RADIAL MIX-BLENDER CLONE

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Introduction

Radial Engineering's Mix-Blender is a two track mixer with an effects loop. The mixer can set the level of each input, and a send/return to an effects loop can be used or bypassed. This offers a musician the functionality of a 2 X 1 mixer, as well as blending in a separate effect. This project will clone the features of the Radial Mix-Blender, explaining the circuitry and functions of each part of the device. Additional features are included and some alterations from Radial's design.

Signal Flow

The Mix-Blender takes two inputs: unbalanced ¼" guitar cables. Each input is buffered and amplified, with a knob to adjust each signal's level. A feature not present in the original Mix-Blender that is added in this design is a contour knob - using a Gallien-Kruger contour circuit to adjust the frequency response of each input. Then, the two signals are summed together. Following the mixer, the signal can either be sent to an effects loop or bypassed. The effects loop has send and return ¼" jacks to chain it to the effects device; in my schematics below it will be filled with a Sallen-Key filter. A polarity switch can be used to invert the phase of the signal before sending it. At the return, the effects signal first passes through a buffer and then is blended back with the original signal, with a knob allowing for a mixture of dry/wet signal. Then, the mixed and blended (or bypassed) signal leads to an unbalanced ¼" output.

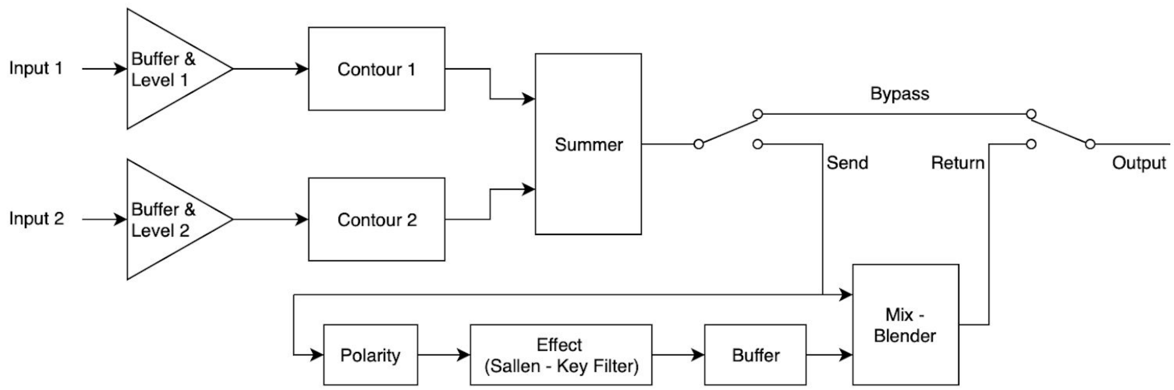


Figure 1. Signal flow diagram of the Radial Mix-Blender clone.

Notes:

1) The +15V and -15V power supply rails on the op-amps in this project should all include bypass capacitors, as shown in figure 2. These bypass caps are used to shunt the noise in the DC power supply to ground in practical application. For a hardware build, they should be located as near the opamp as possible. Due to restrictions on the number of components per schematic, and because the bypass caps serve no purpose in our simulations in CircuitMaker, they are not shown in the following schematics.

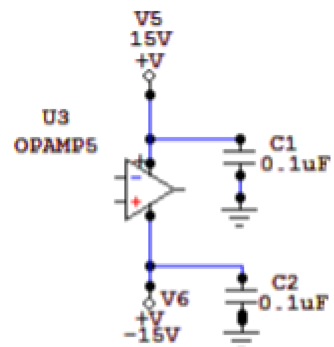


Figure 2. Bypass caps on op-amp rails

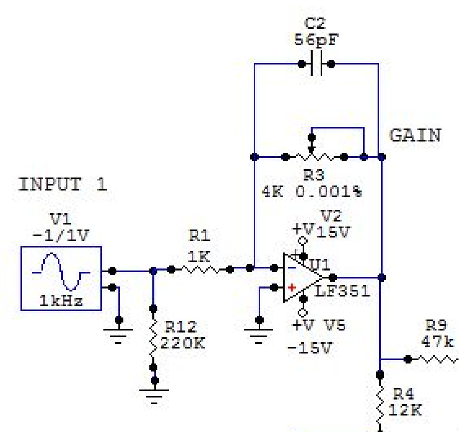
2) Real world applications would also include many other capacitors to reduce the noise introduced in the circuitry, including DC blocking caps inserted in the signal path, DC stabilization caps in non-inverting op-amps (a capacitor to ground on the inverting input), and snubber caps (shunting high frequency noise to ground). Due

to the component limit in CircuitMaker and the fact that these components would serve no purpose in our simulations, these have been omitted.

3) Dual-ganged pots (two potentiometers controlled with the same with knob) should best be connected in the schematic with a dashed line, but CircuitMaker does not permit extra lines like that. I made sure to identify all dual-ganged pots.
4) Due to restrictions in the simultaneous components, no complete circuit schematic could be simulated in full. Thus, there are no input/input transfer functions that can be displayed. Instead, the design is analyzed section by section, with example transfer functions using a sinusoidal signal generator.

