212 (for mounting board #1 above board #2)
4	#8-32 black screw	for mounting module to cabinet
	heat shrink cable	
	cable ties	
	coax cable (RG174/U)	Mouser #566-8216-100 (100 foot spool)
	hookup wire	
	solder	both organic and no clean



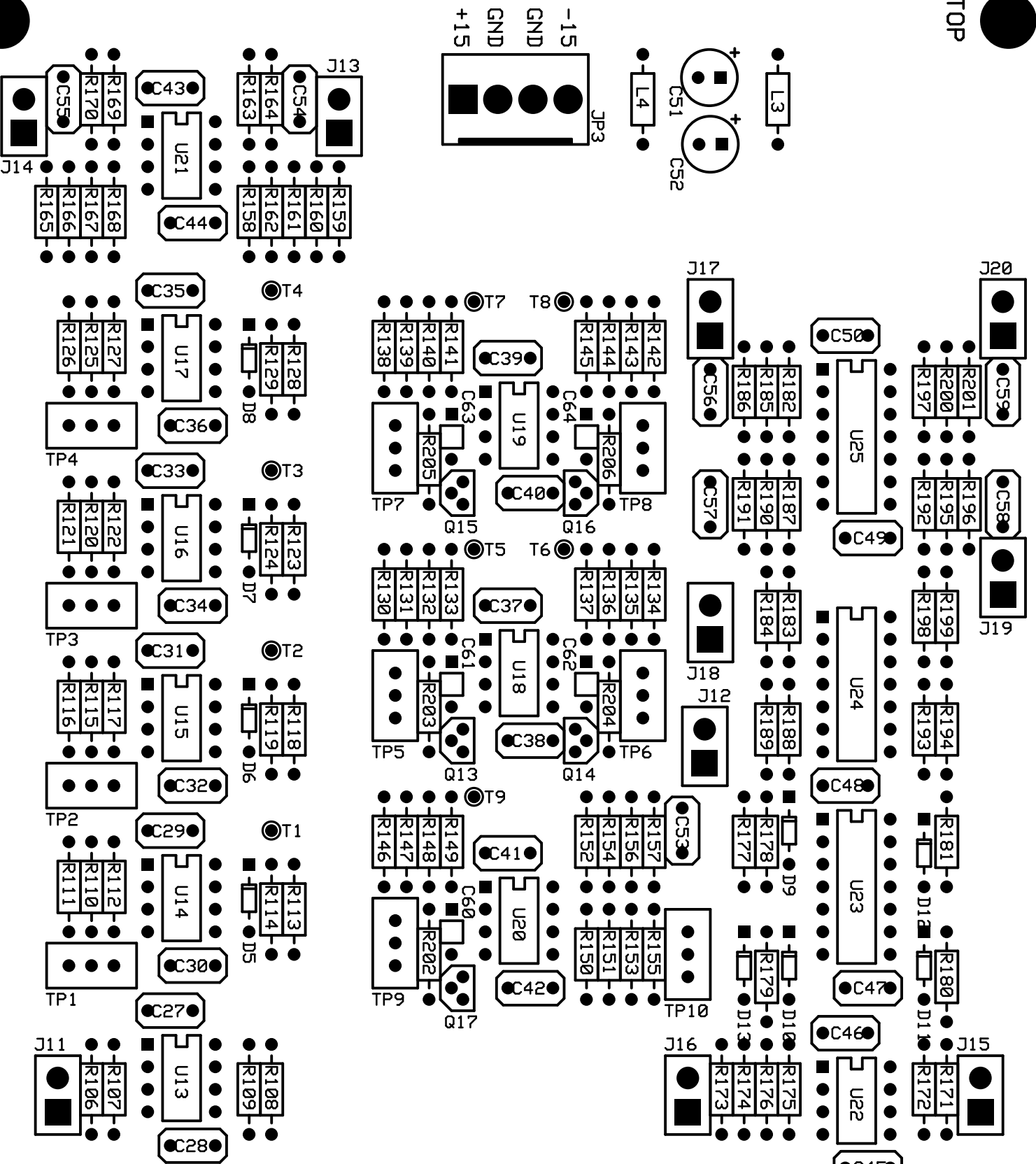
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 Board 1 of 2  
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 Board 2 of 2  
 April 2007