Input Buffers and Levels:

Figure 3. Input buffer and level



The beginning of the signal flow in the Radial Mix-Blender is the processing of two ¼” cable inputs. Only 1 of which is fully shown in our final schematic since the two inputs are identical. The “buffer” means that the op-amp is able to set the input impedance, and provide an extremely low output impedance. Each input has an input impedance of 220K, as set by R12 in Figure 3. Next, an inverting amplifier buffers the signal and sets the level of each input. The relationship between R1, a fixed 1K resistor, and R3, an audio taper potentiometer, in figure 3 sets what our level (gain) will be. This transfer function equation for an inverting op-amp is used:

$$\frac{V\,out}{V\,in} = -\frac{R3}{R1}$$

When R3 has a maximum resistance of 4K, the transfer function equals -4; the signal is inverted, and amplified 12 dB. When R3 has a minimum resistance of 0Ω (a short circuit), the transfer function equals 0; the signal is attenuated to -∞ dB.

Figure 4 shows the signal with the maximum level (inverted, amplified 12dB) and figure 5 shows the signal with minimum level (attenuated -∞ dB). In both graphs, the yellow waveform is the input and green waveform is the output.

In figure 3, C2 functions as an 'anti-squeal capacitor'. It passes high frequency noise in the negative feedback path, causing attenuation in the output.

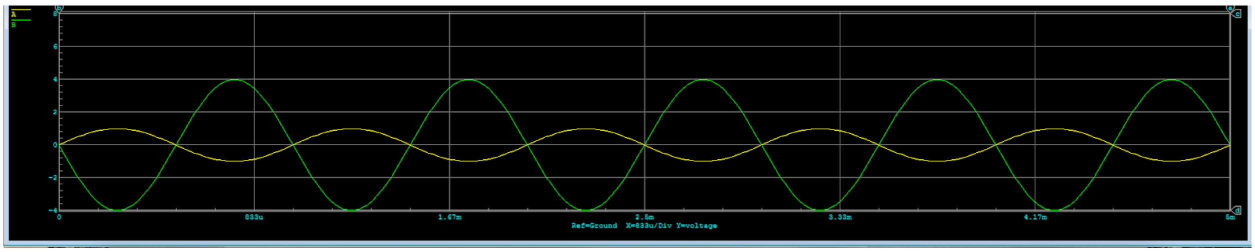


Figure 4. Maximum level on the input inverting amplifier.

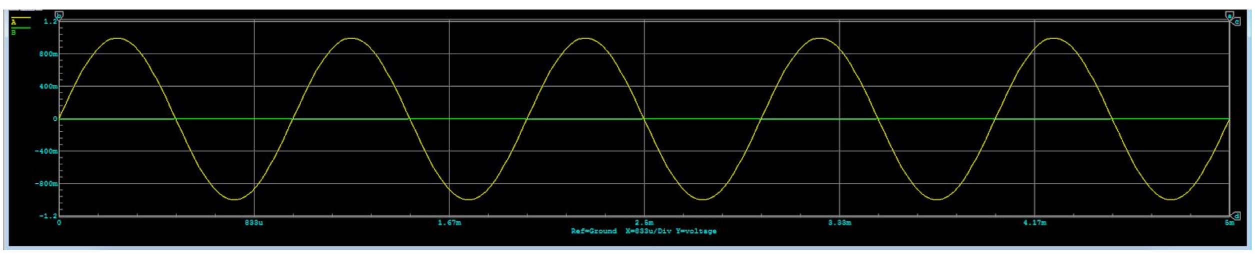


Figure 5. Minimum level on the input inverting amplifier.

Contour Circuitry:

The contour circuit is a part of each input following the buffer and level control. This circuit is based on a Gallien-Kruger design.

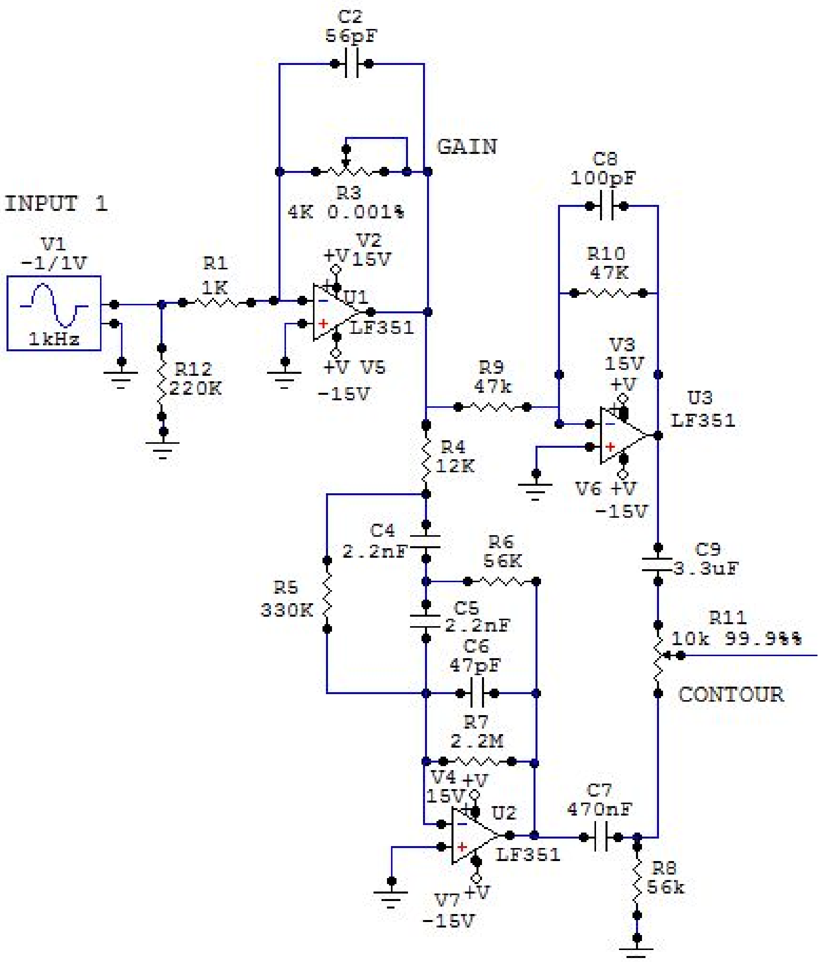


Figure 6. Contour control circuitry following buffer and gain control.

The contour circuit adjusts the frequency response of the input. The contour potentiometer can control the mix between the two inverting op-amp circuits, which have complex filters that can either boost or cut the low end of the signal. Figures 7 and 8 show the frequency responses at the extremes of the contour pot.

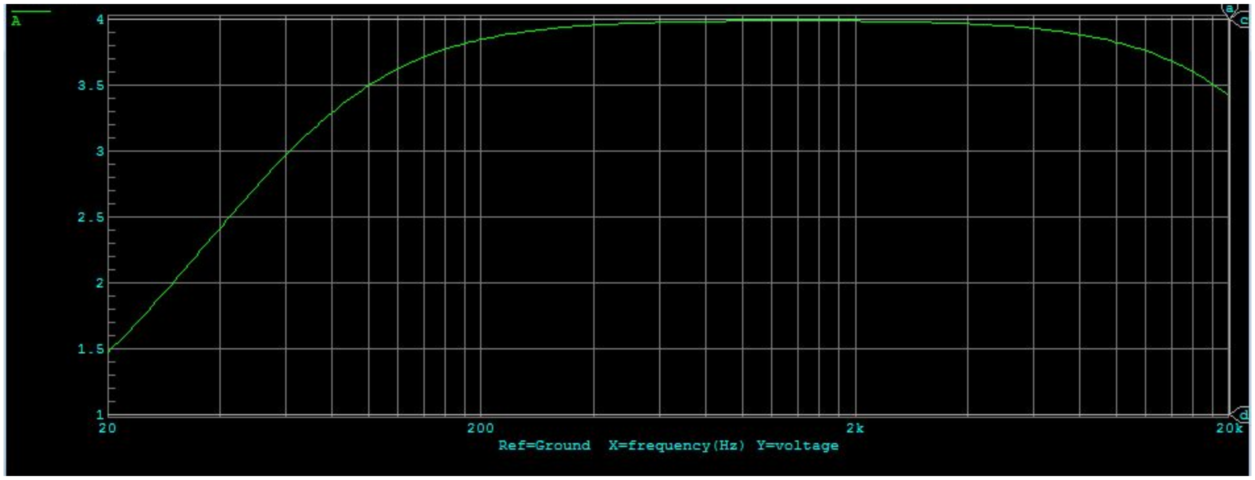


Figure 7. Contour with potentiometer at 0.001%

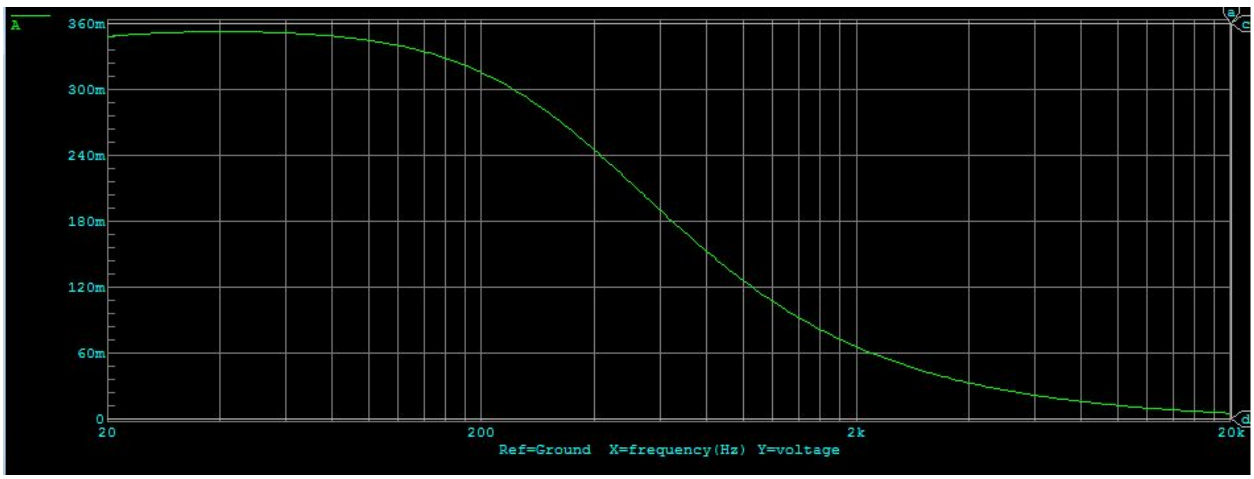


Figure 8. Contour with potentiometer at 99.99%

Summer:

Following the contour potentiometers on the two inputs is the summer. Using an inverting op-amp, the two inputs can be mixed into one signal. The formula below calculates the output of the summer circuit shown in Figure 9.

$$V_{out} = -R13\left(\frac{V_{in1}}{R2} + \frac{V_{in2}}{R15}\right)$$

Since R13 = R2 = R15 = 1k, the two inputs are mixed at the same level (of course their gains can be adjusted earlier in the circuitry). The output of the summer is 180° out of phase from the original inputs.

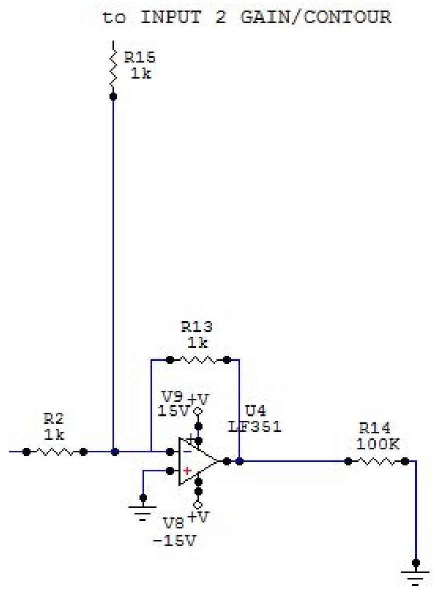


Figure 9. Summer circuitry

Effects:

The polarity switch, send, Sallen-Key filter, return buffer and blender components all fall under the section of the effects loop. These components are shown in figure 10. Note that the entire effects loop can be switched on or true bypassed by using the pair of dual ganged single pole double throw switches S3 and S4.

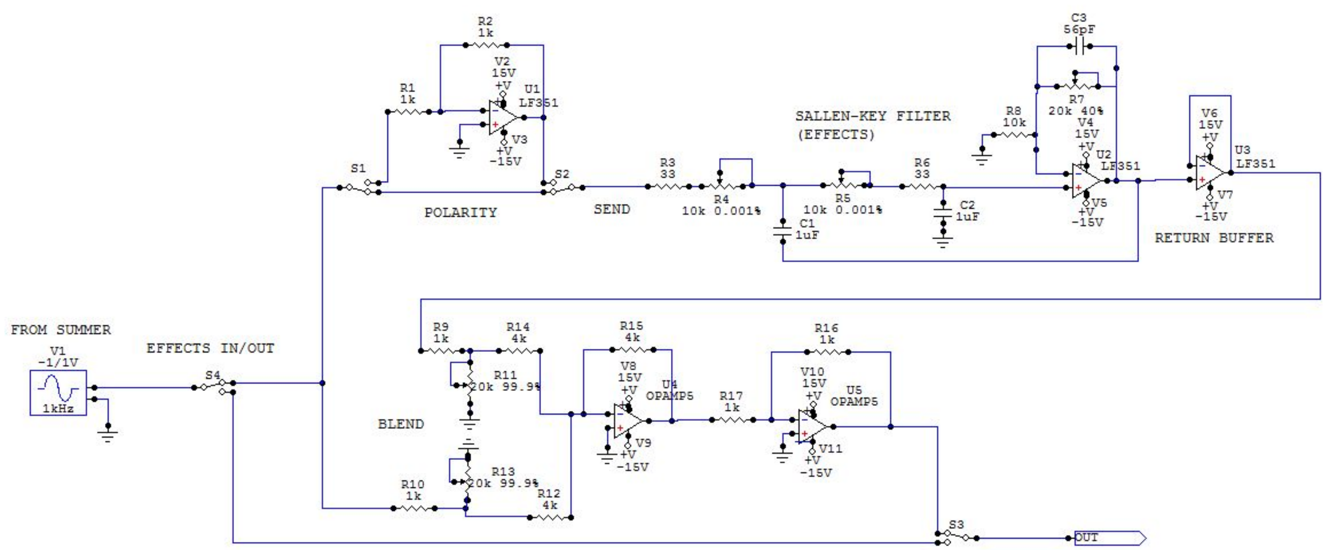


Figure 10. The entire effects loop schematic.

Polarity Switch:

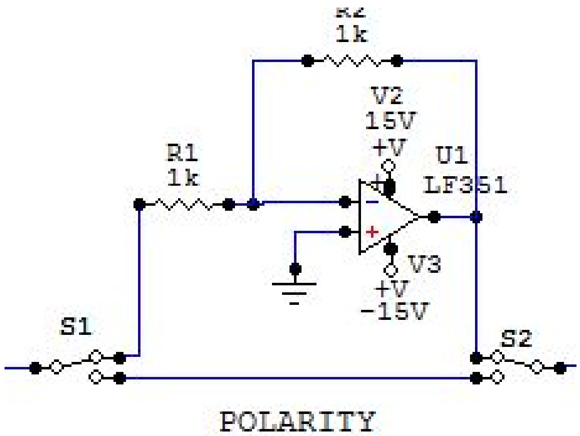


Figure 11. Polarity switch

The polarity switch prior to the effects loop offers the option to process the effects signal with a phase inversion. The circuitry operates between a dual-ganged pair of single pole double throw switches (S1 and S2 in figure 11) to either engage the phase inversion or true bypass it. With the polarity switch on at 180°, the signal passes through an inverting op-amp that has a gain factor of -1.

$$\frac{V\,out}{V\,in} = -\frac{R2}{R1} = -1$$

Resonant Sallen-Key Filter:

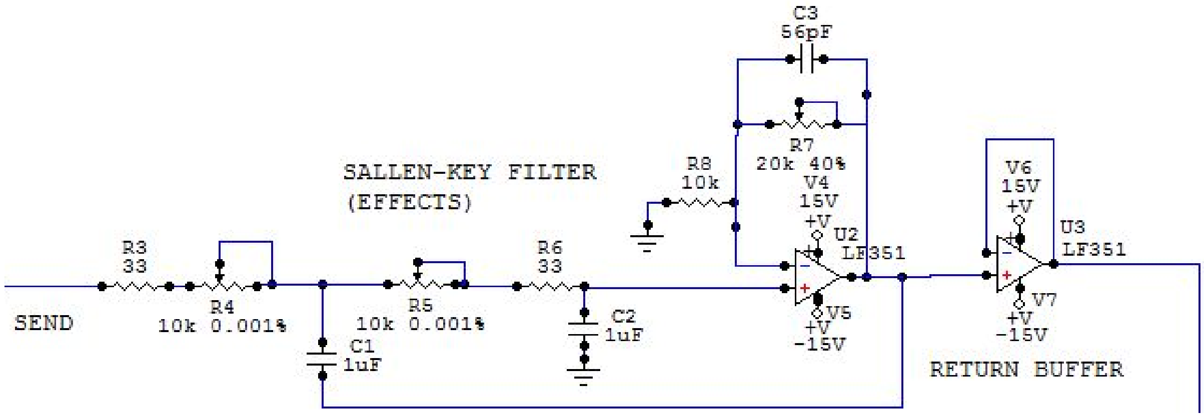


Figure 12. Effects loop send, Sallen-Key filter, and return buffer.

Though Radial Engineering's Mix Blender simply has send and return ¼" jacks for the effects loop, our clone will include a Sallen-Key filter as the "effect". It basically functions as a 2nd order active low pass filter, with a positive feedback path through C1 and a negative feedback path through R7. The filter has a pair of dual ganged potentiometers (R4 and R5) to control the filter cutoff frequency, and the potentiometer (R7) in the negative feedback path controls the resonance, or Q. C3 is an anti-squeal capacitor to reduce high frequency noise via negative feedback. Fixed resistors R3 and R6 are included to ensure a minimum resistance.

The cutoff frequency can be found with the equation:

$$f_c = \frac{1}{2\pi(R3+R4)(R5+R6)(C1)(C2)}$$

It is shown that the fixed resistors R3 and R6 are included to ensure that the potentiometers do not reach a 0Ω resistance, and the filter would not work.

The resonance can be found with the equation:

$$Q = \frac{1}{2 - \frac{R7}{R8}}$$

Figures 13, 14, 15, 16, and 17 show various plots of the Sallen-Key filter with different cutoff and resonance settings. Notice that the higher the cutoff potentiometer setting, the lower the cutoff frequency; the higher the Q potentiometer setting, the greater the resonant peak is. I did not use values higher than 90% on the resonance pot because it created resonant peaks with over 12 gain (simply unrealistic for usage).

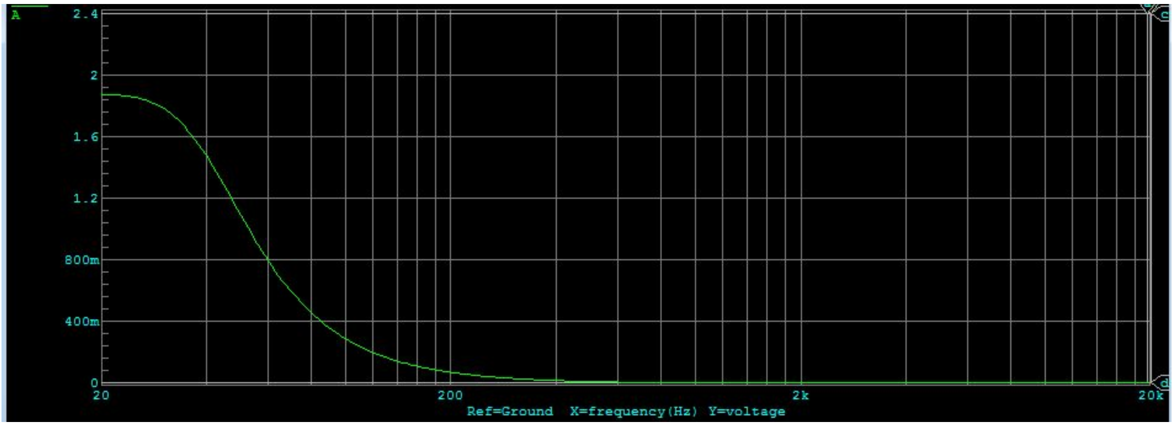


Figure 13. Cutoff pots at 40%, resonance pot at 40%

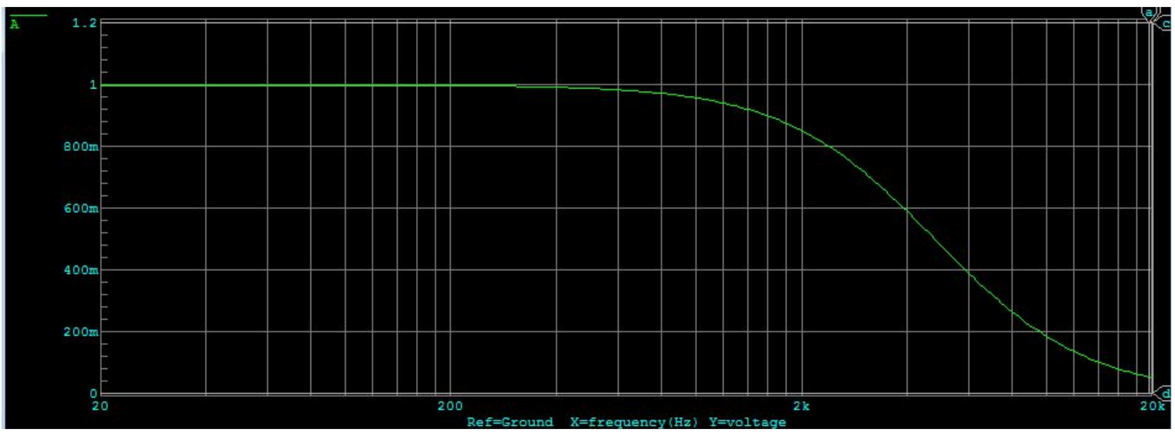


Figure 14. Cutoff pots at 0.001%, resonance pot at 0.001%

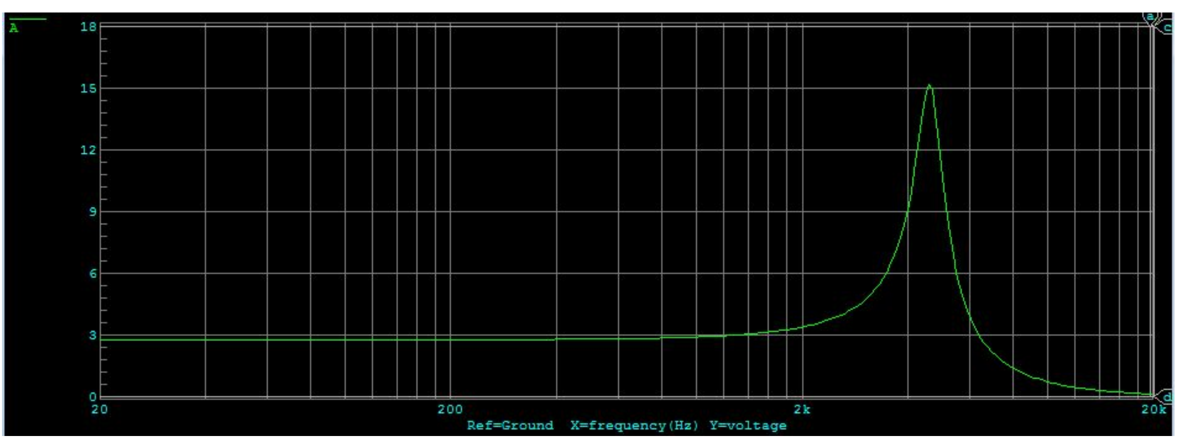


Figure 15. Cutoff pots at 0.001%, resonance pot at 90%

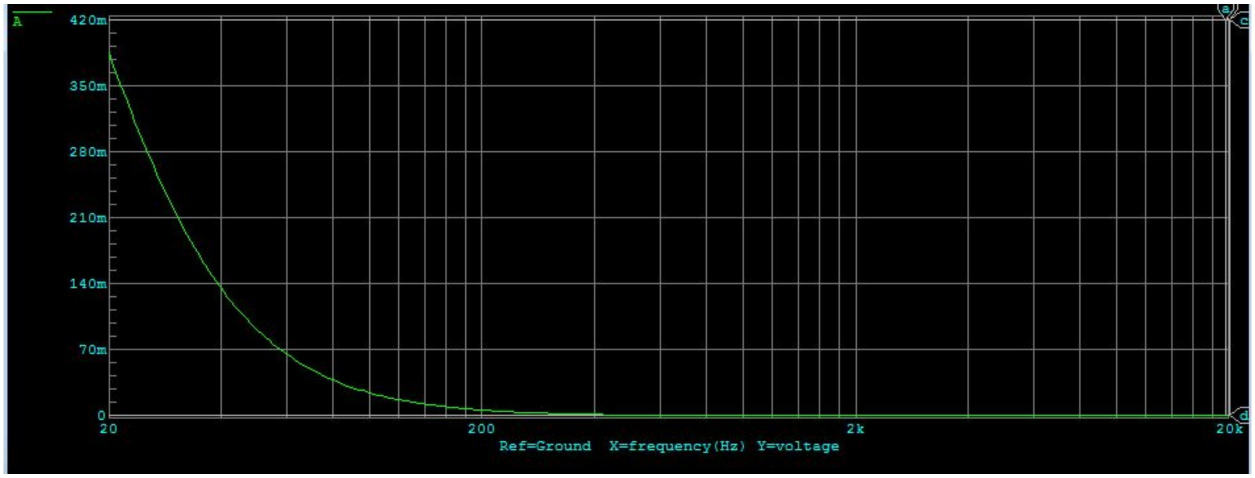


Figure 16. Cutoff pots at 99.99%, resonance pot at 0.001%

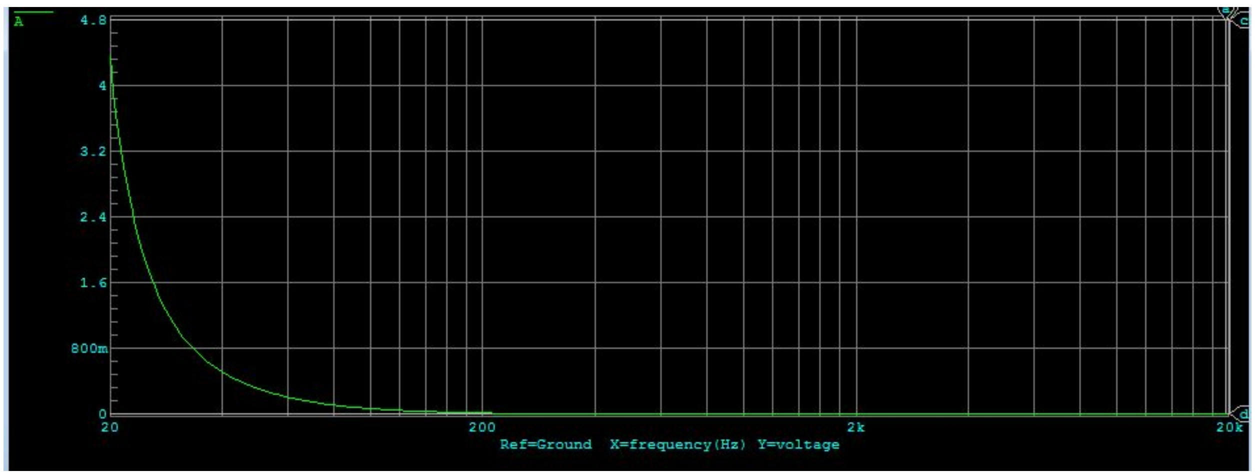


Figure 17. Cutoff pots at 99.99%, resonance pot at 90%

Return Buffer:

The return buffer is simply a unity gain buffer op-amp, which sets a very large input impedance after the effects loop. It is a necessary component to preserve proper gain staging and prevent loading.

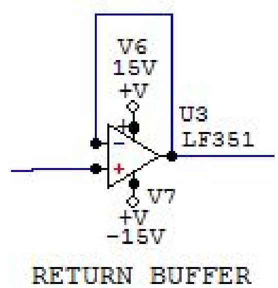


Figure 18. Return buffer

Blender:

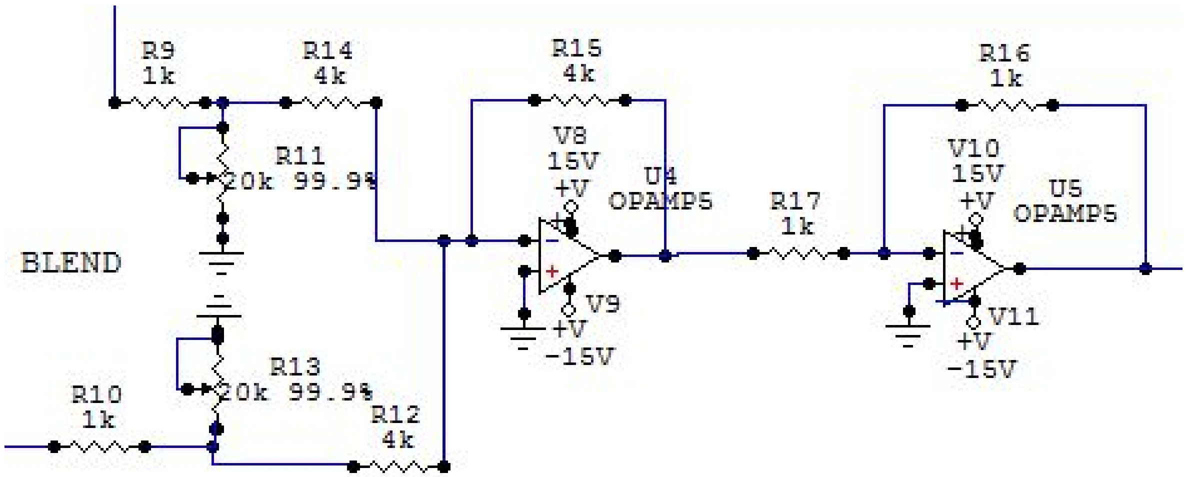


Figure 19. Blend knob, summer, and inverting op-amp.

The final part of the effects loops is the blender. This is made up of a blend knob controlling the relative levels of the "wet" effects loop and "dry" original signal. The blend knob controls a pair of dual-ganged pots that each control a resistor divider in the dry and wet signal paths, but with opposite potentiometer configurations.

Resistor divider transfer function:

$$\frac{V_{out}}{V_{in}} = \frac{R11}{R9 + R11} \text{ and } \frac{V_{out}}{V_{in}} = \frac{R13}{R10 + R13}$$

Note that R11 and R13 are dual-ganged pots.

When the pot is at an extreme, one signal will be shunted to ground and the other will almost completely pass. The opposite is true when the pot is at the opposite extreme. This allows for the blend knob to allow for a 100% wet or 100% dry signal, and any ratio of their levels in between.

Following this blend control, another summing inverting amplifier mixes the two signals into one signal, also phase inverting the signal. Another inverting op-amp with unity gain follows it, simply to invert the phase again.

Outputs:

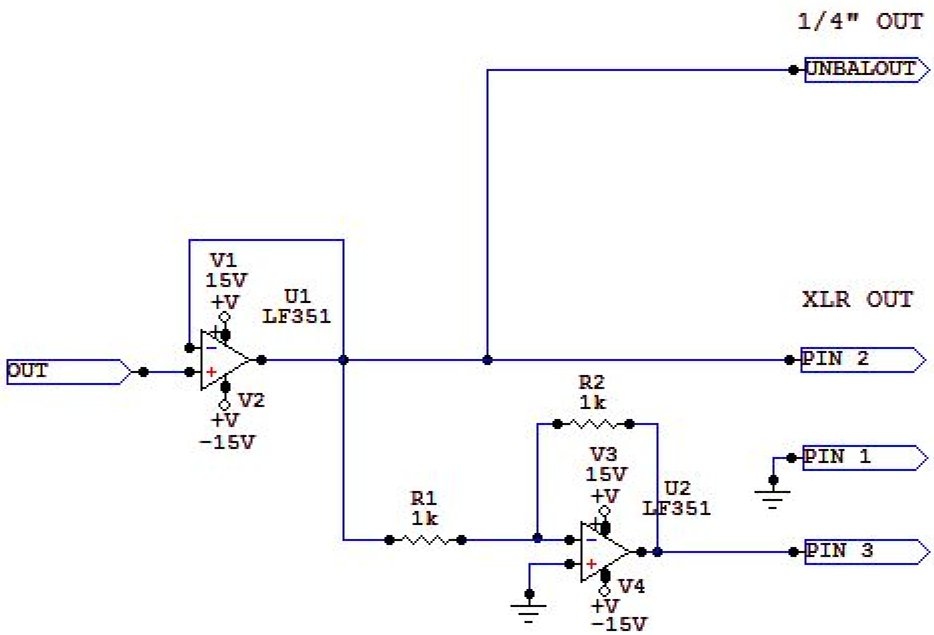


Figure 20. The ¼” and XLR cable outputs of the Mix-Blender.

Following the effects loop (which may also be bypassed), several outputs are available. First, a splitter buffer op-amp (“spluffer”) ensures that the output impedance is near zero, preventing loading and allowing us to split the outputs. A ¼” cable unbalanced output is tapped straight from the spluffer. An XLR cable output is also created by having a hot pin 2 output, a grounded pin 1, and a cold pin 3 that follows an inverting op-amp with unity gain.

Conclusion:

This modified clone of Radial Engineering’s Mix-Blender offers several useful features that a musician may use. It can process two inputs as a mixer, send them into an effects loop, and control the ratio of wet and dry signal. Options for polarity switch and effects bypass are also available. The design includes features not present in the original, including the contour controls of each input, a Sallen-Key active low pass filter, and XLR output.